NATIONAL WATER SUPPLY & DRAINAGE BOARD (NWSDB)
MINISTRY OF WATER SUPPLY AND DRAINAGE
THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA

PREPARATORY SURVEY ON ANURADHAPURA NORTH INTEGRATED WATER SUPPLY PROJECT IN THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA

FINAL REPORT
(VOLUME II : MAIN)

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JAPAN INTERNATIONAL COOPERATION AGENCY

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Preparatory Study - Summary Sheet for Planning

1. Field: Water Supply	**Anuradhapura North Integrated Water Supply Project**	Report Page
2. Outline of Plan	The Project is to integrate 56 existing small-scale water supply schemes dispersed in 6 DSDs in the northeastern part of Anuradhapura District into two regional systems, namely one for 2 DSDs and the other for 4 DSDs, cover the new area currently not served by water supply and to deliver water to the isolated areas not covered by pipe borne water supply systems due to low cost-effectiveness.	
3. Preconditions for Planning		
3.1 Supreme Plan, Beneficiaries, etc.	Out of a total population of 237,520 persons (2024) in 6 DSDs, served population is 170,490 persons, or 122,465 persons for pipe borne water supply and 48,025 persons for water delivery service by bowsers	P4-21
3.2 Meteorology	Climatology: dry zone Temperature: stable at 29～30ºC for April to September and around 26ºC during the coldest months of December to January Rainfall: 1,285 mm/year on average (two-thirds falls during October to March and more than 70% out of them are concentrated in October to December	P2-3~5
3.2 Topography and Geology	The project area covers three river basins. Ground elevations vary in the range of 91 m to 121 m for Mahakanadarawa area and 50 m to146 m in Wahalkada area with gentle slopes. There are more than 2,500 irrigation reservoirs dispersed. There is a base rock 2 m to 3 m below the ground in general with exposed rocks in some places.	P2-1~3 P5-40
3.3 Population and Water Demand Projection	Mahakanadarawa System 2024 / 2034 Design population: 97,333 persons / 111,900 persons Served population: 70,097 persons / 111,900 persons Design flow (Daily max.): 8,585 m^3/day / 17,297 m^3/day Wahalkada System 2024 / 2034 Design population: 140,187 persons / 161,468 persons Served population: 100,393 persons / 161,468 persons Design flow (Daily max.): 13,318 m^3/day / 26,870 m^3/day	P4-21 P4-21
3.4 Project Evaluation	EIRR (excluding CKD-related benefit) [*1]: 6.91% for Mahakanadarawa System 6.59% for Wahalkada System Both proposed water treatment plant (WTP) sites are located out of the sanctuary and environmentally-sensitive area. The change of land use from forest and archeological impact license have been already approved. IEE/EIA are not required due to water intake from an irrigation canal for both cases, but the environmental protection license must be obtained three months before the commissioning of water supply facilities.	P10-18 P10-20 P9-26~28
4. Study and Planning		

4.1 Study Conducted	1) Topographic survey	Line survey: 179 km, Area survey: 21.269 ha Minor area survey: 10 places, Bathymetric survey: 1 place Bathymetric survey intake area: 1 place	
	2) Geological survey	Conducted at 2 WTP sites and 12 elevated tank sites Total length of boring: 206.25m Standard penetration test: 187 samples including laboratory tests	
	3) Water quality examination	Irrigation reservoirs and canals: 6 times for 7 samples at 3 locations CBO water sources and private (groundwater): One time at 16 locations	P4-28~35 P2-34~38
	4) Socio-economic survey	NWSDB service area: 135 samples, CBO service area: 299 samples, industrial customers: 101 samples and non-service area: 450 samples, or 989samples in total	
	5) Fauna and flora survey	Conducted at 2 irrigation reservoirs, 2 WTP sites and 18 elevated tank sites and one sites on tranmission pipeline route, or 23 sites in total	
5. Design			
5.1 Design Criteria Used	Japan Waterworks Association: “Design Criteria for Water supply Facilities (2000)” Susumu Kawamura：”Integrated Design of Water Treatment Facilities”, John Wiley & Sons, Inc., 1991 NWSDB：Design Manual (March 1989))		
5.2 Design Conditions	Mahakanadarawa / Wahalkada 1) Intake: 9,400 m^3/day(2024) / 14,400 m^3/day(2024) 2) Daily max. water demand: 8,600 m^3/day(2024) / 13,300 m^3/day(2024)		P5-26,5-30
5.3 Major Facilities	1) WTP	Mahakanadarawa System Sedimentation basin: W4.0 m × L10.4 m × H4.0 m × 4 units Rapid sand filter: W3.0 m × L5.5 m × 4 units Others include chlorination chamber, clear water reservoir, backwash drain recycling tank, thickener, sludge drying bed, administrative building, etc. Wahalkada System Sedimentation basin: W4.0 m × L14.4 m × H4.0 m × 4 units Rapid sand filter: W4.0 m × L6.0 m × 4 units Others include chlorination chamber, clear water reservoir, backwash drain recycling tank, thickener, sludge drying bed, administrative building, etc.	P5-27 P5-31
	2) Transmission System	Mahakanadarawa System Main: 250~450 mm × 42.3 km Sub-main: 100~250 mm × 50.8 km Wahalkada System Main: 300~450 mm × 117.3 km	P5-54 P5-54

		Sub-main: 100~250 mm × 24.3 km	
	3) Distribution System	Mahakanadarawa System Main: 100~400 mm × 141.4 km、 Sub-system: 50~200 mm × 365.6 km Wahalkada System Main:100~400 mm × 326.7 km Sub-system: 50~200 mm × 546.0 km	P5-54 P5-54
	4) Elevated Tank	Mahakanadarawa System 250 m^3, 750 m^3, 1,250 m^3, 2,000 m^3: one unit for each Wahalkada System 250 m^3 × 3 units, 500 m^3 × 3 units, 750 m^3 × 2 units, 1,250 m^3 × 1 unit, 1,500 m^3 × 1 unit, 2,000 m^3 × 1 unit	P5-55~59 P5-55~59
	5) Ground Reservoir	Mahakanadarawa System 1,000 m^3, 1,500 m^3: one unit for each Wahalkada System 500 m^3 × 3 units, 1,000 m^3 × 2 units, 1,500 m^3 × 1 unit	P5-55~59 P5-55~59
5.4 Annex	Pump house, operational complex. chlorination bldg, workshop, staff quarters, etc. will be constructed		P5-55~59
5.5 Study on stability	Not done		

6. Considerations (Issues in Planning)

・For distribution pipeline routes, topographic survey was not conducted due to huge length. The size and length of distribution pipes given in the report is the estimation by selecting the model areas in the project area, conducting the distribution network analysis and applying the length by size to the entire project area.

・The geological survey was not conducted for five additionally proposed elevated tank sites, due to the delay of permission by the agencies concerned. The preliminary design was done based on the geological characteristics obtained in other sites.

・The topographic and geological survey was not conducted for a water intake station near the Wahalkada WTP site in consideration of farmers' fear on the reduction of irrigation water due to its close location to an irrigation canal. The preliminary design was done based on the geological characteristics obtained in other sites.

・It is supposed that piping materials required for service pipes will be provided by NWSDB and the installation work will be done by customers under the direction and supervision of NWSDB.

*1 EIRR is based on the method described in this report, but may be different depending on the benefit evaluation method.

EXECUTIVE SUMMARY

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1 WATER SUPPLY SECTOR IN SRI LANKA

1.1 National Development Plan (Mahinda Chintana - Vision for the Future)

"Mahinda Chintana - Vision for the Future", or the Five-year Plan of Sri Lanka, which was declared in August 2010, covering a period of 2011 to 2016 is articulated identifying specific targets aiming at achieving the Millennium Development Goals (MDGs) ahead of time. Among Mahinda Chintana Goals (MCGs) for 2016 include the following with other targets as shown in **Table 1** toward ***"Increasing access to clean water in urban areas from 65 to 90 percent"***.

Table 1 Access to Safe Water Coverage

Year	2005	2009	2015	2020*
Safe water coverage (%)	80	85	94	100
Pipe borne water availability (%)	29	37	44	60
Water connections ('000) (NWSDB schemes)	907	1,267	1,600	3,000

Source: "Mahinda Chintana – Vision for the Future", Department of National Planning, Ministry of Financing and Planning, 2010

1.2 Sector Organizations

The water supply sector is divided into two sub sectors as shown in **Table 2**.

Table 2 Water Supply Sub Sector

	Urban water supply sub sector	Rural water supply sub sector
Object area	Towns, cities, urban centres, industries and suburban areas	Rural areas
Key Actors	Ministry of Water Supply and Drainage NWSDB Provincial Councils Municipal Councils Urban Councils Pradeshiya Sabhas	Provincial Councils Local Authorities Community Based Organizations (CBOs) Non-Government Organizations (NGOs)
Water service mode	Pipe borne water supply	Dug wells Tube wells Rain water harvesting Small-scale pipe water supply

Source: "National Policy on Drinking Water", June 2009

For the urban area, NWSDB is responsible for the provision of water supply through the implementation of large scale water supply, in consultation with relevant local authorities under the superintendence and direction of the Ministry of Water Supply and Drainage. In principle, NWSDB directly manages and operates the water supply facilities implemented by itself from operation and maintenance to billing and collection. For this purpose, the country is divided into five regions (Western, Central, Eastern, Northern and Southern) and eleven areas to which Additional General Managers and Deputy General Managers are deployed for management.

A rural area for this purpose is defined as any Grama Niladaree (GN) Division within a Pradeshiya Sabha (PS) area. The Provincial Councils are responsible for the implementation of small-scale rural water supply through local authorities (municipal councils, urban councils, pradeshiya sabhas). The roles of the Government, Provincial Council and the Local Government Authorities should be to regulate and facilitate in the implementation of the sector activities while the Community Based Organization (CBOs), Private Sector and NGOs should be the providers of services. Local Authorities also may provide services when required. In the National Policy for Rural Water Supply and Sanitation Sector (July 2001) says that users should (1) be encouraged to own and manage the facilities and assets, (2) be encouraged to share the capital investment incurred in creating the facilities, and (3) bear the full responsibility of sustainable operation and maintenance of the facilities.

1.3 Activities and Policies of International Development Partners and National Agencies of the Sector

After the conflict termination in April 2009, a variety of countries offer a helping hand to the assistance for Sri Lanka. According to “Performance Report 2011” by the Ministry of Water Supply and Drainage, there are thirty foreign-funded water supply and sewerage projects in which twelve countries and four international agencies are involved as shown in **Table 3**.

Table 3 Bi- and Multi-lateral Assistance to Sectors in Sri Lanka

	Water Supply			Sewerage
	Urban	Rural	Others	
Bilateral and Multi-lateral Assistance	Japan (JICA) Denmark (DANIDA) Hungary Spain Netherland Germany (KfW) Korea Austria Australia France Belgium	ADB	ADB UNICEF WB IFRC (Red Cross)	Japan Australia Sweden (SIDA)
	11 countries	1 agency	4 agencies	3 countries

Major donors during the year 2011 are ADB, JICA (Japan), KfW (Germany), SIDA (Sweden) , UNICEF, IFRC (International Federation of Red Cross and Red Crescent Societies), Austria, France, Spain, Hungary, Korea and Netherland.

2 NATURAL AND SOCIAL CONDITION

2.1 General

Anuradhapura is located about 280 km north-northeast of Colombo, and about 140 km north-northwest of Kandy and is an inland district in the North Central Province. The district is classified as a dry zone climatologically with less rainfall and has about 2,500 small tanks for irrigational use. The district capital of Anuradhapura and its surrounding area was the first capital of the Ancient Sunghalese Dynasty that flourished from the 3rd century BC to the 9th century AD and is registered as the world's cultural heritage.

The study area consisting of six Divisional Secretariat Divisions (DSDs), namely Padaviya, Kebithigollewa, Horowpothana, Kahatagasdigilia, Medawachchiya and Rambewa is located in the northeast part of Anuradhapura District as shown in **Figure 1** and is bounded by Trincomalee District to the east and by Vavuniya District to the north. It has a total area of 286,268 ha, a total population of 175,890 persons (2001 Census) and is a typical rural area.

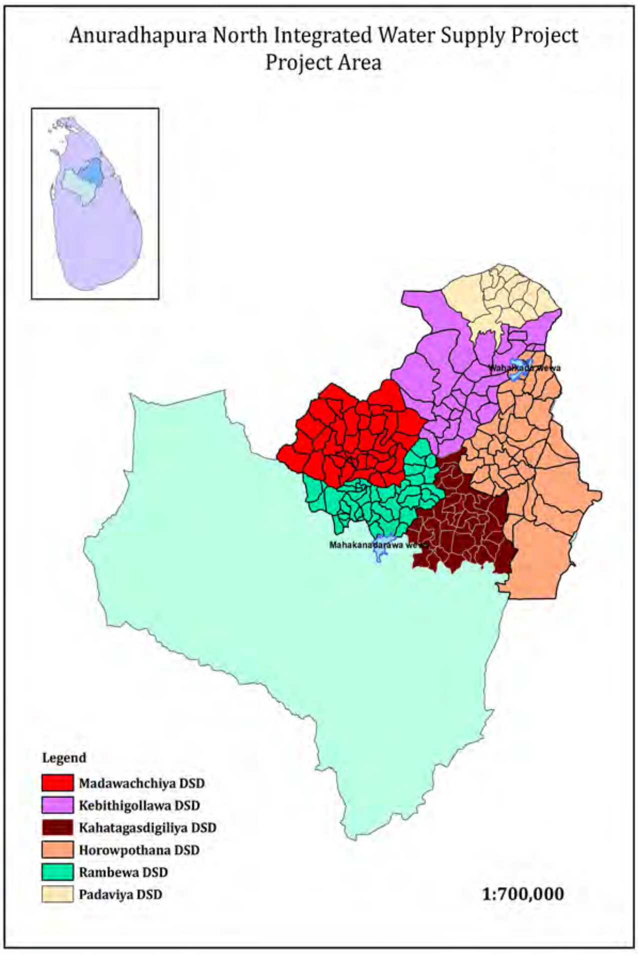


Figure 1
Location of Study Area

2.2 Natural Conditions

The climatological pattern is classified into two seasons for cultivation purposes as follows:

- Maha season from October to March called as the wet season
- Yala season from April to September called as the dry season

(1) Temperature

During the dry season from April to September, the monthly average temperature is very stable in the range of 29ºC to 30ºC. However at the start of the wet season from October, the temperature decreases with the coldest months being December and January at about 26 ºC, following which the temperature increases.

(2) Rainfall

The annual average rainfall in the period from 1961 to 1990 in Anuradhapura District was 1,285 mm, but more than two-thirds of the annual rainfall occurs in the Maha season. In addition, as more than 70% of the rainfall during this period is concentrated in the period from October to December, there is a large monthly fluctuation in rainfall.

2.3 Social Conditions

2.3.1 Population

Population, population density and population growth rate of Sri Lanka, Anuradhapura District and the study area is summarised in **Table 4**.

Table 4 Population, Population density and Growth Rate of Sri Lanka, Anuradhapura

	Area (km^2)	Population ('1,000)			Population Density (persons/km^2)		Annual Average Growth Rate (%)	
		1981	2001	2012	2001	2012	2001/1981	2012/2001
Sri Lanka	**66,510**	**14,846.8**	**18,797.3**	**20,277.6**	**300**	**323**	**1.16**	**0.71**
Urban		3,192.7	-	-			-	-
Rural		11,654.3	-	-			-	-
Anuradhapura	**7,179**	**587.9**	**745.7**	**855.6**	**112**	**128**	**1.25**	**1.33**
(% to Sri Lanka)		(4.0%)	(4.0%)	(4.2%)				
Urban		41.4	53.2	-			1.26	-
Rural		546.5	692.5	-			1.19	-
Study Area	**2,843**		**175,890**	**205,171**	**62**	**72**		**1.41**
Padaviya	240		21,146	22,924	88	96		0.74
Kebithigollewa	615		19,457	22,227	32	36		1.22
Horowpothana	845		29,642	36,714	35	43		1.96
Kahatagasdigiliya	352		33,572	40,137	95	114		1.64
Medawachchiya	482		40,469	46,743	84	97		1.32
Rambewa	309		31,604	36,426	102	118		1.30

- The total national population in the Census 2011 is 20,277,597 persons with an annual average growth rate of 0.71% in the period from 2001 to 2012, which is lower than 1.16% in the period from 1981 to 2001.
- Similarly, the population in Anuradhapura District in the Census 2011 is 855,562 persons with an annual average growth rate of 1.33% in the period from 2001 to 2012, which is the highest out of 18 districts covered in the Census 2011 and a small increase from the growth rate of 1.25% in the period from 1981 to 2001.

2.3.2 Land Use

The land use includes large areas of paddy fields, scrublands, forested areas, mixed cultivations, chena cultivations, home gardens and residences. The majority of the people in the area are farmers and largely depend on paddy cultivation. Apart from that the district economy is predominantly centred on chena and home gardens with vegetable cultivation. Additionally animal husbandry including cattle, goat and poultry is also common in some locations.

2.3.3 Income and Expenditure

(1) Income and Expenditure

The average monthly household income in the Household Income and Expenditure Survey 2009/2010 was Rs.36,451 as a whole, Rs.47,783 in urban areas and Rs.35,228 in rural areas at the national level, and Rs.37,586 in Anuradhapura District. While, the average monthly household expenditure was Rs.31,331 as a whole, Rs.44,928 in urban areas and Rs.29,423 in rural areas, and Rs.29,065 in Anuradhapura District.

(2) Percentage of Water Rate to Disposal Income in the Household Income and Expenditure

The monthly water and electricity bills[1] are Rs.99.75 and Rs.531.64 per household on national average, respectively, of which percentages to the total household income are 0.27% and 1.45%. The World Bank[2] estimates the limit for household affordability to pay for water supply services as 4% of household income. The present water charge in Sri Lanka at 0.27% of household income is around one-fifteenth of the ceiling (4%) set by an International organization.

Since the HI value for the country 8.9% for 2009/10, all the poor can be considered to belong to the1st decile or 10% from the lowest. On the assumption of a population of 4 persons/ household and an average water consumption of 11 m^3/month (= 4 persons × 91 Lpcd × 30.4 days/month), the water rate (Rs.168) is 2.8% to the 1st income decile median of Rs.6,080 in case of applying the

1 Source: Department of Census and Statistics, "Household Income and Expenditure Survey -2009/10", August 2011
2 "Information and Modeling Issues in Designing Water and Sanitation Subsidy Scheme", The World Bank, May 2000

special tariff (Domestic - Samurdhi Receipients), which is within 4% of the disposal income recommended by the World Bank. Even applying the normal tariff (Domestic – Non Samurdhi Tenement Garden) to the customer exceeding the 1st income decile median, the water rate is in the range of 2.8% to 2.6% to the disposal income which is in the level of no problem. This result suggests that there are households with an income of below Rs.4,200 (= Rs.168 / 0.04) that the water rate exceeds 4% of the disposal income. The percentage of the number of such households is estimated at about 3.5% (= 5% × Rs.4,200 / Rs.6,080) to the total district household number and about 0.8% (= 3.5% × 0.236) to the study area household number using the population percentage of study area to the whole district

2.4 Necessity of the Project

2.4.1 Principal Drinking Water Source

(1) Principal Drinking Water Source

In Census 2011, 75.4% of the people in the study area relied on groundwater through from dug wells (72.6%) and tube wells (2.8%), and tap water (4.1%), 18.9% on tap water and the remaining 5.7% on others such as bowser, bottled water, river, etc. (Note: the population coverage by water supply in the study area is approximately 27% according to the existing CBO water supply schemes survey, some of them may not regard tap water as the main water source in spite of the connection to a water supply schemes.) There are a decrease in the use of groundwater and an increase in the use of tap water. For the type of wells, unprotected dug wells and deep tube wells has substantially decreased and the protected dug wells have become popular. However, since the water source of such small-scale water supply schemes are almost groundwater, there is no change in relying on groundwater.

(2) Water-fetching Distance to Water Source

Since the data on water-fetching distance in the study area is not available, that is described using the district-level data.

The distribution of drinking water sources in Sri Lanka is 76.3% within premises and 23.7% outside premises, while in Anuradhapura District, they are 58.0% and 42.0% respectively. It shows that the percentage of a drinking water source outside premises is rather high. The percentage of the number of households engaged in the water-fetching work is secondarily high following that in Jaffina District.

The distance allocation from a housing unit to a drinking water source is 16.0% for equal or less than 100 m, 3.3% for 101 – 200 m, 3.1% for 201 – 500 m and 1.3% for above 500 m (The national average for a rural area is 16.4%, 3.7%, 3.5% and 1.4%, respectively.), while in Anuradhapura District they are 18.3%, 7.8%, 9.5% and 6.4%, respectively, showing that the people in the district are forced the water-fetching work for a longer distance than a national average. As for the water-fetching distance, Anuradhapura District is ranked at the second for within 100 m, third for 101 to 200 m and second for above 500 m. On a national basis, the district is placed in a severe condition as well as Jaffina District. In case of tap water, 43.4% of housing units have a tap indoors, 38.2% within premises and 18.4% outside premises. It means that one out of five housing units have no tap within premises.

(3) Per Capita Water Consumption at Existing CBOs

There are 50 existing water supply schemes maintained and operated by CBOs in the study area, of which the per capita water consumption is 66 Lpcd at 46 existing CBOs on average.

(4) Water Quailty at Existing CBOs

1) Distribution of fluoride concentration of groundwater in Sri Lanka

Fluoride is present particularly in rocks, soils and water in Sri Lanka. In 1987, a nationwide field survey was carried out and the distribution of fluoride concentration in groundwater was revealed. High concentration of fluoride occurs in several places and the study area is seriously affected.

2) Fluoride and hardness Concentratiion in the Study Area

Although there are 50 water supply schemes under CBOs in the study area out of which 45 CBOs have their water quality data of tap water. A fluoride concentration is above a desirable standard of 0.6 mg/L in 27 CBOs and above a permissible limit of 1.5 mg/L in 6 CBOs with the maximum value of 1.9 mg/L. The served population who are exposed to a risk of fluorosis by a fluoride concentration above a desirable limit counts 29,460 persons against 8,205 persons with no risk. The rate of populations with a risk versus with no risk is 78.2:21.8, that is to say, four out of five persons are exposed to a risk of fluorosis. Among them, a served population of 4,435 persons are exposed to a higher risk due to a fluoride concentration of above a permissible limit. In addition, out of 21 CBOs with a water quality data of hardness, 18 CBOs have above a desirable limit of 250 mg/L. The high concentration of hardness as well as fluoride is a big characteristics of this area.

(5) Water Supply Hours at CBOs

NWSDB NC has 24 water supply schemes and almost performs 24-hour water supply, which is ranked as the top class in NWSDB RSCs. While looking at the study area, out of 46 water supply schemes surveyed, water supply hours are reportedly significantly limited during a dry period at 20 water supply schemes. They are less than five hours at ten schemes, five to ten hours at six schemes and ten to fifteen hours at four schemes. In addition, two water supply schemes limit the maximum water supply hours at eight hours. The water supply hours in the worst cases are two hours in Ekamuthu and three hours in Dimuthu, Samagi and Suwasetha.

(6) Technical Problems at Existing CBOs

The existing CBO water supply systems have technical problems in designing and operation such as no master meter at water tanks and/or tube-well pumps, leakage, no operational valve, insufficient pressure due to under-sized pipes, improper chlorination, unstable power supply, invisible customer meter location, malfunction of tube-well pumps and water shortage in the dry season.

2.4.2 Dental Fluorosis

Dental fluorosis has been recognized as an endemic problem affecting different areas of Sri Lanka with naturally occurring fluorides in drinking water. In 2002-2003, the National Oral Health Survey was conducted by the Ministry of Health and Nutrition under cooperation of WHO. Using such data, the CFI (Community Fluorosis Index) in each district was calculated for only the results of 12 age as dental fluorosis significantly occurs until such age.

The CFI is calculated as shown in **Figure 2** with the following formula. The weightage is defined based on the classification of cases. If the CFI is above 0.6, generally it can be said that dental fluorosis is a public health problem in the area.

CFI = ∑weightage x number in each score group/number of cases examined

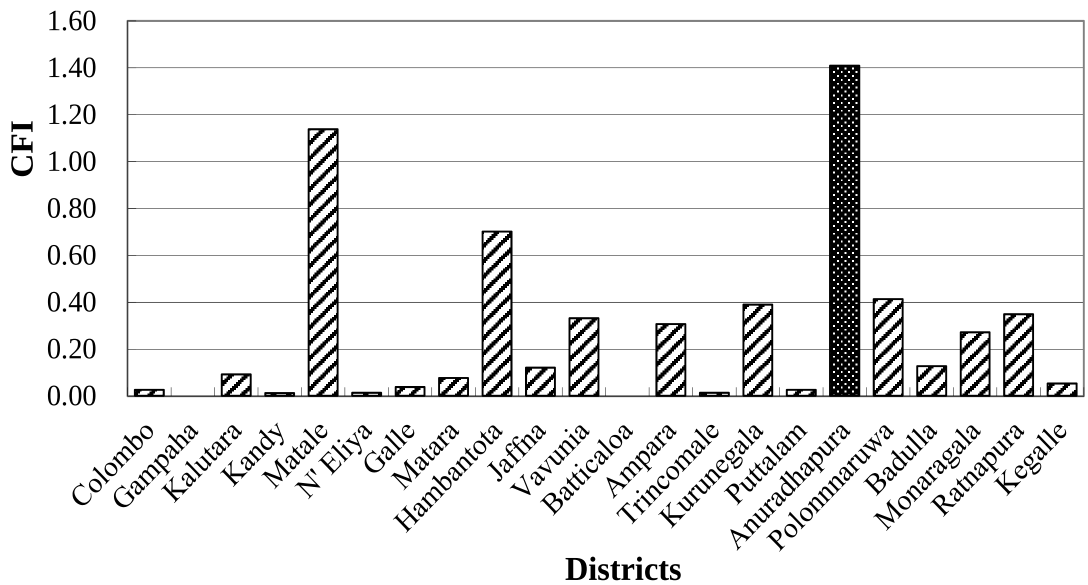


Figure 2 Comparison of CFI

2.4.3 Chronic Kidney Diseases (CKD)

Chronic kidney disease (CKD) is a progressive loss in renal function over a period of months or years. CKD is an emerging health problem and it has a high economical cost on the patient, family, community and health system. In recent years, an increase in CKD cases has been observed in some parts of the country especially in the North Central Provinces.

Since 2003, the Provincial Department of Health Services has also conducted a DSD-wise CKD prevalence survey in the North Central Province. The prevalence in each DSD were compared as shown in **Figure 3**. The distribution of the CKD prevalence is not equal, with the highest rates in Medawachchiya, Kebitigollewa and Padaviya, which are all within the study area.

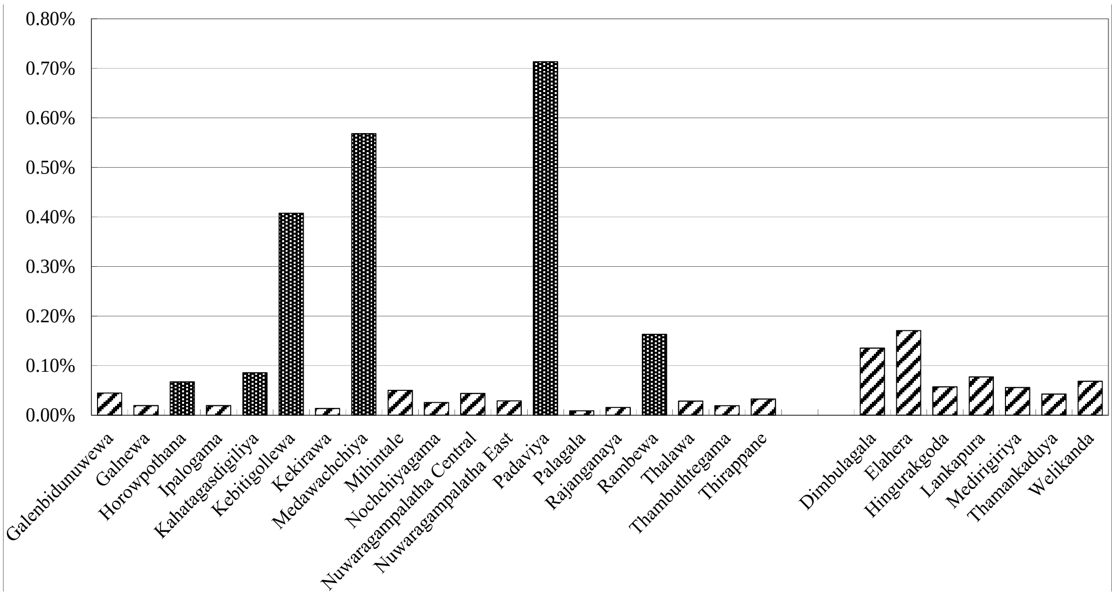


Figure 3 DSD-wise Distribution of CKD in North Central Province

Compared to dental fluorosis, the causes of CKD are still unclear. For example, in Padaviya and Medawachchiya there are high levels of fluoride in drinking water and high levels of CKD prevalence. On the other hand, in Kebitigollewa the level of fluoride in drinking water is low, but the CKD prevalence is high. More detailed investigation will be needed to identify the cause(s) of CKD. However, at least it is well known that high fluoride levels of drinking water causes worsening CKD for CKD patients. Provision of treated surface water supply which is able to supply lower levels of fluoride will help to protect people's daily life.

2.4.4 Necessity of the Project

As mentioned above, the necessity of the project can be summarized as follows:.

The people in the study area are facing the following problems regarding the principal water source and existing water supply schemes.

- According to the Census 2011, 75.4% of the people in the study area rely on groundwater as the principal water source and 18.9% of the people use tap water through the NWSDB's and CBO's water supply schemes. However the water source of such

water supply schemes is groundwater with a few exceptions
- The people in the study area are forced to be engaged in the water-fetching work for a distance longer than that in other districts.
- Four out of five persons are exposed to the risk of fluorosis in the study area.
- Many existing CBO’s water supply schemes have experienced the water shortage during the dry season and cannot maintain the 24-hour water supply.
- Most existing CBO’s water supply schemes have a variety of problems in structure, designing and operation.

Then water quality problem. Water quality of drinking water sources is an important issue which is directly related to the health of residents. Therefore, a groundwater quality survey of the current drinking water source was conducted. As a result, it was found in the survey that the most significant problem is the high concentration of fluoride. It was also confirmed that dental fluorosis due to high level fluorosis has occurred in Anuradhapura and the prevalence is higher than in other districts.

Removal of fluoride from the current groundwater sources is unrealistic from the viewpoint of technical and economic considerations. Therefore, it is urgently necessary to proceed with a project which utilizes surface water sources with low fluoride concentration. In addition, although Anuradhapura has been known as an area with a high prevalence of CKD, DSDs with a high prevalence of CKD were also found within the project area. However, no clear cause of CKD has been identified yet. For example, the project survey found that some DSDs showed a high prevalence of CKD with high fluoride concentration in drinking water sources, but in other DSDs there was no relationship between the CKD and fluoride concentrations. However, even if it is not possible to identify the causes of CKD, at least it is well known that high fluoride levels of drinking water causes worsening CKD for CKD patients[3]. Conversion to surface water sources which is able to supply lower levels of fluoride will significantly contribute to residents health.

As mentioned above, in order to solve the current water quantity and quality problem, it is essential to implement this project promptly.

3 EXISTING WATER SUPPLY FACILITIES IN THE STUDY AREA

3.1 Water Supply Schemes in Anuradhapura District

Water supply schemes in Anuradhapura District are classified into those operated and maintained by NWSDB and Community-Based Organizations (CBOs). Water supply schemes under CBOs are

[3] *Based on the talk of Dr. Akio Koizumi, Professor of Graduate School of Medicine, Kyoto University, Kyoto, Japan*

further categorized into those constructed under ADB 3rd and 4th projects and Community Water Supply and Sanitation Project (CWSSP) under the WB's assistance, but they are hereinafter named generically CBOs. Water supply schemes in Anuradhapura District are summarized as shown in **Table 5**.

Table 5 Water Supply Schemes in Anuradhapura District

No of families	171,060
Population	855,304
Water Supply Schemes	18
No of service connections - NWSDB	54,220
Total No. of Beneficiaries	325,320
Piped water coverage - NWSDB	37%
Rural Schemes Coverage - CBO	19%
Total Piped Water Supply Coverage in the District	56%

Source: NWSDB RSC(N/C)

3.2 Existing Water Supply Facilities under NWSDB (N/C)

There are 24 water supply schemes operated by NWSDB (N/C). Out of these 24 schemes, 18 are located in Anuradhapura District, whereas six are located in Polonnaruwa District

The large- and medium-scale schemes mostly use surface water and with full treatment used, typically pre-chlorination + aeration + sedimentation + rapid sand filtration + post-chlorination. The small-scale schemes are using ground water (bore holes and tube wells) with chlorination for treatment. The development of water supply started in Anuradhapura Town in 1972 and expanded to the fringe areas to the east and north in the 2000's. Other medium-scale schemes were developed in the 1980's and small-scale schemes in the 1980-90's. Usually mechanical and electrical equipment in water treatment plants and pump stations has deteriorated 20 to 30 years after construction. Therefore, some facilities which were constructed in the 1980's need rehabilitation or augmentation due to the increase in water demand. The water supply system in NWSDB (N/C) RSC, supplies water 24 hours, 7 days a week, except when there is a power failure, repair of leakage etc, which occasionally occurred.

3.3 Existing Water Supply Facilities under NWSDB in the Study Area

There are 56 water supply schemes in total in the project areas including 50 numbers of CBOs facilities (served population: approximately 38,700 persons, coverage: 19.1%) and 6 number of NWSDB facilities (served population: approximately 16,000 persons, coverage: 7.8%), out of which Rambewa is not an independent system but a part of Anuradhapura North Water Supply Scheme (WSS) and Mihintale WSS with both water sources in Nuwarawewa.

The served population by these six NWSDB systems is approximately 16,000 with a population coverage of 7.8%. Their water sources NWSDB facilities in the area started their operation in the period between 1964 and 1989. System capacities are ranging from 137 to 1,062 m^3/day, and all of their water sources rely on ground water except for Rambewa similarly to those for CBO water supply schemes. The total capacity of storage tank is 685 m^3, and all storage tanks are of the elevated tank except Padaviya. High fluoride concentrations are found in Horowpothana, Kahatagasdigiliya and Medawachchiya.

3.4 Existing Water Supply Facilities under CBO in the Study Area

The existing CBO water supply scheme survey reveals as follows:

- Out of 50 CBOs, 7 CBOs has not yet started into operation or been operated
- CBOs supply schemes covers 19 % of the total population of the Project area Therefore, it is crucial to maintain CBO's system under sound management.
- 44 CBOs out of 50 are functioned and most of CBOs have started their operation from the year 2006 or around.
- Due to the power failure or water shortage, all the CBOs systems have operated under limited water supply hours. Water shortage occurs in the dry season from August to October
- A high concentration of fluoride are found in many CBOs and also high hardness in some CBOs.
- CBO facilities are relatively new and only two elevated tanks are required for repairing.
- Distribution pipe network is all PVC type 600 with diameters ranging from OD 32 mm to 225 mm. The pipe sizes are too small in some CBOs, hence water pressure at the distribution pipe end is not enough.
- Bulk meter is not installed or not functioned in many CBOs, which makes difficult to control the NRW.
- Chlorination is, in principle not properly made. It is presumed that most of CBOs have used hypochlorite only occasionally or not used at all.
- Through the survey, many sketch of distribution networks are collected, however they are not accurate, and cannot be used for analysis. No updated information has been found.
- The CBO is operated and managed by the community members.

4 PROJECTION OF POPULATION AND WATER DEMAND IN THE STUDY AREA

4.1 Basic Policy for Planning

The study area covers six DSDs (Divisional Secretary Divisions), namely, Padaviya, Kebithigollewa, Horowpothana, Kahatagasdigiliya, Medawachchiya and Rambewa which are located in the north-eastern part of Anuradhapura District with a population of 204,738 persons (estimated for the year of 2012) and an area of 2,740.48 km^2 forming the typical rural area. The people in this area mainly rely their drinking water source on groundwater through dug/tube wells, however due to a high content of fluoride in groundwater, the patience of dental and skeletal diseases occur. In addition, they say that a high prevalence of chronic kidney diseases (CKDs) is also attributed to the high fluoride concentration in Sri Lanka. In the study area, there are six water supply systems operated and maintained by NWSDB and 50 water supply schemes under CBOs. They are all small-scale water supply schemes with water sources in dug/tube wells except for one CBO system and mostly have a problem of high fluoride concentration in groundwater. Water shortage is also found in the many existing CBO systems especially during the dry season.

To solve these problems, the new water supply system is proposed to integrate the existing NWSDB and CBO water supply schemes under the following basic policy for planning:

- The water source will be converted from groundwater to surface water to meet the Sri Lanka drinking water standards. The surface water will be taken from the irrigation canals originated from Mahakanadarawa Tank and Wahalkada Tank for irrigational purpose.
- Taking into account the overall topography of the study area and the location of proposed water sources, the study area will be divided into two water supply systems, namely, Mahakanadarawa System covering Medawachchiya and Rambewa DSDs and Wahalkada System covering Padaviya, Kebithigollewa, Horowpothana and Kahatagasdigiliya DSDs.
- The proposed water supply sytems will supply water to the existing service area under NEWSDB and CBOs and the new service area currently not served,
- The study area is composed of 194 GNDs under six DSDs, out of which 60.8% of GNDs have a population density of less than 100 persons per km2 and 87.6% of GNDs for less than 200 persons /km2. Since the population is sparsed thinly in an extensive area as mentioned-above, it is clearly not cost-effective to develop ordinary water supply systems (hereinafter referred to as “ pipe borne water supply”). For this reason, some area will be covered by non pipe borne water supply systems in which safe water treated at water treatment plants will be delivered by water bowser to the water tanks strategically arranged to minimise the water-fetching works of the people (hereinafter referred to as “bowser water supply”).
- The new water transmission pipes will be connected to the elevated tanks of existing systems and the existing water distribution facilities will be used as they will be as much as possible.
- Some out of the existing CBO systems will be excluded from the integration to the new water supply systems, if they have currently no problem in quality, quantity, operation, etc.

4.2 Estimation of Design Water Supply

(1) Design Service Area

The design service area shall be six DSDs, namely, Padaviya, Kebithigollewa, Horowpothana, Kahatagasdigiliya, Medawachchiya and Rambewa which are located in the north-eastern part of Anuradhapura District.

(2) Design Period

NWSDB Design Manual (March 1989) describes that "*As a general principle it is recommended that future urban schemes be designed for a 20-year planning horizon in two 10-year stages*". For reference, the Japanese design criteria recommend to set the target year at15 to 20 years ahead. Therefore, it is reasonable to set the target year in 2034 with an interim target year of 2024 for staged construction.

(3) Design Parameters

Based on the design parameters, water demand is estimated as shown in **Tables 6 to Table 8**.

Table 6 Parameters for Water Demand Estimation

Parameters	Basis
Design Population	Projected changing the annual population growth rate corresponding to the local conditions of each GND based on the actual one of Census 1980-2001
Demarcation of GNDs by water supply mode	Based on the location of facilities of existing CBO WSS and proposed WSS, urban centre and main roads
Existing CBOs to be excluded from integration	Based on the conditions such as no problem in water quality and quantity or distance from the proposed WSS transmission routes in addition to no major operational trouble at present
Non domestic consumption	Based on the actual performance at the existing small-scale WSS under NWSDB operation
Per capita domestic consumption	Based on the actual performance (CBO average: 66Lpcd, NWSDB WSS in the study area: 85-107 Lpcd) considering an annual increment of 0.5 Lpcd from 80 Lpcd in the base year of 2012..
NRW	Based on the actual performance of NWSDB N/C
Design Served population	Based on the assumption of population coverage (%)
Design Load Factor	Based on the actual performance of NWSDB N/C
Production Capacity	Considered 5% allowance for miscellaneous use at WTP

Table 7 Water Demand in the Target Year of 2034

Design Water Demand		Application to Facility Design	Unit	Mahakanadarawa System			Waghalkada System		
Water Supply Mode				Pipe Borne Water Supply	Bowser Water Supply	Total	Pipe Borne Water Supply	Bowser Water Supply	Total
Design Population			(prs.)	92,597	19,303	111,900	144,745	16,723	161,468
Per Capita Domestic Water Consumption	= 80 + 0.5 x (2034 - 2012) = 91		(Lpcd)	91	10		91	10	
Premium for Non-domestic Water (35%)	= 1.35			1.35	1		1.35	1	
NRW Ratio (20%)	= 100 / (100 - 20) = 1.25			1.25	1		1.25	1	
Design Daily Average Water Supply (Dave)			(m^3/day)	14,219	193	14,412	22,227	167	22,394
Design Load Factor to Dmax	= 1.2								
Design Daily Maximum Water Supply (Dmax)	= Dave x 1.20	Transmission facility	(m^3/day)			17,294			26,873
Design Peak Factor	= 2.0								
Design Hourly Maximum Water Supply (Hmax)	= Dmax x 2.0	Dstribution facility	(m^3/day)			34,588			53,746
Design Water Intake	= Dmax x 1.05	Intake pump station	(m^3/day)			18,245			28,217
		Raw water				18,200			28,200
		transmission facility				▲ 600			▲ 600
		WTP							
Water Right			(m^3/day)			**18,800**			**28,800**

Table 8 Yearly Water Demand for Mahakanadarawa and Wahalkada Systems

Mahakanadarawa System (Encl. Independent CBO)

		2012 *3	2014 *3	2016 *3	2018	2020	2022	2024	2026	2028	2030	2032	2034
Total Population (persons)		**83,858**	**86,208**	**88,626**	**91,120**	**93,684**	**96,321**	**99,043**	**101,838**	**104,719**	**107,686**	**110,736**	**113,884**
46 - Maha Kumbukgollewa *1	Population	1,430	1,473	1,518	1,564	1,611	1,660	1,710	1,761	1,815	1,870	1,926	1,984
	Served Population	286	589	789	860	886	996	1,026	1,233	1,361	1,496	1,733	1,984
	Water Demand	39	81	109	120	126	143	149	181	202	225	263	305
Target Total Population (persons)		**82,428**	**84,735**	**87,108**	**89,556**	**92,073**	**94,661**	**97,333**	**100,077**	**102,904**	**105,816**	**108,810**	**111,900**
for Pipe Borne WS	Pipe Borne WSS	62,778	64,665	66,608	68,613	70,680	72,808	75,010	82,347	84,796	87,319	89,915	92,597
	(Existing)	46,591	48,010	49,473	50,982	52,541	54,141	55,802	57,512	59,277	61,098	62,974	64,912
	(New)	16,187	16,655	17,135	17,631	18,139	18,667	19,208	24,835	25,519	26,221	26,941	27,685
for Non Pipe Borne WS	Non Pipe Borne WSS	19,650	20,070	20,500	20,943	21,393	21,853	22,323	17,730	18,108	18,497	18,895	19,303
Coverage (%)		**31.4**	**59.4**	**63.0**	**65.2**	**67.5**	**69.7**	**72.0**	**74.8**	**82.1**	**88.4**	**94.7**	**100.0**
for Pipe Borne WS	Pipe Borne WSS	41.2	46.8	51.6	54.6	57.7	60.7	63.7	69.4	78.2	85.9	93.6	100.0
	(Existing)	56.0	60.0	64.0	68.0	72.0	76.0	80.0	84.0	88.0	92.0	96.0	100.0
	(New)	0.0	10.0	17.0	17.0	17.0	17.0	17.0	40.0	60.0	75.0	90.0	100.0
for Non Pipe Borne WS	Non Pipe Borne WSS	100	100	100	100	100	100	100	100	100	100	100	100
Served Population (persons) *2		**25,892**	**50,347**	**54,890**	**58,431**	**62,142**	**66,025**	**70,097**	**74,846**	**84,458**	**93,515**	**103,019**	**111,900**
for Pipe Borne WS	Pipe Borne WSS	25,892	30,277	34,390	37,488	40,749	44,172	47,774	57,116	66,350	75,018	84,124	92,597
	(Existing)	25,892	28,611	31,476	34,491	37,665	40,998	44,509	48,196	52,073	56,144	60,419	64,912
	(New)	-	1,666	2,914	2,997	3,084	3,174	3,265	8,920	14,277	18,874	23,705	27,685
for Non Pipe Borne WS	Non Pipe Borne WSS	-	20,070	20,500	20,943	21,393	21,853	22,323	17,730	18,108	18,497	18,895	19,303
Water Demand (Dave: m3/day)		**3,495**	**4,341**	**4,961**	**5,456**	**5,994**	**6,557**	**7,154**	**8,562**	**10,029**	**11,448**	**12,963**	**14,414**
Pipe Borne WS	Pipe Borne WSS	3,495	4,141	4,756	5,247	5,779	6,337	6,982	8,384	9,847	11,263	12,774	14,221
	(Existing)	3,495	3,913	4,354	4,828	5,341	5,882	6,459	7,075	7,728	8,429	9,175	9,970
	(New)	-	228	402	419	438	455	523	1,309	2,119	2,834	3,599	4,251
Non Pipe Borne WS	Non Pipe Borne WSS	-	200	205	209	215	220	172	178	182	185	189	193
Water Demand for Transmission (Dmax = Dave x 1.20 : m3/day)		**4,194**	**5,209**	**5,953**	**6,547**	**7,193**	**7,868**	**8,585**	**10,274**	**12,035**	**13,738**	**15,556**	**17,297**
Water Demand for Treatment (= Dmax x 1.05 : m3/day)		**4,400**	**5,500**	**6,300**	**6,900**	**7,600**	**8,300**	**9,000**	**10,800**	**12,600**	**14,400**	**16,300**	**18,200**

Wahalkada System (Encl. Independent CBOs)

		2012 *3	2014 *3	2016 *3	2018	2020	2022	2024	2026	2028	2030	2032	2034
Total Population (persons)		**120,880**	**124,293**	**127,794**	**131,417**	**135,150**	**138,985**	**142,940**	**147,008**	**151,200**	**155,525**	**159,978**	**164,562**
32 - Kurulugama *1		1,354	1,379	1,403	1,429	1,455	1,481	1,508	1,535	1,563	1,591	1,620	1,649
119 - Ihala Angunachchiya *1		1,041	1,073	1,105	1,139	1,173	1,208	1,245	1,283	1,321	1,361	1,402	1,445
Sub-Total		2,395	2,452	2,508	2,568	2,628	2,689	2,753	2,818	2,884	2,952	3,022	3,094
Served Population													
32 - Kurulugama *1		271	552	730	786	800	889	905	1,075	1,172	1,273	1,458	1,649
119 - Ihala Angunachchiya *1		208	429	575	626	645	725	747	898	991	1,089	1,262	1,445
Sub-Total		479	981	1,305	1,412	1,445	1,614	1,652	1,973	2,163	2,362	2,720	3,094
Water Demand													
32 - Kurulugama *1		37	75	101	110	113	128	131	158	174	191	221	253
119 - Ihala Angunachchiya *1		28	59	80	88	91	104	108	132	147	164	192	222
Sub-Total		65	134	181	198	204	232	239	290	321	355	413	475
Target Total Population (persons)		**118,485**	**121,841**	**125,286**	**128,849**	**132,522**	**136,296**	**140,187**	**144,190**	**148,316**	**152,573**	**156,956**	**161,468**
for Pipe Borne WS	Pipe Borne WSS	95,911	98,775	101,715	104,766	107,907	111,145	114,485	128,836	132,633	136,549	140,587	144,745
	(Existing)	49,985	51,530	53,117	54,762	56,462	58,216	60,026	67,997	70,064	72,193	74,394	76,664
	(New)	45,926	47,245	48,598	50,004	51,445	52,929	54,459	60,839	62,569	64,356	66,193	68,081
for Non Pipe Borne WS	Non Pipe Borne WSS	22,574	23,066	23,571	24,083	24,615	25,151	25,702	15,354	15,683	16,024	16,369	16,723
Coverage (%)		**22.7**	**51.2**	**62.7**	**64.8**	**66.9**	**69.1**	**71.6**	**74.2**	**80.7**	**87.1**	**93.6**	**100.0**
for Pipe Borne WS	Pipe Borne WSS	28.1	39.9	54.0	56.7	59.4	62.1	65.2	71.2	78.4	85.6	92.8	100.0
	(Existing)	54.0	18.0	62.0	66.0	71.0	75.0	79.0	59.0	80.0	84.0	87.0	91.0
	(New)	0.0	20.0	45.0	46.0	47.0	48.0	50.0	60.0	70.0	80.0	90.0	100.0
for Non Pipe Borne WS	Non Pipe Borne WSS	100	100	100	100	100	100	100	100	100	100	100	100
Served Population (persons) *2		**26,925**	**62,431**	**78,510**	**83,471**	**88,692**	**94,133**	**100,393**	**107,042**	**119,656**	**132,911**	**146,846**	**161,468**
for Pipe Borne WS	Pipe Borne WSS	26,925	39,365	54,939	59,388	64,077	68,982	74,691	91,688	103,973	116,887	130,477	144,745
	(Existing)	26,925	29,916	33,072	36,392	39,895	43,576	47,449	51,521	55,803	60,302	65,033	70,000
	(New)	-	9,449	21,867	22,996	24,182	25,406	27,242	40,167	48,170	56,585	65,444	74,745
for Non Pipe Borne WS	Non Pipe Borne WSS	-	23,066	23,571	24,083	24,615	25,151	25,702	15,354	15,683	16,024	16,369	16,723
Water Demand (Dave: m3/day)		**3,636**	**6,611**	**7,843**	**8,556**	**9,336**	**10,147**	**11,098**	**13,616**	**15,599**	**17,719**	**19,979**	**22,392**
Pipe Borne WS	Pipe Borne WSS	3,636	5,384	7,608	8,315	9,087	9,893	10,841	13,463	15,441	17,556	19,815	22,225
	(Existing)	3,636	4,203	4,577	5,097	5,658	6,248	6,888	7,566	8,286	9,058	9,874	10,748
	(New)	-	2,240	3,031	3,218	3,429	3,645	3,953	5,897	7,155	8,498	9,941	11,477
Non Pipe Borne WS	Non Pipe Borne WSS	-	1,227	235	241	249	254	257	153	158	163	164	167
Water Demand for Transmission (Dmax = Dave x 1.20 : m3/day)		**4,363**	**7,933**	**9,412**	**10,267**	**11,203**	**12,176**	**13,318**	**16,339**	**18,719**	**21,263**	**23,975**	**26,870**
Water Demand for Treatment (= Dmax x 1.05 : m3/day)		**4,600**	**8,300**	**9,900**	**10,800**	**11,800**	**12,800**	**14,000**	**17,200**	**19,700**	**22,300**	**25,200**	**28,200**

(4) Design Flow of Water Treatment Plants for Stage Construction

Both water treatment plants for Mahakanadarawa and Wahalkada Systems shall be constructed by stage construction. The reasons for stage construction is described in **Section 5.2.1**. The design flow for Phase 1 (2024) and Long-term Plan (2034) is shown in **Table 9**.

Table 9 Design Flow of Water Treatment Plants for Stage Construction

	Phase 1 (2024)	Long-term Plan (2034)
Mahakanadarawa WTP		
Daily Maximum Water Supply	8,950 m3/day	17,900 m3/day
Production Capacity	9,400 m3/day	18,800 m3/day
Wahalkada WTP		
Daily Maximum Water Supply	13,700m3/day	27,400 m3/day
Production Capacity	14,400 m3/day	28,800 m3/day

4.3 Water Availability

4.3.1 Water source

As mentioned in Chapter 2, there is a high risk of fluoride concentration in the groundwater of the Study Area, therefore the source for drinking water needs to be shifted to the surface water. In the Study Area of Anuradhapura District, there are available only seasonal rivers, that flows during the rainy season, therefore, the surface water source for drinking water is expected only from water reservoirs, Mahakanadarawa wewa and Wahalkada wewa.

4.3.2 Water Quality

Seasonal changes of water quality due to rainy and dry seasons also occurs. Recharge water of targeted water sources in the dry season is reduced, and the existing water in targeted water sources are concentrated by evaporation so the contents are increased. This trend is remarkable in Mahakandawara wewa though Wahalkada shows less of a trend of this.

In Sri Lanka, high concentrations of fluoride are found in groundwater in many areas and the project area is also known as a higher concentration area of fluoride. Therefore, continuous water quality monitoring of the said parameter is essential. As fluoride is a substance derived from minerals, both groundwater and surface water contain flouride if it has come into contact with the mineral. As for fluoride in targeted water sources, the same as EC, Cl and Hardness, the concentrations are lower in the rainy season and becomes higher in the dry season. The trends are shown as follows.

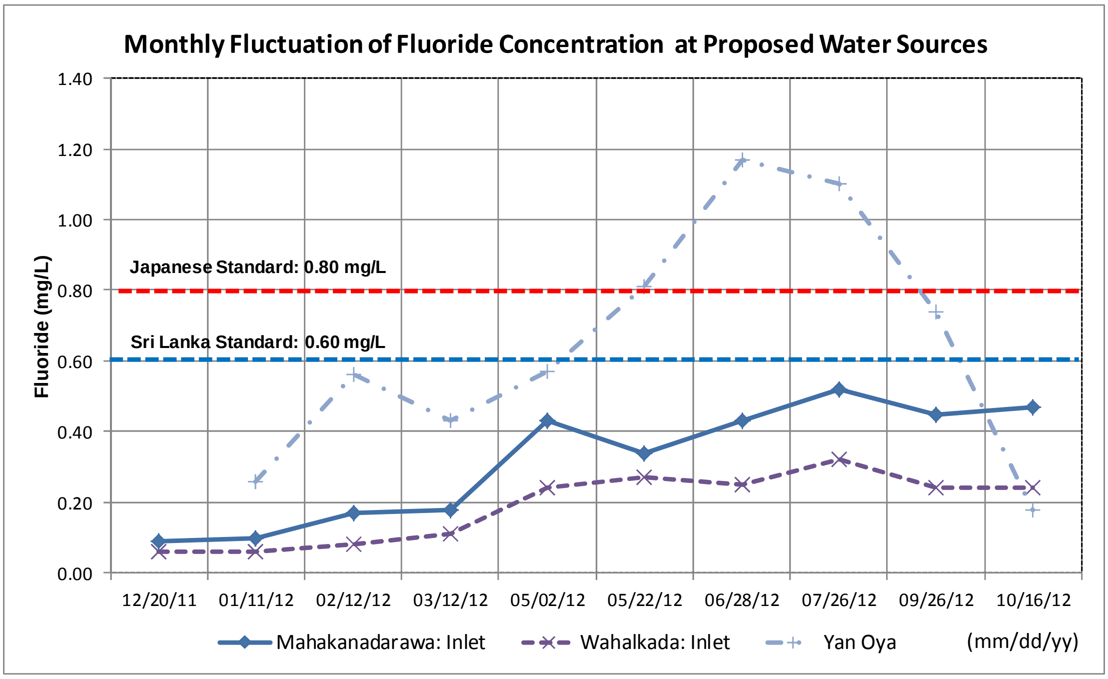


Figure 4 Water Quality (Fluoride)

4.3.3 Present Operation of Irrigation Reservoir

The water uses of the above tanks are irrigation and fisheries. Irrigation water is mainly used for paddy fields and partly used for other upland crops under an annual irrigation program. The general condition of the irrigation scheme is shown in **Table 10**.

Table 10 General Condition of Irrigation Scheme

Item	Outline
Irrigation period in Maha	Nov. – March
Irrigation period in Yala	May – September
Major Crops	Rice (Paddy field)
Irrigation Area	Mahakanadarawa Scheme : Max. Irrigable area: 6,000Ac（2,420ha) Irrigable area by FSL: 3,600Ac（1,460ha） (around 50% is available in Yala season) Wahalkada Scheme : Max. Irrigable area: 2,257Ac（910ha) Irrigable area by FSL: 2,000Ac（810ha）

Table 4.6 shows the annual irrigation water use in 2009-2011. In the case of the Mahakanadarawa scheme, water use varied from 19.41 to 42.42 MCM, with the amount partly being dependent on the quantity of water stored early in the season. On the other hand, in the case of the Wahalkada scheme, the variation in irrigation water use is not as big as in the Mahakanadarawa scheme, ranging from about 12 to 16 MCM, with the storage volume early in

the season varying.

Table 11 Irrigation Water Used in 2009-2011

	Mahakanadarawa tank		Wahalkada Tank	
	Storage in Jan. 1 (MCM)	Irrigation Water Supply (MCM)	Storage in Jan. 1 (MCM)	Irrigation Water Supply (MCM)
Gross Calc. for Average Rainfall		22.2		10.9
2009	44.78	No data	17.45	12.13
2010	22.50	19.41	21.50	16.13
2011	44.78	42.42	26.73	15.95

4.3.4 Water Availability from Irrigation Reservoir

(1) Gross Estimation of Water Balance

The gross water balance is estimated by assuming runoff coefficients as shown in **Table 12**. The runoff coefficient from the whole catchment area is estimated at 20% in Wahalkada Wewa, and 8% in Mahakanadarawa Wewa. Seepage is neglected because this is a relatively small amount, compared to the total storage volume.

Table 12 Gross Estimation of Water Balance

	Mahakanadarawa	Wahalkada
Average Rainfall (mm/yr)	1,240	1,440
Catchment Area(km^2)	334	83
Runoff Coefficient (%)	8	20
Water Area of Reservoir (km^2)	9	2.1
Annual inflow to the Reservoir (MCM)	33.13	23.90
Volume by rainfall (MCM)	11.16	2.96
Evaporation from water surface (MCM)	11.93	2.60
Seepage (MCM)	—	—
Average Annual Storage (MCM)	32.36	23.77
Average Annual Storage (Acft)	26,244	19,278

(2) Water intake for drinking water in 2016, 2024 and 2034

Water intake for drinking water is estimated as shown in **Table 13**.

Table 13 Water Intake for Drinking Water

Drinking Water Supply	Mahakanadarawa Tank		Wahalkada Tank	
	(m^3/day)	(MCM/year)	(m^3/day)	(MCM/year)
Water intake in 2016	6,700	2.45	10,500	3.83
Water intake in 2024	9,400	3.25	14,400	5.26
Water intake in 2034	18,800	6.53	28,800	10.00

(3) Irrigation water

Tendency of storage variation in both reservoirs, annual irrigation water use is estimated as follows.

- Mahakanadarawa scheme: 20-30 MCM (40 MCM is corresponding to water use for FSL)
- Wahalkada scheme: 12-16 MCM

4.3.5 Mahakanadarawa Wewa

(1) Situation

For Mahakandarawa wewa, the average annual storage is estimated at around 32.36 MCM, and the irrigation use varies between 20-30 MCM/year. On the other hand, the water supply for drinking will be annually 3.25 MCM in 2024 and 6.53 MCM in 2034. Assuming that the priority is given to water supply for drinking, the water shortage will occur even in 2016 for an irrigation use of 30 MCM/year. If the NCP Canal Project will not be completed, water allocation between irrigation and water supply for drinking will be a big issue, since an amount of water shortage will increase.

If the NCP Canal Project will be completed in 2016 as scheduled, it will catch the commencement of operation for water supply in 2018 (**Figure 5**). Basically, the NCP Canal Project includes drinking water of around 70 MCM/year for 15 major towns in North Central and North Provinces. Most of the target towns served by the Mahakanadarawa water supply system under the "Anuradhapura North Integrated Water Supply Project" are corresponding to the towns covered by the NCP Canal Project. In 2034, the total amount of 80.53 MCM composed of 6.53 MCM for water supply and 74 MCM required to irrigate the maximum irrigation area of 2,420 ha of the Mahakanadarawa Irrigation Scheme will be necessary for both purposes. However, the average storage of Mahakanadarawa Wewa is approximately 32.36 MCM, and the balance of 48.17 MCM should be covered by the NCP Canal Project with a design capacity of 700 MCM which will make the further supplement of water possible. Therefore, an enough amount of water will be maintained for both water supply and irrigation (**Figure 6**).

(2) Implementation Schedule of the NCP Canal Project

GOSL has taken an initiative to implement the Moragahakanda/Kalu Ganga Project which was identified as essential infrastructure for the implementation of the NCP Canal Project. The Moragahakanda/Kalu Ganga Project is under construction since 2007, and programmed to be completed by 2014. However, the project has been delayed because of financial and environmental problems. Finally, the Chinese Government agreed to provide loan assistance in 2012, then the Project started the second stage. According to the newspapers, the Project is expectedly completed by 2016.

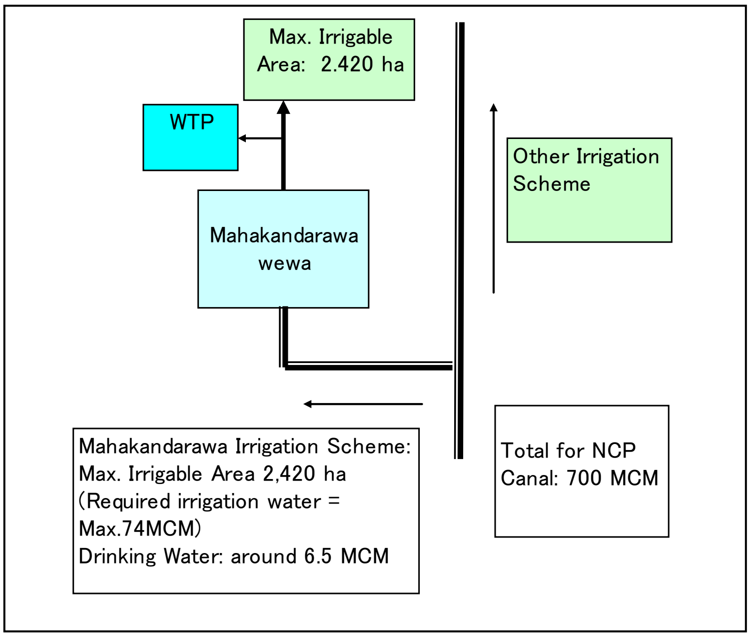


Figure 5　Image of Assumed Additional Water from NCP Project

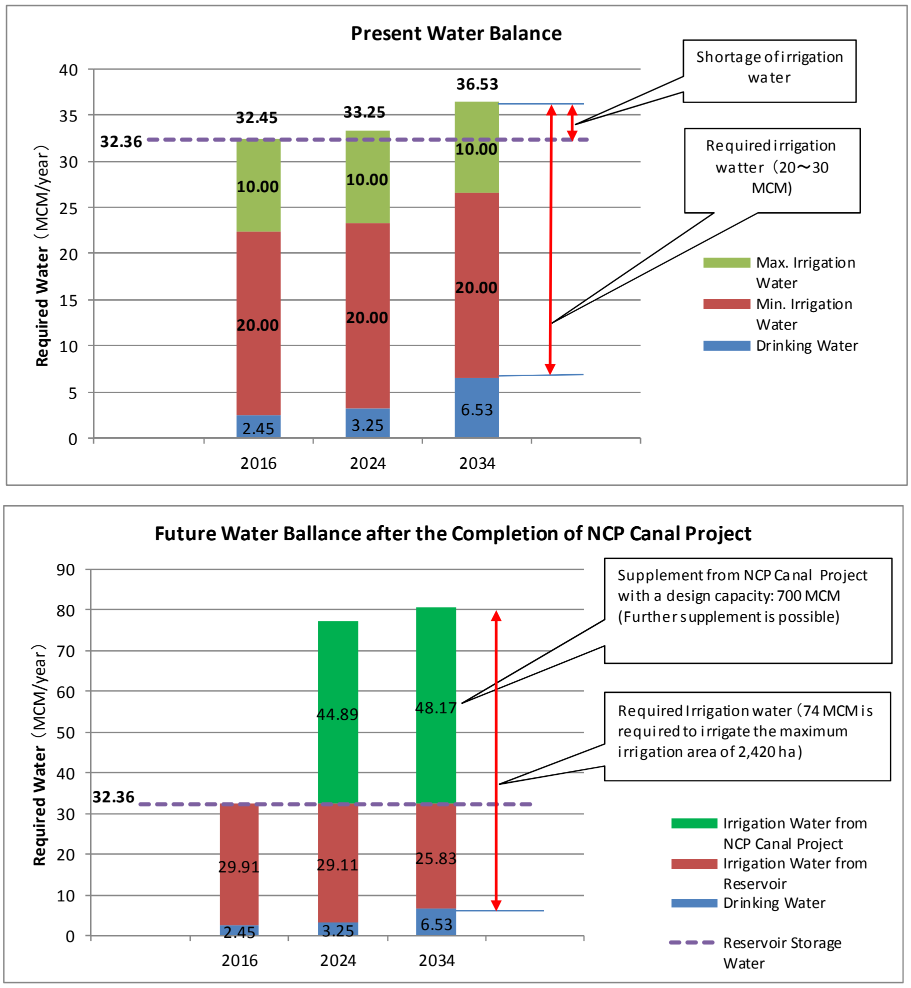


Figure 6　Water Availability in the Mahakanadarawa Wewa

4.3.6 Wahalkada Wewa

(1) Situation

For Wahalkada Wewa, the average annual storage is estimated at around 23.77 MCM, and the irrigation use varies between 12-16 MCM. On the other hand, the water supply for drinking will be annually 5.26 MCM in 2024 and 10.00 MCM in 2034. According to this result, this reservoir water will not be enough to cover the water use for water supply and irrigation without an appropriate allocation in 2034.

The Yan Oya Reservoir Project will have an irrigable area of 4,780 ha by a new reservoir capacity of 254 MCM. Its left side irrigation canal will pass in the Wahalkada Irrigation Scheme, and irrigate an area of around 400 ha under the Wahalkada Irrigation Scheme. An additional water supply from Yan Oya Reservoir Project is assumed 7 MCM at the maximum as shown in **Figure 7** In other word, the Wahalkada Wewa will have an excess water with the same amount as it, namely 5.94 MCM to 11.51 MCM as shown in **Figure 8**. Therefore, the storage water will be enough for water supply and irrigation even in 2034.

It should be noted that the Yan Oya Reservoir has a problem in water quality. The fluoride concentrations of the Yan Oya River has recorded 0.81 mg/L to 1.2 mg/L in May to July 2012 exceeding the Japanese drinking water standard of 0.8 mg/L, while those of the Wahalkada Wewa has kept 0.25 mg/L to 0.38 mg/L during the same period. Therefore, the water to be used for drinking water supply should be that of the Wahalkada Wewa.

(2) Implementation Schedule of the Yan Oya Reservoir Project

Financial award was signed with a project cost of Rs.19 billion between the Chinese and Sri Lankan Governments in November 4, 2011. The EIA report has been submitted to the CEA and review of it is still in progress. After the approval of the EIA, the construction work is expected to start and around 4 years will be required for the completion of the project.

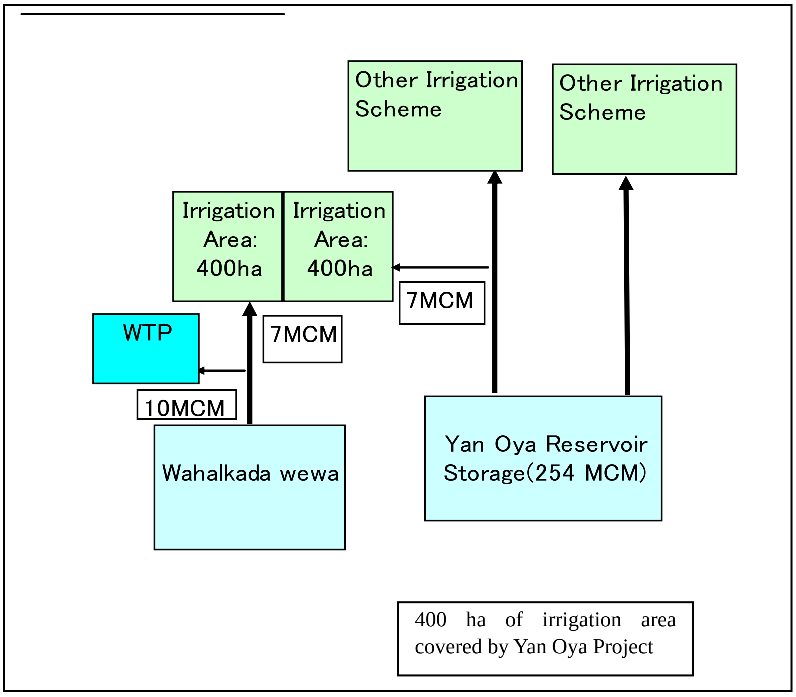
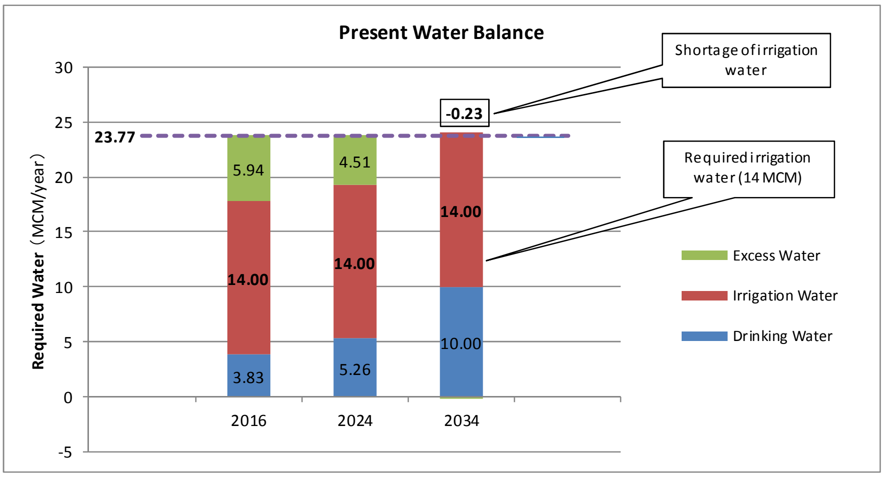


Figure 7 Image of Assumed Additional Water from Yan Oya Project



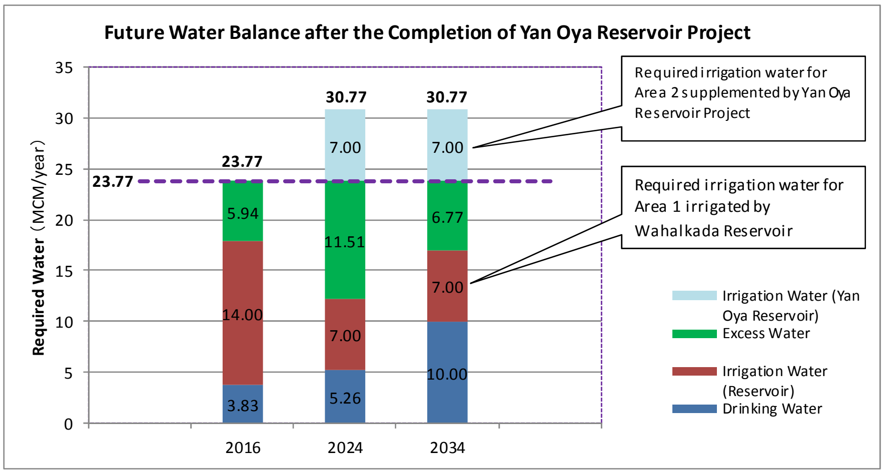


Figure 8 Water Availability in the Wahalkada Wewa

5 PLAN OF PROPOSED WATER SUPPLY SYSTEM

5.1 Water Intake Works

The Irrigation Department, as the management entity for the Mahakanadarawa and Wahalkada Reservoirs, considered intake methods for the Project, and decided that only the canal intake method is suitable

Drinking water will be supplied based on the agreement between the Irrigation Department and NWSDB. A Memorandum of Understanding (MOU) for extracting water from Mahakanadarawa Wewa and Wahalkada Wewa for the Anuradhapura North Water Supply Scheme is in Article 3 shown in **Table 14**.

Table 14 Memorandum for Extracting Water

Year	2016	2034	Remarks
Mahakanadarawa	6,700 m3/day	18,800 m3/day	Amount in 2016 will be after completion of WTP Amount in long term plan will be after completion of Upper Elahara Canal Project
Wahalkada	10,500 m3/day	28,800 m3/day	

In case of periods of exceptional water scarcity, Article 9 mentions that the Irrigation Department, Irrigation Management Division, NWSDB, Divisional Secretary, Member of Project Management Committee (established under the Irrigation Ordinance and chaired by the District Secretary) will hold a meeting and decide on water allocation rights.

5.2 Water Treatment Plant

5.2.1 Stage Construction of water treatment Plants

Since the water transmission and distribution facilities is constructed with a full design capacity for the year of 2034 due to the difficulty in split construction, the water treatment plant, etc. to which stage construction is applicable, shall be constructed with a half capacity for the year of 2024 to reduce an initial investment as much as possible.

- NWSDB Design Manual (March 1989) *recommend the ten-year stage construction.*
- The NWSDB Guidelines suggest the difficulty to increase the population coverage by water supply in the rural area.
  - 92.8% of the people in the study area have any types of their own water sources. Whether the people will connect to a water supply system or not is left to their discretion.
  - Even though connected to a water supply system, the people may use either of groundwater or tap water selectively by use.

  – Even though the pipe borne water supply is applied to GNDs, it will take time to attain the full coverage of a distribution network in the situation of a population density of less than 100 persons per km^2 that a housing unit is located every 100 m to 400 m.
- If the equipment is installed in full construction but not in stage construction, a variety of waste will occur. The equipment once installed will be unavoidably idle.
- Assuming that the total construction cost will be reduced by 10% in case of full construction of a water treatment plant, the comparative study of FIRR shows that FIRR of stage construction will be better than that of full construction.
- The NCP Canal and Yan Oya Reservoir projects that supplement the water supply condition of Mahakanadarawa and Wahalkada Tanks have not yet started and their completion time has not been assured.

5.2.2 Selection of Water Treatment Process

There are two major treatment processes to select: slow sand filters and rapid sand filters.
Slow sand filters are simple, cost effective, reliable, and easy to operate. However slow sand filters generally treat source water turbidity of less than 10 degrees successfully. Rapid sand filters can treat high turbidity water if the water is properly coagulated and settled out. The turbidity of Mahakanadarawa and Wahalkada water is higher than 10 degrees and ranges 1 to 20 degrees. There is a possibility that roughing filters can serve as a pretreatment to reduce the turbidity loading to the slow sand filters. To determine the applicability of the slow sand filters with help of roughing filters, pilot plant tests were conducted. However, the turbidity was insufficiently removed, less than 5 degrees even though adjusting the filtration velocity, and for the color, no difference was observed and treated water was yellowish green color.

In conclusion, the implementation of rapid sand filter system is recommended for the Anuradhapura North Water Supply Project. Rapid sand filter systems are widely used in Sri Lanka so that Water Board will have no difficulties in operation and maintenance. Also it is recommended to install ACF (Active Carbon Filter) as soon as possible to remove the odor, if a bad odor occurred in the treated water for a long period, after operation of Phase - 1 facility started. Wooden and coconut granular carbon produced in Sri Lanka is available there. Some water treatment plants in Sri Lanka use powder and granular activated carbon.

5.2.3 Mahakanadarawa WTP

(1) Flow diagram

The flow diagram of Mahakanadarawa WTP are shown in **Figure 9**.

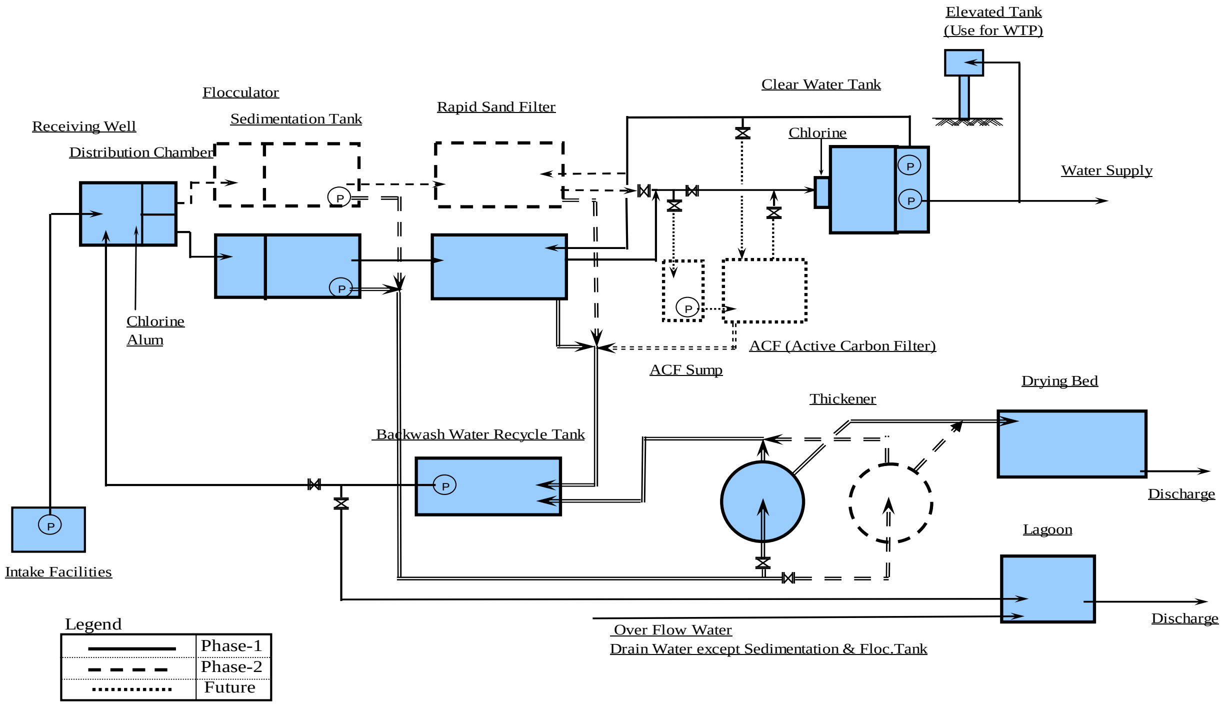


Figure 9 Flow Diagram of Mahakanadarawa WTP

(2) Outline of Mahakanadarawa WTP

Mahakanadarawa WTP takes water from an irrigation canal from Mahakanadarawa Tank at approximately 120m downstream of Mahakanadarawa Tank. The WTP is located on the left of the irrigation channel. The capacity of the WTP including 5% treatment process loss is shown in **Table 15**.

Table 15 Capacity of Proposed WTP

Year	In 2024	In 2034	Remarks
Water rights (m3/d)	6,700 to 18,800	18,800	
Water demand (day ave.) (m3/d)	7,154	14,414	According to water demand projection
Water demand (day Max.) (m3/d)	8,600	17,300	day ave. x 1.2
Production capacity of WTP(m3/d)	8,900	17,900	Output of WTP; Capacity of WTP x 0.95
Capacity of WTP (m3/d)	9,400	18,800	Input to WTP

Table 16 Detail of Facilities

Facility	Phase-1	Phase-2	Remarks
Receiving Well	W4.0m x L4.6m x H6.0m x 1unit	-	*
Distribution Chamber	W2.0m x L2.0m x H5.0m x 2units	-	*
Flocculator tank	5 stages x 62.8m3 x 4 units	5 stages x 62.8m3 x 4 units	
Sedimentation tank	W4.0m x L10.4m x H4.0m x 4units	W4.0m x L10.4m x H4.0m x 4unit	Plate settler
Rapid sand filter tank	W3.0m x L5.5m x 4units	W3.0m x L5.5m x 4units	
ACF sump	W8.0m x L12.0m x H3.0m x 1unit		future
ACF tank	W2.5m x L5.0m x 4units		future

Facility	Phase-1	Phase-2	Remarks
Chlorine Mixing Chamber	W2.0m x L5.0m x H4.0m x 2units	-	*
Reservoir	W8.0m x L17.0 x H4.0m x 2units	-	*
Backwash water recycle tank	W4.0m x L14.0 x H3.0m x 2units	-	*
Thickener	Dia 10.0m x H4.0m x 1unit	Dia 10.0m x H4.0m x 1unit	
Drying bed	W12.5m x L20.0m x H1.0m x 4units	W12.5m x L20.0m x H1.0m x 2units	
Lagoon	W10.0m x 27.0m x 1.0m x 1unit	-	*
Administration Bldg.	W12.0m x L25m x 2 stories	-	*
Chemical house	W11.5m x L12.0m	-	*
Chlorine House including neutralization facilities	W12.0m x L14.0m	-	*
Pump House	W8.0m x L26.5m	-	*
Blower House	W7.3m x L13.5m		*
Generator House	W4.5m x L8.0m	-	*
Ware House	W10.0m x L17.0m	-	*

*The capacity of the facilities constructed in phase 1 includes the whole capacity required for the project up to Phase 2.

5.2.4 Wahalkada WTP

(1) Flow diagram

The flow diagram of Wahalkada WTP is the same as in **Figure 9**.

(2) Outline of Wahalkada WTP

Wahalkada WTP takes water from an irrigation canal from Wahalkada Tank at approximately 420m downstream from Wahalkada Tank. The capacity of the WTP is determined in consideration of water rights, daily maximum water demand and 5% treatment process loss in **Table 17**.

Table 17 Capacity of Proposed WTP

Year	In 2024	In 2034	Remarks
Water rights (m3/d)	10,500-28,800	28,800	
Water demand (day ave.) (m3/d)	11,098	22,392	According to water demand projection
Water demand (day Max.) (m3/d)	13,300	26,900	day ave. x 1.2
Production capacity of WTP(m3/d)	13,700	27,400	Output of WTP; Capacity of WTP x 0.95
Capacity of WTP (m3/d)	14,400	28,800	Input to WTP

The treatment process is the same as at Mahakanadarawa WTP, except that an elevated tank is provided to supply water to the neighboring villages. Treated water is pumped to the elevated tank, which is located in the WTP site and also to the served areas through transmission pipelines.

The facilities in Wahalkada WTP are summarized in **Table 18**.

Table 18 Detail of Facilities

Facility	Phase-1	Phase-2	Remarks
Receiving Well	W5.6 x L5.0m x H6.0m x 1unit	-	*
Distribution Chamber	W2.5 x L2.0m x H5.0m x 2units	-	*
Flocculator tank	7stages x89.3m^3 x 4 units	7stages x89.3m^3 x 4 units	
Sedimentation tank	W4.0m x L14.4m x H4.0m x 4units	W4.0m x L14.4m x H4.0m x 4unit	Plate settler
Rapid sand filter tank	W4.0m x L6.0m x 4units	W4.0m x L6.0m x 4units	
ACF sump	W10.0m x L14.0m x H3.0m x 1unit		future
ACF tank	W3.5m x L5.0m x 4units		future
Chlorine Mixing Chamber	W2.0m x L6.75m x H4.0m x 2units	-	*
Reservoir	W10.0m x L21.0m x H4.0m x 2units	-	*
Backwash water recycle tank	W5.0m x L15.0m x H4.0m x 2units	-	*
Thickener	Dia 12.5m x H4.0m x 1unit	Dia 12.5m x H4.0m x 1unit	
Drying bed	W15.0m x L25.0m x H1.0m x 4units	W15.0m x L25.0m x H1.0m x 2units	
Lagoon	W12.0m x 25.0m x 1.5m x 1unit	-	*
Administration Bldg.	W12.0m x L25m x 2 stories	-	*
Chemical house	W11.5m x L12.0m	-	*
Chlorine House including neutralization facilities	W12.0m x L14.0m	-	*
Pump House	W8.0m x L35.0m	-	*
Blower House	W7.3m x L13.5m		*
Generator House	W5.0m x L9.5m	-	*
Ware House	W10.0m x L17.0m	-	*

*The capacity of the facilities constructed in phase 1 includes the whole capacity required for the project up to Phase 2.

5.3 Transmission and Distribution System

5.3.1 Transmission System

There are six NWSDB's systems and 50 existing community water supply systems in the project area. The NWSDB systems, covering 25 GNDs, are located in the core area(s). Generally, each CBO covers a part of a GND. Some CBOs, however, cover multiple GNDs or two to three GNDs. New water supply systems for GNDs other than the existing CBOs will be constructed under this project. However some of the GNDs will not have piped supply systems, but will be supplied from an indirect system to which water will be transferred by water tankers (Bowsers). All the existing CBOs receive treated water at their elevated tanks except for three CBOs.

The number of GNDs presently supplied by NWSDB, existing CBO or new system established under the present project is summarized in **Table 19**. **Figure 10** shows such GNDs supplied by the existing piped system, new system and indirect supply.

Table 19 Summery of GNDs in Project Area

DSD	NWSDB	GNDs by CBOs	New GNDs		Indirect (Isolated) GNDs	
			Year 2024	Year 2034	Year 2024	Year 2034
Padaviya [1)]	3	4	5	8	4	1
Kebithigollewa	5	2	17	17	1	1
Medawachchiya	8	13	8	9	6	5
Rambewa	4	12	6	10	16	12
Horowpothana	2	6	21	21	8	8
Kahatagasdigiliya	3	18	7	11	12	8
Total	25	55	64	76	47	35

Note [1)]: GND 2 of Padaviya DSD is supplied from both NWSDB and existing CBO (29)

Two water sources are selected for the present integrated water supply system in the northern and southern parts of the project area, namely Wahalkada Wewa and Mahakanadarawa Wewa respectively, from where raw water is conveyed, after treatment, to the entire project area through two transmission systems.

The transmission system from the Mahakanadarawa Wewa is named as the Mahakanadarawa System, which will cover DSDs of Medawachchiya and Rambewa. The Wahalkada system from Wahalkada Wewa transmits treated water to the DSDs of Padaviya, Kebithigollewa, Horowpothana and Kahatagasdigiliya.

From the demand projection for the year of 2034, the transmission capacity for the Mahakanadarawa and Wahalkada systems is determined as 17,300 m^3/day and 26,900 m^3/day respectively.

Each transmission system is composed of a transmission main system and a sub-main system. The main system is formed to cover the entire supply zone from the respective water treatment plant and the sub-system supplements the main system to convey bulk water to the elevated tanks, which are placed at strategic locations to distribute water to the new system of GNDs and transmit bulk water to the existing CBOs.

The transmission main system is composed of transmission mains and service centers where a pumping station and an elevated tank are provided. In addition, booster pump stations are provided at strategic locations. The transmission main route of each system is, in general, selected to run along the main roads mentioned above, from the water treatment plant and between service centers. Elevated tanks are provided at key locations to distribute treated water directly to the new distribution systems of GNDs. On the other hand, the existing systems will receive bulk water from the transmission system at the elevated tanks.

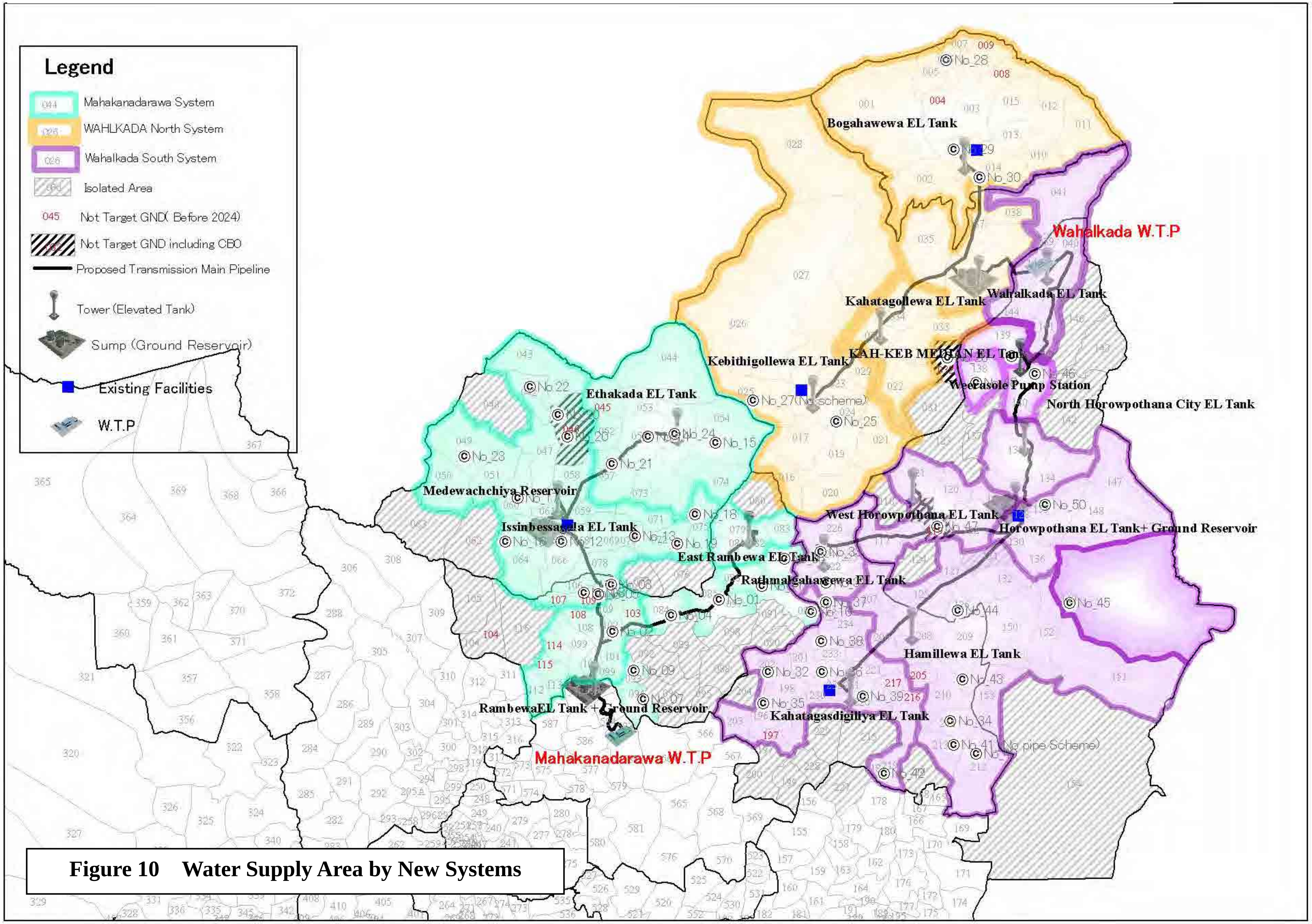


Figure 10 Water Supply Area by New Systems

5.3.2 Distribution System

Distribution system is composed of distribution main and distribution sub-system. Distribution main conveys water from the elevated tank directly to the GND's distribution sub-system which distributes water to each customer directly. On the other hand, the main feeds water to the existing elevated tank of CBO, from where distribution sub-system distributes water to each customer. In both cases, a water meter will be installed at the inlet of either distribution sub-system of new system of GND or existing elevated tank of CBO.

1) Distribution Main

The preliminary design of distribution main is carried out using Google map to obtain distance and ground elevation for analysis of sizing of distribution main for the purpose of cost estimate. The sizing of distribution main was determined peak hour demand of year 2034 requirement for new system of GND and day maximum demand of year 2034 for the existing CBO.

2) Distribution Sub-system

The study on distribution sub-system is carried out mainly for cost estimate purpose using the unit length of each size of distribution pipe per service connection obtained from network analysis of model networks at three typical existing CBO systems with a different size. Using unit length to service connection, the pipeline length for each size was estimated for Phase I (year 2024) based on the following considerations:

- Pipeline lengths of 100mm or larger were estimated for year 2034 requirement
- Pipeline lengths of 50mm and 75mm were estimated for year 2024 requirement corresponding to the construction period.

5.3.3 Major Facilities of Transmission and Distribution System

The summary of major facilities of transmission and distribution system is presented below and in **Tables 5.7**.

I. Mahakanadarawa System

1) Transmission Mains	250 – 450 mm x 42.3 km
2) Transmission Sub-mains	100 – 250 mm x 50.8 km
3) Distribution Mains	200 – 400 mm x 141.4 km
4)-1 Distribution Sub-System (NWSDB scheme)	50 – 200 mm x 201.6 km
4)-2 Distribution Sub-System (Existing CBO scheme)	50 – 200 mm x 315.1 km

II. Mahakanadarawa System

1) Transmission Mains 300 – 450 mm x 117.3 km

2) Transmission Sub-mains 100 – 250 mm x 24.3 km

3) Distribution Mains 100 – 400 mm x 326.7 km

4)-1 Distribution Sub-System (NWSDB scheme) 50 – 200 mm x 378.4 km

4)-2 Distribution Sub-System (Existing CBO scheme) 50 – 200 mm x 254.6 km

Table 20 Summery Table of the Facilities to Be Constructed

System	Site	Elevated Tank	Ground Reservoir	Pump House	Operational Complex *1	Chlorinator Building	Generator	Workshops	Quarters for Staff	Quarters for Operator	Surge Tank (100m3)
Mahakanadarawa	Rambewa	1,250m3	1,500m3	✓	✓	✓	✓		✓	✓	
	Medawachchiya		1,000m3	✓	✓*2 *3	✓	✓	✓	✓	✓	
	Issinbassagala	2,000m3				✓				✓	
	Ethakada	750m3				✓				✓	
	East Rambewa	250m3				✓				✓	
	Mahakanadarawa ~Rambewa										✓✓
Wahalkada South	Wahalkada	500m3				✓				✓	
	Kahatagollewa	250m3	1,000m3	✓		✓	✓			✓	
	Bogahawewa	2,000m3			✓	✓			✓	✓	
	KAH-KEB Median	250m3				✓				✓	
	Kebithigollewa	750m3	500m3	✓	✓*3	✓	✓	✓	✓	✓	
Wahalkada North	Weerasole		1,500m3	✓		✓	✓			✓	
	North Horowpothana	250m3				✓				✓	✓
	Horowpothana	500m3	1,000m3	✓	✓*3	✓	✓	✓	✓	✓	
	West Horowpothana	750m3				✓				✓	
	Rathmalgahawewa	500m3				✓				✓	
	Hamillewa	1,250m3				✓				✓	
	Kahatagasdigilliya	1,500m3	500m3	✓	✓	✓	✓		✓	✓	
Total		**15**	**7**	**7**	**6**	**17**	**7**	**3**	**6**	**17**	**3**

*1 Lab., OICs Office, Customer Counter, Room for Crews
*2 Satelite Office is to be included
*2 OIC Office should be replaced to Area Engineers Office

5.4 Water Supply System for Isolated Areas

The Project is to integrate the existing small-scale water supply systems into two large-scale ones.

The following priority of factors is considered to select service areas of two pipe borne water supply systems.

1st GNDs with an existing water supply system
2nd GNDs where the facilities of a proposed water supply system are included
3rd GNDs covering a urban centre including its surrounding GNDs
4th GNDs along with main roads designated

As the result of analysis, the remaining areas are categorized as isolated areas. The population is 53,500 for isolated areas, 225,000 for non-isolated areas and 278,500 in total for the target year of 2034, respectively.

The water supply system in the isolated areas consists of water tanks (capacity 5 m3) and water bowsers (capacity 5 m3) and 10 Lpcd of water will be provided to each population.
Figure 5. 3 shows the concept of water supply system in the isolated area. Totally, 107 water tanks and 20 water bowsers are required for the water supply for the isolated areas.

6 MANAGEMENT, OPERATION AND MAINTENANCE OF THE PROPOSED WATER SUPPLY SYSTEM

6.1 Project Implementation Arrangements

The project implementation system will consist of the following: (i) The ***project executing agency*** will the MWSD. Its role will be oversight monitoring of NWSDB's responsibilities in implementing the project. This will be performed through its Planning and Monitoring Division and its Procurement Division. (ii) The ***project implementing agency*** will be NWSDB. Its role will be technical monitoring and financial monitoring of the project, which it has had plenty of previous experiences. This will be performed by the Office of Water Supply Projects. (iii) A ***project management and coordination unit*** (PMCU), to be headed by a Project Director, will be created under the Office of Water Supply Projects, but will be physically based in the North Central RSC. It will manage the day-to-day activities of the Project and will be involved in the entire cycle of the project as reflected in the whole range of services to be provided by the project consultants' team. (iv) The ***project coordination committee*** (PCC) will be composed of the representatives of the key stakeholders of the Project. The DGM of the N/C RSC will chair the PCC, with the PD of the PMCU as co-chair. The key stakeholders identified are the Central Environment Authority, the Irrigation Department, the Department of Wildlife Conservation, the Department of Health Services, the Department of Archaeology, the Department of Forestry, the Land Commissioner's General Department, the Local Authorities and representatives of Community-Based Organisations in the six project areas.

6.2 Operation and Maintenance Organisation

(1) Enhancement of Existing Service Centres and New Set-up
There are four water supply schemes presently operating in the Project Area. However, Rambewa will need to be organised into a new water supply scheme to manage the newly constructed facilities that will be operational by 2018. Meantime, the other three existing WSS shall be expanded to enable it to take on the added O&M responsibilities given the new facilities.

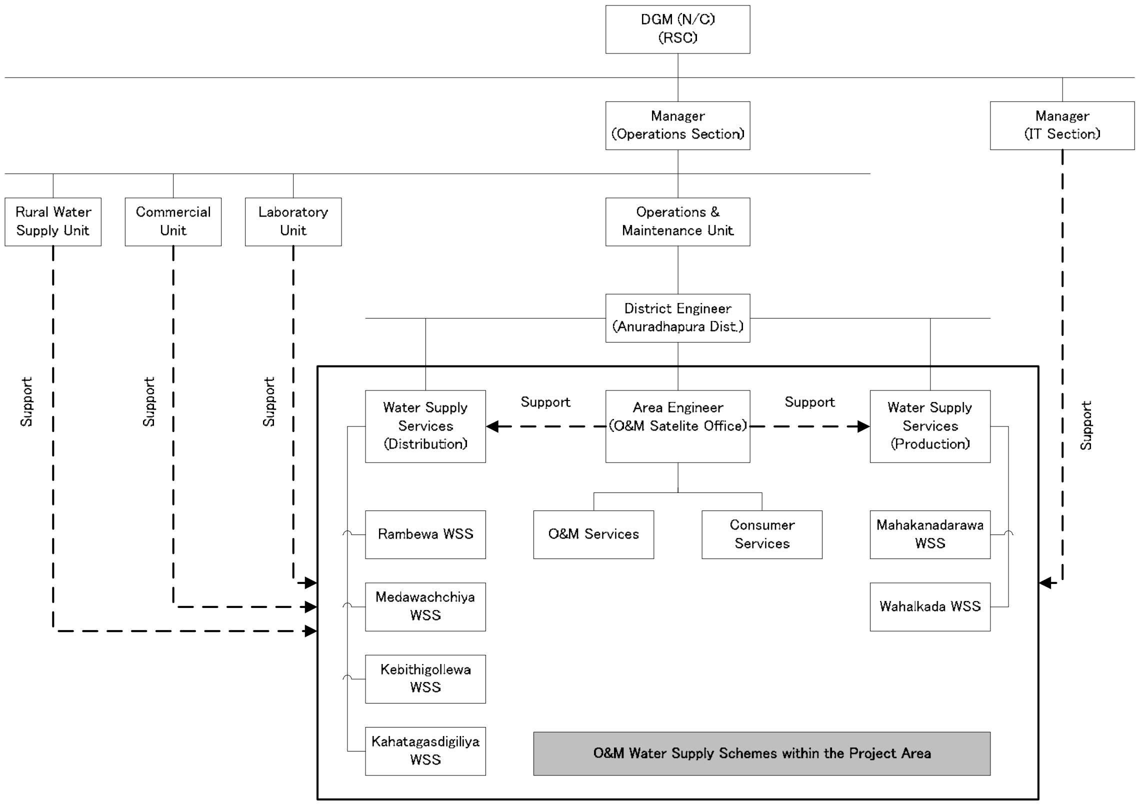


Figure 11 O&M Organization and Supporting System after Commissioning

(2) Establishment of Mahakanadarawa and Wahalkada Water Supply Schemes

Two new water supply schemes are be organised to operate and maintain the Mahakanadarawa and Wahalkada water treatment plants before the end of the construction period, to have ample lead time to train for the pre-operation and star-up operational phases of the WTPs.

(3) Establishment of O&M Area (Satellite) Office for WSS in the Project Area

It is proposed that the O&M satellite office be organised in Medawachchiya, to be staffed by five personnel (headed by an officer-in-charge). The area office will function to: (i) *deliver quick response to O&M and technical issues* that need immediate resolution and which were inadequately dealt with by the schemes; (ii) *provide closer consumer service support services* considering the increased number of new customers to be generated by the completion of the Project, (iii) *spearhead the public information, education and communication (IEC) programme* on the importance of water to health; (iv) *assist the WSS in delivering potable water* to the remote villages not covered by the piped system, but which is required due to water quality health concerns.

(4) Enhancing Other Sections / Units in Support of O&M

There are other sections and units in the NC RSC that need to be enhanced to support the proper operation and maintenance of the new facilities. These are the (i) regional laboratory, for the upgrade of laboratory facilities and training on water quality monitoring; (ii) the rural water supply unit, for capacity building of CBOs and spearheading the public awareness campaign under the IEC programme; (iii) the commercial unit, for improving customer services guided by the NWSDB Customer Charter; and (iv) the IT section, for the enhancement of customer services through the expanded use of the call centre service, and the improvement of billing efficiency with the use of a point-of-sales system.

(5) Supporting O&M through Equipment and Engineering Software

It is equally important that the water supply schemes, the O&M area office, and the regional workshop are equipped with basic O&M equipment and vehicles. The equipment proposed are four units each of asphalt cutters, tapping machines, compactors, and vibrating hammers; six units of portable generators; one unit of small lift hoist / crane; one unit of pump bed test / machine; and 20 units of assorted vehicles (cabs, water bowser, mini-backhoe and motorcycles. The latest versions of engineering software (01 with 5-user licence) required are: Small World Water Network Information System, ArcGIS, WaterCAD, Surge Analysis Software, Structural Design Software, and Project Management Software

6.3 Mode of Water Supply Services

(1) Community Based Organisations

CBOs operating in the Project area were formed as rural community organisations capable of providing and sustaining the management of the water supply and sanitation facilities to their beneficiary community under either ADB, World Bank or bilateral projects. The functions of the CBOS are enshrined in the National Policy for Rural Water Supply.

(2) CBO-Managed Water Supply Schemes in the Project Area

Based on the criteria for the inclusion of CBOs into the project’s service area, three CBOs, namely (i) Tristar and (ii) Dirimathaya and (iii) Al Naja will be excluded for various reasons.

In terms of suitability of the CBOs for inclusion / connection to the bulk water system, 36 CBOs or 72 percent are technically suitable, thus can be recommended for immediate inclusion; 06 CBOs or 12 percent are recommended, but improvements are required; 05 CBOs or 10 percent are also recommended, pending resolution of larger issues; and 03 or six percent are excluded, as explained above. Actions to address the issues by the NWSDB NC are proposed in this Study.

As for the willingness of the CBOs to connect to the bulk water system, a resounding majority of 42 CBOs or 84 percent are willing to connect to the new distribution system. One CBO (two percent) said it was not willing to connect; one (two percent) was undecided; one (two percent) did not respond. One the other hand, one (two percent) does not have CBO/scheme, while one (two percent) is a rainwater harvesting scheme. Three CBOs (six percent) have been excluded from the study.

(3) Approaches in Providing Water Supply Services to the CBOs

In view of the preceding, it is proposed to categorise CBOs for inter-connection with the bulk supply, as shown below:

Table 21 Categorisation of CBOs Based on Willingness to Connect, Conditions Set and Technical Suitability

CBO	CATEGORY 1	CATEGORY 2	CATEGORY 3	CATEGORY 4	CATEGORY 5
	• Willing to connect • No conditions • Suitable for bulk supply	• Willing to connect • No conditions • Requires improvements	• Willing to connect • With conditions • Suitable for bulk supply	• Willing to connect • Requires major rehabilitation • Undecided	• Not willing to connect • Excluded
TOTAL	**11**	**6**	**24**	**5**	**4**
%	***22***	***12***	***48***	***10***	***8***

After the new water supply system will enter into operation, NWSDB will be responsible for management, operation and maintenance of new systems. If NWSDB will take over the existing CBO system based on the resolution at the general meeting of the community, the NWSDB's water tariff is imposed to the respective customers, while if the existing CBO will keep an independence from NWSDB, the NWSDB's bulk water supply rate will be imposed to the total water consumption of the CBO. For the new service area, since NWSDB has no intention to allow the new CBO establishment. NWSDB's water tariff will be applied to all the new customers. Takeover of the existing CBO facilities will be done in principle for nothing, since the materials required for the construction of facilities were originally provided by the Government for nothing.

In case of a bulk supply from NWSDB to existing CBOs, the bulk supply charge will be newly imposed, while the consumerable expenditures such as electricity or diesel oil and chlorine will be cut from the present expenditures. The profit/loss estimated reveals that 17 CBOs (about 41%) out of 41CBOs will show a loss. Although the total payment of one community will be higher than the current one, the water supply by NWSDB still has advantages of (i) safe water supply to meet the Sri Lankan drinking water standards even for fluoride, (ii) stable water supply even in the dry season, (iii) proper chlorination of water, (iv) professional operation and maintenance for distribution facilities such as replacement of defective water meters, repair of leaks.

7 PROJECT COST

7.1 Preamble (Basis for Cost Estimation)

Following conditions were referenced from the JICA F/F Common Matters to be considered for Sri Lanka in preparation of the cost estimation for this project.

1) Base Year — August 2012
2) Exchange Rate — USD 1 = JPY 78.2
USD 1 = Rs. 132.1
Rs. 1 = JPY 0.592
3) Price Escalation Rate — Foreign Currency = 2.1%,
Local Currency = 4.0%
4) Physical Contingency — 5.0%
5) Administration Cost — 9.0% of eligible and non-eligible portions
6) VAT — 12 % (of the expenditure in local currency and foreign currency of the eligible portion)
7) Import Tax — 27% (of the expenditure in foreign currency of eligible construction portion)

7.2 Project Cost Estimation

A summary of estimate capital cost for the Anuradhapura North Integrated Water Supply Project is tabulated in **Table 22** and **Table 23**

The estimate capital cost for the Mahakanadarawa portion of the project subjected to the JICA Loan is 5.166 billion yen (Foreign Portion: 2.623 billion yen and Local Portion: RS. 4.295 billion) and that for the Wahalkada portion is 7.696 billion Yen (Foreign Portion: 4.045 billion Yen and Local Portion: Rs. 6.166 billion).

Table 22 Mahakanadarawa Estimated Project Costs (Stage-1)

Item	Cost in Million		
	FC	LC	Total
	(JPY)	(Rs.)	(JPY)
A. ELIGIBLE PORTION			
Ⅰ) Procurement / Construction	1,951	3,990	4,314
Ⅱ) Consulting Services	378	305	559
Sub-total (Ⅰ + Ⅱ)	2,330	4,295	4,872
B. NON ELIGIBLE PORTION			
a. Procurement/ Construction	12	97	69
b. Land Acquisition	0	19	11
c. Administration cost	0	753	446
d. VAT	0	1,004	594

Item	Cost in Million		
	FC	LC	Total
	(JPY)	(Rs.)	(JPY)
e. Import Tax	0	895	530
Sub-total (a+b+c+d+e)	12	2,769	1,651
TOTAL (A+B)	2,341	7,064	6,523
C. INTEREST DURING CONSTRUCTION	253	0	253
D. COMITTMENT CHARGE	41	0	41
GRAND TOTAL (A+B+C+D)	2,635	7,064	6,817
E. JICA FINANCE PORTION INCLD. IDC (A + C + D)	**2,623**	**4,295**	**5,166**

Table 23 Wahalkada Estimated Project Costs (Stage-1)

Item	Cost in Million		
	FC	LC	Total
	(JPY)	(Rs.)	(JPY)
A. ELIGIBLE PORTION			
Ⅰ) Procurement / Construction	3,489	5,868	6,963
Ⅱ) Consulting Services	175	298	352
Sub-total (Ⅰ + Ⅱ)	3,664	6,166	7,315
B. NON ELIGIBLE PORTION			
a. Procurement/ Construction	14	122	86
b. Land Acquisition	0	10	6
c. Administration cost	0	1,126	667
d. VAT	0	1,501	889
e. Import Tax	0	1,598	946
Sub-total (a+b+c+d+e)	14	4,358	2,594
TOTAL (A+B)	3,679	10,524	9,909
C. INTEREST DURING CONSTRUCTION	320	0	320
D. COMITTMENT CHARGE	61	0	61
GRAND TOTAL (A+B+C+D)	4,060	10,524	10,290
E. JICA FINANCE PORTION INCLD. IDC (A + C + D)	**4,045**	**6,166**	**7,696**

Note: The Project cost will be discussed and finalised in the Appraisal of Wahalkada Scheme.

7.3 Operation and Maintenance Cost

The following table summarizes the operation and maintenance cost.

Table 24 Operation and Maintenance Cost for the Proposed Water Supply System

O&M Cost (Rs/m^3)		Mahakanadarawa		Wahalkada	
		Stage-1	Stage-2	Stage-1	Stage-2
Water Consumption	m^3/d	7,500	14,900	11,400	22,900
Salary	Rs/year	14,356,100		13,023,953	
Electricity	Rs/m^3	10.54	13.32	16.76	17.90
Chemical - Chlorine	Rs/m^3	0,61		0,61	
Chemical - Alum, Lime	Rs/m^3	1.10		1.10	
Repair & Maintenance	Rs/m^3	3.00		3.00	

8 IMPLEMENTATION PLAN

8.1 Project Implementation Schedule

The expected overall schedule is shown in **Figure 12**. In preparing the overall schedule, following was considered for pre-construction and construction stages.

Two JICA Loan Packages will be applied for this Project. One package consists of the detailed design of both Mahakanadarawa and Wahalkada Water Supply Systems and construction of Mahakanadarawa Water Supply System. The other package consists of the construction of Wahalkada Water Supply System.

Table 25 Proposed Project Implementation Schedule

Description	Schedule
Pledge of JICA Loan	December 2012
Exchange of Notes between GOB and GOJ	March 2013
Signing of Loan Agreement (Mahakaanadarawa Stage-1)	N/A
Signing of Loan Agreement (Wahalkada Stage-1)	February 2014
Selection of consultant for Designing & Construction Supervision	8 months
Detailed Engineering Design, Preparation of specifications	10 months
Contractor Prequalification (P/Q), evaluation and JICA concurrence	7 months
Tender documents for individual project components, JICA concurrence on tender documents	2 months
Project Tender period	2 months
Evaluation of tender proposals	2 months
JICA concurrence on tender evaluation (Contractor proposals)	1 month
Contract negotiation	1.5 months
JICA concurrence on contract award	0.5 month
L/C Issuance for project	1 month
Total period of Construction Work (Mahakanadarawa)	33 months
Completion of the Project and Plant trails (Mahakanadarawa)	March 2018
Total period of Construction Work (Wahalkada)	36 months
Completion of the Project and Plant trails (Wahalkada)	October 2018 [*1]
O&M Training	4 months (December 2017 to March 2018)

Note: [*1] Implementation schedule will be discussed and finalised in the Appraisal of Wahalkada Scheme.

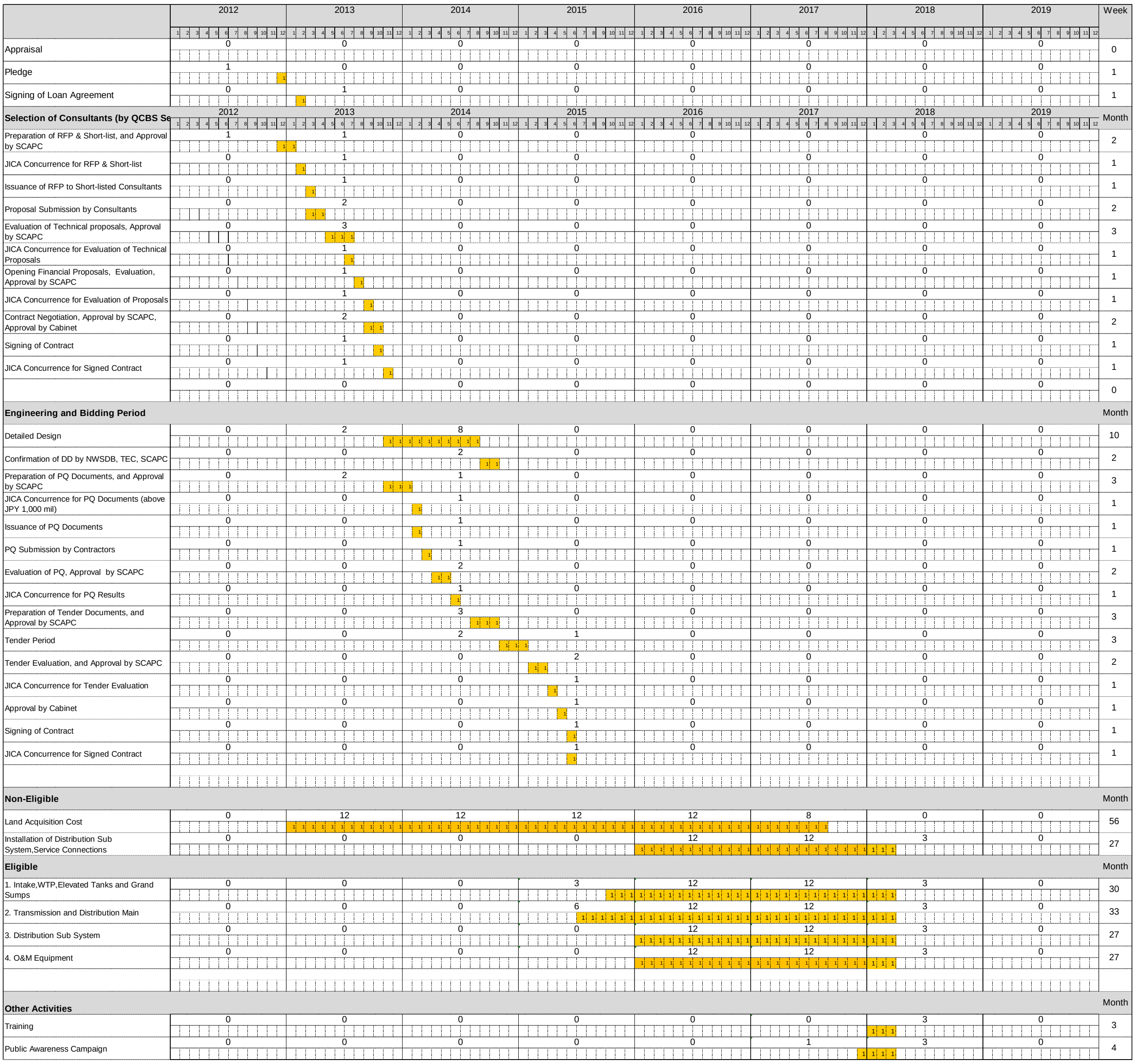


Figure 12 Implementation Schedule

8.2 Contract Package

Construction packaging for the Project is one of the most important factors for the smooth implementation of all the components.

Proposed contract packages, total eight packages for the JICA ODA loan for the Project, which are shown in **Table 26** and **Table 27**. The construction periods of packages are assumed and summarised as follows, considering the size of the project and work volume and workability.

Table 26 Proposed Contract Packages for Mahakanadarawa Project

Package	Components	Cost (million Yen)	Period (month)	Procurement
Package 1	Intake, WTP, Ground Sumps and Elevated Tanks	1,712	30	ICB
Package 2	Transmission/Distribution Mains	1,263	33	ICB
Package 3	Distribution Sub-System	534	27	LCB
Package 4	O&M Goodss	68	12	LCB
Package 5	Installation of Distribution Sub-System and House Connections	56	27	-

Table 27 Proposed Contract Packages for Wahalkada Project

Package	Components	Cost (million Yen)	Period (month)	Procurement
Package 1	Intake, WTP, Ground Sumps and Elevated Tanks	2,543	37	ICB
Package 2	Transmission/Distribution Mains	2,534	40	ICB
Package 3	Distribution Sub-System	604	34	LCB
Package 4	O&M Goods	72	19	LCB
Package 5	Installation of Distribution Sub-System and House Connections	69	34	-

ICB (International Competitive Bidding) packages are selected with consideration of level of required technology/engineering, sizes of the packages etc. which the local contractors have limited experiences in the contents of the works, and less technical and financial capacities. In this aspect, Package 1 consists of all civil, architectural, mechanical and electrical works in Intake Station, Water Treatment Plant, Ground Sumps and Elevated Tanks. The package requires higher technology/engineering for complicated structures and good coordination between different types of works. Package 2 needs experiences of long HDPE pipeline installations. HDPE with large diameter such as 450mm is still new for Sri Lankan Contractors and total length of over 250km.

However the rest of the packages are procured by LCB (Local Competitive Bidding) for the local contractors to provide business opportunities. Especially Package 3 consists of 1) 3-1: PVC 100-200mm supply and installation, 2) 3-2: PVC 50-75mm supply 3) 3-3: PVC 50-75mm installation etc. Pipe length of the Distribution Sub-System, currently proposed is tentative and will be determine by the detailed design.

Installation of PVC 50mm is categorizsed into Non-Eligible portion which Sri Lanka side will implement. NWSDB and CBO have many experiences through ADB funded project in this project area using community manpower to install small size of pipelines with NWSDB's piping materials and advices/supervision. This practice in the area will accelerate development of the distribution sub-systems.

8.3 Procurement Method

The selection of the consultant will need to be conducted by NWSDB in accordance with the JICA Guidelines and Government Procurement Guidelines – 2006 of Sri Lanka. The selection process of the consultant will have to be initiated as soon as possible, after the commitment for the finance is made by the Japanese side. Preparation of tender documents and detailed design will be carried out by the consultant to be selected and employed by NWSDB.

Conditions applied in the tender documents to select the contractor will also have to meet the requirements in the JICA Guidelines and Government Procurement Guidelines – 2006 of Sri Lanka. JICA normally requires that the procurement of goods and services will be obtained through ICB. Construction will, therefore, be carried out by the contractor/s awarded the contract through the ICB procurement method. For contractor selection, the following "Construction as designed" will be applied in this Project.

Contractors are issued for the detailed drawings to construct the facilities designed by the Employer and/or consultants. Construction will follow the detailed dimensions and specifications which are stipulated in the tender documents. Liability of the contractor will be limited to quality of the construction work as long as the facilities are built as designed. Preparation of design drawings will take a longer time compared with the design-build method. However, selection of the contractor is smooth and easy due to the evaluation mainly focus on the financial proposals among pre-qualified bidders strictly selected by technical and financial aspects of capacity, reliability, experiences etc.

9 Environmental and Social Consideration

9.1 Natural Conditions

(1) Natural Conditions in the Study Area

The project area is a suburban and rural area, which is located in the northern part of Anuradhapura District. The climate is classified into the dry zone. The main industry is the agriculture for rice as a main crop. The land covered by forest and shrub is the largest in area. Compared with the heavy rain area, the species of fauna and flora are less and the biodiversity is poor due to less rare species. Some of project sites are lacated in the forest but they are the secondary forest and special attention is not required for the environmental protection.

(2) Protected Area

[Sanctuary]

The protection of a sanctuary is provided in "Fauna and Flora Protection Ordinance" and is controlled by the Department of Wildlife Conservation. The level of protection of a sanctuary is not so severe among the protection areas and a mion development action ican be done with a permission of the authority although being required the implementation of EIA/IEE.

Around Mahakanadarawa Wewa, one of the proposed water sources in the project is designated as a sanctuary. The boundaries of an sanctyary is defined as within 400 yards (366 m) from the Full Supply Level of the reservoir or a center line of the bund wherever there is a bund as an artificial structure. While, the Central Environmental Authority (CEA) designated the buffer zone within 100 m from the boundary as a most susceptible area to an environmental impact. Since in the initial plan of the project, water was planned to be taken from the reservoir directly, the project was classified into Category B due to the fear of an impact on the protection area. However, thereafter, the plan of direct water intake was cancelled and instead changed so as to take water from an irrigation canal of the reservoir and the site for a water treatment plant was fixed outside a sanctuary. Therefore, an environmental impact was significantly reduced.

[Environmental Sensitive Area]

The prescribed projects which are requested to implement EIA/IEE are defined and listed in the Gazette no 772/22 of 24th June, 1993 and 859/14 of 23rd February 1995. Only large-scale development projects that are likely to have significant impacts on the environment are listed as prescribed projects. There are two categories, although they are not applicable to the project.

On the other hand, from the view point of the susceptibility of an environmental impact, the following points were expected to be problematic.

- Within 100 meters from the boundaries of or within any area declared as a Sanctuary under the Fauna and Flora Protection Ordinance
- Within 100 meters from the high flood level contour of or within a public lake as defined in the Crown Lands Ordinance.

In the project, the water source is the reservoir but both an intake works and water treatment plant are more than 100 m downstream of the reservoir for both cases and the prescribed project is not applicable to.

[Forest]

There is no forest reserve land in the proposed sites. But if the land is designated as the forest, the permission for land use alteration is required from the Department of Forestry. NWSDB has received the permission for those of the construction sites that is included in the forest from the Department of Forestry

[Archeological Impact]

All the projects are required the assessment of an archeological impact. NWSDB has the permission of project implementation at the stage of pre-feasibility study. For the sites changed thereafter, NWSDB has submiited an additional application and got the permission for almost sites except for three locations which have been still waiting for the permission.

[Necessity of IEE/EIA]

In the initial plan, the direct water intake from the reservoir was supposed, but due to the instruction from the Irrigation Department, a water intake from the irrigation canal downstream of the reservoir was decided and any development action will not be done within the sanctuary or environmentally sensitive area. Therefore, although the environmental consideration will be required subsequently, it is not necessary to conduct the IEE/EIA. The environmental recommendation has been already received from the CEA, it is required to meet the conditions described therein. On the other hand, NWSDB has an obligation to get the environmental protection license three months before the commencement of facility operation.

9.2 Social Consideration

(1) Minority and Indigenous People

There are indigenous people called **'Veddas'** in Sri Lanka, but there are none living in the study area. The ethnic composition in the study area is 91% Sinhalese, 1% Tamil and 8% Muslim. In Anuradhapura, the ratio of Sinhalese is higher than the national average at more than 90%.

(2) Socio-economic Conditions

The largest land use of the study area is covered by forest, followed by scrub. Cultivated land is mainly paddy fields. 70% of the people are engaged in the agriculture. The area has two rainy seasons, namely the months of October to December which is the main cultivation season and the period of March to April with scattered rains. Double cropping is possible if the rainfall is enough. The irrigation agriculture has been done from the ancient times in the study area with many tanks. Although the people have been trying to make use of limited water resource as much as possible, but the annual harvest heavily relies on the available water amount. Therefore. the desiring level of the people for water is very high. According the annual report of the Central Bank for the year of 2012, the poverty household in Anuradhapura District is 4.6% which is higher than the national average of 7.0%.

9.3 Human Resettlement and Land Acquisition

(1) Human Resettlement

Although the proposed sites for water treatment plants are the government land but there are the illegal occupants. For the Wahalkada site, the measures to shift the so as to avoid the human resettlement is taken. However, for the Mahakanadarawa site, since the available land limited for the facility layout, the human resettlement of one occupant is finally required. Therefore, the preliminary human resettlement programme was prepared. In Sri Lanka, there is the National Involuntary Resettlement Policy（NIRP）which has no significant gap with the JICA's guidelines including the compensation in accordance with the reacquisition price. The guideline has already established for the contents to be included in the RAP which meets the JICA requirements. NWSDB has already started the explanation to the residents on the project and resettlement. The household is the family of two, Sinhalese or the majority people in Sri Lanka.

(2) Land Acquisition

Most of the project sites (30 acres) are the government land and NWSDB can use them through the payment of a lease fee, while 2. 2 acres of them is the private land which requires the acquisition. For all sites, the procedures to transfer the right for land use have been already commenced and waited for the progress of public process among the agencies concerned which will take usually six months.

9.4 Mitigation Measures

The adverse impacts and its mitigation measures are listed in **Table 28**. The column of Impact shows the evaluation of potential impact after taking mitigation measures.

Table 28 List of Adverse Impacts and Its Mitigation Measures

Pre construction stage

Impact	Object	Mitigation measures	Impact	In charge or implemented by	Supervising
Noise and vibration	Pump, generator and other noise generation facility	● Low noise/vibration pump and generator are specified in tender document. ● Building is designed with the consideration to decrease noise and vibration to meet the requirement. ● Location of these facilities is examined.	Minor	NWSDB HO	PMU (CEA)
Waste	Construction waste and Domestic waste	● Waste management plan is prepared under discussion with CEA and DS. ● Temporally dumping area is secured.	Minor	NWSDB RSC	PMU DS CEA
Ecological impact	Clearing land	● Clearing land and cutting tree are planned under the discussion with Forest Dept and/or CEA.	Minor	NWSDB RSC	PMU Forest Dept CEA
	Rare species	● Making a plan of transplant and recovery of habitat	Minor	NWSDB RSC	PMU Wildlife dept CEA
Resettlement	Resettlement	● Progress of resettlement and its fairness are monitored.	Minor	NWSDB RSC	PMU DS
Social impact	Stakeholder meeting	● Discussion and making agreement about construction schedule, procedure, and impact	Minor	NWSDB RSC	PMU PCC
	Public relation activities for local residents	● Explanation for local residents and to develop understanding about construction work schedule, expected impacts, mitigation measures etc.	Minor	NWSDB RSC	PMU DS

NWSDB RSC : National Water Supply and Drainage Board
PMU: Project Management Unit
PCC: Project Coordination Committee
DS: Divisional Secretariat
Additional GM for water supply

Construction stage

Impact		Mitigation measures	Impact	In charge or implemented by	Supervising
Air pollution	Exhaust gas	● To ensure the use of vehicles and machineries officially registered, and properly maintained.	Minor	Contractor	PMU
	Dust	● To cover the earth or dusty materials ● To sprinkle water to prevent the dust raising.	Minor	Contractor	PMU
	Leakage of chlorine gas	● Guidance of proper installation ● Safety training to laborer	Minor	Contractor	PMU
Noise	Vehicles and machinery	● To ensure the use of vehicles and machineries officially registered, and properly maintained. ● Unnecessary idling is not allowed. ● Route of transportation is examined to prevent noise or other effect on vicinity.	Minor	Contractor	PMU
	Construction work	● To avoid doing the work generating noise and vibration at nighttime.	Minor	Contractor	PMU

Impact		Mitigation measures	Impact	In charge or implemented by	Supervising
		● Sound insulation wall will be used if necessary.			
Water quality	Water source	● Making water resource protection plan with the commitment of relevant authority	Minor	PMU	PD
	Discharge water	● Clean water such as rain water is separately collected to prevent from mixing with muddy materials ● Turbid water generated by earthwork is introduced to the sedimentation basin and turbid material will be settled. ● If necessary further treatment (use of coagulant) is done.	Minor	Contractor	PMU
	Domestic effluent	● Effluent is treated by the soak pit.	Minor	Contractor	PMU
	Oil and grease	● Oil and grease are kept separately in the container. ● Oil absorbent is prepared.	Minor	Contractor	PMU
Waste	Construction waste	● The waste reduction plan and dumping procedure will be proposed at the tender document and implemented. ● The temporally dumping yard for construction waste is secured. ● Waste is segregated in order to recycling purpose. ● Recyclable material is transferred to the recycling manufacturer. ● Waste which is not recyclable is disposed to follow the fixed rule of relevant DS.	Minor	Contractor	PMU
	Domestic waste generated by laborer	● Domestic waste is placed at the temporally damping yard, and transferred to the officially operated disposal field	Minor	Contractor	PMU
Ecological environment	Violation to ecosystem	● Training and awareness program for laborer is planned and done. ● Scheduled patrol of the site	Minor	Contractor	PMU
	Trees and plant	● Clearing land is minimized and the large tree is remained as far as possible, or transplanted.	Minor	Contractor	PMU
	Rare species	● If the special species will be found out at the site, report to NWSDB and receive the guidance of CEA or wildlife dept.	Minor	Contractor	PMU CEA Wildlife dept
Archaeological impact	Excavating antiquity	● If the antiquity will be excavated at the site, report to NWSDB and receive the guidance of Archaeological dept.	Minor	Contractor	PMU Archaeological dept.
Social impact	Social conflict caused by laborer	● Training and awareness program for laborer are planned and done. ● Security guard is appointed.	Minor	Contractor	PMU
	Inconvenience of livelihood	● Pipe laying work on the road is planned carefully to prevent inconvenience as much as possible. ● Refraining from working during peak hours to prevent road traffic blocks ● Public notice prior to construction	Minor	Contractor	PMU
Working	Occupational	● Training and awareness program	Minor	Contractor	PMU

Impact		Mitigation measures	Impact	In charge or implemented by	Supervising
condition	safety	for laborer is planned and done. ● Safety tools are provided to laborer by Contractor.			

Operation stage

Impact		Mitigation measures	Impact	In charge or implemented by	Supervising
Air pollution	Leakage of chlorine gas	● Gas monitor is working always at proper condition ● Safety training to laborer	Minor	NWSDB RSC	NWSDB HO
Noise	Noise generation facility (pump etc)	● To ensure the proper operation and maintenance	Minor	NWSDB RSC	NWSDB HO
Water quality	Discharge water	● Under drain water from sludge drying bed should be managed to meet the standards.	Minor	NWSDB RSC	NWSDB HO
	Domestic effluent	● Effluent is treated by the soak pit.	Minor	NWSDB RSC	NWSDB HO
	Oil and grease	● Oil and grease are kept separately in the container	Minor	NWSDB RSC	NWSDB HO
Waste	Domestic waste	● Domestic waste is placed at the temporally collection place, and transferred to the officially operated disposal field	Minor	NWSDB RSC	NWSDB HO
	Sludge	● Sludge is dried up at the drying bed to reduce its quantity ● Dried sludge is dumped by the contract with the approval of land owner.	Minor	NWSDB RSC	NWSDB HO
Working condition	Safety and health	● Safety and emergency tool is always ready. ● Safety training is provided on schedule. ● Newly hired employee shall have safety training.	Minor	NWSDB RSC	NWSDB HO

10 FINANCIAL AND ECONOMIC ANALYSIS

10.1 Financial Analysis

(1) Preconditions and Methods

- The calculation is based on the net or constant price because tariffs are controlled by the government and not easy to raise although inflation is occurring.
- The investment amount and the construction schedule are used as described in Chapter 7, “Project Cost,” and Chapter 8, “Project Implementation.” The investment costs include taxes, but they exclude interest payments during the construction period, because IRR treats only cash flow.
- Part of the invested assets such as buildings and plants has longer lives (depreciation periods) such as 50 or 60 years and the planning period is shorter so that the remaining residual values of these long life assets are input as minus investment at the end of the

calculation period. However, shorter life assets such as machines and vehicles are not reinvested after their lifetimes such as seven or 10 years end within the planning period because they are usually used continuously and not reinvested.

- The income from operation is based on the tariffs, but specifically, the billed amount and water used in 2011 shown by the NWSDB statistics are used to calculate income per water volume (North Central Region domestic 25.0 Rs./ m3) and this unit is multiplied by the estimated demand water volume. However, the NWSDB tariffs were raised from October 1, 2012 and new income per water volume is not clear because there is no statistic data after the tariff increase. Assuming the income per water volume becomes 1.5 times. The North Central Region domestic 25.0 Rs./ m3 increases to 37.5 Rs./ m3 (=25 x 1.5). Therefore, this FIRR calculation uses 37.5 Rs./ m3 as income per water volume.
- The operations costs are based on the estimates described in 7.6 “Operation and Maintenance Cost,” Chapter 7, “Project Cost.”

(2) FIRR Results

1) Mahakanadarawa

- The Mahakanadarawa water source area FIRR calculation result is -2.71% (Case 1: Phase 2 investment in 2024 is made). In Case 2, Phase 2 investment is not made and the water demand after 2025 is the same as that in 2024. In both cases, FIRRs are minus and so this project cannot be covered by the profits. The difference between the two cases is 0.12% and small. In order to make it positive, the tariffs should be raised 2.5 times of the present level. In addition, since this is calculated in net (constant price), it is assumed that tariffs are almost always revised based on the inflation in gross (market price).
- Since the tariffs need to be 2.5 times of the present level in order to make FIRR positive, sensitivity analyses are neither effective nor useful. Therefore, sensitivity analysis is omitted. However, NWSDB will bear only 20% of the investment costs in this project because this project area includes no municipalities. Instead of sensitivity analysis, FIRR of a case that investment cost decreases to 20% of the total investment is calculated. If the income per water volume increases 1.5 times (37.5 Rs./m3) because of the tariff raise, the FIRR becomes positive (0.42%). NWSDB may be able to pay interest and repay JICA if making efforts. However, this does not mean that the total project is covered by the profits. Of course, this 1.5 times increase of tariffs is also based on the additional inflation coverage.

2) Wahalkada

- The result of Wahalkada FIRR calculation is -2.88% in Case 1 and -2.80% in Case 2. The result is a little worse than those of Mahakanadarawa Cases because Wahalkada is a lower-density area and the investment is less efficient than Mahakanadarawa.

- Similarly to the Mahakanadarawa case, a case in which NWSDB's burden is 20% of the investment is calculated and the FIRR becomes 1.5%, higher than the Mahakanadarawa case because of the more demand compared with the reduced investment.

10.2 Economic Analysis

(1) Preconditions and Methods

The preconditions and methods of EIRR calculation are similar to those of FIRR above, but with some differences as follows.

- The investment costs exclude taxes and interest payments during the construction period. In addition, domestic currency part of the investment is converted to border price using a conversion factor. The conversion factor, 0.9, used in Sri Lanka will also be used in this analysis.
- Benefits are estimated instead of the operation income in FIRR, but it is necessary to explain the benefits in detail so that they are described separately below.

(2) Benefits

- Main benefits are derived from willingness-to-pay (WTP) amounts. The other benefits are reduction of medical and related costs caused by water borne diseases such as diarrhea, dysentery and viral hepatitis.
- The WTP amounts are set based on the new users (No Supply) group as lower amount of either actual payment per m3 or 4% income per m3 because No Supply group and CBO users can use safer water of NWSDB by the project. In addition, these benefits are calculated only for No Supply group and CBO user group. Although some existing NWSDB water users use well water, the benefits of NWSDB users are excluded in this benefit calculation because the benefits should be conservative..
- Water borne diseases such as fluorosis, diarrhea, dysentery and viral hepatitis can be reduced as this project enables the residents to use clean and better quality water. Although some diseases such as diarrhea, dysentery and viral hepatitis are not only caused by water but also by bad foods and unsanitary conditions, the social economic survey separated the users into three groups, namely NWSDB, CBO and No Supply, so that the water borne disease rates in these groups can be compared.

(3) EIRR Results

1) Mahakanadarawa

- In Case 1 (with Phase 2 investment), the EIRR EIRR of Mahakandarawa Case 1 (Unit: Mill. Rs.) is 6.91% and is better as compared with those of other water supply projects. In addition, if CKD benefits are included, the EIRR becomes 11.8%, a satisfactory figure.

- In Case 2 (without the additional investment), the EIRR is 5.54%, less than that of Case 1. If CKD benefits are included, the EIRR becomes 10.4%.
- In order to estimate sensitivity, the investment, operational costs and benefits are changed to plus 10% or minus 10%. The investment cost change affects the EIRR the most, but the difference is only -0.73% or +0.86%. The second most effective change is the operations cost and the difference is -0.06% or +0.07%. The benefit change difference is very small at –0.01% or +0.01%.

Table 29 Mahakanadarawa Sensitivity Analysis Results

Alternatives	Investment Plus 10%	Op. Cost Plus 10%	Benefits Minus 10%	Standard (Case 1)	Investment Minus 10%	Op. Cost Minus 10%	Benefits Plus 10%
EIRR	6.18%	6.85%	6.90%	6.91%	7.77%	6.98%	6.92%

2) Wahalkada

- The Wahalkada water resource area mainly consists of the DSDs other than Rambewa and Medawachchiya. WTPs of these four DSDs are used. The result of EIRR is 6.59% (Case 1). If CKD benefits are included, the EIRR becomes 11.5%. Case 2 EIRR is 4.46% and lower than that of Case 1 (6.59%).
- In order to estimate sensitivity, the investment, operational costs and benefits are changed to plus 10% or minus 10%. The results are shown in Table 10.15. The investment cost change affects the EIRR most, but the difference is only -0.70% or +0.81%. The second most effective change is the operations cost and the difference is -0.10% or +0.09%. The benefit change difference is very small at –0.01% or +0.01%.

11 OPERATION AND EFFECT INDICATORS

11.1 Operation Indicators

The operation indicators are to show to what extent the water supply scheme is operated efficiently, to achieve the target.

In addition to usual operational indicators for water supply such as served population (persons), water distribution (m3/day), facility utilisation rate (%) and NRW ratio (%), the compliance rate of drinking standard for fluoride concentration (%) is proposed.

The purpose of this project to supply safe water to customers especially focusing on the Sri Lankan Drinking Standard for a fluoride concentration of 0.6 mg/L. The compliance rate of the said standard should be 100%. The analysis shall be conducted semi-monthly.

Table 30 Operation Indicators for Water supply

Cate-gorty	Indicators	Calculation Equation of Indicators	Target		
			Present	2020	2024
Mahakanadarawa System					
Basic	Served population (persons)	Served population by pipe borne water supply = (No. of connections) × (Average per HU population) Served population by bowsers = (total population) Total served population = Served population + Served population by bowsers	25,900 0 25,900	40,700 21,400 62,100	47,800 22,300 70,100
Basic	Water distribution (m^3/day)	Daily maximum water distribution = (the biggest one in the daily water distribution records throughout a year) Daily average water distribution = (annual water distribution amount) / (annual days)	0 0	7,193 5,994	8,585 7,154
Basic	Facility utilization rate (%)	Facility utilization rate (Max.) = (Daily maximum water production) / (treatment capacity) × 100 Facility utilization rate (Ave.) = (Daily average water production) / (treatment capacity) × 100	0 0	83 70	103 90
Basic	Compliance rate of drinking standard for fluoride (%)	No. of samples with a fluoride concentration of below 0.6 mg/L / Total no. of samples *100	-	100	100
Basic	NRW ratio (%)	NRW ratio＝(NRW volume) / (water distribution) × 100	-	20%	20%
Wahalkada System					
Basic	Served population (persons)	Served population by pipe borne water supply = (No. of connections) × (Average per HU population) Served population by bowsers = (total population) Total served population = Served population + Served population by bowsers	26,900 0 26,900	64,100 24,600 88,700	74,700 25,700 100,400
Basic	Water distribution (m^3/day)	Daily maximum water distribution = (the biggest one in the daily water distribution records throughout a year) Daily average water distribution = (annual water distribution amount) / (annual days)	0 0	11,203 9,336	13,318 11,098
Basic	Facility utilization rate (%)	Facility utilization rate (Max.) = (Daily maximum water production) / (treatment capacity) × 100 Facility utilization rate (Ave.) = (Daily average water production) / (treatment capacity) × 100	0 0	78 65	93 77
Basic	Compliance rate of drinking standard for fluoride (%)	No. of samples with a fluoride concentration of below 0.6 mg/L / Total no. of samples *100	-	100	100
Basic	NRW ratio (%)	NRW ratio＝(NRW volume) / (water distribution) × 100	-	20%	20%

11.2 Effect Indicators

9.2 Effect Indicators

The effect indicators shows that the people's living will be comfortable and the risk reduction that may be suffered from skeletal and dental fluorosis as well as chronic kidney diseases.

In addition to usual effect indicators for water supply such as population coverage (%) and per capita daily consumption (Lpcd), the fluorosis risk avoidance rate (%) is proposed.

When the water source of existing CBO has a fluoride concentration above the Sri Lankan Drinking standard (0.6 mg/L), such served population is defined as the population with a risk for fluorosis. Assuming that the percentage of the population with a risk to the total population within the existing CBO service area is applicable to the entire study area, it can be reduced with the connection to a proposed integrated water supply system as shown in **Table 25**

Table 25 Fluorosis Risk Rate (Mahakanadarawa Service Area)

Population with a risk for fluorosis (2012)	16,930 persons	
Population with no risk for fluorosis (2012)	3,135 persons	
Percentage of population with a risk (2012)	16,930 / 20,065 × 100 = 84.4%	
Water supply mode in 2020	Total population	Served population
Pipe borne water supply	70,680 persons	40,749 persons (57.7%)
Bowser water supply	21,393 persons	21,393 persons (100%)
Total	92,073 persons	62,142 persons (67.5%)
Prevalence risk in 2020	(92,073 – 62,142) / 92,073 × 100 = 32.5%	

Table 26 Effect Indicators for Water supply

Cate-gorty	Indicators	Calculation Equation of Indicators	Target		
			Present	2020	2024
Mahakanadarawa System					
Basic	Population coverage by water supply	(Pipe borne water supply) Population coverage = (Served population) / (Administrative population) × 100	41%	58%	64%
		(Water delivery service by bowsers) Population coverage = (Served population) / (Administrative population) × 100	0 %	100%	100%
		(Population coverage for an access to safe water) Population coverage = (Served population) / (Administrative population) × 100	31%	68%	72%
Basic	Fluoride risk rate	(Fluoride risk rate) = 100 - (Population coverage for an access to safe water)	-	32%	28%
Assist	Per capita consumption	Per capita daily maximum consumption = (Daily maximum domestic consumption) / (Served population)	96 Lpcd	101 Lpcd	103 Lpcd
		Per capita daily average consumption = (Daily average domestic consumption) / (Served population)	80 Lpcd	84 Lpcd	86 Lpcd

		(Administrative population) × 100 (Water delivery service by bowsers) Population coverage = (Served population) / (Administrative population) × 100 (Population coverage for an access to safe water) Population coverage = (Served population) / (Administrative population) × 100	28% 0 % 23%	59% 100% 67%	65% 100% 72%
Basic	Fluoride risk rate	(Fluoride risk rate) = 100 - (Population coverage for an access to safe water)	-	33%	28%
Assist	Per capita consumption	Per capita daily maximum consumption = (Daily maximum domestic consumption) / (Served population) Per capita daily average consumption = (Daily average domestic consumption) / (Served population)	96 Lpcd 80 Lpcd	101 Lpcd 84 Lpcd	103 Lpcd 86 Lpcd

12 Project Risk

12.1 Project Risk

The proposed Project is constructed based on the important preconditions described below. If any of them will be lack, it may cause a serious problem in the management, operation and maintenance of proposed water supply systems.

(1) Water Availability

This project assures the sustainability of drinking water supply from Mahakanadarawa Wewa and Wahalkada Wewa as water sources under the assumption that the NCP Canal Project and Yan Oya Reservoir Project will be implemented. Therefore, the progress of the irrigation projects concerned should be carefully monitored and prompt action be taken to drive the project. as required.

(2) Water Quality of Proposed Water Sources

During the JICA study period covering from May to October 2012, in spite that the study area has experienced the severer drought than usual with no precipitation, the fluoride concentrations of both Mahakanadarawa Wewa and Wahalkada Wewa as the proposed water sources for drinking water supply were 0.52 mg/L and 0.38 mg/, respectively, at the maximum below the Sri Lankan Drinking Water Standard of 0.6 mg/L, although they have shown an increase of fluoride concentrations for April to July. For this reason, fluoride concentrations of both Mahakanadarawa Wewa and Wahalkada Wewa should be monitored subsequently thereafter.

In the North Central Province, water is used repeatedly for irrigation in the cascade irrigation system. Attention be paid for the use of agricultural chemicals in their basins and measures to ban their use should be taken to ensure the safety of water sources for drinking water, if required.

(3) Increase of Coverage and Water Demand in the Proposed Water Supply System

Due to the high level prevalence of dental fluorosis and chronic kidney diseases (CKDs) in the project area, the people have great expectations for the project to shift the water source from groundwater to surface water with a less fluoride concentration. However, as NWSDB has so far experienced the difficulty to increase the coverage by pipe borne water supply in the rural area, it is a risk to over-estimate such situations. It depends on an awareness campaign to what extent the number of connections can be increased. If actual water consumption will be less than the estimation, the income will be decreased resulting in a heavy financial burden on NWSDB.

12.2 Considerations in Planning

(1) Geological Survey Not Conducted for Some Facility Sites

The geological survey for some facility sites such as elevated tanks, intake works, etc. couldn't be conducted and the preliminary design of such facilities was done based on the general geological characteristics obtained from other sites surveyed in the project area.

(2) Quantity Survey for Distribution Systems

The size and length of water distribution pipes given in this report are estimated by selecting the model area in the project are, conducting a distribution network analysis, checking the pipe length by size, and applying the per connection pipe length by size to the entire project area, and will not correspond to the actual requirement.

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1.2 Sri Lanka Drinking Water Standards
1.3 The Hydrogeochemical Atlas of Sri Lanka, C.B. DISSANAYAKE & S.V.R. WEERASOORIYA,

Reference 2 Longitudinal Section of Transmission Pipelines Drawings

Reference 3 Laws and Regulations about Social and Environmental Consideration

3.1(a) National Environmental Act 1980
3.1(b) National Environmental Act amendment 2000
3.2 Land Acquisition Act
3.3 Fauna Flora Protection Act 22(2009)
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3.7 National Involuntary Resettlement Policy (NIRP) 2001
3.8 Protection & Quality Reg. 1534-18_2008 (EPL)
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3.12 EIA amendment (Prescribed activities) 1104.22_1999
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3.18 Reg. 1295-11_2003, Gas emission
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3.22 Reg. 1159-22_2000, Prescribed project EPL
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3.28 Mahaweli irrigation forest act
3.29 Basic Information Questionnaire, Water board to CEA

ABBREVIATIONS

AC pipe	Asbestos Cement Pipe
ADB	Asian Development Bank
AIA	Archaeological Impact Assessment
ANIWSP	Anuradhapura North Integrated Water Supply Project
BIQ	Basic Information Questionnaire
CBO	Community-Based Organization
CEA	Central Environmental Authority, the Ministry of Environment and Natural Resources (ME&NR)
CEB	Ceylon Electric Board
CFI	Community Fluorosis Index
CKD	Chronic Kidney Diseases
CMC	Colombo Municipal Council
CRM	Certified Reference Material
CWSSP	Community Water Supply and Sanitation Program
DI pipe	Ductile Iron Pipe
DSD	Divisional Secretary Division
EA	Engineering Assistant
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EOI	Expression of Interest
ET	Elevated Tank
FB	Freeboard
FC	Foreign Currency
FIRR	Financial Internal Rate of Return
FR	Forest Reserve
FSD	Full Supply Depth
FSL	Full Storage Level
GND	Grama Niladhari Division
GOJ	Government of Japan
GOSL	Government of Sri Lanka
GPRS	General Packed Radio Service
HH	Household
HWL	High Water Level
ID	Irrigation Department
IDP	Internally Displaced Persons
IEE	Initial Environmental Examination
IFRC	International Federation of Red Cross and Red Crescent Societies
JICA	Japan International Cooperation Agency
KfW	German Government-owned Development Bank, (Kreditanstalt für Wiederaufbau)
NC	North Central
LA	Local Authority
LAA	Land Acquisition Act
LB	Left Bank
LC	Local Currency
LCD	Liquid Crystal Display
Lpcd	Litre per capita per day
LWL	Low Water Level
MCB	Miniature Circuit Breaker

MCC	Motor Control Centre
MCCB	Molded Case Circuit Breaker
MCGs	Mahinda Chintana Goals
MCM	Million Cubic Meter (1,000,000 m^3)
MDGs	Millennium Development Goals
MWSD	Ministry of Water Supply and Drainage
NABL	National Accreditation Board for Testing and Calibration Laboratories
N/C	North Central
NCP	North Central Province
ND	Nominal Diameter
NEA	National Environmental Act
NEP	National Environmental Policy
NHWA	National Heritage Wilderness Area
NIRP	National Involuntary Resettlement Policy
NRW	Non Revenue Water
NWSDB	National Water Supply and Drainage Board
OIC	Officer-in-Charge
PAA	Project Approving Agency
PCC	Project Coordination Committee
PCV pipe	Un-plasticized Polyvinyl Chloride Pipe
PD	Project Director
PEA	Project Executing Agency
PE pipe	Polyethylene Pipe
PLC	Programmable Logic Controler
PMU	Project Management Unit
PR	Proposed Reserve
PS	Pump Station
RAP	Resettlement Action Plan
RSC(N/C)	Regional Support Centre (North Central)
RSF	Rapid Sand Filter
RWS	Rural Water Supply
SCADA	Supervisory Control and Data Acquisition
SIDA	Swedish International Development Agency
SLAB	Sri Lanka Accreditation Board
SP	Steel Pipe
SSF	Slow Sand Filter
TEC	Technical Evaluation Committee
UDA	Urban Development Authority
UNICEF	United Nations International Children's Emergency Fund
UPS	Uninterruptible Power Systems
VPN	Virtual Private Network
VSD	Variable Speed Driver
WB	World Bank
WFP	Work and Financial Plan
WHO	World Health Organization
WLPSA	Wildlife Protected Area
WSP	Water Supply Project
WSS	Water Supply Scheme
WTP	Water Treatment Plant

Ac	= 4,047 m^2
Acft	= 1,234 m^3

CHAPTER 1

WATER SUPPLY SECTOR IN SRI LANKA

CHAPTER 1 WATER SUPPLY SECTOR IN SRI LANKA

1.1 Country Background

(1) Domestic Affairs

Sri Lanka is a democratic country, which adopts the presidential system. Since independence in 1948, the political power has generally alternated between the two main political parties, namely SLFP (Sri Lanka Freedom Party) and UNP (United National Party) through elections. At present, the UPFA (United People's Freedom Alliance) with a core of SLFP has taken over the reins of government under the President Mahinda Rajapaksa, who was elected in November 2005.

In May 2009, President Mahinda Rajapaksa terminated the conflict in the country. Due to his popularity nationally, he was reelected in the presidential election, which was conducted in January 2010. The governing party, UPFA had a majority of 144 seats out of the 255 members in the parliament in the general election, which was conducted in April 2010, as well as more than seventy percent of the majorities in the local government election in 2011.

(2) Economic conditions

Sri Lanka's economy historically depended on traditional plantation crops such as tea, rubber and coconut, but the manufacturing industry, as well as wholesale and retail commerce, etc. have developed and recently garment products became the biggest export item.

The real GDP growth rate was 8.0% in 2010 with a per capita GDP of US$2,400 (Rs.271,346) [1], the highest in the past 30 years. The contribution of the service industry to the GDP in 2010 was very high, as internal demand was stimulated by termination of the conflict. Wholesale and retail commerce also had a strong showing and in addition, hotel and restaurant businesses showed significant growth due to an increase in the number of tourists. The demand for restoration of the northern and eastern areas of the country and construction materials for various infrastructure projects has also increased.

1.2 Present Situation and Issues in the Sector

1.2.1 National Development Plan and Sector Development Plan

(1) National Development Plan (Mahinda Chintana - Vision for the Future)

"Mahinda Chintana - Vision for the Future", or the Five-year Plan of Sri Lanka, which was declared in August 2010, covering a period of 2011 to 2016 is articulated identifying specific

[1] *Source: "Economic and Social Statistics of Sri Lanka 2012", Central Bank of Sri Lanka*

targets aiming at achieving the Millennium Development Goals (MDGs) ahead of time. Among Mahinda Chintana Goals (MCGs) for 2016 include the following with other targets as shown in **Table 1.1**, toward ***"Increasing access to clean water in urban areas from 65 to 90 percent"***.

Table 1.1 Safe Water and Sewerage Coverage

Year	2005	2009	2015	2020*
Safe water coverage (%)	80	85	94	100
Pipe borne water availability (%)	29	37	44	60
Water connections ('000) (NWSDB schemes)	907	1,267	1,600	3,000
Pipe borne sewerage coverage (%)	2.0	2.5	3.0	7.0

Source: "Mahinda Chintana – Vision for the Future", Department of National Planning, Ministry of Financing and Planning, 2010

Mahinda Chintana also gives a strategic approach to "City Water Supply 2020" as shown in **Table 1.2**.

For the emerging metro centres and large townships as shown in **Table 1.3**, water supply and sewerage related infrastructure assets will be created to cater for the long-term and growing demands:

Table 1.2 City Water Supply 2020

Affordability	
Per capita consumption	
Average tariff	
Production cost	
Quality	
Quality compliance	
Treatment facilities	
Breakdown frequency	
Reliability	
Hours of supply	24 hrs
City coverage	100%
Efficiency	
Non revenue water	20%
Staff per 1,000 connections	5
Customer complaints	No
Response to requests	100%

Source: "Mahinda Chintana – Vision for The Future", Department of National Planning, Ministry of Financing and Planning, 2010

Table 1.3 Strategic Approach

Emerging metro centres	Kandy, Hambantota, Trincomalee, Dambulla, Jaffna, Galle, Gampaha, Kurunegala, Nuwara Eliya
Large Township	Vanuviya, Badulla, Matara, Anuradhapura, Ratnapura

Source: "Mahinda Chintana – Vision for The Future", Department of National Planning, Ministry of Financing and Planning, 2010

(2) National Policy on Drinking Water (Updated on June 2009)

In the National Policy on Drinking Water, "**1.5 Principles of the Policy**" includes the following nine principles.

i) Access to safe drinking water is a basic human right with commensurate responsibilities on the recipients.
ii) Planning and development will be people centered, participatory and demand responsive.
iii) The government acts as the custodian for the protection and proper management of drinking water resources.
iv) Abstraction of water and the protection of the resource shall be carried out in recognition of downstream impacts.
v) Where issues arise relating to competing demands, drinking water needs will have priority over the others, with reasonable consideration for other important needs.
vi) Development of drinking water supplies and distribution of water to people shall be done efficiently and equitably.
vii) Piped water supplies will be provided to populations/communities where other supply arrangements are inadequate.
viii) The operational activities will be decentralized to the lowest appropriate level, giving due consideration to the capacity and efficiency.
ix) Water safety will be practiced at all levels and ensured by all parties.

Among others, v) is most important as it gives the first priority to drinking water over others.

The following ideas in "**5.0 Cost Recovery**" attract attention:

- The following cost components of processing and delivery will be recovered through a service charge.
  - capital cost and interest incurred
  - operation and maintenance cost
  - replacement and rehabilitation cost
- In consideration of the lifeline requirement a subsidy shall be provided to the poor and marginalized communities.
- The cost recovery system shall be applicable and be implemented uniformly within respective administrative boundaries.

The above suggests full cost recovery, consideration for the poor and allowance for different water tariffs compared to the current situation where there is a uniform tariff throughout the whole of the country.

(3) NWSDB Corporate Plan 2012-2016 (Draft)

In response to "Mahinda Chintana", NWSDB has prepared a draft "Corporate Plan 2012 – 2016" to clarify their principles and values, functions, goals and objectives and strategies.

NWSDB is not covering the whole of the drinking water sector in the country and part of this provision will be done by some Local Authorities and other organizations as described in "**1.2.4 Sector Organization**". As shown in **Table 1.4**, NWSDB plans to supply about 40% of the population in 2016 with a pipe borne water supply, compared to about 52% of the total population served. However the above figures are not consistent with the pipe borne water availability of 44% in 2015 in "Mahinda Chintana"

Table 1.4 Planned Water Supply & Sewerage Coverage 2012 - 2016

Year	2011	2012	2013	2014	2015	2016
Population	20,861,045	21,0 69,655	21,280,352	21,493,156	21,708,087	21,925,168
Pipe borne water supply coverage	9,074,555	9,523,484	10,001,765	10,488,660	10,984,292	11,488,788
NWSDB pipe borne water supply connected coverage (%)	33.00%	34.50%	36.00%	37.40%	38.90%	40.40%
Overall pipe borne water supply connected coverage (%)	43.50%	45.20%	47.00%	48.80%	50.60%	52.40%
Pipe borne sewerage coverage**	479,804	505,672	532,009	558,822	586,118	613,905
Pipe borne sewerage coverage (%)	2.30%	2.40%	2.50%	2.60%	2.70%	2.80%

Source: NWSDB, "Corporate Plan 2012 – 2016 (Draft)"

1.2.2 Water Supply Undertakings (Service Ratios and Level)

The present situation of water supply service under NWSDB is summarised as shown in **Table 1.5** and **Table 1.6**, respectively.

Findings are as follows:

- The population coverage under NWSDB control was 36.9% as of December 2009.
- The total number of connections was 1,353,573, out of which 349,372 (25.8%) were in the

Central area, 164,259 (12.1%) in the Western-central area, 163,335 (12.1%) in the Western-south area and 141,601 (10.5%) in the Western-north area. Colombo and Kandy, as well as the areas surrounding both cities account for 60.5% of the total number of connections.

- The NRW ratio ranged from 13.8% in the North-eastern area to 37.8% in Sabaragamuwa, whereas in the Colombo Municipal Council (CMC) area it was 53.05%, which is significantly higher than the national average of 32.1%.
- The number of staff per 1,000 connections was lowest in the Western-central area (Colombo) at 2 followed by 4.2 in the Western-south area (Kalutara), 5 in the Western-north area (Gampaha) and 6 in the Central (Kandy, Matale and Nuwala Eliya) and North-central (Anuradhapura and Polonnaruwa) area. Uva has the highest number of staff per 1,000 connections at 27.4. As shown in **Table 1.6**, for the whole of NWSDB, the number of staff per 1,000 connections decreased steadily from 8.2 in 2007 to 7.5 in 2008 and 7.2 in 2009.
- Water availability or the time of water supply is worst at 3.7 hours per day in the Northern area followed by 9.6 hours in Uva, 10.9 hours in the Eastern area, 12.0 hours in the Western-south area and 12.9 hours in the North-western area. In the case of the Northern area, the damage caused by the conflict, which ended in 2009 is significant.
- The average tariff exceeds the production cost in only three out of 11 regions. The average tariff of the Western-central area (Colombo) is 2.56 times the production cost followed by 1.26 times in the Western-south area (Kalutara and 1.15 times in the Central area (Kandy, Matale and Nuwala Eliya). On the contrary, in the Northern and North-western areas the average tariff is 0.45 times and 0.48 times the production cost, respectively.
- As shown in **Table 1.6**, the percentage of the number of estimated bills to total bills decreased from 12% in 2007 to 7% in both 2008 and 2009, but this figure is still high.
- Per capita consumption ranges from 94.0 Lpcd in Uva to 138.5 Lpcd in Sabaragamuwa.
- The collection period of accounts receivables has improved from 60 days for domestic and commercial institutions and 65 days for government institutions in 2008 to 55 days and 44 days, respectively, in 2009, with the improvement for government institutions being significant (refer to **Table 1.6**).

Table 1.5 NWSDB Key Facts and Figures

Service Indicators	Regional Support Centre (Regional Average)										
	Western - North	Western - Central	Western - South	Central	North - Western	North - Central	Sabaraga-muwa	Southern	Uva	Northern	Eastern
	2008	2008	2008	2009	2008	2008	2008	2008	2008	2008	2008
Number of Connections (As of December 2010)	141,401	164,259	163,335	349,372	40,947	62,579	69,264	203,820	56,771	6,456	95,169
1 Service Standard Indicators											
Water Coverage (%) Pipe System maintained by NWSDB	25.1%	33.5%	48.4%	29.4%	5.9%	16.9%	9.3%	35.1%	16.2%	3.8%	23.9%
Per Capita Consumption (l/c/d)	117.1	125.7	122.3	101.3	99.7	103.2	138.5	103.6	94	116.7	79.7
Water Availability (hours)	21.4	23.2	12	22	12.9	24	18.6	22.4	9.6	3.7	10.9
Water Quality - Bacteriological Quality Compliance	94.7%	n/a	95.1%	97.7%	97.7%	99.7%	92.8%	96.5%	94.1%	96.2%	96.2%
Water Quality - Bacteriological Testing Compliance	100.0%	n/a	100.0%	83.3%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Water Quality - All Samples Compliance	95.8%	n/a	99.5%	95.7%	40.9%	94.4%	98.3%	84.8%	71.2%	96.3%	88.8%
Sewerage Coverage (%)	2.5%	0.0%	2.3%	0.1%	-	-	-	0.3%	-	-	-
2 Operational Indicators											
Non-Revenue Water (%)	24.1%	33.5%	33.0%	32.5%	13.8%	19.8%	37.8%	30.5%	30.0%	16.4%	32.9%
Non-Revenue Water - m3/conn/day	0.23	0.49	0.32	0.20	0.10	0.16	0.28	0.27	0.23	0.12	0.27
Defective Meters per '000 connections	51	15	23	16	8	48	44.9	17.3	124.6	22	29
Total Staff/ 1000 connection	5	2	4.2	6	9	6	7.4	6.5	27.4	20	11
Operational Staff/ 1000 connection	3	2	4.1	5	8	6	6	3.5	25.4	15	10
Estimated Bills/ 1000 connections	126	53	80	33	18	112	18.9	44.9	186.4	168	89
3 Performance in Customer Service											
Response to requests for new service connections (%)	95.8%	94.8%	90.0%	100.0%	100.0%	100.0%	94.6%	90.2%	90.8%	76.9%	62.2%
Customer Complaints Volume (Complaints/ 1000 connection)	109.1	13.5	219.3	135	56.6	11.1	34.9	127.7	230	17.7	7.1
Customer Complaints Resolution	86.2%	91.6%	33.0%	94.5%	86.9%	91.1%	94.3%	86.3%	67.5%	83.3%	81.4%
4 Key Performance Indicators (KPIs)											
Collection Ratio (%)	102.0%	98.7%	99.0%	110.0%	99.1%	102.9%	99.7%	99.3%	97.4%	78.4%	97.1%
Accounts Receivable Period (months)	4.2	2.6	4.8	1.4	1.6	3.1	3.8	3.0	3.3	7.2	4.2
Collectable Accounts Receivable Period (months)	1.4	1.7	1.5	0.4	0.1	1.8	1.7	1.2	1.3	2.9	2.6
Operating Ratio	1.01	0.54	1.02	1.00	1.69	0.98	1.42	1.26	1.34	1.98	1.57
Production Cost (LKR/ m3 Produced)	17.08	11.42	15.36	19.60	31.70	25.71	24.60	21.52	24.42	56.46	25.35
Average Tariff (LKR/ m3 Sold)	16.68	29.25	19.30	22.50	15.31	21.20	20.71	16.32	18.68	25.64	15.59
Stock Efficiency (LKR/ connection)	2,189	1,323	1,790	2,602	2,672	3,754	1,888	2,227	n/a	n/a	2,528

Source: NWSDB Website

Table 1.6 NWSDB Progress Towards Stated Goals

Goal	Key Objective:	Target end 2007	Achievement end 2007	Target end 2008	Achievement end 2008	Target end 2009	Achievement end 2009
1. Increase WS and sanitation coverage	1.1 Pipe-borne water supply coverage	32.0%	32.0%	33.9%	34.0%	37.5%	36.9%
	1.2 Piped sewerage coverage	2.50%	2.40%	2.60%	2.40%	2.70%	2.50%
	1.3 Access to safe drinking water supply coverage	76.4%	77.0%*	77.6%	78.0%*	79.5%	80.0%*
	1.4 Total sanitation covei		83.2%*		85.7%*		85.7%*
2. Improve operational efficiency	2.1 NRW (island-wide)	33.0%	33.1%	33.0%	32.1%	32.0%	31.1%
	2.2 Total staff for 1,000 connections	8.3	8.2	7.8	7.6	7.5	7.2
	2.3 Expenditure on power to total recurrent cost	23.0%	22.7%	23.0%	24.3%	23.0%	22.6%
	2.4 Maintenance exp enses to total recurrent cost	7.5%	5.1%	7.5%	4.1%	7.0%	4.7%
	2.5 Establishment expenses to total recurrent cost	10.5%	9.5%	10.5%	10.9%	10.0%	10.7%
3. Achieve customer satisfaction	3.1 Public awareness programmes to be carried out (schools/other)	20 Nos.	12 Nos.	30 Nos.	32 Nos.	30 Nos.	37 Nos.
	3.2 Complaints unresolved to total received	10.0%	7.3%	9.0%	7.3%		
4. Increase commercial viability	4.1 % of estimated bills to total number of bills	10%	12%	10%	7%	8%	7%
	4.2 Collection efficiency lOO%	100%	100%	100%	99%	100%	94%
	4.3 Accounts receivable from -						
	(a) Domestic and commercial institutions	60 days	60 days	60 days	60 days	60 days	55 days
	(b) Government institutions	65 days	65 days	60 days	65 days	60 days	44 days
5. Ensure greater accountability	Initiatives were taken to develop a whole range of management and business tools on human resource development, management information system and business plan.#						
	* Delegation of financial authority						
	* Training on budgetary control & financial regulations						
	* Audits on commercial operations						
	* Audits on stores and supplies						
	* Audits on cash/ cheque payments						
	* Audits on construction contracts						
	* Valuation of assets						
	* Improved management information and coordination						
6. Promote Institutional Development	6.1 In-house training programmes	150	113	150	105	160	110
	6.2 In-country external training (no. of persons)	240	258	240	272	250	170
	6.3 Overseas training (no. of persons)	75	68	75	129	80	115
7. Provide facilities and service supp ort to rural and marginalis ed communities	7.1 Rural water supply by the NWSDB (managed by CBOs)	4.5%	4.5%	4.5%	4.0%	5.0%	4.5%

* Estimated as 83.1% for water supply and 96.7% for sanitation from a sample survey carried out during 2006-2007 by the Department of Census and Statistics excluding Jaffna, Kilinochchi, Mullaitivu, Mannar and Vavuniya districts.

The Merchant Bank of Sri Lanka has been selected to prepare the Business Plan; The draft plan prepared was presented to the senior M anagement of NWSDB for comments. Under ADB Technical Assistance 7078, separate business plan are being prepared for RSCs for decentralized service delivery in the water sector.

Source: NWSDB, "Annual Reports 2007-2009"

1.2.3 Water Resource and Management

The water resources in Sri Lanka have been facing the following problems since 1990's.

- Water scarcity due to spatial and seasonal variations especially in the dry zone
- Water demand increase caused by rapid industrial growth, urbanization and irrigational water requirement in the agricultural sector
- Water pollution because of haphazard disposal of industrial and domestic waste
- Soil erosion and salinity intrusion attributed to indiscriminate sand mining in the river courses

Problems such as depletion and deterioration of water resources, competition over water within and among sectors and associated conflict over allocation of water have emerged making it very difficult to manage water resources within the existing institutional and legal framework

These problems demand the integrated management of water resources. Asian Development Bank (ADB) funded Water Resources Management Project aiming at establishing institutions for integrated water resources management (IWRM) and adopting strategic planning and management approach for the management of river basins (Water Resources Policy, 2000). The existing water resources management institutions lacks arrangements for all the stakeholders to participate in decision making for managing water resources in a river basin context.

There are 20 principle agencies set up by the Government of Sri Lanka to plan and implement different activities related to management of water resources including the Irrigation Department (ID), the National Water Supply and Drainage Board (NWSDB), the Ceylon Electricity Board (CEB), the Mahaweli Authority of Sri Lanka, etc. and 10 main enactments providing legal authority and power to the water sector agencies for managing water resources.

The new policy to set up a legal and institutional framework for establishing integrated water resource management (IWRM) proposed the establishment of new institutions specifically the National Water Resources Authority (NWRA), the Water Resources Council (WRC) and the Water Resources Tribunal (WRT) to deal with changes required for sustainable water resources management as shown in **Table 1.7** and **Figure 1.1**.

Table 1.7 Proposed Organization for National Water Resources Management

Organisation	Function
National Water Resources Authority (NWRA)	The apex body in the water sector, responsible for coordination, planning, regulation, and monitoring of water resources in the country.- formulation of policy proposals; - river basin planning and catchment management; - issuing of bulk water entitlements; and - monitoring and enforcement.
Water Resources Council (WRC)	A permanent high level coordinating and advisory body
Water Resources Tribunal (WRT)	An independent appeal tribunal for parties affected by water entitlements administered by the NWRA
River Basin Committees	To be created by NWRA in selected river basins for the allocation of entitlements.

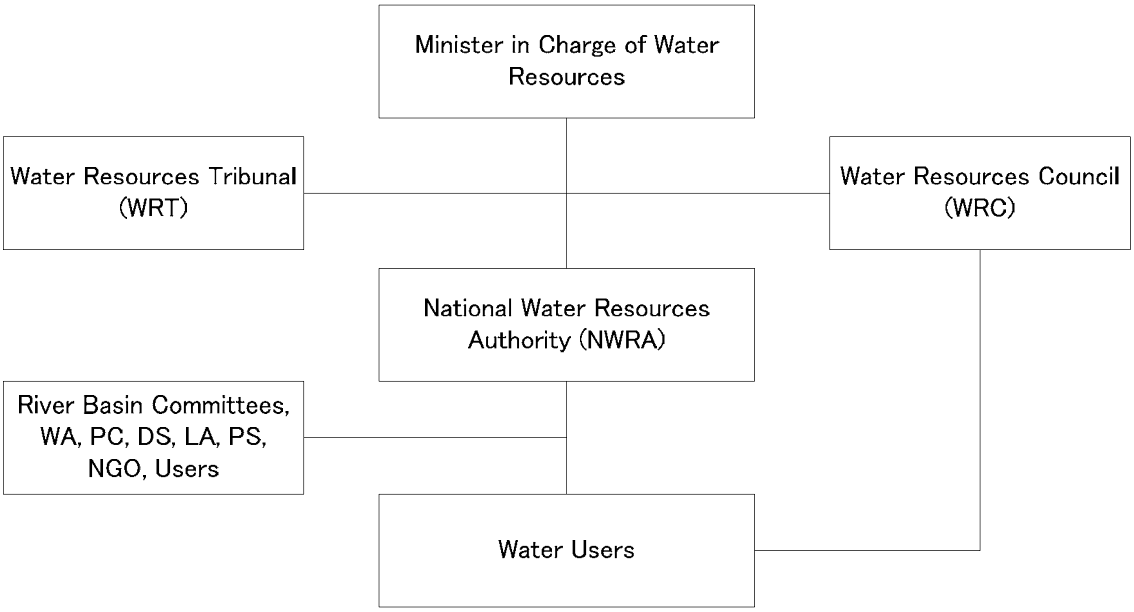


Figure 1.1 Proposed Framework of National Water Resource Management

The Government successfully established a national water sector apex body since 1996 in the form of the national Water Resources Council (WRC), supported by a full-time Water Resources Secretariat (WRS). This was an interim arrangement, pending the establishment of the National Water Resources Authority. The new “National Water Resources Policy and Institutional Arrangements” was passed by the Cabinet of Ministers in 2000. A National Water Resources Act was drafted which would establish the NWRA and set up formalised River Basin Committees for the allocation of water rights, among other functions. To date this has not been passed into law.

Later the WRS has changed its role and been termed by some the Interim National Water Resources Authority for a while, but the WRC and WRS were brought under the purview of the Ministry of Irrigation and Water Resources Management in 2001 and then were moved to the new Ministry of Mahaweli and River Basin Development by Presidential Decree in April 2004.

At present, the Irrigation Department under the Ministry of Irrigation and Water Resources Management is responsible for preparation of master plan for development of the different river basins for the optimum utilization of land and water resources under the objective for development of land and water resources for irrigated agriculture, hydropower, flood control, domestic usage, industrial usage and aquaculture development.

1.2.4 Sector Organizations

The water supply sector is divided into two sub sectors as shown in **Table 1.8**.

Table 1.8 Water Supply Sub Sector

	Urban water supply sub sector	Rural water supply sub sector
Object area	Towns, cities, urban centres, industries and suburban areas	Rural areas
Key Actors	Ministry of Water Supply and Drainage NWSDB Provincial Councils Municipal Councils Urban Councils Pradeshiya Sabhas	Provincial Councils Local Authorities Community Based Organizations (CBOs) Non-Government Organizations (NGOs)
Water service mode	Pipe borne water supply	Dug wells Tube wells Rain water harvesting Small-scale pipe water supply

Source: "National Policy on Drinking Water", June 2009
Note: From Wikipedia

For the urban area, NWSDB is responsible for the provision of water supply through the implementation of large scale water supply, in consultation with relevant local authorities under the superintendence and direction of the Ministry of Water Supply and Drainage. In principle, NWSDB directly manages and operates the water supply facilities implemented by itself from operation and maintenance to billing and collection. For this purpose, the country is divided into five regions (Western, Central, Eastern, Northern and Southern) and eleven areas to which Additional General Managers and Deputy General Manages are deployed for management.

A rural area for this purpose is defined as any Grama Niladaree (GN) Division within a Pradeshiya Sabha (PS) area. The Provincial Councils are responsible for the implementation of small-scale rural water supply through local authorities (municipal councils、urban councils, pradeshiya sabhas). The roles of the Government, Provincial Council and the Local Government Authorities should be to regulate and facilitate in the implementation of the sector activities while the Community Based Organization (CBOs), Private Sector and NGOs should be the providers of services. Local Authorities also may provide services when required. In the National Policy for Rural Water Supply and Sanitation Sector (July 2001) says that users should (1) be encouraged to own and manage the facilities and assets, (2) be encouraged to share the capital investment incurred in creating the facilities, and (3) bear the full responsibility of sustainable operation and maintenance of the facilities.

As shown in **Table 1.4**, the target of population coverage by pipe borne water supply is 52.4% as a whole out of which 40.4% is undertaken by NWSDB for attainment and the remaining 12.0% is the target for rural water supply.

Local government is the third and lowest level of government in Sri Lanka - after the central government and provincial councils. The local government bodies are collectively known as local authorities. They are responsible for providing a variety of local public services including roads, sanitation, drains, housing, libraries, public parks and recreational facilities. Local authorities are divided into three different groups: municipal councils, urban councils and rural councils (pradeshiya sabha). As of January 2011 there were 335 local authorities (18 municipal councils, 42 urban councils and 270 rural councils). All local authorities are elected using the open list proportional representation system.

The role of agencies, which are involved in the water supply sector is shown in **Table 1.9**.

Table 1.9 Role of Agencies Involved in Water Supply Sector

Functions	Ministry	NWSDB	Provincial Council	Local Authorities	Users (CBOs)
Formulate the national policy	×				
Facilitate with the Government to secure internal and external funding for sector development	×				
Monitor the sub-sector development activities	×				
Coordinate, monitor and promote sub-sector development activities	×				
Undertake design, construction and operation of pipe borne water supply schemes		×			
Provide technical assistance		×			
Transfer the O&M function of RWS schemes to LAs and CBOs		×			
Enact the RWS and sanitation policy			×		
Coordinate the planning and implementation of RWS schemes implemented and managed by LAs			×		
Monitor the RWS sub-sector development activities			×		
Make decisions on resource allocation among LAs			×		
Prepare policies, guidelines and strategies for all sector development activities			×		
Undertake planning, design and implementation of RWS schemes				×	
Undertake the O&M of water schemes				×	
Facilitate the CBOs in implementing and managing the water supply systems and provide the necessary technical assistance to CBOs				×	
Coordinate and participate with the service provider in sector development activities					×
Actively participate and contribute during the planning, design and construction stages of a project					×
Implement and manage community water supply schemes by forming CBOs					×

LAs: Local Authorities, CBOs: Community Based Organizations

RWS: Rural water supply

Source: Prepared by the Study Team based on "the National Policy of Drinking Water"

1.2.5 Financial Situations of the Sector

The financial aspects of the whole of NWSDB are reviewed.

According to the financial statements of NWSDB from 2003 to 2011, the profit/ loss table is shown in **Table 1.10**. The operating account balances show an operating profit in 2003, 2005, 2006, 2009 and 2011.

The tariff was increased in 2004 and in the following two years there was an operating profit mainly due to the increase in income from sales. However the tariff increase had a short term effect, because in the second year (2006) after the increase, profits decreased and after that there were operating losses in 2007 and 2008, with the loss in 2008 being much higher than the previous year. Therefore, the tariff was increased in 2008, which resulted in an operating profit in 2009, followed by a large operating loss in 2010.

In 2011, an operating profit was achieved and it is understood that NWSDB made efforts to cut costs. This year is unusual from the aspect of the current account balance, because non-operating account losses were much more than operating profits and so the current account balance which was negative from 2003 to 2010, became positive in 2011 for the first time during the past nine years.

However, it is not possible to comments on whether current account profits will continue in the future, as the tariff is controlled by the government at a low level and increases in the tariff are generally delayed and do not keep up with inflation. In addition, the finance cost in 2011 was less than in 2009 and 2010, by approximately 0.5 billion Rs in each year. If the finance cost in 2011 was at the level of the cost in 2009 or 2010, the non-operating loss would be 1.78 billion Rs., which is more than the operating profit (1.76 billion Rs.) and as such the current account balance would be negative (This is discussed again later in balance sheet analysis).

Among the direct operating costs (expenses), personnel costs are the biggest in most years, accounting for 44.8% in 2011. The second biggest operating cost in 2011 was administration overheads with a share of 32.8%. The above two costs account for more than 75% of direct operating costs. However, the average annual increase in repair and maintenance costs was higher than for all other direct operating costs (18.0%) from 2003 to 2011. The second highest was that of rents, rates, taxes, etc. (17.3%). Operating costs for pumping and depreciation showed lower average annual increase rates (9.1% and 9.2%, respectively), excluding that of other operating costs that fluctuate.

NWSDB’s balance sheet from 2003 to 2011 is shown in **Table 1.11**. The first table shows “assets.” The “capital work in progress” in the non-current assets is more than “property, plant & equipment” in every year and increases every year. This means that construction and rehabilitation work is always more than fixed assets.

The second table shows “equity and liabilities.” In “capital and reserves,” “government grant” and “capital grants” are very high in the past nine years accounting for 85% of “total equity and liabilities” in 2011. In addition, “capital grants” (mostly foreign grants) were less than the “government grant” from 2003 to 2005, but since then they have been more than the “government grant” in every year except for 2007. It is also noticeable that the “accumulated loss" increased each year and this is covered by grants and liabilities. It is strange that the "accumulated loss" increased in 2011 although the current account balance was positive in this year. However, it has been ascertained that the "accumulated loss" increased because of prior year adjustments, such as salary arrears and Ministry advance write-off. In the "non-current liabilities," the "loan payable" is less than grants, but it increased every year. Furthermore, the "loan interest payable" has been increasing in recent years, in particular from 2008. This corresponds to the discussion about the finance costs in the profit/ loss above. This means more loan interest payments were delayed recently and the current account balance seems red substantially in 2011.

Consequently, the financial situations of NWSDB do not seem sound. NWSDB has a lot of loans and so has to pay the loan interest and repay the loans. However, it can make neither operating profits nor current balance profits easily. In order to improve the situation, it is necessary to increase revenues and cut expenses. However, the income relates closely to the tariff which is controlled by the government, so it is not easy to increase revenues. It seems that if NWSDB lacks money, the government may give grants. Therefore, NWSDB cannot be considered a financially independent sustainable entity.

Table 1.10 Profit/ Loss of NWSDB

(Unit: Rs.)

Item Year	2003	2004	2005	2006	2007	2008	2009	2010	2011
Sales of water	4,135,900,339	4,263,830,351	5,446,263,579	5,869,448,092	6,481,915,574	6,743,217,327	9,669,975,867	10,744,059,534	11,616,045,254
Other operating income	727,867,450	645,046,477	814,457,513	1,074,822,450	1,129,364,580	1,391,118,020	1,397,317,115	1,566,297,797	2,081,716,017
Operating Income	4,863,767,789	4,908,876,828	6,260,721,092	6,944,270,542	7,611,280,154	8,134,335,347	11,067,292,982	12,310,357,331	13,697,761,271
Direct operating expenses	2,834,131,407	3,454,131,782	3,604,024,192	4,080,524,657	4,902,547,316	6,088,841,694	6,321,949,712	7,061,727,544	7,470,490,082
Personnel cost	1,068,274,105	1,408,733,213	1,599,810,859	1,829,346,805	2,335,091,573	2,633,355,899	2,830,486,142	3,346,857,362	3,345,000,435
Pumping cost	1,207,036,638	1,248,338,029	1,217,702,035	1,360,669,505	1,587,873,327	2,104,778,364	2,025,805,684	2,103,576,701	2,417,486,303
Chemical cost	193,376,960	286,914,658	301,387,232	319,570,787	349,492,607	436,027,228	421,702,108	412,935,647	426,959,662
Repairs & maintenance	155,126,555	238,273,589	221,268,901	256,858,175	287,034,821	454,778,478	485,572,435	560,276,883	581,807,386
Establishment expenses	91,162,859	106,428,937	122,737,408	137,637,825	152,013,097	213,069,370	229,811,749	248,970,965	272,493,532
Rent, rates, taxes, etc.	119,154,290	165,443,357	141,117,757	176,441,560	191,041,890	246,832,355	328,571,593	389,084,987	426,742,765
Administration overheads	784,536,152	962,238,646	999,273,784	1,348,603,525	1,762,775,528	1,895,309,365	2,062,268,144	2,564,857,342	2,447,412,103
Depreciation	966,206,589	752,748,842	1,043,413,735	1,100,006,942	1,381,373,713	1,397,510,699	1,409,852,073	3,258,762,679	1,769,054,208
Other operating expenses		123,242,899	177,410,662	159,864,181	139,810,303	468,138,615	1,089,308,312	3,953,088,317	249,979,834
Operating Expenditure	4,584,874,148	5,292,362,169	5,824,122,373	6,688,999,305	8,186,506,860	9,849,800,373	10,883,378,241	16,838,435,882	11,936,936,227
Operating Profit/ Loss	278,893,641	-383,485,341	436,598,719	255,271,237	-575,226,706	-1,715,465,026	183,914,741	-4,528,078,551	1,760,825,044
Non-operating income	136,474,325	96,556,001	32,633,847	114,477,942	203,386,141	59,918,167	48,782,302	97,644,018	131,257,102
Finance cost	613,048,615	647,054,533	663,370,716	511,983,308	851,942,058	1,192,769,345	1,568,941,934	1,419,459,214	943,355,146
Tsunami cost/Revaluation deficit	0	0	0	7,981,932	0	0	0	0	474,261,491
Non-operating Profit/ Loss	-476,574,290	-550,498,532	-630,736,869	-405,487,298	-648,555,917	-1,132,851,178	-1,520,159,632	-1,321,815,196	-1,286,359,535
Current-account payment balance	-197,680,649	-933,983,873	-194,138,150	-150,216,061	-1,223,782,623	-2,848,316,204	-1,336,244,891	-5,849,893,747	474,465,509

Source: NWSDB

Table 1.11(1) Assets in Balance Sheet of NWSDB

(Unit: Million Rs.)

Item Year	2003	2004	2005	2006	2007	2008	2009	2010	2011
Non-current Assets	54,864	66,462	77,358	89,991	100,813	115,632	135,978	149,210	178,292
Property, Plant & Equipment	24,649	25,419	36,767	42,182	52,406	55,197	63,086	73,666	84,271
Capital Work in Progress	29,460	40,402	40,448	47,681	48,291	60,344	72,815	75,479	93,974
Intangible Assets	96	96	0	0	0	0	0	0	0
Investments	660	545	144	129	115	91	77	65	47
Current Assets	9,503	9,533	11,852	13,620	13,094	15,190	13,460	14,984	14,479
Non-operating Assets	0	0	192	191	191	191	159	187	130
Inventories	2,113	1,891	2,151	2,283	2,602	3,081	3,306	3,283	3,553
Trade & Other Receivables	3,209	3,872	4,994	5,079	6,021	5,250	4,301	4,164	4,631
Deposits & Advances	3,104	2,771	3,171	4,209	2,945	5,422	4,766	5,578	4,463
Investments	762	969	673	1,650	850	423	304	612	987
Cash & Cash Equivalents	315	29	672	207	484	823	625	1,161	715
Total Assets	64,368	75,995	89,210	103,611	113,907	130,822	149,438	164,194	192,772

Source: NWSDB

Table 1.11(2) Equity and Liabilities in Balance Sheet of NWSDB

(Unit: Million Rs.)

Item Year	2003	2004	2005	2006	2007	2008	2009	2010	2011
Capital and Reserves	50,469	60,544	71,964	84,174	92,797	105,226	118,734	128,381	150,712
Assets taken over from Government	185	185	185	185	185	185	185	185	185
Equity Capital/ Government Grant	27,730	31,545	36,693	42,361	48,851	54,560	58,446	62,618	69,440
Capital Grants	22,878	29,976	36,339	43,096	46,507	56,142	67,190	78,620	94,203
Capital Recovery Fund	742	881	1,060	1,261	1,487	1,819	2,151	2,532	3,041
Staff Welfare Fund	10	10	12	12	12	15	13	13	14
Revaluation Reserve	310	310	310	310	310	310	310	0	0
Accumulated Profit/ Loss	-1,388	-2,363	-2,635	-3,051	-4,555	-7,804	-9,560	-15,588	-16,172
Non-current Liabilities	12,113	13,310	14,948	17,301	18,257	20,281	23,324	26,475	31,474
Loan Payable	10,816	11,913	13,466	15,697	16,526	18,113	20,137	23,071	27,839
Other Deferred Liabilities	1,297	1,397	1,482	1,604	1,731	2,167	3,188	3,405	3,635
Current Liabilities	1,787	2,141	2,298	2,136	2,852	5,315	7,379	9,338	10,586
Creditors	1,147	1,170	1,203	1,081	1,210	1,347	2,173	2,345	3,489
Loan Capital Payable	0	0	573	295	699	1,411	2,256	2,362	2,688
Loan Interest Payable	289	230	91	142	284	1,457	1,896	3,157	2,465
Non-operating Liabilities	0	0	115	115	115	115	115	161	133
Other Payables	351	740	317	502	544	985	939	1,312	1,811
Total Equity and Liabilities	64,368	75,995	89,210	103,611	113,907	130,822	149,438	164,194	192,772

Source: NWSDB

1.2.6 Activities and Policies of International Donors and National Agencies of the Sector

After the conflict termination in April 2009, a variety of countries offer a helping hand to the assistance for Sri Lanka. According to “Performance Report 2011” published by the Ministry of Water Supply and Drainage, there are thirty foreign-funded projects in which twelve countries and four international agencies are involved in the water supply and sewerage sectors (refer to **Appendix 1.2** for details). They are categorized on the sector basis as shown in **Table 1.12**.

Table 1.12 Bi- and Multi-lateral Assistance to Sectors in Sri Lanka

	Water Supply			Sewerage
	Urban	Rural	Others	
Bilateral and Multi-lateral Assistance	Japan (JICA) Denmark (DANIDA) Hungary Spain Netherland Germany (KfW) Korea Austria Australia France Belgium	ADB	ADB UNICEF WB IFRC (Red Cross)	Japan Australia Sweden (SIDA)
	11 countries	1 agency	4 agencies	3 countries

Major donors during the year 2011 are ADB, JICA (Japan), KfW (Germany), SIDA (Sweden) , UNICEF, IFRC (International Federation of Red Cross and Red Crescent Societies), Austria, France, Spain, Hungary, Korea and Netherland. As shown in **Table 1.10**, JICA provides assistance to both water supply and sewerage sectors, although focusing on urban water supply. On the contrary, ADB has concentrated into rural water supply and provided 6^{th} assistance following 3^{rd} and 4^{th} assistance. JICA assistance includes not only the hard components represented by the construction of facilities but also the soft components like capacity building. KfW supports the energy saving project at Ambatale

ADB and IFRC were concerned with Tsunami-related assistance, while UNICEF is addressing to water, sanitation and hygiene programme and WB to the increase of number of sewerage connections and access to safe sanitation focusing on the poor.

CHAPTER 2

NATURAL AND SOCIAL CONDITIONS

CHAPTER 2 NATURAL AND SOCIAL CONDITION

2.1 General

Anuradhapura is located about 280 km north-northeast of Colombo, and about 140 km north-northwest of Kandy and is an inland district in the North Central Province. The district is classified as a dry zone climatologically with less rainfall and has about 2,500 small tanks for irrigational use. The district capital of Anuradhapura and its surrounding area was the first capital of the Ancient Sunghalese Dynasty that flourished from the 3rd century BC to the 9th century AD and is registered as the world's cultural heritage.

The study area consisting of six Divisional Secretariat Divisions (DSDs), namely Padaviya, Kebithigollewa, Horowpothana, Kahatagasdigilia, Medawachchiya and Rambewa is located in the northeast part of Anuradhapura District as shown in **Figure 2.1** and is bounded by Trincomalee District to the east and by Vavuniya District to the north. It has a total area of 286,268 ha, a total population of 175,890 persons (2001 Census) and is a typical rural area.

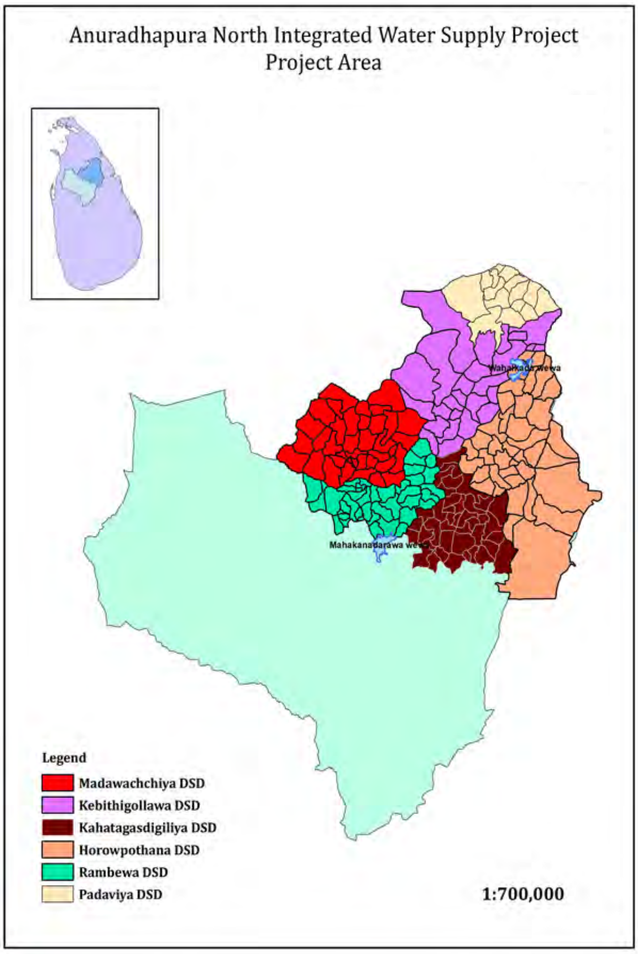


Figure 2.1
Location of Study Area

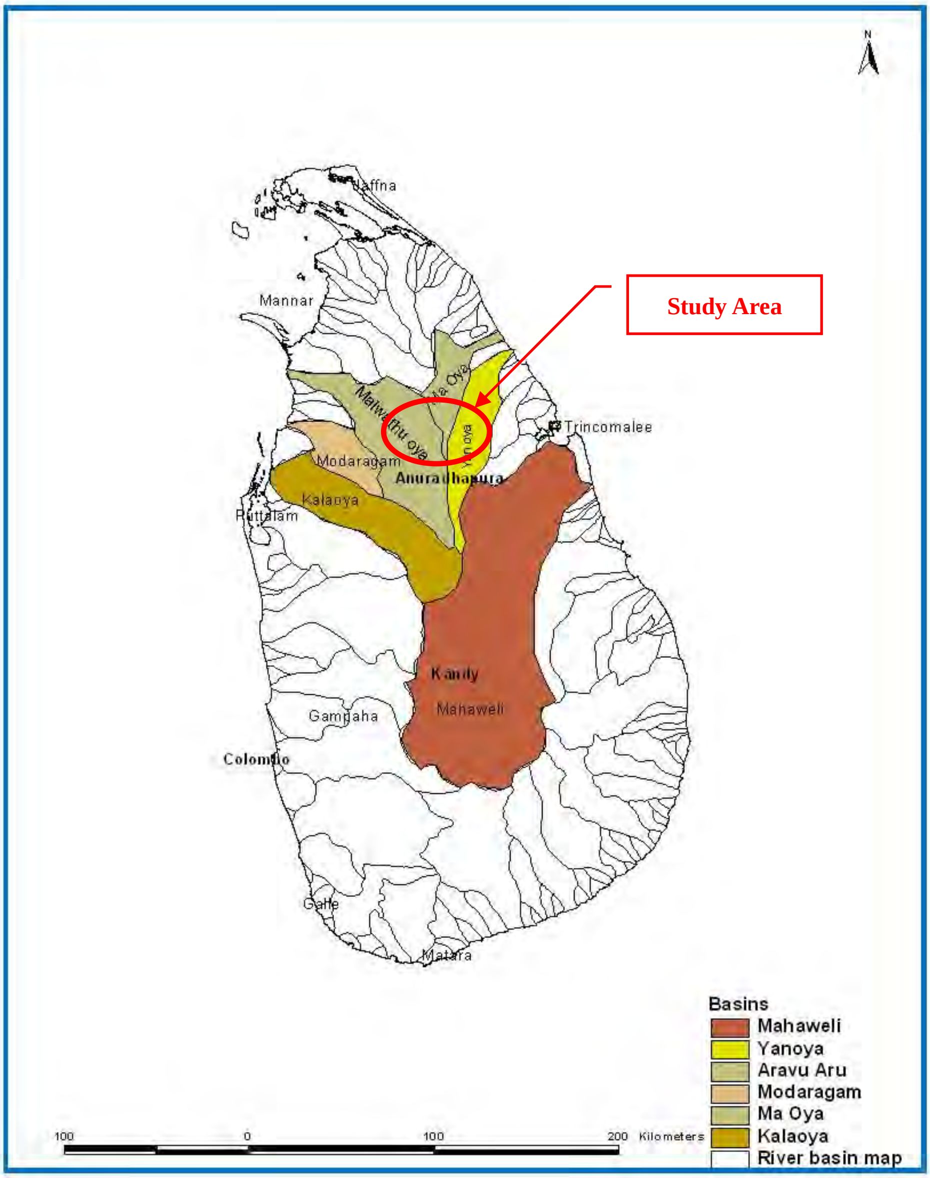
2.2 Natural Conditions

2.2.1 Topography

The study area extends over three river basins, namely, (1) Malwathu Oya, (2) Ma Oya and (3) Yan Oya. The watershed between the Ma Oya and Yan Oya runs one to two km west of national road B211, while that between the Malwathu Oya and the Ma Oya and Yan Oya runs almost in the centre between national road A9 and B538 as shown in **Figure 2.2**.

The western terrain of the Malwathu Oya watershed generally slopes downwards in a northwesterly direction, while the eastern terrain slopes downwards in a southeasterly direction with undulations.

There are many major tanks in the study area that hold water throughout the year; however the minor tanks run dry during the dry period until they are replenished during the northeast monsoon.



Source: HYDROSULT Inc, "Anuradhapura Pilot Area – groundwater Monitoring Program", September 2010

Figure 2.2 River Basin

2.2.2 Geology

The geology of the major part of the study area is highly crystalline, formed by metamorphosis of well bedded sediments in an old geosyncline. Within the study area there are five rock types which are generally in the Central and Eastern parts of the district of the Highland series. Mica mines in Kebithigollewa and limestone deposits in Palagala to Horowpathana are the major mineral resources in the study area.

In the North Central region, the so-called "hard rock" or crystalline basement complex of rocks are well known for their very limited quantities of shallow groundwater. It is now recognized that this shallow groundwater benefits from the presence of several small tank cascades systems that are distributed across this landscape. This has enabled the recent development of agrowell farming, especially in the Anuradhapura district where it is reported that around 15,000 agrowells are in operation; and almost all of these are situated in the lower aspects of the shallow inland valleys which receive some degree of seepage from the small village tanks that are located upstream.[1] (Refer to **Section 4.3.1** (2) for more details).

Fluoride, derived from fluorite (the principal fluoride mineral in igneous rocks) and the minerals apatite and mica, is generally present in only low concentration in groundwater. Volcanic or fumarolic gases may contain fluoride, and in some areas these may be the source of fluoride in groundwater.[2]

2.2.3 Climate

(1) Temperature

The climatological pattern is classified into two seasons for cultivation purposes in Sri Lanka as follows:

- Maha season from October to March called as the wet season
- Yala season from April to September called as the dry season

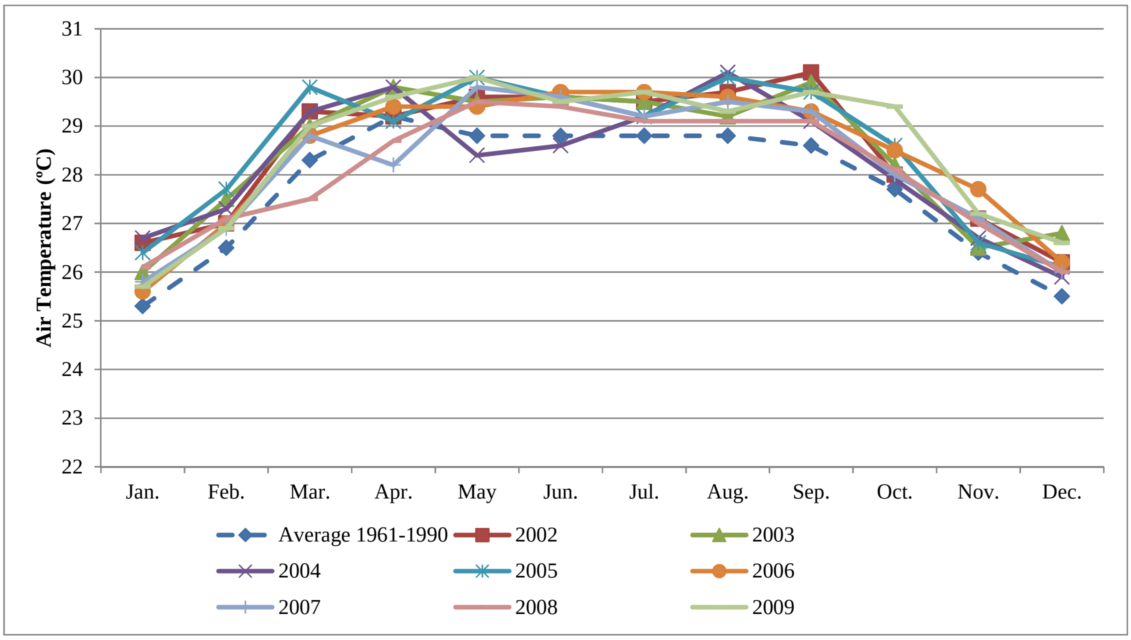
During the dry season from April to September, the monthly average temperature is very stable in the range of 29ºC to 30ºC. However at the start of the wet season from October, the temperature decreases with the coldest months being December and January at about 26 ºC, following which the temperature increases (refer to **Figure 2.3**).

Compared with the average temperature for 30 years from 1961 to 1990, it is noticeable that the

[1] *C. R. Panabokle, "Nature of occurence and sustainable use of groundwater resources for agriculture in the North central, north westen and North easternregions of Sri Lanka", Tropical Agriculture Research and Extention, July 2003*

[2] *Fletcher G. Driscoll, "Groundwater and Wells – Second Edition", Johnson Filtration Systems Inc., 1989*

temperature during the period of 2004 to 2009 was generally higher.

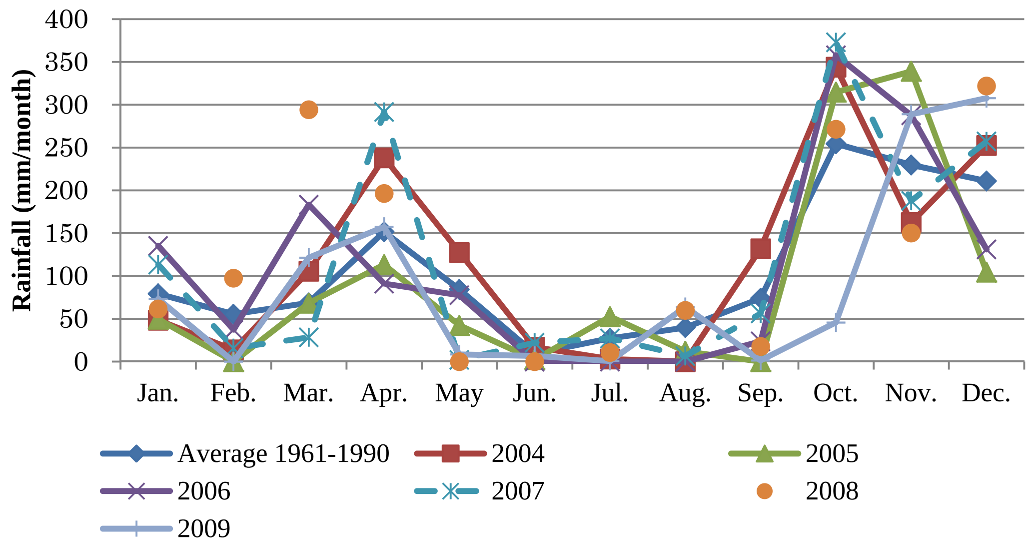


Source: "Statistical Abstract 2010", Department of Census and Statistics

Figure 2.3 Monthly Average Temperature in Anuradhapura District (2004~2009)

(2) Rainfall

The annual average rainfall in the period from 1961 to 1990 in Anuradhapura District was 1,285 mm, but more than two-thirds of the annual rainfall occurs in the Maha season. In addition, as more than 70% of the rainfall during this period is concentrated in the period from October to December, there is a large monthly fluctuation in rainfall, as shown in **Figure 2.4**.

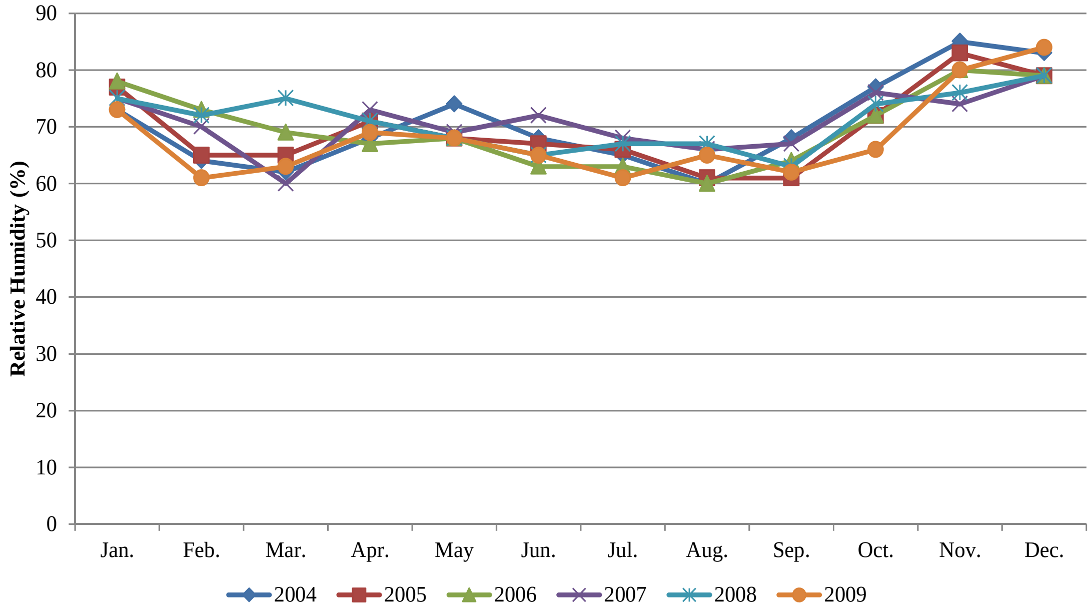


Source: "Statistical Abstract 2010", Department of Census and Statistics

Figure 2.4 Monthly Rainfall in Anuradhapura District (2004~2009)

(3) Relative Humidity

Relative humidity is stable during the period from February to September, then begins to increase with a peak of between 79% and 84% in December, following which it decreases.



Source: "Statistical Abstract 2010", Department of Census and Statistics

Figure 2.5 Monthly Average Relative Humidity in Anuradhapura District (2004~2009)

2.3 Social Conditions

2.3.1 Population

Population, population density and population growth rate of Sri Lanka, Anuradhapura District and study area is summarised in **Table 2.1**.

- The total population of Sri Lanka in the Census 2011 was 20,277,600 persons and the annual average population growth rate was significantly declined from previous 1.16% (1981-2001) to 0.71% (2001-2012).
- Vavuniya and Mullative Districts, which are located north of Anuradhapura District had the highest growth rate of 2.2%, while Jaffna District had the lowest at minus 2.0%, probably due to people being internally displaced people by the conflict.
- The total population of Anuradhapura District in the above census was 745,693 persons, composed of an urban population of 53,151 (7.1%), a rural population of 691,573 (92.7%) and an estate population of 969 (0.1%).

Table 2.1 Population, Population density and Growth Rate of Sri Lanka, Anuradhapura

	Area (km^2)	Population ('1,000)			Population Density (persons/km^2)		Annual Average Growth Rate (%)	
		1981	2001	2012	2001	2012	2001/1981	2012/2001
Sri Lanka	**66,510**	**14,846.8**	**18,797.3**	**20,277.6**	**300**	**323**	**1.16**	**0.71**
Urban		3,192.7	-	-			-	-
Rural		11,654.3	-	-			-	-
Anuradhapura	**7,179**	**587.9**	**745.7**	**855.6**	**112**	**128**	**1.25**	**1.33**
(% to Sri Lanka)		(4.0%)	(4.0%)	(4.2%)				
Urban		41.4	53.2	-			1.26	-
Rural		546.5	692.5	-			1.19	-
Study Area	**2,843**		**175,890**	**205,171**	**62**	**72**		**1.41**
Padaviya	240		21,146	22,924	88	96		0.74
Kebithigollewa	615		19,457	22,227	32	36		1.22
Horowpothana	845		29,642	36,714	35	43		1.96
Kahatagasdigiliya	352		33,572	40,137	95	114		1.64
Medawachchiya	482		40,469	46,743	84	97		1.32
Rambewa	309		31,604	36,426	102	118		1.30

- In Anuradhapura District, Anuradhapura and its surrounding area is categorised as an urban area with a population of 53,151 persons and all of the remaining is categorized as a rural area. Therefore, the entire study area is considered as a rural area.
- The average population density of Anuradhapura District was 104.0 persons/km^2 in the 2001 Census, with the density in the study area being lower than in other DSDs, especially in Kebithigollewa in Horowapothana. At 31.7 persons/km^2 and 35.8 persons/km^2 respectively. For reference, the average population density of the study area was 62.3 persons/km^2 in the 2001 Census.
- The total national population in the 2012 Census is 20,277,597 persons with an annual average growth rate of 0.71% in the period from 2001 to 2012, which is lower than 1.16% in the period from 1981 to 2001.
- Similarly, the population in the Anuradhapura district in the 2012 Census is 855,562 persons with an annual average growth rate of 1.33% in the period from 2001 to 2012, which is the highest out of the 18 districts covered in the Census 2001 and a small increase from the growth rate of 1.25% in the period from 1981 to 2001.

2.3.2 Land Use

Anuradhapura is the largest of all districts in Sri Lanka, covering an area of 738,953 ha which is 11% of the whole country’s land surface. The land use includes large areas of paddy fields, scrublands, forested areas, mixed cultivations, Chena cultivations, home gardens and residences. The majority of the people in the area are farmers and largely depend on paddy cultivation. Apart from that the district economy is predominantly centred on chena and home gardens with vegetable cultivation. Additionally animal husbandry including cattle, goat and poultry is also common in some locations.

The land area for agricultural use in the study area is summarised in **Table 2.2**.

Table 2.2 Land Area for Agricultural Use in the Study Area

	Land Area (ha)	Paddy (ha)	Highland Crop (ha)
Padaviya	**23,119**	**4,841**	**389**
Kebithigollewa	**56,062**	**5,304**	**593**
Horoupotana	**85,487**	**10,924**	**178**
Kahatagas digil iya	**33,141**	**8,605**	**575**
Medawachehiya	**50,730**	**6,791**	**666**
Rambewa	**25.509**	**7,399**	**671**
Total	**274,048**	**43,864**	**3,072**

Note: Highland crop means cashew, arecant, mango, orange, lime, jack, plantain and papaw.

2.3.3 Income and Expenditure

(1) Income

The national average monthly household income in the Household Income and Expenditure Survey 2009/2010 was Rs.36,451, Rs.47,783 in urban areas and Rs.35,228 in rural areas (73.7% of that in urban areas).

The average monthly household income in the North Central Province to which Anuradhapura District belongs was Rs.35,577, which is slightly below the national average (97.6%); however in Anuradhapura District itself the average income was Rs.37,586, which is a little bit higher than the national average (103.1%). For the average income, Anuradhapura District was ranked in 5th position behind Colombo (Rs.51,070), Gampala (Rs.48,870), Ratnapura (Rs.41,312) and Vanuviya (Rs.39,640). Details of the above are shown in **Table 2.3**, with other information on income shown in **Table 2.4** and **Table 2.5**.

Table 2.3 Average and Median of Household Income (Average Monthly) (2009/10)

	Mean Rs.	Median Rs.		Mean Rs.	Median Rs.
Sri Lanka	36,451	23,746	**District**		
Urban	47,783	31,000	Colombo	51,070	34,186
Rural	35,228	23,126	Gampaha	48,870	29,821
Estate	24,162	17,366	Kalutara	35,780	27,511
			Kandy	33,063	22,450
Province			Matale	30,013	18,606
Westem	47,118	30,600	Nuwaraeliya	31,029	21,431
Central	31,895	21,410	Galle	31,376	21,886
Southem	32,514	23,253	Matara	30,980	23,048
Northem	23,712	16,710	Hambantota	36,879	26,406
Eastem	23,922	18,030	Jaffna	18,917	14,815
NorthWestem	35,586	20,961	Vavunlya	39,640	29,370
NorthCentral	35,577	24,993	Batticaloa	22,844	16,129
Uva	28,717	19,761	Ampara	24,721	19,082
Sabaragamuwa	36,173	21,676	Trincomalee	24,291	19,154
			Kurunegala	36,922	20,778
			Puttalama	32,918	21,593
			Anuradhapura	37,586	25,682
			Polonnaruwa	31,526	22,634
			Badulla	32,313	20,982
			Moneragala	22,161	17,226
			Ratnapura	41,312	22,154
			KeEalle	29,342	21,122

Source: Department of Census and Statistics, "Household Income and Expenditure Survey -2009/10", August 2011

Table 2.4 Share of Income to Total HH Income by HH Income Deciles (2009/10)

Decil group	Sri Lanka		Urban		Rural		Estate	
	Income group (Rs.)	Share of income (%)	Income group (Rs.)	Share of income (%)	Income group (Rs.)	Share of income (%)	Income group (Rs.)	Share of income (%)
	All deciles	**100.0**		**100.0**		**100.0**		**100.0**
1	Less than 8,627	1.6	Less than 12,000	1.7	Less than 8,333	1.6	Less than 7,380	2.1
2	8,627-12,500	2.9	12,000-16,854	2.9	8,334-12,143	2.9	7,381-10,658	3.8
3	12,501-16,019	3.9	16,855-21,526	4.0	12,144-15,690	4.0	10,659-12,700	4.8
4	16,020-19,655	4.9	21,527-26,107	5.0	15,691-19,167	4.9	12,701-14,815	5.7
5	19,656-23,746	6.0	26,108-3,1000	6.0	19,168-23,126	6.0	14,816-17,366	6.7
6	23,747-28,502	7.1	31,001-3,7533	7.2	31,270-27,795	7.2	17,367-20,320	7.8
7	28,503-35,167	8.7	37,534-46,510	0.8	27,796-34,179	8.7	20,321-23,700	9.1
8	35,168-44,762	10.8	46,51 1-60,389	11.1	34,180-43,169	10.9	23,701-28,010	10.6
9	44,763-64,443	14.6	60,390-87,667	15.1	43,170-61,693	14.5	28,011-37,629	13.4
10	More than 64,443	39.5	More than 87,667	38.2	More than 61,693	39.3	More than 37,629	36.0

Source: Department of Census and Statistics, "Household Income and Expenditure Survey -2009/10", August 2011

Table 2.5 Share of Income to Total HH Income and Percentage of HH by National HH Income Decile and Sector (2009/10)

Decile Group	Income group	Percentage of households				Share of income			
		Total	Urban	Rural	Estate	Total	Urban	Rural	Estate
	(Rs.)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
	All deciles	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1	Less than 8,627	10.0	5.0	10.7	13.4	1.6	0.6	1.7	3.2
2	8,627-12,500	10.0	6.6	10.3	15.3	2.9	1.5	3.1	6.8
3	12,501-16,019	10.0	6.7	10.2	15.8	3.9	2.0	4.1	9.2
4	16,020-19,655	10.0	8.1	10.1	14.0	4.9	3.0	5.1	10.2
5	19,656-23,746	10.0	8.2	10.2	11.9	6.0	3.7	6.3	10.7
6	23,747-28,502	10.0	10.5	9.9	10.6	7.1	5.7	7.3	11.4
7	28,503-35,167	10.0	11.5	9.9	7.0	8.7	7.7	1.9	9.3
8	35,168-44,762	10.0	11.9	9.9	5.5	10.8	9.9	11.1	1.9
9	44,763-64,443	10.0	13.9	9.7	3.9	14.6	15.7	14.6	8.3
10	More than 64,443	10.0	17.7	9.1	2.7	39.5	50.3	37.7	22.0

Source: Department of Census and Statistics, "Household Income and Expenditure Survey -2009/10", August 2011

In **Table 2.3**, the income average of Anuradhapura District is Rs.37,586 (Rs.36,451 on the national level), but the median is Rs.25,682 (Rs.23,746) or 68.3% (65.1%) to an average showing the significant bias to the lower direction. In the decile, the income data is arranged from the lowest to the highest and divided equally into ten groups in population size, the average is almost equal to the median in each decile except for the 10th income decile to which the bias are concentrated as shown in **Table 2.6**. Adversely, the median is 6.2% higher than the average in the 1st income decile.

Table 2.6 Relationship between Average and Median in the Decile

Decil Group	Range (Rs.)	Mean (Rs.)	Median (Rs.)	Percentage (%) (Mean=100)
	All groups	36,451	23,746	65.1
1	Less than 8,627	5,723	6,080	106.2
2	8,627－12,500	10,691	10,750	100.6
3	12,501－1,6019	14,285	14,283	100.0
4	16,020－19,655	17,833	17,821	99.9
5	19,656－23,746	21,712	21,685	99.9
6	23,747－28,502	26,047	26,000	99.8
7	28,503－35,167	31,656	31,506	99.5
8	35,168－44,762	39,448	39,157	99.3
9	44,763－64,443	53,192	52,531	98.8
10	More than 64,443	143,969	90,737	63.0

(2) Expenditure

The national average monthly household expenditure in the Household Income and Expenditure Survey 2009/2010 was Rs.31,331, Rs.44,928 in urban areas and Rs.29,423 in rural areas, which is 65.5% or about two-thirds of that of the urban area (refer to **Table 2.7**).

The average expenditure in the North Central Province to which Anuradhapura District belongs was Rs.29,065, which is slightly below the national average (94.0%), while that in Anuradhapura District itself was Rs.29,065, which is also lower than the national average (92.8%). For the average expenditure, Anuradhapura District was ranked in 9th position behind Colombo (Rs.47,291), Gampala (Rs.41,062), Kalutara (Rs.35,549) and so on, as shown in **Table 2.6**.

(3) Percentage of Water Rate to Disposal Income in the Household Income and Expenditure

The monthly water and electricity bills[3] are Rs.99.75 and Rs.531.64 per household on national average, respectively, of which percentages to the total household income are 0.27% and 1.45%. The World Bank[4] estimates the limit for household affordability to pay for water supply services as 4% of household income. The Pan American Health Organization[5] also recommends that the total water supply and sewerage charge should be less than 5% of the household income, consisting of 3.5% for water supply and 1.5% for sewerage. The present water charge in Sri Lanka at 0.27% of household income is around one-twelfth of the ceiling (3.5%) set by an International organization.

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[3] *Source: Department of Census and Statistics, "Household Income and Expenditure Survey -2009/10", August 2011*

[4] *"Information and Modeling Issues in Designing Water and Sanitation Subsidy Scheme", The World Bank, May 2000*

[5] *"Methodology of Economic Evaluation in Development Study – 9. Water Supply -", JICA, march 2002 (Japanese)*

Table 2.7 Average Monthly HH Expenditure (2009/10)

Sector/Province/District	Total expenditure (Rs)	Expenditure on food & drink (Rs)	Food ratio (%)	Expenditure on non-food items (Rs)	Non-food ratio (%)
Sri Lanka	31,331	13,267	42	18,064	57.7
Sector					
Urban	44,928	16,003	36	28,925	64.4
Rural	29,423	12,859	44	16,564	56.3
Estate	23,988	12,201	51	11,792	49.2
Province					
Western	42,399	15,028	35	27,373	64.6
Central	28,308	12,669	45	15,639	55.2
Southern	28,809	12,628	44	16,181	56.2
Northern	25,656	15,102	59	10,553	41.1
Eastern	25,265	14,512	57	10,753	42.6
North Western	25,927	12,183	47	13,744	53.0
North Central	29,480	12,073	41	17,407	59.0
Uva	23,547	11,030	47	12,518	53.2
Sabaragamuwa	25,583	11,877	46	13,706	53.6
District					
Colombo	47,291	16,121	34	31,171	65.9
Gampaha	41,062	14,473	35	26,589	64.8
Kalutara	35,549	14,021	39	21,534	60.6
Kandy	29,767	12,773	43	16,994	57.1
Matale	26,528	11,739	44	14,789	55.7
Nuwaraeliya	26,841	13,105	49	13,736	51.2
Galle	27,370	12,514	46	14,855	54.3
Matara	29,408	12,561	43	16,846	57.3
Hambantota	30,744	12,941	42	17,803	57.9
Jaffna	22,725	14,787	65	7,938	34.9
Vavuniya	35,391	16,149	46	19,242	54.4
Batticaloa	23,508	13,799	59	9,709	41.3
Ampara	26,699	14,956	56	11,743	44.0
Trincomalee	25,623	14,906	58	10,717	41.8
Kurunegala	25,201	11,618	46	13,582	53.9
Puttalama	27,376	13,310	49	14,066	51.4
Anuradhapura	29,065	11,795	41	17,271	59.4
Polonnaruwa	30,315	12,635	42	17,680	58.3
Badulla	24,873	10,865	44	14,008	56.3
Moneragala	21,131	11,331	54	9,800	46.4
Ratnapura	25,477	11,732	46	13,745	54.0
Kegalle	25,723	12,069	47	13,654	53.1

Source: Department of Census and Statistics, "Household Income and Expenditure Survey -2009/10", August 2011

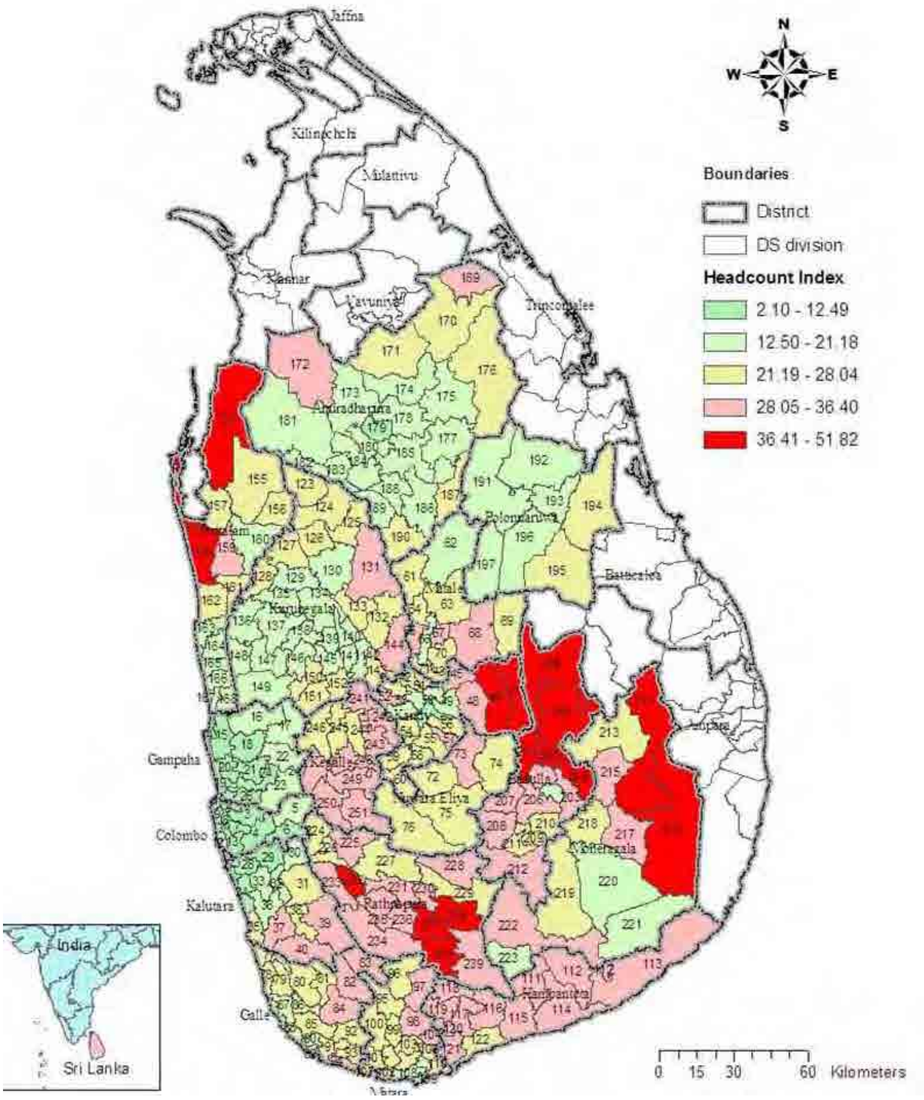
According to "Household Income and Expenditure Survey – 2009/10" (hereinafter referred to as "HIES 2009/10"), the HI (Poverty Head Count Index, the percentage of population below Poverty Line) in Anuradhapura District is 5.7%, ranked at the 4th following Vavuniya (2.3%), Colombo (3.6%) and Gampaha (3.9%) and categorised into a relatively rich province group. However, the five DSDs out of six DSDs in the study area have the higher HI values than the district average with 28.2% of the poor population against 23.6% of the total population in 2001 as shown in **Table 2.8** and **Figure 2.6**.

Table 2.8 Households Index (HI) and Household Population below Poverty Line

Study Area/ District	Headcount Index (HI)	Household Population Below Poverty (HPBPL) (persons)	Remarks
Study Area			
Padaviya	34.33	6,893	
Kebithigollewa	27.74	5,127	
Horowpothana	24.95	7,250	
Kahatagas digiliya	19.63	6,464	
Medawachchiya	21.34	8,113	
Rambewa	20.57	6,339	
		40,186	全県貧困層の 28.2%
Anuradhapura District	20.00	142,308	

Poverty Line is one of the widely used indicators to measure poverty in Sri Lanka. The purpose of estimating poverty line is to capture the basic needs necessary to meet minimum living standards

Headcount Index (HI) is defined as the percentage of **Household Population Below Poverty (HPBPL)**.



Source: "Household and Expenditure Survey – 2002" & "Census of Population and Housing – 2002" Department of Census and Statistics, 2005/07/01)

Figure 2.6 Households Index (HI) by DSD (2002)

The poverty line is to capture the basic needs necessary to meet minimum living standard defining the consumption bundle which include food and non-food items, and raises as the individual component price increases. The poverty line was Rs.2,142 at national level and Rs.2,099 in Anuradhapura District in the year of 2012, which increased to Rs.3,579 and Rs.3,508, respective in November 2012, but those corresponding to 2009/10 were not available.

Table 2.9 Basic Data

Year of Data	Item	Whole		Urban		Rural	
		Income (Rs.)	Percentage (%)	Income (Rs.)	Percentage (%)	Income (Rs.)	Percentage (%)
2009/10	1st Decile Average	5,723					
2009/10	1st Decile Median	6,080	5.0				
2009/10	Poverty Line (Anuradhapura Dist.)	N/A	8.9 (5.7)	N/A	5.3	N/A	9.4
2012-Nov.	Poverty Line (Anuradhapura Dist.)	3,579 (3,508)					
2009/10	1st Decile Upper Limit	8,627	10.0	12,000	10	8,333	10

Note: As the HI value of Anuradhapura District in 2009/10 was 8.9%, it should be placed between the median (5%) and the upper limit (10%) of the income 1st decile, but the poverty line for November 2012 is Rs, 3,508 which is below a 1st decile median of Rs.6,080 with a discrepancy, although the poverty line for 2009/10 is not available.

As shown in **Table 2.9**, the data for urban, rural, Anuradhapura District is not available, therefore the data for the whole or the country is used for the following study:

Since the HI value for the country 8.9% for 2009/10, all the poor can be considered to belong to the1st decile or 10% from the lowest. On the assumption of a population of 4 persons/ household and an average water consumption of 11 m^3/month (= 4 persons × 91 Lpcd × 30.4 days/month), the water rate (Rs.168) is 2.8% to the 1st income decile median of Rs.6,080 in case of applying the special tariff (Domestic - Samurdhi Receipients), which is within 4% of the disposal income recommended by the World Bank. Even applying the normal tariff (Domestic – Non Samurdhi Tenement Garden) to the customer exceeding the 1st income decile median, the water rate is in the range of 2.8% to 2.6% to the disposal income which is in the level of no problem. This result suggests that there are households with an income of below Rs.4,200 (= Rs.168 / 0.04) that the water rate exceeds 4% of the disposal income. The percentage of the number of such households is estimated at about 3.5% (= 5% × Rs.4,200 / Rs.6,080) to the total district household number and about 0.8% (= 3.5% × 0.236) to the study area household number using the population percentage of study area to the whole district

In this connection, under the old water tariff before September 30, 2012, the water rate of households with an income below the poverty line was Rs. 80.1 which was raised to Rs. 168 under the new tariff, or 110% up three times higher than that (37%) of households in the 1st income decile to which the normal tariff is applied

Table 2.10 Water Tariff

(1) Customers below Poverty Line (Special Rate)

New Water Tariff (Effective since October 1, 2012			Water Amount（m^3）	Water Rate（Rs.）
Consumption（m^3）	Service Charge（Rs.）	Volumetric charge（Rs./m^3）		
00-05	50	5	5	25
06-10	50	10	5	50
11-15	50	15	1	15
Monthly service Charge applied to a consumption of 11 m^3/month				50
Billing before Taxation				140
VAT（20%）				28
Total				168
Percentage to the Median of First Decil Group of Rs.6,080 = (168 / 6,080) x 100				2.8%

(2) Customers of First Decil Group (Ordinary Rate)

New Water Tariff (Effective since October 1, 2012			Water Amount（m^3）	Water Rate（Rs.）
Consumption（m^3）	Consumption（m^3）	Consumption（m^3）		
00-05	50	8	5	40
06-10	65	11	5	55
11-15	70	20	1	20
Monthly service Charge applied to a consumption of 11 m^3/month				70
Billing before Taxation				185
VAT（20%）				37
Total				222
Percentage to the Upper Limit of First Decil Group of Rs.8,627 = (222 / 8,627) x 100				2.6%

(4) Poor Households

The percentage of poor households nationally based on the official poverty line has reduced from 24.3% in 1995/96 to 19.2% in 2002, 12.6% in 2006-07 and 7.0% in 2009/10, while the percentages in the same years in Anuradhapura District were 21.9%, 17.2%, 12.7% and 4.6%, respectively, following a similar pattern to the situation nationally, as shown in **Table 2.11**.

Table 2.11 Percentage of Poor Households Based on the Official Poverty Line

	1990/91	1995/96	2002	2006-07	2009/10
Percentage of poor households (%)					
Sri Lanka	21.8	24.3	19.2	12.6	7.0
Anuradhapura	20.1	21.9	17.2	12.7	4.6
Official poverty line (Rs.)					
Sri Lanka	475	833	1,423	2142	
Anuradhapura	456	816	1,380	2,099	

Source: "Announcement of the Official Poverty Line", Department of census and Statistics, 2004 June

Note: The official poverty line are Rs.3,545 at the national level and Rs.3,474 in Anuradhapura District for September 2012.

2.3.4 Sanitation Conditions

(1) Toilet Facilities

According to the Census 2001 and 2011, in Anuradhapura District, the availability of a toilet was changed as shown in **Table 2.12**. The percentage of “exclusively for the household” was increased to 83% from 73.2% but is still lower than the average of Sri Lanka (86.5%), the percentage of “not using a toilet” was decreased to 2.2% from 12.7% but is still higher than the average of Sri Lanka (1.7%). From these censuses, the toilet facilities condition in Anuradhapura district was improved but is still behind the average of Sri Lanka.

Table 2.12 Condition of Toilet Facilities in Anuradhapura District

Census	Exclusively by the household	Sharing with the another household	No toilet but sharing with another household	Common/ Public	Not using toilet
2001	73.20%	7.70%	4.60%	0.50%	12.70%
2011	83.00%	9.30%	3.30%	0.10%	2.20%
variation	9.80%	1.60%	-1.30%	-0.40%	-10.50%

For the study area, “exclusively for the household” was 79.65% or 3.4% lower than that for the district, whereas “not using a toilet” was 4.3%, or 2.1% higher than that for the district. There were no significant differences in other categories, when comparing the study area with the district. This result shows the study area is still behind condition from the average of the district but the differences have been narrowed. Especially housing units “not using a toilet” ranged from 2.3% to 5.7% in census 2011 is much lower than that of in census 2001 (from 23.5% to 33.3%).

In summary as far as sanitation is concerned, the situation in the study area was worse than that in the district, based upon the above census. The situation in the district and study area is summarized in **Figure 2.7**.

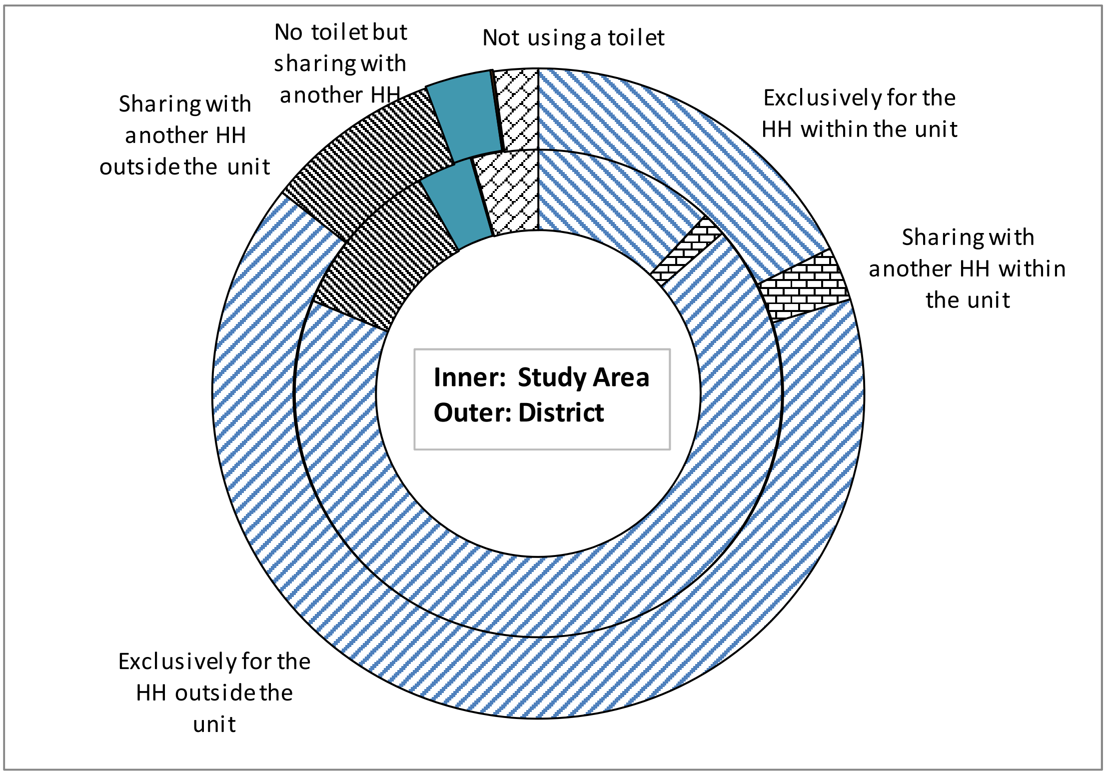


Figure 2.7 Availability of the Toilet in Anuradhapura District and the Study Area

(2) Type of Toilets

As for the type of toilets, Census 2011 data is not available. The following description is based on Census 2001 data.

From the viewpoint of the toilet type in the district, the percentages were 47.9% for “water seal” or almost a half in the district, 13.5% for “pour flush”, 21.6% for “pit”, 2.4% for “others”, 12.7% for “not using a toilet” and 2.1% for “not reported”. This shows a delay in the provision of improved sanitation.

For the study area, the percentage of “pit” was 12.8% or 8.8% below that in the district, while that of “not using a toilet” was 24.4% or 11.7% above that in the district.

For the DSDs in the study area, the percentage of “water seal” in Horowpothana was 38.5% or 9.4% below that in the district, and that of “pit” in Padaviya was 36.6% or 15.0% above that in the district. There are no significant differences in other types of toilet, when comparing the situation in the DSDs and the district. The situation in the district and study area is summarized in **Figure 2.8**.

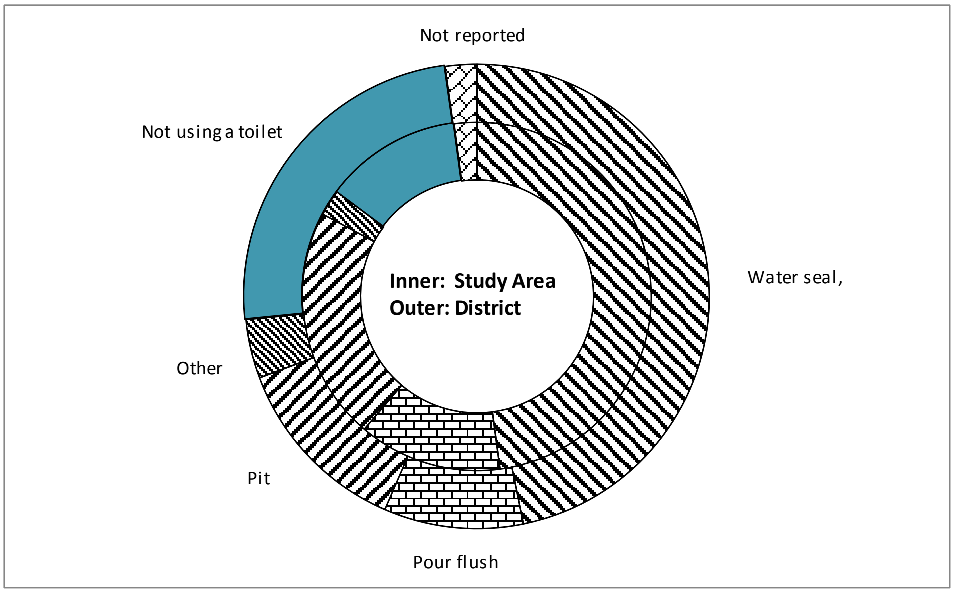


Figure 2.8 Type of Toilet in Anuradhapura District and the Study Area

Although Padaviya had a high percentage of toilets “exclusively for the household”, it also had a high percentage of “pit”, which shows a delay in the provision of improved sanitation in the area. Considering the whole of the study area, about one quarter of households did not have a toilet “exclusively for the household” and were either sharing with another household or not using a toilet. In addition, the spread of improved sanitation is delayed.

The JICA study team visited some schools in the study area. Most of schools, have pour flush toilets and the number of students per toilet is more than 50 students. Besides, maintenance condition is so different in each school. The school in Medawachchiya has a kind of cleaning system by their parents. In this school, 4 parents should clean the school facilities includes toilets. In another school, there are some pour flush type toilets but there is not enough water, so they cannot use toilets in the school. The students and teachers go to some houses or a mosque near from the school to use toilets.

Figure 2.9 Used Toilets for Girls

Figure 2.10 Not Used Toilets

(3) Sanitation improvement projects

Some sanitation improvement projects have been put in operation in 25 CBOs by ADB. In most of CBOs, some toilets were installed and in some CBOs, some motivation campaigns about sanitation were held. The detail of these projects is described in **Chapter 9.**

2.3.5 Source for Drinking Water

(1) Dug/Tube Well

In the study area, housing units depend on the following for drinking water source: (i) protected shallow wells within premises (24.8%), (ii) protected shallow wells without premises (40.0%), (iii) not protected shallow wells (15.5%), (iv) tube wells (12.5%), (v) tap water (4.1%), (vi) other (tank, river, etc.) (1.8%) and (vii) not reported (1.4%) in the Census 2001[6]. Accordingly, 92.8% of housing units had some form of well and used ground water for drinking. It should be noted that pipe water coverage was 9.8% in the whole of Anuradhapura District in 2001, which is higher than that for the study area.

(2) Rainwater Harvesting[7]

Domestic rainwater harvesting has been revived in Sri Lanka since 1995 with the Community Water Supply and Sanitation Project (CWSSP). At present, there are over 31,000 domestic rainwater harvesting systems in the country and more than 10% of such facilities have been constructed in Anuradhapura District in the dry zone, (where there is a high level of fluoride concentration in groundwater), as shown in **Figure 2.11**.

Rainwater is one of the purest sources of water available, as it does not come into contact with many of the pollutants such as exhaust gas from vehicles, smoke, dust, etc. which are emitted in urban areas, especially in rural areas such as the study area. It is free and can be used for both drinking water and non-drinking water purposes.

6 Department of Census and Statistics – Sri Lanka, "Census of Population and Housing 2001 – Anuradhapura District – Fnal Results (CD-ROM)"

7 Tanuja Ariyananda, "Domestic Rainwater Harvesting as a Water Supply Option in Sri Lanka", Hydro Nepal Issue No.6, January 2010

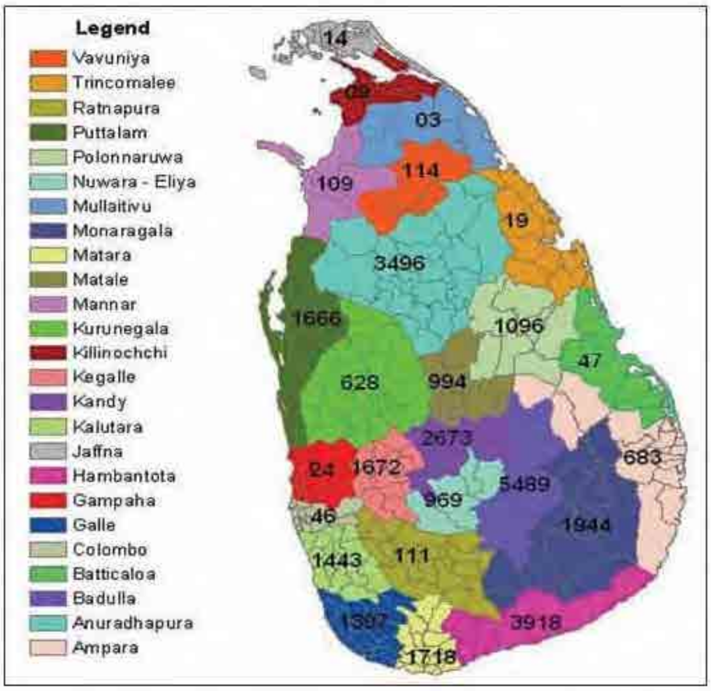


Figure 2.11 Distribution of the Number of Rainwater Harvesting Systems

In 2005, the Government of Sri Lanka, realizing the importance of rainwater harvesting to overcome the water scarcity in the country, passed a national policy of rainwater harvesting. Today, more than 23 institutions and organizations are promoting water harvesting nationwide.

Free-standing Ferro cement tanks with a volume of 5 m^3 (refer to **Figure 2.11**) are often seen in the study area, which are designed on the following assumptions:

Family size:	5 persons
Per capita consumption:	20 L/day
Maximum dry period:	50 days
Required volume:	$5 \times 20 \times 50 = 5{,}000$ Liters or 5 m^3

2.3.6 Solid Waste Disposal

(1) Solid waste management in the study area

All 6 DS in the study area have garbage collection systems in certain areas and final disposal sites, the detail shows in the **Table 2.13**. Only in Rambewa DS, the disposal method in the final disposal site is land fill, other 5 DSs have only open dump site.

Table 2.13 Solid Waste Management Condition in the Study Area

DSD (Pradesiyah Sabah)	Rambewa	Madawachchi	Paraviya	Kebithigollewa	Horoupothana	Kahatagasdigillia
Population	36,426	46,743	22,924	22,227	36,714	40,137
Collection cover ratio (by population)	12.2%	22.0%	14.0%	66.0%	61.0%	30.0%
Quantity of collected waste (ton/week)	15	24	18	14	12	15
No. of Collection vehicle	2	1	2*1	1	1	3
No. of Collection crew	4	11	3	3	8	8
Disposal Method	Land fill	Open dump	Rainy season: Soil cover Dry season: Open dump & burning			
Cost for solid waste management (Rs/year)	1,200,000	4,048,100	240,000	540,000	2,801,600	3,600,000
Collection experience	3 years	9 years	2.5 years	7 years	9 years	NA
Other projects/ programs	1 for compost	2for compost	1 for compost	1 for compost	1 for compost, 1 for separation	1 for compost

** Source of the number of population: Census of population and housing, 2011*
Source of other figures: Interview with the chairman of each DS

Figure 2.12
Landfill Dump Site in Rambewa

Figure 2.13
Open Dump Site in Medawachchiya

(2) Solid waste management projects

From March 2007 to March 2011, there is a JICA technical cooperation project, “Capacity Upgrading Project for the National Solid Waste Management Support Center” in Sri Lanka. The aim of this project is to upgrade the capacity of solid waste management in each local government and had some training programs for the officers and some constructions of compost facilities. According to this project, in the all DS, there are compost projects funded by JICA. Except for JICA-funded compost project, there are two projects supported by the national government. One is a kind of compost project related with organic agricultural project, the other one is a garbage separation project based on the school.

2.4 Economic Conditions

According to the employment population by industry in Sri Lanka (**Table 2.14**), the population engaged in agriculture decreased from 46.8% in 1990 to 32.6% in 2001 (or a 14.2 percentage points decrease), while the population engaged in industry increased from 13.3% to 17.0% (or a 3.7 percentage points increase). In the same period employment in trade and hotels increased from 9.6% to 13.0% (or a 3.4 percentage points increase) and in services from 15.7% to 18.5% (or a 2.8 percentage points increase). The transition from an agriculture-dependent economy has been steadily progressing.

Table 2.14 Employment Persons by Major Industrial Groups

(Unit: %)

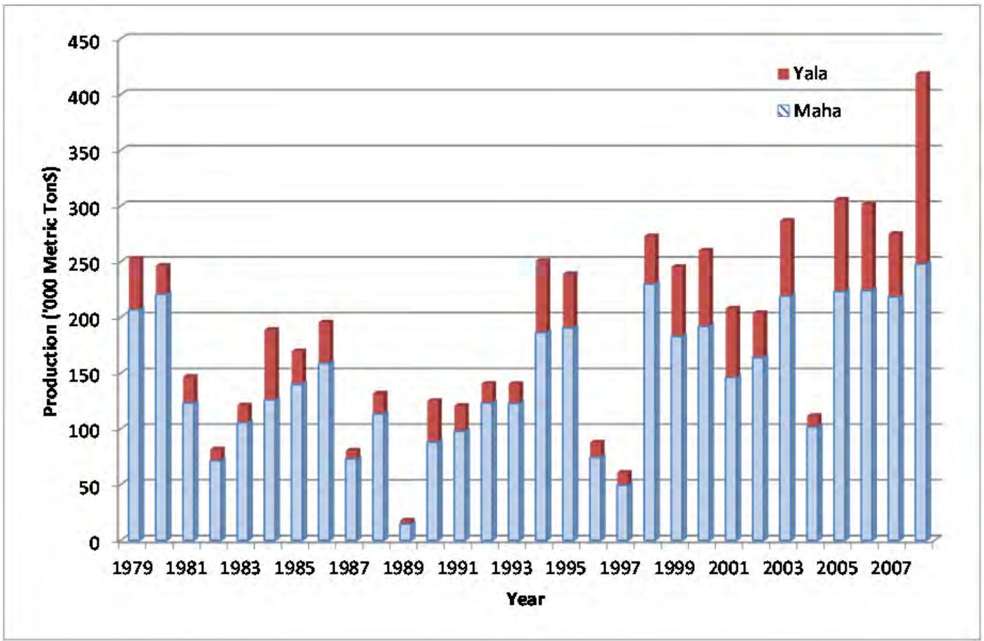
Year	Agriculture	Manufacturing	Construction	Trade & Hotels	Transport storage & comm.	Insurance, real estate & business service	Service	Other	Not defined
1990	46.8	13.3	3.9	9.6	4.1	1.3	15.7	2.2	3.2
1991	42.5	15	4.7	107	4.1	1.9	14.8	1.5	4.8
1992	42.1	13.1	4.8	11.3	4.4	1.5	16.9	2	4
1993	41.5	13.2	4.4	11.1	4.1	1.6	17.5	2.2	4.5
1994	39.5	14.3	4.1	12.2	4.7	1.8	18.1	1.4	4
1995	36.7	14.7	5.3	12.2	4.7	1.5	17.3	2.1	5.4
1996	34.4	14.6	5.4	12	4.9	2	18.2	2.1	3.5
1997	36.2	16.4	5.6	12.4	4.8	1.7	17.3	2.2	3.5
1998	39.3	14.9	5	11.6	4.9	1.9	17.1	2	3.2
1999	36.3	14.8	5.3	12.1	5.1	1.6	18.4	1.8	4.5
2000	36	16.6	5.5	12.7	4.9	2.1	17.5	1.6	3.2
2001	32.6	17	5.2	13	6.2	2.3	18.5	1.8	3.4

Source: "Statistical Abstract 2010", Department of Census and Statistics

2.4.1 Agriculture

The main industry of Anuradhapura District is agriculture but it does not produce significant quantities of the three major export products of the country, namely rubber, tea and coconut, accounting for only 3.6 % of the national total, with the major agricultural product being rice.

For the rice harvest from the paddy field, Anuradhapura District is ranked 4th in the country with a national share of 8.8% to 10.8% and it can be said that Anuradhapura District is one of the major rice-producing districts in Sri Lanka. However, as shown in **Figure 2.14**, the yearly fluctuation of the rice harvest is heavily dependent on to what extent the irrigational water requirement is met during the drought period. Histrorical data shows that a long-term drought occurred during the period from 1987 to 1993.



Source: "Statistical Abstract 2010", Department of Census and Statistics

Figure 2.14 Yearly Fluctuation of Rice Harvest in Anuradhapura District

Apart from rice, the province's other products include sesame, millet, chilies, peanuts, fruit, vegetables and dairy produce.

2.4.2 Industry

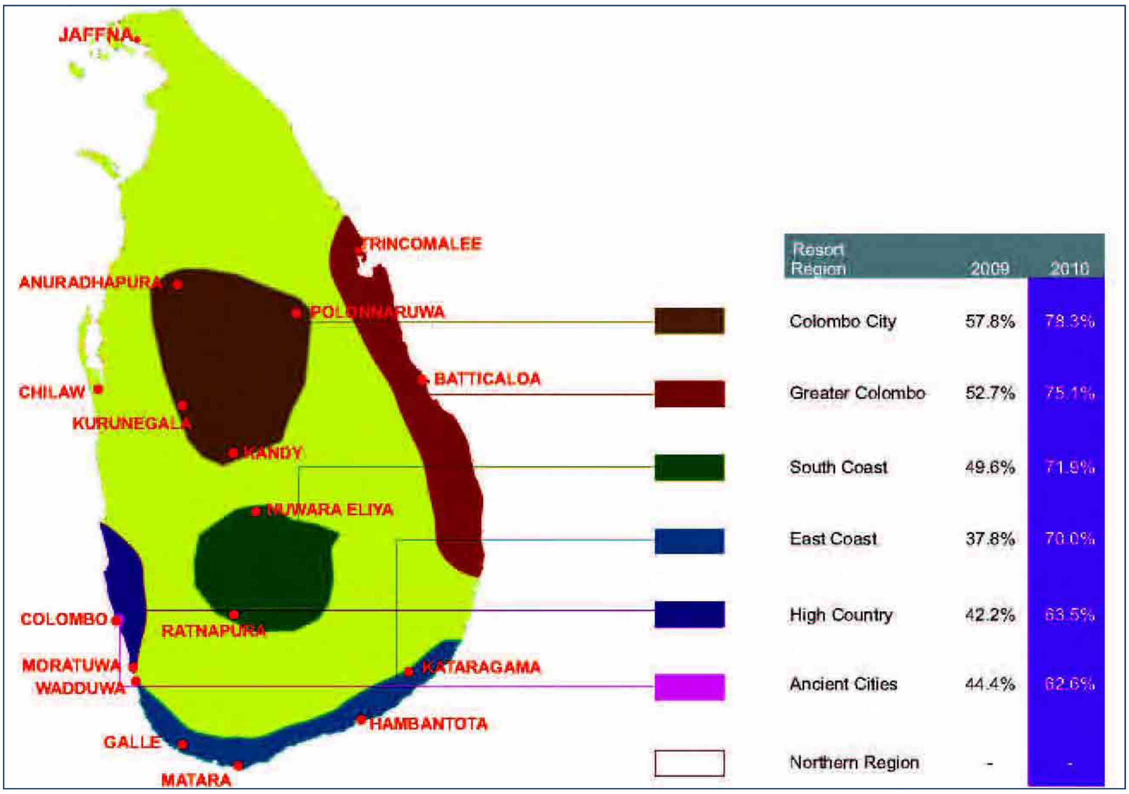
The industrial output product of Anuradhapura District in 2008 was Rs.12,036 billion, which is equivalent to 0.7% of the national industrial product of Rs.1,618,344 million. In the meaning of industrialization, Anuradhapura District is obviously lagging behind other parts of the country.

2.4.3 Tourism

Tourism areas in Sri Lanka are classified into seven resort regions as shown in **Figure 2.15** Anuradhapura District belongs to the group of “Ancient Cities” together with Kandy, Polonnaruwa and Kurunegala, focusing on the ancient Buddhism relics.

For the accommodation capacity (rooms) in Graded Establishment, Ancient Cities have kept a share of about 20% during the period from 2001 to 2010, but for the occupancy rates, there has been a drastic change. From 2001 to 2004, occupancy increased from 39.1% to 60.4%, but in

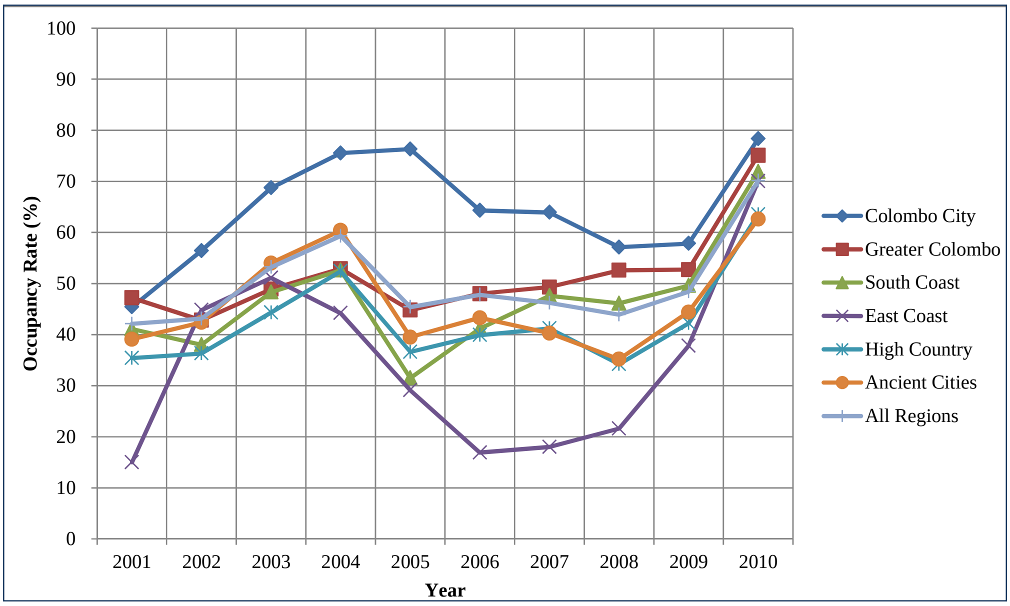
2005, there was a drastic drop to 39.5% and since that it has hovered at a low level of about 40%. In 2010 there was a significant improvement to 62.6%, or 18.2 percentage points up from the previous year of 44.4%, due to the end of conflict. **Figure 2.16** shows the trends in all regions combined and in each region, except for the Northern Region.



Source: Sri Lanka Tourism Development Authority, "Annual Statistical Report of Sri Lanka Tourism - 2010"

Figure 2.15 Resort Regions in Sri Lanka

Development of the tourism industry is expected to be significant in the future.



Source: Sri Lanka Tourism Development Authority, "Annual Statistical Report of Sri Lanka Tourism - 2010"

Figure 2.16 Occupancy Rate by Region (2020-2010)

According to the 2010 data, Kandy which had 55.6% of the total number of foreigners (375,939 guests) and 57.4% of the total number of locals (235,845 guests) in the Ancient Cities, was by far the most popular location. Anuradhapura had only 6.2% of the total number of foreigners (41,747 guests) and 12.7% of the total number of locals (52,326 guests). The number of foreigners (676,356 guests) in the Ancient Cities was 1.65 times the number of locals (411,055 guests), showing that foreigners had a higher interest in the area than locals; however in the case of Anuradhapura, the number of foreigners was 80% of the number of locals.

2.5 Necessity of the project

2.5.1 General

In the Anuradhapura North area, or the study area for the Preparatory Study on Anuradhapura North Integrated Water Supply Project, a number of small scale water supply systems under the operation and maintenance of the Community-Based Organizations (CBOs) and NWSDB are dispersed; however only about 60% of the total population receive piped water supply. In addition, the quantity of water amount is not enough to provide a 24-hour water supply.

Due to the lack of piped water supply coverage, most of the people living in the study area basically depend on groundwater sources such as tube wells and dug wells. According to the reports obtained from the NWSDB regional laboratory and water quality survey conducted by the project, groundwater contains high fluoride and other chemical substances, thereby is sometimes unsuitable for drinking purposes. However, since there are no other water sources, local residents have no choice but to use such contaminated groundwater for drinking purpose. Especially, due to high concentration of fluoride, the prevalence of patients with fluorisis in the study area is very high.

Due to the above conditions, this project is proposed to solve the above problems, and thus has been started as a high priority project. Further information about the need for the project is as follows.

2.5.2 Drinking Water Source

(1) Principal Drinking Water Source

According to Census 2001 (**Table 2.15**), the drinking water sources are composed of groundwater (92.7%) from dug wells (80.2%) and tube wells (12.5%), and tap water (4.1%). The rural water supply was not reported at this point.

Table 2.15 Principal Source of Drinking Water in the Study Area (2001 & 2011)

Drinking Water Source (2001)

		Well				Pipe Born Water				Other			
	No. of HHs	Protected Well within Premises	Protected Well outside Premises	Unprotected Well	Tube Well	Tap within Unit	Tap within Premises but outside Unit	Tap outside Premises	Rural Water Supply Project	Bowser	Bottled Water	River / Tank / Stream / Spring and Other	Not Reported
	(HHs.)	(HHs)	(HHs)	(HHs)	(HHs)	(HHs)	(HHs)	(HHs)	(HHs)	(HHs)	(HHs)	(HHs)	
Anuradhapura District	189,699	41,482	71,316	25,931	26,630		12,279	5,858				3,538	2,665
			138,729		26,630		18,137		-		3,538		2,665
Wahalkada Area													
Padaviya	5,452	1,039	1,176	2,037	520		253	161				216	50
Kebithigollewa	4,903	932	1,845	1,086	560		139	87				151	103
Horowpothana	7,578	1,913	3,332	887	1,079		49	68				158	92
Kahatagasdigiliya	8,619	2,141	4,201	677	814		480	158				61	87
Sub-total	26,552	6,025	10,554	4,687	2,973		921	474				586	332
			21,266		2,973		1,395		-		586		332
Mahakanadarawa Area													
Medawachchiya	10,338	2,974	3,627	1,387	1,654		193	216				68	219
Rambewa	8,230	2,179	3,867	905	1,007		11	16				173	72
Sub-total	18,568	5,153	7,494	2,292	2,661		204	232				241	291
			14,939		2,661		436		-		241		291
Total	45,120	11,178	18,048	6,979	5,634		1,125	706				827	623
			36,205		5,634		1,831		-		827		623

Source: "Census 2001", Department of Census and Statistics

Drinking Water Source (2011)

		Well				Pipe Born Water				Other		
	No. of HHs	Protected Well within Premises	Protected Well outside Premises	Unprotected Well	Tube Well	Tap within Unit	Tap within Premises but outside Unit	Tap outside Premises	Rural Water Supply Project	Bowser	Bottled Water	River / Tank / Stream / Spring and Other
	(HHs.)	(HHs)	(HHs)	(HHs)	(HHs)	(HHs)	(HHs)	(HHs)	(HHs)	(HHs)	(HHs)	(HHs)
Anuradhapura District	**228,304**	**51,306**	**63,130**	**8,681**	**5,758**	**32,167**	**16,093**	**7,585**	**35,803**	**261**	**2,394**	**5,126**
			123,117		5,758		55,845		35,803		7,781	
Wahalkada Area												
Padaviya	6,203	1,833	1,897	616	109	244	311	91	844	10	26	222
Kebithigollewa	5,991	1,927	2,055	168	135	174	163	29	315		4	1,021
Horowpothana	9,352	3,988	4,449	212	144	32	30	6	295		39	157
Kahatagasdigiliya	10,386	3,355	4,404	179	114	463	340	73	1,236	1	126	95
Sub-total	**31,932**	**11,103**	**12,805**	**1,175**	**502**	**913**	**844**	**199**	**2,690**	**11**	**195**	**1,495**
			25,083		502		1,956		2,690		1,701	
Mahakanadarawa Area												
Medawachchiya	12,560	3,420	4,350	407	780	652	583	215	1,210	14	336	593
Rambewa	9,757	2,739	3,162	214	229	459	357	446	1,691		58	402
Sub-total	**22,317**	**6,159**	**7,512**	**621**	**1,009**	**1,111**	**940**	**661**	**2,901**	**14**	**394**	**995**
			14,292		1,009		2,712		2,901		1,403	
Total	**54,249**	**17,262**	**20,317**	**1,796**	**1,511**	**2,024**	**1,784**	**860**	**5,591**	**25**	**589**	**2,490**
			39,375		1,511		4,668		5,591		3,104	

Source: "Census 2011", Department of Census and Statistics

In Census 2011 (**Table 2.15)**, 75.4% of the people in the study area relied on groundwater through dug wells (72.6%) and tube wells (2.8%), and tap water (18.9%), and the remaining 5.7% on others such as bowser, bottled water, river, etc. (Note: the population coverage by water supply in the study area is approximately 27% according to the existing CBO water supply schemes survey, some of them may not regard tap water as the main water source in spite of the connection to a water supply schemes.) There are a decrease in the use of groundwater and an increase in the use of tap water. For the type of wells, unprotected dug wells and deep tube wells has substantially decreased and the protected dug wells have become popular. However, the water source of such small-scale water supply schemes are almost groundwater, there is no change in relying on groundwater.

1) Dug Wells and Deep Tubewells

Dug wells are shallow open wells which are less than 10 m deep, and are wells from which water is pulled using a bucket or other available container which can hold water (refer to **Figure 2.17** for a typical dug well). As groundwater from dug wells is a low cost water source for most rural and semi rural water supply, dug wells are distributed thoughout the country and provide the basic drinking water supply to a major proportion of rural residents. On the other hand, dug wells have disadvantages in comparison to tubewells. They are more difficult to protect from contamination and their yields are also very low, because they do not penetrate into the reliable, productive water table aquifer.

Figure 2.17 Dug Well

Deep tubewells are genarally more than 20 m deep wells from which water is pumped out using a submersible pump. Groundwater is allowed to enter the casing by either an open end pipe, perforated pipe or a well screen, depending on the size of the aquifer soil particles. Deep tubewells can protect from contamination, and their yields are relatively stable even in the dry season, because they penetrate into the productive water table aquifer.

Figure 2.18 shows a typical deep tubewell.

Figure 2.18 Deep Tubewell

2) Water Abstraction Facilities in CBOs

There are several rural water supply organizations using groundwater that is NWSDB, CBO and CWSSP. As CBOs account for the majority of these organizations, water abstraction facilities in CBO were investigated.

Considering these characteristics mentioned above, CBO has been using a combination of dug wells and deep tubewells. The ratio of the two methods are 57% and 43%, respectively, as shown in **Figure 2.19.** The datails of CBO information are in **Appendix 2.1**.

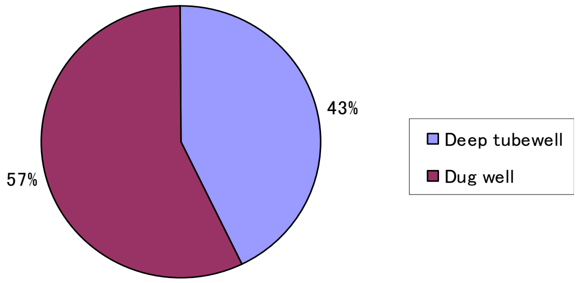


Figure 2.19 Water Abstraction Facilities in CBO

3) Spring water

There are some spring water (which is a “type” of groundwater) sites. Specifically spring water occurs in natural situations where water flows to the ground surface from underground. In the project area, this water sources occurs only in limited areas such as in Kebitigollewa DSD, as shown in **Figure 2.20**. In this location the spring water is of good quality and as such the local people prefer to use it for drinking purposes.

Figure 2.20 Spring Water in Kebitigollewa DSD

(2) Water-fetching Distance to Water Source

Since the data on water-fetching distance in the study area is not available, that is described using the district-level data.

Table 2.16 Water-fetching Distance in Anuradhapura District

Sector and District	Distance						
				Outside Premises			
	Total (%)	Within premises (%)	Outside Premises (%)	≤ 100 m (%)	101 – 200 m (%)	201 – 500 m (%)	> 500 m (%)
Sri Lanka	**100**	**76.3**	**23.7**	**16.0**	**3.3**	**3.1**	**1.3**
Urban	100	88.9	11.1	8.9	0.7	0.9	0.6
Rural	100	75.0	25.0	16.4	3.7	3.5	1.4
Estate	100	62.0	38.0	31.1	3.7	3.1	0.1
Anuradhapura	**100**	**58.0**	**42.0**	**18.3**	**7.8**	**9.5**	**6.4**

Source: Department of Census and Statistics, "Household Income and Expenditure Survey -2009/10", August 2011

The distribution of drinking water sources in Sri Lanka is 76.3% within premises and 23.7% outside premises, while in Anuradhapura District, they are 58.0% and 42.0% respectively. It shows that the percentage of a drinking water source outside premises is rather high. The percentage of the number of households engaged in the water-fetching work is secondarily high following that in Jaffina District.

The distance allocation from a housing unit to a drinking water source is 16.0% for equal or less than 100 m, 3.3% for 101 – 200 m, 3.1% for 201 – 500 m and 1.3% for above 500 m (The national average for a rural area is 16.4%, 3.7%, 3.5% and 1.4%, respectively.), while in Anuradhapura District they are 18.3%, 7.8%, 9.5% and 6.4%, respectively, showing that the people in the district are forced the water-fetching work for a longer distance than a national average. As for the water-fetching distance, Anuradhapura District is ranked at the second for within 100 m, third for 101 to 200 m and second for above 500 m. On a national basis, the district is placed in a severe condition as well as Jaffina District.

In case of tap water, 43.4% of housing units have a tap indoors, 38.2% within premises and 18.4% outside premises. It means that one out of five housing units have no tap within premises.

(3) Per Capita Water Consumption at Existing CBOs

There are 50 existing water supply schemes maintained and operated by CBOs in the study area, of which the per capita water consumption is 66 Lpcd at 46 existing CBOs on average.

(4) Water Quailty at Existing CBOs

Although there are 50 water supply schemes under CBOs in the study area out of which 45 CBOs have their water quality data of tap water as shown in **Table 2.17**. A fluoride concentration is above a desirable standard of 0.6 mg/L in 27 CBOs and above a permissible limit of 1.5 mg/L in 6 CBOs with the maximum value of 1.9 mg/L. The served population who are exposed to a risk of fluorosis by a fluoride concentration above a desirable limit counts 29,460 persons against 8,205 persons with no risk. The rate of populations with a risk versus with no risk is 78.2:21.8, that is to say, four out of five persons are exposed to a risk of fluorosis. Among them, a served population of 4,435 persons are exposed to a higher risk due to a fluoride concentration of above a permissible limit.

Table 2.17 Water Quality of CBO's Supply System

S/N	Name of CBO	Water Quality							
		Hardness	Iron	Fluoride	Odor	Color	Turbi	pH	Condictivity
01	Swashakthi CBO	–		0.85	None	Clear	0.05	7.86	860
02	Ikra CBO	–	–	0.83	None	Clear	0.06	7.72	950
03	Arunalu CBO	–	–	0.59	Fishy	Clear	0.1	7.93	940
04	Samagi CBO	–		1.01	None	Clear	0	7.76	930
05	Ekamuthu CBO	–		0.32	None	Clear	0.08	7.74	700
	Ekamuthu CBO – Katukaliyawa			1.19	–	Clear	0.03	7.77	880
06	Rangiri CBO	–		0.88	None	Clear	0.03	7.79	1080
07	Nildiyadahara CBO	360/280	–	0.72	–	Clear	0.15	7.77	740
08	Eksath CBO	340	–	0.4,0.78	None	Clear			
09	Mahasen CBO	80	–	0.39	–	clear	0.08	7.6	730
10	Dimuthu CBO	312	–	0.57	–	Clear	0.12	7.91	610
11	Pragathi CBO	344	–	1.38	–	Clear	0.05	7.7	1450
12	Jayashakthi CBO	–		1.9	None	Clear	0.06	7.76	1570
13	Samagi CBO	332/270/330		1.08	None	Clear	0.07	7.8	1000
14	Samagi CBO	–	–	0.5	–	<5	0.02	–	590
15	Ekamuthu CBO	–		0.81	–	<5	0.03	–	650
16	Ran Arulnalu CBO	490/720/640	0.03/–/–	1.55/1.1/0.36					
17	Isuru CBO	High	–	0.98	None	Clear	0.05	7.84	1060
18	Randiya Dhahara CBO	–	–	1.15	None	Clear	0.09	7.76	840
19	Nelum CBO	–		1.11	None	Clear	0.05	7.86	970
20	Diriyamatha CBO	250/261/284		0.83	–	Clear	0.1	7.75	700
	Diriyamatha CBO –			0.69	–	Clear	0.12	7.79	870
21	Gemunu CBO	–		0.75	–	<5	0.21	–	950
22	Sisila Diyadahara CBO	–		0.76	None	Clear	0.06	7.86	880
23	Diriya Shakthi	373/342		0.86	None	Clear	0.1	7.64	1220
24	Ridi Nadee	–		0.21	None	Clear	0.06	7.75	610
25	Shakthi CBO	324	3.3	0.1		N/A			
26	Al-Naja	–	–	–					
27	CBO not formed &	–	–	–					
28	Parakum CBO	108	0.14	1.04	–	Clear	0	7.76	740
29	Suwasehana CBO	1.13	–	1.13		Clear	0.07	7.76	740
30	Suwasetha CBO	–	–	0.96		Clear	0.04	7.63	740
31	Vajira CBO	262/204		1.5/1.54					
32	Pragathi CBO	–		0.58	None	Clear	0.08	7.54	1430
33	Janasetha CBO	–	–	1.37		Clear	0.01	7.85	670
34	Sobasisila CBO	–		0.67		Clear	0.02	7.64	810
35	Randiya	–	–	0.31		Clear	0.14	7.76	760
36	Nilmini	–		–					
37	Senath CBO	–		1.9	None	Clear	0.02	7.75	1240
38	Eksath CBO	296		1.62	None	Clear	0.02	7.78	860
39	Praja Shakthi	–		0.42	None	Clear	0.01	7.85	520
40	Apsara	–		1.35		Clear	0.14	7.69	1380
41	Pinibindu CBO								
42	Sham Sham	–		–					
43	Ekamuthu CBO	264		0.14		Clear	0.05	7.6	640
44	Pradeepa	448		0.82		Clear	0.01	7.8	1150
45	Upul CBO	290		0.92		Clear	0	7.83	1000
46	Jalasavi	–		1.58		Clear	0.02	7.74	1330
47	Tristar CBO	300	–	0.001		2.5>	4.1	8.3	
48	Alhidra CBO	300		0.04	N/A	2.5	1.3	6.9	
49	Adhikwa CBO	280	–	0.7	N/A				
50	Hansajala CBO	442		1.8	N/A	<5	1	7.6	

In addition, out of 21 CBOs with a water quality data of hardness, 18 CBOs have above a desirable limit of 250 mg/L. The high concentration of hardness as well as fluoride is a big characteristics of this area.

(5) Water Supply Hours at CBOs

NWSDB NC has 24 water supply schemes and almost performs 24-hour water supply, which is ranked as the top class in NWSDB RSCs.

While looking at the study area, out of 46 water supply schemes surveyed, water supply hours are reportedly significantly limited during a dry period at 20 water supply schemes. They are less than five hours at ten schemes, five to ten hours at six schemes and ten to fifteen hours at four schemes. In addition, two water supply schemes limit the maximum water supply hours at eight hours. The water supply hours in the worst cases are two hours in Ekamuthu and three hours in Dimuthu, Samagi and Suwasetha.

Therefore, the people in the study area is forced the poor water supply conditions in comparison with other service area in NWSDB NC enjoying the 24-hour water supply.

(6) Technical Problems at Existing CBOs

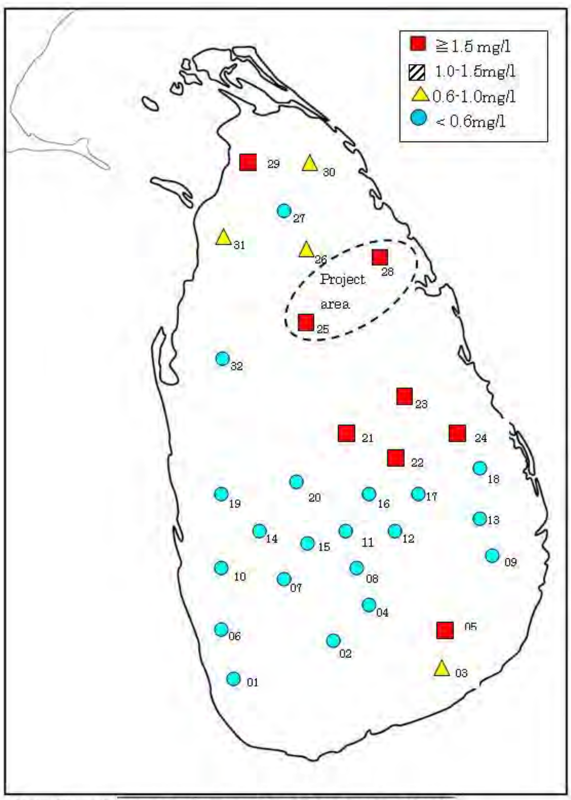
The existing CBO water supply systems have the following technical problems in structure, designing and operation.

- No master valves at water tanks and/or tube-well pumps are installed.
- Leakage from tanks and/or pipeline
- No operational valves (air valve, gate valve and wash-out valves, etc.) are installed.
- Insufficient pressure due to under-sized pipes
- No proper chlorination dosage.
- Unstable electricity supply (power cut/voltage variation)
- Invisible customer meters
- Malfunction of tube-well pump
- Little water in dry season

2.5.2 Dental Fluorosis

(1) Distribution of fluoride concentration of groundwater in Sri Lanka

Fluoride is present particularly in rocks, soils and water in Sri Lanka. Fluoride occurs naturally in water due to weathering of rocks that contain fluoride rich minerals such as hornblende; $NaCa_2(Mg,Fe,Al)_5(Si,Al)_8O_{22}(OH,F)_2$, biotite; $K(Mg,Fe)_3(AlSi_3O_{10})(OH,F)_2$, apatite; $Ca_5(PO4)_3(F,Cl,OH)$ and fluorite; $CaTiSi(O,F)_5$. In 1987, a nationwide field survey was carried out and fluoride in groundwater was revealed. From the survey results, the two major types of groundwater, Ca-Cl type and Ca-HCO_3 type, were selected and the fluoride concentrations of each were compiled. **Figure 2.21** shows the distribution of fluoride concentration in groundwater in Sri Lanka from the above survey. As shown in the figure, high concentration of fluoride occurs in several places and the study area is seriously affected. Detailed data are included in **Appendix 2.2**.



Note: Fluoride concentration ranged 1.0-1.5mg/l was not found

Source: "The Hydrogeochemical Atlas of Sri Lanka - 1985", Department of Geology, University of Peradenia

Figure 2.21 Distribution for Fluoride Concentration of Groundwater in Sri Lanka

(2) Distribution of Fluoride Concentration in the Study Area

NWSDB has been functioning as a testing laboratory not only for NWSDB facilities but also for other water supply organizations.

For the horizontal distribution (refer to **Figure 2.22**), it can be said that in 5 out of 6 DSD fluoride exceeded 0.6 mg/l and levels in excess of 1.5 mg/l of fluoride were found in Madawchchiya, Kahadagasdigilliya and Horowpathana. In Kebitigollawa fluoride was less than 0.6mg/l.

For vertical distribution, though it was not cleary distributed, there is a tendency that groundwater in deep aquifers has a higher fluoride concentration than that in shallow aquifers as shown in **Figure 2.23**. This is because groundwater generally occurs in association with geological materials containing soluble minerals and therefore higher concentrations of those minerals such as fluoride are normally expected in deep groundwater compared to shallow groundwater.

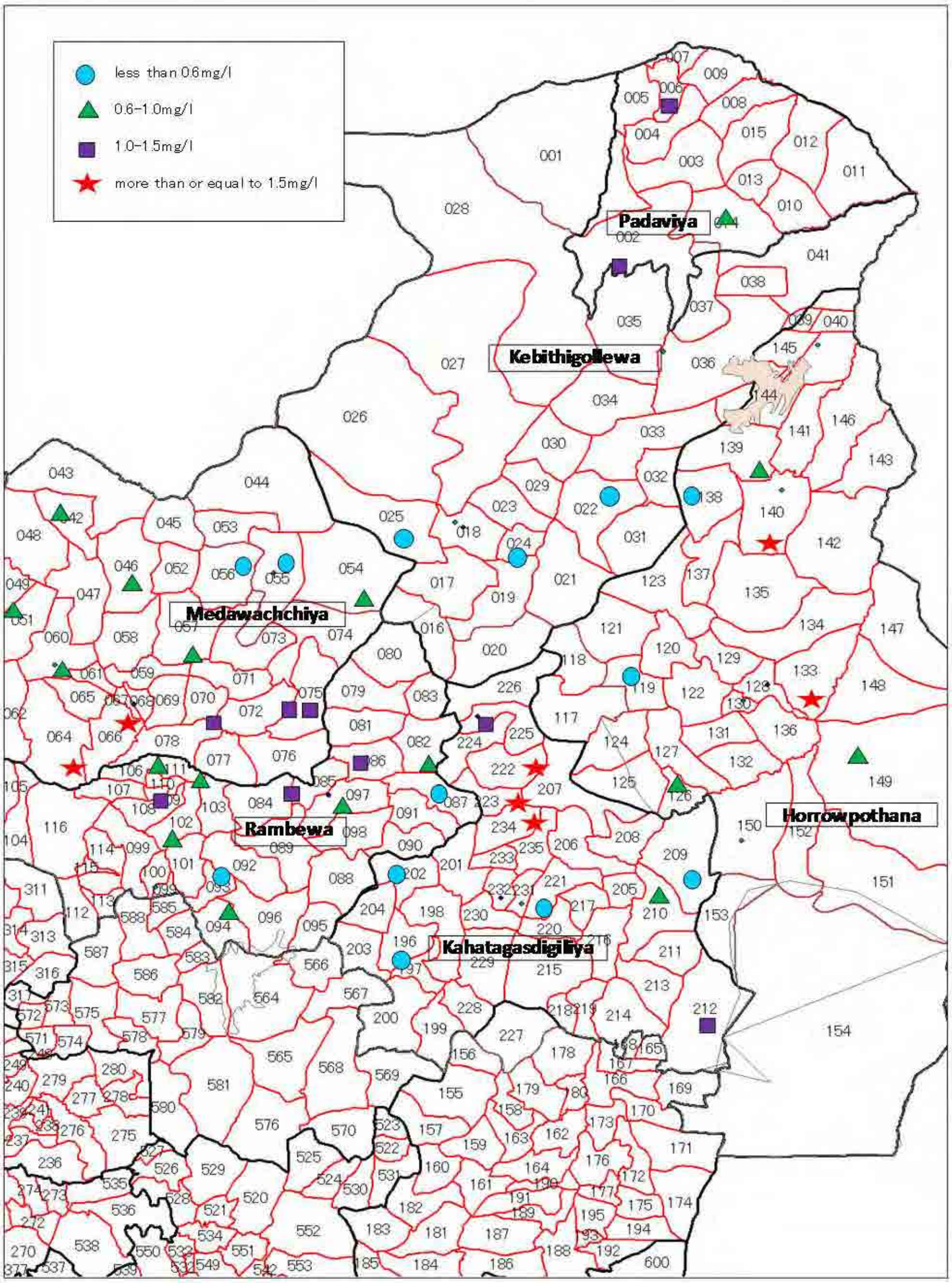


Figure 2.22 Fluoride Results for CBO Supply Water (Horizontal Distribution)

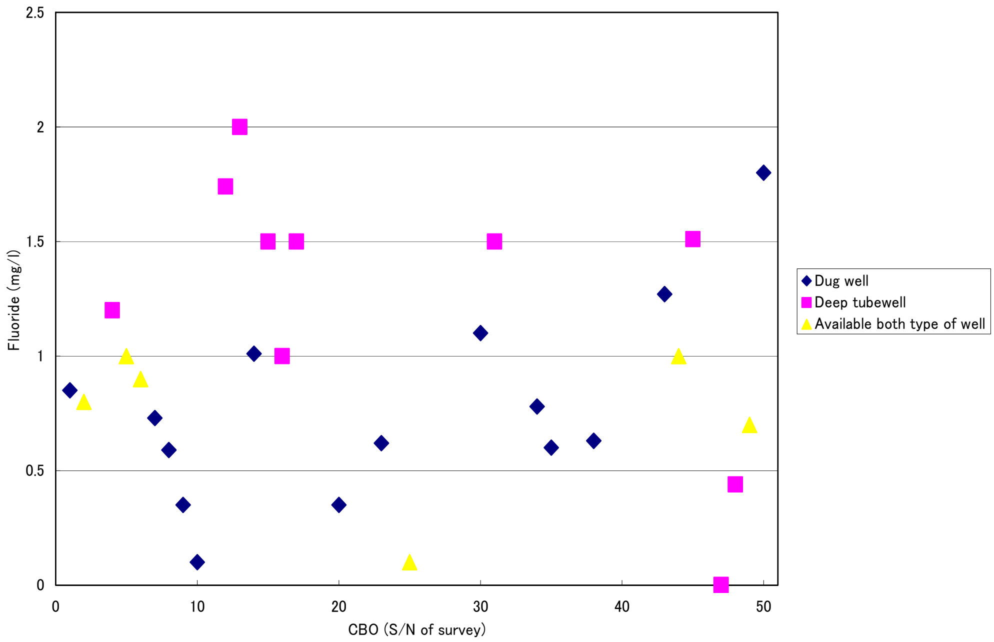


Figure 2.23 Fluoride Results for CBO Supply Water (Vertical Distribution)

(3) Results and Trend of Examination under JICA Study

Based on the existing data of groundwater as mentioned in the previous section, the JICA Study Team selected 16 groundwater sampling stations in order to examine water quality in detail. The selected sampling stations and their fluoride concentrations are shown in **Figure 2.24**. The field sampling was carried out in July 2012.

1) Methodology

The water samples for groundwarer quality analysis were collected from 16 sampling stations which were 14 CBO groundwater (dug wells and deep tubewells), 1 private dug well and 1 public spring well. The samples were systematically collected during the survey. The methods of sampling, analysis and quality assessment mentioned above were well planned and performed as follows.

(1-1) Sampling and field analysis

- For CBO groundwater, samples were collected from drains under each water tank which are used for chlorination. However, these drains were sometimes broken or not available and so it was not possible to take samples. In that case, samples were collected from the nearby tap.
- One private dug well was selected in Kebitigollawa, as there was no working CBO station in this location and people are drinking water from their own dug wells.
- One public spring well was also selected for the same reason as for the private dug well.
- The samples were collected in decontaminated containers, and were preserved during transport to the laboratory. All parameters are analysed in the laboratory except pH

which was measured at the sites mentioned above.

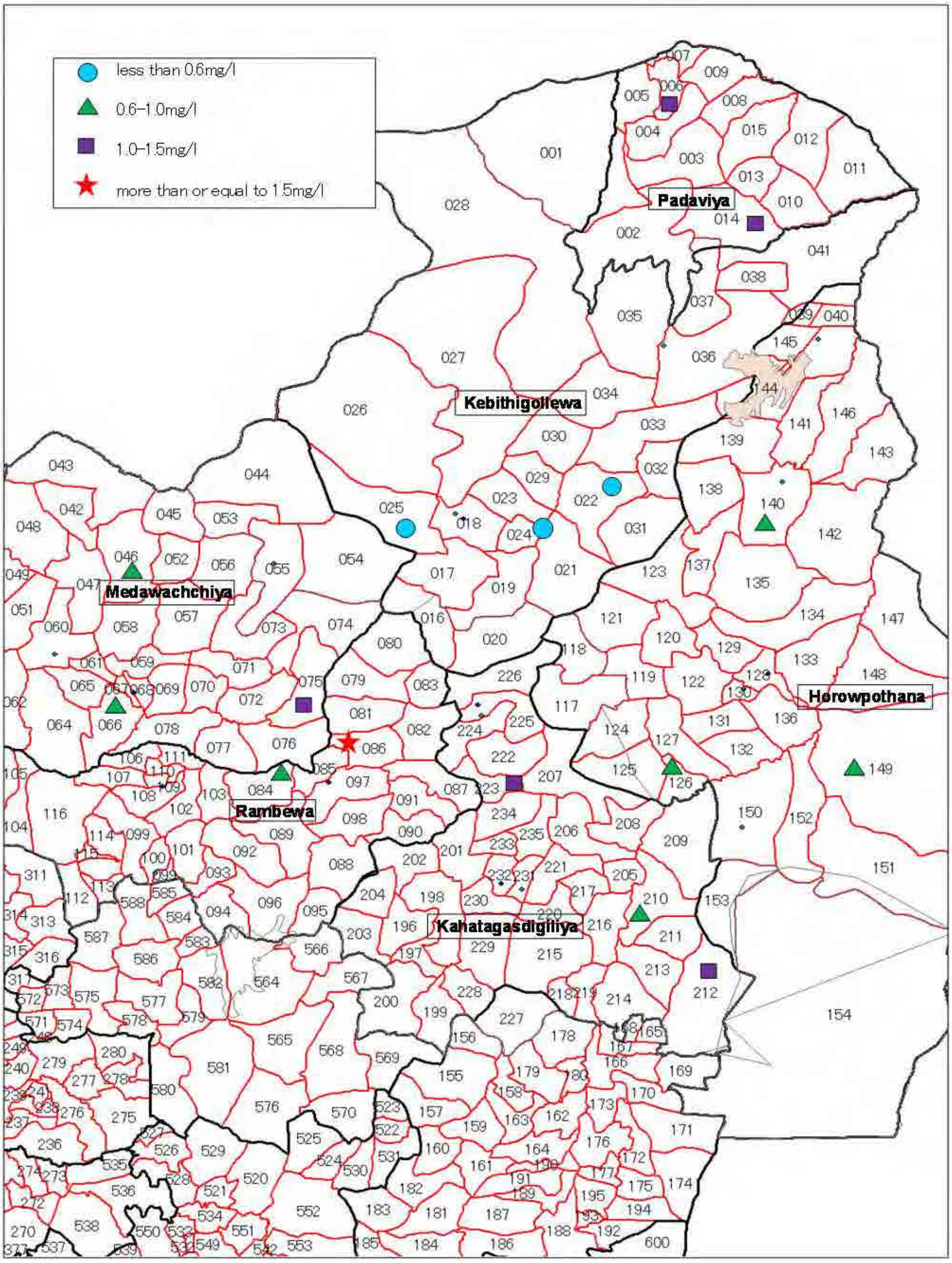


Figure 2.24 Selected Groundwater Sampling Stations and Fluoride Concentrations

Photos of sampling locations are shown in **Figure 2.25**.

Figure 2.25 CBO Water Tank (left) and Sampling Drain (Right)

(1-2) Laboratory analysis

The laboratory analyses was carried out at the SGS Lanka (Pvt) Ltd, the subcontractor's laboratory (hereafter SGS) which is accredited by Sri Lanka Accreditation Board (SLAB) and National Accreditation Board for Testing and Calibration Laboratories, India (NABL) under ISO 17025. The methods for the chemical and microbiological analysis of water are based on Sri Lankan drinking water standard 614:1983 and other standard methods such as APHA (American Public Health Association) or EPA (U.S. Environmental Protection Agency). **Table 2.18** outlines the test method followed.

Table 2.18 Analytical Parameters and Methods

Analytical item	Methods used
Colour	APHA 2120 B: 2005
Turbidity	APHA 2130 B: 2005
Odor	APHA 21st Ed. 2005, SLS 614: 1983 Part1
Taste	APHA 21st Ed. 2005, SLS 614: 1983 Part1
pH	APHA 4500 H+ B: 2005
Electrical Conductivity	APHA 2520 B: 2005
Chloride	APHA 4500-Cl B: 2005
Free residual chlorine	APHA 4500-Cl G: 2005
Free ammonia	SLS 614: 1983 Part 1, Appendix B
Nitrite	APHA 4500-NO2 B: 2005
Nitrate	APHA 4500-NO3 B: 2005
Albminoid ammonia	SLS 614: 1983 Part 1, Appendix B
Fluoride	APHA 4500-F- C: 2005
Iron	APHA 3500-Fe B: 2005
Sulphate	APHA 4500-SO_4^{2-} E: 2005
Alkalinity	APHA 2320 B: 2005
Total residue	APHA 2540 B: 2005
Hardness	APHA 2340 C: 2005
Phosphate	APHA 4500-P- C: 2005
As	APHA 3120B: 2005
Cd	APHA 3120B: 2006

2) Results

(2-1) General characteristics of targeted water sources

The results of the laboratory analysis for the selected groundwater are shown in **Table 2.19**. From these data, some general characteristics are found as mentioned below.

Since groundwater occurs in association with geological materials containing soluble minerals, higher concentrations of dissolved materials/parameters such as fluoride, hardness and electrical conductivity are observed in the survey results relative to the surface water results. All sampling stations show almost the same chemical characteristics except ones in Kebithigollewa DS division. They show lower fluoride, hardness and electrical conductivity. It can be said that groundwater samples in Kebithigollewa contain less carbonate minerals and it may relate to fluoride content as mentioned later.

Another problem is observed through the results even though it is not groundwater quality itself. All samples of “sampling point B”, which were sampled at a tap close to the water tank, show no free residual chloride. It means this water distributed to users is not chlorinated properly.

The chlorination of drinking water supplies has greatly reduced the prevalence of waterborne diseases as it is effective against almost all bacteria and viruses. Therefore, it is essential for water treatment. This needs to be remedied immediately.

(2-2) Fluoride

Fluoride is one current problem for drinking water in the project area. A total of 6.3% of fluoride samples exceeded the permissible limit, and 81% exceeded the desirable Sri Lankan drinking water standard. This occurrence is originated from minerals as mentioned before. It is notable that only one sample exceeded the permissible standard but the permissible standard is going to be revised (apparently by 2013) from 1.5 to 0.6mg/l. It means that 81% of surveyed CBO groundwater will exceed the revised standard of fluoride. Fluoride is distributed widely throughout the project area except Kebitigollewa.

(2-3)Hardness

High hardness concentration may cause scale deposition in the treatment works, distribution system and pipework and tanks within buildings. It also results in excessive soap consumption and subsequent “scum” formation. When such water is heated, deposits of calcium carbonate scale are also formed. A total of 13% of hardness samples exceeded the permissible limit, and 75% exceeded the desirable Sri Lankan drinking water standard.

Table 2.19 The results of the laboratory analysis for the selected groundwater

DSD	S/N of GND	Sampling station	Sampling point	Type of water source	Date	Odor	Colour	Turbidity	Taste	pH	Electrical C	Chloride	Free residual C	Free ammonia	Alkalinity	Albminoid ammonia	Nitrite	Nitrate	Fluoride	Phosphate	Total residue	Hardness	Ion	Arsenic	Cadmium	Sulphate
							Hazen Unit	NTU		-	μS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/l	mg/L	mg/L	mg/L	mg/L	mg/L
Rambewa	84	CBO	B	Deep tubewell	12/07/10	Unobject.	<2.5	1.1	objectional	7.2	952	121	<0.01	<0.01	340	0.02	<0.01	0.64	0.92	0.4	584	329	<0.1	<0.02	<0.005	42
	86	CBO	B	Dugwell	12/07/10	Unobject.	<2.5	1.1	objectional	7.4	1430	204	<0.01	<0.01	468	0.03	<0.01	1.2	1.5	0.39	971	630	<0.1	<0.02	<0.005	42
Madawachchiya	46	CBO	B	Dugwell	12/07/10	Unobject.	<2.5	1	objectional	7.2	689	34	<0.01	<0.01	357	0.02	<0.01	<0.05	0.73	<0.15	444	265	<0.1	<0.02	<0.005	17
	66	CBO	A	Deep tubewell	12/07/10	Unobject.	<2.5	1	Object.	7.4	1571	237	<0.01	<0.01	468	0.03	<0.01	0.37	0.98	0.54	943	489	<0.1	<0.02	<0.005	49
	75	CBO	B	Dugwell	12/07/10	Unobject.	<2.5	1	Unobject.	7.1	837	58	<0.01	<0.01	386	<0.01	<0.01	2.7	1.2	0.3	614	471	<0.1	<0.02	<0.005	6.6
Kebithigollewa	22	Private well	C	Dugwell	12/07/11	Unobject.	<2.5	0.9	Unobject.	6.7	473	49	<0.01	<0.01	160	0.01	<0.01	2.1	0.22	0.47	385	203	<0.1	<0.02	<0.005	13
	24	CBO	A	Dugwell	12/07/11	Unobject.	<2.5	0.8	Unobject.	6.9	619	51	<0.01	<0.01	287	0.01	<0.01	<0.05	0.29	0.37	415	248	<0.1	<0.02	<0.005	6
	25	Public well	C	Spring	12/07/11	Unobject.	<2.5	0.9	Unobject.	5.4	140	42	<0.01	<0.01	107	<0.01	<0.01	0.87	0.06	0.19	113	79	<0.1	<0.02	<0.005	2.4
Padaviya	6	CBO	B	Deep tubewell	12/06/29	Unobject.	<2.5	0.3	Unobject.	7.3	681	47	<0.01	<0.01	328	0.02	<0.01	0.14	1.1	0.69	453	269	<0.1	<0.02	<0.005	19
	14	CBO	B	Dugwell	12/06/29	Unobject.	<2.5	0.3	Unobject.	7.2	750	43	<0.01	<0.01	340	0.02	<0.01	1.1	1.2	0.86	542	290	<0.1	<0.02	<0.005	25
Kahatagasdigiliy	210	CBO	B	Dugwell	12/07/12	Unobject.	<2.5	1.1	Unobject.	7.4	922	135	<0.01	<0.01	299	<0.01	<0.01		0.62	0.81	598	286	<0.1	<0.02	<0.005	9.3
	212	CBO	B	Dugwell	12/07/12	Unobject.	<2.5	0.9	Object.	7.5	1347	169	<0.01	<0.01	492	<0.01	<0.01	1.9	1.4	0.54	898	621	<0.1	<0.02	<0.005	42
	223	CBO	B	Dugwell	12/07/10	Unobject.	<2.5	0.8	Unobject.	7.1	1140	135	<0.01	<0.01	414	0.05	<0.01	0.48	1.1	0.76	713	88	<0.1	<0.02	<0.005	25
Horowpothana	126	CBO	B	Deep tubewell	12/07/11	Unobject.	<2.5	0.8	Unobject.	7.2	1149	138	<0.01	<0.01	439	<0.01	<0.01	0.09	0.92	0.61	753	555	<0.1	<0.02	<0.005	18
	140	CBO	B	Deep tubewell	12/07/11	Unobject.	<2.5	1	Unobject.	7.3	1444	194	<0.01	<0.01	468	0.01	<0.01	0.15	0.74	<0.15	1028	574	<0.1	<0.02	<0.005	39
	149	CBO	B	Deep tubewell	12/07/11	Unobject.	<2.5	1.2	Unobject.	7.4	928	109	<0.01	<0.01	312	<0.01	<0.01	0.36	0.95	<0.15	646	314	<0.1	<0.02	<0.005	39
Sri Lanka Standards (Desireble)						-	5	2		7.0-8.5	750	200			200				0.6	-	500	250	0.3	-	-	200
Sri Lanka Standards (Permissible)						Unobject.	30	8	Unobject.	6.5-9.0	3500	1200	0.2	0.06	400	0.15	0.01	10	1.5	2	2000	600	1	0.05	0.005	400

Sampling point A: Sampled before tubewell water enters the water tank
Sampling point B: Sampled at a tap close to the water tank
Sampling point C: Sampled directly from the well

(2-4) Relationship between fluoride and other parameters

It seems that there is some relationship between fluoride and other parameters as shown below. As mentioned before, the groundwater samples in Kebithigollewa show different characteristics including lower fluoride. There is one possibility that higher groundwater movement may occur in

Kebithigollewa. It is also suggested by the presence of spring water well in Kebithigollewa and the fact that the fluoride concentration of the spring well is quite low (0.06 mg/l).

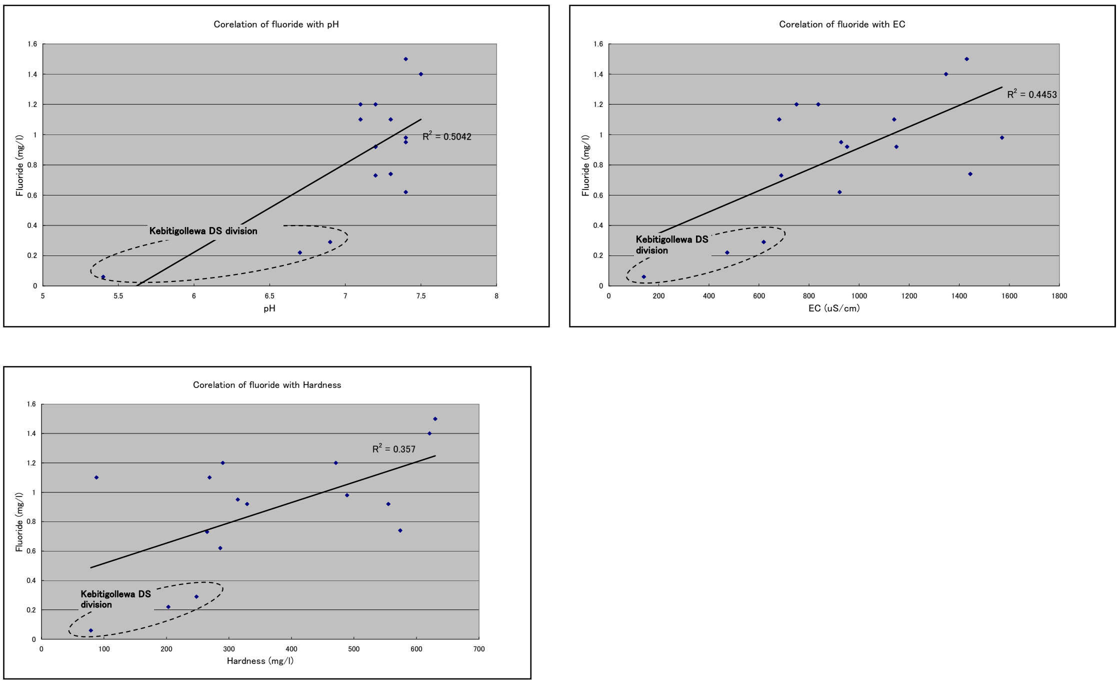


Figure 2.26 Relationship between fluoride and other parameters

3) Conclusion

The results of groundwater survey show non-conformity to the drinking standard of several parameters, namely taste, pH, electrical conductivity, free residual chlorine, alkalinity, fluoride, total residue and hardness. Especially high levels of fluoride and lack of free residual chlorine are most serious, and require immediate action.

As for relationship between fluoride and other parameters, the survey results show that high concentrations of fluoride mainly occurs at higher pH, electrical conductivity and hardness which indicate higher mineral contents. A spring well sample in Kebithigollewa which has higher groundwater movement shows quite low fluoride level and other samples in Kebithigollewa showed similar trends.

(4) Dental Fluorosis

Dental fluorosis has been recognized as an endemic problem affecting different areas of Sri Lanka with naturally occurring fluorides in drinking water. In 2002-2003, the National Oral Health Survey was conducted by the Ministry of Health and Nutrition under cooperation of WHO (see **Appendix 2.3**). The following results have been extracted from the above survey and the CFI (Community Fluorosis Index) in each district was calculated by the JICA Study Team. Though 12, 15 and 35-44 age of people were surveyed in the said survey, only the results of 12 age were extracted and used as dental fluorosis significantly occurs until such age.

The CFI was first published in 1934 and finalized in 1942. This index became the most universally accepted classification system for dental fluorosis.

(1) Classification of Criteria of Cases

The survey was done by interviews and clinical oral examination, and the classifications of criteria for dental fluorosis are as follows.

Table 2.20 Classification of Criteria of Cases

Score	Criteria	Weightage
0-Norrnal	The enamel surface is smooth, glossy	0.0
1-Questionable	The enamel shows slight aberntions from the translucency of normal enamel. May range from white flakes to occasional spots.	0.5
2-Very mild	Small opaque white areas scattered over tooth but involving less than 25% of labial surface.	1.0
3-Mild	White opacity covers less than 50% of the tooth surface.	2.0
4-Moderate	The enamel surface show marked wear and brown stain is frequently disfiguring.	3.0
5-Severe	Enamel surface badly affected, Pitted, worn areas and brown stains are widespread.	4.0

Source: the National Oral Health Survey 2002-2003

To calculate the Community Fluorosis Index, weight age is given. The CFIs are calculated according to the formula,

$$CFI = \Sigma \text{weightage x number in each score group/number of cases examined}$$

If the CFI is above 0.6, generally it can be said that dental fluorosis is a public health problem in the area.

(2) Prevalence of Dental Fluorosis

The prevalence of dental fluorosis was evaluated by CFI. The said survey results and calculated

CFI are shown in **Table 2.21**.

Table 2.21 Survey Results and Calculated CFI

No	Districts	Questionable (%)	Very mild (%)	Mild (%)	Moderate (%)	Severe (%)	CFI
1	Colombo	0	0	1.3	0	0	0.03
2	Gampaha	0	0	0	0	0	0.00
3	Kalutara	0	0	0.8	2.5	0	0.09
4	Kandy	0.8	0.8	0	0	0	0.01
5	Matale	7.5	7.5	17.5	22.5	0	1.14
6	N' Eliya	0	1.3	0	0	0	0.01
7	Galle	2.5	2.5	0	0	0	0.04
8	Matara	0	5	1.3	0	0	0.08
9	Hambantota	11	8.5	4.9	7.3	6.1	0.70
10	Jaffna	1.3	2.5	2.5	1.3	0	0.12
11	Vavunia	2.9	10.5	2.6	5.3	0	0.33
12	Batticaloa	0	0	0	0	0	0.00
13	Ampara	1.3	10	2.5	5	0	0.31
14	Trincomale	2.5	0	0	0	0	0.01
15	Kurunegala	7.5	8.8	6.3	3.8	0.6	0.39
16	Puttalam	0	0	1.3	0	0	0.03
17	Anuradhapura	3.8	18.8	31.3	12.5	5	1.41
18	Polonnnaruwa	2.5	22.5	5	2.5	0	0.41
19	Badulla	2.5	3.8	3.8	0	0	0.13
20	Monaragala	8.8	6.3	2.5	3.8	0	0.27
21	Ratnapura	4.2	1.7	5.8	4.2	1.7	0.35
22	Kegalle	0	1.3	0	1.3	0	0.05

Source: the National Oral Health Survey 2002-2003 except CFI

Note: No. of Districts is different from current situation as the survey was done in 2002-2003

(3) Comparison and District-wise Distribution of Dental Fluorosis

Based on the calculated CFI, the comparison of Anuradhapura with other districts and CFI distribution is shown in **Figure 2.27** and **Figure 2.28**.

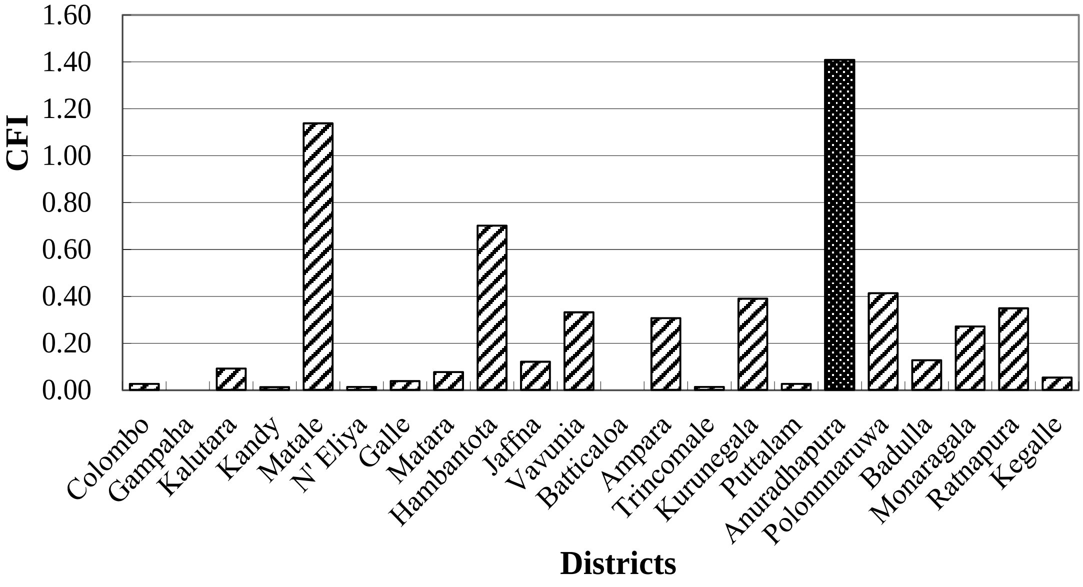


Figure 2.27 Comparison of CFI

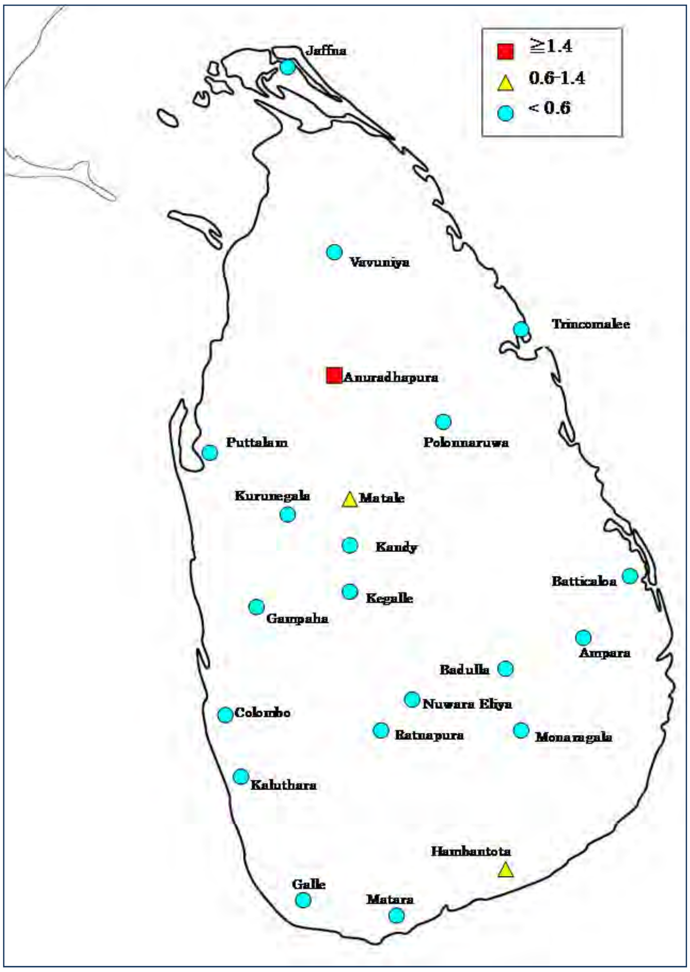


Figure 2.28 District-wise of CFI

(4) Conclusion

There was a distinct regional variation in the prevalence as well as severity of dental fluorosis in the districts of Anuradhapura and Matale followed by Hambantota. Anuradhapura district had the highest CFI at 1.41. As stated previously if the CFI is greater than 0.6, then this is a public health problem and as such immediate countermeasures are required in Anuradhapura district. Obviously one of causes of a high CFI is the high fluoride level in drinking water and therefore a safe drinking water supply is urgently required.

2.5.3 Chronic Kidney Diseases (CKD)

Chronic kidney disease (CKD) is a progressive loss in renal function over a period of months or years. CKD is an emerging health problem and it has a high economical cost on the patient, family, community and health system. In recent years, an increase in CKD cases has been observed in some parts of the country especially in the North Central provinces.

(1) Classification of Criteria of Cases

Generally the severity of chronic kidney disease is classified into five stages, with stage 1 being the mildest and usually causing few symptoms and stage 5 being a severe illness with poor life expectancy, if untreated. However, severity of CKD was not classified and individual patients were simply counted in the following two surveys. In the surveys CKD was identified by a blood test and testing of a urine sample.

(2) Prevalence of CKD

1) Prevalence of CKD in some selected area in Sri Lanka

In 2010, a survey was carried out by Peradeniya University and this showed that Medwachiya, which is a part of the study area, had the highest prevalence of CKD among the adult (more than 18 years) population at 3.7% and 5% of the overall population, in comparison to other regions surveyed. **Table 2.22** shows the prevalence of CKD. It can be said that the study area covers locations where there are public health problems.

Table 2.22 Prevalence of CKD in Some Selected Area in Sri Lanka

Province	**North Central**	North Central	Uva	Central	Southern	Eastern
Region	**Medawachchiya**	Huruluwewa	Girandurukotte	Yatinuwara	Hambanthota	Ampara
Year surveyed	**2003**	2001-2005	2006	2004	2008	2008
Sample size	**4,107**	233	1,345	253	4,023	3,232
CKD prevalence >18 years (%)	**3.7**	3.2	3.9	3.2	2.53	2.2
Overall Population (%)	**5**	0.2	4	3.2	3.49	3.15

Source: Chronic kidney diseases of uncertain etiology (CKDue) in Sri Lanka, 2010

2) DSD-wise prevalence of CKD in North Central Province

Since 2003, the Provincial Department of Health Services has also conducted a DSD-wise CKD prevalence survey in the North Central Province. As the survey periods were different in each district, the data were averaged by the JICA Study Team, in order to facilitate comparison with each other, as shown in **Table 2.23**.

Table 2.23 DSD-wise CKD Prevalence Survey in North Central Province

In Anuradhapura District					
No	MOH(≒DSD) area	Total patients in 2003-2011	Patient in av./year	Population in 2010	Patient in av./year/poplation
1	Galenbidunuwewa	207	23	51664	0.04%
2	Galnewa	64	7	36937	0.02%
3	*Horowpothana*	*274*	*30*	45329	0.07%
4	Ipalogama	73	8	41967	0.02%
5	*Kahatagasdigiliya*	*330*	*37*	42859	0.09%
6	*Kebitigollewa*	*878*	*98*	23938	0.41%
7	Kekirawa	107	12	87592	0.01%
8	*Medawachchiya*	*2723*	*303*	53240	0.57%
9	Mihintale	156	17	34546	0.05%
10	Nochchiyagama	123	14	53270	0.03%
11	Nuwaragampalatha Central	346	38	87936	0.04%
12	Nuwaragampalatha East	262	29	101256	0.03%
13	*Padaviya*	*2275*	*253*	35432	0.71%
14	Palagala	29	3	37414	0.01%
15	Rajanganaya	53	6	37773	0.02%
16	*Rambewa*	*659*	*73*	44917	0.16%
17	Thalawa	160	18	63153	0.03%
18	Thambuthtegama	73	8	42752	0.02%
19	Thirappane	102	11	35024	0.03%
In Polonnaruwa District					
No	MOH(≒DSD) area	Total patiants in 2006-2011	Av. /year	Population in 2010	Patiant in av./year/poplation
1	Dimbulagala	440	73	54231	0.14%
2	Elahera	475	79	46371	0.17%
3	Hingurakgoda	209	35	61171	0.06%
4	Lankapura	181	30	39150	0.08%
5	Medirigiriya	228	38	68375	0.06%
6	Thamankaduya	225	38	88164	0.04%
7	Welikanda	176	29	42999	0.07%

(3) DSD-wise Distribution of CKD prevalence

From the survey on DSD-wise prevalence of CKD in the North Central area, the prevalence in each DSD were compared as shown in **Figure 2.29**. As shown in the figure, the distribution on the prevalence of CKD is not equal, with the highest rates in Medawachchiya, Kebitigollewa and Padaviya, which are all within the study area.

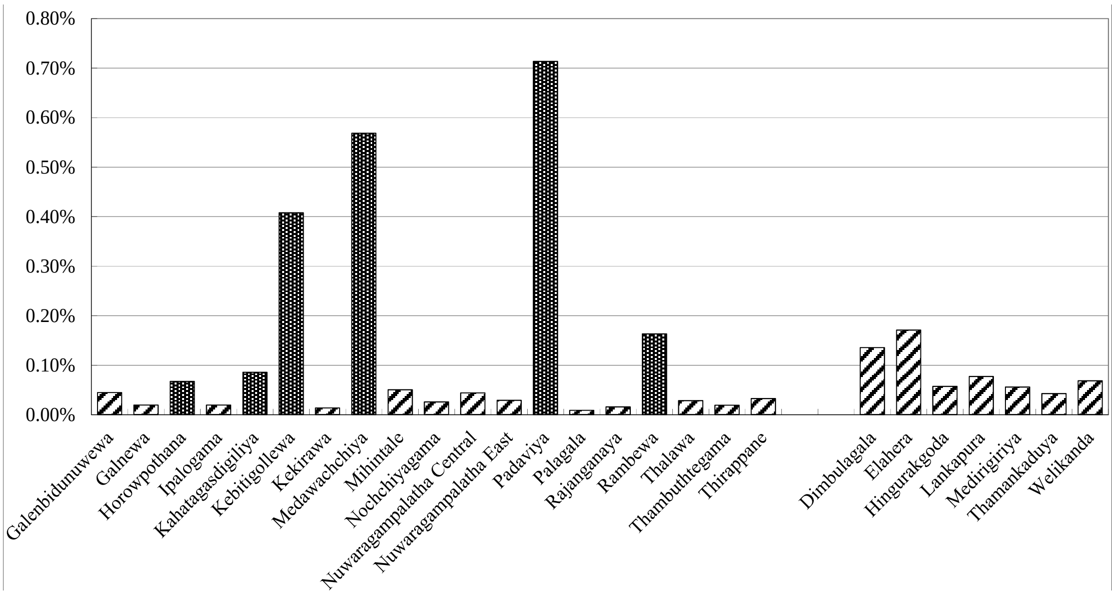


Figure 2.29 DSD-wise Distribution of CKD in North Central

(4) Conclusion

Compared to dental fluorosis, the causes of CKD are still unclear. For example, in Padaviya and Medawachchiya there are high levels of fluoride in drinking water and high levels of prevalence of CKD. On the other hand, in Kebitigollewa the level of fluoride in drinking water is low, but the prevalence of CKD is high. More detailed investigation will be needed to identify the cause(s) of CKD. However, at least it is considered that high fluoride levels of drinking water causes worsening CKD for CKD patients. Provision of treated surface water supply which is able to supply lower levels of fluoride will help to protect people's daily life.

2.5.4 Necessity of the Project

As mentioned above, the necessity of the project can be summarized as follows:.

The people in the study area are facing the following problems regarding the principal water source and existing water supply schemes.

- According to the Census 2011, 75.4% of the people in the study area rely on groundwater as the principal water source and 18.9% of the people use tap water through the NWSDB's and CBO's water supply schemes. However the water source of such water supply schemes is groundwater with a few exceptions

- The people in the study area are forced to be engaged in the water-fetching work for a distance longer than that in other districts.
- Four out of five persons are exposed to the risk of fluorosis in the study area.
- Many existing CBO's water supply schemes have experienced the water shortage during the dry season and cannot maintain the 24-hour water supply.
- Most existing CBO's water supply schemes have a variety of problems in structure, designing and operation.

Then water quality problem. Water quality of drinking water sources is an important issue which is directly related to the health of residents. Therefore, a groundwater quality survey of the current drinking water source was conducted. As a result, it was found in the survey that the most significant problem is the high concentration of fluoride. It was also confirmed that dental fluorosis due to high level fluorosis has occurred in Anuradhapura and the prevalence is higher than in other districts.

Removal of fluoride from the current groundwater sources is unrealistic from the viewpoint of technical and economic considerations. Therefore, it is urgently necessary to proceed with a project which utilizes surface water sources with low fluoride concentration. In addition, although Anuradhapura has been known as an area with a high prevalence of CKD, DSDs with a high prevalence of CKD were also found within the project area. However, no clear cause of CKD has been identified yet. For example, the project survey found that some DSDs showed a high prevalence of CKD with high fluoride concentration in drinking water sources, but in other DSDs there was no relationship between the CKD and fluoride concentrations. However, even if it is not possible to identify the causes of CKD, at least it is well known that high fluoride levels of drinking water causes worsening CKD for CKD patients[8]. Conversion to surface water sources which is able to supply lower levels of fluoride will significantly contribute to residents health.

As mentioned above, in order to solve the current water quality and quality problem, it is essential to implement this project promptly.

[8] *Based on the talk of Dr. Akio Koizumi, Professor of Graduate School of Medicine, Kyoto University, Kyoto, Japan*

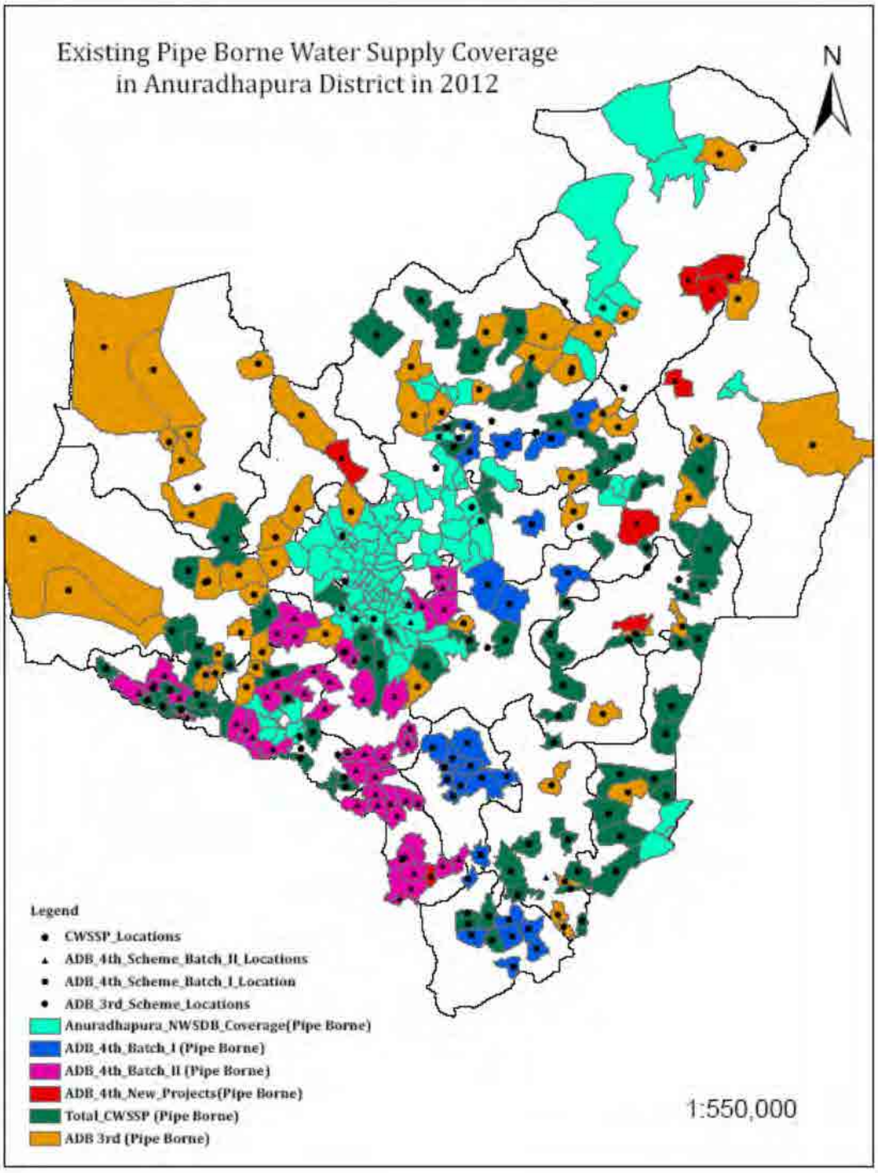
CHAPTER 3

EXISTING WATER SUPPLY FACILITIES IN THE STUDY AREA

CHAPTER 3 EXISTING WATER SUPPLY FACILITIES IN THE STUDY AREA

3.1 Water Supply Schemes in Anuradhapura District

Water supply schemes in Anuradhapura District are classified into those operated and maintained by NWSDB and Community-Based Organizations (CBOs) as shown in **Figure 3.1**. Water supply schemes under CBOs are further categorized into those constructed under ADB 3rd and 4th projects and Community Water Supply and Sanitation Project (CWSSP) under the WB's assistance, but they are hereinafter named generically CBOs.



Note: As shown in **Table 3.1**, NWSDB has 18 water supply systems in Anuradhapura District, but some of them are not shown herein.

Figure 3.1 Water Supply Schemes under NWSDB and CBOs in Anuradhapura District

Water supply schemes in Anuradhapura District are summarized as shown in **Table 3.1**.

Table 3.1 Water Supply Schemes in Anuradhapura District

No of families	171,060
Population	855,304
Water Supply Schemes - NWSDB	18
No of service connections - NWSDB	54,220
Total No. of Beneficiaries - NWSDB	325,320
Piped water coverage - NWSDB	37%
Rural Schemes Coverage - CBO	19%
Total Piped Water Supply Coverage in the District	56%

Source: NWSDB RSC(N/C)

Note: A water supply scheme means the working unit in NWSDB, which is not necessarily established based on the service area of each water treatment plant. The large-scale water treatment plant or project is handled as one of working units, therefore there may be separate water supply schemes for a water treatment plant and water transmission and distribution system under one water supply system. The number of water supply schemes in **Table 3.1** shows the number of independent water supply systems.

The CBO organizes the people and participates the distribution pipe installation work in the form of labour contribution using the materials provided by the government in the rural areas and is responsible for operation and maintenance of water supply facilities under a self-support accounting system placing the person–in-charge after its completion. However, most of CBOs are facing the difficulties in inadequate quantity of water supplied, deteriorating quality of water, increasing cost, inadequate revenue, lack of technical expertise and social and managerial problems.

NWSDB, in response to the requests from the CBOs and other agencies concerned, has taken the following steps to mitigate above situation.

- Establishment of rural water supply and sanitation units in all districts to provide necessary back up support for CBOs.
- Amending NWSDB act to facilitate activities of CBOs
- Enactment of bylaws
- Establishment of Credit Development Fund
- Enhance facilities for water quality testing
- Strengthening of coordination of sector partners by provincial level coordination meetings

For the study area, there are 56 water supply schemes in total in the project areas including 50 numbers of CBOs facilities and 6 number of NWSDB facilities out of which Rambewa is not an independent system but a part of Anuradhapura North and Mihintale WSSs with both water sources in Nuwarawewa. Piped water is in fact being supplied to approximately 55,000 people

(CBO 39,000 pers, NWSDB 16,600 pers) through CBO and NWSDB facilities, which is approximately 27% of the population in the six DSDs (refer to **Section 3.3** for more details).

The situations of NWSDB in Anuradhapura District and NWSDB and CBOs in the Study Area are described in **Sections 3.2 to 3.4**, respectively.

3.2 Existing Water Supply Facilities under NWSDB in Anuradhapura District

There are 24 water supply schemes operated by NWSDB (NC). Out of these 24 schemes, 18 are located in Anuradhapura District, whereas six are located in Polonnaruwa District Existing water supply facilities (schemes) in NWSDB (NC), Anuradhapura District and Polonnaruwa District are outlined in the following table by water source, treatment process, production capacity (m^3/d) and year constructed. Detailed information is shown in **Appendix 3.1**.

Five schemes in Anuradhapura District are located in the study area, namely Kebithigollewa, Kahatagasdigiliya, Horowpothana, Medawachchiya and Padaviya.

Table 3.2 Existing Water Supply Facilities in NWSDB (NC)

No.	Scheme	Water Source	Treatment Process	Served Population	Production (m^3/d)	Year Constructed
Anuradhapura District						
1	Anuradhapura New Town	Surface water	Full (RSF+Cl)	43,476	10,761	1972/84/05
2	Anuradhapura East	Surface water	Full (RSF+Cl)	20,000	2,787	2005
3	Anuradhapura North	Surface water	Full (RSF+Cl)	21,968	4,000	2008
4	Mihintale	Surface water	Full (RSF+Cl)	10,000	1,700	1985
5	Sacred City	Surface water	Full (RSF+Cl)	17,000	4,500	1984
6	*Medawachchiya*	Groundwater	Bleaching	5,000	-	1985
7	*Kebithigollawa*	Groundwater	Full (RSF+Cl)	3,200	600	1975
8	*Padaviya*	Groundwater	Chlorination	2,400	350	1991
9	*Kahatagasdigiliya*	Groundwater	Chlorination	3,800	350	1982
10	*Horowpothana*	Groundwater	Chlorination	650	150	1977
11	Thambuttegama	Surface water	Full (RSF+Cl)	11,500	1,500	1988
12	Eppawala	Surface water	Full (RSF+Cl)	600	120	1984
13	Maradankadawala	Surface water	Chlorination	5,000	4,000	2007
14	Kekirawa	Groundwater	Full (RSF+Cl)	20,500	3,300	1985
15	Habarana	Groundwater	Chlorination	3,000	400	1986
16	Galnewa-Bulnewa	Surface water	Full (RSF+Cl)	11,000	1,200	2002
17	Thalawa	Surface water	Full (RSF+Cl)	16,943	2,200	2007
18	Nachchaduwa	Surface water	Full (RSF+Cl)	7,000	980	2007
Polonnaruwa District						
19	Polonnaruwa	Surface water	Full (RSF+Cl)	35,000	5,232	1986
20	Hingurakgoda	Surface water	Full (RSF+Cl)	11,500	2,200	1986
21	Minneriya	Surface water	Full (RSF+Cl)	7,600	2,300	2003
22	Dimbulagala	Groundwater	Chlorination	-	200	1985
23	Bakamuna	Surface water	Full (RSF+Cl)	-	1,000	2003
24	Gallalla	Surface water	Full (RSF+Cl)	-	13,500	2011
25	Dehiattakandiya	Surface water	Full (RSF+Cl)	4,785	800	1993

Note: Although there are a total of 33 water supply schemes under the RSC(N/C) – 21 in the Anuradhapura district, and 12 in the Polonnaruwa district. **Table 3.2** shows only those that data is available.

The large- and medium-scale schemes mostly use surface water and with full treatment used, typically pre-chlorination + aeration + sedimentation + rapid sand filtration + post-chlorination. The small-scale schemes are using ground water (bore holes and tube wells) with chlorination for treatment. The development of water supply started in Anuradhapura Town in 1972 and expanded to the fringe areas to the east and north in the 2000’s. Other medium-scale schemes were developed in the 1980’s and small-scale schemes in the 1980-90’s.

Usually mechanical and electrical equipment in water treatment plants and pump stations has deteriorated 20 to 30 years after construction. Therefore, some facilities which were constructed in the 1980’s need rehabilitation or augmentation due to the increase in water demand.

The water supply system in NWSDB RSC(N/C), supplies water 24 hours, 7 days a week, except when there is a power failure, repair of leakage etc, which occasionally occurred.

As for the quality of water, high fluoride concentrations and hardness were recorded in the water, which is supplied from some water supply systems which have ground water sources, such as Medawachchiya, Padaviya, Kahatagasdigiliya, Horowpothana, Eppawala and Kerira High fluoride concentrations and hardness were recorded in the dry season between June and September.

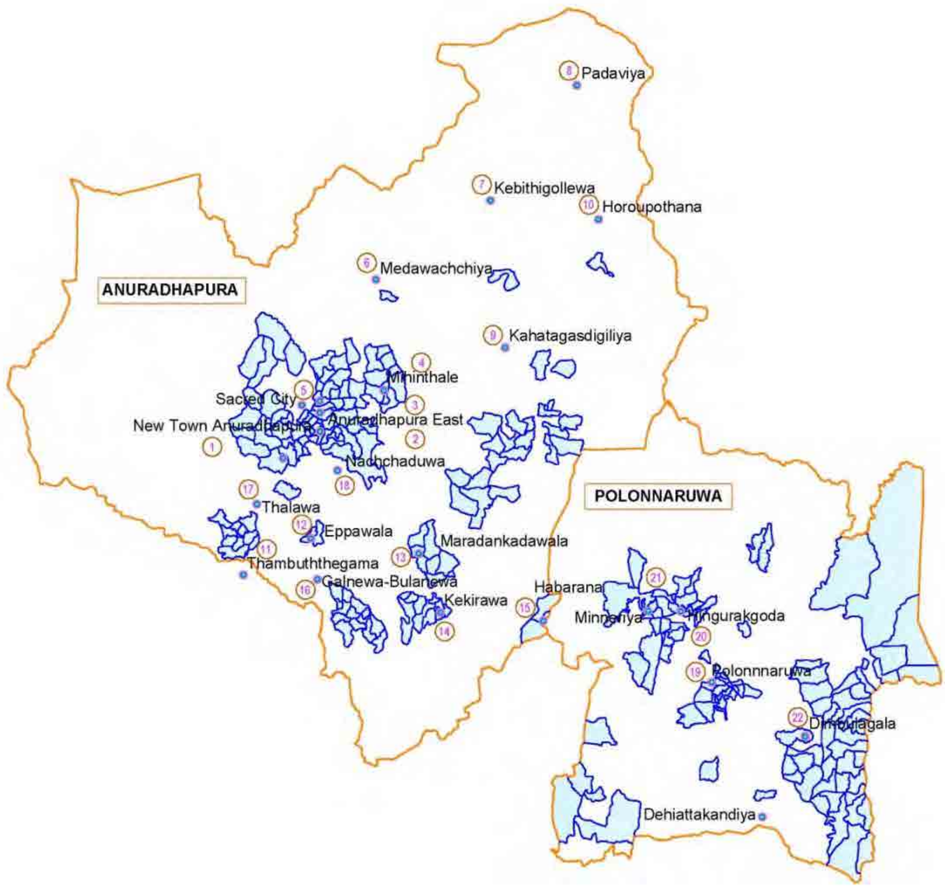


Figure 3.2 Existing Water Supply Facilities in NWSDB (NC)

3.2.1 Organizational

(1)Operation and Maintenance Organisation

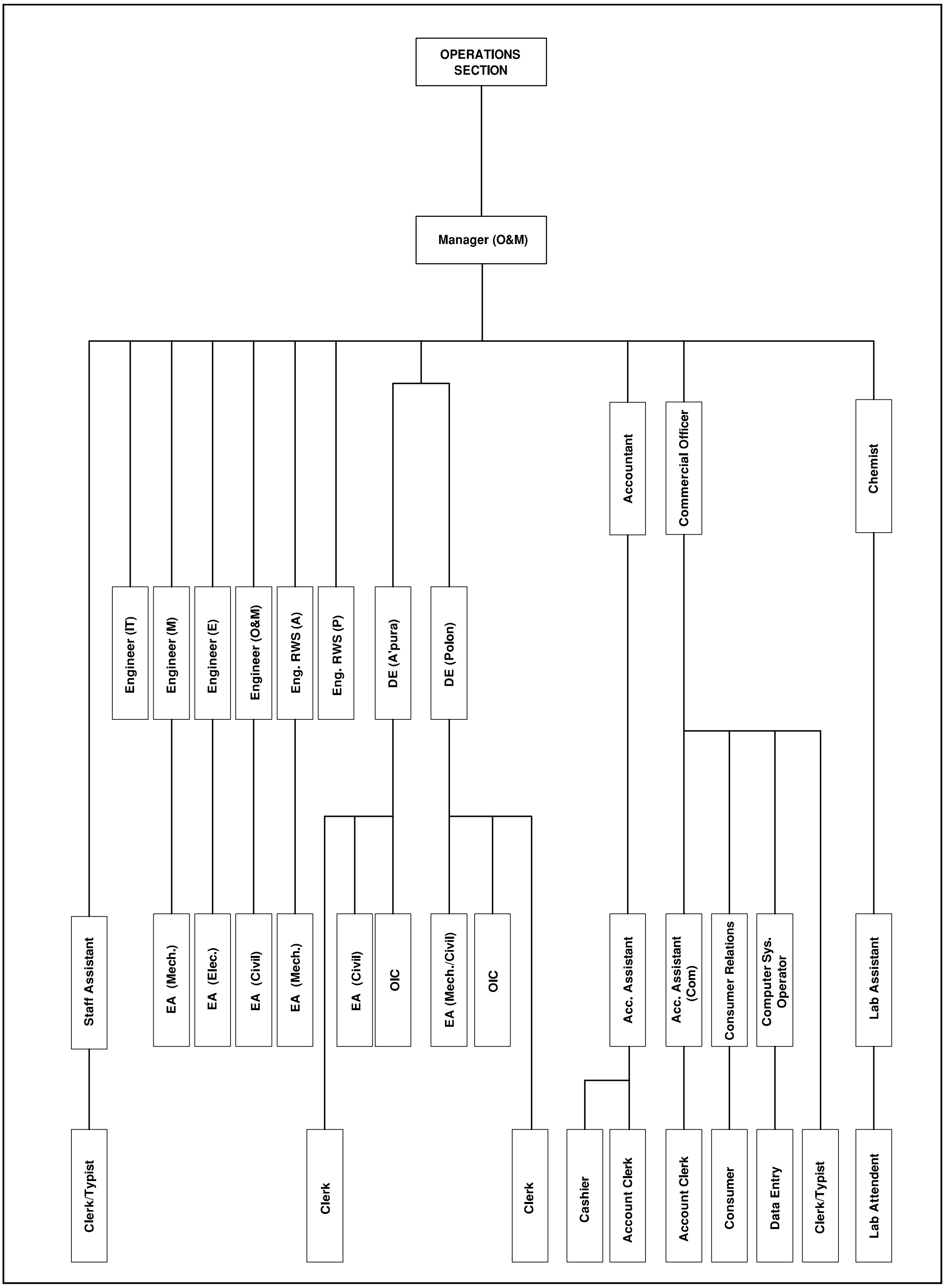
The sound operation and maintenance (O&M) of the facilities after completion entails an organisation that is ready, capable, and skilled in performing the required works. Proper and rapid response is also essential in maintaining and repairing mechanical and electrical equipment at the water treatment plants and pumping stations, as well as the water transmission and distribution pipelines. Lastly, water quality management has to ensure compliance with the national standards.

1) The Operations Section

Certain criteria need to be satisfied for an organization to have a good O&M system. Among these criteria are: (i) Having a rational O&M organisational structure in place, together with written job descriptions for each position that clearly define the O&M roles and responsibilities; (ii) Having competent and trained O&M personnel to execute the operation and maintenance activities; (iii) The availability of tools, equipment, vehicles, instrumentation, and chemicals to perform the required O&M work; (iv) The presence of stores to provide spare parts and supplies for prompt repair and maintenance work; (v) The availability of outside contractors to provide quality O&M services; and (vi) An operation and maintenance program that is customized to the needs of the organization.

a) Structure of the Operations Section

The organisational structure of the Operations Section, which is headed by the O&M Manager, is shown in **Figure 3.3**. This section performs all operation and maintenance activities of the regional support centre. While the organisational structure is more inclined to show and highlight positions and grade levels (ranks) of the section personnel, in actuality, the section is divided into functional units. These are (i) The Operation and Maintenance (O&M) Unit, (ii) The Rural Water Supply (RWS) Unit, (iii) The Commercial Unit, (iv) The Regional Laboratory, and (v) The O&M Workshop. Among these five units, it is the O&M Unit that is also organised spatially, or along geographic (service) areas. The total number of personnel IN the Operations Section is as follows: Posts in the Approved Cadre, 391, of which 315 posts have been filled up, and 76 posts remain vacant. In addition, there are 31 outsourced / casual personnel.



Source: Human Resource Office, NWSDB SC(N/C)

Figure 3.3 Current Organisational Structure of the Operations Section, NWSDB N/C

- The O&M Unit

The O&M Unit is headed by the O&M Manager, who is also the concurrent head of the Section. The Unit is charged with producing and distributing adequate and potable water to the satisfaction of its consumers. It performs its functions through the water supply schemes, the smallest operating unit under the NWSDB, which, in addition to water supply operations, also performs managerial, commercial (consumer services), and administrative support functions. The O&M unit is divided into two districts – the Anuradhapura and Pollonuwara districts, headed by district engineers, under each of which there are several operational water supply schemes.

- The O&M Workshop

The O&M Workshop is a centralised unit that undertakes both corrective and preventive maintenance services for all the WSS. According to the officers-in-charge OICs of the WSS in the six study areas, a team of engineers visit the WSS on a monthly basis to provide preventive maintenance services, such as checking and cleaning of pumps and other equipment; while routine preventive maintenance work, such as oil and lubrication, is handled by the WSS. When a pump breakdown cannot be repaired at the WSS level, the workshop team at the RSC is called to perform corrective action or repair. However, if the regional workshop cannot accomplish the required repair, the RSC then requests for the assistance of the Head Office, or outsources the repair work.

- The Regional Laboratory

The Regional Laboratory provides services for water and wastewater quality monitoring and control. It ensures that water supplied by the schemes is in compliance with the national standards for drinking water in Sri Lanka. It performs monthly water quality testing on physical, biological and chemical parameters of samples collected by the WSS. In addition, the laboratory provides its services to other schemes outside the RSC(N/C) and to registered rural water supply CBOs, for which it provides two free tests per year.

- The Commercial Unit

The Commercial Unit supports the NWSDB customer charter by providing prompt and satisfactory customer service, particularly for new connections and reconnections. It also attends and finds solutions to service complaints, requests and other observations of the consumers, and implements the disconnection policy of NWSDB. The Unit also consolidates all billing and collection and consumer services data submitted by the WSS.

- The RWS Unit

The RWS Unit initiates, as well as supports, rural water supply organizing activities in the Anuradhapura and Pollonurawa districts. It provides technical assistance to the CBOs to enable them to capably manage, operate and maintain water supply (and sanitation) facilities for their membership. It also coordinates with the other sectors – government, non-government, private and public – where there is a problem of water quantity, or where water quality is not suitable.

In addition to the organisational structure and delineation of unit functions, there are written job descriptions for all categories / designations in the Approved Cadre of NWSDB, including those of the O&M personnel. The job descriptions delineate the vertical reporting lines upward (superior[s]) and downward (subordinates[s]); the posting and grade level; the division and location; the purpose of job; and work environment and conditions. They define the key responsibilities, broken down into critical key responsibilities, supportive key responsibilities and supportive responsibilities. They also identify accountability, norms, authority and relationships. It seems, however, that in the RSC, the O&M personnel are not fully aware of the existence of their own particular job descriptions.

(2) Organisation of Water Supply Schemes in the Study Area

There are a total of 33 water supply schemes under the RSC – 21 in the Anuradhapura district, and 12 in the Pollonurawa district. **Appendix 3.2(a)** shows the distribution of O&M personnel of water supply schemes under the Anuradhapura district; while that of the Pollonuwara district is found in **Appendix 3.2(b).**

Each scheme is headed by an OIC who holds the cadre category/designation of engineering assistant (EA). Five smaller schemes share officers-in-charge / engineering assistants, as follows: (i) Thuruwila, which shares EA with Natchchiyaduwa WSS; (ii) Padaviya, which shares EA with Kebithigollewa WSS; (iii) Horowpothana, which shares EA with Kahatagasdigiliya WSS; (iv) Mahakadalawa and (v) Habarana, which both share EA with Kerikawa. The number and distribution of O&M personnel in the six study areas are shown in **Table 3.3**.

Table 3.3 Distribution of O&M Personnel in the WSS of the Six Study Areas

OFFICE SCHEME	POST (CATEGORY)	Outsourced / Contractual	Approved Posts		Total
			Vacant	Filled	
ANURADHAPURA NORTH WSS (This WSS covers Rambewa)					**13**
	Engineering Assistant			1	
	Pump Operator Mechanic			4	
	Pipefitter			2	
	Driver			1	
	Labourer	2		3	
MEDAWACHCHIYA WSS					**8**
	Engineering Assistant			1	
	Pump Operator	1		2	
	Pipefitter			1	
	Meter Reader	1			
	Labourer	1		1	
KEBITHIGOLLEWA WSS (EA/OIC covers Padaviya)					**6**
	Engineering Assistant			1	
	Pump Operator Mechanic			3	
	Labourer			2	
PADAVIYA WSS					**7**
	Pump Operator Mechanic			3	
	Pipefitter			1	
	Caretaker			1	
	Labourer			2	
KAHATAGASDIGILIYA WSS (EA/OIC covers Horowpothana)					**7**
	Engineering Assistant			1	
	Pump Operator			1	
	Pipefitter			1	
	Labourer	3		1	
HOROWPOTHANA WSS					**2**
	Caretaker	2			
TOTAL		**10**	**0**	**33**	**43**

Source of Raw Data: HR Office and O&M Section (As of July 2012)

A closer look at the water supply schemes shows different types of schemes – purely distribution or purely production-type schemes; water treatment plant-type schemes; a mix of production, treatment and distribution. The operations of the mixed schemes encompass a wide range of water utility activities such as production and treatment, distribution, billing and collection and other consumer services, human resources and support services. The number of O&M personnel, therefore, is dependent on the type of WSS. The number and distribution of O&M personnel in the three water treatment plant schemes in Anuradhapura City are shown in **Table 3.4**.

Table 3.4 Distribution of O&M Personnel in the WTP/WSS in Anuradhapura City

WTP / WSS (Anuradhapura City)	POST (CATEGORY)	Outsourced / Contractual	Approved Posts		Total
			Vacant	Filled	
THURUWILA WTP					**9**
	Engineering Assistant			2	
	Electrician			1	
	Plant Operator Technician			3	
	Labour		3		
SACRED CITY WSS					**30**
	Engineering Assistant			1	
	Pump Operator Mechanic			3	
	Storekeeper			1	
	Meter Reader	3	2		
	Pipefitter			3	
	Driver			1	
	Labour	9	2	5	
ANURADHAPURA NEW TOWN WSS					**24**
	Engineering Assistant			1	
	Lab Supervisor			1	
	Store Keeper			1	
	Meter Reader	2		3	
	Pipefitter			4	
	Driver			1	
	Labour	2		9	
NUWARAWEWA WTP (Under the Anuradhapura New Town)					**13**
	Engineering Assistant			1	
	Pump Operator Mechanic			7	
	Pipefitter			1	
	Labour	1		3	
TOTAL		**17**	**7**	**52**	**76**

Source of Raw Data: HR Office and O&M Section (As of July 2012)

Note: For **Table 3.2** and **Table 3.3**) **"**Approved Posts" means posts in the approved cadre of NWSDB, whether these have been filled or not been filled, in which case the post is vacant; while **"**Outsourced or Contractual" means posts that are not in the Approved Cadre of NWSDB RSC(N/C), but for which people have been hired (outsourced) on contract basis to perform particular tasks.

(3) Profile of the O&M Personnel in the Study Areas

A survey was undertaken on the O&M personnel in the water supply schemes in the study areas to ascertain their profile in terms of age, employment status, number of years of employment with NWSDB, educational level and trainings received. Of the 34 personnel surveyed, 64.71% had permanent employment status, 8.82% were casual, while the rest did not indicate their status. This is consistent with the fact that labourers, caretakers and meter readers are outsourced in the scheme levels.

Table 3.5 Profile of O&M Personnel according to Age and Years with NWSDB

Water Supply Scheme	# of Employees 1/	Average Age	Average Years with NWSDB N/C
Medawachchiya WSS	6	47	20
Kebithegollewa and Horowpothana WSS	5	44	21
Padaviya WSS	8	52	28
Kahatagasdigiliya WSS	4	47	23
Anuradhapura North (Rambewa) WSS	11	52	25
Total	**34**	-	-

1/ Number of employees who returned survey questionnaire from the six study areas.

As to the educational attainment of the O&M personnel, **Table 3.6** reveals a low level of education where approximately 65% did not reach high school and 3% did not possess any formal education. This may be explained by that the skills requirements in the WSS are usually in the labour and equivalent grades. However, the inadequacy of educational attainment was not augmented by vocational or other short courses, as attendance at these was not reported by any of the personnel surveyed.

Table 3.6 Profile of O&M Personnel according to Educational Level

Water Supply Scheme	Primary	Secondary	Grade 7/8	High School	High School (NCT)	University Level	No Education
Medawachchiya WSS	0	5	0	0	1	0	0
Kebithegollewa and Horowpothana WSS	0	0	1	4	0	0	0
Padaviya WSS	1	0	3	2	1	0	1
Kahatagasdigiliya WSS	1	1	0	2	0	0	0
Anuradhapura North (Rambewa) WSS	9	1	0	0	0	1	0
Total	11	7	4	8	2	1	1
Percentage	32.35%	20.59%	11.76%	23.53%	5.88%	2.94%	2.94%

Ideally, regular and on-the-job training should be made available for personnel who have low levels of education and whose jobs are skills-based. However, such is not the case for the O&M personnel in the WSS surveyed. As shown in **Table 3.7**, the personnel received only a total or 30 days training, which translates to a very low 1.4 days of training days per employee over the last five years. (Note that this low number may be influenced by “no data” submitted by the survey participants/O&M personnel of Anuradhapura North (Rambewa) on the training portion of the questionnaire).

Table 3.7 Training Profile of O&M Personnel for the Six Study Areas

Water Supply Scheme	Total Training Days	Average per Employee
Medawachchiya WSS	9	2
Kebithegollewa and Horowpothana WSS	4	1
Padaviya WSS	5	1
Kahatagasdigiliya WSS	12	3
Anuradhapura North (Rambewa)	0	0
Total	**30**	

The bulk of training was provided by the NWSDB; although there were two other organisations that also provided training. The day-long training "courses" were on the following: repair and maintenance of small pumps, chlorinators and pipes; use of chlorine in water treatment, construction technology, new connections estimation and new accounts, rain water harvesting, 5S training, and administrative procedures. **Appendix 3.2(c)** provides the summary of profile of the O&M personnel surveyed.

(4) O&M Practices of the WSS

A good operations and maintenance program on the WSS level consists of two basic components – standard operating procedures and O&M records. The WSS surveyed could not present written standard operating procedures that describe how each operational task is to be performed. However, the OICs/EAs concerned stated that by experience and by training, and with their guidance and supervision, the personnel of the WSS visited possess sufficient technical knowledge in operating and maintaining WSS equipment.

As for O&M records and/or reports, **Table 3.8** provides the list of O&M records and frequency of reporting to the RSC, which in turn submits the same to the NWSDB Head Office.

Table 3.8 Frequency of O&M Reports / Records

	NAME OF REPORT / RECORD	CONTENT	FREQUENCY	
			Daily	Monthly
1.	Water Production Report	Volume of water produced per source	✓	
2.	Water Quality Report	Results of tests on 12 parameters for physical and chemical qualities, and 3 parameters for bacteriological quality		✓
3.	Data Relating to Operational Aspect Report	Reports on 17 aspects – water production, major breakdowns, number of staff, chemical consumption, replacement of old or defective meters, total number of connections, disconnections, illegal connections, number and types of leaks in distribution and main lines and repairs or replacements made		✓
4.	Monthly Detail Report	Similar content as *Data Relating to Operational Aspect* in terms of production, metered connections and leak repair		✓
5.	Energy Conservation Report	Energy consumption and production per pumping station		✓
6.	Rainfall Report	Daily report on whether or not there is rainfall, its measurement in millimetres, time of occurrence and other observations	✓	
7.	Operating Expense Report	Reports on total income from water sales less capital recovery costs, and total operating expenses from salary cost, utility cost chemical cost, repair and maintenance cost, establishment cost or office running cost security rent, finance charges and others, showing defective metre cost, new connection materials and extension cost		✓
8.	Billing and Collection Information Report	Reports on the particular billing period for a region/ area for all consumer categories and payment details		✓
9.	Defective Meter Report	Reports on number defective meters, including serial numbers, and meter reading		✓
10.	Details on New Water Connection	Name and address of new consumer, type and date of connection, meter number and reading		✓
11.	Consumer Complaint / Bill Adjustment	Contains nature and number of consumer complaints, and action taken		✓
12.	Attendance Sheet	Attendance of personnel assigned to the WSS	✓	✓
13.	Employee Leaves	Leaves of personnel assigned to the WSS		✓
14.	Overtime Sheet	Overtime report of WSS workers	✓	✓

While not all WSS has stores or a storekeeper position, the OIC is tasked to manage the inventory of fixed equipment and consumables. Reports and records to monitor and control the inventory of different supply types and spares parts, are: (i) Inventory Report on Program Usage, (ii) Stores Register Record; (iii) Material Issue Note; and (iv) Material Transfer Note.

In the maintenance of the transmission and distribution systems, water towers and associated hardware are inspected regularly, while pipelines and fittings are visually inspected for leaks. In addition to this, the consumers are active in reporting observed leaks to the WSS office for its immediate repair. Non-functioning and malfunctioning water meters are also reported to the WSS office either by the meter readers or the consumers themselves after which these are either repaired, or if beyond repair, are replaced.

As mentioned earlier, preventive and corrective maintenance are performed on pumps, motors, motor control panels, valves, instrumentation, control equipment, chemical mixing tanks and associated hardware, flocculators and sedimentation tanks, filters, chlorinators and building structures by both the WSS personnel and the O&M workshop team / unit at the RSC. Corrective maintenance work that cannot be done by the RSC is brought to the attention of the Head Office, or is referred to outside service contractors.

3.2.2 Technical

(1) Operation

The water supply system is operated by a team of operators, caretakers, meter readers, drivers, labours etc. headed by OIC (Officer-in-Charge). The team operates and monitors the pumps and treatment plants in the system. The OIC has the responsibility to operate, monitor and maintain the water supply system. At present most of water supply facilities are operating smoothly.

The OIC has to report monthly on the operation to the Operation Manager (O&M) in RSC(N/C). The monthly report covers all the aspects relating to the system operation and contains the following information.

a. treated water produced (m3/month)
b. major downtime (hrs)
c. power/chemical consumption
d. nos. of staff
e. billing
f. leak
g. defective water meters etc.

Table 3.9 Operation of Water Supply Facilities in NWSDB (NC)

Scheme	Total Prod.	Total Consump.	NRW (%)	Leak Reported	Leak Repairs	Total Conn.	Illegal Conn.	Defect. meter	Defect. (%)	Defective meter Replace-ment	Disconn.	Zero Bills	Zero Bills (%)	Est. Bills	Est. Bills %	Total No. of Staff
I. Anuradhapura District																
Anuradhapura New Town	400,148	269,986	32.5	98	98	11,236	0	82	0.7	74	413	506	4.5	178	1.6	38
Anuradhapura East	130,792	117,371	10.3	49	49	5,587	0	26	0.5	26	65	199	3.6	48	0.9	12
Anuradhapura North	141,075	119,921	15.0	15	15	6,083	0	30	0.5	32	40	219	3.6	127	2.1	11
Mihintale	68,571	50,501	26.4	28	28	2,640	0	12	0.5	12	78	138	5.2	49	1.9	14
Sacred City	146,021	125,727	13.9	36	36	4,758	0	42	0.9	29	69	231	4.9	116	2.4	16
Medawachchiya	26,718	20,275	24.1	8	8	1,267	0	40	3.2	38	55	71	5.6	83	6.6	7
Kebithigollawa	15,880	12,035	24.2	14	14	853	0	4	0.5	4	49	67	7.9	11	1.3	4
Padaviya	12,292	8,697	29.2	12	12	595	0	2	0.3	2	21	23	3.9	9	1.5	8
Kahatagasdigiliya	21,701	14,905	31.3	34	34	1,093	0	3	0.3	3	37		0.0	15	1.4	4
Horowpothana	3,660	3,377	7.7	8	8	172	0	1	0.6	1	18		0.0	7	4.1	
Thambuttegama	58,832	48,551	17.5	36	36	3,178	0	19	0.6	19	95	119	3.7	38	1.2	12
Eppawala	3,617	3,532	2.4	3	3	150	0	1	0.7	1	10	13	8.7	5	3.3	4
Maradankadawala	141,115	103,607	26.6			1,279	0	0	0.0	0	11	28	2.2	5	0.4	21
Kekirawa				12	12	6,025	0	11	0.2	6	141	399	6.6	37	0.6	
Habarana	14,379	11,707	18.6	6	6	775	0	0	0.0	0	11	56	7.2	2	0.3	4
Galnewa-Bulnewa	45,994	34,116	25.8	12	12	2,934	0	8	0.3	8	41	64	2.2	12	0.4	6
Thalawa	86,215	71,302	17.3	80	80	4,290	0	7	0.2	7	19	177	4.1	9	0.2	4
Nachchaduwa	29,016	24,022	17.2	6	6	1,936	0	0	0.0	0	10	60	3.1	0	0.0	5
II. Polonnaruwa District																
Polonnaruwa	204,887	136,629	33.3	61	61	7,830	0	57	0.7	52	193	317	4.0	124	1.6	32
Hingurakgoda	85,422	54,924	35.7	43	43	2,917	0	22	0.8	22	92	137	4.7	31	1.1	6
Minneriya	62,581	55,161	11.9	12	12	2,026	0	5	0.2	5	42	76	3.8	9	0.4	13
Dimbulagala	4,100	4,100	0.0	0	0	2	0	0	0.0	0	0	0	0.0	0	0.0	1
Bakamuna	15,718	10,955	30.3	0	0	757	0	0	0.0	0	12	31	4.1	22	2.9	3
Gallalla*	11,571	1,990	82.8	0	0	243	0	0	0.0	0	0	0	0.0	0	0.0	1
Total (2 districts)	1,730,305	1,303,391	24.3	573	573	68,626	0	372	0.5	341	1,522	2,931	4.3	937	1.4	226

Note: Gallala is newly commissioned and is not operated constantly. Therefore, it is not calculated in “Total-NRW”. *Source: NWSDB (NC), March 2012*

The above table is prepared by RSC(N/C) to monitor the NRW in each water supply system. The NRW is accurately monitored and calculated by using meter readings of bulk meters and water meters from all connections. The range of NRW is between around 10 to 35%, with the exception of two locations. In the large-scale and old systems NRW is higher at more than 30%, in comparison with that in the small-scale and new systems, where it is less than 20%. The table also shows all NRW related information, such as number of leaks, illegal connections, defective meters, zero-bills and estimated bills. By close monitoring of the information, NWSDB endeavors to minimize NRW.

Along with NRW, NWSDB (NC) is conscious on cost and expenses, and all necessary information.

(2) Maintenance

Maintenance services mainly consist of leak repair works and mechanical/electrical repair works. The leak repair works are mostly implemented by OIC's team based on leaks reported, as breakdown maintenance. As for mechanical/electrical equipment, the Regional Workshop is implementing breakdown and preventive maintenance.

1) Breakdown Maintenance

The following table shows major repair works and implementing organizations. Due to lack of maintenance machines and manpower, some repair works are transferred to the Central Workshop at NWSDB Head Office and some works are ordered to be undertaken by private companies.

It is cost effective to utilize the Central Workshop or private companies, instead of having all machines and manpower to meet peak repair works or complicated works which rarely occur.

Table 3.10 Major Repair Works and Organization

Repair work	NWSDB Head Office Central Workshop	NWSDB RSC(N/C) Regional Workshop	Private (Colombo)
Burnt motor	✓		
Pump overhaul		✓	
Generator overhaul			✓
Automation - PLC	✓(programming)	✓(setting)	✓(special)
Automation - instrument			✓
Panel		✓	✓(special)
Others		✓	

All maintenance services done by the Regional Workshop of NWSDB RSC(N/C) are recorded on a Workshop Job Card, which includes Scheme/ Job Description/ Cost (material, machine, labor, transport, others and overheads) for cost control.

2) Preventive Maintenance

Preventive maintenance is conducted to keep equipment working and/or extend the life of the equipment. The Regional Workshop of NWSDB RSC(N/C) in principle implements preventive maintenance for all water supply systems once a month, and usually it takes 15 working days. By the end of every month, the workshop plans the schedule of the preventive maintenance, and implements accordingly, considering the urgent requirements for breakdown maintenance.

Monthly Inspection Check List	centrifugal pump, borehole pump, air blower, compressor, generator (including motor and starter)

Table 3.11 Schedule of the Preventive Maintenance

Equip	No	Maintenance Task	Freq
Pump	1.1	Clean Exterior surfaces & Control cubical by Vacuum Cleaner	2M
	1.2	Grease bearing / Change bearing Lube oil	1M
	1.3	Check gland packing / mechanical seal replace if necessary	2M
	1.4	Check shaft alignment motor shaft	2M
	1.5	Check shaft sleeve for gland & mechanical seal replace if necessary	2M
	1.6	Check coupling bushes, replace if necessary, Check for shafting alignment	2M
	1.7	Check flow rate	1M
Motor	2.1	Check slip ring and clean / adjust carbon brushes	2M
	2.2	Check for vibration & operating temperature	1M
	2.3	Clean dust by vacuum cleaner / brushes	1M
	2.4	Check for noisy bearing / grease bearing	1M
	2.5	Check wire terminals for loose connections	1M
	2.6	Check balance full load current	1M
	2.7	Check insulation resistance	6M
Starter	3.1	Clean dust by vacuum cleaner	1M
	3.2	Check wire terminals for loose connections / & overheating	1M
	3.3	Check proper operation of relays, connectors, indicating lamps, meters etc.	1M
Common	4.1	Building Lights	1M
	4.2	Street Lamps	1M
	4.3	Lighting protection system Earth	1M
	4.4	Pump replacement	A
	4.5	Hour run meter value	1M

Beside the monthly preventive maintenance, operators at the plants or the stations implement daily inspection. The inspection consists of checking appearance, unusual noise, vibration, temperature, tightness of bolts, gauged pressure etc.

Daily Inspection Check List	centrifugal pump, borehole pump, air blower, compressor, generator, motor, clarifier, mixer

Table 3.12 A List of Daily Inspection for the Monthly Preventive Maintenance

No.	Maintenance Task	Frequency
1−1	Cleaning exterior surfaces.	Daily
1−2	Check free rotation of pump.	Daily
1−3	Check foundation bolts for tightness.	Daily
1−4	Check for unusual noise, vibration and rise in temperature.	Daily
1−5	Check gland packing leakage, adjust if necessary.	Daily
1−6	Check the functioning of vacuum & pressure gauges.	Daily
1−7	Check shaft coupling for tightness.	Daily

3.2.3 Financial

North Central Regional Office of NWSDB covers this project site. Therefore, the financial situation of this regional office is analyzed at first.

The accountant of the office provided JICA Study Team with “Income and Expenditure Statements” from 2006 to 2011. They can be shown in **Table 3.13**.

Table 3.13 Revenues and Expenditures of North Central Office

(Unit: Rs.)

Item / Year	2006	2007	2008	2009	2010	2011
Sales of water	211,529,041	228,146,633	248,423,362	404,774,818	438,335,713	481,521,169
Other operating income	24,386,682	48,339,366	83,346,790	72,501,027	77,598,820	67,715,576
Operating Income	276,485,999	235,915,723	331,770,152	477,275,845	515,934,533	549,236,745
Direct operating expense	184,099,380	226,161,790	283,311,215	317,241,696	369,840,475	401,377,546
Personnel cost	97,070,685	125,864,817	140,762,285	155,568,143	186,361,433	187,710,103
Utility cost	41,276,082	47,198,858	77,254,487	66,683,530	78,007,992	89,072,286
Chemical cost	16,478,972	19,083,357	25,471,952	29,157,320	26,791,869	27,156,443
Repairs & maintenance	10,767,587	12,471,710	7,489,222	24,934,072	29,290,055	31,068,927
Establishment expenses	6,941,355	8,693,522	11,138,275	14,387,781	15,586,225	17,658,668
Rent, rates, taxes, etc.	11,564,699	12,849,526	21,194,994	26,510,850	33,802,901	48,711,119
Other operating expenses	11,791,880	26,482,579	31,312,587	34,738,424	40,848,121	32,408,216
Operating Expenditure	195,891,260	252,644,369	314,623,802	351,980,120	410,688,596	433,785,762
Operating Surplus/ Deficit	40,024,463	23,841,630	17,146,350	125,295,725	105,245,937	115,450,983

Source: North Central Office, NWSDB

The table shows surplus every year in the past six years. From 2009, the surpluses are more than 100 million Rs. reflecting the tariff raise in 2009. Therefore, North Central Office can sustain itself financially from the viewpoint of cash flow. However, the operating expenditures do not include depreciation. In addition, the account does not include non-operating account such as finance costs. The Head Office manages those matters so that it is necessary to analyze the whole financial aspects of NWSDB as follows.

(2) Water Tariff

The latest water tariff was issued on 18 September, 2012 and in force from 1 October 2012 in accordance with the National Water Supply and Drainage Law No.02 of 1974 (Refer to

Appendix 3.3).

3.2.4 Water Supply Development Plan of NWSDB in Anuradhapura District

Currently 12 water supply projects are nominated for future development in Anuradhapura District as shown in **Table 3.14** and **Appendix 3.4**.

Table 3.14 Water Supply Development Project in Anuradhapura District

Sr. No	Project Name	Cost (million Rs)	Population	Capacity (m3 / d)	Present Status
I. Anuradhapura District					
1	Anuradhapura South integrated WSP - Phase II	12,275.0	73,412	21,000	Eol evaluation completed RFP completed
			29,897	5,500	
			36,211	7,000	
2	Anuradhapura North Integrated WSP	10,462.0	186,025	22,500	JICA team has mobilized to do feasibility study
			85,500	11,250	
3	Mahawilachchiya	976.0	21,980	4,500	Awaiting for funding
4	Padaviya	2,055.0	42,000	9,000	Included in the Anuradhapura North project
5	Galenbindunuwewa	1,707.8	77,125	13,500	Awaiting for funding
6	Thambuttegama	1,805.0	155,000	-	Arranged to get Chinese fund
7	Parasangaswewa (Included Paragoda)	31.0	3,956	-	Awaiting for funding
8	Viharapalugama	365.0	22,000	1,184	
9	Palugaswewa Integrated	2,237.4	37,652	6,750	Awaiting for funding
10	Eppawal	4,537.0	84,000	15,000	Awaiting for NPD & source Approval
11	Galnewa-Bulnewa	-	-	-	under study
12	Rajanganaya	-	-	-	Studies will be completed within two months
II. Polonnaruwa District					
13	Lankapura WSS	1,853.0	55,428	9,000	Awaiting for funding
14	Welikanda	2,776.0	58,247	9,000	Awaiting for funding
15	Dimbulagala	-	-	-	PAC Will be completed within 03 months
16	Hingurakgoda	609.0	36,233	-	PAC report has been sent to P&D - H/O for the comment
17	Minneriya	832.0	52,464	9,000	
18	Elahera-Bakamoona	-	-	-	Study to be started
19	Medirigiriya Stage 2	825.0	-	-	to be sent to P&D-O/H section for comments

Source: NWSDB (NC)

Two projects are under process for implementation. The Ministry of Water Supply & Drainage nominated five “Priority Water Supply Projects” in June 2011, and both Anuradhapura South Integrated WSP - Phase II and Anuradhapura North Integrated WSP were selected. These five projects were planned to be implemented by potential investors or project developers on a design build basis supported with funding arrangement.

Anuradhapura South Integrated WSP - Phase II is under EOI (Expression of Interest) evaluation, while, the EOI for the Anuradhapura North Integrated WSP was canceled, because JICA dispatched their study team for a preparatory study to identify the potential for funding. All other development projects have a small project cost.

3.3 Existing Water Supply Facilities under NWSDB in the Study Area

There are 56 water supply schemes in total in the project areas including 50 numbers of CBOs facilities and 6 number of NWSDB facilities out of which Rambewa is not an independent system but a part of Anuradhapura North Water Supply Scheme (WSS) and Mihintale WSS with both water sources in Nuwarawewa.

Table 3.15 below shows the number of existing water supply schemes and the served population in each DSD, in which it is apparent that the service coverage in Rambewa and Medawachchiya DSD is higher than in other areas (34.1% and 30.9% respectively), with coverage in Horowpothana (13.8%) and Kebithigollewa (16.6%) being lower than in other areas. There are only six NWSDB supply facilities located in six different DSDs, and approximately 30% of the population are served by NWSDB and the remainder by CBOs.

Table 3.15 Existing Supply Schemes and Served Population

DSD	No. of Water Supply Schemes			Served Population				Population (2012)
	NWSDB	CBOs	Total	NWSDB	CBOs	Total	Coverage (%)	
Wahalkada								
Padaviya	1	3	4	2,191	4,675	6,866	28.5	24,130
Kebithigollewa	1	3	4	2,585	1,165	3,750	16.6	22,555
Horowpothana	1	7	8	705	4,005	4,710	13.8	34,044
Kahatagasdigiliya	1	13	14	3,656	8,760	12,416	32.1	38,688
Sub-total	4	26	30	9,137	18,605	27,742	23.2	119,417
Mahakanadarawa								
Medawachchiya	1	13	14	4,630	9,905	14,535	30.9	47,100
Rambewa	1	11	12	2,139	10,160	12,299	34.1	36,024
Sub-total	2	24	26	6,769	20,065	26,834	32.3	83,124
Total	6	50	56	15,906 (7.8%)	38,670 (19.1%)	54,576 (26.9%)	26.9	202,541 (100%)

(5) NWSDB Facilities in the areas

In the project areas, there are six NWSDB water supply facilities, however source of Rambewa system is out of the Project area although some of GNDs are included in the Project area.

Therefore, Rambewa is excluded in this section. **Table 3.16** shows general information on the five NWSDB's facilities.

Table 3.16 NWSDB Facilities (General Information)

Facility Name	Starting Year	Served Pop	System Capacity (m^3/d)	Water souce		Storage		Distribution Pipes	
				Type	nos.	Type	Capacity	Type	Lnegth (m)
Padavia	1990	2,191	578	Deep	3	Ground	40m3	PVC	13,205
Kebithigollewa	1973	2,585	677	Deep	3	Elevated	225m3	PVC	35,832
Horowpothana	1979	705	137	Deep	1	Elevated	50m3	PVC	3,150
Kahatagasdigiliya	1982	3,656	893	Deep	1	Elevated	100m3	PVC	26,200
Medawachchiya	1965	4,630	1,062	Deep/Shallow	5 / 2	Elevated	135m3 x2	PVC/AC/DI	56,491

The population served with water by NWSDB is 14,000 and average service coverage is 47.5%. NWSDB facilities in the area started their operation in the period between 1964 and 1989. The oldest facility is Medawachchiya system. System capacities are ranging from 137 to 1,062 m^3/day, and all of their water sources rely on ground water. The total capacity of storage tank is 685 m^3 , and all storage tanks are of the elevated tank except Padaviya.

Distribution pipes are PCV pipes except in Medawachchiya, where ACP (Asbestos Cement Pipe) are partly used for 50 – 225 mm in diameters. There is no Non Revenue Water data available in these systems.

In the survey, only three water quality items of pH, Turbidity and Fluoride were collected as shown in **Table 3.17**.

Table 3.17 Water Quality of NWSDB Facilities in the Area

Facility Name	pH	Turbidity	Fluorine
Padaviya	7.65	0.49	0.32
Kebithigollewa	7.01	1.29	0.11
Horowpathana	7.64	6.13	1.42
Kahatagasdigiliya	7.62	0.50	1.90
Medawachchiya	7.53	0.50	0.77

3.4 Existing Water Supply Facilities under CBO in the Study Area

3.4.1 General

(1) General

In the Anuradhapura Integrated Water Supply Project Area, a number of small scale water supply systems have been located under the operation and maintenance of Community Based Organizations (CBOs) which funded by ADB-3rd or ADB-4th. In addition, Community Water Supply and Sanitation Program (CWSSP) have been funded by World Bank (WB). However, as a CBO supply system, these all water facilities have been operated at the moment.

A survey of the existing water supply system was carried out to analyze present water supply conditions and problems encountered in the water supply facilities, and this provides essential information for the planning of a new water supply system.

Since information and data available to understand and analyze the present water supply conditions were limited, implementation of a detailed survey was indispensable. The survey of the existing water supply system was implemented comprehensively through interview to CBO staffs by a local consultants firm.

NWSDB on the other hand, have operated six existing water supply facilities in Rambewa, Medawachchiya, Kebithigollewa, Padaviya, Kahatagasdigilliya and Hollowpothana. The preparatory survey team conducted data collection and survey directly for the NWSDB's facilities through interview to OIC staffs.

The survey aims to search the followings.

- General Information: name of CBO, location, contact details, year of establishment, year/period of operation, service area, population.
- Water supply system details including, type of water source, treatment system, water storage and detail of distribution system. Supply conditions such as: supply service (continuous/ intermittent), supply pressure, and estimated water loss.
- Details of operation and maintenance including managerial and operational personnel, consumption of power / fuel, chemicals, repairs / replacements etc.
- Financial conditions including revenue (water tariff, connection fee and other revenue) and expenditure including annual cost of personnel, power, chlorine, cost of maintenance and depreciation.
- Willingness to connect to new surface water system including proposed tariff.
- Relevant data and information of service area, system layout and drawing of major facilities.

The field survey was commenced on 25th May 2012 and completed by the end of July 2012, and the results of surveys were given as described in **Sections 3.4.2 to 3.4.4**.

In the survey area at the present, the majority of people are provided water by the community operated water supply facilities (CBOs), and only a limited people are served by piped water supplied by NWSDB.

The list of existing CBO water facilities is shown below in **Table 3.18**,

.

Table 3.18 List of CBO Water Facilities

S/N	Name of CBO	Location				Population of GND			Population served
		PS	DS	GND	Village	No of Village Covered	No of Village Excluded	Population in Service GND	
01	Swashakthi CBO	Rambewa	Rambewa	Kendewa (97) & Galkandagama (85)	Kendewa	3	-	3000	755
02	Ikra CBO	Rambewa	Rambewa	Ikkirigollawa (102)	Ikkirigollawa	3	-	-	3015
03	Arunalu CBO	Rambewa	Rambewa	Sangilikandarawa (111)	Sangilikandarawa	5	-		915
04	Samagi CBO	Rambewa	Rambewa	Thalgahawewa (84)	Thalgahawewa	2	0		660
05	Ekamuthu CBO	Rambewa	Rambewa	Wahamalgollawa (109)	Wamalgollawe	1	-		1220
06	Rangiri CBO	Rambewa	Rambewa	Wewalkatiya (82)	Wewalkatiya	2	-		590
07	Nildiyadahara CBO	Rambewa	Rambewa	Maha Kandarawa yaya -01 (94)	Maha Kandarawa Yaya	1	-	1080	715
08	Eksath CBO	Rambewa	Rambewa	Katukeliya - 106	Katukeliya	3	-	1080	575
09	Mahasen CBO	Rambewa	Rambewa	Mahakandarayaya - 02 (93)	Weliwewa	3	-	-	755
10	Dimuthu CBO	Rambewa	Rambewa	Ihala Kolangaswewa (87)	Ihala Kolangaswewa	3	-	1050	325
11	Pragithi CBO	Rambewa	Rambewa	Bala Honda Wewa(86) &Ihala Kolangaswewa (87)	Bala Hondawewa	4	-	885	635
12	Jayashakthi CBO	Madawachchiya	Madawachchiya	Katuwela (66)	Katuwela	3	1		1090
13	Samagi CBO	Madawchchiya	Madawchchiya	Halambagaswewa (70)	Halambagaswewa, Palukandawewa	2	-		935
14	Samagi CBO	Madawachchiya	Madawachchiya	Ataweeragollewa (56)	Pahala Thammannagama, Kubukkollawa, Attaweeragollawa	3	-	1580	540
15	Ekamuthu CBO	Madawachchiya	Madawachchiya	Hirulugama (54)	Hirulugama	1	-		855
16	Ran Arulnalu CBO	Madawachchiya	Madawachchiya	Wiralmurippu (64)	Wiralmurippu, Kulikkada	2	-	1375	945
17	Isuru CBO	Madawachchiya	Madawachchiya	Kadawathgama (60)	Kadawathgama	3	-	2640	895
18	Randiya Dhahara CBO	Madawachchiya	Madawachchiya	Unagaswewa (75)	Unagaswewa	3	-		520
19	Nelum CBO	Madawachchiya	Madawachchiya	Kirigalwewa (72)	Kirigalwewa	4	-		680
20	Diriyamatha CBO	Madawachchiya	Madawachchiya	Maha Kumbugollawa (46)	Maha Kumbugollawa, Kuda Halmillawa	3	-		890
21	Gemunu CBO	Madawachchiya	Madawachchiya	Maha Divulwewa (57)	Maha Divulwewa	1	2		345
22	Sisila Diyadahara CBO	Madawachchiya	Madawachchiya	Kidawarankulama (42)	Kidawarankulama	2	-		935
23	Diriyamatha CBO	Madawachchiya	Madawachchiya	Periyakulama (49), Yakkawewa (50)	Periyakulama	3	1		675
24	Ridi Nadi	Madawachchiya	Madawachchiya	Athakade (55)	Athakade	2	1		600
25	Shakthi CBO	Kebithigollawa	Kebithigollawa	Ayyatigewewa (24)	Ayyatigewewa	1	-	2015	1165
26	Al-Naja	Kebitigollawa	Kebitigollawa	Muslim Attaweerawewa (32)	Attaweerawewa (Paranagama, Aluthgama, Kurulugama)	2	-	2050	Connection not given yet
27	CBO not formed & Scheme Not implemented	Kebitigollawa	Kebitigollawa	Gonumariyaya (25)	Gonumariyaya	-	-	-	-
28	Parakum CBO	Padaviya	Padaviya	Parakramapura(06), Buddhangala(05), Elikumbulagala (07)	Parakiramapura Town	11	5	-	2820
29	Suwasehana CBO	Padaviya	Padaviya	18 Kanuwa (02)	18 Kanuwa, Deewara Gammanan, Isipathana gama	3	-	1750	945
30	Suwasetha CBO	Padaviya	Padaviya	Bogahawewa (14)	Bogahawewa	6	-	1750	910
31	Vajira CBO	Kahadagasdigilliya	Kahadagasdigilliya	Maha Kumbukwewa (222)	Maha Kumbukwewa	2	-		665
32	Pragathi CBO	Kahadagasdigilliya	Kahadagasdigilliya	Moragahawela (202)	Moragahawela	3	1		640

Table 3.18 List of CBO Water Facilities (cont'd)

S/N	Name of CBO	Location				Population of GND			Population served
		PS	DS	GND	Village	No of Village Covered	No of Village Excluded	Population in Service GND	
33	Janasetha CBO	Kahadagasdihilliya	Kahadagasdihilliya	Ratmalgahawewa(225), Paalishpothana(224), Kirigallawa (226)	Palispothana	5	5	1500	920
34	Sobasisila CBO	Kahadagasdigiliya	Kahadagasdigiliya	Pandarella(210), Panwella (211)	Kokabe, Panderellawewa, Panwella, Thimbiriwewa	4	3		875
35	Randiya	Kahatagasthigiliya	Kahatagasthigiliya	Ranpathwila (196)	Ranpathwila (196) Rotapukuna	2	-		1130
36	Nilmini	Kahatagasthigiliya	Kahatagasthigiliya	Kokmaduwa(201)	Kokmaduwa	1	3		795
37	Senath CBO	Kahadagasdigilliya	Kahadagasdigilliya	Gonamaruwewa (223)	Gonamaruwewa, Nelugolla Kade	2	1		385
38	Eksath CBO	Kahadagsdiliyya	Kahadagsdiliyya	Turukkuragama (234) & Maha Kiri Ibbawa (233)	Aluthwattha, Galwala, Hijra Mawatha, Maha Kiri Ibbawa	4	3		470
39	Praja Shakthi CBO	Kahadagasdigilliya	Kahadagasdigilliya	Mahawewa (221)	Wirandagollawa, Mahawewa	5	1		810
40	Apsara	Kahadagasdigiliya	Kahadagasdigiliya	Meekumbukwewa (212)	Meeminnawala, Aluthwewa, Kumbukwewa	3	-		1480
41	Pinibindu CBO	Kahadagasdigiliya	Kahadagasdigiliya	Ambagahawewa - 213	Rainwater supply implmented in 60 Households. No Piped Water Supply				
42	Sham Sham	Kahadagasdigilliya	Kahadagasdigilliya	Weligollawa (218), Kuncha Halmillawa (219)	Weligollawa, Kunchahalmillawa, Ihalamillawa	3	-		210
43	Ekamuthu CBO	Kahadagasdigilliya	Kahadagasdigilliya	Kumbukgollawa (209)	Kumbukgollawa	1	2		380
44	Pradeepa	Horowpathana	Horowpathana	Wadigewewa (126)	Wadigewewa	5	1		805
45	Upul CBO	Horowpathana	Horowpathana	Parangiwadiya (149)	Parangiwadiya	2	-		905
46	Jalasavi	Horowpathana	Horowpathana	Kapugollewa (140)	Kapugollewa	2	1		785
47	Tristar CBO	Horowpathana	Horowpathana	Agunuchchiya (119)	Parangiwadiya	2	1		215
48	Alhidra CBO	Horowpathana	Horowpathana	Anolondawewa (138)	Alondawewa	2	1		730
49	Adhikwa CBO	Horowpathana	Horowpathana	Weerasole (139)	Weerasole	1	1		-
50	Hansajala CBO	Horowpathana	Horowpathana	Maradankadawala (133)	Maradankadawala	3	2		565

In accordance with the survey, seven CBO have not been operated nor started operation as described herein below.

- No.27 Gonumariyaya CBO (Kebithigollewa DSD): Project has not been implemented; thus no water supply facility exists.
- No.26 Al Naja CBO (Kebithigollewa DSD): Construction work has not been completed; thus supply of water has not been commenced.
- No.36 Nilmini CBO (Kahatagasdigiliya DSD): In 2010 the water pump was broken due to lightning; since then no water has been provided.
- No.47 Tristar CBO (Horowpothana DSD), No.48 Alhidra CBO (Horowpothana DSD) and No. 49 Adhikawa CBO (Horowpothana DSD): Construction has been completed, but the CBO organizations have not been formally organized and water is used without proper management.
- N0.41 Pinibindu CBO (Kahatagasdigiliya DSD): No CBO has been organized, as there is no

proper water source and people rely on rainwater.

Figure 3.4 is a location map of CBO's facilities, which shows that the facilities are sparsely located over the project area.

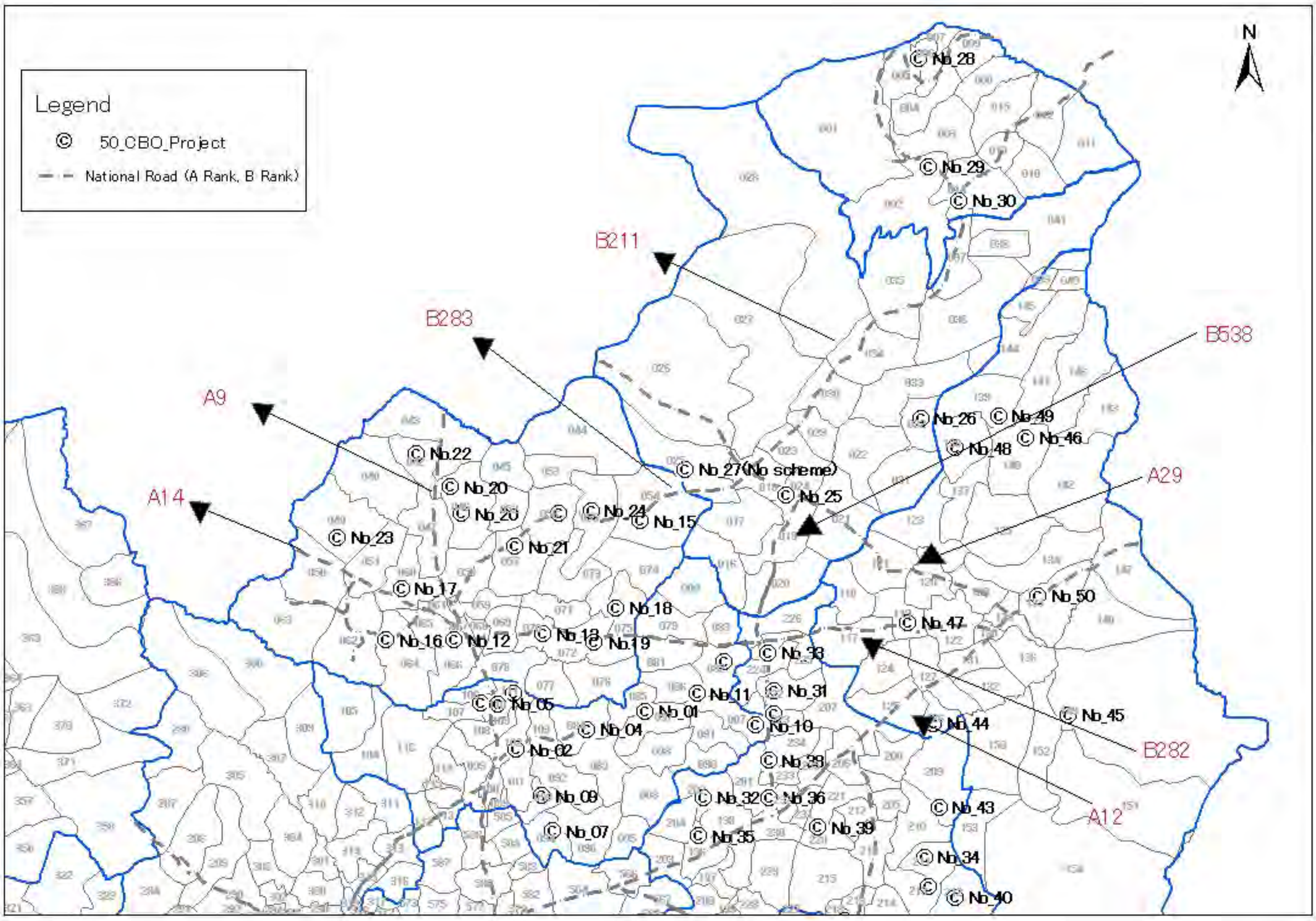


Figure 3.4 Distribution Map of CBO Facilities

The earliest operation of CBO's facilities was commenced in the year 2003 and most of CBOs started their operation from the 2006 to 2009. All of CBO's facilities are relatively new, and they are, more or less, still in good conditions and it is expected to be used in the future, with the exception of in the seven CBOs, as described earlier. **Figure 3.5** shows years of commencement of operation of CBOs.

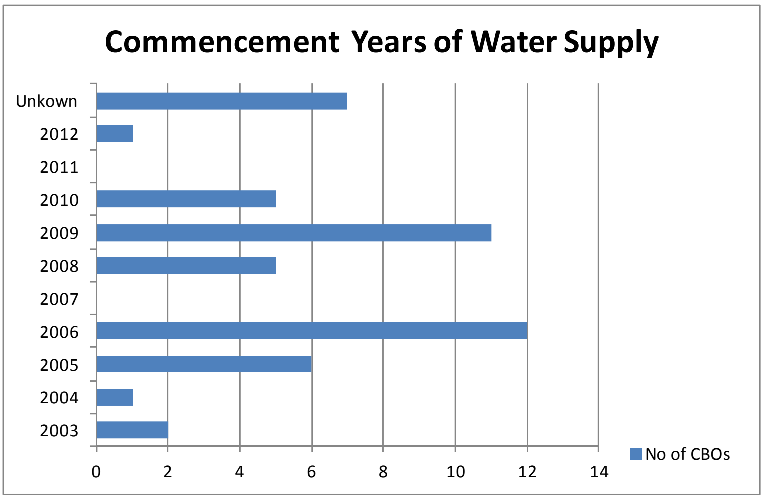


Figure 3.5 Commencement Year of CBO Facilities

(2) Water sources

In the most of CBOs, ground water is used either by installation of shallow wells, deep wells or a combination of both. CBO No. 41 Pinibindu in Kahatagasdigiliya DSD relies on rain water because of the limitation of the water source, and only 60 people are served in this CBO service area. The detailed analysis of water quality is described in another section, however, it is briefly described based on the field survey results related to hardness and fluoride concentrations which are of the most concern to people in these areas. Caution shall be paid that information has been collected from CBO's managerial persons by the field team, and accuracy could be confirmed.

Many CBOs stated that the systems have insufficient water quantity especially in dry season, insufficient supply pressure, poor and unsuitable water quality, etc.

The following are the problems that CBO's managerial persons have stated during the field survey:

- 10 CBOs stated; "We have a problem in shortage of water during dry season."
- 3 CBOs stated; "Not sufficient pressure in the line so that water could not reach the end of the system or higher places.
- 2 CBOs stated; "We have difficulties to further increase the number of connections to houses because of insufficient water."
- 3 CBOs stated; "We cannot operate the system continuously due to low voltage of electricity."

Table 3.19 presents kinds of water source of CBOs and water quality of hardness and Fluoride in **Table 3.20**.

Table 3.19 Water Source in CBO Facilities

Water source	No. of CBOs
Deep wells	16
Shallow wells	24
Both types of wells	7
Rainwater	1
Surface water	Non

Table 3.20 Hardness and Fluoride

	Hardness	Fluoride
No. of CBOs	20	24
Ave.	323 mg/L	0.88 mg/L
Max.	720 mg/L	1.80 mg/L
Min.	80 mg/L	Less than 0.1 mg/L

(3) Water Quality

According to the field survey, there is no CBO which has treatment facilities, such as filters or aerations. Further, limited chlorination facilities were installed in the water supply facilities, Eight CBOs have experience of dosing hypochlorite in the elevated tanks either occasionally or consistently. Most of CBOs have not dosed chlorine due to either lack of skill relating to O&M or financial reason.

Water quality information collected by the field team is listed in **Table 2.17**.

(4) Components of Facilities

In most CBO's water supply systems, raw water is taken either from deep wells or shallow wells, then pumped up to elevated tanks, before being distributed by gravity to houses through PVC pipes. As shown in **Table 3.21** and **Table 3.22** the total storage capacity in all CBOs is 2,805 m^3 and on average 58 m^3 of storage capacity is provide in each CBO's water supply system.

In accordance with the field survey, low water levels of elevated tanks are between 10 and 15 m from the ground level and water depth is about 2.1 m. Information of distribution pipes was collected from 48 CBOs. Distribution pipes are PVC type 600 (PN6) with nominal diameters of 25 mm to 150(OD160) mm. Many CBOs use small size of distribution pipe of less than 50(OD63) mm in diameter.

Table 3.21 Capacity of Elevated Tanks

No. of CBOs	48
Total Capacity	2,805 m^3
Ave.	58.5 m^3
Max.	22.5 m^3
Min.	20 m^3

Table 3.22 Distribution Pipes

No. of CBOs	48
Total Length	392,299 m
Ave.	8,173 m
Per Connection	51 m

3.4.2 Operation and Maintenance

(1)Present Condition on O&M (Operation and Maintenance)

A committee has been formed in most of CBO water supply schemes and the committee manages water supply system. Members of the committee are locally elected personnel by the community, who are like school teachers, public sector employees or local businesspersons. Operation and maintenance of the system is carried out on a day-to-day basis by two to three persons selected persons, one clerical and one or two technical personnel usually. **Table 3.24** shows the consumption of electricity and chlorine, repairs/replacement and maintenance.

For the maintenance of facilities, it was observed that;

- Repair and/or replacement of distribution pipelines have been carried out by 33 CBOs in the past.
- Water meters have been replaced by 16 CBOs. The total meters replaced were 276 meters.
- Elevated tanks have been cleaned several times by 20 CBOs .

Although the levels of O&M practice vary by the CBO, the majority of CBOs are seemed to carry out operation and maintenance in a good manner, for routine operation and maintenance.

However, the following operation and maintenance problems were reported by the field survey team:

- 6 CBOs (No.02 Ikra CBO, No.06 Rangiri CBO, No.33 Janasetha CBO, No.46 Jalasavi CBO, No.48 Alhidra CBO and No.40 Apsara Meekumbukwewa CBO): Gate valves or pipes are leaking.
- 5 CBOs (No.06 Rangiri, No.10 Dimuthu CBO, No.35 Randiya CBO, No.37 Senath CBO and No.40 Apsara CBO): CBO management is poor and capacity building is necessary.
- No.36 Nilmini CBO: leakage from elevated tank.
- No.50 Hansajala CBO: Connection pipe to elevated tank to be replaced.
- All CWSSP schemes (No.07Nildiyadahar, No.08Eksath, No.09Mahasen, No.10Dimuthu, No.11Pragithi, No.18Randiya Dhahara, No.19Nelum, No.20Diriyamatha, No.21Gemunu, No.22Sisila Diyadahara, No.23Diriyamatha No.24Ridi Nadi, No.36Nilmini, No.37Senath, No.38Eksath, No.39Praja Shakthi, No.40Apsara, No.42 Sham Sham, No.43Ekamuthu): no bulk meters are installed.

Table 2.17 Water Quality of CBO's Supply System

S/N	DSD	Water Source	Water Quality							
			Hardness (mg/L)	Iron (mg/L)	Fluoride (mg/L)	Odor	Color (Haxen Unit)	Turbidity (NTU)	pH	Conductivity (μS/cm)
1	Swashakthi CBO	S	-		**0.85**	None	Clear	0.05	7.86	**860**
2	Ikra CBO	D-1, S-1	-	-	**0.83**	None	Clear	0.06	7.72	**950**
3	Arunalu CBO	S	-	-	**0.59**	fishy	Clear	0.1	7.93	**940**
4	Samagi CBO	D	-		**1.01**	None	Clear	0	7.76	**930**
5	Ekamuthu CBO	S	-		0.32	None	Clear	0.08	7.74	700
	Ekamuthu CBO-Kakukaliyawa				**1.19**	-	Clear	0.03	7.77	**880**
6	Rangiri CBO	D	-		**0.88**	None	Clear	0.03	7.79	**1,080**
7	Nildiyadahara CBO	S	**360/280**	-	**0.72**	-	Clear	0.15	7.77	740
8	Eksath CBO	S	**340**	-	**0.4/0.78**					
9	Mahasen CBO	S	80	-	0.39	-	Clear	0.08	7.6	730
10	Dimuthu CBO		**312**	-	0.57	-	Clear	0.12	7.91	610
11	Pragithi CBO		**344**	-	**1.38**	-	Clear	0.05	7.7	**1,450**
12	Jayashakthi CBO	D	-		**1.9**	None	Clear	0.06	7.76	**1,570**
13	Samagi CBO	D	**332/270/330**		**1.08**	-	Clear	0.07	7.8	**1,000**
14	Samagi CBO	S	-	-	0.5	-	<5	0.02	-	590
15	Ekamuthu CBO	D	-		**0.81**	-	<5	0.03	-	650
16	Ran Arulnalu CBO	D	**490/720/640**	0.03/-/-	**1.55/1.1/0.36**					
17	Isuru CBO	D	High	-	**0.98**	None	Clear	0.05	7.84	**1,060**
18	Randiya Dhahara CBO		-	-	**1.15**	None	Clear	0.09	7.76	**840**
19	Nelum CBO	S	-		**1.11**	None	Clear	0.05	7.86	**970**
20	Diriyamatha CBO		**250/261/284**		**0.83**	-	Clear	0.1	7.75	**700**
	Diriyamatha CBO				**0.69**	-	Clear	0.12	7.79	**870**
21	Gemunu CBO		-		**0.75**	-	<5	0.21	-	**950**
22	Sisila Diyadahara CBO		-		**0.76**	None	Clear	0.06	7.83	**880**
23	Diriyamatha CBO		**373/342**		**0.86**	None	Clear	0.1	7.64	**1,220**
24	Ridi Nadi				0.21	None	Clear	0.06	7.75	610
25	Shakthi CBO	D	**324**	**3.3**	0.1					
26	Al-Naja	D	-	-						
27	CBO not formed		-	-						
28	Parakum CBO	D	108	0.14	**1.04**	-	Clear	0	7.76	740
29	Suwasehana CBO	D	1.13	-	**1.13**	-	Clear	0.07	7.76	740
30	Suwasetha CBO	S	-	-	**0.96**	-	Clear	0.04	7.63	740
31	Vajira CBO	D	**262/204**		**1.5/1.54**					
32	Pragathi CBO	D	-		0.58	None	Clear	0.08	7.54	**1,430**
33	Janasetha CBO	S	-	-	**1.37**	-	Clear	0.01	7.85	670
34	Sobasisila CBO	S	-		**0.67**	-	Clear	0.02	7.64	810
35	Randiya	S-2	-	-	0.31	-	Clear	0.14	7.76	760
36	Nilmini	D	-							
37	Senath CBO		-		**1.9**	None	Clear	0.02	7.75	**1,240**
38	Eksath CBO	S	**296**		**1.62**	None	Clear	0.02	7.78	**860**
39	Praja Shakthi CBO		-		0.42	None	Clear	0.01	7.85	520
40	Apsara	S	-		**1.35**	-	Clear	0.14	7.69	1,380
41	Pinibindu CBO	R								
42	Sham Sham		-							
43	Ekamuthu CBO	Well-2	**264**		0.14	-	Clear	0.05	7.6	640
44	Pradeepa	D	**448**		**0.82**	-	Clear	0.01	7.8	**1,150**
45	Upul CBO	D	**290**		**0.92**	-	Clear	0	7.83	**1,000**
46	Jalasavi	D	-		**1.58**	-	Clear	0.02	7.74	**1,330**
47	Tristar CBO	D	**300**	-	0.001					
48	Alhidra CBO	D	**300**		0.04					
49	Adhikwa CBO	D	**280**	-	**0.7**					
50	Hansajala CBO	S	**442**		**1.8**					
	Sri Lanka Standard (Desirable)		**250**	**0.3**	**0.6**		**5**	**2**	**7.0-8.5**	**750**
	Sri Lanka Standard (Permissible)		**600**	**1**	**1.5**	**Unobjection**	**30**	**8**	**6.5-9.0**	**3,500**

S: Shallow Well, D: Deep Well, R: Rain Water Tank The figure after hyphon (-) shows the number of wells.

300 Above the desirable limit **300** Above the permissible limit

In addition, out of 21 CBOs with a water quality data of hardness, 18 CBOs have above a desirable limit of 250 mg/L. The high concentration of hardness as well as fluoride is a big characteristics of this area.

Information on Non-Revenue Water (NRW) has not been obtained from the CBO's managerial people. Thus, an examination on NRW was made including as follows.

NRW in CBO's water supply schemes is estimated adopting the following methods.

1) Comparing distribution water measured by bulk meter and consumption record.
2) Comparing distribution water estimated by pump capacity with operation hours and consumption record where bulk meter is not available or malfunctioned.
3) Flow Monitoring of night flow, by using elevated tank measuring water level drop during night time, where above two methods are not possible or they are considered to be checked.

The summary of NRW Results for 27 schemes is given in **Table 3.24**. The details of calculation of NRW for the schemes are given in Annex.

Table 3.24 Results of Leakage Tests of Non-Revenue Water / Leakage

S/ No	GND	GND No	DS Division	NRW %		
				Field Test	Bulk Meter	Pump Detail
1	Kendewa	97	Rambewa		20.75	
3	Sangilikandarawa	111	Rambewa		23.68	
8	Thalgahawewa	84	Rambewa		18.44	16.9
9	Mahakandarayaya 02	93	Rambewa	22.95		
	Average for Rambewa DSD			**22.95**	**20.96**	**16.9**
12	Katuwela	66	Madawachchiya	30.14		
13	Halambagaswewa	70	Madawachchiya	18.28	22	10.2
14	Attaweeragollawa	56	Madawachchiya			18.42
15	Hirulugama	54	Madawachchiya			11.67
16	Wiralmurippu	64	Madawachchiya		10.7	
17	Kadawathgama	60	Madawachchiya		8.39	16.74
19	Kirigalwewa	72	Madawachchiya	14.31		
22	Kidawarankulama	42	Madawachchiya			46.32
23	Periyakulama	49	Madawachchiya	41.38		
24	Athakade	55	Madawachchiya	16.03		
	Average for Madawachchiya DSD			**24.03**	**13.70**	**20.67**
25	Ayyatigewewa	24	Kebitigollawa	17.97		
	Average for Kebitigollawa DSD			**17.97**		
29	18 Kanuwa	2	Padaviya	16.98		12.91
	Average for Padaviya DSD			**16,98**		**12.91**
31	Maha Kumbukwewa	222	Kahadagasdigilliya		29.53	24.89

S/ No	GND	GND No	DS Division	NRW %		
				Field Test	Bulk Meter	Pump Detail
32	Moragahawewa	202	Kahatagasdigiliya		4.51	6.97
33	Palispotana	224	Kahatagasdigiliya		29.4	26.92
34	Pandaralla	210	Kahadagasdigilliya			21.74
38	Turrukkuragama	234	Kahadagasdigilliya	2.75		
39	Mahawewa	221	Kahadagasdigilliya	6.84		
40	Meekumbukwewa	212	Kahadagasdigilliya	33.96		
43	Kumbukgollawa	209	Kahadagasdigilliya	19.17		
	Average for Kahadagasdigilliya DSD			**15.68**	**16.95**	**18.54**
44	Wadigawewa	126	Horowpothana		4.63	
45	Parangiyawadi	149	Horowpothana		3.58	
50	Maradankadawala	133	Horowpothana	23.74		
	Average for Horowpothana DSD			**23.74**	**4.10**	

As a result of NRW tests in typical 27 CBOs, NRW were assessed at ranging from 4.10 to 24.03%..

In relation to NRW, the following problems were identified:

- NRW of seven (7) NWSDB systems could not be obtained due to lack of data and large scale and complex system.
- Shortage of resources such as manpower, materials and vehicles for leak detection and repair,
- Lack of knowledge and skills for active leakage survey technology, and
- No specific programme for leakage control supported by NWSDB.
- Pipe data on water distribution network only covers up to the diameter of 63 mm or bigger. Smaller diameters are not covered in most cases, and
- Pipeline information in many CBOs has not been updated. Continuous update and verification of the pipeline information is necessary for the efficient operation and maintenance.

3.4.3 Financial Conditions

Information is collected from all CBOs with the exception of the CBOs which have not been in operation.

(1) Tariff and Revenue

Main sources of revenue are payment of water supply based on the tariffs and connection fee (as most CBOs have such charge) when a new family joins to the CBO. In some CBOs, suspension charge is also adopted if anyone delays paying a water bill.

Tariff information is obtained from 44 CBOs (except CBOs are not functioned), among which typical tariff structures are shown in **Table 3.25**
Most of CBOs have adopted a similar tariff structure. Water tariff is composed of basic charge and consumption rate by block progressive tariff rate. In addition, a connection charge is levied on the consumer, and similarly replacement of meter is also charged to the consumer.

Tariff is varied depending on the CBOs scheme. ADB3rd and ADB4th schemes generally have a minimum tariff varying from Rs. 10/- to 20/- per m^3 in Volumetric Rate.

However, in CWSSP schemes the tariff is higher than the above rates varying from Rs. 10/- to 30/- per unit.

Table 3.25 Sample of CBO Tariff Structures

Serial No: 01	**CBO: Swashakthi**	**PS: Rambewa**		**GND : Kendewa (97) & Galkandagama (85)**			
	Structure:	unit rate with a block progressive water rate					
	consumption:	< (10)	(11) ~ (30)	> (30)			
	volumetric rate:	20	30	40			
Serial No: 12	**CBO: Jayashakthi**	**PS: Madawachchiya**		**GND : Katuwela (66)**			
	Structure:	unit rate with a block progressive water rate					
	consumption:	< (10)	(11) ~ (15)	(16) ~ (20)	(21) ~ (25)	(26) ~ (30)	> (30)
	volumetric rate:	15	17	20	23	25	30
Serial No: 25	**CBO: Shakthi**	**PS: Kebithigollawa**		**GND : Ayyatigewewa (24)**			
	Structure:	unit rate with a block progressive water rate					
	consumption:	< (10)	(11) ~ (15)	(16) ~ (20)	(21) ~ (25)	> (26)	
	volumetric rate:	10	15	17	22	27	
Serial No: 28	**CBO: Parakum**	**PS: Padaviya**		**GND : Parakramapura(06), Buddhangala(05), Elikumbulagala (07)**			
	Structure:	unit rate with a block progressive water rate					
	consumption:	< (10)	(11) ~ (15)	(16) ~ (20)	(21) ~ (25)	> (26)	
	volumetric rate:	10	12.5	15	18	20	
Serial No: 31	**CBO: Vajira**	**PS: Kahadagasdigilliya**			**GND : Maha Kumbukwewa**		
	Structure:	unit rate with a block progressive water rate					
	consumption:	< (10)	(11) ~ (15)	(16) ~ (20)	(21) ~ (25)	> (26)	
	volumetric rate:	20	22.5	25	27.5	30	
Serial No: 50	**CBO: Hansajala**	**PS: Horowpathana**		**GND : Maradankadawala**			
	Structure:	unit rate with a block progressive water rate					
	consumption:	< (15)	(16) ~ (20)	(21) ~ (25)	> (26)		
	volumetric rate:	15	20	25	30		
	Base charge (Rs/mon):	50					
	Minimum monthly charge (Rs/mon):	10					

(2) Expenditure

CBOs expenditures are basically composed of (1) personnel costs (payment to operating staff), (2)electricity, (3) maintenance costs, (4)purchase of chemical and (5)other miscellaneous costs. The shares of personnel costs range from 0% to 68.1% and 45% on average. The shares of consumable costs in the expenditures are from 23.3% to 72.5% and the average is 40.7%. The shares of maintenance costs in the expenditures are from 0% to 63.2% and the average is 14%. The Personnel costs and electricity bills are the major expenses. And the maintenance costs are widely varied from zero to Rs. 240,000 per year depending on conditions of facilities and/or manner of maintenance philosophy. (Zero expenditure is doubtful though, it may be due to lack of book keeping)

Figure 3.6 shows the composition of expenditures by category in the year 2011. Among the total expenditure, O&M personnel and power consumption are 82% of the expenditures.

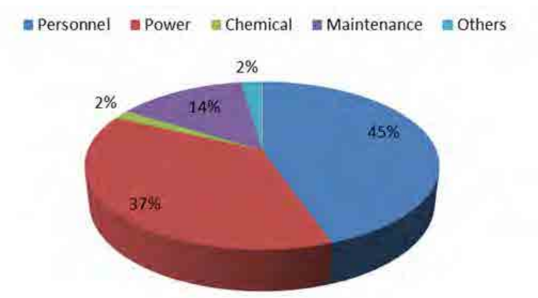


Figure 3.6 Expenditure of CBO

(3) Financial Status

Based on the CBO survey results, the financial situation of CBOs can be summarized in **Table 3.26**. Although some CBOs did not answer the questions about their financial conditions, the other answering CBOs financial accounts are good. All the CBOs, which answered, show more revenues than expenditures. The profit rates to revenues (mostly sales) are from 5% to 73.8% and it is 44.6% on average.

For reference, profit (Rs.) per unit sold water (m^3) is shown in the right column of the table. It ranges from 0.9 to 43 and the average is 11.7. The difference is too large.

Table 3.26 Profit/ Loss of CBOs

(Unit: Rs.)

DSD	GND	CBO	Revenue	Expenditure	Profit/loss	Profit / Revenue	Personnel / Expenditure	Consumables / Expenditure	Maintenance / Expenditure
Padaviya	Padaviya	Suwasehana	1,025,364	425,928	599,436	58.5%	19.7%	23.9%	56.3%
	Parakramapura	Parakum	2,045,400	618,380	1,427,020	69.8%	56.3%	31.2%	12.5%
	Bogahawewa	Suwasetha	730,052	478,348	251,704	34.5%	37.6%	34.4%	28.0%
Kebithigollewa	Ayyatigewewa	Shakthi	562,758	534,519	28,239	5.0%	40.4%	27.8%	31.8%
Medawachchiya	Kidawarankulama	Sisila Diyadahara	535,060	373,612	161,448	30.2%	41.8%	55.6%	2.7%
	Maha Kumbugollewa	Diriyamatha	562,228	421,037	141,191	25.1%	42.8%	33.5%	23.8%
	Periyakulama &Yakawewa	Diriyashakthi	490,000	362,432	127,568	26.0%	36.4%	57.2%	6.3%
	Hirulugama	Ekamuthu	394,796	358,672	36,124	9.2%	55.2%	33.6%	11.2%
	Athakade	Ridinadi	446,472	224,569	221,903	49.7%	53.4%	32.3%	14.3%
	Ataweeragollewa	Samagi	434,792	289,904	144,888	33.3%	33.1%	63.4%	3.4%
	Maha Divulwewa	Gemunu	192,684	81,420	111,264	57.7%	36.8%	63.2%	0.0%
	Kadawathgama	Isuru	714,806	476,204	238,602	33.4%	54.2%	29.3%	16.5%
	Viralmurippuwa	Ran Arulnalu	402,264	176,323	225,941	56.2%	57.8%	39.8%	2.3%
	Katuwela	Jayashakthi	927,904	632,164	295,740	31.9%	45.6%	46.5%	7.9%
	Helabagaswewa	Samagi	1,270,584	332,448	938,136	73.8%	57.4%	32.1%	10.5%
	Kirigalwewa	Nelum	286,620	159,624	126,996	44.3%	45.1%	54.9%	0.0%
	Unagasewewa	Randiya Dhahara	527,540	291,700	235,840	44.7%	26.7%	62.1%	11.1%
Rambewa	Wewelketia & Thamarahamillewa	Rangiri	341,832	192,492	149,340	43.7%	49.9%	50.1%	0.0%
	Talgahawewa	Samagi	432,168	260,950	171,218	39.6%	62.1%	27.4%	10.5%
	Balahodawewa	Pragithi	290,772	123,515	167,257	57.5%	53.4%	37.8%	8.7%
	Ihala Kolongasw.	Dimuthu	147,732	81,263	66,469	45.0%	59.1%	37.6%	3.3%

DSD	GND	CBO	Revenue	Expenditure	Profit/loss	Profit / Revenue	Personnel / Expenditure	Consumables / Expenditure	Maintenance / Expenditure
Rambewa	Mahakanadarawa 2	Mahasen	319,376	266,966	52,410	16.4%	44.9%	50.2%	4.9%
	Mahakanadarawa 1	Nildiyadahara	391,396	242,219	149,177	38.1%	47.1%	38.5%	14.4%
	Kedewa & Galkandegama	Swashakthi	441,276	199,605	241,671	54.8%	60.1%	32.5%	7.3%
	Ikirigollewa	Ikra	1,883,160	1,084,874	798,286	42.4%	49.8%	48.7%	1.5%
	Katukeliyawa	Eksath	305,352	226,842	78,510	25.7%	42.3%	24.1%	33.6%
	Wahamalgollewa 3	Ekamuthu	616,920	347,832	269,088	43.6%	48.3%	50.4%	1.3%
	Sangilikanadarawa	Arunalu	974,584	466,315	508,269	52.2%	38.6%	46.7%	14.7%
Horowpothana	Wadigawewa	Pradeepa	382,908	226,651	156,257	40.8%	52.9%	23.3%	23.7%
	Maradankadawela	Hansajala	392,044	224,817	167,227	42.7%	0.0%	36.8%	63.2%
	Kapugollewa	Jalasavi	331,324	224,859	106,465	32.1%	41.8%	36.9%	12.3%
	Parangiyawadiya	Upul	613,428	224,501	388,927	63.4%	58.8%	31.0%	10.2%
Kahatagasdigiliya	Moragahawela	Pragathi	339,660	176,620	163,040	48.0%	67.9%	26.4%	5.7%
	Kubukgollewa	Ekamuthu	200,900	159,532	41,368	20.6%	30.1%	64.0%	5.9%
	Pandarellewa & Panwella	Sobasisila	510,720	242,664	268,056	52.5%	49.5%	50.5%	0.0%
	Mee-Kumbukwewa	Apsara	290,592	192,548	98,044	33.7%	49.9%	49.1%	1.0%
	Mahawewa	Praja Shakthi	624,740	368,669	256,071	41.0%	40.7%	27.0%	32.4%
	Maha Kubukwewa	Vajira	431,496	290,632	140,864	32.6%	68.1%	24.3%	7.6%
	Gonumeru Wewa	Senath	275,312	185,640	89,672	32.6%	12.9%	72.5%	14.5%
	Palippothana ~ Kirigallewa	Janasetha	615,476	249,024	366,452	59.5%	48.2%	47.0%	4.8%
	M. Kiribbewa & Kurukuragama	Eksath	214,800	196,116	18,684	8.7%	49.0%	51.0%	0.0%
Average			558,958	309,571	249,387	44.6%	46.5%	40.7%	15.7%

Source: CBO Survey

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3.4.4 Summary of Survey Results

(1) Existing Conditions in CBO Water Supply Schemes

The conditions of exiting water supply schemes are summarized for the **Table 3.27** as follows.

- CBOs supply schemes are presently the major water supply system where about 70 % of served population or 19 % of total population of the Project area is supplied by CBO's system. Therefore, it is crucial to maintain CBO's system with sound manner.
- 44 CBOs out of 50 are functioned and most of CBOs have started their operation from the year 2006 or around.
- All elevated tanks other than S/No. 36 Kokmaduwa in Kahadagasdigilliya (leakages are observed) are sound to receive treated water by ANIWSP.
- Most of CBOs express their willing to connect to the treated water system constructed by the present project of Anuradhapura North Integrated Water Supply Project (ANIWSP), and they desire to keep operation and maintenance by themselves. (except one CBO – 10 Mimuth CBO was not willing to connect)
- Distribution pipe network is all PVC type 600 with the diameter ranging from OD 32 mm to 225 mm. The length of the distribution system varies depending on the size of CBSs schemes, ranging from 4.5 Km to 24 km.
- Bulk meter is not installed or not functioned in many CBOs, which makes difficult to monitor tendency of distribution water and monitor and control of NRW

Table 3.27 Summary of the Present Condition of the CBO

S/ No.	CBO	GND	Present Conditions
01	Swashakthi	Kendewa (97), Galkandagama (85)	The 60m^3 water tower is structurally sound and the distribution system is satisfactorily. NRW is 20.75%using bulk meter readings. The present system capacity is 160m^3/day.
02	Ikra	Ikkirigollawa (102)	The 225m^3 water tower is structurally sound. The system capacity is 516 m^3/ day. Water source is shallow well and deep well. There are some valve leaks.
03	Arunalu	Sangilikandarawa (111)	The 80 m^3 water tower is in good condition. The water source is a shallow well and deep well. The current system capacity is 196m^3/day. O&M and financial management are satisfactory. Suitable for bulk supply.
04	Samagi	Thalgahawewa (84)	The 40m^3 water tower is in good condition. Water source is a deep well. The system capacity is 111m^3/day and NRW 18.44%.O&M and financial management are fairly satisfactory.
05	Ekamuthu	Wahamalgollawa (109)	The 80m^3 water tower is in good condition. The water source is deep well and shallow well. The system capacity is 227m^3/day. NRW not available, but there are visible leaks. No record of repairs/ replacement in distribution system. O&M is fair and financial management is satisfactory. Cumulative balance is Rs. 3.5 Million. Suitable for bulk supply with increase in staff to 3 nos. and training of O&M group and CBO key staff. .

S/ No.	CBO	GND	Present Conditions
06	Rangiri	Wewalkatiya (82)	The $60m^3$ water tower is in good condition. The water source is deep well (satisfactory) and shallow well (not fully completed). The system capacity is $179m^3$/day. The tapping pressure is low (4m). There are considerable gate valve leaks.
07	Nildiyadahara	Maha Kandarawa yaya -01 (94)	The $40m^3$ water tower and the distribution system are in good condition. The water source is a shallow well and the system capacity is $108m^3$/day. Financial management is satisfactory. Connection to bulk supply system is recommended.
08	Eksath	Katukeliya - 106	The $40m^3$ water tower is structurally sound. The water source is a shallow well and the system capacity is $89m^3$/day. NRW not available. The distribution system is in fairly good condition. O&M and financial management are satisfactory.
09	Mahasen	Mahakandarayaya - 02 (93)	The $40m^3$ water tower is structurally sound. The water source is a shallow well and the system capacity is $110m^3$/day. No evidence of repair/ replacement and well/ tank cleaning during maintenance (2011).Field test indicate NRW of 22.95% and the distribution system appear satisfactory. Annual revenue and expenditure is maintained.
10	Dimuthu	Ihala Kolangaswewa (87)	The $20m^3$ water tower in good condition. The water source is a shallow well and the system capacity is $72m^3$/day. NRW value unreliable. No evidence of repair/ replacement and well/ tank cleaning during maintenance (2011). Annual revenue and expenditure is maintained.
11	Pragithi	Bala Honda Wewa (86) Ihala Kolangaswewa (87)	The $40m^3$ water tower in good condition. There is no indication of leakage in the distribution system. The water source is a shallow well and the system capacity is $109m^3$/day. NRW is not estimated. There has been repair and replacement of pipes, but no evidence of maintaining pump, well & tank during 2011. Annual revenue and expenditure is maintained.
12	Jayashakthi	Katuwela (66)	The $60m^3$ water tower in good condition. The water source is a deep well and the system capacity is $216m^3$/day, but the fluoride level is high (1.9 mg/L). Field measurements indicate NRW of 30.14%. O&M and financial management are satisfactory and the scheme is running with good profit.
13	Samagi	Halambagaswewa (70)	The $50m^3$ water tower in good condition. The water source is a deep well and the system capacity is $180m^3$/day. Field test indicate NRW is 18.28%. O&M and financial management are satisfactory and the scheme is running with good profit.
14	Samagi	Ataweeragollewa (56)	The $60m^3$ water tower in good condition. The water source is a shallow well and the system capacity is $144m^3$/day. Pump details indicate NRW as 18.42%. Annual revenue and expenditure is maintained.
15	Ekamuthu	Hirulugama (54)	The $50m^3$ water tower in good condition. The water source is a deep well and the system capacity is $144m^3$/day. The tapping pressure is low (4m). Pump details indicate NRW is 11.67%. No evidence of repair/ replacement and well/ tank cleaning during maintenance (2011). Annual revenue and expenditure is maintained.
16	Ran Arulnalu	Wiralmurippu (64)	The $30m^3$ water tower is in satisfactorily condition. The water source is a deep well and the current system capacity is $173m^3$/day which need to expand to $250m^3$/day. NRW is 10.7% (bulk meter reading). Hardness and fluoride exceed permissible limits. Annual revenue and expenditure is maintained.
17	Isuru	Kadawathgama (60)	The $60m^3$ water tower and distribution system are in good condition and the CBO functioning well. The water source is a deep well and the system capacity is $180m^3$/day to be expanded to $225m^3$/ day. NRW from pump details is 16.12%. Rs. 79,000 spent on maintenance and the O&M

S/ No.	CBO	GND	Present Conditions
			and financial management are satisfactory.
18	Randiya Dhahara	Unagaswewa (75)	The 40m^3 water tower is in good condition. The water source is a shallow well and the system capacity is 90m^3/day. No data to calculate NRW. The distribution system is maintained fairly well and the financial management is satisfactory.
19	Nelum	Kirigalwewa (72)	The 40/60m^3 water tower is in satisfactorily condition. The water source is a shallow well and the current system capacity is 105m^3/day, to be expanded to163m^3/day. Field test indicate 14.31% NRW. No evidence of maintenance expenditure, but financial management is satisfactory. The distribution system is satisfactory.
20	Diriyamatha	Maha-Kumbugollawa (46)	The two 40m^3 water towers are in satisfactorily condition. The water source is 2 shallow wells and the system capacity is 169m^3/day. NRW not recorded. The Annual revenue and expenditure is maintained.
21	Gemunu	Maha Divulwewa (57)	The 40m^3 water tower is in satisfactorily condition. The water source is a shallow well and the system capacity is 98m^3/day. NRW not recorded. Tapping pressure is low (3m). Maintenance level is low (no expenses recorded). Annual revenue and expenditure is maintained.
22	Sisila Diyadahara	Kidawarankulama (42)	The 40m^3 water tower is in satisfactorily condition. The water source is a shallow well and the system capacity is 139m^3/day. Tapping pressure is very low (2m) in section of the distribution system. Pump details give 46.32% NRW (can be due to illegal tapping for agriculture / industry). Repair, replacement of pipes and cleaning of well / tank. Annual revenue and expenditure is maintained.
23	Diriyamatha	Periyakulama(49), Yakkawewa (50)	The 40m^3 water tower is in satisfactorily condition. The water source is a shallow well, providing water of moderately high hardness and the system capacity is 95m^3/day. Field test indicate NRW of 41.38% (can be due to illegal tapping for agriculture/ industry). Repair, replacement of pipes and frequent cleaning of well / tank. The financial management is satisfactory.
24	Ridi Nadi	Athakade (55)	The 40m^3 water tower is in satisfactorily condition. The water source is a shallow well and the system capacity is 87m^3/day. Field test indicate NRW of 16.03%. Distribution system is satisfactory but no evidence of Maintenance (2011). Annual revenue and expenditure is maintained.
25	Shakthi	Ayyatigewewa (24)	The 60m^3 water tower is in satisfactorily condition. The water sources are Deep well & shallow well and the system capacity is 252m^3/day. Field test indicate NRW of 17.97%. Maintenance included repair &, replacement of pipes. The financial management is satisfactory.
26	Al-Naja	Muslim Attaweerawewa (32	This ADB 4 funded scheme is newly constructed (2012) & not yet commissioned. The 30m^3 & 40 m^3 water towers are both new and structurally sound. This scheme established in 2009 is not commissioned yet.
27	No CBO	Gonumariyaya (25)	The Scheme is not implemented. Hence there is no water supply scheme to be incorporated to ANIWSP.
28	Parakum	Parakramapura(06), Buddhangala(05), Elikumbulagala (07)	This is the largest among the community water supply schemes. The 225m^3 RC water tower is structurally sound. Water source is 02 deep well and the system capacity is 405m^3/day. The O&M of the Distribution system & financial management are satisfactory. The annual balance is Rs.1.4 million & the scheme is sustainable.
29	Suwasehana	18 Kanuwa (02)	The 35m^3 capacity water tower is in good condition. The water source is a deep well and the system capacity is 124 m^3/day & field tests indicate

S/ No.	CBO	GND	Present Conditions
			16.98% NRW. Hardness & fluoride levels are moderately high. The distribution system is well maintained & financial management is good. The annual balance is nearly Rs. 600,000/-.
30	Suwasetha	Bogahawewa (14)	The 40m^3 water tower is in good condition. The water source is a shallow well. The system capacity is 173m^3/day. There is no NRW measurement. The scheme maintenances is satisfactory and financial management is good, with a annual balance over Rs. 250,000/-
31	Vajira	Maha Kumbukwewa (222)	The 60m^3 water tower is structurally sound, water source is a deep well and the system capacity is 108m^3/day. The water has high fluoride (1.5/1.54 mg/L) and the water loss is 29.5% (bulk meter). The annual revenue & expenditure is maintained. The scheme is running in good condition. This scheme can be connected to bulk supply.
32	Pragathi	Moragahawela (202)	The 40m^3 water tower is in good condition. The water source is a deep well & the system capacity is 90m^3/day. In the maintenance of the scheme in 2011 no pipe repair/ replacement was necessary, but repair/service of pump & cleaning of well & tank was done. NRW is recorded as 4.51% (bulk meter) & 6.97 % (pump details). The O&M and the financial management are satisfactory.
33	Janasetha	Ratmalgahawewa(225), Paalishpothana(224), Kirigallawa (226)	The 60m^3 water tower is structurally sound and the shallow well is the water source. The system capacity is 144m^3/day. The fluoride level is 1.37mg/L & only 8 hrs. supply during dry period. NRW based in bulk meter reading is 29.4% & by pump details is 26.92 %. The annual revenue and expenditure is maintained. CBO is willing to get bulk connection.
34	Sobasisila	Pandarella(210), Panwella (211)	The 60m^3 water tower in in sound condition. The water source is a shallow well & the system capacity is 126m^3/day. The NRW is 21.74% based on pump details – only 4hrs/day supply during dry period. Scheme maintenance satisfactory. Annual revenue & expenditure is well maintained.
35	Randiya	Ranpathwila (196)	The 80m^3 RC Water tower is structurally sound. The water source is a shallow well & the system capacity is 180m^3/day. No value of NRW. Very little expenditure on system maintenance. The annual revenue & expenditure is well maintained and the annual balance is nearly 2/3rd of the revenue.
36	Nilmini	Kokmaduwa(201)	This is a CWSSP scheme. The 40m^3 water tower appear to be structurally sound. The scheme started operation in 2006, but the borehole pump was damaged in the same year. The scheme did not operate from late 2006. The system capacity was 55m^3/ day. The water quality was not acceptable due to high hardness. The presently community travel 2-3 km to collect water.
37	Senath	Gonamaruwewa (223)	This is a CWSSP Scheme with a 60m^3 water tower in good condition. The water source is a shallow well & the system capacity is 83m^3/day. The fluoride level is high at 1.9mg/L No power at the intake and a land master tractor engine is used to drive the pump. There is no record of repair/replacing pipes & repair /service/ pump and cleaning well / tank during 2011. Also only one employed technical staff was used.
38	Eksath	Turukkuragama (234) & Maha Kiri Ibbawa (233)	This is a CWSSP scheme. The 40 m^3 water tower is in good condition. The water source is a shallow well & the system capacity is 89m^3/ day. The well water hardness is 296 mg/L & fluoride is 1.62 mg/L. Field test indicate low NRW of 2.75%. There is very low pressure in part of the distribution system. The annual revenue & expenditure is not correctly maintained. Only one pump is working, CBO willing to connect to bulk

S/ No.	CBO	GND	Present Conditions
			supply.
39	Praja Shakthi	Mahawewa (221)	The 40m^3 water tower is in good condition. The water source is two shallow wells and the system capacity is 110m^3/day. But the water supply is limited to 12hrs/day normally and 2.5hrs/day during dry period. Field test indicate NRW of 6.84%. During maintenance in 2011. The annual revenue & expenditure is maintained.
40	Apsara	Meekumbukwewa (212)	The 30m^3 capacity water tower is in good condition. The water source is one shallow well & the system capacity is 82m^3/day. The water supply has to be restricted to12 hrs/day during dry period. The fluoride level is 1.35 mg/L. Field test indicate NRW of 33.96%. The annual revenue and expenditure is maintained. The tapping pressure is satisfactory (10m).
41	Pinibindu	Ambagahawewa - 213	This is a rainwater harvesting scheme 60 households have individual collection systems. CBO is willing to be connected bulk supply.
42	Sham Sham	Weligollawa (218), Kuncha Halmillawa (219)	This is a CWSSP scheme, with 40m^3 water tower which appears to be in good condition. The water source is a bore hole (deep well) which failed after one year operation in 2008. The pump was also damaged & is not replaced. CBO wishes to connect to bulk supply. However, if the scheme is to be incorporated the system must be “charged” and the status of the water tank & distribution system checked.
43	Ekamuthu	Kumbukgollawa (209)	The 35m^3 water tower is in good condition. The water source is a shallow well & the system capacity is 93m^3/day. The water supply is only 2 hrs/day during dry period. Both hardness & fluorides are moderately high. Field tests indicate NRW of 19.17%. There is no power & diesel driven pump is used. The annual revenue and expenditure in recorded, but the annual balance is small.
44	Pradeepa	Wadigewewa (126)	The 50m^3 water tower & distribution system are in good condition. The water sources consist of the deep well and 04 shallow wells. The system capacity is 145m^3/day. Hardness level is 448 mg/L fluoride 0.82 mg/L. The annual revenue & expenditure are well maintained.
45	Upul	Parangiwadiya (149)	The 60m^3 water tower is structurally sound. The water source is a deep well & the system capacity is 145m^3/day. Though water quality results are: Hardness 290 mg/L & Fluoride 0.92 mg/L the consumers complain in of high fluoride. The distribution is a good condition & maintained well. The financial management is also very good with an annual revenue of Rs. 613,428/ - and an annual balance of Rs.389,000/-.
46	Jalasavi	Kapugollewa (140)	The 50m^3 water tower is in good condition. The water source is deep well. The system capacity is 112m^3/day. The water quality is a problem with high fluoride of 1.58 mg/L. The distribution system has many leaking valves and the leaking valves at domestic connections. Field test indicate NRW of 34%. The annual revenue & expenditure is maintained.
47	Tristar	Agunuchchiya (119)	The 60m^3 water tower is structurally sound. The water source consists of 2 deep wells. Hardness is 290 mg/L & fluoride is 0.92mg/L. The full system capacity is not fixed as the scheme is only partially operating. The scheme is not handed over to the CBO and O&M is not started and the tariff is not charged, though water is being used. CBO is willing to connect to bulk supply.

S/ No.	CBO	GND	Present Conditions
48	Alhidra	Anolondawewa (138)	This CBO is adjacent to Weerasole and also completed in March 2012. The $80m^3$ water tower is new in good condition. The water source consists of 2 deep well (tube wells) & the system capacity is $335m^3$/day. Though the system is not officially opened for consumes water is supplied as connection are given. This is increased from 35 units in March 2012 to 884 units in May 2012.
49	Adhikwa	Weerasole (139)	The $40m^3$ water tower is new and structurally sound. The water source consist of 1 tube well & 01 shallow well. The water quality is tolerable (Hardness 280 mg/L & fluoride 0.70 mg/L). The scheme is under NWSDB but water is supplied to part of the consumers. The completed scheme is not handed over to CBO.
50	Hansajala	Maradankadawala (133)	The $50m^3$ water tower is satisfactory but the pipe network has not been properly constructed to cover the whole service area. The water source is 01 shallow well & the system capacity is $150m^3$/day. The water quality is poor, hardness is 442 mg/L & fluoride level is 0.8mg/L. Field test indicates NRW of 23.74%. The annual revenue and expenditure is not fully recorded. Full time staff is not recruited.

(2) Problems in CBO Managed Water Supply Schemes

As a result of the survey, the existing facilities of CBOs are mostly in good conditions except a few CBOs. It is, however identified the problems in technical and non-technical aspects as shown in **Table 3.28**.

- None of CBOs has 24-hour continuous supply. The reason are (1) shortage of raw water source of groundwater especially in dry season and (2) unstable power supply in some CBOs.
- High concentration of fluoride and also high hardness of well water are observed in many wells of CBOs.
- In several CBOs distribution pipe networks, where pipelines are less than OD65mm diameter, the pipe sizes are too small; hence water pressure at the distribution pipe end is not enough.
- Bulk meters are not installed or not functioned in many CBOs, which makes difficult to monitor distribution of water and to control NRW.
- Cash flow of the most of CBOs is positive, while their water tariff is relatively higher than that of NWSDB.
- Chlorination is, in principle not properly made. It is presumed that most of CBOs have used hypochlorite only occasionally or not used at all.
- Through the survey, many sketch of distribution networks are collected, however they are not accurate, and cannot be used for analysis. No updated information has been found.

Table 3.28 Summary of Problems in the CBOs

S/ No.	CBO	GND	Problems													
			Technical									Non Technical				
			A	B	C	D	E	F	G	H	I	a	b	c	d	e
1	Swashakthi	Kendewa (97), Galkandagama (85)									X					
2	Ikra	Ikkirigollawa (102)	X	X	X			X		X						
3	Arunalu	Sangilikandarawa (111)									X					
4	Samagi	Thalgahawewa (84)										X		X	X	X
5	Ekamuthu	Wahamalgollawa (109)														
6	Rangiri	Wewalkatiya (82)		X			X						X			
7	Nildiyadahara	Maha Kandarawa yaya -01 (94)	X		X				X		X		X			
8	Eksath	Katukeliya (106)	X		X		X				X		X			
9	Mahasen	Mahakandarayaya - 02 (93)	X		X		X				X		X			
10	Dimuthu	Ihala Kolangaswewa (87)	X		X		X				X		X			
11	Pragithi	Bala Honda Wewa (86), Ihala Kolangaswewa (87)	X		X		X						X			
12	Jayashakthi	Katuwela (66)	X								X					
13	Samagi	Halambagaswewa (70)														
14	Samagi	Ataweeragollewa (56)	X				X						X			
15	Ekamuthu	Hirulugama (54)	X			X							X			
16	Ran Arulnalu	Wiralmurippu (64)	X											X		
17	Isuru	Kadawathgama (60)														
18	Randiya Dhahara	Unagaswewa (75)	X		X		X	X					X			
19	Nelum	Kirigalwewa (72)	X				X				X		X			
20	Diriyamatha	Maha-Kumbugollawa (46)	X		X		X						X			
21	Gemunu	Maha Divulwewa (57)	X			X	X						X			
22	Sisila Diyadahara	Kidawarankulama (42)	X		X	X	X						X			
23	Diriyamatha	Periyakulama (49), Yakkawewa (50)	X		X		X	X			X		X			
24	Ridi Nadi	Athakade (55)	X				X				X					
25	Shakthi	Ayyatigewewa (24)	X								X					
26	Al-Naja	Muslim Attaweerawewa (32)	X				X						X			
27	No CBO	Gonumariyaya (25)														
28	Parakum	Parakramapura (06), Uddhangala (05), Elikumbulagala (07)	X													
29	Suwasehana	18 Kanuwa (02)	X				X						X			
30	Suwasetha	Bogahawewa (14)	X								X		X			
31	Vajira	Maha Kumbukwewa														
32	Pragathi	Moragahawela (202)														
33	Janasetha	Ratmalgahawewa (225), Paalishpothana (224), Kirigallawa (226)						X			X	X				
34	Sobasisila	Pandarella(210), Panwella (211)	X								X					
35	Randiya	Ranpathwila (196)	X								X					
36	Nilmini	Kokmaduwa (201)	X				X						X			
37	Senath	Gonamaruwewa (223)	X		X		X	X			X		X		X	
38	Eksath	Turukkuragama (234), Maha Kiri Ibbawa (233)	X			X	X				X		X			
39	Praja Shakthi	Mahawewa (221)	X				X				X		X			
40	Apsara	Meekumbukwewa (212)	X	X			X				X		X			
41	Pinibindu	Ambagahawewa (213)														
42	Sham Sham	Weligollawa (218), Kuncha Halmillawa	X		X		X						X			
43	Ekamuthu	Kumbukgollawa (209)	X			X	X	X			X		X			
44	Pradeepa	Wadigewewa (126)												X		
45	Upul	Parangiwadiya (149)		X	X									X		
46	Jalasavi	Kapugollewa (140)		X										X	X	
47	Tristar	Agunuchchiya (119)														
48	Alhidra	Anolondawewa (138)														
49	Adhikwa	Weerasole (139)														
50	Hansajala	Maradankadawala (133)		X	X									X		

Technical

A: No master valves at water tanks and/or tube-well pumps are installed.

B: Leakage from tanks and/or pipeline

C: No operational valves (air valve, gate valve and wash-out valves, etc.) are installed.

D: Insufficient pressure due to under-sized pipes
E: No proper chlorination dosage.
F: Unstable electricity supply (power cut/voltage variation)
G: Invisible customer meters
H: Malfunction of tube-well pump
I: Little water in dry season
Non Technical
a: O&M records not succeeded due to change of committee member
b: No administration office
c: No proper O&M record keeping due to insufficient training
d: No enough number of O&M staff
e: Poor management of billing system (meter reader does not read exactly)

(3) Conclusion and Recommendations

- Most of CBOs' facilities are new and in good conditions. They are capable to receive bulk water supply from ANIWSP.
- All CBOs in operation (with the exception of one CBO) are willing to connect to the bulk water supply system and desire to maintain operation and maintenance by themselves.
- In order that the ANIWSP connects and supplies bulk water to the CBOs, the following technical and non-technical recommendations are taken into account:
    - Proper installation of valves such as air valve, wash out valve and sectional valve shall be made in CBOs' distribution lines.
    - On connecting to the ANIWSP, it is necessary to install bulk meter at the inlet pipe of each CBO's tank, which will be a scope of ANIWSP. In addition installation of another master meters at the outlet of CBOs tanks are recommended with the assistance by NWSDB.
    - Repair and rehabilitation of network is recommended where low pressure is observed resulting from unsuitable pipe sizes in a part of distribution system.
    - NRW is properly monitored and controlled with an assistance of NWSDB. Where NRW ratios are higher than 20%, counter measures will be taken.
    - With the assistance of NWSDB, necessary capacity building is conducted for CBOs managerial staff, which includes billing system, record keeping, technics of O&M, etc.

Div. Sec. Area - : Rambewa, GN Division - : Wewalkatiya - 82

From left Eelvated tank, shallow well pumps and CBO office

Div. Sec. Area - : Madawachchiya, GN Division - : Katuwela (66)

Bore Hall Intake

Pump House

Panel Board

Div. Sec. Area - : Kebitigollawa, GN Division - : Ataweerawewa (22)

Tank 2-30 m3 Tank, Muslim

Intake

Pump House

Figure 3.7 Existing Facilities in Each DSD

Div. Sec. Area - : Padaviya, GN Division - : Bogahawewa (14)

Water Tower

Shallow Well Intake

Pump House

Div. Sec. Area - : Kahatagasdigiliya, GN Division - : Pandarallawa (210)

Shallow Well Intake

Flow Meter

Panel

Div. Sec. Area - :Horowpothana, GN Division - : Ihala Angunochchiya CBO

Water Tower

Control Room -01

Intake Borehole No-01

Figure 3.7 Existing Facilities in Each DSD (Cont'd)

CHAPTER 4

PROJECTION OF POPULATION AND WATER DEMAND IN THE STUDY AREA

CHAPTER 4 PROJECTION OF POPULATION AND WATER DEMAND IN THE STUDY AREA

4.1 Basic Policy for Planning

The study area covers six DSDs (Divisional Secretary Divisions), namely, Padaviya, Kebithigollewa, Horowpothana, Kahatagasdigiliya, Medawachchiya and Rambewa which are located in the north-eastern part of Anuradhapura District with a population of 204,738 persons (estimated for the year of 2012) and an area of 2,740.48 km^2 forming the typical rural area. The people in this area mainly rely their drinking water source on groundwater through dug/tube wells, however due to a high content of fluoride in groundwater, the patience of dental and skeletal diseases occur. In addition, they say that a high prevalence of chronic kidney diseases (CKDs) is also attributed to the high fluoride concentration in Sri Lanka. In the study area, as described in **Chapter 3**, there are six water supply systems operated and maintained by NWSDB and 50 water supply schemes under CBOs. They are all small-scale water supply schemes with water sources in dug/tube wells except for one CBO system and mostly have a problem of high fluoride concentration in groundwater. Water shortage is also found in the many existing CBO systems especially during the dry season.

To solve these problems, the new water supply system is proposed to integrate the existing NWSDB and CBO water supply schemes under the following basic policy for planning:

- The water source will be converted from groundwater to surface water to meet the Sri Lanka drinking water standards. The surface water will be taken from the irrigation canals originated from Mahakanadarawa Tank and Wahalkada Tank for irrigational purpose.
- Taking into account the overall topography of the study area and the location of proposed water sources, the study area will be divided into two water supply systems, namely, Mahakanadarawa System covering Medawachchiya and Rambewa DSDs and Wahalkada System covering Padaviya, Kebithigollewa, Horowpothana and Kahatagasdigiliya DSDs. (See below for “one integrated water supply system” as an alternative)
- The proposed water supply sytems will supply water to the existing service area under NWSDB and CBOs and the new service area currently not served,
- The study area is composed of 194 GNDs under six DSDs, out of which 60.8% of GNDs have a population density of less than 100 persons per km2 and 87.6% of GNDs for less than 200 persons /km2. Since the population is sparsed thinly in an extensive area as mentioned-above, it is clearly not cost-effective to develop ordinary water supply systems (hereinafter referred to as “ pipe borne water supply”). For this reason, some area will be covered by non pipe borne water supply systems in which safe water treated at water treatment plants will be delivered by water bowser to the water tanks strategically arranged to minimise the water-fetching works of the people (hereinafter referred to as “bowser water supply”).
- The new water transmission pipes will be connected to the elevated tanks of existing

systems and the existing water distribution facilities will be used as they will be as much as possible.

- Some out of the existing CBO systems will be excluded from the integration to the new water supply systems, if they have currently no problem in quality, quantity, operation, etc.

<For one integrated water supply system as an alternative>

In the study area, another option to cover the whole study area by one water supply system is considered but excluded due to the reason described below.

The study area is divided into the eastern and western areas by the ridge with ground elevations of +146M at Kahatagasdigiliya, +122M at Rathmalgahawewa and +122M at Kebithigolle proposed for elevated tank sites running in the almost centre of the study area, and has slopes to the Mahakanadarawa WTP site southwestward (GE +91M) and the Wahalkada WTP site ((GE +56M)) northeastward. Since the Wahalkada WTP site is located at the lowest ground elevation in the study area, it has the most disadvantage to transmit all amount of water from the WTP to the whole area from the viewpoint of energy consumption. On the contrary, it is possible to transmit water from Mahakanadarawa WTP site with less energy consumption. However, the storage capacity of Wahalkada Wewa is not enough to cover the water demand for irrigation and drinking water supply in the year of 2016 even in case of two water supply system, namely Mahakanadarawa System and Wahalkada System and water intake from Mahakanadarawa Wewa with a full amount will clearly make water shortage more serious, that is to say, there is a problem in the stability as a water source. Hence there is a crucial disadvantage for water supply from either Mahakanadarawa Wewa or Wahalkada Wewa from the different reasons. Such problems can be mitigated by dividing the study area into two parts and constructing an independent water supply system, respectively.

The design water supply is estimated in accordance with the flowchart as shown in **Figure 4.1**.

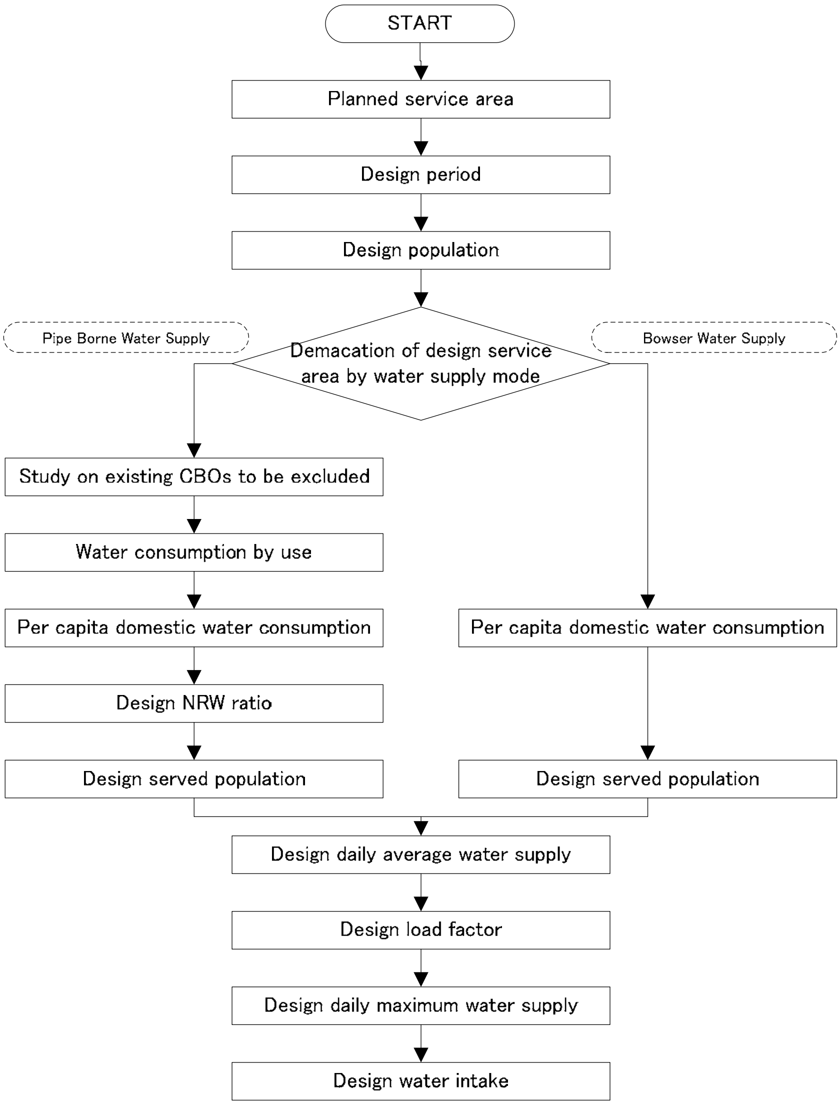

Figure 4.1 Flowchart of Design Water Supply Estimation

4.2 Estimation of Design Water Supply

4.2.1 Design Service Area

The design service area shall be six DSDs, namely, Padaviya, Kebithigollewa, Horowpothana, Kahatagasdigiliya, Medawachchiya and Rambewa which are located in the north-eastern part of Anuradhapura District, as previously stated.

4.2.2 Design Period

“Pre-Feasibility Report on Anuradhapura North Integrated Water Supply” prepared by NWSDB in

December 2012 set the target year in 2034. NWSDB Design Manual (March 1989) describes that "*As a general principle it is recommended that future urban schemes be designed for a 20-year planning horizon in two 10-year stages*". For reference, the Japanese design criteria recommend to set the target year at15 to 20 years ahead. Therefore, it is reasonable to set the target year in 2034 with an interim target year of 2024 for staged construction.

4.2.3 Design Population

The percentage of the population in the Anuradhapura District of the total national population was 2.6% in 1963, 3.1% in 1971 and 4.0% in 1981 showing a steady increase, but thereafter being similar to 1981 at 4.0% in 2001 and 4.2% in 2012, as shown in **Table 4.1**.

Table 4.1 Historical Census Population

	1953	1963	1971	1981	2001	2012
Population						
Sri Lanka	8,097.9	10,582.0	12,689.9	14,846.8	18,797.3	20,277.6
Urban	1,239.1	2,016.3	2,848.1	3,192.7	-	-
Rural	6,858.7	8,565.8	9,841.8	11,654.3	-	-
Anuradhapura (% to Sri Lanka)	229.3 (2.8%)	279.8 (2.6%)	388.8 (3.1%)	587.9 (4.0%)	745.7 (4.0%)	855.6 (4.2%)
Urban	18.4	32.9	38.8	41.4	53.2	-
Rural	210.9	246.9	349.9	546.5	692.5	-
Annual Average Growth Rate						
Sri Lanka	2.8	2.7	2.3	1.6	1.16	0.71
Urban	2.8	5.0	4.4	1.1	-	-
Rural	2.8	2.2	1.8	1.7	-	-
Anuradhapura	7.4	2.0	4.2	4.2	1.25	1.33
Urban	5.9	6.0	2.1	0.7	1.26	-
Rural	7.5	1.6	4.5	4.6	1.19	-

Source: "Statistical Abstract 2010", Department of Census and Statistics

Source: "Population of Sri Lanka by District – Preliminary Report (Provisional) - 1", Department of Census and Statistics, April 20, 2012

For the urban area of Anuradhapura District, the annual average growth rates were 2.1% in the 1960s and 0.7% in the 1970s, both of which were lower than the national urban average of 4.4% and 1.1%, respectively. The average growth rate in the period from 1981 to 2001 was 1.26%, marginally higher than the national average of 1.16%.

On the contrary, the annual average growth rates in the rural areas were 4.5% in the 1960s and 4.6% in the 1970s, both of which were significantly higher than the national average of 1.8% and 1.7%, respectively. The average growth rate in the period from 1981 to 2001 was 1.19%, which is also a little bit higher than the national average of 1.16%.

The rural population in Anuradhapura District has increased from 246,900 in 1963 to 692,500 in 2001 or 2.8 times during this period. The annual growth rates of the national population were 2.7% in the period to 1963, and 2.3%, 1.6%, 1.16% and 0.71% in the subsequent periods to 1971, 1981, 2001 and 2012 respectively.

Therefore, even though the agricultural development policy will be assumed, it is considered that the high growth rate which occurred in the period from 1981 to 2001 in Anuradhapura District cannot be expected in the future. Then, the GNDs in the study area are classified into four types in consideration of local conditions as shown below. The annual average growth rate of 1.2% for 1981 to 2001 is applied to GNDs adjoining the GNDs with the national roads, 0.3%-increased 1.5% to the GNDs with the national roads and 0.3%-decreased 0.9% to remaing GNDs except for the GNDs currently forming the urban centre of each DSD and its surrounding area to which 1.8% is applied due to the high potential for future development, since they are located at the crossings of national roads.

GNDs with a main road	1.5%
GNDs adjoining to the above GNDs	1.2%
Remaining GNDs	0.9%
GND as the city centre and its surrounding GNDs	1.8%

The population projection is summarized in **Table 4.2** (The GND-level population in Census 2012 was not available at the time of population projection.).

Table 4.2 Population Projection in the Study Area

	Census	Estimated Population			Annual Average Growth Rate (%)		
	2001	**2012**	**2024**	**2034**	**2012/2001**	**2024/2012**	**2034/2012**
Padaviya	21,146	24,403	28,583	32,655	1.31	1.33	1.33
Kebithigollewa	19,457	23,007	27,661	32,276	1.54	1.55	1.55
Horoupothana	29,642	34,374	40,462	46,412	1.36	1.37	1.37
Kahatagasdigillia	33,572	39,096	46,234	53,219	1.39	1.41	1.41
Sub-total	**103,817**	**120,880**	**142,940**	**164,562**	**1.39**	**1.41**	**1.41**
Medawachchiya	40,469	47,533	56,688	65,677	1.47	1.48	1.48
Rambewa	31,604	36,325	42,355	48,207	1.27	1.29	1.29
Sub-total	**72,073**	**83,858**	**99,043**	**113,884**	**1.39**	**1.40**	**1.40**
Total	**175,890**	**204,738**	**241,983**	**278,446**	**1.39**	**1.40**	**1.41**

The gap of design population between NWSDB Pre-Feasibility Study Report and JICA study is described in **Appendix 4.1** for reference.

4.2.4 Demarcation of Design Service Area by Water Supply Mode

In the study area, the population is distributed extensively and the population density is low. The maximum population density is 15.4 persons/ha in Medawachchiya West (Medawachchiya GND 67) followed by 6.6 persons/ha in Medawachchiya East (Medawachchiya GND 68), 5.6 persons/ha in Elikimbulagala (Padaviya GND 7) and 5.6 persons/ha in Pandukabhayapura (Rambewa GND 115), respectively, with about 87.7% of GNDs having a population density of less than 2 persons/ha (**Figure 4.2**). In fact, in some sections even along the main roads, there is no housing unit or housing units are very sparsely distributed. Hence, the idea that a water distribution network will be developed along with the road network is obviously not cost-effective.

For this reason, it is necessary to categorize the GNDs into two groups, namely, (1) ones to provide a piped water supply system and (2) the others to deliver water by any other means, for example, the use of water bowsers, which are called “the isolated areas”.

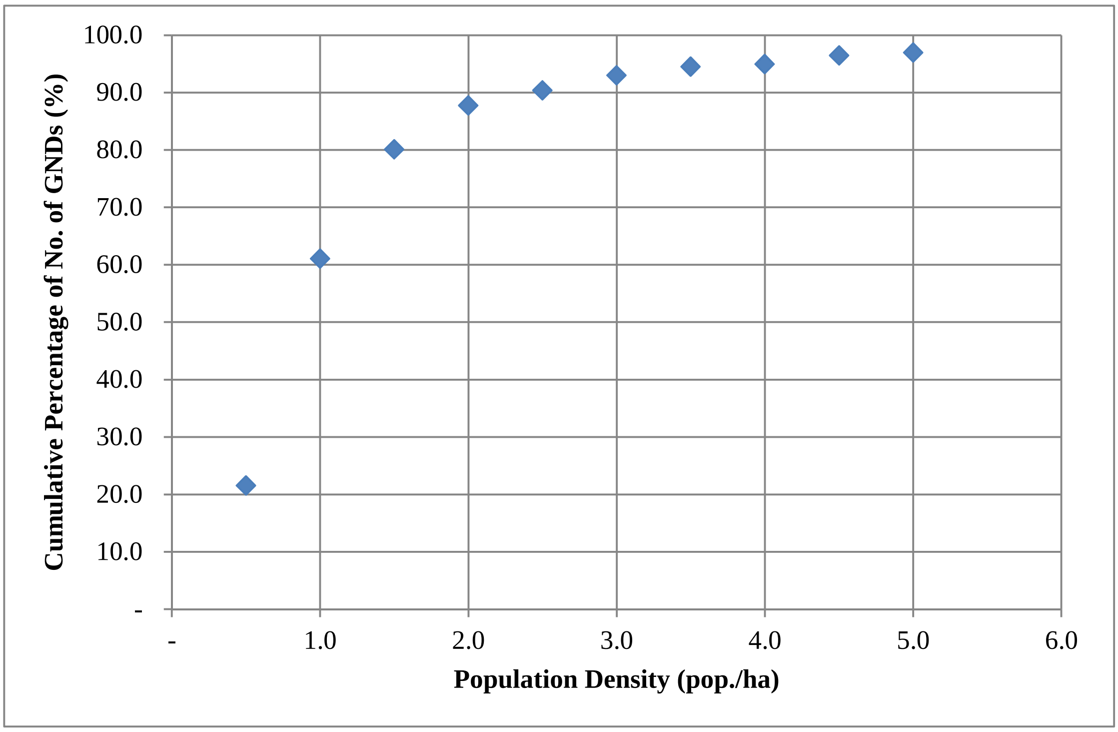

Figure 4.2 Distribution of GND Population Density in the Study Area (2001)

The following four factors are considered for the identification of isolated areas (GNDs):

1) **Figure 4.3** shows the distribution of existing water supply systems by category such as NWSDB, ADB-3rd, ADB-4th and CWSSP.
2) **Figure 4.4** shows the location of structures such as a water treatment plant, pumping stations and service reservoirs proposed for an integrated water supply system, as well as the routes in which water transmission mains will be installed. In the construction of a

new system, cooperation of the residents is indispensable and special attention should be paid for the provision of water distribution pipes to respond to their high expectations.

3) **Figure 4.5** shows the urban centre of respective DSDs and their surrounding GNDs, which have a high potential for development in the future
4) **Figure 4.6** shows the route of main roads compared to the location of GNDs. The main roads designated below have a potential for development following the urban centre in the study area as stated in 3) above.

   Class A national road: A9, A12, A14, A20
   Class B national road: B282, B283, B211, B538

These four factors are prioritized from the viewpoint of importance as follows:

Since one of the purposes of the Project is to integrate the existing small-scale water supply systems into two large-scale ones, the first priority should be given to GNDs with an existing water supply system. This is followed by GNDs and the surrounding ones, where the structures proposed for an integrated water supply system will be located as well as the routes that water transmission mains will be installed to respond to their cooperation to the construction works and high expectation for connection. From the viewpoint of development potentiality in the future, the urban center and GNDs along main roads have the third and fourth priority.

The priority of factors is summarized below.

1st GNDs with an existing water supply system
2nd GNDs where the facilities of a proposed water supply system are included
3rd GNDs covering a urban centre including its surrounding GNDs
4th GNDs along with main roads designated

From the overlapping of these factors, the following three options are developed:

Option 1 (refer to **Figure 4.7**): All

Existing system + Proposed system + Urban centre + Main roads

Option 2 (refer to **Figure 4.8**):

Existing system + Proposed system + Urban centre

Option 3 (refer to **Figure 4.8**):

Existing system + Proposed system

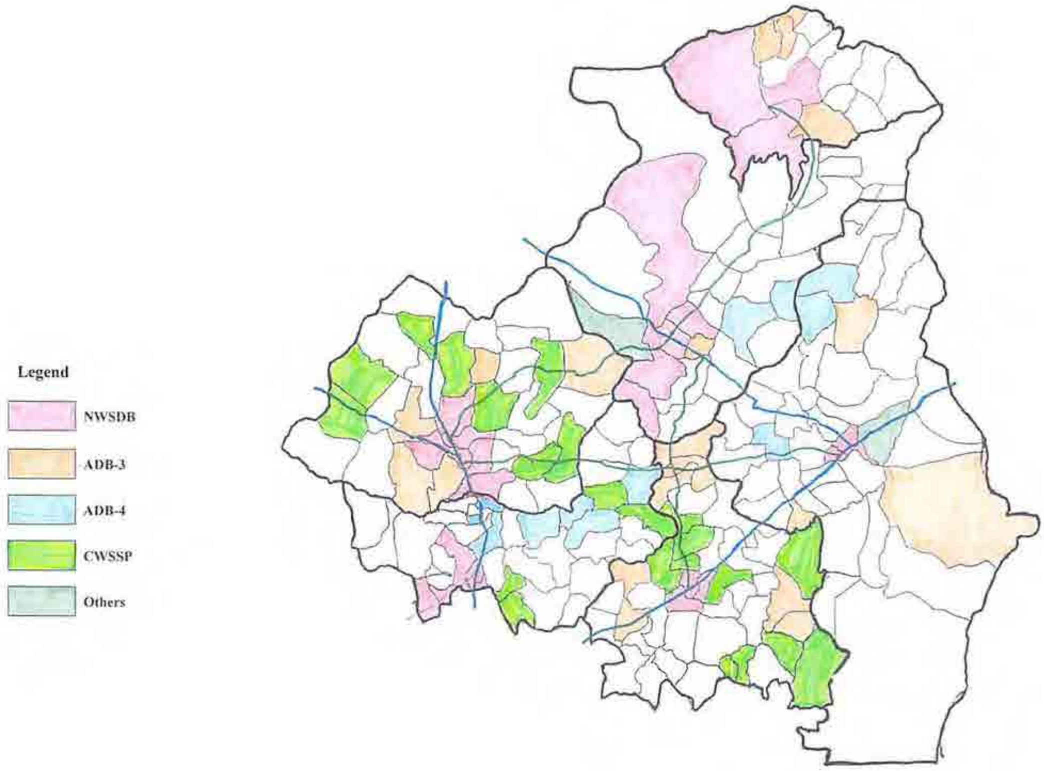

Figure 4.3 Existing Water Supply Scheme in the Study Area

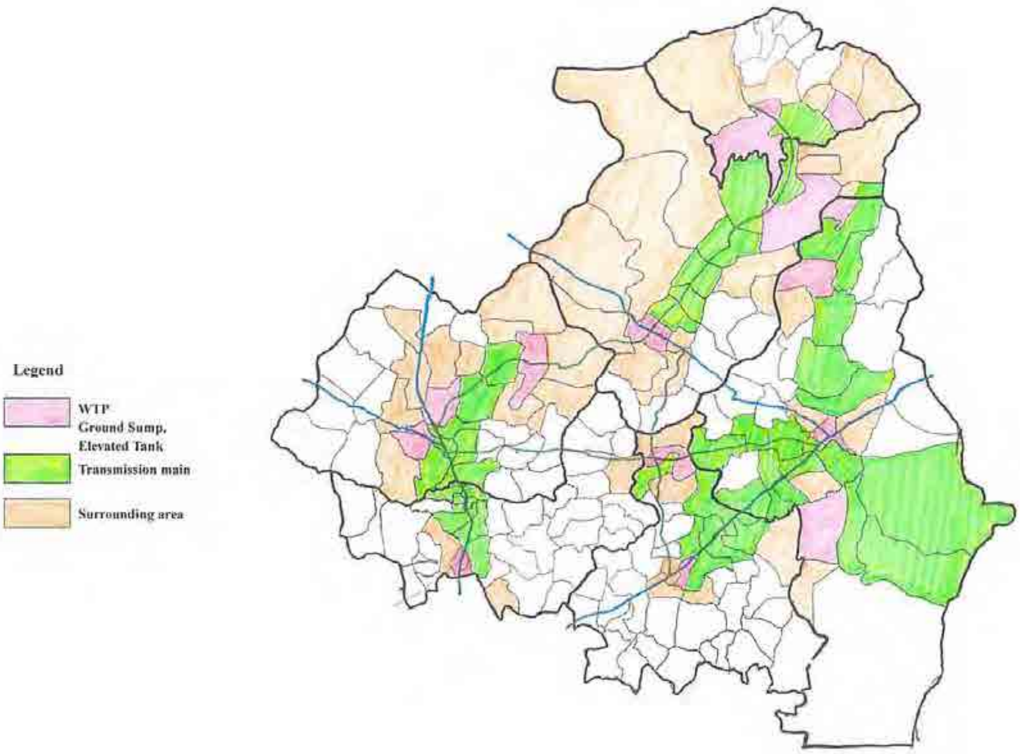

Figure 4.4 Proposed Water Supply Scheme in the Study Area

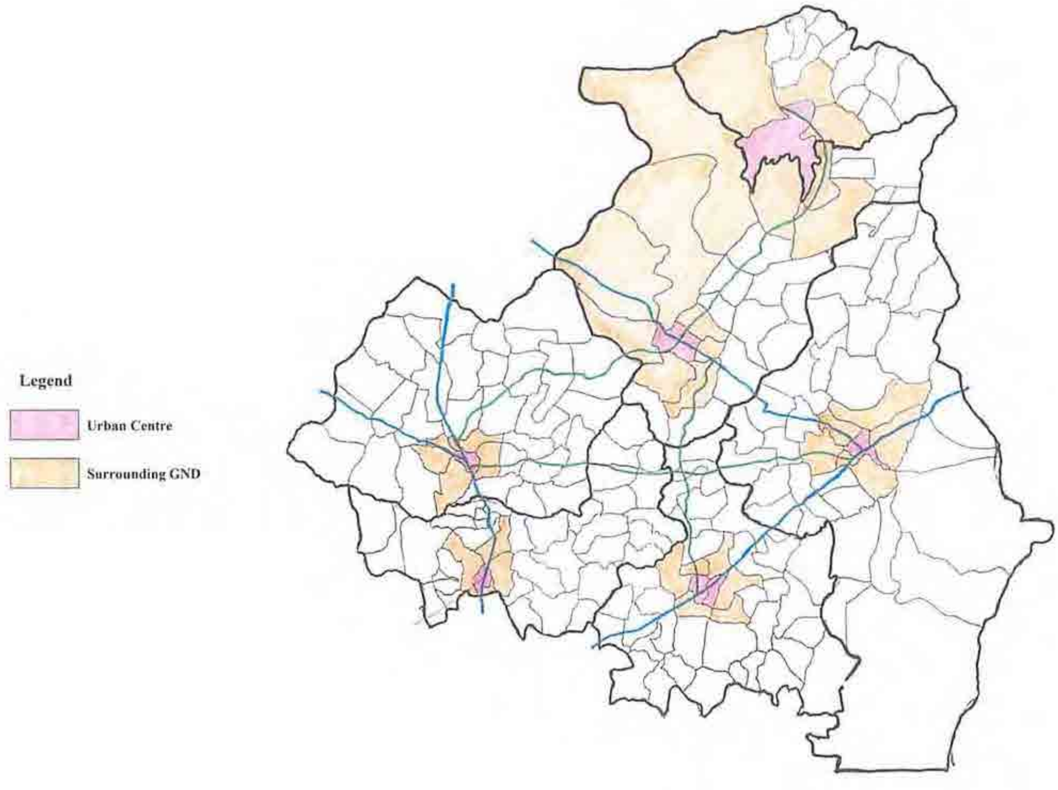

Figure 4.5 Urban Centre

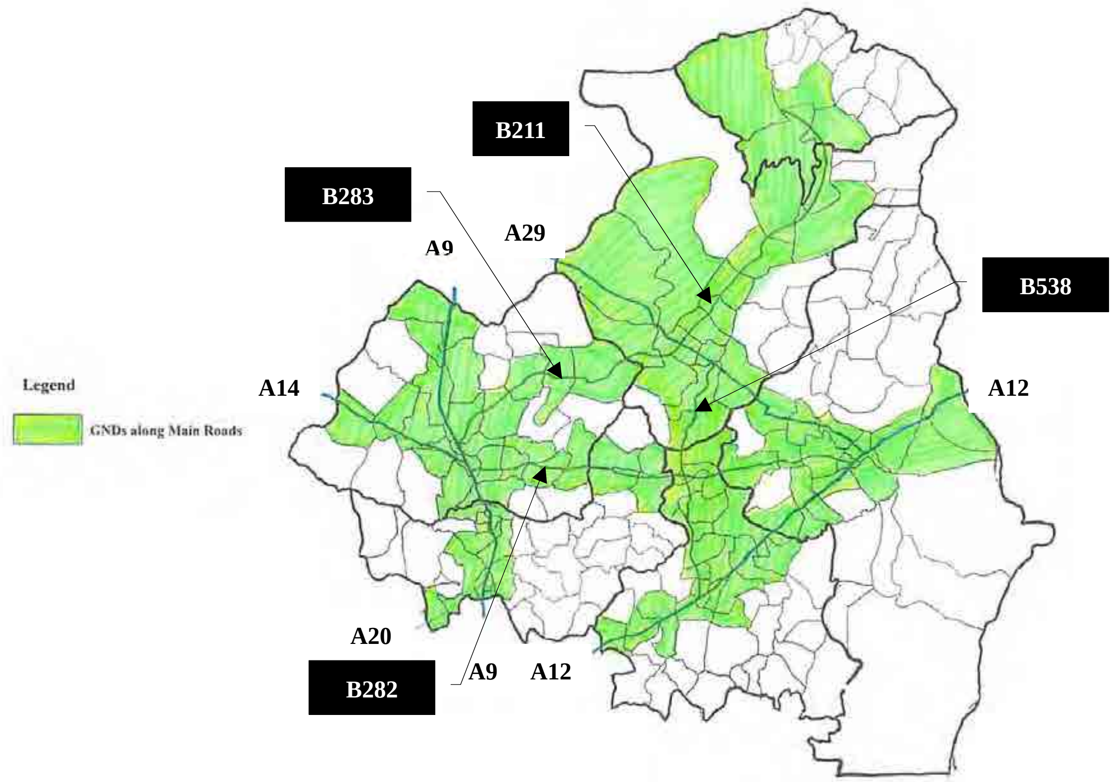

Figure 4.6 Main Road

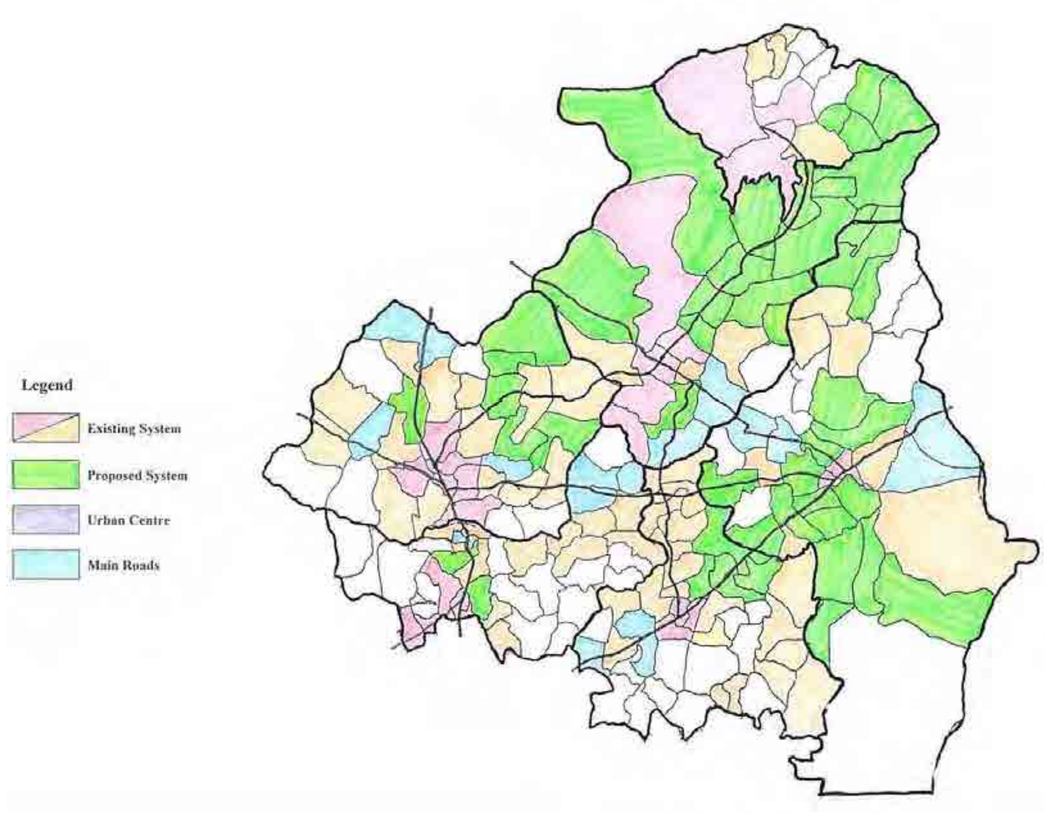

Figure 4.7 Option 1 (No. of Isolated Areas: 47 GNDs)

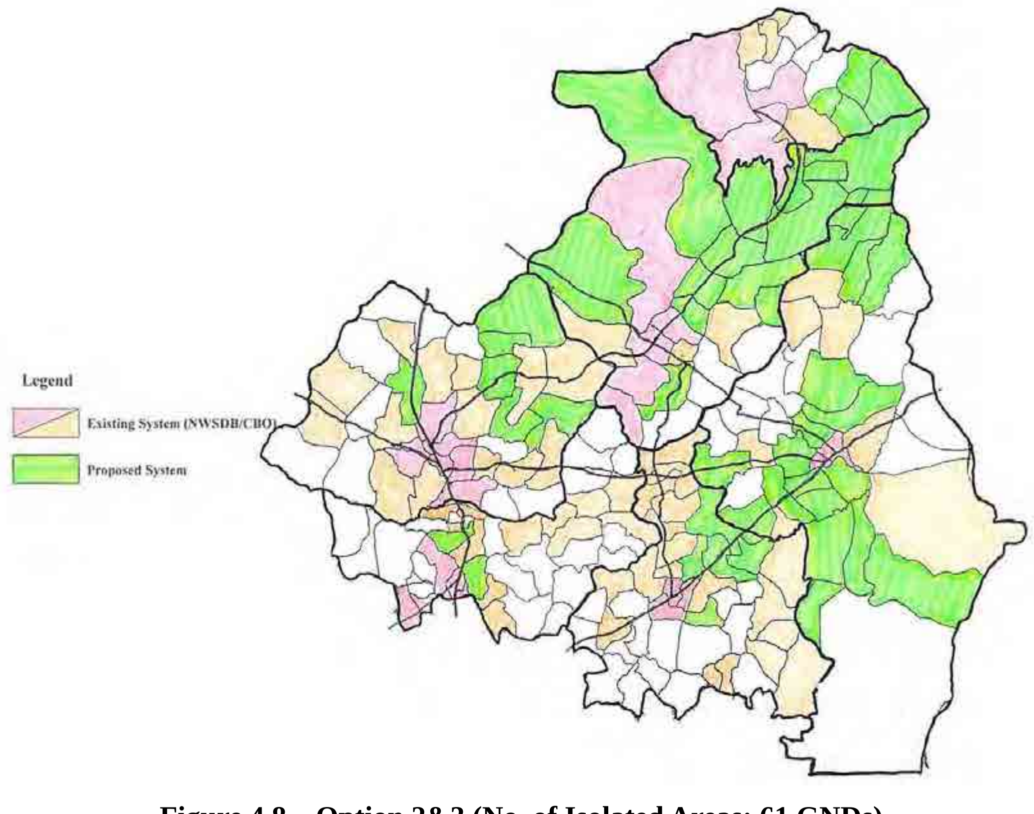

Figure 4.8 Option 2&3 (No. of Isolated Areas: 61 GNDs)

Option 2 shows the same result as that of Option 3, since all the GNDs involved in the urban centres are also involved in the category of existing and/or proposed water supply systems.

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The GNDs which are excluded from the above options are then identified and termed as "**isolated areas**", for which a different water supply system to a piped water supply system shall be considered for these areas.

The results of water demand estimation by option are shown in **Table 4.3** in brief (refer to **Appendix 4.2(b)** for details).

Table 4.3 Comparison of Three Options

Option	Design pop. (pers.)	No. of GNDs as isolated areas	Design water demand on the daily maximum basis (m3/day)	
			Mahakanadarawa	Wahalkada
1	**278,446**	**47**	**17,900**	**27,400**
2&3	278,446	61	16,500	25,800

In **Table 4.3**, the results of Options 2 and 3 are exactly the same, which means that GNDs as the city centre has been already included in other three factors.

4.2.5 Existing CBOs to Be Excluded from Integration

1) No problem in Fluoride Concentration

According to **Table 4.4**, out of 50 existing CBO water supply schemes, water quality examination was done at 33 CBOs and 5 CBOs show fluoride concentrations of below the Sri Lankan drinking standard. The operational status of these CBOs is shown in **Table 4.4** involving several problems.

Table 4.4 CBOs with No problem in Fluoride Concentration

S/N	Name of CBO	Supply Service hours/day	Fluoride (mg/L)	Extent of Satisfaction		Major Problem, if any	Connected to ANIWSS?
				Quantity	Quality		
09	Mahasen CBO	24/6	0.39 / 0.3	Tolerable	Satisfy	Limited water Aug. - Oct.	Yes
10	Dimuthu CBO	24/3	0.1	Tolerable	Satisfy	Limited water Aug. - Oct.	Yes
20	Diriyamatha CBO	24	0.28 / 0.44 / 0.32	Satisfy	Satisfy		**No**
25	Shakthi CBO	24	0.1	Tolerable	Problem	High Iron 3.3 mg/L	Yes
47	Tristar CBO	24	0.001	Satisfy	Satisfy		**No**

Source: Prepared by the Study Team based on "Existing CBO Water Supply Scheme Survey"

- Problem in water quality 1 CBO (25)
- Limited water supply during Aug. to Oct. 2 CBOs (09,10)

Note: Figures in parentheses shows S/N of CBO in **Table 4.12.**

As a result, two CBOs (20 and 47) has no problem in quantity and quality.

2) CBO Located Far Away from Proposed Transmission Main Routes

Table 4.5 shows the existing CBO water supply schemes locating far away from proposed transmission main routes. These CBOs have also many problems in operation.

Table 4.5 CBOs Located Far Away from Proposed Transmission Main Routes

S/N	Name of CBO	Supply Service hours/day	Fluoride (mg/L)	Extent of Satisfaction		Major Problem, if any	Connected to ANIWSS?
				Quantity	Quality		
01	Swashakthi CBO	24/5	0.85	Shortage	Satisfy	4hrs. Supply in dry period	Yes
07	Nildiyadahara CBO	24/5	0.72 / 0.47 / 1.0	Tolerable	Problem	Limited water Aug. - Oct.	Yes
09	Mahasen CBO	24/6	0.39 / 0.3	Tolerable	Satisfy	Limited water Aug. - Oct.	Yes
11	Pragathi CBO	24	1.1	Satisfy	Satisfy		Yes
26	Al-Naja	-	-	-	-	Not yet commissioned	**No**
34	Sobasisila CBO	24/4	0.78	Tolerable	Satisfy	4hrs. Supply in dry period	Yes
41	Pinibindu CBO					Rainwater Supply	Yes
42	Sham Sham	24		Poor	Poor		Yes
43	Ekamuthu CBO	24/2	1.27	Shortage	Satisfy		Yes
45	Upul CBO	24	1.51	Satisfy	Problem	High Flouride	Yes
46	Jalasavi	24		Satisfy	Problem	High Flouride 1.58 mg/L	Yes

Source: Prepared by the Study Team based on "Existing CBO Water Supply Scheme Survey"

- High fluoride concentration above the standard 7 CBOs (01, 07, 11, 34, 43, 45, 46)
- Limited water supply during Aug. to Oct. 3 CBOs (07, 09, 43)
- Limited water supply in dry period 2 CBOs (01, 34)
- Not yet commissioned 1 CBO (26)
- Rainwater supply 1 CBO (41)
- Poor in quantity and quality 1 CBO (42)

Note: Figures in parentheses shows S/N of CBO in **Table 4.13**.

Although there is no information on the operational status of S/N 26 Al-Naja due to "not yet commissioned", but it is considered in good conditions due to the latest water supply scheme.

Therfore, the following three CBOs, namely 2 CBOs of "No problem in Fluoride Concentration" group and one CBO of "CBO Located Far Away from Proposed Transmission Main Routes" group, are considered to have no necessity to connect to the proposed integrated water supply system

- 20. Diriyamatha CBO (Maha Kumbugollawa [GND S/N 46])
- 47. Tristar CBO (Agunuchchiya [GND S/N 119])
- 26. Al-Naja (Muslim Attaweerawewa [GND S/N 32])

4.2.6 Breakdown of Water Consumption

The breakdown of water consumption in 19 water supply systems under NWSDB in the Anuradhapura District in March 2012 is shown in **Appendix 4.2(a)**. Based on the rate of the number of connections to the total number of connections, such areas are divided into three groups, namely (1) large (more than or equal to 10%), (2) middle (5% to 10%) and (3) small (less than 5%) for comparison as shown in **Table 4.6**. All five DSDs in the study area except for Rambewa which are included in Anuradhapura North and Mihintale Systems, are classified into the small-scale group.

Table 4.6 Breakdown of Water Consumption in Anuradhapura District (March 2012)

(a) Number

Category	Large-scale (.>10%)		Middle-scale (5%~10%)		Small-scale (≤5%)		Overall	
	Conn. (nos.)	Cons. (m3/mo.)	Conn. (nos.)	Cons. (m3/mo.)	Conn. (nos.)	Cons. (m3/mo.)	Conn. (nos.)	Cons. (m3/mo.)
Domestic	20,343	324,026	19,658	267,402	9,514	121,363	49,515	712,791
Schools	32	13,585	57	5,006	31	3,993	120	22,584
Govt. institution	196	31,088	155	6,423	121	10,270	472	47,781
Army	24	51,831	9	13,463	10	1,977	43	67,271
Police	9	2,916	17	2,122	14	2,764	40	7,802
Hospitals	16	25,128	25	3,318	22	5,580	63	34,026
Commercial/Industrial	2,079	50,691	1,010	13,648	938	16,290	4,027	80,629
Religious	97	5,481	119	46,709	54	3,154	270	55,344
Others	110	2,532	135	8,388	56	701	301	11,621
Total	22,906	507,278	21,185	366,479	10,760	166,092	54,851	1,039,849

(b) Percentage

Category	Large-scale (.>10%)		Middle-scale (5%~10%)		Small-scale (≤5%)		Overall	
	Conn. (%)	Cons. (%)	Conn. (%)	Cons. (%)	Conn. (%)	Cons. (%)	Conn. (%)	Cons. (%)
Domestic	88.8	63.9	92.8	73.0	88.4	73.1	90.3	68.5
Schools	0.1	2.7	0.3	1.4	0.3	2.4	0.2	2.2
Govt. institution	0.9	6.1	0.7	1.8	1.1	6.2	0.9	4.6
Army	0.1	10.2	0.0	3.7	0.1	1.2	0.1	6.5
Police	0.0	0.6	0.1	0.6	0.1	1.7	0.1	0.8
Hospitals	0.1	5.0	0.1	0.9	0.2	3.4	0.1	3.3
Commercial/Industrial	9.0	10.0	4.8	3.7	8.7	9.8	7.3	7.7
Religious	0.4	1.1	0.5	12.7	0.5	1.9	0.5	5.3
Others	0.5	0.5	0.6	2.3	0.5	0.4	0.5	1.0
Total	99.9	100.1	99.9	100.1	99.9	100.1	100.0	99.9

Source: NWSDB

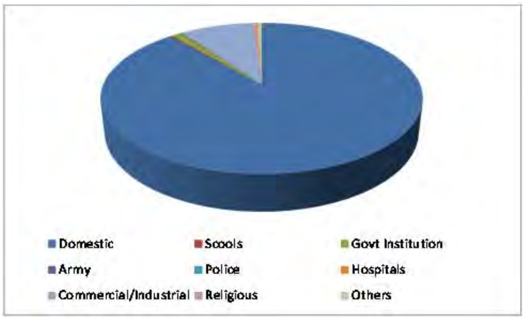
Note:

1) “Domestic” means the summation of “Domestic”, “Board quarters”, “Govt. Quarters” and “Domestic Samurdhi”.
2) “Commercial/Industrial” the summation of “Commercial Institution”, “Tourist/Guest”, “Industrial/Construction” and “Other Commercial and Private”.
3) “Others” means the summation of “Tenaman Garden”, “Stand Post”, “Garden Taps” and “NWSDB premises”.
4) The percentage of “Domestic Samurdhi” is 0.1% in the number of connections and 0.1% in monthly consumption.
5) Stand post counts 65 units with a total consumption of 376 m3/month.

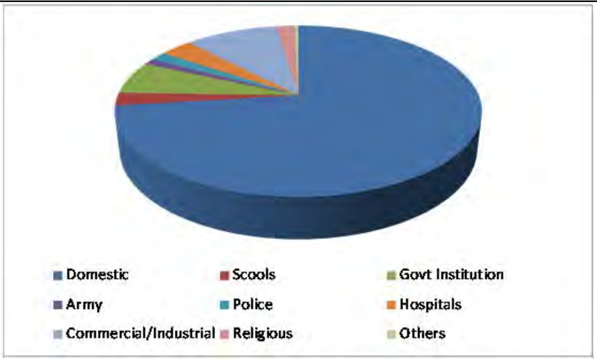
Classification of areas is as follows:

Large (3):	Anuradhapura, Anuradhapura North, Anuradhapura East
Middle (6):	Kekirawa, Ipalogama, Sacret City, Tambuttegama, Galnawa,Talawa
Small (10):	Eppawala, Habarana, Horowpothana, Kahatagasdigilia, Kebithigollewa, Maradankadawala, Medawachchiya, Mihintale, Padaviya Village, Nachchaduwa

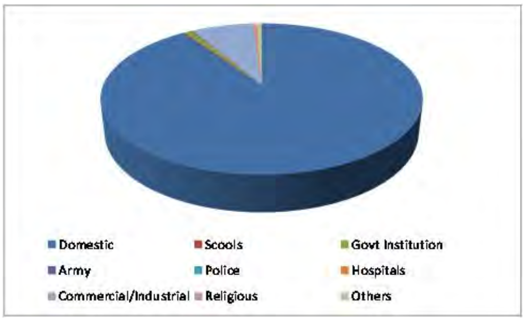
In a small-scale water supply systems, domestic connections account for about 90% of the total number of connections, but about 75% of water consumption followed by 15% for institutional use and 10% for commercial/industrial use, as shown in **Figure 4.9**. For the entire district, the percentage of army and religious uses is higher than that in the small-scale group, whereas domestic use is 5% lower than that in the small-scale group.



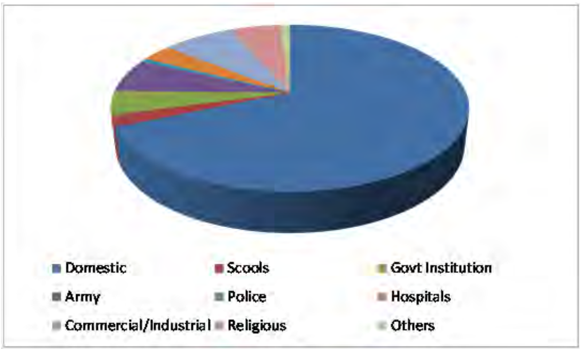
Small-scale system (No. of connections)



Small-scale system (Water consumption)



Entire district (No. of connections)



Entire district (Water consumption)

*Source: Prepared by the Study Team based on **Table 4.6***

Figure 4.9 Composition of Consumption in the Small-Scale Group and Entire District

Based upon the above, non-domestic water use equivalent to 35 % of domestic consumption is added to the per capita water consumption in order to calculate the water demand projection.

4.2.7 Per Capita Domestic Water Consumption

(1) Pipe Borne Water Supply

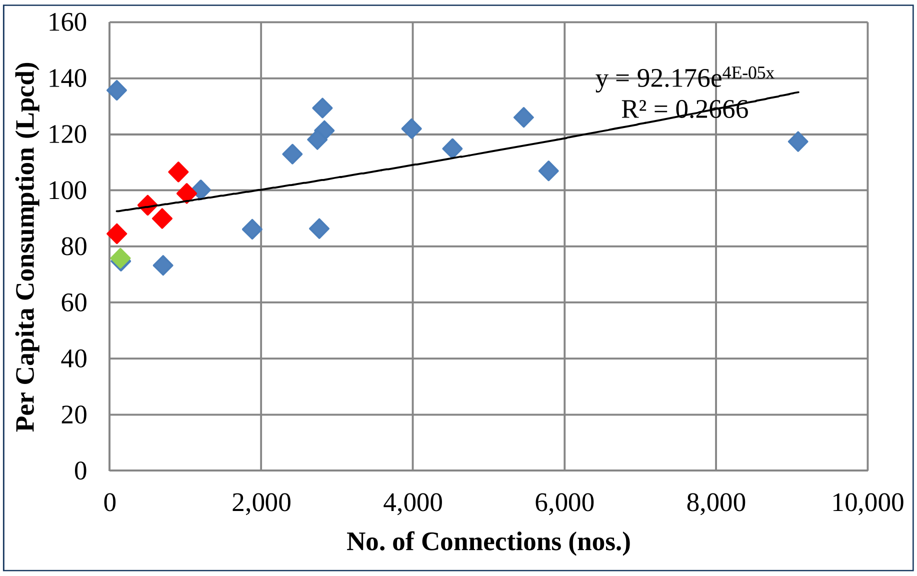
Per capita water consumption is calculated by dividing the water consumption by served population, which is obtained from the number of connections and per house unit population. The relationship between the number of connections and per capita water consumption is shown in **Table 4.7** and **Figure 4.10**.

There is a trend that the higher the number of connections the bigger is the per capita water consumption, although the correlation between the two is not so strong.

Table 4.7 Relationship between No. of Connections and Per Capita Consumption

Area No.	Location	Consumption (m^3/mo.)	Connection (nos.)	Consumption (Lpcd)	Family Size (pers./HU)
1	Anuradhapura	160,833	9,085	117	5.03
27	Anuradhapura North	79,363	5,794	107	4.27
30	Anu-East	83,830	5,464	126	4.06
18	Sacret City	66,526	4,524	115	4.27
28	Thalawa	55,658	3,983	122	3.82
13	Ipalogama	38,382	2,836	121	3.72
25	Galnawa	38,595	2,809	129	3.54
10	Kekirawa	30,782	2,766	86	4.30
21	Thambuththega	37,459	2,740	118	3.86
14	Mihinthale	35,215	2,413	113	4.31
29	Nachchaduwa	21,318	1,884	86	4.38
11	Maradankadawala	14,436	1,202	100	4.00
12	Medawachchiya	13,005	1,017	99	4.31
8	Kahatagasdigiliya	11,890	907	107	4.10
5	Habarana	8,464	705	73	5.47
9	Kebithigollewe	8,567	693	90	4.58
15	Padaviya Village	5,863	502	95	4.11
III	Mahakanadaeawa Yaya 02-93	1,170	151	75	3.46
II	Mahakanadarawa Yaya 01-94	1,182	142	76	3.66
4	Eppawala	1,617	96	136	4.14
7	Horowpothana	988	95	85	4.10

Source: Prepared by the Study Team using NWSDB data



Source: Prepared by the Study Team

Note: Red and green marks show NWSDB and DBO systems, respectively, in the study area.

Figure 4.10 Relationship between No. of Connections and Per Capita Consumption

The existing CBO water supply scheme survey reveals that the average per capita consumption is 66 Lpcd at 46 CBOs during three months from February to April 2012 with no fear of water shortage due to the rainy season. Its frequency distribution is shown in **Figure 4.11**. While they are in the range of 85 to 107 Lpcd at five water supply systems under NWSDB located within the study area as shown in **Table 4.7**. Although there is an obvious gap between both per capita consumptions, this is caused by the service area of the NWSDB system covering the urban center and its surrounding area of each DSD where the water consumption is generally higher than the rural area.

The low per capita consumption at the existing CBOs suggests the following three possibilities:

- Unreliability on the existing CBO water supply (quantity, quality, operation, etc.)
- Selective use of either well water and tap water by use
- Affordability –to-pay for CBOs’ water tariff

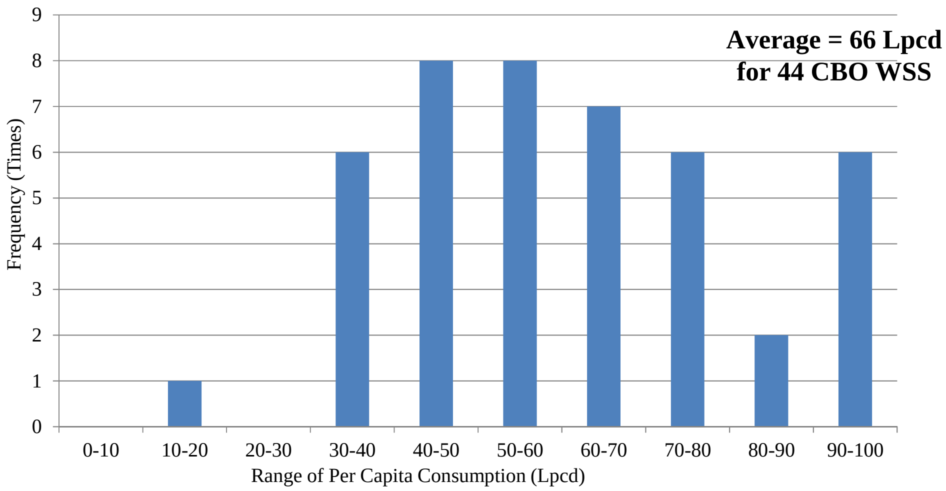


Figure 4.11 Frequency Distribution of Per Capita Consumption at Existing CBOs

Since the NWSDB water supply system covers the core area of the respective DSDs, which is the most developed area in the study area, the per capita water consumption is considered to be relatively higher than in other areas. Therefore, the per capita water consumption is set at 80 Lpcd for the year of 2012 with an annual increment of 0.5 Lpcd. Accordingly, the per capita water consumption is 86 Lpcd in 2024 and 91 Lpcd in 2034.

(2) Bowser Water Supply

However, for the isolated areas, as discussed later, the per capita water consumption is fixed at 10 Lpcd with no annual increment, since the NWSDB Guidelines for rural Water Supply says that *"The strategy to supply safe drinking water to these communities would be to develop a means of providing a supply of treated water exclusively for drinking and cooking purposes. A per capita supply of 5 – 6 Lpcd is considered adequate."*

4.2.8 Non-revenue Water (NRW)

The average NRW ratio of NWSDB in 2009 is 53.05% on national average in CMC, compared to 31.07% island wide in the same year, which shows the relatively low value in the developing countries as shown in **Table 4.8**. It is 19.8% especially in RSC (N/C) which is better following 13.8% in RSC(North-Western) and 16.4% in RSC(North).

Table 4.8 Non-Revenue Water Ratio

	2005	2006	2007	2008	2009
CMC	51.25	51.83	53.19	53.96	53.05
Island wide	33.83	34.37	33.09	32.13	31.07
RSC (North Central)				19.80	

Source: NWSDB, "Annual Report 2009"

In the project, the water distribution facilities in the existing water supply schemes will be used for the proposed integrated water supply system as much as possible; however since water transmission and other distribution pipelines will be newly installed, the present NRW level of 20% in Anuradhapura District is assumed to be maintained in the future.

4.2.9 Design Served Population

(1) Pipe Borne Water Supply

The change in the number of connections for 2001-2012 at five water supply systems under NWSDB in the study area is shown in **Figure 4.12**.

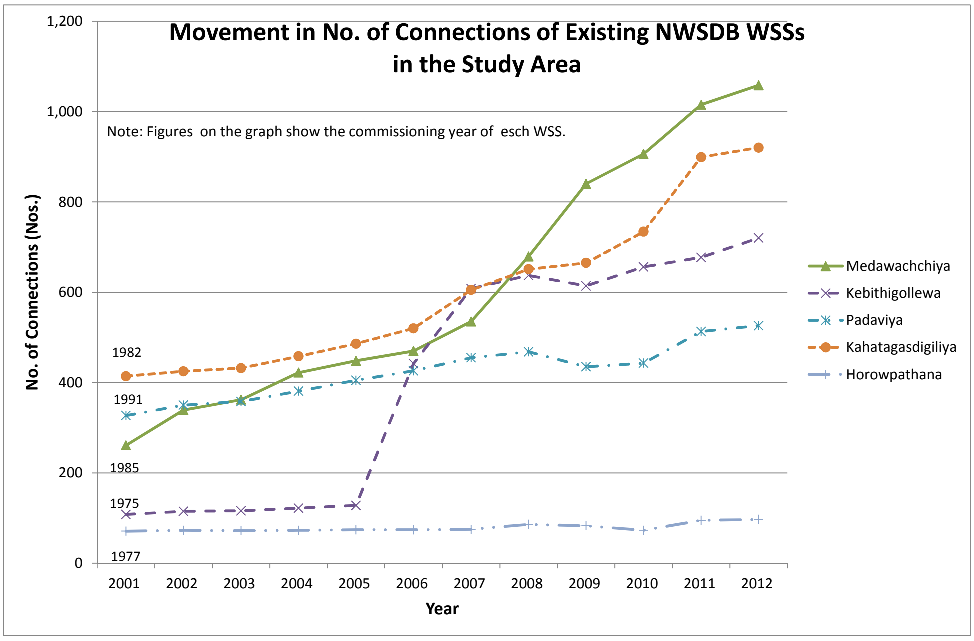


Figure 4.12 Change in the No. of Connections at Five Water Supply Systems under NWSDB

Taking into account the commissioning year of each system as shown in **Figure 4.12**, the increase of connection number in the past was very slow even in the study area. The annual increase from the commissioning year to 2001 is 32.7 connections in Padaviya, 10.8 connections in Kebithigollewa, 3.0 connections in Horowpothana, 21.8 connections in Katahagasdigiliya and 16.3 connections in Medawachchiya, although 314 connections was recorded at Kebithigollewa in 2006. Since the people with high expectation for pipe bore water supply would like to connect to a system as soon as possible, the connection works to a system will have a peak during a few years after the completion of a system and thereafter become slow in general.

In the GNDs with an existing system, the population coverage is assumed to grow linearly from the present coverage to 100% in 2034, while in those with no system, the population coverage is assumed to become larger in the later years

(2) Bowser Water Supply

Water supply in the isolated area will be done regularly using water bowsers and arranging the water tank at the convenient locations for water fetching of the people. Population coverage is set at 100% constant.

4.2.10 Design Load Factor to Daily Maximum Water Supply

The monthly fluctuation of five NWSDB water supply systems in the study area is shown in **Table 4.9**, in which the maximum monthly demand varies from 1.18 to 1.23 times the average monthly demand with an average of 1.15. The conversion factor from the average daily demand to the maximum daily demand, which is usually higher than that to the maximum monthly demand, is set at 1.20.

Table 4.9 Monthly Water Supply Fluctuation in NWSDB Systems in the Study Area

	Padaviya Village				Horowpothana				Kahatagosdigiliya				Kebithigollewe				Medawachchiya				Total			
	Conn.	Cons.	Per Conn.		Conn.	Cons.	Per Conn.		Conn.	Cons.	Per Conn.		Conn.	Cons.	Per Conn.		Conn.	Cons.	Per Conn.		Conn.	Cons.	Per Conn.	
	(nos.)	(m3/mo.)	(m3/mo.)	(%)	(nos.)	(m3/mo.)	(m3/mo.)	(%)	(nos.)	(m3/mo.)	(m3/mo.)	(%)	(nos.)	(m3/mo.)	(m3/mo.)	(%)	(nos.)	(m3/mo.)	(m3/mo.)	(%)	(nos.)	(m3/mo.)	(m3/mo.)	(%)
Jan.	577	9,230	16.0	0.86	158	2,885	18.3	0.91	948	13,399	14.1	0.93	822	9,764	11.9	0.80	1,186	17,212	14.5	0.89	3,691	52,490	14.2	0.88
Feb.	577	10,291	17.8	1.06	159	2,430	15.3	0.84	955	13,222	13.8	1.01	823	9,971	12.1	0.91	1,188	15,736	13.2	0.90	3,702	51,650	14.0	0.96
Mar.	577	9,413	16.3	0.88	161	2,487	15.4	0.77	975	13,216	13.6	0.90	825	9,855	11.9	0.80	1,188	19,301	16.2	1.00	3,726	54,272	14.6	0.90
Apr.	578	10,431	18.0	1.00	163	3,223	19.8	1.02	983	14,621	14.9	1.02	825	12,615	15.3	1.07	1,188	16,104	13.6	0.87	3,737	56,994	15.3	0.98
May	578	11,136	19.3	1.04	163	3,049	18.7	0.93	1,005	12,941	12.9	0.85	828	12,398	15.0	1.01	1,202	20,846	17.3	1.07	3,776	60,370	16.0	0.99
Jun.	578	12,786	22.1	1.23	165	3,350	20.3	1.05	1,017	15,413	15.2	1.04	830	14,050	16.9	1.18	1,204	19,610	16.3	1.04	3,794	65,209	17.2	1.10
Jul.	578	11,383	19.7	1.06	165	3,351	20.3	1.01	1,017	18,902	18.6	1.23	831	13,607	16.4	1.11	1,204	23,180	19.3	1.19	3,795	70,423	18.6	1.15
Aug.	582	11,462	19.7	1.06	168	3,689	22.0	1.10	1,032	15,481	15.0	0.99	835	13,231	15.8	1.07	1,209	21,864	18.1	1.11	3,826	65,727	17.2	1.06
Sep.	582	11,153	19.2	1.07	168	3,907	23.3	1.20	1,049	17,222	16.4	1.12	846	13,842	16.4	1.15	1,214	21,065	17.4	1.11	3,859	67,189	17.4	1.11
Oct.	584	11,300	19.3	1.04	168	3,657	21.8	1.09	1,060	17,304	16.3	1.08	848	12,579	14.8	1.00	1,233	19,689	16.0	0.99	3,893	64,529	16.6	1.03
Nov.	584	9,698	16.6	0.92	168	3,364	20.0	1.03	1,076	14,367	13.4	0.92	848	11,761	13.9	0.97	1,234	18,619	15.1	0.96	3,910	57,809	14.8	0.95
Dec.	590	8,982	15.2	0.82	170	3,412	20.1	1.00	1,084	14,053	13.0	0.86	851	11,185	13.1	0.89	1,256	17,283	13.8	0.85	3,951	54,915	13.9	0.86
Ave.	580	349		0.601	165	107		0.647	1,017	495		0.487	834	398		0.477	1,209	633		0.524	3,805	1,982		0.521

4.2.11 Design Daily Average and Maximum Water Supply and Design Production Capacity

The design fundamentals are summarized in **Table 4.10** and **Figure 4.13** shows the service area of water borne and bowser water supply. Yearly change of design daily average water supply, design daily maximum water supply and design water production is shown in **Table 4.11** for Mahakanadarawa System and Wahalkada System, respectively. Design water production capacity is set so as to have 5% allowance to design daily maximum water supply taking into account the miscellaneous use of water at a water treatment plant.

Table 4.10 Summary of Design Fundamentals

Design Water Demand		Application to Facility Design	Unit	Mahakanadarawa System			Waghalkada System		
Water Supply Mode				Pipe Borne Water Supply	Bowser Water Supply	Total	Pipe Borne Water Supply	Bowser Water Supply	Total
Design Population			(prs.)	92,597	19,303	111,900	144,745	16,723	161,468
Per Capita Domestic Water Consumption	= 80 + 0.5 x (2034 - 2012) = 91		(Lpcd)	91	10		91	10	
Premium for Non-domestic Water (35%)	= 1.35			1.35	1		1.35	1	
NRW Ratio (20%)	= 100 / (100 - 20) = 1.25			1.25	1		1.25	1	
Design Daily Average Water Supply (Dave)			(m^3/day)	14,219	193	14,412	22,227	167	22,394
Design Load Factor to Dmax	= 1.2								
Design Daily Maximum Water Supply (Dmax)	= Dave x 1.20	Transmission facility	(m^3/day)			17,294			26,873
Design Peak Factor	= 2.0								
Design Hourly Maximum Water Supply (Hmax)	= Dmax x 2.0	Dstribution facility	(m^3/day)			34,588			53,746
Design Water Intake	= Dmax x 1.05	Intake pump station	(m^3/day)			18,245			28,217
		Raw water				18,200			28,200
		transmission facility				▲ 600			▲ 600
		WTP							
Water Right			(m^3/day)			**18,800**			**28,800**

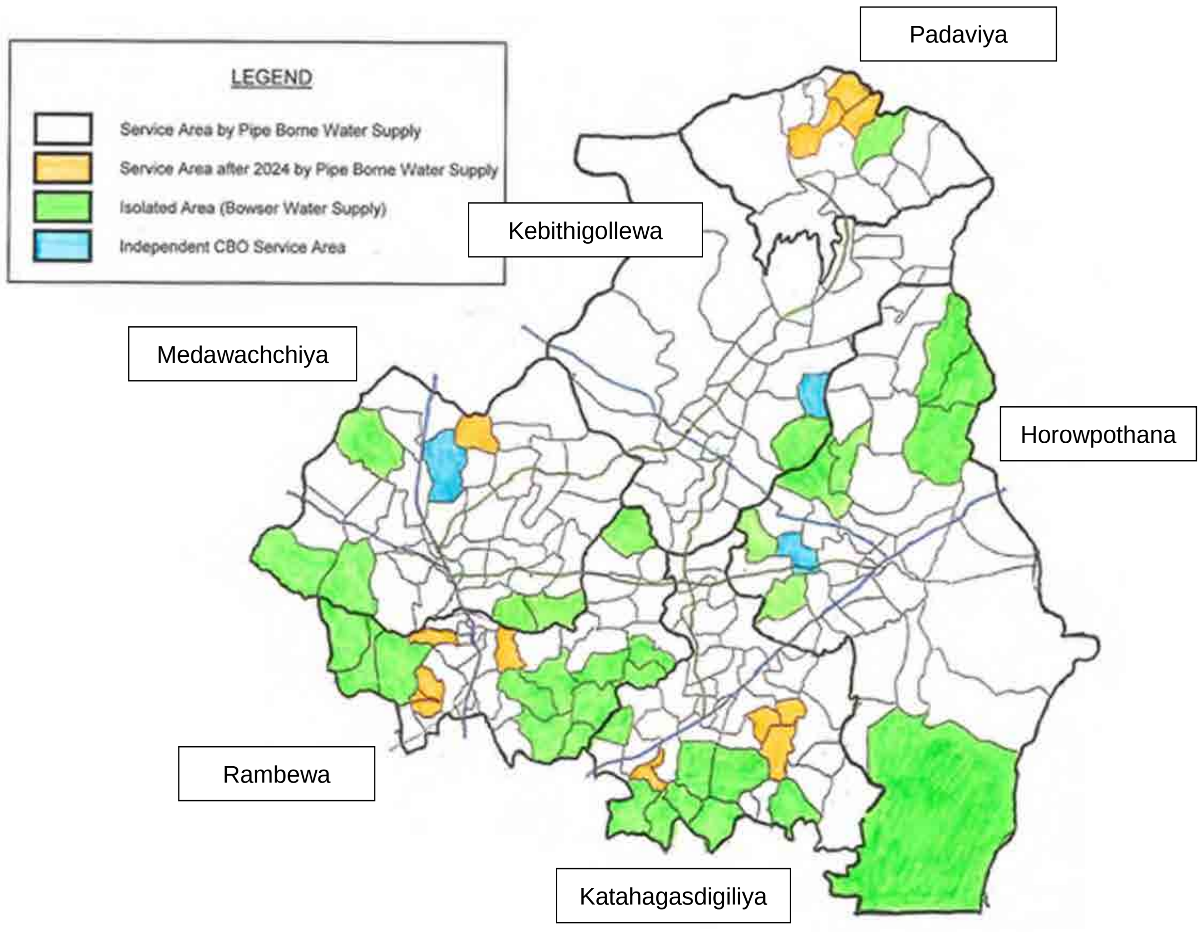


Figure 4.13 Service Area by Pipe Borne and Bowser Water Supply

Table 4.11 Annual Change in Design Daily Average and Maximum Water Supply

Mahakanadarawa System (Encl. Independent CBO)

		2012 *3	2014 *3	2016 *3	2018	2020	2022	2024	2026	2028	2030	2032	2034
Total Population (persons)		**83,858**	**86,208**	**88,626**	**91,120**	**93,684**	**96,321**	**99,043**	**101,838**	**104,719**	**107,686**	**110,736**	**113,884**
46 - Maha Kumbukgollewa *1	Population	1,430	1,473	1,518	1,564	1,611	1,660	1,710	1,761	1,815	1,870	1,926	1,984
	Served Population	286	589	789	860	886	996	1,026	1,233	1,361	1,496	1,733	1,984
	Water Demand	39	81	109	120	126	143	149	181	202	225	263	305
Target Total Population (persons)		**82,428**	**84,735**	**87,108**	**89,556**	**92,073**	**94,661**	**97,333**	**100,077**	**102,904**	**105,816**	**108,810**	**111,900**
for Pipe Borne WS	Pipe Borne WSS	62,778	64,665	66,608	68,613	70,680	72,808	75,010	82,347	84,796	87,319	89,915	92,597
	(Existing)	46,591	48,010	49,473	50,982	52,541	54,141	55,802	57,512	59,277	61,098	62,974	64,912
	(New)	16,187	16,655	17,135	17,631	18,139	18,667	19,208	24,835	25,519	26,221	26,941	27,685
for Non Pipe Borne WS	Non Pipe Borne WSS	19,650	20,070	20,500	20,943	21,393	21,853	22,323	17,730	18,108	18,497	18,895	19,303
Coverage (%)		**31.4**	**59.4**	**63.0**	**65.2**	**67.5**	**69.7**	**72.0**	**74.8**	**82.1**	**88.4**	**94.7**	**100.0**
for Pipe Borne WS	Pipe Borne WSS	41.2	46.8	51.6	54.6	57.7	60.7	63.7	69.4	78.2	85.9	93.6	100.0
	(Existing)	56.0	60.0	64.0	68.0	72.0	76.0	80.0	84.0	88.0	92.0	96.0	100.0
	(New)	0.0	10.0	17.0	17.0	17.0	17.0	17.0	40.0	60.0	75.0	90.0	100.0
for Non Pipe Borne WS	Non Pipe Borne WSS	100	100	100	100	100	100	100	100	100	100	100	100
Served Population (persons) *2		**25,892**	**50,347**	**54,890**	**58,431**	**62,142**	**66,025**	**70,097**	**74,846**	**84,458**	**93,515**	**103,019**	**111,900**
for Pipe Borne WS	Pipe Borne WSS	25,892	30,277	34,390	37,488	40,749	44,172	47,774	57,116	66,350	75,018	84,124	92,597
	(Existing)	25,892	28,611	31,476	34,491	37,665	40,998	44,509	48,196	52,073	56,144	60,419	64,912
	(New)	-	1,666	2,914	2,997	3,084	3,174	3,265	8,920	14,277	18,874	23,705	27,685
for Non Pipe Borne WS	Non Pipe Borne WSS	-	20,070	20,500	20,943	21,393	21,853	22,323	17,730	18,108	18,497	18,895	19,303
Water Demand (Dave: m3/day)		**3,495**	**4,341**	**4,961**	**5,456**	**5,994**	**6,557**	**7,154**	**8,562**	**10,029**	**11,448**	**12,963**	**14,414**
Pipe Borne WS	Pipe Borne WSS	3,495	4,141	4,756	5,247	5,779	6,337	6,982	8,384	9,847	11,263	12,774	14,221
	(Existing)	3,495	3,913	4,354	4,828	5,341	5,882	6,459	7,075	7,728	8,429	9,175	9,970
	(New)	-	228	402	419	438	455	523	1,309	2,119	2,834	3,599	4,251
Non Pipe Borne WS	Non Pipe Borne WSS	-	200	205	209	215	220	172	178	182	185	189	193
Water Demand for Transmission (Dmax = Dave x 1.20 : m3/day)		**4,194**	**5,209**	**5,953**	**6,547**	**7,193**	**7,868**	**8,585**	**10,274**	**12,035**	**13,738**	**15,556**	**17,297**
Water Demand for Treatment (= Dmax x 1.05 : m3/day)		**4,400**	**5,500**	**6,300**	**6,900**	**7,600**	**8,300**	**9,000**	**10,800**	**12,600**	**14,400**	**16,300**	**18,200**

Wahalkada System (Encl. Independent CBOs)

		2012 *3	2014 *3	2016 *3	2018	2020	2022	2024	2026	2028	2030	2032	2034
Total Population (persons)		**120,880**	**124,293**	**127,794**	**131,417**	**135,150**	**138,985**	**142,940**	**147,008**	**151,200**	**155,525**	**159,978**	**164,562**
32 - Kurulugama *1		1,354	1,379	1,403	1,429	1,455	1,481	1,508	1,535	1,563	1,591	1,620	1,649
119 - Ihala Angunachchiya *1		1,041	1,073	1,105	1,139	1,173	1,208	1,245	1,283	1,321	1,361	1,402	1,445
Sub-Total		2,395	2,452	2,508	2,568	2,628	2,689	2,753	2,818	2,884	2,952	3,022	3,094
Served Population													
32 - Kurulugama *1		271	552	730	786	800	889	905	1,075	1,172	1,273	1,458	1,649
119 - Ihala Angunachchiya *1		208	429	575	626	645	725	747	898	991	1,089	1,262	1,445
Sub-Total		479	981	1,305	1,412	1,445	1,614	1,652	1,973	2,163	2,362	2,720	3,094
Water Demand													
32 - Kurulugama *1		37	75	101	110	113	128	131	158	174	191	221	253
119 - Ihala Angunachchiya *1		28	59	80	88	91	104	108	132	147	164	192	222
Sub-Total		65	134	181	198	204	232	239	290	321	355	413	475
Target Total Population (persons)		**118,485**	**121,841**	**125,286**	**128,849**	**132,522**	**136,296**	**140,187**	**144,190**	**148,316**	**152,573**	**156,956**	**161,468**
for Pipe Borne WS	Pipe Borne WSS	95,911	98,775	101,715	104,766	107,907	111,145	114,485	128,836	132,633	136,549	140,587	144,745
	(Existing)	49,985	51,530	53,117	54,762	56,462	58,216	60,026	67,997	70,064	72,193	74,394	76,664
	(New)	45,926	47,245	48,598	50,004	51,445	52,929	54,459	60,839	62,569	64,356	66,193	68,081
for Non Pipe Borne WS	Non Pipe Borne WSS	22,574	23,066	23,571	24,083	24,615	25,151	25,702	15,354	15,683	16,024	16,369	16,723
Coverage (%)		**22.7**	**51.2**	**62.7**	**64.8**	**66.9**	**69.1**	**71.6**	**74.2**	**80.7**	**87.1**	**93.6**	**100.0**
for Pipe Borne WS	Pipe Borne WSS	28.1	39.9	54.0	56.7	59.4	62.1	65.2	71.2	78.4	85.6	92.8	100.0
	(Existing)	54.0	18.0	62.0	66.0	71.0	75.0	79.0	59.0	80.0	84.0	87.0	91.0
	(New)	0.0	20.0	45.0	46.0	47.0	48.0	50.0	60.0	70.0	80.0	90.0	100.0
for Non Pipe Borne WS	Non Pipe Borne WSS	100	100	100	100	100	100	100	100	100	100	100	100
Served Population (persons) *2		**26,925**	**62,431**	**78,510**	**83,471**	**88,692**	**94,133**	**100,393**	**107,042**	**119,656**	**132,911**	**146,846**	**161,468**
for Pipe Borne WS	Pipe Borne WSS	26,925	39,365	54,939	59,388	64,077	68,982	74,691	91,688	103,973	116,887	130,477	144,745
	(Existing)	26,925	29,916	33,072	36,392	39,895	43,576	47,449	51,521	55,803	60,302	65,033	70,000
	(New)	-	9,449	21,867	22,996	24,182	25,406	27,242	40,167	48,170	56,585	65,444	74,745
for Non Pipe Borne WS	Non Pipe Borne WSS	-	23,066	23,571	24,083	24,615	25,151	25,702	15,354	15,683	16,024	16,369	16,723
Water Demand (Dave: m3/day)		**3,636**	**6,611**	**7,843**	**8,556**	**9,336**	**10,147**	**11,098**	**13,616**	**15,599**	**17,719**	**19,979**	**22,392**
Pipe Borne WS	Pipe Borne WSS	3,636	5,384	7,608	8,315	9,087	9,893	10,841	13,463	15,441	17,556	19,815	22,225
	(Existing)	3,636	4,203	4,577	5,097	5,658	6,248	6,888	7,566	8,286	9,058	9,874	10,748
	(New)	-	2,240	3,031	3,218	3,429	3,645	3,953	5,897	7,155	8,498	9,941	11,477
Non Pipe Borne WS	Non Pipe Borne WSS	-	1,227	235	241	249	254	257	153	158	163	164	167
Water Demand for Transmission (Dmax = Dave x 1.20 : m3/day)		**4,363**	**7,933**	**9,412**	**10,267**	**11,203**	**12,176**	**13,318**	**16,339**	**18,719**	**21,263**	**23,975**	**26,870**
Water Demand for Treatment (= Dmax x 1.05 : m3/day)		**4,600**	**8,300**	**9,900**	**10,800**	**11,800**	**12,800**	**14,000**	**17,200**	**19,700**	**22,300**	**25,200**	**28,200**

*1 GND excluded from integration

*2 Served population increases as the number of connections increases.

*3 The served population for both pipe borne and non pipe borne water supply before 2018 when the new water supply systems will enter into operation shows the potential figure.

*4 Some GNDs will shift from bowser service area to pipe borne water supply service area in Stage-2 (2025-2034)

4.2.12 Design Flow of Water Treatment Plants for Stage Construction

Both water treatment plants for Mahakanadarawa and Wahalkada Systems shall be constructed by stage construction. The reasons for stage construction is described in **Section 5.2.1**.

The design flow for Phase 1 (2024) and Long-term Plan (2034) is shown in **Table 4.12**.

Table 4.12 Design Flow of Water Treatment Plants for Stage Construction

	Stage-1 (2024)	Stage-2 (2034)
Mahakanadarawa WTP		
Daily Maximum Water Supply	8,950 m3/day	17,900 m3/day
Production Capacity	9,400 m3/day	18,800 m3/day
Wahalkada WTP		
Daily Maximum Water Supply	13,700m3/day	27,400 m3/day
Production Capacity	14,400 m3/day	28,800 m3/day

4.3 Water Availability

As mentioned in **Section 2.5**, there is a high risk of fluoride concentration in the groundwater of the Study Area, therefore the source for drinking water needs to be shifted to the surface water. This section will discuss availability of the water source focused only on surface water.

In the Study Area of Anuradhapura District, there are available only seasonal rivers, that flows during the rainy season, therefore, the surface water source for drinking water is expected only from water reservoirs, Mahakanadarawa wewa and Wahalkada wewa.

4.3.1 Water source

(1) Climate

1) Climate Data

Rainfall and Temperature data is collected from Meteorological Department in Sri Lanka (refer to **Appendix 4.3(a) to (d)**)..

Table 4.13 Outline of the Stations

Station	Observation Items	Observation Year	ID
Anuradhapura *	Integrated	1870 ～ present	43421
Wahalkada	Rainfall	1997 ～ present	01AN527B

** Nearest rainfall station of Mahakanadarawa is at Anuradhapura*

2) Monthly Average Rainfall, Temperature and Evaporation

This area belongs to the Central Dry Zone with annual rainfall of 1000mm～1500mm.

The amount of rainfall varies depending upon the South-East Monsoon between May and September (Yala period) and the North-East Monsoon between November and March (Maha Period). **Figure 4.14** and **Figure 4.15** show the monthly average rainfall in Anuradhapura and

Wahalkada stations. The rainy season is from October to January, and light rain period is available in Anuradhapura during April to May, but in Wahalkada. Annual rainfall is around 1240mm in Anuradhapura, and around 1440mm in Wahalkada.

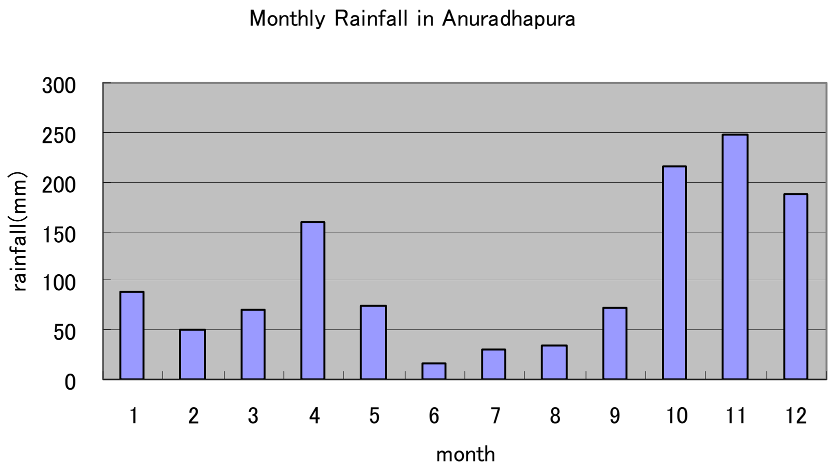


Figure 4.14 Monthly Average Rainfall in Anuradhapura Station

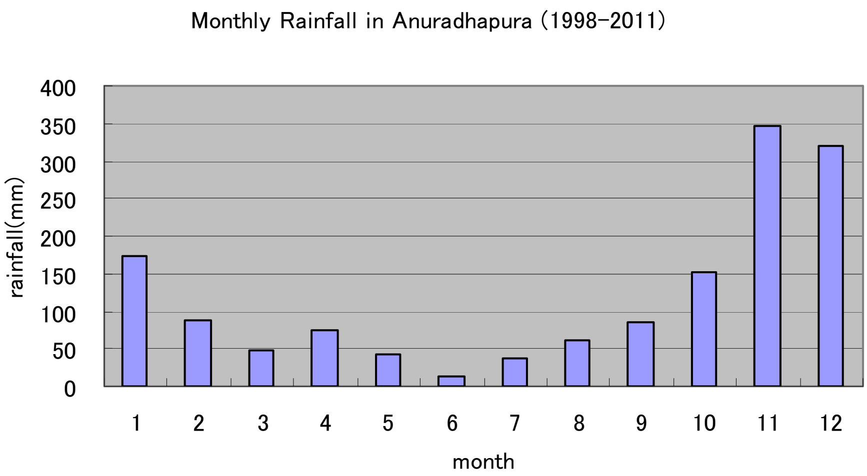


Figure 4.15 Monthly Average Rainfall in Wahalkada

Daily evaporation data at Mahailuppallama Station and Vavuniya Station is shown in **Table 4.14**.

Table 4.14 Monthly Average Evaporation (2000～2011)

(Unit:mm/day)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yearly
Maha Iluppallama	2.39	3.20	3.84	3.59	4.19	4.5	4.68	4.83	4.66	3.39	2.26	2.04	1326
Vavuniva	2.16	2.88	3.46	3.40	4.13	4.58	4.53	4.34	4.46	2.94	1.92	1.84	1237

Source: Meteorological Department

3) Long-term Annual Rainfall

Figure 4.16 shows the annual rainfall of Anuradhapura Station in 1980～2010, with 5 year moving averages. Average of annual rainfall is 1246mm. 5 year moving average rainfall varies not so much, therefore tendency of rainfall is considered relatively stable.

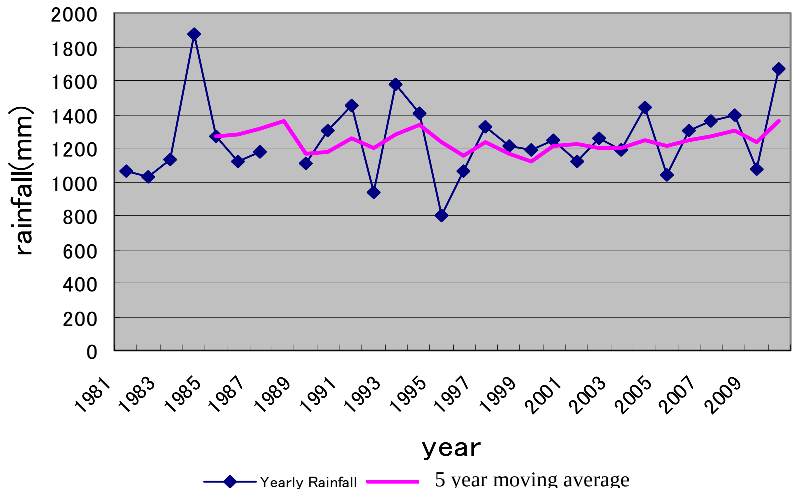


Figure 4.16 Annual Rainfall in Anuradhapura Station(1981-2010)

Figure 4.17 shows the annual rainfall at Wahalkada Station in the period from 1998 to 2011, with 5 year moving averages. The average annual rainfall is 1440mm. It is noticeable that rainfall from the end of 2010 to February 2011 was very high and the annual rainfall in 2011 was 2,300mm. The 5 year moving average rainfall does not vary much and therefore the trend of rainfall is considered to be relatively stable.

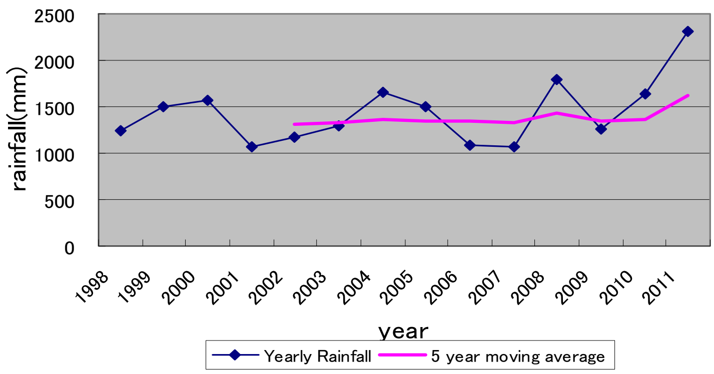
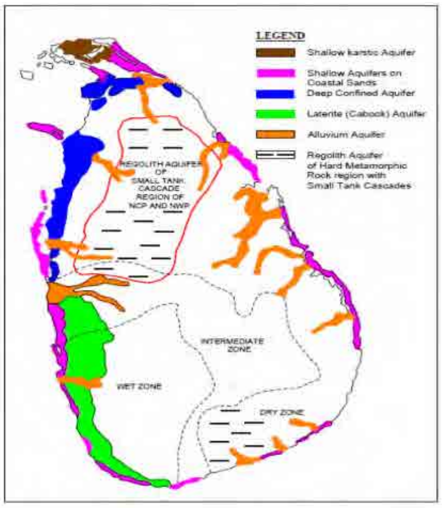


Figure 4.17 Annual Rainfall in Anuradhapura Station(1998-2011)

(2) Condition of the catchment area

According to "Groundwater Resources of Sri Lanka : Water Resources Board, 2005", the Project Area is classified as "Shallow Regolith Aquifer of the Hard Rock Region" (ref. **Figure 4.18** Groundwater Zone in Sri Lanka）.

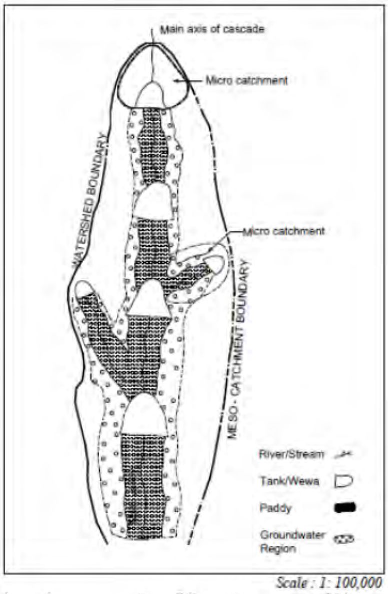


Source: Groundwater Resources of Sri Lanka ：Water Resources Board, 2005

Figure 4.18 Groundwater Classification

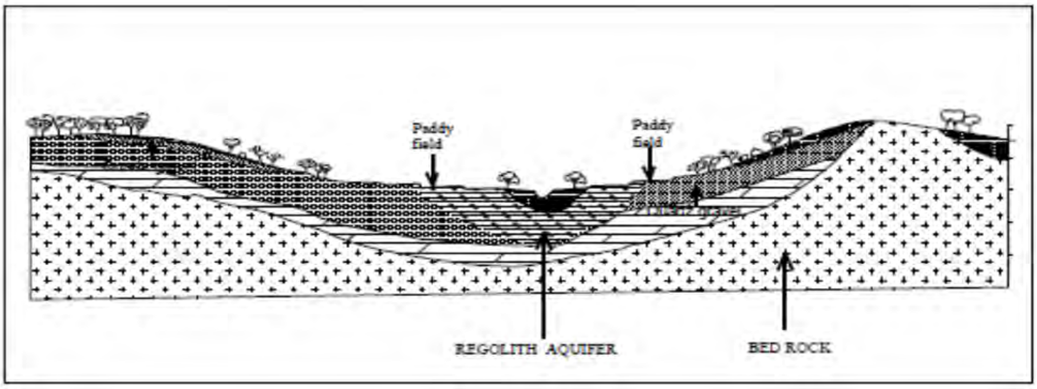
It has been recognized that groundwater in the hard rock region is found both in the weathered rock zone, or regolith, as well as in the deeper fracture zone of the basement rocks.

The shallow regolith aquifer is mainly confined to a narrow belt along the inland valley systems of this undulating mantled plain landscape, benefited from small tank cascade, as shown in **Figure 4.19** and **Figure 4.20**. The average thickness of the regolith in this region is not more than 10m and the traditional hand-dug wells have been abstracting water from this basement regolith aquifer for village domestic requirement. These small tank cascade systems are used for irrigation and have an influence on the water cycle in the catchment area.



Source: Groundwater Resources of Sri Lanka ：Water Resources Board, 2005

Figure 4.19 Image of Small Tank Cascade in Sri Lanka



Source: Groundwater Resources of Sri Lanka ：Water Resources Board, 2005:

Figure 4.20 Image of the Flow under Tank Cascade

The catchment areas of Mahakanadarawa and Wahalkada tanks are shown in **Figure 4.21** and **Figure 4.22**

Many small tanks exist in the catchment area, and flow from the catchment area to the reservoir occurs directly from both the surrounding area of the reservoir and groundwater flow from catchment area.

Table 4.15 shows the catchment area, direct flow area and water area of Mahakanadarawa and Wahalkada Wewa, which are estimated from the topographic map scaled at 1:50,000 and the Satellite image by Google.

Table 4.15 General Features of Reservoirs

Reservoir	Mahakanadarawa	Wahalkada
Catchment Area(km2)	334	83
Catchment Area with direct flow(km2)	83	47
Water Area(ｋｍ2)	9	2.1

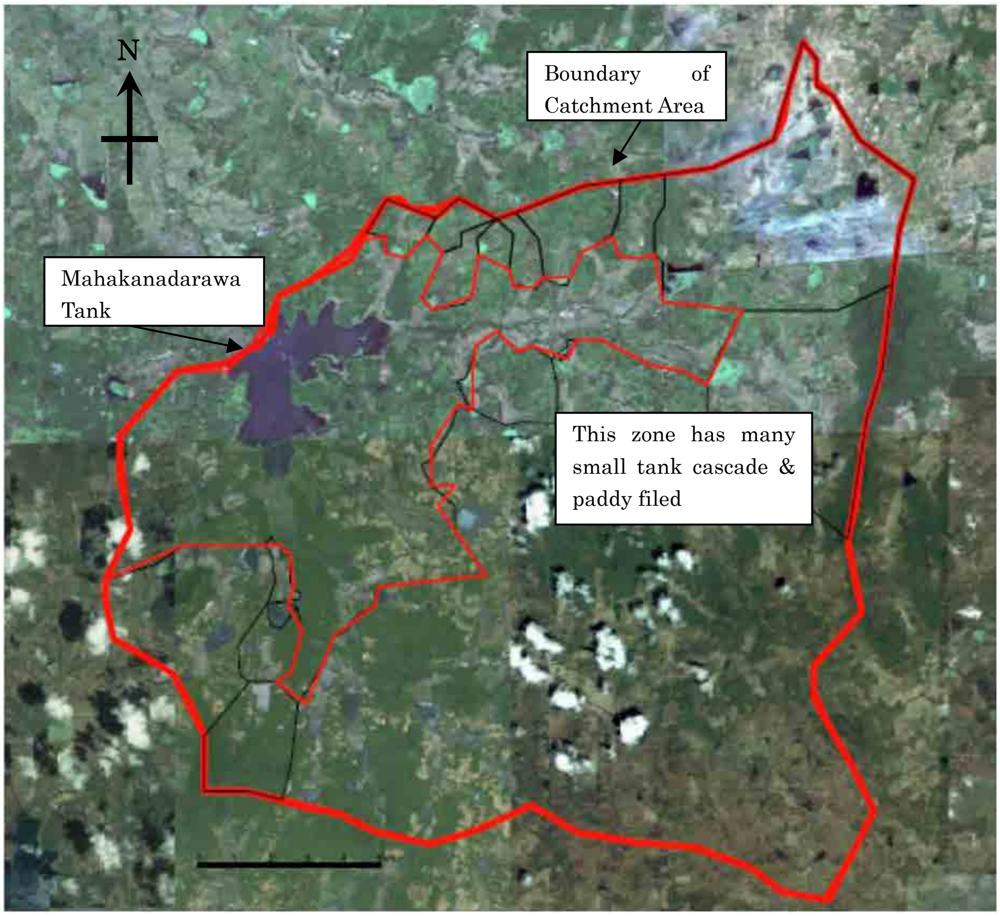


Figure 4.21 Mahakanadarawa Wewa Catchment Area

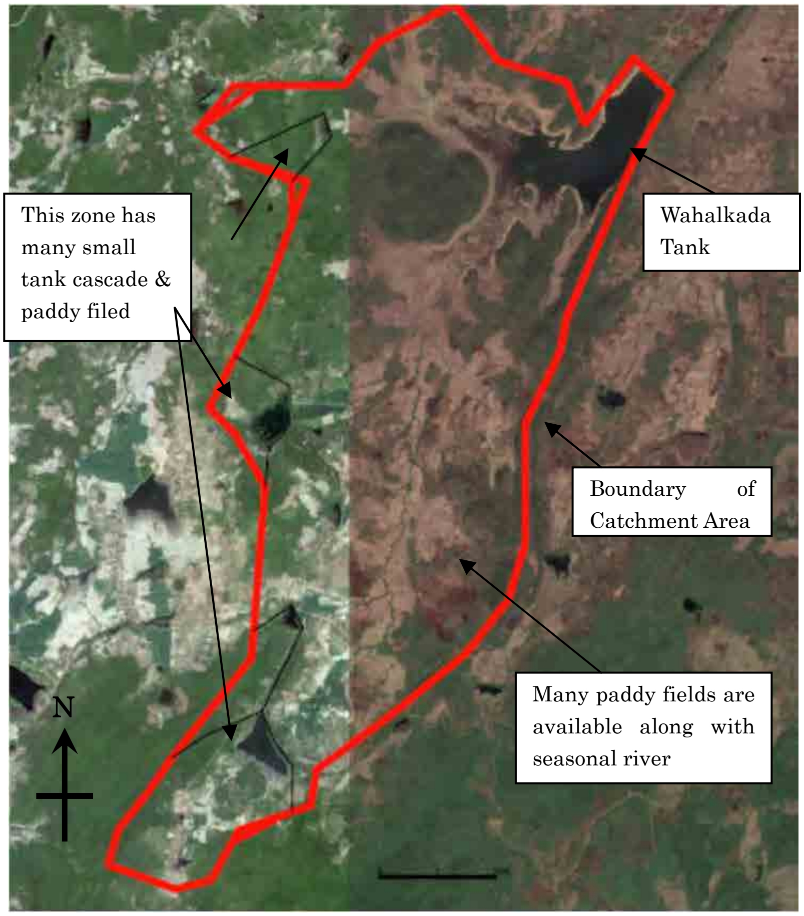


Figure 4.22 Wahalkada Wewa Catchment Area

4.3.2 Water Quality

(1) Purpose

To evaluate the water resources for a safe drinking water supply, it is very important to investigate essential water quality parameters in the water resources. The analysis of water quality can provide chemical and biological characteristics of the water as well as basic information of the safety of the water. Attention should be paid particularly on some substances that will have a health impact by drinking. In this subchapter, at first the general characteristics of Mahakandawara wewa, Wahalkada wewa and Yan Oya irrigation water are mentioned. The results of the general water quality analysis done in the study are evaluated by comparison with the Sri Lanka drinking water standard 614:1983.

A series of quality control measures, which are operational techniques and activities that are used to fulfill requirements of JICA Study Team for quality tests, were also conducted. The quality control program conducted consists of an internal quality control and an external quality control. Additionally, data comparison between the NWSDB lab in Anuradhapura and the SGS's

laboratory in Colombo, the subcontractor under the Study Team, was also performed as part of capacity development of the NWSDB lab.
As for groundwater survey, see **Section 2.5.2**

(2) Water quality analysis

1) Methodology

The water samples for water quality analysis were collected from targeteded water sources, Mahakandawara wewa, Wahalkada wewa and Yan Oya. The samples were systematically collected during the survey. The methods of sampling, analysis and quality assess mentioned above planned and performed as follows.

(a) Sampling and field analysis

For Mahakandawara and Wahalkada wewa, sampling locations at the sites are as follows.

- Irrigation canal
- Near the outlet connecting to an irrigation canal within wewa at a depth of 30cm from the water surface)
- Deepest point (minimum 50 m away from embankment)

In case irrigation water was not discharged, the sample of irrigation canal was instead collected near the outlet connecting to an irrigation canal within wewa.

For Yan Oya, the sampling was to be carried out at a location downstream of the junction of the three rivers.

In total seven samples were to be collected and analysed every month. Each sampling location was as follows.

Table 4.16 Sampling Sites with GPS Coordinates

Sampling site	GPS coordinates
a. Mahakandawara Irrigation canal	8.39253, 80.53843
b. Mahakandawara Irrigation canal connection	8.38967, 80.53348
c. Mahakandawara Deepest point	8.38062, 80.54088
d. Wahalkada Irrigation canal	8.73882, 80.85230
e. Wahalkada Irrigation canal connection	8.73838, 80.85268
f. Wahalkada Deepest point	8.73750, 80.85218
g. Yan Oya	8.75373, 80.87997

The samples were collected in decontaminated containers, and were preserved during transport to the laboratory. All parameters were analysed in the laboratory except pH which was measured at the sites mentioned above.

Figure 4.23 Location of Sampling Sites (Mahakandawara Wewa)

Figure 4.24 Location of Sampling Sites (Wahalkada Wewa)

Figure 4.25 Location of Sampling Sites (Yan Oya Reservoir Water)

(b) Laboratory analysis

The laboratory analyses was carried out at the SGS. The methods for the chemical and microbiological analysis of water are based on Sri Lankan drinking water standard 614:1983 (refer to **Reference 1.2**) and other standard methods such as APHA (American Public Health Association) or EPA (U.S. Environmental Protection Agency). **Table 4.17** outlines the test method followed. It is noted that JICA directly conducted preliminary water quality survey from December 2011 until April 2012 though analysis paremeters are somewhat different. These results are also shown as reference.

Table 4.17 Analytical Parameters and Methods

Analytical item	Methods used
Colour	APHA 2120 B: 2005
Turbidity	APHA 2130 B: 2005
Odor	SLS 614: 1983 Part 1
Taste	SLS 614: 1983 Part 1
pH	APHA 4500 H+ B: 2005
Electrical Conductivity	APHA 2520 B: 2005
Chloride	APHA 4500-Cl B: 2005
Free ammonia	SLS 614: 1983 Part 1
Nitrite	APHA 4500-NO2 B: 2005
Nitrate	APHA 4500-NO3 B: 2005
Albminoid ammonia	SLS 614: 1983 Part 1
Fluoride	APHA 4500-F- C: 2005
Iron	APHA 3500-Fe B: 2005
Sulphate	APHA 4500-SO_4^{2-} E: 2005
Alkalinity	APHA 2320 B: 2005
Total residue	APHA 2540 B: 2005
Hardness	APHA 2340 C: 2005
Phosphate	APHA 4500-P- C: 2005
As	APHA 3120 B: 2005
Cd	APHA 3120 B: 2006
CN	APHA 4500-CN-E, Colorimetric Method
Pb	APHA 3120 B: 2005
Hg	APHA 3120 B: 2005
Se	APHA 3120 B: 2005
T-Cr	APHA 3120 B: 2005
Total coliform	SLS – 614:1983, Part 2 (most probable number)
E-Coli	SLS – 614:1983, Part 2 (most probable number)
Chlorophyl-a	EPA 446

2) Results

(a) General characteristics of targeted water sources

The results of the laboratory chemical and microbiological analysis for the targeted water sources are shown in **Table 4.18**. From these data, some general characteristics are found as mentioned below.

Table 4.18 Results of Laboratory Chemical and Microbiological Analysis for Proposed Water Sources

Water source	Sampling station	Date	Odor	Colour	Turbidity	Taste	pH	EC	Chloride	Free residual C	Free ammonia	Alkalinity	Albminoid ammonia	Nitrite	Nitrate	Fluoride	Phosphate	Total residue	Hardness	Ion	Sulphate	Anionic detergent	Phenol conpound	COD	O&G	Ca	Mg	Cu	Mn	Zn	Al	Total plate count	E. coli	Total coliform	Chlorophyl a
				Hazen Unit	NTU		-	μS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/l	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	CFU/mL	MPN/100mL	MPN/100mL	mg/L
Mahakanadarawa Wewa	inlet	11/12/20	Object.	5	4	Object.	6.7	344	51	<0.04	<0.04	86	<0.04	<0.01	0.26	0.09	<0.05	166	96	0.1	2	<0.1	<0.002	14	<1	16	14	<0.02	<0,03	<0.01	<0.08	3.2×10^{2}	13	79	
	outlet	11/12/20	Object.	5	4	Object.	6.5	343	51	<0.04	<0.04	88	<0.04	<0.01	0.11	0.08	0.05	164	92	0.1	2	<0.1	<0.002	17	<1	16	13	<0.02	<0,03	<0.01	<0.08	2.0×10^{2}	5	8	
	Deepest	11/12/21	Object.	5	3.8	Object.	6.7	343	51	<0.04	<0.04	87	<0.04	<0.01	0.07	0.11	<0.05	176	96	0.1	2	<0.1	<0.002	20	<1	16	14	<0.02	<0,03	<0.01	<0.08	1.7×10^{2}	ND	23	
	inlet	12/01/11	Unobject.	7.5	3.7	Unobject.	7.8	348	52	<0.04	<0.04	93	0.05	<0.01	0.09	0.10	0.2	132	95	0.2	1.4	<0.1	<0.002	<5	<1	18	12	<0.02	<0,03	<0.01	<0.08	34	ND	8	
	outlet	12/01/21	Unobject.	10	3.5	Unobject.	7.9	355	53	<0.04	0.22	94	0.35	<0.01	0.07	0.12	0.16	172	96	0.1	1	<0.1	<0.002	<5	<1	18	13	<0.02	<0,03	<0.01	<0.08	64	ND	9	
	Deepest	12/01/21	Unobject.	7.5	2.9	Unobject.	7.7	370	52	<0.04	0.2	97	0.28	<0.01	0.07	0.14	0.23	170	96	0.3	1.4	<0.1	<0.002	<5	<1	17	13	<0.02	<0,03	<0.01	<0.08	40	ND	8	
	inlet	12/02/14	Unobject.	5	2.7	Unobject.	7.6	411	61	0.14	0.04	107	0.36	<0.01	<0.05	0.17	0.06	226	104	0.2	1.4	<0.1	<0.002	21	<1	18	9.0	<0.02	<0,03	<0.01	<0.08	4.9×10^{2}	13	130	
	outlet	12/02/14	Unobject.	5	3.7	Unobject.	7.7	415	54	<0.04	0.22	107	0.33	0.01	<0.05	0.33	0.09	235	105	0.2	3.4	<0.1	<0.002	16	<1	30	9.7	<0.02	<0,03	<0.01	<0.08	2.0×10^{2}	13	79	
	Deepest	12/02/14	Unobject.	5	6.8	Unobject.	7.7	417	60	0.1	0.15	96	0.22	<0.01	<0.05	0.30	0.06	234	109	0.3	1.5	<0.1	<0.002	20	<1	22	9.2	<0.02	<0,03	<0.01	<0.08	9.5×10^{2}	2	79	
	inlet	12/03/19	Unobject.	ND	3.9	Unobject.	7.6	471	76	<0.04	0.05	112	0.27	0.05	0.41	0.18	<0.05	279	94	0.48	4	<0.1	<0.002	42	<1	21	10.0	<0.02	<0,03	<0.01	<0.08	3.0×10^{3}	ND	2	
	outlet	12/03/19	Unobject.	ND	3	Unobject.	7.9	462	79	<0.04	0.07	120	0.28	0.01	0.38	0.17	<0.05	250	100	<0.1	4.2	<0.1	<0.002	14	<1	22	11.0	<0.02	<0,03	<0.01	<0.08	5.8×10^{3}	ND	240	
	Deepest	12/03/19	Unobject.	ND	3	Unobject.	7.8	470	79	<0.04	0.05	55	0.23	<0.01	0.23	0.17	<0.05	263	96	<0.1	5.4	<0.1	<0.002	10	<1	22	10	<0.02	<0,03	<0.01	<0.08	2.3×10^{3}	ND	5	
	inlet	12/05/02	Unobject.	5	5.1	Unobject.	8.2	464	74	<0.04	0.33	138	0.91	<0.01	0.12	0.43	0.1	277	148	0.2	2.1	<0.1	<0.002	14	<1	24	22.0	<0.02	0.11	0.04	0.1	2.8×10^{3}	ND	33	
	outlet	12/05/02	Unobject.	5	4.3	Unobject.	7.4	223	80	<0.04	0.3	139	0.82	<0.01	0.21	0.38	0.06	208	144	<0.1	1.5	<0.1	<0.002	20	<1	24	21.0	0.35	0.16	0.09	<0.08	2.8×10^{3}	8	49	
	Deepest	12/05/02	Unobject.	5	3.4	Unobject.	7.7	251	79	<0.04	0.38	134	0.84	<0.01	0.18	0.37	<0.05	264	144	0.1	1.8	<0.1	<0.002	22	<1	24	21	<0.02	0.12	0.02	<0.08	1.6×10^{3}	ND	13	
	IC Conn. S.	12/05/22	Unobject.	5	6.8	Unobject.	8.2	512	86		<0.04	130	0.49	<0.01	0.16	0.34	0.14	339	142	0.2	3.8												23	23	0.0022
	IC Conn. B.	12/05/22	Unobject.	5	7.5	Object.	8	512	85		0.16	125	0.66	<0.01	0.15	0.38	0.12	332	144	0.3	2												13	23	0.074
	Deepest	12/05/22	Unobject.	5	8.8	Object.	7.4	509	86		<0.04	134	0.57	<0.01	0.3	0.37	0.1	361	146	0.1	1.6												2	33	0.091
	IC Conn. S.	12/06/28	Unobject.	7.5	15	Object.	8.6	576	95		<0.04	100	0.14	<0.01	0.19	0.43	0.54	375	151	0.6	12												ND	25	0.2
	IC Conn. B.	12/06/28	Unobject.	10	15	Object.	8.5	580	77		0.02	110	0.12	0.02	0.45	0.36	0.8	289	119	0.4	10												2	25	0.2
	Deepest	12/06/28	Unobject.	10	16	Object.	8.4	585	92		<0.04	143	0.15	<0.01	0.21	0.45	0.92	359	158	0.5	9.9												2	25	0.18
	IC Conn. S.	12/07/26	Unobject.	10	12	Object.	8.5	620	105		<0.01	152	0.26	<0.01	0.54	0.52	0.21	400	161	0.6	1.6												8	1600	0.21
	IC Conn. B.	12/07/26	Unobject.	10	11	Object.	8.2	624	103		0.02	70	0.22	<0.01	0.13	0.51	<0.21	404	163	<0.1	1.9												2	80	0.28
	Deepest	12/07/26	Unobject.	10	13	Object.	8.4	625	104		0.02	94	0.33	<0.01	0.56	0.51	<0.21	399	159	0.8	2.4												7	70	0.23
	IC Conn. S.	12/09/26	Unobject.	10	18	Object.	8.4	736	142		0.53	162	2.7	<0.01	0.3	0.45	0.32	456	173	0.6	23												8	23	0.54
	IC Conn. B.	12/09/26	Unobject.	10	18	Object.	8.3	746	140		0.45	162	2.3	<0.01	0.57	0.46	0.3	457	179	0.6	21												14	35	0.59
	Deepest	12/09/26	Unobject.	10	20	Object.	8.7	738	144		0.35	164	2.5	<0.01	0.27	0.47	0.31	480	173	0.6	22												2	8	0.5
	IC Conn. S.	12/10/16	Unobject.	10	15	Object.	7.9	711	131		0.12	155	1.6	<0.01	0.27	0.47	0.21	420	196	0.4	8.9												80	1600	0.34
	IC Conn. B.	12/10/16	Unobject.	10	27	Object.	7.3	719	133		0.13	152	1.6	<0.01	0.24	0.46	0.25	436	186	1	12												45	1600	0.38
	Deepest	12/10/16	Unobject.	10	20	Object.	7.6	685	123		0.14	184	1.8	<0.01	0.21	0.44	0.22	369	182	0.5	11												35	250	0.55
Wahalkada Wewa	inlet	11/12/21	Object.	ND	4.9	Object.	7.8	204	11	<0.04	<0.04	85	<0.04	<0.01	0.1	0.06	<0.05	84	69	0.1	2	<0.1	<0.002	13	<1	16	7	<0.02	<0,03	<0.01	<0.08	46	ND	8	
	outlet	11/12/21	Object.	ND	3.6	Object.	6.9	198	12	<0.04	<0.04	85	<0.04	<0.01	0.09	0.06	<0.05	82	71	0.2	3	<0.1	0.0002	12	<1	16	8	<0.02	<0,03	<0.01	<0.08	79	ND	8	
	Deepest	11/12/21	Object.	2.5	2.7	Object.	7.2	202	12	<0.04	<0.04	85	<0.04	<0.01	0.09	0.08	<0.05	90	78	0.2	2	<0.1	0.0002	15	<1	16	9	<0.02	<0,03	<0.01	<0.08	58	ND	23	
	inlet	12/01/12	Unobject.	10	4.7	Unobject.	8.7	200	12	<0.04	0.28	90	0.42	<0.01	0.1	0.07	0.14	86	70	0.2	1.4	<0.1	<0.002	<5	<1	15	8	<0.02	<0,03	<0.01	<0.08	1.0×10^{2}	5	27	
	outlet	12/01/12	Unobject.	10	4.5	Object.	8.5	203	12	<0.04	0.35	93	0.63	<0.01	0.08	0.07	0.15	70	68	0.2	1.5	<0.1	<0.002	<5	<1	15	7	<0.02	<0,03	<0.01	<0.08	1.1×10^{2}	5	34	
	Deepest	12/01/12	Unobject.	10	4.3	Unobject.	8.5	201	12	<0.04	0.39	86	0.53	<0.01	0.1	0.08	0.2	110	70	0.2	1.4	<0.1	<0.002	<5	<1	16	7	<0.02	<0,03	<0.01	<0.08	93	ND	17	
	inlet	12/02/15	Unobject.	5	4.6	Unobject.	8.0	218	12	<0.04	0.93	79	0.37	<0.01	0.26	0.11	0.1	136	77	<0.1	1.4	<0.1	<0.002	13	<1	16	3.4	<0.02	<0,03	<0.01	<0.08	1.0×10^{3}	8	49	
	outlet	12/02/15	Unobject.	5	7.3	Unobject.	8.4	222	12	<0.04	0.07	92	0.24	<0.01	<0.05	0.11	0.2	138	76	0.4	2.8	<0.1	<0.002	18	<1	14	4.5	<0.02	<0,03	<0.01	<0.08	1.7×10^{3}	ND	8	
	Deepest	12/02/15	Unobject.	5	1	Unobject.	7.8	222	12	<0.04	0.24	97	0.23	<0.01	0.21	0.22	0.06	128	72	<0.1	1.7	<0.1	<0.002	5	<1	17	3.2	<0.02	<0,03	<0.01	<0.08	49	ND	17	
	inlet	12/03/20	Unobject.	ND	3.5	Unobject.	8.7	237	15	<0.04	0.09	105	0.48	<0.01	<0.05	0.11	<0.05	180	54	<0.1	4.8	<0.1	<0.002	<5	<1	19	0.8	<0.02	<0,03	<0.01	0.3	5.9×10^{2}	ND	130	
	outlet	12/03/20	Unobject.	ND	3.4	Unobject.	8.7	233	15	<0.04	0.08	101	0.18	0.02	0.53	0.11	<0.05	137	56	<0.1	4.2	<0.1	<0.002	<5	<1	17	0.9	<0.02	<0,03	<0.01	0.4	6.0×10^{3}	ND	240	
	Deepest	12/03/20	Unobject.	ND	5.1	Unobject.	8.6	232	14	<0.04	0.09	118	0.18	<0.01	0.4	0.12	<0.05	132	56	0.1	4.8	<0.1	<0.002	5	<1	18	1.7	<0.02	<0,03	<0.01	<0.08	2.0×10^{2}	ND	79	
	inlet	12/05/03	Unobject.	5	1.3	Unobject.	8.1	240	15	<0.04	<0.04	118	0.93	<0.01	0.24	0.24	0.06	96	96	0.2	1.9	<0.1	<0.002	18	<1	18	12.0	<0.02	0.15	0.03	<0.08	1.4×10^{3}	5	22	
	outlet	12/05/03	Unobject.	5	3.6	Unobject.	8.2	245	15	<0.04	0.06	138	0.99	<0.01	0.23	0.24	<0.05	149	92	0.1	2.3	<0.1	<0.002	17	<1	17	12.0	<0.02	0.08	0.07	1.1	1.0×10^{3}	ND	170	
	Deepest	12/05/03	Unobject.	5	1.9	Unobject.	7.9	243	13	<0.04	0.06	126	1.01	<0.01	0.18	0.23	0.11	183	96	0.5	1.6	<0.1	<0.002	19	<1	19	12	0.08	0.1	0.1	<0.08	1.7×10^{3}	ND	33	
	IC Conn. S.	12/05/22	Unobject.	5	13	Object.	8	250	17		0.18	106	0.63	<0.01	0.12	0.27	0.07	178	98	0.1	2.8												ND	23	0.059
	IC Conn. B.	12/05/22	Unobject.	5	10	Object.	8.2	250	16		0.05	105	0.53	<0.01	0.14	0.29	0.24	176	98	<0.1	<1.7												ND	33	0.0911
	Deepest	12/05/22	Unobject.	5	11	Object.	8.1	249	16		0.05	102	0.62	<0.01	0.14	0.26	0.17	168	107	<0.1	2												ND	8	0.098
	IC Conn. S.	12/06/29	Unobject.	10	15	Unobject.	8.2	260	17		0.03	116	0.14	<0.01	0.19	0.25	0.53	172	79	0.3	12.2												2	25	0.26
	Irrigation C.	12/06/29	Unobject.	10	15	Unobject.	8.2	266	16		0.03	111	0.17	<0.01	0.21	0.28	0.36	184	100	0.3	8.8												8	25	0.25
	Deepest	12/06/29	Unobject.	10	15	Object.	7.9	266	17		0.04	110	0.14	<0.01	0.19	0.27	0.54	183	83	0.3	3.3												ND	25	0.19
	IC Conn. S.	12/07/27	Unobject.	10	11	Object.	7.8	270	18		0.06	118	0.21	<0.01	0.13	0.32	<0.21	212	91	0.7	1.6												ND	8	0.51
	Irrigation C.	12/07/27	Unobject.	7.5	3	Object.	8.2	275	18		0.17	118	0.15	<0.01	0.42	0.38	0.3	124	101	0.4	1.5												350	1600	0.37
	Deepest	12/07/27	Unobject.	10	9	Object.	8.6	270	18		0.04	124	0.23	<0.01	0.12	0.32	<0.21	196	93	0.2	1.4												5	25	0.5
	IC Conn. S.	12/09/25	Unobject.	10	19	Object.	8.7	288	47		0.36	119	3.1	<0.01	0.17	0.24	<0.15	187	87	0.2	13												ND	5	0.34
	IC Conn. B.	12/09/25	Unobject.	10	20	Object.	8.7	284	71		0.42	123	2.9	<0.01	0.12	0.23	0.29	175	85	0.1	13												ND	2	0.29
	Deepest	12/09/25	Unobject.	10	19	Object.	8.6	292	22		0.41	116	2.3	<0.01	0.17	0.24	0.25	205	111	0.2	13												ND	8	0.36
	IC Conn. S.	12/10/17	Unobject.	10	16	Object.	8.3	278	20		0.24	116	1.7	<0.01	0.14	0.24	0.31	168	96	0.3	6.6												17	130	0.42
	IC Conn. B.	12/10/17	Unobject.	10	14	Object.	8.1	274	20		0.39	114	1.6	<0.01	0.17	0.23	0.18	162	102	0.2	6.8												5	33	0.39
	Deepest	12/10/17	Unobject.	10	15	Object.	8.2	276	18		0.43	112	1.8	<0.01	0.13	0.23	0.26	175	98	0.2	6.1												ND	8	0.45
Yan Oya	Stream	12/01/12	Unobject.	10	24.3	Object.	8.2	600	83	<0.04	0.18	173	0.27	0.01	0.6	0.26	0.07	331	188	1.5	11	<0.1	<0.002	<5	ND	35	25	ND	ND	<0.01	<0.08	2.5×10^{2}	240	540	
	Stream	12/02/14	Unobject.	7.5	9	Unobject.	7.8	721	110	<0.04	0.42	187	0.2	<0.01	0.24	0.56	0.16	440	201	0.2	21	<0.1	<0.002	17	ND	20	36	ND	ND	<0.01	<0.08	1.8×10^{3}	33	70	
	Stream	12/03/20	Unobject.	ND	2.4	Unobject.	7.9	1186	230	<0.04	0.06	73	0.17	0.01	0.57	0.43	<0.05	612	342	0.5	3.8	<0.1	<0.002	<5	ND	82	63	ND	ND	<0.01	0.6	2.3×10^{3}	130	130	
	Stream	12/05/02	Unobject.	5	6.4	Unobject.	7.7	492	181	<0.04	<0.04	212	0.33	<0.01	0.58	0.57	0.38	386	295	0.3	30	<0.1	<0.002	16	ND	39	48	ND	0.11	0.35	0.25	5.3×10^{3}	ND	130	
	Stream	12/05/23	Unobject.	5.6	5.6	Object.	7.9	2010	466		0.22	316	0.2	<0.01	0.1	0.81	0.26	1634	569	0.3	46												23	79	0.0058
	Stream	12/06/29	Unobject.	5	3.8	Unobject.	7.9	3320	840		<0.04	369	0.05	<0.01	0.15	1.2	0.54	1401	957	<0.1	101												8	25	0.01
	Stream	12/07/27	Unobject.	5	6	Object.	7.9	1769	108		0.03	264	0.2	<0.01	0.81	1.1	<0.21	1332	485	0.5	62												25	25	0.049
	Stream	12/09/25	Unobject.	5	2.7	Object.	7.7	4680	1360		1.72	369	4.4	<0.01	0.18	0.74	0.17	3742	1311	0.2	11												25	130	0.15
	Stream	12/10/17	Unobject.	20	7.8	Object.	7.4	452	72		0.19	75	0.71	<0.01	0.22	0.18	0.45	371	128	5.2	51												79	240	0.21
Sri Lanka Standards (Desirable)			-	5	2		7.0-8.5	750	200			200				0.6	-	500	250	0.3	200	0.2	0.0001			100	(30-150)	0.05	0.05	5			0	0	
Sri Lanka Standards (Permissible)			Unobject.	30	8	Unobject.	6.5-9.0	3500	1200	0.2	0.06	400	0.15	0.01	10	1.5	2	2000	600	1	400	1	0.0002	10	1.0	240	140	1.5	0.5	15	0.2	(100)	0	10	

Chlorophyl a: In case result is less than 0.08mg/l (LOD), raw data is shown as reference

ND: Not detected

IC Conn. S. : Irrigation Canal Connection Surface

IC Conn. B. : Irrigation Canal Connection Bottom

Irrigation C. : Irrigation Canal

Table 4.18 Results of Laboratory Chemical and Microbiological Analysis For Proposed Water Sources (Cont'd)

Water source	Sampling station	Date	Arsenic	Cadmium	Cyanide	Lead	Mercury	Selenium	Total chromuim
			mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Mahakanadarawa Wewa	inlet	11/12/20	<0.01	<0.005	<0.03	<0.03	<0.001	<0.01	<0.02
	outlet	11/12/20	<0.01	<0.005	<0.03	<0.03	<0.001	<0.01	<0.02
	Deepest	11/12/21	<0.01	<0.005	<0.03	<0.03	<0.001	<0.01	<0.02
	inlet	12/01/11	<0.02	<0.005	<0.03	<0.03	<0.001	<0.005	<0.02
	outlet	12/01/21	<0.02	<0.005	<0.03	<0.03	<0.001	<0.005	<0.02
	Deepest	12/01/21	<0.02	<0.005	<0.03	<0.03	<0.001	<0.005	<0.02
	inlet	12/02/14	<0.02	<0.005	<0.06	<0.03	<0.001	<0.005	<0.03
	outlet	12/02/14	<0.02	<0.005	<0.06	<0.03	<0.001	<0.005	<0.03
	Deepest	12/02/14	<0.02	<0.005	<0.06	<0.03	<0.001	<0.005	<0.03
	inlet	12/03/19	<0.01	<0.005	<0.06	<0.03	<0.0005	<0.005	<0.02
	outlet	12/03/19	<0.01	<0.005	<0.06	<0.03	<0.0005	<0.005	<0.02
	Deepest	12/03/19	<0.01	<0.005	<0.06	<0.03	<0.0005	<0.005	<0.02
	inlet	12/05/02	<0.02	<0.005	<0.06	<0.03	<0.001	<0.005	<0.02
	outlet	12/05/02	<0.02	<0.005	<0.06	<0.03	<0.001	<0.005	<0.02
	Deepest	12/05/02	<0.02	<0.005	<0.06	<0.03	<0.001	<0.005	<0.02
	IC Conn. S.	12/05/22	<0.01	<0.005	<0.06	<0.01	<0.0005	<0.01	<0.01
	IC Conn. B.	12/05/22	<0.01	<0.005	<0.06	<0.01	<0.0005	<0.01	<0.01
	Deepest	12/05/22	<0.01	<0.005	<0.06	<0.01	<0.0005	<0.01	<0.01
	IC Conn. S.	12/06/28	<0.02	<0.005	<0.06	<0.03	<0.001	<0.005	<0.02
	IC Conn. B.	12/06/28	<0.02	<0.005	<0.06	<0.03	<0.001	<0.005	<0.02
	Deepest	12/06/28	<0.02	<0.005	<0.06	<0.03	<0.001	<0.005	<0.02
	IC Conn. S.	12/07/26	<0.02	<0.005	<0.03	<0.04	<0.001	<0.01	<0.01
	IC Conn. B.	12/07/26	<0.02	<0.005	<0.03	<0.04	<0.001	<0.01	<0.01
	Deepest	12/07/26	<0.02	<0.005	<0.03	<0.04	<0.001	<0.01	<0.01
	IC Conn. S.	12/09/26	<0.02	<0.005	<0.03	<0.04	<0.001	<0.01	<0.01
	IC Conn. B.	12/09/26	<0.02	<0.005	<0.03	<0.04	<0.001	<0.01	<0.01
	Deepest	12/09/26	<0.02	<0.005	<0.03	<0.04	<0.001	<0.01	<0.01
	IC Conn. S.	12/10/16	<0.02	<0.005	<0.03	<0.04	<0.001	<0.01	<0.01
	IC Conn. B.	12/10/16	<0.02	<0.005	<0.03	<0.04	<0.001	<0.01	<0.01
	Deepest	12/10/16	<0.02	<0.005	<0.03	<0.04	<0.001	<0.01	<0.01
Wahalkada Wewa	inlet	11/12/21	<0.01	<0.005	<0.03	<0.03	<0.001	<0.01	<0.02
	outlet	11/12/21	<0.01	<0.005	<0.03	<0.03	<0.001	<0.01	<0.02
	Deepest	11/12/21	<0.01	<0.005	<0.03	<0.03	<0.001	<0.01	<0.02
	inlet	12/01/12	<0.02	<0.005	<0.03	<0.03	<0.001	<0.005	<0.02
	outlet	12/01/12	<0.02	<0.005	<0.03	<0.03	<0.001	<0.005	<0.02
	Deepest	12/01/12	<0.02	<0.005	<0.03	<0.03	<0.001	<0.005	<0.02
	inlet	12/02/15	<0.02	<0.005	<0.06	<0.03	<0.001	<0.005	<0.03
	outlet	12/02/15	<0.02	<0.005	<0.06	<0.03	<0.001	<0.005	<0.03
	Deepest	12/02/15	<0.02	<0.005	<0.06	<0.03	<0.001	<0.005	<0.03
	inlet	12/03/20	<0.01	<0.005	<0.06	<0.03	<0.0005	<0.005	<0.02
	outlet	12/03/20	<0.01	<0.005	<0.06	<0.03	<0.0005	<0.005	<0.02
	Deepest	12/03/20	<0.01	<0.005	<0.06	<0.03	<0.0005	<0.005	<0.02
	inlet	12/05/03	<0.02	<0.005	<0.06	<0.03	<0.001	<0.005	<0.02
	outlet	12/05/03	<0.02	<0.005	<0.06	<0.03	<0.001	<0.005	<0.02
	Deepest	12/05/03	<0.02	<0.005	<0.06	<0.03	<0.001	<0.005	<0.02
	IC Conn. S.	12/05/22	<0.01	<0.005	<0.06	<0.01	<0.0005	<0.01	<0.01
	IC Conn. B.	12/05/22	<0.01	<0.005	<0.06	<0.01	<0.0005	<0.01	0.01
	Deepest	12/05/22	<0.01	<0.005	<0.06	<0.01	<0.0005	<0.01	<0.01
	IC Conn. S.	12/06/29	<0.02	<0.005	<0.06	<0.03	<0.001	<0.005	<0.02
	Irrigation C.	12/06/29	<0.02	<0.005	<0.06	<0.03	<0.001	<0.005	<0.02
	Deepest	12/06/29	<0.02	<0.005	<0.06	<0.03	<0.001	<0.005	<0.02
	IC Conn. S.	12/07/26	<0.02	<0.005	<0.03	<0.04	<0.001	<0.01	<0.01
	Irrigation C.	12/07/26	<0.02	<0.005	<0.03	<0.04	<0.001	<0.01	<0.01
	Deepest	12/07/26	<0.02	<0.005	<0.03	<0.04	<0.001	<0.01	<0.01
	IC Conn. S.	12/09/25	<0.02	<0.005	<0.03	<0.04	<0.001	<0.01	<0.01
	IC Conn. B.	12/09/25	<0.02	<0.005	<0.03	<0.04	<0.001	<0.01	<0.01
	Deepest	12/09/25	<0.02	<0.005	<0.03	<0.04	<0.001	<0.01	<0.01
	IC Conn. S.	12/10/17	<0.02	<0.005	<0.03	<0.04	<0.001	<0.01	<0.01
	IC Conn. B.	12/10/17	<0.02	<0.005	<0.03	<0.04	<0.001	<0.01	<0.01
	Deepest	12/10/17	<0.02	<0.005	<0.03	<0.04	<0.001	<0.01	<0.01
Yan Oya	Stream	12/01/12	<0.02	<0.005	<0.03	<0.03	<0.001	<0.005	<0.02
	Stream	12/02/14	<0.02	<0.005	<0.06	<0.03	<0.001	<0.005	<0.03
	Stream	12/03/20	<0.01	<0.005	<0.06	<0.03	<0.0005	<0.005	<0.02
	Stream	12/05/02	<0.02	<0.005	<0.06	<0.03	<0.001	<0.005	<0.02
	Stream	12/05/23	<0.01	<0.005	<0.06	<0.01	<0.0005	<0.01	<0.01
	Stream	12/06/29	<0.02	<0.005	<0.06	<0.03	<0.001	<0.005	<0.02
	Stream	12/07/27	<0.02	<0.005	<0.03	<0.04	<0.001	<0.01	<0.01
	Stream	12/09/25	<0.02	<0.005	<0.03	<0.04	<0.001	<0.01	<0.01
	Stream	12/10/17	<0.02	<0.005	<0.03	<0.04	<0.001	<0.01	<0.01
Sri Lanka Standards (Desireble)			-	-	-	-	-	-	-
Sri Lanka Standards (Permissible)			0.05	0.005	0.05	0.05	<0.001	0.01	0.05

Table 4.18 Results of Laboratory Chemical and Microbiological Analysis for Proposed Water Sources (Cont'd))

Water source	Sampling station	Date	alpha - HCH	beta - HCH	gamma - HCH	delta - HCH	ALDRIN	DIELDRIN	HEPTACHLOR	HEPTACHLOR EPOXIDE	ENDRIN	ENDRIN ALDEHYDE	ENDOSULFAN I	ENDOSULFAN II	ENDOSULFAN SULPHATE	o.p' DDT	p.p' DDT	o.p' DDD	p.p' DDD
			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/l	mg/L
Mahakanadarawa Wewa	inlet	11/12/20	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	outlet	11/12/20	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Deepest point	11/12/21	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	inlet	12/01/11	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	outlet	12/01/21	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Deepest point	12/01/21	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	inlet	12/02/14	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	outlet	12/02/14	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Deepest point	12/02/14	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	inlet	12/03/19	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	outlet	12/03/19	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Deepest point	12/03/19	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	inlet	12/05/2	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	outlet	12/05/2	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Deepest point	12/05/2	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Wahalkada Wewa	inlet	11/12/21	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	outlet	11/12/21	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Deepest point	11/12/21	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	inlet	12/01/12	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	outlet	12/01/12	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Deepest point	12/01/12	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	inlet	12/02/15	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	outlet	12/02/15	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Deepest point	12/02/15	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	inlet	12/03/20	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	outlet	12/03/20	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Deepest point	12/03/20	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	inlet	12/05/3	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	outlet	12/05/3	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Deepest point	12/05/3	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Yan Oya	Stream	12/01/12	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Stream	12/02/14	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Stream	12/03/20	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Stream	12/05/2	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Water source	Sampling station	Date	CHLOROPYRIFOS	DIMETHOATE	DIAZINON	FENTHION	FENITROTHION	MALATHION	PARATHION	PARATHION METHYL	PIRIMIPHOS METHYL	PROFENOPHOS	QUINALPHOS	CARBOFURAN	CHLOROTHALONIL	CAPTAN	METALAXYL	ALACHLOR	PROPANIL
			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/l	mg/l	mg/l	mg/l	mg/l
Mahakanadarawa Wewa	inlet	11/12/20	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	outlet	11/12/20	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Deepest point	11/12/21	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	inlet	12/01/11	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	outlet	12/01/21	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Deepest point	12/01/21	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	inlet	12/02/14	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	outlet	12/02/14	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Deepest point	12/02/14	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	inlet	12/03/19	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	outlet	12/03/19	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Deepest point	12/03/19	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	inlet	12/05/2	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	outlet	12/05/2	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Deepest point	12/05/2	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Wahalkada Wewa	inlet	11/12/21	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	outlet	11/12/21	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Deepest point	11/12/21	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	inlet	12/01/12	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	outlet	12/01/12	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Deepest point	12/01/12	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	inlet	12/02/15	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	outlet	12/02/15	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Deepest point	12/02/15	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	inlet	12/03/20	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	outlet	12/03/20	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Deepest point	12/03/20	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	inlet	12/05/3	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	outlet	12/05/3	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Deepest point	12/05/3	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Yan Oya	Stream	12/01/12	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Stream	12/02/14	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Stream	12/03/20	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Stream	12/05/2	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Firstly, it can be said that eutrophication of the lakes has progressed at both the target water sources. Eutrophication occurs by nutrition increases such as nitrogen and phosphorous, then phytoplankton in the water increases due to the nutrition increases. High concentration of albuminoid ammonia and free ammonia in the water quality results show this phenomenon. In addition, both the target water sources have a greenish color and the water quality results show the high color values and chlorophyll a. It can be said that this greenish color caused by phytoplankton is increasing in the water. High concentration of albuminoid ammonia and COD seems to reflect an increase in the content of organic matter in lake water by phytoplankton growth. Both the target water sources show high value, around 8 of pH, and it seems to be due to the carbonate consumption and hydroxyl ions release in water by the growth of phytoplankton. Such eutrophication seems not be caused by human sewage as the population sorrounding both water souces is not high. One possibility is overfertilization of paddy fields and other fields surrounding the water sources.

Seasonal changes of water quality due to rainy and dry seasons also occurs. Recharge water of targeted water sources in the dry season is reduced, and the existing water in targeted water sources are concentrated by evaporation so the contents are increased. This trend is remarkable in Mahakandawara wewa though Wahalkada shows less of a trend of this. The figures below show the said change of some water quality parameters of both water sources.

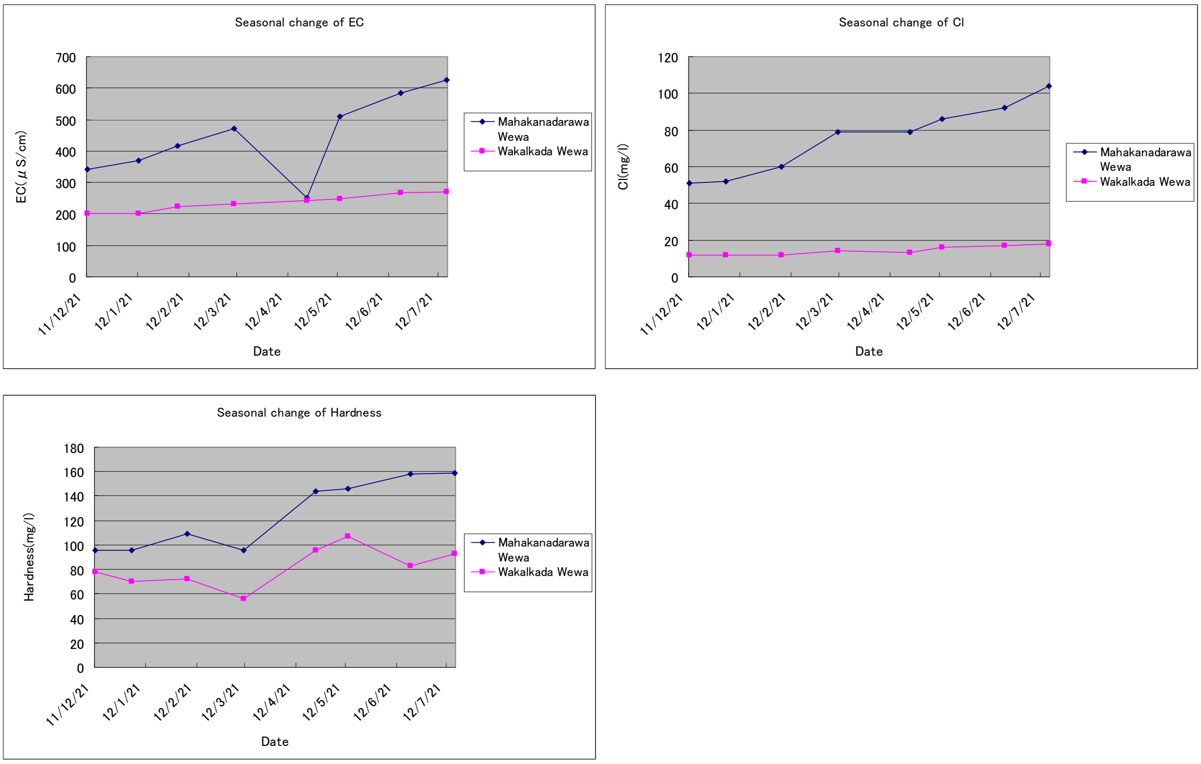


Figure 4.26 Seasonal Change of Water Quality

(b) Fluoride in targeted water sources

Fluorine is a common element that is widely distributed in the earth's crust and exists in the form of fluorides in a number of minerals, such as fluorspar, cryolite and fluorapatite. Traces of fluorides are present in many waters, with higher concentrations often associated with underground sources. In areas rich in fluoride-containing minerals, well water may contain up to about 10 mg/l, although much higher concentrations can be found. High fluoride concentrations can be found in many parts of the world, particularly in parts of India, China, Central Africa and South America, but high concentrations can be encountered locally in most parts of the world.

In Sri Lanka, high concentrations of fluoride are found in groundwater in many areas and the project area is also known as a higher concentration area of fluoride. Therefore, continuous water quality monitoring of the said parameter is essential. As fluoride is a substance derived from minerals, both groundwater and surface water contain flouride if it has come into contact with the mineral. As for fluoride in targeted water sources, the same as EC, Cl and Hardness, the concentrations are lower in the rainy season and becomes higher in the dry season. The trends are shown as follows.

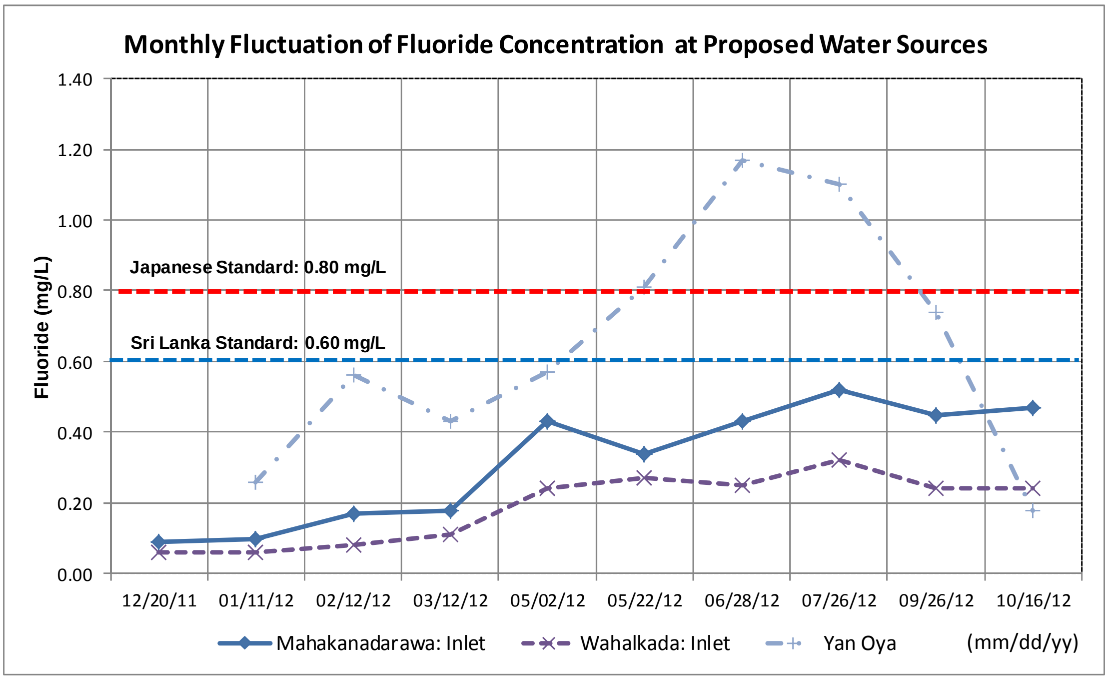


Figure 4.27 Seasonal Change of Fluoride

As shown in **Figure 4.27**, from May to June in the dry season, the fluoride concentrations have increased in any of three water source candidates, especially in Yan Oya of which fluoride has recorded at 1.2 mg/L in June and which cannot be used for drinking water supply without any treatment for fluoride removal. Those in Mahakanadarawa Wewa and

Wahalkada Wewa have also increased to 0.52 mg/L and 0.38 mg/L, respectively. Some of other parameters have exceeded the Sri Lankan drinking water standards but they were within the level to be treated in the course of water treatment.

(c) Evaluation of specific parameters including Sri Lankan standard comparison for targeted water sources

(c1) Odor and Taste

In the target water sources, taste and odor seem to be mainly produced by phytoplankton and aquatic plants. Though industrial and human wastes can also create odor and taste, they are quite low around the water source.

A total of 13% of odor samples and 46% of taste samples exceeded the permissible Sri Lankan drinking water standard. The planned treatment method for water purification plant will treat them.

(c2) Turbidity

Turbidity results from the scattering and absorption of incident light by particles, and the transparency is the limit of visibility in the water. Both can vary seasonally according to biological activity in the water and surface run-off carrying soil particles. As for the targeted water sources, turbidity is high. It seems to be caused by biological activity in the water. A total of 35% of turbidity samples exceeded the permissible Sri Lankan drinking water standard. As turbidity is easily treated at a purification plant, there will be no problem.

(c3) pH

pH is an important variable in water quality assessment as it influences many biological and chemical processes within a water body and all processes associated with water supply and treatment. When measuring the effects of an effluent discharge, it can be used to help determine the extent of the effluent plume in the water body. As these target water sources show, higher pH values are occurred by the photosynthesis and respiration cycles of algae in such eutrophic waters.

All samples are within the permissible Sri Lankan drinking water standard, although many samples show a high pH.

(c4) Free ammonia

Ammonia occurs naturally in water bodies arising from the breakdown of nitrogenous organic and inorganic matter in soil and water, excretion by biota, reduction of the nitrogen gas in water by micro-organisms and from gas exchange with the atmosphere. In water, free ammonia exists with the ammonium ion. In all, 48% of free ammonia samples exceeded the permissible Sri Lankan drinking water standard. It seems that as a result of the death and decay of aquatic organisms, phytoplankton and bacteria in nutritionally rich waters. Free ammonia will be reduced through the water treatment process, thereby this excess will be resolved.

(c5) Albminoid ammonia

Albuminoid ammonia results from rapid decomposition that is induced artificially. It is a measure of the amount of organic matter present which may decay, and is simply what would be produced naturally in the course of time. As the results show, free and albuminoid ammonia are both high in the water resources. It means that they contain much decaying matter and would be decayed of aquatic organisms. A total of 77% of albuminoid ammonia samples exceeded the permissible Sri Lankan standard. The same as free ammonia, albuminoid ammonia will be reduced through the water treatment process, thereby this excess will be resolved.

(c6) Nitrate and nitrite

The nitrate is the common form of combined nitrogen found in natural waters. It may be biochemically reduced to nitrite by denitrification processes, usually under anaerobic conditions. The nitrite is rapidly oxidized to nitrate. Natural sources of nitrate in surface waters include igneous rocks and plant and animal debris. Nitrate is an essential nutrient for aquatic plants and seasonal fluctuations can be caused by plant growth and decay. Sometimes nitrate and nitrite are enhanced by municipal and industrial wastewater, including leachates from waste disposal sites and sanitary landfills. However, the targeted water sources are located in rural areas so use of inorganic nitrate fertilizers seems to be a possible source. In all, 10% of nitrite samples and none of nitrate samples exceeded the permissible Sri Lankan drinking water standard. The same as free ammonia, nitrate and nitrite will be reduced through the water treatment process, thereby this excess will be resolved.

(c7) Phenol compounds

Phenol compounds are an important group of pollutants which enter water bodies in the waste discharges of many different industries. They are also rarely formed naturally during the metabolism of aquatic organisms, biochemical decay and transformation of organic matter in the water and in bottom sediments.

They have detrimental effects on the quality and ecological condition of water bodies through direct effects on living organisms. The presence of phenol compounds causes deterioration in the organoleptic characteristics so they are strictly controlled in drinking water. Two phenol compound samples (7%) showed the same as the permissible Sri Lankan drinking water standard that is 0.0002mg/l. As there is less possibility of industrial pollution, the cause is unclear so far.

(c8) Chemical oxygen demand

Freshwater like the target water sources contain organic matter which can be measured by chemical oxygen demand (COD). The COD is a measure of the oxygen equivalent of the organic matter in a water sample that is susceptible to oxidation by a strong chemical oxidant. The COD is widely used as a measure of the susceptibility to oxidation of the organic and inorganic materials present in water bodies so. Though the test for COD is non-specific and it does not identify the oxidisable material such as the organic and inorganic material present, phytoplankton growth is a most probable reason due to the consideration of other test results. A total of 70% of COD samples exceeded the permissible Sri Lankan drinking water standard. However, this will be reduced through the water treatment process, thereby this excess will be resolved.

(c9) Aluminum

Aluminum occurs in the earth’s crust in combination with silicon and oxygen to form feldspars, micas, and clay minerals. Therefore, this occurrence in the target water sources is quite natural as there are so many such minerals in Sri Lanka. A total of 10% of Aluminum samples exceeded the permissible Sri Lankan standard and it occurred only in Wahalkada Wewa. Generally aluminum potassium sulfate (alum), aluminum compound itself, is used in water-treatment processes to flocculate suspended particles, and it can be left as residue of aluminum in the finished water.

(c10) Total coliform and E. coli

The total coliform group includes both faecal and environmental species. Total coliforms include organisms that can survive and grow in water. Some of these bacteria are excreted in the faeces of humans and animals, but many coliforms are able to multiply in water and soil environments. E. coli is a kind of coliform and present in very high numbers in human and animal faeces and is rarely found in the absence of faecal pollution. Therefore, it is considered the most suitable index of faecal contamination. Occurrence of E. coli seems not to be human faeces but animal faeces as the populations around the both water sources are low. In all 77% of total coliform and 42% of E. Coli samples exceeded the permissible Sri Lankan drinking water standard. However, this will be eliminated through the water treatment process, thereby this excess will be resolved.

(d) General characteristics of Yan Oya reservoir water

Yan Oya Reservoir to be newly constructed will has a plan to supply water to the part of an irrigation area for Wahalkada Scheme and improve the water use condition of Wahalkada Wewa.

The results of the laboratory chemical and microbiological analysis for the Yan Oya reservoir water are shown in **Table 4.18**. From these data, some general characteristics are found.

Firstly, it can be said that Yan Oya water shows a groundwater characteristics even though it is a surface water. Higher concentration of EC, chloride, hardness, fluoride, iron, sulphate, magnesium and aluminum compared with Mahakandawara and Wahalkada wewa were found. Some comparison figures are shown below.

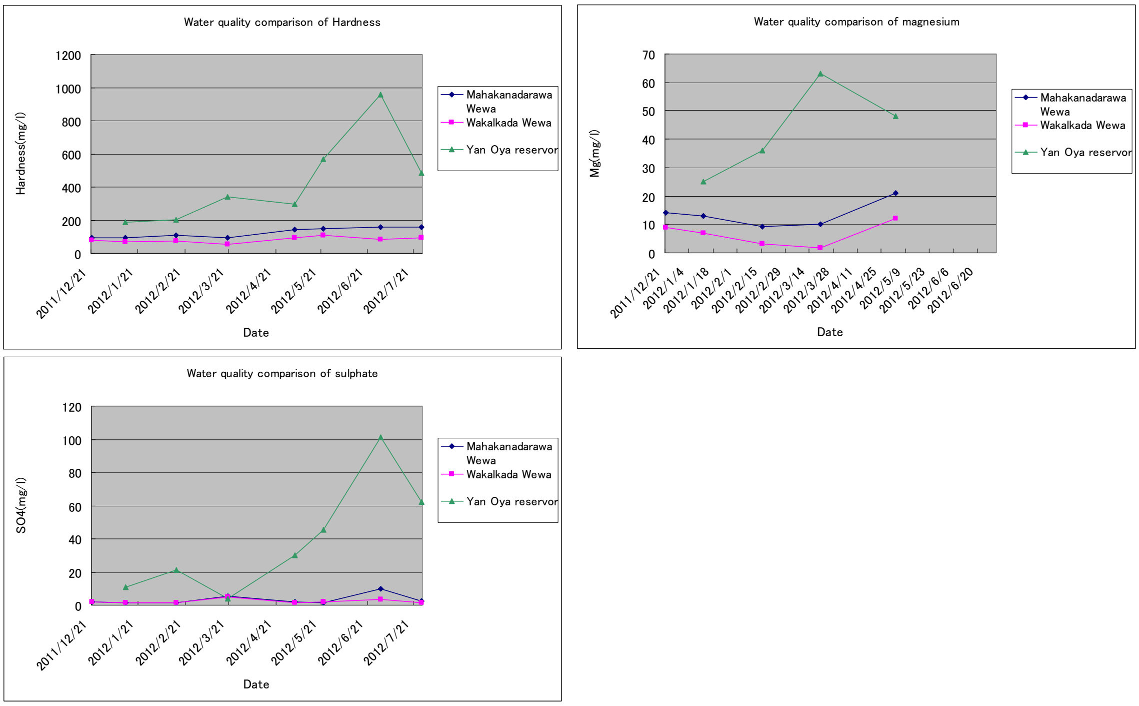


Figure 4.28 Water Quality Comparison

It seems that the water source of Yan Oya water contains a kind of groundwater located above the sampling site. On the other hand, the same as Mahakandawara and Wahalkada wewa, Yan Oya water contains high concentration of free and albuminoid ammonia. It seems to be caused by fertilizer application around Yan Oya as well. However, unlike the said two water sources, Yan Oya showed lower chlorophyl a concentration. It is because the water at Yan Oya water is flowing and not stagnant, meaning there is less chance of photosynthesis for phytoplankton growth to occour. Therefore, high COD, and free and albuminoid ammonia are caused not by the phytoplankton growth. One possible cause is influent animal waste around the Yan Oya stream. High values of Total coliform and E. coli indicate this.

(e) Fluoride in Yan Oya water

Unlike the other two water sources, Yan Oya shows a high fluoride content. As mentioned, one of Yan Oya water source seems to be groundwater, and that groundwater may have a high concentration of fluoride. Compared with other proposed water sources, fluoride concentrations of Yan Oya water have exceeded 0.6 mg/L for a period of May to September as shown in **Figure 4.26**, which is the desirable level of Sri Lankan drinking water standard.

(f) Evaluation of specific parameters including Sri Lankan standard comparison for Yan Oya

(f1) Turbidity

In all, 29% of turbidity samples exceeded the permissible Sri Lankan drinking water standard. The reason is unknown but it seems not to be biological activity in the water. As turbidity is easily treated at a purification plant, this will not cause a problem. For general information of turbidity, see section c2

(f2) Taste

A total of 43% of taste samples exceeded the permissible Sri Lankan drinking water standard. The reason is unknown but slow sand filter method which is planned treatment method for water purification plant is able to treat them. For general information of taste, see section c1

(f2) Free and albminoid ammonia

In all, 57% of free ammonia and 86% of albminoid ammonia samples exceeded the permissible Sri Lankan drinking water standard. It seems that this is caused by fertilizer application in the same manner as Mahakandawara and Wahalkada wewa, and another possible cause is animal waste around the Yan Oya stream. Free and albminoid ammonia will be reduced through the water treatment process, thereby this excess will be resolved. For general information of free and albminoid ammonia, see section c8.

(f3) Iron

Iron occurs in the minerals hematite, magnetite, taconite, and pyrite. The iron originates by solution at sites of either reduction of ferric hydroxides or oxidation of ferrous sulphide and the process is strongly influenced by microbiological activity. The occurrence of iron in streams like Yan Oya and in lakes like Mahakandawara and Wahalkada wewa is natural, though groundwater generally contains higher iron than surface water. A total of 14% of iron samples exceeded the permissible Sri Lankan drinking water standard. However, this will be eliminated through the water treatment process, thereby this excess will be resolved.

(f4) Chemical oxygen demand

A total 50% of COD samples exceeded the permissible Sri Lankan drinking water standard. It seems that it is caused by decay of aquatic organisms and animal waste around the Yan Oya stream. However, this will be reduced through the water treatment process, thereby this excess will be resolved. For general information of COD, see section c8.

(f5) Aluminum

A total of 50% of Aluminum samples exceeded the permissible Sri Lankan drinking water standard. As is the case with Mahakandawara and Wahalkada wewa, it seems that this occurrence is originated from groundwater as there are so many minerals containing aluminum in Sri Lanka. Generally aluminum potassium sulfate (alum), aluminum compound itself, is used in water-treatment processes to flocculate suspended particles, and it can be left as residue of aluminum in the finished water. For general information of aluminum, see section c9.

(f6) Total coliform and E. coli

All samples of total coliform and 86% of E. Coli samples exceeded the permissible Sri Lankan drinking water standard. This figure far exceeds the 40% of samples found at Mahakandawara and Wahalkada wewa. It seems that it is caused by animal waste around the Yan Oya stream. As this contamination will be eliminated through the water treatment process, its excess will be resolved. For general information of aluminum, see section c10.

(3) Quality control

A series of quality control measures, which are operational techniques and activities that are used to fulfill requirements of JICA Study Team for quality tests, were also conducted. The quality control program conducted consists of an internal quality control and an external quality control. The former refers to activities conducted within a laboratory to confirm performance and the latter refers to activities to compare with Japanese laboratory.

Additionally, data comparison NWSDB Anuradhapura lab to subcontractor lab was also conducted to evaluate the performance and find the problem.

1) Internal quality control

For the internal quality control, accuracy control of subcontractor's lab using a certified reference material (CRM) was conducted. Certified reference materials (CRMs) are matrix-matched materials with assigned target values and assigned ranges for each variable, reliably determined from data obtained by repeated analysis. Target and range values may be generated from data produced by several laboratories using different analytical methods. Since CRM is prepared and checked under carefully controlled conditions, they are costly to produce and correspondingly expensive to purchase. Therefore, JST conducted this activity only one time in June.

(a) CRM used

- Model: Ontario-99,
- Manufactured by: Canada Environment
- Source water: Lake water with spike

(b) Procedures

CRM was prepared and provided the subcontractor lab with regular monitoring sample in June. The lab analyzed CRM with other regular samples and reported to JICA Study Team.

(c) Results

Analysis results of CRM by subcontractor are shown below.

Table 4.19 Analysis Results of CRM

Analytical parameters	Expected values (mg/l)	Analysis results by subcontractor (mg/l)	Recovery (%)
Alkalinity	93.1	97	104%
Chloride	20.8	21	101%
Fluoride	0.63	0.70	111%
Hardness	124	129	104%
Sulphate	26	37	142%

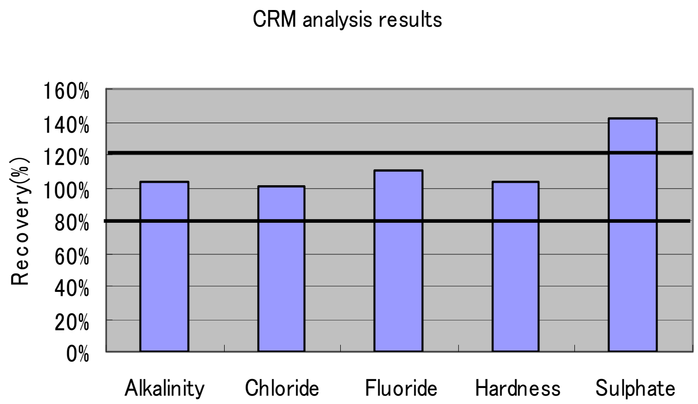


Figure 4.29 Recovery of CRM Results

As the results shown, subcontractor's lab performed good recovery which ranged within 120 to 80% for Alkalinity, Chloride, Fluoride and Hardness. However, Sulphate's recovery showed 142% and out of our expected criteria. The lab investigated the possible reason such as miscalculation or mistype but no mistake was found. Therefore, the cause is still unknown as it was only one time proficiency test and unable to test again due to the CRM volume limitation.

2) External quality control

External quality control (laboratory intercomparison)

External quality control is a way of confirming the accuracy of analytical results by comparing the results of analyses made in one laboratory with the results obtained by others conducting the same analysis on the same material. This time a subcontractor lab and a Japanese lab results were simply compared so no statistical analysis was done.

(a) Sample used

- Sampling point: Mahakandawara wewa
- Sampling location: Irrigation canal connection
- Source water: Lake water without spike
- Laboratory used for comparison: Environmental Control Center, Japan

(b) Procedures

In the regular monitoring at irrigation canal connection of Mahakandawara wewa in May, the said sample was carefully subsampled into two sets. One was analyzed by subcontractor lab as usual and the other was sent to Japan to be analyzed by the Environmental Control Center. The results were compared and evaluated as follows.

(c) Results

Analysis results by subcontractor and Japanese labs are shown below.

Table 4.20 Analysis Result Comparison

Analytical parameters	Analysis results by Japanese lab (mg/l)	Analysis results by subcontractor lab (mg/l)	Recovery (%)
Fluoride	0.27	0.34	79%
Arsenic	<0.001	<0.02	100%**
Cadmium	<0.0003	<0.005	100%**
Lead	<0.001	<0.03	100%**
Mercury	<0.0005	<0.001	100%**
Selenium	<0.001	<0.005	100%**
Total Chromium	<0.001	<0.05	100%**
Iron	0.16	0.15*	107%

*----- Subcontractor lab performs LOD of Iron analysis as 0.1mg/l so raw data of 2 digits is shown as reference

**----As both lab showed below LOD, the recovery shall be 100%

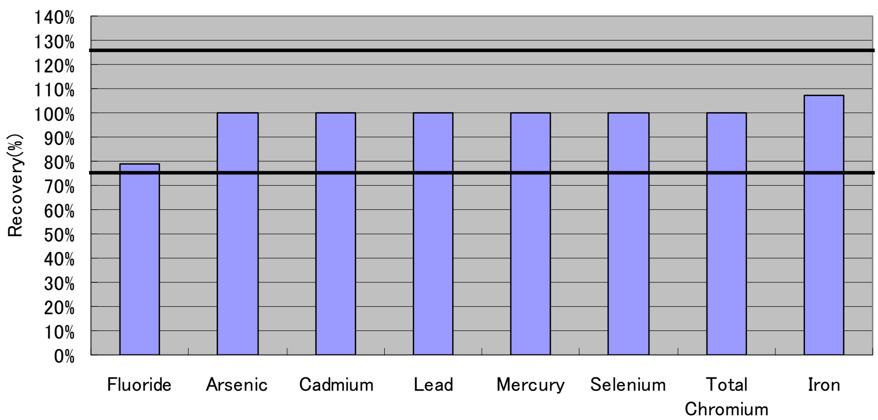


Figure 4.30 Recovery of Results

As the results shown, subcontractor's lab performed good recovery which ranged within 125 to 75% for all analytical parameters. Though fluoride result showed lower performance, it was acceptable as fluoride test is one of the variable analytical parameter.

3) Data comparison for NWSDB Anuradhapura lab

Data comparison of NWSDB Anuradhapura lab with subcontractor lab conducted for fluoride test as follows.

(a) Sample used

- Mahakandadrawa wewa
- Wahalkada wewa
- Yan Oya

(b) Procedures

In the regular monitoring of Mahakandawara and Wahalkada wewa in May, the samples were carefully subsampled into two sets for fluoride. One was analyzed by subcontractor lab and the other was done by NWSDB Anuradhapura lab. The results were compared and evaluated as follows.

Table 4.21 Analysis Result Comparison

	Mahakanadarawa Wewa			Wahalkada Wewa			Yan Oya
	Outlet surface	Outlet bottom	Lake center	Outlet surface	Outlet bottom	Lake center	River stream
SGS lab	0.34	0.38	0.37	0.27	0.29	0.26	0.81
NWSDB lab	---	0.1	0.12	0.12	0.14	0	0.62

Though the data volume is still limited, it is observed that NWSDB Anuradhapura lab generally performed lower concentration than the subcontractor lab, based on their respective results. Judging from the fact that the subcontracted lab performed well in the internal and external quality control, it seems that the NWSDB lab shows lower values of fluoride than true values. There are some possible causes but one thing to be done is sample pretreatment to remove interferences.

4) Conclusion

Generally, the subcontractor laboratory performed well and fulfilled the requirement of quality test except sulphate. For sulphate, other investigation is required later.

As for Data comparison for NWSDB Anuradhapura lab, investigation of the cause needs more time and maybe another program will be required such as dispatching of an expert(s).

4.3.3 Present Operation of Irrigation Reservoir

(1) Entity of the operation and management

Operation and management of the irrigation tanks is under the responsibility of the Irrigation Department, which is an “A class” Governmental Department. The Department was formed 110 years ago and is subject to the control and direction of the Ministry of Irrigation and Water Management, which is overall in charge of Irrigation. The Irrigation Department implements the policies and programs of the Ministry, as the principal organization for the regulation and control of irrigation waters.

The Regional Director of Irrigation, Anuradhapura has responsibility for the Mahakanadarawa and Wahalkada tanks. Four Irrigation Engineer Offices, which are located in Radviya, Anuradhapura, Rajanganay and Hurulu Wewa, and one Regional Engineer Office, which is located in Nachchaduwa for are responsible for management of irrigation schemes. Operation and management of Mahakanadarawa tank is controlled by the Irrigation Engineer’s Office in Mahakanadarawa, and Wahalkada tank is controlled by the Office in Radviya.

(2) Condition of Irrigation and Water Use

The water uses of the above tanks are irrigation and fisheries. Irrigation water is mainly used for paddy fields and partly used for other upland crops under an annual irrigation program. The general condition of the irrigation scheme and basic factors of the irrigation program in this region are shown in **Table 4.22**.

Table 4.22 General Condition of the irrigation

Item	Outline
Irrigation period in Maha	Nov. – March
Irrigation period in Yala	May – August
Major Crops	Rice(Paddy field)
Irrigation Area	Mahakanadarawa Scheme： Max. Irrigable area: 6,000Ac（2,420ha) Irrigable area by FSL: 3,600Ac（1,460ha） (around 50% of 3,000 Ac is available in Yala season) Wahalkada Scheme： Max. Irrigable area: 2,257Ac（910ha) Irrigable area by FSL: 2,000Ac（810ha）

The irrigation water requirement is approximately calculated based on the above and the following conditions:

- Potential Evapotranspiration:
  - Mahakanadarawa Scheme: Data at Mahailluppallama Station
  - Wahalkada Scheme: Data at Vavniya Station
- Cropping factor: 0.90～1.15, depending on the growing stage
- Rainfall:
  - Mahakanadarawa Scheme: Data at Anuradhapura Station with efficiency of 80%
  - Wahalkada Scheme: Data at Wahalkada Station with efficiency of 80%
- Irrigation Period: Yala in May-August, Maha in Nov.-March
- Irrigation Area:
  - Mahakanadarawa Scheme: 1460 ha
  - Wahalkada Scheme: 810 ha
- Efficiency: 40% (case of no lining canal)

The annual irrigation water requirement for the Mahakanadarawa Scheme is approximately 22.2 MCM and that for Wahalkda is approximately 10.9 MCM as shown in **Table 4.23** and **Table 4.24**.

Table 4.23 Estimation of Irrigation Use in Mahakanadarawa Scheme

Month	1	2	3	4	5	6	7	8	9	10	11	12	Total
Cropping Calender (paddy field)	Maha				Yala						Maha		
(A) Days of month	31	28	31	30	31	30	31	31	30	31	30	31	
(B) kc	1.2	1.2	0.9		1.0	1.15	1.2	0.9			1.0	1.15	
(C) ETO (mm/day)	2.4	3.2	3.8	3.6	4.2	4.5	4.7	4.8	4.7	3.4	2.3	2	
(D) ETO (mm/month)	74.4	89.6	117.8	108	130.2	135	145.7	148.8	141	105.4	69	62	
(E) Etcrop (mm/month)	89.3	107.5	106	0	130.2	155.3	174.8	133.9	0	0	69	71.3	
(F) Crop water requirement (m^3/ha/month)	893	1,075	1,060	0	1,302	1,553	1,748	1,339	0	0	690	713	
(G) Rainfall (mm/month)	90	51	70	159	74	15	30	33	73	223	248	188	1254
(H) Effecive rainfall (m^3/ha/month)	717	408	558	1274	588	122	236	267	586	1784	1986	1502	
(I) Net water requirement (m^3/ha/month)	176	667	503	0	714	1,430	1,512	1,072	0	0	0	0	
(J) Irrigation area (ha) - FSL	1,460	1,460	1,460	1,460	1,460	1,460	1,460	1,460	1,460	1,460	1,460	1,460	
(K) Net water requirement (m^3/month)	257.2	974.1	733.7	0.0	1,042.2	2,088.5	2,207.8	1,565.0	0.0	0.0	0.0	0.0	8,868.4
(L) Efficiency	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	
(M) Gross water requirement (m^3/month)	642.9	2,435.3	1,834.3	0.0	2,605.4	5,221.1	5,519.5	3,912.5	0.0	0.0	0.0	0.0	22,171.0

Table 4.24 Estimation of Irrigation Use in Wahalkada Scheme

Month	1	2	3	4	5	6	7	8	9	10	11	12	Total
Cropping Calender (paddy field)	Maha				Yala						Maha		
(A) Days of month	31	28	31	30	31	30	31	31	30	31	30	31	
(B) kc	1.2	1.2	0.9		1.0	1.15	1.2	0.9			1.0	1.15	
(C) ETO (mm/day)	2.16	2.88	3.46	3.4	4.13	4.58	4.53	4.34	4.46	2.94	1.92	1.84	
(D) ETO (mm/month)	66.96	80.64	107.26	102	128.03	137.4	140.43	134.54	133.8	91.14	57.6	57.04	
(E) Etcrop (mm/month)	80.4	96.8	96.5	0	128	158	168.5	121.1	0	0	57.6	65.6	
(F) Crop water requirement (m^3/ha/month)	804	968	965	0	1,280	1,580	1,685	1,211	0	0	576	656	
(G) Rainfall (mm/month)	173	88	49	74	43	13	36	61	85	152	346	321	1441
(H) Effecive rainfall (m^3/ha/month)	1,380	707	389	590	341	107	289	490	683	1,217	2,765	2,569	
(I) Net water requirement (7000 m^3/ha/month)	0	261	576	0	939	1,473	1396	721	0	0	0	0	
(J) Irrigation area (ha) - FSL	809	809	809	809	809	809	809	809	809	809	809	809	
(K) Net water requirement (m^3/month)	0.0	210.8	466.2	0.0	0.8	1,191.9	1.1	583.2	0.0	0.0	0.0	0.0	4.3
(L) Efficiency	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	
(M) Gross water requirement ('1000 m^3/month)	0.0	527.1	1,165.6	0.0	1,899.4	2,979.6	2,823.3	1,457.9	0.0	0.0	0.0	0.0	10,853.0

(3) Operation Method for Irrigation Water Use

Mahakanadarawa scheme has 2 intake wells for irrigation and the Wahalkada Scheme has one. The irrigation water requirement varies throughout the year depending on factors such as storage volume, market price, availability of man power and machinery. Representatives of farmer’s organization and the irrigation department discuss and determine the water volume and period for irrigation. Normally, there is a period of between 10 and 14 days for preparation period, then water is supplied 5 days, followed by a period of 5 days with no water, with the cycle continuously repeating. Water is controlled to keep a minimum water depth of 25 mm in the paddy field.

Table 4.25 shows the annual irrigation water use in 2009-2011. In the case of the Mahakanadarawa scheme, water use varied from 19.41 to 42.42 MCM, with the amount partly being dependent on the quantity of water stored early in the season. On the other hand, in the case of the Wahalkada scheme, the variation in irrigation water use is not as big as in the Mahakanadarawa scheme, ranging from about 12 to 16 MCM, with the storage volume early in the season varying.

Table 4.25 Irrigation Water Used in 2009-2011

	Mahakanadarawa tank		Wahalkada Tank	
	Storage in Jan. 1 (MCM)	Irrigation Water Supply (MCM)	Storage in Jan. 1 (MCM)	Irrigation Water Supply (MCM)
Gross Calc. for Average Rainfall		22.2		10.9
2009	44.78	No data	17.45	12.13
2010	22.50	19.41	21.50	16.13
2011	44.78	42.42	26.73	15.95

Figure 4.31 and **Figure 4.32** show the daily irrigation use in these irrigation schemes in the period 2090-2011. These figures show that irrigation water use is almost corresponding with the Yala and Maha periods, and some irrigation water is used in the Maha period, even in the rainy season.

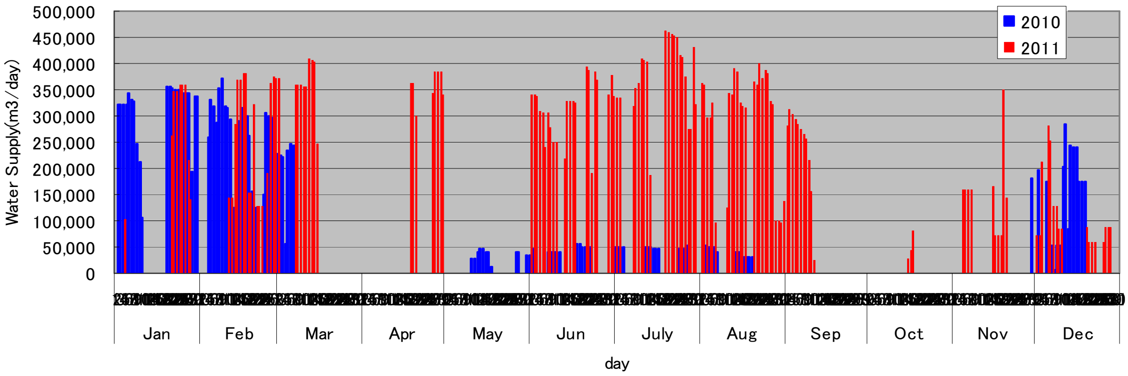


Figure 4.31 Irrigation Water Use in Mahakanadarawa Scheme（2009-2011）

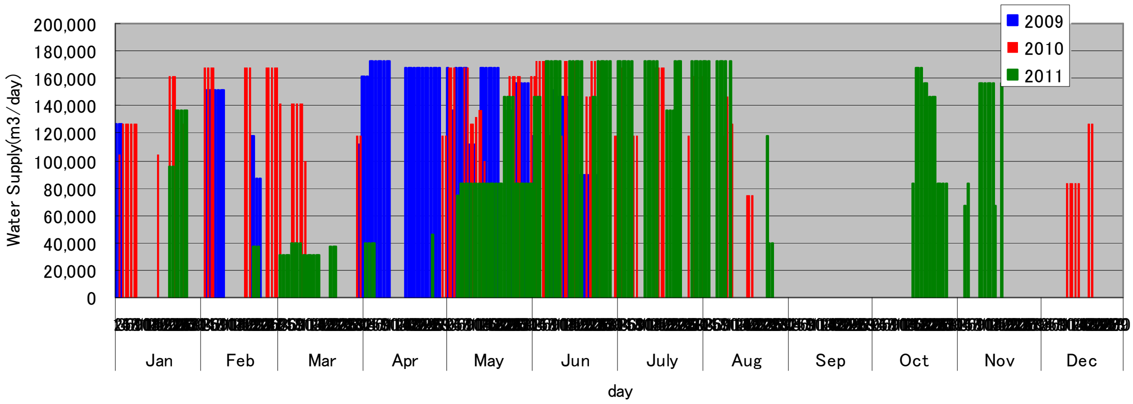


Figure 4.32 Irrigation Water Use in Wahalkada Scheme（2009-2011）

(2) Storage Variation of Mahakanadarawa and Wahalkada Wewa

Table 4.26 shows general details of the above reservoirs (refer to **Appendix 4.3(f)** for details).

Table 4.26 General Data of Mahakanadarawa and Wahalkada Tank

Item	Mahakanadarawa Wewa	Wahalkada Wewa
Full Supply Level (FSL)	311 ft	155 ft
Gross Storage for FSL	36,250 Ac.ft	43,000 Ac.ft
Dead Storage	2,000 Ac.ft	2,025 Ac.ft
High Flood Level	315 ft	156 ft
Top level	320 ft	162 ft
Top Width	18 ft	20 ft
Max. Height	19 ft	40 ft
Intake	2 places RB: Intake well、sluice gate LB: Intake well, sluice gate	1 places Intake well、sluice gate
Canal	2lines、only LB Canal in dry season	1 line

The water level and storage data of the reservoirs was collected from the Irrigation Regional Office in Anuradhapura (refer to **Appendix 4.3(g)** for details).

<u>Mahakanadarawa Wewa</u>

(a) This reservoir is a type of cycle regulation dam, and the storage amount varies year by year due to rainfall variation. Storage of Mahakanadarawa Wewa has been over the Full Storage Level (FSL) 4 times in the past 11 years.

(b) Many small tank cascades and paddy field exist in the catchment area, therefore this condition can affect inflow mechanism to the reservoir, i.e., initial rainfall is stored in small tanks and even in paddy fields. Direct flow to the reservoir can be limited to only the area surrounding the reservoir.

(c) Minimum storage was recorded in 2006, 500Acft (0.61MCM). The water level on the sill corresponding to this storage is 0.08 m.

(d) Irrigation water use in Yala season is determined based on the water level in the reservoir in the period March-May. When water level was FSL in January 2004, around 28,000Acft (34.4MCM) of water were used for irrigation in 3 months from April. This amount corresponds to 0.38MCM per day.

On the other hand, the storage volume was about 18,000Acft (22.14MCM) in January 2005, and only 15,000Acft (18.5MCM) were used for irrigation, corresponding to 167Acft (0.205MCM). Basically, the Mahakanadarawa scheme has the potential to irrigate an area of 6,000 Ac (2,420 ha). However, because of the limitation of water, 3,000 Ac is normally irrigated even under FSL storage conditions. The irrigation area in rhe Yala season is 1,500 Ac (730 ha), 50% of the area under FSL storage conditions.

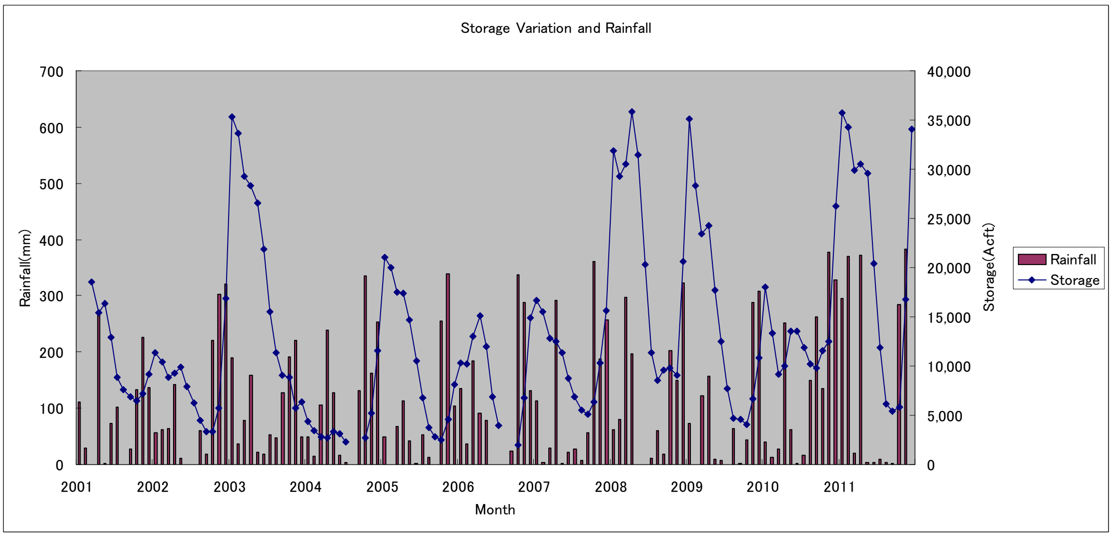


Figure 4.33 Monthly Rainfall and Storage in Mahakanadarawa Tank

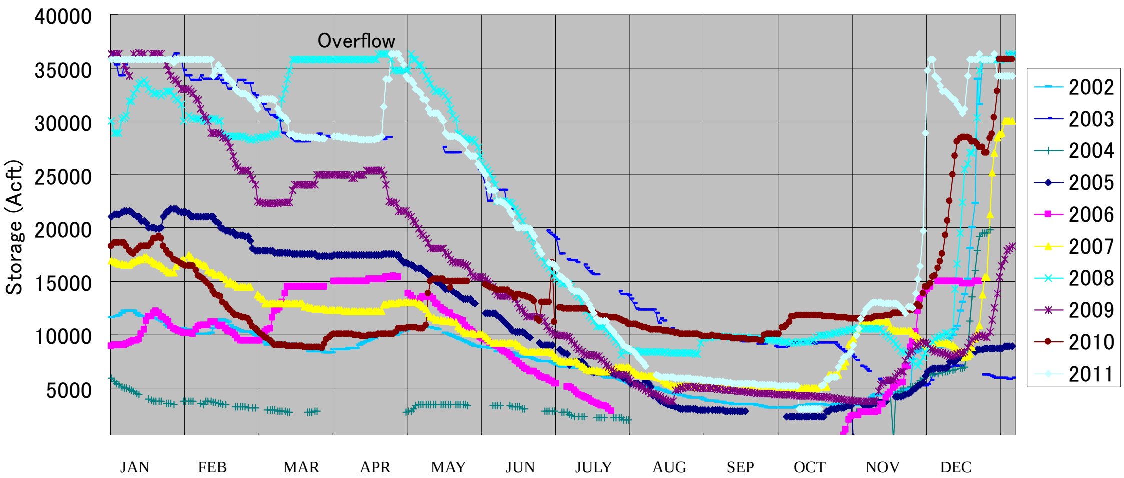


Figure 4.34 Monthly Variation of Storage in Mahakanadarawa Wewa

Wahalkada Wewa

(a) This reservoir is a type of cycle regulation dam, and the storage amount varies year by year due to rainfall variation. Storage of Wahalkada Wewa has been over the Full Supply Level (FSL) only once in the past 11 years.

(b) Many small tank cascades and paddy fields are present in the catchment area of this reservoir; therefore this condition can affect the flow into the reservoir, i.e., initial rainfall is stored in small tank and even paddy field. Direct flow can be limited to from only the area surrounding the reservoir.

(c) Storage of the reservoir has been recorded at about 35,000 Acft in 2005 and 2006 and the storage amount was less than 20,000 Acft until 2010. The amount of rainfall in these years has not been so low 1,256mm - 1,799mm.

(d) The record of storage in February of 2011 shows 59,000 Acft, which is bigger than the gross storage of 43,000 Acft. According to information from the Irrigation Engineer's office in Padaviya, the water inflow in 2011 was quite large, and the water was flowing over the near point of the spillway. The Irrigation Department is considering expansion of spillway.

(e) Minimum storage was recorded in 2010, as 2,025Acft. The water level on the sill corresponding to this storage is 0.85m.

(f) Regardless of the storage amount, irrigation water use has a tendency to be the same amount in the period from April to July.

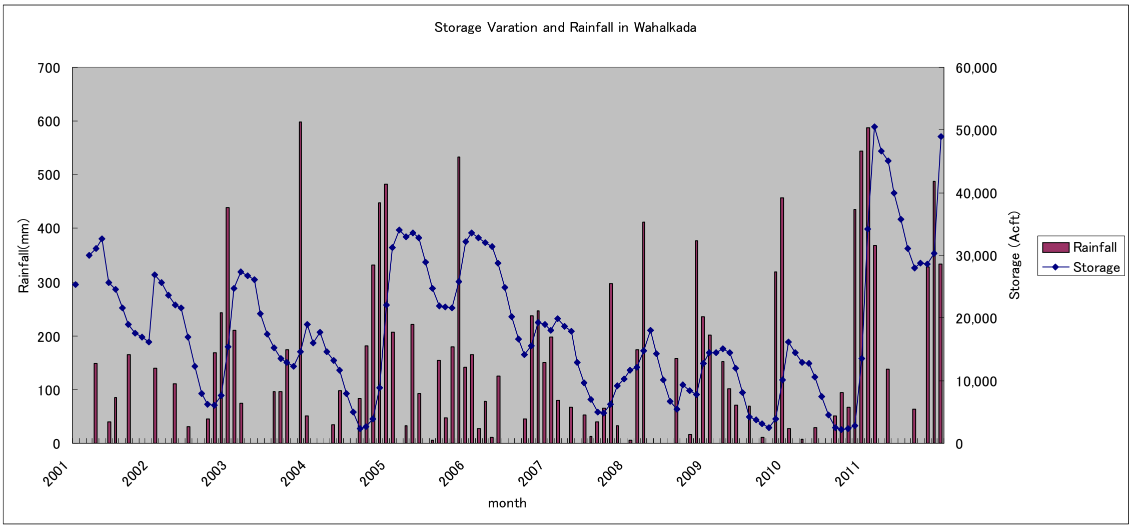


Figure 4.35 Monthly Rainfall and Storage in Wahalkada Tank

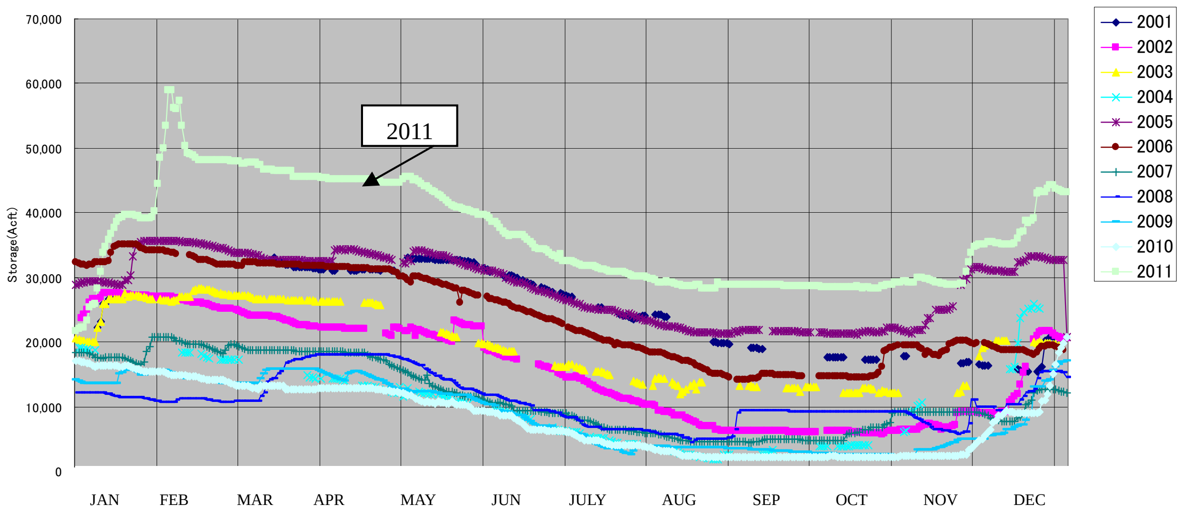


Figure 4.36 Monthly Variation of Storage in Wahalkada Tank

4.3.4 Water Availability from Irrigation Reservoir

The objective of this analysis is to evaluate the availability of water for drinking use from Mahakanadarawa and Wahalkada Wewa. The storage amount in the reservoirs vary depending upon rainfall and irrigation use, which itself is dependent on many factors such as agriculture marketing aspect, use of machinery, input of man power, etc.

Because of the limited study period, no direct measurement of inflow to and outflow from the reservoirs or detailed model simulation was carried out. Basically, collected data and information from the Meteorological Department and Regional Irrigation Department were used for the evaluation.

(1) Water Balance of the reservoirs

An estimate of the gross annual water balance of reservoirs has been made. Factors in the water balance are inflow from the catchment area, rainfall, evaporation, seepage and irrigation use, as shown in **Figure 4.37**.

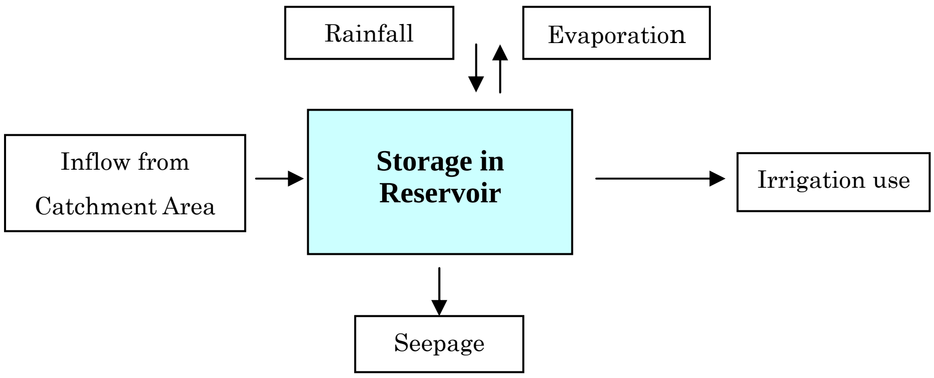


Figure 4.37 Image of Water Balance

1) Rainfall

Average annual rainfall in the Study Area is used as follows.

Anuradhapura Station : 1,246 mm

Wahalkada Station : 1,441 mm

2) Estimation of run-off from catchment area

Gross run-off coefficient from the catchment area to the reservoir is analyzed based on the increase in reservoir's storage and monthly rainfall from October to January at the start of the rainy season.

According to the intake data of the Irrigation Department, irrigation water is used even in the rainy season; therefore the calculated coefficient is considered on the safe side in order to maintain storage.

Table 4.27 and **Table 4.28** show that values of runoff varies between 3%～12% in Mahakanadarawa and between 5%～26% in Wahalkada. The catchment areas include many small tanks and paddy fields and as such the initial and small amounts of rainfall can be stored in these places. Furthermore, outflow to the reservoir is only from the surrounding area and after filling of the paddy fields and small tanks, i.e. the variation in run off is due to the volume and continuity of rainfall.

Table 4.27 Runoff Coefficient Calculated in Mahakanadarawa Tank

Year-Year	Rainfall (mm)	Storage change (MCM)	Catchment Area (km^2)	Rainfall x Catchment Area (MCM)	Runoff Coefficient (%)
2001-2002	554	5.98	334	184.87	3.2
2002-2003	1,033	39.41	334	344.86	11.4
2003-2004	509	-5.52	334	170.11	-
2004-2005	801	22.58	334	267.40	8.4
2005-2006	834	9.56	334	278.66	3.4
2006-2007	870	18.07	334	290.45	6.2
2007-2008	868	31.52	334	289.88	10.9
2008-2009	747	31.16	334	249.56	12.5
2009-2010	682	17.17	334	228.34	7.5
2010-2011	1,134	29.80	334	381.16	7.9
					Average: 8%

Table 4.28 Runoff Coefficient Calculated in Wahalkada Tank

Year-Year	Rainfall (mm)	Storage change (MCM)	Catchment Area (km^2)	Rainfall x Catchment Area (MCM)	Runoff Coefficient (%)
2001-2002	643	4.96	83	53.40	9.3
2002-2003	1,061	23.96	83	88.10	27.2
2003-2004	648	5.23	83	53.82	9.7
2004-2005	1,468	39.11	83	121.83	32.1
2005-2006	1,020	13.53	83	84.64	16.0
2006-2007	833	3.98	83	69.13	5.8
2007-2008	568	8.90	83	47.12	18.9
2008-2009	705	11.10	83	58.47	19.0
2009-2010	804	13.32	83	66.77	19.9
2010-2011	1,823	59.05	83	153.13	38.6
					Average: 20%

3) Gross Estimation of Water Balance

The gross Water Balance is estimated by assuming runoff coefficients. Based on the mentioned calculation, the runoff coefficient from the whole catchment area is estimated at 20% in Wahalkada Wewa, and 8% in Mahakanadarawa Wewa.

Seepage is neglected because this is a relatively small amount, compared to the total storage volume.

Table 4.29 Gross Estimation of Water Balance

	Mahakanadarawa	Wahalkada
Average Rainfall (mm/yr)	1,240	1,440
Catchment Area(km^2)	334	83
Runoff Coefficient (%)	8	20
Water Area of Reservoir (km^2)	9	2.1
Annual inflow to the Reservoir (MCM)	33.13	23.90
Volume by rainfall (MCM)	11.16	2.96
Evaporation from water surface (MCM)	11.93	2.60
Seepage (MCM)	—	—
Average Annual Storage (MCM)	32.36	23.77
Average Annual Storage (Acft)	26,244	19,278

(2) Water availability for the Project

As a conclusion, water availability in Mahakanadarawa Wewa and Whahalkada Wewa is examined with following conditions.

- Average annual storage (MCM)
- Water supply for drinking water in 2016, 2024 and 2034
- Irrigation water
- NCP Canal Project and Yan Oya Reservoir Project

1) Average annual storage (MCM)

Average annual storage of two reservoirs is as follows.

- Mahakanadarawa Wewa: 32.36 MCM
- Wahalkada Wewa: 23.77 MCM

2) Water intake for drinking water in 2016, 2024 and 2034

Water intake for drinking water is estimated as shown in **Table 4.30** (See **Section 4.3.1**).

Table 4.30 Water Intake for Drinking Water

Drinking Water Supply	Mahakanadarawa Tank		Wahalkada Tank	
	(m^3/day)	(MCM/year)	(m^3/day)	(MCM/year)
Water intake in 2016	6,700	2.45	10,500	3.83
Water intake in 2024	9,400	3.25	14,400	5.26
Water intake in 2034	18,800	6.53	28,800	10.00

3) Irrigation water

Based on the Irrigation use shown in **Table 4.23** and **Table 2.34** tendency of storage variation in both reservoirs, annual irrigation water use is estimated as follows.

- Mahakanadarawa scheme: 20-30 MCM (40 MCM is corresponding to water use for FSL)
- Wahalkada scheme: 12-16 MCM

4.3.5 Water Right

Reform of the water institution, National Water Resources Policy, Act and Regulation including the water right administration system has been proposed in cooperation with ADB, FAO, however, still under consideration.

According to “Water Institutional Reforms in Sri Lanka” by Madar Samad, International Water Management Institute, concerning laws of water right are as follows:

１) Irrigation Ordiance (No.32)

The Irrigation Ordinance (No. 32, 1946) was first enacted in 1856 by the British colonial administration to both legalize customary irrigation practices and to prescribe the conditions for water extraction, particularly for paddy cultivation. This ordinance has been amended from time to time to keep pace with the changing socio-economic conditions and requirements.

2) The State Lands Ordinance

The State Lands Ordinance (No. 8, Part IX) of 1947 defines public and private water and specifies the water uses for which no permit is required. It provides for the regulation and control of public water and streams through a system of permits and establishes the formal rights of the state to use, manage and control public water. Notably, this ordinance does not mandate a planning system nor does it address important issues such as inter-sectoral allocation including that during droughts and for environment.

3) Mahaweli Authority of Sri Lanka Act

The Mahaweli Authority of Sri Lanka Act (No. 23) of 1979 empowers the Mahaweli Authority of Sri Lanka (MASL) to use and develop the water resources of the Mahaweli River or any major river considered to be a special area in relation to which MASL exercises its authority. MASL is empowered to plan and implement all development activities under the Mahaweli Development Project that include irrigation, hydropower generation and land settlement.

Therefore, existing principal water rights are almost on the water allocation by the State (the Irrigation Department and the Mahaweli Authority of Sri Lanka) and customary irrigation practices particularly those attached to small tanks and anicuts.

In case of Mahakandarawa Wewa and Wahalkada Wewa, these reservoirs were constructed by the Irrigation Department in order to supply water for irrigation schemes, therefore the Irrigation Department, as an organization of the State, has water rights and controls allocation.

However, according to the Irrigation Ordinance, the Commissioner has responsible for the general supervision and control of Government Agent and “the Cultivation Committee or the Agrarian Service Committee”, established under the Agricultural lands Law (No.42, 1973) or the Agrarian Service Act (No.58, 1979), respectively, has power to make rules for all or any of the irrigation works. Therefore, it is pointed out that farmer’s consensus building is very important to proceed with the allocation of water from these reservoirs.

4.3.6 Mahakanadarawa Wewa

(1) Situation

For Mahakandarawa wewa, the average annual storage is estimated at around 32.36 MCM, and the irrigation use varies between 20-30 MCM/year. On the other hand, the water supply for drinking will be annually 3.25 MCM in 2024 and 6.53 MCM in 2034. Assuming that the priority is given to water supply for drinking, the water shortage will occur even in 2016 for an irrigation use of 30 MCM/year. If the NCP Canal Project will not be completed, water allocation between irrigation and water supply for drinking will be a big issue, since an amount of water shortage will increase.

If the NCP Canal Project will be completed in 2016 as scheduled, it will catch the commencement of operation for water supply in 2018. Basically, the NCP Canal Project includes drinking water of around 70 MCM/year for 15 major towns in North Central and North Provinces. Most of the target towns served by the Mahakanadarawa water supply system under the “Anuradhapura North Integrated Water Supply Project” are corresponding to the towns covered by the NCP Canal Project. In 2034, the total amount of 80.53 MCM composed of 6.53 MCM for water supply and 74 MCM required to irrigate the maximum irrigation area of 2,420 ha of the Mahakanadarawa Irrigation Scheme, presently cultivated by irrigation and rainfall, will be necessary for both purposes. However, the average storage of Mahakanadarawa Wewa is approximately 32.36 MCM, and the balance of 48.17 MCM should be covered by the NCP Canal Project with a design capacity of 700 MCM which will make the further supplement of water possible. Therefore, an enough amount of water will be maintained for both water supply and irrigation

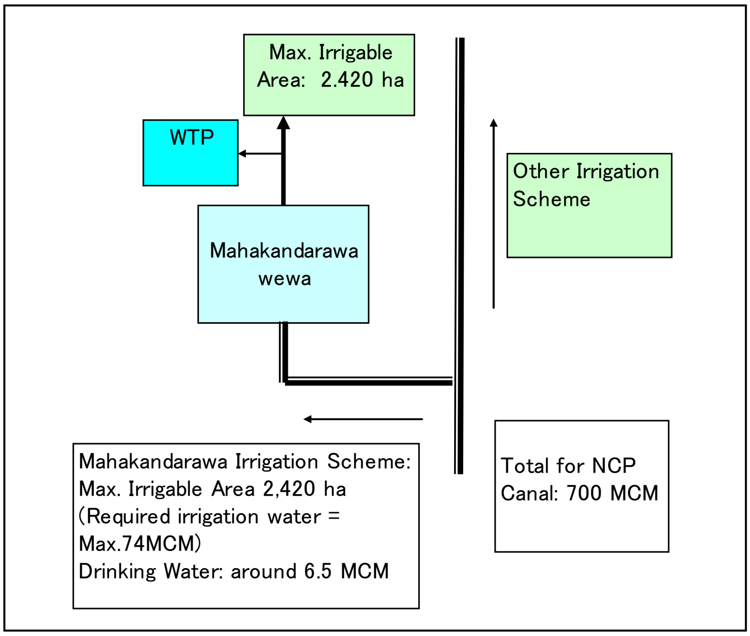
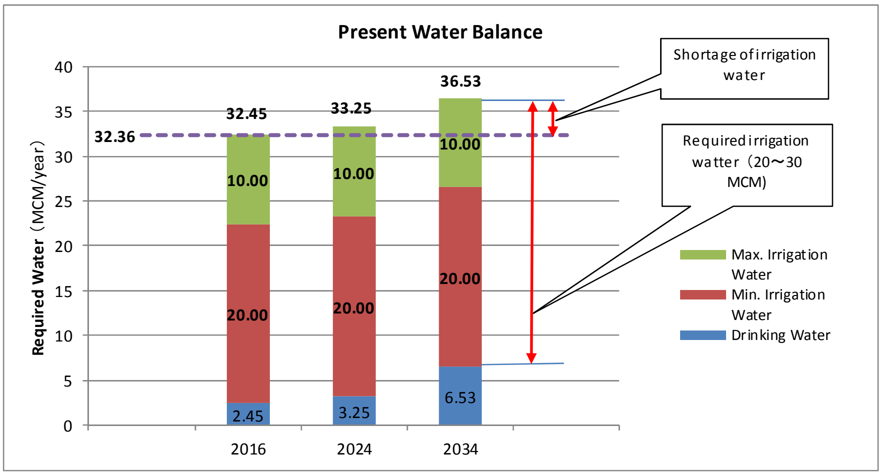


Figure 4.38 Image of Assumed Additional Water from NCP Project



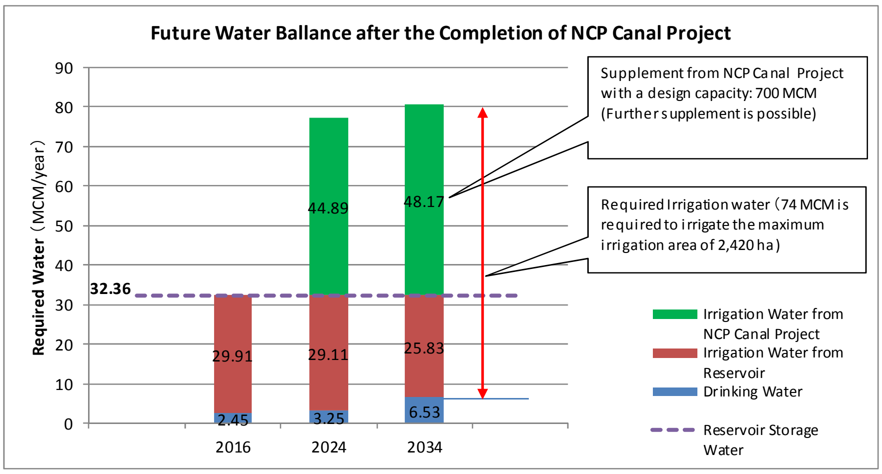


Figure 4.39 Water Availability in the Mahakanadarawa Wewa

(2) Implementation Schedule of the NCP Canal Project

GOSL has taken an initiative to implement the Moragahakanda/Kalu Ganga Project which was identified as essential infrastructure for the implementation of the NCP Canal Project. The Moragahakanda/Kalu Ganga Project is under construction since 2007, and programmed to be completed by 2014. However, the Moragahakanda/Kalu Ganga project has been delayed because of financial and environmental problems. Finally, the Chinese Government agreed to provide loan assistance in 2012, then the Moragahakanda/Kalu Ganga Project started the second stage. According to the newspapers, this Project is expectedly completed by 2016. GOSL has idea to start NCP Canal Project as soon as possible. However, the finance for NCP Project is under request, and mentioned schedule of the implementation of the NCP Project is not sure.

4.3.7 Wahalkada Wewa

(1) Situation

For Wahalkada Wewa, the average annual storage is estimated at around 23.77 MCM, and the irrigation use varies between 12-16 MCM. On the other hand, the water supply for drinking will be annually 5.26 MCM in 2024 and 10.00 MCM in 2034. According to this result, this reservoir water will not be enough to cover the water use for water supply and irrigation without an appropriate allocation in 2034.

The Yan Oya Reservoir Project will have an irrigable area of 4,780 ha by a new reservoir capacity of 254 MCM. Its left side irrigation canal will pass in the Wahalkada Irrigation Scheme, and irrigate an area of around 400 ha under the Wahalkada Irrigation Scheme based on the Proposal for Yan Oya Reservoir Project prepared by China’s Contractor (CAMC Engineering Co., Ltd.). An additional water supply from Yan Oya Reservoir Project is assumed 7 MCM at the maximum as shown in **Figure 4.40**. This figure shows the water balance of the existing irrigation scheme of 800 ha based on the mentioned Proposal.

In other word, the Wahalkada Wewa will have an excess water with the same amount as it, namely 5.94 MCM to 11.51 MCM as shown in **Figure 4.41**. Therefore, the storage water will be enough for water supply and irrigation even in 2034.

It should be noted that the Yan Oya Reservoir has a problem in water quality. The fluoride concentrations of the Yan Oya River has recorded 0.81 mg/L to 1.2 mg/L in May to July 2012 exceeding the Japanese drinking water standard of 0.8 mg/L, while those of the Wahalkada Wewa has kept 0.25 mg/L to 0.38 mg/L during the same period. Therefore, the water to be used for drinking water supply should be that of the Wahalkada Wewa.

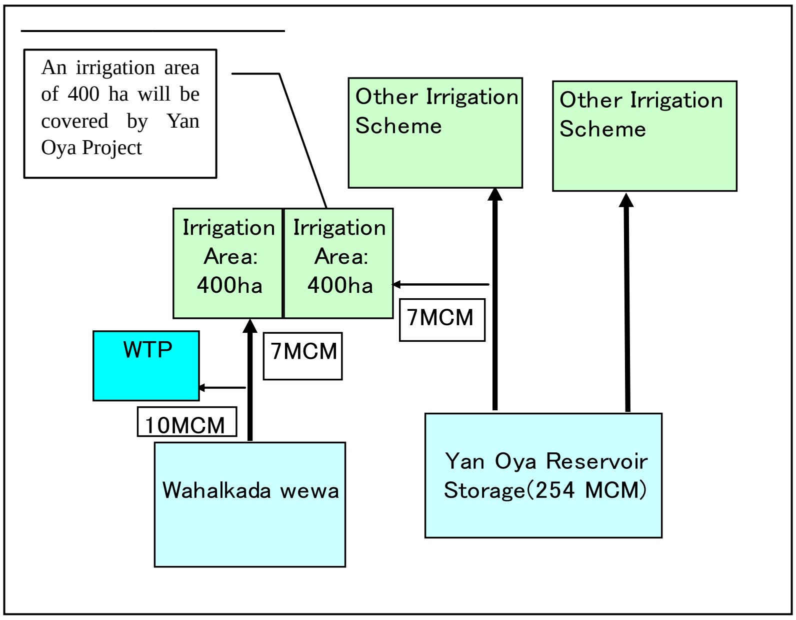
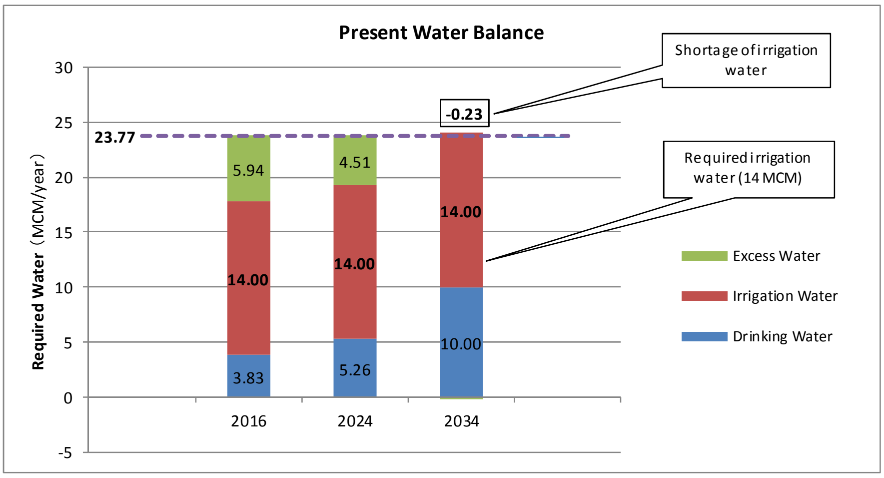


Figure 4.40 Image of Assumed Additional Water from Yan Oya Project



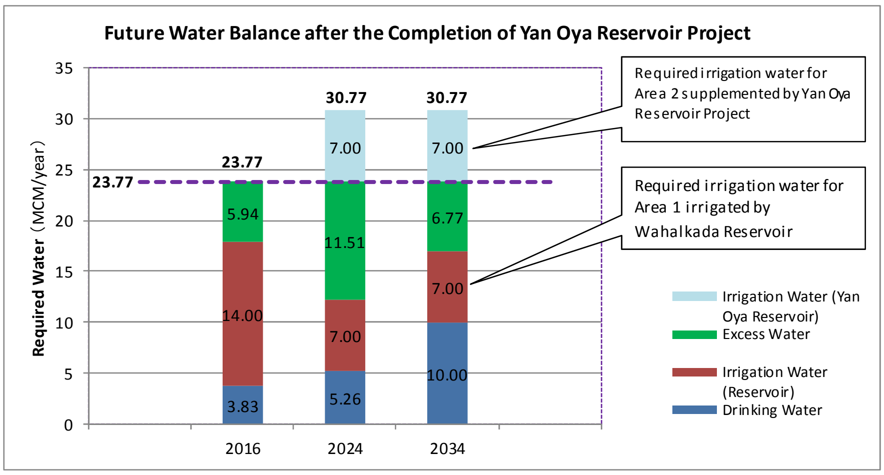


Figure 4.41 Water Availability in the Wahalkada Wewa

(2) Implementation Schedule of the Yan Oya Reservoir Project

Financial award was signed with a project cost of Rs.19 billion between the Chinese and Sri Lankan Governments in November 4, 2011. The EIA report has been submitted to the CEA and review of it is still in progress. According to the Irrigation Department, evaluation of the EIA was expected to announce in 2012. After the approval of the EIA, the construction work is expected to start and around 4 years will be required for the completion of the project.

4.3.8 North Central Province (NCP) Canal Development Project

(1) Outline

In the 1960', GOSL promoted the Mahaweli Development Program (MDP) to attain self-sufficiency in food by providing spare land for cultivation to landless people and existing water scarce irrigation schemes in the Northern Dry Zone areas of NCP, NP and EP with the objectives of guaranteed irrigation water, increase in job opportunities and to minimize the shortage of electric power.

North Central Province (NCP) Canal Development Project is the last project to be implemented under the original MDP. The general components of the NCP Canal Project are as follows.

Reservoirs:

Morogahakanda Dam (521 MCM)

Kaluganga (144 MCM)

Sub Projects:

a) Randenigala- kalu Ganga Transfer Canal Complex
b) Kainga Nuwara - Angamedilla-Minneriya tank Pumping Complex
c) NWP Diversion Canal
d) Pali Aru, Parangi Aru twin Tank Complex
e) NCP Canal from end of Upper Elahera Canal to Chemmadu Kulam Tank
f) Integrated development of NCP target area
g) Other relevant projects

Sub Project-5 Description:

Irrigation Canal from Upper Elahera to Chemmadu Kulam: Capacity 35-20 m^3/s. length 92m)

Sub Project-6 Integrated Development of NCP Target Area

Supply to 1000 minor tank cascades with command area of 3,000 ha, 10,000 ha of new land, 12,000 ha hnder major tanks, and 70 MCM of about 15 main Towns

(2) Relationship with Mahakanadarawa Wewa

About 1,060 MCM annually could be delivered to Upper Elahera canal from Moragahakanda and Kaluganga reservoir, out of which about 700 MCM could be utilized for the NCP Canal Development Project.

As shown in **Figure 4.42**, the Mahakanadarawa Irrigation scheme is also included in the target area. This Project includes irrigation water supply to existing irrigation area, and supplementary transmission water to the Mahakanadarawa Wewa.

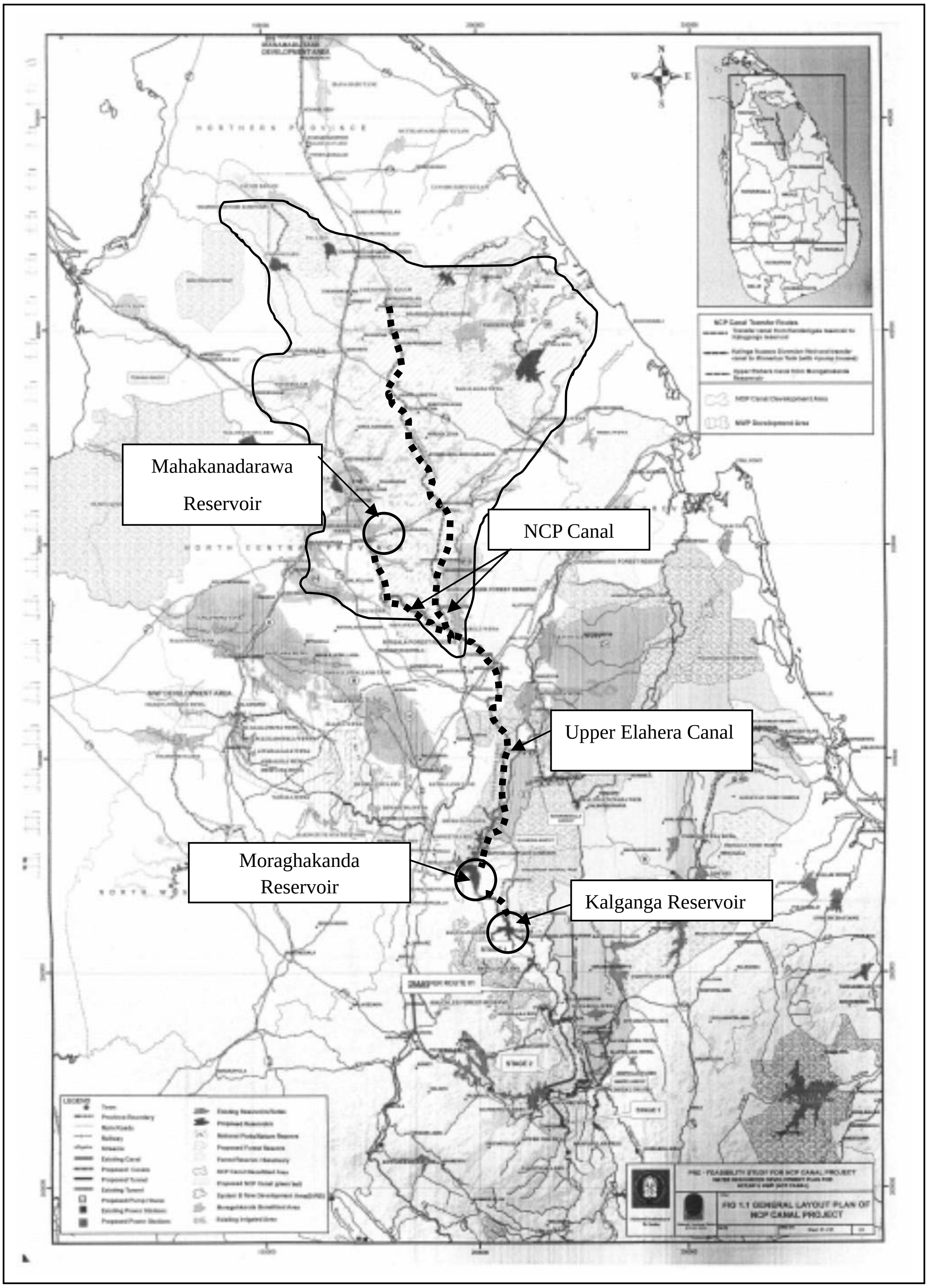


Figure 4.42 NCP Canal Development Project Location Map

(3) Project implementation Schedule

GOSL has taken an initiative to implement the Moragahakanda/ Kalu Ganga Project which was identified as essential infrastructure for the implementation of the NCP Canal Project. The Moragahakanda/ Kalu Ganga Project is under construction from 2007, and programmed to be completed by year 2014. However, the project has been delayed because of financial and environmental problems. Finally, the Chinese Government agreed to provide loan assistance in 2012, then the Project started the second stage. According to the newspapers, the Project is expected to finish in 2016. The finance for NCP Project is under request.

NCP Canal Project is planned to proceed in the following stages.

Stage 0	Update of Pre-Feasibility Study and detailed design of the components in 2012-2014
Stage 1	Randenigala-Kalu Ganga Transfer Complex- Stage1 in 2014-2017 (Irrigation scheme of Mahakanadarawa is covered in this Stage)
Stage 2	Randenigala-Kalu Ganga Transfer Complex- Stage2 in2016-2019
Stage 3	Randenigala-Kalu Ganga Transfer Complex- Stage3 in 2018-2022

(4) Water Availability for Water Supply

According to the “Pre-Feasibility Study for NCP Canal Project, Water Resources Development Plan for NCP & NWP (NCP Canal), 2002 by Mahaweli Authority of Sri Lanka”, Component for Target area 1&2 including Mahakanadarawa Area has “Multi Sector Development Strategy” objectives, which include not only irrigation but also uses for drinking and industry water as a high priority.

As a need of the NCP Canal Project, it is reported that acute kidney disease is spreading in the NCP due to non-availability of good quality drinking water, thus creating severe economic and social problems among the farming community. The government is spending large sums of money to provide health facilities to the affected persons who are suffering from kidney disease. The only way to provide much needed drinking water and irrigation water to this area is to revive the NCP Canal Project proposed in the original Mahaweli Master Plan.

Furthermore, drinking water supply of 70 MCM annually to about 15 main towns in NCP and NP is planned in the Pre-Feasibility Study Report. According to the Water Board in Anuradhapura, discussion on this theme between the Ministry of Irrigation and Water Resources Management has started, but detailed plan has not been completed.

(5) Water Quality of Planned Reservoirs

The NCP Canal Project, which plans to provide water to Mahakanadarawa, has two main water resources. One is the planned Moragahakanda reservoir and the other is Kalu Ganga reservoir. The water flow from both reservoirs to Mahakanadarawa is shown in **Figure 4.43.**

chemical analysis of water are based on Sri Lankan drinking water standard 614:1983 and other standard methods such as APHA or EPA. Table 2.8 in chapter 2.5.2 outlines the test method followed. According to the *Moragahakanda Biodiversity Study Report*, the dry seasons of this area are from January to February, and from June to September. Therefore, sampling was done in September to investigate the highest level of water quality contents. Both sampling locations were selected downstream of planned reservoirs of NCP canal project as shown in **Figure 4.44** and the water quality results are shown in **Table 4.31**.

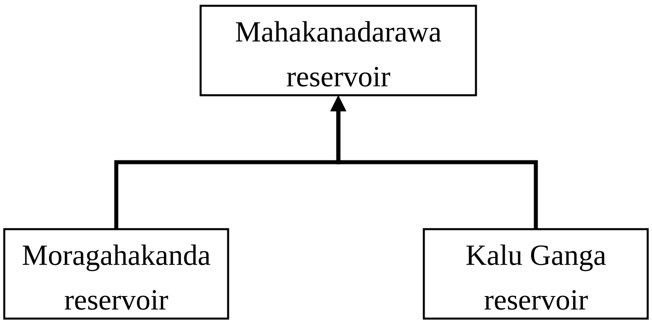


Figure 4.43 Water Flow from Both Reservoirs to Mahakanadarawa

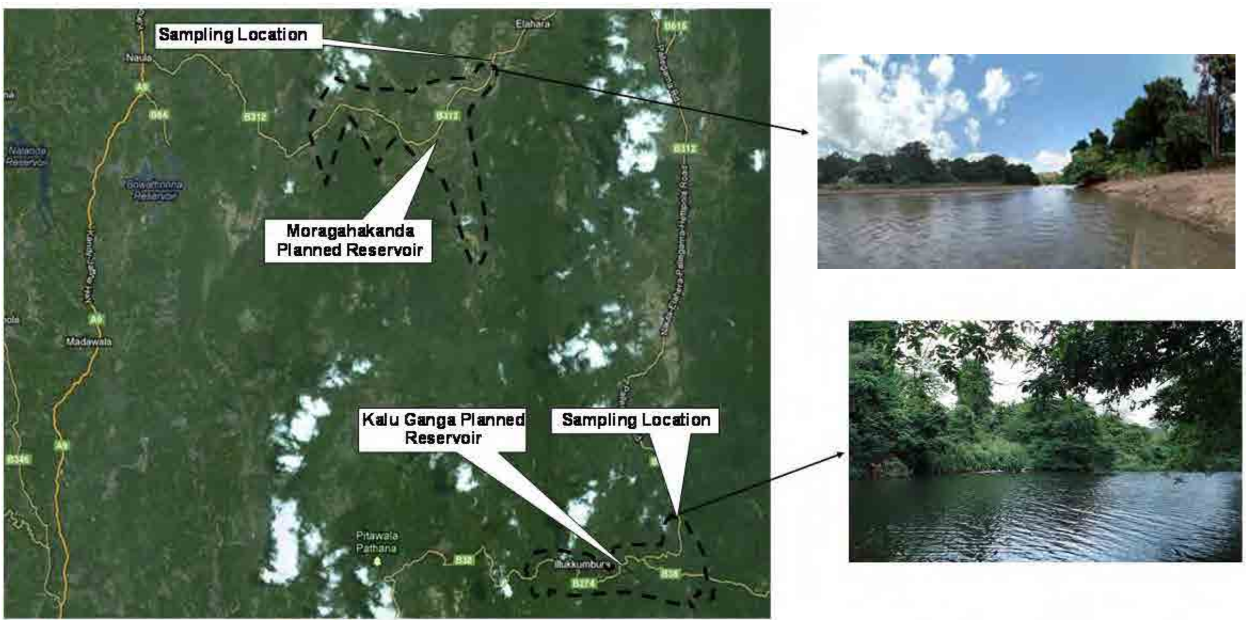


Figure 4.44 Planned Reservoirs of Moragahakanda and Kalu Ganga and Sampling Locations

Water quality results of the two water resources and the drinking water standards in Sri Lanka were compared. For Moragahakanda: a colour sample of 7.5 exceeded the desirable level (<5 Hazen Unit), a turbidity sample of 19 exceeded the permissible level (<8 NTU), a taste sample of “Objectionable” exceeded the permissible level (“Unobjectionable”) and a nitrite sample of 0.07mg/l exceeded the permissible level (<0.01mg/l) of the Sri Lankan standards. For Kalu Ganga: a colour sample of 5 exceeded the desirable level (<5 Hazen Unit) and a taste sample of

Hazen Unit), a turbidity sample of 19 exceeded the permissible level (<8 NTU), a taste sample of "Objectionable" exceeded the permissible level ("Unobjectionable") and a nitrite sample of 0.07mg/l exceeded the permissible level (<0.01mg/l) of the Sri Lankan standards. For Kalu Ganga: a colour sample of 5 exceeded the desirable level (<5 Hazen Unit) and a taste sample of "Objectionable" exceeded the permissible level ("Unobjectionable") of the Sri Lankan standard. However, these will be reduced through the water treatment process, thereby these excess will be resolved.

In conclusion, both water resources which will supply water to Mahakandarawa wewa will not cause any adverse impact on the water quality of the said wewa.

Table 4.31 Water Quality Results for Moragahakanda and Kalu Ganga Reservoirs

Sampling location	Type of water source	Date	Odor	Colour	Turbidity	Taste	pH	Electrical C	Chloride	Free ammonia	Alkalinity
				Hazen Unit	NTU		-	μS/cm	mg/L	mg/L	mg/L
Moragahakanda	River	12/09/20	Unobjec.	7.5	19	Objec.	7.6	310	7	0.05	65
Kalu Ganga	River	12/09/20	Unobjec.	5	1.1	Objec.	7.5	118	6	<0.05	144
Sri Lanka Standards (Desireble)			-	5	2		7.0-8.5	750	200		200
Sri Lanka Standards (Permissible)			Unobjec.	30	8	Unobjec.	6.5-9.0	3500	1200	0.06	400

Sampling location	Type of water source	Date	Albminoid ammonia	Nitrite	Nitrate	Fluoride	Phosphate	Total residue	Hardness	Iron	Sulphate
			mg/L	mg/L	mg/L	mg/L	mg/L	mg/l	mg/L	mg/L	mg/L
Moragahakanda	River	12/09/20	0.06	0.07	0.85	0.08	0.31	215	78	<0.1	14
Kalu Ganga	River	12/09/20	<0.01	<0.01	<0.05	0.11	<0.2	82	153	<0.1	13
Sri Lanka Standards (Desireble)						0.6	-	500	250	0.3	200
Sri Lanka Standards (Permissible)			0.15	0.01	10	1.5	2	2000	600	1	400

Objec.: Objectionale, Unobjec.: Unobjectionable

4.3.9 Yan Oya Reservoir Project

(1) Outline

Yan Oya reservoir project is planned to provide irrigation water for the Northern and Eastern provinces and drinking water for people in the Anuradhapura and Trincomalee Districts.

Under this project, a reservoir will be constructed at Pangurugaswewa, across the lower side of the Yan Oya. Water from this reservoir will be diverted to another major reservoir in Padaviya and 4,780_hectares of land will receive irrigation water from this source. The project includes two main irrigational canals along the banks of the Yan Oya and an anicut dam to release surplus water to the nearly 20 kilometers of channels (See **Figure 4.45**).

Location of the Reservoir: east of Wahalkada Tank, Pangurugaswewa Village
Storage: 254 MCM（205,000 Acft）
Irrigation Area: 4,780 ha
RB Irrigation Canal discharge: 6 m^3/sec
LB Irrigation Canal discharge: 6 m^3/sec
Canal Length： LB Main Canal: 20.3 km
RB main Canal: 15.0 km
Secondary canal：40 km

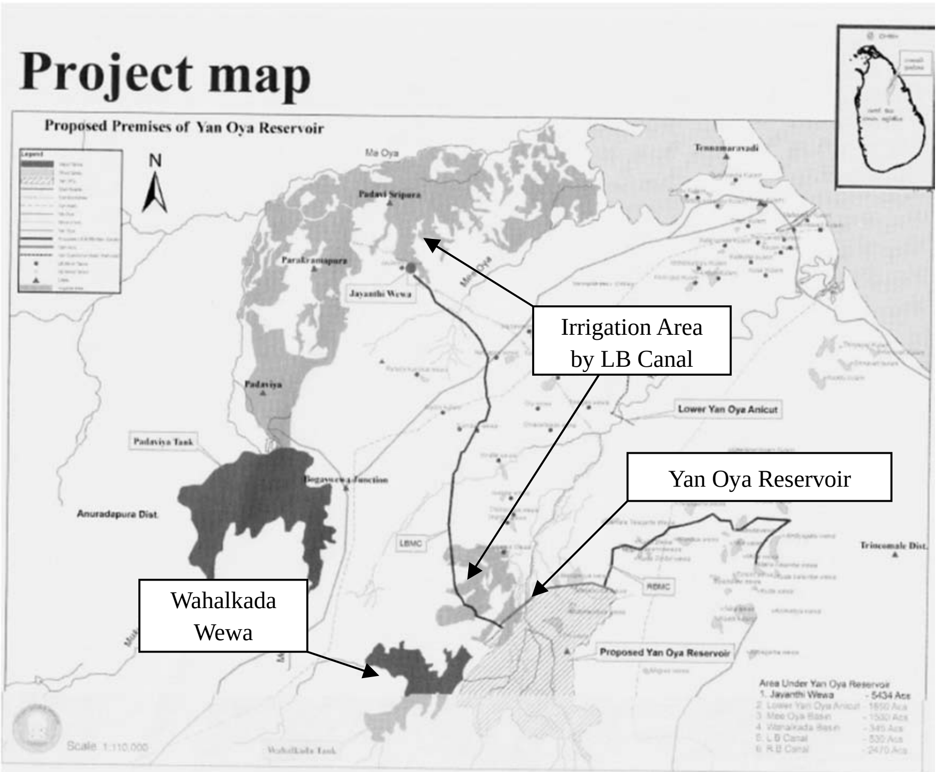


Figure 4.45 Yan Oya Project Location Map

(2) Relationship with Wahalkada Wewa

This project will be conducted in the Yan Oya river flowing eastern side of Wahalkada Wewa. New canals are planned as Right bank canal and Left bank canal, with the Left bank canal passing the irrigation area of the Wahalkada scheme. One of the objectives of the Project is to provide drinking water for Anuradhapura District.

(3) Project Implementation Schedule

Financial Award was signed between China and Sri Lanka in Nov.4, 2011(Project Cost Rp.19 billion).

The EIA report has been submitted to CEA and review of it is still in progress. After approval of the EIA, construction is expected to start and around 4 years will be required for completion of the project.

(4) Water Availability for Water Supply

Yan Oya Reservoir Project will cover around 400 ha of the Wahalkada irrigation scheme, corresponding to 50% of existing irrigation area, by a reservoir with a capacity of 254 MCM. Therefore, required irrigation water supply from Wahalkada Wewa will be reduced almost 50%.

4.3.10 Measures against Global Climate Change

(1) Global Climate Change and Sri Lanka

According to “Climate Risk and Adaption Country Profile, Sri Lanka”, made by the Global Facility for Disaster Reduction (GFDRR) and the Team of the Enviornment Department of the World Bank, the following is pointed out:

- Mean annual temperatures are projected to increase by 1.0 ℃. Mean rainfall is projected to change by 4%, with almost all models (Global Climate Models, etc.) showing a decrease compared to historical records, with accompanying changes in the quantity and spatial distribution of rainfall.
- Projections of future rainfall are less reliable under Global Circulation Models for island nations(in part due to their coarse spatial resolution, which fails to capture local processes driving rainfall dynamics such as feedback and convection). What is clear, however, is that climate variability and extreme events across Sri Lanka will increase in the future.

The hazard impacts of Floods and droughts across Sri Lanka are summarized below:

Historical records from 1974-2004 indicate that floods and droughts are increasing. The south-west monsoons (May to September) cause severe flooding in the western and south-western provinces; the north-east monsoon (December –February) cause flooding in the eastern, northern, and north-central provinces; while a huge part of the island is drought-prone from February to April and, if there is a subsidiary drought in the normal rainy season from May to June, drought can extend until September. In the past 30 years floods have been affecting more than 10 million people, while droughts have affected more than 6 million.

(2) Climate Change found in Anuradhapura District

Kotmale:	35%
Victoria:	14.7%
Randenigala:	18.4%
Castlereeigh:	14.0%

According to the Ceylon Electricity Board (CEB), a shortage of power from the Hydro-power plant is compensated for by the Geo-thermal power plant, therefore daily Rp.200 million is losing by this situation.

Concerning agriculture, the Ministry of Agriculture announced that a total of 150,000 acres of paddy field was damaged in Anuradhapura, Polonnaruwa, Jaffna, Kilinochchi, Puttalam, Kurunegala, Batticaloa, Ampara, Moneragala, Nuwara, Eliya Districts.

In the case of drinking water, the quantity of water stored in reservoirs is a concern. Additionally, when the villagers don't have piped water, they have a tendency to get damage. Because they usually use shallow wells, diameter is 1-2m & depth in 10m, and this draught makes water level lowering and drying water of the well. Therefore, they need to carry water from the place of deep tube well by CBO/NWSDB with small plastic container.

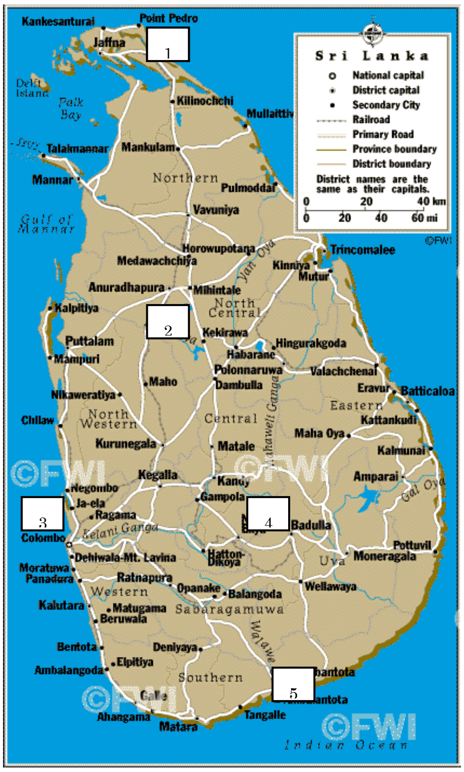


Figure 4.46 Location of the cities

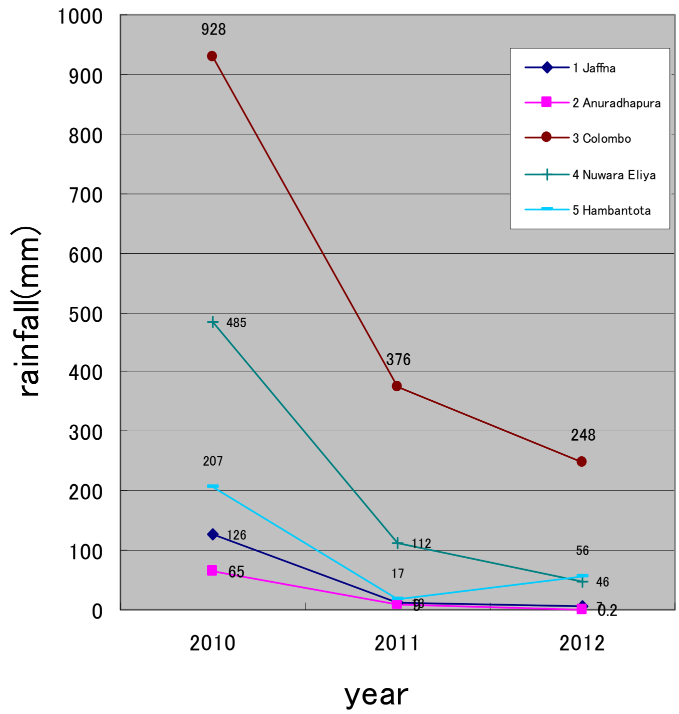


Figure 4.47 May-July Rainfall in 2010-2012

(3) Measures against Global Climate Change

Measures against Global Climate Change by the Project are expected on “Improvement of the rural water supply” and “Improvement of water resource management”.

1) Improvement of the rural water supply

The target area of the Project is in the Anuradhapura North area, covering a population of around 200,000 in 2012 and around 280,00 in 2034, a significant increase in the population from 2012.

From this population, the population served NWSDB’s water is estimated at about 50,000-60,000 (25-30%); therefore 70-75 % of population is using shallow wells constructed in the garden of their houses.

As mentioned above, dug well can get influence of draught, draw down of water level, and many villagers need to face bring water from other locations. If they have a water source from NWSDB nearby their houses they can bring water using plastic tanks. However if this source is not available, they have no choice but to use water from ponds or swamps.

The Project aims to distribute safety water to the local people in this area, via water treatment plant(s) using surface water from Mahakanadarawa wewa and Wahalkada wewa.

Therefore, this Project will contribute to avoid water supply problems which are caused by climate change in the Project Area.

2) Improvement of water resource management

In the Project, the water source will be from existing reservoirs Mahakanadarawa and Wahalkada. Supplementary water will be expected from the “Yan Oya Reservoir Project” and the “NCP Canal Development Project” in the future. Allocation of water between irrigation water and other uses will be an important issue for the Project when droughts occur. This allocation will be decided at a meeting of officers from ID, NWSDB, Divisional secretary and a representative of the Project Management Committees established under the irrigation ordinance and chaired by the District Secretary (from draft of memorandum of understanding between ID and NWSDB for extracting water from Mahakanadarawa wewa & Wahalkada wewa for the Anuradhapura North Water Supply Scheme).

Therefore, improved water management will be expected as a result of the Project.

CHAPTER 5

PLAN OF PROPOSED WATER SUPPLY SYSTEM

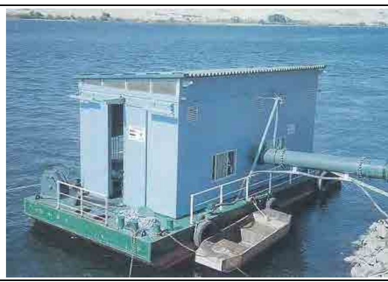
CHAPTER 5 PLAN OF PROPOSED WATER SUPPLY SYSTEM

5.1 Water Intake Works

5.1.1 Selection of Water Intake Method

This section reviews the various intake methods such as the intake well, pontoon, rail and canal types in order to decide the most suitable intake method for this Project.

Table 5.1 Comparison of Intake Method

Method	Outline	Image
Intake well	This method is commonly used in lakes and reservoirs. It is an option for vertical intake levels if some intake holes are made on the well's wall. Even if the water level varies significantly a stable intake is expected. Foundation should be stable. The construction cost is higher than other methods if the water depth is large.	
Pontoon	This method is proposed as a tentative facility, if construction on the reservoir is not possible. The pump and electrical panels are installed on a metallic float, which needs to be connected by wire to anchors. The location of the intake can be moved. This method is not suitable if the water level varies significantly. Installation is not difficult and the cost is economical.	
Inclined rail	This method is proposed as a tentative facility, if construction on the reservoir is not possible. A rail is installed on the incline of the bank, and the pump position is moved to suit the water level. Installation is not difficult and the cost is economical.	
Canal Intake	Water is taken from the existing irrigation canal, which is operated by the Irrigation Department. Prerequisite conditions for this type of intake are that approval to its use is required from ID and also that the required quantity of water can be discharged throughout the year. The existing irrigation intake well takes water from the basement sill; therefore water quality has the characteristics of lake bottom water, if the water level is continuously high. Construction cost is economical, but the construction period is limited in out of irrigation season.	

The Irrigation Department, as management entity for the Mahakanadarawa and Wahalkada Reservoirs, considered intake methods for the Project, and decided that only the canal intake method is suitable because of the following reasons.

- The Irrigation Department has experience that the construction of the foundations of intake wells damaged the bank when construction took place in 1986 at the Kantale reservoir. Therefore direct construction on the bank and inside the reservoir is not approved as of now.
- Direct construction on the bank and inside the reservoir will be subject to an EIA Study, which will take time.
- Many farmers, fishermen and persons concerned with environmental organizations are anxious about the new intake well, because of the perception that an excessive amount of water will be drawn out, thus affecting these stakeholders.

The locations of the intake at the canal in Mahakanadarawa and Wahalkada tanks are selected in conjunction with the Irrigation Department and Water Board, with the distance from the banks of the reservoirs being more than 100m at high water level.

The tentative locations for the intakes are shown in **Figure 5.1** and **Figure 5.2**.

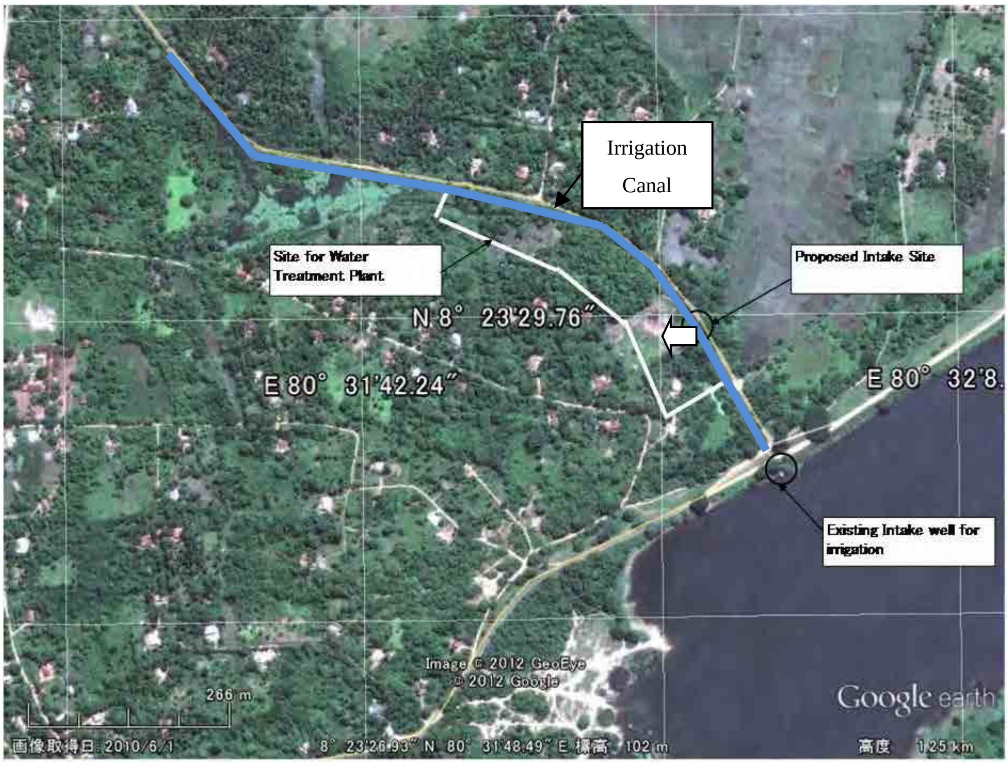


Figure 5.1 Proposed Intake Sites for Mahakanadarawa Wewa

Figure 5.2 Proposed Intake Sites for Wahalkada Wewa

Considerable challenges of this intake method from irrigation canal are as follows.

(a) Aging risk of the facility

Around 50 years have passed after construction of Mahakanadarawa Wewa, and approximately 40 years for the Wahalakda Wewa.

Information of the aged reservoirs is available in the home page of "Dam Safety and Water Resources Planning Project (DSWRPP)" under the Ministry of Irrigation and Water Resources Management. The following 32 dams in **Table 5.2** are designated to be rehabilitated by responsible organization.

Table 5.2 Dams Designated to Be Rehabilitated

Organization	Dam
Department of Irrigation	1) Parakrama Samudraya, 2) Minneriya Wewa, 3) Girithale Wewa, 4) Kawudulla Wewa, 5) Vendrasan Wewa, 6) Kanthale Wewa, 7) Nachchaduwa Wewa, 8) Nuwara Wewa, 9) Thissa Wewa, 10) Rajanganaya Reservoir, 11) Usgala-Siyambalangamuwa, 12) Hurulu Wewa, 13) Inginimitiya Reservoir, 14) Ridiyagama Reservoir, 15) Thabbowa Reservoir, 16) Nalanda Reservoir
Mahaweli Authority	1) Bowathenna Reservoir, 2) Polgolla Diversion, 3) Victoria Reservoir, 4) Randenigala Reservoir, 5) Rantambe Reservoir, 6) Kothmale Reservoir, 7) Kala Wewa, 8) Kandalama Reservoir, 9) Dambulu Oya Reservoir, 10) Maduru Oya Reservoir, 11) Chandrika Wewa
Ceylon Electricity Board	1) Canyon, 2) Castlereigh, 3) Lakshapana, 4) Norton
NWSDB	1) Kalatuwawa

Source : http://www.damsafety.lk/Information/List_of_dams.html

Mahakanadarawa Wewa and Wahalkada Wewa are not listed in **Table 5.2**. However, the condition of its concrete structure and mechanical devices has been observed to have significantly aged. There is possibility that the existing intake wells and installed mechanical devices at the gate may break, and if repairs are not undertaken promptly, then drinking water supply may be disrupted.
Therefore, it is recommended that NWSDB make equipment like submersible water pump and generator available in case of emergency.

(b) Measurement, Record and Control of intake discharge

Water released for irrigation use from Mahakanadarawa Wewa and Wahalkada Wewa is controlled by the operators of Irrigation Department. This is performed using the sluice gate of the intake well, and discharge volume is measured by gate's opening and reservoir's water level.
In the case of the Wahalkada scheme, a Parshall flume is installed near the small bridge to the temple. The Padaviya Irrigation Engineer's Office said the discharge is examined with this device.

Drinking water will be supplied based on the agreement between Irrigation Department and NWSDB. A Memorandum of Understanding (MOU) for extracting water from Mahakanadarawa Wewa and Wahalkada Wewa for the Anuradhapura North Water Supply Scheme is in Article 3 shown in **Table 5.3**.

Table 5.3 Memorandum for Extracting Water

Year	2016	2034	Remarks
Mahakanadarawa	6,700 m3/day	18,800 m3/day	Amount in 2016 will be after completion of WTP Amount in long term plan will be after completion of Upper Elahara Canal Project
Wahalkada	10,500 m3/day	28,800 m3/day	

In case of periods of exceptional water scarcity, Article 9 mentions that the Irrigation Department, Irrigation Management Division, NWSDB, Divisional Secretary, Member of Project Management Committee (established under the Irrigation Ordinance and chaired by the District Secretary) will hold a meeting and decide on water allocation rights.

In conducting water management of the reservoirs with Irrigation Department, the measurement and record of the discharge and sharing of information and control of discharge issues should be considered.

1) Measurement and record of the discharge and sharing of information
Water resource management of both reservoirs with Irrigation Department should be established

under a reliable relationship, thus it is recommended that accurate measurement of discharge should be made and information sharing between agencies be maintained regularly and/or periodically.

Figure 5.3 shows image of the canal intake in Mahakanadarawa Wewa.

For the irrigation canal, there is turn out device to the irrigation area in east side. Therefore, intake for drinking water will be down stream from this point.

The condition of distribution should be clarified, and this entails the measurement of discharges of the following – the main canal at Q1, the branch canal at Q2, and the intake discharge for drinking Q3. In addition, feedback on this data should be provided to the operators of intake well and WTP.

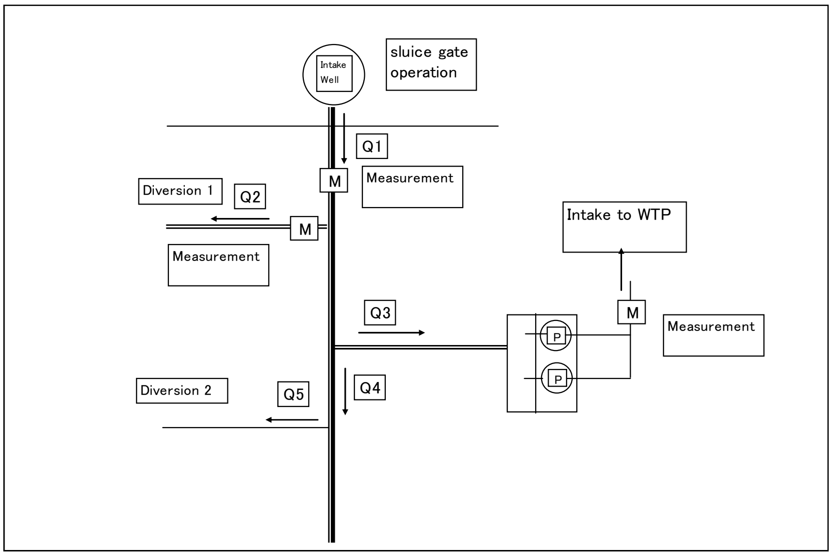


Figure 5.3 Schematic View of Intake Well for Mahakanadarawa WTP

Figure 5.4 shows image of the canal intake in Wahalkada Wewa, which has a measurement device near the small bridge to the Temple. This Parshall flume has a standard size and the width of its throat section is 10'. The limitation of minimum and maximum discharge are as follows.

- Max. discharge: 5.67 m^3/sec
- Min. discharge: 0.17 m^3/sec

By 2016, the water supply for drinking will be 0.12 (m3/sec) and the measuring device is not suitable for such a small dsichage. However, the required discharge for water supply will increase yearly,

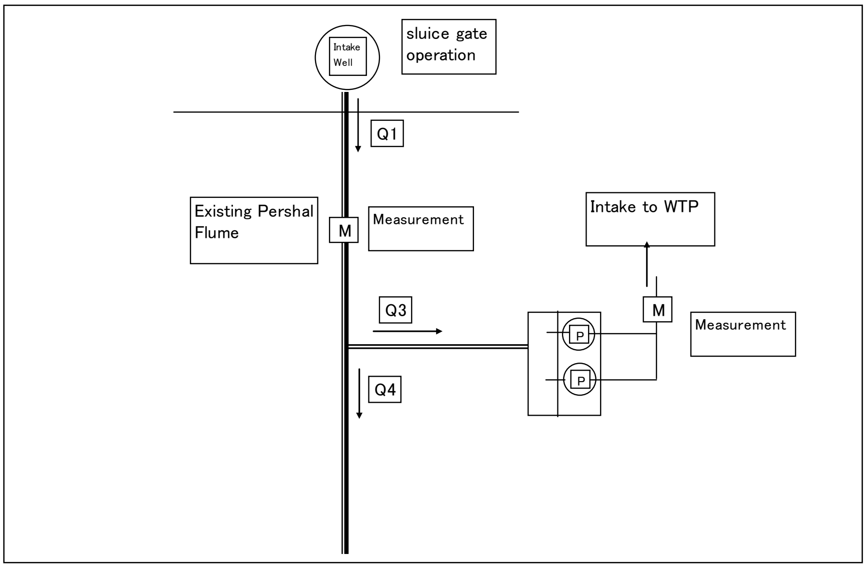


Figure 5.4 Schematic View of Intake well for Wahalkada WTP

2) Control of discharge

The release of water for irrigation from the reservoirs is controlled by the operators of Irrigation Department. The required water is estimated by the gate's opening and reservoir's water level, and adjustments are made on the sluice gate of the intake well.

It is expected that discharge volume for drinking water supply will not be controlled considering that requirements are minimal compared to that required for irrigation water, especially during the no-irrigation periods. **Table 5.4** shows discharge in cubic meter per second. Discharge water for drinking in 2016 is only 3-6% of that discharged for irrigation.

Table 5.4 Discharge for Irrigation and Drinking Water in 2016-2034

(unit : m^3/sec)

Scheme	2016	2024	2034	Irrigation
Mahakanadarawa	0.08	0.11	0.22	0.3～3.0
Wahalkada	0.12	0.16	0.33	1.0～2.0

During periods when irrigation is required, the canal discharge will be composed of irrigation water and drinking water, and it may be necessary to partially allocate water for these two uses. However, in the no irrigation period, the small volume of drinking water may be allowed to flow in the canal.

The following are three studies that can be considered as countermeasures.

Case 1: To install a concrete box connected with pipes and control valves

A concrete box will be installed at the end of sluice and pipes will be connected to the irrigation canal and to the water treatment plant. Stop Valve for the irrigation canal is closed, and control valve for drinking water is used during the no-irrigation period. However, this location is in the Sanctuary Zone, therefore this construction is likely to be prohibited.

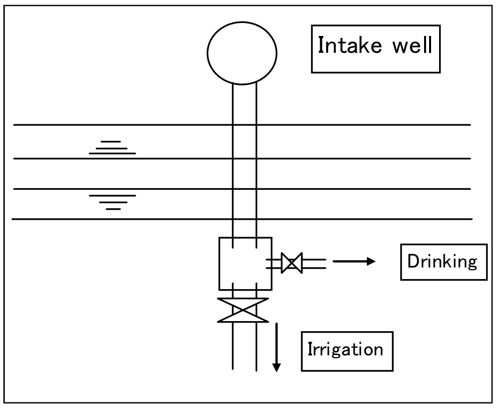


Figure 5.5 Sketch of Solution of Canal Intake (Case 1)

Case 2: To install a control gate in the irrigation canal and use as a buffer tank
In this case, a control gate is installed downstream of the intake diversion to the water treatment plant. In order to arrange difference of discharge between drinking water and released water from the intake well, the irrigation canal shall be used as a buffer tank by the gate to control water level.

If water level is 50cm, and location of weir is 100m from end of sluice, buffer volume can be around 150m3. In this case, the sluice gate at the intake well will require time-controlled operations.

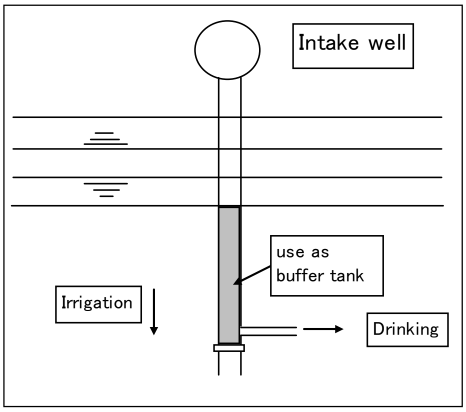


Figure 5.6 Sketch of Solution of Canal Intake (Case 2)

Case 3: Release water from the intake well with a little higher amount than the designed discharge, and remaining water is reverted back to the irrigation canal.

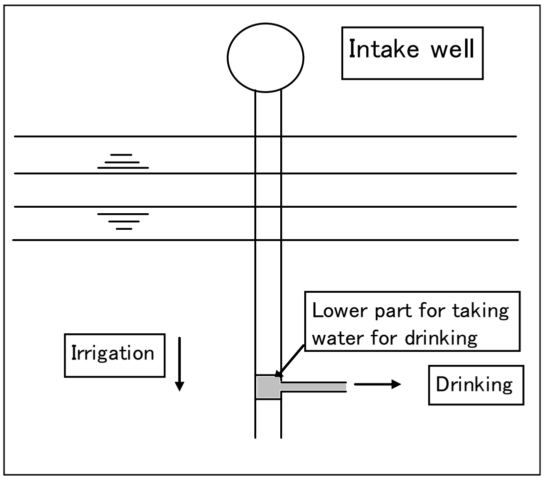


Figure 5.7 Sketch of Solution of Canal Intake (Case 3)

On the other hand, following conditions shall be considered before installing any structure in the canal.

- Length of the irrigation canal from the intake well to the terminal irrigation area is around 15-20km in Mahakanadarawa and Wahalkada Irrigation Schemes. Basically, an intake structure can be minimized to avoid any influence on the canal flow.

- Discharge for drinking water is much smaller than for irrigation, and intake pump is planned to transmit such water to the water treatment plant. The level of the pump intake pit can be installed much lower, meaning, it is not required to maintain the same intake level in the irrigation canal. Therefore, the use of a control gate at the irrigation canal may no longer be required because of the level control for intake.

After analyzing the three cases, Case 3 is chosen to be employed for the design. This design should, however, be reviewed with the Irrigation Department, and the Operational Organization of the Reservoir. Before finalization, it is necessary to re-check the discharge control accuracy of the intake well.

5.1.2 Design Criteria

Design criteria for the intake work are as follows.

(1) The location of the intake facility is more than 100m from high water level.

(2) Design discharge between the sluice and intake for drinking water is the total amount of maximum irrigation water supply and daily maximum of drinking water in 2034.

(3) Mahakanadarawa irrigation scheme has two irrigation canals, i.e., the right bank canal and the left bank canal. Topographic condition of intake in the reservoir is reviewed with reservoir's planning map transferred from the Irrigation Department. Surrounding area of the left bank

intake well is deep, i.e., it is considered to keep enough depth to take water even in dry season. However, the area of the right bank well is relatively shallow, i.e., there is a risk that intake water will decrease in dry season. Finally, the left bank side was selected for the location of the intake facility for drinking water.

(4) The timing of and quantity of discharge of irrigation water supply varies in the Yala and Maha period. Canal discharge is assumed as follows.

- No irrigation period: Discharge for drinking water
- Irrigation period: Discharge for drinking water and irrigation water

5.1.3 Outline of Water Intake Facilities

(1) Mahakanadarawa Intake

Information of the irrigation scheme from Irrigation Department is as follows.

Table 5.5 General Features of Canal (Case: Concrete Lining for Trapezoid)

Item	RB	LB
Q(m^3/sec)	2.83	3.40
FSD(m)	1.22	1.10
FB(m)	0.91	0.91
BW(m)	1.83	3.05
Length(km)	17.18	20.92

Source: Irrigation Department

Table 5.6 Record of Maximum and Minimum Canal Discharge

Year	Max. Discharge (m^3/sec)	Min. Discharge (m^3/sec)
2010	2.51	0.08
2011	3.03	0.21

Source: Irrigation Department

The shape of the canal at the proposed intake point is rectangular, with the canal having a concrete lining. The following design criteria are applied, based on the calculation using Manning's Formula (Calculation sheet is attached in **Appendix 5.1(a)**).

Max. irrigation discharge:	3.4 m^3/sec
Max. intake discharge for drinking water:	0.22 m^3/sec（18,800 m^3/day in 2034）
Canal discharge in irrigation period:	0.62～3.62 m^3/sec
Width of existing irrigation canal at intake point:	3.5 m
Height of existing canal:	2.2 m
Max. water depth in canal:	1.45 m

(1.70 m is observed water mark in the site)

Water depth just for drinking water in 2034:	0.22 m
Design height of lower portion of the canal:	0.30 m
Max. water level for irrigation and drinking water:	1.51 m

Figure 5.8 shows outline of intake facility.

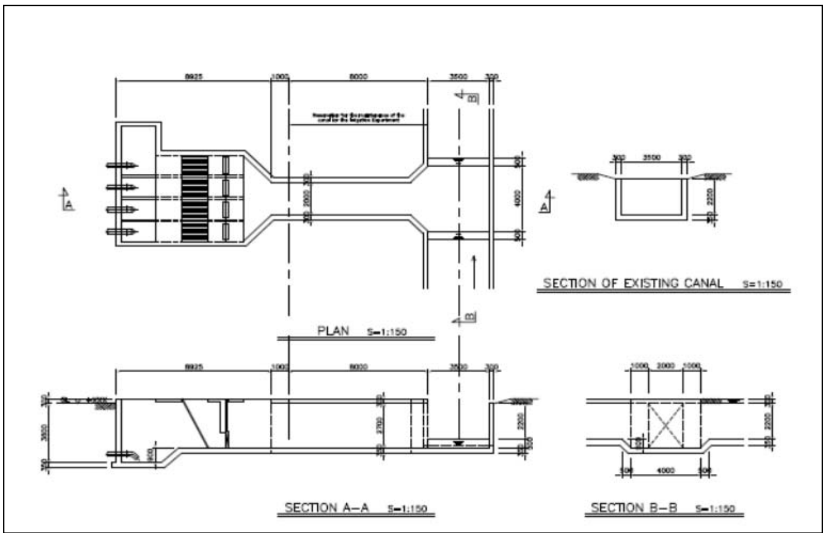


Figure 5.8 Outline of Intake Facility in Mahakanadarawa Wewa

(2) Wahalkada Intake

Information of the irrigation scheme from Irrigation Department is as follows.

Table 5.7 General Features of Canal (Case: Concrete Lining for Trapezoidal)

Item	Dimension
Q(m^3/sec)	1.56
FSD(m)	0.76
FB(m)	0.74
BW(m)	3.05

Table 5.8 Record of Maximum and Minimum Canal Discharge

Year	Max. Discharge (m^3/sec)	Min. Discharge (m^3/sec)
2009	2.0	1.01
2010	2.0	0.87
2011	2.0	0.36

Source: Irrigation Department

The shape of the canal at the proposed intake point is trapezoidal with slopes of 1:1, but it does not have a lining. The following design criteria are applied based on the calculation using

Manning's Formula (Calculation sheet is attached in **Appendix 5.1(b)**).

Max. irrigation discharge: 2.0 m^3/sec
Max. intake discharge for drinking water: 0.34 m^3/sec （28,800 m^3/day in 2034）
Canal discharge in irrigation period: 0.70～2.34 m^3/sec
Width of existing irrigation canal at intake point: 4.5m
Height of existing canal: 2.1m
Max. irrigation water depth in canal: 0.91m
Water depth just for drinking water in 2034: 0.32m
Design height of lower portion of the canal: 0.40m
Max. water level for irrigation and drinking water: 1.00m

Figure 5. 9 shows outline of intake facility.

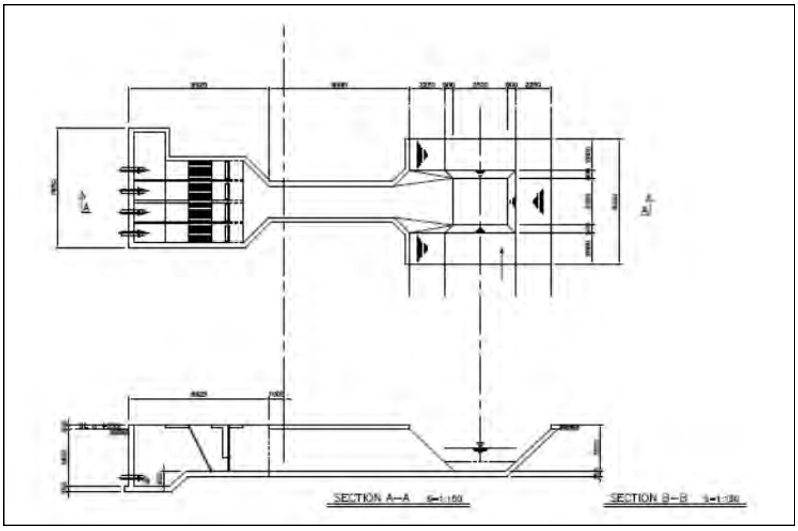


Figure 5.9 Outline of Intake Facility in Wahalkada Wewa

5.2 Water Treatment Plant

5.2.1 Stage Construction of water treatment Plants

Since the water transmission and distribution facilities is constructed with a full design capacity for the year of 2034 due to the difficulty in split construction, the water treatment plant, etc. to which stage construction is applicable, shall be constructed with a capacity for the year of 2024 to reduce an initial investment as much as possible.

The following are the reasons adopting stage construction in this Project:

(1) NWSDB Design Criteria

NWSDB Design Manual (March 1989) describes that "*As a general principle it is recommended that future urban schemes be designed for a 20-year planning horizon in two 10-year stages*". Therefore, it is reasonable to set the target year in 2034 with an interim target year of 2024 for stage construction.

(2) NWSDB Guideline for Rural water Supply

The NWSDB Guidelines suggest the difficulty to increase the population coverage by water supply in the rural area. Although the willingness of the people to connect to the proposed pipe borne water supply system to be operated and maintained by NWSDB seems high due to the high level content of fluoride in groundwater as a water source in the study area, there is a risk to overestimate it.

1) Difficulty to increase the coverage

The change in the number of connections since the commissioning year even at five water supply systems under NWSDB in the study area was very slow. Since the people with high expectation for pipe bore water supply would like to connect to a system as soon as possible, the connection works to a system will have a peak during a few years after the completion of a system and thereafter become slow in general.

2) Alternative water source in rural area

92.8% of the people in the study area have any types of their own water sources (although almost relying on groundwater). Whether the people will connect to a water supply system or not is left to their discretion. There are many cases that the coverage increased less than expected so far. It should be noted that a quarter of the people didn't use a toilet in 2001 and the percentage of the household population below the poverty line was high as 28.2% against the district average of 20.0% in 2002.

3) Selective use of either tap water or groundwater

Even though connected to a water supply system, the people may use either of groundwater or tap water selectively by use, that is to say, a coverage ratio will increase, but water demand will not increase so much. Therefore, it is advisable to watch the change of actual water demand carefully but not the apparent coverage ratio.

According the Census 2011, the major drinking water source survey reveals that 75.4% of the people in the study area rely on groundwater from dug well (72.6%) and tube well (2.8%), respectively, 18.9% on tap water and remaining 5.7% on others such as bowser, bottled water, river, etc. According to the existing CBO water supply facility survey in **Section 3.3.1**, the population coverage by water supply is approximately 27% including those under NWSDB. It may suggest that some customers doesn't regard tap water as the main drinking water source in spite of the connection to a water supply system.

4) Long-term pipe installation work

Even though the pipe borne water supply is applied to GNDs, it will take a long time to attain the full population coverage, since a population density of 100 persons per km^2 means that a housing unit (HU) is located every 100 m to 400 m, assuming that it is occupied by 4 persons on average as shown in **Figure 5.1**.

100 persons/km^2 = 1 person/ha = 4 persons/4 ha = 1 HU/4 ha

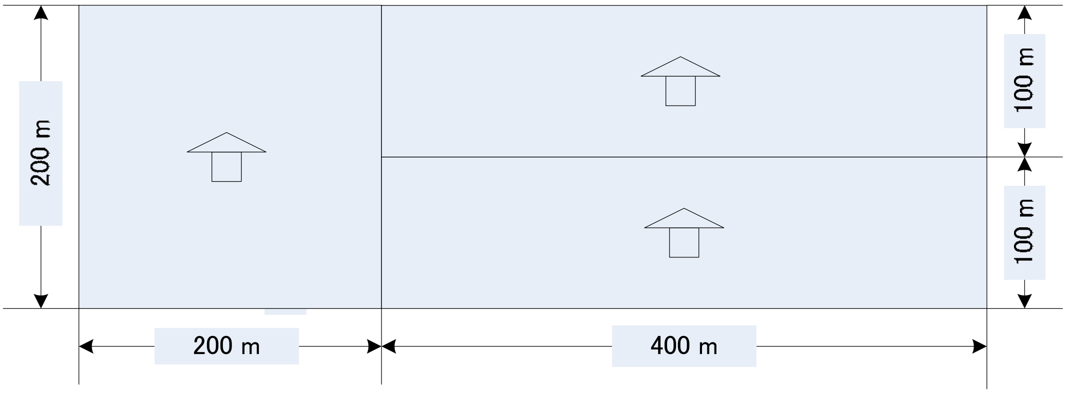


Figure 5.10 Situation of Housing Unit Distribution

(3) Waste in full construction

If the equipment is installed in full construction but not in stage construction, a variety of waste will occur. Some extent of water demand will be maintained through the connection of existing NWSDB and CBO water supply schemes to a new system but thereafter the water supply amount will rely on the growth in the number of connections and per capita water consumption. However, since there is no occurrence of such situation that the water demand will at once reach to a design capacity, the equipment once installed will be unavoidably idle and the following situations will occur.

- The service life of mechanical and electrical equipment is generally ten to fifteen years. It is counted from the time installed and wasted.
- Once the equipment is installed, it is required to operate it in the rotation programme even though the water supply amount is less, which makes plant operation complicated. Since the deterioration occurs leaving it without any maintenance after operation, cleaning and inspection of such equipment are also necessary.
- The replacement of equipment will be concentrated in specific years which will be a big financial burden.

(4) Deterioration of FIRR

In case of full construction of a water treatment plant, it is possible to reduce the price of materials used for the construction work through a mass order, cut the expenses by shortening the overall construction period, and to finally reduce the construction cost as a whole. However, by full construction, an initial investment will increase and some mechanical and electrical equipment will be installed earlier than scheduled resulting in their earlier replacement. Here assuming that the total construction cost will be reduced by 10%, the comparative study of FIRR is done between the stage construction and full construction. As there will be no increase in water demand

and revenue even though the full construction will be adopted, and the increase in an initial investment, FIRR will be worsened as shown in **Table 5.9**.

Table 5.9 FIRR Comparison between Stage and Full Constructions

(1) Stage Construction

Year	Investment	Revenues	Expenditures	Cash flow
2012	0.0			0
2013	82.2			-82.2
2014	437.5			-437.5
2015	1,093.1			-1,093
2016	3,508.7			-3,509
2017	3,641.5			-3,642
2018	960.1	56	34	-938.1
2019	14.9	78	46	17.1
2020		82	48	34
2021		86	49	37
2022		90	51	39
2023		94	53	41
2024	786.5	98	54	-742.5
2025		108	66	42
2026		117	71	46
2027		127	76	51
2028		137	80	57
2029		147	85	62
2030		157	90	67
2031		167	95	72
2032		177	100	77
2033		187	104	83
2034		197	109	88
2035		207	114	93
2036		217	119	98
2037		227	124	103
2038		237	128	109
2039	-4,674	247	133	4,788
FIRR				-2.65%

(2) Full Construction (10% Reduction)

Year	Investment	Revenues	Expenditures	Cash flow
2012	0.0			0
2013	81.8			-81.8
2014	437.2			-437.2
2015	1,126.9			-1,127
2016	3,645.1			-3,645
2017	3,777.9			-3,778
2018	994.0	56	34	-972
2019	14.6	78	46	17.4
2020		82	48	34
2021		86	49	37
2022		90	51	39
2023		94	53	41
2024		98	54	44
2025		108	66	42
2026		117	71	46
2027		127	76	51
2028		137	80	57
2029		147	85	62
2030		157	90	67
2031		167	95	72
2032		177	100	77
2033	786.5	187	104	-703.5
2034		197	109	88
2035		207	114	93
2036		217	119	98
2037		227	124	103
2038		237	128	109
2039	-4,950	247	133	5,064
FIRR				-2.69%

(5) Progress of irrigation projects

According to the plan, the NCP Canal and Yan Oya Reservoir projects that supplement the water supply condition of Mahakanadarawa and Wahalkada Tanks will be completed around the time that new water supply systems will be completed. However, these projects have not yet started and the completion time of them has not been assured. In addition, the possibility that the delay and/or suspension of their construction works will occur, should be taken into account. Since the farmers' association will never allow to use water with more than the amount admitted as the water right for drinking water supply, as long as the proposed irrigation projects will not be completed, there is a high risk to construct a water treatment plant at once with a full design capacity for the year of 2034.

5.2.2 Selection of Water Treatment Process

(1) Existing WTPs

1) Capacity, Water Source and Treatment Processes of Existing WTPs

There are three existing WTPs in Anuradhapura City, with the water source for all the WTPs being irrigation tanks. The water treatment process of the WTPs consists of coagulation, flocculation, sedimentation and rapid sand filtration. The capacity and water source of the WTPs are shown in **Table 5.10**.

Table 5.10 Existing WTPs in Anuradhapura

WTP	Capacity (m^3/d)	Source
New Town	13,500	Nuwara Tank
Sacred City	4,500	Thissa Tank
Thuruwila	21,000	Thuruwila Tank

2) Raw water quality

The raw water quality of each of the existing WTPs, which is shown in **Appendix 5.2(a)**, is similar. Turbidity and color tend to increase slightly at the beginning of the rainy season, but these do not fluctuate significantly throughout the year. The pH is comparatively high, nearly 8.0 on average and 8.5 as a maximum.

3) Odor in the supply water

In May 2012, muddy odor from tap water was detected in one of the water-supplied areas. In other areas, the similar odor was not detected. With respect to the areas that have odor problems previously, Thuruwila WTP may be the cause of the odor problem since the area with odor problems are located in the area served by Thunuwila WTP. It has been observed that as the water level in the tank is reduced, the odor problem starts to show up in other water supply areas too, where the water is supplied from other WTPs. This problem usually continues until the beginning of rain season, starting from the middle of October.

(2) Proposed WTPs

1) Raw water quality

The water quality of Mahakanadarawa and Wahalkada irrigation tanks is shown in **Table 5.11** and **Table 5.12**. Both irrigation tanks will be the water source for the proposed WTPs in the project. Turbidity and color in both water sources are low, but the pH is high and similar to that in the water sources of the existing WTPs.

Table 5.11 Water Quality of Wahalkada Tank

	Date	Water Temperature (℃)	Dissolved Oxygen 1) (mg/L)	pH	Turbidity (degree)	Color (degree)	Odor
Surface water	17/05/2012	30.1	8.3	8.89	12.4	26.5	None
Bottom water	Ditto	30.0	7.2	-	-	-	ditto

1) Saturated concentration of dissolved Oxygen is 7.53mg/L at water temperature 30-degree Centigrade
2) The measuring instruments for turbidity and color manufactured by Kyouritsu Rikagakukenkyusyosei Corporation are used. To measure color, turbidity is not removed prior. Therefore, color is different from true color. This condition also applies to Section 5.2.

Table 5.12 Water Quality of Mahakanadarawa Tank

	Date	Water Temperature (℃)	Dissolved Oxygen 1) (mg/L)	pH	Turbidity (degree)	Color (degree)	Odor
Surface water	15/05/2012	29.4	7.2	8.46	7.3	22.5	None
Bottom water	ditto	29.3	6.2	8.36	10.9	31	ditto

1) Saturated concentration of dissolved Oxygen is 7.53mg/L at water temperature 30-degree Centigrade

July 4th, 2012: Wahalkada Tank water has muddy or musty odor.
July 8th, 2012: Mahakanadarawa Tank water does not have odor.
July 17th, 2012: Thuruwila Tank water has strong muddy odor.
July25th, 2012: Wahalkada Tank water does not have odor.
July 28th, 2012: Wahalkada Tank water does not have odor.

2) Jar Test (Coagulation Test)

Jar tests were performed on Mahakanadarawa Tank water. The results of the jar tests are shown in the following pictures and table.

A dosage rate of aluminum sulfate of 40mg/L or higher resulted in developing large floc and clear water. The turbidity and color both decreased as the aluminum sulfate dose rate increased. The optimum coagulant dose is determined to be 60mg/L as turbidity and color is low enough and the formed floc settled down quickly. The quality of Wahalkada Tank water is similar to Mahakanadarawa water so the results of the jar test can be applied to Wahalkada water.

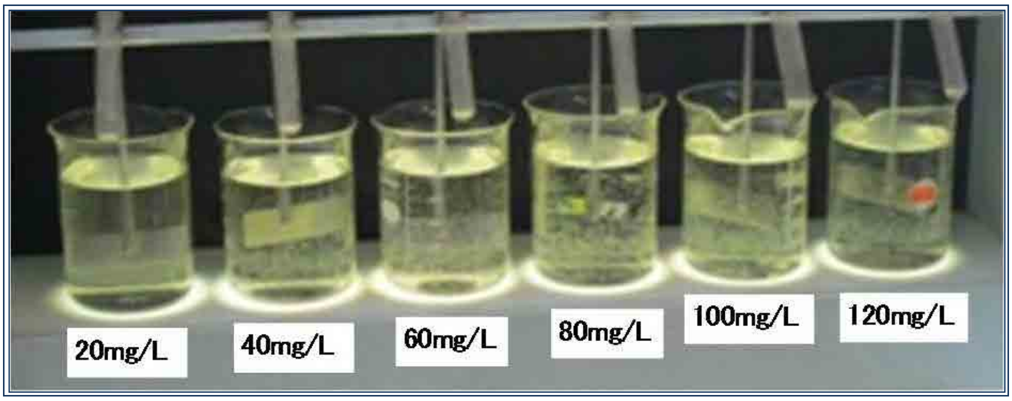


Figure 5.11 Jar Test under Stirring

Table 5.13 Results of the Jar Tests (Surface Water of Mahakanadarawa Tank)

Parameter	Raw water	Aluminum sulfate dosage rate (mg/L)					
		20	40	60	80	100	120
pH	8.46	7.83	7.44	7.37	7.13	6.93	6.8
Turbidity (degree)	7.3	4.9	2.6	1.3	0.5	0.1	0.0
Color (degree)	22.5	16.0	9.5	7.0	4.5	3.0	2.0

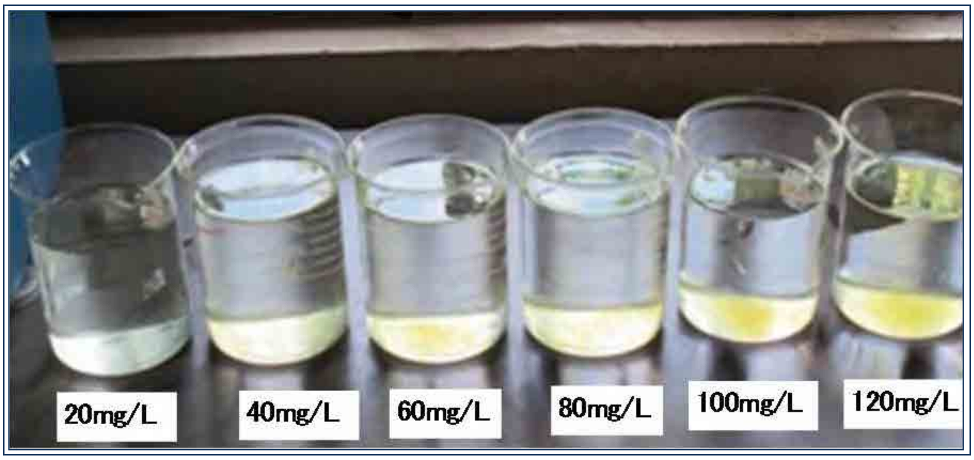


Figure 5.12 Results of the Jar Tests

3) The amount of sludge and sludge treatment

Since the pH in the raw water is high, more aluminum sulfate is required to form large floc and achieve good coagulation. This results increase in sludge production.

<Example>

When the turbidity of the raw water is 10 degrees, 60mg/L of aluminum sulfate is required for coagulation. The ratio of the aluminum sulfate sludge to the turbidity sludge is 1.5 to 1.0, which means that aluminum sulfate sludge accounts for 60% of the total sludge.

(3) Selection of the Water Treatment Process

Generally there are two major treatment process alternatives to purify water; rapid sand filter and slow sand filter (including ecological filter). The rapid sand filter is primarily used where raw water has a high turbidity. Slow sand filters can be used for low turbidity water, as in the case of Mahakanadarawa and Wahalkada waters. This section discusses the best option between rapid sand filter and slow sand filter for the proposed water treatment plants.

1) Odor in supplied water

It is difficult for rapid sand filters to remove odor. The rapid sand filter is currently used in Thuruwila WTP and this plant produces water with muddy smell. Slow sand filters are able to remove or reduce odor. People in the proposed service area of the project are using ground water, which does not smell at all, for their daily water consumption. It is recommended that water with no odor should be supplied to the area, otherwise residents will complain a lot.

The following table shows the tap water quality in the proposed area to be served by the project.

Table 5.14 Tap Water Quality in Proposed Served Area

Location	Odor	pH	Turbidity (degree)	Color (degree)	Fluoride (mg/L)
1) Kebithigollewa	none	7.34	0.2	0.5	0.64
2) Near Wahalkada Tank	none	6.9	0.2	0.1	0.14
3) Tap water located at between 1) and 2)	none	7.48	0.1	0.0	1.17

2) The production and the treatment of the sludge

Figure 5.13 and **Figure 5.14** show general sludge treatment processes for rapid sand and slow sand filters.

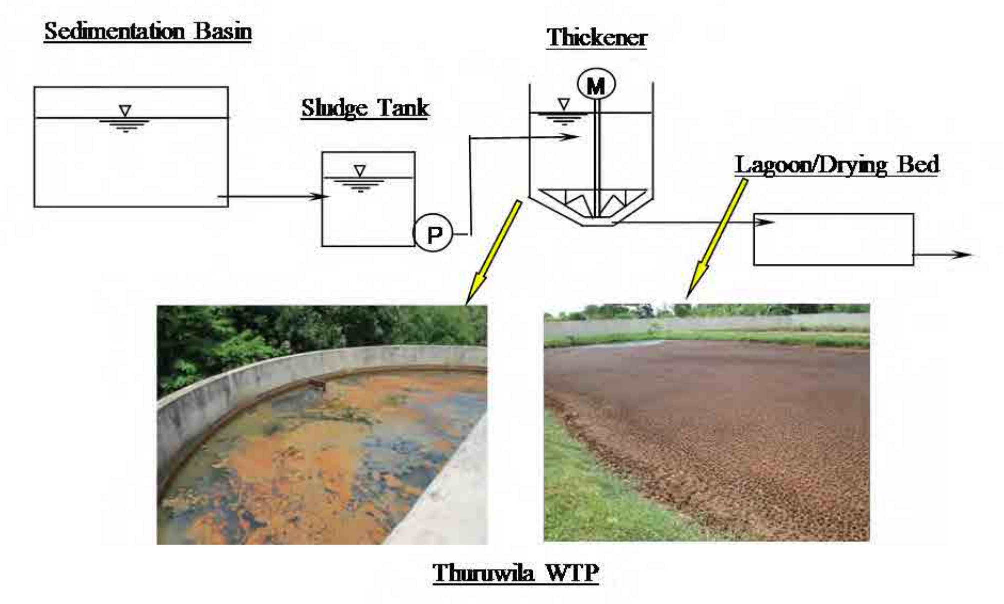


Figure 5.13 Sludge Treatment Process for Rapid Sand Filter

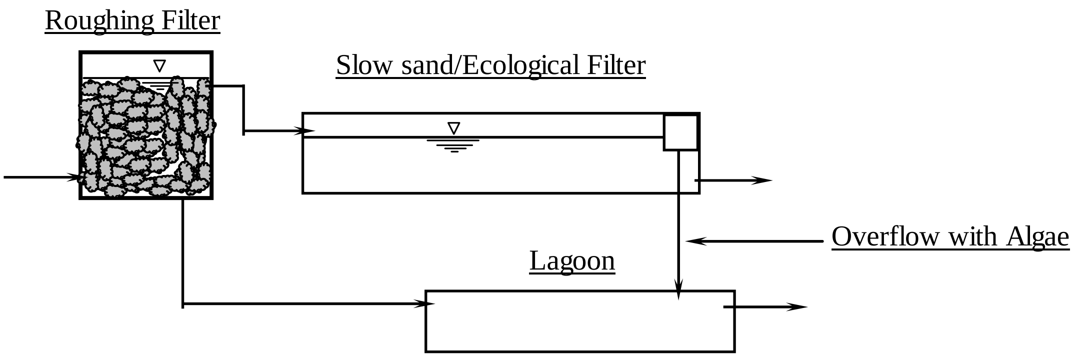


Figure 5.14 Sludge Treatment Process for Slow Sand Filter

The sludge treatment process for rapid sand filters consists of a sludge tank with pumps, a thickener with a mixer and a lagoon or drying beds. On the other hand, slow sand filters need only lagoon treatment. Sludge and backwash waste produced by the rapid sand filter system includes aluminum, as this process uses aluminum sulfate as a coagulant, but the slow sand filter process does not require the addition of aluminum sulfate.

The rapid sand filter system produces twice as much sludge as the slow sand filter system, because of the coagulant that is added to the process. The ratio of the aluminum sulfate sludge to the turbidity sludge is 1.5 to 1.0, as stated previously. Sludge from the slow sand filter system consists of mainly turbidity and small quantities of algae. Furthermore, dried sludge from the slow sand filter can be used as fertilizer for agriculture, while sludge from the rapid sand filter is difficult to use for this purpose.

3) Removal of Fluoride

The rapid sand filter system uses aluminum sulfate and it can remove some of the fluoride that is present in the raw water.

Table 5.15 shows the results of the jar tests, which were carried out to ascertain how much fluoride can be removed by aluminum sulfate at different dosage rates. This shows that the fluoride removal rate was between 15 and 22%.

Table 5.15 Results of the Jar Tests

	Raw water (silt added)	Aluminum sulfate dosage rate (mg/L)					
		20	40	60	80	100	120
pH	7.5	7.48	7.38	7.3	7.19	7.14	7.07
Turbidity (degree)	13.9	0.4	0.0	0.0	0.0	0.0	0.0
Color		0.5	0.5	0.5	1.5	1.5	2.5
Fluoride (mg/L)	1.03	0.81	0.88	0.87	0.86	0.82	0.80
Removability of Fluoride (%)		21	15	16	17	20	22

4) Pilot Plant of the Slow Sand Filter (Including Ecological Filter)

The JICA study team conducted pilot plant tests on the slow sand filter system shown in **Figure 5. 15** and **Table 5.16**.

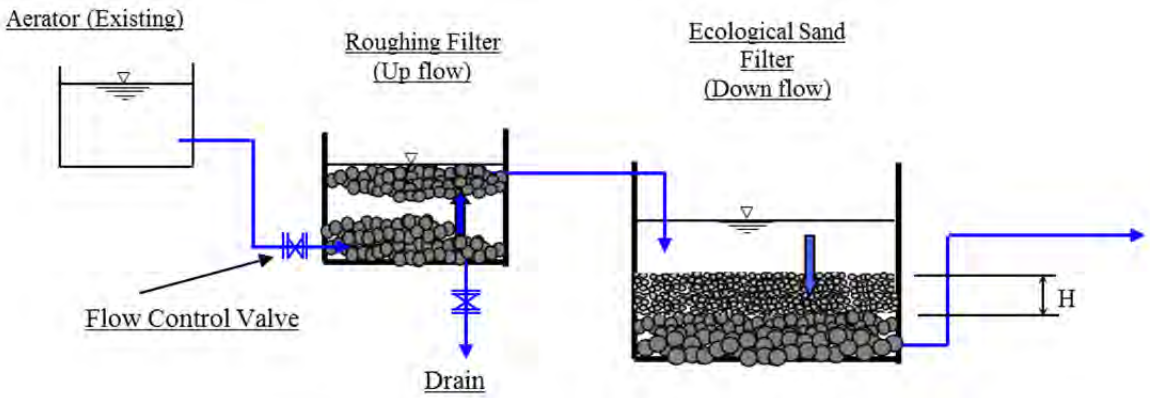


Figure 5.15 Pilot Plant Test Flow Diagram

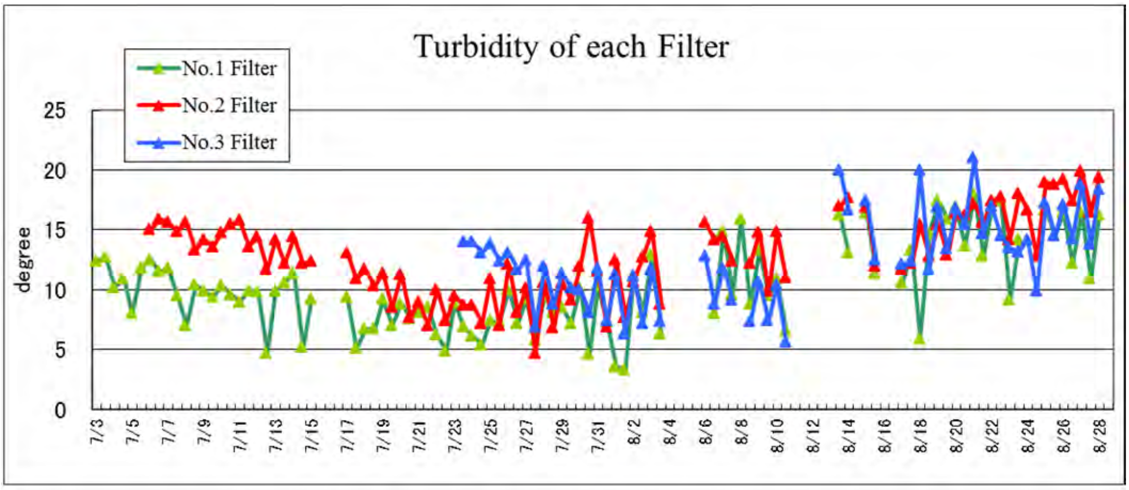
Table 5.16 Detail of Ecological Sand Filters in the Pilot Plant

No.1	No.2	No.3
Filter speed (Down flow)		
7 – 10m/d	**5m/d**	**5m/d**
Filter media Depth (H)		
15cm	**10cm**	**10cm**
Filter Media Size		
		
Commencement Day of Pilot Plant Operation		
July 3rd	**July 6th**	**July 24th**
∗The water source for sand filter No.2 at the beginning was the raw water, not the treated water by the roughing filter. For increase in the filtration head loss, the water source was changed to the treated water by the roughing filter.		

5) Results of the pilot plant test (Refer to **Appendix 5.2.2** for more details)

a. Comparison of Treated Water Quality in Each Sand Filter Nos: 1, 2 and 3

The following figures show the turbidity and color of the treated water for each sand filter Nos.1, 2 and 3. Based on the results, the turbidity and color of the water in each sand filter was improved. The water quality did not show any progressive improvement and hit equilibrium state 3 to 4 weeks (1 week for sand filter No.3) after the commencement of the pilot plant operation. In addition, due to deterioration in the raw water quality, the treated water quality was also similarly worsened. The similar results were observed from each sand filter without noticeable difference.



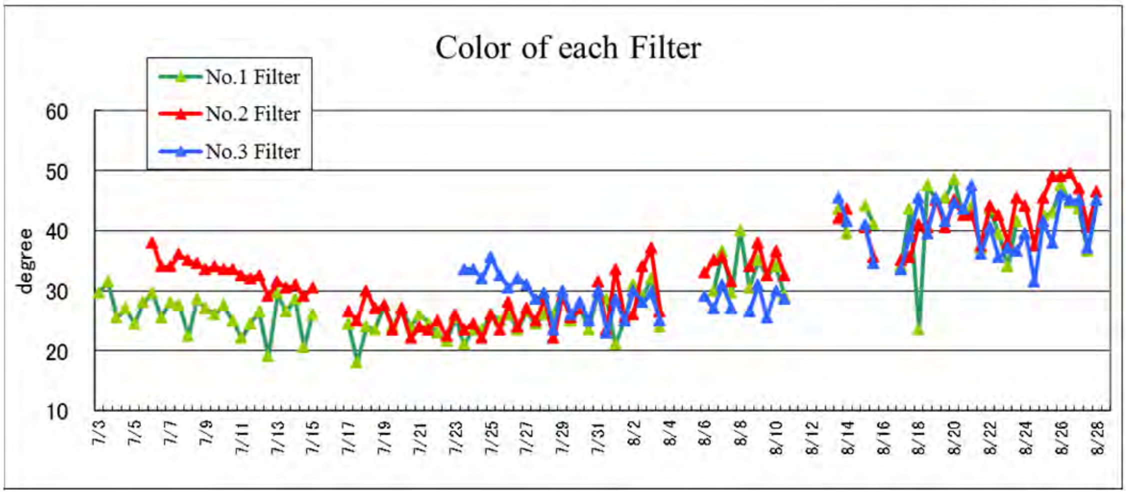


Figure 5.17 Comparison of Treated Water Quality in Each Sand Filter

b. Raw Water and Treated Water Quality

The following table shows the turbidity and color of the raw water and the treated water for each sand filter. Since the turbidity and color of the water source is in high value, the quality of the pilot plant treated water is not good. The removal of turbidity and color of the treated water in comparison with the raw water is 50 to 60 % and 30 to 40% respectively. During the water treatment process, the color removal rate is not good results.

Table 5.17 Raw Water and Treated Water Quality

	No1 filter	No2 filter	No3 filter
Duration of Pilot Plant	Jul.3rd-Aug.28th (57days)	Jul.6th-Aug.28th (54days)	Jul.24th-Aug.28th (36days)
Raw water			
Turbidity Ave.(degree)	26.5	26.8	30.2
Color Ave.(degree)	49.1	49.9	56.1
Roughing filter water			
Turbidity Ave.(degree)	17.5	17.7	20.1
Color Ave.(degree)	39.5	40.2	45.2
Removal Rate Comparing with Raw water			
Turbidity (%)	34	34	33
Color (%)	20	19	19
Filter Water			
Turbidity Ave.(degree)	10.3	12.9	12.6
Color Ave.(degree)	30.6	33.1	34.1
Removal Rate Comparing with Raw Water			
Turbidity (%)	61	52	58
Color (%)	38	34	39
Removal Rate Comparing with Roughing Filter Water			
Turbidity (%)	41	27	37
Color (%)	23	18	25

c. Comparison of Color

The colors of raw water and the treated water were compared as shown in the pictures below:

Figure 5.16 Comparison of Raw and Treated Water

The treated water in the pilot plant was compared with the treated water from the Sacred City

WTP and Thuruwila WTP where water was treated using rapid sand filter system, the treated water from the pilot plant was much more yellowish green color. Since the water in Wahalkada Tank, which is one of the project water sources, in comparison with the water in Thissa Tank, which is water source for Sacred City WTP, had the similar color of yellowish green. Therefore with the result of the pilot plan, the implementation of slow sand system will not improve the color of the water in the Wahalkada Tank. In addition, the removal rate of the turbidity in pilot plant is worse than that in Thuruwila WTP. The turbidity of the treated water in Sacred City WTP is higher due to the treatment process was not functioned properly since the facilities have been aged and the filter sand was contaminated by over used. Near the end of the pilot plant operation, the existing sand filter was started to be replaced with new.

6) Selection of the water treatment process

There are two major treatment processes to select: slow sand filters and rapid sand filters.
Slow sand filters are simple, cost effective, reliable, and easy to operate. However slow sand filters generally treat source water turbidity of less than 10 degrees successfully. Rapid sand filters can treat high turbidity water if the water is properly coagulated and settled out. The turbidity of Mahakanadarawa and Wahalkada water is higher than 10 degrees and ranges 1 to 20 degrees. There is a possibility that roughing filters can serve as a pretreatment to reduce the turbidity loading to the slow sand filters. To determine the applicability of the slow sand filters with help of roughing filters, pilot plant tests were conducted.

During the pilot plant operation, the water in the water source and the water treated by roughing filter contained much higher turbidity than water suitable for slow sand filter systems. Therefore, this condition was not suitable for slow sand filters to function properly and efficiently. Even the velocity in the sand filters were set lower than the original calculated velocity, the turbidity was insufficiently removed, less than 5 degrees. For the color, no difference was observed and the treated water was yellowish green color.

The water source used for the pilot plan operation was taken during the middle of dry season which could affect the experiment results. For a purpose of the portable water sources, the Anuradhapura North Water Supply project is proposed to intake the water from Mahakandarawa Tank and Wahalkada Tank, which currently used only for the irrigation purpose. With the additional intake of the water for the portable water purpose, the water levels in both tanks can be lower than the current condition, and the similar condition to the Anuradhapura City Water Supply can be predicted. In considerations of the above conditions and results, the implementation of slow sand filter system for the project is not suitable and recommended. In conclusion, the implementation of rapid sand filter system is recommended for the Anuradhapura North Water Supply project. Rapid sand filter systems are widely used in Sri Lanka so that Water Board will have no difficulties in operation and maintenance. Also it is recommended to install ACF (Active Carbon Filter) as soon as possible to remove the odor, if a bad odor occurred in the treated water for a long period, after operation of Phase - 1 facility started. Wooden and coconut granular carbon produced in Sri Lanka is available there. Some water treatment plants in Sri Lanka use powder and granular activated carbon.

5.2.3 Design Criteria

Target water quality of treated water is shown in **Table 5.19**.

Table 5.19 Target Turbidity of Treated Water by Process

	Unit	Target
Settled water	NTU	1 – 5
Filtered water	NTU	0 – 1
Treated water	NTU	To meet the Sri Lankan drinking water standard

The design criteria of the facilities are shown in **Table 5.18**.

Table 5.18 Design Criteria

Facility Name	Item	Value
Receiving Well/distribution tank	Detention Time	More than 1.5min
Flocculator	Detention Time	20-40 min
	G value	10 - 75/s
	GT value	23,000 to 210,000
Sedimentation tank (plate settler)	Surface load of the plate settler	7 – 14mm/min
	Upward flow velocity	< 80 mm/min
Sand filter	Filtration rate	< 200m/d (when one tank is stand by)
ACF (Active Carbon Filter) sump (future)	Detention Time	5-25 min
ACF (Active Carbon Filter: future)	Space velocity	SV=5 – 10 /hr
Clear water reservoir	Detention Time	1 hr
Backwash water recycle tank	Capacity	> amount of backwash water of 2 sand filters
Thickener	Detention Time of sludge	24 – 48 hr
	Loading rate of sludge	10 – 20 kg/m2/d
Drying bed	Loading rate of sludge	40 – 80 kg/m2

Source: "Design Criteria for Waterworks Facilities", Japan Water Works Association, 2000
"Integrated Design of Water Treatment Facilities", Susumu Kawamura, 1991

<u>The more detailed design criteria shall be studied and determined during the detailed design stage.</u>

5.2.4 Mahakanadarawa WTP

(1) Location

The location of Mahakanadarawa WTP is shown in **1**.

(2) Flow Diagram

The flow diagram of Mahakanadarawa WTP is shown in **Figure 5.18**.

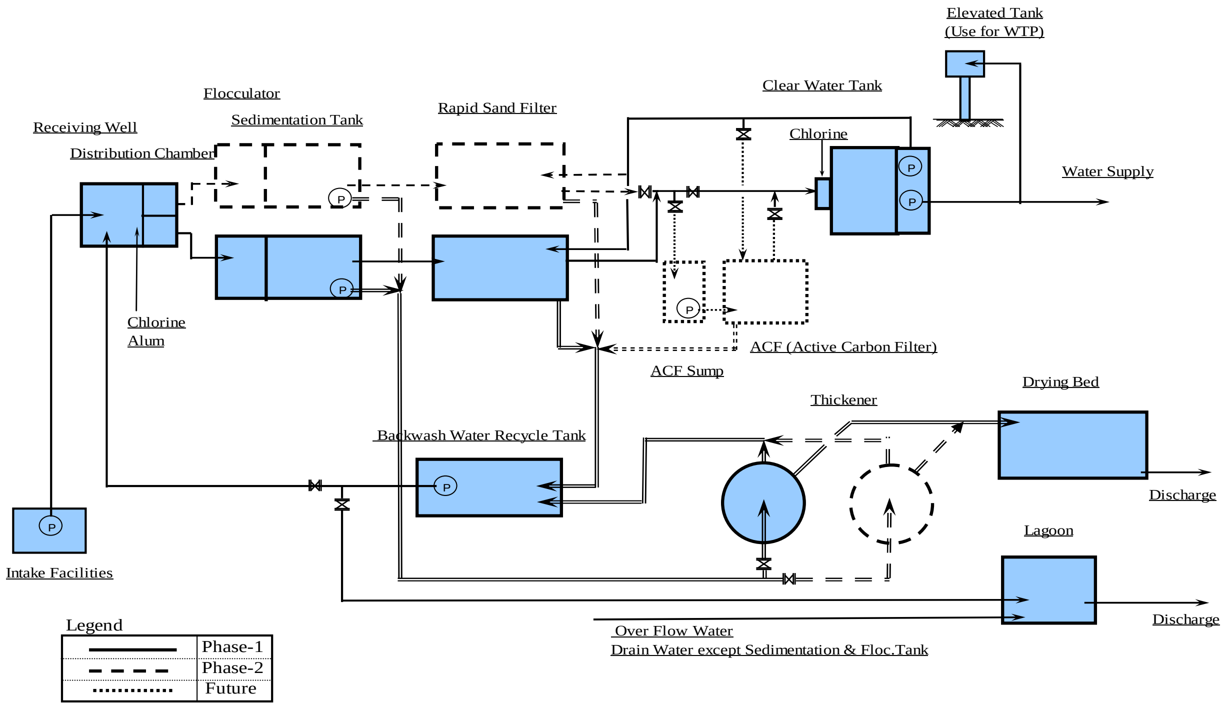


Figure 5.18 Flow Diagram of Mahakanadarawa WTP

(3) Layout

The layout of the facilities in Mahakanadarawa WTP is shown in **Figure 5.19**.

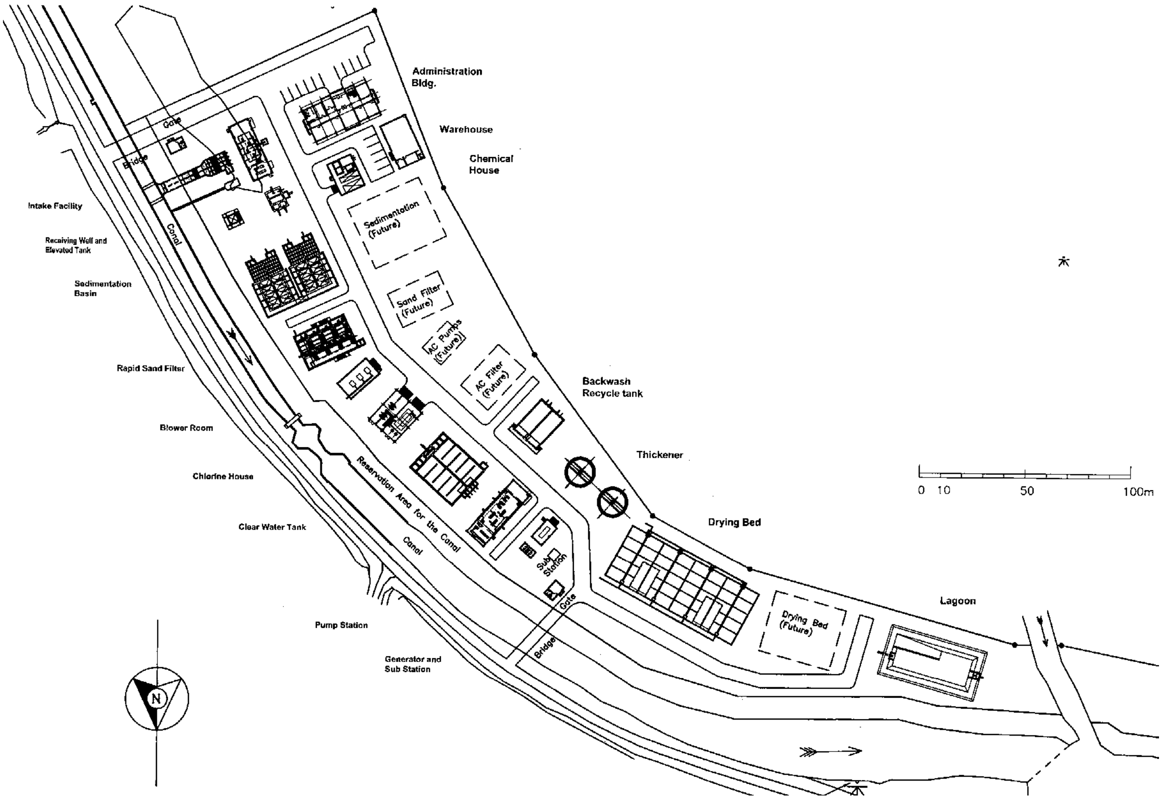


Figure 5.19 Layout of Mahakanadarawa WTP

(1) Outline of Mahakanadarawa WTP

Mahakanadarawa WTP takes water from an irrigation canal from Mahakanadarawa Tank at approximately 120m downstream of Mahakanadarawa Tank. The WTP is located on the left of the irrigation channel. The capacity of the WTP including 5% treatment process loss is shown in **Table 5.20**.

Table 5.20 Capacity of Mahakanadarawa WTP

Year	Stage-1 (2024)	Stage-2 (2034)	Remarks
Water rights (m3/d)	—*	18,800	
Water demand (day ave.) (m3/d)	7,154	14,414	According to water demand projection
Water demand (day Max.) (m3/d)	8,600	17,300	day ave. x 1.2
Production capacity of WTP(m3/d)	8,900	17,900	Output of WTP; Capacity of WTP x 0.95
Capacity of WTP (m3/d)	9,400	18,800	Input to WTP

Note: * Water right is set at 6,700 m3/day for 2016 and 18,800 m3/day for 2034 in the MOU between the Irrigation Department and NWSDB. Therefore, it is supposed that an amount of 6,700- 18,800 m3/day will be available for the year of 2024.

The intake water is delivered to the receiving well, which includes distribution chambers to supply water evenly to the flocculator tank that will be constructed in the Phase-1 and long term plan. At the outflow of the receiving well, both chlorine and aluminum sulfate will be injected.

A weir and a valve are installed at the entrance at each flocculator tank to control the inflow. The outflow from the vertical baffled channel flocculator is conveyed to the inclined plate sedimentation tank, which removes sludge. The outflow from the sedimentation tank without sludge is conveyed to a rapid sand filter, and then the filtered water is conveyed to the clear water reservoir, to which chlorine is added.

After the start the operation of Phase-1 facilities, if strong bad odor occurs for a long term in the treated water, ACF is proposed to be added to remove the odor. The outflow from the rapid sand filter is proposed to be pumped into the ACF by an ACP sump pump. The filtered water is conveyed to the clear water reservoir by gravity, and the treated water is supplied to the served area by transmission pumps. The necessity of ACF shall be studied and determined during the detailed design stage.

Both the sand filter and ACF are cleaned with air and water. The backwash water flows into the backwash water recycle tank and then pumped to the receiving well for recycling water.

Sludge collected at the bottom of the sedimentation tank is regularly released by opening a valve and pumped to the thickener. In the thickener, water is separated from the sludge, the sludge is conveyed to the drying bed, and the water is conveyed to the backwash water recycle tank for a purpose of recycling water. Accumulated sludge in the drying bed is removed after this is dried. The total capacity of lagoons is designed to handle the overflow water, drainage water, and the water from the backwash water recycle tank for emergency.

The facilities in Mahakanadarawa WTP are summarized in **Table 5.21**.

Table 5.21 Detail of Mahakanadarawa WTP

Facility	Stage-1	Stage-2	Remarks
Receiving Well	W4.0m x L4.6m x H6.0m x 1unit	-	*
Distribution Chamber	W2.0m x L2.0m x H5.0m x 2units	-	*
Flocculator tank	5 stages x 62.8m3 x 4 units	5 stages x 62.8m3 x 4 units	
Sedimentation tank	W4.0m x L10.4m x H4.0m x 4units	W4.0m x L10.4m x H4.0m x 4unit	Plate settler
Rapid sand filter tank	W3.0m x L5.5m x 4units	W3.0m x L5.5m x 4units	
ACF sump	W8.0m x L12.0m x H3.0m x 1unit		future
ACF tank	W2.5m x L5.0m x 4units		future
Chlorine Mixing Chamber	W2.0m x L5.0m x H4.0m x 2units	-	*
Reservoir	W8.0m x L17.0 x H4.0m x 2units	-	*
Backwash water recycle tank	W4.0m x L14.0 x H3.0m x 2units	-	*

Facility	Stage-1	Stage-2	Remarks
Thickener	Dia 10.0m x H4.0m x 1unit	Dia 10.0m x H4.0m x 1unit	
Drying bed	W12.5m x L20.0m x H1.0m x 4units	W12.5m x L20.0m x H1.0m x 2units	
Lagoon	W10.0m x 27.0m x 1.0m x 1unit	-	*
Administration Bldg.	W12.0m x L25m x 2 stories	-	*
Chemical house	W11.5m x L12.0m	-	*
Chlorine House including neutralization facilities	W12.0m x L14.0m	-	*
Pump House	W8.0m x L26.5m	-	*
Blower House	W7.3m x L13.5m		*
Generator House	W4.5m x L8.0m	-	*
Ware House	W10.0m x L17.0m	-	*

*The capacity of the facilities constructed in Stage-1 includes the whole capacity required for the Project up to Stage-2.

<u>Attention be paid for the following:</u>

- <u>The necessity of the central laboratory shall be shall be studied and determined during the detailed design stage.</u>
- <u>The necessity, location and contents of a complete workshop shall be studied and determined during the detailed design stage.</u>
- <u>The material of the outlet weir launders, lamellar of the clarifies, uniformity coefficient of proposed lapid sand filters shall be studied and determined during the detailed design stage.</u>

5.3.5 Wahalkada WTP

(1) Location

The location of Wahalkada WTP is shown in **Figure 5.20**.

(2) Flow diagram

The flow diagram of Wahalkada WTP is shown in **Figure 5.21**.

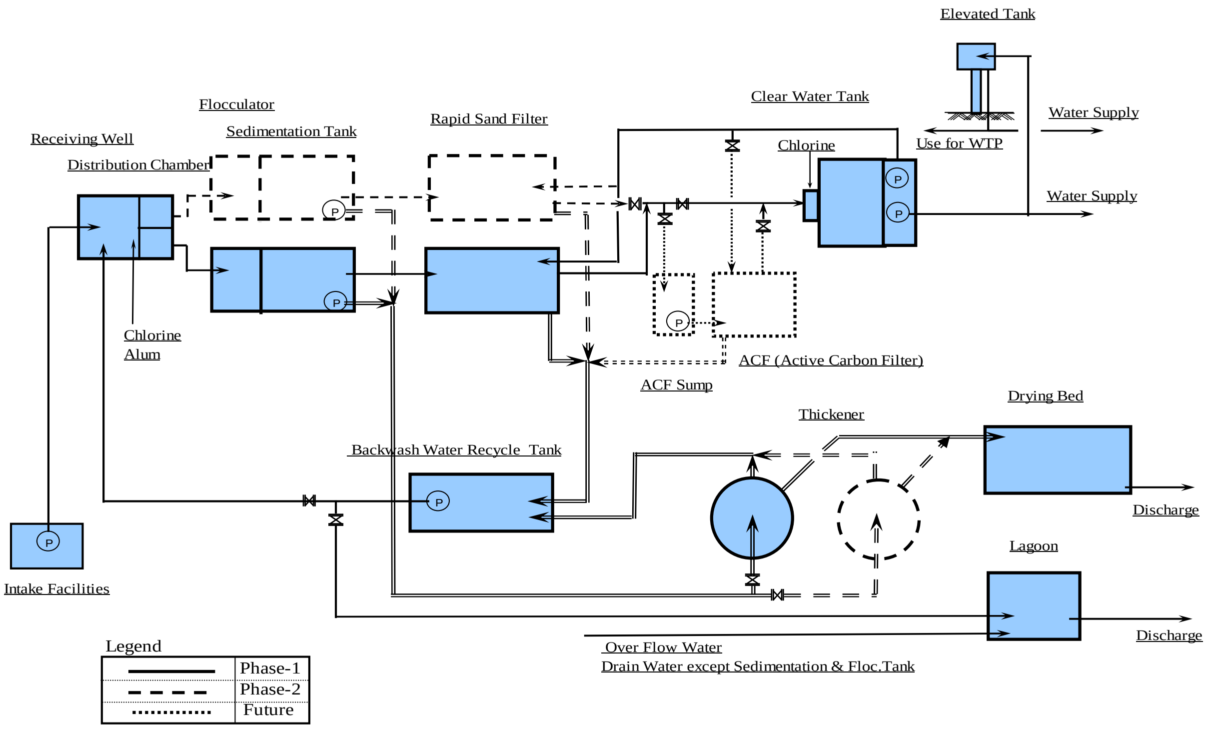


Figure 5.20 Flow Diagram of Wahalkada WTP

(3) Layout of the facilities

The layout of the facilities in Wahalkada WTP is shown in **Figure 5.23**.

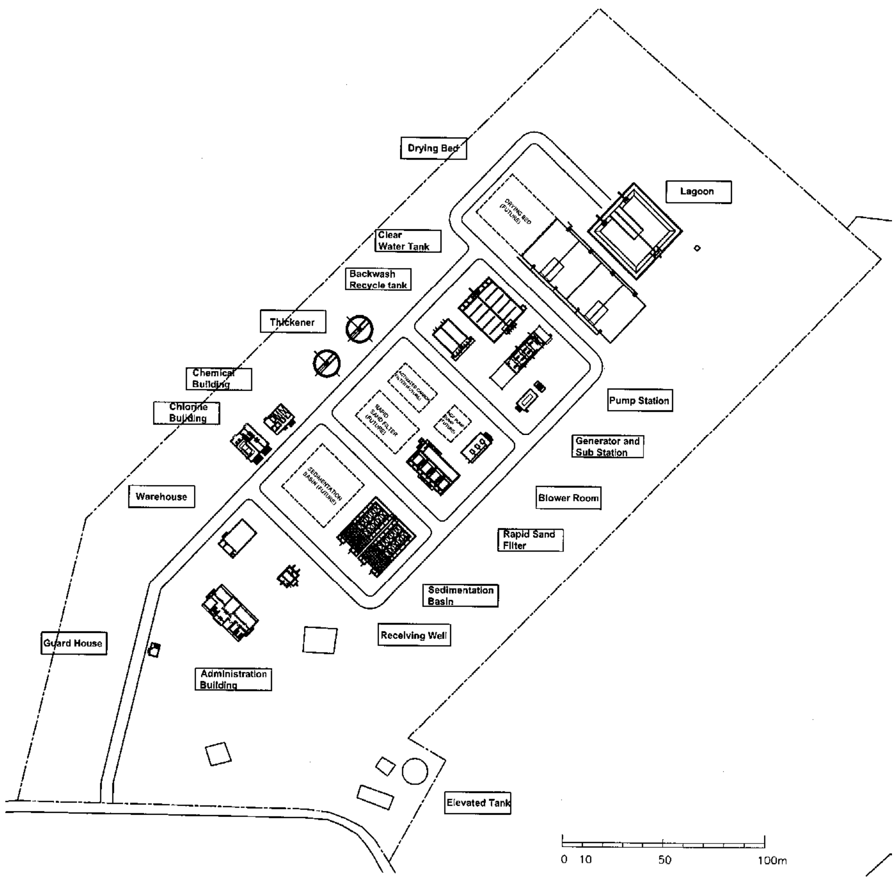


Figure 5.21 Layout of Wahalkada WTP

(4) Outline of Wahalkada WTP

Wahalkada WTP takes water from an irrigation canal from Wahalkada Tank at approximately 420m downstream from Wahalkada Tank. The capacity of the WTP is determined in consideration of water rights, daily maximum water demand and 5% treatment process loss in **Table 5.22**.

Water demand in 2024 is projected to be mostly half of that in 2034 so that major treatment facilities in 2024 such as sedimentation basin and rapid sand filter should be half capacity of the long term plan in 2034 in order to increase operational efficiency, ratio of utilization and the service life of the facilities.

Table 5.22 Capacity of Wahalkada WTP

Year	Stage-1 (2024)	Stage-2 (2034)	Remarks
Water rights (m3/d)	—*	28,800	
Water demand (day ave.) (m3/d)	11,098	22,392	According to water demand projection
Water demand (day Max.) (m3/d)	13,300	26,900	day ave. x 1.2
Production capacity of WTP(m3/d)	13,700	27,400	Output of WTP; Capacity of WTP x 0.95
Capacity of WTP (m3/d)	14,400	28,800	Input to WTP

Note: * Water right is set at 10,500 m3/day for 2016 and 28,800 m3/day for 2034 in the MOU between the Irrigation Department and NWSDB. Therefore, it is supposed that an amount of 10,500-28,800 m3/day will be available for the year of 2024.

The treatment process is the same as at Mahakanadarawa WTP, except that an elevated tank is provided to supply water to the neighboring villages. Treated water is pumped to the elevated tank, which is located in the WTP site and also to the served areas through transmission pipelines.

The facilities in Wahalkada WTP are summarized in **Table 5.23**.

Table 5.23 Detail of Wahalkada WTP

Facility	Stage-1	Stage-2	Remarks
Receiving Well	W5.6 x L5.0m x H6.0m x 1 unit	-	*
Distribution Chamber	W2.5 x L2.0m x H5.0m x 2 units	-	*
Flocculator tank	7 stages x89.3m^3 x 4 units	7 stages x89.3m^3 x 4 units	
Sedimentation tank	W4.0m x L14.4m x H4.0m x 4units	W4.0m x L14.4m x H4.0m x 4unit	Plate settler
Rapid sand filter tank	W4.0m x L6.0m x 4units	W4.0m x L6.0m x 4units	
ACF sump	W10.0m x L14.0m x H3.0m x 1unit		future
ACF tank	W3.5m x L5.0m x 4units		future
Chlorine Mixing Chamber	W2.0m x L6.75m x H4.0m x 2units	-	*
Reservoir	W10.0m x L21.0m x H4.0m x 2units	-	*
Backwash water recycle tank	W5.0m x L15.0m x H4.0m x 2units	-	*
Thickener	Dia 12.5m x H4.0m x 1unit	Dia 12.5m x H4.0m x 1unit	
Drying bed	W15.0m x L25.0m x H1.0m x 4units	W15.0m x L25.0m x H1.0m x 2units	
Lagoon	W12.0m x 25.0m x 1.5m x 1unit	-	*
Administration Bldg.	W12.0m x L25m x 2 stories	-	*
Chemical house	W11.5m x L12.0m	-	*
Chlorine House including neutralization facilities	W12.0m x L14.0m	-	*
Pump House	W8.0m x L35.0m	-	*
Blower House	W7.3m x L13.5m		*
Generator House	W5.0m x L9.5m	-	*
Ware House	W10.0m x L17.0m	-	*

*The capacity of the facilities constructed in Stage-1 includes the whole capacity required for the Project up to Stage-2.

5.3 Transmission and Distribution System

5.3.1 Description of Project Area

The project area is comprised of six DSDs, which are further divided into 194 GNDs covering an area of about 2,863 km^2. The six DSDs are Padaviya, Kebithigollewa, Medawachchiya, Rambewa, Horowpothana and Kahatagasdigiliya. The population in the project area is estimated to be 204,700 in 2012, which indicates a low population density at less than 1 person/ha on the average.

There are several main roads of route A and B in the project area as shown in **Figure 5.22**. There are four Route A roads and seven Route B roads. The core areas (urban center) are formed with multiple DSDs at six locations as shown in **Figure 5.22**. These core areas are located at the intersection or intersections of the above-mentioned main roads as the development centers of the project area, including Bogahawewa in Padaviya DSD, Kebithigollewa in Kebithigollewa DSD, Medawachchiya in Medawachchiya DSD, Rambewa in Rambewa DSD, Horowpothana in Horowpothana DSD and Kahatagasdigiliya in Kahatagasdigiliya DSD. Villages are sparsely located along the main roads or inland from such roads in each GND. The project area is covered in forests, paddy lands, artificial lakes (tanks) and other vacant lands. The villages are located, in general, beside or near the tank (reservoir) and paddy fields. The road network is also limited in these areas.

Ground elevations in the project area vary widely from +30m up to +150m. The local topography is not necessarily flat, but sometimes fluctuates considerably within GNDs.

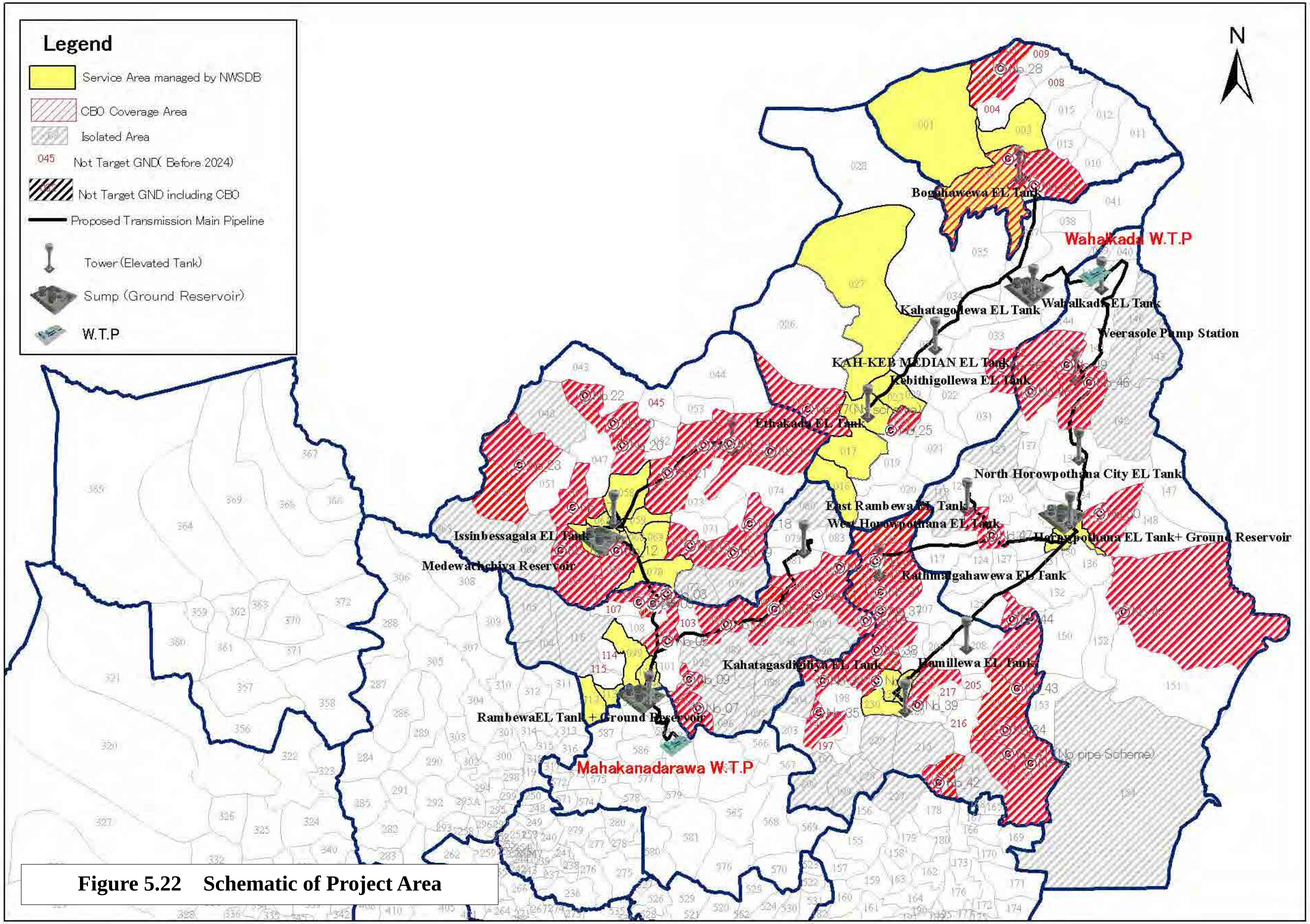


Figure 5.22 Schematic of Project Area

5.3.2 Planning Concept of the System

The system plan for transmission and distribution was made based on the water demand for the target year of 2034, and the dimensions of the major facilities such as transmission mains, distribution mains, ground reservoirs, elevated tanks, etc. were determined based on the requirement for the year 2034. The dimensions of minor facilities such as distribution sub-system were determined for the year of 2024 for the project implementation.

(1) Transmission System

There are six NWSDB's systems and 50 existing community water supply systems (CBO and CWSSP) in the project area. The NWSDB systems, covering 25 GNDs, are located in the core area(s). Generally, each CBO covers a part of a GND. Some CBOs, however, cover multiple GNDs or two to three GNDs. New water supply systems for GNDs other than the existing CBOs will be constructed under this project. However some of the GNDs will not have piped supply systems, but will be supplied from an indirect system to which water will be transferred by water tankers (Bowsers). All the existing CBOs receive treated water at their elevated tanks except for three (3) CBOs as mentioned in **Section 4.2.5**. They area CBO 20 (GND 46), CBO26 (GND 32) and CBO 47 (GND 119)

The number of GNDs presently supplied by NWSDB, existing CBO or new system established under the present project is summarized as follows:

Table 5.24 Summery of GNDs in Project Area

DSD	GNDs currently supplied by NWSDB	GNDs currently supplied by CBOs	GNDs supplied by new water supply systems		GNDs receiving bowser delivery water supply	
			Year 2024	Year 2034	Year 2024	Year 2034
Padaviya [1)]	3	4	5	8	4	1
Kebithigollewa	5	2	17	17	1	1
Medawachchiya	8	13	8	9	6	5
Rambewa	4	12	6	10	16	12
Horowpothana	2	6	21	21	8	8
Kahatagasdigiliya	3	18	7	11	12	8
Total	25	55	64	76	47	35

Note [1)]: GND 2 of Padaviya DSD is supplied from both NWSDB and existing CBO (29)

Figure 5.24 shows such GNDs supplied by the existing piped system, new system and indirect supply.

Two water sources are selected for the present integrated water supply system in the northern and southern parts of the project area, namely Wahalkada Wewa and Mahakanadarawa Wewa respectively, from where raw water is conveyed, after treatment, to the entire project area through two transmission systems.

The transmission system from the Mahakanadarawa Wewa is named as the Mahakanadarawa System, which will cover DSDs of Medawachchiya and Rambewa. The Wahalkada system from Wahalkada Wewa transmits treated water to the DSDs of Padaviya, Kebithigollewa, Horowpothana and Kahatagasdigiliya.

From the demand projection for the year of 2034, the transmission capacity for the Mahakanadarawa and Wahalkada systems is determined as 17,300 m^3/day and 26,900 m^3/day respectively.

Each transmission system is composed of a transmission main system and a sub-main system. The main system is formed to cover the entire supply zone from the respective water treatment plant and the sub-system supplements the main system to convey bulk water to the elevated tanks, which are placed at strategic locations to distribute water to the new system of GNDs and transmit bulk water to the existing CBOs.

The transmission main system is composed of transmission mains and service centers where a pumping station and an elevated tank are provided. In addition, booster pump stations are provided at strategic locations. The transmission main route of each system is, in general, selected to run along the main roads mentioned above, from the water treatment plant and between service centers. Elevated tanks are provided at key locations to distribute treated water directly to the new distribution systems of GNDs. On the other hand, the existing systems will receive bulk water from the transmission system at the elevated tanks.

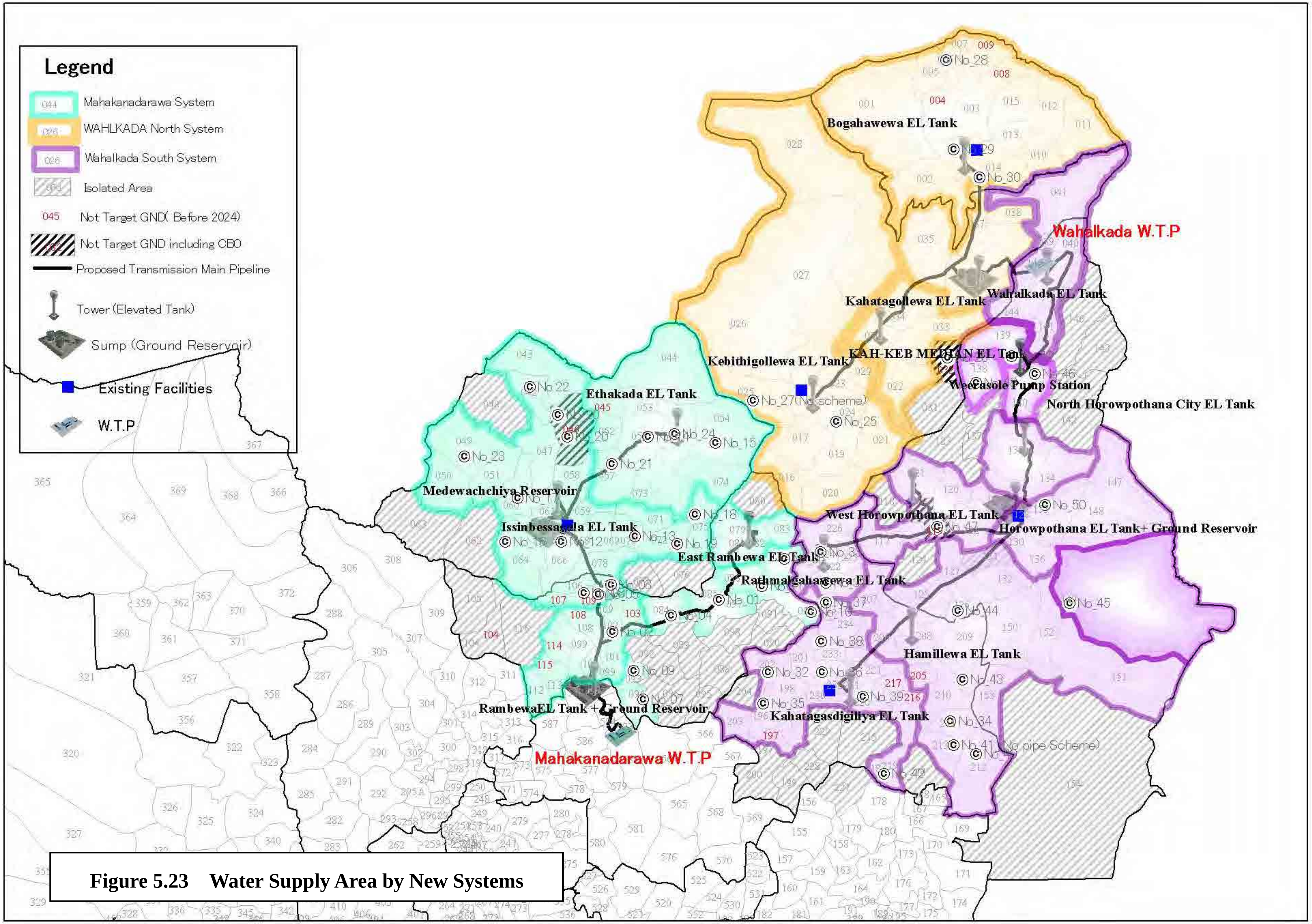


Figure 5.23 Water Supply Area by New Systems

Fifteen elevated tanks, four in the Mahakanadarawa system and 11 in the Wahalkada system, are strategically positioned to cover the entire service area. **Table 5.25** shows the area covered by each elevated tank.

Table 5.25 Covering Area of Elevated Tanks

Transmission System	Elevated Tank	Covering area (ha)
Mahakanadarawa System	I-1 ET (Rambewa)	6,387
	I-2 ET (Issinbassagala)	22,333
	I-3 ET (Ethakada)	13,269
	I-4 ET (East Rambewa)	2,590
Wahalkada System	II-1 ET (Wahalkada)	8,545
	II-2 ET (Kahatagollewa)	7,979
	II-3 ET (Bogahawewa)	24,252
	II-4 ET (KAH-KEB Median)	6,839
	II-5 ET (Kebithigollewa)	37,952
	II-6 ET (North Horowpothana)	4,408
	II-7 ET (Horowpothana)	8,522
	II-8 ET (West Horowpothana)	5,782
	II-9 ET (Rathmalgahawewa)	5,571
	II-10 ET (Hamillewa)	26,695
	II-11 ET (Kahatagasdigiliya)	12,244

It is noted that transmission to some of the CBOs, which are remotely located from the transmission main at high ground elevation, will need to be boosted to the level of their respective elevated tanks as shown in **Figure 5.26** for the Mahakanadarawa system and **Figure 5.27** for the Wahalkada system.

(2) Distribution System

There are two systems of distribution, one is the system for the existing CBO systems operated independently by individual CBOs, and the other is the new system for GNDs operated under NWSDB.

The existing CBO's system will receive bulk water from the transmission system operated by NWSDB, and distribute water through the existing distribution network. The new system of the GND will be directly distributed from the elevated tank constructed under the project, and the entire system will be operated by NWSDB. The service area of the existing system under NWSDB will receive bulk water also from the transmission system at the elevated tank and distribute water to its distribution network. In accordance due to the increase in demand, the existing service area will be reduced to meet the capacity of the existing distribution system including the existing elevated tank. The remaining area after reduction of its service area will be covered by the new distribution system constructed under this project.

The CBO is assumed to continue to operate and manage the existing system only. On the other hand, the expansion of service area of CBO due to demand increase is assumed to be handled as

NWSDB considers appropriate.

5.3.3 Design Criteria

(1) Selection of Pipe Materials

Pipe materials to be applied for transmission and distribution pipelines are examined in accordance with the characteristics of pipe materials, locations where they will be installed, and economy of construction.

The range of sizes for transmission main, sub-main and distribution network will be as follows:

Transmission Main:	ND 250mm to 450mm
Transmission Sub-main:	ND 100mm to 250mm
Distribution Main:	ND 100mm to 400mm
Distribution Sub-system (network):	ND 50mm to 200mm

Among pipe materials prevailing, the following are considered as applicable for piping work for the above pipelines:

DCIP or DIP:	Ductile cast Iron Pipe
SP:	Steel Pipe
PE:	Polyethylene Pipe
PVC:	Un-plasticized Polyvinyl Chloride Pipe

The conditions of the installation sites and pressure conditions vary widely depending on functions and range of pipelines, as mentioned. But in general, these conditions are classified as shown in **Table 5.26**.

Table 5.26 Condition of Pipeline

Pipeline	Site Conditions	Pressure Conditions
Transmission Main	Underground piping installed alone main road, thus traffic load is to be duly considered	High pressure of 10 bar or less [1)]
Transmission Sub-main / Distribution main	Underground piping installed along the public road with possible surface loading by traffic	The pressure is less than 10 bar
Distribution Network	Underground piping installed within the village at rural area, thus traffic load is limited	Low pressure of less than 2 bar

1) The pressure of some section of transmission main will exceed 10 bar caused by water hammer, where pipes with rated pressure of 16 bar will be used.

The major factor in the selection of pipe materials is its cost. **Table 5.27** shows the unit price of DIP and PE for comparison, in accordance with cost quotation.

Table 5.27 Unit Price of Pipe Materials

(Unit: Rs/m)

ND (mm)	DIP	PE
450	20,457	15,689
400	17,228	12,856
350	13,913	10,022
300	11,207	7,932
250	9,308	4,919
200	7,240	3,918
150	5,434	2,043

The general features of pipe materials and the evaluation on the application of each pipe material are summarized in **Table 5.28**.

Table 5.28 Evaluation of Pipe Materials

Description	DIP	SP	PE	PVC
Safety against external Load				
Underground piping	◎	◎	△	△
As structure member	○	◎	×	×
Safety against internal pressure	◎	◎	○	○
Roughness on internal surface	○	○	◎	◎
Water tightness of joint	○	◎	◎	○
Adaptability against soft/poor soil	○	○	○	○
Workability for installation	○	△	△	◎
Transportation and handling	○	△	△	△
Corrosion resistance	△	×	○	○
Resistance against acid water	×	×	◎	◎
Applicable Size	80〜2600	50-2400	20-1600	20-600

Where, ◎: excellent, ○: good enough, △: tolerable, ×: not recommended

From the above evaluation on pipe materials, the recommended pipe materials are summarized as follows:

Transmission Main: PE considering importance as main facility for transmission system, low roughness of internal surface, which reduces friction loss for transmission and economy for applied range of pipe sizes, in comparison with DIP and SP. It is noted, however, that care shall be taken for pipe installation, especially in rocky soil conditions and where there are traffic loads. Sand bed and backfill up to above the crown of the pipe shall be provided.

Transmission Sub-main/ Distribution Main: PE for the same reasons as above.

Distribution Sub-system: PVC considering the small size of pipelines, limited external loads and economy of construction.

Special construction: SP or DIP will be used for crossing works such as major roads, river crossings by pipe bridges and inverted siphon depending on the site conditions and method of crossings.

(2) Transmission Hydraulics

Key Ground Elevation:

Transmission mains are planned between the water treatment plant and the service centers by pumping. The ground elevations at such sites for the construction of the major facilities are important to determine the size of the transmission main and the dimensions of the pump facilities. Based on the topographical and line surveys, the key ground elevations are determined as shown in **Table 5.29**.

Table 5.29 Key Ground Elevation of Transmission System

Transmission System	Pump Station / Main Elevated Tank	Ground Elevation (m)
Mahakanadarawa System	Water Treatment Plant I (Mahakanadarawa WTP)	+ 91.0
	Pump Station I-1 PS / Elevated Tank I-1 ET (Rambewa)	+ 89.5
	Pump Station I-2 PS (Medawachchiya)	+ 100.0
	Elevated Tank I-2 ET (Issinbassagala)	+ 113.0
	Elevated Tank I-3 ET (Ethakada)	+ 121.0
	Elevated Tank I-4 East Rambewa	+ 112.0
Wahalkada System	Water Treatment Plant II, Elevated Tank II-1 ET (Wahalkada WTP)	+ 61.0
	Pump Station II-1 PS / Elevated Tank II-2 ET (Kahatagollewa)	+ 68.0
	Elevated Tank II-3 ET (Bogahawewa)	+ 66.0
	Elevated Tank II-4 (KAH-KEB Median)	+ 94.5
	Pump Station II-2 PS, Elevated Tank II-5 ET (Kebithigollewa)	+ 122.0
	Pump Station II-3 PS (Weerasole)	+ 57.0
	Elevated Tank II-6 (North Horowpothana)	+ 86.0
	Pump Station II-4 PS / Elevated Tank II-7 ET (Horowpothana)	+ 73.5
	Elevated Tank II-8 ET (West Horowpothana)	+ 116.0
	Elevated Tank II-9 ET (Rathmalgahawewa)	+ 122.0
	Elevated Tank II-10 ET (Hamillewa)	+ 101.7
	Pump Station II-5 PS / Elevated Tank II-11 (Kahatagasdigiliya)	+ 146.0

Water Levels

Water levels of above major facilities are set as follows:

Water Treatment Plant: Clear water reservoir: HWL/LWL: as determined by preliminary design by WTP

Ground Reservoir and Pump Sump: HWL: 2 meter above ground elevation
LWL : 2 meter below ground elevation

Elevated Tank: HWL: 25 meters above ground elevation
LWL: 21 meters above ground elevation

Hydraulic Analysis

The Hazen-William Formula is used for friction loss analysis of pipelines, where the friction loss coefficient (C-Value) is applied assuming that pipe materials will be either PE or PVC as follows:

Transmission Pipeline: 130
Distribution Main: 130
Distribution Sub-system: 120

The transmission hydraulics shall be re-checked during the detailed design stage for the Stage-1 and Stage-2 flow.

Pressure Condition

For safe operation of the transmission system, the hydraulic profile of the pipeline should be such that the pressure is positive at any point along the pipeline route.

Surge along Pipelines

Pipelines shall be designed for any operating condition, including pressure surge at time of sudden pump stops due to power failure. In such cases, negative pressure may occur along the pipeline. The negative pressure, however, shall be not less than -5 m or approximately at any points along the pipeline.

(3) Dimensions of Ground Reservoirs and Main Elevated Tanks

Dimensions of ground reservoir at pump station and elevated tank will be determined using the following retention times:

Ground Reservoir:	2 hours
Elevated Tank:	8 hours

The height of elevated tanks is planned such that the low water level is 21 m above ground elevation, as stated above.

(4) Distribution Mains and Distribution Sub-system of GND

Distribution system will be composed of distribution main and sub-system. The pipe material used for distribution mains, which will transfer distribution water to each GND with a tree type system in general, will be PE taking its importance into account. On the other hand, the pipe material used for the distribution sub-system (networks) in the GNDs will be PVC, taking into account the smaller diameter of the pipes, length of the pipelines, limited external loads and low cost.

Pressure at the receiving point of bulk water is set at 15 meters using following hydraulic conditions:

Pressure at the tapping point:	10 meters
Head loss of distribution sub-system:	3 meters

The peak factor for water distribution is taken as 2 times of the maximum day demand.

(5) Installation of Valves

The transmission and distribution mains will be provided with valves at the following locations:

Main Valve:	at branches and the place right after along the pipeline, major crossings of main roads, downstream of blow-offs, upstream of air valves, every 2 – 3 km interval and other places as required.

Blow-off: at concave points of pipeline profile near river and drains which are available.

Air Valve: at convex points of pipeline profile

(6) Earth Cover of Pipeline

The earth cover of pipeline is set at, in general, the following depths:

Transmission main and Distribution Primary Mains: 1.2 meters

Distribution network (Secondary & Tertiary): 1.0 meters

Bedding of pipes will be provided with sand or appropriate soil with a minimum of 10 cm thickness. Similar soil materials will be used for backfilling up to 10 cm above the pipe crown.

5.3.4 Mahakanadarawa System

A schematic flow diagram of the Mahakanadarawa System is shown on **Figure 5.24**.
The Mahakanadarawa system for transmission main is composed of four (4) sections as follows:

Section 1: from Mahakanadarawa WTP to Rambewa Service Center (Pump station/Elevated tank) along local road

Section 2: From Rambewa Pump station to Medawachchiya Pump station along Route A9 and A14 at the end span

Section 3: From Medawachchiya Pump station to Issinbassagala Elevated tank along bypass between Routes A9 and A14

Section 4: From Medawachchiya Pump station to Ethakada Elevated tank along Route B211

(1) Section 1

The treated water is transferred through a ND 450mm transmission main to the distribution reservoir of Rambewa service center, where a pump station (I-1PS) and an elevated tank (I-1ET) will be provided. The pipe length is approximately 7.1 km. The elevated tank at Rambewa will cover a new system serving twelve (12) GNDs by direct distribution and one CBO to its elevated tank.

Two surge tanks (one way tank) are planned to be located right after WTP and before the Service Center to guard against surging caused by sudden stop of pump operation.

(2) Section 2

Treated water will be further transferred through a ND 450 ~ 400 mm transmission main to the ground reservoir (I-2PS) at the service center of Medawachchiya. The pipe length is approximately 15.8 km (ND450mm at 3.2 km and ND400mm at 12.6 km). On the way to Medawachchiya pump station from Rambewa, a branch for a transmission sub-main is installed at approximately 3.2 km from Rambewa service center (point “a”) to convey bulk water to eight existing CBOs and one elevated tank (East Rambewa, I-4 ET) for direct distribution to the new systems in three GNDs.

Another branch (point "b") at about 3.8 km downstream from Point "a" will be provided to transmit bulk water to three existing CBOs.

After Point "b", the transmission main runs approximately 8.8 km up to the ground reservoir at Medawachchiya pump station (II-2 PS).

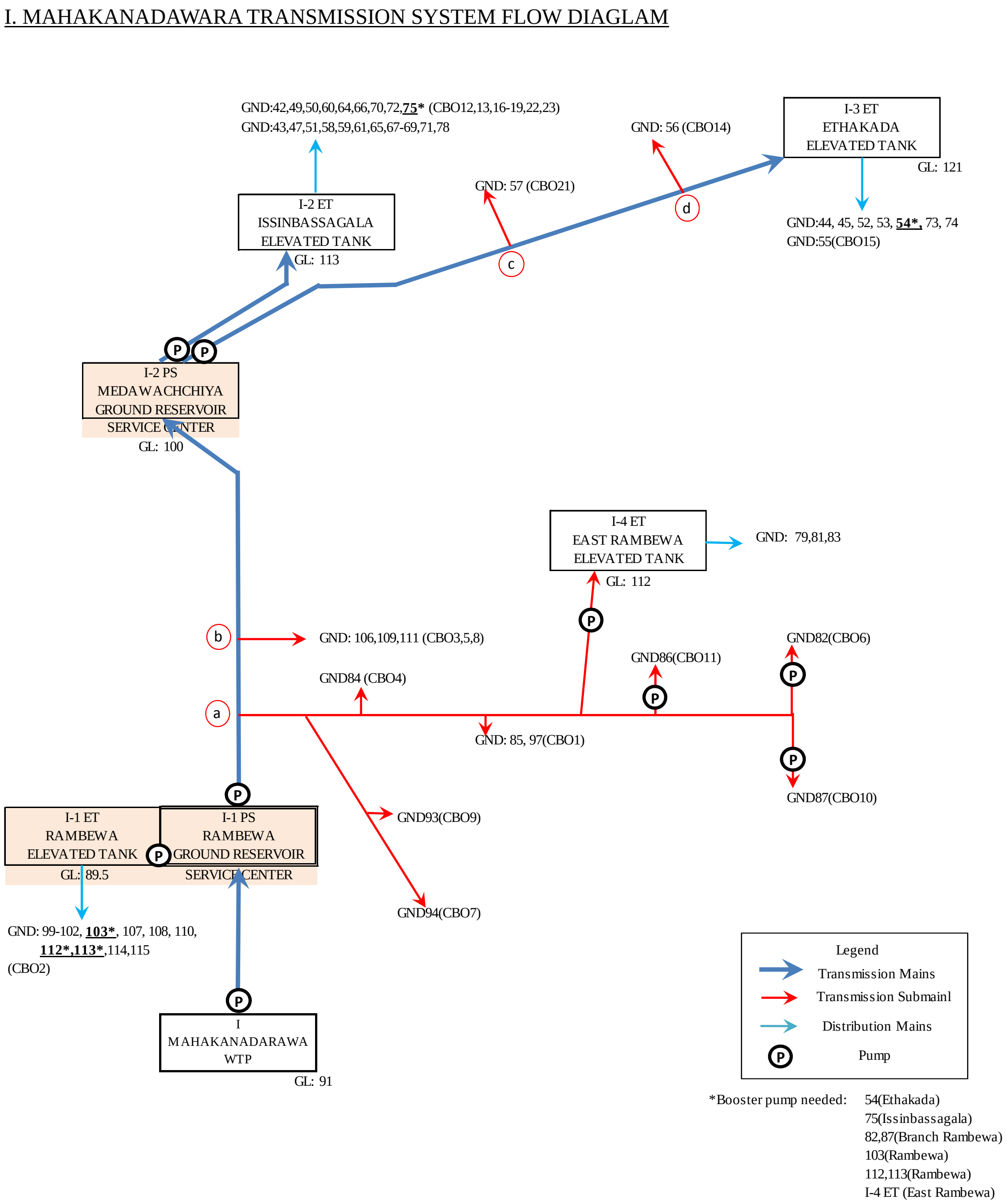


Figure 5.24 Schematic Flow Diagram of the Mahakanadarawa System

(3) Section 3

From Medawachchiya pump station where water is pumped up to the elevated tank at

Issinbassagala (I-2ET). The size of main is ND 350mm, with a length of approximately 3.1 km. The Issinbassagala elevated tank transfers bulk water to the existing elevated tank of NWSDB which cover eight GNDs, nine existing CBOs and direct distribution to new systems in four GNDs.

Due to the limited capacity of the existing distribution system of NWSDB, the present service area will be reduced, due to the increase in demand, and replaced by a new distribution system from the new elevated tank.

(4) Section 4

The Medawachchiya pump station also transfers water through a ND 250 to 300 mm transmission main to the elevated tank at Ethakada (II-3ET). The pipe length is approximately 14.4 km. The Ethakada elevated tank will cover two existing CBO and new systems in six GNDs. At 7.1 km and 11.3 km from the pump station, two branches (at point “c” and “d”) will be provided to transmit bulk water to one existing CBO each.

Table 5.30 summarizes the existing system (NWSDB and CBOs) and new system for GNDs to be fed from transmission mains and covered by respective new elevated tanks by the Mahakanadarawa transmission system.

Table 5.30 Existing and New Systems Covered by New Elevated Tank

Elevated Tank	NWSDB System	CBO System	New System
I-1 ET (Rambewa)	-	-	99, 100, 101,102, 103, 107, 108, 110, 112, 113, 114, 115
I-2 ET (Issinbassagala)	51, 58, 59, 61, 65, 67, 68, 69, 78	42, 49, 60, 64, 66, 70, 72, 75	43, 47, 71
I-3 ET (Ethakada)	-	54, 55	44, 45, 52, 53, 73, 74
I-4 ET (East Rambewa)	-	-	79, 81, 83
Transmission mains	-	46, 57, 55, 75, 82, 84, 85, 86, 87, 93, 94, 97, 102, 106, 109, 111	-

Note [1)]: There are four GNDs presently supplied from existing water supply source which is however located outside of the project area. The supply condition of these GNDs are poor at present due to remote from the supply source, therefore they are included in the present system planned.

(5) Transmission Sub-main

As mentioned above, the transmission sub-mains are planned at four branches of transmission main to convey water to a new elevated tank at East Rambewa and the existing CBOs. A total length of transmission sub-main is estimated at about 46.2 km which size is ranging from 250mm to 100mm in diameters.

To determine size of transmission main and sub-main of Mahakanadarawa system, hydraulic analysis has been carried out. The results of above hydraulic analysis is presented in **Appendix 5.3 (a)** and **5.3 (b)** for transmission main and sub-main respectively.

5.3.5 Wahalkada System

The Wahalkada System is further divided into two sub-systems to cover northern part and Southern part of its service area. The former is named as Wahalkada Sub-system IIA and the latter as Wahalkada Sub-system IIB.
A schematic flow diagram of the Wahalkada System is shown in **Figure 5.25**.

To determine the size of transmission main and sub-main of Wahalkada system, hydraulic analysis has been carried out. The results of above hydraulic analysis are presented in Appendix 5.3.1-a and 5.3.1-b also for transmission main and sub-main respectively.

II. WAHALKADA TRANSMISSION SYSTEM FLOW DIAGLAM

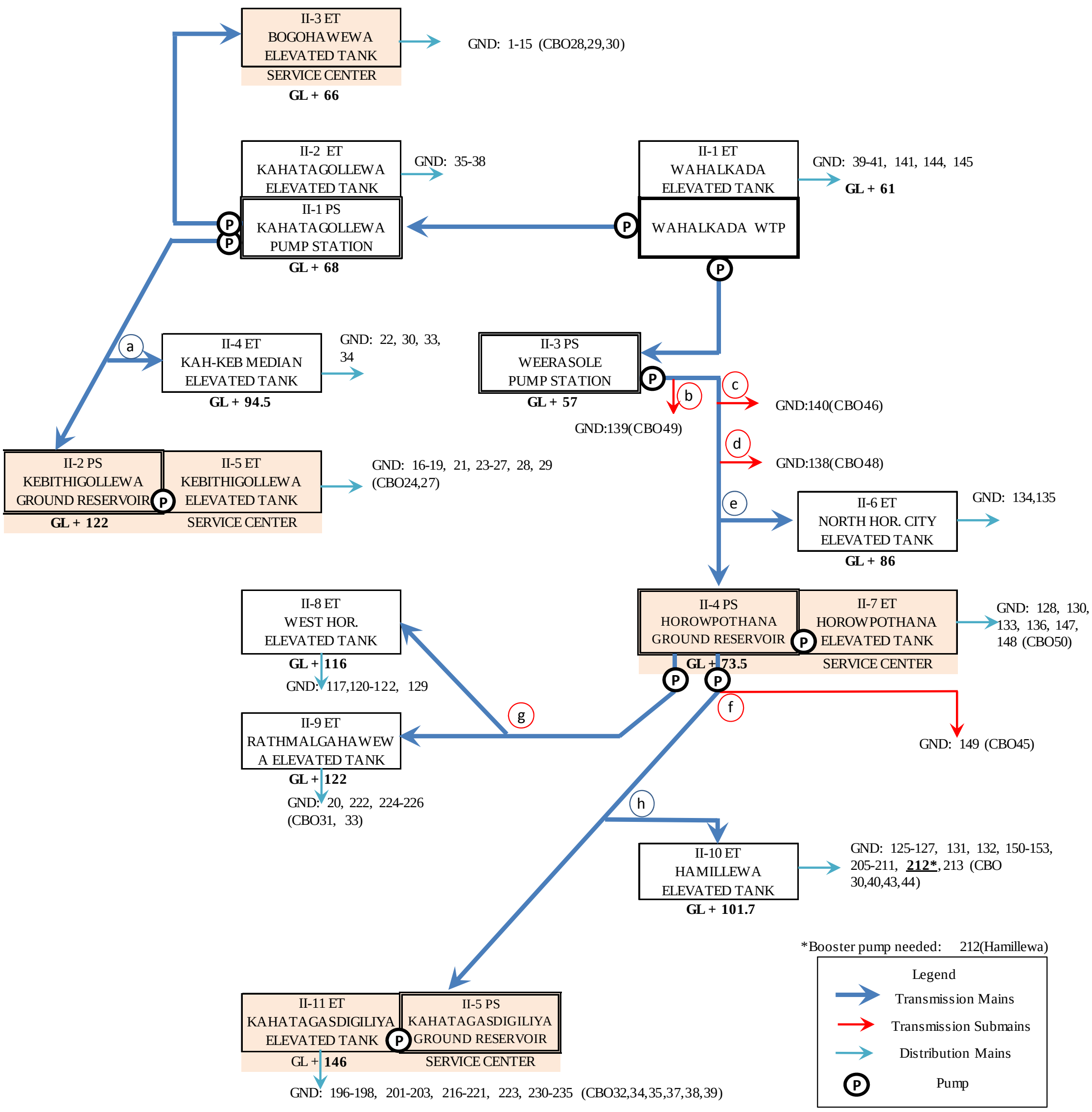


Figure 5.25 Schematic Flow Diagram of the Wahalkada System

(1) Wahalkada Sub-system IIA

Wahalkada Sub-system IIA conveys treated water (about 11,600 m^3/day as maximum day demand) to two service centers at Bogahawewa and Kebithigollewa. Wahalkada elevated tank (II-1 ET), which is located within the water treatment plant premises, distributes bulk water to five GNDs located in the area surrounding the water treatment plant by gravity.

The Wahalkada transmission sub-system IIA is composed of three sections as follows:

Section 1: from Wahalkada WTP to Kahatagollewa pump station along local road

Section 2: from Kahatagollewa pump station to Bogahawewa elevated tank along Route B 211

Section 3: from Kahatagollewa pump station to Kebithigollewa pump station along Route B 211

1) Section 1

Treated water is conveyed to the Kahatagollewa pump station (II-1 PS) from Wahalkada WTP through a transmission main of ND 400mm with a length of approximately 7.8 km. Transmitted water is lifted to an elevated tank (II-2 ET) in the same premises as the pump station, from where water is distributed to new systems in four (4) GNDs.

2) Section 2

The Kahatagollewa pump station transfers water to Bogahawewa Elevated tank (II-3 ET) at the service center in DSD Padaviya through a 12.0 km long approximately transmission main of ND 350 mm diameter. The elevated tank covers the entire service area of Padaviya, based on the topographical conditions. Although the majority of the service areas are located remotely from the tank, the ground elevation of these areas is more than 20 meters lower than ground level of the elevated tank. The tank will transmit bulk water to the existing system of NWSDB and CBOs. The remaining service areas will be supplied directly by gravity flow from the elevated tank.

3) Section 3

Water transmitted to the Kahatagollewa pump station is further boosted to Kebithigollewa service centers (II-2 PS and II-5 ET) in DSD Kebithigollewa through 20.1 km of ND 350mm transmission main, installed along Route B 211. The elevated tank is provided beside Kebithigollewa pump station to distribute water to new systems in five GNDs, two existing CBOs and five and the existing system under NWSDB, which covers five GNDs.

A branch (at Point “a”), at approximately 10.1 km downstream of Kahatagollewa pump station, is provided to feed bulk water to an elevated tank (II-3 ET). The elevated tank covers new systems in four GNDs.

Table 5.31 summarizes the existing system (NWSDB and CBOs) and new system for GNDs to be fed from transmission mains and distributed by respective new elevated tanks by Wahalkada transmission system II A.

Table 5.31 Existing and New Systems Covered by New Elevated Tank

Elevated Tank	NWSDB System	CBO System	New System
II-1 ET (Wahalkada)	-	-	39, 40, 41, 141, 144, 145
II-2 ET (Kahatagollewa)	-	-	35, 36, 37, 38
II-3 ET (Bogahawewa)	1, 2, 3	5, 6, 7, 14	4, 8, 9, 10, 11, 12, 13, 15
II-4 ET (KAH-KEB Median)	-	-	22, 30, 33, 34
II-5 (Kebithigollewa)	16, 17, 18, 23, 27	24, 25	19, 21, 26, 28, 29
Transmission Mains	-	32	-

Note [1]: GND 2 is covered by both NWSDB and CBO systems

(2) Wahalkada Sub-system IIB

About 15,200 m3/day of treated water from Wahalkada water treatment plant is conveyed to the area under Wahalkada Sub-system IIB of two service centers at Horowpothana and Kahatagasdigiliya.

The Wahalkada Sub-system IIB is composed of three sections as follows:

Section 1: from Wahalkada WTP to Horowpothana pump station along local road

Section 2: from Horowpothana pump station to Kahatagasdigiliya pump station along Route A12

Section 3: from Horowpothana pump station to Rathmalgahawewa elevated tank along Route B282

1) Section 1

The first section is between the Wahalkada water treatment plant (WTP II) and Horowpothana service center (II-4PS / II-7ET), where water transmitted from the water treatment plant is boosted at Weerasole (II-3PS) up to the Horowpothana service center. Due to the long distance between the water treatment plant and Horowpothana, (approximately 30km in length), a booster pump station is provided at Weerasole. Also the specific topographical features along the main route between Weerasole and Horowpothana are taken into account. There are two high points at about 7.4 km from Weerasole and 1.5 km before Horowpothana. The transmission main installed in this section is ND 450 mm in diameter and approximately 15.5 km long and runs along a local road. No main road is available in this area.

Four branches, after Weerasole pump station, are provided along this section. The first branch (point “b”) feeds one existing CBO at about 0.5 km from the pump station, and the second branch (point “c”) conveys water to one existing CBO also at about 1 km downstream from point “b”. The third branch (point “d”) feeds water to one existing CBO at about 4.0 km downstream of branch “c”. The forth branch feeds water to a new elevated tank (II-6 ET: North Horowpothana) at about 8.0 km upstream of Horowpothana service center. The elevated tank covers two new systems in GNDs.

It is noted that transmitted water is planned to receive at higher elevation (9 m high from ground elevation at Horowpothana Pump Station) due to the specific pipeline profile between Weerasole and Horowpothana as mentioned. The hydraulic gradient shall be above the pipeline with ample safety. Transmission main installed at a high point is located only 1.5 km upstream of Horowpothana pump station. Also this is effective to reduce the negative effect caused by surges by sudden stops of pump operation caused by power failure.

2) Section 2

Water received at Horowpothana service center is further pumped in two directions to Kahatagasdigiliya and Rathmalgahawewa elevated tank.

Transmitted water to Horowpothana Service center is lifted to the elevated tank (II-7 ET) located at this service center covers one existing CBO, two GNDs supplied by NWSDB at present and new systems for three GNDs.

Section 2 of transmission main is the route between Horowpothana service and Kahatagasdigiliya service centers along Route A 12. The length of the transmission main in this section is approximately 22.4 km with a diameter of ND 450 mm.

On the way to Kahatagasdigiliya service center, two branches are provided at points “f” and “h”. At the first branch (approximately 0.6 km from Horowpothana pump station), bulk water is fed to one existing CBO. The second branch, at 9.3 km upstream of Kahatagasdigiliya, transmit water to Hamillewa elevated tank (II-10 ET), which covers five existing CBOs and new systems for13 GNDs.

Kahatagasdigiliya elevated tank (II-11 ET), after receiving water lifted from the pump station, transmit bulk water to three (3) GNDs of the existing NWSDB system and nine existing CBOs by gravity. Also it distributes water directly to new systems of seven GNDs.

3) Section 3

Horowpothana pump station transfers water to Rathmalgahawewa elevated tank (II-9 ET) through ND 300 in diameters for approx. 19.2 km. At about 8.4km from Horowpothana pump station (branch g), a branch is provided to feed water to the West Horowpothana elevated tank (II-8) which feeds water to new system of five GNDs.

Table 5.32 summarizes the existing system (NWSDB and CBOs) and new system for GNDs to be covered by respective new elevate tanks by the Mahakanadarawa transmission system.

Table 5.32 Existing and New Systems Covered by New Elevated Tank

Elevated Tank	NWSDB System	CBO System	New System
II-6 North Horowpothana City	-	-	134,135
II-7 Horowpothana	128, 130	133	136, 147, 148
II-8 West Horowpothana	-	-	117,120,121,122,129
II-9 Rathmalgahawewa	-	222, 224, 225, 226	20
II-10 Hamillewa	-	126,209, 210, 211, 212, 213	125, 127, 131, 132, 150, 151, 152, 153, 205, 206, 207, 208
II-11 Kahatagasdigiliya	230, 231, 232	196, 201, 202, 218, 219,	197, 198, 203, 216, 217,

		221, 223, 233, 234	220, 235
Transmission Mains	-	119, 138, 139, 140, 149	-

(3) Transmission Sub-main

Transmission sub-mains are planned from branches of transmission mains to convey water to four new elevated reservoirs (II-4 ET, II-6 ET, II-8 ET and II-10 ET) and the existing CBOs. A total length of transmission sub-main is estimated at about 22 km composing of 0.2 km and 21.8 km in Sub-section A and B respectively, which pipe size is ranging from 250mm to 100mm in diameters.

5.3.6 Distribution System

(1) Method of Estimate

Distribution system, as mentioned earlier, is composed of distribution main and distribution sub-system. **Figure 5.26** illustrates definitive plan of the distribution system.

As shown on **Figure 5.26**, distribution main conveys water from the elevated tank directly to the GND's distribution sub-system which distributes water to each customer directly. On the other hand, the main feeds water to the existing elevated tank of CBO, from where distribution sub-system distributes water to each customer. In both cases, a water meter will be installed at the inlet of either distribution sub-system of new system of GND or existing elevated tank of CBO.

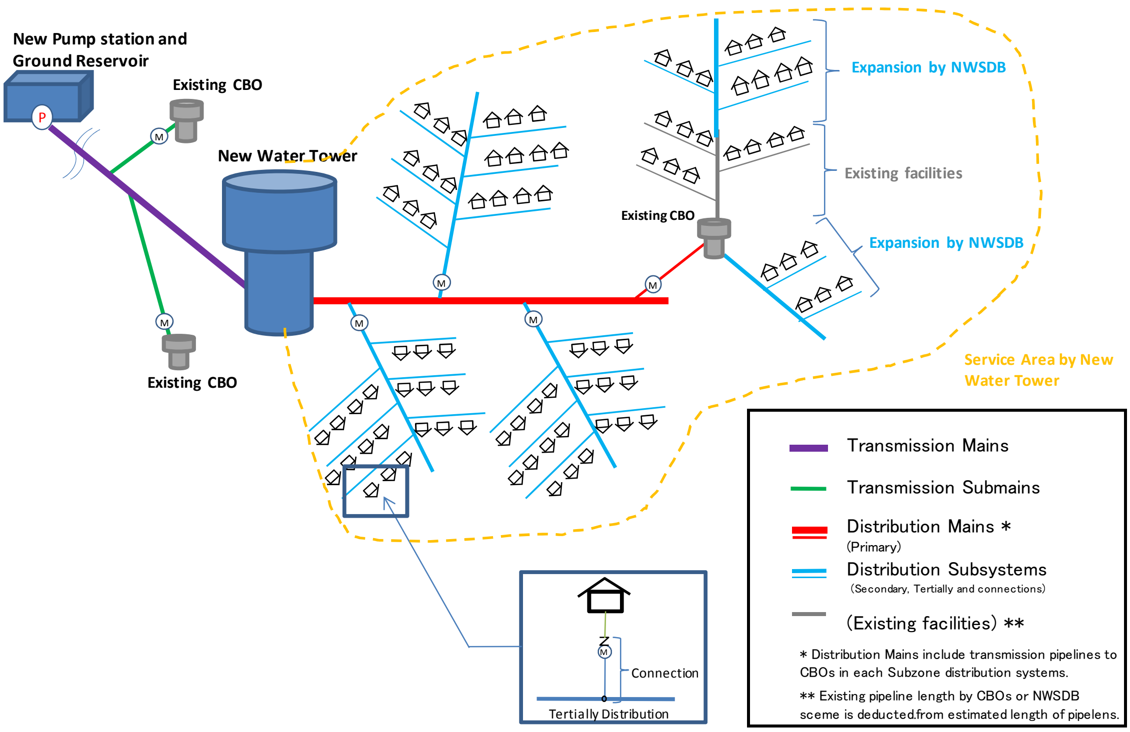


Fig. 5.26 Definitive Diagram of Distribution Systems

1) Distribution Trunk Main

The preliminary design of distribution main is carried out using Google map to obtain distance and ground elevation for analysis of sizing of distribution main for the purpose of cost estimate.

Appendix 5.3 (b) presents general layout of the distribution main for each subzone (11 subzones from elevated tanks) and hydraulic analysis

2) Distribution Sub-system (Refer to **Appendix 5.3 (c)**)

The study on distribution sub-system is carried out mainly for cost estimate purpose based on the following procedures:

- Firstly, select three networks (small, medium and large systems) designed by the existing CBO system. The system capacities of the above systems are 100m3/day as small system, 150m3/day as medium system and 300m3/day as large system.
- Secondly, determine the scale of the distribution systems of 150m3/day for small system, 300m3/day for medium system and 600m3/day for large system as day average demand in 2034.
- Then, by enlarging existing system in length and node discharge in proportion to demand difference, the network model was established. Using the above network model, network analysis was carried out to obtain size and pipeline length.
- Finally, unit length of each size of distribution pipe per service connection was analyzed to obtain pipeline length by size for respective size of network.
- Using above unit length, pipeline length of each size were estimated by GND.

(2) Pipeline length

1) Distribution Main

The sizing of distribution main was determined peak hour demand of year 2034 requirement for new system of GND and day maximum demand of year 2034 for the existing CBO.

Based on the hydraulic analysis of the distribution main, length of each size of pipeline was obtained as presented in **Table 5.34**.

2) Distribution Sub-system

Using unit length to service connection, the pipeline length for each size was estimated for Phase I (year 2024) based on the following considerations:

- Pipeline lengths of 100mm or larger were estimated for year 2034 requirement
- Pipeline lengths of 50mm and 75mm were estimated for year 2024 requirement corresponding to the construction period.

The results of pipeline length for Stage-1 requirement are summarized in **Table 5.34** also. It should be noted that the length in the table is for a year 2024 requirement which corresponds to the project implementation period.

The number of service connections required for the project implementation is also shown in **Table 5.33**.

Table 5.33 Additional Quantities of Service Connections

Items	Mahakanadarawa		Wahalkada		Total
	NWSDB	CBO	NWSDB	CBO	
Service Connection by 2018 (Nos.)	1,647	1,279	2,940	1,529	7,395
Service Connection (2019-2024) (Nos.)	1,134	1,474	1,361	1,580	5,549
Total by 2024 (Nos.)	2,781	2,753	4,301	3,109	12,944

5.3.7 Major Facilities of Transmission and Distribution System

(1) General

Major facilities presented in this sub-section are for civil structures, buildings, and pipelines excluding mechanical and electrical equipment which are described in Sub-sections 5.4 and 5.5 respectively.

The major facilities include transmission mains and sub-mains, ground reservoirs and sumps for pump stations, elevated tanks for distribution, operation buildings and distribution mains. The service center will be provided with a ground reservoir, pump station, operation building and other miscellaneous facilities. Elevated tanks will be placed at strategic locations where a caretaker/operator quarter will be provided.

(2) Ground Reservoir

The retention time of ground reservoirs is taken at two hours for transmission flow as mentioned previously. The ground reservoir, which is a reinforced concrete structure, is divided into two compartments for maintenance. The reservoir is equipped with an inlet and outlet valve installed in each compartment. In addition, a drain pipe with valve and overflow pipe is installed in each compartment.

(3) Pump Station

The pump station, which is comprised of a pump room and electrical/control room, is provided adjacent to the reservoir. The transmission pumps are installed in the pump room and electrical and control equipment are housed in the electrical room, adjacent to the pump room. The pump station is a single story, reinforced concrete structures.

(4) Elevated Tank

The elevated tank having eight hours' retention time is circular in shape, constructed of reinforced concrete, as shown on the standard drawings. The height at low water level is set as 21 m above ground elevation with water depth of 6-7 meters depending on its volume capacity. The elevated tank is supported by a cylinder-shaped concrete structure in which access to the tank and pipe gallery will be provided.

(5) AE/OIC Office

The AE/OIC Office is composed of an AE/OIC office, a customer counter, a zonal laboratory, night duty room, washrooms and an entrance hall. The purpose of the zonal laboratory is water quality testing in transmission and distribution system and therefore it is assumed to be equipped only with testing facilities for residual chlorine, turbidity and pH.

(6) Chlorination House

The chlorination house, equipped with liquid chlorine dosage equipment, is provided at every ground reservoir or elevated tank sites. The house is composed of a chlorine storage room, a chlorination room (chlorine ejector), a booster pump room, chlorine bath for chlorine neutralization and eye shower.

(7) Generator House

Beside the pump station, a generator house is provided for emergency use in case of power supply failure. The generator house will be a single story reinforced concrete structure with an oil storage tank outside.

(8) Staff and Caretaker/Operators' Quarters

Operator/Caretaker's quarters will be constructed at each Ground Reservoir or Elevated Tank sites. In addition, staff quarters will be constructed in the premises of six service centers at Rambewa, Medawachchiya, Bogahawewa, Kebithigollewa, Horowpothana and Kahatagasdigiliya. The quarters are assumed to be of a size suitable for one operator with his family.

(9) Area Engineer's Office with SCADA system/ Costumer Counter

An Area Engineer's Offices with SCADA system will be constructed for each DS division in six service centers at Rambewa, Medawachchiya, Bogahawewa, Kebithigollewa, Horowpothana and Kahatagasdigiliya. The building is combined with the customer service counter for the payment of the bill in each DS division. The Area Engineer's Office with SCADA system/ Customer Counter will be a single story reinforced concrete structure.

(10) Workshop

A workshop is provided for the storages pipes, customer meters and repairing materials and also space for the maintenance activity. It will be placed at strategic places in service centers such as Medawachchiya, Kebithigollewa and Horowpothana. Workshops will be single story reinforced concrete structures.

(11) Transmission and Distribution Mains

As mentioned previously, the transmission pipeline systems are composed of transmission mains and sub-mains. The transmission mains form a grid system between the water treatment plant, service centers and elevated tanks. Transmission sub-mains will be branched from the transmission mains to the elevated tanks located at strategic locations to cover respective GNDs for distribution.

The distribution system is composed of distribution main and sub-system as mentioned previously. The distribution main is installed between the elevated tanks to the respective GND at their receiving points, from where the distribution sub-system (network) will be installed to distribute water to the respective consumers.

The summary of major facilities of transmission and distribution system is presented in **Tables 5.34 to 5.36** and **Figure 5.27** below:

Table 5.34 Summery of Pipelines of Transmission and Distribution System

Items/ Length of Pipelines (km)	Nominal Diameter (mm)										Total
	50	75	100	150	200	250	300	350	400	450	
I. Mahakanadarawa System											
1) Transmission Mains	-	-	-	-	-	7.6	7.5	3.3	13.1	10.8	**42.3**
2) Transmission Sub-mains	-	-	23.0	5.9	21.6	0.3	-	-	-	-	**50.8**
3) Distribution Mains	-	-	7.0	55.5	41.2	26.1	4.3	5.6	1.7	-	**141.4**
4)-1 Distribution Sub-System (NWSDB scheme)	80.2	25.6	59.7	31.3	4.8	-	-	-	-	-	**201.6**
4)-2 Distribution Sub-System (Existing CBO scheme)	130.6	113.8	49.1	18.8	2.8	-	-	-	-	-	**315.1**
Subtotal*	**210.8**	**139.4**	**138.8**	**111.5**	**70.4**	**34.0**	**11.8**	**8.9**	**14.8**	**10.8**	**751.2**
II. Wahalkada System											
1) Transmission Mains	-	-	-	-	-	-	20.2	33.7	20.8	42.6	**117.3**
2) Transmission Sub-mains	-	-	18.6	0.1	5.0	0.6	-	-	-	-	**24.3**
3) Distribution Mains	-	-	46.0	138.0	72.9	43.7	11.7	9.8	4.6	-	**326.7**
4)-1 Distribution Sub-System (NWSDB scheme)	148.5	63.2	127.2	32.8	6.7	-	-	-	-	-	**378.4**
4)-2 Distribution Sub-System (Existing CBO scheme)	102.7	75.7	48.3	23.4	4.5	-	-	-	-	-	**254.6**
Subtotal*	**251.2**	**138.9**	**240.1**	**194.3**	**89.1**	**44.3**	**31.9**	**43.5**	**25.4**	**42.6**	**1101.3**
Total	**462.0**	**278.3**	**378.9**	**305.8**	**159.5**	**78.3**	**43.7**	**52.4**	**40.2**	**53.4**	**1852.5**

Note 1): length of transmission main in the above table includes additional 5% of estimated length that will be allowed when latent site conditions are considered.

2): lengths of transmission sub-main and distribution main in the above table include additional 10% of estimated length that will be allowed since the estimate is based on Google map which is considered as not accurate enough.

3): length of distribution sub-system in the above table includes additional 10% of estimated length that will be allowed since the estimate is based on the plot type design based on network model which is considered not accurate enough

1)~3): HDPE, **4)-1~2:** PVC

* Subtotal of each items:

1) Transmission Mains: **159.6 km**, 2) Transmission Sub-mains: **75.1 km**, 3) Distribution Mains: **468.1 km**

4) Distribution Sub-System (NWSDB scheme): **580.0 km**, (Existing CBO scheme): **569.7 km**

Table 5.35 Summery of the Facilities to Be Constructed

System	Site	Elevated Tank	Ground Reservoir	Pump House	Operational Complex *1	Chlorinator Building	Generator	Workshops	Quarters for Staff	Quarters for Operator	Surge Tank (100m3)
Mahakanadarawa	Rambewa	1,250m3	1,500m3	✓	✓	✓	✓		✓	✓	
	Medawachchiya		1,000m3	✓	✓ *2 *3	✓	✓	✓	✓	✓	
	Issinbassagala	2,000m3				✓				✓	
	Ethakada	750m3				✓				✓	
	East Rambewa	250m3				✓				✓	
	Mahakanadarawa ~Rambewa										✓✓
Wahalkada South	Wahalkada	500m3				✓				✓	
	Kahatagollewa	250m3	1,000m3	✓		✓	✓			✓	
	Bogahawewa	2,000m3			✓	✓			✓	✓	
	KAH-KEB Median	250m3				✓				✓	
	Kebithigollewa	750m3	500m3	✓	✓ *3	✓	✓	✓	✓	✓	
Wahalkada North	Weerasole		1,500m3	✓		✓	✓			✓	
	North Horowpothana	250m3				✓				✓	✓
	Horowpothana	500m3	1,000m3	✓	✓ *3	✓	✓	✓	✓	✓	
	West Horowpothana	750m3				✓				✓	
	Rathmalgahawewa	500m3				✓				✓	
	Hamillewa	1,250m3				✓				✓	
	Kahatagasdigilliya	1,500m3	500m3	✓	✓	✓	✓		✓	✓	
Total		**15**	**7**	**7**	**6**	**17**	**7**	**3**	**6**	**17**	**3**
Symbol											

*1 Lab., OICs Office, Customer Counter, Room for Crews

*2 Satelite Office is to be included

*2 OIC Office should be replaced to Area Engineers Office

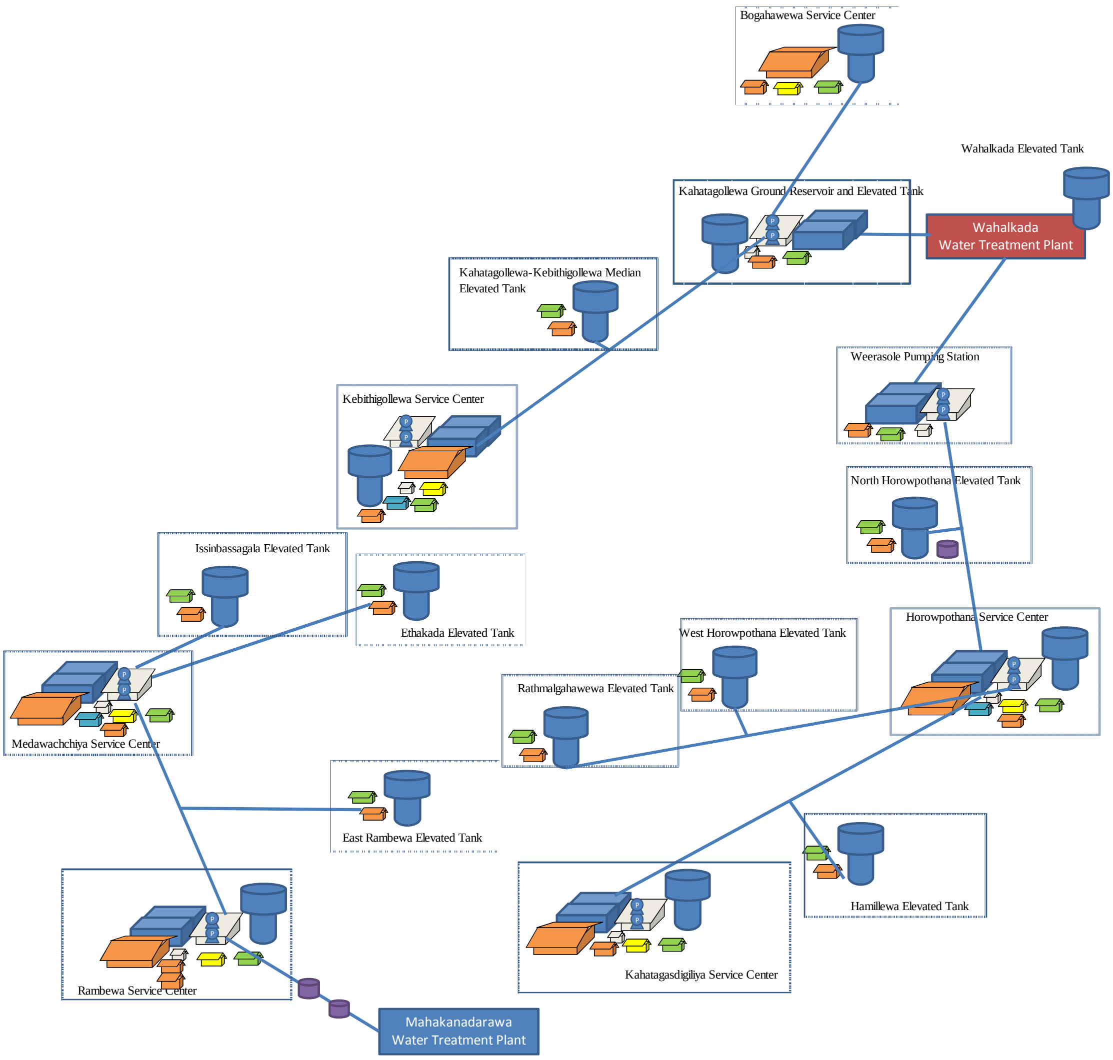


Figure 5.27 Summary Diagram of the Facilities to be Constructed

Table 5.36 Major Facilities of Transmission and Distribution System

DS Division	Land Location	Facilities to be constructed
Rambewa	Rambewa *	Elevated Tank (1,250m3) Ground Reservoir (1,500m3) Pump House / Power Control Unit Generator Operational complex — Zonal Lab Operational complex — OIC Sub-office with SCADA monitor Operational complex — Customer Counter Operational complex — Room for crews Chlorinator Building Staff Quarters Caretaker/Operator Quarters Guard House Parking/Bowser Station
	East Rambewa	Elevated Tank (250m3) Chlorinator Building Caretaker/Operator Qts
	Surge Tank A	One Way Surge Tank (100m3)
	Surge Tank B	One Way Surge Tank (100m3)
Medawachchiya	Medawachchiya *	Ground Reservoir (1,000m3) Pump House / Power Control Unit Generator Operational complex - Zonal Lab Operational complex - Area Eng. office with SCADA monitor Operational complex - Customer Counter Operational complex - Room for crews Chlorinator Building Workshop Staff Quarters Caretaker/Operator Quarters Guard House Parking/Bowser Station
	Issinbassagala	Elevated Tank (2,000m3) Chlorinator building Caretaker/Operator Qts
	Ethakada	Elevated Tank (750m3) Chlorinator Building Caretaker/Operator Qts
Horowpothana	Wahalkada	Elevated Tank (500m3)
	Weerasole	Ground Reservoir (1,500m3) Chlorinator Building Generator Caretaker/Operator Qts Parking/Bowser Station
	Horowpothana *	Elevated Tank (500m3) Ground Reservoir (1,000m3) Pump House / Power Control Unit Generator Operational complex -Zonal Lab Operational complex -BCustomer Counter

DS Division	Land Location	Facilities to be constructed
		Operational complex — Room for crews Chlorinator Building Workshop Staff Quarters Caretaker/Operator Quarters Guard House Parking/Bowser Station
	North Horowpothana City	Elevated Tank (250m3) Chlorinator Building Caretaker/Operator Qts One Way Surge Tank Parking/Bowser Station
	West Horowpothana	Elevated Tank (750m3) Chlorinator Building (100m2) x1 Caretaker/Operator Qts (100m2) x1
	Hamillewa	Elevated Tank (1,250m3) Chlorinator Building Caretaker/Operator Qts
Kahatagasdigiliya	Kahatagasdigiliya *	Elevated Tank (1,500m3) Ground Reservoir (500m3) Pump House / Power Control Unit Generator OIC Sub-office with SCADA monitor / Customer Counter Operational complex - Zonal Lab Operational complex - OIC Sub-office with SCADA monitor Operational complex - Customer Counter Operational complex - Room for crews Chlorinator Building Staff Quarters Caretaker/Operator Quarters Guard House Parking/Bowser Station
	Rathmalgahawewa	Elevated Tank (500m3) Chlorinator Building Caretaker/Operator Qts
Kebithigollewa	Kebithigollewa *	Elevated Tank (750m3) Ground Reservoir (500m3) Pump House / Power Control Unit Generator Operational complex - Zonal Lab Operational complex - Area Eng. office with SCADA monitor Operational complex - Customer Counter Operational complex - Room for crews Workshop Chlorinator Building Staff Quarters Caretaker/Operator Quarters Guard House Parking/Bowser Station
	KEB-KAH Median	Elevated Tank (250m3) Chlorinator Building

DS Division	Land Location	Facilities to be constructed
		Caretaker/Operator Quarters
	Kahatagollewa	Ground Reservoir (1,000m3)) Elevated Tank (250m3) Chlorinator Building Caretaker/Operator Quarters
Padaviya	Bogahawewa *	Elevated Tank (2,000m3) Operational complex - Zonal Lab Operational complex - OIC Sub-office with SCADA monitor Operational complex - Customer Counter Operational complex - Room for crews Chlorinator Building Staff Quarters Caretaker/Operator Quarters Guard House Parking/Bowser Station

* Service Center

5.4 Mechanical Equipment

5.4.1 Design Criteria of Pumping Stations

Design of equipment and the planning of pumping stations are based on criteria issued by NWSDB as shown below, and from the survey results of the existing pump stations.

(1) Design Manual D5, Mechanical, Electrical and Instrumentation Aspects of Water Supply Design March 1989
(2) Procurement of Supply and Install Mechanical & Electrical Equipment and Accessories for Water Supply Scheme
(3) NWSDB/SBD/S&I/Water Pump: Specifications for Horizontal Shaft Driven Double Suction Pumping Sets and Accessories
(4) NWSDB/SBD/S&I/Water Pump: Specifications for End Suction Vertical Delivery Back Pull out Centrifugal Pumping Sets and Accessories

5.4.2 Planning of Pump Station

The pump stations particularly take the following points into consideration:
(1) Energy conservation
Design systems to minimize use of energy and provide better energy efficiency, such that the pumps are effectively operated and save electric power.
(2) Operation
The facilities in pumping stations should allow easy operation and maintenance.

(3) Water intake

It is considered as the plan under which the required water for the city can be certainly taken through one year from an irrigation canal and a measure of discharging the sand/silt deposit on intake waterways.

(4) Water Hammer

Water hammer analysis is conducted such that water can be transmitted safely.

5.4.3 Intake Facility

Water taken from an irrigation canal is conveyed to the pump suction pit by an open channel. In the pump suction pit, it is necessary to lower the bottom from the level of irrigation canal in order to keep air from going into a pump, thus sand/silt is deposited in the pump suction pit. Therefore, a facility which discharges the sand/silt from the pump pit to a sand sedimentation pond is planned. After discharging periodically to the pond by pump, the clear supernatant liquid is returned to the irrigation canal, and the sand/silt which is deposited is removed manually by workers.

The intake facility includes the following:

(1) Gate equipment which is installed at the intake point for stopping water at drainage work

(2) Submersible drainage pump with a beating impeller, which exhausts the sand/silt

(3) Gantry crane for lifting and moving a submersible drainage pump on the pump suction pit

(4) Sand sedimentation pond in which water and sand/silt are separated

<u>The requirement for grit removal equipment shall be studied and determined during the detailed design stage based on the status of silt deposition in raw water confirmed.</u>

5.4.4 Pump

<u>The pump floor elevation shall be set so as not to have the damage at the time of flood based on the study during the detailed design stage.</u>

<u>Control method of transmission systems shall be studied and determined during the detailed design stage.</u>

(1) Operation system of pump

1) Control of intake pump

Intake pump stations are built in or near the site of the water treatment plant, and operation is performed from the administration building of the plant. Since the change in water supply demand from when operation will start in 2018 to the target year of 2034, or roughly in the range of 25% (of the 2034 demand) to 100%, the pumps need to operate efficiently, corresponding to the change in demand. Therefore, an operating system that the pump speed is adjusted according to the change in water demand, which is more effective than operation method of pump number and valve control, is adopted. Speed control (VVVF system) equipment is equipped in each pump panel, and the pump speed is determined according to the required amount of water from the administration building of the water treatment plant.

2) Control of transmitting pump with a motor rating of 15kW or more

Although the number control of pumps is carried out at the existing pump station, looking at the water level of the transmitted tank, the power loss becomes large. Therefore, speed control which can smoothly supply water of the required amount to suit the demand is adopted.

Operation of pumps is carried out using a system which adjusts the speed manually, based on the water level signal from the water tank, which is the same method as is used for existing pumps. A water level meter is installed in each water tank and the SCADA system sends the water level signal to the pump station as discussed in Clause 5.5.

3) Control of transmitting pump with a motor rating of 11kW or less.

For the pump with motor rating such as 11kW or less, the number control of pumps by discharge water levels is selected for that the energy-conservation advantage is small.

(2) The number of pumps

It is desirable to select a number pumps (4) because the water demand will increase from 25% (of 2034 demand) in 2018 to 100% in 2034. However, since the speed control system is used, it is possible to reduce the number of pumps. Therefore, the number of pumps is decided as shown in **Table 5.37.**

All essential pump systems include one standby pump/motor set to provide.

Table 5.37 Number of Pump Installed

Application	To be installed in initial stage		To be installed in future stage	Reason for selection
	Duty pump	Standby pump		
Transmission pumps	One (1) set	One (1) set	One (1) set	
Intake pumps	Two (2) sets	One (1) set	One (1) set	Intake pumps are required to have higher flow controllability.

(3) Type of pump and materials

The horizontal pump, which has easier maintenance than a vertical pump, is selected. For that purpose, the pump stations and water tanks are separated from each other.

The pump speed is selected as 1500 min^{-1} from the standard pump range because of higher efficiency compared to high-speed pumps operating at 3000 min^{-1}.

The materials of the main parts of a pump are as follows, taking into consideration the possibility of corrosion by chlorine.

1) Pump shaft : Stainless Steel
2) Impeller : Stainless Steel Casting
3) Casing : Cast Iron
4) Shaft Sleeve : Stainless Steel

5.4.5 Electric Motor

(1) Type of electric motor

The electric motor is directly coupled with the pump, and the specification of the motor is according to the requirements of "NWSDB/SBD/S&I/Water Pump".

1) Type of motor : Squirrel cage induction motor, indoor
2) Starting method : Variable speed drive for 15kW or more
: Soft start for 11kW or less
3) Voltage : 400V ±6%
4) Frequency : 50Hz
5) Insulation : F-class
6) Temperature rise : B-class
7) Enclosure : IP55
8) Speed : 4-pole

5.4.6 Selection of Pump

(1) Water transmission routes

The water transmission routes in Mahakanadarawa area are shown as **Figure 5.28** and the water transmission routes in Wahalkada are as shown in **Figure 5.29** and **Figure 5.30.** Pump stations will be constructed at intake places, near ground reservoirs and in the treatment plants.

Table 5.38 Pump Station and Pump No. in the Mahakanadarawa Area

Pump station	Pump No.
The Mahakanadarawa	Pa, Pb
The Rambewa	Pc, Pd
The Medawachiya	Pe, Pf

Table 5.39 Pump Station and Pump No. in the Wahalkada Area

Pump station	Pump No.
The Wahalkada	Pg, Ph, Pi, Po
The Kahatagollewa	Pj, Pk, Pl
The Kebithigollewa	Pm
The Weerasole	Pp
The Horowpohana	Pq, Pr, Ps
The Kahatagasdigiliya	Pt

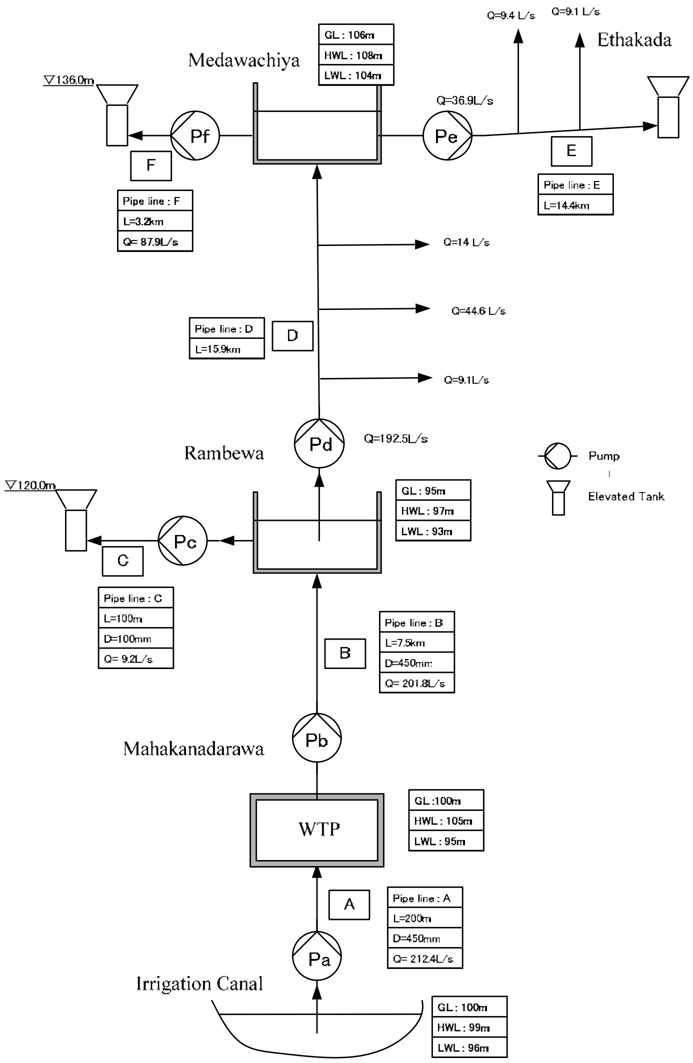


Figure 5.28 Water Transmission Flow for Mahakanadarawa

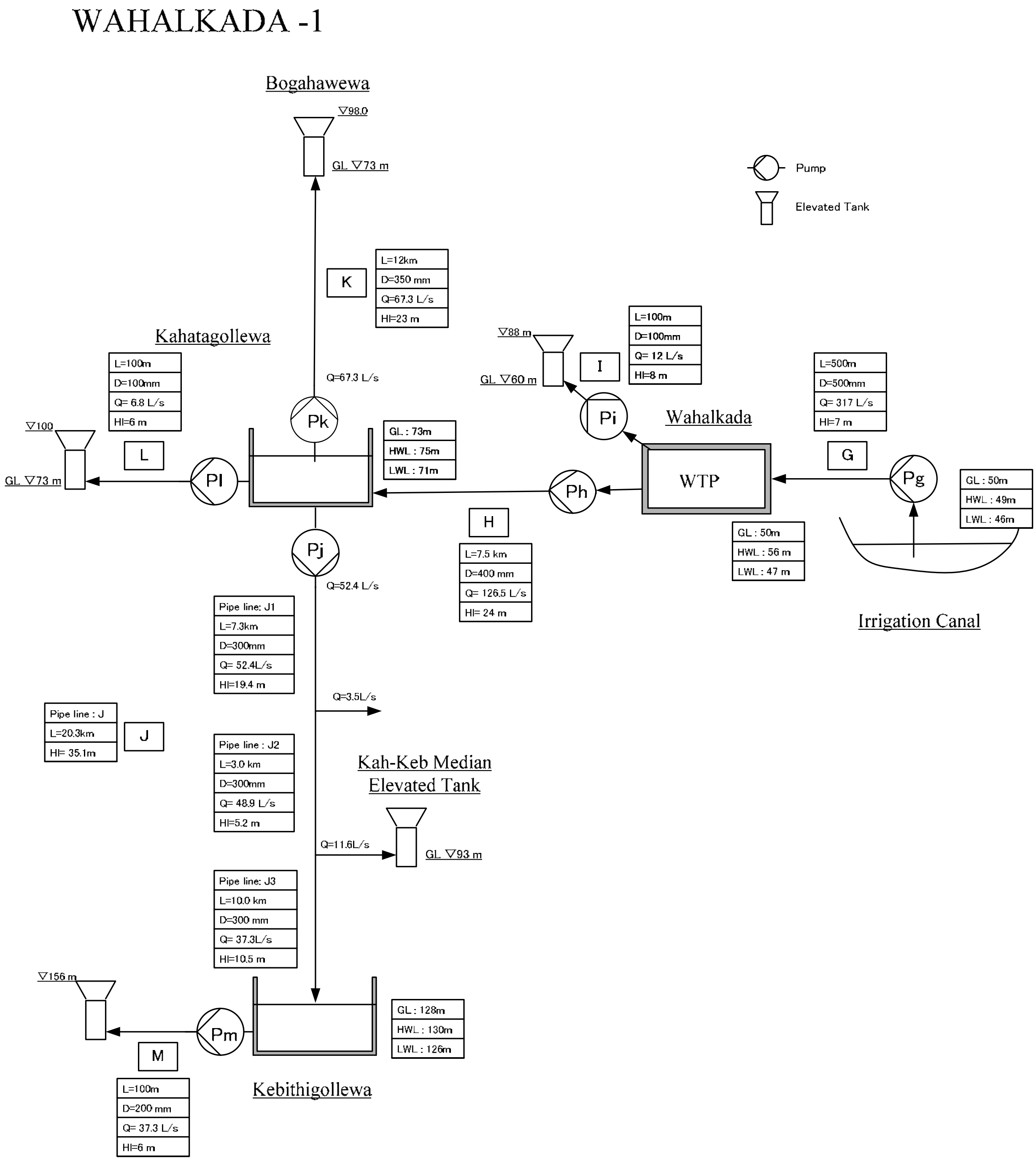


Figure 5.29 Water Transmission Flow for Wahalkada Area-1

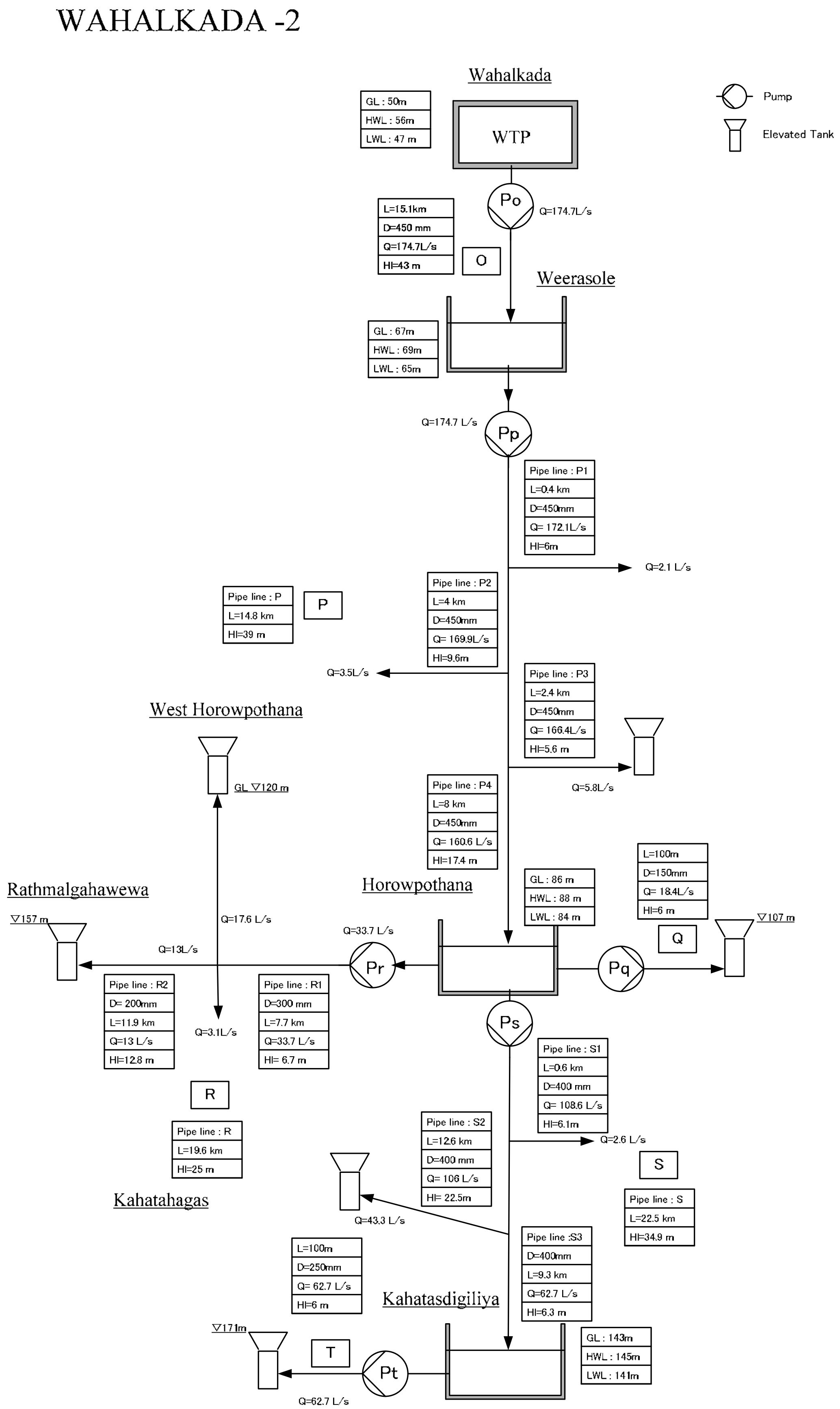


Figure 5.30 Water Transmission Flow for Wahalkada Area-2

(2) Calculation of total head

The amount of water supply, friction loss and total pump head of each transmission pipeline are shown in **Tables 5.40 to 5.42**.

Table 5.40 Calculation of Total Head for Mahakanadarawa

Item		Unit	Pa	Pb	Pc	Pd	Pe	Pf
Total flow	QT	m3/s	0.212	0.202	0.030	0.172	0.037	0.088
Suction level	Hs	M	96	97	93	93	104	104
Discharge level	Hd	M	106	97	123	108	151	139
Actual head	Ha	M	10	0	30	15	47	35
Length of pipe	L	M	200	7,500	100	15,900	14,400	3,200
Pipe diameter	D	M	0.45	0.45	0.15	0.45	0.25	0.35
Velocity	Dv	m/s	1.336	1.269	1.704	1.079	0.752	0.914
Friction loss	Hl1	M	1	25	2	40	39	8
Other loss	Hl2	M	5	5	5	5	5	5
Total loss	HL	M	6	30	7	45	44	13
Total head	H	M	16	30	37	60	91	48

Table 5.41 Calculation of Total Head for Wahalkada-1

Item		Unit	Pg	Ph	Pi	Pj	Pk	Pl	Pm
Total flow	QT	m^3/s	0.317	0.1265	0.012	0.0524	0.0673	0.0068	0.0373
Suction level	Hs	M	46	47	47	71	71	71	126
Discharge level	Hd	M	56	75	88	130	98	100	156
Actual head	Ha	M	10	28	41	59	27	29	30
Length of pipe	L	M	500	7,500	100	20,300	12,000	100	100
Pipe diameter	D	M	0.5	0.4	0.1	300	0.35	0.1	0.2
Velocity	Dv	m/s	1.615	1.007	1.529	-	0.700	0.866	1.188
Friction loss	Hl1	M	2	19	3	30	18	1	1
Other loss	Hl2	M	5	5	5	5	5	5	5
Total loss	HL	M	7	24	8	35	23	6	6
Total head	H	M	18	52	49	95	50	35	36

Table 5.42 Calculation of Total Head for Wahalkada-2

Item		Unit	Po	Pp	Pq	Pr	Ps	Pt
Total flow	QT	m^3/s	0.1747	0.1747	0.018	0.034	0.1086	0.0627
Suction level	Hs	M	47	65	84	84	84	141
Discharge level	Hd	m	69	88	107	157	145	171
Actual head	Ha	m	22	23	23	73	61	30
Length of pipe	L	m	15,100	14,800	100	19,600	22,500	100
Pipe diameter	D	m	0.45	450	0.15	300/200	400	0.25
Velocity	Dv	m/s	1.099	-	1.042	-	-	1.278
Friction loss	Hl1	m	38	34	1	20	30	1
Other loss	Hl2	m	5	5	5	5	5	5
Total loss	HL	m	43	39	6	25	35	6
Total head	H	m	66	62	29	98	96	36

(3) Specification of pump

It is necessary to plan selection of a pump so that cavitation does not occur at operating points. Therefore, it is desirable to select a pump so that the pump capacity is located at smaller capacity than the pump design capacity. The specifications of pumps are shown in **Tables 5.43 to 5.45**.

Table 5.43 Specification of Pump for Mahakanadarawa

Item		Unit	Pa	Pb	Pc	Pd	Pe	Pf
Type of pump			DV	DV	MC	DV	MC	ES
Diameter	D	mm	200	200	100	200	100	150
Number of Pump Duty + spare(1)			3	2	2	2	2	2
Pump capacity	QP	M^3/min	4.25	6.05	0.90	5.15	1.11	2.64
Total head	H	m	16	30	37	60	91	48
Pump speed	N	min^{-1}	1475	1475	1475	1475	1475	1475
Motor output	kW	kW	15	45	11	90	30	37

DV: Double suction volute pump
MC: Multi-stage centrifugal pump
ES : End suction volute pump

Table 5.44 Specification of Pump for Wahalkada-1

Item		Unit	Pg	Ph	Pi	Pj	Pk	Pl	Pm
Type of pump			DV	DV	MC	MC	ES	MC	ES
Pump diameter	D	mm	250	200	65	125	125	65	125
Number of pump Duty + spare(1)			3	2	2	2	2	2	2
Pump capacity	QP	m^3/min	6.34	3.80	0.36	1.57	2.02	0.20	1.12
Total head	H	m	18	52	49	95	50	35	36
Pump speed	N	min^{-1}	1475	1475	1475	1475	1475	1475	1475
Motor output	kW	kW	30	55	5.5	45	30	3.7	15

Table 5.45 Specification of Pump for Wahalkada-2

Item		Unit	Po	Pp	Pq	Pr	Ps	Pt
Type of pump			DV	DV	MC	MC	MC	ES
Pump diameter	D	mm	250	250	80	100	150	125
Number of pump Duty + spare(1)			2	2	2	2	2	2
Pump capacity	QP	m^3/min	5.24	5.24	0.55	1.01	3.26	1.88
Total head	H	m	66	62	29	98	96	36
Pump speed	N	min^{-1}	1475	1475	1475	1475	1475	1475
Motor output	kW	kW	90	90	5.5	30	75	22

(4) Spare parts

Spare parts are equipped at each pump as follows, according to “NWSDN/SBD/S&I/Water Pump: Specification, October-Version 2”.

a. Impeller	: 1 set
b. Shaft sleeves	: 2 sets
c. Pump bearings	: 2 sets
d. Motor bearings	: 1 set
e. Impeller neck rings	: 1 set
f. Casing wear rings	: 1 set
g. Coupling bushes	: 1 set
h. Gland	: 1 set
i. Gland packing	: 1 set
j. All gaskets, seals and packings	: 2 sets
k. Stuffing box gland with nuts & bolts	: 1 set

5.4.7 Other Equipment

The following equipment is installed in each pump station.

(1) Overhead traveling crane
All motions of traverse, travel and lifting are manually operated.
(2) Flow control valve
One flow control valve is installed at each transmission pipe.
(3) Valves for suction and discharge of pump
Since pumps are installed in a position lower than the low water level of suction tank, a sluice valve is equipped at the pump suction side, and a check valve and a motor operated valve in the pump discharge side.
(4) Indoor piping
The indoor piping is made from Mild Steel, with flanges of ISO PN16.
(5) Drain pumps in pump room
One drain pump with one standby is provided.

5.4.8 Measures against Water Hammer

(1) Water hammer measure system
The general features of the different surge protection measures are shown in **Table 5.46**.

Table 5.46 Comparison of Measure System

Measure system	General feature
One-way Surge tank system	Although it is a simple method, the installation space is needed on the pipeline, and in order that the setting position may be left distantly from the pump station. There is a fault that maintenance management is difficult.
Surge vessel system	It is not suitable for the pipeline form such as passing the mountain, flat and going-down slope. It is expensive, and it is not easy to maintain because this system consists of many equipment and instruments. In case of bladder accumulator type, the selection which meets actual requirements such as size, gas volume and pressure is difficult.
Flywheel method	Maintenance management is very easy and reliable, and it is economical. The effect is almost the same as surge vessel system.
Air valve	When negative pressure arises in pipeline by down surge, it is the simplest system that puts air in a pipe and relieves negative pressure. However, if a pump is again started in the condition where air remains in pipe, there is a danger of air hammer generating. The reliability of the functional maintenance is very low.

It is judged from the above table that the flywheel method is the most appropriate system and this is adopted. The main reasons for this are easy maintenance management and cost saving.

However, if negative pressure cannot be prevented by using the flywheel system only, in cases such as pipelines passing over a mountain, the one-way surge tank is installed at the high point of the pipeline.

(2) Pipelines to be analyzed

It is expected that the dangerous negative pressure (below -5m) for the transmission pipelines sending water to the elevated tanks does not occur, because the water level in elevated tanks is 20m to 25m higher than pipeline level. Therefore, the calculations of surge analysis are conducted for the pipelines from pump stations to ground reservoirs. The water transmission flows are shown in **Figures 5.30 to 5.32**, and the pipelines analyzed are listed as follows.

Mahakanadarawa Area ：B and D pipelines
Wahalkada Area-1 ：H and J pipelines
Wahalkada Area-2 :O, P and S pipeline

(3) Result of water hammer analysis

The negative pressure which result from the down surge makes higher than dangerous negative pressure -5m in consideration of calculation or a survey error. The results of surge analysis and measure for preventing the dangerous pressure are shown in **Tables 5.47 to 5.49**.

Table 5.47 Measure Method for the Mahakanadarawa Area

Pipe No.	From	To	Pipe length (m)	Dia. (mm)	Flow (L/s)	Result of analysis and measure
B	WTP	Rambewa	7,500	450	202	Dangerous negative pressure occurs. Since there is a high ground point in the middle of pipeline, it is necessary to install a one-way surge tank. Measure with a one-way surge tank and with flywheel GD^2 $50kgm^2$
D	Rambewa	Medawachiya	15,900	450, 400	172	Dangerous negative pressure occurs. Measure with flywheel GD^2 $100kgm^2$

WTP: Water treatment plant

The analysis of water hammer is attached in APPENDIX

Table 5.48 Measure Method for the Mahakanadarawa Area-1

Pipe No.	From	To	Pipe length (m)	Dia. (mm)	Flow (L/s)	Result of analysis and measure
H	WTP	Kahatagollewa	7,500	450	127	Dangerous negative pressure occurs. Measure with flywheel GD^2 $150kgm^2$
J	Kahatagolle wa	Kebithigollewa	20,300	450, 400	52.4	No dangerous negative pressure

Table 5.49 Measure Method for the Wahalkada Area-2

Pipe No.	From	To	Pipe length (m)	Dia. (mm)	Flow (L/s)	Result and measure
O	WTP	Weerasole	15,100	450	175	Dangerous negative pressure occurs. Measure with flywheel GD^2 $150kgm^2$
P	Weerasole	Horowpothana	14,800	450	175	Dangerous negative pressure occurs. Since there are high ground points in the middle of pipeline, it is necessary to install a one-way surge tank. Measure with one surge tank and flywheels GD^2 $200kgm^2$
S	Horowpotha na	Kahatagasdigiliya	22,500	400	109	Dangerous negative pressure occurs. Measure with flywheel GD^2 $100kgm^2$

(4) The proposed systems

The proposed systems consist of the following equipment.

1) Flywheel method

A flywheel is equipped between a pump and an electric motor as shown in **Figure 5.31.**

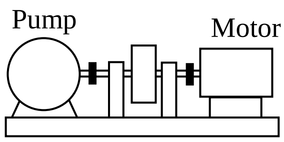


Figure 5.31 Flywheel

2) One-way Surge Tank

Composition of one-way surge is shown in **Figure 5.32**. The tank is installed 3 m above ground.

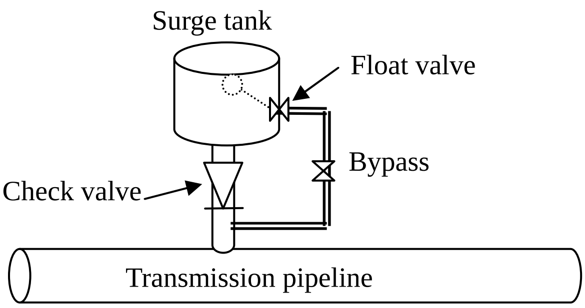


Figure 5.32 One-way Surge Tank

5.5 Electrical Equipment

5.5.1 Electricity Power Supply

(1) Incoming Facilities

In Democratic Socialist Republic of Sri Lanka, electricity power generating, transmission, and distribution are managed by Ceylon Electricity Board (here in after: CEB). No grid-station of CEB is furnished in North Central of Anuradhapura area, and 33 kV power transmission lines are supplied by over head lines from Anuradhapura grid-stations.

The power distribution to water supply facilities will be classified into the categories mentioned below by CEB. In these categories, Low voltage means three-phase four lines 50Hz 440/230V while Medium voltage means three-phase three lines 50Hz 11/33kV. In this project, 33kV will be applied.

Category I-1: This category shall apply to the consumers who require 400/230 nominal voltage at individual incoming point and whose power demand is less than or equal to 42kVA. If there is an existing transformer supplied by CEB close to the incoming point (within 400m), the consumer will not have to bear the installation cost. But if not, the consumer will be required to install a new transformer and bear a half of installation cost.

Category I-2: This category shall apply to the consumers who require 400/230 nominal voltage at individual incoming point and whose power demand exceeds 42kVA. In case the power demand exceeds 42kVA and up to 63kVA, incoming medium voltage line and power transformer shall be installed by CEB and fifty percent of the installation cost shall be owned by consumer. In case the power demand exceeds 63kVA, full of those costs shall be borne by consumer. Concerning metering, over 42kVA up to 1MVA, kilo watt-hour will be measured at the secondary side of transformer by CEB metering device, and exceeding 1MVA, primary side of transformer will be measured by it. No upper limitation is set for this contract demand.

Category I-3: This category shall apply to the consumers who require 11/33kV at individual incoming point. In this case, power receiving facility shall be constructed by the customer and power receiving capacity will have no limitation except for the lower side limitation, 1 MVA.

However, the construction cost of power receiving facility will be expensive because the power distribution voltage applied in the North Central area is 33kV. So it is not suggested to apply this category I-3 even if the power rate is lower than Category I-2 by 0.2 rupees per kilo watt-hour., except for the facility including high-voltage motors.

Elevated tanks and GND Transmission pump stations, which have no main power loads other than Chlorination booster pumps, will be applied General Purpose (GP-1). Other facilities such as water treatment plants and ground water reservoirs will be applied Category I-1 or Category I-2 mentioned above. However, after the site survey, there is not existing transformer near the low demand ground reservoirs; Kahatagasdigiliya and it is better to install the transformer for own use not to infect the voltage fluctuation to surrounding consumers. So, all facilities except for elevated tank sites; Ishinbassakgala, Etakada, Bogahawewa, Kah-Keb Medium, North Hor.Cith, West Hor., Rathmalgahawewa and Hamillewa, and GND Transmission Pump sites will be applied Category I-2.

In the case of Category I-2, housing for the power measurement panel will be installed and owned by customer based on the CEB standard drawings.

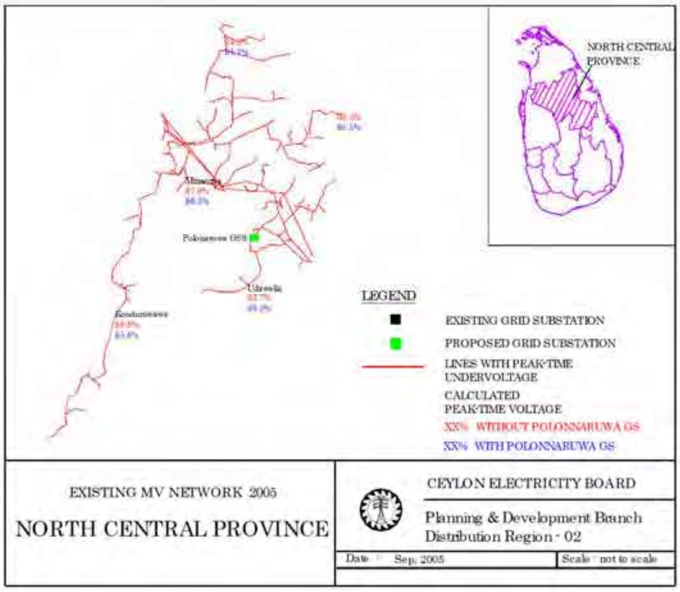
According to the comments of CEB, there is no actual example of double power incoming system so there is no choice but to install single power incoming system for all medium voltage receiving facilities.

Electricity rate discount based on power factor correction is not set up in the tariff. On the other hand, demand rate will be discounted corresponding to the power factor correction since the rate is determined by kVA. On this design, static capacitor for power factor correction will not be applied because of using VSD (Variable Speed Driver) for all transmission pumps, while it is

described to install static capacitor to the loads whose capacity is more than 25kW to improve the power factor from 85% to 95% on the Specifications for Horizontal Shaft Driven Double Suction Pumping Sets and Accessories (here in after: NWSDB Specifications).
The installation cost for 33kV medium voltage distribution line is 2.4MRs per 1km, and this cost is increasing year by year as reported by CEB.

(2) Reliability of electricity power source

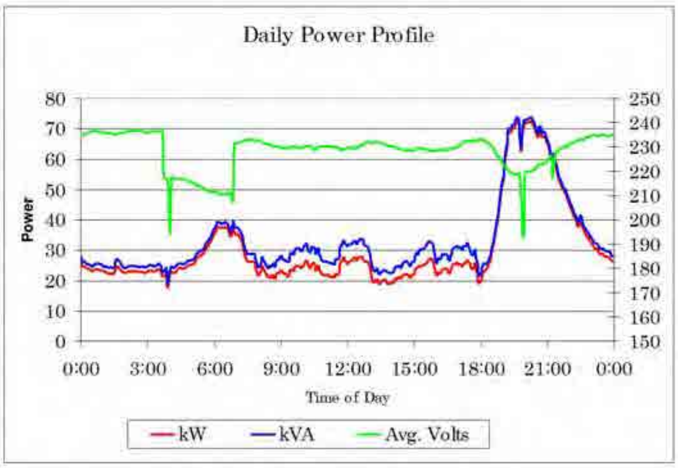
The study team investigated about blackout continuation time, voltage fluctuation and frequency fluctuation etc. to check the reliability of electricity power source to CEB. But there was no answer from the CEB in the study period. From the annual report of CEB in 2009, it is reported that: One of the key tasks the planning area was improving the reliability of supply provided to its customers. In this respect, many actions were taken to improve operation of Distribution Control Centers, Automation of Distribution network operations. During the year, the average failure rate of MV network of the region was 5.7 per 100 line km. per month. The same for LV network was 14.9 per 100 line km. per month. The corresponding figures for the previous year (2008) were 5.8 and 16.7 respectively. The main causes of the failures were vegetation, brunches from distance, burning of jumpers and aging of components.



Source: "Rural Electrification and Network Expansion Strategy", ADB Sept.2006"

Figure 5.33 Peak Time Under Voltage Area

On the other hand, from the Final Phase 2 Report of Rural Electrification and Network Expansion Strategy ADB in September 2006, the data logging survey was undertaken with the support of CEB, in five villages in representative areas throughout Sri Lanka. From this report, from four o'clock to seven o'clock in the morning, seven percent of voltage drop was come up and from seven o'clock to nine o'clock in the



Source: "Rural Electrification and Network Expansion Strategy", ADB Sept.2006"

Figure 5.34 Daily Power Profile in Anuradhapura

evening, about four percent of voltage drop was came up. (See **Figure 5.34**)

The voltage drop brings on the excess current to the motor and it involves the risk of motor burn out. A voltage monitor should be installed in the main low voltage panel secondary side of main transformer to prevent the excess current, under voltage, phase failure and phase reverse in the NWSDB standard specifications.
By this protection, it is very high to trip the main molded circuit breaker of main low voltage panel and a long blackout is comparatively expected. On this report, fuel tank capacity is decided to bear 24hours power interruption.

(3) Power demand and rates
Proposed facilities will be applied for the category I-1 and I-2 for Industry Use except for elevated tanks and GND transmission pump stations.
For the elevated tanks and GND transmission pump stations, the category for General Purpose Use will be applied.
An electricity tariff of the category I-1 and I-2 is calculated as shown **Table 5.50** and **Table 5.51**. General Purpose Use is calculated as shown **Table 5.52**.

Table 5.50 Rate for Category I-1

Time Zone		Rs/kWh	FAC	Fixed Charge
All Time	00:00～24:00	10.5	15%	240 (Rs/Month)

FAC: Fuel Adjustment Charge in 2012

Table 5.51 Rate for Category I-2

Time Zone		Rs/kWh	FAC	Fixed Charge	Demand Charge
Peak	05:30～18:30	13.6	15%	3000 (Rs/ Month)	850 (Rs/ kVA) (Rs/Max. Demand/ Month)
Off Peak	18:30～22:30	7.35	15%		
Day	22:30～05:30	10.45	15%		

FAC: Fuel Adjustment Charge in 2012

Table 5.52 Rate for Category GP-1

Time Zone		Rs/kWh	FAC	Fixed Charge
All Time	00:00~24:00	19.50	25%	240 (Rs/ Month)

FAC: Fuel Adjustment Charge in 2012

From the above Tables, assumption of power demand and rates for the facilities of water supply systems are approximately estimated as shown **Table 5.53** in case Rapid Sand Filter with Activated Carbon Filter which could be installed in near future for the water treatment plant.

Table 5.53 Power Demand and Rate

Location	2024 Demand (kW)	2034 Demand (kW)	2024 Rate per year (Rs)	2034 Rate per year (Rs)
Mahakanadarawa WTP & Intake	120.9	215.2	15,448,056	27,468,669
Rambewa Ground Water Reservoir	48.5	187.4	6,222,516	23,917,776
Medawachchiya Ground water Reservoir	33.3	126.2	4,272,421	16,117,398
Wahalkada Water Intake	39.2	84.2	5,033,340	21,393,105
Wahalkada WTP	202.8	378.5	25,879,342	48,281,659
Kahatagollewa Ground Water Reservoir	72.3	147.2	9,245,672	18,802,665
Kebithgollewa Ground Water Reservoir	16.6	32.6	2,149,750	4,186,388
Weerasole Ground Water Reservoir	84.1	167.6	10,753,108	21,393,105
Horowpothana Ground Water Reservoir	100.1	204.5	12,790,256	26,098,313
Kahatagasdigiliya Ground Water Reservoir	13.0	45.2	1,690,904	5,792,348
Sub-total for Category I-2			93,485,365	213,451,426
Each Elevated Tanks (8 locations)	8*3.6	8*6.1	3,033,856	5,118,264
Each GND Transmission Pump (7 locations)	7*2.8	7*4.4	2,057,727	3,284,687
Sub-total for Category GP-1			5,091,583	8,402,951
Total			98,576,948	221,854,377

FAC of Category GP-1 is assumed 25%.

Unit Power Rates at 2024 and 2034 for Makahanadarawa and Wahalkada area are assumed as **Table 5.54** respectively in case Rapid Sand Filter with Activated Carbon Filter is installed for the water treatment plant.

Table 5.54 Unit Power Rates in case of Rapid Sand Filter with Activated Carbon Filter

Year	Location	Makahanadarawa	Wahalkada	Total
2024	Water Supply (m^3/year)	3,248,500	4,927,500	8,176,000
	Electricity Rate (Rs/year)	28,844,455	69,732,493	98,575,948
	Unit Power Rate (Rs/m^3)	8.88	14.15	12.06
2034	Water Supply (m^3/year)	6,533,500	10,001,000	16,534,500
	Electricity Rate (Rs/year)	72,238,638	149,615,739	221,854,377
	Unit Power Rate (Rs/m^3)	11.06	14.96	13.42

(4) Power transformer

Transformer Capacity will be calculated by the formula as shown below.

Transformer Capacity (kVA) = Total Loads (kW) *(β*α)/ (η*φ)

Here, φ: Total power factor

η: Total efficiency

β: Demand factor

α: Safety factor

In this formula, spare motor capacity will not be included in the Total Loads.

Capacity of transformers for each facility considering the assumed power demand is shown below. The list for elevated tanks is omitted herein as low-voltage power will be supplied to them.

Table 5.55 Transformer Capacity

Location	2024 Required Capacity(kVA)	2034 Required Capacity (kVA)	Transformer Capacity (kVA)
Mahakanadarawa WTP & Intake	400	630	630
Rambewa Ground Water Reservoir	160	400	400
Medawachchiya Ground water Reservoir	100	250	250
Wahalkada Water Intake	160	160	160
Wahalkada Water Treatment Plant	630	800	800
Kahatagollewa Ground Water Reservoir	160	250	250
Kebithgollewa Ground Water Reservoir	63	63	63
Weerasole Ground Reservoir	160	250	250
Horowpothana Ground Water Reservoir	160	400	400
Kahatagasdigiliya Ground Water Reservoir	63	100	100

Rapid Sand Filter will be applied for each Water Treatment Plant.

Construction of this project is planned to be completed in 2018. The target year of 1st phase is 2024 while the ultimate target year is 2034. It means that only six years will have passed in 2024 since the proposed facilities start service. In addition, the installation cost of transformers shall be borne by NWSDB although the transformers will be installed by CEB. Considering that enhancement will be required six years later than start of the service, it is reasonable the capacity of transformers installed will cover the ultimate phase power demand from the beginning.

5.5.2 Power Generator

Actual record of the CEB grid-stations power failure for this area is not informed in this study period. But, electricity power reliability at the North Central Area is low, as described as¥¥in section 5.6.1(2). Diesel engine generator for the emergency is indispensable to supply water steadily as during times of blackout time. The continuing time of power failure is expected to be a long time. So, the storage volume of fuel tank will be designed for twenty-four hours use so as to be able to fill the gap when the fuel storage comes low. The fuel tank will be basically installed outside.

Considering the high frequency of power failure and request from NWSDB, installation of stand-by generator will be imperative.

According to environmental recommendation from the Central Environmental Authority for the Water Purification Plant at Wahalkada Proposed by the National Water Supply and Drainage Board, noise regulation of proposed area requires less than 45 dB at night at the boundary of the proposed site and surrounding area. In principle, enclosed sound attenuated type stand-by generators can be planned to comply with the regulation.

As a most commonly used type, diesel generator will be applied for this project.

No generators will be installed at the facility only for an elevated tank. Standby power supply for instrumentation and monitoring equipment at the elevated tanks, such as level meters and wireless communication devices for SCADA, will be backed up by UPS for approximately 30 minutes.

Capacity of generators installed for each facility considering the assumed power demand will be shown as **Table 5.56**.

As same as transformer, these generators will also cover the ultimate phase power demand from the beginning.

Table 5.56 Generator Capacity

Location	2024 Required Capacity(kVA)	2034 Required Capacity (kVA)	Generator Capacity (kVA)
Mahakanadarawa WTP & Intake	200	300	300
Rambewa Ground Water Reservoir	200	300	300
Medawachchiya Ground water Reservoir	150	250	250
Wahalkada Water Intake	100	150	150
Wahalkada Water Treatment Plant	375	625	625
Kahatagollewa Ground Water Reservoir	150	250	250
Kebithgollewa Ground Water Reservoir	50	75	75
Weerasole Ground Reservoir	150	300	300
Horowpothana Ground Water Reservoir	200	375	375
Kahatagasdigiliya Ground Water Reservoir	75	75	75

5.5.3 Low Voltage Facilities

As for motor starters, standards requirement is mentioned in detail in the specification of NWSDB
This proposal will comply with the specification as follow.

(1) Motor Control Centre（MCC）
MCC will be composed following items.

1) Panel enclosures
2) Bus-bars with MCCB's (Distribution section)
3) Supply incoming section
4) Small power distribution section
5) Motor starting sections
6) Automatic controllers & indicators
7) Cabling

Enclosures shall be of sheet metal construction using 1.5 mm. thick steel sheets with corrosion resistant coat while enclosures shall be protected to IP 55. Maximum operating height of the enclosure shall not exceed 2000 mm.
Incoming section will be required following item.

1) One 4 pole molded case circuit breaker of adequate capacity with thermal magnetic overload and earth fault trip
2) One ammeter with selector switch for monitoring phase currents
3) One power factor meter
4) One voltmeter with selector switch for monitoring phase to neutral and phase to phase voltages
5) One supply voltage monitor with the following features and interlocked with all motor starters
    (a) Phase failure protection
    (b) Supply voltage imbalance (adjustable)
    (c) Under and over voltage (adjustable)
    (d) Phase reversal
6) Lamp indicator to indicate operating condition of supply voltage monitor
7) Incoming terminals
8) Surge suppression device (surge arrestors)
9) Duty selector switch with interlocking arrangements
10) One of three phases four pole MCCB of 30A. The capacity of MCCB shall be incorporated in the panel board for an auxiliary power supply.

Motor starters shall comply with BS 587 (Specification Motor starters and controllers) or equivalent. Starter shall be adequately rated for the required number of starts per hour and in any case not less than 6 starts per hour. Contactors incorporated in motor starter shall conform to BS 775 (Specification. Motor starters and controllers) and BS 5424 (Specification for control-gear for voltages up to and including 1000 V A.C. and 1200 V D.C. Additional requirements for contactors subject to certification) or equivalent. If the method of starting is Auto Transformer, then over heating protection for the Auto Transformer coils shall be provided.

Motor starter panel to be provided shall consist of the following basic elements. Motor Starter section will be required following item.

1) One 3 pole MCCB with adequate rated capacity and thermal magnetic overload trip to serve as the feeder for the starter.
2) One three phase adjustable thermal overload
3) For three phase ammeter to rated phase current and ammeter shall be marked according to the phase designations, like R- phase etc.
4) Indicator lamps to indicate following:
   (a) Pump running
   (b) Pump tripped (overload)
   (c) Pump stopped
   (d) Pump tripped (low water level)
5) Hours run meter
6) Adequate set of control relays, timers etc. necessary for operation.
7) 2 pole – MCB for control supply.
8) Thermal protector relay connected to thermal sensors, mounted in the Motor windings.
9) Power factor correction capacitors to correct the power factor to 0.95 lagging for motors of 25 kW and above.
10) Auto transformers (if applicable)

For automatic controllers and interlocks, the following shall be required.

1) Automatic cut –off of the pumps when the well level in the sump is below the minimum level.
2) Control relays, transducers, cables etc. necessary for realizing above shall be provided.

MCCB and MC shall be required to comply with IEC regulations.

5.5.4 Instrumentation Facilities

Flow meters, level meters and pressure meters will be installed in this project to monitor the quantitative parameters. As for qualitative parameters, there are turbidity, pH, temperature, chlorine ion concentration, color, conductivity and alkalinity of raw water, chlorine ion concentration at the discharge of filter, turbidity and residual chlorine of the effluent required to be monitored in general. Considering the lifetime of automatic measuring instrument, which is generally short, and difficulty of troubleshooting at site, water quality as mentioned above will be manually analyzed in a water testing laboratory by means of drawing sampling water from each section.

Surge arrester will be installed to both transmitter and receiver to prevent from lightning surge since it frequently thunders in Sri Lanka.

There are four types of typical flow meters, electromagnetic type, inserting electromagnetic type, venturi(orifice) with differential pressure transmitter type, and ultrasonic type. Accuracy of inserting electromagnetic type and ultrasonic type is about ±2%, and this accuracy could be even much worse depending on the fixing. In addition, electromagnetic type is quite expensive and difficult to be maintained when it is in trouble.

On the other hand, a type of flow meter with differential pressure transmitter is easy to be replaced when it has trouble. Although this type of flow meter causes some pressure loss at the measuring part, there are ones which cause less pressure loss than Venturi's such as Dall tube type.

For these reasons, Dall tube type flow meter with differential pressure transmitter will be proposed for this project.

As for level meters, there are differential pressure type, submersible type, float type, capacitance type, ultra sonic type, and so on. In principle, differential pressure type will be proposed unless there is any interference to fixing condition since differential pressure type is accurate enough and relatively reasonable among them. In addition, submersible type will be proposed if the measuring and fixing from the upper side of water is required because it has no moving parts and relatively does not require the strict accuracy of fixing.

5.5.5 Monitor and Control Facilities

(1) Central monitoring and control system

SCADA (Supervisory Control And Data Acquisition) will be installed as the most proven central monitoring system in Sri Lanka.

The water supply system proposed in this project comprises Makahanadarawa network and Wahalkada network. The SCADA will be designed to cover each network systematically which will contain a water treatment plant, transmission and distribution pipelines.

Two LCD monitoring devices and two printers for logging and alarming compose central monitoring system. The two LCD devices shall be configured as dual redundant system, one primary and the other hot-standby, so that the standby one can take over the primary one in case of the failure occurred in the primary one without interruption to the plant operation.

(2) Water transmission and distribution system monitoring

There are three communication network systems which have been more installed recently because of their inexpensiveness than existing telemeter system as a remote monitoring communication system. The first one is wireless communication system using UHF, the second one is VPN communication system combining the technology of the existing telephone line (ADSL) and the internet. And the third one is GPRS communication system utilizing the packet communication of the GSM network.

The GPRS system is relatively reasonable to use and applied worldwide. Considering the fact that existing elevated tanks in Anuradhapura area also utilize it, GPRS system will be proposed in this project.

The study team conformed to the supplier who has the experience to install GRPS system in Kandy project, the transmission condition of GRPS in North Central area.

NWSDB specification mentioned automatic control should not be installed when utilizing GPRS system. According to the specification, the engineers for monitoring will need to stay at site on 24 hours basis and manually operate pumps monitoring the water level of elevated tank.

To make the operation easier, LCD device to monitor water level of each elevated tank will be installed at the ground reservoir which has pumps to transmit the water to two or more elevated tanks or ground reservoir. The LCD device has the function to alarm operators by making a phone call to or mailing to.

At the elevated tanks, a float type valve will be installed to avoid overflow. To prevent the pumps from continuously operating when the float valve is closed, the pumps will be automatically stopped with an interlock by detecting the combination signals of non-flow from a flow meter and transmission high pressure from a pressure switch. Obviously, an interlock will be also required to stop the pumps when the water level is below the minimum level.

(3) Control for water transmission and distribution

For example, from WTP clear water reservoir to distribution reservoirs communication will be applied as follows;

At the ultimate stage, there will be four pumps (including one standby) installed for the transmission from clear water reservoir to distribution reservoir.

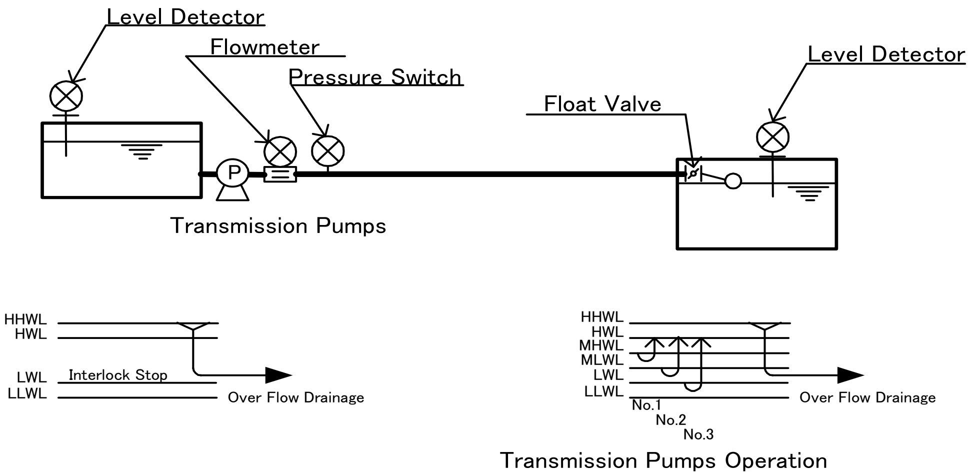


Figure 5.35 Transmission Pump Operation Diagram

Operators will normally select the number of pumps to be operated according to the water level of distribution reservoir. The signals of water level will be transmitted from a PLC of distribution reservoir to one of WTP through the GPRS packet communication system.

In case of communication failure, inflow of the distribution reservoir will be shut out by floating valve set at HHWL over flow level.

5.6 Outline of Proposed Water Supply System

5.6.1 Mahakanadarawa Integrated Water Supply System

The following table summarizes the facilities in the Mahakanadarawa Integrated Water Supply System.

Table 5.57 Mahakanadarawa Integrated Water Supply System

I. Mahakanadarawa		
Intake Facilities/Water Treatment Plant		
Location/Facilities		Fascilities to be constructed
Mahakanadarawa	Intake Facilities	Intake Gate Screen Intake Pump (4.25m3/min x 15m x 15kW) x (3+1)
	WTP	Production: 9,400 m3/d Receiving Well Roughing Filter Slow Sand Filter/Ecological Filter Clear Water Reservoir Transmission Pump (6.05m3/min x 32m x 45kW) x (2+1) Sludge Lagoon
Transmission/Distribution Facilities		

DS Division	Land Location (Extent)	Fascilities to be constructed
Rambewa	Rambewa * (1.5AC)	Elevated Tank (1,250m3) Ground Reservoir (1,500m3) Pump house / power control unit (120m2) x1 Generator (30m2) x1 Area Engineers office with SCADA system / Customer Counter (125m2) x1 Operational complex (100m2) x1 — Zonal Lab (RCl, Turbidity, pH) Chlorinator Building Room for crews Staff Quarters (100m2) x1 Caretaker/Operator Quarters (100m2) x1 Parking
	East Rambewa (1AC)	Elevated Tank (250m3) Chlorinator Building (100m2) x1 Caretaker/Operator Qts (100m2) x1
	Surge Tank A	One Way Surge Tank (100m3)
	Surge Tank B	One Way Surge Tank (100m3)
Medawachchiya	Medawachchiya * (2AC)	Ground Reservoir (1,000m3) Pump House / Power Control Unit (100m2) Generator (30m2) x1 Area Engineers office with SCADA system / Customer Counter (125m2) x1 Operational complex (100m2) x1 — Zonal Lab (RCl, Turbidity, pH) Chlorinator Building Room for crews Workshop (170m2) x1
		Staff Quarters (100m2) x1 Caretaker/Operator Quarters (100m2) x1 Parking
	Issinbassagala (1AC)	Elevated Tank (2,000m3) Chlorinator Building (100m2) x1 Caretaker/Operator Qts (100m2) x1
	Ethakada (1AC)	Elevated Tank (750m3) Chlorinator Building (100m2) x1 Caretaker/Operator Qts (100m2) x1

5.6.2 Wahalkada Integrated Water Supply System

The Following table summarizes the facilities in the Wahalkada Integrated Water Supply System.

Table 5.58 Wahalkada Integrated Water Supply System

II. Wahalkada		
Intake Facilities/Water Treatment Plant		
Location/Facilities		Fascilities to be constructed
Wahalkada	Intake Facilities	Intake Gate Screen Intake Pump (6.56m3/min x 22m x 30kW) x (3+1)

	WTP	Production: 14,400 m3/d Receiving Well Roughing Filter Slow Sand Filter/Ecological Filter Clear Water Reservoir Transmission Pump (0.29m3/min x 41m x 5.5kW) x (1+1) Transmission Pump (5.22m3/min x 62m x 90kW) x (2+1) Transmission Pump (3.97m3/min x 51m x 55kW) x (2+1) Sludge Lagoon Elevated Tank (500m3)
Transmission/Distribution Facilities		
DS Division	Land Location (Extent)	Fascilities to be constructed
Horowpothana	Weerasole (1AC)	Ground Reservoir (1,500m3) Generator (30m2) x1 Caretaker/Operator Qts (100m2) x1
	Horowpothana * (0.5AC)	Elevated Tank (500m3) Ground Reservoir (1,000m3) Pump house / power control unit (120m2) Generator (40m2) x1 Operational complex (100m2) x1 — Zonal Lab (RCl, Turbidity, pH) Chlorinator Building Room for crews Workshop (170m2) x1 Staff Quarters (100m2) x1 Caretaker/Operator Quarters (100m2) x1 Area Engineers office with SCADA system / Customer Counter Parking
	North Horowpothana City	Elevated Tank (250m3) Chlorinator Building (100m2) x1 Caretaker/Operator Qts (100m2) x1 One Way Surge Tank (100m3)
	West Horowpothana	Elevated Tank (750m3) Chlorinator building (100m2) x1 Caretaker/Operator Qts (100m2) x1
	Hamillewa	Elevated Tank (1,250m3) Chlorinator Building (100m2) x1 Caretaker/Operator Qts (100m2) x1
Kahatagasdigiliya	Kahatagasdigiliya * (1AC)	Elevated Tank (1,500m3) Ground Reservoir (500m3) Pump House / Power Control Unit (100m2) Generator (30m2) x1 Area Engineers office with SCADA system / Customer Counter Operational complex (100m2) x1 — Zonal lab (RCl, Turbidity, pH)
Kahatagasdigiliya	Kahatagasdigiliya * (1AC)	Chlorinator Building Room for crews Staff Quarters (100m2) x1 Caretaker/Operator Quarters (100m2) x1
	Rathmalgahawewa (1AC)	Elevated Tank (500m3) Chlorinator Building (100m2) x1 Caretaker/Operator Qts (100m2) x1
Kebithigollewa	Kebithigollewa * (1AC)	Elevated Tank (750m3) Ground Reservoir (500m3)

		Pump House / Power Control Unit (120m2) Generator (20m2) x1 Operational complex (100m2) x1 — Zonal Lab (RCl, Turbidity, pH) Chlorinator building Room for crews Workshop (170m2) x1 Staff Quarters (100m2) x1 Caretaker/Operator Quarters (100m2) x1 Area Engineers office with SCADA system / Customer Counter Parking
	KEB-KAH Median	Elevated Tank (250m3) Chlorinator Building x1 Caretaker/Operator Quarters x1
	Kahatagollewa (1AC)	Ground Reservoir (1,000m3) Elevated Tank (250m3) Chlorinator Building x1 Caretaker/Operator Quarters x1
Padaviya	Bogahawewa * (2AC)	Elevated Tank (2,000m3) Ground Reservoir (500m3) Pump House / Power Control Unit (100m2) Generator (20m2) x1 Area Engineers office with SCADA system / Customer Counter Operational complex (100m2) x1 — Zonal Lab (RCl, Turbidity, pH) Chlorinator Building Room for crews Staff Quarters (100m2) x1 Caretaker/Operator Quarters (100m2) x1 Parking

5.7 Water Supply System for Isolated Areas

The Project is to integrate the existing small-scale water supply systems into two large-scale ones. The following priority of factors is considered to select service areas of two pipe borne water supply systems.

- 1st GNDs with an existing water supply system
- 2nd GNDs where the facilities of a proposed water supply system are included
- 3rd GNDs covering a urban centre including its surrounding GNDs
- 4th GNDs along with main roads designated

As the result of analysis, the remaining areas are categorized as isolated areas. The population is 53,500 for isolated areas, 225,000 for non-isolated areas and 278,500 in total for the target year of 2034, respectively.

Details of the isolated areas are listed in the following table.

Table 5.59 Isolated Area

G.N. Division number and name	Area (ha)	Total population (2001)	No. of HHs	Population (2024)	Water Demand (2024)	Population (2034)	Water Demand (2024)
I. Mahananadarawa System							
Medawachchiya D.S.Division							
45 - Paranahalmillewa	902.05	1,067	303	1,404	14	1,582	16
48 - Anekattiya	2,290.82	796	199	1,047	10	1,180	12
63 - Thammenne Elawaka	2,533.44	1,368	360	1,800	18	2,028	20
62 - Puleliya	2,208.39	1,321	354	1,738	17	1,958	20
77 - Lindawewa	852.35	610	188	803	8	904	9
76 - Karambankulama	1,256.39	734	211	966	10	1,088	11
Sub-total	**10,043.44**	**5,896**	**1,615**	**7,758**	**78**	**8,740**	**87**
Rambewa D.S.Division							
105 - Kolibendawewa	1,725.96	1,032	255	1,268	13	1,387	14
104 - Medagama	1,146.29	988	245	1,214	12	1,328	13
116 - Kadurugasdamana	1,969.33	1,081	301	1,328	13	1,453	15
107 - Siyambalagaswewa	449.88	525	149	691	7	778	8
103 - Diviyaudabendawewa	629.29	681	208	896	9	1,009	10
80 - Ambagahawewa	1,299.20	555	157	730	7	823	8
91 - Konakumbukwewa	743.92	637	188	783	8	856	9
89 - Kallanchiya	1,232.46	768	194	944	9	1,032	10
92 - Gonewa	1,123.47	977	238	1,285	13	1,448	14
114 - Mahawewa	748.03	957	260	1,176	12	1,286	13
115 - Pandukabhayapura	116.20	650	186	799	8	874	9
98 - Kapiriggama	923.89	443	115	583	6	657	7
90 - Peenagama	677.59	668	199	821	8	898	9
88 - Meemalwewa	1,189.00	462	118	568	6	621	6
95 - Rotawewa	609.34	560	149	737	7	830	8
96 - Kudagama	1,397.79	604	157	742	7	812	8
Sub-total	**15,981.64**	**11,588**	**3,119**	**14,565**	**146**	**16,092**	**161**
Total	**26,025.08**	**17,484**	**4,734**	**22,323**	**223**	**24,832**	**248**
II. Wahalkada System							
Padaviya D.S.Division							
9 - Abhayapura	895.77	1,599	417	1,965	20	2,149	21
8 - Maithreepura	934.85	1,292	316	1,700	17	1,915	19
4 - Track B	1,038.58	1,754	471	2,308	23	2,600	26
15 - Balayawewa	1,298.12	864	224	1,137	11	1,281	13
Sub-total	**4,167.32**	**5,509**	**1,428**	**7,110**	**71**	**7,945**	**79**
Kebithigollewa D.S.Division							
31 - Bandaraulpatha	1,569.03	501	133	616	6	673	7
Sub-total	**1,569.03**	**501**	**133**	**616**	**6**	**673**	**7**
Horowpothana D.S.Division							
146 - Maradanmaduwa	2,141.24	602	168	740	7	809	8
143 - Wagollakada	1,591.62	589	136	724	7	792	8
142 - Dutuwewa	2,937.95	905	229	1,191	12	1,342	13
137 - Thawalanhalmillewa	1,051.22	381	101	468	5	512	5
123 - Thimbiriettawala	1,725.58	776	152	1,021	10	1,150	12
118 - Rasnaka Wewa	966.23	500	143	658	7	741	7
124 - Gammahegewewa	1,117.69	602	178	792	8	892	9
154 - Dematawewa	19,145.36	488	133	600	6	656	7
Sub-total	**30,676.89**	**4,843**	**1,240**	**6,194**	**62**	**6,894**	**69**
Kahatagasdigiliya D.S.Division							
205 - Sampathgama	426.29	1,056	259	1,389	14	1,565	16
217 - Thallattewa	488.06	766	206	1,008	10	1,135	11
204 - Samadhigama	655.37	617	159	812	8	915	9
216 - Konwewa	926.61	1,056	251	1,298	13	1,419	14
214 - Tikkampothana	1,168.82	310	84	381	4	417	4
215 - Divulwewa	1,845.45	889	216	1,092	11	1,195	12
229 - Diganhalmillawewa	1,247.62	923	249	1,214	12	1,368	14
227 - Kelenikawewa	1,244.46	828	192	1,017	10	1,113	11
228 - Nelugollakada	625.83	572	152	753	8	848	8
197 - Ellawewa	442.83	763	200	1,004	10	1,131	11
200 - Nekutunu Wewa	1,378.26	817	230	1,075	11	1,211	12
199 - Kanadara-Rathmale	825.68	601	162	739	7	808	8
Sub-total	**11,275.28**	**9,198**	**2,360**	**11,782**	**118**	**13,125**	**131**
Total	**47,688.52**	**20,051**	**5,161**	**25,702**	**257**	**28,637**	**286**
Grand Total	**73,713.60**	**37,535**	**9,895**	**48,025**	**480**	**53,469**	**535**

Figure 5.38 shows the concept of water supply system in the isolated area.

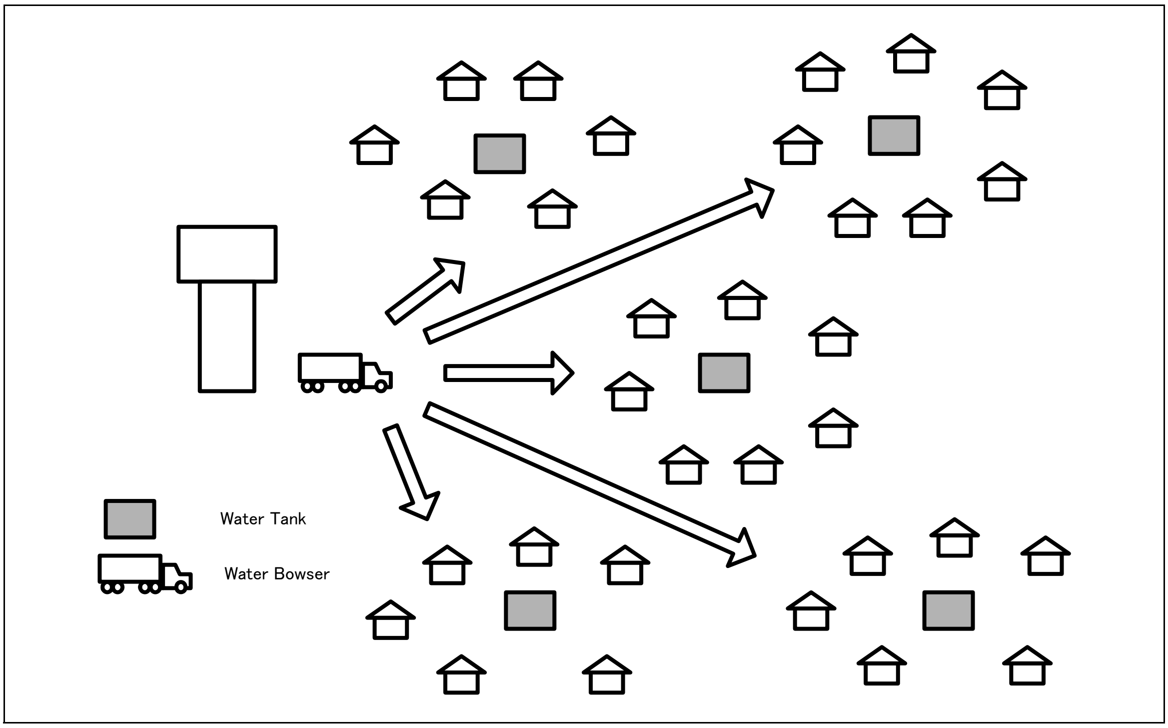


Figure 5.36 Water Supply System in Isolated Area

The water supply system in the isolated areas consists of water tanks (capacity 5 m^3) and water bowsers (capacity 5 m^3) and 10 Lpcd of water will be provided to each population. The numbers of water tanks and water bowsers are calculated as follows.

population x 10 Lpcd = water demand

water demand / 5 m^3 = number of water tank

number of water tank / 6 locations/day = number of water bowser

Example of Madewachchiya Station for 45 - Paranahalmillewa.

(45 - Paranahalmillewa)

1,582 x 10 Lpcd = 15,820 Lpd = 15.8 m^3/d => 16 m^3/d

16 m^3 / 5 m^3 = 3.3 tanks => 4 tanks

(Madewachchiya Station)

This station serves water to 15 water tanks.

15 tanks / 6 locations/day = 2.5 water bowser => 3 water bowsers

The calculation results are shown in **Table 5.59**. Totally, 107 water tanks and 20 water bowsers are required for the water supply for the isolated areas.

Table 5.60 Water Tanks and Bowsers in Isolated Areas

Station	G.N. Division number and name	Water Demand (2024)	Water Tank ($5m^3$)	Water Bowser ($5m^3$)
I. Mahananadarawa System				
Madewachchiya	45 - Paranahalmillewa	16	3	3
	48 - Anekattiya	12	2	
	63 - Thammenne Elawaka	20	4	
	62 - Puleliya	20	4	
	80 - Ambagahawewa	8	2	
Sub-total		**76**	**15**	**3**
Rembewa	77 - Lindawewa	9	2	6
	76 - Karambankulama	11	2	
	105 - Kolibendawewa	14	3	
	104 - Medagama	13	3	
	116 - Kadurugasdamana	15	3	
	107 - Siyambalagaswewa	8	2	
	103 - Diviyaudabendawewa	10	2	
	91 - Konakumbukwewa	9	2	
	89 - Kallanchiya	10	2	
	92 - Gonewa	14	3	
	114 - Mahawewa	13	3	
	115 - Pandukabhayapura	9	2	
	98 - Kapiriggama	7	1	
	90 - Peenagama	9	2	
	88 - Meemalwewa	6	1	
	95 - Rotawewa	8	2	
	96 - Kudagama	8	2	
Sub-total		**173**	**35**	**6**
Total		**248**	**50**	**9**
II. Wahalkada System				
Bogohawewa	9 - Abhayapura	22	4	3
	8 - Maithreepura	19	4	
	4 - Track B	26	5	
	15 - Balayawewa	13	3	
Sub-total		**80**	**16**	**3**
Weelasol	146 - Maradanmaduwa	8	2	1
	143 - Wagollakada	8	2	
	142 - Dutuwewa	13	3	
Sub-total		**29**	**6**	**1**
West Horowpothana	31 - Bandaraulpatha	7	1	2
	137 - Thawalanhalmillewa	5	1	
	123 - Thimbiriettawala	12	2	
	118 - Rasnaka Wewa	7	1	
	124 - Gammahegewewa	9	2	
Sub-total		**40**	**8**	**2**
Kahatasdigiliya	154 - Dematawewa	7	1	5
	205 - Sampathgama	16	3	
	217 - Thallattewa	11	2	
	204 - Samadhigama	9	2	
	216 - Konwewa	14	3	
	215 - Divulwewa	12	2	
	214 - Tikkampothana	4	1	
	229 - Diganhalmillawewa	14	3	
	227 - Kelenikawewa	11	2	
	228 - Nelugollakada	8	2	
	197 - Ellawewa	11	2	
	200 - Nekutunu Wewa	12	2	
	199 - Kanadara-Rathmale	8	2	
Sub-total		**138**	**28**	**5**
Total		**287**	**57**	**11**
Grand Total		**535**	**107**	**20**

5.8 Strategic Plan (Staged Development Plan)

5.8.1 Necessity of Priority and Staged Development

The proposed Water Supply System will require a large amount of capital investment and many years to complete. In general, such large projects become feasible for implementation if they are implemented through several construction stages with appropriate development steps or prioritized implementation.

The development priority is also utilized in selecting a priority project in the later chapter. Further, the priority is needed for investment decision by financial or investment institutions. Projects are typically composed of several components and usually higher priority components or the components that create higher profit are implemented first. For the above reasons a development priority for the Water Supply System is considered by preparing a number of alternative project packages.

5.8.2 Proposed Project Components

Many project components have been proposed in the previous chapter. The water supply facilities consist of the following facilities:

1) Intake facilities
2) Water treatment plants
3) Water transmission pump facilities
4) Water transmission pipelines
5) Ground reservoirs (sumps)/elevated tanks
6) Water distribution piping networks

However, it is essential for a new water supply system to be developed in one stage from the water sources (intake facilities) to houses (water distribution piping networks/house connections). Therefore “facility-base development”, cannot be applied, and for example only intake facilities and water treatment plants will be constructed in the first stage.

5.8.3 Comparison of Staging

Figure 5.37 simplifies the schematic flow diagram of **Figure 5.24** and **Figure 5.25** to facilitate the understanding of an overall system composition which is divided into two water supply systems, namely (1) Mahakanadarawa System and (2) Wahalkada System. In the Wahalkada System, two water transmission pipelines directs to the north (Bogahawewa) and west (Kebhitigollewa), and the south (Horowpothana), respectively from the Wahalkada Water Treatment Plant.

Applicable staged development options are “water demand-base development” and “district-base development”. The following figures show the concepts of the two staged development options.

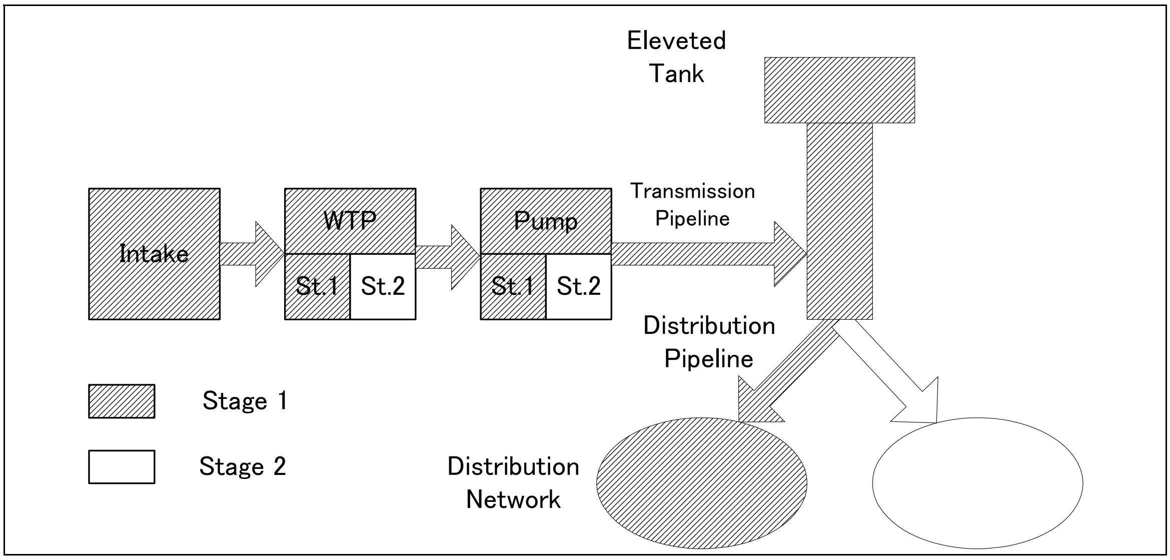


Figure 5.37 Water Demand-base Development

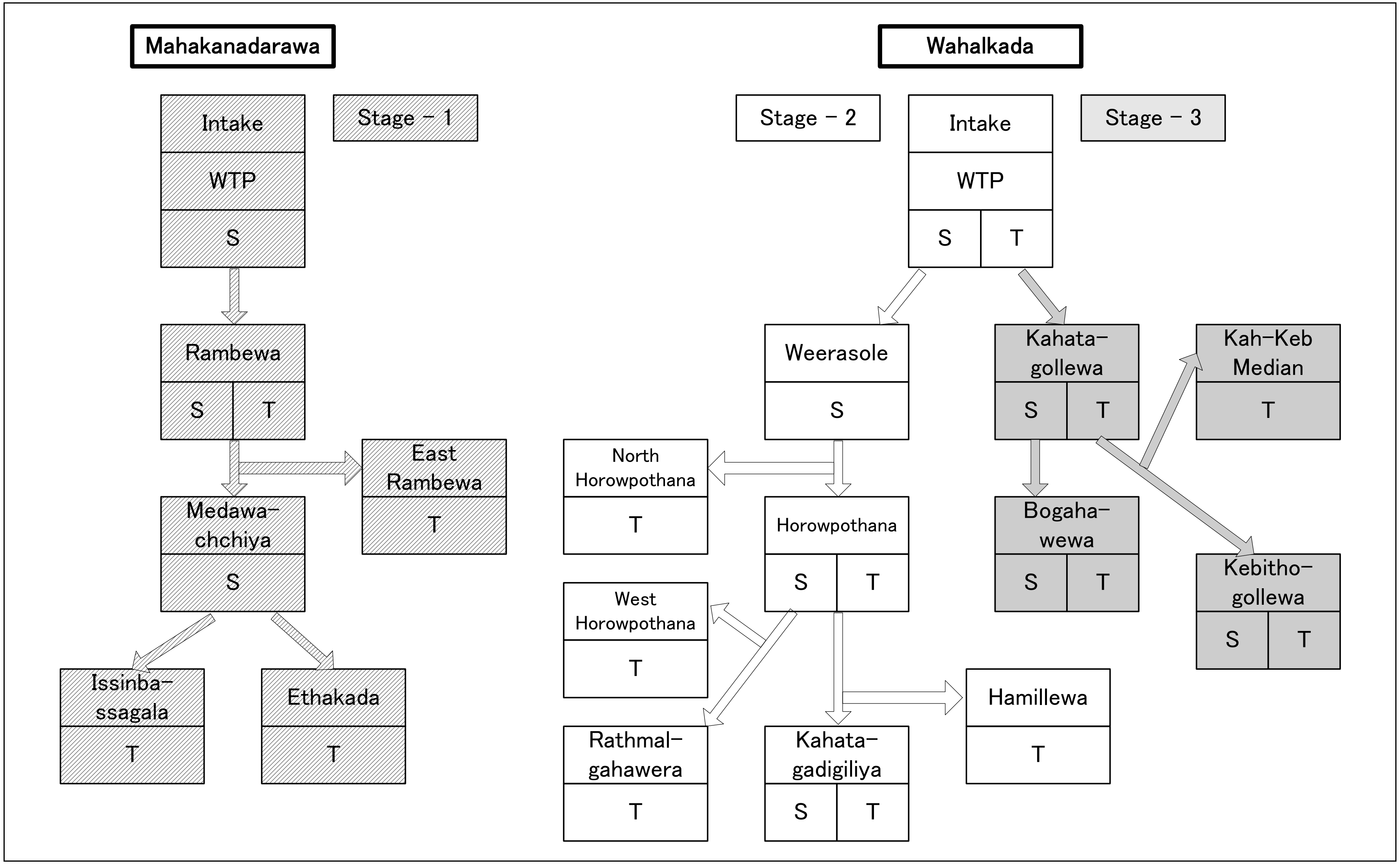


Figure 5.38 District-base Development

These two types of staged development are able to compare in the following table.

Table 5.61 Comparison of Development

Item	Water demand-base development	District-base development
Stage (Production)	1-1. Water demand on 2024 Mahakanadarawa 9,400 m^3/d	1. Mahakanadarawa Mahakanadarawa 18,800 m^3/d
	1-1. Water demand on 2024 Wahaklkada 14,400 m^3/d	2. Wahalkada – I Wahalkada 16,500 m^3/d
	1-1. Water demand on 2034 Mahakanadarawa 9,400 m^3/d Wahalkada 14,400 m3/d	3. Wahalkada – II Wahalkada 13,500 m^3/d
Cost (Estimate)	Stage 1 – 70 % Stage 2 – 30 %	Stage 1 – 40 % Stage 2 – 35 % Stage 3 – 25 %
Advantage	➢ All study areas are developed from the first stage.	➢ Investment can be minimized in the first stage.
Disadvantage	➢ Large investment is required from the first stage.	➢ Only limited area will be improved in the earlier stage.

Since many people in the study area are suffering a bad quality of water from their own water sources or the CBO water supply systems, it is recommended to apply “Water demand-base development” in order to supply safe and good-quality water for as many people as possible from the first stage.

CHAPTER 6

MANAGEMENT, OPERATION AND MAINTENANCE OF PROPOSED WATER SUPPLY SYSTEM

CHAPTER 6 MANAGEMENT, OPERATION AND MAINTENANCE OF PROPOSED WATER SUPPLY SYSTEM

This section provides a brief background of NWSDB as an institution and examines its current organization structure, with focus on the organization and operating structure of the NWSDB Regional Support Centre (North Central), which stands to benefit from the implementation of this Project. It assesses the capacity of the RSC and proposes capacity building / training and development programmes to enhance organisational skills and improve individual or staff competencies to manage, operate and maintain the new facilities / system thereby transforming organizational and individual potentials into actuality. It also assesses the organizations concerned in project implementation; then defines, describes and delineates the sharing of roles and responsibilities among these organizations to mitigate managerial, financial and technical problems may arise in the case of the project’s implementation.

The sound operation and maintenance of the facilities after its completion entails an organization that is ready, capable, and skilled in performing the required works. Thus, after an examination of the current O&M organisation, this section proposes a strengthened O&M organization so that proper and rapid response can be attained when operating and maintaining mechanical and electrical equipment at the water treatment plants and pumping stations, when detecting and repairing leaks in the water transmission and distribution pipelines, and when ensuring compliance to Sri Lankan water quality standards.

Finally, the section also examines the modes by which water supply services can be distributed to the RSC service area, which also consists of community-based water supply organisations or CBOs. It proposes strategies and approaches in the provision of water supply services to the CBOs, which includes the categorization of CBOs based on their willingness to connect, conditions for connecting, and the technical suitability of the CBO water supply system for bulk connection. In terms of the tariff system of the CBOs, there are varied tariff structures and charges. The examination of these tariff systems will keep the RSC apprised of the average monthly household water bill on a per CBO basis as it embarks on its awareness campaign to get the CBOs to connect to its new distribution facilities.

6.1 Project Implementation Organization

The National Water Supply and Drainage Board (NWSDB), together with the Urban and Municipal Councils and Pradeshiya Sabhas, are legally mandated to provide safe water and sanitation in the entire Sri Lanka. The NWSDB, which is under the Ministry of Water Supply and Drainage (MWSD), is the primary agency responsible for water supply and sanitation. It core competence lies in planning and developing; designing and constructing; managing, operating and maintaining larger urban water supply schemes; and of late, supporting the development of rural schemes in areas declared under the NWSDB Act.

The organizational set-up and the institutional capacity of NWSDB have been the subject of both analysis and recommendation, mostly as a component of project studies funded and/or assisted by multilateral and bilateral development and aid cooperation agencies. These projects were aimed at improving and expanding water supply infrastructure and services while strengthening the institution's capacity for service delivery by focusing on either one or more of the following: water utilities' management and managerial effectiveness, financial management and viability, technical competence and operational efficiency, human resource management and development, project management and implementation capacity, and regional operations and decentralization.

6.1.1 NWSDB Organization

The existing organisation structure of NWSDB has evolved from a number of internal and external institutional development initiatives. It is also as a result of operating under a more comprehensive framework of sector reforms and policies since it was established in 1974, in addition to the amendments to its original charter in 1992, which has given NWSDB stronger policy enforcement powers.

The latest organization structure of NWSDB is shown in **Appendix 6.1 (a).** However, this organization structure is currently undergoing revision, with the approval, in 2011, of the *NWSDB Approved Cadre (Category-wise and Salary Code)*. The revision process includes a series of discussions with the 37 trade unions within NWSDB. The new and updated organization structure will be only issued after completion of the revision process, and when the attendant *Scheme of Recruitment and Promotion* is drafted and eventually approved.[1]

The NWSDB Approved Cadre provides for 246 categories and designations spread over 15 Board Grades. It calls for a total manpower complement of 10,119 personnel. As of 01 July 2012, the actual number of personnel stood at 9,193, or 926 less than the approved number allowed in the cadre.

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[1] Interview with Mrs. Chandra Siriyani Weerasinghe, Assistant General Manager for Human Resource Management, NWSDB, 04 July 2012.

To enable to fulfil its mission and vision, as well as the seven-point goals stated in its Corporate Plan (2012-2016), NWSDB is organized along both functional and geographical lines. Functionally, the NWSDB has the following major offices: (i) Policy and Planning, (ii) Water Supply Projects, (iii) Sewerage, (iv) Corporate Services, (v) Personnel and Administration (vi) Commercial (vii) Finance, and (viii) Internal Audit. Geographically, NWSDB has three regional offices under which 14 regional support centres have been organized, and are fully operational. These are the Western Regional Office which takes charge of four regional support centres; the Southern / Eastern Regional Office, under which are five regional support centres, and the Northern / Central Regional Office, which has five regional support centres under it. These functional and geographic organisational dimensions are carried over to the organization structure of the regional support centres where the smallest operational unit is the water supply scheme.

(1) The Regional Support Centres

The Regional Support Centres (RSC), headed by a Deputy General Manager or an Assistant General Manager, were established to provide necessary assistance and support to the daily operations of the water supply and sewerage systems. The RSCs also manage projects aimed at expanding water supply and sanitation services to villages and towns within their jurisdiction.

The RSC is where the functions of water supply / water utility are performed such as: water utility management; technical (engineering) services such as sector planning, water supply planning and development, design and construction; water supply operations and maintenance of facilities; commercial operations including major customer service activities such as billing and collection and the maintenance of customer accounts; financial operations such as general accounting, budgeting and financial reporting, and the consolidation of all operating and financial reports; and administrative operations such as human resource management and other administrative support services.

(2) The District Offices

The District Office, headed by a district engineer, oversees the operation and maintenance of the water supply schemes (WSS), and coordinates the planning and development of the different WSS together with the RSC. The District Office provides supervision over the officers-in-charge of the WSS, and is staffed by administrative and technical personnel. It consolidates reports from the different WSS, prepares cost estimates for minor works, and gives inputs to proposed capital works.

(3) The Water Supply Schemes

The Water Supply Schemes are headed by an officer-in charge (OIC). Being the smallest operating unit of NWSDB, the WSS is a microcosm of the RSC, performing production, treatment, distribution of water, as well as undertaking repairs, small extensions, and minor rehabilitation. It also undertakes commercial tasks such as meter reading, distribution of pre-addressed water bills during reading time, processing of application for new service connections, reconnections and disconnections; and administrative tasks such as monitoring and reporting of employee attendance / leaves and inventory management. The WSS coordinates closely with its customer base attending to customer inquiries and complaints, as well as supports the technical requirements of CBOs around its area of operation.

6.1.2 NWSDB Regional Support Centre (North Central)

The NWSDB RSC(N/C) is one of 14 RSCs under the NWSDB, and is one of five under the Northern / Central Regional Office) Zone. It is headed by a deputy general manager, and supported by an assistant general manager, and is composed of five operating units/sections, namely: (i) Development Section, (ii) Operations Section, (iii) Commercial and Financial Section, (iv) Human Resources Section, and (v) IT Section. The current organization structure of NWSDB RSC(N/C) is presented in **Appendix 6.1(b)**; while the total number of personnel distributed by Section / Unit is shown in **Table 6.1**.

Table 6.1 Current Number of NWSDB RSC(N/C) Personnel according to Section / Unit

Office / Section	Sub-section / Unit	Sub-Total per Unit	Total per Section
DEPUTY GENERAL MANAGER			**4**
Deputy General Manager		1	
DGM Staff		3	
DEVELOPMENT			**66**
Assistant General Manager		1	
	1) Mechanical / Electrical	1	
	2) Planning and Design	16	
	3) Sector Planning	5	
	4) Construction	13	
	5) Ground Water	30	
FINANCE AND COMMERCIAL			**3**
Chief Accountant		1	
	1) Finance	2	
HUMAN RESOURCES			**10**
Manager, Support Services		1	
	1) Support Services	9	
INFORMATION TECHNOLOGY			**2**
	1) Information Technology	2	
OPERATIONS			**307**
Manager, O&M		1	
Assistant Manager, O&M		1	
	1) Operation & Maintenance	18	
	2) Regional Workshop	17	
	3) District Engineering		
	a) Anuradhapura District	173	
	b) Polonnaruwa District	69	
	4) Commercial		
	a) Accounting	10	
	b) Customer Service	15	
	5) Laboratory	3	
	GRAND TOTAL		**392**

Source: HR Section, as of 15 September 2012.

(1) Functions of the Sections in the N/C RSC Structure

There is no formal functional chart that describes, delineates and defines the broad and specific responsibilities of the sections organised under the North Central RSC. This impacts the efficient and effective management and operation of the RSC, since accountability and responsibility cannot be fully pinpointed. This is exacerbated by the fact that certain core utility functions and sub-functions are still centralised in the Head Office, although other functions have already been decentralised. Examples of functions centralised in the Head Office are human resource management, particularly recruitment, selection and placement (including transfers), promotions, training and development (for Grades 7 and up), and HR records' maintenance. The same is true with financial management and accounting, business planning, asset management, and capital budgeting. Decentralised functions are those pertaining to operation and maintenance, sector planning and development, and construction for small local projects, and billing and collection. The following are the functions being performed by the Sections:

1) The Development Section

The Development Section is headed by the Assistant General Manager, who is concurrently the second-in-command in the RSC. The Section undertakes sector planning activities, such as the preparation of pre-feasibility studies for new schemes, studies of small-scale water supply projects as requested by the external sector, and data collection, research and maintenance of the water supply database. It also performs general planning and design work, such as the preparation of proposals and initial estimates for service improvements; preparation of tender and construction documents; design of treatment works for GOSL funded projects; procurement activities and procurement planning for capital budget projects; rehabilitation of existing treatment plants based on O&M requirements; design and rehabilitation for NRW reduction works; and the study of pipeline extensions and pipeline shifting works. It also undertakes construction management for water supply schemes' projects of the RSC. The groundwater unit under this Section undertakes and/or supervises well development and drilling activities.

2) The Operations Section

The Operations Section is headed by the O&M Manager, who is also the concurrent head of its O&M Unit. The Section is in charge of production and treatment of water, and its distribution to its consumers. It ensures that the water supplied to its consumers complies with the Sri Lankan national standards for drinking water, is adequate for the growing population, and the water service reliable. It provides consumer services, such as: (i) connecting new consumers to the system; (ii) implementing the disconnection / reconnection policies of the NWSDB; (iii) responding to consumer requests and complaints with dispatch; and (iv) billing and collection. It operates and maintains all water supply facilities and equipment efficiently and effectively and in accordance with NWSDB standards through the water supply schemes. It also promotes the establishment of, and provides assistance to, rural water supply organisations, such as the CBOs, to ensure availability of safe water (and sanitation) in areas not reached by NWSDB's services.

3) The Commercial and Finance Section

The Commercial and Financial Section is headed by the Chief Accountant. The Section prepares the annual operating and capital budget requirements of the RSC, and supports the accounting and finance requirements of the Head Office, where financial management is centralised. In addition, it coordinates with the Commercial Unit under the Operations Section in terms of achieving billing targets and collection efficiency ratios set by the Head Office.

4) The Human Resource Section

The Human Resources Section is headed by the Manager, Human Resources. This Section prepares the annual personnel requirement (HR plan) and staffing actions for the RSC for submission to, and approval by the Head Office. It performs tasks delegated to it by the Head Office, where human resource management and development functions are centralised. It coordinates / conducts training for those in Board Grades 7 and lower. It also provides support services, such as supplies management, to the RSC.

5) The IT Section

This Section takes charge of maintaining the following: (i) all information technology (IT) and electronic equipment; (ii) all servers of the North Central RSC, all radio communications units (frequency bands); and the SCADA system. It administers the RSC's call centre operations, which is the customer care unit with a 24-hour online service. It also implements the IT modules of the RSC such as human resources, financial, commercial, attendance, and inventory management modules / systems.

(2) The Approved Cadre for North Central RSC

The *2011 NWSDB Approved Cadre* provides for 441 personnel for the North Central RSC. However, this July 2012, an additional complement of 44 O&M personnel was approved by the Department of Management Services, Ministry of Finance, bringing to 485 the total number of personnel in the North Central RSC approved cadre, spread along 65 categories / designations covering 11 Board Grades as shown in **Appendix 6.1(c). Table 6.2** shows the Approved Cadre distributed according to sections in the NC RSC.

Table 6.2 Approved Cadre Distributed according to Sections in the NWSDB RSC(N/C)

Board Grade	Categories Designation	DGM	SECTIONS				
			DEV'T	O&M	COMM & FIN	HR	IT
2	Deputy General Manager	1					
3	Assistant General Manager		1				
4	Manager (Operation and Maintenance)			1			
	Chief Engineer (Civil)		3				
	Chief Engineer (Mechanical)		1				
	Manager (Ground Water)		1				
	Manager (Human Resources)					1	
	Chief Accountant				1		
	Chief Sociologist		1				
7	Hydrogeologist /Geologist		2				
	Engineer (Civil) / District Engineer		10	3			
	Engineer (Electrical)			2			
	Engineer (Mechanical)			2			
	Computer Hardware Engineer (IT)						1
	Chemist			2			
	Asset Management Officer				1		
	Commercial Officer (Opns / Investigation)			2			
	Accountant			1	1		
	Cost Accountant				1		
	Sociologist		1				
	Quantity Surveyor		1				
8	Human Resource Officer					1	
	Supply Officer					1	
	Personnel Assistant Secretary	1					
	Assistant Engineer		2	20			
	System Administrator						1
9	Engineering Assistant (Civil)		10	19			
	Engineering Assistant (Mechanical)		1	7			
	Engineering Assistant (Electrical)		1	3			
	Draughtsman		2				
	Management Assistant Supra (Audit)			1			
	Management Assistant Supra (Accounts) [Accounts Asst]			2			
	Management Assistant Supra (Accounts Commercial) [Acct Asst Commercial]			1			
	Management Assistant (Costing)				2		
	Consumer Relations Assistant			1			
	Management Assistant Supra (HR)[Staff Asst]			1			
	Laboratory Assistant			2			
	Computer System Operator			1			
	Driller		8				
10	Management Assistant (Accounts Clerk)			7	2		
	Computer Hardware Technician						1
11	Management Assistant (Human Resources) [General Clerk]		3	12		3	
	Management Assistant (Consumer Relations)[Consumer Relations Clerk]			4			
12	Management Assistant (Cash & Funds) Cashier			2			
	Plant Operation Technician			9			
	Management Assistant (Data Entry Operator)			4			
	Management Assistant (Word Proc English)		1	1			
	Management Assistant (Word Proc Sinhala)					1	
	Management Assistant (Store Keeping) [Store Keeper]		1	6			
	Laboratory Attendant			2			
	Meter Reading Inspector			1			
	Management Assistant (Receptionist)			1			

Board Grade	**Categories Designation**	DGM	**SECTIONS**				
			DEV'T	O&M	COMM & FIN	HR	IT
13	Meter Reader			31			
	Driver	1	8	24			
	Labour Supervisor		2	10			
	Mechanic			3			
	Electrician			4			
	Plant Operator Mechanic			44			
	Carpenter			1			
	Circuit Bungalow Keeper			3			
	Mason			2			
	Pipe Fitter			31			
	Cook			1			
15	Caretaker			3			
	Labourer	1	20	100	1	4	1
	TOTAL	**4**	**80**	**377**	**9**	**11**	**4**

(3) The Proposed Cadre to Support the Project (2018)

There is an approval process that has to be followed should the NC RSC request for additional / new cadre. Considering that this Project will entail the development and construction of new facilities, having the right number and right qualifications of the additional staff to manage, operate and maintain the new facilities will be an essential part of successful project implementation. **Figure 6.1** provides the process in requesting for additional cadre for the RSC.

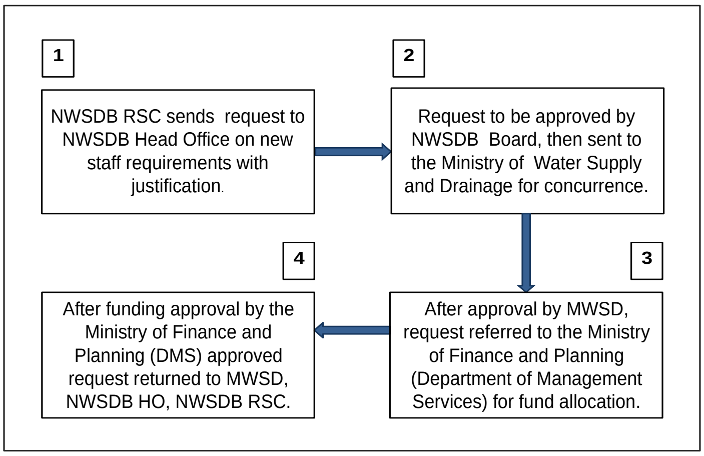

Figure 6.1 Process of Approval for New Staff/Cadre

Once the request for new staff / cadre is approved, then the NWSDB will commence recruitment based on the *Scheme for Recruitment and Promotion*, either recruiting internally, adhering, however, to the internal allotment criteria, or externally, where the required position is advertised. In any case, the qualification and experience criteria for each position, plus the officially recognized recruitment process(es) will have to be strictly complied with. The proposed cadre is shown in **Table 6.3**.

Table 6.3 Proposed Cadre for NWSDB RSC(N/C) for 2018 by Board Grades

Board Grade	Categories / Designation	Approved Cadre (2012)	Proposed New Cadre (2018)
2	Deputy General Manager	1	0
3	Assistant General Manager	1	0
4	Manager (Operation & Maintenance)	1	0
	Chief Engineer (Civil)	3	0
	Chief Engineer (Mechanical)	1	0
	Manager (Ground Water)	1	0
	Manager (Human Resources)	1	0
	Manager (IT)	None	1
	Manager (Training)	None	1
	Chief Accountant	1	0
	Chief Sociologist	1	0
5	Senior Human Resource Officer	None	1
6	Training Officer	None	2
7	Hydrogeologist / Geologist	2	0
	Engineer (Civil) / District Engineer	13	1
	Engineer (Electrical)	2	0
	Engineer (Mechanical)	2	0
	Computer Hardware Engineer (IT)	1	0
	Chemist	2	0
	Asset Management Officer	1	0
	Commercial Officer (Operations / Investigation)	2	0
	Accountant	2	0
	Cost Accountant	1	0
	Sociologist	1	0
	Quantity Surveyor	1	0
8	Human Resource Officer	1	0
	Supplies Officer	1	0
	Personnel Assistant / Secretary	1	0
	Assistant Engineer	22	0
	System Administrator	1	1
9	Engineer Assistant (Civil)	29	0
	Engineer Assistant (Mechanical)	8	1
	Engineer Assistant (Electrical)	4	1
	Engineer Assistant (O&M) (WTP)	0	3
	Draughtsman	2	0
	Management Assistant Supra (Audit)	1	0
	Management Assistant Supra (Accounts)(Accounts Asst.)	2	0
	Management Assistant Supra (Accounts Comm) (Account Asst Comm)	1	0
	Management Assistant (Costing)	2	0
	Consumer Relation Assistant	1	1
	Management Assistant Supra (Human Res) (Staff Asst)	1	1
	Laboratory Assistant	2	1
	Computer System Operator	1	0
	Driller	8	0
10	Management Assistant (Accounts Clerk)	9	0
	Computer Hardware Technician	1	0
11	Management Assistant (Human Resource) (General Clerk)	18	0
	Management Assistant (Consumer Relation)(Consumer Relation Clerk)	4	0
12	Management Assistant (Cash and Funds) Cashier	2	0
	Plant Operation Technician	9	6
	Management Assistant (Data Entry Operator)	4	0
	Management Assistant (Word Processing English)	2	1
	Management Assistant (Word Processing Sinhala)	1	1
	Management Assistant (Store Keeping) (Store Keeper)	7	0
	Laboratory Attendant	2	1
	Meter Reading Inspector	1	0
	Management Assistant (Receptionist)	1	0

Board Grade	Categories / Designation	Approved Cadre (2012)	Proposed New Cadre (2018)
13	Meter Reader	31	1
	Driver	33	4
	Labour Supervisor	12	0
	Mechanic	3	0
	Electrician	4	2
	Plant Operation Mechanic	44	6
	Carpenter	1	0
	Circuit Bungalow Keeper	3	0
	Mason	2	0
	Pipe Fitter	31	8
	Cook	1	0
15	Caretaker	3	9
	Labourer	127	9
	TOTAL	**485**	**63**

As shown in the Table above, 63 new personnel will have to be recruited. It is recommended that the recruitment process start at least a year before the expected completion of construction, or on 2017, so that there is ample time for the entire recruitment, selection and placement (RSP) processes. The details of the staff distribution for the 63 personnel are further explained later into this Chapter.

(4) The NWSDB RSC(N/C) Organisational Structure with Proposed New Units for 2018

The organisational structure of NWSDB RSC(N/C) will, for all intents and purposes, remain the same. However, because of the Project, certain necessary additions to the structure are proposed. This is in line with strengthening the O&M organisation, to ensure appropriate and sustainable, efficient and effective operation and maintenance of the new facilities and also that the consumers – whether the CBOs or the directly-served households – are provided with the reliable 24-hour service, adequate and safe water supply.

The organisation structure showing the proposed new units is shown in **Figure 6.2.** However, the details relating to the proposed Area Engineer’s Office are explained in “**Section 6.2: The Operation and Maintenance Organisation”**; while the details to support the Training Unit / Centre are in “**Section 6.1.4: Capacity Development of the Implementation Organisation”** in particular, “2) Setting up a Training Unit and a Regional Training Centre”.

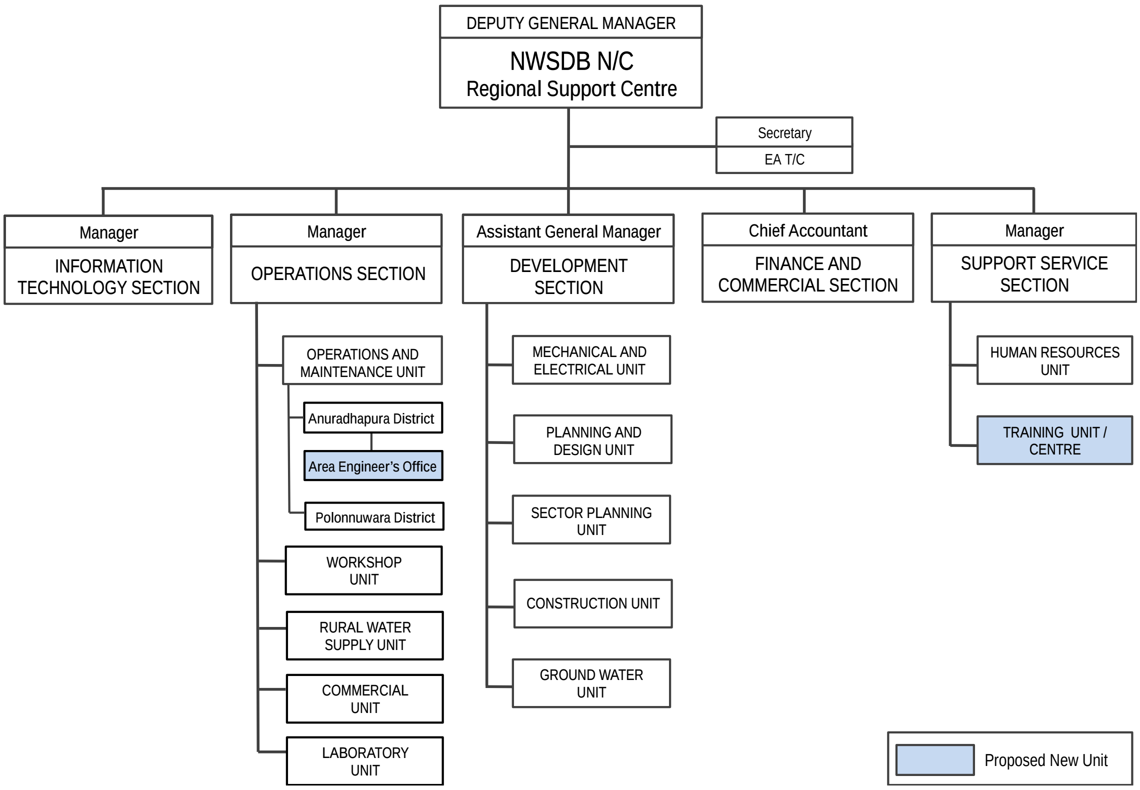

Figure 6.2 Proposed New Units for NWSDB North Central RSC

6.1.3 Project Implementation Arrangements

Ensuring the successful implementation of the Anuradhapura North Integrated Water Supply Project necessitates setting up a rational project implementation system that would take into consideration the requirements of, and the agreements between, the proposed lender, in this case the Government of Japan (GOJ) and the borrower, the Government of Sri Lanka (GOSL).

This section addresses setting up the project implementation system, which requires identifying the key institutions / stakeholders that have varying interests and involvements in project's implementation, setting up project organizations to support smooth project implementation and successful project completion, then defining and/or clarifying the roles and responsibilities of the project organizations within the set framework.

(1) Key Stakeholders

The key stakeholder institutions with interest in the project's implementation are the Central Environment Authority, the Department of Irrigation, the Department of Wildlife Conservation, the Department of Health, the Land Commissioner's General Department, the Department of Archaeology, and the Forestry Department. In addition, there are the local government authorities and the CBOs.

1) Central Environment Authority

The CEA is the government agency under the Ministry of Environment and Natural Resources. It is responsible for ensuring compliance to the Environmental Impact Assessment (EIA) procedure for projects under the National Environment Act. The EIA is a major planning tool aimed at identifying likely effects of a particular project on the environment, and finding ways to reduce unacceptable impacts so that the project is shaped to suit the local environment. It is a mandatory requirement for the establishment of sustainable development projects in Sri Lanka, which this Project is identified.

2) The Irrigation Department

The Irrigation Department is under the Ministry of Irrigation and Water Resource Management. It is the principal government organization responsible for the regulation and control of inland waters. This Project intends to tap water from the irrigation systems / facilities / tanks of the Irrigation Department and transmit this to the proposed water treatment plants before distribution to the six project areas. The rules and regulations imposed by the Department of Irrigation must be complied with, which makes this department a key stakeholder where close coordination must be established and maintained.

3) The Department of Wildlife Conservation

Under the purview of the Ministry of Environment and Natural Resources, the Department of Wildlife Conservation has a unique mandate of protecting, conserving and preserving Sri Lanka’s ecosystem, its wildlife and nature, its forests, its fauna and flora, and its rich biological resources, including their habitats. The interest of this Department is in ensuring that the Project adheres to the National Wildlife Policy of Sri Lanka, the Fauna and Flora Protection Ordinance, and the regulations supporting the Network of Wildlife Protected Areas (WLPAs).

4) The Department of Health Services

The Department of Health Services is responsible for the providing effective health services to the people of Sri Lanka, where environmental health measures, such as supply of safe and adequate water and sanitation, play a key role. Thus, the Department has special concern over the successful implementation of the Project, as it will improve the quality of water being supplied to the project area, which is known to have high levels of fluoride concentration in its groundwater. The aim is to reduce incidences of fluorosis that causes abnormality in teeth and bones, as well as prevent the rapid increase in chronic kidney diseases, which the Sri Lankan government suspects is due to the high fluoride content in drinking water.

5) The Department of Archaeology

The Department of Archaeology is the apex institution and chief regulatory body for the protection, conservation and management of Sri Lanka's archaeological heritage. Since the Project area has very close proximity to the ruins of Buddhism in Anuradhapura, which has been designated as a world cultural heritage by UNESCO, there exists the possibility of important archaeological finds, meriting the inclusion of this Department as a key Project stakeholder.

6) The Land Commissioner's General Department

One of the mandates of the Ministry of Land and Land Development is the allocation of lands for development projects. The lands where the water facilities are to be built have been identified as government land. This makes the Ministry, particularly the Land Commissioner's General Department, as an important stakeholder in the project.

7) The Forestry Department

The Forestry Department is government agency under the Ministry of Environment and Natural Resources whose mandate is to sustainably manage, conserve and develop the forest and tree resources of Sri Lanka while contributing to national prosperity and economy of the country and its people. It implements the Forest Ordinance, an important legislation for managing state owned forests. The Forestry Department is an important stakeholder because it owns the land where the proposed WTP will be constructed in Wahalkada. In addition, the Forestry Department ensures that development Projects adhere to these other laws / ordinances / policies – the National Heritage and Wilderness Area Act, the Fauna and Flora Protection Ordinance, the National Environmental (Protection) Act, the Soil Conservation Act, the Felling of Trees (Control) Act, and the Land Legislation (Land Development Ordinance, Crown Land Ordinance, Land Settlement Ordinance).

8) The Local Authorities

Local Authorities is the collective nomenclature for local government bodies, which are divided into four different groups – provincial councils, municipal councils, urban councils and the divisional councils or the *pradeshiya sabha*. Laws require local authorities to carry out regulatory and administrative functions, promote public health, and provide physical structures and specific services, such as roads, drains, water supply and sanitation, housing, waste collection, markets, public parks and recreational facilities. The implementation of the Project will have the local authorities as stakeholders, not only because their immediate constituents will stand to benefit from it, but also because the project will be constructed within its areas.

The role of the local authorities under the *National Policy on Water* is to (i) undertake planning, design and implementation of small and medium rural water supply schemes; (ii) undertake the operation and maintenance of small and medium scale water schemes, (iii) ensure quality and standards of services, (iv) develop and build partnerships for operations and maintenance activities for the enhancement of service delivery, (v) facilitate the CBOs in implementing and managing the water supply systems and provide them with necessary technical assistance, and (vi) ensure environmental harmony in all development activities and the sustainability of the sub-sector through cost recovery.

9) Community Based Organisations (CBOs)

Community-based organisations have been known to be very active in the supplying water and sanitation to the Sri Lankan countryside / villages. There are 50 registered CBOs presently operating in project area, and their interest in the successful implementation of the project is the additional supply of safe water for its own (and new) consumers. These CBOs can also plan on expanding their own distribution system as a consequence, thus improving service coverage, adequacy and water quality.

The *National Policy on Water* has listed the responsibilities of the community as water "user" by promoting the formation of CBOs to implement and manage community water supply schemes. CBOs are also tasked to coordinate, participate, and/or contribute in sector development activities during planning, design and construction stages of a project, contribute towards the preservation, protection and conservation of water resources, and recognize the value of the service and contribute towards cost recovery to sustain service.

(2) The General Implementation Framework for the Project

The aim of the *National Policy on Water* is setting a direction for all stakeholders in the drinking water sector so that the broader goals and objectives established by the Government are achieved. In this manner, not only are issues related to quality and quantity aspects resolved, but also the commitment of the service providers and the users for the sustainable utilisation of drinking water is promoted.

In implementing this Project, there is a need to put in place, as well as situate the roles of, institutions and stakeholders involved in a project implementation framework. This framework, indicated in **Figure 6.3**, shall define and govern the general and specific interactions among the project organisations.

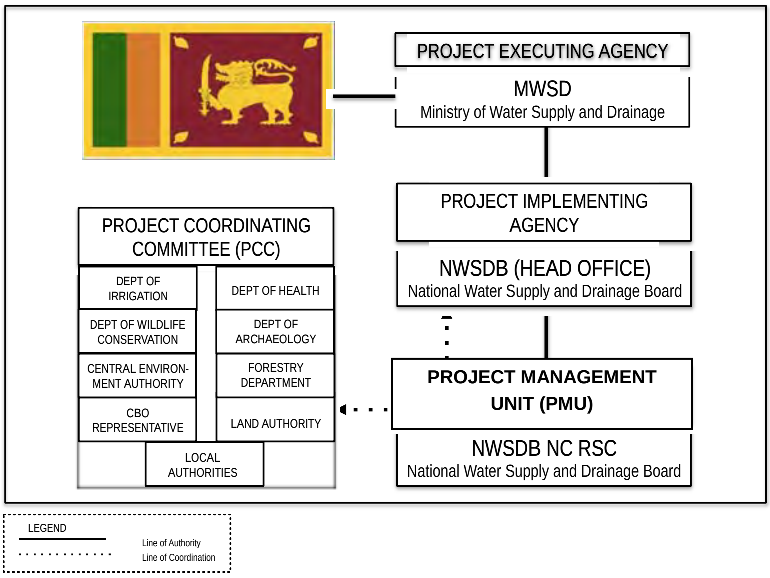

FIGURE 6.3 General Project Implementation Framework

The figure shows that a *line of authority* (represented by a solid line) exists between the Government of Sri Lanka (GOSL) and the Ministry of Drainage and Water Supply (MWSD), which will be the Project Executing Agency. The Ministry is under the supervision and authority of the Government and among its responsibilities are formulating national policies and programmes, and laws and regulations on water supply, sanitation and drainage

A *line of authority* also links the MWSD and the National Water Supply and Drainage Board (NWSDB), which will be the Project Implementation Agency. The NWSDB is the only organisation under the purview of MWSD, which in turn, is responsible for facilitating and guiding the NWSDB in implementing programs and projects in accordance with national priorities.

The North Central RSC is one of the operating arms of NWSDB. As such, the Head Office has direct authority, control and supervision over the N/C RSC even if technical functions, such as planning and development as well as operation and maintenance have been decentralized to the RSC. The N/C RSC will house the Project Management and Coordination (PMCU) with personnel coming primarily from NWSDB HO Unit. A *line of authority* symbolizes the relationship between the NWSDB HO and NWSDB RSC(N/C).

The project stakeholders will be organised into the Project Coordination Committee (PCC). This will enable their varied interests to be addressed by NWSDB during project implementation. The coordinative relationship between the PCC and the NWSDB (through the NWSDB RSC(N/C)) is described by *line of coordination* (represented by a dotted line).

It should be noted that project implementation and management shall generally be spelled out in and governed by the Loan Agreement to be signed between GOSL and GOJ. It will include adherence to the Contract particulars that specify the mutual rights and obligations of each party, which emphasize abiding by all relevant GOSL laws. It will also provide for setting up and supporting a project organisation (Project Management and Coordination Unit) for the duration of implementation, and strengthening this unit as a primary consideration in the project implementation process.

(3) Roles and Responsibilities of the Project Organisations

Each of the project organisations enumerated in the general implementation framework has responsibilities to discharge, as summarised in **Table 6.4**.

Table 6.4 Roles and Responsibilities of Project Organisations

PROJECT ORGANISATION	INSTITUTION	MAIN ROLE	RESPONSIBILITY
Project Executing Agency	Ministry of Water Supply and Drainage	Oversight	General Procurement Disbursement
Project Implementation Agency	National Water Supply and Drainage board	Technical Supervision and Monitoring	Procurement Disbursement Monitoring
Project Management and Coordination Unit	NWSDB	Project Management, Field Supervision, Monitoring and Coordination	General Project Management
	NWSDB North Central	Coordination	Coordination of Implementation Issues
Project Coordination Committee	Key Stakeholders	Coordination	Coordination of Implementation Issues

1) Project Executing Agency

The project executing agency will be the MWSD, whose mission is "to facilitate stakeholders to serve the nation by providing safe drinking water and adequate sanitation facilities, ensuring protection of water sources and environmental equality in the drinking water supply sector". Pursuant to this mission, the MWSD is granted legislative, policy, regulatory and coordinative powers and functions to achieve the water supply goals contained in the "Mahinda Chinta" development plan, and the development objectives of the Millennium Development Goals. Inherent in the exercise of its mandate and its powers is oversight, which refers to the crucial role of monitoring and reviewing actions taken by agencies of government under its purview.

(a) General Role of MWSD as Executing Agency

The general role of MWSD is oversight, which will be in holding the NWSDB accountable for implementing the project in compliance with the terms and conditions set forth in the Loan Agreement to be signed between GOSL and GOJ as well as in conformance to Government's laws, rules and regulations. Note that the implementation of this project will be undertaken by the NWSDB, which is the only agency under the MWSD. Thus, oversight is designed to facilitate project implementation and expedite problem-solving as one link, or is a part of the multi-level performance-based expenditure management system within the national framework for monitoring and evaluating public sector projects of the GOSL.

The MWSD has the Planning and Monitoring Division to perform its oversight role. This division is responsible for planning, monitoring and reviewing the progress of foreign and locally funded development projects implemented by the NWSDB. The general mechanisms for the executing agency to maintain effective oversight are:

- Establish a monitoring and evaluation system that would track the progress of the Project against the technical and financial plan.
- Formulate and/or recommend on policy issues referred to it because of legal or other conflicts that may impede the smooth implementation of the Project.
- Identify and set-up mechanisms for systematic and coordinated delivery of services by tapping other Ministries and/or Agencies to augment and support the process of project implementation, such as land acquisition.
- Identify the priority list of projects, and include in the yearly budget call, all related facilities required for the Project, but not covered under the loan proceeds, but is a part of GOSL's responsibility under the Loan Agreement.
- Make recommendations on investments related to the Project and include these in the priority investment program of the GOSL.
- Ensure the timely release of counterpart (local) funds, if needed, for the Project to the appropriate Ministry.
- Report to the Government on the over-all progress of the Project, if required.
- Call regular meetings (quarterly) for the duration of the Project, and special meetings should the need arise.

(b) Procurement and Disbursement Responsibilities of MWSD

Generally, the employment of consultants and procurement of all goods and services financed out of the proceeds of the loan are made in accordance with JICA's guidelines for procurement. Because of the size and nature of the project, it is expected that the civil works contracts will be awarded on the basis of international competitive bidding. There is a domestic contracting industry in GOSL, and sub-project surveys, investigations, and designs carried out with JICA funding can be undertaken by prequalified local contractors (private sector companies, institutes, and universities) selected by NWSDB, but confirmed by MWSD, on the basis of local competitive bidding using procedures acceptable to JICA. Procurement of materials and equipment is also expected through local bidding for the reason mentioned above.

The extent of involvement in procurement responsibilities will depend on the final terms and conditions of the Loan Agreement. These responsibilities are as follows:

- If required, MWSD will assist the NWSDB by providing an expert staff in NWSDB's Evaluation Committee to select and employ the Consultants for the Project, based on the *Guidelines for the Selection and Procurement of Consultants for JICA ODA Loans*.
- MWSD will confirm the action/decision of the NWSDB Board of Directors in negotiating with, awarding and signing the contract with the winning Consultant, where the signatory to the contract will be either be the General Manager of the NWSDB, or the Chairman of the NWSDB's Board of Directors, or both.
- If required, MWSD will assist the NWSDB by providing an expert staff in NWSDB's Evaluation Committee to select and procure civil works Contractors, based on the *Guidelines for Procurement under JICA ODA Loans.*
- MWSD will confirm the action/decision of the NWSDB's Board of Directors on the selection and procurement of the civil works contractors, as well as on the procurement of goods and other services, based on the *Guidelines for Procurement under JICA ODA Loans*, where the signatory to the contract will be either be the General Manager of NWSDB, or the Chairman of the Board of Directors, or both.

It should be noted that the MWSB has a Procurement Division, which functions to facilitate and/or expedite the procurement process relevant to water supply and sewerage projects implemented with local and foreign funds, both at Ministry and Cabinet procurement levels.

In addition, the executing agency also has responsibilities in disbursement. Since disbursement of JICA funds follow the principle of payment against invoice and other evidences, together with the certification of completed work, GOSL shall advance the funds to start the Project activities, and then claim reimbursement from JICA every time a certain portion of the work is completed. The responsibilities of GOSL in disbursement are specified in the Loan Agreement, and GOSL will abide by the disbursement procedures such as *Commitment Procedures*, the *Reimbursement Procedure*, and *Transfer Procedures*.

2) Project Implementing Agency

The Project Implementing Agency is the NWSDB, which will exercise monitoring and technical supervision over the project. While JICA has a built-in monitoring system of ODA projects, NWSDB has developed its own monitoring system that tracks the progress of the project against the technical and financial plan. This function is performed under the office of the Additional General Manager for the Water Supply Projects.

(a) Monitoring Role of NWSDB as the Project Implementing Agency

The objective of monitoring is to achieve efficient and effective project implementation as it keeps an eye on the progress of implementation and provides relevant and timely feedback to project managers and implementers. Feedback is necessary to provide project management the basis for improving operational plans, taking appropriate corrective actions or measures in case of shortfalls, and therefore, putting the implementation back on track. Technical monitoring shall include scope, time or schedule, quality, and performance monitoring; while financial monitoring shall include cost (budget), procurement, and disbursements monitoring.

Normally specified in the Loan Agreement would be the submission of *Quarterly Reports* to JICA until the completion of the project; as well as the *Project Completion Report* not later than six months after the completion of the project, using specified official forms and details of the report. All these reports will be prepared by PMCU, with the assistance of the Consultants, and when submitted to JICA will bear the final approval and signature of the duly authorized official.

On its own end, MWSD may require NWSDB to submit regular monitoring reports on project implementation activities, and of the work of the Consultants. The content and regularity of monitoring may be designed jointly by NWSDB and MWSD.

Therefore, the first level project monitoring is actual field monitoring, which will be performed by the Project Management and Coordination Unit, to be created at the Office of the Additional General Manager for Water Supply. The second-level monitoring will be done by NWSDB in its role as the Implementing Agency, NWSDB. The third level monitoring is the oversight level to be performed by the MWSD.

These levels of monitoring will surely facilitate project implementation because problems not sufficiently addressed on the first level, can be re-identified or resolved if it recurs on the second level and so forth, thereby integrating monitoring into a feedback loop that ends up into the next planning period. Either the NWSDB management or MWSD can require PMCU to submit regular (weekly, or every two weeks, or monthly, depending on the requirement) monitoring reports, specifying items that need to be reported. Monthly face-to-face meetings can be initiated to deal with those problems that may not have been adequately addressed.

(b) Procurement and Disbursement Responsibilities of NWSDB

Generally, the responsibilities of the Project Implementing Agency in procurement and disbursement are contained in the Loan Agreement. These are:

- Selection and employment, negotiation, awarding and signing the contract with the winning Consultant based on the *Guidelines for the Selection and Procurement of Consultants for JICA ODA Loans*, where the signatory to the contract will be either be the NWSDB General Manager or the Chairman of the NWSDB Board, or both.
- With the assistance of the Consultant, performing the prequalification of tender, tender calling, tender evaluation, and contract negotiation for the civil works contractors, as well as on the procurement of goods and other services, based on the *Guidelines for Procurement under JICA ODA Loans*, where the signatory to the contract will be either be NWSDB General Manager or the Chairman of the NWSDB Board, or both.
- Undertaking project compliance to covenants stipulated in the Loan Agreement.

As discussed earlier, disbursement of JICA funds follow the principle of payment against invoice and other evidences, together with the certification of completed work. All responsibilities in disbursements are again specified in the loan agreement and in the JICA disbursement procedures. PMCU, with the assistance of the project consultant's team shall carry out the final review and approval of all documents submitted to it by the contractors and suppliers and submit the same to the Additional General Manager / General Manager, who will affix his signature prior to its transmittal to JICA.

3) Project Management and Coordination Unit

The Project Management and Coordination Unit will be established at the Office of the Additional General Manager for Water Supply Projects. A Project Director (PD) shall be appointed / assigned to head the Unit, and he/she shall be selected from the technical and professional ranks of NWSDB.

Although the physical location of the PMCU will be in at the NWSDB North Central RSC where the facilities will be constructed, the PMCU will retain its direct authority and supervisory link with the Office of Water Supply Projects in the Head Office.

(a) General Role of PMCU

The PMCU shall be tasked with managing the day-to-day activities of the project at the field level. Providing day-to-day supervision over the management of the project means addressing technical skills like scheduling, cost estimating, and risk management; and also encompasses other disciplines such as scope definition, procurement management, financial management, asset management, human resource management, environmental and social considerations, and communications.

The NWSDB is quite familiar with managing projects of this scale funded from foreign bilateral or multilateral sources. The experiences obtained have contributed not only to their well-developed project management skills, but also to their knowledge of international loan procedures and working with Project Consultants.

(b) Project Management and Coordination Responsibilities of the PMCU

While it shall be working very closely with the Project Consultants, the PMCU's tasks relate to the application of project management concepts, tools and techniques. This addresses the full range of activities from the beginning (initiating) to the end (closure) of a project, and the management of multiple sub-activities within the project. PMCU shall be involved in the entire cycle of the project as reflected in the whole range of services to be provided by the Consultant.

- Provide day-to-day supervision and management over the project.
- Review billing and expenditure statements. Prepare request for loan availment according to GOSL and JICA disbursement procedures.
- Prepare and submit comprehensive work and financial plans (WFP) for the approval of the NWSDB General Manager, through the Additional GM for Water Supply Projects and submit the same to MWSD for monitoring purposes.
- Undertake project management within the approved work plans and report the progress of the project to NWSDB Management, and if required, to MWSD.
- Initiate coordination with the PCC (as project stakeholders) concerning project implementation bottlenecks that would be within these stakeholders' ability to resolve.
- Prepare and submit to NWSDB Management and/or MWSD annual progress reports for information of the Government.
- Prepare and submit project completion reports, conduct closing workshop and prepare project acceptance certificate.
- After the completion of the project, NWSDB will have the option of retaining the PCMU staff and place them in vacant technical posts, if warranted.

(c) Proposed Staff Requirement for the PMCU

The proposed staff requirement for the PMCU is for 10 members, as shown in **Table 6.5**. It is recommended that the Project Director be appointed solely for this project given the scope and scale and project completion time, which is approximately four years. Other personnel needed for the PMCU should also come from the current roster of NWSDB Head Office or N/C RSC to effect synergies and opportunity for training and development. Others that cannot be filled from the existing ranks shall be hired on a contractual basis for the duration of the project. Recruitment and selection, however, will follow the government regulations and processes on hiring. It will also be based on the NWSDB's *Scheme of Recruitment and Promotions*, which describes the academic and professional qualifications, as well as the experience requirements for the positions.

Table 6.5 Proposed Staff Requirement for the PMCU

	PMCU Position	Category in Approved Cadre	Proposed Number
Engineering/Technical Staff			
1	Project Director	Project Director	1
2	Project Manager	Chief Engineer	1
3	Project Engineer	Engineer (Civil)	2
4	Project Engineering Assistant	Engineering Assistant	3
Administrative Staff			
5	Project Accountant	Accountant	1
6	Administrative Assistant	Management Assistant (Data Entry Operator)	1
7	Driver	Driver	1
		Total	**10**

(d) Job Tasks of PMCU Staff

Each member of the PMCU will discharge his/her responsibilities in keeping with objectives of the Project. As such, the main and specific job description / tasks for each member of the PMCU are described and defined in **Table 6.6**.

Table 6.6 Main and Specific Job Tasks of PMCU Staff

Job Title	Main	Specific
Project Director (PD)	On **the operating level**, will ensure that objectives / targets of Project are achieved efficiently and effectively and according to schedules, plans and procedures agreed upon by JICA and the GOSL. On **the monitoring level,** will attend the regular meetings to be called by NWSDB Management on the implementation of this ODA project and bring to its attention urgent issues for immediate resolution. On **the policy level,** the PD, as the PCC chair, will proactively coordinate and collaborate with the key stakeholders especially on matters that may need policy decisions and resolutions.	As **over-all in charge of project management and coordination activities**. • Responsible for reviewing all documents and communications going to the GM / Addl GM, for approval or endorsement to external offices. • Responsible for direction and guidance over PMCU staff. • Responsible for management and supervision of technical tasks, such as the review of detailed design, and construction management of the new facilities (treatment plants, distribution tanks and reservoirs, water transmission and distribution network).

Project Manager (PM)	Directly manages and supervises work for the project and work outputs of the PMCU staff.	• Reviews and confirms the scope of work of consultants for the approval of the Project Director; • Defines the roles and responsibilities of each PMCU team member and secure their respective commitments; • Defines the outputs, resource constraints, timelines and quality expectations for the submission of the outputs by each team member. • Develops the work and financial plans of the project for approval of the NWSDB Management through the PD and determines the resource and logistical constraints to complete the objectives of the project.
	Develops systems, policies/rules and procedures to manage and monitor the implementation of the project components.	• Monitoring benchmarks to evaluate the progress of the project; • Monitoring the progress of the Consultant and Contractors in terms of scope, time and budget using the appropriate software; • Database and monitoring system that will enable quick and accurate online downloading of information on the progress of the project; • Development and implementation of standards, guidelines and regulations
	Ensures the timeliness and quality of outputs of the Consultants, contractors and suppliers.	• Reviews all reports of the Consultant and recommends the appropriate action, where necessary; • Recommends to the PD the dispatch of people for field visits, coordination and inspection; • Reviews post-field reports and identifies issues with the necessary recommendations for submission to PD; • Reviews and recommends invoices, including certification of work completion/acceptance of Consultant and contractors/suppliers for billing purposes;
	Manages and monitors all pertinent activities, like work flow and records management; administrative coordination and financial transactions.	
	Reviews and manages the monitoring plan for the natural and social environment, and other social considerations;	
	Provides regular progress and performance evaluation reports and to the NWSDB Management, MWSD, GOSL and JICA through the PD.	
Project Engineer (PE)	*Reports directly to the PM:* Responsible for the field-level implementation and management by providing direction for the effective and efficient field implementation of the different components of the project, while also monitoring the performance of the contractor and the field experts of the Consultant;	• Assists the PM in his responsibility for the management and supervision of technical studies to be undertaken; • Directly oversees and supervises the implementation of field-level activities, particularly in civil works construction; • Certifies the completion of work and payments of suppliers; • Develops and undertakes planning activities, such as but not limited to, the work (technical) and financial plans for submission to and approval of NWSDB Management and undertake the implementation of the approved work plan;

		• Monitors project activities and accomplishments, using the designed monitoring system; • Prepares supporting reports on the progress of the project for NWSDB, MWSD, the Government, and the JICA; • Reviews monitoring report of consultants and contractor's work and submits this to through the PMCU's chain of command.
Project Engineering Assistant (PEA)	*Reports directly to the PE:* Responsible for efficient and effective support and assistance to the Project Engineers field-level implementation and management.	• Validates the progress of implementation of each activity in the work plan; • Assists in monitoring the activities and accomplishments of the project; • Assists in preparing regular supporting reports for various users; • Facilitates the preparation of the work (technical) and financial plan; • Reports and/or find solutions to problems encountered in the field. • Assists in monitoring the performance of the contractor and the field experts of the Consultant; • Prepares regular field inspection reports; • Reports any deviations and problems to the PE.
Draftsman	Provides drafting services and supports other technical requirements of the Project, as necessitated by the PD and PM.	
Project Accountant PA)	*Reports directly to the PD* Performs project accounting and financial functions such as disbursements and cash management.	• Prepares the financial portion of the WFP; • Keeps all project accounts up-to-date while assists in maintaining project book of accounts; • Ensures timely preparation of report of disbursements and periodic accounting reports of the Project; • Processes vouchers and documents for disbursement of project funds.
Administrative Assistant (AA)	*Reports directly to the PD* Performs administration work such as records keeping, office management, and support services.	• Develops, maintains and manages the Project's HR system, records system, project office documents and communications system, as well as physical facilities and supplies; • Coordinates and processes procurement of goods and services for the PMCU; • Processes request for payments from suppliers and reviews compliance with GOSL and JICA procedures; • Prepares request for payment for suppliers, contractors and consultants.
Driver	Drivers shall be maintained under the Administrative Assistant under the office of the PD.	• Ensures the safe transport of passengers and goods within the project sites; • Performs regular maintenance works on the vehicles assigned to them.

(e) Proposed PMCU Organisation Chart

The organisation chart of the PMCU is shown in **Figure 6.4**. The chart indicates not only the number of personnel for the Unit, but also clearly specifies the authority, responsibility and communication (reporting) lines.

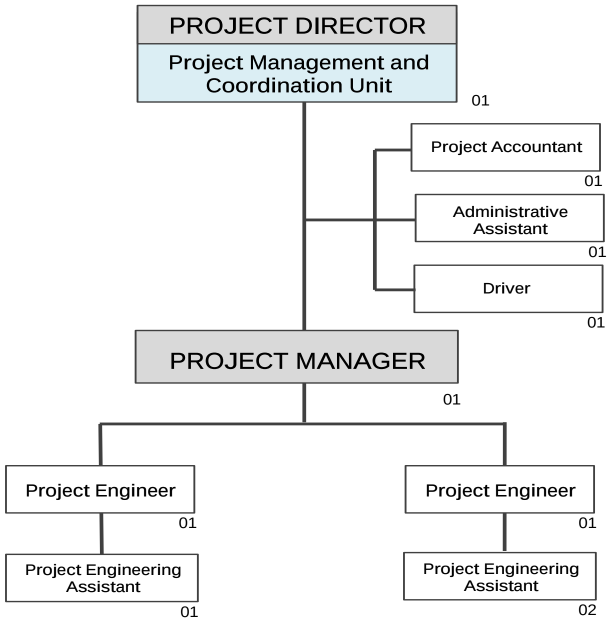

Figure 6.4 Proposed Organisation Chart of PMCU

4) Project Coordination Committee

The PCC shall be composed of the key stakeholder organizations, which have varied and, sometimes, differing interests in the Project, stemming from the stakeholders' specific mandates and legal responsibilities. It is the aim of the PCC to ensure that all these interests converge, and that conflicts are resolved for the smooth implementation of the project. The following guidelines are recommended:

(1) Membership to the PCC

- The stakeholder organizations will nominate their official representative and alternate representative to the PCC in writing addressed to the General Manager, NWSDB – Attention: Additional General Manager for Water Supply Projects.
- As much as possible, the official representative and alternate representative shall be those officials assigned to the regional or provincial offices of the Ministries or Departments concerned in Anuradhapura, who have decision making authority(ies).
- In like manner, the quad-level local authorities will also nominate in writing their representative and alternate representative to the PCC.
- The CBOs will meet for the purpose of selecting (or electing) their representative and alternate representative to the PCC, such that there will be six CBO representatives, one from each of the six study areas.

(2) Role of NWSDB RSC in the PCC

- The PCC chair will be the DGM of the North Central RSC, with the Project Director acting as co-chair.
- For purposes of coordination, quarterly meetings will be held to apprise the PCC members of the progress of the project, and to discuss and find solutions to issues raised.
- Special meetings can be called should the need arise.
- The N/C RSC will provide secretariat services to the Committee, and will also be the official depository of the PCC minutes of the meetings.
- Meeting rules will be deliberated upon by the Committee in an organisational meeting called for that purpose.

6.1.4 Capacity Development of the Implementation Organisation

This section provides the capacity building / training and development approaches for the NWSDB North Central RSC given the requirements, results and impacts brought about by the Project. The objectives of capacity building and development are, therefore, twofold. First is to enhance the capacity / ability of the NC RSC, as an institution, to perform the activities related to the operation and maintenance of the newly constructed facilities. Second is to enhance the existing skills of key staff, as well as identified group(s) of personnel with the competencies required to manage, operate and maintain the new facilities / system thereby transforming organizational and individual potentials into actuality.

(1) The Current Training Organisation

Training and development is a centralised function, with the Manpower Development and Training Office being the dedicated unit primarily tasked to plan, develop, and implement the training requirements through a Staff Training Plan that “includes continuous training, hands-on experience utilizing new technologies and management techniques” conducted either internally or externally.

1) Head Office

In-house training programmes are broadly categorised into (i) technical courses; (ii) non-technical courses, (iii) computer training courses; and (iv) training courses for select external institutions. All these training are conducted by the trainers of the NWSDB in its Training Centre located in Colombo City. For 2012, 154 training courses were programmed to be conducted by the Centre totalling 15,000 training hours. See **Appendix 6.1(d)** for the list of technical training programmes (2012); **Appendix 6.1(e)** for the list of non-technical training programmes (2012); **Appendix 6.1(f)** for the list of computer training courses (2012); and **Appendix 6.1(g)** for training courses conducted for external institutions (2012).

In-country (external) training programmes are categorised into (i) graduate and postgraduate degree courses (doctorate, master's and post graduate diploma courses) offered by government-recognized universities and educational institutions of higher learning, (ii) diploma courses offered by reputable and government-recognised institutes; and (iii) short specialised courses, certificate courses, and advanced courses offered by reputable institutes, government-recognised universities, and engineering organisations. See **Appendix 6.1(h)** for the list of graduate and postgraduate degree programmes (2012); **Appendix 6.1(i)** for the list of diploma programmes (2012); and **Appendix 6.1(j)** for the list of short, certificate and advanced courses (2012).

In addition to in-house and in-country training, NWSDB key personnel also receive overseas training, usually part of the capacity building phase of foreign-assisted projects. For 2012, 75 staff members have been programmed to receive various types of training overseas.

Table 6.7 gives the targets for all training to be conducted by the NWSDB Training Centre from 2012 to 2016.

Table 6.7 Training Targets of NWSDB (2012-2016)

Description	Unit of Measurement	2012	2013	2014	2015	2016
In-house Training	No. of Programs	150	150	160	160	160
In-Country (External) Training	No. of Persons	240	240	250	250	250
Overseas Training	No. of Persons	75	75	80	80	80

Source: NWSDB Corporate Plan 2012-2016, p 27.

(2) North Central RSC

Training of RSC staff is conducted by the NWSDB Training Division and the RSC. **Table 6.8** provides the trainings received by a range of staff categories, such as engineers, engineering assistants, cashiers and drivers. The total number participants who received training are 40 in 2010 and 293 in 2011, which translates into a total of 112 and 436 training days for 2010 and 2011, respectively.

Table 6.8 Training Received by NC RSC Staff for 2010 and 2011

	Title of Training	Conducted By	Target Group	Duration (No. of Days)	No. of Participants	Total Training Days
	Year 2010					
1.	Industrial Training for Engineers	RSC	Engineers	18	10	180
2.	Office Procedure for Cashiers	RSC	Cashiers	2	2	4
3.	Training for Drivers	RSC	Drivers	1	28	28
	Year 2011					
1.	Flow Measurement Control	Training Division, NWSDB HO	Engineering Assistant	1	33	33
2.	Traffic Laws (Sinhala)	RSC	Drivers	1	24	24
3.	Maintenance of Gas Chlorine	NWSDB HO	Engineering Assistants	3	33	99
4.	Water Treatment Process	NWSDB HO	Engineering Assistants	2	40	80
5.	O&M Aerometers and Sedimentation Tank	NWSDB HO	Engineering Assistants	2	33	66
6.	Surge Analysis for Engineers	NWSDB HO	Engineers	5	1	5
7.	Geographic Information System	RSC	Engineering Assistants	1	12	12
8.	Water CAD Application	RSC	Engineering Assistants	1	12	12
9.	MS Word 2007	RSC	Engineers / EAs	1	5	5
10.	Field Visit to Dowatenne Power Plant	Ceylon Electricity Board	Mixed	1	50	50
11.	Attitude Development and Time Management	RSC	Mixed	1	50	50

Source: HR Office, NWSDB RSC(N/C), July 2012.

Except for one training which lasted for 18 days, the duration of training(s) was from one to five days. This has given rise to the request from the RSC that training be localized in the regional centre, to save both on travel time and accommodation, and to maximize the training benefit to cover other staff who may not have been included due to costs.

This view was shared by NWSDB (Addl GM for Corporate Services and Asst GM for Manpower Development and Training). The Head Office conducts a total of 15,000 training days per annum, and therefore sees the necessity of strengthening the regional centres to enable them to conduct their own training. This would necessitate having a training facility equipped with basic training equipment to cater to the area, the training of trainers, and the development of training modules and courses on a wide variety of subject matters. Linkage with other training institutions must also be developed.

(2) Enhancing Organisational Capacity in Training and Development

While training is also conducted at the regional support centre levels, much of the training is still done centrally at the NWSDB Training Centre in Colombo. There is a need to greatly enhance the organisational capacity of NWSDB RSC(N/C) in the area of training and development by: (i) the development and implementation of a North Central RSC Training Plan; (ii) setting up a regional-level training unit / centre to implement the training plan; and (iii) staffing the regional training unit / centre.

1) The Development and Implementation of a *North Central RSC Training Plan*

While the Head Office integrates the training requirements of all regional support centres, as well as prepares and implements the country-wide training and development plan, it can allow for even greater participation of the RSC by decentralising the development and implementation of the regional-level training plan, which can be done by the NC RSC through these recommended steps:

- Undertaking a training needs analysis (TNA) for the entire RSC starting with each organisational section/unit/office, then for each category in the cadre, and ending with each staff/personnel;
- Linking the TNA to performance management (as part of the entire human resources management model) and to the result of the performance evaluation done on each staff member;
- Preparing a five-year "North Central RSC Training Plan" which (i) answers the unique training needs of the RSC, (ii) is aligned with the comprehensive strategic human resource development plan of the Head Office, and (iii) identifies resource requirements for its sustained implementation;
- Implementing the NC RSC Training Plan on an annual basis, together with the NWSDB Training Centre at the Head Office;
- Reviewing, updating and evaluating the NC RSC Training Plan yearly to incorporate emerging capacity development and training needs and to improve on programme content and delivery.

2) Setting up a Training Unit / Regional Training Centre

The issue of where training should be conducted has been brought up in support of localising training on a regional basis in order to achieve training efficiency and effectiveness. Training efficiency redounds to savings on travel time, which could be better spent on the actual training itself; savings both on travel and accommodation costs; and fully maximising the training effort and costs by being able to cover staff who may otherwise have been left out due to cost constraints if training was conducted in Colombo. Training effectiveness comes from being able to use local cases and experiences as "lessons learned" tools; having longer on-the-job training as compared to if training was not in the jobholder's area; and having ample time to demonstrate competencies learned for skills-based training programmes.

The idea of setting up regional training unit / centre is not new considering the number of training programmes conducted and the number of participants being trained by the Training Centre in Colombo. As for the North Central RSC, the Head Office sees the necessity of strengthening the regional support centre to enable it to conduct most of its own training, as well as for the RSCs nearby. To accomplish this, the NC RSC must have the following basic components:

(a) Basic components in establishing a training unit or centre

- *Training infrastructure, training facilities and spaces,* which are the "hard component" of establishing a training unit or centre. These are: (i) a conference room for large-style lectures; (ii) seminar rooms(s) for multi-purpose, small sized instructions; (iii) workshop space(s) for hands-on practical training; (iv) administrative support space(s) for trainers' offices and general storage areas; and (v) user support spaces to be used for the library or reading room, dining or snack room, and rest rooms.
- *Training and communications equipment,* which are the support components of establishing a training unit or centre as it reinforces face-to-face training and web-based lectures and training programmes. These are: (i) computer(s) and networks; (ii) audio-visual and still camera and video equipment; (iii) basic O&M training equipment to support practical or hands-on training on water supply O&M, such as for leak detection and repair, water meter connection and disconnection and repair, and so forth; (iv) other training aids.
- *Training programmes and courses and its materials, manuals and* modules, which are *the soft component* of establishing a training unit / centre. Many of these have been developed by the NWSDB Training Centre, and can be revised and/or updated. New materials and modules to replace out-dated or obsolete materials, or to support new training courses can be developed by outsourcing training and content experts. All programmes and courses will specify: (i) the knowledge, behavioural, attitudinal and skills *objectives*; (ii) the training *content* or the knowledge and skills to be learned, which may be presented in manual, video and/or training module formats; and (iii) the training *methodology(ies)* appropriate to the training objectives, suitable to the level of the participant-learner, and applicable to the type of knowledge, skill or competencies to be developed.

(b) Establishing the *Training Unit* (Intermediate Measure)

During the detailed design and construction phases of the project, the NWSDB RSC(N/C) can allocate, from its existing inventory of buildings and facilities, the physical location and structure to house the Training Unit. Training equipment can be subcontracted on demand basis, while current training materials and modules can be updated based on users' and participants' feedback. However, all these still need financial resources, if the NC RSC were to provide the superior level of training services. It can, therefore, source the required funds from NWSDB, or from development assistance.

(c) Establishing the *Regional Training Centre* (2018)

Training infrastructure and facilities for the regional training centre is proposed by 2018. The same is true with furnishing the centre with necessary equipment for lecture-type and practical training, including equipment to support web-based training. The latter will allow connection with the NWSDB Training Centre in Colombo, to enable NC RSC to have access to distinguished lecturers not available in the region.

The fund support / financial resources for the hard component, the support component and the soft component (as discussed earlier in this section) can either come from NWSDB funds or be the subject of new development assistance, or a mix of both. What is important is that training and development activities are demand driven, based on actual and local training needs, and answer NC RSC's management and O&M requirements.

3) Staffing the Training Unit (Intermediate) and the Regional Training Centre (2018)

As of August 2012, the Human Resources Section, headed by the Manager, has a total of 10 personnel as shown in **Table 6.9.** However, the HR section staff is concerned with recurring administrative and personnel work, such as the preparation of the annual and project-related personnel requirements and staffing actions for submission to the Head Office. It also provides support services to the RSC in the area of supplies management.

Table 6.9 Human Resources Section Staff, 2012

	Post / Category / Designation	Board Grade	No. in Approved Cadre
1	Manager, Human Resources	4	1
2	Human Resource Officer	7	1
3	Supply Officer	7	1
4	Management Assistant (Clerical HR)	9	3
5	Labour	15	4
		Total	**10**

It must be noted that the extent of decentralisation of HR functions to the RSCs is still on-going at the NWSDB. It would take time for HR functions to be fully devolved. This is true in the area of training where the RSC, at present, is made to coordinate training with the Head Office, and conducts certain training programmes, but only for those in Board Grades 7 and lower.

Thus, to operationalize and regionalise training and development activities, the NC RSC needs to provide a minimum number of qualified and cadre-approved staff for the proposed training unit. With the establishment of and eventual staffing of the training unit, capacity enhancement of RSC staff and O&M personnel can be addressed based on the current and future demands of the organisation. Considering the RSC will be looking forward to the improvement of its water facilities / system, it is imperative that its human resources be made ready to take on the actual management as well as operation and maintenance of the new facilities.

1) Staffing for Training Unit

The proposed training unit will be made a part of the Human Resource Section, and will function under the leadership of the Manager, Human Resources, where logically, training and development is a vibrant part of the human resources management cycle. The training unit will become the core of the future regional training centre, growing and developing experience and expertise in planning and implementing training programmes / courses. As shown in **Table 6.10**, by 2017-18, three staff members would have been hired to start up the operations of the training unit. Its priority activity will be the preparation, development and implementation of a five-year *North Central RSC Training Plan* (as described earlier). **Figure 6.5** shows the organisation structure for the training unit.

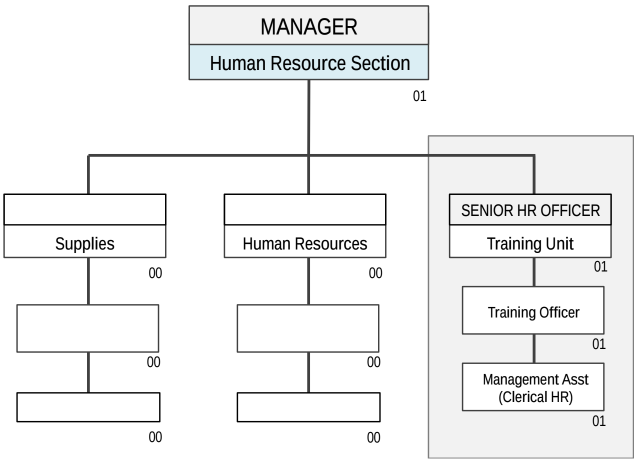

Figure 6.5 Proposed Organisation Structure of the Training Unit (Intermediate)

2) Staffing for the Regional Training Centre (2018)

The Training Unit will be spun off into a full-fledged Regional Training Centre (RTC) attached to (and not under) the Human Resources Section, thereby enabling the NC RSC to take advantage of economies of scope and scale, as well as the learning curve. During this time, the North Central RSC will see an increase in: (i) the number of programmes and courses offered; (ii) the number of participants to its training programmes; and (iii) the frequency of training. The projected increase in training activities will result from extending training to the neighbouring RSCs (North, Central and North Western) and from the completion of construction of the water supply facilities. It will also take on the added function of providing training services in the areas of small water utility management and O&M to the personnel of the 50 CBOs operating in the area, the number of which would likely go up in the future due to increased water supply from the NC RSC.

Table 6.10 Staffing for Training Unit and Regional Training Centre

	Post / Designation	Board Grade	Proposed Number of Staff		Total 2018
			Training Unit	Training Centre	
1	Manager, Training	4	-	1	1
2	Senior Human Resource Officer	5	1	-	1
3	Training Officer	6	1	1	2
4	Management Assistant (Clerical HR)	9	1	-	1
5	Management Assistant (Sinhala)	12	-	1	1
6	Management Assistant (English)	12	-	1	1
		Total	**03**	**4**	**7**

The Regional Training Centre is proposed to be headed by a Manager, Training, and shall be assisted by three additional staff members, thus bringing to seven the total staff complement for the RTC (including those from the former Training Unit). Subject matter experts will be insourced from NWSDB Head Office, or outsourced from industry and/or the academe depending on the training course(s) to be conducted. **Figure 6.6** presents the proposed organisation structure for the Regional Training Centre.

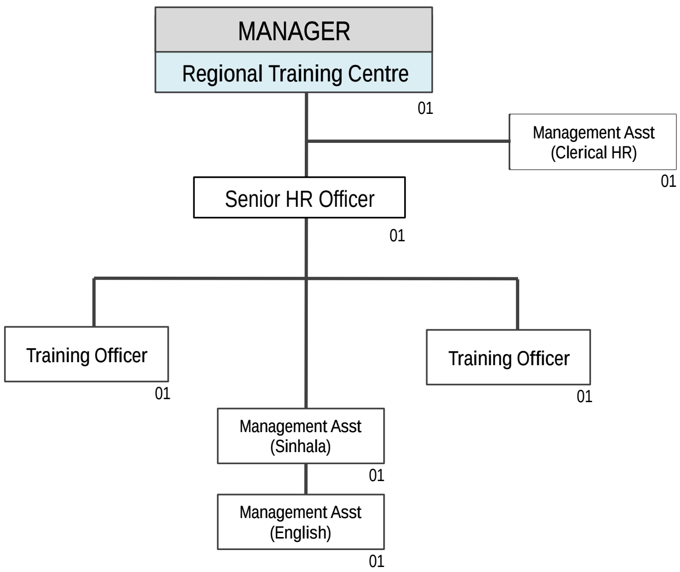

Figure 6.6 Proposed Organisation Structure of the Regional Training Centre (2018)

(4) Enhancing Staff Capacity through Training and Development

Establishing and operationalizing the training unit / centre are the first important steps in developing the capacity of the implementation organisation, or the NC RSC. Next comes the other half of the equation – developing and enhancing the capacity of the staff through the implementation of the training plan. Training and development activities for the key staff, as well as identified group(s) of personnel tasked to manage, operate and maintain the new facilities / system will have to be rationally and systematically performed.

1) General and Specific Approaches

The general approach to enhancing staff capacity is to acknowledge that all personnel will require various types of training in the short and medium term. This becomes even more important given both the educational attainment and training profiles of the O&M staff. Thus, training should not be designed as a sporadic separate activity, but rather address specific current and emerging needs of the North Central RSC.

This approach provides for training that will cover (i) the entire organization; (ii) the sections and units based on their specific functional roles and responsibilities, and (iii) individual skills training, based on job function and position held. The latter, however, will require a more in-depth training needs assessment, subjecting each candidate to more detailed review of his qualifications and aptitude, to ensure the matching of proposed training with job requirements and individual capacity. Until this is done, there is little room for training to be successful.

Three specific approaches to training will be utilized to enhance the staff capacity of NC RSC. The first will be the traditional approach where the training staff designs the objectives, contents, techniques, and evaluation for the participants, with the training staff providing the intervention to skills development. The second is the experiential approach where the trainer provides learning experiences, thus making the learner an active partner in the training process. This approach emphasizes real job situations or can simulate conditions in which the trainee(s) currently operates or will eventually operate. Thus, the trainers and the trainees jointly determine the training objectives and other elements of training with the trainers primarily serving as facilitators, catalysts, or resource persons. The third approach is the competency-based or performance-based approach where the emphasis is given to the trainees' acquiring a specific observable skill for a task, and then attaining the skill by demonstrating it with a given level of competency or proficiency. This approach is mostly task or skill centred and is applicable for on-the-job training.

(a) Developing a Core of Trainers

It becomes imperative for the NC RSC to begin identifying who, from its own ranks, will make up the core of technical trainers (apart from the training staff to be hired) to conduct training using the experiential and competency-based approaches. This core of technical trainers should possess relevant experience, proven skills and considerable knowledge on a particular technical area. It is proposed that this core of technical trainers be given an extensive “trainers training” course to develop proper skills directed at making them effective instructors / trainers in their recognised field(s) of expertise.

(b) Language of Instruction

The language(s) of instruction for training will be bi-lingual – English and Sinhala – although the balance we would best left to the discretion of the trainer. What is important is that the language used must promote full understanding of the training and retention of what has been learned. Thus, training materials, modules and hand-outs should also be bi-lingual (English and Sinhala).

(c) Developing a Knowledge Base

A knowledge base is best described as a centralized repository for information. The NC RSC has accumulated and will continue to accumulate much information through its experience in operating and maintaining water supply facilities. These various types of experiences, if systematically collected, organized and retrieved, can be of significant use internally towards improving WSS’ operations and enhancing training. It will also be of value externally, that is, in assisting the CBOs and the water supply units of the local authorities to improve water supply services. A well-organized knowledge base will save NC RSC resources, and will increase organisational and staff capacity on water supply management, operation and maintenance.

2) Levels of Training for North Central RSC

There should be a series of *organization-wide* training designed and developed for all NC RSC staff members to provide them with the big picture or macro perspective of the RSC. Topics suggested are NWSDB Vision-Mission-Objectives-Strategies; NWSDB RSC(N/C) policies, organisation structure, broad and specific functions (sections and units); overview of NC RSC water supply facilities, its operations and maintenance; and personnel rules and regulations. This type of training is usually taken for granted, but is actually necessary as key personnel of the RSC are routinely re-assigned to another area after serving in one RSC for a period of time. The training is also seen to promote organisational pride and an understanding of how one’s job affects and relates to another person’s.

Training should also be designed and conducted by *functional area* of the organization, or by specific section and/or unit. This micro perspective will ensure that the staff of each section recognises the contribution of their own section(s) to the NC RSC’s total effort / success. Focus should not only be by section functions and responsibilities, but also on the importance of coordination and linkages between and among sections and units, if only to highlight unity of effort and cohesion as ingredients to efficiency and productivity.

Training will also be done by the *individual (staff) level*. It is proposed that the training for selected / identified employees commences only after a more detailed training needs assessment. Individual training must be matched with the proposed trainee's qualifications, the job presently held, and the skills needed for the job-holder to perform at the minimum acceptable standards of the particular job. This requires three things: (i) the evaluation of all jobs / positions in the organization; (ii) the development of job qualification standards; and (iii) having job or position descriptions for each job family. With these requirements, training investments will be well spent.

The NWSDB has the critical inputs to ensure that staff-level training can more easily be designed, developed and customised by the proposed Training Unit. It has written job descriptions for all categories / designations in the Approved Cadre.[2] In addition, it also has a performance evaluation system in place for executive and non-executive grades / categories.[3] All that is needed are for the human resources and/or training staff to translate these inputs into the *North Central RSC Training Plan,* which shall take into consideration the training needs analysis results.

3) Proposed Training Programme / Courses

The proposed training programmes / courses will be focused on ensuring the sound operation and maintenance of the newly constructed water production and water distribution facilities, including the transmission and distribution network, and all related mechanical, electrical, and water laboratory equipment and appurtenances. The training will be divided into in-country and overseas training and will cover the following areas: utility management, project management, operations and maintenance, water quality, human resources, and public information and education. Note that the in-country and overseas training will be included in a more comprehensive capacity development (soft component) sub-project, which is discussed further in this section.

(a) In-country Training

The proposed in-country training programme is divided into technical courses (Project Management, Water Treatment Plant Operations and Maintenance, Network Installation and Maintenance, Water Quality Monitoring); and non-technical courses (Human

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2 The job descriptions delineate the vertical reporting lines upward (superior[s]) and downward (subordinates[s]); the posting and grade level; the division and location; the purpose of job; and work environment and conditions. It also defines the key (critical and supportive) responsibilities; and identifies accountability, norms, authority and relationships.

3 The performance evaluation system specifies the composition of evaluation panels for each category and spells out the evaluation procedure, such as guidelines, reasons for the evaluation, the criteria or measures of performance, and the evaluation period.

Resources Management [focus on Training and Development], Public Information, Education and Communication, and the Trainers Training), as presented in **Table 6.11**.

Table 6.11 Proposed In-Country Training Programme

	Title of Training	Proposed Participants	Duration
1.	Project Management	Total 10 participants • *Development Section*: 06 participants Preferably the Unit Heads of Mechanical / Electrical, Planning and Design, Sector Planning, Construction, and Groundwater Units • *O&M Section*: 04 participants Preferably the O&M Manager and Assistant Manager, District Engineers of Pollonuwara and Anuradhapura Districts	10 days
2.	Water Treatment Plant Operations and Maintenance	Total: 20 participants • *Optional*: O&M Manager and Assistant Manager • Heads of all WTPs in NC RSC, personnel of the new Mahakanadarawa and Wahalkada (WTP) WSS • Staff of the Proposed O&M Area Office • Head, Regional Laboratory • Head, Workshop Unit	20 days
3.	Water Distribution system Operation and Maintenance	Total: 25 participants • Engineering Assistants and Staff of the WSS of the Six Project Areas, Staff of the proposed O&M Satellite Office • Selected Engineering Assistants of NC RSC • Head, Workshop Unit	20 days
4.	Human Resources Management	Total: 12 participants • Heads of all Sections • Key Personnel of Human Resources Section • Staff of the proposed Training Unit	05 days
5.	Public Information, Education and Communication	Total: 12 participants • Head, Commercial Unit • Head, Rural Water Supply Unit • Key personnel of the Customer Service and RWS units • Engineering Assistants of the Six Project Areas and the proposed O&M Satellite Office	05 days
6.	Trainers Training	Total: 15 participants • Identified subject matter experts on technical training • Identified subject matter experts on non-technical (management) training	05 days
7.	Water Quality Monitoring	Total: maximum of 07 participants • Chemists • Laboratory Assistants • Laboratory Attendants	20 days

The coverage of the training courses is as follows:

- The Project Management Training Course

  The participants will learn the Project Management Framework as the basic structure for understanding the environment in which the Project operates enabling the implementers to manage the day-to-day activities of the North Anuradhapura Integrated Water Supply Project for its successful completion. By being taught the project management knowledge areas and processes, the various elements of the project will be properly planned, coordinated, executed and controlled. Costs will be more carefully planned, budgeted and controlled; human resources be more effectively utilized and developed; work quality assured; information and communication on performance reported; risks minimized, and project procurement better planned and controlled.

The training will include such topics as: Introduction to the Modern Concept of Project Management and project management framework along with the nine knowledge areas including Integration, Time, Cost, Risk, Quality, Communication, Human Resource, Procurement and Scope Management. Starting from the Initiation process for a project, participants will be introduced to the detailed process of Planning, Execution, Control and Closing.

- The Public Information Education and Communication Training Course
  The participants will learn the Information, Education and Communication Framework and the different ways by which the North Central Regional Support Centre can convey its message(s) and policies across its various stakeholders. By doing so, the participants will be able to classify its messages, develop IEC strategies that would be appropriate for its various publics / audiences, and learn to use the most suitable media to deliver its message. The ultimate objective is getting the target audience not only to be aware of the NC RSC's important messages, but to have a deeper understanding of its meaning, and to act positively based on this understanding.

  The training will include topics such as the Introduction to Information Education and Communication Processes, Public Relations, Public Consultations, Media Relations, Advocacy, Public Awareness, Events Management, Communication Infrastructure, and Evaluation of Communications Programmes. Messages that can be used for the IEC programme(s) are: water conservation and the preservation of the environment; water, health and hygiene; water quality and water borne diseases (dental and skeletal fluorosis and chronic kidney diseases). Others topics can fall under customer services, such as the conduct of consumer surveys; water service coverage to the poor and disadvantaged; handling customer services and customer accounts, new connections, reconnections, disconnections and customer complaints.

- The Water Treatment Plant O&M Training Course
  The training is designed for the O&M staff of the two new water treatment plants / schemes to safely and effectively manage and maintain the intake, transmission and WTP facilities. While the training programme will include basic classroom

(theoretical) learning, it will provide numerous practical (job-site) learning opportunities and activities.

Training will cover the following topics: Types and quality of water sources; Structure of water source, materials, intake water volume, and allocation of water intake facility; Water theory of treatment process and hydraulic capacity; Stages of conventional water treatment; Structure, material and allocation of chemical facility; Raw water quality and annual fluctuation of water levels. On the operations side, topics will be: Operation methodology of raw water intake dependent on the required water demand; Operation the intake pumps dependent on the required water demand; Operation methodology for the water treatment process dependent on the required water demand and raw water quality; Methodology for investigation the process water qualities (iron, manganese, turbidity, color, pH and residual chlorine); Methodology and handling of the sludge treatment; Required daily and regular maintenance for water treatment plant; Preventive maintenance; Water quality control; Information, documentation and records keeping; Safety regulations; Workshop and stores; Vehicles and transport; O&M cost estimation; and Responsibilities of the WTP operators.

- Distribution System O&M Training Course
  The training is designed for the O&M staff at the water supply schemes to safely and effectively manage and maintain the distribution facilities and network of pipelines. While the training programme will include basic classroom (theoretical) learning, it will provide numerous practical (job-site) learning opportunities and activities.

  Training will cover the following topics: Theory of water distribution in a water supply system; NC RSC's distribution network system, diameter of pipe, pipe material and hydraulic capacity; NRW control, measurement and reduction program and methodology of investigation for leakage volume; Methodology of distributing the required water amount into each distribution block; Installation method of consumer flow meter; Operating the tools for installation of consumer flow meter / bulk meter; Mapping, records and reports. The practical aspects will include operating and maintaining water distribution systems, emphasizing role and duties of water distribution system operators, procedures for operating and maintaining water towers, components and characteristics of distribution system facilities, operating and maintaining distribution systems, maintaining water quality in the system, disinfecting new and repaired facilities as well as water delivered to consumers, and techniques for recognizing hazards and developing safe procedures and programs.

- Water Quality Monitoring Training Course

  The training is designed for water laboratory personnel and will include the following topics: Water quality monitoring principles and strategies – sampling methods samples protocol, sampling handling, special parameters quality assurance, safety and security, data management, interpretation and reporting; Water quality sampling and analysis – source water quality monitoring, tap water quality monitoring, demonstration of selected, basic measurements and methods including QA/QC techniques; and Laboratory certification. Practical aspects of the training will include laboratory management including equipment O&M, and planning regular water quality monitoring for the new WTPs.

- Human Resources Management Training Course

  The training provides an analysis of human resources' role in organizations, and identifies future trends and needs from preparing policies and procedures manuals to identifying the elements of effective performance management. Topics will cover the following: Changing role of HR in NWSDB; Functions and roles of HR within the organization; Human Resource Management Principles (recruitment, selection and placement, performance appraisal); Employment Process in government / civil service; Organisational and employee development; and Change management.

- Trainers' Training Course

  The training will allow the participants will discover new training methodologies in engaging the trainee-audience, and develop into a confident facilitator of learning, not just a mere presenter or lecturer. Topics will cover the following: Active adult learning by determining how team-building, on-the-job assessment and immediate learning involvement can occur at the earliest stages of a training program; Assessment, or distinguishing problems that can be addressed by training and devising questions for use in a training assessment; Objectives setting that focuses on outcomes and results rather that on topics and identifies objectives as affective, behavioural or cognitive; Implementing "active training" that chooses methods and formats appropriate to the objective and training audience; Facilitating and engaging the trainees through presentations, lectures, and experiential learning activities; and Feedback and evaluating techniques.

(b) Overseas Training

It is also proposed that overseas training be designed and conducted for the top management team of the NWSDB (Head Office and NC RSC) on water utility management best practices. The 15-day training will consist of three-day visits to three water utilities[4] that have been recognized for management and operational excellence, such as the Phnom Penh Water Supply Authority (Cambodia)[5], Manila Water (Philippines)[6], and Hyderabad Metropolitan Water Supply and Sewerage Board (India)[7]. The training will also include another three-day visit to a water utility in Japan that has set an exemplary record in reducing non-revenue water.

The general approach for the overseas training will be similar to a twinning program, albeit in an abbreviated form. It will be an arrangement where NWSDB will be paired off with three water utilities with similar characteristics, but which had been able to gain considerable expertise in aspects of water utility performance. The idea is to match the stronger utility (expert) with the developing utility (recipient) to enable the latter to improve in any of the following areas: service coverage and delivery, financial sustainability, governance, NRW reduction, customer service improvement, development of a training center, tariffs and financial management, to name a few. Thus, the specific purpose of the training is to learn from the best practice of the expert water utility and to share this valuable expertise with NWSDB. The training will consist of lecture-type discussions with the general managers or administrators of the expert water utilities or water authorities, plus an observation-tour of relevant water supply facilities. See **Table 6.12** for the proposed overseas training.

Table 6.12 Proposed Overseas Training Programme

	Title of Training	Proposed Participants	Duration
1.	Overseas Training on Water Utility Management Best Practices	Total Participants: 07 *From NWSDB HO* – 03 participants *From the North Central RSC* – 04 participants (Deputy General Manager, Assistant General Manager, Chief Engineer, and Manager O&M)	15 days (including travel time)

[4] The choice of water utilities to be visited is tentative, and will be subject to the final choice of NWSDB and JICA.

[5] The *Asian Development Bank Water Prize (2004)* for overhauling Phnom Penh's water supply system and demonstrating leadership and innovation in project financing and governance; and the *Stockholm Water Industry Award (2010)* for contribution to sustainable water management.

[6] Four-time awardee of the *Corporate Governance Asia Recognition Award*, the latest being in 2010 for its continuing commitment to the development of corporate governance in the region; and the *Finance Asia: Asia’s Best Companies (2011)*, for the mid-cap category, the 2nd best in Asia for *Corporate Social Responsibility*, and the 3rd for *Corporate Governance*.

[7] The *National Urban Water Awards (2010)* from the Government of India in the financial reforms category for its “Online Mobile Bill Generation and Collection Improvement through Process Reengineering”.

4) The Capacity Development (Soft Component) Sub-Project

Capacity development is an effective countermeasure to address the O&M issues earlier identified such as the existing quality of human resources, the operations system and operating procedures; the corrective and preventive maintenance system, and the need for appropriate technology in training and development. In this connection, the capacity development (soft component) sub-project will integrate the following activities: (i) the aforementioned in-country and overseas training courses, (ii) the conduct of a training needs analysis, (iii) the development of the five-year NWSDB RSC(N/C) Training Plan, (iv) the development of course modules, and (v) the issuance of written O&M manuals. This would require financial resources, which can come from either the NWSDB Head Office or accessed from overseas development assistance. **Table 6.13** shows the summary of activities and outputs for the sub-project.

Table 6.13 Capacity Development Sub-Project Activities and Outputs

	Activities	Outputs
1.	Conceptualize, develop and conduct the in-country technical and non-technical training courses	• Conduct of four technical training courses: o Project Management o Water Treatment Plant O&M o Water Distribution System O&M o Water Quality Monitoring • Conduct of three non technical training courses: o Human Resources Management (focus on Training and Development) o Public Information, Education and Communication o Trainers Training
2.	Develop the five-year Training and Development Plan for the NC RSC, which will require the completion of a Training Needs Assessment as baseline information	• Training Needs Assessment Report • Five-Year Training and Development Plan
3.	Develop course modules and training materials for the seven training courses	• Course modules and training materials for the four technical training courses • Course modules and training materials for the three non-technical training courses
4.	Develop the WTP Operation and Maintenance Manual, the O&M Water Distribution System Operation and Maintenance Manual, and the Water Quality Monitoring Manual subsequent to the conduct of the three training courses under the same topic/area	• WTP Operation and Maintenance Manual • O&M Water Distribution System Operation and Maintenance Manual • Water Quality Monitoring Procedural Manual
5.	Design and conduct an overseas training programme for NWSDB Head Office and NWSDB RSC(N/C) top management	• Conduct of Overseas Training on Water Utility Best Practices

6.2 Operation and Maintenance Organization

The water supply schemes currently operating in the project area will also operate and maintain the newly constructed facilities such as: (i) elevated water towers, (ii) groundwater reservoirs; (iii) equipment and appurtenances such as pumps, generators, surge tanks, and power control units; (iv) workshops, chlorinator buildings, operational complexes (with zonal labs); (v) the primary, secondary and tertiary distribution lines; and (vi) grounds and buildings. There is a need therefore to expand the organisation of these water supply schemes.

In addition, two new water supply schemes will have to be organised to operate and maintain the following new facilities: (i) the intake structure / facility and equipment; (ii) the raw water conveyance pipelines; (iii) the water treatment plant facilities, equipment and appurtenances; (iv) the transmission mains; and (v) the transmission sub-mains that link the WTP to the different elevated water towers.

Considering that the service area (formerly project area) is geographically extensive, and its service population widely dispersed, there is a need to establish an O&M satellite office (Area Engineering Office) to provide for another layer of organisational support to the water supply schemes, adhering to the organisational principles of span of control and coordination.

The need for additional O&M staff before the end of the construction period (2018) is to ensure the smooth transition from pre-operations to the full operations of the newly constructed distribution facilities and networks. In this connection, the following guidelines are proposed:

- Strategic recruitment shall be observed so that efficient utilisation of and synergy among O&M staff can be achieved. In any case, hiring of new personnel will strictly follow the Sri Lankan government's recruitment and selection process(es).
- The number of new staff will be kept to a minimum since existing personnel shall also be utilised for O&M of the new facilities, with focus on further maximising their productivity through (re)training.
- Recruitment will also take into consideration keeping a low staff productivity index (SPI) or number of staff to number of connections ratio without prejudice to efficient service to the customers.
- The present number of outsourced / contractual personnel (caretakers, labourers and meter readers) shall be retained through 2018, as they are already serving the current operational requirements of their respective WSS.
- Outsourcing as a strategy will continue to be utilised, especially for the following services (posts) – meter reading services (meter readers), new connections services (labourers), leak detection and repair services (pipefitters and labourers), and security guards. However, the recruitment schedule for these posts will be phased, and will be dependent on the solid projections of the number of new connections / customers to be generated as a result of this water supply improvement project.
- As far as practicable, outsourcing for the labour grades will be from the trained personnel of CBOs or farmers' organisations within the area, to provide jobs, and to keep good relations within the community.

- The additional labour grades required by the end of the construction period are: (i) Pump Operator Mechanics, to operate and maintain pumps, generators, and other electro-mechanical equipment; (ii) Pipefitters, to operate the workshops, service new connections, and repair pipe leaks; (iii) Caretakers, to maintain of newly constructed facilities, buildings and ground; (iv) Drivers, primarily to drive service crews as well as water delivery vehicles to non-piped (isolated) areas; and (v) Labourers, to assist service crews, to assist in maintenance and security services of buildings and grounds.

6.2.1 Additional O&M Staff/Cadre for the Existing WSS in the Project Area

There are four water supply schemes presently operating in the project area. However, Rambewa will need to be organised into a new water supply scheme to manage the newly constructed facilities that will be operational by 2018. Meantime, the other three existing WSS shall be expanded to enable it to take on the added O&M responsibilities given the new facilities. **Table 6.14** provides the water supply schemes and its area(s) of coverage.

Table 6.14 The Water Supply Schemes and Coverage

WSS	Name of Water Supply Schemes	Status	Coverage (Facilities in Project Area)
1	Rambewa Water Supply Scheme	New	Rambewa
2	Khatagasdigiliya Water Supply Scheme	Existing	Kahatagasdigiliya and Horowpothana
3	Kebithigollewa Water Supply Scheme	Existing	Kebithigollewa and Padaviya
4	Medawachchiya Water Supply Scheme	Existing	Medawachchiya

(1) New O&M Cadre for Rambewa Water Supply Scheme

Rambewa will have its share of water supply facilities that will necessitate organising the Rambewa WSS. It will be headed by an Engineering Assistant (OIC) and supported by six O&M staff as shown in **Table 6.15.**

Table 6.15 O&M Staff for New Rambewa WSS

Post (Category)	Board Grade	New Staff / Cadre		Total By 2018
		Outsourced Contractual	New	
Engineering Assistant (O&M)	9	-	1	1
Pump Operator Mechanic	13	-	1	1
Pipefitter	13	-	2	2
Caretaker	15	-	1	1
Labourer	15	-	1	1
Total		**0**	**6**	**6**

(2) O&M Staff for the Kahatagasdigiliya Water Supply Scheme (includes Horowpothana)

The current area of coverage of Kahatagasdigiliya WSS includes Horowpothana. This set-up will be continued even with the construction of new facilities in Horowpothana (including North and West Horowpothana, Weerasole, Hamiwela and Wahalkada) and in Kahatagasdigiliya (including Rathmalgahawewa). However, by the end of the construction period, nine additional personnel will be required to operate and maintain the new facilities in both Kahatagasdigiliya and Horowpothana bringing to 18 the total number of O&M staff, as shown in **Table 6.16**.

Table 6.16 O&M Staff for Katahagasdigiliya WSS (includes Horowpothana)

Post (Category)	Board Grade	Current Staff (2012)			Additional Staff		Total
		Outsourced Contractual	Approved Posts		Outsourced Contractual	New	By 2018
			Vacant	Filled			
Engineering Assistant (O&M)	9	-	-	1	-	-	1
Pump Operator Mechanic	13	-	-	1	-	2	3
Pipefitter	13	-	-	1	-	2	3
Driver	13	-	-	-	-	1	1
Caretaker	15	2 [1/]		-	-	2	4
Labourer	15	3	-	1	-	2	6
Total		**5**	**0**	**04**	**0**	**9**	**18**

1/ The two caretaker posts are the only posts currently assigned to Horowpothana.

(3) O&M Staff for the Kebithigollewa Water Supply Scheme (includes Padaviya)

The existing area of operations of Kebithigollewa WSS includes Padaviya. This will not change even with the construction of new facilities in Kebithigollewa (including KEB-KAH Median and Kahatagollewa) and in Padaviya (including Bogahawewa). However, an additional eight staff are required to operate and maintain the newly constructed facilities, in addition to the current number of 16 staff, as shown in **Table 6.17**.

Table 6.17 O&M Staff for Kebithigollewa WSS (includes Padaviya)

Post (Category)	Board Grade	Current Staff (2012)			Additional Staff		Total
		Outsourced Contractual	Approved Posts		Outsourced Contractual	New	(By 2018)
			Vacant	Filled			
Engineering Assistant / OIC (O&M)	9	-	-	1	-	-	1
Pump Operator Mechanic	13	-	-	6 [1/]	-	1	7
Pipefitter	13	-	-	1	-	2	3
Driver	13	-	-	-	-	1	1
Caretaker	15	1 [2/]		-	-	2	3
Labourer	15	3	-	4 [3/]	-	2	9
Total		**4**	**0**	**12**	**0**	**8**	**24**

1/ Three pump operator mechanics are assigned to Padaviya, while the other three are assigned to Kebithigollewa.
2/ Caretaker post is assigned to Padaviya.
3/ Two labourer posts are assigned to Padaviya and two to Kebithigollewa.

(4) O&M Staff for the Medawachchiya Water Supply Scheme

Medawachchiya is the only WSS that does not cover any other GND in its area of operations. Aside from Medawachchiya, facilities will also be constructed in Issinbassagala and Ethakada, which will require six additional staff, as presented in **Table 6.18**.

Table 6.18 O&M Staff for Medawachchiya WSS

Post (Category)	Board Grade	Current Staff (2012)			Additional Staff		Total By 2018
		Outsourced Contractual	Approved Posts		Outsourced Contractual	New	
			Vacant	Filled			
Engineering Assistant / OIC (O&M)	9	-	-	1	-	-	1
Pump Operator Mechanic	13	1	-	2	-	1	4
Meter Reader	13	-	-	1	-	-	1
Pipefitter	13	-	-	1	-	1	2
Driver	13	-	-	-	-	1	1
Caretaker	15	-	-	-		2	2
Labourer	15	1	-	1	-	1	3
Total		**02**	**0**	**06**	**0**	**6**	**14**

6.2.2 New O&M Cadre for the Mahakandarawa and Wahalkada Water Supply Schemes

Two new water supply schemes will be organised to operate and maintain the Mahakanadarawa and Wahalkada water treatment plants before the end of the construction period. This is necessary to have ample lead time in order to train the new O&M cadre for the pre-operation and start-up operational phases of the WTP.

(1) The Mahakanadarawa Water Supply Scheme

The proposed O&M cadre for the Mahakanadarawa Water Supply Scheme will be headed by an officer-in-charge (water treatment plant) / engineering assistant. He/She will be supported by plant technicians working on an eight-hour shift, as well as an electrician, pump operator technician, laboratory attendant, caretaker and labourer. In addition, a pipefitter is required, as the workshop intended for the Rambewa area will be constructed in the Mahakanadarawa WTP site. The personnel requirement for this scheme is shown in **Table 6.19**. Should additional personnel in the labour grades be required, these can be outsourced or hired on a contractual basis, whenever the need arises. See **Figure 6.7** for the proposed organisation structure of the Mahakanadarawa Water Supply Scheme.

Table 6.19 New O&M Cadre for the Mahakanadarawa WSS

Post (Category)	Board Grade	New Staff / Cadre		Total By 2018
		Outsourced Contractual	New	
Engineering Assistant / Officer-in-Charge (WTP)	9	-	1	1
Plant Technician	12	-	3	3
Pump Operator Mechanic	13	-	1	1
Electrician	13	-	1	1
Lab Attendant	13	-	1	1
Pipefitter	13	-	1	1
Caretaker	15	-	1	1
Labourer	15	-	1	1
Total		**0**	**10**	**10**

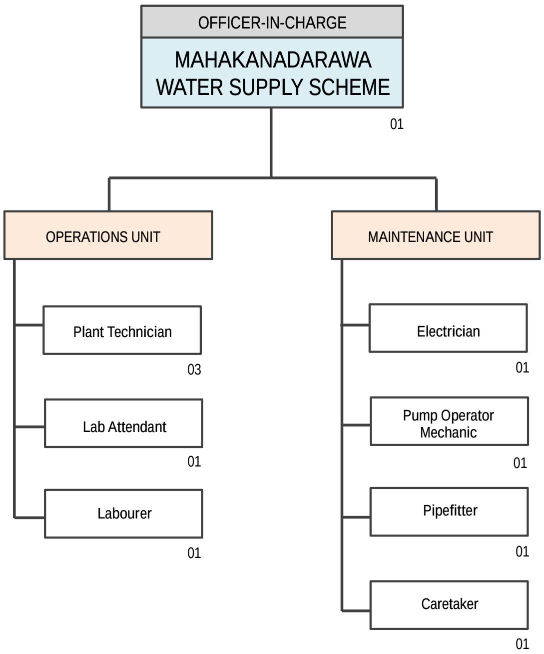

Figure 6.7 Proposed Organisation Structure of the Mahakanadarawa WSS

(2) The Wahalkada Water Supply Scheme

The Wahalkada Water Supply Scheme has a larger production capacity than Mahakanadarawa. It will be headed by an officer-in-charge (water treatment plant) / engineering assistant. He/She will be supported by plant technicians working on an eight-hour shift, as well as an electrician, pump operator mechanic, laboratory attendant, caretaker and labourer, as shown in **Table 6.20**. Should additional personnel in the labour grades be required, these can be outsourced or hired on a contractual basis, whenever the need arises. See **Figure 6.8** for the organisation structure of the Wahalkada Water Supply Scheme.

Table 6.20 New O&M Cadre for the Wahalkada WSS

Post (Category)	**Board Grade**	**New Staff / Cadre**		**Total** By 2018
		Outsourced Contractual	New	
Engineering Assistant / Officer-in-Charge (WTP)	9	-	1	1
Plant Technician	12	-	3	3
Pump Operator Mechanic	13	-	1	1
Electrician	13		1	1
Lab Attendant	13	-	1	1
Caretaker	15	-	1	1
Labourer	15	-	2	2
Total		**0**	**10**	**10**

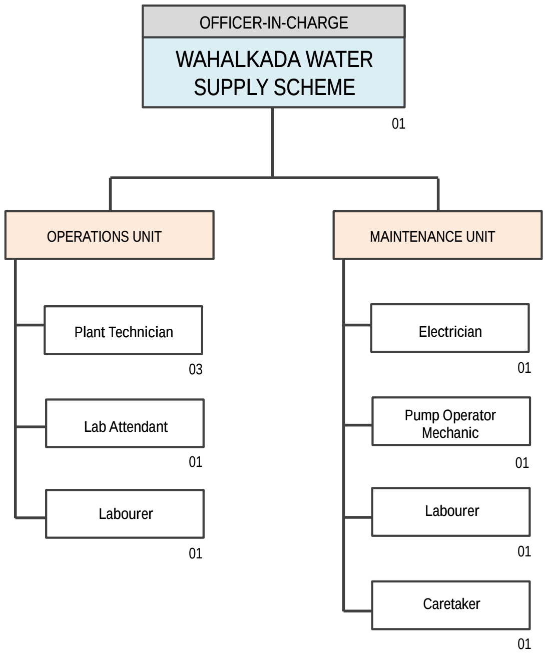

Figure 6.8 Proposed Organisation Structure of the Wahalkada WSS

6.2.3 Proposed O&M Area (Satellite) Office for the WSS in the Project Area

In 2018, with the completion of the Project, NWSDB RSC(N/C) will be faced with the following scenario – providing water supply to a service area (formerly project area) that is geographically extensive, and whose service population is widely dispersed. It will also see its existing water supply schemes take on additional managerial and operational responsibilities as a consequence of having new facilities, but whose physical location is far from the regional centre's operational resources. Given these impacts, and adhering to the organisational principles of span of control and coordination, there is a need to provide another layer of organisational support to the water supply schemes – the establishment of an O&M satellite office.

(1) Functions of the O&M Area (Satellite) Office

It is proposed that the O&M satellite office be organised in Medawachchiya, this place being the most developed among the GNDs, and situated at the crossroads of the project areas/WSS. The satellite office will have the following functions: (i) to *deliver quick response to O&M and technical issues* that need immediate resolution and which were inadequately dealt with by the water supply schemes; (ii) to *provide closer consumer service support services* considering the increased number of new customers to be generated by the completion of the project, (iii) to *spearhead the public information, education and communication (IEC) programme* on the importance of water to health; (iv) to *assist the WSS in delivering potable water* to the remote villages not covered by the piped system, but which is required due to water quality health concerns.

(2) Manning of the O&M Area (Satellite) Office

The satellite office will not duplicate neither the functions nor the personnel of the water supply schemes, but rather, will provide the required level of intermediary and supplementary assistance and support to finding solutions to the water supply schemes' technical issues and consumer concerns. It will assist the personnel of the WSS to be ready, capable, and skilled in performing the required works, and in maintaining and repairing mechanical and electrical equipment at the water treatment plants and pumping stations, as well as the water transmission and distribution pipelines, and in being able to make the public aware of the health benefits of connecting to the water system that supplies water that complies with national standards. **Table 6.21** presents the proposed manning for the O&M satellite office, which will be organised upon the completion of construction of the water facilities in 2018.

Table 6.21 Proposed Manning of O&M Area (Satellite) Office

Post (Category)	**Board Grade**	**New Staff / Cadre**		**Total** By 2018
		Outsourced Contractual	New	
Area Engineer (Civil)	7	-	1	1
Mechanical Engineer	8		1	1
Electrical Engineer	8		1	1
Engineering Assistant (Mechanical)	9	-	1	1
Engineering Assistant (Electrical)	9		1	1
Consumer Relations Assistant	9	-	1	1
Electricians	13		2	2
Mechanics	13		2	2
Labourers	15		2	2
Driver [1/]	13	-	1	1
	Total	**0**	**13**	**13**

1/ The number of drivers will depend on the number of water delivery tankers / water lorries, and the vehicles for service crews. Personnel for this post can also be outsourced.

(3) Structure of the O&M Area (Satellite) Office

As a new unit / office, the O&M Area Office, headed by the Area Engineer, will be under the Operations Section, specifically directly under the Anuradhapura District, headed by the District Engineer. Thus, the Area Engineer will fall under the direct supervision and authority of the District Engineer. The proposed organisation structure of the O&M Area Office is presented in **Figure 6.9**.

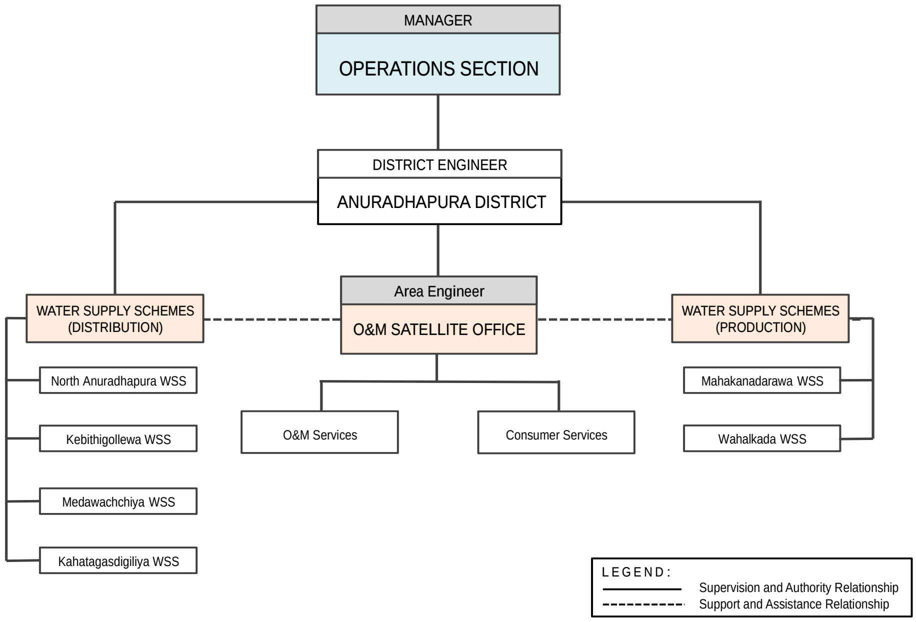

Figure 6.9 Organisational Structure of O&M Area (Satellite) Office

As shown in the organisation structure, the water supply schemes – Rambewa, Kebithigollewa, Medawachchiya, Kebithigollewa, Mahakanadarawa and Wahalkada – will remain under the direct supervision and authority of the Anuradhapura District. The solid line represents the authority or vertical relationship between the O&M Satellite Office and the Anuradhapura District up to the O&M Section level.

However, as earlier explained, the O&M Area (Satellite) Office will provide intermediary and supplementary assistance and support to the water supply schemes' technical issues and consumer concerns, and actively assist the WSS personnel in ensuring the efficient operation and maintenance of the production and distribution facilities, equipment, buildings; and in safeguarding health through the supply of safe water. Thus, there is no supervision or authority relationship between the O&M Area Office and the water supply schemes, but the relationship will be horizontal, or one of technical assistance and support, which is represented by a dotted line.

6.2.4 Enhancing Other Sections / Units in Support of O&M

There are also other sections and units in the NC RSC that need to be enhanced to support the proper operation and maintenance of the new facilities. These are the regional laboratory, the rural water supply unit, the commercial unit, and the IT section.

(1) The Regional (Central) Laboratory

The regional (central) laboratory, which is responsible for water quality monitoring and control, will see increased work with the new Mahakanadarawa and Wahalkada WTPs and the expanded WSSs in the project area. In addition to the chemical, physical and biological indicators being tested, there is also a need to develop the ability to test for pesticides, heavy metals and algal toxicity in the water, especially that the project area is where CKD and dental fluorosis are most prevalent. This will require upgrading the laboratory equipment, and enhancing the skills of the laboratory personnel through training. (See equipment list in the water quality section write-up and section on capacity development for training).

With the upgraded regional (central) laboratory, the NC RSC is committed to work towards water quality laboratory accreditation with the Sri Lanka Accreditation Board, based on ISO/IEC 17025 to ensure the competence of the laboratory in generating reliable and technically valid test results. Having accreditation will enable the laboratory to more effectively monitor the drinking water quality of its service area, and other organisations that seek its services.

Therefore, it is recommended that the approved (but vacant) laboratory attendant post be filled up by 2018, in addition to having additional laboratory assistant and laboratory attendant's posts, as shown in **Table 6.22**.

Table 6.22 Laboratory Unit Staffing Plan

Post (Category)	Board Grade	Current Staff (2012)			Additional Staff		Total (By 2018)
		Outsourced Contractual	Approved Posts		Outsourced Contractual	New	
			Vacant	Filled			
Chemist	7	-	-	1	-	-	1
Laboratory Assistant	9	-	-	1	-	1	2
Laboratory Attendant	12	-	1	1	-	1	3
Total		**0**	**1**	**3**	**0**	**2**	**6**

(2) Rural Water Supply Unit

The RWS unit is subsumed in both the Anuradhapura and Pollonuwara District Engineering offices. The RWS in the Anuradhapura district engineering office will take a more active role in rallying the community-based organisations in the area in mutually supportive mechanisms. One is in the provision of technical assistance to the CBOs in such fields as water supply planning and design, operation and maintenance, finding suitable solutions to water quality and quantity issues, and also in enhancing the CBO's capacity to respond to disasters. Towards this end, CBOs request for the training of their personnel in such areas as pre-CBO formation, billing and collection, pump rehabilitation and maintenance, community leadership and cooperation, and community development and change. The NC RSC (through the RWS unit) delivers, on the average, three CBO training programmes per quarter, as well as provides advice on technical or collection problems.

The RWS unit will take a lead role in promoting CBO's inter-connection with the new distribution system in 2018 when additional water supply would be made available in the Project area, taking into consideration the categorization of CBOs discussed later in this Section.

The RWS unit will also spearhead a programme to generate public awareness on the health benefits derived from the Project. This would involve conceptualising, designing and implementing information, education and communication (IEC) programmes on the importance of having safe water and reliable water supply, and its positive effect on health and productivity. In other words, the pubic awareness programme will have messages for each target audience – for CBOs, for school children, and for households – and will also utilize the most suitable media such as face-to-face (village) meetings, print media (newspapers, leaflets, posters) and broadcast media (radio, TV). Right now, the Public Relations Office (NWSDB Head Office) has produced leaflets, posters, video, film and even radio campaigns that can be utilized for the awareness programme, but customized approaches should also be considered. (See the part on capacity development for proposed training on IEC / public awareness).

(3) The Commercial Unit (O&M Section)

The Commercial Office is specifically guided by the NWSDB Customer Charter covering the provision of new connections and re-connections, dealing with customer complaints on meter reading / issues, and response to customers, among others. With the completion of the Project, more consumers are expected to connect to the system, translating to an increased number of connections to be serviced, billed and collected from. Thus, mobility is important factor to consider also in responding quickly to customer issues, hence the need to procure vehicles. (See **Table 6.26** for the list of vehicles to support customer services).

However, even with the increased number of customers to be serviced, it is not recommended to open additional (cadre) posts for meter readers / bill collectors; but rather continue the current strategy of outsourcing meter reading and billing services. This would allow for greater efficiency because hiring would be based on the actual increase(s) in the number of consumers, in addition to the plan to fully automate billing and collection system, connected to through a POS system, and the use of remote operated water meters.

(5) IT Section

The soon-to be-constructed Mahakanadarawa and Wahalkada water treatment plants will use the SCADA system, thus fully automating the operational processes of these plants. This system will also include the water distribution process, necessitating that the sub-offices be connected with SCADA monitors to enable the officers-in-charge to check on the system within their respective water supply schemes. It is important that the IT staff be knowledgeable on the software system concepts, application(s), and solutions as well as the hardware component(s). This will enable it to effectively respond to any eventual problems especially when the operations of the system will be turned over to the RSC from the vendor. Other projects that the IT section is now involved in are: the enhancement of customer services through the expanded use of the call centre service, and the improvement of billing efficiency with the use of a point-of-sales system.

However, the IT section should not only deploy appropriate technology for the RSC, but also provide and generate useful information for management decision making. As of this time, the Northern Central Zone has an IT Manager that services the requirements of the five regional support centres under the Zone, namely, the Central, North Western, North Central, Northern and Northern Central RSCs. The IT Section is currently composed of four posts – two posts which have been filled, and two posts which remain vacant. However, by 2018, with the number of IT activities in progress and/or in the pipeline, the vacant posts will need to be filled up by qualified IT personnel, in addition to two more recommended, as shown in **Table 6.23**.

Table 6.23 IT Section Staffing Plan

Post (Category)	Board Grade	Current Staff (2012)			Additional Staff		Total (By 2018)
		Outsourced Contractual	Approved Posts		Outsourced Contractual	New	
			Vacant	Filled			
IT Manager	4					1	1
Computer Hardware Engineer	7		1				1
System Administrator	8	-	-	1	-	1	2
Computer Hardware Technician	10	-	1	-	-	-	1
Labourer	15	-	-	1	-	-	1
Total		**0**	**2**	**2**	**0**	**2**	**6**

6.2.5 Supporting O&M through Equipment and Engineering Software

(1) Equipping the WSS, the O&M Area Office and the Regional Workshop

To enable the water supply schemes to accomplish its functions, it will have to be equipped with basic O&M equipment and vehicles. For cost efficiency, some basic maintenance equipment and vehicles for rapid response mobility will be co-located in the “Area Engineer’s” Office in Medawachchiya, but will be available for use by all the water supply schemes in the area. **Table 6.24** provides the requirement for the O&M equipment.

Table 6.24 Proposed O&M Equipment for WSS and O&M Area Office

Equipment	No. of Units	Distribution
Asphalt Cutters	4	Rambewa WSS, Kahatagasdigiliya WSS, Medawachwhiya WSS, Kebithigollewa WSS
Tapping Machines	4	Rambewa WSS, Kahatagasdigiliya WSS, Medawachwhiya WSS, Kebithigollewa WSS
Compactors	4	Rambewa WSS, Kahatagasdigiliya WSS, Medawachwhiya WSS, Kebithigollewa WSS
Vibrating Hammers	4	Rambewa WSS, Kahatagasdigiliya WSS, Medawachwhiya WSS, Kebithigollewa WSS
Portable Generators	6	Rambewa WSS, Kahatagasdigiliya WSS, Medawachwhiya WSS, Kebithigollewa WSS, Mahakanadarawa WSS, WahalkadaWSS

In addition to O&M equipment, there is also a need to support the equipment requirements of the regional workshop. While the water supply schemes have their own workshops for routine repair and maintenance activities, those that cannot be handled on the scheme level are handled by the regional workshop. **Table 6.25** contains the list of equipment for the regional workshop.

Table 6.25 Proposed Equipment for Regional Workshop

Equipment	No. of Units
Small Lift Hoist / Crane	1
Pump Test Bed / Machine	1

The water supply schemes need mobility to (i) enable its service crews to readily respond to repair and maintenance requirements of the water treatment plants, the transmission and distribution networks; (ii) respond to customer requests for service connections and other complaints; (iii) provide safe water to isolated villages or clusters of households. In this connection, basic vehicles are required, as shown in **Table 6.26**.

Table 6.26 Proposed Basic Vehicle(s) List for WSS and O&M Area Office

Vehicles	No. of Units	Distribution	Main Purpose
Crew Cab	4	• Rambewa WSS • Kahatagasdigiliya WSS • Medawachwhiya WSS • Kebithigollewa WSS	Use of service crews for: i) new connections, ii) leak detection and repair
Single Cabs	2	• Mahakanadarawa WSS • Wahalkada WSS	Use of service crews for O&M of water treatment facilities (intake, transmission and WTP equipment)
Double Cabs	4	O&M Area (satellite) Office	To service the water supply schemes in the area
Water Bowser	3	• O&M Area (satellite) Office (to service Rambewa, Kahatagasdigiliya and Medawachchiya WSS) • Kebithigollewa WSS • Mahakanadarawa WSS	To provide water to non-piped borne areas
Mini-Backhoe	2	• O&M Area (satellite) Office (for Medawachichiya, Kahatagasdigiliya, Rambewa) • Kebithigollewa (Padaviya)	For new service connections and leak repair
Motorcycles	7	One for each WSS, plus area office	Customer service

(2) Supporting Planning, Design and Operations

The project will also require the latest version of engineering software packages to assist planning and design activities, and to support proper analysis and operation of the water supply system. The software will come with vendor-arranged training for selected staff of the Development, O&M, and the IT sections. The list of proposed software packages is shown in **Table 6.27.**

Table 6.27 Proposed Engineering Software Packages

Name of Software	No. of Units
Small World Water Network Information System	1 with 5-user licence
ArcGIS	1 with 5-user licence
WaterCAD	1 with 5-user licence
Surge Analysis Software	1 with 5-user licence
Structural Design Software	1 with 5-user licence
Project Management Software	1 with 5-user licence

6.3 Mode of Water Supply Services

The provision of water supply services, particularly in the rural sector, recognizes not only the value of water as a finite and vulnerable resource, but also acknowledges "the need for institutional arrangement for the efficient management of facilities with community participation and the stakeholders."[8] Towards this end, a national policy framework was issued in 2001 that spelled out the principles of the policy; the scope of the sector, such as the definition of the rural area and the description on access to levels of water supply; the sector partners and their responsibilities and regulatory powers; and legislative support for the sector.

The principles of the rural water supply (RWS) policy emphasize that water has to be recognized as an economic good and that activities must promote participatory approaches among users, planners and policymakers. It also clarifies the collective privilege(s) and responsibility(ies) of the water users – that users should be encouraged to own and manage the facilities and assets and share the capital investment incurred in creating the facilities, but should bear the full responsibility of sustainable operation and maintenance of the facilities.

Water supply providers with regulatory functions in the sector are the national government, through the NWSDB, the provincial governments and the local authorities, while purely water service providers are the Community Based Organization (CBOs), Private Sector and NGOs.

[8] Ministry of Urban Development, Construction and Public Utilities. *National Policy for Rural Water Supply and Sanitation Sector*, July 2001.

6.3.1 Community Based Organisations

(1) Definition and Form of Organisation

The RWS Policy defines CBOs "as groups formed or rural community organisation capable for the provision and sustainable management of water supply and sanitation facilities to their membership." CBOs are must be registered to be recognized as authorized institutions to take part in the development of the sector. They can take on the form of either a trust, development society, NGO or as a company under the Companies' Act, and are given authority to raise funds, obtain loans, receive grants, develop services, levy tariffs and manage facilities. The CBOs are accountable to their beneficiary community.

(2) Functions of CBOs

The functions of the CBOs are actually subject to the regulations imposed and standards set by the Government, Provincial Council and the Local Authorities. Enumerated among its functions are:

- To assess the needs, the demand and the aspirations of the communities for water supply, sanitation facilities and services;
- Assess the technical feasibility and economic viability of different options for providing water supply and sanitation facilities;
- Arrange internal funding;
- Play the key role in planning, designing, preparing proposals, implementing and managing the facilities and assets;
- Ensure the participation of user community and other partners at all stages of the process;
- Manage the facilities and services in a sustainable manner and to the satisfaction of the user community; and
- Conserve the environment with emphasis on water sources and watershed areas.

6.3.2 CBO-Managed Water Supply Schemes in the Project Area

It is envisioned that with the completion of the Project, the population in the project area be provided with safe water, adequate and reliable water supply. However, this may be true with those areas presently serviced by the NWSDB RSC(N/C), and 50 CBOs now operating and providing water in the project area, should the latter be willing to be connected to the new system.

Based on the criteria for the inclusion of CBOs into the project's service area, three CBOs namely, (i) Tristar, (ii) Dirimathaya and (iii) Al Naja will be excluded for various reasons, as described in **Section 4.2.5**. **Table 6.28** shows the list of CBOs and status of inclusion /

exclusion in the Project.

Table 6.28 Status of CBOs Included/Excluded in the Project

NAME OF WSS	#	NAME OF GND	NAME OF CBO	Remarks
RAMBEWA	1	Kendewa (97)	Swashakthi	Operational
	2	Ikirigollawa (102)	Ikra	Operational
	3	Sangilikanadarawa (111)	Arunalu	Operational
	4	Thalgahawewa (84)	Samagi	Operational
	5	Wahamalgollawa (109)	Ekamuthu	Operational
	6	Wewalkatiya (82)	Rangiri	Operational
	7	Maha Kandadarawa Yaya 01 (94)	Nildiyadahara	Operational
	8	Katukaliyawa (106)	Eksath	Operational
	9	Maha Kandarawa Yaya 02 (93)	Mahasen	Operational
	10	Ihala Kolongaswewa (87),	Dimuthu	Operational
	11	Bala Hodawewa (86), Ihala Kolangaswewa (87)	Pragathi	Operational
MEDWACHCHIYA	12	Katuwela (66)	Jayashakthi	Operational
	13	Halambagaswewa (70)	Samagi	Operational
	14	Ataweeragollewa (56)	Samagi	Operational
	15	Hirallugama (54)	Ekamuthu	Operational
	16	Wiralmurippuwa (64)	Ran Arunalu	Operational
	17	Kadawathgama (60)	Isuru	Operational
	18	Unagaswewa (75)	Randiya Dahara	Operational
	19	Kirigalwewa (72	Nelum	Operational
	20	Maha Kumbugollawa (46)	Diriyamatha	Operational; Excluded
	21	Maha Dilvuwewa (57)	Gamunu	Operational
	22	Kidawarankulama (42)	Sisila Diyahara	Operational
	23	Periyakulama (49),Yakkawewa (50)	Diriya Shakthi	Operational
	24	Athakade (55)	Ridi Nadi	Operational
KEBITHIGOLLEWA	25	Ayyathigewewa (24)	Shakthi	Operational
	26	Muslim Ataweerawewa (22)	Al Naja	Not commissioned; Excluded
	27	Gonumariyawa (25)	None	No CBO
PADAVIYA	28	Parakramapura (06)	Parakum	Operational
	29	18 Kanuwa (02)	Suwasehana	Operational
	30	Bogahawewa (14)	Suwasetha	Operational
KAHATAGASDIGILIYA	31	Mahakumukwewa (222)	Wajira	Operational
	32	Moragahawela (202)	Pragathi	Operational
	33	Palispothana (224)	Jansetha	Operational
	34	Pandarallawa (210)	Sobasisila	Operational
	35	Ranpathwila (196)	Randiya	Operational
	36	Kokmaduwa (201)	Nilmini	CBO Not Functioning
	37	Gonamaruwewa (223)	Seneth	Operational
	38	Turukkuragama (234)	Eksath	Operational
	39	Mahawewa (221)	Praja Shakthi	Operational
	40	Meekumbukwewa (212)	Apsara	Operational
	41	Ambagahawewa (213)	Pinibindu	Operational, Not Piped
	42	Waligollewa (218)	Sham Sham	Operational
	43	Kumbukgollawa (209)	Ekamuthu	Operational
HOROWPOTHANA	44	Wadigawewa (126)	Praeepa	Operational
	45	Parangiwadiya (149)	Upul	Operational
	46	Kapugollewa (140)	Jalasavi	Operational
	47	Angunochchiya (119)	Tri Star	Operational; Excluded
	48	Alonolondawewa (138)	Al Hidra	Near Operational
	49	Weerasole (139)	Adhikwa	Near Operational
	50	Maradanadawala (133)	Hansajala	Operational

(1) CBO Staff in the Project Area

The management and operations of the CBOs are generally performed by two staff members –

one technical and the other non-technical. The technical staff is in charge of operating and maintaining the pump(s) and maintaining the water source area. The non-technical staff is in charge of reading meters, and billing and collection. Most of the CBO staff are volunteers, who are employed either as teachers, government officials or local businessmen. They are remunerated based on revenue.

The CBO staff has been trained, receiving their first training upon CBO formation, on technical matters such as O&M of the scheme, and on managerial matters such as financial management, billing and collection and so forth. In the course of the CBO's operations, they request / receive follow-up training from the NWSDB RSC(N/C). In cases where the training is inadequate for repairing a pump, for example, the CBO goes to the nearest NWSDB RSC(N/C) water supply scheme for assistance.

(2) Problems of the CBO-Managed Water Supply Schemes

The CBOs operating in the project area suffer from a myriad of technical and non-technical problems. Technical problems can be traced to the lack of proper operation and maintenance of pumps, valves and bulk meters; the lack of repair and maintenance of distribution lines resulting to low water pressure in the mains; water quality problems because of inexistent or inadequate chlorination facilities and poor quality (high fluoride content for some CBOs) water at source; and insufficiency of water especially during the dry season. Non-technical problems can be grouped into the lack of transparency in CBO operations; shortage of trained people to manage the CBO and to operate and maintain the system; and the absence of records and in many cases, of accounting records and of proper keeping practices, and increasing gaps between costs and revenues.[9]

(3) Suitability of CBOs for Incorporation into NWSDB RSC(N/C) or for Bulk Supply

Problems notwithstanding, the facilities of most of the CBOs surveyed were either in "good" or "structurally sound" condition, making them candidates for bulk supply. However, there are a number of minor and major technical and non-technical problems faced by the CBOs. Thus, the CBOs were further assessed according to being suitable for immediate inclusion for bulk supply; recommended for inclusion but will require improvements, or would require that stated problems be addressed or resolved as shown in **Table 6.29.**

Based on survey team's assessment, 36 out of 50 CBOs or 72 percent are suitable for connection to the new system; 11 CBOs or 22 percent are also suitable for connection to the bulk system, but technical and non-technical problems need to be resolved. On the other hand, three CBOs or

[9] This is the summation of the problems which have been listed on a per CBO basis (total - 50 CBOs) found in Table 3.3 of the Final Report: *Status Survey on the Existing Water Supply Schemes*, earlier mentioned in this section.

six percent have been excluded, as earlier explained. See **Appendix 6.3(a).** for the detailed assessment of the 50 CBOs.

Table 6.29 Summary of Assessment of CBOs on Suitability for Bulk Supply

	Recommended for Immediate Inclusion	**Recommended (But Will Require Improvements)**		**Excluded**
	Suitable for immediate inclusion	Requires improvements before inclusion	Stated problems must be first addressed	
Total CBOs	**36**	**6**	**5**	**3**

As for the issue on improvements required or problems to be addressed before the CBOs' inclusion for bulk water supply, the NWSDB RSC(N/C) can take some necessary actions to resolve the issues. These are indicated in **Table 6.30**.

Table 6.30 Proposed Actions by NWSDB RSC(N/C) on the CBOs with Issues

CBO #	**Name of CBO**	**Improvements required / Problems addressed before inclusion**	**Proposed action(s) by NWSDB RSC(N/C)**
6	Rangiri	CBO management needs improvement; lack of good financial management; poor O&M of facilities	• Reorganize the CBO • Retrain CBO staff in all aspects of CBO management and operations; • Provide basic O&M guidelines and accounting systems
21	Gamunu	NRW not recorded; Tapping pressure low; Maintenance level low; Replacement of small and undersized diameter pipes required	Make a more detailed assessment and feasibility of technical and financial requirements to replace pipelines and other improvements
22	Sisila Diyahara	Field tests show NRW at 46.32%; Replacement / repair of pipes required	Make a more detailed assessment and feasibility of technical and financial requirements to replace pipelines and other improvements
23	Diriya Shakthi	Field tests show NRW at 41.38%; Replacement / repair of pipes required	Make a more detailed assessment and feasibility of technical and financial requirements to replace pipelines and other improvements

CBO #	Name of CBO	Improvements required / Problems addressed before inclusion	Proposed action(s) by NWSDB RSC(N/C)
27	No CBO/Scheme	Scheme / CBO must be organized before connection to bulk supply	• Organize the CBO • Train CBO staff in all aspects of CBO management and operations • Provide basic O&M guidelines and accounting systems; or • Direct distribution by NC RSC
36	Nilmini	Scheme did not operate from 2006	• Re-organize the CBO • Retrain CBO staff in all aspects of CBO management and operations • Provide basic O&M guidelines and accounting systems • Make a more detailed assessment and feasibility of technical and financial requirements to re-start CBO such as a thorough systems check before initial operation of scheme to determine adverse effects on water tank and distribution system
37	Seneth	Complete overhaul of CBO management (run by one person) for unreliable records and lack of transparency	• Reorganize the CBO • Retrain CBO staff in all aspects of CBO management and operations; • Provide basic O&M guidelines and accounting systems to promote transparency
40	Apsara	Field test shows NRW at 33.96%; Replacement / repair of pipes required	Make a more detailed assessment and feasibility of technical and financial requirements to replace pipelines and other improvements
41	Pinibindu	A rainwater harvesting scheme of 60 households; CBO to be formed for pipe borne water supply; new distribution system to be built	• Organize the CBO • Train CBO staff in all aspects of CBO management and operations • Provide basic O&M guidelines and accounting systems • Or, direct distribution by NC RSC
42	Sham Sham	Water source failed after one year of operation (2008); damaged pump not replaced; status of tank and distribution system to be checked; pipe has numerous leaks and must be replaced; CBO must be revitalized	• Reorganize the CBO • Retrain CBO staff in all aspects of CBO management and operations • Provide basic O&M guidelines and accounting systems • Make a more detailed assessment and feasibility of technical and financial requirements to re-start CBO
44	Pradeepa	Lack of leadership direction in CBO	Reorganize the CBO; retrain CBO staff in all aspects of CBO management and operations; Provide basic O&M guidelines and accounting systems

(4) Willingness of the CBOs to be Incorporated / Connected to the New System

The technical suitability of the CBOs to be incorporated into the NWSDB is only part of the equation. The CBOs must indicate their willingness, and if there is any reluctance, the reasons should be known, so that NWSDB RSC(N/C) can be apprised and corrective measures undertaken. **Table 6.31** provides the summary of the CBO's responses.

Table 6.31 Willingness of CBOs to Connect to NWSDB Bulk System

CBO	Willingness to Connect			Condition(s) to Connect			No Condition Specified
	Yes	No	Undecided	24-Hour Water Supply	Better Quality Water	Retain O&M Authority	
1	✓			✓	✓	✓	
2	✓			✓	✓	✓	
3	✓			✓	✓	✓	
4	✓			✓	✓	✓	
5	✓			-	-	-	✓
6	No comment			-	-	-	
7	✓			✓	✓	✓	
8	✓			✓	-	✓	
9	✓			✓	-	✓	
10		✓		-	-	-	
11	✓			-	-	✓	
12	✓			✓	✓	✓	
13	✓			✓	✓	✓	
14	✓			✓	✓	✓	
15	✓			-	-	-	✓
16	✓			✓	✓	✓	
17	✓			✓	✓	✓	
18	✓			✓	✓	✓	
19	✓			-	-	-	✓
20	Excluded						
21	✓			✓	-	-	✓
22	✓			-	-	-	✓
23	✓			✓	✓	-	✓
24	✓			✓	✓	-	✓
25	✓			✓	✓	✓	
26	Excluded						
27	No CBO / No Scheme						
28	✓			-	-	-	✓
29	✓			✓	✓	✓	
30	✓			✓	✓	✓	
31	✓			-	-	-	✓
32	✓			✓	✓	✓	
33	✓			✓	-	✓	
34	✓			-	-	-	✓
35	✓			✓	✓	✓	
36	✓			✓	✓	✓	
37	✓			-	-	-	✓
38	✓			-	-	-	✓
39			✓	-	-	-	✓
40	✓						✓
41	Not a Piped System						
42	✓			-	-	-	✓
43	✓			-	-	✓	
44	✓			-	-	-	✓
45	✓			-	-	-	✓
46	✓			-	-	✓	
47	Excluded						
48	✓			-	-	✓	
49	✓			-	-	✓	
50	✓			-	-	-	✓
	42	**1**	**1**	**22**	**18**	**24**	**18**

Note: Information analysed from Summary Sheet No. 7 – Willingness to Connect to the New Bulk System Final Report, "Status Survey of the Existing Water Supply Schemes for the Preparatory Survey on Anuradhapura North Integrated Water Supply Project" by Ceywater Consultants, August 2012.

As can be gleaned from the **Table 6.31**, a resounding majority of 42 CBOs or 84 percent are willing to connect to the new distribution system. One CBO (two percent) said it was not willing to connect; one (two percent) was undecided; one (two percent) did not respond. On the other hand, one (two percent) does not have CBO/scheme, while one (two percent) is a rainwater harvesting scheme. Three CBOs (six percent) have been excluded from the study. However the final decision is made at the general meeting of the community, therefore, through an awareness campaign, such present stance of CBOs could be changed.

This willingness to connect to the new distribution system corroborates with the results of the social survey's willingness-to-pay in the sense that "100 percent of the CBO respondents expressed their willingness-to-pay if they get a better water supply through NWSDB RSC(N/C) where about 50 % of the CBO respondents expressed that they are willing to pay any reasonable amount upon receiving a quality water supply as they severely suffer due to absence of a proper water supply in the area."[10]

However, of the 42 CBOs willing to connect to the bulk system, 22 CBOs gave the condition that if connected to the new system, they want to retain the authority to operate and maintain the CBO. They also expect that water service to be available 24 hours per day, and that water distributed to be of better quality than what they are now producing. Eighteen CBOs, on the other hand, did not categorically specify retaining the authority for O&M as a requirement to connecting to the new system, but mentioned wanting assurance of 24-hour water service, in addition to having safe and potable water.

6.3.3 Approaches in Providing Water Supply Services to CBOs

There are several approaches in getting the CBOs to connect to the new system, given the information / data on technical suitability of the CBO systems, technical and non-technical issues to be resolved, the CBOs willingness to connect and conditions for connecting. As such it is proposed to rationally categorize the CBOs based on the information / data presented.

(1) Categorization of CBO Inter-Connection with NWSDB RSC(N/C)

It is proposed that the first category would be comprised of CBOs that have indicated their willingness to connect to the new system, without any conditions, and whose systems have been assessed as suitable for immediate bulk supply connection. There are 11 CBOs (22 percent) that fall under Category 1.

[10] Final Report. *Social Survey Conducted for the Feasibility Study of Anuradhapura North Integrated Water Supply Project* by Engineering Consultants (Pvt) Ltd., September 2012, p.24.

The second category would be the CBOs who are willing to connect, also without conditions, but whose systems need improvements or have issues to be resolved. These CBOs will be more accepting of being inter-connected to the system, since they are presently experiencing either unsatisfactory service, having water quality problems, or inadequate water supply. Six CBOs (12 percent) fall under Category 2.

The third category CBOs are those willing to connect, but with conditions, although their systems have been assessed as suitable for immediate connection. The water supply systems of the third category CBOs are generally still in good working condition, and can continue provide an acceptable level of service to the community. There are 24 CBOs (48 percent) that fall under Category 3.

The fourth category are CBOs that require major rehabilitation to precede an efficient inter-connection, because these are either non-functioning, not a pipe borne system, or have no CBO / no scheme organised. These also include water CBOs who are undecided or made no comment. Five CBOs (10 percent) fall under Category 4.

The fifth or last category is the CBOs that have been excluded from the project study and the CBO not willing connect. There are four CBOs (8 percent) that fall under Category 5. See **Table 6.32** for list of CBOs and their categorization, and **Appendix 6.3(b)** for the summary table on suitability, conditions, willingness to connect and categorisation.

Table 6.32 Categorisation of CBOs Based on Willingness to Connect, Conditions Set and Technical Suitability

CBO	CATEGORY 1	CATEGORY 2	CATEGORY 3	CATEGORY 4	CATEGORY5
	• Willing to connect • No conditions • Suitable for bulk supply	• Willing to connect • No conditions • Requires improvements	• Willing to connect • With conditions • Suitable for bulk supply	• Willing to connect • Requires major rehabilitation • Undecided	• Not willing to connect • Excluded
1			o		
2			o		
3			o		
4			o		
5	❖				
6				•	
7			o		
8			o		
9			o		
10					▪
11			o		
12			o		
13			o		
14			o		
15	❖				
16			o		
17			o		
18			o		
19	❖				
20					▪
21		➢			
22		➢			
23		➢			
24	❖				
25			o		
26					▪
27				•	
28	❖				
29			o		
30			o		
31	❖				
32			o		
33			o		
34	❖				
35			o		
36				•	
37		➢			
38	❖				
39				•	
40	❖				
41				•	
42		➢			
43			o		
44		➢			
45	❖				
46			o		
47					▪
48			o		
49			o		
50	❖				
TOTAL	**11**	**6**	**24**	**5**	**4**

(2) Strategies in the Provision of Water Supply Services

It must be emphasized that CBOs are composed of beneficiary households. They were formed on the basis of consultation and participation, which has become an important factor in its success. Through this process, the various stakeholders' influence, share control and make decisions over development initiatives and resources that affect them. Thus, NWSDB RSC(N/C) must be able to provide water supply through the following strategies: (i) bulk distribution through the existing CBOs by encouraging them to connect to the new system; (ii) direct distribution, by constructing the required distribution lines to an expanded urban centre or new cluster of populations, or by takeover or turnover of CBO facilities, depending on the arrangement with the CBOs; and (iii) distribution by water tankers to isolated or far flung areas that are not reachable by the distribution system. See **Figure 6.10** below.

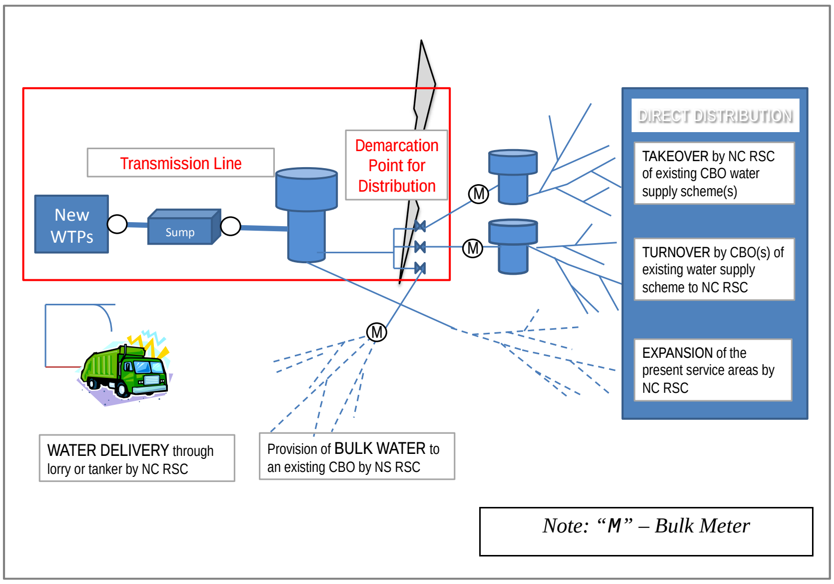

Figure 6.10 Provision of Water Supply Services

It is of utmost importance, therefore, that the NWSDB RSC(N/C) establish closer and deeper consultative mechanisms with the CBOs to determine how they want to be supplied with water from the new system, preferably using as a guide the CBO categorisation discussed earlier in this section. This demand-driven participatory approach would help resolve issues that could hinder inter-connection. See **Table 6.33** for a more detailed summary of the manner of supply service provision.

Table 6.33 Manner of Providing Water Supply Services

DISTRIBUTION METHOD	By Existing CBO	By Direct Distribution			By Water Tankers
OVERVIEW	Bulk supply to CBO by RSC	Turnover of CBO facilities to RSC(N/C)	Takeover of CBO facilities by RSC(N/C)	By NWSDB RSC(N/C)	By NWSDB RSC(N/C)
DESCRIPTION	CBO keeps its current organisational characteristics	CBO voluntarily turns over facilities for management by RSC	RSC employs compulsory take over of CBO facilities	RSC expands its existing urban service area(s)	Isolated house-hold clusters not part of CBO or RSC
DISTRIBUTION FACILITIES	• CBO to connect to RSC using bulk meter • CBO to provide rehabilitation to minor/damaged facilities • CBO to expand own distribution network	• RSC to provide rehabilitation to minor/damaged facilities • RSC to expand distribution network	• RSC to provide rehabilitation to minor/damaged facilities • RSC to expand distribution network	RSC to construct new distribution network(s)	Constructing distribution pipelines is not economically feasible
MANAGEMENT AUTHORITY	• CBO retains management authority	• Management authority is RSC	• Management authority is RSC	• Management authority is RSC	• Management authority is RSC
O&M RESPONSIBILITY	• CBO retains responsibility for O&M	• Responsibility for O&M to be decided between CBO and RSC(N/C)	• Responsibility for O&M to be decided between CBO and RSC(N/C)	• RSC retains responsibility for O&M	• RSC retains responsibility for O&M
TARIFF COLLECTION	• CBO retains responsibility for tariff collection	• Responsibility for tariff collection to be decided between CBO and RSC(N/C)	• Responsibility for tariff collection to be decided between CBO and RSC(N/C)	• RSC retains responsibility for tariff collection	• RSC is responsible for setting water charges

As can be gleaned from the above discussion, the CBOs will still retain water distribution rights over its service area. As such, NWSDB RSC(N/C) should vigorously continue to fulfil its mandate of providing technical assistance for such schemes that are operated and managed by the community. It has to strengthen and sustain training activities for the CBOs, capacitating them in operations and maintenance, financial management, billing and collection, records keeping, and governance. It has to re-establish the institutional basis and legal recognition of the CBOs by ensuring the presence of By-Laws, Rules of Business Conduct, preparation of Annual Reports. Finally, it has to put in place a database system of the CBOs that are supplied with water from RSC(N/C) as a monitoring tool of CBO technical and financial operations.

6.4 Water Tariff Systems

The CBO tariff system is prepared with the assistance of the CBO itself and the CBO project proponents. Usually, the system includes the following (i) replacement cost (ii) future rehabilitation cost (iii) capital investment (iv) O&M cost, including staff salary. All tariff systems have to be presented and accepted by the CBO in a general meeting called for the purpose, with a required minimum participation / presence of two-thirds of its membership.

(1) CBOs Tariff System

Domestic water tariff is available for 44 out of 50 CBO schemes in the Project area, while non-domestic water tariff is available for only 25 CBO schemes. The reason for this shortfall is that free water supply is provided to public institutions such as schools and temples.

Tariff charges vary from scheme to scheme. There is a basic monthly fee levied on each customer, with majority of CBOs (52 percent) charging within the range of Rs. 50-59, as shown in **Table 6.34**.

Table 6.34 Basic Monthly Fee Charged by CBOs in the Project Area

Basic Charge (in Rs.)	<49	50-59	60-69	70-79	80-89	90-99	100	150	No data
No. of CBOs	1	26	6	3	3	1	4	1	5
%	2	52	12	6	6	2	8	2	10

Note: Information sourced and analysed from *Annex 3 – Water Tariff Structure for each CBO,* "Status Survey of the Existing Water Supply Schemes for the Preparatory Survey on Anuradhapura North Integrated Water Supply Project" by Ceywater Consultants, August 2012.

As for the per unit consumption charges, the results of the Status Survey revealed that ADB-supported projects generally charge lower tariffs, which range from Rs. 15 to 20 per unit; while CWSSP schemes have higher tariff, varying from Rs. 21 to 27 per unit.

The CBOs in the Project area also impose a connection / re-connection charge on the customer equivalent to the costs incurred. Replacement of the water meter is also charged to the customer. **Table 6.35** shows the re-connection fees imposed.

Table 6.35 Reconnection Fee Charged by CBOs in the Project Area

Reconnection Fee (in Rs.)	250-499	500-749	750-999	1000	2000	3000	No charge	No data
No. of CBOs	3	16	5	5	3	1	2	15
%	6	32	10	10	6	2	4	30

Tariff structure also varies among CBOs. Although all CBOs have a basic charge per household connection, tariff is structured using a unit rate with a block progressive rate. Volumetric rate increases as the consumption increases. The Status Survey used a sample rate analysis for a sample household in each of the 50 CBOs with an average monthly consumption of 18 cubic meters. The formula used is: Base Charge + Consumption Tariff + Tax. The results of the sample rate analysis provide a good idea, for comparison purposes, on the average water bill of a sample household in each CBO.

As shown in **Table 6.36**, sample households of 18 CBOs, or 36 percent, have water bills within the range of Rs. 300-399; the sample households of 13 CBOs, or 26 percent, have water bills within the range of Rs. 400-499.

Table 6.36 Sample Analysis of Monthly Water Bill of CBO Households

Sample Monthly Water Bill (in Rs.)	200-299	300-399	400-499	500-599	600-699	No data
No. of CBOs	9	18	13	3	1	6
%	18	36	26	6	2	12

This amount is similar to the one confirmed through the social survey conducted which found out that the average amount paid by CBO users come up to Rs. 346 per month, while the average amount paid by the consumer is Rs. 400 per month.

After the new water supply system will enter into operation, NWSDB will be responsible for management, operation and maintenance of new systems. If NWSDB will take over the existing CBO system based on the resolution at the general meeting of the community, the NWSDB's water tariff is imposed to the respective customers, while if the existing CBO will keep an independence from NWSDB, the NWSDB's bulk water supply rate will be imposed to the total water consumption of the CBO. For the new service area, since NWSDB has no intention to allow the new CBO establishment. NWSDB's water tariff will be applied to all the new customers. Takeover of the existing CBO facilities will be done in principle for nothing, since the materials required for the construction of facilities were originally provided by the Government for nothing.

In case of a bulk supply from NWSDB to existing CBOs, the bulk supply charge will be newly imposed, while the consumable expenditures such as electricity or diesel oil and chlorine will be cut from the present expenditures. The profit/loss is then estimated as indicated in **Table 6.37**, in which 17 CBOs (about 41%) out of 41CBOs will show a loss. Although the total payment of one community will be higher than the current one, the water supply by NWSDB still has advantages of (i) safe water supply to meet the Sri Lankan drinking water standards even for fluoride, (ii) stable water supply even in the dry season, (iii) proper chlorination of water, (iv) professional operation and maintenance for distribution facilities such as replacement of defective water meters, repair of leaks.

6.5 Cost Sharing

The connection work of transmission mains and sub-mains to the existing elevated tanks under the CBOs water supply schemes will be done in the Project with no cost to existing CBOs.

In the new service area, distribution mains and sub-systems will be installed in the Project. For small-size distribution pipes (below 100 mm) NWSDB has a plan to provide materials and install them by the people's labour contribution based on the request of the community people under the NWSDB's supervision, which is also helpful to heighten the willingness to connect to a new system. In case of a new connection, NWSDB is responsible for the service pipe installation work from the branch of distribution pipes to a water meter, while an applicant for the remaining work from the meter outlet to the taps. The connection fee varies from Rs.4,000 to Rs.20,000 depending on the cost estimation. If there is a pavement road, the cost to break and reinstate the pavement is borne by an applicant who is required to pay such cost to the relevant authorities beforehand.

Table 6.37 Estimation of Revenue and Expenditure in Case of an Application of Bulk Supply Charge to Existing CBOs

DSD	GND	CBO	No. of Connections (Conn.)	Water Consumption (m3/month)	Bulk Supply Payment (Rs./year)	Revenue (Rs./year)	Present Expenditure at CBOs Total (Rs./year)	Personnel (Rs./year)	Consumables (Rs./year)	Maintenance (Rs./year)	Profit/Loss (Rs./year)
Padaviya	Padaviya	Suwasehana	192	1,989	405,756	1,025,364	425,928	84,000	101,928	240,000	295,608
	Parakramapura	Parakum	576	9,307	1,898,628	2,045,400	618,380	348,000	192,780	77,600	-278,828
	Bogahawewa	Suwasetha	186	2,661	542,844	730,052	478,348	180,000	164,484	133,864	-126,656
Kebithigollewa	Ayyatigewewa	Shakthi	235	2,583	526,932	562,758	534,519	216,000	148,589	169,930	-350,104
Medawachchiya	Kidawarankulama	Sisila Diyadahara	190	1,762	359,448	535,060	373,612	156,000	207,612	10,000	9,612
	Maha Kumbugollewa	Diriyamatha	180	1,460	297,840	562,228	421,037	180,000	141,037	100,000	-15,612
	Periyakulama &Yakawewa	Diriyashakthi	138	1,365	278,460	490,000	362,432	132,000	207,432	23,000	56,540
	Hirulugama	Ekamuthu	173	1,953	398,412	394,796	358,672	198,000	120,672	40,000	-241,616
	Athakade	Ridinadi	121	938	191,352	446,472	224,569	120,000	72,480	32,089	103,031
	Ataweeragollewa	Samagi	110	1,266	258,264	434,792	289,904	96,000	183,904	10,000	70,528
	Maha Divulwewa	Gemunu	70	487	99,348	192,684	81,420	30,000	51,420	0	63,336
	Kadawathgama	Isuru	181	1,915	390,660	714,806	476,204	258,000	139,404	78,800	-12,654
	Viralmurippuwa	Ran Arulnalu	192	1,907	389,028	402,264	176,323	102,000	70,188	4,135	-92,899
	Katuwela	Jayashakthi	220	2,932	598,128	927,904	632,164	288,000	294,164	50,000	-8,224
	Helabagaswewa	Samagi	190	1,818	370,872	1,270,584	332,448	190,800	106,848	34,800	674,112
	Kirigalwewa	Nelum	139	660	134,640	286,620	159,624	72,000	87,624	0	79,980
	Unagasewewa	Randiya Dhahara	107	1,018	207,672	527,540	291,700	78,000	181,200	32,500	209,368
Rambewa	Wewelketia & Thamarahamillewa	Rangiri	120	797	162,588	341,832	192,492	96,000	96,492	0	83,244
	Talgahawewa	Samagi	135	973	198,492	432,168	260,950	162,000	71,440	27,510	44,166
	Balahodawewa	Pragithi	128	726	148,104	290,772	123,515	66,000	46,748	10,767	65,901
	Ihala Kolongasw.	Dimuthu	67	417	85,068	147,732	81,263	48,000	30,576	2,687	11,977
	Mahakanadarawa 2	Mahasen	153	1,336	272,544	319,376	266,966	120,000	134,016	12,950	-86,118
	Mahakanadarawa 1	Nildiyadahara	144	1,175	239,700	391,396	242,219	114,000	93,219	35,000	2,696
	Kedewa & Galkandegama	Swashakthi	154	949	193,596	441,276	199,605	120,000	64,968	14,637	113,043
	Ikirigollewa	Ikra	613	8,645	1,763,580	1,883,160	1,084,874	540,000	528,361	16,513	-436,933
	Katukeliyawa	Eksath	118	1,632	332,928	305,352	226,842	96,000	54,684	76,158	-199,734
	Wahamalgollewa 3	Ekamuthu	245	1,448	295,392	616,920	347,832	168,000	175,332	4,500	149,028
	Sangilikanadarawa	Arunalu	183	2,834	578,136	974,584	466,315	180,000	217,920	68,395	148,053
Horowpothana	Wadigawewa	Pradeepa	161	1,578	321,912	382,908	226,651	120,000	52,880	53,771	-112,775
	Maradankadawela	Hansajala	111	1,231	251,124	392,044	224,817		82,632	142,185	-1,265
	Kapugollewa	Jalasavi	157	1,107	225,828	331,324	224,859	94,000	82,882	47,977	-36,481
	Parangiyawadiya	Upul	195	1,691	344,964	613,428	224,501	132,000	69,701	22,800	113,664
Kahatagasdigiliya	Moragahawela	Pragathi	131	855	174,420	339,660	176,620	120,000	46,620	10,000	35,240
	Kubukgollewa	Ekamuthu	78	447	91,188	200,900	159,532	48,000	102,172	9,360	52,352
	Pandarellewa & Panwella	Sobasisila	178	2,254	459,816	510,720	242,664	120,000	122,664	0	-69,096
	Mee-Kumbukwewa	Apsara	101	492	100,368	290,592	192,548	96,000	94,548	2,000	92,224
	Mahawewa	Praja Shakthi	165	1,089	222,156	624,740	368,669	150,000	99,395	119,274	133,310
	Maha Kubukwewa	Vajira	135	1,233	251,532	431,496	290,632	198,000	70,632	22,000	-40,036
	Gonumeru Wewa	Senath	79	525	107,100	275,312	185,640	24,000	134,640	27,000	117,212
	Palippothana ~ Kirigallewa	Janasetha	189	1,952	398,208	615,476	249,024	120,000	117,024	12,000	85,268
	M. Kiribbewa & Kurukuragama	Eksath	100	930	189,720	214,800	196,116	96,000	100,116	0	-70,920

Note: Profit/Loss = Revenue - (Bulk Supply Payment + Personnel Expenditure + Maintenance Expenditure)
The water tariff for the bulk supply of water to CBOs is Rs.17 per cubic meter with no service charge.

CHAPTER 7

PROJECT COST

CHAPTER 7 PROJECT COST

The project cost for the Anuradhapura North Integrated Water Project is prepared based on the list of the proposed water facilities provided in Chapter 5.

7.1 Preamble (Basis for Cost Estimation)

Following conditions were referenced from the JICA F/F Common Matters to be considered for Sri Lanka in preparation of the cost estimation for this project.

1)	Base Year	August 2012
2)	Exchange Rate	USD 1 = JPY 78.2 USD 1 = Rs. 132.1 Rs. 1 = JPY 0.592
3)	Price Escalation Rate	Foreign Currency = 2.1%, Local Currency = 4.0%
4)	Physical Contingency	5.0%
5)	Administration Cost	9.0% of eligible and non-eligible portions
6)	VAT	12 % (of the expenditure in local currency and foreign currency of the eligible portion)
7)	Import Tax	27% (of the expenditure in foreign currency of eligible construction portion)

Import Taxes in Sri Lanka are set forth and overseen by Sri Lanka Custom and vary depended on materials. Per Annex 2 in the NWSDB Rate 2012 and Sri Lanka Custom Tariff book, a total duty as % of CIF is obtained as follow:

- Civil Components:
  - HDPE (Tariff Heading 3917.21): 46%
  - Valves and Parts (Tariff Heading 8481.10-90): 12%

- Mechanical Components (BOQ base) 23.3%
- Electrical Components (BOQ base): 15.0%
  Including following items, but not limited,
  - Pump (Tariff Heading 8413.70.10): 35%
  - Pump Parts (Tariff Heading 8413.91): 0%

7.2 References for Unit Prices

For water supply and drainage projects in Sri Lanka, NWSDB publishes annually unit prices as in a book called “Rates”. There are two ways to prepare cost estimation using the Rates for these types of projects in Sri Lanka: 1) Rates for Total Cost Estimates, and 2) Rates for BOQ. The “Rates for Total Cost Estimates” uses one all-inclusive unit price, which includes all elements of a particular item to be installed or constructed. On the other hand, the “Rates for BOQ” add all associated unit prices to derive a cost to install or build the item.

To prepare the cost estimation for this project, the information on the unit prices of materials, equipment, and labour in Sri Lanka was collected from both NWSDB Rates 2012 and the local and international contractors, which are qualified for participating ICB projects, and then compared the collected prices to analyse the unit price differences. The unit prices collected from the contractors reflect the most current marketing prices for construction materials and activities. The NWSDB Rate Book projects unit prices and BOQs based on the collected construction cost data up to the previous years. Therefore, these prices may not reflect the most accurate prices for the current market in Sri Lanka. The JICA Team carefully compared these unit prices based on the current price escalation for construction costs in Sri Lanka and the trends and determined unit prices to be utilized for this project.

7.3 Considerations for Preparing Cost Estimation

Based on the interviews and obtained data from the local contractors and agencies in preparation of the project cost estimation, the following items were considered.

(1) Rock Excavation

Based on the field visits to the proposed water facility sites, different sizes of large rocks above ground and/or at ground in some locations were observed. In addition, based on the geotechnical report prepared by the local consultant, the following information were observed and summarized below:

- Basement Rock:
  - ➢ The geotechnical reports indicate that rocks are observed approximately 1 m below at a majority of investigated places for the proposed transmission and distribution main pipes.
  - ➢ The geotechnical reports indicate that rocks are observed approximately 1.5 m below at a majority of investigated places for the proposed structures.

The soil covers over the proposed transmission and distribution main pipes and the distribution sub pipes from the top of the pipes are 1.2 m and 1.0 m respectively. The largest diameter of the proposed pipes is HDPE 450 mm. Therefore, the trench depth for the pipes is approximately 2 m from the ground level with all other foundation materials and pipe wall thickness. For purposes of the cost estimation, 50% (1.0/2.0 = 0.5) of the overall excavation related to the pipe installation is considered as rock excavation.

For the concrete structure such as the proposed ground reservoirs and elevated tanks, the excavation depth varies from a range of 3 m to 7 m below the ground level where completely weathered rock and basement rock are observed per the obtained borehole investigation information to estimate the rock excavation. The estimated average depth of the proposed structures is 2.5 m from the ground. As stated above, the average depth of the rock beneath the ground starts approximately at 1.5 m. Therefore, approximately 40% (1.0/ 2.5 =0.4) of the excavation for the proposed structures is included as rock excavation.

To research the ratio among the different soil types of excavation, the unit prices were collected from the local contractors and Rates 2012. **Table 7.1** shows the comparison summary of the unit prices for the different soil types of excavation by different resources. Based on the hearings and the collected data from the local contractors, a unit price of rock excavation is approximately 5 to 9 times more than that of normal soil excavation. A unit price of rock excavation used in the project cost estimation is set forth by 5 times more than that of normal soil.

Table 7.1 Excavation Unit Price with Different Soil Types

Excavation Items	Specification	Unit	NWSDB[1]		Sierra[2]		Maeda[3]	
			Rs	Ratio	Rs	Ratio	Rs	Ratio
Normal Soil	0 < Depth < 1 m	m^3	548	1.00	1,500	1.00	572	1.00
Disintegrated Rock	0 < Depth < 1 m	m^3	1,567	2.86	1,800	1.20	635	1.11
Rock	0 < Depth < 1 m	m^3	2,615	4.77	9,000	6.00	4,826	8.44

Source: 1. NWSDB 2012 Rates p.61, 2. Unit Prices obtained from Sierra Construction, 3. Unit Prices obtained from Maeda Corporation
Note: Unit prices are used to compare the ratio between normal soil and rock excavation.

(2) Procurement Procedure

In Sri Lanka, bidding document procurement of works procedure is set forth by the Procurement Manual published by Sri Lanka National Procurement Agency, commonly known as “Blue Book” in Sri Lanka. According to the manual, a different authority oversees projects depending on a total cost of the project as shown in the table below:

Table 7.2 Committee Involvements According to Project Costs

Authority	Foreign Founded Projects
Cabinet Appointed Procurement Committee (CAPC)	More than Rs 500 Million
Ministry Procurement Committee (MPC)	Up to Rs. 500 Million
Department Procurement Committee (DPC)/ Project Procurement Committee (PPC) - NWSDB	Up to Rs 150 Million
Regional Procurement Committee	Up to Rs 5 Million

Resource: Sri Lanka Procurement Manual by National Procurement Agency `

According to the Blue Book, FIDIC 2010 MDB Harmonized Version shall be referenced for International Competitive Bidding (ICB), and the Standard Bidding Document Procurement of Works by Institute for Construction Training and Development (ICTAD) shall be referenced for National Competitive Bidding (NCB). Even though the procurement guidelines and rules are different for different type of biddings, the basic flow of the bidding procedure is similar to each other.

However, the schedule may be affected by the involvement of different authorities due to longer duration on overall evaluation process, which can be expected to be 30 days longer or more if more than one committee is involved. The overall schedule and duration of the procurement procedure is determined during preparation of tender documents.

7.4 Project Cost Estimation

A summary of estimate capital cost for the Anuradhapura North Integrated Water Supply Project is tabulated in **Table 7.3**,

Table 7.5 and **Table 7.6** include the annual fund requirement (JICA Loan). The estimate capital cost for the Mahakanadarawa portion of the project subjected to the JICA Loan is 5.166 billion yen (Foreign Portion: 2.623 billion yen and Local Portion: RS. 4.295 billion) and that for the Wahalkada portion is 7.696 billion Yen (Foreign Portion: 4.045 billion Yen and Local Portion: Rs. 6.166 billion). However, for Wahalkada Scheme the Project cost will be discussed and finalised in the Appraisal. The project cost estimation is prepared for the facilities proposed for the projected water demand of 2034 and for some facilities to be constructed for the water demand of 2024 under stage construction which was discussed more detail in **Chapter 5**.

The details of the construction cost are included in **Appendix 7.4**.

Table 7.3 Mahakanadarawa Estimated Project Costs (Stage-1)

Item	Cost in Million		
	FC	LC	Total
	(JPY)	(Rs.)	(JPY)
A. ELIGIBLE PORTION			
Ⅰ) Procurement / Construction	1,951	3,990	4,314
Ⅱ) Consulting Services	378	305	559
Sub-total (Ⅰ+Ⅱ)	2,330	4,295	4,872
B. NON ELIGIBLE PORTION			
a. Procurement/ Construction	12	97	69
b. Land Acquisition	0	19	11
c. Administration cost	0	753	446
d. VAT	0	1,004	594
e. Import Tax	0	895	530
Sub-total (a+b+c+d+e)	12	2,769	1,651
TOTAL (A+B)	2,341	7,064	6,523
C. INTEREST DURING CONSTRUCTION	253	0	253
D. COMITTMENT CHARGE	41	0	41
GRAND TOTAL (A+B+C+D)	2,635	7,064	6,817
E. JICA FINANCE PORTION INCLD. IDC (A + C + D)	**2,623**	**4,295**	**5,166**

Table 7.4 Wahalkada Estimated Project Costs (Stage-1)

Item	Cost in Million		
	FC	LC	Total
	(JPY)	(Rs.)	(JPY)
A. ELIGIBLE PORTION			
Ⅰ) Procurement / Construction	3,489	5,868	6,963
Ⅱ) Consulting Services	175	298	352
Sub-total (Ⅰ+Ⅱ)	3,664	6,166	7,315
B. NON ELIGIBLE PORTION			
a. Procurement/ Construction	14	122	86
b. Land Acquisition	0	10	6
c. Administration cost	0	1,126	667
d. VAT	0	1,501	889
e. Import Tax	0	1,598	946
Sub-total (a+b+c+d+e)	14	4,358	2,594
TOTAL (A+B)	3,679	10,524	9,909
C. INTEREST DURING CONSTRUCTION	320	0	320
D. COMITTMENT CHARGE	61	0	61
GRAND TOTAL (A+B+C+D)	4,060	10,524	10,290
E. JICA FINANCE PORTION INCLD. IDC (A + C + D)	**4,045**	**6,166**	**7,696**

Note: The Project cost will be discussed and finalised in the Appraisal of Wahalkada Scheme.

Table 7.5 Mahakanadarawa Disbursement Schedule (Stage-1)

Annual Fund Requirement

Base Year for Cost Estimation:	Oct, 2012			FC & Total: JPY million	
Exchange Rates	Rs. = Yen	0.592		LC	: Rs. million
Price Escalation:	FC: 2.1%	LC:	4.0%		
Physical Contingency	5%				
Physical Contingency for Consultant	5%				

Item	Total			2012			2013			2014			2015			2016			2017			2018			2019		
	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total
A. ELIGIBLE PORTION																											
Ⅰ) Procurement / Construction	1,951	3,990	4,314	0	0	0	0	0	0	0	0	0	271	316	458	737	1,590	1,678	752	1,654	1,731	192	430	446	0	0	0
1. Intake,WTP,Elevated Tanks and Grand	708	1,697	1,712	0	0	0	0	0	0	0	0	0	71	170	171	283	679	685	283	679	685	71	170	171	0	0	0
2. Transmission and Distribution Main	944	540	1,263	0	0	0	0	0	0	0	0	0	172	98	230	343	196	459	343	196	459	86	49	115	0	0	0
3. Distribution Sub System	43	829	534	0	0	0	0	0	0	0	0	0	0	0	0	19	369	237	19	369	237	5	92	59	0	0	0
4. O&M Equipment	0	115	68	0	0	0	0	0	0	0	0	0	0	0	0	0	51	30	0	51	30	0	13	8	0	0	0
Base cost for JICA financing	1,695	3,181	3,578	0	0	0	0	0	0	0	0	0	242	268	401	645	1,295	1,412	645	1,295	1,412	161	324	353	0	0	0
Price escalation	164	620	531	0	0	0	0	0	0	0	0	0	16	33	35	56	220	186	71	280	237	21	86	72	0	0	0
Physical contingency	93	190	205	0	0	0	0	0	0	0	0	0	13	15	22	35	76	80	36	79	82	9	20	21	0	0	0
Ⅱ) Consulting services	378	305	559	0	0	0	25	15	33	163	91	217	33	35	54	57	61	93	66	73	109	31	29	48	4	1	4
Base cost	337	253	487	0	0	0	23	14	31	149	80	196	30	29	47	50	50	79	56	57	90	26	22	39	3	1	4
Price escalation	23	38	45	0	0	0	0	1	1	6	7	10	2	4	4	4	8	9	6	12	14	3	6	7	0	0	1
Physical contingency	18	15	27	0	0	0	1	1	2	8	4	10	2	2	3	3	3	4	3	3	5	1	1	2	0	0	0
Total (Ⅰ + Ⅱ)	2,330	4,295	4,872	0	0	0	25	15	33	163	91	217	304	351	512	793	1,652	1,771	818	1,727	1,840	223	459	495	4	1	4
B. NON ELIGIBLE PORTION																											
a Installation of Distribution Sub, Service Connection	12	97	69	0	0	0	0	0	0	0	0	0	0	0	0	5	42	30	5	44	31	1	11	8	0	0	0
Base cost	10	77	56	0	0	0	0	0	0	0	0	0	0	0	0	4	34	25	4	34	25	1	9	6	0	0	0
Price escalation	1	16	10	0	0	0	0	0	0	0	0	0	0	0	0	0	6	4	0	7	5	0	2	1	0	0	0
Physical contingency	1	5	3	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	2	1	0	1	0	0	0	0
b Land Acquisition	0	19	11	0	0	0	0	4	2	0	4	2	0	4	2	0	4	3	0	3	2	0	0	0	0	0	0
Base cost	0	16	10	0	0	0	0	4	2	0	4	2	0	4	2	0	4	2	0	2	1	0	0	0	0	0	0
Price escalation	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0
Physical contingency	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
c Administration cost	0	753	446	0	0	0	0	5	3	0	33	20	0	78	46	0	274	162	0	285	169	0	76	45	0	1	0
d VAT	0	1,004	594	0	0	0	0	7	4	0	44	26	0	104	62	0	366	216	0	380	225	0	102	60	0	1	1
e Import Tax	0	895	530	0	0	0	0	0	0	0	0	0	0	124	73	0	338	200	0	345	204	0	88	52	0	0	0
Total (a+b+c+d+e)	12	2,769	1,651	0	0	0	0	17	10	0	82	48	0	310	184	5	1,025	612	5	1,057	631	1	278	166	0	2	1
TOTAL (A+B)	2,341	7,064	6,523	0	0	0	25	31	43	163	173	265	304	661	695	798	2,676	2,383	823	2,783	2,471	224	737	661	4	3	5
C. Interest during Construction	253	0	253	0	0	0	0	0	0	0	0	0	10	0	10	36	0	36	62	0	62	70	0	70	74	0	74
Interest during Construction(Const.)	252	0	252	0	0	0	0	0	0	0	0	0	10	0	10	36	0	36	62	0	62	70	0	70	73	0	73
Interest during Construction (Consul.)	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
D. Commitment Charge	41	0	41	0	0	0	6	0	6	6	0	6	6	0	6	6	0	6	6	0	6	5	0	5	5	0	5
GRAND TOTAL (A+B+C+D)	2,635	7,064	6,817	0	0	0	31	31	49	169	173	272	321	661	712	841	2,676	2,425	891	2,783	2,539	300	737	736	83	3	85
E. JICA finance portion incl. IDC (A + C + D	2,623	4,295	5,166	0	0	0	31	15	40	169	91	223	321	351	528	835	1,652	1,813	886	1,727	1,908	298	459	570	83	1	84

Administration Cost = 9%
VAT= 12% of the expenditure in local currency of the eligible portion
Import Tax= 27%

Table 7.6 Wahalkada Disbursement Schedule (Stage-1)

Annual Fund Requirement

Base Year for Cost Estimation: Oct, 2012 FC & Total: JPY million
Exchange Rates Rs. = Yen 0.592 LC : Rs. million
Price Escalation: FC: 2.1% LC: 4.0%
Physical Contingency 5%
Physical Contingency for Consultant 5%

Item	Total			2012			2013			2014			2015			2016			2017			2018			2019		
	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total
A. ELIGIBLE PORTION																												
I) Procurement / Construction	3,489	5,868	6,963	0	0	0	0	0	0	0	0	0	417	424	669	1,063	1,825	2,144	1,085	1,938	2,233	923	1,680	1,918	0	0	0
1. Intake,WTP,Elevated Tanks and Grand	1,033	2,549	2,543	0	0	0	0	0	0	0	0	0	84	207	206	335	827	825	335	827	825	279	689	687	0	0	0
2. Transmission and Distribution Main	1,931	1,018	2,534	0	0	0	0	0	0	0	0	0	290	153	380	579	305	760	579	305	760	483	254	633	0	0	0
3. Distribution Sub System	48	940	604	0	0	0	0	0	0	0	0	0	0	0	0	17	332	213	17	332	213	14	276	178	0	0	0
4. O&M Equipment	0	121	72	0	0	0	0	0	0	0	0	0	0	0	0	0	22	13	0	54	32	0	45	27	0	0	0
Base cost for JICA financing	3,013	4,627	5,753	0	0	0	0	0	0	0	0	0	374	359	586	932	1,486	1,811	932	1,517	1,830	776	1,265	1,525	0	0	0
Price escalation	310	962	879	0	0	0	0	0	0	0	0	0	24	45	51	81	252	230	102	329	297	103	336	302	0	0	0
Physical contingency	166	279	332	0	0	0	0	0	0	0	0	0	20	20	32	51	87	102	52	92	106	44	80	91	0	0	0
II) Consulting services	175	298	352	0	0	0	0	0	0	0	0	0	9	33	29	28	70	69	33	84	83	101	110	166	4	1	5
Base cost	149	234	288	0	0	0	0	0	0	0	0	0	8	28	25	24	57	58	28	66	67	85	83	134	3	1	4
Price escalation	18	50	47	0	0	0	0	0	0	0	0	0	1	3	3	2	10	8	3	14	12	11	22	24	0	0	1
Physical contingency	8	14	17	0	0	0	0	0	0	0	0	0	0	2	1	1	3	3	2	4	4	5	5	8	0	0	0
Total (I + II)	3,664	6,166	7,315	0	0	0	0	0	0	0	0	0	427	457	697	1,091	1,895	2,213	1,118	2,023	2,316	1,025	1,790	2,084	4	1	5
B. NON ELIGIBLE PORTION																												
a Installation of Distribution Sub, Service Connection	14	122	86	0	0	0	0	0	0	0	0	0	0	0	0	5	41	29	5	43	30	4	37	26	0	0	0
Base cost	12	95	69	0	0	0	0	0	0	0	0	0	0	0	0	4	34	24	4	34	24	4	28	20	0	0	0
Price escalation	1	20	13	0	0	0	0	0	0	0	0	0	0	0	0	0	6	4	0	7	5	0	7	5	0	0	0
Physical contingency	1	6	4	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	2	1	0	2	1	0	0	0
b Land Acquisition	0	10	6	0	0	0	0	0	0	0	0	0	0	0	0	0	6	4	0	4	3	0	0	0	0	0	0
Base cost	0	8	5	0	0	0	0	0	0	0	0	0	0	0	0	0	5	3	0	3	2	0	0	0	0	0	0
Price escalation	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0
Physical contingency	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
c Administration cost	0	1,126	667	0	0	0	0	0	0	0	0	0	0	106	63	0	341	202	0	357	211	0	321	190	0	1	0
d VAT	0	1,501	889	0	0	0	0	0	0	0	0	0	0	141	84	0	455	269	0	476	282	0	428	253	0	1	1
e Import Tax	0	1,598	946	0	0	0	0	0	0	0	0	0	0	190	113	0	487	288	0	497	294	0	423	250	0	0	0
Total (a+b+c+d+e)	14	4,358	2,594	0	0	0	0	0	0	0	0	0	0	438	259	5	1,331	793	5	1,378	821	4	1,209	720	0	2	1
TOTAL (A+B)	3,679	10,524	9,909	0	0	0	0	0	0	0	0	0	427	895	956	1,096	3,226	3,006	1,123	3,400	3,136	1,029	2,999	2,805	4	3	6
C. Interest during Construction	320	0	320	0	0	0	0	0	0	0	0	0	9	0	9	40	0	40	71	0	71	99	0	99	101	0	101
Interest during Construction(Const.)	320	0	320	0	0	0	0	0	0	0	0	0	9	0	9	40	0	40	71	0	71	99	0	99	101	0	101
Interest during Construction (Consul.)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
D. Commitment Charge	61	0	61	0	0	0	9	0	9	9	0	9	9	0	9	9	0	9	9	0	9	8	0	8	8	0	8
GRAND TOTAL (A+B+C+D)	4,060	10,524	10,290	0	0	0	9	0	9	9	0	9	445	895	975	1,144	3,226	3,054	1,204	3,400	3,217	1,136	2,999	2,911	112	3	114
E. JICA finance portion incl. IDC (A + C + D	4,045	6,166	7,696	0	0	0	9	0	9	9	0	9	445	457	716	1,139	1,895	2,261	1,199	2,023	2,396	1,132	1,790	2,191	112	1	113

Administration Cost = 9%
VAT= 12% of the expenditure in local currency of the eligible portion
Import Tax= 27%

Note: The Project cost will be discussed and finalised in the Appraisal of Wahalkada Scheme.

7.4.1 Eligible Cost

(1) Construction Cost

The summary of construction cost is tabulated as shown in **Table 7.7.**

Table 7.7 Construction Cost per Package (Stage-1)

Yen in Million and RS. in Million

Package	Description	FC (JPY)	LC (Rs.)	Total (JPY)
Mahakanadarawa				
1	Intake,WTP,Elevated Tanks and Grand Sumps	708	1,697	1,712
2	Transmission and Distribution Main*	944	540	1,263
3	Distribution Sub System	43	829	534
4	O&M Equipment	0	115	68
	Price escalation	164	620	531
	Physical contingency	93	190	205
	Total	**1,951**	**3,990**	**4,314**
Wahalkada				
1	Intake,WTP,Elevated Tanks and Grand Sumps	1,033	2,549	2,543
2	Transmission and Distribution Main*	1,931	1,018	2,534
3	Distribution Sub System	48	940	604
4	O&M Equipment	0	121	72
	Price escalation	310	962	879
	Physical contingency	166	279	332
	Total	**3,489**	**5,868**	**6,963**

Note: The cost of Wahalkada Scheme will be discussed and finalised in the Appraisal.

(2) Water Bowsers and Tanks in Isolated Area

To supply water to the isolated area defined and explained in Chapter 5 previously, water bowsers and elevated water tanks are proposed in this project. This portion is very critical component to fulfil this project mission of distributing the quality and safe water to people in the Anuradhapura North area. The total estimated cost for supplying water to isolated areas using water bowsers and tanks in this project is approximately Rs. 180.7 million. The water tanks and water bowsers are included as a part of the following packages:

Mahakanadarawa

- 5 m^3 Elevated Water Tanks , Rs. 25 million in Package 3
- 5 m^3 Water Bowsers, Rs. 57.24 million in “Vehicles” of Package 4

Wahalkada

- 5 m^3 Elevated Water Tanks, Rs. 28.5 million included in Package 3:
- 5 m^3 Water Bowsers, Rs. 69.96 million included in "Vehicles" of Package 4

In consideration of cost effectiveness and procurement schedule, the activity is recommended not to be divided into Mahakanadarawa and Wahalkada to keep a flow of activities simple and smooth.

A summary table of the water bowsers and elevated water tank is as shown in **Table 7.8**.

Table 7.8 Cost for Water Bowsers and Water Elevated Tanks in the Isolated Area

Station	5m^3 Water Tank		5m^3 Water Bowser	
	ea	Cost (Rs. Million)	ea	Cost (Rs. Million)
Mahakadarawa				
Medewachchiya	15		3	
Rembewa	35		6	
Sub-total	50	25	9	57.24
Wahalkada				
Bogohawewa	16		3	
Weelasol	6		1	
West Horowpothana	8		2	
Kahatasdigiliya	28		5	
Sub-total	57	28.5	11	69.96
Total	168	53.5	20	127.2
Ground Total (Water Tank + Water Bowser)				180.7

(3) Consulting Services

The consulting services include 1) detailed designs, 2) tender process assistance, 3) construction supervision, 4) facilitation of implementation of Environmental Management Plan (EMP), Environmental Monitoring Plan (EMoP) and Resettlement Action Plan (RAPEMP), 5) technology transfer on construction supervision of proposed water supply facilities, 6) training for capacity development of NWSDB's staff, and 7) guidance for public awareness campaign of Anuradhapura North Integrated Water Supply Project. This will consist of both international and local professionals and local supportive and administrative staffs to fulfill the project tasks. The foreign professionals are necessary to be a part of the project to share their expertise and knowledge with the local professionals. The local professional and supportive and administrative staff will be able to contribute more efficient process to the project since the local staff are much more familiar with the local procedures and regulations by utilizing existing

networks with government and local authorities.
The detailed engineering design consists of water intake, water treatment plants, transmission pipe lines, distribution pipe mains, distributions sub-mains, ground reservoirs, elevated water tanks, and all other related works including road and pipe water bridges in Mahakanadarawa and Wahalkada areas. In addition, it will include preparation of detailed technical specification and tender document, construction supervision, and technology transfer on construction supervision during the construction for all packages mentioned in other sections.

During preparation of the tender document, the following matters relating to the construction activities shall be addressed: 1) sorting demolishing and recycling materials onsite or offsite, 2) monitoring and controlling runoff from the construction activities, 3) monitoring and controlling noise and vibration from the construction activities, 4) providing safe environment for workers to work and neighbors to live, including not limited to, providing safety tools and proper barriers for encompassing the construction site. Therefore, the cost associated with these activities will be properly included to bidding costs prepared by contractors.

The consulting services for facilitation of implementation of EMP, EMoP, and RAP consists of updating the EMP, assisting to identify the environmental responsibilities in the preparation of bidding documents, updating RAP as necessary, assessing the social impacts and prepare social development plans to address the identified impacts, monitor land acquisition and compensation activities being undertaken by NWSDB and other authorities by preparing monthly progress reports, supervising EMP implementation and monitoring works to ensure in accordance with the EMP, and assisting NWSDB in the capacity building of NWSDB staff on environmental management through trainings.

The consulting service for capacity building and development consists of conceptualizing and developing the training plans for NWSDB RSC (NC) and conducting the actual training based on the organized plans.

The consulting service for public awareness campaign consists of informing and educating the general public of the present situation of health damage in the project area caused by the use of groundwater, the objectives of the proposed project, the importance of connection to a proposed water supply system under the project and payment of water tariff for sustainable operation and management of water supply facilities through collecting data, analyzing the data, preparing reports and conducting seminars and public campaigns.

A total cost estimation of all consulting services mentioned above as follows:

1) Mahakanadarawa: 559 million yen
(Foreign portion: 378 million yen, Local portion: Rs. 305 million)
2) Wahalkada: 352 million yen (Will be discussed and finalised in the Appraisal.)

(Foreign portion: 175 million yen, Local portion: Rs. 298 million)

This total consulting service cost includes as follows:

1) Mahakanadarawa: 396 man-months of foreign and local experts
760 man-months of additional supporting staffs

2) Wahalkada: 260 man-months of foreign and local expert
674 man-months of additional supporting staffs.

The expected cost items of the consulting services are shown in **Table 7.9** for the Detailed Design Consultant Services and Project Management Services.

Table 7.9 Mahakanadarawa Estimated Cost for Consulting Services (Stage-1)

USD 1 = JPY 78.2 Rs. 1 = JPY 0.592

			Unit	Qty.	Foreign Portion (JPY '000))		Local Portion (Rs. '000)		Combined Total (JPY '000))
					Rate	Amount	Rate	Amount	
A	Remuneration								
	1	Professional (A)	M/M	85	2,562,000	217,770		0	217,770
	2	Professional (B)	M/M	311		0	350,000	108,850	64,439
	3	Supporting Staffs	M/M	760		0	93,026	70,700	41,854
		Subtotal of A				217,770		179,550	324,064
B	Direct Cost								
	1	International Airfare-1		13	350,000	4,550			4,550
	2	International Airfare-2		29		0	250,000	7,250	4,292
	3	Domestic Travel		0	5,000	0		0	0
	4	Accom. Allowance_A-1	Month	42	300,000	12,600		0	12,600
		Accom. Allowance_A-2	Month	43	150,000	6,450		0	6,450
		Travelling Allowance_B	Month	0		0	10,000	0	0
	5	Vehicle Rental	Month	300		0	200,000	60,000	35,520
	6	Office Rental	M/M	20		0	300,000	6,000	3,552
	7	International Communications	M/M	70	50,000	3,500		0	3,500
	8	Domestic Communications	M/M	70	10,000	700		0	700
	9	Office Supply	M/M	70	100,000	7,000		0	7,000
	10	Office Furniture and Equip	LS	1	2,220,000	2,220		0	2,220
	11	Report Preparation	LS	0	370,000	0		0	0
	12	Topographic Survey	LS	1	21,312,000	21,312		0	21,312
	13	Geographic Survey	LS	1	3,700,000	3,700		0	3,700
	14	Water Quality Survey	LS	1	222,000	222		0	222
	15	Supply of software w/ license	LS	1	10,000,000	10,000		0	10,000
	16	Provisional Sum	LS	1	20,000,000	40,000		0	40,000
	17	Home Office Support	M/M	70	100,000	7,000		0	7,000
		Subtotal of B				119,254		73,250	162,618
		Grand Total				**337,024**		**252,800**	**486,682**

Table 7.10 Wahalkada Estimated Cost for Consulting Services (Stage-2)

USD 1 = JPY 78.2 Rs. 1 = JPY 0.592

			Unit	Qty.	Foreign Portion (JPY '000))		Local Portion (Rs. '000)		Combined Total (JPY '000))
					Rate	Amount	Rate	Amount	
A	Remuneration								
	1	Professional (A)	M/M	27	2,562,000	69,174		0	69,174
	2	Professional (B)	M/M	233		0	350,000	81,550	48,278
	3	Supporting Staffs	M/M	674		0	94,214	63,500	37,592
		Subtotal of A				69,174		145,050	155,044
B	Direct Cost								
	1	International Airfare-1		1	350,000	350			350
	2	International Airfare-2		7		0	250,000	1,750	1,036
	3	Domestic Travel		0	5,000	0		0	0
	4	Accom. Allowance_A-1	Month	8	300,000	2,400		0	2,400
		Accom. Allowance_A-2	Month	19	150,000	2,850		0	2,850
		Travelling Allowance_B	Month	0			10,000	0	0
	5	Vehicle Rental	Month			0		0	0
	6	Office Rental	M/M	437			200,000	87,400	51,741
	7	International Communications	M/M	0			300,000	0	0
	8	Domestic Communications	M/M	42	50,000	2,100		0	2,100
	9	Office Supply	M/M	42	10,000	420		0	420
	10	Office Furniture and Equip	LS	42	100,000	4,200		0	4,200
	11	Report Preparation	LS	0	3,780,000	0		0	0
	12	Topographic Survey	LS	1	36,288,000	36,288		0	36,288
	13	Geographic Survey	LS	1	6,300,000	6,300		0	6,300
	14	Water Quality Survey	LS	1	378,000	378		0	378
	15	Provisional Sum	LS	1	20,000,000	20,000		0	20,000
	16	Home Office Support	M/M	42	100,000	4,200		0	4,200
		Subtotal of B				80,116		89,150	132,893
		Grand Total				**149,290**		**234,200**	**287,936**

Note: The cost of Wahalkada Scheme will be discussed and finalised in the Appraisal.

7.4.2 Non-Eligible Cost

(1) Land Acquisition

Land acquisition for the proposed water facilities of this project is situated on two different types of lands, private and public lands. Each type of land has a different process to acquire for proposed water facilities uses and explained more details in Chapter 9. The private land is required to be purchased with the acquisition process set forth by Sri Lanka Land Acquisition Act 1950, No. 9. Since public land in Sri Lanka is known as "common" land for common benefits, the process and condition are different from that for the private land. Generally, public land (common land) is allowed to be leased from Sri Lanka Government with annual fee after successful completing the leasing process overseen by multiple Sri Lanka governmental departments according to Assessment Department in NWSDB Anuradhapura office. The total estimated cost for land acquisition with this project is approximately Rs. 25 Million (Mahakanadarawa = Rs. 16.47 Million, Wahalkada = Rs. 8.4 Million). The activities associated with Land Acquisition will be started when the Mahakanadarawa portion of the project starts. In consideration of cost effectiveness and schedule, the activity is recommended not to be divided into Mahakanadarawa and Wahalkada to keep a flow of activities simple and smooth. The cost associated with Land Acquisition is included only to Mahakanadarawa.

A summary table of the proposed water facilities, which require land acquisition is as shown in **Table 7.11**.

Table 7.11 Estimated Cost for Proposed Land Acquisition/ Resettlement

Land Type	Estimated Area	Land Acquisition Type	Estimated Cost
	Ac		(Rs. Million)
Mahakanadarawa 1. Land Acquisition			
Public	13.0	Lease	5.2
Private	2.2	Purchase	7.3
NWSDB	0.0	Lease	0.0
Su`b-Total	15.2		12.5
2. Resettlement (moving from the Mahakanadarawa WTP proposed property to private land)			
Private	0.02	Purchase	0.07
Resettlement (including new house, utilities connections, moving cost, and rental allowance)			3.9
Sub-Total	0.02		3.97
Total (Maha)	**15.22**		**16.47**
Wahalkada 1. Land Acquisition			
Public	17.0	Lease	6.8
Private	0.0	Purchase	0.0
NWSDB	4.0	Lease	1.6
Total (Waha)	**21.0**		**8.4**

Notes: In Sri Lanka, land value is evaluated by Valuation Department in each Regional Office and the process will take place after the commencement of the project.

(2) Distribution Sub System (PVC 50 mm) and Service Connections

Installation of Distribution Sub System (PVC 50 mm) and Service Connections from closest distribution sub main pipes to water meters for residential houses are a part of the NWSDB funds as non-eligible portion of this project. The installation of the PVCs with a diameter smaller than or equivalent to 50 mmm in the Distribution Sub System and both the installation and supply of Service Connections are subjected to be covered by NWSDB funds.

Table 7.12 Distribution Sub System and Service Connections

	FC (JPY Million)	LC (Rs. Million)	FC (JPY Million)
Mahakanadarawa			
Base Cost	10	77	56
Price Escalation	1	16	10
Physical Contingency	1	5	3
Total	**12**	**97**	**69**
Wahalkada			
Base Cost	12	95	69
Price Escalation	1	20	13
Physical Contingency	1	6	4
Total	**14**	**122**	**86**

7.5 Operation and Maintenance Cost

(1) Current Operation and Maintenance

In 2011, NWSDB (NC) produced 18.74 million m^3 of drinking water in the North Central Province (Anuradhapura and Polonnaruwa Districts). The operating expenses were categorized into 1) salary, 2) utility, 3) chemical, 4) extension/new connection, 5) repair/maintenance, 6) establishment, 7) security/rent. The annual operating expenses in 2011 are summarized in the following table.

The same cost information is available for Thuruwila Water treatment plant. The plant where applies rapid sand filtration process and produced 5.35 million m^3 of drinking water in 2011.

Table 7.13 Operation and Maintenance NWSDB (NC) and Thuruwila WTP in 2011

Description	NWSDB RSC(N/C) (Production: 18,740,000 m3/yr)			Thuruwila WTP (Production: 5,350,000 m3/yr)		
	Expense (Rs./yr))	Unit Cost (Rs./m3)	Ratio	Expense (Rs./yr))	Unit Cost (Rs./m3)	Ratio
Perm/Casual Salarie	122,687,437	6.55	28.28%	2,035,099	0.38	6.18%
Ove rtime	26,306,862	1.4	6.06%	518,663	0.1	1.57%
Others	19,445,789	1.04	4.48%	279,890	0.05	0.85%
EPF.ETF	18,171,642	0.97	4.19%	300,090	0.06	0.91%
Medical Expences	1,098,373	0.06	0.25%	4,553	0	0.01%
Total Salary Cost	**187,710,103**	**10.02**	**43.27%**	**3,138.30**	**0.59**	**9.53%**
Utilities,Electricity	87,579,809	4.67	20.19%	17,309,342	3.24	52.54%
Others	1,492,477	0.08	0.34%	1,102,350	0.21	3.35%
Total Utility Cost	**89,072,286**	**4.75**	**20.53%**	**18,411,692**	**3.44**	**55.88%**
Chemical chlorine	11,440,053	0.61	2.64%	2,175,000	0.41	6.60%
Alum, Lime	13,970,050	0.75	3.22%	5,891,367	1.1	17.88%
Bleaching Powder	1,070,449	0.06	0.25%	11,908	0	0.04%
Other Chemicals	675,891	0.04	0.16%	389,886	0.07	1.18%
Total Chemical Cost	**27,156,443**	**1.45**	**6.26%**	**8,468,161**	**1.58**	**25.70%**
Extension Cost	9,700,760	0.52	2.24%	0	0	0.00%
New Connection Materi	16,079,677	0.86	3.71%	0	0	0.00%
Defective Metre Cost	6,430,914	0.34	1.48%	0	0	0.00%
Others	196,865	0.01	0.05%	0	0	0.00%
Total Cost	**32,408,216**	**1.73**	**7.47%**	**0**	**0**	**0.00%**
Repair & Maintanance	31,068,927	1.66	7.16%	499,404	0.09	1.52%
Total Cost	**31,068,927**	**1.66**	**7.16%**	**499.404**	**0.09**	**1.52%**
Establishment.Printi	1,944,599	0.1	0.45%	1,353	0	0.00%
Subsistence	3,671,557	0.2	0.85%	112,807	0.02	0.34%
Vehicle Running	7,439,021	0.4	1.71%	17,590	0	0.05%
Telephone etc.	4,603,491	0.25	1.06%	89,692	0.02	0.27%
Total Estabilishment Cost	**17,658,668**	**0.94**	**4.07%**	**221.442**	**0.04**	**0.67%**
Security.Rent etc.	35,151,859	1.88	3.10%	2,208,230	0.41	6.70%
Fianance Charges	13,559,260	0.72	3.13%	0	0	0.00%
Total Other Cost	48,711,119	2.6	11.23%	2,208.23	0.41	6.70%
Total Operating Expenses	**433,785,762**	**23.15**	**100.00%**	**32,947,224**	**6.16**	**100.00%**

The cost of operation and maintenance were obtained from the above data.

Table 7.14 Electricity and Chemical Consumption per Cubic Meter

O&M Cost (Rs/m^3)	NWSDB (NC) All Water Supply System	Water Treatment Plant
Electricity	4.67	3.24
Chemical - Chlorine	0,61	0.41
Chemical - Alum, Lime	0.75	1.10
Repair & Maintenance	1.66	0.09

(2) Salary Cost

As described in Chapter 6, new organization is proposed for management, operation and maintenance of proposed water supply system.

Table 7.15 Salary of Staff required for the Proposed Water Supply System

Mahakanadarawa				Wahalkada			
Location	No.	Basic Salary	Allowance	Location	No.	Basic Salary	Allowance
Mahakanadarawa	10	225,733	52,000	Wah alkada	10	223,995	52,000
Rambewa	10	149,106	52,000	Kahatagasdigiliya	10	180,644	46,800
Area Engineer's office	10	121,044	26,000	Kebithigollewa	10	159,800	41,600
Medawachchiya	10	119,850	31,200			564,439	140,400
Su b-Total	**40**	**615,733**	**161,200**	**Sub-Total**			**30**
Total Monthly Salary			**776,933**	**Total Monthly Salary**			**704,839**
Overtime			197,984	Overtime			179,613
Others			106,856	Others			96,941
EPR/ETF			114,568	EPR/ETF			103,937
Total Monthly Salary Cost			**1,196,342**	**Total Monthly Salary Cost**			**1,085,329**
Total Annual Salary Cost			**14,356,100**	**Total Annual Salary Cost**			**13,023,953**

Note: The above number of staff shall be assigned for the operation and maintenance of the systems. The salary cost shall be fixed cost.

(3) Electricity

Electricity is a variable cost related to the volume of water for production/distribution.

Table 7.16 Electricity Consumption for the Proposed Water Supply System

O&M Cost (Rs/m^3)		Mahakanadarawa	Wahalkada
Daily Average Water Consumption (m^3/d)	Stage 1	7,500	11,400
	Stage 2	14,900	22,900
Electricity (million Rs/year)	Stage 1	28.84	69.73
	Stage 2	72,24	149.62
Electricity (Rs/m^3)	Stage 1	10.54	16.76
	Stage 2	13.32	17.90

The above electricity (Rs/m3) is calculated for each water supply system and at each stage. Electricity consumption per cubic meter of water for Wahalkada System is higher than that for Mahakanadarawa, because Wahalkada WTP is located at a lower elevation.

(4) Chemicals

Chemical cost is variable cost relating to volume of water for production/distribution.

Table 7.17 Chemical Consumption for the Proposed Water Supply System

O&M Cost (Rs/m3)	Mahakanadarawa/ Wahalkada
Chemical - Chlorine	0,61
Chemical - Alum, Lime	1.10

Cost of chlorine consumption is applied in "All Water Supply System in NWSDB (NC)" in the above **Table 7.13** Electricity and **Table 7.14** Chemical Consumption per Cubic Meter. It can be the typical cost for chlorine consumption in the water distribution system, while cost of

(5) Repair and Maintenance Cost

The average repair and maintenance cost per cubic meter in NWSDB (NC) is Rs1.66/m^3. However, more intensive maintenance, including preventive maintenance is required. Therefore the repair and maintenance cost will be roughly doubled.

Table 7.18 Repair and Maintenance Cost for the Proposed Water Supply System

O&M Cost (Rs/m3)	Mahakanadarawa/ Wahalkada
Repair & Maintenance	3.00

(6) Operation and Maintenance Cost

The following table summarizes the operation and maintenance cost.

Table 7.19 Operation and Maintenance Cost for the Proposed Water Supply System

O&M Cost (Rs/m^3)		Mahakanadarawa		Wahalkada	
		Stage 1	Stage 2	Stage1	Stage 2
Water Consumption	m^3/d	7,500	14,900	11,400	22,900
Salary	Rs/year	14,356,100		13,023,953	
Electricity	Rs/m^3	10.54	13.32	16.76	17.90
Chemical - Chlorine	Rs/m^3	0,61		0,61	
Chemical - Alum, Lime	Rs/m^3	1.10		1.10	
Repair & Maintenance	Rs/m^3	3.00		3.00	

CHAPTER 8

PROJECT IMPLEMENTATION

CHAPTER 8 IMPLEMENTATION PLAN

8.1 Project Implementation Schedule

The expected overall schedule is shown in **Figure 8.1** for pre-construction and construction stages.

Two JICA Loan Packages will be applied for this Project. One package consists of the detailed design of both Mahakanadarawa and Wahalkada Water Supply Systems and construction of Mahakanadarawa Water Supply System. The other package consists of the construction of Wahalkada Water Supply System.

Table 8.1 Proposed Project Implementation Schedule

Description	Schedule
Pledge of JICA Loan	December 2012
Exchange of Notes between GOB and GOJ	March 2013
Signing of Loan Agreement (Mahakaanadarawa Stage-1)	March 2013
Signing of Loan Agreement (Wahalkada Stage-1)	N/A
Selection of consultant for Designing & Construction Supervision	8 months
Detailed Engineering Design, Preparation of specifications	10 months
Contractor Prequalification (P/Q), evaluation and JICA concurrence	7 months
Tender documents for individual project components, JICA concurrence on tender documents	2 months
Project Tender period	2 months
Evaluation of tender proposals	2 months
JICA concurrence on tender evaluation (Contractor proposals)	1 month
Contract negotiation	1.5 months
JICA concurrence on contract award	0.5 month
L/C Issuance for project	1 month
Total period of Construction Work (Mahakanadarawa)	33 months
Completion of the Project and Plant trails (Mahakanadarawa)	March 2018
Total period of Construction Work (Wahalkada)	36 months
Completion of the Project and Plant trails (Wahalkada)	October 2018*1
O&M Training	4 months (December 2017 to March 2018)

Note: *1 Implementation schedule will be discussed and finalised in the Appraisal of Wahalkada Scheme.

Implementation of the Project will consist of the six major processes:

1) Preparation of finances
2) Selection of the consultant for detailed design and construction supervision
3) Preparation of tender documents and detailed design
4) Tender of build-operate contractors/consortiums
5) Construction and commissioning
6) Supervision of O&M activities for the initial year by consultant (advisory role)

	2012	2013	2014	2015	2016	2017	2018	2019	Week
Appraisal	0	0	0	0	0	0	0	0	0
Pledge	1	0	0	0	0	0	0	0	1
Signing of Loan Agreement	0	1	0	0	0	0	0	0	1
Selection of Consultants (by QCBS Se	2012	2013	2014	2015	2016	2017	2018	2019	Month
Preparation of RFP & Short-list, and Approval by SCAPC	1	1	0	0	0	0	0	0	2
JICA Concurrence for RFP & Short-list	0	1	0	0	0	0	0	0	1
Issuance of RFP to Short-listed Consultants	0	1	0	0	0	0	0	0	1
Proposal Submission by Consultants	0	2	0	0	0	0	0	0	2
Evaluation of Technical proposals, Approval by SCAPC	0	3	0	0	0	0	0	0	3
JICA Concurrence for Evaluation of Technical Proposals	0	1	0	0	0	0	0	0	1
Opening Financial Proposals, Evaluation, Approval by SCAPC	0	1	0	0	0	0	0	0	1
JICA Concurrence for Evaluation of Proposals	0	1	0	0	0	0	0	0	1
Contract Negotiation, Approval by SCAPC, Approval by Cabinet	0	2	0	0	0	0	0	0	2
Signing of Contract	0	1	0	0	0	0	0	0	1
JICA Concurrence for Signed Contract	0	1	0	0	0	0	0	0	1
	0	0	0	0	0	0	0	0	0
Engineering and Bidding Period									Month
Detailed Design	0	2	8	0	0	0	0	0	10
Confirmation of DD by NWSDB, TEC, SCAPC	0	0	2	0	0	0	0	0	2
Preparation of PQ Documents, and Approval by SCAPC	0	2	1	0	0	0	0	0	3
JICA Concurrence for PQ Documents (above JPY 1,000 mil)	0	0	1	0	0	0	0	0	1
Issuance of PQ Documents	0	0	1	0	0	0	0	0	1
PQ Submission by Contractors	0	0	1	0	0	0	0	0	1
Evaluation of PQ, Approval by SCAPC	0	0	2	0	0	0	0	0	2
JICA Concurrence for PQ Results	0	0	1	0	0	0	0	0	1
Preparation of Tender Documents, and Approval by SCAPC	0	0	3	0	0	0	0	0	3
Tender Period	0	0	2	1	0	0	0	0	3
Tender Evaluation, and Approval by SCAPC	0	0	0	2	0	0	0	0	2
JICA Concurrence for Tender Evaluation	0	0	0	1	0	0	0	0	1
Approval by Cabinet	0	0	0	1	0	0	0	0	1
Signing of Contract	0	0	0	1	0	0	0	0	1
JICA Concurrence for Signed Contract	0	0	0	1	0	0	0	0	1
Non-Eligible									Month
Land Acquisition Cost	0	12	12	12	12	8	0	0	56
Installation of Distribution Sub System,Service Connections	0	0	0	0	12	12	3	0	27
Eligible									Month
1. Intake,WTP,Elevated Tanks and Grand Sumps	0	0	0	3	12	12	3	0	30
2. Transmission and Distribution Main	0	0	0	6	12	12	3	0	33
3. Distribution Sub System	0	0	0	0	12	12	3	0	27
4. O&M Equipment	0	0	0	0	12	12	3	0	27
Other Activities									Month
Training	0	0	0	0	0	0	3	0	3
Public Awareness Campaign	0	0	0	0	0	1	3	0	4

Figure 8.1 Implementation Schedule

8.2 Contract Package

Construction packaging for the Project is one of the most important factors for the smooth implementation of all the components.

Construction works of water treatment plant will need several kinds of experience and expertise such as civil, structural, mechanical, electrical and instrumentation works. Coordination management among all these types of works will be a critical component. The time invested for such coordination management will affect the timely completion of the project. Mechanical and electrical works will be implemented after the most of the structures have been completed.

Careful arrangement with civil and architectural works will be required for the installation of mechanical and electrical equipment.

From the aspect of construction supervision and management, a project management consultant will be required to substantially review the contractors' work, organize progress meetings, scheduling, factory inspection, issue accomplishment certification, quality control, and preparation of documents for payment.

Under the JICA ODA loan procedures, the contract package shall be concurred by JICA for each stage of the prequalification evaluation, tender evaluation, and contract. In principle, under the JICA ODA loan procedure, tendering shall be done as International Competitive Bidding (ICB).

Proposed contract packages, total eight packages for the JICA ODA loan for the Project, which are shown in **Table 8.2**. The construction periods of packages are assumed and summarised as follows, considering the size of the project and work volume and workability.

Table 8.2 Proposed Contract Packages for Mahakanadarawa Project

Package	Components	Cost (million Yen)	Period (month)	Procurement
Package 1	Intake, WTP, Ground Sumps and Elevated Tanks	1,712	30	ICB
Package 2	Transmission/Distribution Mains	1,263	33	ICB
Package 3	Distribution Sub-System	534	27	LCB
Package 4	O&M Goods	68	12	LCB
Package 5	Installation of Distribution Sub-System and HouseConnections	56	27	-

Table 8.3 Proposed Contract Packages for Wahalkada Project

Package	Components	Cost (million Yen)	Period (month)	Procurement
Package 1	Intake, WTP, Ground Sumps and Elevated Tanks	2,543	37	ICB
Package 2	Transmission/Distribution Mains	2,534	40	ICB
Package 3	Distribution Sub-System	604	34	LCB
Package 4	O&M Goods	72	19	LCB
Package 5	Installation of Distribution Sub-System and HouseConnections	69	34	-

ICB (International Competitive Bidding) packages are selected with consideration of level of required technology/engineering, sizes of the packages etc. which the local contractors have limited experiences in the contents of the works, and less technical and financial capacities. In this aspect, Package 1 consists of all civil, architectural, mechanical and electrical works in

Intake Station, Water Treatment Plant, Ground Sumps and Elevated Tanks. The package requires higher technology/engineering for complicated structures and good coordination between different types of works. Package 2 needs experiences of long HDPE pipeline installations. HDPE with large diameter such as 450mm is still new for Sri Lankan Contractors and total length of over 250km.

However the rest of the packages are procured by LCB (Local Competitive Bidding) for the local contractors to provide business opportunities. Especially Package 3 consists of 1) 3-1: PVC 100-200mm supply and installation, 2) 3-2: PVC 50-75mm supply 3) 3-3: PVC 50-75mm installation etc. Pipe length of the Distribution Sub-System, currently proposed is tentative and will be determine by the detailed design.

Installation of PVC 50mm is categorised into Non-Eligible portion which Sri Lanka side will implement. NWSDB and CBO have many experiences through ADB funded project in this project area using community manpower to install small size of pipelines with NWSDB's piping materials and advices/supervision. This practice in the area will accelerate development of the distribution sub-systems.

8.3 Procurement Method

The selection of the consultant will need to be conducted by NWSDB in accordance with the JICA Guidelines and Government Procurement Guidelines – 2006 of Sri Lanka. The selection process of the consultant will have to be initiated as soon as possible, after the commitment for the finance is made by the Japanese side. Preparation of tender documents and detailed design will be carried out by the consultant to be selected and employed by NWSDB.

Conditions applied in the tender documents to select the contractor will also have to meet the requirements in the JICA Guidelines and Government Procurement Guidelines – 2006 of Sri Lanka. JICA normally requires that the procurement of goods and services will be obtained through ICB. Construction will, therefore, be carried out by the contractor/s awarded the contract through the ICB procurement method.

There are two major methods of construction contract based on the design conditions.

(1) Construction as designed

Contractors are issued for the detailed drawings to construct the facilities designed by the Employer and/or consultants. Construction will follow the detailed dimensions and specifications which are stipulated in the tender documents. Liability of the contractor will be limited to quality of the construction work as long as the facilities are built as designed. Preparation of design drawings will take a longer time compared with the design-build method. However, selection of the contractor is smooth and easy due to the evaluation mainly focus on the financial proposals among pre-qualified bidders strictly selected by technical and financial aspects of capacity, reliability, experiences etc.

(2) Design-build concept

Tender documents and drawings stipulate the minimum requirements for construction. Contractors will have flexibility in construction details. However, they are subject to approval by the Employer and/or consultants. As the structural design is normally carried out by the Contractor, time for the preparation of the tender document by the Employer and/or consultants will be shortened. The Contractor should be liable his own design. Preparation of the tender drawings in full details by the Employer and/or consultants will take longer time while introduction of the "design-build (turn-key) concept" will shorten the time for the design stage.

However, with the advantages of the design-build (turn-key) concept, there are several issues need to be considered in the design-build concept. These issues are important for mitigation of the unnecessary time wastage during the construction period to be spent for review and revision of the design submitted by the Contractor.

From the above consideration and JICA's experiences, "Construction as designed" will be applied in this Project.

The construction materials for civil works such as concrete, RC pile, sand, gravel, brick, reinforcement bar, sheet pile can be procured in Sri Lanka by the Contractor as per specifications in tender document. Pipe material such as HDPE is imported from suitable countries through ICB. Construction machinery such as excavator, pile driver, dump truck and bulldozer except a pipe jacking machine can be leased in Sri Lanka. Major mechanical equipment such as pumps, chemical dosing equipment and valves can be imported from suitable countries. Electrical equipment such as control panels, transformer and generator can be imported from suitable countries. While minor items such as cables can be procured in Sri Lanka if the specifications are fulfilled.

As described in the previous section, major packages, Packages 1/2/3/5/6/7 shall apply the ICB procurement method, while simple and small distribution pipe-laying packages 4/8 shall apply the NCB procurement method.

8.4 Consulting Services (TOR)

NWSDB shall procure consultant services for detailed design of Anuradhapura North Integrated Water Supply Project and consultant shall consist of both international and national experts, sub-professionals and supporting staff.

Two JICA Loan Packages will be applied for this Project. The first is for consulting services consisting of the detailed design of both Mahakanadarawa and Wahalkada Water Supply Systems and construction supervision of Mahakanadarawa Water Supply System. The other is for consulting service covering only the construction supervision of Wahalkada Water Supply System.

The consulting services consist of detailed engineering design of the water intake, raw water transmission pipe line, water treatment plants at Mahakanadarawa and Wahalkada, transmission pumping facilities and transmission/distribution pipelines, ground reservoirs, elevated tanks, distribution sub-system for Mahakanadarawa and Wahalkada Systems, including all other related works, such as water pipe bridges and road restoration. The detail design will include preparation of detail technical specification and tender document for the works
NWSDB also shall procure construction supervision services for the management of the Project and the consultant shall consist of both international and national experts, sub-professionals and supporting staff.

There are several issues to be considered in the design stage from both technical and economical points of view as described below:

1) Participation of national consultants

Participation of national consultants is necessary for technology transfer from the international consultants. National consultants will also be able to contribute in making economical designs since they are familiar with local practices for construction works and locally available materials and equipment in Sri Lanka.

2) Approval of detailed design

During the design stage, engineering consultants appointed for the Project should be required to submit sufficient details to the Employer for their design prior to the preparation of the final design and specifications.

3) Process design

Process design will have to be determined considering not only technical aspects of operation but also cost-effective aspects. The treatment method, each treatment unit performance, detailed alignment etc. will have to be determined considering the reliability of the process, total costs for pipelines, structures and equipment as well as operation and maintenance costs.

4) Specifications

Specifications are to be developed by the design consultants to make contractors develop adequate confidence in preparing; costs for construction, equipment and O&M; ease of O&M; availability of services etc. in the design stage to select the best fit the conditions of the Project. Any equipment and machinery as well as material required for construction that is available and best fit condition.

CHAPTER 9

ENVIRONMENTAL AND SOCIAL CONSIDERATION

Chapter 9 ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

9.1 Project Summary

9.1.1 Project Title

The Anuradhapura North Integrated Water Supply Project (ANIWSP).

9.1.2 Project Summary

The project is planned to provide safe drinking water in the northern part of Anuradhapura in Sri Lanka. The current main water source in this area is groundwater and it is usually supplied by small scale piped water supply systems or from individual wells. The groundwater in the area contains a high concentration of hardness and sometime contains a high concentration of fluoride. It is believed that the bad water quality brings about endemic diseases such as fluorosis and CKDs. For this reason, the NWSDB has decided to establish a water supply system in the area using an alternative water source from surface waters.

The planned project will provide a positive impact to the people in the area by improving their living standards. On the other hand, the project might have negative impacts on the natural environment and social conditions. Mahakanadarawa WTP was planned to extract water directly from the tank which is designated as Sanctuary, so this Project was considered as category B.

9.2 General Conditions for Environmental and Social Considerations of the Project Area

9.2.1 Land Use

The project area is a suburban and rural area, which is located in the northern part of Anuradhapura district. The largest land use of project area is covered forest, followed by covered scrub. Cultivated land is mainly paddy fields. The area occupied by tanks is relatively high and there are a large number of tanks, as the area is dry. Irrigation using water from tanks has been carried out since ancient times. **Figure 9.1** shows land use in the Project area.

There are main 35 tanks and 21 middle tanks, totally 56 tanks are under the Irrigation Department control. On the other hand, the relative smaller tanks are under the control of Agrarian services department of Ministry of Agriculture, and the number is 877. **Table 9.1** shows the number of tanks in the Project area. Additionally, there are many abandon tanks too.

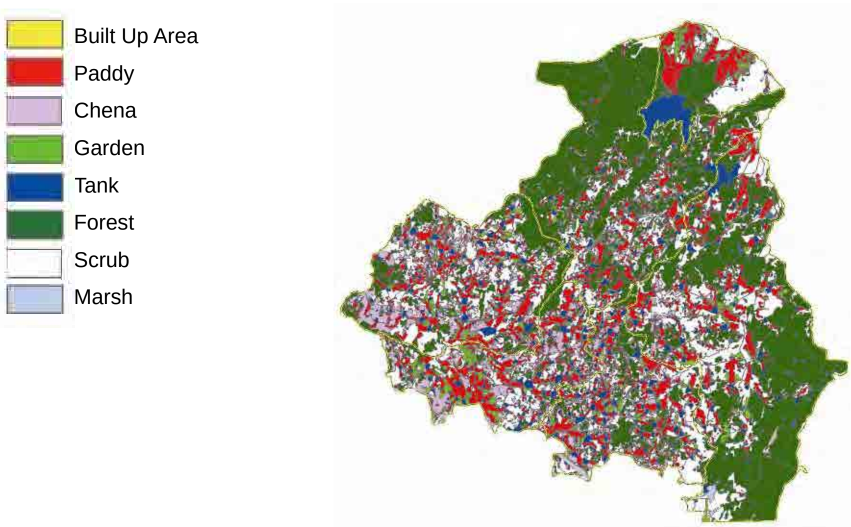

Figure 9.1 Land Use of the Project Area

Table 9.1 Tanks in the Project Area

DSD	Major/median irrigation tanks	Minor irrigation tanks
Padaviya	5	34
Kebithigollewa	11	204
Medawachchiya	-	-
Rambewa	10	181
Horowpothana	22	215
Kahatagasdigiliya	8	222

9.2.2 Ethnic Group

The ethnic composition of Sri Lanka is 76% Sinhalese, 15% Tamil and 9% Muslim. In Anuradhapura, the ratio of Sinhalese is higher than the national average at more than 90%.

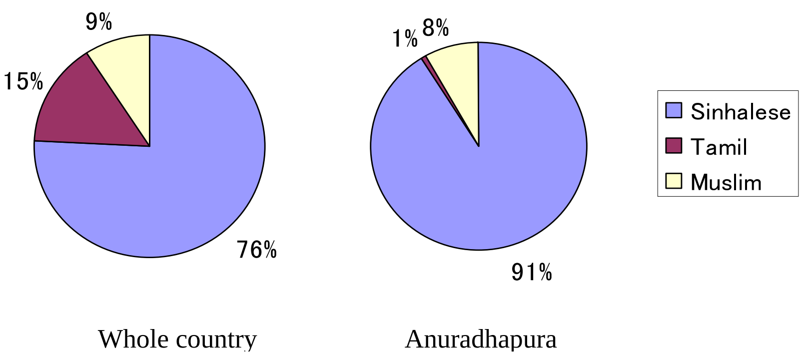

Figure 9.2 Ethnic Composition

There are indigenous people called **'Veddas'** in Sri Lanka, but there are none living in the project area. Tamil and Muslim are considered as minority in this area but they seem to live together without conflict.

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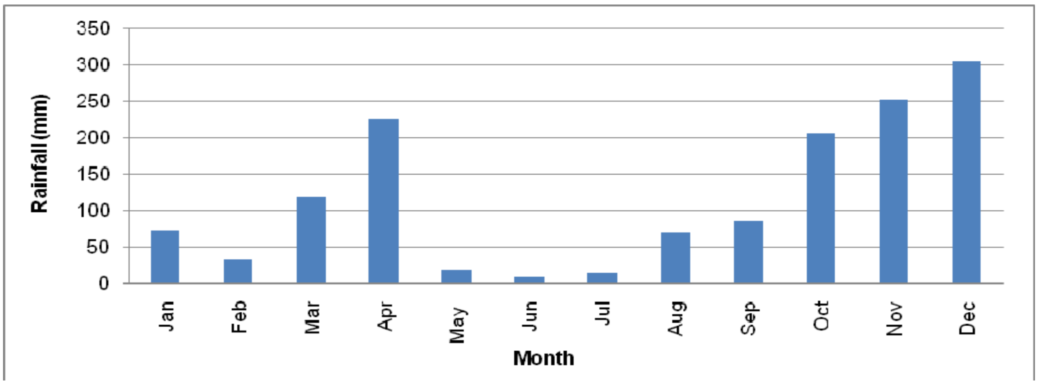
9.2.3 Environmental Condition in the Study Area

(1) Climate

The Anuradhapura District falls within the dry zone of Sri Lanka. According to the records of the Department of Meteorology, the average monthly temperature varies between a minimum of 24.0ºC and a maximum of 32.8ºC. The relative humidity ranges from 69% during the day to 90% at night. The area experiences rain as the result of the northeast monsoon and to a lesser degree from the southwest monsoon. The mean annual rainfall in the last 4 years is 1,401 mm. Peak rainfall occurs during the months of October to December, when about 75% of the total annual rainfall occurs. Scattered rains are experienced during March to April when the inter-monsoon rain is uncertain. The dry season in the region extends from May to July. **Figure 9.3** shows the rainfall pattern in the project area.



Source: Department of Meteorology

Figure 9.3 Monthly Average Rainfalls in Anuradhapura

(2) Air quality

No air quality measurements have been conducted recently in the study area. However the CEA carried out monitoring in Anuradhapura town, in 1999. The measured one hour average for all parameters was well below the National Ambient Air Quality Standards, including for Carbon Monoxide (CO), Sulphur Dioxide (SO_2), Oxides of Nitrogen (NO_x), Nitrogen Dioxide (NO_2) and Nitric Oxide (NO). With regard to the project area, where no highly polluting industries exist and the number of vehicles is much lower than in other areas, except the areas where main roads traverse, the ambient air quality is expected to be within the National Ambient Air Quality Standards.

Table 9.2 Ambient Air Quality Measurements in Anuradhapura, 1999

Parameter	Averaging time	Unit	Maximum permissible level	Japanese standard	Recorded level
Particulate Matter	1 hr	µg/m3	100*	100	32.4
Carbon Monoxide (CO)	1 hr	ppm	26.00	10	0.35
Sulphur Dioxide (SO_2)	1 hr	ppm	0.08	0.04	0.002
Nitrogen Dioxide(NO_2)	1 hr	ppm	0.13	0.04 ~ 0.06 or less	0.003

* For 24 hour average time as the National Environmental (Ambient Air Quality) Regulations, 1994 and its amended version in 2008 not specify Maximum permissible level for 1 hour average PM10.
Source: Environmental Atlas of Sri Lanka, Central Environmental Authority, 2005Source: *Environmental Atlas of Sri Lanka, Central Environmental Authority, 2005*

(3) Topography, Geology and Soil

The study area is a part of north-central Sri Lanka and the topography is generally flat and some undulating part, with elevations ranging from below 100m to about 200m in the highest parts. Ridges, escarpments valleys are significant in the area. The Kala Oya, Malwathu Oya, and Yan Oya are the major river basins in the district and there are many major tanks that hold water throughout the year; however the minor tanks suffer from water shortages during the dry period.

The geology of the area belongs to the Highland complex and is overlain by Quaternary and superficial deposits on the Precambrian strata. Figure 9.4 describes the schematic geology and climate in Sri Lanka. The Highland complex is composed mainly of inter-banded metamorphosed sediments, occurring as crystalline metamorphic rocks, and occupies a broad belt running across the centre of the island in a S-W to N-E direction, east of the Anuradhapura District. A general geology map of the area is given in **Figure 9.5**.

Figure 9.4 Geology and Climate of Sri Lanka

The soil map of the area (**Figure 9.6**) shows that the surface geological strata is covered with three different types of soils classified according to agricultural suitability. They are

- Reddish brown Earths and Low Humic Gley soils;
- Red Yelloe Podzolic soils with dark B horizon and Red-Yellow Podzolic with prominent A1 horizon and;
- Alluvial soils of variable drainage and texture

Figure 9.5 General Geology of the Area

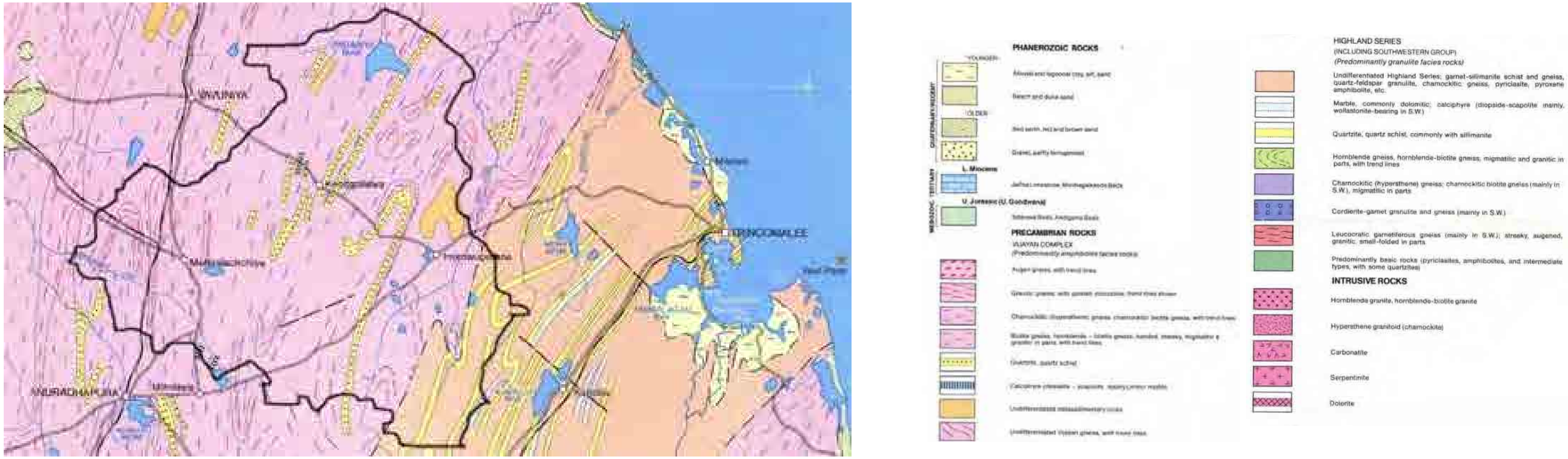
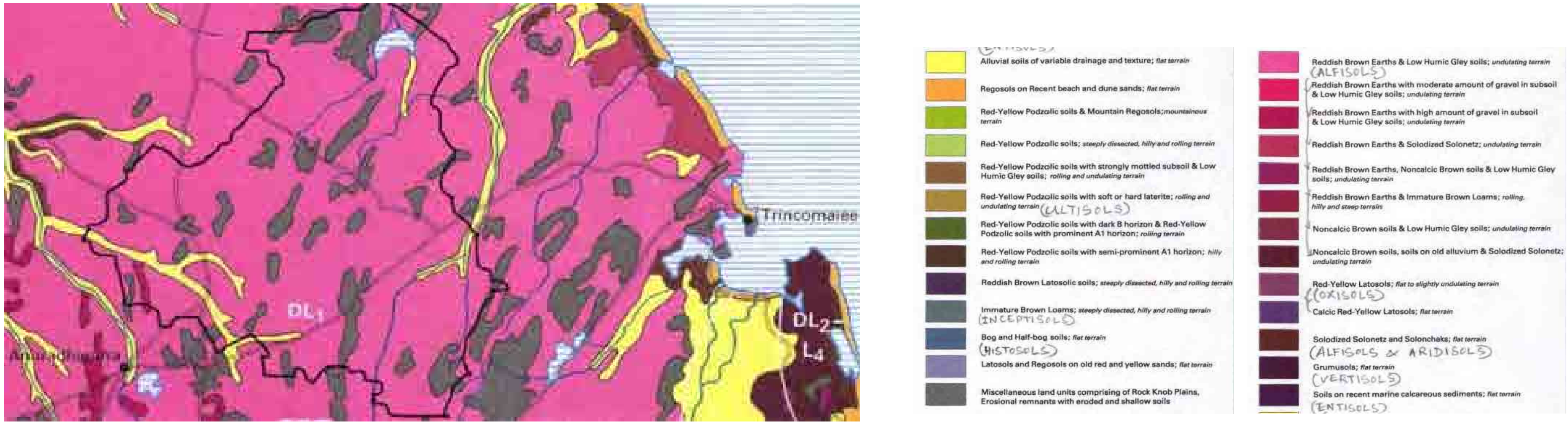


Figure 9.6 Soil Map of the Area



(4) Ecological Resources

The area in which the project is to be located belongs to the DL1 agro ecological zone and generally comprises of dry mixed evergreen forest types. DL1 stands for Dry Zone (Rainfall < 1,500 mm) and Low Country (0 - 300 MSL) category 1, which indicates rice soil type in Sri Lanka. The forests in the area are dominated by Manilkara hexandra (Sinhala - Palu), Chloroxylon sweitenia (Sinhala - Burutha), Drypetes sepiaria (Weera), Feronia limonia (Divul), Vitex altissima (Milla), Syzygium spp (Dan), Azadirachta indica (Kohomba) and Chukrasia tabularis (Hulan Hik).

There are several protected areas (**Table 9.3** and **Table 9.4**), and vegetation in such areas provides good feeding and resting places for wild fauna, especially birds, butterflies and other insect groups. In all the other places, the natural habitat of the project area has been subjected to various anthropogenic activities for many decades. The main habitat types found in the project area include reservoirs, paddy fields, home gardens and secondarily grown forest patches.

(5) Description of protected areas and designated areas in the study area

1) The Protected Area stipulated by CEA

The National Environmental Act No.47 of 1980 (hereinafter referred as to NEA) has provisions which allow the Central Environmental Authority CEA) to declare specific areas as Environmental Protection Areas through an order published in a Gazette. Once the CEA declares an area as an Environmental Protection area, any planning scheme or project stops in that area. However, up to date, only six such sites have been declared under the provision and none of them are situated within Anuradhapura District. The six declared Environmental Protection Areas are as follows.

- Muthurajawela Wetland
- Thalangama Tank
- Gregory Lake
- Knuckles Forest
- Maragala Mountain Range
- Walawwatta Wathurana Swamp Forest

On the other hand, an environmentally sensitive area which requires approval for development on the basis of EIA/IEE is defined in Gazettes (Extra-ordinary no.772/22 24th June 1993, 1104/22 6th November 1999 and 1108/1 29th November 1999). The following conditions could conflict with the project.

- Any reservation beyond the full supply level of a reservoir
- Within 100 meters from the boundaries of or within any area declared as a Sanctuary under the Fauna and Flora Protection Ordinance
- Within 100 meters from the high flood level contour of or within a public lake as

defined in the Crown Lands Ordinance.

2) The Protected Area stipulated by Forest department

Three types of protected areas are administered by the Forest Department as enforced by the Forest Ordinance of 1907 and its amendments namely Forest Reserve (FR), Proposed Reserve (PR) and National Heritage Wilderness Area (NHWA). The protected areas under the preview of the Forest Department which are located within the project areas are as follows.

Table 9.3 Protected Areas under Forest Ordinance

Protected Area	Category	Notification Date	Extent (ha)
Mihintale	FR	14.11.1924	3,308.2
Madawachchiya	PR	-	2,892.5
Issanbessawewa	FR	07.06.1901	441.9
Hinna	PR	-	1,021.8
Etakaduwa	PR	-	7,689.0
Wedakada	PR	-	5,180.0

FR - Forest Reserve; PR - Proposed Reserve; Source: National Conservation Review (NCR) Report Volume 1 (1997)

3) The Protected Area stipulated by Department of Wildlife Conservation

Fauna and Flora Protection Ordinance No. 2 of 1937 (and its amendments) constitutes Sanctuary and seven categories of National Reserves.

<National reserves>

- Strict Natural Reserve (SNR)
- National Park (NP)
- Nature Reserve (NR)
- Jungle Corridor
- Refuge
- Marine Reserve
- Buffer zone

<Sanctuary>

The protected areas under the preview of the Department of Wildlife Conservation which are located within the project areas are listed in **Table 9.4**. The Mahakanadarawa tank is one of the planned water sources for the project.

Table 9.4 Protected Areas under Flora and Fauna Ordinance

Protected Area	Category	Notification Date	Extent (ha)
Mahakanadarawa Wewa	Sanctuary	09.12.1966	1,679.7
Mihintale	Sanctuary	27.05.1938	999.6
Padawiya Tank	Sanctuary	21.06.1963	6,475.0

Source: National Conservation Review (NCR) Report Volume 1 (1997)

The level of protection of a Sanctuary is not as severe as that for National Reserves. A minor development action can be done with a permission of authority. According to the Fauna and Flora Protection Ordinance, the following activities are prohibited in a Sanctuary.

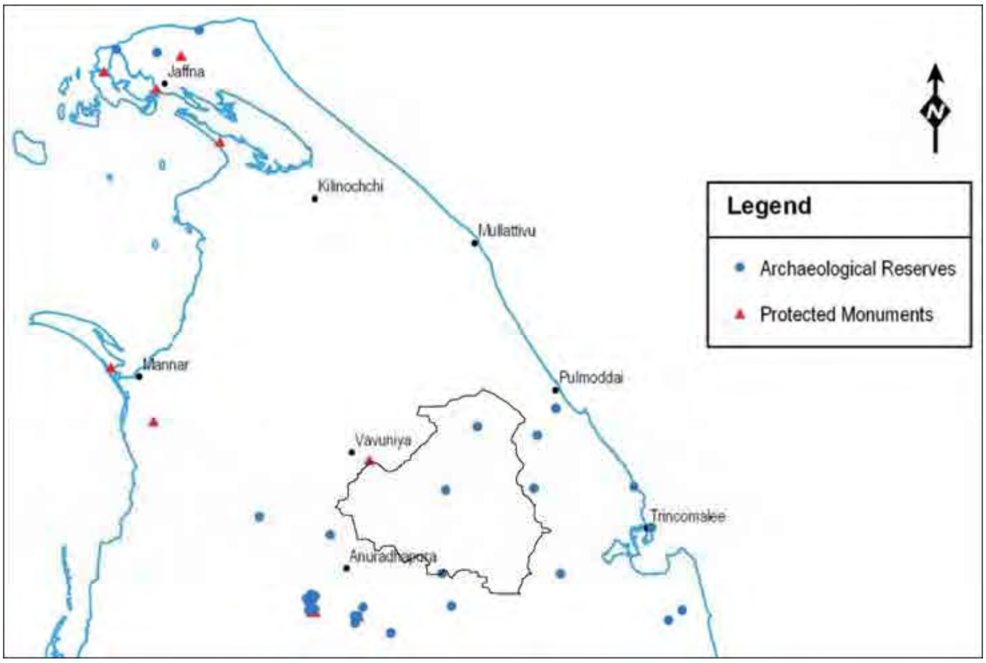
- Hunting, shooting, killing or taking any wild animal, taking or destroying egg of bird or reptile or nest of bird
- Carrying gun or explosive
- Fishing or taking aquatic animal or plant from water without permission
- Removing archaeological, pre-historic, historical, geological or other scientific interesting object, or any other object of mineral value without permission
- Firing a gun, doing any act to disturb wild animal, or interfere breeding place
- Constructing or using hide or ambushing for hunting, shooting, injuring wild animal, bird or reptile
- Setting, laying or spreading any pitfall, trap, snare or other instrument

The following are prohibited on any State Land within a Sanctuary.

- Damaging or destroying plant, taking, collecting or removing plant
- Clearing land for cultivation, mining or any other purpose
- Kindling or carrying fire
- Possessing or using any trap, explosive, or poisonous substance
- Making any fresh clearing
- Erecting building permanent or temporary without permission
- Constructing or using road

4) The Protected Area stipulated by Department of Archaeology

The archaeological sites of Sri Lanka can be separated into 3 major groups i.e. (1) proto-historic sites, (2) prehistoric sites and (3) archaeological reserves and protected monuments. Archaeological reserves and protected monuments located within the project area are shown in **Figure 9.7**. The planned construction sites are located outside of the protected sites.



Source: Environmental Atlas of Sri Lanka, Central Environmental Authority, 2005

Figure 9.7 Archaeological Reserves and Protected Monuments

5) The Protected Area stipulated by Irrigation department

Irrigation Department has set apart reservations for protection and safety of the structural components of all the schemes by Department Circular No. 10/1986. This will apply to all the schemes managed by the Irrigation Department within the project area.

6) The Declared Area of Urban Development

Under the law of Urban Development Authority (U.D.A.), certain urban areas are declared as a development area for the better Physical & Economic utilization of such areas. Mihintale Pradeshiya Saba and Medawachchiya Pradeshiya Saba have been declared as this type of area.

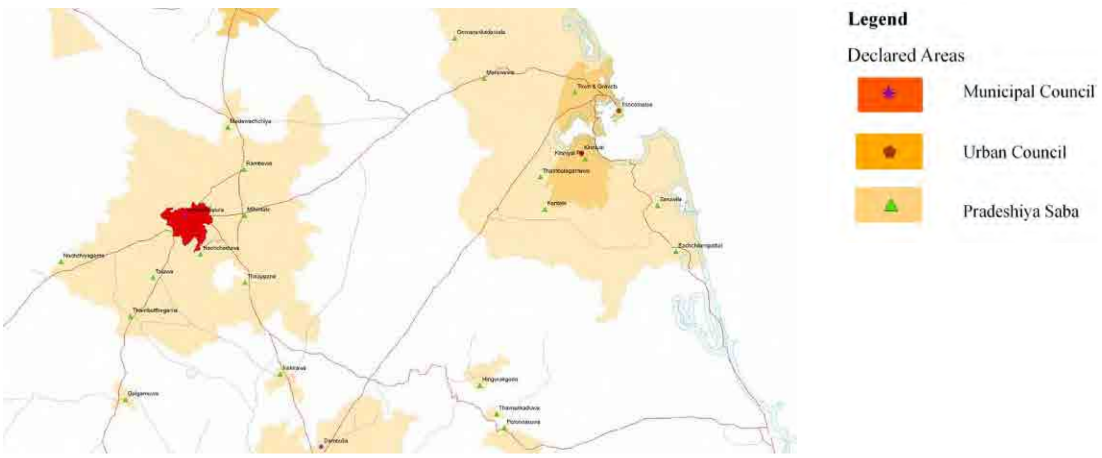


Figure 9.8 Areas Declared under Urban Development Authority Act

9.2.4 Social Conditions in the Study Area

The project service area consists of six DSDs namely; Padaviya, Kebithigollewa, Horowpathana, Kahatagasdigiliya, Medawashchiya and Rambewa. However, the Mahakanadarawa Tank which is one of the two water sources of the project is located within Mihintale DSD. The intake and Water Treatment Plant will be most likely located within Mihintale DSD, within the impact area of the project. Therefore for this study, Mihintale DSD was also taken into account.

The total population in the project area is 225,590, which is distributed over an area of 299,271 ha. The highest population is recorded in Madawachchiya whilst the lowest is in Kebithigollewa. The population density varies from 1.379 capita/ha highest in Rambewa to 0.386 in both Kebithigollewa and Horoupatana

Table 9.5 Population and Per Capita Land Used by Divisional Level – 2010

DSD	Population			Area (ha)	Population Density	Per capita land consumption (ha)
	Male	Female	Total			
Padaviya	11,940	11,597	23,537	23,119	1.018	0.98
Kebithigollewa	11,077	10,580	21,657	56,062	0.386	2.59
Medawachchiya	22,615	22,429	45,044	50,730	0.888	1.13
Rambewa	17,411	17,766	35,177	25,509	1.379	0.73
Kahatagasdigiliya	18,457	18,911	37,368	33,141	1.128	0.89
Horoupotana	16,536	16,457	32,993	85,487	0.386	2.59
Total 6 DSD	98,036	97,740	195,776	274,048	0.864	1.485
Mihintale	14,938	14,876	29,814	25,223	1.182	0.85

Source: Department of Census and Statistics

(1) Agriculture

Paddy cultivation is mainly carried out by making use of the irrigation systems in the area. The irrigation systems are categorized as Major and Minor. Rainfed farming is also a key source of harvesting paddy. A total of 46,749.9 ha is under paddy cultivation, of which 60% is by Minor irrigation, 26% by Major irrigation and 14% Rainfed.

Table 9.6 Cultivated Extent of Paddy by Divisional Level – 2010

(Extent in ha)

DSD	By Irrigation		Rainfed	Total
	Major	Minor		
Padaviya	2,762	1,082	996	4,841
Kebithigollewa	1,562	3,570	172	5,304
Medawachchiya	820	5,533	439	6,791
Rambewa	3,229	3,367	804	7,399
Kahatagasdigiliya	934	6,324	1,347	8,605
Horoupotana	2,614	5,988	2,322	10,924
Total 6 DSD	11,921	25,864	6,079	43,864
Mihintale	359	2,165	362	2,886

Source: Department of Census and Statistics of Sri Lanka

The main highland crops in the project area are Cashew, Arecant, Mango, Orange, Lime, Jack, Plantain and Papaw. In Mihinthale DSD, 787.7 ha is utilized for harvesting highland crops, while 178.4 ha is used in Horoupatana for this purpose.

Table 9.7 Highland Crop Statistics by Divisional Level – 2010

(Extent in ha)

DSD	Cashew	Arecant	Mango	Orange	Lime	Jack	Plantain	Papaw
Padaviya	75.9	4.8	35.7	32	38.2	74.5	107.2	20.2
Kebithigollewa	73.6	16.1	106.3	35	54.4	99.6	175.6	32.7
Medawachchiya	116.9	18.4	111.9	37.8	73.1	126.8	136.9	44.2
Rambewa	98.3	11.7	140	52.2	78.5	98.8	159	32.3
Kahatagasdigiliya	70.2	4.4	116.3	40.8	69.5	88.4	145.3	40.4
Horoupotana	16.4	0.5	42.3	17.4	21.9	29.4	41.6	8.9
Mihintale	246.3	0	127.4	53.1	95	114.4	125.7	25.8

Department of Census and Statistics of Sri Lanka

(2) Education

A total of 196 schools are established in the project beneficial area, and Mihinthale has only 18 schools in the DS. With respect to National Schools, only Madawachchiya DS has one school that comes under this category. All the other schools in the project area are of 1AB, Grade 1C, Grade 2C and Grade 3 categories.

Table 9.8 Classifications of Schools by Divisional Level 2010

DSD	National Schools	1AB Schools	Grade I C Schools	Grade 2 Schools	Grade 3 Schools	Total
Padaviya	0	1	5	9	5	20
Kebithigollewa	0	0	2	8	17	27
Medawachchiya	1	0	4	18	16	39
Rambewa	0	0	4	17	12	33
Kahatagasdigiliya	0	1	6	14	18	39
Horoupotana	0	0	3	16	19	38
Mihintale	0	0	4	10	4	18

Source: Department of Census and Statistics of Sri Lanka

(3) Healthcare

There are 14 hospitals in the project area. Most of the hospitals have less than 75 beds and 5 wards. Padaviya Hospital is recorded to have the highest number of beds and wards, 127 and 6 respectively.

Table 9.9 Information on Government Hospitals by Divisional Level – 2010

D.S. Division	Name of hospital	No of wards	No of beds	No of outdoor patients	No of indoor patients
Padviya	Padviya	6	127	83157	8504
	Samapath Nuwara	2	77	25486	4312
Kabithigollava	Kabithigollava	5	63	90122	6569
Madawachchiya	Madawachchiya	4	105	87016	10068
	Puneava	1	5	5149	0
Rabava	Rabava	3	46	25754	4136
	Kallanchiya	2	9	15709	1304
Kahatagasthigiliya	Kahatagasthigiliya	4	74	86331	7713
	Rathmalgahaweva	3	41	55472	2200
Horovipothana	Horovipothana	5	72	53746	4151
	Kapugollawa	2	28	21214	1858
	Wahalkada	1	11	11982	0
Mihinthale	Mihinthale	5	100	89040	4254
	Thammennava	3	32	38850	3369

Source: Department of Census and Statistics of Sri Lanka

9.2.5 Result of Social Survey in the Study Area

(1) Purpose

The scope of the social survey in the Project area, is to determine and record socioeconomic status of the beneficiary population, determine the present status of the safe drinking water availability, the status of sanitation and health, specially water borne diseases such as Renal failure and Fluorosis which are known to be the most abundant in the target project area. In addition, it was aimed to find the views of the target community on the benefits anticipated and capability to pay on the new water supply.

(2) Methodology

The survey was carried out in the Project coverage area which are of 190 Grama Niladhari Divisions (GNDs) in six DSDs; Horowpothana, Kahatagasdigiliya, Kebithigollewa, Medawachchiya, Rambewa and Padaviya.

The social survey was carried out through a questionnaire survey targeting a total sample of about 990 households and commercial places. The sample was selected in terms of three kinds of population, 1: Existing piped supply water users group (hereinafter referred to as 'User group'), 2: Non-supplied group ('Non-user group'), and 3: Commercial /public utilities group. The number of samples is shown in **Table 9.10**.

Table 9.10 The Number of Samples

DS Division	Existing piped water users		Non-supplied group	Commercial/ public utilities group
	CBO	NWSDB		
Padaviya	29	19	47	17
Kebithigollewa	9	27	55	17
Medawachchiya	79	40	98	16
Rambewa	94	10	87	17
Horowpothana	29	5	81	17
Kahatagasdigiliya	59	34	86	17
Total	**299**	**135**	**454**	**101**

The survey was done through a household questionnaire survey and formal discussions with respective Grama Niladhari according to a predefined format. As a part of the survey, informal discussions with target community and respective officers in DS office, collecting available secondary data was done in order to identify the ground situation of the study area and to identify the actual need of the proposed water supply project targeting Mahakandarawa and Wahalkada tanks.

(3) Overview of Social and Economic Conditions Highlighted by the Survey

1) Economic activities

The economy of the project area is predominantly centered on paddy cultivation. Census data revealed that land utilization of Anuradhapura district in 2008, is about 128,719.79 ha and 59,084.05 ha for paddy and chena cultivation respectively. **Table 9.11** describes the community involvement in the main occupation categories in the project area.

Table 9.11 Main Occupation Sectors in the Project Area

DSD	Agriculture sector	Government sector	Private sector
Padaviya	3,883	1,991	315
Kebithigollewa	4,818	2,424	698
Medawachchiya	10,018	2,071	2,286
Rambewa	9,405	3,159	2,132
Horowpothana	10,958	3,011	1,086
Kahatagasdigiliya	11,346	2,939	576

Source: Respective DSD profile – 2011 data

The above data reveals that majority of the families living in the project area are involved in agriculture sector, while considerable amount of other people engaged in government and private sectors. The farmers mostly engaged in paddy cultivation during “Maha” season (December – February) where they get lot of rain for cultivation. Rest of the period of the year, farmers cultivates Other Food Crops (OFCs) and practice “Chena” cultivation. Majority of the government employees are belongs to the defense sector. There are people who engaged in Freshwater fishing activities associated with the tank systems distributed in the project area. Livestock sector is an important component of the farming system of the project area that generates additional income, employment opportunities and highly nutritious food. Majority of people in the area depend on dairy farming using chattels, goats etc.

In addition, there are small-scale businesspersons, engaging bakery, carpentry, brick industries and self-employments. The water businesses is popular due to the drinking water scarcity in the area and people sell bottled drinking water with no proper sealing for LKR 100/- (30 L) with the delivery service, obtained from natural springs found specially in Kebithigollewa area. There is less number of people working overseas employments.

2) Education

There is no significant difference between User group and Non-user group in education level. Most of people living in this area have a considerable level of education. The majority of about 50 % of the respondents have studied up to Ordinary level (O/L) while more than 40% of the respondents have Advance level (A/L) qualifications. **Figure 9.9** shows that nearly 2 % have the higher education qualifications.

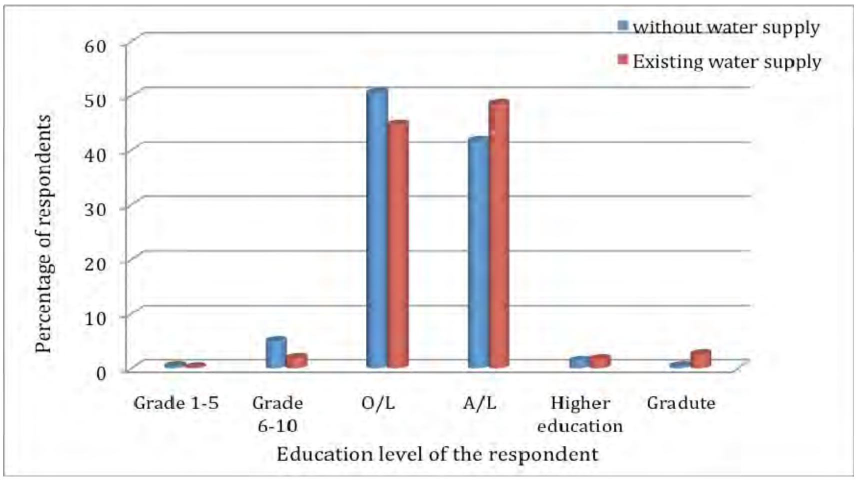


Figure 9.9 Educational Level of Respondent

3) Housing

The community living in the project area is a rural community where majority of the houses are permanent houses, while there are total of about 6,569 with no house for their shelter. The people without houses living in temporary places and they move around the area. The status of the housing in the project area is given in **Table 9.12**.

Table 9.12 Housing Condition

DSD	Permanent	Semi-permanent	Temporary	Without house
Padaviya	4,234	1,044	708	677
Kebithigollewa	5,098	662	320	997
Medawachchiya	8,853	3,428	1,205	1,310
Rambewa	7,311	2,287	455	1,100
Horowpothana	6,557	2,556	637	771
Kahatagasdigiliya	8,459	1,861	332	1,714
Total	**40,512**	**11,838**	**3,657**	**6,569**

Source: Respective DSD profile – 2011 data

4) Size of Family

The average number of family members in the study area is 4. There is no significant difference between User group and Non-user group.

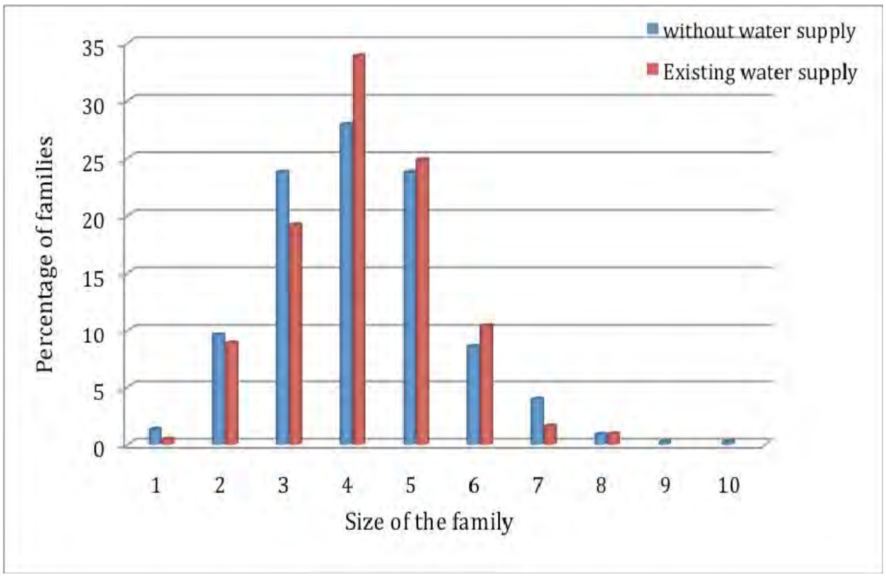


Figure 9.10 Size of Family

5) Income

Main income source for the people in this area is farming.

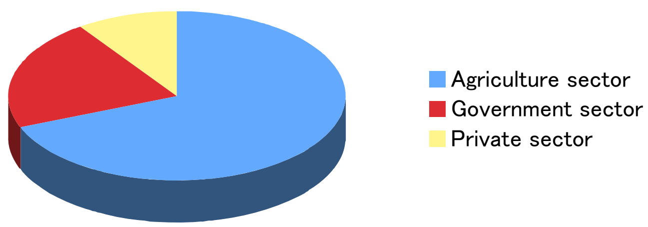


Figure 9.11 Main Occupation Sectors in the Project Area

Source: Respective DSD profile – 2011 data

Water supply area is located urban and suburban area usually, so the distribution pattern of Water user group is a bit different from Non user group.

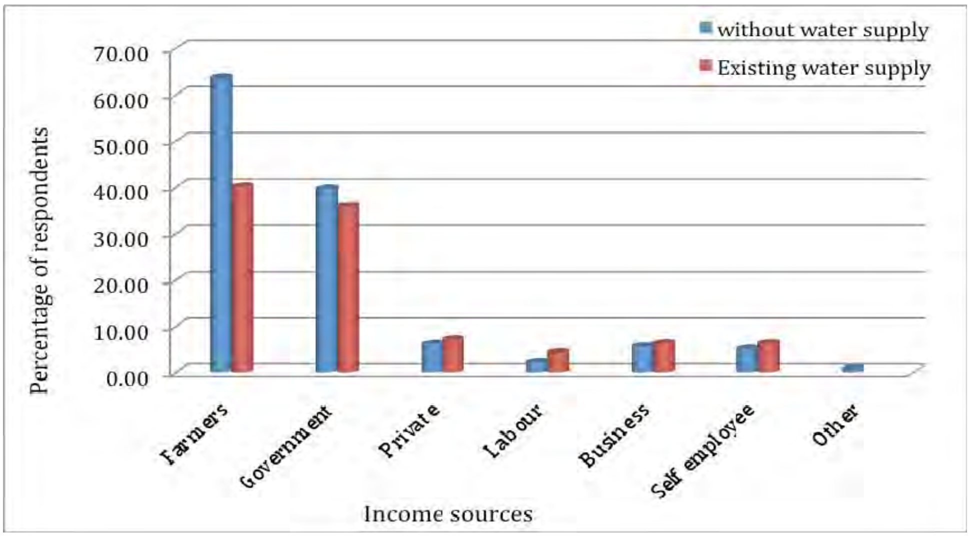


Figure 9.12 Income Sources

There is not found the big difference between User group and Non-user group in income level. The figure of income level is shown in **Table 9.13** and its distribution are shown in **Figure 9.13**.

Table 9.13 Income Level

(Unit: Rs.)

Group	Minimum	Mean	Medium	Maximum
Users	4,000	33,070	25,000	400,000
Non-users	1,600	37,270	25,000	405,000

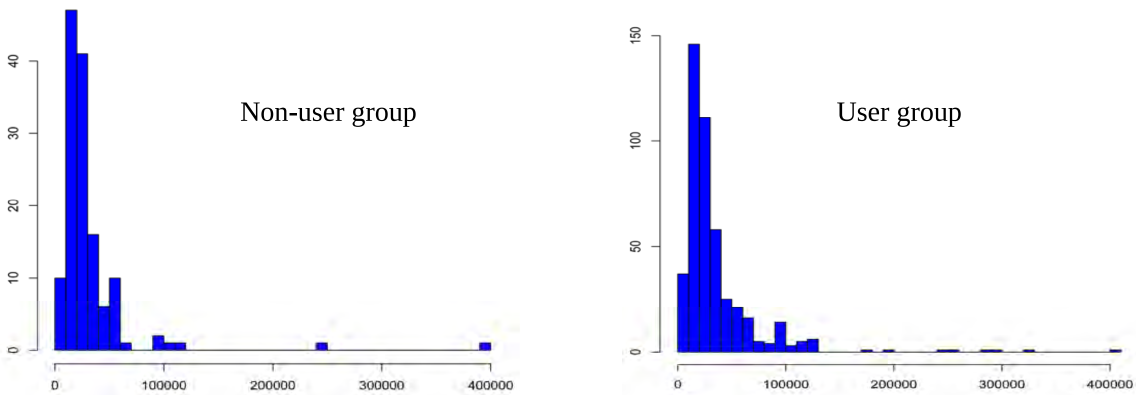


Figure 9.13 Distribution of Income

As stated in Central Bank Report of 2012, the poor household percentage in Anuradhapura district is 4.6 while this figure has been estimated as 7.0 % for whole country.

6) Water Source

The water source for drinking purpose of the User group is shown in Figure. The fact clearly shown in it is that nearly 35 % of the CBO water users depend on other water sources for drinking purpose even though they can use the piped water. 31% of CBO users don't satisfy the water quality, its figure is higher than the water user of NWSDB supply.

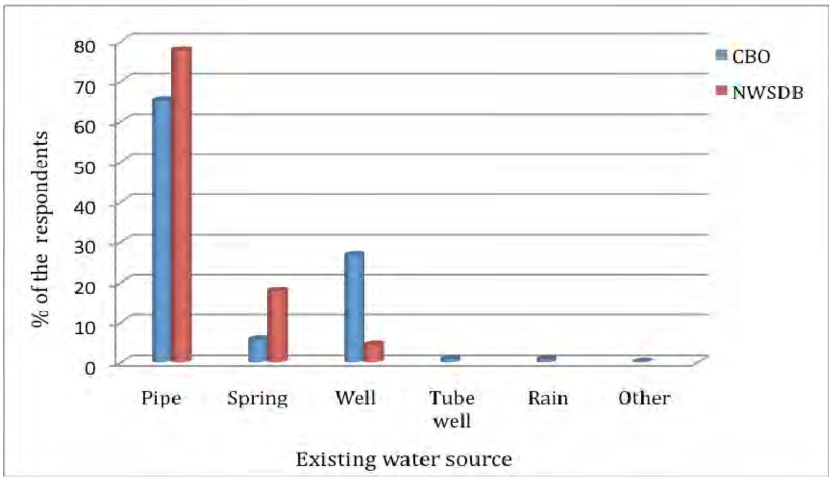


Figure 9.14 Drinking Water Source of the Existing Water User Respondents

Water sources for the Non-user group are shown in **Figure 9.15**.

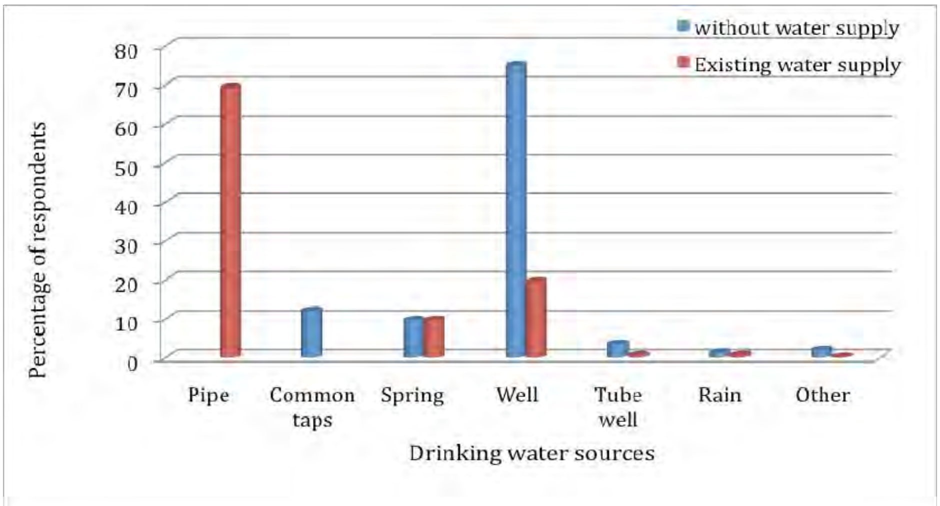


Figure 9.15 Drinking Water Source of Non-user Group

6) The problems of existing water supply

Figure 9.16 shows the problems identified by the users both of NWSDB and CBO. The tendency of answer is almost same in both users groups. The most frequent answer is the problem of water quantity and quality. It is notable that the more than 10% uses proclaimed that the cost for water was too high. About 20% of users NWSDB answered there was no issues and it is double of the CBO users.

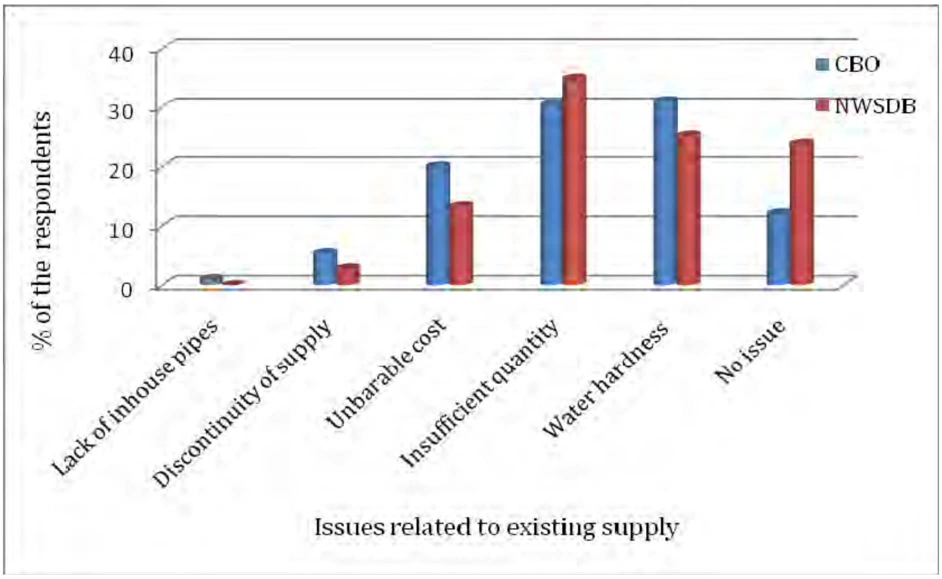


Figure 9.16 Problem of Supplied Water

9.3 Institutions and Organizations regarding Environmental and Social Consideration in Sri Lanka

The hierarchy of legislation in Sri Lanka is shown below.

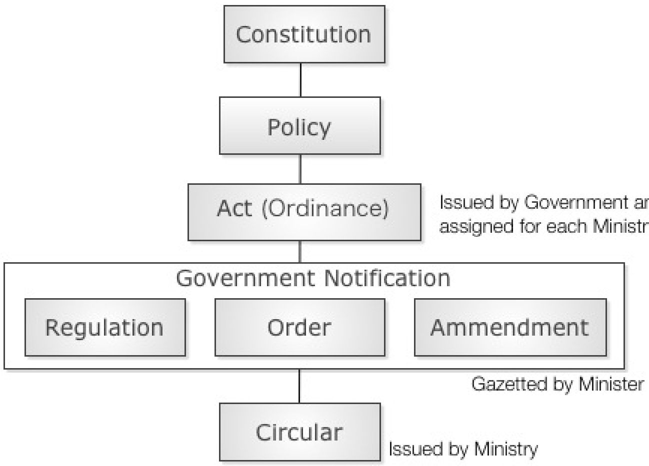


Figure 9.17 Hierarchy of Legislation in Sri Lanka

Under the constitution, Government enacts Policies and Acts. An Act is designated to each

Ministry, and more detailed regulations or amendments are stated as a Government Notification in a Gazette. Each ministry issues the circular as a ministerial decree for more practical use.

9.3.1 Policy of Environment Protection in Sri Lanka

The Constitution of Sri Lanka identifies "The duty of every person in Sri Lanka to protect nature and conserve its riches" Chapter VI, Art. 28 (f). To support this fundamental duty, the Government of Sri Lanka (GOSL) recognized the need for an explicit National Environmental Policy (NEP) to guide decision makers towards a more sustainable development pathway. The policy consists of a vision, objectives, principles, policy statements and strategies.

Vision: *"To achieve a healthy and pleasant environment sustaining nature for the well-being of the people and the economy"*

Objective: *"Protection and conservation of the integrity of the nation's environment and natural resources through ecologically sustainable development, with due recognition of the contribution of natural resources to economic development and to the quality of life"*

Policy Principles: *Decisions that involve the use, have impact on, or affect the status of natural resources and the environment will apply the following principles:*

- *Environmental and Natural Resource Management will apply an ecosystems approach.*
- *Natural resources will be managed so that it will be ecologically as well as socially sustainable.*
- *Partnerships will be promoted among central, sectoral, provincial, local, NGO, civil society and private sector agencies to encompass the needs of ecological integrity with economic vitality and social development.*
- *Environmental management will be devolved in concordance with constitutional provisions.*
- *The precautionary principle will duly apply to situations where the consequences of decisions are uncertain.*
- *Adequate attention will be paid towards ensuring environmental justice in all situations.*
- *Safe-minimum-standards will apply to essential environmental life-support functions and services in line with the requirements of ecologically sustainable development.*
- *In order to maximize environmental performance, management systems will be continuously revised so that they adapt to changing circumstances and realities.*
- *The benefits arising from the wise use of Sri Lanka's natural resources and the costs of their management will be shared equitably so as to benefit all segments of society.*
- *Polluter-pays principle will be applied to the benefit of industries and society.*
- *The extent of substitution of man-made capital for natural capital will be defined and*

will not exceed critical limits.

9.3.2 Major Environmental Policies in Sri Lanka

National Environment Policy – 2003 The policy aims to promote the sound management of Sri Lanka's environment balancing the needs for social and economic development and environment integrity. It also aims to manage the environment by linking together the activities, interests and perspectives of stakeholders and to assure environmental accountability.
National Forestry Policy – 1995 The policy was drawn up to provide clear directions for safeguarding the remaining natural forests of the country in order to conserve biodiversity, soil and water resources.
The National Policy on Wildlife Conservation – 2000 The policy renews the commitment of the government to conserve wildlife resources through promoting conservation, maintaining ecological processes and life sustaining systems, managing genetic diversity and ensuring sustainable utilization and sharing of equitable benefits arising from biodiversity. It emphasizes the need for effective protected area management with the participation of local communities.
National Air Quality Management Policy – 2000 The policy aims to maintain good air quality to reduce morbidity due to air pollution and in turn reduce national health expenditures.
National Watershed Management Policy – 2004 The policy aims to conserve, protect, rehabilitate, sustainably use and manage the watersheds while managing their environment characteristics with the involvement of people.
Cleaner Production Policy – 2004 The objective of this policy is to incorporate the cleaner production concept and practices into all development sectors of the country.
National Biosafety Policy – 2005 The policy on biosafety set the overall framework in which adequate safety measures will be developed and put into force to minimize possible risks to human health and the environment while extracting maximum benefits from any potential that modern bio technology may offer.
National Air Quality Management Policy – 2000 The purpose of this policy is to maintain good air quality to reduce morbidity due to air pollution and in turn reduce national health expenditures.
National Policy on Wetlands – 2005 The policy seeks to give effect to National Environment Policy and other relevant national policies, while respecting national commitments towards relevant international conventions, protocols, treaties and agreements to which Sri Lanka is a party.
National Policy on Sand as a Resource for the Construction Industry – 2006 The policy statement reflects Sri Lanka's constitutional, international and national obligations, including the Mines and Minerals Act No. 33 of 1992, the National Environmental Act of 1980, the Coast Conservation Act of 1981 and other relevant legislation, regulations and policy statements. It defines the commitment of Government, in partnership with the people, to effectively manage the construction-sand resource for the benefit of present and future generations.
National Policy on Elephant Conservation – 2006 The policy was developed to ensure the long-term survival of the elephant in the wild in Sri Lanka through the

mitigation of the human-elephant confect.
National Policy on Solid Waste Management – 2007 The policy has been prepared to ensure integrated, economically feasible and environmentally sound solid waste management practices for the country at national, provincial and Local Authority level. The main objectives of the policy are (a) to ensure environmental accountability and social responsibility of all waste generators, waste managers and service providers (b) to actively involve individuals and all institutions in integrated and environmentally sound solid waste management practices (c) to maximize resource recovery with a view to minimize the amount of waste for disposal and (d) to minimize adverse environmental impacts due to waste disposal to ensure health and well being of the people and on ecosystems.

9.3.3 Overview of Legal System regarding Environment and Social Consideration

(1) National Environmental Act

The most important and vital governmental organization for environmental protection in Sri Lanka is the Central Environmental Authority (hereinafter referred to as CEA). The CEA was established as an implementing agency in 1981 under the National Environmental Act No. 47 of 1980. Subsequently, the Ministry of Environment was established in December 2001 and this has overall responsibility for the affairs of the CEA, with the objective of integrating environmental considerations in the development process of the country. The CEA was given wider regulatory powers under the National Environment (Amendment) Acts No:56 of 1988 and No:53 of 2000.

The National Environmental Act orders the establishment of a Council which consists of the members of senior officers from related organization as a consulting body.

The authorities given to the CEA with the consultation of the Council are as follows.

- Land use management
- Natural resource management and conservation
- Management policy for fisheries and aquatic resources
- Management policy for wildlife
- .Management policy for forestry
- Management policy on soil conservation

The National Environmental Act is the highest level environmental legal basis in Sri Lanka, and there are enacted regulations under the Act regarding environmental issues such as EIA, natural resource management, waste management, environment protection, environmental qualities.

1) Prescribed Project and EIA/IEE procedure

The prescribed projects which are requested to implement EIA/IEE are defined and listed in the Gazette no 772/22 of 24th June, 1993 and 859/14 of 23rd February 1995. Only large-scale development projects that are likely to have significant impacts on the environment are listed as prescribed projects. There are two categories.

1. By type and the magnitude
   In case of Water Supply Project, the conditions are;
   - All ground water extraction projects of capacity exceeding 1/2 million cubic meters per day.
   - Construction of water treatment plans of capacity exceeding 1/2 million cubic meters

2. By location (e.g. if projects are located wholly of partially within environmentally sensitive areas such as forest and wildlife reserves, stream or lake reservation, archaeological reserve, declared erodible areas etc.

CEA prepared guidelines for implementing EIA named ‘Guidance for Implementing the Environmental Impact Assessment (EIA) Process’, and it was separated into two parts; No.1 for ‘A General Guide for Project Approving Agencies (PAA)’ and No.2 for ‘A General Guide for Conducting Environmental Scoping’. A project proponent can follow the guideline to implement the project with the proper consideration of the environment.

‘Guidance for Implementing the EIA Process No.2’ defines the primary technical topics commonly addressed in an EIA as follows.

- Water Resources
- Pollution issues
- Soils and Land Use
- Forests
- Wildlife and Biological Diversity
- Socio-Cultural and Economic Conditions

The National Environmental Act (NEA) was amended by Act No. 56 of 1988 to include a provision relating to EIA Regulations contained in Part IV C of the statute entitled “Approval of Projects”. This section was further amended by Act No. 53 of 2000. The Central Environmental Authority is the agency charged with the responsibility of implementing the above provisions of the NEA. Depending on the significance of the anticipated impacts, there are two levels in the EIA process. If the environmental impacts of the project are not very significant then the project proponent may be asked to do an Initial Environmental Examination (IEE), which is a relatively short and simple study. However, if the potential impacts appear to be more significant, the project proponent will be requested to do an EIA which is a more detailed and comprehensive study of environmental impacts. EIA reports must be kept open for public comments for 30 working days. IEE reports have been exempted from this requirement.

The National Environmental Act stipulates that approval for all prescribed projects must be granted by a Project Approving Agency (PAA). At present, 23 Government Agencies have been designated as PAAs. A single Project Approving Agency is established as responsible for administrating the EIA process for a project. When there is more than one PAA is involved the appropriate PAA is decided by the CEA. It is important to note that a state agency which is a project proponent cannot function as a PAA for that project. Project Approving Agencies are listed in the Gazette Extra Ordinary No.859/14 of 23rd February 1995 and Gazette Extra Ordinary, No.1373/6 of 29th December 2004.

The best time for a project proponent to submit the preliminary information on the proposed project is as soon as the project concept is finalized and the location of the project is decided. When a prescribed project is referred to CEA through the Basic Information Questionnaire (BIQ) form, the CEA will designate a suitable PAA. Then the PAA will carry out scoping and Terms of Reference (TOR) for the EIA/IEE will be issued to the project proponent. On receipt of an EIA report, the PAA will appoint a Technical Evaluation Committee (TEC) to evaluate the EIA report and make its recommendations. The expected duration of the project approval is shown in **Table 9.14**.

Table 9.14 Summary of Procedure for Obtaining Environmental Clearance from CEA

Legislation	Regulatory Authority	Summary of the procedure	Time scale
National Environmental Act No.47 of 1980 and amended Act No. 56 of 1988; Government Gazette Notifications No. 772/22 of 24th June1993, No. 859/14 of 23rdFebruary 1995, No.1104/22 of 5th November 1999 and No.1108/1 of 29th November 1999	CEA	1. Submit Preliminary information to CEA (BIQ submission)	During feasibility stage
		2. Designate PAA by CEA	
		3. Scoping; Issue of Terms of Reference for EIA/IEE by PAA	36 Days
		4. Conduct the IEE/EIA study and submit the report to PAA	About 60 to 90 Days
		5. Check for adequacy by PAA	14 days
		6. Open for public comments (only for EIA)	30 Days
		7. Review by TEC appointed by to CEA	36 Days
		8. Issuance of approval by PAA / CEA	

Figure 9.18 shows the schematic diagram of EIA/IEE approval procedure.

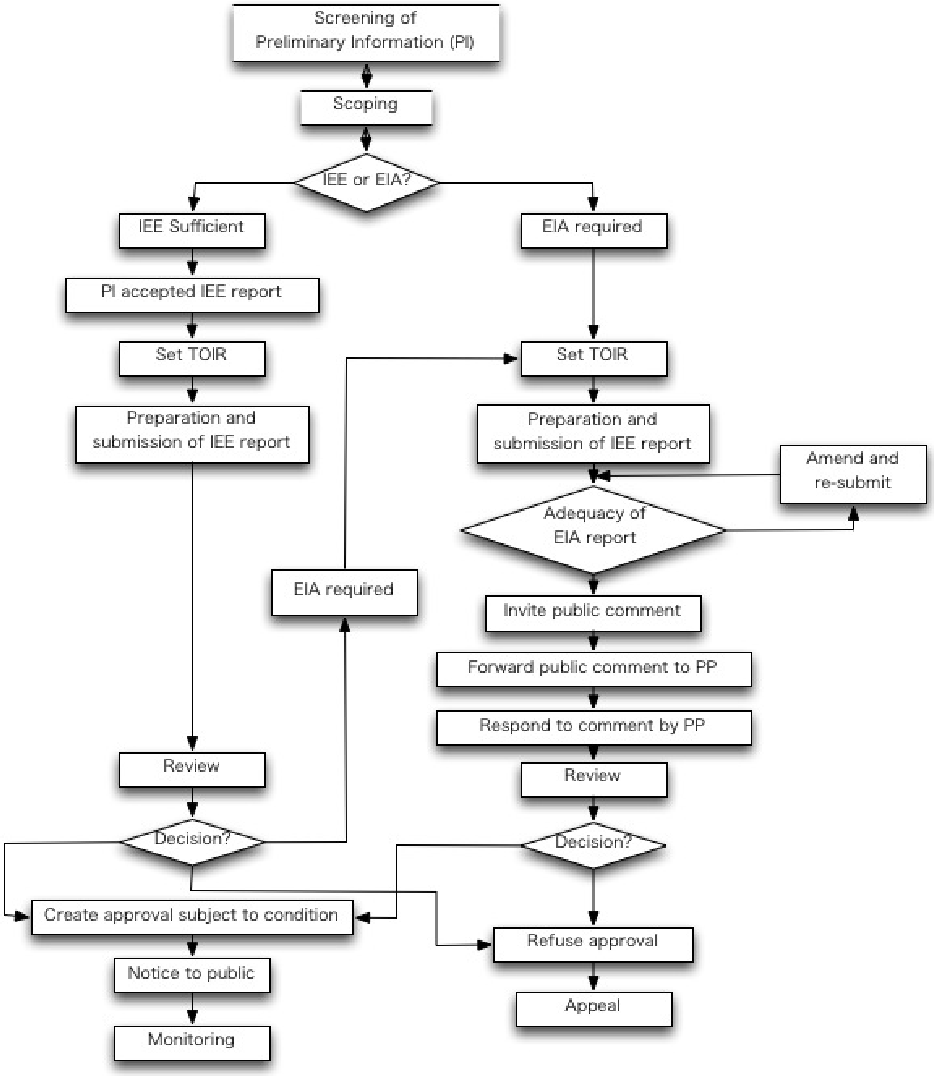


Figure 9.18 Environmental Impact Assessment Procedure

2) Environmental Recommendation

The any projects to establish industrial activities, which are not subject to EIA are advised to obtain environmental recommendation from the CEA for the proposed sites. The purpose of environmental recommendation is to minimize the environmental impact. The potential of the environmental impact of a proposed project is evaluated with respect to the zoning plans of relevant local Authorities surrounding land use, land availability for buffer zones, and the capacity of the area to receive additional pollution load and waste disposal requirements. The document contains the conditions, and the project should take mitigation measures to satisfy the conditions.

3) Environmental Protection License (EPL)

The potential polluting activities are requested to obtain Environmental Protection License

(EPL) under the section 23.A of NEA. The prescribed activities for which a license is required are listed in the Gazette Notification No 1533/16 dated 25.01.2008. Water treatment plants having a treatment capacity of 10,000 or more cubic meters per day is stated as the prescribed activity in part A. The license for a project is issued by Provincial Offices or District Offices of the CEA, and it has maximum one year validity. The project proponent has to renew the license.

(2) Fauna and Flora Act

EIA provisions are also included in the Fauna and Flora (Amended) Act No. 49 of 1993. According to this Act, prior written approval from the Director of Wildlife is necessary for any development activity of any description whatsoever proposed to be established within one mile (1.6km) from the boundary of any National Reserve. Under this enactment, it mandates that such projects should undergo the EIA process in terms of the National Environmental Act.

There are no National Reserves in the project area.

(3) Antiquity Act

An Archaeological Impact Assessment (AIA) should essentially be carried out in respect of a proposed development project to be carried out in every land the extent of which exceeds 0.25ha in accordance with Section 47 read with Section 43(b) of the Antiquities (Amendment) Act No. 24 of 1998 and published in the gazette No. 1152/14 dated 04.10.2000. The purpose of the AIA is to examine whether there are or are not antiquities in the land where the development project is proposed to be carried out, and if there are antiquities in the land, to find the impact of the proposed project on the antiquities and to report alternative measures to be taken. The prescribed projects which are requested to carry out AIA are defined in the above Act.

On receipt of the Employer’s completed application to the departments a copy of such application will be sent to the Regional Office of the Archaeological Department and a preliminary observation report on the place will be obtained. If there are no antiquities in the land according to the recommendation and observation report of the Regional Assistant Director, the said land will be released for the project concerned. If the preliminary observation report has proposed to carry out an AIA, steps will be taken to conduct the survey. The Archaeological Department will call for quotations from the agencies which have registered in the department for conducting the AIA surveys and a competent agency for conducting the AIA will be selected by the Apex Body headed by the Director General of Archaeology. The project developer shall bear the cost of conducting the AIA through the department and the agency shall submit the report within a time period maximum of six weeks. The Director General of Archaeology will make available his decision to the Project concerned after obtaining the recommendations from the Minister in charge of the subject. The summary of procedure for obtaining approval from

Archaeological Department is given in **Table 9.15**.

Table 9.15 Summary of Procedure for Obtaining Archaeological Department Approval

Legislation	Regulatory Authority	Summary of the procedure	Time scale
Under Section 47 read with Section 43(b) of Antiquities (Amendment) Act No. 24 of 1998; Gazette Notification No. 1152/14 dated 04.10.2000	Department of Archaeology Sri Lanka	1. Submit application to the Department	<u>During feasibility stage</u>
		2. Conduct a Preliminary Observation by Regional Office and submit the report to the Department	About 30 days
		3. (i) If there are no antiquities according to the recommendation and observation report, land will be released for the project.	
		(ii) If the preliminary observation report has proposed to carry out an archaeological impact assessment survey, steps will be taken to conduct the survey.	About 30 days
		4. Call for quotations for AIA from registered agencies by the Department and award the survey	
		5. Conduct the AIA survey by the selected agency and submit the report to the Department	42 days
		6. Submit AIA report to Minister in charge for approval	About 30 days
		7. Issuance of permit by the Department	

9.3.4 Applicability for the Project

The regulations specify activities for which environmental assessment is mandatory, and those that could occur by water supply projects are as follows:

- Groundwater extraction projects of capacity exceeding 500,000 cubic meters per day;
- Construction of water treatment plants of capacity exceeding 500,000 cubic meters per day;
- Involuntary resettlement exceeding 100 families
- Projects located in sensitive areas such as:
  1) Any erodible area declared under the Soil Conservation Act (1951, 1953)
  2) Any Flood Area declared under the Flood Protection Ordinance (1924, 1955) and any Flood Protection Area declared under the Sri Lanka Land Reclamation and Development Corporation Act (1968, 1982)
  3) Any reservation beyond the Full Supply Level of a reservoir
  4) Any archaeological reserve, ancient or protected monument as defined or declared under the Antiquities Ordinance (1965)

5) Any area declared under the Botanic Gardens Ordinance (1928, 1973)
6) Areas within, or less than 100m from the boundaries of any area declared under the National Heritage and Wilderness Act (1988): the Forest Ordinance
7) Areas within, or less than 100m from the boundaries of any area declared as a Sanctuary under the Fauna and Flora Protection Ordinance (1937)
8) Areas within, or less than 100m from the high flood level contour of a public lake as defined by the Crown Lands Ordinance (1947, 1949, 1956) including those declared under Section 71 of the Ordinance
9) Areas 60m or less from the bank of a public stream as defined in the Crown Lands Ordinance, with a width of more than 25m at any point.

The capacity of the water treatment plant of ANIWSP is planned. The agreed extraction capacity with Irrigation Department is shown in **Table 9.16**. The amount is well below the criteria of 500,000m^3/d, as stated above.

Table 9.16 Extraction Capacity Agreed with Irrigation Department

	Short term (until 2016)	Long term (until 2034)
Mahakanadarawa	6,800 m^3/d	18,800 m^3/d
Wahalkada	10,500 m^3/d	28,800 m^3/d

The number of families for resettlement is only one, which is well below the criteria of 100 families. In the pre-FS study, the water would be taken from the tank directory. The construction or establishing permanent structure conflicts with the conditions 3), 7) and 8) described above. The project changed the plan, and the water intake is decided to locate outside of the tank and place a certain distance from the tank to prevent any kind of impact to the surrounding environment of the water. The identification of the actual location of the protected area was difficult and confused because the protected area is under the control of many authorities. In order to clarify the problem, the NWSDB sent the letters to relevant authority and obtained the clearance. The clearances for each tank are listed in **Table 9.17**.

Table 9.17 Clearance for Tanks

Submitted to		→	Received from	
Item	Date		Obtaining Permission	Date
Request of approval for (old) Mahakanadarawa WTP	14/12/2011	CEA	Clearance for (old) Mahakanadarawa WTP (NCPO/AD/07/487/2012)	23/02/2012
Request of approval for Wahalkada WTP	13/01/2012	CEA	Clearance for Wahalkada WTP (NCPO/AD/07/499/2012)	23/02/2012
Request of Archeology Impact Assessment	22/09/2011	Dept. of Archeology	Clearance for Wahalkada WTP	04/10/2011
Request of approval for (New)	17/07/2012	CEA	Clearance for (New)	15/08/2012

Submitted to		→	Received from	
Item	Date		Obtaining Permission	Date
Mahakanadarawa WTP			Mahakanadarawa WTP (NCPO/AD/07/487/2012)	
Request of Archeology Impact Assessment	22/11/2011	Dept. of Archeology	Clearance for (New) Mahakanadarawa WTP and Intake (NCPO/AD/07/487/2012)	06/07/2012
Request for the Approval of proposed Anuradhapura North Integrated Water Supply Project	24/7/2012	Dept. of Wildlife conservation	Clearance for (New) Mahakanadarawaw WTP and intake (WL/06/028/460)	02/08/2012

On the other hand, the production capacity is more than 10,000 m^3/day so that the NWSDB has to obtain the EPL three months before starting operation

9.3.5 Requirements, Permissions and Standards

Requirements and permissions required for Project implementation are given below;

Table 9.18 Summary of Environmental Compliance Requirements for the Project Activities

	Project activity	Applicable Legislation	Statutory Requirement	Authorizing Body
1	Groundwater extraction projects of capacity exceeding 500,000 cubic meters per day	National Environment Act (NEA)	Environmental Clearance (EC)	Central Environment Authority (CEA)
2	Water treatment plant exceeding 500,000 cubic meters per day	NEA	EC	CEA
3	All activities in sensitive areas	NEA	EC	CEA
4	**All activities that require site clearance**	**Municipal Councils Ordinance No. 29 of 1947, the Urban Councils Ordinance No. 61 of 1939 and the Pradeshiya Sabha Act No. 15 of 1987 as amended**	**Clearance**	**Municipal Councils, Urban Councils and Pradeshiya Sabhas**
5	**All activities that require cutting of trees**	**Felling of Trees (Control) Act No 9 of 1951**	**Tree-cutting Permit**	**Forest Department**
6	All s activities within a 1 mile (1.6 km) radius of a national reserve	Section 14 of Fauna and Flora Protection (Amendment) Act, No. 22 of 2009	Clearance	Department of Wildlife Conservation
7	**All activities in close proximity of a reserve forest**	**Forests Ordinance No. 16 of 1907 as amended**	**Clearance**	**Forest Department**
8	All s activities in and around fishery	Fisheries and Aquatic	Clearance	Director of Fisheries

	Project activity	Applicable Legislation	Statutory Requirement	Authorizing Body
	reserves	Resources Act No. 2 of 1996		and Aquatic Resources
9	**All activities in proximity of archaeological reserves**	**Antiquities Ordinance No. 9 of 1940 as amended**	**Clearance**	**Department of Archaeology**
10	**All activities in and around irrigation development**	**Irrigation Development Act**	**Clearance**	**Director, Irrigation Department**
11	**All activities in and around declared urban development areas**	**Urban Development Authority Act No. 41 1978 and No. 4 of 1982**	**Clearance**	**Regional Director UDA**
12	**Water treatment plants having a treatment capacity of 10,000 or more cubic meters per day.**	**Gazette Notification No 1533/16 dated 25.01.2008**	**Environmental Protection License**	**CEA**

The hatched requirements are applicable to the ANIWSP.

The specific regulations and standards regarding environment and social consideration which will be applied to the Project are listed in **Table 9.19**.

Table 9.19 Summary of Basis of Regulations and Standards

Air Quality (discharge and ambient)	Discharge: No standard Ambient: The National Environmental (Ambient Air Quality) Regulations, 1994, published in Gazette Extraordinary, No. 850/4 of December, 1994 amended No. 1562/22 - Friday, August 15, 2008
Water Quality (discharge and ambient)	Discharge: National Environmental (Protection and Quality) Regulations, No. 1 of 2008 - Schedule I Ambient: Proposed standard
Drinking Water Quality	Sri Lanka Standards for potable water – SLS 614: 1983
Wastes (domestic and water treatment operation)	As specified in Environmental Protection License
Noise and Vibration	Noise: National Environmental (Noise Control) Regulations No.1 1996 Vibration: Proposed standards
Forest	Forest Ordinance No. 16 of 1907 (as amended) and the Rules and Regulations under the Ordinance
Wildlife	Fauna and Flora Protection Ordinance No. 2 of 1937 (as amended by Act Nos. 49 of 1993, 12 of 2005) and the Regulations under the Ordinance
Landscape	UDA Act No. 41 1978 and No. 4 of 1982
Heritage (Archeology)	Antiquities Ordinance No. 9 of 1940 as amended
Involuntary Resettlement	National Involuntary Resettlement Action Plan; Land Acquisition Act No.09 of 1950 (As Amended)
Protection of minority	The Constitution of Sri Lanka, 1978 as amended
Land expropriation and compensation	National Involuntary Resettlement Action Plan; Land Acquisition Act No.09 of 1950 (As Amended)
Safety of Labor	Factories Ordinance

9.4 Scoping Result and Research TOR

The scoping was done with the basis of the requirements of both Sri Lankan law and the JICA guidelines. The items cover all those in the check list attached in the JICA guideline in accordance with the condition stated in the CEA clearance, and also to follow the CEA guidance.

The CEA specifies the procedure on how to determine the significant impacts in the 'Guidance for Implementing the EIA Process'. It says that significant impacts should be determined based on considerations of both context and intensity, and the impacts should be evaluated in terms of following items.

1. Impacts that may be considered both beneficial and adverse.
2. The degree of effect on public health or safety
3. The degree of effect on unique characteristics of a geographic area; religious or cultural resources, archeological resources, nature reserves, wetlands, scenic areas, ecologically crucial areas, environmentally sensitive areas
4. The degree of impact on the environmental and social conditions, which is highly controversial
5. The degree of possible effect on the environment, highly uncertain or unique of unknown risks
6. The degree of effect for the future as a precedent.
7. The case of the total effect cannot be ignorable even they are insignificant individually.
8. The degree of effect for the right of future generation.

The scoping result is shown in **Table 9.20** and the research TOR is shown in **Table 9.21**.

Table 9.20 Scoping Result

	Item	Impact	Description
Pollution control (Construction stage)	Air	B (-)	Vehicles for construction generate exhaust gas and dust.
	Water quality	B (-)	There is possibility that turbid water will be generated by the construction work.
	Waste	B (-)	The construction work will generate surplus soil and waste.
	Noise and vibration	B (-)	Heavy equipment and trucks for construction will increase noise and vibration.
	Subsidence	D (0)	Groundwater level lowering work is not used.
Pollution control (operation stage)	Air	B (-)	There is possibility of spill from chlorine storage installation or chlorine dosing facility.
	Water quality	B (-)	Wastewater generated by the plant can contaminate the environment. Water quality of tank will not be changed because the facilities is located downstream, and amount of water use is not changed significantly.

	Item	Impact	Description
	Waste	B (-)	Sludge by the treatment process could contaminate the environment.
	Noise and vibration	B (-)	The operation of facility generates noise and vibration.
	Subsidence	D (0)	There is no possibility the plant will cause the subsidence because of no use of groundwater.
	Protected area	B (-)	The project site is not inside the protected area, but in the vicinity.
	Ecosystem (construction stage)	B (-)	Trees inside and around the site will be cut and it decreases the habitat of living things. Heavy equipment and vehicles generates noise and vibration, and this could worsen the living environment of living things.
	Ecosystem (Operation stage)	B (-)	There is no groundwater extraction and the water use amount is not changed much, so groundwater recharge is not affected significantly. The permanent discharge from the tank is only irrigation canal so the natural condition of river is not considerable. On the other hand, if the water will be taken from the canal for drinking water treatment, it results to secure the base flow discharge.
Social environment	Resettlement	B (-)	A few families are required to move.
	Living and livelihood	B (-)	Acquisition of cultivation land is suspected。(Decision of site is required) In case, the farmers benefit will be decreased. It is a project to convert the use of water from irrigation to drinking. The users of irrigation water (farmer) will decrease the benefit. Water tariff will increase when CBO receive water from NWSDB.
	Heritage	C	Department of archeology issued the letter of clearance. Newly added sites require additional Clearance.
	Landscape	D (0)	The project will not develop any large-scale structure which can change the local landscape.
	Ethnic group	D (0)	In the Project site, there are no indigenous people. The main ethnic group is Sinhalese.
	Labor environment	C	Labor environment will be secured under the relevant regulations.
Others	Effect by construction	B (-)	Estimation of migration of labor power is necessary. Traffic jam will be avoided.
	Monitoring	B (-)	Monitoring plan should be established.

＊Evaluation A（- - -or - -）: medium scale or large scale effect is expected

B(-)：effect is low

C：effect is unclear

D(0): no effect or improving direction

Table 9.21 Research TOR

Items	Survey items	Method
EIA and	(1) Monitoring of progress of obtaining	(1) Collection of information of required

Items	Survey items	Method
Environmental Permits	permissions	permissions. Hearing, Holding stakeholder meeting and obtain the written document.
Explanation to the Local Stakeholders	(1) Plan of awareness program (2) Activities of Regional project coordination committee	(1) It must be included in MOU (2) Meeting minute of regional project committee
Examination of Alternatives	(1) Water sources (2) Location of WTP and other facilities (3) Construction method	(1) Study mitigation measures to minimize adverse effect to environment and existing beneficiary (2)Minimizing land acquisition and resettlement, maximize the benefit (3) Study of construction method and route to minimize the adverse effect on environment and traffic.
Air	(1) Environmental standards(Sri Lanka, Japan, WHO, etc) (2) Current condition of Air pollution (3) Location of premise, school, hospital near the Project site (4)Effect of construction	(1) Literature survey (2) Literature survey (3) Field survey and hearing (4) Study of construction type, procedure, period, location, using equipment, transportation road
Water quality	(1) Water quality of water source (2) Current condition of water use (3) Suitability for drinking purpose	(1) Literature survey, hearing (2) Field survey and hearing (3) Field survey and pilot treatment
Waste	(1) Management of construction waste (2) Management of sludge	(1) Hearing of relevant organization, Case research (2) Hearing of relevant organization, Case research
Noise and vibration	(1) Environmental standards(Sri Lanka, Japan, WHO, etc) (2) Distance from source to the premises, school, hospital. (3) Effect of construction	(1) Literature survey (2) Literature survey, hearing (3) Study of construction type, procedure, period, location, using equipment, transportation road, simulation
Protected area	(1) Find the boundary of protected area (2) Confirmation of the positional relation between project site and protected area	(1) Hearing from relevant authority, obtaining written document such as meeting minute. (2) Hearing from relevant authority, monitoring the progress of obtaining permission
Ecosystem	(1) Inhabitation of endangered species (2) Study of the Project site	(1) Literature survey, hearing, site survey (2) Site survey
Land acquisition, resettlement	Magnitude of land acquisition, and resettlement In case of the land acquisition and resettlement is required, relocation plan is prepared.	Literature survey, hearing, site survey Making a relocation plan on the basis of Sri Lankan Act JICA guideline, Operational Policy 4.12 of WB.

Items	Survey items	Method
Living and Livelihood	(1) Sentiment of resident for changing water system (2) Change of livelihood, in case of land acquisition (3) Sentiment of resident for the possibility to increase the water tariff.	(1) (3) Socioeconomic survey (2) Hearing to the villagers
Heritage	(1) Possibility of important heritage existence in the Project area (2) Procedure for the case of excavated remains during construction	(1) Hearing with archeology department (2) Literature survey and hearing
Ethnic group, indigenous group	Condition of ethnic group, indigenous group in the Project site.	Hearing to the relevant authority and site survey
Labor environment	Sri Lankan regulation regarding labor environment and safety Safety measures for labors	Literature survey, hearing, case survey Planning of countermeasures and training regarding labor safety
Social infrastructure, service	Road condition of the Project site and vicinity	Projection of the traffic jam during construction
Monitoring	Adequacy of monitoring plan	Evaluation of monitoring plan

9.5 Result of Study

9.5.1 Examination of Alternatives

(1) Location of water intake and treatment plant

Originally, the location of the treatment plant was planned to be very near to a protected area and water would be taken from the tank directly. It means that the intake point will be within an environmentally sensitive area, so the original location was supposed to have an adverse effect on the natural environment. The intake point and location of the treatment plant were shifted in accordance with the suggestion of the Irrigation Department, and these facilities are now located outside of the protected area. An adverse effect on the environment is considered ignorable for the issues regarding location. However, still there is possibility to generate an adverse effect on the environment especially in construction period.

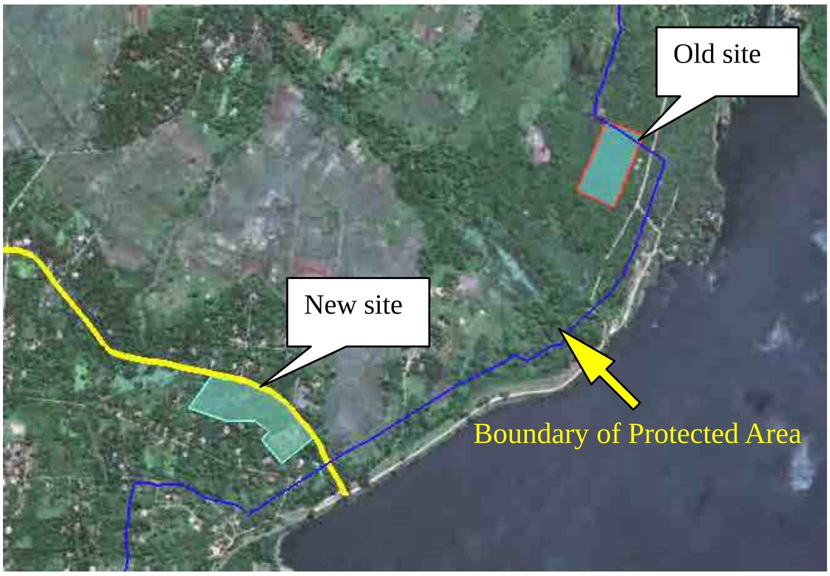


Figure 9.19 Mahakanadarawa Site Examination

In case of planned water treatment plan site of Wahalkada, three or four illegal occupants were recognized in the site. The Project decided to shift the site to prevent the any involuntary resettlement of irrespective titles.

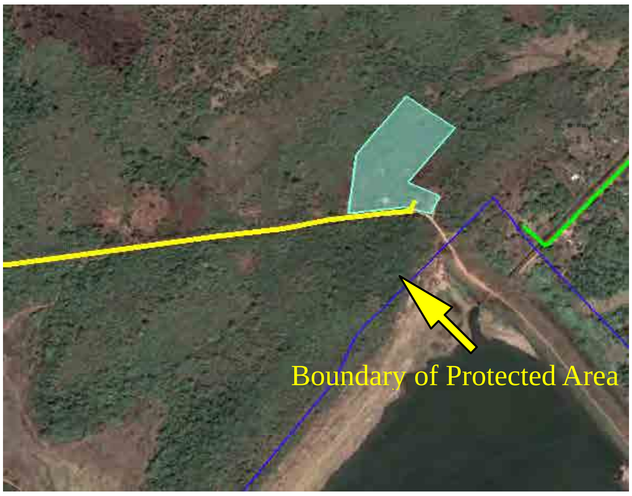


Figure 9.20 Wahalkada Site Examination

(2) Method of water intake

The methods of water intake are compared in **Chapter 5**. The study team examined and compared the method and tried to find the most environmentally friendly way. The comparison among four types of method is shown in **Table 9.22**.

Table 9.22 Comparison of Intake Method

	Method	Technical description	Evaluation of Impact
1	Intake well	This method is commonly used in lakes and reservoirs. Selection of intake depth is possible. Foundation should be stable.	The establishment of permanent construction inside the environmentally sensitive area results in serious effect.
2	Pontoon	This method uses floating body and the pump and electrical panels are installed on it. It needs wire anchors. The location of the intake can be moved. This method is not suitable if the water level varies significantly. Installation is not difficult and the cost is economical.	This method can reduce the adverse effect to compare to the method 1. But there is possibility that the floating movable body disturbs the habitat.
3	Inclined rail	A rail is installed on the incline of the bank, and the pump position is moved to suit the water level. Installation is not difficult and the cost is economical.	The adverse effect is lesser than method 1. But still it needs the construction work on the bund.
4	Canal Intake	Water is taken from the existing irrigation canal, which is operated by the Irrigation Department. The existing irrigation intake well takes water from the basement sill; therefore water quality has the characteristics of lake bottom water.	The intake does not affect directory the reservoir. The environmental impact is ignorable. The result of water quality monitoring reveals that the water quality does not differ significantly in depth.

Technically, the intake well method was considered the best procedure, but the environmental adverse effect seemed significant. On the other hand, the Irrigation Department raised the question to the construction work on the bund which was established many centuries ago. And Irrigation Department has a water right of full use of tank water and thought the difficulty of controlling extracted water quantity if the water was directly extracted from the tank. Alternatively, the idea of canal intake was examined. It seemed the best way from the viewpoint of protection of the environment surrounding the tank and irrigation reserve. The Project selected the canal intake procedure finally.

(3) Treatment procedure

The study team compared the water treatment procedure between the rapid sand filter method and slow sand filter method. The technical discussion is written in **Chapter 5**.

Here the result of comparison from the viewpoint of environmental and social considerations is tabled.

Table 9.23 Comparison of Treatment Procedure

	Item	Rapid sand filter (RSF)	Slow sand filter (SSF)	Evaluation
1	Area	Smaller area	Larger area	The area of land clearing is lesser in RSF and magnitude of the environmental impact will be smaller
2	Chemicals	Coagulant, pH adjuster, etc.	Not required	The use of chemical increase cost and waste.
3	Production of	Sludge amount is larger and	Sludge amount is almost	Smaller amount of sludge

	Item	Rapid sand filter (RSF)	Slow sand filter (SSF)	Evaluation
	sludge	sludge treatment procedure requires more energy	half of RSF	production save the energy and space for dumping
4	Quality of treated water	RSF is effective for removal of turbid. And it can reduce the color.	Result of experiment clealy shows that SSF cannot remove turbidity and color sufficiently.	The treated water by SSF is not suitable for drinking and domestic purpose of use due to high turbidity and color.

Slow sand filter method was considered environmental friendly and the Project was going to apply this procedure. But the result of practical experiment showed that SSF was not suitable for the raw water of this Project. Most essential requirement for the water supply is to secure the safe water supply. If the treated water contains unacceptable turbidity, it suggests the other materials are remaining in water. Due to the difficulty of treatment, the RSF procedure was selected with the consideration of principle of water supply and human's need,

(4) Configuration of facilities and buildings

Configuration of faculties and buildings are considered for reducing the potential impact to the surroundings. The noise and vibration generating facilities are located in the middle in the site as much as possible..

9.6 Evaluation of Impact

9.6.1 Air Quality

The expected causes of air pollution are exhaust gas by vehicles and heavy machineries and chlorine gas of leakage from chlorine gas storage place and chlorine injection facility.

(1) Exhaust gas

The regulation of exhaust gas was established under NEA as National Environmental (Air Emission, Fuel and Vehicle Importation Standards) Regulation in Gazette1137/35 23rd June 2000 in Sri Lanka.

Table 9.24 Discharge Standards for Petrol Vehicles

Type of Vehicle	Pollution Standard		Remarks
	Carbon Monoxide (CO (%vol)	Hydrocarbon HC (ppm v/v)	
Petrol wo/cc	a. > 5 years 3.0 < 5 years	1200	Low idling
Petrol w/cc	2	400	Low idling

Where:
wo/cc - Without catalytic converter
w/cc - with catalytic converter
. >5 years - vehicles more that 5 years old from the year of manufacture (used / unused)
< 5 years - vehicles less than 5 years old from the year of manufacture

Table 9.25 Discharge Standards for Diesel Vehicles

Type of Vehicle	Smoke Capacity% (k factor m-1)	
	Idle	Load
Diesel – Tare less than 1728 Kg Including three wheelers	65 (2.44)	75 (3.22)
Diesel – Tare more than 1728 kg	65 (2.44)	75 (3.22)

Table 9.26 Ambient Air Quality Standards

<table>
<tr><th rowspan="2"></th><th rowspan="2">Pollutant</th><th rowspan="2">Averaging Time*</th><th colspan="2">Maximum Permissible Level</th><th rowspan="2"></th></tr>
<tr><th>μgm^{-3}</th><th>ppm</th></tr>
<tr><td rowspan="2">1</td><td rowspan="2">Particulate Matter - Aerodynamic diameter is less than 10 µm in size (PM_{10})</td><td>Annual</td><td>50</td><td>—</td><td rowspan="4">Hi-volume sampling and Gravimtric or Beta Attenuation
Hi-volume sampling and Gravimtric or Beta Attenuation</td></tr>
<tr><td>24 hrs.</td><td>100</td><td>—</td></tr>
<tr><td rowspan="2">2</td><td rowspan="2">Particulate Matter - Aerodynamic diameter is less than 2.5 µm in size ($PM_{2.5}$)</td><td>Annual</td><td>25</td><td>—</td></tr>
<tr><td>24 hrs.</td><td>50</td><td>—</td></tr>
<tr><td rowspan="3">3</td><td rowspan="3">Nitrogen Dioxide (NO_2)</td><td>24 hrs.</td><td>100</td><td>0.05</td><td rowspan="3">Colorimetric using saltzman Method or equivalent Gas phase chemiluminescence</td></tr>
<tr><td>8 hrs.</td><td>150</td><td>0.08</td></tr>
<tr><td>1hr.</td><td>250</td><td>0.13</td></tr>
<tr><td rowspan="3">4</td><td rowspan="3">Sulphur Dixoxide (SO_2)</td><td>24 hrs.</td><td>80</td><td>0.03</td><td rowspan="3">Pararosaniliene Method or equivalent Pulse Flourescent</td></tr>
<tr><td>8 hrs.</td><td>120</td><td>0.05</td></tr>
<tr><td>1hrs.</td><td>200</td><td>0.08</td></tr>
<tr><td>5</td><td>Ozone (O_3)</td><td>1 hr.</td><td>200</td><td>0.1</td><td>Chemiluminescence Method or equivalent Ultraviolet photometric</td></tr>
<tr><td rowspan="3">6</td><td rowspan="3">Carbon Monoxide (CO)</td><td>8 hrs.</td><td>10,000</td><td>9</td><td rowspan="3">Non-Dispersive Infrared Spectroscopy”</td></tr>
<tr><td>1 hr</td><td>30,000</td><td>26</td></tr>
<tr><td>Anytime</td><td>58,000</td><td>50</td></tr>
</table>

The proper use of vehicle and machinery with sufficient maintenance achieves that the exhaust gas will meet the standards. The management of vehicle and machinery is obligation of the contractor and it is mentioned in the contract document.

(2) Chlorine

The Project uses chlorine for disinfection purpose and its source is chlorine gas. Chlorine gas has distinct and irritating odor and is hazardous for health. It is harmful if inhaled, and it causes respiratory tract burns, skin burns, and eye burns. It is physical hazards that containers may rupture or explode if exposed to heat. The gas dissolves quickly to water and generate hydrochloric acid which is harmful and corrosive and reacts with metals violently. For these reasons, the spill and leakage have to be prevented under severe controlling in order to secure workers’ health and protect the surrounding environment. The chlorine gas is heavier than air, its specific gravity is 2.5, and accordingly the evaporated gas runs down and stays. The gas is liquidized and kept in the cylinder. For the operation, gas is vaporized and introduced to the chlorinator, and dissolved into water to make chlorine water for disinfection. Consequently, the potential spill or leakage zone is from the chlorine storage house to chlorinator. Additionally, the minor potential is at the injection point of chlorine.

According to the design of the WTP facility, an automatic neutralization facility is attached to the storage room for the countermeasure to spill or leakage. The spilled or leaked chlorine gas will be collected and introduced to the scrubber and absorbed in liquid. It will be treated by neutralization facility safely. The gas leak detectors are placed at appropriate positions. Once the concentration of chlorine gas reaches certain level, the neutralization system will start working automatically. This system is able to lower the potential hazardous risk of chlorine gas exceedingly.

There are no specific regulatory criteria for the chlorine gas concentration in terms of occupational safety or environmental protection in Sri Lanka. But the standards provided by United States Department of Labor standards are usually referred. **Table 9.27** summarizes the referable values of chlorine concentration.

Table 9.27 Occupational Safety and Health Guideline for Chlorine

	ppm	mg/m3	Source
Permissible exposure limit	1	3	United States Department of Labor
Advisable limit	0.5	1.5	National Institute of Occupational Safety & Health
Evaluation standard	0.5	1.5	Notification No. 53 Department of Labor（Japan）

This level is achieved by the gas leak detector setting.

9.6.2 Water Quality

(1) Water Quality of Raw Water

Mahakanadarawa tank is located southern part of the Project area and population density is relative higher than northern part. Small villages exist in the vicinity and there are economic activities in catchment area. On the other hand, Wahalkada tank is located in sparse population area. The land of catchment is mainly covered by forest and paddy field, and the less potential of contamination. The monitoring of water quality of the water resources has been done since September 2010. The safety of the raw water was ensured by the research and it is described in Chapter 4.3.2. Some parameters exceeded the Sri Lankan drinking water standards, but these parameters are easy to remove from the water by the usual water treatment process, and any harmful chemicals were not detected in the research period. The monitored parameters and its detection conditions are summarized in **Table 9.28**

Table 9.28 Summary of Water Quality Monitoring

Detection condition	Parameters
Always less than desirable level	Electrical Conductivity, Chloride, Alkalinity, Nitrate, Fluoride, Phosphate, Total residue, Hardness, Sulphate, Anionic detergent, Phenolic compounds, Oil and grease, Ca, Mg, Zn, Chlorophyl a, Arsenic, Cadmium, Cyanide, Lead, Mercury, Selenium, Total Chromium, Pesticides
Sometime exceed desirable level but never exceed permissible level	Color, Chloride, Fluoride, Iron, Cupper, Manganese, Total Plate Count,
Exceed permissible level	Odor, Turbidity, Taste, pH, Ammonia, Albuminoidal ammonia, Nitrite, COD, Aluminum, E. Coli, Total coliform

The treatment plant and intake are located downstream of the tank and elevation of the facilities is lower than the bottom of tank, so there is no chance that any kinds of discharge water pollute the tank water.

(2) Impact of the Project

Two major impacts of the Project are considered significance.

- Change of water environment caused by the new water use.
- Load of discharge from the Project activities

1) Impact of new water use

Currently, the main water use of the tanks is irrigation purpose except a little amount of domestic use of villagers living in vicinity. The capacity of water resources is examined in Chapter 4.3.4, and the conclusion is that the additional water use for the Project does not affect the total impoundment quantity significantly. However, the farmers feel the scarcity of water for irrigation, and in fact, the quantity of irrigation water directory affects the amount of product. Besides, the other projects of irrigation scheme development are ongoing parallel, e.g. NCP canal project and Yan Oja project, and these projects will improve the water supply condition for the cultivation remarkably in this area. Assumingly, the Project will start operation in 2018, and the other projects will have started water supply for the area before 2018. The time schedule is shown in **Table 9.29** .The impact is not significant.

Table 9.29 Time Schedule of Relevant Project

		2012	2013	2014	2015	2016	2017	2018	2019
ANIWSP	DD								
	Construction								
NCP	DD								
	Construction								
Yan Oya	EIA								
	Construction								

2) Impact of discharge water from the Project activities

The standard of discharge water applicable to the Project is shown in **Table 9.30**.

Table 9.30 Tolerable Limit of Discharge to Inland Surface Water

No.	Parameter	Unit type of limit	Tolerance Limit values
1	Total suspended solids	mg/1, max.	50
2	Particle size of the total suspended solids	µm, less than	50
3	pH at ambient temperature	-	6.0 - 8.5
4	Biochemical oxygen demand (BOD_5 5 days at 20℃ or BOD3 $_3$ days at 27℃)	mg/1, max.	30
5	Temperature of discharge	℃, max.	Shall no exceed 400℃ in any section of the stream within 15 m down stream from the effluent outlet.
6	Oils and greases	mg/1, max.	10
7	Phenolic compounds (as C_6H_5OH)	mg/2, max.	1
8	Chemical oxygen demand (COD)	mg/3, max.	250
9	Colour	Wavelength Range 436 nm (Yellow range) 525nm (Red range) 620nm (Blue range)	Maximum spectral absorption coefficient $7m^{-1}$ $5m^{-1}$ $3m^{-1}$
10	Dissolved phosphates (as P)	mg/1, max.	5
11	Total Kjeldahl nitrogen (as N)	mg/1, max.	150
12	Ammoniacal nitrogen (as N)	mg/1, max.	50
13	Cyanide (as CN)	mg/1, max.	0.2
14	Total residual chlorine	mg/1, max.	1
15	Flourides (as F)	mg/1, max.	2
16	Sulphide (as S)	mg/1, max.	2
17	Arsenic (as As)	mg/1, max.	0.2
18	Cadmium (as Cd)	mg/1, max.	0.1
19	Chromium, total (as Cr)	mg/1, max.	0.5
20	Chromium, Hexavalent (as Cr6+)	mg/1, max.	0.1
21	Copper (as Cu)	mg/1, max.	3
22	Iron (as Fe)	mg/1, max.	3
23	Lead (as Pb)	mg/1, max.	0.1
24	Mercury (as Hg)	mg/1, max.	0.0005
25	Nickel (as Ni)	mg/1, max.	3
26	Selenium (as Se)	mg/1, max.	0.05
27	Zinc (as Zn)	mg/1, max.	2
28	Pesticides	mg/1, max.	0.005
29	Detergents/surfactants	mg/1, max.	5
30	Faecal Coliform	MPN/100 ml, max	40
31	Radio Active Material : (a) Alpha emitters (b) beta emitters	micro curie/ml, max micro curie/ml, max	10^{-8} 10^{-7}

<Construction Stage>

The main source of discharge from the construction site is rainwater. The rainwater is collected separately and let flow into drainage ditch, because the water quality of rain is safe as it is. There is no use of hazardous chemicals during the construction, and only few chance of contamination. Some construction works such as earth excavation, soil transfer, etc can generate turbid water. The turbid water is introduced into the sedimentation basin and turbid material will be settled down. The supernatant fluid will be discharged. If necessary, the coagulant will be used for enhancing the removal of turbid. The discharge water from the site is managed to meet the discharge water standards of Sri Lanka.

The contractor will prepare and manage potable toilets for laborers during construction.

<Operational Stage>

The discharge in operation was divided into two categories, (1) domestic wastewater and (2) water from drying bed.

The domestic wastewater of employees is treated by a septic tank and supernatant is discharged into a soak pit for infiltration into the ground.

The water treatment process is carefully considered to reduce the quantity of discharge by recycling, e.g. backwash water from the filter is transferred to the receiving well for recycling. The largest amount of discharge generated by usual operation is separated water from sludge. The sludge from sedimentation tank is transferred to a thickener tank and the thickened sludge is introduced to a drying bed. The separated water at the thickener is transferred to Backwash waste tank for recycling. The water in sludge will be evaporated in the drying bed, and under drain is discharged after discharge water quality will meet the requirement.

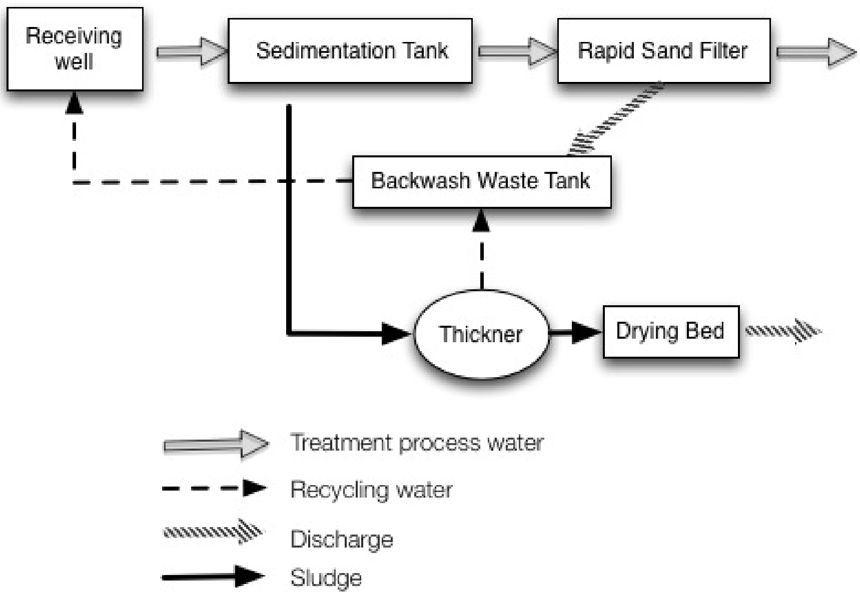


Figure 9.21 Schematic Diagram of Flow of Water and Sludge

9.6.3 Waste

1) Construction waste (Construction Stage only)

Construction waste is defined as waste from construction work, such as, cut tree, excavated soil, removed rock, packing material, and any other material related to construction. These are generated only the time of construction. The construction waste soil or rock material are treated properly by the contractor with the consultation of local authority. The contractor will place recycle bins in the yard for refuse segregation. The can, glass, plastic, cardboard, etc will be stored separately and will be transferred to recycling traders.

There has been started the establishment of recycling system in Sri Lanka in some limited area. The recycling practice is also being done by Anuradhapura municipality. The municipality sends the recyclable waste to a plant in Kurunegala after segregation of collected solid waste. The plant is located about 110km far from Anuradhapura. The Project is able to use the plant for recycling, and some particular material such as cans and empty bottles are collected by local company. The Project utilizes such system fully and reduces any type of solid waste. For this reason the segregation of solid waste is necessary at the consumption site.

2) Domestic waste (Construction and operation stage)

Domestic waste usually consists of garbage and rubbish. The domestic waste is collected to the certain temporally waste-collection point. And it will be transferred to the officially operated disposal field. The decomposable waste is treated by the compost. The solid waste disposal is operated properly with the guidance of the Pradeshiya Sabha.

3) Sludge (Operation stage only)

Sludge processing flow is shown **Figure 9.21**. The Sludge is generated by coagulation process and settled down at the sedimentation tank. The sedimentation is transferred to Thickener, and part of solid is condensed. Condensate is transferred to the drying bed and dried up under open air. The previous practice of NWSDB for sludge management was that the NWSDB went for tender of the disposal of dried sludge, which includes the services of collection, transport, carrying into the dumping site, with the approval letter of the landowner. In case of the Thuruwila WTP in Anuradhapura, the farmer organization is working for this business.

9.6.4 Noise and Vibration

<Construction stage>

Main expected sources of noise and vibration are vehicles and heavy machinery used for construction work. The permissible noise level for construction work is set by Gazette 924/12 21th May 1996. It is said that noise levels caused by such activity shall not be carried on for a period which in the aggregate exceeds three months, without the written consent of the Authority given in respect of any such particular activity.

Table 9.31 Maximum Permissible Noise Levels at Boundaries of the Land in which the Source of Noise Is Located in Laeq' ,T, for Construction Activities

	Duration	Laeq', T
Day time	6:00 ~ 18:00	75
Night time	18:00 ~ 6:00	50

The noise level generated by construction activities is 90 to 110dB usually. Assumingly the one noise source generates 100dB, the noise at the 7m far is fall in 75dB in open-air condition. Generally, the construction work can be controlled if the certain distance is kept to the boundary. If it is difficult, the use of tools for decreasing noise and vibration is recommended, such as sound insulation wall, sound proof cover, etc. The noise generating construction work is not done in night time. The noise generated construction stage is considered manageable.

<Operation stage>

The requirement of noise level is shown in **Table 9.32**. The Project area is categorized in Rural Residential Area.

Table 9.32 Maximum Permissible Noise Levels at Boundaries in LAeq, T, for Industrial Activities

Aria	Day time	Night time
Rural Residential Area	55	45
Urban Residential Area	60	50
Noise Sensitive Area	50	45
Mixed Residential	63	55
Commercial Areas	65	55
Industrial Area	70	60
Japanese Environmental Standard		
A (residential area)	55	45

Main sources of noise and vibration are pumps and generator.

The following table shows the configuration of noise creating machinery.

Table 9.33 Noise Generating Facilities and Estimated Noise

Pumps

DSD	Name	Noise level/ number of pumps	Number of pumps	Maximum number of operation	Distance from pump to the boundary	Expected maximum noise at boundary
Mahhakanadawara	WTP	80	3	2	32	45
	Intake	75	4	3	12	50
Rambewa	I-1 PS Rambewa	76~83	6	4	>15m	55
Medawachchiya	I-2 PS Medawachchiya	80~81	6	4	>15m	55
Wahalkada	WTP	73~81	3	2	63	40
	Intake	78	4	3	10	53
Kebithigollewa	II-1 PS Kahatagollewa	73~82	9	6	10	56
Kebithigollewa	II-2 Kebithigollewa	80~82	3	2	>15m	55
Horowpothana	II-3 Weerasole	83	3	2	>15m	53
Horowpothana	II-4 Horowpothana	72~84	9	6	10m	58
Kahatagasdigiliya	II-5 Kahatagasdigiliya	79	3	2	10m	52

Generators

DSD	Name	Noise level (Ultra low noise type)	Distance from pump to the boundary	Expected maximum noise at boundary
Mahhakanadawara	WTP	75	25	47
Wahalkada	WTP	75	73	38
	Intake	75	2	69

The expected maximum noise at boundary is calculated by simple noise damping model by use of point source case at the condition of maximum use of pumps. In almost all cases, the daytime noise level requirement is satisfied. But, the nighttime requirement is difficult to achieve if nothing is done. These pumps are set in the building and the wall can work as noise insulation in a certain dB level. The design of the building is considered from the viewpoint of the noise reduction.

Following measures are effective to reduce the noise level

- Use an appropriate foundation to reduce the vibration
- Use the sound decreasing tools or materials such as sound deadener, proof material, and sound insulating wall.
- The alignment is examined carefully to minimize the noise and vibration

By taking the noise protection measures, the noise and vibration level can meet the requirement.

9.6.5 Protected Area

The protected area near the Project site is explained in the **Section 9.2.3 (5)**. The Mahakanadarawa treatment plant was planned to extract water from Mahakanadarawa tank which was designated as the Sanctuary. However, the water intake location was changed to the irrigation canal and the location is now outside of the Sanctuary that was confirmed by the Department of Wildlife conservation. In addition, the location of the water treatment plant and intake point are shifted to hold the distance from the boundary of the Sanctuary more than 100m with the consideration of the concept of the buffer zone by the CEA for the environmental protection. Consequently, the environmental impact is highly decreased.

The all proposed sites are located outside of the protected area. But especially in construction stage, certain plan of transportation should be made to reduce the any negative effect on environment.

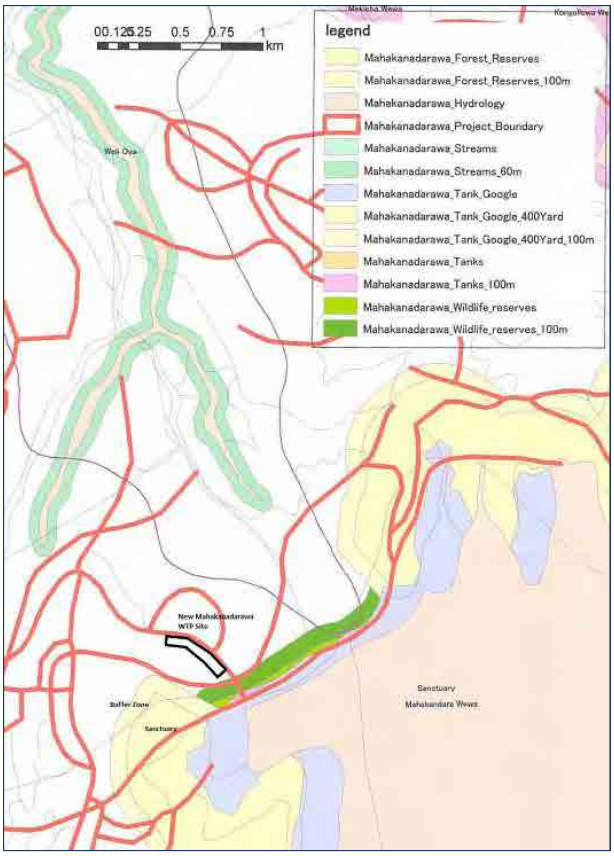


Figure 9.22 Environmental Protected Area in Mahakanadarawa

9.6.6 Eco System

The Fauna and Flora survey was carried out at the proposed project site.

1) Methodology of survey

The survey was limited to sites that are identified for various project activities (the direct impact zone). The principal habitat types found within the direct impact zone was investigated and the fauna and flora present was listed. Interviews were held with officials and communities in the area of influence to discuss safety issues, technical aspects, proposed remedial measures, and to identify environmental impact of proposed interventions.

Study Period: Phase I of this study was conducted during August 2012 while phase II was conducted in October immediately after the onset of North-east monsoon rains.

Sample Locations: During phase I, all sites identified for project activities in the

Mahakanadarawa scheme and some of the sites selected in the Wahalkada scheme were investigated. During Phase II, sites that were omitted during the Phase I and some of the environmentally sensitive sites identified during phase I was investigated. The list of sites investigated during the two phases are listed in the **Table 9.34**.

Table 9.34 The list of sites investigated during the two phases of the biodiversity survey

Name of project Location	Code	Phase 1	Phase 2
Mahakanadarawa Scheme			
Mahakanadarawa Tank and Surrounding Vegetation	(MT & SV)	✓	✓
Mahakanadarawa Water Treatment Plant Location	(M1)	✓	✓
Rambewa Sump & Water Tank Location	(M2)	✓	
Medawachchiya Sump Location	(M3)	✓	✓
Isenbessagala Water Tank Location	(M4)	✓	
Ethakada Water Tank Location	(M5)	✓	✓
East Rambewa Water Tank Location	(M6)	✓	✓
Wahalkada Scheme			
Wahalkada Tank and Surrounding Vegetation	(WT & SV)		✓
Wahalkada Water Treatment Plant Location (WTP)	(W1)		✓
Conveyor Pipeline to Wahalkada WTP	(CP)		✓
Kahatagollewa Water Tank Location	(W2)		✓
Bogahewa Sump Location	(W5)		✓
Weerasole Water Tank Location	(W6)		✓
Horowpothana Sump & Existing Tank Location	(W7)	✓	
Rathmalgahawewa Water Tank Location	(W9)	✓	✓
Kahatagasdigiliya Water Tank Location	(W10)	✓	
Kebithigollewa Existing Tank Location	(W11)	✓	
Kahatagollewa- Kebithigollewa Water Tank Location	(W12)		✓
North Horowpothana Water Tank Location	(W13)		✓
West Horowpothana Alt. 1 Location	(W14)	✓	✓
West Horowpothana Alt. 2 Location	(W15)	✓	
Halmillewa Water Tank Location	(W16)	✓	✓

2) Result of survey

(a) Habitats of the project area

The major natural habitats found in the project area are degraded dry-mixed evergreen forest (secondary forest), rock outcrops in the hills and riverine forests on the banks of streams. The types of habitats observed in each site are listed in the **Table 9.35**.

Table 9.35 Types of Habitat

Code	Name of the sample location	Main Habitat/ Vegetation Types
M1	Mahakanadarawa Water Treatment Plant	Water logged area and associated vegetation, Home garden, Secondary forests, Scrublands, Open area vegetation (Abandoned Land)
M2	Rambewa Sump & Water Tank	Home garden
M3	Medawachchiya Sump	Secondary forest
M4	Isenbessagala Water Tank	Abandoned land
M5	Ethakada Water Tank	Abandoned land, Secondary forest

Code	Name of the sample location	Main Habitat/ Vegetation Types
M6	East Rambewa Water Tank	Secondary forest
MT & SV	Mahakanadarawa Tank and Surrounding Vegetation	Exposed tank bed, Riparian vegetation, Surrounding rock outcrops and associated vegetation, Surrounding scrubland and forest vegetation
W1	Wahalkada Water Treatment Plant Location	Chena land, Secondary forests, Seasonal stream and associated vegetation, Abandoned land, Home gardens, Seasonal paddy lands
CP	Conveyor Pipeline to Wahalkada WTP	Seasonal paddy lands, Forest plantation
W2	Kahatagollewa Water Tank	Abandoned land
W5	Bogahewa Sump	Scrubland
W6	Weerasole Water Tank	Chena land
W7	Horowpothana Sump & Existing Tank	Home Garden
W9	Rathmalgahawewa Water Tank	Rock outcrop associated vegetation
W10	Kahatagasdigiliya Water Tank	Home garden
W11	Kebithigollewa Existing Tank	Home garden
W12	Kahatagollewa- Kebithigollewa Water Tank	Chena land
W13	North Horowpothana Water Tank	Abandoned land, Secondary forest
W14	West Horowpothana Alt. 1	Scrubland
W15	West Horowpothana Alt. 2	Abandoned land
W16	Halmillewa Water Tank	Secondary forest
WT & SV	Wahalkada Tank and Surrounding Vegetations	Exposed tank bed, Surrounding forests

The dry-mixed evergreen forest is the typical dry zone forest found in the project area dominated by species such as Palu (Manilkara hexandra), Wira (Drypetes sepiaria) and Burutha (Chloroxylon swietenia). Forests observed on the surrounding hills of Wahalkada tank and Mahakanadarawa tank resembles dry-mixed evergreen forests. Forest vegetation observed at Mahakanadarawa water treatment plant location, Medawachchiya sump location, Ethakada water tank location, East Rambewa water tank location, Wahalkada water treatment plant location, North Horowpothana water tank location and Halmillewa water tank location are more disturbed and degraded, hence categorized as degraded dry-mixed evergreen forests or secondary forests or open forests.

Most of the forest patches in the project area is degraded due to the forest clearance for chena cultivation. After abandonment, these lands are colonized by pioneer species such as herbs and scrub vegetation. The degraded areas are not converted back to the closed-canopy forests through natural succession and these could be regarded as scrublands.

(b) Flora of the Project Area

A total number of 245 plant species including 12 endemic and 6 nationally threatened species were recorded during the field survey within the study area. A summary of the plant species observed is given in **Table 9.36**. The majority of the plant species recorded are tree species (118) followed by herbaceous species (55), climbers (44), shrubs (26) and epiphyte (2) (Table 2). About 17.5 % of the recoded plant species are exotic to the country and about

77.5 % of the recorded plants are native species. None of the recorded plant species are unique or restricted to the project area.

Table 9.36 Summary of the Plant Species Recorded During the Study

Plant Type	Total	Threatened	Endemic	Native	Introduced
Tree	118	EN – 1, VU – 3	9	91	18
Shrub	26	0	0	17	9
Herb	55	0	0	41	14
Epiphyte	2	VU – 1	0	2	0
Climber/ Creeper	44	VU – 1	3	39	2
Total	**245**	**EN – 1, VU – 5**	**12 (5%)**	**190 (77.5%)**	**43 (17.5%)**

Abbreviations used: **EN** - Endangered, **VU** – Vulnerable

Out of 245 plant species recorded in the proposed project area during the field study, 12 (5 %) plant species are endemic to the country and 6 endemic plant species observed in and around the project sites are listed as Nationally Threatened. The detailed results are listed in **Appendix 9.6(a)**.

Table 9.37 Endemic and Nationally Threatened Plant Species recorded from the project sites

Family	Scientific Name	Local Name	HA	TS	CS
Apocynaceae	*Wrightia angustifolia*		T	E	
Arecaceae	*Calamus rotang*	Heen Wewel	C	N	VU
Asteraceae	*Vernonia zeylanica*	Pupula	C	E	
Celastraceae	*Cassine glauca*	Neralu	T	E	
Convolvulaceae	*Argyreia populifolia*	Giritilla	C	E	
Ebenaceae	*Diospyros ebenum*	Kaluwara	T	N	EN
Ebenaceae	*Diospyros nummulariifolia*		T	E	
Erythroxylaceae	*Erythroxylum zeylanicum*		T	E	
Euphorbiaceae	*Cleistanthus pallidus*		T	E	
Euphorbiaceae	*Drypetes gardneri*	Gal Wira	T	E	
Euphorbiaceae	*Margaritaria indicus*	Karawu	T	N	VU
Fabaceae	*Derris parviflora*	Kala Wel	C	E	
Melastomataceae	*Memecylon capitellatum*		T	E	
Orchidaceae	*Vanda tessellata*		Ep	N	VU
Rubiaceae	*Haldina cordifolia*	Kolon	T	N	VU
Rubiaceae	*Mitragyna parvifolia*	Helamba	T	N	VU
Rutaceae	*Micromelum minutum*	Wal Karapincha	T	E	
Sapindaceae	*Glenniea unijuga*	Wal Mora	T	E	

Abbreviations used: **HA** - Habit, **T** - Tree, **C** - Climber or Creeper, **Ep** - Epiphyte, **TS** - Taxonomic Status, **E** - Endemic species, **N** - Native species, **CS** - Conservation Status, **EN** - Endangered, **VU** - Vulnerable

(b) Fauna of the Project Area

Total number of 147 faunal species including 7 endemics was recorded during the survey. The faunal assemblage also included 5 species that are listed as Nationally Threatened and 4 speies listed as Glbally Threatened. A further 7 species of butterflies, birds and mammals that are listed as Nationally Near Threatened (NT) (IUCN SL and MENR, 2007) were also recorded in the project area. The faunal assemblage recorded in the project area also included two species of exotic fish and two species of migrant birds.

Table 9.38 Summary Information of the Fauna Observed during the Survey

Taxonomic Group	Total	Endemic	Migrant	Exotic	CR	EN	VU	NT
Dragon flies	9							
Butterflies	22					1		1
Fish	11	1		2				
Amphibians	3							
Reptiles	12	1					1	
Birds	74	2	2					4(2)
Mammals	16	3				1(3)	2(1)	2(1)
Total	147	7	2	2	0	2(3)	3(1)	7(3)

Abbreviations used: **CR** - Critically Endangered, **EN** - Endangered, **VU** - Vulnerable, **NT** - Near Threatened

A total of seven endemic species of fauna were recorded from the study area (**Table 9.38**). Many of these endemic species show an island wide distribution. None of the endemic species observed are restricted to the study area. Observed low endemicity in the project area is not an unusual phenomenon given the fact that dry zone habitats support lesser number of endemics.

Three Nationally and four Globally Threatened species of fauna were recorded from the study area. In addition, Seven Nationally and three Globally Near Threatened species were also recorded in the various habitats present in the direct impact zone of the project site. As in the case of endemic species number of threatened species was also found to be low in the immediate impact zone of the project. This is usually the case in the dry zone as most of the threatened species are restricted to the wet zone of Sri Lanka. Further, none of the threatened species are restricted to this area since all of these species show relatively wide distributions in Sri Lanka albeit being listed as threatened due to number of threats that operate on these species. The detailed results are listed in **Appendix 9.6(b)**.

Table 9.39 List of endemic and threatened fauna observed during the survey

Family	Scientific Name	English Name	TS	NCS	GCS
BUTTERFLIES					
Lycaenidae	*Jamides alecto*	Metallic Cerulean	N	NT	
Nymphalidae	*Junonia orithya*	Blue pansy	N	EN	
FISHES					
Cyprinidae	*Puntius singhala*	Filamented Barb	E		
REPTILES					
Agamidae	*Otocryptis nigristigma*	Black spotted kangaroo lizard	E		
Testudinidae	*Geochelone elegans*	Indian star tortoise	N	VU	

Family	Scientific Name	English Name	TS	NCS	GCS
BIRDS					
Bucerotidae	*Anthracoceros coronatus*	Malabar Pied Hornbill	N	NT	NT
Burhinidae	*Burhinus oedicnemus*	Eurasian Thick-knee	N		NT
Ciconiidae	*Ciconia episcopus*	Woolly-necked Stork	N	NT	
Hirundinidae	*Hirundo daurica*	Red-rumped Swallow	M	NT	
Phasianidae	*Gallus lafayetii*	Sri Lanka Junglefowl	E		
Timalidae	*Pellorneum fuscocapillum*	Sri Lanka Brown-capped Babbler	E	NT	
MAMMALS					
Cercopithecidae	*Macaca sinica*	Sri Lanka toque monkey	E	NT	EN
Cercopithecidae	*Semnopithecus vetulus*	Purple-faced leaf monkey	E	VU	EN
Cercopithecidae	*Semnopithecus priam*	Grey langur	N	NT	NT
Elephantidae	*Elephas maximus*	Elephant	N	VU	EN
Sciuridae	*Ratufa macroura*	Giant squirrel	N		NT
Ursidae	*Melursus ursinus*	Sloth bear	N	EN	VU

Abbreviations: **NCS** - National Conservation Status; : **GCS** – Global Conservation Status; **EN** - Endangered, **VU** - Vulnerable, **NT** - Near Threatened;

(c) Conclusion

The proposed project areas lie within the low country dry zone. The most abundant habits/ landuse types observed in the direct impact zone of the project sites include home gardens, abandoned lands and cultivated lands. The area supported mostly common plant or animal species associated with such human influenced habitats. Only few species of endemic or threatened fauna and flora were observed in and around the project site. This low numbers of endemic and threatened species in the area is consistent with the distribution pattern of endemic and threatened species in Sri Lanka, where majority of these species are restricted to the natural habitats in the wet zone of Sri Lanka. None of these endemic or threatened species observed are restricted to the project area or will be adversely affected by the proposed project activities. No major invasive plant species was observed at the project sites. No critically endangered species were found in the project area. There is no nesting place in the Project site and many of fauna species can move . For these reasons, the adverse impact on ecosystem is not so large. However, the land clearance and construction work could disturb the ecosystem, so the mitigation measures should be taken.

	
Mahakanadarawa Tank and Surrounding Vegetations	Mahakanadarawa Water Treatment Plant Site (M1)
	
Rambewa Sump & Tank Site (M2)	Medawachchiya Sump Site (M3)
	
Isenbessagala Tank Site (M4)	Ethakada Tank Site (M5)

Figure 9.23 Photographic Catalogue of Study Sites

	
East Rambewa Tank Site (M6)	Wahalkada Tank and Surrounding Vegetations
	
Wahalkada Water Treatment Plant Site (W1)	Conveyor Pipeline to Wahalkada WTP
	
Kahatagollewa Water Tank Site (W2)	Bogahewa Sump Site (W5)

Figure 9.23 Photographic Catalogue of Study Sites (Cont'd)

	
Weerasole Water Tank Site (W6)	Horowpothana Sump & Existing Tank Site (W7)
	
Rathmalgahawewa Tank Site (W9)	Kahatagasdigiliya Tank Site (W10)
	
Kebithigollewa Existing Tank Site (W11)	Kahatagollewa- Kebithigollewa Water Tank Site (W12)

Figure 9.23 Photographic Catalogue of Study Sites (Cont'd)

North Horowpothana Water Tank Site (W13)

West Horowpothana Alternative-2 Site (W14)

West Horowpothana Alternative-1 Site (W15)

Halmillewa Tank Site (W16)

Junonia orithya (Blue Pansy), Recoded Endangered (EN) Butterfly Species

Figure 9.23 Photographic Catalogue of Study Sites (Cont'd)

9.6.7 Living and livelihood

The living and livelihood of people in the Project area is changed greatly in water sources and water use pattern.

Currently, the main water source in this area is groundwater even if the case of piped water supply. There are two types of water supply scheme; CBO and NWSDB that use the groundwater for supply.

100% CBO users are willing to have the water supply by the new scheme of NWSDB. And they expect to get better quality water for 24 hours supply. The water resource they want is tank water (70%), spring water (7%), and others answered ‘good water’ (23%). On the other hand, the 100% of existing NWSDB water supply users are also willing to have the new water supply scheme with the use of other water source. 83% of respondents wish to receive the supply water of treated tank water 4% wish spring water, other 13% wish ‘good water’.
In case of the people who don’t have piped water supply service, 99% are willing to have the water supply and 85% of them wish the tank water as water source, 8% wish spring water, 7% wish ‘good water’ and near 1% wish ground water.

Almost all people living in the area hope to have the new water supply scheme with the use of surface or spring water.

The willingness to pay for the new water supply scheme is summarized in **Table 9.40**. The parenthetic value is current payment amount of water supply for reference. NWSDB users pay a little more than CBO users in average, and are willing to pay a bit more in the same way. The Non-user group shows more amount for willingness to pay.

Table 9.40 Willingness to Pay for New Water Scheme

User group	Minimum	Medium	Mean	Maximum	% of RA*
CBO User WTP	80 (70)	300 (300)	354 (346)	2,500 (1,500)	44
NWSDB User WTP	200 (70)	400 (300)	477 (409)	1,000 (2.300)	72
Non user	100	300	460	10,000	54

* RA: The answer ‘relevant amount’ or ‘reasonable price’

In this questionnaire survey, many of respondents didn’t answer with the apparent figure for the amount. More than half respondents answered such as ‘relevant amount’ or ‘reasonable price’. The percentage of such answered is shown in same table.

The research result shows the positive attitude of the people for the new water supply scheme. The people already have the supplied water service want to pay a bit more for the better quality water and better service.

9.6.8 Heritage

The project site is located outside of the archaeological reserves and protected monuments which are declared by the Department of Archaeology. Not only that, the project obtained the clearance for carrying out the survey and construction at the proposed site from the Department of Archaeology. However, the whole Anuradhapura is known as ancient kingdom and there is a possibility to have buried antiquity. The special treat procedure during construction stage has to be determined in a contract document with the guidance of Department of Archaeology.

In case the antiquities are excavated during construction, the usual procedure what the project proponent should follow is shown as follows, and the all of discovered things will belong to Department of Archaeology.

1) The project proponent should stop the construction work, and make a contact to the regional office of the Department of Archaeology.
2) The Department of Archaeology sends an officer to the site. The officer provides the guidance how to carry out the construction work. And the construction will continue. The officer does not stay continuously, but responsible for the supervising.
3) In case the antiquity is excavated again, the project proponent should stop the work and wait for the direction by the Department of Archaeology.

These protocols are clearly written in contract document. The example of ICTAD chapter 4.16, it is said that 'All fossils, coins, articles of value or antiquity, and structures and other remains or items of geological or archaeological interest found on the Site shall be placed under the care and authority of the Employer. The Contractor shall take reasonable precautions to prevent Contractor's Personnel or other persons from removing or damaging any of these findings.'

9.6.9 Minority and Ethnic Group

According to the report of the social survey, the indigenous group does not exist in the project site. The minority group in this area is Muslim and Tamil. The directly affected person who needs to resettle the house belongs to majority group.

9.6.10 Labor Environment

<Construction stage>

Labor environment is managed by the contractor with the guidance of PMCU. The essential required measures for occupational safety, health, and hazard management are written in a contract paper in accordance with the Sri Lankan Law and international practice. The general specification document of bigger contract price project is prepared on the basis of the 'Standard Bidding Document Procurement of Works (Major Contracts)' published by Institute for Construction Training and Development (ICTAD) in Sri Lanka. In case of international bidding, ' Conditions of Contract for Works of Civil Engineering Construction' published by Federation Internationale des ingenieurs-conseils（FIDIC）is used as a basis. The labor environment is conserved with these contract conditions. The contractor is responsible for implementing the conditions and providing the safety facility, safety tools, and training for safety program.

For example, following expression is said as an important duty in above documents.

The contractor shall, throughout the execution and completion of the Works and the remedying of any defects therein:

(a) have full regard for the safety of all persons entitled to be upon the Site and keep the Site and the Works in an orderly state appropriate to the avoidance of danger to such persons

(b) provide and maintain at his own cost all lights, guards, fencing, warning signs and watching, when and where necessary or required by the Engineer or by any duly constituted authority, for the protection of the Works or for the safety and convenience of the public ore others.

(c) take all reasonable steps to protect the environment on and off the Site and to avoid damage or nuisance to persons or to property of the pubic or others resulting from pollution, noise or other causes arising as a consequence of his methods of operation.

Table 9.41 Legal System of Labor Environment

Field	Corresponding law
Terms and conditions of employment	• The Shop and Office Employees (Regulation of employment & remuneration) Act • Wages Board Ordinance
Social security	• Employees provident Fund • Employees Trust Fund • Payment of Gratuity Act
Industrial safety	• Factories Ordinance • Workmen's Compensation Ordinance
Employment of women and children	• Employment of Women, Young Persons and Children Act • Maternity Benefits Ordinance

The Factory Ordinance defines and orders the issues related to occupational safety, health and hazards management. The activities required on the Ordinance will be secured by the contract condition which is made under the 'Standard Bidding Document Procurement of Works' or 'Conditions of Contract'.

<Operation Stage>
The labor environment is under responsibility of the NWSDB in operation stage. NWSDB should prepare the safety materials as an actual thing, and provide training and drill as a capacity development of the labors. The special safety tools such as eye washer and shower for emergency case of chlorine leakage are designed.

9.7 Mitigation Measures

List of adverse impacts and its mitigation measures
The adverse impacts and its mitigation measures are listed in **Table 9.42**. The column of Impact shows the evaluation of potential impact after taking mitigation measures.

Table 9.42 List of Adverse Impacts and Its Mitigation Measures

Pre construction stage

Impact	Object	Mitigation measures	Impact	In charge or implemented by	Supervising
Noise and vibration	Pump, generator and other noise generation facility	● Low noise/vibration pump and generator are specified in tender document. ● Building is designed with the consideration to decrease noise and vibration to meet the requirement. ● Location of these facilities is examined.	Minor	NWSDB HO	PMU (CEA)
Waste	Construction waste and Domestic waste	● Waste management plan is prepared under discussion with CEA and DS. ● Temporally dumping area is secured.	Minor	NWSDB RSC	PMU DS CEA
Ecological impact	Clearing land	● Clearing land and cutting tree are planned under the discussion with Forest Dept and/or CEA.	Minor	NWSDB RSC	PMU Forest Dept CEA
	Rare species	● Making a plan of transplant and recovery of habitat	Minor	NWSDB RSC	PMU Wildlife dept CEA
Resettlement	Resettlement	● Progress of resettlement and its fairness are monitored.	Minor	NWSDB RSC	PMU DS
Social impact	Stakeholder meeting	● Discussion and making agreement about construction schedule, procedure, and impact	Minor	NWSDB RSC	PMU PCC
	Public relation activities for local residents	● Explanation for local residents and to develop understanding about construction work schedule, expected impacts, mitigation measures etc.	Minor	NWSDB RSC	PMU DS

NWSDB RSC : National Water Supply and Drainage Board
PMU: Project Management Unit
PCC: Project Coordination Committee
DS: Divisional Secretariat
Additional GM for water supply

Construction stage

Impact		Mitigation measures	Impact	In charge or implemented by	Supervising
Air pollution	Exhaust gas	● To ensure the use of vehicles and machineries officially registered, and properly maintained.	Minor	Contractor	PMU
	Dust	● To cover the earth or dusty materials ● To sprinkle water to prevent the dust raising.	Minor	Contractor	PMU
	Leakage of chlorine gas	● Guidance of proper installation ● Safety training to laborer	Minor	Contractor	PMU

Impact		Mitigation measures	Impact	In charge or implemented by	Supervising
Noise	Vehicles and machinery	● To ensure the use of vehicles and machineries officially registered, and properly maintained. ● Unnecessary idling is not allowed. ● Route of transportation is examined to prevent noise or other effect on vicinity.	Minor	Contractor	PMU
	Construction work	● To avoid doing the work generating noise and vibration at nighttime. ● Sound insulation wall will be used if necessary.	Minor	Contractor	PMU
Water quality	Water source	● Making water resource protection plan with the commitment of relevant authority	Minor	PMU	PD
	Discharge water	● Clean water such as rain water is separately collected to prevent from mixing with muddy materials ● Turbid water generated by earthwork is introduced to the sedimentation basin and turbid material will be settled. ● If necessary further treatment (use of coagulant) is done.	Minor	Contractor	PMU
	Domestic effluent	● Effluent is treated by the soak pit.	Minor	Contractor	PMU
	Oil and grease	● Oil and grease are kept separately in the container. ● Oil absorbent is prepared.	Minor	Contractor	PMU
Waste	Construction waste	● The waste reduction plan and dumping procedure will be proposed at the tender document and implemented. ● The temporally dumping yard for construction waste is secured. ● Waste is segregated in order to recycling purpose. ● Recyclable material is transferred to the recycling manufacturer. ● Waste which is not recyclable is disposed to follow the fixed rule of relevant DS.	Minor	Contractor	PMU
	Domestic waste generated by laborer	● Domestic waste is placed at the temporally damping yard, and transferred to the officially operated disposal field	Minor	Contractor	PMU
Ecological environment	Violation to ecosystem	● Training and awareness program for laborer is planned and done. ● Scheduled patrol of the site	Minor	Contractor	PMU
	Trees and plant	● Clearing land is minimized and the large tree is remained as far as possible, or transplanted.	Minor	Contractor	PMU

Impact		Mitigation measures	Impact	In charge or implemented by	Supervising
	Rare species	● If the special species will be found out at the site, report to NWSDB and receive the guidance of CEA or wildlife dept.	Minor	Contractor	PMU CEA Wildlife dept
Archaeological impact	Excavating antiquity	● If the antiquity will be excavated at the site, report to NWSDB and receive the guidance of Archaeological dept.	Minor	Contractor	PMU Archaeological dept.
Social impact	Social conflict caused by laborer	● Training and awareness program for laborer are planned and done. ● Security guard is appointed.	Minor	Contractor	PMU
	Inconvenience of livelihood	● Pipe laying work on the road is planned carefully to prevent inconvenience as much as possible. ● Refraining from working during peak hours to prevent road traffic blocks ● Public notice prior to construction	Minor	Contractor	PMU
Working condition	Occupational safety	● Training and awareness program for laborer is planned and done. ● Safety tools are provided to laborer by Contractor.	Minor	Contractor	PMU

Operation stage

Impact		Mitigation measures	Impact	In charge or implemented by	Supervising
Air pollution	Leakage of chlorine gas	● Gas monitor is working always at proper condition ● Safety training to laborer	Minor	NWSDB RSC	NWSDB HO
Noise	Noise generation facility (pump etc)	● To ensure the proper operation and maintenance	Minor	NWSDB RSC	NWSDB HO
Water quality	Discharge water	● Under drain water from sludge drying bed should be managed to meet the standards.	Minor	NWSDB RSC	NWSDB HO
	Domestic effluent	● Effluent is treated by the soak pit.	Minor	NWSDB RSC	NWSDB HO
	Oil and grease	● Oil and grease are kept separately in the container	Minor	NWSDB RSC	NWSDB HO
Waste	Domestic waste	● Domestic waste is placed at the temporally collection place, and transferred to the officially operated disposal field	Minor	NWSDB RSC	NWSDB HO
	Sludge	● Sludge is dried up at the drying bed to reduce its quantity ● Dried sludge is dumped by the contract with the approval of land	Minor	NWSDB RSC	NWSDB HO

Impact		Mitigation measures	Impact	In charge or implemented by	Supervising
		owner.			
Working condition	Safety and health	● Safety and emergency tool is always ready. ● Safety training is provided on schedule. ● Newly hired employee shall have safety training.	Minor	NWSDB RSC	NWSDB HO

9.8 Monitoring Plan

The monitoring is important to check whether the impacts on environmental and social conditions are mitigated and controlled sufficiently. The monitoring activities divide into three stages; designing stage, construction stage operational stage.

<Monitoring of designing stage>
The design regarding mitigation measures is examined in this stage. And the progress of obtaining permission and progress of resettlement are checked too.

<Monitoring of construction stage>
The expected impacts caused by the construction activities are mainly monitored by the Contractor under the supervision of the NWSDB. The concept of monitoring scheme is shown in **Figure 9.23**.

<Monitoring of Operational stage>
NWSDB is responsible for continuous monitoring for protecting environmental and social condition, and for checking proficiency of the operation.

9.8.1 Structural plan of monitoring

In order to carry out successful and effective monitoring, the structural establishment with appropriate assigning of task and responsibility is important.

Project Coordination Committee will be established and it will provide the table of discussion for any issues arises at the site.

The monitoring structure is proposed as follows.

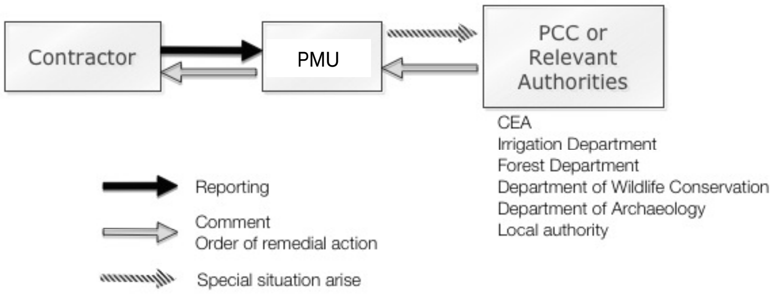


Figure 9.23 Monitoring Structure for Construction Stage

The tasks of concerning organizations are summarized in **Table 9.43**

Table 9.43 Tasks of Relevant Organization for Resettlement

Organization	Task
Construction Contractor	Implementing mitigation measures as proposed Conducting monitoring Reporting to the NWSDB
PMU (Project Management Unit)	Making monitoring plan Examine the monitoring result and provide appropriate guidance to contractor Reporting to DS Reporting to other authority if needs arise
PCC (Project Coordination Committee)	Supervising project activities in any regards
CEA	Providing consultation for environmental protection issues
Divisional Secretariat	Superintending the whole project activities Managing the public consultation
Irrigation department	Providing consultation for the design, construction procedure, monitoring of construction, and water intake operation
Forest department	Providing consultation for clearing land and proper land use
Department of Archaeology	Supervising the construction work in case of the important antiquity is excavated
Department of Wildlife Conservation	Providing consultation for any issues regarding ecosystem

Table 9.44 Monitoring Plan

Items	Monitoring parameters	Procedure	Frequency	Implemented and reported by	Report to
Designing stage					
Procurement	Suitability of specification	Checking the specification to meet the proposed mitigation measures	1 time	NWSDB	PMCU
Waste	Waste management procedure	Checking dumping plan and obtaining agreement with local authority	1 time	NWSDB	PMCU
Resettlement	Progress of resettlement plan	Checklist of resettlement plan	1 time	NWSDB	PMCU
Ecological environment	Clearing land procedure	Checking the plan of clearing and obtaining permission	1 time	NWSDB	PMCU
	Rare species	Checking the plan of transplant and recovery of habitat	1 time	NWSDB	PMCU
Social impact caused by laborer of construction	Awareness raising program	Training plan of laborer	1 time	NWSDB	PMCU
Construction stage					
Air quality	Vehicle maintenance condition	Check the registered vehicles and its maintenance record	Once a month	Contractor	PMCU
	Dust	Observation at the site	Once a month	Contractor	PMCU
	Chlorine gas emission	Check and calibrate the gas leak detector	Once a month	Contractor	PMCU
Water quality	Discharge water quality	Measurement of turbidity	Everyday during soil work	Contractor	PMCU
Noise	Working time of construction	Working record	Once a week	Contractor	PMCU
	Noise at boundary	Measurement of noise at the boundary of the site	Once a month both in daytime and night time	Contractor	PMCU
Ecological environment	Violation to ecosystem, such as cutting tree, hunting, killing taking plants and animals, disturbing habitat etc.	Patrol of construction site	Once a week	Contractor	PMCU
Waste	Construction waste	Condition of segregation Past record of recycling	Every 3 months	Contractor	PMCU

Items	Monitoring parameters	Procedure	Frequency	Implemented and reported by	Report to
	Domestic waste	Observation of temporally dumping yard	Every 3 months	Contractor	PMCU
Operation stage					
Air quality	Chlorine gas leakage	Measurement of gas concentration and check and calibration of gas leak detector	Once a week	NWSDB RSC	NWSDB
Raw water quality	Parameters listed in drinking water quality	Chemical analysis by laboratory	Once a month	NWSDB RSC	NWSDB
Distributing water quality	Parameters listed in drinking water quality	Chemical analysis by laboratory	Once a month	NWSDB RSC	NWSDB
Discharge water quality	Parameters listed in discharge water quality	Chemical analysis by laboratory	Every 3 months	NWSDB RSC	NWSDB
Occupational safety	Chlorine gas leakage	Measurement of gas concentration	Checking the daily record	NWSDB RSC	NWSDB
Noise	Noise at the boundary	Measurement of noise	Every 3 months	NWSDB RSC	NWSDB
Waste	Sludge	Observation of the drying bed Checking the record of sludge disposal	Every 4 months	NWSDB RSC	NWSDB

9.9 Stakeholder Meeting

9.9.1 Information Sharing with Stakeholders

Public participation is a part of the EIA process. The public has a right to be informed about the coming projects. In order to prevent future conflict, activities regarding information sharing and raising public awareness are important and essential.

(1) Information sharing with CBOs
NWSDB holds technical training program for CBOs on a regular basis and utilizes the opportunity for public information.

(2) Information sharing with the local representatives
A meeting titled 'Anuradhapura district water supply activities progress review meeting' was held on 11 June 2012, chaired by the Minister of Water Supply and Drainage. The main attendants were representatives and officials from the north central province, such as member of provincial council, chairman of Pradeshiya Saba, district secretary, divisional secretary, and relevant authorities. DGM (NC) explained about the ongoing and future water supply projects including the ANIWSP. A questions and answers session was held and many issues regarding project implementation were discussed among the stakeholders.

(3) Information sharing with the local authority
The meeting to discuss the environmental compliance with local authority was held on 30th May 2012 in order to confirm necessary actions for environmental and social issues regarding the Project implementation. The meeting minute is attached as Appendix 9.9(a).

9.9.2 Explanation Meeting

NWSDB and DSD held the explanation meeting to the direct affected people on 7th August, 8th and 23rd September and 10th October. Agendas, attendant lists and meeting minute are attached as Appendix 9,9(b). The villagers who are mainly beneficially of irrigation had shown negative attitude to the Project understood the necessity of the Project and agreed to cooperate with the Project. The MOU was concluded between ?? It is attached as Appendix 9.9(c).

9.10 Land Acquisition and Human Resettlement

9.10.1 Necessity of resettlement and land acquisition

NWSDB searched the project area in government land as much as possible, and most of land is in government land. The largest land use of the Project is land for the water treatment plant. The land for two treatment plants were found in government land and the current land leaseholders agreed to transfer the right. The other land necessary for the Project is the land for distribution network. Following table shows the required land area. The site was examined carefully to minimize the private land use and to maximize the efficiency of the distribution. Only a small area of land is private land.

Table 9.45 Land Acquisition Plan

Land Type	Area (Ac)	Land Acquisition Process
Public	30	Lease
Private	2.2	Purchase
NWSDB	4	N/A
Total	36.2	

NWSDB found the illegal occupants in both treatment plant sites. On the basis of Sri Lankan policy of resettlement and JICA guideline, the people who are expected to move from present living place should be compensated and received appropriate assistance even if they are illegal occupant.

9.10.2 Legal Framework and Its Organization for Acquisition and Human Resettlement

(1) Sri Lankan Legal Framework

Sri Lanka has many laws and regulations in terms of land acquisition and resettlement.

- Land Acquisition Act No 9 of 1950
- National Environmental Act No 47 of 1980
- Road Development Authority Act No 73 of 1981
- State Lands Act No 13 of 1949
- State Lands (Recovery of Possession) Act No 7 of 1979
- Urban Development Authority Law No 41 of 1978
- Municipal Councils Ordinance No 29 of 1947
- Urban Development Projects (Special Provisions) Act No 2 of 1980
- Sri Lanka Land Reclamation and Development Corporation Act No 15 of 1968
- Land Development Ordinance No 19 of 1935
- Prescription Ordinance No 22 of 1971
- Law of Compensation for Improvements

The most important documents are explained in following text.

1) Land Acquisition Act

The Land Acquisition Act (LAA) of 1950 was established for financial compensation at current market prices, and compensate for income loss from certain types of affected economic activities. It has been amended to fit the current requirement. It does not require project executing agencies (PEA) to address key resettlement issues such as (a) exploring alternative project options that avoid or minimize impacts on people; (b) compensating those who do not have title to land; (c) consulting affected people and hosts on resettlement options; (d) providing for successful social and economic integration of the affected people and their hosts, and (e) full social and economic rehabilitation of the affected people.

All land acquisition work is carried out under the Land Acquisition Act. The NWSDB was given the authority to obtain the land for public purpose with the concurrence of the landowners. The main actions should be taken are listed as follows.

a) Submission of proposals

NWSDB has the investigations for the land selection for public purpose

b) Submission of application, publication

NWSDB submits the application to the relevant Ministry for land acquisition, which contains (a) Application for acquisition of land, (b) Special report of the Head of the institution, (c) and tracing of the proposed land. After obtaining the approval of the Ministry, NWSDB is going to publish a notification on Gazette.

c) Calling for objection

Minister of Land sends the order to the Acquiring officer for publication. The officer prepares notice and expose to public to provide an opportunity for enabling objection for minimum 14 days and maximum 21 days.

d) Taking possession of land

e) Publication for providing opportunity to the public for complaining.

2) NIRP

The Government of Sri Lanka adopted the National Involuntary Resettlement Policy (NIRP) in May 2001 to ensure that affected persons by development projects are treated in a fair and equitable manner and to ensure they are not impoverished in the process, thereby establishing the framework for project planning and implementation.

Key requirements stated in the NIRP are as follows.

- Take all necessary steps to avoid or reduce involuntary resettlement
- Prepare a comprehensive Resettlement Action Plan (RAP) where 20 or more families are affected. If less than 20 families are affected, a plan at a lesser level of detail

should be prepared.

- Where involuntary resettlement is unavoidable, affected persons should be informed fully and consulted on resettlement and compensation options.
- Affected persons should be fully involved in the selection of relocation sites, livelihood compensation and development options at the earliest opportunity.
- Cash compensation should be an option for all affected persons. Replacement land should be an option for compensation in the case of loss of land.
- Compensation for loss of land, structures, other assets, and income should be based on full 'replacement cost'.
- Resettlement should be planned as a development activity for the affected persons.
- Absence of formal title to land by some affected persons should not be a bar to compensation.
- Particular attention to be paid to households headed by women, and vulnerable groups among affected persons, and appropriate assistance provided to help them improve their status.
- Full cost of compensation and resettlement should be borne by the project proponent.
-

NIRP stipulates that any development project that causes the physical or economic resettlement of affected persons requires the preparation of a Resettlement Action Plan (RAP). In case less than 20 families are involved in the resettlement, an abbreviated RAP shall be prepared. The components of an abbreviated RAP are as follows.

a) Scope of land acquisition and resettlement
b) Policy framework and entitlements
c) Public participation and grievance redress
d) Compensation, relocation and income restoration
e) Institutional framework
f) Resettlement budget and financing plan
g) Implementation schedule
h) Monitoring and evaluation

3) Guidelines for the preparation of a resettlement action plan

This document was prepared by the Ministry of Land in June 2003 in order to provide assistance in the preparation of a Resettlement Action Plan (RAP) as required under the NIRP. It provides practical detailed procedure to make a RAP, e.g., the required research, contents, information to be included in each component, and action required for preparation.

(2) JICA Policy

The key principle of JICA policies on involuntary resettlement is summarized below.

I. Involuntary resettlement and loss of means of livelihood are to be avoided when feasible by exploring all viable alternatives

II. When, population displacement is unavoidable, effective measures to minimize the impact and to compensate for losses should be taken

III. People who must be resettled involuntarily and people whose means of livelihood will be hindered or lost must be sufficiently compensated and supported, so that they can improve or at least restore their standard of living, income opportunities and production levels to pre-project levels

IV. Compensation must be based on the full replacement cost5 as much as possible

V. Compensation and other kinds of assistance must be provided prior to displacement

VI. For projects that entail large-scale involuntary resettlement, resettlement action plans must be prepared and made available to the public. It is desirable that the resettlement action plan include elements laid out in the World Bank Safeguard Policy, OP 4.12, Annex A.

VII. In preparing a resettlement action plan, consultations must be held with the affected people and their communities based on sufficient information made available to them in advance. When consultations are held, explanations must be given in a form, manner, and language that are understandable to the affected people.

VIII. Appropriate participation of affected people must be promoted in planning, implementation, and monitoring of resettlement action plans

IX. Appropriate and accessible grievance mechanisms must be established for the affected people and their communities.(

Above principles are complemented by World Bank OP 4.12, since it is stated in JICA Guideline that “JICA confirms that projects do not deviate significantly from the World Bank’s Safeguard Policies”. Additional key principle based on World Bank OP 4.12 is as follows

X. Affected people are to be identified and recorded as early as possible in order to establish their eligibility through an initial baseline survey (including population census that serves as an eligibility cut-off date, asset inventory, and socioeconomic survey), preferably at the project identification stage, to prevent a subsequent influx of encroachers of others who wish to take advance of such benefits

XI. Eligibility of Benefits include, the PAPs who have formal legal rights to land (including customary and traditional land rights recognized under law), the PAPs who don't have formal legal rights to land at the time of census but have a claim to such land or assets and the PAPs who have no recognizable legal right to the land they are occupying.

XII. Preference should be given to land-based resettlement strategies for displaced persons whose livelihoods are land-based

XIII. Provide support for the transition period (between displacement and livelihood restoration

XIV. Particular attention must be paid to the needs of the vulnerable groups among those displaced, especially those below the poverty line, landless, elderly, women and children, ethnic minorities etc

XV. For projects that entail land acquisition or involuntary resettlement of fewer than 200 people, abbreviated resettlement plan is to be prepared

In addition to the above core principles on the JICA policy, it also laid emphasis on a detailed resettlement policy inclusive of all the above points; project specific resettlement plan; institutional framework for implementation; monitoring and evaluation mechanism; time schedule for implementation; and, detailed Financial Plan etc

(3) Comparison between the JICA Guideline and Sri Lanka Law

The following table shows the result of comparison between the JICA Guideline and Sri Lanka Law

Table 9.46 Comparison between JICA Guideline and Sri Lankan Law

No.	JICA Guidelines	NIRP	Gap between JICA Guideline and NIRP
1.	Involuntary resettlement and loss of means of livelihood are to be avoided when feasible by exploring all viable alternatives. (JICA GL)	Involuntary resettlement should be avoided or reduced as much as possible by reviewing alternatives to the project as well as alternatives within the project. (NIRP – 4. Policy Principles, Bullet 01)	No difference between JICA guideline and NIRP on this issue.
2.	When population displacement is unavoidable, effective measures to minimize impact and to compensate for losses should be taken. (JICA GL)	Where involuntary resettlement is unavoidable, affected people should be assisted to re-establish themselves and improve their quality of life. (NIRP – 4. Policy Principles, Bullet 02)	The NIRP concurs with JICA policy on this issue.
3.	People who must be resettled involuntarily and people whose means of livelihood will be hindered or lost must be sufficiently compensated and supported, so that they can improve or at least restore their standard of living, income opportunities and production levels to pre-project levels. (JICA GL)	Affected persons should be fully involved in the selection of relocation sites, livelihood compensation and development options at the earliest opportunity. (NIRP – 4. Policy Principles, Bullet 04)	The NIRP concurs with JICA policy on this issue.
4.	Compensation must be based on the full replacement cost as much as possible. (JICA GL)	Compensation for loss of land, structures, other assets and income should be based on full replacement cost and should be paid promptly. This should include transaction costs. (NIRP – 4. Policy Principles, Bullet 06)	No difference between JICA guideline and NIRP on this issue.
5.	Compensation and other kinds of assistance must be provided prior to displacement. (JICA GL)	Not mentioned particularly	The NIRP does not mention the timing of compensation.

No.	JICA Guidelines	NIRP	Gap between JICA Guideline and NIRP
6.	For projects that entail large-scale involuntary resettlement, resettlement action plans must be prepared and made available to the public. (JICA GL)	A comprehensive Resettlement Action Plan will be required where 20 or more families are affected. If less than 20 families are affected the policy still applies but a plan can be prepared to a lesser level of detail. (NIRP – 3 Scope, Bullet 2 and 3)	This case the affected households are supposed to be four. JICA guideline does not mention clearly the case of small-scale resettlement.
7.	In preparing a resettlement action plan, consultations must be held with the affected people and their communities based on sufficient information made available to them in advance. (JICA GL)	To assist those affected to be economically and socially integrated into the host communities, participatory measures should be designed and implemented. (NIRP – 4 Policy Principles, Bullet 08)	The NIRP concurs with JICA policy on this issue.
8.	When consultations are held, explanations must be given in a form, manner, and language that are understandable to the affected people.	Not mentioned particularly	Not mentioned particularly
9.	Appropriate participation of affected people must be promoted in planning, implementation, and monitoring of resettlement action plans. (JICA GL)	Affected persons should be fully involved in the selection of relocation sites, livelihood compensation and development options at the earliest opportunity. (NIRP – 4. Policy Principles, Bullet 06)	No difference between JICA guideline and NIRP on this issue.
10.	Appropriate and accessible grievance mechanisms must be established for the affected people and their communities. (JICA GL)	A system of internal monitoring should be established by PEAs to monitor implementation of Resettlement Action Plans, including budget, schedule, and delivery of entitlements, consultation, grievances and benefits. (NIRP – 6.Monitoring and Evaluation, Bullet 01)	No difference between JICA guideline and NIRP on this issue.
11.	Affected people are to be identified and recorded as early as possible in order to establish their eligibility through an initial baseline survey (including population census that serves as an eligibility cut-off date, asset inventory, and socioeconomic survey), preferably at the project identification stage, to prevent a subsequent influx of encroachers of others who wish to take advance of such benefits. (WB OP4.12 Para.6)	Not mentioned particularly	The NIRP does not mention establishing a population record through census

No.	JICA Guidelines	NIRP	Gap between JICA Guideline and NIRP
12.	Eligibility of benefits includes, the PAPs who have formal legal rights to land (including customary and traditional land rights recognized under law), the PAPs who don't have formal legal rights to land at the time of census but have a claim to such land or assets and the PAPs who have no recognizable legal right to the land they are occupying. (WB OP4.12 Para.15)	Affected persons who do not have documented title to land should receive fair and just treatment. (NIRP – 4. Policy Principles, Bullet 11)	No difference between WB OP4.12 and NIRP on this issue
13.	Preference should be given to land-based resettlement strategies for displaced persons whose livelihoods are land-based. (WB OP4.12 Para.11)	Not mentioned particularly	The NIRP does not mention about this issue.
14.	Provide support for the transition period (between displacement and livelihood restoration). (WB OP4.12 Para.6)	Not mentioned particularly	The NIRP does not mention about transition period support.
15.	Particular attention must be paid to the needs of the vulnerable groups among those displaced, especially those below the poverty line, landless, elderly, women and children, ethnic minorities etc. (WB OP4.12 Para.8)	Vulnerable groups should be identified and given appropriate assistance to substantially improve their living standards. (NIRP – 4. Policy Principles, Bullet 12)	No difference between WB OP4.12 and NIRP on this issue

9.10.3 Project Policy and Entitle Matrix

The Project implements the resettlement under following policy.

I. The Government of Sri Lanka will use the Project Resettlement Policy for the Anuradhapura North Integrated Water Supply Project specifically because existing national laws and regulations have not been designed to address involuntary resettlement according to international practice, including JICA's policy. The Project Policy is aimed at filling-in any gaps in what local laws and regulations cannot provide in order to help ensure that PAPs are able to rehabilitate themselves to at least their pre-project condition. This section discusses the principles of the Project Policy and the entitlements of the PAPs based on the type and degree of their losses. Where there are gaps between Sri Lanka legal framework for resettlement and JICA's Policy on Involuntary Resettlement, practicable mutually agreeable approaches will be designed consistent with Government practices and JICA's Policy.

II. Land acquisition and involuntary resettlement will be avoided where feasible, or minimized, by identifying possible alternative project designs that have the least adverse impact on the communities in the project area.

III. Where displacement of households is unavoidable, all PAPs (including communities) losing assets, livelihoods or resources will be fully compensated and assisted so that they can improve, or at least restore, their former economic and social conditions.

IV. Compensation and rehabilitation support will be provided to any PAPs, that is, any person or household or business which on account of project implementation would have his, her or their: Standard of living adversely affected Right, title or interest in any house, interest in, or right to use, any land (including premises, agricultural and grazing land, commercial properties, tenancy, or right in annual or perennial crops and trees or any other fixed or moveable assets, acquired or possessed, temporarily or permanently;Income earning opportunities, business, occupation, work or place of residence or habitat adversely affected temporarily or permanently; orSocial and cultural activities and relationships affected or any other losses that may be identified during the process of resettlement planning

V. All affected people will be eligible for compensation and rehabilitation assistance, irrespective of tenure status, social or economic standing and any such factors that may discriminate against achievement of the objectives outlined above. Lack of legal rights to the assets lost or adversely affected tenure status and social or economic status will not bar the PAPs from entitlements to such compensation and rehabilitation measures or resettlement objectives.)All PAPs residing, working, doing business and/or cultivating land within the project impacted areas as of the date of the latest census and inventory of lost assets(IOL), are entitled to compensation for their lost assets (land and/or non-land assets), at replacement cost, if available and restoration of incomes and businesses, and will be provided with rehabilitation measures sufficient to assist them to improve or at least maintain their pre-project living standards, income-earning capacity and production levels.

VI. PAPs that lose only part of their physical assets will not be left with a portion that will be inadequate to sustain their current standard of living. The minimum size of remaining land and structures will be agreed during the resettlement planning process

VII. People temporarily affected are to be considered PAPs and resettlement plans address the issue of temporary acquisition.

VIII. Where a host community is affected by the development of a resettlement site in that community, the host community shall be involved in any resettlement planning and decision-making. All attempts shall be made to minimize the adverse impacts of resettlement upon host communities.

IX. The resettlement plans will be designed in accordance with Sri Lanka’s National Involuntary Resettlement Policy and JICA’s Policy on Involuntary Resettlement.

X. The Resettlement Plan will be translated into local languages and disclosed for the reference of PAPs as well as other interested groups.

XI. Payment for land and/or non-land assets will be based on the principle of replacement cost

XII. Compensation for PAPs dependent on agricultural activities will be land-based wherever possible. Land-based strategies may include provision of replacement land, ensuring greater security of tenure, and upgrading livelihoods of people without legal land titles. If replacement land is not available, other strategies may be built around opportunities for re-training, skill development, wage employment, or self-employment, including access to credit. Solely cash compensation will be avoided as an option if possible, as this may not address losses that are not easily quantified, such as access to services and traditional rights, and may eventually lead to those populations being worse off than without the project.

XIII. Replacement lands, if the preferred option of PAPs, should be within the immediate vicinity of the affected lands wherever possible and be of comparable productive capacity and potential6. As a second option, sites should be identified that minimize the social disruption of those affected; such lands should also have access to services and facilities similar to those available in the lands affected.

XIV. Resettlement assistance will be provided not only for immediate loss, but also for a transition period needed to restore livelihood and standards of living of PAPs. Such support could take the form of short-term jobs, subsistence support, salary maintenance, or similar arrangements

XV. The resettlement plan must consider the needs of those most vulnerable to the adverse impacts of resettlement (including the poor, those without legal title to land, ethnic minorities, women, children, elderly and disabled) and ensure they are considered in resettlement planning and mitigation measures identified. Assistance should be provided to help them improve their socio-economic status.

XVI. PAPs will be involved in the process of developing and implementing resettlement plans

XVII. PAPs and their communities will be consulted about the project, the rights and options available to them, and proposed mitigation measures for adverse effects, and to the extent possible be involved in the decisions that are made concerning their resettlement.

XVIII. Adequate budgetary support will be fully committed and made available to cover the costs of land acquisition (including compensation and income restoration measures) within the agreed implementation period. The funds for all resettlement activities will come from the Government

XIX. Displacement does not occur before provision of compensation and of other assistance required for relocation. Sufficient civic infrastructure must be provided in resettlement site prior to relocation. Acquisition of assets, payment of compensation, and the resettlement and start of the livelihood rehabilitation activities of PAPs, will be completed prior to any construction activities, except when a court of law orders so in expropriation cases. (Livelihood restoration measures must also be in place but not necessarily completed prior to construction activities, as these may be ongoing activities.)

XX. Organization and administrative arrangements for the effective preparation and implementation of the resettlement plan will be identified and in place prior to the commencement of the process; this will include the provision of adequate human resources for supervision, consultation, and monitoring of land acquisition and rehabilitation activities

XXI. Appropriate reporting (including auditing and redress functions), monitoring and evaluation mechanisms, will be identified and set in place as part of the resettlement management system. An external monitoring group will be hired

Based on the Project Policy, the entitle matrix is defined as **Table 9.39**.

Table 9.47 Entitle Matrix for the Project

	Type of Loss	Application	Definition of Entitled Person	Compensation Policy	Implementation Issues	Responsible Agency
1	Loss of land	Vacant plot, Agricultural land homestead land	Irrespective of title	• Compensation at replacement value or land-for-land where feasible. If land-for-land is offered, titles will be in the name of original landowners. Joint titles in the name of husband and wife will be offered in the case of married APs. • Fees, taxes, and other charges related to replacement land. • Notice to harvest standing seasonal crops and compensation in item 2.	•Finding alternative lands	• The Divisional Secretary will make arrangements for alternative lands and determine the rental allowance in case of emergency shifting.
2	Loss of Residential Structure	Permanent and full loss of residential structure	Occupants irrespective of title	• Project bare the cost of construction of the Affected Residential Structure as per District Housing Committee regulations. • Shifting assistance for households. • Rental allowance per month in case of emergency shifting until the offer of permanent relocation to new house. • Replacement value of the structure and other assets in the land (or part of the structure and other assets, if remainder is viable).	•Finding alternative lands	• The Divisional Secretary will determine the rental allowance in case of emergency shifting.
3	Impacts on vulnerable APs	All impacts	Vulnerable APs Vulnerable APs including the poor, elderly APs, ethnic minority households, female-headed households, and disabled	•Land. Further to item 1, in case of total loss of land, and a total dependency on agriculture, land-for-land compensation if signified by the AP. •A special grant of Rs 15,000 per AP/household to improve living standards of vulnerable APs and households •Vulnerable families eligible for government welfare assistance, will be supported with Samrudhi poverty alleviation scheme or PIMA scheme	•Vulnerable households will be identified during the census.	•Regional Office will verify the extent of impacts through a 100% surveys of AHs determine assistance, verify and identify vulnerable households.

	Type of Loss	Application	Definition of Entitled Person	Compensation Policy	Implementation Issues	Responsible Agency
				•Employment in civil works for this Project		
3	Loss and temporary impacts on common resources	Common resources	Communities	• Replacement or restoration of the affected community facilities – including public water stand posts, public utility posts, temples, shrines, etc.	-	•EA and Contractor.
4	Livelihood Restoration (Grant & Training)	Permanent effects on livelihood	APs/household	•Training for up to two members (male and female where applicable) of AP households to receive skills and vocational training, to an amount of Rs 12,000 per member; •Training, credit access and skill training support for maximum two youths (one male and one female) from the resettled families for livelihood strengthening with the help of NGOs	•Requirement of the training need to be identified	Regional Office
5	Any other loss not identified	-	-	• Unanticipated resettlement impacts will be documented and mitigated based on the principles of the Resettlement Framework.	-	• Regional Office will ascertain the nature and extent of such loss. EA will finalize the entitlements in line with the Resettlement Framework.

9.10.4 Scope of Land Acquisition and Resettlement Impact

Most of the sites are located in government land, and NWSDB will lease the land with payment. On the other hand, there are two private lands and the total area of these is 2.2 acres.

1) Number of Project affected Units

The number of the Project affected units and persons is listed in **Table 9.48**.

Table 9.48 Number of Project Affected Persons

Type of loss	No of PAUs (HH)			No of PAPs		
	Legal	Illegal	Total	Legal	Illegal	Total
Required for displacement						
1 Structure owner on Gov. land	0	1	1	0	0	0
Total	0	1	1	0	0	0

Land

Location	Land Type	Affected (m2)	Total
Mahakanaradawa Project Site	Housing Land	1,000	1,000
Total	Housing Land	1,000	1,000

Premises

Location	Type of building	Sub total	Total
Mahakanaradawa Project Site	Single stories, brick, asbestos sheet roof	1	1

2) Cut off date

The cut-off-date of eligibility refers to the date prior to which the occupation or use of the project area makes residents/users of the same eligible to be categorized as PAPs and be eligible to Project entitlements. In the Project, Cut-off dates for titleholders will be the date of notification under the Land Acquisition Act and for non-titled holders will be the beginning date of the population census. This date has been disclosed to each affected village by the relevant local governments and the villages have disclosed to their populations. The establishment of the eligibility cut-off date is intended to prevent the influx of ineligible non-residents who might take advantage of Project entitlements.

9.10.5 Measures of Compensation and Assistance

(1) Institutional responsibility

Institutional responsibility is listed in **Table 9.49**.

Table 9.49 Institutional Responsibility

Institution	Responsibility
Project Management and Coordination Unit (PMCU) in NWSDB	Preparation of RAP, holding stakeholder meeting, implementing RAP with DS,
Board of directors in NWSDB	Internal approving body for RAP
Project Director (PD)	Management of planning and implementation, monitoring
NWSDB	Payment of compensation
District secretariat	Estimation of compensation (evaluation officer)
Divisional secretariat	Approving RAP, finding and providing land for relocation, providing permission of survey, providing long-term lease permission, implementing RAP with NWSDB, grievance management
Grama Niladhari	Addressing of PAP
Other stakeholders	Consulting the RAP implementation,

(2) Compensation

Currently identified PAP is one household in Mahanakandarawa area, The result of interview done by NWSDB is attached as **Appendix 9.10(a)**, The identified PAP and his entitle, compensation are shown in **Table 9.50**.

Table 9.50 Identified PAP

	Name of affected person Entitlement	Impact	Compensation
1	Mr. A. O. Anurusiri Permanent and full loss of residential structure Occupants irrespective of title	Loss of house in Mahakanadarawa WTP site	• Project bare the cost of construction of the Affected Residential Structure as per District Housing Committee regulations. • Shifting assistance for households. • Rental allowance per month in case of emergency shifting until the offer of permanent relocation to new house. • Replacement value of the structure and other assets in the land (or part of the structure and other assets, if remainder is viable).

9.10.6 Grievance Redress Mechanism (GRM)

The first contact person respond to a grievance is the Divisional Secretariat land officer. The land officer and social specialist will take care to resolve grievances. If the grievance is not settled, DS will contact to PMCU and PMCU will make a discussion for grievance mediation in presence of DS officer . If the problem is not solved, the person can appeal to the court.

9.10.7 Monitoring

PMCU is responsible for monitoring and appoints one social specialist to carry out it. The monitoring form is used for reporting. The result of monitoring has to be shared by periodic reports and ad hoc reports with the request of PD.

The monitoring form is shown below.

Table 9.51 Monitoring Form

Preparation of resettlement site

No	Explanation of the site (e.g. Area, etc.)	Status (Completed (date) / not complete)	Details (e.g.Site selection, identification of candidate sites, discussion with PAPs, Development of the site, etc.)	Expected Date of Completion
1				
2				
3				
4				

Public Consultation

No	Date	Place	Contents of the consultation / main comments and answers
1			
2			

Resettlement activities

Resettlement activities	Planned Total	Unit	Progress in Quantity			Progress in %		Expected Date of Completion	Responsible Organization
			During the Quarter	Till the Last Quarter	Up to the Quarter	Till the Last Quarter	Up to the Quarter		
Preparation of RAP									
Approval of RAP									
Finalization of PAPs List									
Progress of Compensation Payment									
Progress of Land Acquisition (All Lots)									
Lot 1									
Lot 2									
Progress of Relocation of People									

9.10.8 Human Resettlement Cost and Finance

NWSDB made an estimation for resettlement cost, and it is shown in **Table 9.52**.

Table 9.52 Human Resettlement Cost

	Activity	Total (SLR)
1	Estimate cost for the structure (House)	3,634,874
2	Cost for providing Water	30,000
3	Cost for providing Electricity	100,000
4	Transportation cost for furniture and other house equipments	5,000
5	Rental allowance (if necessary) Rs 5,000 per month	60,000
	Total	3,829,847

The estimation was done by NWSDB, but officially, it should be done by District Estimation Officer. The official estimation will be submitted.
The all cost regarding resettlement is bared by a project proponent, NWSDB.

9.10.9 Implementation Schedule of Land Acquisition and Resettlement

The schedule prepared by the NWSDB for the land acquisition and resettlement are shown below.

Table 9.53 Schedule for acquiring Private Lands

Step	Description	Period	
		from	to
1	Publication of gazette notification under section 92 of NWSDB Act and sending proposal for acquisition to the land ministry.	Completed	
2	Order under section 2 of land acquisition Act and relevant matters after which, Divisional Secretary publish the section 02 notice in three languages and send a survey requisition to the senior superintend of surveys to prepare an advanced tracing.	01 Nov2012	30 Nov 2012
3	Senior superintend of surveys prepare the advance tracing and send it to the Divisional Secretary	01 Dec 2012	28 Feb 2013
4	Action under section 4 includes calling for objections and inquiry.	01 Mar 2013	31 May 2013
5	Action under provision 38 (a) and section 5 (after the inquiries over) which will indicate that ministry of lands decides to acquire the land for public purpose.	01 Jun 2013	31 Aug 2013
6	Preparing survey plan and compensation measures as per Section 7 and section 8 the Land Acquisition Act.	01 Sep 2013	31 Dec 2013

Table 9.54 Schedule for acquiring Government Lands

Step	Description	Period	
		From	To
1	Send the request to the Divisional Secretary to get the scheduled land by NWSDB	Completed	
2	Divisional Secretary and NWSDB requests regarding the land and details, consent of the relevant organization to which land belongs	01 Nov 2012	31 Dec 2012
3	Preparation of report by the Divisional Secretary regarding the state land get approval from land commission. Through the provincial land commission. If the land belong to any other organization, then preparation of report by Divisional Secretary regarding the land and get approval from Land use Planning committee and send to land commission	01 Jan 2013	30 Apr 2013
4	After the land commission General's approval, land will be handed over to the NWSDB by the Divisional Secretary.	01 May 2013	30 Sep 2013
5	Signing the lease agreement with NWSDB	01 Oct 2013	30 Apr 2013

Table 9.55 Relocation and Resettlement Plan for House holder at Mahakanadarawa Treatment plant site

Steps	Description	Period	
1.	Prepare a resettlement action plan for resettlement process	01 Oct 2012	31 Dec 2012
2.	Negotiation and agreement with the House holder for resettlement process	Already House holder has agreed with NWSDB for the resettlement	
3.	Prepare memorandum of understanding MOU), sign it with the house holders and send MOU to Divisional Secretary and request a land to construct house	01 Oct 2012	31 Dec 2012
4.	Construction of the house and resettlement of the House holder	01 Jan 2014	31 Dec 2014

The NWSDB and DSD made an agreement with the occupant. He said in the agreement that he understood the condition and he agreed to leave the place after he receive new house constructed at the 20P plot of land allocated by the DS. (Appendix 9.10(b))

9.11 Environmental Check List

The evaluation with the JICA checklist is shown in **Table 9.49**.

Table 9.56 Environmental Checklist

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
1 Permits and Explanation	(1) EIA and Environmental Permits	(a) Have EIA reports been already prepared in official process? (b) Have EIA reports been approved by authorities of the host country's government? (c) Have EIA reports been unconditionally approved? If conditions are imposed on the approval of EIA reports, are the conditions satisfied? (d) In addition to the above approvals, have other required environmental permits been obtained from the appropriate regulatory authorities of the host country's government?	(a) N/A (b) N/A (c) N/A (d) Y	(a) (b) (c)Under currently proposed project condition, EIA is not required. On the other hand, IEE level research was done by the Project. (d) Obtained clearances are as follows; ・ Clearance of Archeology dept ・Clearance of Irrigation dept ・ Clearance of Forest dept ・Clearance of CEA
	(2) Explanation to the Local Stakeholders	(a) Have contents of the project and the potential impacts been adequately explained to the Local stakeholders based on appropriate procedures, including information disclosure? Is understanding obtained from the Local stakeholders? (b) Have the comment from the stakeholders (such as local residents) been reflected to the project design?	(a) Y (b) Y	(a) NWSDB carried out the explanation session on 7th August. After election (8th September), NWSDB held the stakeholder meeting-23th September.(For Wahalkada) (b) The water intake procedure is changed due to the comment of the Irrigation Dept. The water intake quantity ~~is~~ will be decided with the agreement of stakeholders in case of unexpected drought.
	(3) Examination of Alternatives	(a) Have alternative plans of the project been examined with social and environmental considerations?	(a) Y	(a) Water intake procedure, location of facilities, course of pipe laying, treatment procedure were examined and the relative low impact plan was selected..

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
2 Pollution Control	(1) Air Quality	(a) Is there a possibility that chlorine from chlorine storage facilities and chlorine injection facilities will cause air pollution? Are any mitigating measures taken? (b) Do chlorine concentrations within the working environments comply with the country's occupational health and safety standards?	(a) N (b) N	(a) The chlorine gas neutralization system is provided. The gas leak detector will be installed whih is able to start the neutralization system automatically so that the possibility of chlorine gas leakage is very low. (b) Sri Lankan Occupational Health Standards for chlorine is not existing. The facility will be designed to satisfy the American standards. Operation of exhaust fan acchives the standard requirement.

Occupational Safety and Health Guideline for Chlorine

	ppm	mg/m3	
Permissible exposure limit	1	3	US dept of Labor
Advisable limit	0.5	1.5	NIOSH
Evaluation standard	0.5	1.5	Japan

Ambient Air Quality

	Pollutant	Averaging Time*	Maximum Permissible Level		Method of measurement
			μgm-3	ppm	
1	Particulate Matter - Aerodynamic diameter is less than 10 μm in size (PM_{10})	Annual	50	Ñ	Hi-volume sampling and Gravimtric or Beta Attenuation
		24 hrs.	100	Ñ	
2	Particulate Matter - Aerodynamic diameter is less than 2.5 μm in size ($PM_{2.5}$)	Annual	25	Ñ	Hi-volume sampling and Gravimtric or Beta Attenuation
		24 hrs.	50	Ñ	
3	Nitrogen Dioxide (NO_2)	24 hrs.	100	0.05	Colorimetric using saltzman Method or equivalent Gas phase chemiluminescence
		8 hrs.	150	0.08	
		1hr.	250	0.13	
4	Sulphur Dixoxide (SO_2)	24 hrs.	80	0.03	Pararosaniliene Method or equivalent Pulse Flourescent
		8 hrs.	120	0.05	
		1hrs.	200	0.08	
5	Ozone (O_3)	1 hr.	200	0.1	Chemiluminescence Method or equivalent Ultraviolet photometric
6	Carbon Monoxide (CO)	8 hrs.	10,000	9	Non-Dispersive Infrared SpectroscopyÓ
		1 hr.	30,000	26	
		Any time	58,000	50	

<table>
<tr><th>Category</th><th>Environmental Item</th><th>Main Check Items</th><th>Yes: Y
No: N</th><th>Confirmation of Environmental Considerations
(Reasons, Mitigation Measures)</th></tr>
<tr><td></td><td>(2) Water Quality</td><td>(a) Do pollutants, such as SS, BOD, COD contained in effluents discharged by the facility operations comply with the country’s effluent standards?</td><td>(a) Y</td><td>(a) Turbid water generated during construction works is collected to the sedimentation pond for solid-liquid separation. Domestic wastewater of employees is treated by a septic tank and supernatant is discharged into a soak pit for infiltration into the ground. The backwash drain generated during by the usual plant operation is collected in to drain ponds for solid-liquid separation. So the treated effluent will meet the Sri Lankan discharge water quality standard.

Tolerable limit of discharge to inland surface water
<table>
<tr><th>No.</th><th>Parameter</th><th>Unit type of limit</th><th>Tolerance Limit values</th></tr>
<tr><td>1</td><td>Total suspended solids</td><td>mg/1, max.</td><td>50</td></tr>
<tr><td>2</td><td>Particle size of the total suspended solids</td><td>µm, less than</td><td>50</td></tr>
<tr><td>3</td><td>pH at ambient temperature</td><td>-</td><td>6.0 - 8.5</td></tr>
<tr><td>4</td><td>Biochemical oxygen demand (BOD_5 5 days at 20 ℃ or BOD3 3 days at 27 ℃)</td><td>mg/1, max.</td><td>30</td></tr>
<tr><td>5</td><td>Temperature of discharge</td><td>℃ , max.</td><td>Shall no exceed 400 ℃ in any section of the stream within 15 m down stream from the effluent outlet.</td></tr>
<tr><td>6</td><td>Oils and greases</td><td>mg/1, max.</td><td>10</td></tr>
<tr><td>7</td><td>Phenolic compounds (as C_6H_5OH)</td><td>mg/2, max.</td><td>1</td></tr>
<tr><td>8</td><td>Chemical oxygen demand (COD)</td><td>mg/3, max.</td><td>250</td></tr>
<tr><td>9</td><td>Colour</td><td>Wavelength Range
436 nm (Yellow range)
525nm (Red range)
620nm (Blue range)</td><td>Maximum spectral absorption coefficient
$7m^{-1}$
$5m^{-1}$
[illegible]</td></tr>
<tr><td>10</td><td>Dissolved phosphates (as P)</td><td>mg/1, max.</td><td>5</td></tr>
<tr><td>11</td><td>Total Kjeldahl nitrogen (as N)</td><td>mg/1, max.</td><td>150</td></tr>
<tr><td>12</td><td>Ammoniacal nitrogen (as N)</td><td>mg/1, max.</td><td>50</td></tr>
<tr><td>13</td><td>Cyanide (as CN)</td><td>mg/1, max.</td><td>0.2</td></tr>
<tr><td>14</td><td>Total residual chlorine</td><td>mg/1, max.</td><td>1</td></tr>
<tr><td>15</td><td>Flourides (as F)</td><td>mg/1, max.</td><td>2</td></tr>
<tr><td>16</td><td>Sulphide (as S)</td><td>mg/1, max.</td><td>2</td></tr>
<tr><td>17</td><td>Arsenic (as As)</td><td>mg/1, max.</td><td>0.2</td></tr>
<tr><td>18</td><td>Cadmium (as Cd)</td><td>mg/1, max.</td><td>0.1</td></tr>
<tr><td>19</td><td>Chromium, total (as Cr)</td><td>mg/1, max.</td><td>0.5</td></tr>
<tr><td>20</td><td>Chromium, Hexavalent (as Cr6+)</td><td>mg/1, max.</td><td>0.1</td></tr>
<tr><td>21</td><td>Copper (as Cu)</td><td>mg/1, max.</td><td>3</td></tr>
<tr><td>22</td><td>Iron (as Fe)</td><td>mg/1, max.</td><td>3</td></tr>
<tr><td>23</td><td>Lead (as Pb)</td><td>mg/1, max.</td><td>0.1</td></tr>
<tr><td>24</td><td>Mercury (as Hg)</td><td>mg/1, max.</td><td>0.0005</td></tr>
<tr><td>25</td><td>Nickel (as Ni)</td><td>mg/1, max.</td><td>3</td></tr>
<tr><td>26</td><td>Selenium (as Se)</td><td>mg/1, max.</td><td>0.05</td></tr>
<tr><td>27</td><td>Zinc (as Zn)</td><td>mg/1, max.</td><td>2</td></tr>
<tr><td>28</td><td>Pesticides</td><td>mg/1, max.</td><td>0.005</td></tr>
<tr><td>29</td><td>Detergents/surfactants</td><td>mg/1, max.</td><td>5</td></tr>
<tr><td>30</td><td>Faecal Coliform</td><td>MPN/100 ml, max</td><td>40</td></tr>
<tr><td>31</td><td>Radio Active Material :
(a) Alpha emitters
(b) beta emitters</td><td>
micro curie/ml, max
micro curie/ml, max</td><td>
10^{-8}
10^{-7}</td></tr>
</table>
</td></tr>
<tr><td></td><td>(3) Wastes</td><td>(a) Are wastes, such as sludge generated by the facility operations properly treated and disposed in accordance with the country’s regulations?</td><td>(a) Y</td><td>(a) The generated sludge is collected from chemical sedimentation basins and condensed by thickener. Condensed sludge is transferred to sludge lagoons to be dried by solar evaporation. The dried sludge is hauled to the solid waste dumping site for final disposal.</td></tr>
</table>

<table>
<tr><th>Category</th><th>Environmental Item</th><th>Main Check Items</th><th>Yes: Y
No: N</th><th>Confirmation of Environmental Considerations
(Reasons, Mitigation Measures)</th></tr>
<tr><td rowspan="2"></td><td>(4) Noise and Vibration</td><td>(a) Do noise and vibrations generated from the facilities, such as pumping stations comply with the country’s standards?</td><td>(a) Y</td><td>(a) The main generating sources of noise and vibration are generator and pump. The low-noise type and low- vibration type equipment is selected for reduction of noise and vibration and installed in the building so as to meet the Sri Lankan standards. The standards to be followed is shown below.

Maximum permissible Noise Levels at Boundaries of the land in which source of noise is located in LaeqÕ ,T, for construction activities
<table><tr><th></th><th>LaeqÕ, T</th></tr><tr><td>Day time</td><td>75</td></tr><tr><td>Night time</td><td>50</td></tr></table>
Maximum permissible Noise Levels at Boundaries in LAeq, T, for industrial activities
<table><tr><th>Aria</th><th>Day time</th><th>Night time</th></tr><tr><td>Rural Residential Area</td><td>55</td><td>45</td></tr><tr><td>Urban Residential Area</td><td>60</td><td>50</td></tr><tr><td>Noise Sensitive Area</td><td>50</td><td>45</td></tr><tr><td>Mixed Residential</td><td>63</td><td>55</td></tr><tr><td>Commercial Areas</td><td>65</td><td>55</td></tr><tr><td>Industrial Area</td><td>70</td><td>60</td></tr><tr><td colspan="3">Japanese Environmental Standard</td></tr><tr><td>A (residential area)</td><td>55</td><td>45</td></tr></table></td></tr>
<tr><td>(5) Subsidence</td><td>(a) In the case of extraction of a large volume of groundwater, is there a possibility that the extraction of groundwater will cause subsidence?</td><td>(a) N</td><td>(a) The project does not extract groundwater.</td></tr>
<tr><td>3 Natural Environment</td><td>(1) Protected Areas</td><td>(a) Is the project site or discharge area located in protected areas designated by the country’s laws or international treaties and conventions? Is there a possibility that the project will affect the protected areas?</td><td>(a) N</td><td>(a) The project area is located outside of protected area. However, the environmental impact should be minimized.</td></tr>
</table>

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
	(2) Ecosystem	(a) Does the project site encompass primeval forests, tropical rain forests, ecologically valuable habitats (e.g., coral reefs, mangroves, or tidal flats)? (b) Does the project site or discharge area encompass the protected habitats of endangered species designated by the country's laws or international treaties and conventions? (c) If significant ecological impacts are anticipated, are adequate protection measures taken to reduce the impacts on the ecosystem? (d) Is there a possibility that the amount of water used (e.g., surface water, groundwater) by project will adversely affect aquatic environments, such as rivers? Are adequate measures taken to reduce the impacts on aquatic environments, such as aquatic organisms?	(a) N (b) N (c) N/A (d) N	(a) Some part of project area is located in the forest but the forest does not require special attention for conservation. (b) According to the report of ecological survey, a few number of endemic and endangered species were found. But these species are dominant in the wet area, and the protection of habitat in the project area is not so seriously required. . (c) The significant ecological impact is not expected. (d) The project takes water from irrigation canal so the adverse effect to the aquatic environment is limited. Furthermore, the purpose of the use of the project, the water will let flow on a steady basis. it will improve the environment.
	(3) Hydrology	(a) Is there a possibility that the amount of water used (e.g., surface water, groundwater) by the project will adversely affect surface water and groundwater flows?	(a) N	(a) Currently, the water is used only the purpose of irrigation. The project will share a part of current water use, so the effect is negligible.

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
4 Social Environment	(1) Resettlement	(a) Is involuntary resettlement caused by project implementation? If involuntary resettlement is caused, are efforts made to minimize the impacts caused by the resettlement? (b) Is adequate explanation on compensation and resettlement assistance given to affected people prior to resettlement? (c) Is the resettlement plan, including compensation with full replacement costs, restoration of livelihoods and living standards developed based on socioeconomic studies on resettlement? (d) Is the compensations going to be paid prior to the resettlement? (e) Is the compensation policies prepared in document? (f) Does the resettlement plan pay particular attention to vulnerable groups or people, including women, children, the elderly, people below the poverty line, ethnic minorities, and indigenous peoples? (g) Are agreements with the affected people obtained prior to resettlement? (h) Is the organizational framework established to properly implement resettlement? Are the capacity and budget secured to implement the plan? (i) Are any plans developed to monitor the impacts of resettlement? (j) Is the grievance redress mechanism established?	(a) Y (b) Y (c) Y (d) Y (e) Y (f) N/A (g) Y (h) Y (i) Y (j) Y	(a) One illegal occupants house is located in the Mahakanadarawa WTP site. NWSDB is preparing RAP in accordance with the JICA guidelines and Sri Lankan 'National Involuntary Resettlement Policy' . (b) NWSDB and DSD explained the Project and necessity of change of the land use to the occupant. The occupant understood the necessity of the Project and agreed to leave the place. (c) Compensation with full replacement costs, restoration of livelihoods and living standards are secured. (d) Compensations will be paid prior to the physical resettlement. (e) Sri Lanka has 'National Involuntary Resettlement Policy' approved by Cabinet in 2001. And there is no big gap from JICA Guideline. (f) The occupants are married couple only and belong to ethnically major group. They will be supplied the new land near their relatives. They are not considered as people in vulnerable group. (g) NWSDB obtained the agreement letter from occupants. (h) NWSDB shall bare the cost for resettlement. The estimation is done by District evaluation officer. Divisional secretariat and NWSD are responsible for taking care of the ocupants. (i) Monitoring plan is written in the RAP. (j) DS is the first contact window of grievance. If the problem is not solved, DS will request the participation of NWSDB and find the solution.
4 Social Environment	(2) Living and Livelihood	(a) Is there a possibility that the project will adversely affect the living conditions of inhabitants? Are adequate measures considered to reduce the impacts, if necessary?(b) Is there a possibility that the amount of water used (e.g., surface water, groundwater) by the project will adversely affect the existing water uses and water area uses?	(a) Y (b) N	(a) Currently, the farmers in the area feel that the water supply capacity is not sufficient, but the other parallel going project for integration of irrigation system will increase the water supply in the area and the total water demand will be secured. (b) The villagers living the surrounding of the tank use tank water for domestic use. But same reason described above can solve the potential problem.

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
	(3) Heritage	(a) Is there a possibility that the project will damage the local archaeological, historical, cultural, and religious heritage? Are adequate measures considered to protect these sites in accordance with the country's laws?	(a) N	(a) The project area is not located in archaeological reserves. However, the project will take care and make an action plan in the case of excavating antiquities.
	(4) Landscape	(a) Is there a possibility that the project will adversely affect the local landscape? Are necessary measures taken?	(a) N	(a) The size of all facilities are small and the effect on the landscape is ignorable.
	(5) Ethnic Minorities and Indigenous Peoples	(a) Are considerations given to reduce impacts on the culture and lifestyle of ethnic minorities and indigenous peoples? (b) Are all of the rights of ethnic minorities and indigenous peoples in relation to land and resources respected?	(a) N/A (b) N/A	There is no indigenous group in the project area. And any ethnic minorities are not affected by the project.
	(6) Working Conditions	(a) Is the project proponent not violating any laws and ordinances associated with the working conditions of the country which the project proponent should observe in the project? (b) Are tangible safety considerations in place for individuals involved in the project, such as the installation of safety equipment which prevents industrial accidents, and management of hazardous materials? (c) Are intangible measures being planned and implemented for individuals involved in the project, such as the establishment of a safety and health program, and safety training (including traffic safety and public health) for workers etc.? (d) Are appropriate measures taken to ensure that security guards involved in the project not to violate safety of other individuals involved, or local residents?	(a) N (b) Y (c) Y (d) Y	(a) NWSDB follows the Labor law, Factories Ordinance. (b) The contract condition is made under the 'Standard Bidding Document Procurement of Works' or 'Conditions of Contract'. And the Occupational safety and hazardous management will be secured. (c) It will be specified in a contract document, and implemented (d) It will be specified in a contract document, and implemented.

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
5 Others	(1) Impacts during Construction	(a) Are adequate measures considered to reduce impacts during construction (e.g., noise, vibrations, turbid water, dust, exhaust gases, and wastes)? (b) If construction activities adversely affect the natural environment (ecosystem), are adequate measures considered to reduce impacts? (c) If construction activities adversely affect the social environment, are adequate measures considered to reduce impacts? (d) If the construction activities might cause traffic congestion, are adequate measures considered to reduce such impacts?	(a) Y (b) Y (c) Y (d) Y	(a) The contractor has to obey the contract document and take appropriate measures to protect environment and social conditions. ・Noise and vibration is controlled by the proper use of well maintained vehicles and machineries. The night time work is avoided. In case, the use of special tools or material to reduce the noise and vibration such us sound barrier is used. ・Turbid water is collected separately and treated by sedimentation basin. if necessary the coagulant will be used. ・Waste will be managed by the contractor. It shall be segregated and recycled as much as possible. Temporally stock place is secured and the waste is treated with the consultation of DS. ・Dust is controlled by watering and use of cover. ・Emission of exhausted gases is manageable by use of registered vehicles and machinery with proper maintenance. (b) The protection and mitigation measures are taken. (c) The people living in the project site is only one married couple,. RAP is prepared for them for fair resettlement.. (d) The construction activities are prenticed to the inhabitant who is potentially affected for traffic congestion. Construstion plan is descloised.

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
5 Others	(2) Monitoring	(a) Does the proponent develop and implement monitoring program for the environmental items that are considered to have potential impacts? (b) What are the items, methods and frequencies of the monitoring program? (c) Does the proponent establish an adequate monitoring framework (organization, personnel, equipment, and adequate budget to sustain the monitoring framework)? (d) Are any regulatory requirements pertaining to the monitoring report system identified, such as the format and frequency of reports from the proponent to the regulatory authorities?	(a) Y (b) refer the plan (c) Y (d) Y	(a)(b)(c)The project prepares the monitoring plan, shown below. (d) The project is requested to obtain the EPL (Environmental Protection License). The reporting format is included. The license is fixed-term and reporting is requested.

Monitoring Plan

Items	Monitoring parameters	Procedure	Frequency	Implemented and reported by	Report to
Designing stage					
Procurement	Suitability of specification	Checking the specification to meet the proposed mitigation measures	1 time	NWSDB	PMCU
Waste	Waste managemen procedure	Checking dumping plan and obtainin agreement with local authority	1 time	NWSDB	PMCU
Resettlement	Progress of resettlemen plan	Checklist of resettlement plan	1 time	NWSDB	PMCU
Ecological environmen	Clearing land procedure	Checking the plan of clearing and obtaining permission	1 time	NWSDB	PMCU
	Rare species	Checking the plan of transplant and recovery of habitat	1 time	NWSDB	PMCU
Social impact caused by laborer of construction	Awareness raising progra	Training plan of laborer	1 time	NWSDB	PMCU
Construction stage					
Air quality	Vehicle maintenanc condition	Check the registered vehicles and its maintenance record	Once a month	Contractor	PMCU
	Dust	Observation at the site	Once a month	Contractor	PMCU
	Chlorine gas emission	Check and calibrate the gas leak detector	Once a month	Contractor	PMCU
Water quality	Discharge water quality	Measurement of turbidity	Everyday during soil work	Contractor	PMCU
Noise	Working time of constructio	Working record	Once a week	Contractor	PMCU
	Noise at boundary	Measurement of noise at the boundary of the site	Once a month both in daytime and night time	Contractor	PMCU
Ecological environme	Violation to ecosystem, such as cutting tree, hunting killing taking plants and animals, disturbing habita etc.	Patrol of construction site	Once a week	Contractor	PMCU
Waste	Construction waste	Condition of segregation Past record of recycling	Every 3 months	Contractor	PMCU
	Domestic waste	Observation of temporally dumpin yard	Every 3 months	Contractor	PMCU
Operation stage					
Air quality	Chlorine gas leakage	Measurement of gas concentratio and check and calibration of gas leak detector	Once a week	NWSDB RSC	NWSDB
Raw water quality	Parameters listed in drinking water quality	Chemical analysis by laboratory	Once a month	NWSDB RSC	NWSDB
Distributing water quality	Parameters listed in drinking water quality	Chemical analysis by laboratory	Once a month	NWSDB RSC	NWSDB
Discharge water quality	Parameters listed in discharge water quality	Chemical analysis by laboratory	Every 3 months	NWSDB RSC	NWSDB
Occupational safety	Chlorine gas leakage	Measurement of gas concentration	Checking the daily record	NWSDB RSC	NWSDB
Noise	Noise at the boundary	Measurement of noise	Every 3 months	NWSDB RSC	NWSDB
Waste	Sludge	Observation of the drying bed Checking the record of sludge disposal	Every 4 months	NWSDB RSC	NWSDB

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No: N</th><th>Confirmation of Environmental Considerations
(Reasons, Mitigation Measures)</th></tr>
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Preparation of resettlement site
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<tr><td rowspan="2">6 Note</td><td>Reference to Checklist of Other Sectors</td><td>(a) Where necessary, pertinent items described in the Dam and River Projects checklist should also be checked.</td><td>(a) N/A</td><td>(a) The project does not develop the dam and canal. The project only use the existing facilities for irrigation. There is no item to conflict with the Dam and River Projects checklist.</td></tr>
<tr><td>Note on Using Environmental Checklist</td><td>(a) If necessary, the impacts to transboundary or global issues should be confirmed (e.g., the project includes factors that may cause problems, such as transboundary waste treatment, acid rain, destruction of the ozone layer, or global warming).</td><td>(a) N/A</td><td>(a) There is no negative impact to transboundary or global issues because the project is small scale water supply scheme targeting the improvement of living standards.</td></tr>
</table>

9.12 Recommendation

The pre-F/S was done by the NWSDB in 2011 for the Project. At that time, the Mahakanadarawa tank was not recognized as the Sanctuary, and the problem regarding water extraction was not noticed. In this study, the site selection and design were proposed for the purpose of preventing any conflict and adverse effect as much as possible. Some remaining problems are solved with the proper action of mitigation measures. Therefore the management is important to complete the mitigation measures.

The environmental adverse effect is generally limited in a water supply project. The impact is mainly created by the construction activities. For that reason, the tender document and contract paper are important to clarify the responsibility of contractor to do the positive action of environmental and social protection. The concrete monitoring scheme is also required and it must lead to immediate remedial action.

The quantity of water is limited in the area so that the Project relies on the other irrigation water developing projects. The result of social survey shows the positive willingness to obtain new safe water supply. However, the same people appealed the scarcity of water and fear of reduction of irrigation water. The explanation and awareness campaign are important to educate the people in the area and this type of work should be carried out by the NWSDB in proper manner.

CHAPTER 10

FINANCIAL AND ECONOMIC ANALYSIS

CHAPTER 10 FINANCIAL AND ECONOMIC ANALYSIS

10.1 General

This chapter of financial and economic analysis shows whether this water supply project is financially feasible and economically beneficial. The former financial feasibility is measured by the project financial internal rate of return (FIRR). If project investors are private, FIRR is thought to usually or internationally be at 12%, but this depends on the commercial bank loan interest rate and inflation rate. In Sri Lanka, the Average Weighted Lending Rate was 14.59% in May 2012, according to the web site of the Central Bank of Sri Lanka. The interest rate of ten years' Government Securities is 14.75% in July 2012. Therefore, the bank lending rate can be considered to be between 14% and 15%. The average inflation rate (consumer price) is approximately 7.5% in 2012. According to the National Account (statistics) of Sri Lanka, the deflators (used to convert gross or market price GDP to net or constant price GDP) in 2010 and 2011 are 7.29% and 7.88%, respectively. Thus, the inflation rate can be considered to be between 7% and 8%. Private investors calculate FIRR to be more than the difference between the lending rate of 14 % or 15%, and the inflation rate of 7% or 8%. That means that the minimum FIRR is 7% to 8% in net terms. However, private investors expect profits while considering risks. For example, if the investors want 5% more than the minimum FIRR, then the FIRR would become 12% or 13%.

This water supply project is a public project. The Government or NWSDB does not need to think about profit, but rather be assured of the soft loan interest rate. Therefore, the FIRR of this project should be more than the soft loan interest rate. This is the criterion for project feasibility. If the project FIRR does not satisfy the above criterion, or is too low, this does not necessarily mean that the project should not proceed.

The next method is to use economic cost-benefit analysis. If the FIRR is high enough, the project can be implemented without concern about financing because the project can be covered by the project profits. But if a project is necessary because it improves health or the welfare of the residents, and cannot be financed by the project entity, the project can be supported by the government budget and/or financed from international organizations. For example, roads excluding toll roads do not generate income, but it is necessary to invest in roads because these can facilitate development of regional industries and support people's lives. In this case, economic benefits are estimated in monetary amounts.

In this water supply project, the benefits are in the form of satisfaction expressed by willingness-to pay (WTP) and health impacts (medical cost reduction). Instead of income in the FIRR calculation, these economic benefits are estimated annually and discounted year by year. The cost is the same as the FIRR calculation, namely, consisting of investment cost and annual operation expenses. Thus, the economic internal rate of return (EIRR) can be calculated similarly to the FIRR.

Past World Bank projects have pegged EIRR to be a minimum of 12%, but usually the EIRRs of water supply projects seem lower than the other project EIRRs. In addition to the statistical data, an *ad hoc* social and economic survey in the project site was conducted in order to define and estimate the project benefits. While the income of the project is usually related to tariffs, the payment of tariff largely depends on the economic situation of project site users, namely, their affordability of payment and/or willingness-to-pay. Therefore, the social and economic situation of the project site is summarized indicating the data on estimated benefits of the project, and affordable tariffs, taking into account willingness-to-pay.

Next, the project finance with FIRR is analyzed. After that, the economic (cost-benefit) analysis with EIRR is made to examine the project viability. Lastly, sensitivity analyses are made on the financial and economic estimates to examine uncertainties and risks.

10.2 Social and Economic Conditions (Tariffs and Economic Situations) in Project Area

This section presents the existing tariffs of CBO and NWSDB, after a summary of the general social and economic situation in the project area in Chapter 9, “Environmental and Social Considerations.” In addition, willingness-to-pay and other related matters, directly related to the benefit calculation, are indicated in each benefit explanation.

After the project is completed, new water supply users can be divided into two groups. One is a direct NWSDB water user group. The other is a CBO user group, which is supplied with NWSDB water through CBO systems. The direct NWSDB users will pay the charges based on the tariffs shown in 3.3, Chapter 3. Most of the potential users in the project area are domestic and the domestic charges, which depend on the consumed water volume (m^3 per month), is shown in **Figure 10.1**. The curve seems to become steep from around 30 m^3 per month. The charges per water volume unit (m^3 per month) can be calculated and these are shown in **Figure 10.2**. The charge per unit is based on a minimum consumption of 10 m^3 per month and as consumption increases from 5 m^3 per month, the charge per unit increases. If a customer uses 18 m^3 per month, the charge is 295 Rs. and the charge per unit is 295/ 18 = 16.4 Rs./ m^3.

The CBO users at present are charged based on the tariffs of the CBOs and each CBO sets its tariff independently based on its financial situation. From the CBO survey results, the average charge per water volume unit (m^3) can be calculated by dividing monthly water sales

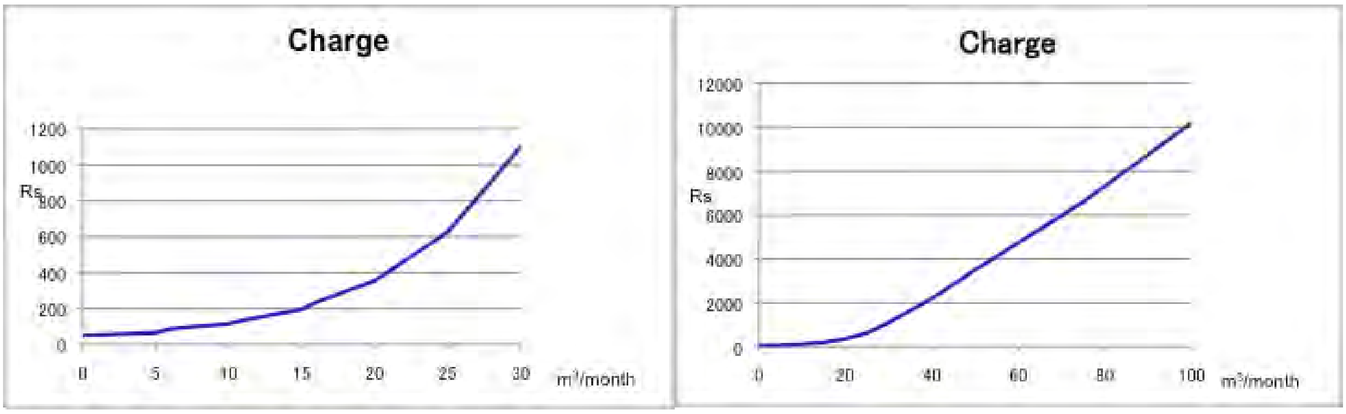

Figure 10.1 Domestic Consumer Charges

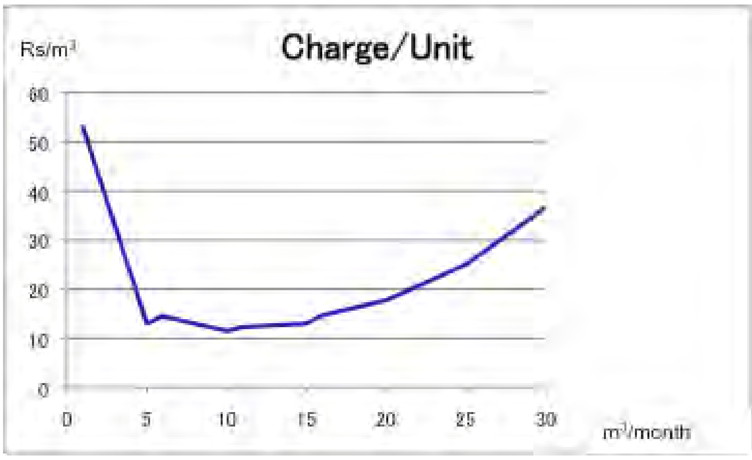

Figure 10.2 Domestic Charges per Unit

(Rs.) by monthly consumption (m^3). On the other hand, if this project is completed, the NWSDB will supply the CBOs with water. Potential users not connected to the CBOs prefer NWSDB water because of concerns about the quality of water supplied by CBOs, although some CBOs are confident about their water quality. NWSDB has tariffs for supplying bulk water to rural water supply schemes maintained by the CBOs. The NWSDB's charges based on the tariffs for CBO and the calculated charges per unit are shown in **Figure 10.3**. Using the CBO's monthly consumption, charges of the NWSDB to CBOs can be calculated and charges per unit can be obtained by dividing this by the monthly consumption. (However, note that consumption is likely to increase because CBOs supply capacities are limited as of now.) The CBO survey also questioned about the model charge for a supposed 18m^3 monthly use based on the CBO tariffs, and the answers can be divided by the 18m^3 and charges per unit can be obtained. These results are shown in **Table 10.1**. The water sales per unit (m^3) of the CBOs indicate an average charge which ranges from 4.7 Rs./m^3 to 44.5 Rs./m^3, the average of which is 19.6 Rs./m^3. NWSDB's average overall charge (revenue per m^3) in 2011 is 38.7 Rs./m^3 (13,320MRs./ 344.3 Mm^3) nationally and 36.1 Rs./m^3 in North Central Region. Obviously, the CBO's average charge is cheaper than NWSDB's, although there are a few CBOs whose charges are higher than NWSDB's.

The model charges per unit (assuming 18m^3/month consumption) are cheaper than sales/m^3 except in seven cases. If the tariffs of NWSDB for CBOs are applied to the current consumption of CBOs, the charges per unit (m^3) will range from 19.3 to 24.6 of which the average is 21.4 Rs./m^3. Therefore, while some CBOs' current charges per unit are more expensive than NWSDB's charges per unit, most CBOs' are actually cheaper than NWSDB's as the averages (19.6 and 21.0, respectively) show. However, in this calculation, the average non-revenue water rate of 20%, is used in order to compare the user price. Specifically, consumption is multiplied by 1.25 (=1/0.8) to calculate the charge of NWSDB bulk water, but the NWSDB charge is divided by consumption without multiplication.

The CBO survey included a question about the proposed (willing-to-pay) price for NWSDB's bulk water. The CBO answers ranged from 20 to 30 Rs./ m^3, but most answers were 25 Rs./m^3. Therefore, CBOs may be satisfied with the NWSDB's bulk tariffs from the viewpoint of the CBO purchase unit price because the NWSDB charge is divided by consumption (multiplied by 1.25). However, the NWSDB tariffs were raised from October 1, 2012 and if the new tariffs are applied to CBO bulk payments, then the situation changes.

If the project is implemented, the CBOs will connect to the NWSDB system and will have to pay the charges to NWSDB. This will increase the CBO expenditures. Among the present expenditures of CBOs that would remain or partially remain are personnel costs, chemical costs, and maintenance costs. However, electricity costs will not be necessary.

Assuming that chemical and maintenance costs are half of the present expenditures, the cost-basis prices of the CBOs can be calculated by summing the water purchase unit price from NWSDB, personnel costs and half of the chemical and maintenance costs per unit (converting annual to monthly based on the CBO survey results). The results are shown in the right column of **Table 10.1** for reference. Some CBOs estimated cost prices are cheaper than the present CBO's charges per unit (five CBOs); however in most CBOs they are higher. The average shows an increase from 19.6 to 30.4Rs./m^3, or an increase of approximately 55%.

In addition, the tariffs of NWSDB were raised from October 1, 2012 and the usage charge was increased from 12 Rs./m^3 to 18 Rs./m^3, or a 50% increase, and monthly service charge

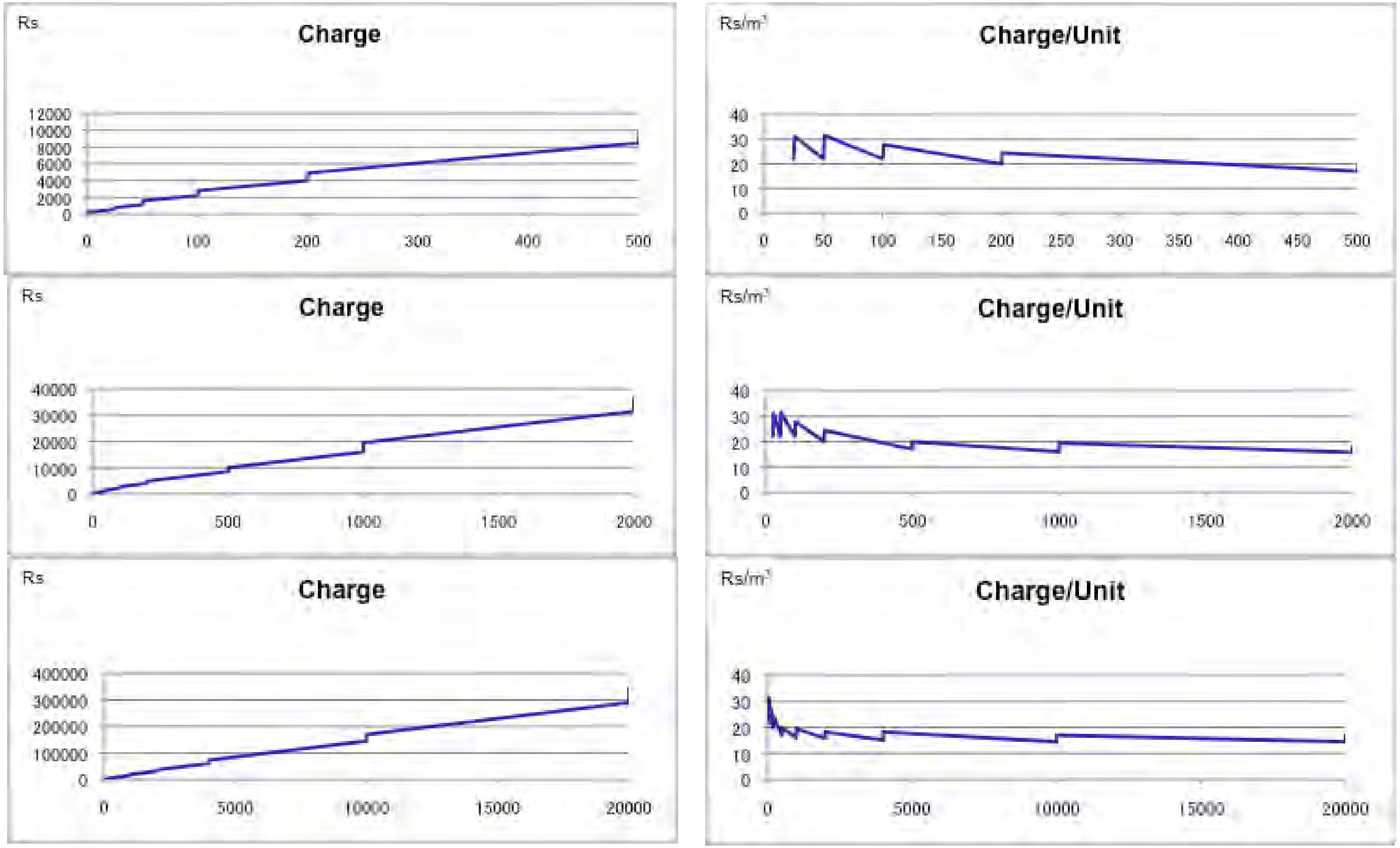

Figure 10.3 Charges of NWSDB to CBO and Charges per Unit

Table 10.1 Charges of CBOs

(Unit: Rs.)

DSD	GND	CBO	Consumption (m^3/month)	Water sales (Rs./month)	Sales/m^3 (Aver. Charge)	Model charge/m^3	NWSDB tariff	Proposed bulk tariff/ m^3	Cost-based price estimate
Padaviya	Padaviya	Suwasehana	1,989	34,502	17.3	13.1	21.3	25.0	29.8
	Parakramapura	Parakum	9,307	43,435	4.7	11.5	20.4	20.0	24.0
	Bogahawewa	Suwasetha	2,661	58,421	22.0	17.2	19.7	22.0	27.4
Kebithigollewa	Ayyatigewewa	Shakthi	2,583	39,069	15.1	12.6	19.8	25.0	29.6
Medawachchiya	Kidawarankulama	Sisila Diyadahara	1,762	36,255	20.6	15.0	22.1	-	29.7
	Maha Kumbugollewa	Diriyamatha	1,460	36,739	25.2	23.9	20.1	NWSDB Tariff	33.4
	Periyakulama &Yakawewa	Diriyashakthi	1,365	37,400	27.4	20.0	20.5	-	29.3
	Hirulugama	Ekamuthu	1,953	29,868	15.3	14.8	21.4	-	31.0
	Athakade	Ridinadi	938	27,756	29.6	21.7	23.0	25.0	35.1
	Ataweeragollewa	Samagi	1,266	19,486	15.4	15.0	20.9	NWSDB Tariff	27.6
	Maha Divulwewa	Gemunu	487	13,057	26.8	-	23.2	25.0	28.3
	Kadawathgama	Isuru	1,967	44,213	22.5	19.8	21.4	30.0	34.0
	Viralmurippuwa	Ran Arulnalu	1,907	31,522	16.5	12.0	21.6	30.0	26.1
	Katuwela	Jayashakthi	2,932	60,917	20.8	16.4	19.3	30.0	28.3
	Helabagaswewa	Samagi	1,818	80,882	44.5	15.0	21.9	25.0	32.2
	Kirigalwewa	Nelum	655	22,525	34.4	-	21.1	-	30.3
	Unagasewewa	Randiya Dhahara	1,018	34,005	33.4	25.0	22.4	25.0	30.1
Rambewa	Wewelketia & Thamarahamillewa	Rangiri	797	26,511	33.3	15.8	20.0	-	30.1
	Talgahawewa	Samagi	973	27,839	28.6	20.0	22.7	30.0	38.1
	Balahodawewa	Pragithi	726	11,731	16.2	19.6	20.5	-	28.7
	Ihala Kolongasw.	Dimuthu	417	9,936	23.8	21.7	24.6	25.0	34.5

DSD	GND	CBO	Consumption (m^3/month)	Water sales (Rs./month)	Sales/m^3 (Aver. Charge)	Model charge/m^3	NWSDB tariff	Proposed bulk tariff/ m^3	Charge estimate
Rambewa	Mahakandarawa 2	Mahasen	1,336	20,918	15.7	16.7	20.6	25.0	28.5
	Mahakandarawa 1	Nildiyadahara	1,175	24,283	20.7	21.3	21.4	25.0	30.7
	Kedewa & Galkandegama	Swashakthi	949	30,433	32.1	22.8	22.9	-	34.1
	Ikirigollewa	Ikra	8,645	145,680	16.9	13.1	20.8	-	26.1
	Katukeliyawa	Eksath	1,632	24,871	15.2	18.0	19.6	25.0	26.4
	Wahamalgollewa 3	Ekamuthu	1,448	41,210	28.5	20.0	20.2	25.0	30.3
	Sangilikanadarawa	Arunalu	2,834	58,842	20.8	15.8	19.4	20.0	26.3
Horowpothana	Wadigawewa	Pradeepa	1,578	19,409	12.3	13.0	19.8	30.0	27.6
	Maradankadawela	Hansajala	1,231	31,412	25.5	25.0	21.1	25.0	25.9
	Kapugollewa	Jalasavi	1,768	26,277	14.9	10.0	22.1	25.0	27.2
	Parangiyawadiya	Upul	1,691	46,244	27.3	17.2	22.4	30.0	29.5
Kahatagasdigiliya	Moragahawela	Pragathi	855	23,650	27.7	20.0	23.8	NWSDB Tariff	36.1
	Kubukgollewa	Ekamuthu	447	15,075	33.7	26.4	23.9	25.0	33.9
	Pandarellewa & Panwella	Sobasisila	2,254	42,560	18.9	15.0	20.5	25.0	25.2
	Mee-Kumbukwewa	Apsara	492	16,716	34.0	21.7	23.1	NWSDB Tariff	39.7
	Mahawewa	Praja Shakthi	1,089	36,520	33.5	20.0	21.9	25.0	37.9
	Maha Kubukwewa	Vajira	1,233	29,033	23.5	21.5	21.1	NWSDB Tariff	35.7
	Gonumeru Wewa	Senath	525	22,776	43.4	30.0	22.6	NWSDB Tariff	28.6
	Palippothana ~ Kirigallewa	Janasetha	1,952	30,789	15.8	16.1	21.4	25.0	27.0
	M. Kiribbewa & Kurukuragama	Eksath	930	17,900	19.2	15.0	23.1	25.0	32.6
Average			1,782	34,894	19.6	18.2	21.4	25.6	30.4

Source: CBO Survey

was raised by 10%. Therefore, the estimated cost prices have risen within 50%. The discussion above is based on the NWSDB's old tariffs, but it is better because the NWSDB tariffs were old during the CBO survey. When the new tariffs are applied to the CBO, the average CBO bulk payment unit to NWSDB becomes 29.7 Rs./m^3, or 1.39 times increase. Thus, it becomes higher than what the CBOs expect to pay (25 Rs./m^3). However, most users accept the charges if they are set relevantly according to the social economic survey.

In practice, tariff increases of CBOs are discussed and decided in member meetings. One CBO president said that their increase in tariff may not be so high, because they would try to keep the increase to a minimum.

10.3 Financial Analysis

10.3.1 Preconditions and Methods

The preconditions and methods of Financial Internal Rate of Return (FIRR) calculation are as follows.

- The calculation is based on the net or constant price because tariffs are controlled by the government and not easy to raise although inflation is occurring.
- The investment amount and the construction schedule are used as described in Chapter 7, "Project Cost," and Chapter 8, "Project Implementation." The investment costs include taxes, but they exclude interest payments during the construction period, because IRR treats only cash flow.
- Part of the invested assets such as buildings and plants has longer lives (depreciation periods) such as 50 or 60 years and the planning period is shorter so that the remaining residual values of these long life assets are input as minus investment at the end of the calculation period. However, shorter life assets such as machines and vehicles are not reinvested after their lifetimes such as seven or 10 years end within the planning period because they are usually used continuously and not reinvested.
- The income from operations is based on the tariffs, but specifically, the billed amount and water used in 2011 shown by the NWSDB statistics are used to calculate income per water volume (national total 38.7 Rs./m^3 or North Central Region domestic 25.0 Rs./ m^3) and this unit is multiplied by the estimated demand water volume. However, the NWSDB tariffs were raised from October 1, 2012 and new income per water volume is not clear because there is no statistic data after the tariff increase. Assuming the income per water volume becomes 1.5 times because domestic usage charge increases 2.67 to 1.33 times depending on the consumption and bulk supply usage charge increases 1.5 times and bulk supply monthly service charge increases 1.1 times. The North Central Region domestic 25.0 Rs./ m^3 increases to 37.5 Rs./ m^3 (=25 x 1.5). Therefore, this FIRR calculation uses 37.5 Rs./ m^3 as income per water volume.
- The operations costs are based on the estimates described in 7.6 "Operation and

Maintenance Cost," Chapter 7, "Project Cost." Specifically, the personnel costs are fixed, but the other costs such as electricity and chemicals are dependent on the consumed water volumes (demands).

10.3.2 FIRR Results

(1) Mahakanadarawa

The Mahakanadarawa water source area FIRR calculation result is shown in **Tables 10.2** (Case 1) and 10.3 (Case 2). In Case 1, Phase 2 investment is made and so the water demand is satisfied. But in Case 2, Phase 2 investment is not made and the water demand after 2025 is the same as that in 2024. In both cases, FIRRs are minus and so this project cannot be covered by the profits. The difference between the two cases is 0.12% and small. In order to make it positive, the tariffs should be raised 2.5 times of the present level. In addition, since this is calculated in net (constant price), it is assumed that tariffs are almost always revised based on the inflation in gross (market price).

Table 10.2 Estimated FIRR (Mahakanadarawa Case 1)

(Unit: Mill. Rs.)

Year	Investment	Revenues	Expenditures	Cash flow
2013	82.2			-82
2014	437.5			-438
2015	1,093.1			-1,093
2016	3,508.7			-3,509
2017	3,641.5			-3,642
2018	960.1	56	34	-938
2019	14.9	78	46	17
2020		82	48	34
2021		86	49	37
2022		90	51	39
2023		94	53	41
2024	786.5	98	54	-743
2025		108	66	41
2026		117	71	46
2027		127	76	52
2028		137	80	57
2029		147	85	62
2030		157	90	67
2031		167	95	72
2032		177	100	78
2033		187	104	83
2034		197	109	88
2035		197	109	88
2036		197	109	88
2037		197	109	88
2038		197	109	88
2039	-4,674	197	109	4,762
FIRR				-2.71%

Source: JICA Study Team

Table 10.3 Estimated FIRR (Mahakanadarawa Case 2)

(Unit: Mill. Rs.)

Year	Investment	Revenues	Expenditures	Cash flow
2013	82.2			-82
2014	437.5			-438
2015	1,093.1			-1,093
2016	3,508.7			-3,509
2017	3,641.5			-3,642
2018	960.1	56	34	-938
2019	14.9	78	46	17
2020		82	48	34
2021		86	49	37
2022		90	51	39
2023		94	53	41
2024		98	54	44
2025		98	54	44
2026		98	54	44
2027		98	54	44
2028		98	54	44
2029		98	54	44
2030		98	54	44
2031		98	54	44
2032		98	54	44
2033		98	54	44
2034		98	54	44
2035		98	54	44
2036		98	54	44
2037		98	54	44
2038		98	54	44
2039	-4,674	98	54	4,718
FIRR				-2.59%

Source: JICA Study Team

Since the tariffs need to be 2.5 times of the present level in order to make FIRR positive, sensitivity analyses that change the revenues or expenditures including investment by plus or minus 10% are neither effective nor useful. Therefore, sensitivity analysis is omitted. However, if a water supply project is located in a rural area, 80% of investment cost is covered by the government grant. Therefore, NWSDB will bear only 20% of the investment costs in this project because this project area includes no municipalities. Instead of sensitivity analysis, FIRR calculation of a case that investment cost decreases to 20% of the total investment is shown in **Table 10.4** (Case 1: with Phase 2 investment). If the income per water volume increases 1.5 times (37.5 Rs./m^3) because of the tariff raise, the FIRR becomes positive (0.42%). In this case, NWSDB can pay interest and repay JICA if making efforts. However, this does not mean that the total project is covered by the profits. Of course, this 1.5 times increase of tariffs is also based on the additional inflation coverage.

Table 10.4 FIRR Calculation (Mahakanadarawa 20% Investment Case)

(Unit: Mill. Rs.)

Year	Investment	Revenues	Expenditures	Cash flow
2013	16.4			-16
2014	87.5			-88
2015	218.6			-210
2016	701.7			-702
2017	728.3			-728
2018	192.0	37	22	-177
2019	3.0	78	46	29
2020		82	48	34
2021		86	49	37
2022		90	51	39
2023		94	53	41
2024	157.3	98	54	-114
2025		108	66	41
2026		117	71	46
2027		127	76	52
2028		137	80	57
2029		147	85	62
2030		157	90	67
2031		167	95	72
2032		177	100	78
2033		187	104	83
2034		197	109	88
2035		197	109	88
2036		197	109	88
2037		197	109	88
2038		197	109	88
2039	-934.8	197	109	1,023
FIRR				0.42%

Source: JICA Study Team

(2) Wahalkada

The result of Wahalkada FIRR calculation is shown in **Table 10.5** (Case 1). In Case 1 (with Phase 2 investment in 2024), the FIRR is -2.88% and in Case 2 (without Phase 2 investment), it is -2.80%. The results are a little worse than those of Mahakanadarawa Cases because Wahalkada is a lower-density area and the investment is less efficient than Mahakanadarawa.

Similarly to the Mahakanadarawa case, a case in which NWSDB's burden is 20% of the investment is calculated and the FIRR becomes 1.5% in Case 1, better than that of Mahakanadarawa because of the proportion of investment reduction to revenues.

Table 10.5 Estimated FIRR (Wahalkada Case 1)

(Unit: Mill. Rs.)

Year	Investment	Revenues	Expenditures	Cash flow
2013	12.9			-13
2014	12.9			-10
2015	1,502.9			-1,542
2016	4,502.9			-4,503
2017	4,593.5			-4,594
2018	4,012.3	20	13	-2,700
2019	18.9	122	83	20
2020		128	86	42
2021		133	89	44
2022		139	93	46
2023		145	96	49
2024	1071.4	152	100	-1,020
2025		169	115	54
2026		186	125	61
2027		200	134	66
2028		214	142	72
2029		228	151	78
2030		243	159	83
2031		258	169	89
2032		273	178	96
2033		290	188	102
2034		306	198	109
2035		306	198	109
2036		306	198	109
2037		306	198	109
2038		306	198	109
2039	-7,035	306	198	7,144
FIRR				-2.88%

Source: JICA Study Team

10.3.3 Tariffs and Future Direction

The tariffs of NSWDB are very low and cannot be easily raised. This distorts the management of NSWDB. Tariffs should be raised to reflect inflation because Sri Lanka has had recent inflation rates of 7% or 8% on the average. In addition, the government controls the tariffs and so NSWDB receives grants and loans from the government. **Table 10.6** shows the international comparison of water supply tariffs. Some countries such as India, China and Tanzania show that costs are not covered, and it is actually the government that supports these water supply entities. Excluding these countries, Sri Lanka's revenue/ m^3 is relatively low considering the low revenue/m^3/GNI (Gross National Income). Thus, government's financial support to NWSDB at keeping the tariff low cannot be continued nor is it sustainable. NWSDB should be an independent management entity able to cover all its costs. In the long term, fiscal autonomy or privatization can be examined.

Table 10.6 International Comparison of GNI and Financial Indexes of Water Supply Entities

(Unit: US$)

Country	Year	GNI per capita	Revenue/m^3	Cost/m^3	Cost coverage	Rev./GNI
Sri Lanka	2006	1,050	0.22	0.22	100.0%	0.00021
Bangladesh	2009	576	0.14	0.10	71.4%	0.00024
India	2009	1,134	0.15	0.26	173.3%	0.00013
Pakistan	2006	700	0.17	0.27	158.8%	0.00024
Indonesia	2004	1,140	0.20	0.15	75.0%	0.00018
Malaysia	2007	5,400	0.39	0.34	87.2%	0.00007
Philippines	2004	1,170	0.28	0.21	75.0%	0.00024
Vietnam	2007	650	0.24	0.13	54.2%	0.00037
China	2009	1,870	0.32	0.37	115.6%	0.00017
Laos	2008	460	0.15	0.14	93.3%	0.00033
Cambodia	2007	380	0.28	0.12	42.9%	0.00074
Mexico	2006	7,000	0.73	0.63	86.3%	0.00010
Panama	2006	4,400	0.25	0.18	72.0%	0.00006
Paraguay	2005	1,200	0.36	0.17	47.2%	0.00030
Peru	2006	2,700	0.45	0.34	75.6%	0.00017
Bolivia	2006	1,020	0.40	0.26	65.0%	0.00039
Kenya	2006	520	0.48	0.25	52.1%	0.00092
Tanzania	2008	410	0.24	0.29	120.8%	0.00059
Ghana	2005	400	0.60	0.53	88.3%	0.00150
Malawi	2004	-	0.26	0.16	61.5%	-
Nigeria	2004	430	0.20	0.14	70.0%	0.00047

Source: C. Berg and A. Danilenko, "The IBNET Water Supply and Sanitation Performance Blue Book," The World Bank, 2011

10.4 Economic Analysis

10.4.1 Preconditions and Methods

The preconditions and methods of EIRR calculation are similar to those of FIRR above, but with some differences, as follows.

- The calculation is on the net or constant price basis.
- The investment amount and the construction schedule are used as described in Chapter 7, "Project Cost," and Chapter 8, "Project Implementation," but the investment costs exclude taxes and interest payments during the construction period. In addition, domestic currency part of the investment is converted to border price using a conversion factor. The conversion factor, 0.9[1], used in Sri Lanka will also be used in this analysis.

[1] [1] ADB, "Sri Lanka: Upper Watershed Management Project," October 2006
ADB, "Sri Lanka: Forest Resources Management Sector Project," September 2010

- The long life investment assets are treated similarly to those in FIRR analysis above.
- Benefits are estimated instead of the operation income in FIRR, but it is necessary to explain the benefits in detail so that they are described separately below.
- The operation costs are the same as those in FIRR analysis.

10.4.2 Benefits

Main benefits are derived from willingness-to-pay (WTP) amounts. The other benefits are reduction of medical and related costs caused by water borne diseases such as diarrhea, dysentery and viral hepatitis.

(1) WTP

Willingness-to pay amounts that users of the new water supply project intend to pay can be seen as benefits in monetary terms. A social and economic survey was conducted in this project study and WTP amounts were surveyed. In addition, income, present water consumption quantity (mainly for drinking) and payment for the water were surveyed. It is said that 3.5% to 5% of income can be paid for water according to the World Bank or ADB. Payment for water, WTP amount and 4% of income are divided by the consumed water quantity in order to compare these. The survey results are shown in **Table 10.7**.

Table 10.7 Actual Payment, WTP

(Unit: Rs./m^3)

DSD	Average Actual Payment for Water				WPT				4% of Income/ m^3			
	WB	CBO	No Supply	Total	WB	CBO	No Supply	Total	WB	CBO	No Supply	Total
KD	20.9	28.2	358.4	28.3	33.3	16.3	29.6	26.5	55.3	137.4	469.4	176.1
HP	63.7	21.8	−	26.8	−	17.4	28.6	24.9	155.6	106.3	293.2	207.2
KG	35.8	32.0	361.1	38.0	−	39.3	78.5	74.1	140.8	99.0	138.8	137.3
Pad	44.8	27.9	188.9	53.2	34.7	39.6	42.1	40.3	79.5	78.0	158.7	110.5
Ram	20.5	27.3	91.1	28.1	−	28.4	97.1	40.2	70.1	94.3	255.5	132.3
Med	22.0	38.6	962.7	36.3	24.0	38.8	43.9	37.9	95.4	136.6	305.4	166.4
Total	27.3	29.9	237.7	33.6	28.6	31.1	52.3	40.6	89.5	114.2	266.3	157.0

Source: JICA Study Team

However, there are some points to be noted as follows.

- There are small sample number groups such as NWSDB water user groups in Horowpothana (Hp), Rambewa (Ram) and Padaviya (Pad).
- In addition, there are some groups in which WTP answers are none such as NWSDB water user groups in Hp, Kebithigollewa (Kg) and Ram.
- WTP answers are fewer in CBO water user groups in Kahatagasdigiliya (Kd), Hp and Kg

and No Supply user groups in Kd, Pad and Kg,

- Actual payment per m3 and 4% income per m3 in No Supply user groups are much larger than those of other user groups such as CBO and NWSDB because No Supply users may use less water at much more expensive prices. For example, a private company is selling purified water at Rs. 2 per liter, namely Rs. 2,000 per m3.

Based on these points, the WTP amounts are set as follows.

- New users of this project are No Supply group users above. This group does not have water supply and may not have suitable WTP amounts as most of the answers are required or relevant prices and answered WTP amounts are low and the specific amount answered is fewer.
- CBO user groups can use tap water, but CBO water quality is not fully acceptable compared with the NWSDB water.
- Therefore, the WTP amount is set based on the No Supply group and the WTP should be set as the lower amount of either actual payment per m3 or 4% income per m3 of the No Supply group because No Supply group and CBO users can use safer water of NWSDB by the project. In addition, these benefits are calculated only for No Supply group and CBO user group. Although some existing NWSDB water users use well water, the benefits of NWSDB users are excluded in this benefit calculation because the benefits should be conservative.

The WTP set is shown in **Table 10.8**.

The existing NWSDB water users may get the same benefits expressed in WTP originally, but having already received the benefits, this set of users are ignored in this calculation because EIRR should be estimated conservatively.

Table 10.8 WTP (Unit: Rs./m^3)

<table>
<tr><th>DSD</th><th>WB</th><th>CBO</th><th>No Supply</th></tr>
<tr><td>KD</td><td></td><td colspan="2">358</td></tr>
<tr><td>HP</td><td></td><td colspan="2">293</td></tr>
<tr><td>KG</td><td></td><td colspan="2">139</td></tr>
<tr><td>Pad</td><td></td><td colspan="2">159</td></tr>
<tr><td>Ram</td><td></td><td colspan="2">255</td></tr>
<tr><td>Med</td><td></td><td colspan="2">305</td></tr>
</table>

Source: JICA Study Team

(2) Water Borne Diseases

Water borne diseases such as fluorosis, diarrhea, dysentery and viral hepatitis can be reduced as this project enables the residents to use clean and better quality water. Although some diseases such as diarrhea, dysentery and viral hepatitis are not only caused by water but also by bad foods and unsanitary conditions, the social economic survey separated the users into three groups, namely NWSDB, CBO and No Supply, so that the water borne disease rates in these groups can be compared.

1) Fluorosis

Fluorosis is caused by fluorides in water. **Table 10.9** shows the fluorosis occurrence rates in the social economic survey result. It is very clear that the rate of NWSDB water user group is the lowest, that of the CBO group is the middle and that of the No Supply group is the highest. The benefits of fluorosis reduction are measured by medical cost reduction. According to the interview with an official (medical doctor) of North Central Provincial Health Services, medical costs of fluorosis are as follows.

- One fluorosis tooth requires Rs. 2,500 to 3,000 as medical treatment cost.
- One patient has 8 to ten teeth.
- Without good water, the patients need to have such treatment within two or three years.

Thus, the annual medical cost of one patient is computed as follows: 2,750 Rs. x 9 teeth /2.5 years = 9,900 Rs. /year.

Table 10.9 Fluorosis Rates

DSD	Fluorosis patients				Population				Patient ratio (%)			
	WB	CBO	No supply	Total	WB	CBO	No supply	Total	WB	CBO	No supply	Total
KD	35	43	86	164	137	253	352	742	25.5%	17.0%	24.4%	22.1%
HP	5	22	72	99	25	111	360	496	20.0%	19.8%	20.0%	20.0%
KG	0	3	11	14	116	32	225	373	0.0%	9.4%	4.9%	3.8%
Pad	0	3	14	17	71	118	186	375	0.0%	2.5%	7.5%	4.5%
Ram	1	69	57	127	48	406	349	803	2.1%	17.0%	16.3%	15.8%
Med	10	19	54	83	160	336	417	913	6.3%	5.7%	12.9%	9.1%
Total	51	159	294	504	557	1,256	1,889	3,702	9.2%	12.7%	15.6%	13.6%

Source: JICA Study Team

The fluorosis rate differences between the NWSDB and the CBO groups and between the NWSDB and the No Supply groups can be seen as the potential beneficial patient rates. Specifically, 15.6 – 12.7= 3.5% and 13.6 – 9.2 = 4.4% are fluorosis rates of beneficial patients, respectively. Therefore, these difference rates are multiplied by CBO population and No Supply (or New Supply) population, respectively. It is assumed that the NWSDB group do not get the benefits as they already use NWSDB water. Or it can also be assumed that the NWSDB group users have fluorosis because of other causes or use of water such as well water or something in addition to NWSDB water.

2) CKD (Chronicle Kidney Disease)

CKD is caused by kidney functional deterioration. However, there are relatively more CKD patients found around the dry zone in Sri Lanka including this project area. This CKD is called CKD unknown origin (CKDU) and the Ministry of Health and WHO, etc. have been studying CKDU, but its causes or are not clear. Therefore, these CKD benefits are treated separately as additional benefits in this calculation.

Table 10.10 shows the CKD rates in the social economic survey result. It is also very clear that the rate of NWSDB water user group is the lowest, that of the CBO group is the middle and that of the No Supply group is the highest, similar to the case of fluorosis.

Table 10.10 CKD Rates

DSD	Fluorosis patients				Population				Patient ratio (%)			
	WB	CBO	No supply	Total	WB	CBO	No supply	Total	WB	CBO	No supply	Total
KD	1	2	11	14	137	253	352	742	0.73%	0.79%	3.13%	1.89%
HP	0	3	3	6	25	111	360	496	0.00%	2.70%	0.83%	1.21%
KG	2	1	7	10	116	32	225	373	1.72%	3.13%	3.11%	2.68%
Pad	2	5	7	14	71	118	186	375	2.82%	4.24%	3.76%	3.73%
Ram	0	7	3	10	48	406	349	803	0.00%	1.72%	0.86%	1.25%
Med	5	11	16	32	160	336	417	913	3.13%	3.27%	3.84%	3.50%
Total	10	29	47	86	557	1,256	1,889	3702	1.87%	2.31%	2.49%	2.32%

Source: JICA Study Team

The CKD rate differences between the groups are also used as CKDU potential beneficial patient rates similarly to the case of fluorosis. However, according to a former medical doctor of Anuradhapura Hospital specializing in kidney disease, these CKD rates are lower than actual patient rates because in 3,000 urine samples collected and tested in a village of Vavuniya, a neighboring district in the north of the project area, it was found that the CKD rate was 15%. There are five stages in CKD. The final fifth stage requires dialysis or kidney transplant operation and without one of these treatments, the patients will die, but before that stage patients may be able to live. Therefore, the actual patients exist more than the rate of 2.3% on average in the social economic survey. Assuming the average CKD rate is 15%, the differences of the three groups are estimated using the ratios as follows.

- The average CKD rates of the three groups and the total average are 1.87% (NWSDB), 2.31% (CBO), 2.49% (No Supply) and 2.32% (total), respectively.
- If the total average is assumed as 1, the three groups ratios become 0.806, 0.996 and 1.073.
- Thus, the total average is assumed 15% and so the group rates become 15 x 0.806 =12.1%, 15 x 0.996 = 14.9% and 15 x 1.073 = 16.1%.

The differences of the above CKD rates can be used to calculate the beneficial CKD patients similarly to the fluorosis case.

The medical costs of CKD depend on the five stages. According to the kidney specialist doctor above, the stage 5 patients rate is approximately 2% of the total patients and the stage 4 rate is 5 to 10%, and so 8% is assumed. At the stage 5, the medical costs of dialysis are Rs. 100,000 /month (3 times per week); while a transplant operation costs Rs. 1 million for one patient and donor; and Rs. 30,000 / month is needed after the operation. But transplant opportunities are scarce, and so dialysis is the medical treatment used in this calculation. At the stage 4, the medical costs are Rs. 15,000 / month. At the stages 1 to 3 that account for remaining 90% of the total CKD patients, the medical costs are Rs. 10,000 / month. In addition, the cost of transportation to and from hospital is assumed at Rs. 5,000 / time.

3) Diarrhea

According to a medical doctor of Padaviya Hospital, there are approximately 30 diarrhea cases per month. With 30 cases /month x 12 months /Pad. population 35,359 = 1.02% is the computed diarrhea rate. In order to get the differences between the user groups, CKD ratios above, namely 0.806, 0.996 and 1.073, and similar fluorosis ratios, 0.677, 0.934 and 1.147, are averaged and 0.742, 0.965 and 1.11 are used for this disease rate differences. The medical costs are Rs. 5,000 / day x 3 days =Rs. 15,000. In addition, the transportation costs are Rs. 5,000 / day, similarly to the CKD case. Furthermore, there are patients who do not go to hospitals. They are approximately three times of the above patients going to hospitals. Their medical costs are Rs. 1,000 per patient.

4) Viral Hepatitis

According to the same medical doctor of Padaviya Hospital, viral hepatitis cases are 1 to 2 cases per month and so 1.5 cases /month x 12 months /Pad. population 35,359 = 0.0509% becomes the disease rate. The ratios between the user groups above are also similar. The medical costs are Rs. 5,000/ day x 8 days= Rs. 40,000. Same transportation costs are also added.

5) Dysentery

Based on the same doctor's information, dysentery cases are approximately 10 /month and so 10 x 12 / 35,359 = 0.34% is the disease rate.

The medical and transportation costs are Rs. (10,000 + 5,000) /day x 3 days = Rs. 45,000

6) Enteric Fever

The doctor said that enteric fever cases are rare and so this is omitted.

10.4.3 EIRR Results

(1) Mahakanadarawa

The Mahakanadarawa water resource area mainly consists of Rambewa and Medawachchiya DSDs. Therefore, WTPs of these two DSDs are used. The result of EIRR is shown in **Tables 10.11 and 10.12**.

In Case 1 (with Phase 2 investment), the EIRR is 6.91% and is better as compared with those of other water supply projects. In addition, if CKD benefits are included, the EIRR becomes 11.8%, a satisfactory figure. In Case 2 (without the additional investment), the EIRR is 5.54%, less than that of Case 1. If CKD benefits are included, the EIRR becomes 10.4%.

Table 10.11 EIRR of Mahakandarawa Case 1 (With Phase 2 Investment)

(Unit: Mill. Rs.)

Year	Investment	Operation Cost	Cash Flow		Benefits					
			Excl. CKD	Incl. CKD	WTP	CKD	Fluorosis	Diarrhea	Viral Hepatit.	Dysente.
2013	72.3		-72	-72						
2014	382.8		-383	-383						
2015	842		-842	-842						
2016	2,718.10		-2,718	-2,718						
2017	2,826.90		-2,827	-2,827						
2018	750.2	34	-429	-158	322	271	27	4	0.4	1.6
2019	14	46	440	809	455	369	37	5	0.6	2.2
2020		48	480	857	481	377	38	5	0.6	2.3
2021		49	507	893	509	386	39	5	0.6	2.3
2022		51	534	928	536	395	40	5	0.6	2.4
2023		53	565	969	568	404	41	5	0.6	2.4
2024	733	54	-137	276	600	413	42	5	0.6	2.5
2025		66	628	1,052	642	424	43	5	0.7	2.5
2026		71	667	1,103	685	436	44	6	0.7	2.6
2027		76	714	1,182	732	468	48	6	0.7	2.8
2028		80	761	1,262	780	501	51	6	0.8	3
2029		85	811	1,342	832	530	54	7	0.8	3.2
2030		90	861	1,421	883	560	57	7	0.9	3.4
2031		95	915	1,505	937	591	60	8	0.9	3.6
2032		100	968	1,589	992	622	63	8	1	3.8
2033		104	1,024	1,674	1,050	649	66	8	1	3.9
2034		109	1,081	1,758	1,108	677	69	9	1.1	4.1
2035		109	1,081	1,758	1,108	677	69	9	1.1	4.1
2036		109	1,081	1,758	1,108	677	69	9	1.1	4.1
2037		109	1,081	1,758	1,108	677	69	9	1.1	4.1
2038		109	1,081	1,758	1,108	677	69	9	1.1	4.1
2039	-3,432	109	4,513	5,190	1,108	677	69	9	1.1	4.1
		EIRR	6.91%	11.80%						

Source: JICA Study Team

In order to estimate sensitivity, the investment, operational costs and benefits are changed to plus 10% or minus 10%. The results are shown in **Table 10.13**. The investment cost change affects the EIRR the most, but the difference is only -0.73% or +0.86%. The second most effective change is the operations cost and the difference is -0.06% or +0.07%. The benefit change difference is very small at –0.01% or +0.01%.

Table 10.12 EIRR of Mahakanadarawa Case 2 (Without Phase 2 Investment)

(Unit: Mill. Rs.)

Year	Investment	Operation Cost	Cash Flow		Benefits					
			Excl. CKD	Incl. CKD	WTP	CKD	Fluorosis	Diarrhea	Viral Hepatit.	Dysente.
2013	72.3		-72	-72						
2014	382.8		-383	-383						
2015	842		-842	-842						
2016	2,718.10		-2,718	-2,718						
2017	2,826.90		-2,827	-2,827						
2018	750.2	34	-429	-158	322	271	27	4	0.4	1.6
2019	14	46	440	809	455	369	37	5	0.6	2.2
2020		48	480	857	481	377	38	5	0.6	2.3
2021		49	507	893	509	386	39	5	0.6	2.3
2022		51	534	928	536	395	40	5	0.6	2.4
2023		53	565	969	568	404	41	5	0.6	2.4
2024		54	596	1,009	600	413	42	5	0.6	2.5
2025		54	596	1,009	600	413	42	5	0.6	2.5
2026		54	596	1,009	600	413	42	5	0.6	2.5
2027		54	596	1,009	600	413	42	5	0.6	2.5
2028		54	596	1,009	600	413	42	5	0.6	2.5
2029		54	596	1,009	600	413	42	5	0.6	2.5
2030		54	596	1,009	600	413	42	5	0.6	2.5
2031		54	596	1,009	600	413	42	5	0.6	2.5
2032		54	596	1,009	600	413	42	5	0.6	2.5
2033		54	596	1,009	600	413	42	5	0.6	2.5
2034		54	596	1,009	600	413	42	5	0.6	2.5
2035		54	596	1,009	600	413	42	5	0.6	2.5
2036		54	596	1,009	600	413	42	5	0.6	2.5
2037		54	596	1,009	600	413	42	5	0.6	2.5
2038		54	596	1,009	600	413	42	5	0.6	2.5
2039	-3,432	54	4,028	4,441	600	413	42	5	0.6	2.5
		EIRR	5.54%	10.40%						

Source: JICA Study Team

Table 10.13 Mahakanadarawa Sensitivity Analysis Results

Alternatives	Investment Plus 10%	Op. Cost Plus 10%	Benefits Minus 10%	Standard (Case 1)	Investment Minus 10%	Op. Cost Minus 10%	Benefits Plus 10%
EIRR	6.18%	6.85%	6.90%	6.91%	7.77%	6.98%	6.92%

Source: JICA Study Team

(2) Wahalkada

The Wahalkada water resource area mainly consists of the DSDs other than Rambewa and Medawachchiya. WTPs of these four DSDs are used. The result of EIRR is 6.59% shown in **Table 10.14** (Case 1). If CKD benefits are included, the EIRR becomes 11.5%. Case 2 EIRR is 4.46% and lower than that of Case 1 (6.59%).

In order to estimate sensitivity, the investment, operational costs and benefits are changed to plus

10% or minus 10%. The results are shown in **Table 10.15**. The investment cost change affects the EIRR most, but the difference is only -0.7% or +0.81%. The second most effective change is the operations cost and the difference is -0.10% or +0.09%. The benefit change difference is very small at –0.01% or +0.01%.

Table 10.14 EIRR of Wahalkada Case 1 (With Phase 2 Investment)

(Unit: Mill. Rs.)

Year	Investment	Operation Cost	Cash Flow		Benefits					
			Excl. CKD	Incl. CKD	WTP	CKD	Fluorosis	Diarrhea	Viral Hepatit.	Dysente.
2013	12.9		-13	-13						
2014	12.9		-13	-13						
2015	1,143.60		-1,144	-1,144						
2016	3,460.00		-3,460	-3,460						
2017	3,534.30		-3,534	-3,534						
2018	3,105.60	13	-3,006	-2,915	101	91	9	1	0.1	0.6
2019	17.9	83	601	1,161	634	560	56	7	0.9	3.5
2020		86	643	1,217	660	573	58	8	0.9	3.5
2021		89	668	1,256	686	588	59	8	0.9	3.6
2022		93	693	1,295	713	602	60	8	1	3.7
2023		96	724	1,343	745	619	62	8	1	3.8
2024	1002	100	-248	389	777	637	64	8	1	3.9
2025		115	847	1,504	882	657	66	9	1.1	4
2026		125	945	1,622	988	677	68	9	1.1	4.2
2027		134	1,021	1,741	1,067	720	72	10	1.2	4.4
2028		142	1,097	1,859	1,147	762	77	10	1.2	4.7
2029		151	1,179	1,987	1,231	808	81	11	1.3	5
2030		159	1,260	2,115	1,316	855	86	11	1.4	5.3
2031		169	1,347	2,250	1,406	903	91	12	1.5	5.6
2032		178	1,434	2,386	1,496	952	96	13	1.5	5.9
2033		188	1,526	2,529	1,592	1,003	101	13	1.6	6.2
2034		198	1,618	2,673	1,688	1,054	106	14	1.7	6.5
2035		198	1,618	2,673	1,688	1,054	106	14	1.7	6.5
2036		198	1,618	2,673	1,688	1,054	106	14	1.7	6.5
2037		198	1,618	2,673	1,688	1,054	106	14	1.7	6.5
2038		198	1,618	2,673	1,688	1,054	106	14	1.7	6.5
2039	-5,157	198	6,775	7,830	1,688	1,054	106	14	1.7	6.5
		EIRR	6.59%	11.50%						

Source: JICA Study Team

Alternatives	Investment Plus 10%	Op. Cost Plus 10%	Benefits Minus 10%	Standard (Case 1)	Investment Minus 10%	Op. Cost Minus 10%	Benefits Plus 10%
EIRR	5.89%	6.49%	6.58%	6.59%	7.40%	6.68%	6.60%

Source: JICA Study Team

The project area covers an area with an extraordinarily high prevalence of CKD and drinking water has a possibility as one of causes for such a disease. Therefore, the people are waiting for drinking water supply by NWSDB eagerly. Since the cause of CKD is still unknown, the economic analysis was done as a basis for the case of exclusion of medical expenses for CKD and the inclusion case is given as a reference. Anyway, if taking into account the willingness of the people to seek for safe water, it is considered reasonable to use the amount in the economic analysis that the people will be able to pay as willingness-to-pay. In addition, it is difficult to get enough water during the drought season in the project area and the stable water supply by NWSDB is also the great hope of the people and it is reasonable to handle the willingness-to-pay as the benefit from this aspect.

10.5 Toward Sustainability of Operation and Maintenance and What Water Supply Management Should Be

In both cases for Mahakanadarawa (**Table 10.2**) and Wahalkada (**Table 10.5**), the revenue is bigger than the O&M cost and it is possible to well manage the proposed water supply system, if there is no investment. Although the investment (cost) is too big resulting in minus FIRR, the business income and expenditure is plus, which makes operations possible. However, it should be noted that depreciation is excluded herein due to a focus of the cash flow. In fact, since the project area is rural, the government bears 80% of the investment while NWSDB shoulders the remaining 20%. In this case, FIRR is plus, namely 0.71% for Mahakanadarawa and 2.0% for Wahalkada, respectively. But when the investment is financed by the loan, the repayment can't be done as long as the interest rate doesn't keep this level of FIRR. It is sure that the revenue over the O&M cost will be maintained.

From the viewpoint what the water supply management should be, the revenue should cover the expenditures including an investment and the principal and interest repayment is possible if FIRR is equal to the interest rate in case of full cover of an investment with a loan. For a private company to operate the water supply business, if the income will be offset by principal and interest repayment with no profit, it is meaningless to make an investment and therefore a company seeks for higher FIRR. It is considered that NWSDB is the public entity and acceptable to such FIRR if it is equal to the interest rate. However, even NWSDB can't manage the business in the situation that FIRR as shown in **Table 10.2** and **Table 10.5** is minus. Therefore, as long as the revenue to maintain FIRR equal to the interest rate in case of an investment financed through a loan is not assured, that is to say, the tariff increase is assured, NWSDB can't operate as a self-support accounting entity. However, the tariff increase is controlled by the government, NWSDB has to receive the subsidy from the government, if so.

For the future direction, if the per capita GDP in Sri Lanka will increase with an average income, the customer will afford to pay the water tariff or should pay the proper water tariff and the government will be released from the policy to control the water tariff in a low level.

On the other hand, if the government is proper, it should accept the tariff increase at least at the level equal to an annual inflation rate (an increment of Consumer Price Index (CPI)). However, the government will setting the equation of [CPI – α] and estimate α as a challenge for productivity improvement to direct NWSDB or negotiate with NWSDB. Since the financial analysis in this report as well as the economical analysis is done with the net, the gross will not be the same as an estimation, as long as the inflation portion will not be added to the actual income and expenditure. That is to say, the revenue, if the tariff will not reflect the inflation, will decrease against the actual cost

CHAPTER 11

OPERATION AND EFFECT INDICATORS

Chapter 11 Operation and Effect Indicators

To check the progress and effect of the proposed Project, the operation and effect indicators are set as shown in **Table 11.1** and **Table 11.2**, respectively.

11.1 Operation Indicators

The operation indicators are to show to what extent the water supply scheme is operated efficiently, to achieve the target.

In the study area, NWSDB has already operated five water supply schemes in the urban centres of the DSDs except for Rambewa DSD and, in addition, a number of the Community-Based Organizations have operated their own small scale water supply schemes. In this report, the objects are the newly proposed integrated water supply schemes and their service areas in Mahakanadarawa and Wahalkada, respectively, therefore the present situation is regarded as none.

- The served population by pipe borne water supply is obtained from multiplying the number of connections by per housing unit population which is calculated from the number of housing units and population by GND in census 2011 (as of October 1, 2012, data is not declared). This served population included those by CBOs as stated below.
- For reference, as the served population by CBO water supply schemes is unknown, the number of connections shall be reported annually by CBOs to NWSDB RSC(NC) as well as water consumption. The data can be used for calculation of per capita water consumption and NRW ratio in respective CBO water supply schemes using the bulk water supply amount.
- The daily maximum and average water supply amount shall exclude that for miscellaneous use in the water treatment plant.
- Some CBOs shows the high level of NRW ratio. However, in case of bulk water supply to existing CBOs, the practice in CBO water supply schemes is separated from the data of NWSDB and, in addition, almost water transmission and distribution pipes will be newly installed in the Project. The NRW ratio is set as 20% almost nearly equal to the present performance of NWSDB RSC(NC).
- The purpose of this project to supply safe water to customers especially focusing on the Sri Lankan Drinking Standard for a fluoride concentration of 0.6 mg/L. The compliance rate of the said standard should be 100%. The analysis shall be conducted semi-monthly.

11.2 Effect Indicators

The effect indicators shows that the people's living will be comfortable and the risk reduction that may be suffered from skeletal and dental fluorosis as well as chronic kidney diseases.

- The services area is divided into two categories, namely one for pipe borne water supply and the other for water delivery service by bowsers. In the pipe borne water supply service area, water can be used for multi purposes as general domestic water, while in the water delivery service area, water use will be limited to drinking and cooking only due to water-fetching works using plastic tanks, etc. The population coverage for an access to safe water is calculated as the total of both services.
- The identification of served population in the water delivery service by bowsers will be expectedly difficult. For a meanwhile, it is recommended that the practice of water use will be estimated through an questionnaire survey at the people's meeting, etc. and an accuracy in estimation will be enhanced through an improvement of such ways.
- 94% of the people in the project area have already any kinds of existing water sources (almost groundwater). When the water consumption will be rather below an amount estimated from the population coverage ratio, it suggests that the people use water selectively either from well water or tap water. Therefore, the timing of water treatment facility augmentation should be decided based on an increase of actual daily average water consumption but not the population coverage.
- Fluorosis risk rate

  When the water source of existing CBO has a fluoride concentration above the Sri Lankan Drinking standard (0.6 mg/L), such served population is defined as the population with a risk for fluorosis. Assuming that the percentage of the population with a risk to the total population within the existing CBO service area is applicable to the entire study area, it can be reduced with the connection to a proposed integrated water supply system

Table 11.1 Fluorosis Risk Avoidance Rate

Mahakanadarawa Service Area

Population with a risk for fluorosis (2012)	16,930 persons	
Population with no risk for fluorosis (2012)	3,135 persons	
Percentage of population with a risk (2012)	16,930 / 20,065 × 100 = 84.4%	
Water supply mode in 2020	Total population	Served population
Pipe borne water supply	70,680 persons	40,749 persons (57.7%)
Bowser water supply	21,393 persons	21,393 persons (100%)
Total	92,073 persons	62,142 persons (67.5%)
Prevalence risk in 2020	(92,073 – 62,142) / 92,073 × 100 = 32.5%	

Wahalkada Service Area

Population with a risk for fluorosis (2012)	12,530 persons	
Population with no risk for fluorosis (2012)	5,370 persons	
Percentage of population with a risk (2012)	12,530 / 17,600 × 100 = 71.2%	
Water supply mode in 2020	Total population	Served population
Pipe borne water supply	107,907 persons	64,077 persons (59.4%)
Bowser water supply	24,615 persons	24,615 persons (100%)
Total	132,522 persons	88,692 persons (66.9%)
Prevalence risk in 2020	(132,522 – 88,692) / 132,522 × 100 = 33.1%	

Table 11.2 Operation Indicators for Water supply

Mahakanadarawa System

Cate-gorty	Indicators	Calculation Equation of Indicators	Target				Purpose
			Present	2020	2024		
Basic	Served population (persons)	Served population by pipe borne water supply = (No. of connections) × (Average per HU population) Served population by bowsers = (total population) Total served population = Served population + Served population by bowsers	25,900 0 25,900	40,700 21,400 62,100	47,800 22,300 70,100		
Basic	Water distribution (m^3/day)	Daily maximum water distribution = (the biggest one in the daily water distribution records throughout a year) Daily average water distribution = (annual water distribution amount) / (annual days)	0 0	7,193 5,994	8,585 7,154		
Basic	Facility utilization rate (%)	Facility utilization rate (Max.) = (Daily maximum water production) / (treatment capacity) × 100 Facility utilization rate (Ave.) = (Daily average water production) / (treatment capacity) × 100	0 0	83 70	103 90		
Basic	Compliance rate of drinking standard for fluoride (%)	No. of samples with a fluoride concentration of below 0.6 mg/L / Total no. of samples *100	-*1	100	100		*1 The drinking standard for fluoride is not complied to at 19 schemes out of 24 existing CBOs
Basic	NRW ratio (%)	NRW ratio＝(NRW volume) / (water distribution) × 100	-*2	20%	20%		*2 Current NRW at NWSDB RSC(N/C) is 19.8% (2008)

Source: Prepared by the Study Team

Table 11.2 Operation Indicators for Water supply (Cont'd)

Wahalkada System

Cate-gorty	Indicators	Calculation Equation of Indicators	Target				Purpose
			Present	2020	2024		
Basic	Served population (persons)	Served population by pipe borne water supply = (No. of connections) × (Average per HU population) Served population by bowsers = (total population) Total served population = Served population + Served population by bowsers	26,900 0 26,900	64,100 24,600 88,700	74,700 25,700 100,400		
Basic	Water distribution (m^3/day)	Daily maximum water distribution = (the biggest one in the daily water distribution records throughout a year) Daily average water distribution = (annual water distribution amount) / (annual days)	0 0	11,203 9,336	13,318 11,098		
Basic	Facility utilization rate (%)	Facility utilization rate (Max.) = (Daily maximum water production) / (treatment capacity) × 100 Facility utilization rate (Ave.) = (Daily average water production) / (treatment capacity) × 100	0 0	78 65	93 77		
Basic	Compliance rate of drinking standard for fluoride (%)	No. of samples with a fluoride concentration of below 0.6 mg/L / Total no. of samples *100	-*1	100	100		*1 The drinking standard for fluoride is not complied to at 13 schemes out of 20 existing CBOs
Basic	NRW ratio (%)	NRW ratio＝(NRW volume) / (water distribution) × 100	-*2	20%	20%		*2 Current NRW at NWSDB RSC(N/C) is 19.8% (2008)

Table 11.3 Effect Indicators for Water Supply

Mahakanadarawa System

Cate-gorty	Indicators	Calculation Equation of Indicators	Target				Purpose
			Present (2012)	2020	2024		
Basic	Population coverage by water supply	(Pipe borne water supply) Population coverage = (Served population) / (Administrative population) × 100 (Water delivery service by bowsers) Population coverage = (Served population) / (Administrative population) × 100 (Population coverage for an access to safe water) Population coverage = (Served population) / (Administrative population) × 100	41% 0 % 31%	58% 100% 68%	64% 100% 72%		Status of risk avoidance being suffered from fluorosis and CKD through shifting of water source from well water to tap water
Basic	Fluoride risk rate	(Fluoride risk rate) = 100 - (Population coverage for an access to safe water)	-	32%	28%		The current rate is 84.4% at the existing service area.
Assist	Per capita consumption	Per capita daily maximum consumption = (Daily maximum domestic consumption) / (Served population) Per capita daily average consumption = (Daily average domestic consumption) / (Served population)	96 Lpcd 80 Lpcd	101 Lpcd 84 Lpcd	103 Lpcd 86 Lpcd		Shifting of water source from well water to tap water

Source: Prepared by the Study Team

Table 11.3 Effect Indicators for Water Supply (Cont'd)

Wahalkada System

Cate-gorty	Indicators	Calculation Equation of Indicators	Target				Purpose
			Present (2012)	2020	2024		
Basic	Population coverage by water supply	(Pipe borne water supply) Population coverage = (Served population) / (Administrative population) × 100 (Water delivery service by bowsers) Population coverage = (Served population) / (Administrative population) × 100 (Population coverage for an access to safe water) Population coverage = (Served population) / (Administrative population) × 100	28% 0 % 23%	59% 100% 67%	65% 100% 72%		Status of risk avoidance being suffered from fluorosis and CKD through shifting of water source from well water to tap water
Basic	Fluoride risk rate	(Fluoride risk rate) = 100 - (Population coverage for an access to safe water)	-	33%	28%		The current rate is 71.2% at the existing service area.
Assist	Per capita consumptio n	Per capita daily maximum consumption = (Daily maximum domestic consumption) / (Served population) Per capita daily average consumption = (Daily average domestic consumption) / (Served population)	96 Lpcd 80 Lpcd	101 Lpcd 84 Lpcd	103 Lpcd 86 Lpcd		Shifting of water source from well water to tap water

Source: Prepared by the Study Team

CHAPTER 12

PROJECT RISK

Chapter 12 Project Risk

12.1 Project Risk

The proposed Project is constructed based on the important preconditions described below. If any of them will be lacking, it may cause a serious problem in the management, operation and maintenance of proposed water supply systems.

(1) Water Availability

This project assures the sustainability of drinking water supply from Mahakanadarawa Wewa and Wahalkada Wewa as water sources under the assumption that the NCP Canal Project and Yan Oya Reservoir Project will be implemented. These irrigation projects will be expectedly completed in the year of 2017 and be commissioned at the time of completion of this integrated water supply project in 2018. However, they have not yet commenced the construction works and it cannot be said that there will be no possibility of delay or suspension. As stated in "**4.3 Water Availability"**, the water balance will be in the tight condition between water use for irrigation and water supply. It can't be foreseen whether the farmers' association will allow with no objection that reservoir water is used for drinking water supply before the completion of the irrigation project. Therefore, the progress of the irrigation projects concerned should be carefully monitored and prompt action be taken to drive the project. as required.

(2) Water Quality of Proposed Water Sources

During the JICA study period covering from May to October 2012, in spite that the study area has experienced the severer drought than usual with no precipitation, the fluoride concentrations of both Mahakanadarawa Wewa and Wahalkada Wewa as the proposed water sources for drinking water supply were 0.52 mg/L and 0.38 mg/, respectively, at the maximum below the Sri Lankan Drinking Water Standard of 0.6 mg/L, although they have shown an increase of fluoride concentrations for April to July. On the Contrary, that of the Yan Oya River has recorded at 1.2 mg/L in July above the Japanese Drinking Water Standard of 0.8 mg/L. There is no problem in terms of the Yan Oya River, since it will not be used for a drinking water source. However, it can't be denied that the basin of proposed water sources has geologically an increasing trend in the dry season. For this reason, fluoride concentrations of both Mahakanadarawa Wewa and Wahalkada Wewa should be monitored subsequently thereafter.

In the North Central Province, water is used repeatedly for irrigation in the cascade irrigation system. If agricultural chemicals are used frequently in their basins, the reservoirs receive the influent with condensed agricultural chemicals. Although according to the water quality examination results for proposed water sources covering the period from November 2011 to April 2012, any abnormal values have not been found in pesticide residues and toxic chemical requirements such as arsenic, cadmium, cyanide, lead, selenium and chromium, attention be paid for the use of agricultural chemicals in their basins and measures to ban their use should be taken to ensure the safety of water sources for drinking water, if required.

(3) Increase of Coverage and Water Demand in the Proposed Water Supply System

In the project area, a high fluoride concentration in groundwater used for drinking water causes the dental fluorosis and is suspected as one of causative substances for chronic kidney diseases (CKDs) which occur in a high level especially in the area. Therefore, the shift of water source from groundwater to surface water with a less fluoride concentration is desired earnestly. For this reason, the people have great expectations for the project and the willingness to connect the new integrated water supply system is considered to be high. However, as NWSDB has so far experienced the difficulty to increase the coverage by pipe borne water supply in the rural area, it is a risk to over-estimate such situations with the following reasons:

- In the project area, the percentage of household population below poverty line is relatively high in the district.
- Almost people have another water sources and the connection to a new pipe borne water supply is left to the people’s discretion.
- Even though connecting to a new system, there is the possibility of selective use of either groundwater or tap water.
- The increase of connections has not been so high even in water supply schemes operated by NWSDB in the project area
- It is expected to take a long time to achieve the 100% coverage by pipe borne water supply in the project area due to a very low population density.

It depends on to what extent those problems can be overcome through an awareness campaign to the people. Attention be paid for not only the coverage but also the increase of actual water consumption.

If actual water consumption will be less than the estimation, the income will be decreased resulting in a heavy financial burden on NWSDB.

12.2 Considerations in Planning

(1) Geological Survey Not Conducted for Some Facility Sites

The geological survey for some facility sites such as elevated tanks, intake works, etc. couldn't be conducted from some reasons during the study period. It should be noted that the preliminary design of such facilities was done based on the assumption that the general geological characteristics obtained from other sites surveyed in the project area can be applicable to the above sites.

(2) Quanty Survey for Distribution Systems

Since the project area is too huge and the communities are located sparsely, the topographic survey was not done for a water distribution system as well as the designing. The size and length of water distribution pipes given in this report are estimated by selecting the model area in the project are, conducting a distribution network analysis, checking the pipe length by size, applying the per connection pipe length by size to the entire project area. It should be therefore noted that such size and length of distribution pipes will not correspond to the actual requirement.