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

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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

1.1 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 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 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

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 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 Objectives	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	2.5%	2.4%	2.6%	2.4%	2.7%	2.5%
	1.3 Access to safe drinking water supply coverage	76.4%	77%*	77.6%	78.0%*	79.5%	80.0%*
	1.4 Total sanitation coverage		83.2%*		85.7%*		85.7%*
2. Improve operational efficiency	2.1 NRW (island-wide)	33.0%	33.09%	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 expenses to total recurrent cost	7.5%	5.11%	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 100%	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 support to rural and marginalised 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 Management 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 Report 2007 - 2009"

1.3 Sector Organizations

The water supply sector is divided into two sub sectors as shown in **Table 1.7**.

Table 1.7 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 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.

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.

1.4 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 1.8**. 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 1.8 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 1.9(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 1.9(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

1.5 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” published 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. They are categorized on the sector basis as shown in **Table 1.10**.

Table 1.10 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 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.

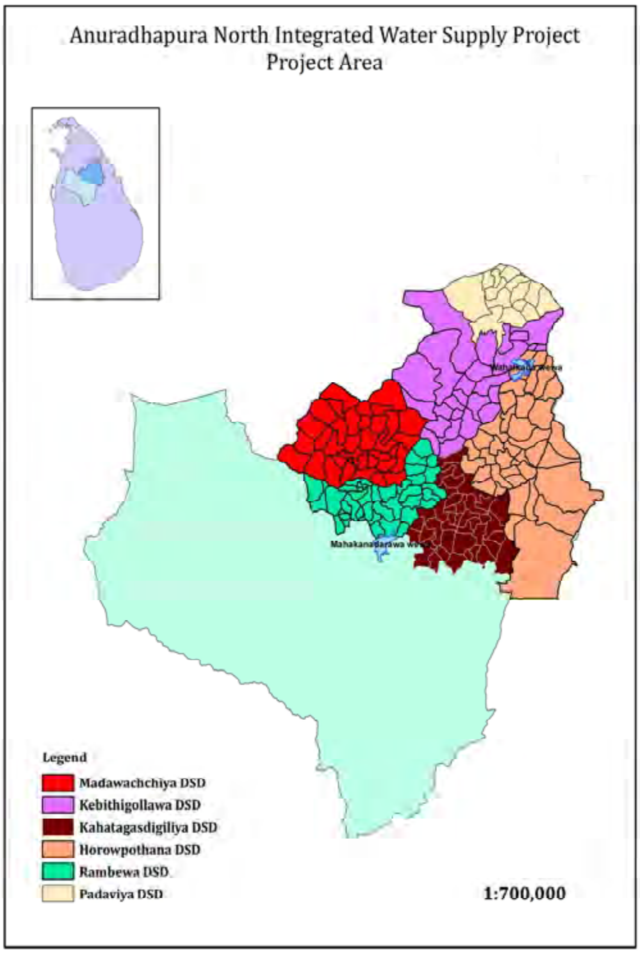

Figure 2.1 Location of Study Area

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.

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.

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]

[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*

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.

(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.

(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.

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**.

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**

	Area (km²)	Population ('1,000)			Population Density (persons/km²)		Annual Average Growth Rate (%)	
		1981	2001	2012	2001	2012	2001/1981	2012/2001
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 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).
- 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%).
- 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/km² in the 2001 Census, with the density in the study area being lower than in other DSDs, especially in Kebithigollewa (31.7 persons/km²) and Horowapothana (35.8 persons/km²), respectively. For reference, the average population density of the study area was 62.3 persons/km² in the Census 2001.
- 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 the 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 the 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

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.

2.3.3 Income and Expenditure

(1) Income

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, which was ranked in 5th position behind Colombo (Rs.51,070), Gampala (Rs.48,870), Ratnapura (Rs.41,312) and Vanuviya (Rs.39,640).

(2) Expenditure

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, which is 65.5% or about two-thirds of that of the urban area at the national level, and Rs.29,065 in Anuradhapura District, which was ranked in 9th position behind Colombo (Rs.47,291), Gampala (Rs.41,062), Kalutara (Rs.35,549) and so on.

(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.

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

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

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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)

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 2.2 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.

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

2.4 Economic Conditions

According to the employment population by industry in Sri Lanka, 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.

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, the yearly fluctuation of the rice harvest is heavily dependent on to what extent the irrigational water requirement is met during the drought period. Historical data shows that a long-term drought occurred during the period from 1987 to 1993.

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 and 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.

2.5 Necessity of the Project

2.5.1 Principal Drinking Water Source

(1) Principal Drinking Water Source

According to Census 2001 (**Table 2.3**), 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 2.3 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 2.3**), 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.

(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 2.4 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. 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 2.5 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** (shaded) 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.

(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

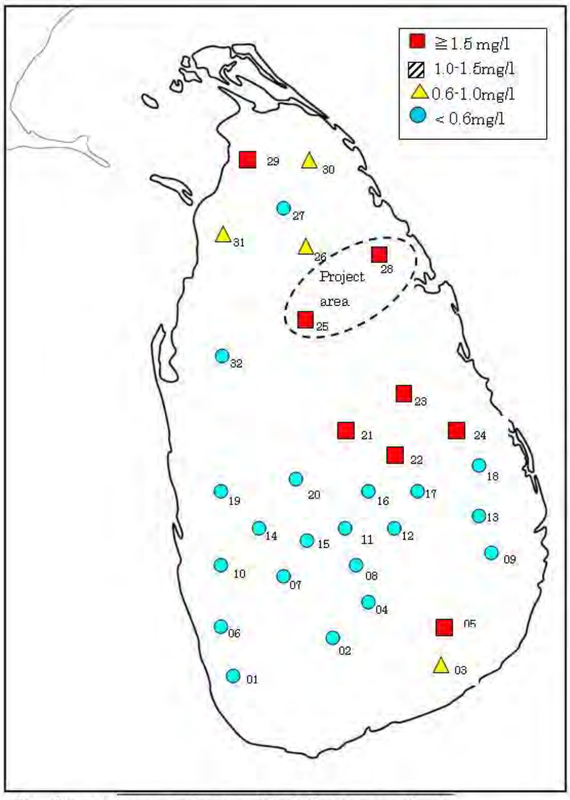
The existing CBO water supply systems have the following technical problems in structure, designing and operation.

- 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 2.2** 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.



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

Figure 2.2 Distribution for Fluoride Concentration of Groundwater in Sri Lanka

(2) Distribution of Fluoride Concentration in the Study Area

For the horizontal distribution (refer to **Figure 2.3**), 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. 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.

The JICA Study Team conducted the water quality examination of groundwater at 15 points mainly sampled from the existing CBO water sources. The results on fluoride concentrations are almost same as those in **Figure 2.3.**

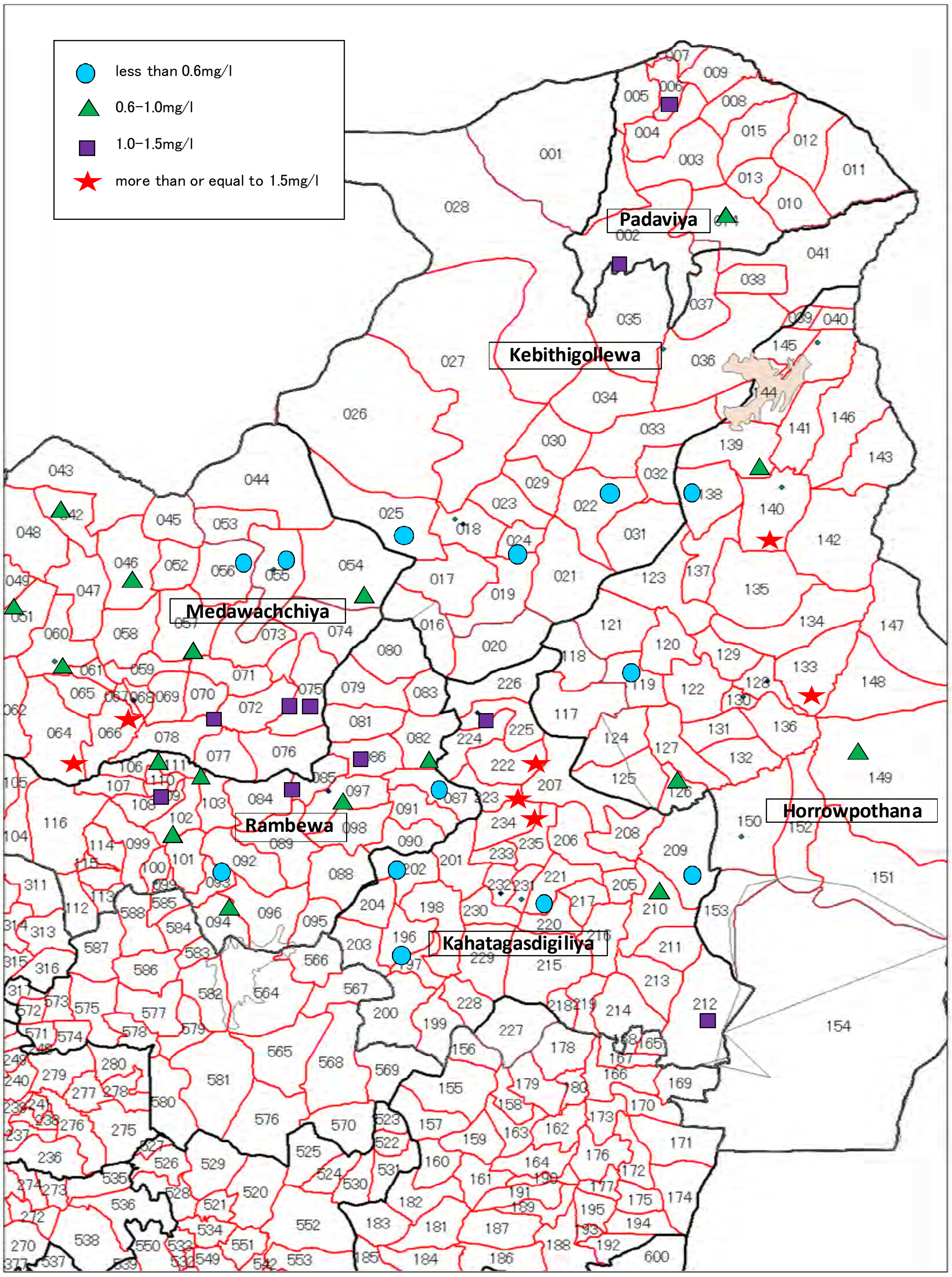


Figure 2.3 Fluoride Results for CBO Supply Water (Horizontal Distribution)

(3) 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 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 is calculated according to the following formula. The weightage is defined based on the classification of cases

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

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

(4) Prevalence of Dental Fluorosis

The prevalence of dental fluorosis was evaluated by CFI. The said survey results and calculated CFI are shown in **Figure 2.4**.

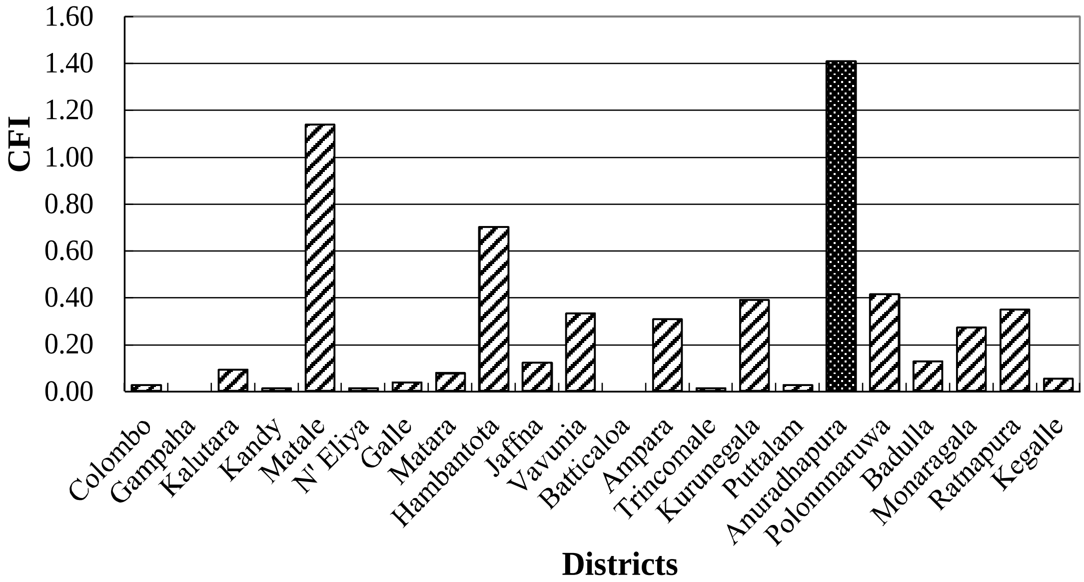


Figure 2.4 Comparison of CFI

(5) 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 2.5**.

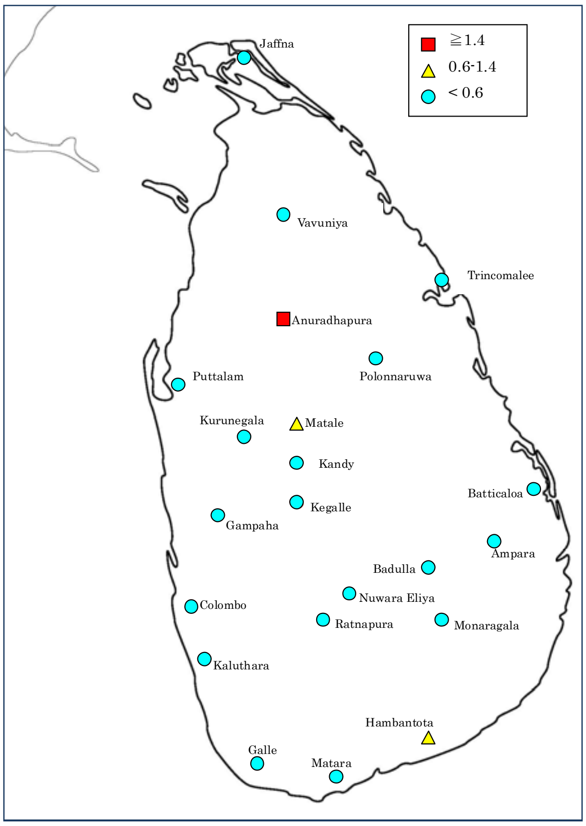


Figure 2.5 District-wise of CFI

(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 2.6** shows the prevalence of CKD. It can be said that the study area covers locations where there are public health problems.

Table 2.6 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.

(3) DSD-wise Distribution of CKD prevalence

From the survey on DSD-wise prevalence of CKD in the North Central Province, the prevalence in each DSD were compared as shown in **Figure 2.6**. 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.

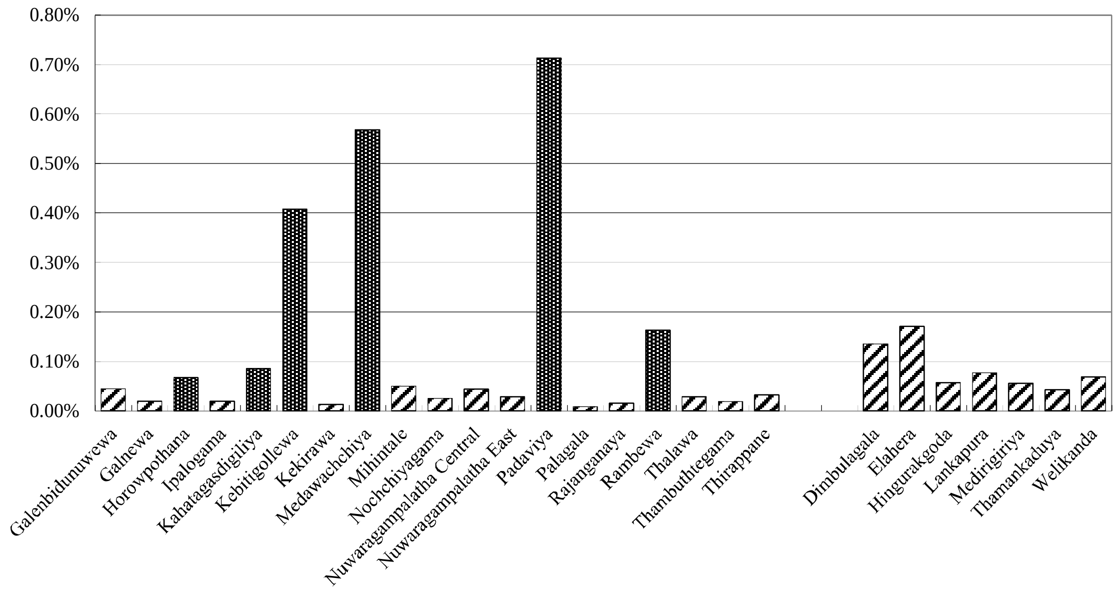


Figure 2.6 DSD-wise Distribution of CKD in North Central Province

(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 considered that high fluoride levels of drinking water causes worsening CKD for CKD patients[6]. Conversion to surface water sources which is able to supply lower levels of fluoride will significantly contribute to residents health.

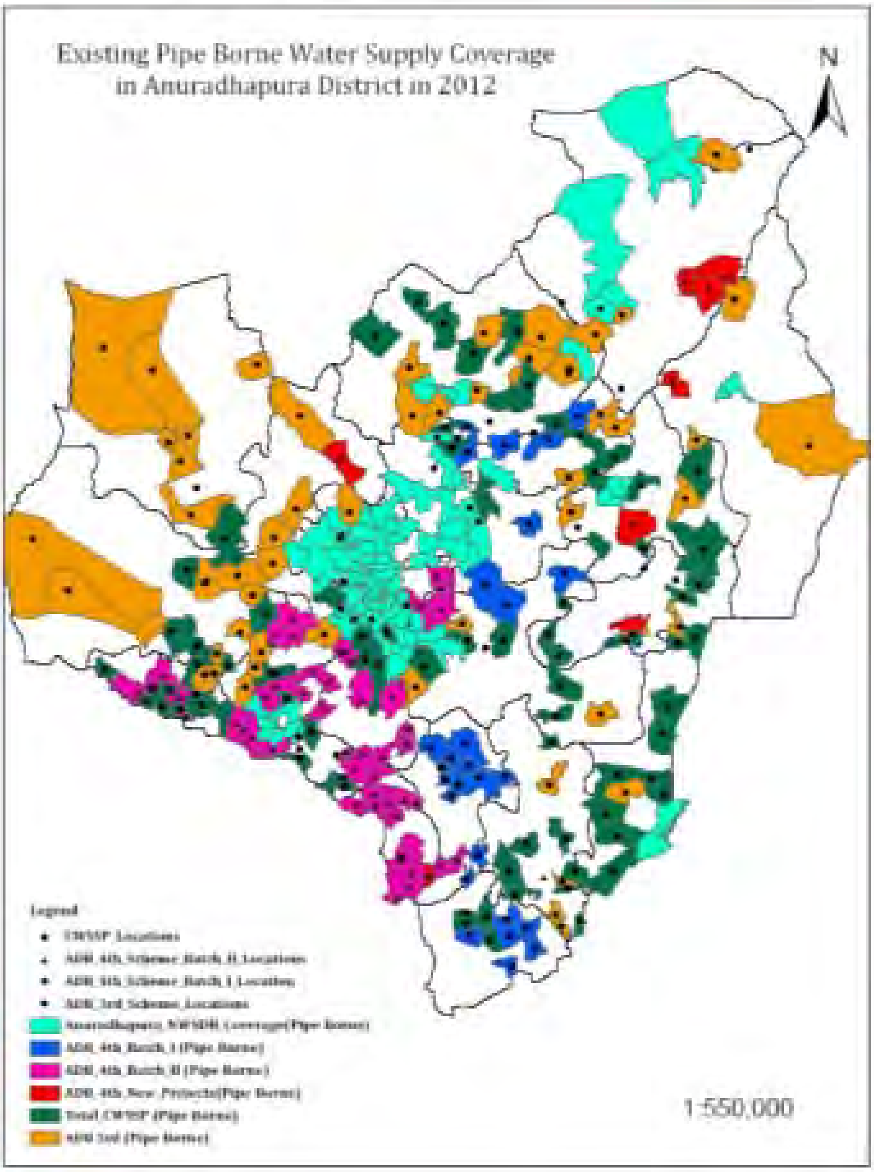
As mentioned above, in order to solve the current water quality and quality problem, it is essential to implement this project promptly.

[6] *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

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

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.

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

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.

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

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.

(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.

Each scheme is headed by an OIC who holds the cadre category/designation of engineering assistant (EA).

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.

(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.

As to the educational attainment of the O&M personnel, a low level of education where approximately 65% did not reach high school and 3% did not possess any formal education.

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.

(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.

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(N/C). Corrective maintenance work that cannot be done by the RSC(N/C) 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 (m^3/month)
(b) Major downtime (hrs)
(c) Power/chemical consumption
(d) Nos. of staff
(e) Billing
(f) Leak
(g) Defective water meters etc.

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 RSC(N/C) 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.

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)

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

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 3.2**.

Table 3.2 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.

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.

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.

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 3.3 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 27% of the population are served by NWSDB and the remainder by CBOs.

Table 3.3 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%)

NWSDB Facilities in the Study Area

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 3.4** shows general information on the five NWSDB's facilities.

Table 3.4 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 3.5**.

Table 3.5 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.

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.

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

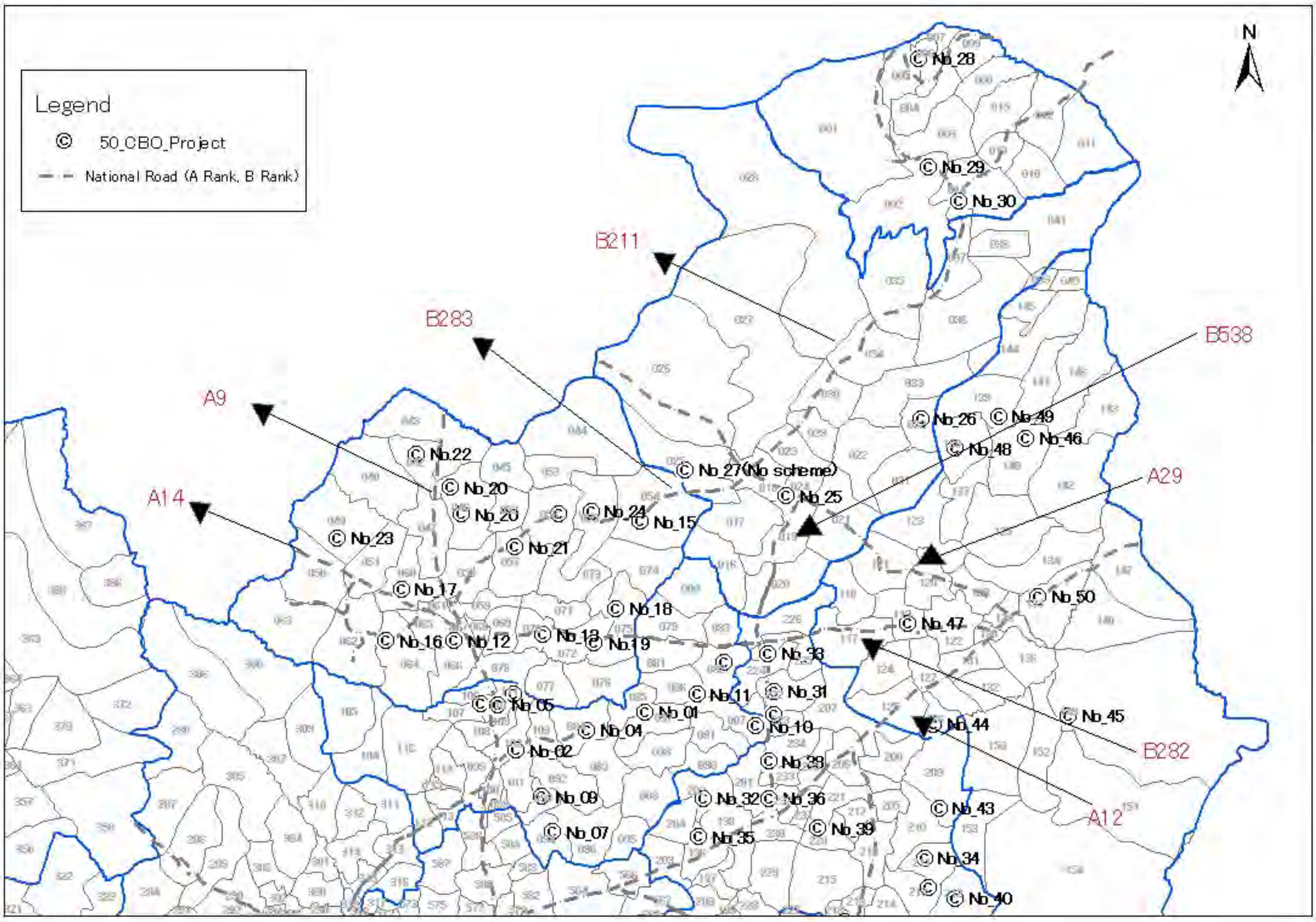


Figure 3.2 Distribution Map of CBO Facilities

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.

(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.

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.”

Present water sources are deep wells at 16 CBOs, shallow wells at 24 CBOs, both deep and shallow wells at 7 CBOs and rainwater at one CBO.

(3) Water Quality (See **Table 3.5**)
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.

(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 3.6** and **Table 3.7** 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 3.6 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 3.7 Distribution Pipes

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

3.4.2 Summary of Survey Results

(1) Existing Conditions in CBO Water Supply Schemes

The conditions of exiting water supply schemes are summarized for the **Table 3.28** 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

(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 listed below

- 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.

Problems in technical and non-technical aspects

A: No master valves at water tanks and/or tube-well pumps are installed.(31 CBOs)
B: Leakage from tanks and/or pipeline (6 CBOs)
C: No operational valves (air valve, gate valve and wash-out valves, etc.) are installed.(14 CBOs)
D: Insufficient pressure due to under-sized pipes (5 CBOs)
E: No proper chlorination dosage.(22 CBOs)
F: Unstable electricity supply (power cut/voltage variation) (6 CBOs)
G: Invisible customer meters (1 CBO)
H: Malfunction of tube-well pump (1 CBO)
I: Little water in dry season (20 CBOs)
a: O&M records not succeeded due to change of committee member (1 CBO)
b: No administration office (24 CBOs)
c: No proper O&M record keeping due to insufficient training (6 CBOs)
d: No enough number of O&M staff (3 CBOs)
e: Poor management of billing system (meter reader does not read exactly) (1 CBO)

(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.

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.
- 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.

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

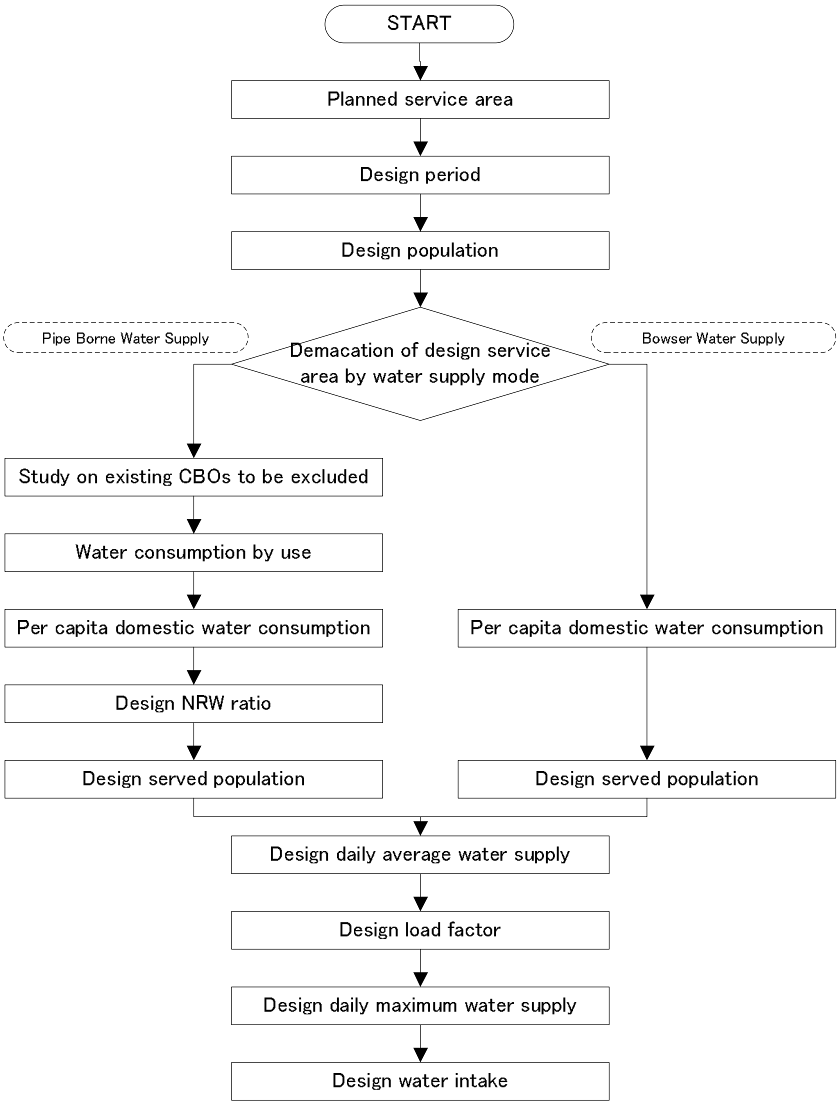


Figure 4.1 Flowchart of Design Water Supply Estimation

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.

4.2.2 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.

4.2.3 Design Population

For the urban area of Anuradhapura District, the average growth rate in the period from 1981 to 2001 was 1.26%, marginally higher than the national average of 1.16%, as shown in **Table 4.1**. On the contrary, for the rural area that in the period from 1981 to 2001 was 1.19%, which is also a little bit higher than the national average of 1.16%.

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

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.

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.

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**

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. About 87.7% of GNDs have a population density of less than 2 persons/ha. 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”.

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

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 4.2**): All

Existing system + Proposed system + Urban centre + Main roads

Option 2:

Existing system + Proposed system + Urban centre

Option 3:

Existing system + Proposed system

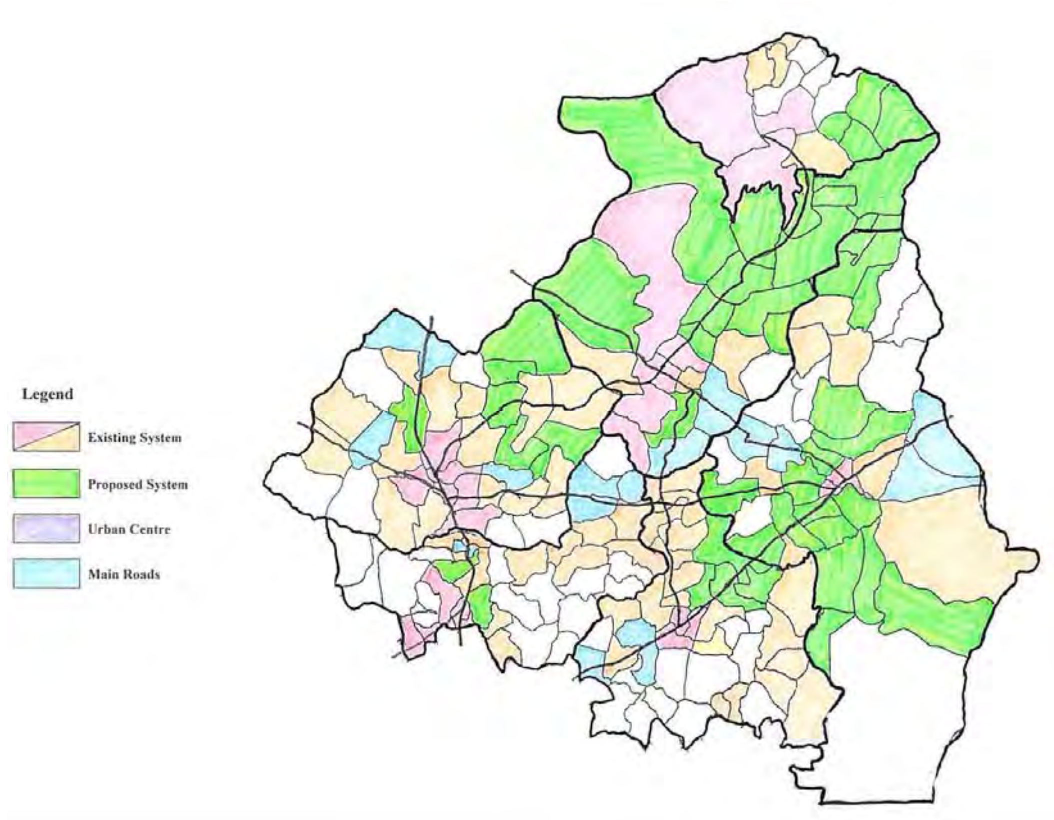


Figure 4.2 Option 1 (No. of Isolated Areas: 47 GNDs)

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

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

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

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. 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
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. While they are in the range of 85 to 107 Lpcd at five water supply systems under NWSDB located within the study area. 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.

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.

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. 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).

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

At five water supply systems under NWSDB 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 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.

4.2.11 Design Daily Average and Maximum Water Supply and Design Production Capacity

The design fundamentals are summarized in **Table 4.4** as well as **Figure 4.3** Showing 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 4.5** 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 4.4 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 Raw water transmission facility WTP	(m^3/day)			18,245 18,200 ▲ 600			28,217 28,200 ▲ 600
Water Right			(m^3/day)			**18,800**			**28,800**

Table 4.5 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)

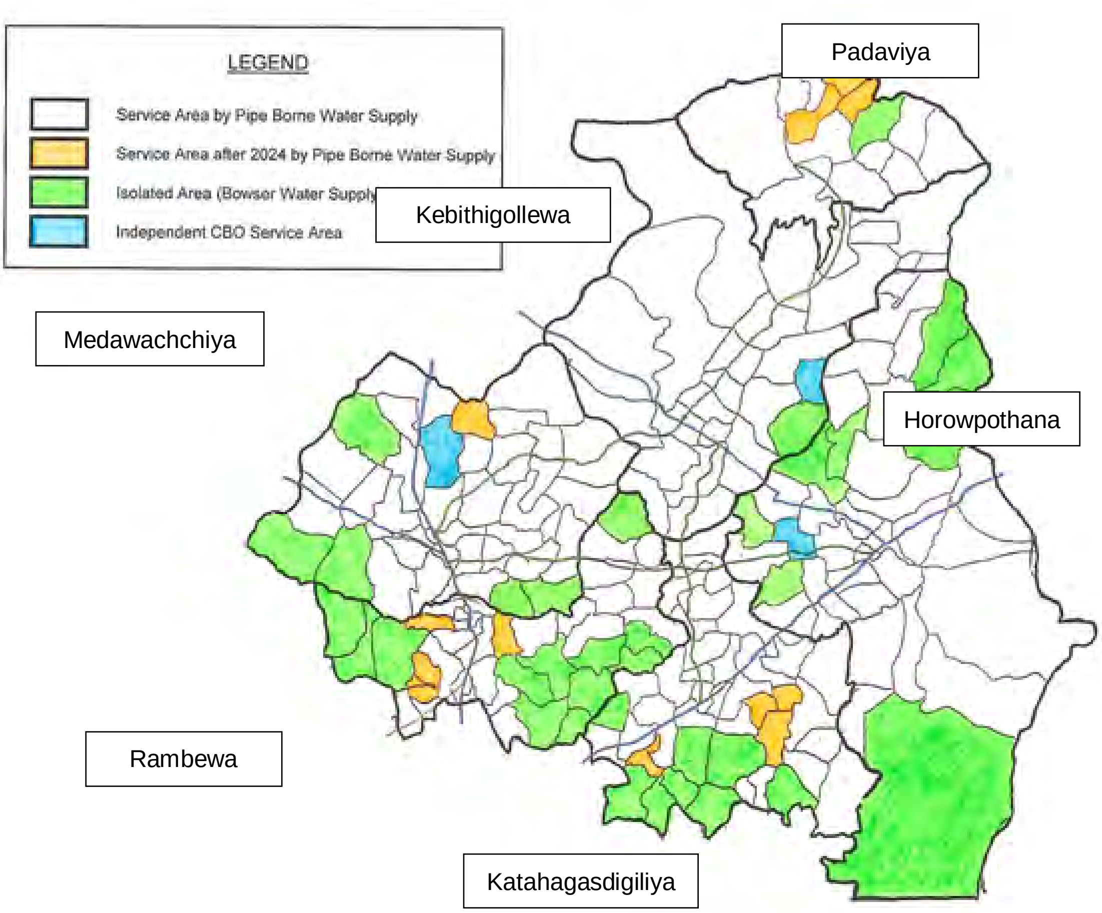


Figure 4.3 Service Area by Pipe Borne and Bowser Water Supply

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 4.6**.

Table 4.6 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

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. 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.

4.3.2 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.

(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 4.7**. From these data, some general characteristics are found as mentioned below.

Table 4.7 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	$3.2x10^2$	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	$2.0x10^2$	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	$1.7x10^2$	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	$4.9x10^2$	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	$2.0x10^2$	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	$9.5x10^2$	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	$3.0x10^3$	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	$5.8x10^3$	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	$2.3x10^3$	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	$2.8x10^3$	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	$2.8x10^3$	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	$1.6x10^3$	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	$1.0x10^2$	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	$1.1x10^2$	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	$1.0x10^3$	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	$1.7x10^3$	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	$5.9x10^2$	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	$6.0x10^3$	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	$2.0x10^2$	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	$1.4x10^3$	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	$1.0x10^3$	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	$1.7x10^3$	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	$2.5x10^2$	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	$1.8x10^3$	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	$2.3x10^3$	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	$5.3x10^2$	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

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.

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.

(b) 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.

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.

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, which is the desirable level of Sri Lankan drinking water standard.

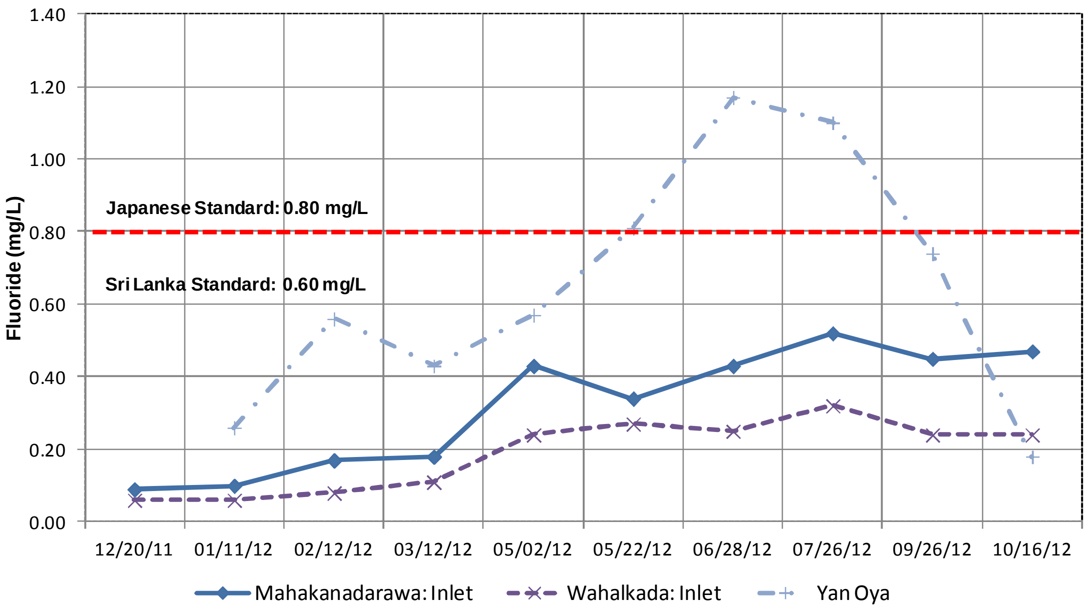


Figure 4.4 Water Quality (Fluoride)

As shown in **Figure 4.4**, 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.

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's 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 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 4.8**.

Table 4.8 General Condition of the irrigation

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% of 3,600 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)

(3) Operation Method for Irrigation Water Use

Mahakanadarawa scheme has two 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 for 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 4.9 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 4.9 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) Storage Variation of Mahakanadarawa and Wahalkada Wewa

Table 4.10 shows general details of the above reservoirs.

Table 4.10 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 Acft	43,000 Acft
Dead Storage	2,000 Acft	2,025 Acft
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.

The storage volume was about 18,000 Acft (22.14 MCM) in January 2005, and only 15,000 Acft (18.5 MCM) were used for irrigation, corresponding to 167 Acft (0.205 MCM). Basically, the Mahakanadarawa scheme has the potential to irrigate an area of 6,000 Ac (2,420ha). However, because of the limitation of water, 3,000 Ac is normally irrigated even under FSL storage conditions. The irrigation area in the Yala season is 1,800 Ac (730ha), 50% of the area under FSL storage conditions.

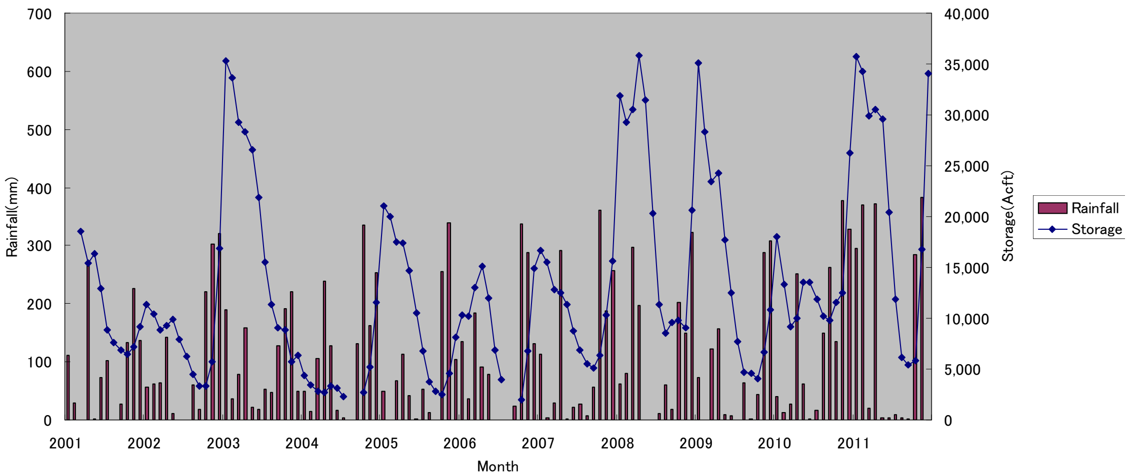


Figure 4.5 Monthly Rainfall and Storage in Mahakanadarawa Tank

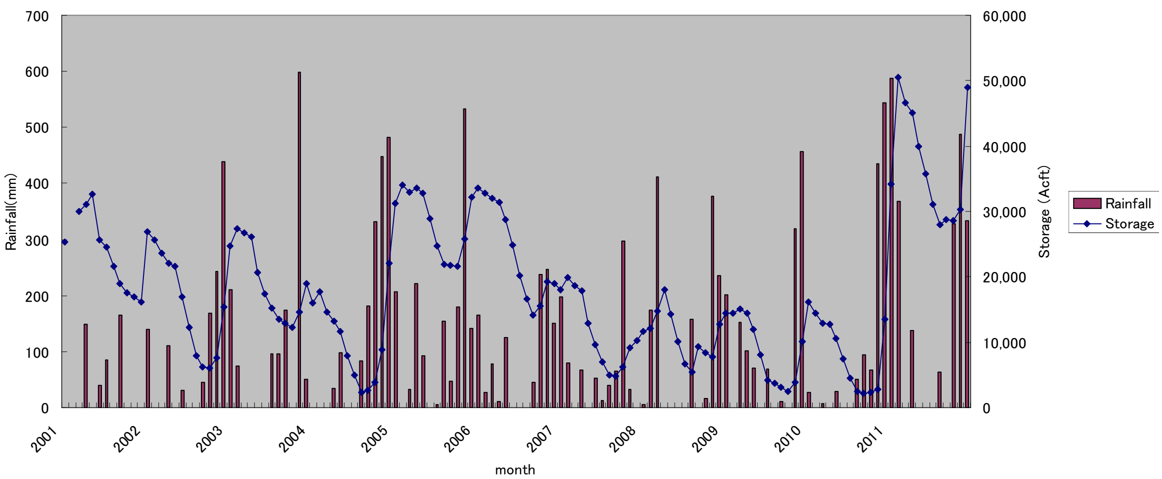


Figure 4.6 Monthly Rainfall and Storage in Wahalkada Tank

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 varies 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 4.7**.

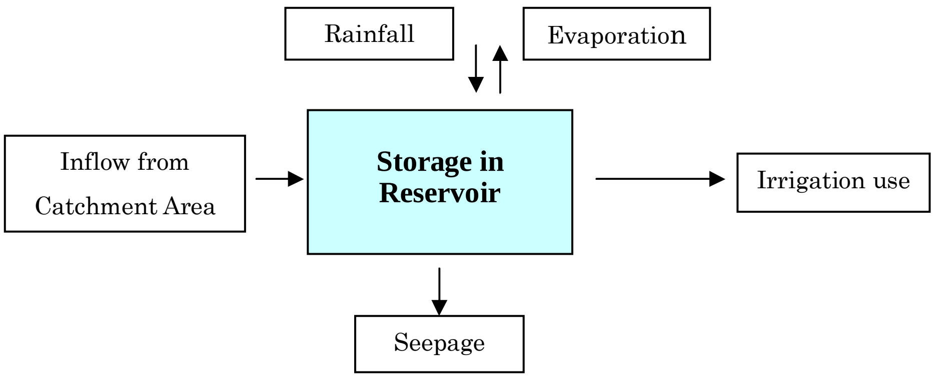


Figure 4.7 Image of Water Balance

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.

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.

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 4.11 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.

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 4.12**.

Table 4.12 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. 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

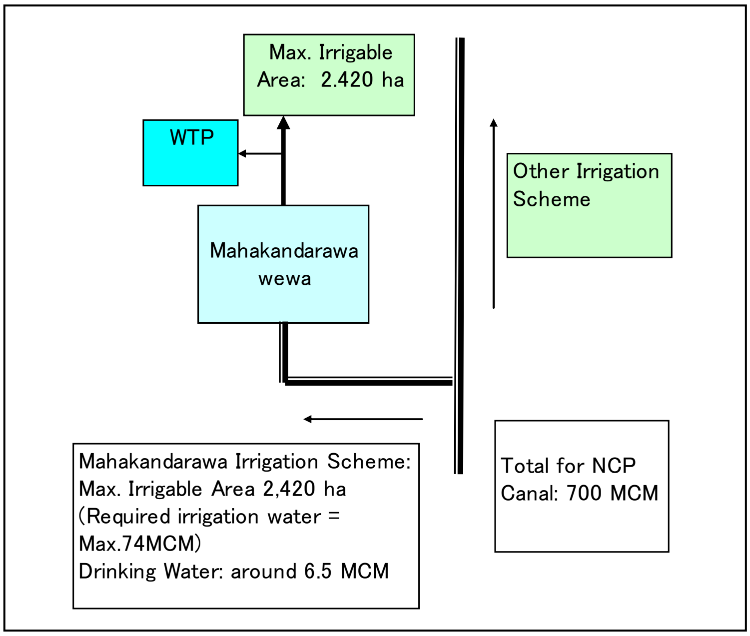


Figure 4.8 Image of Assumed Additional Water from NCP Project

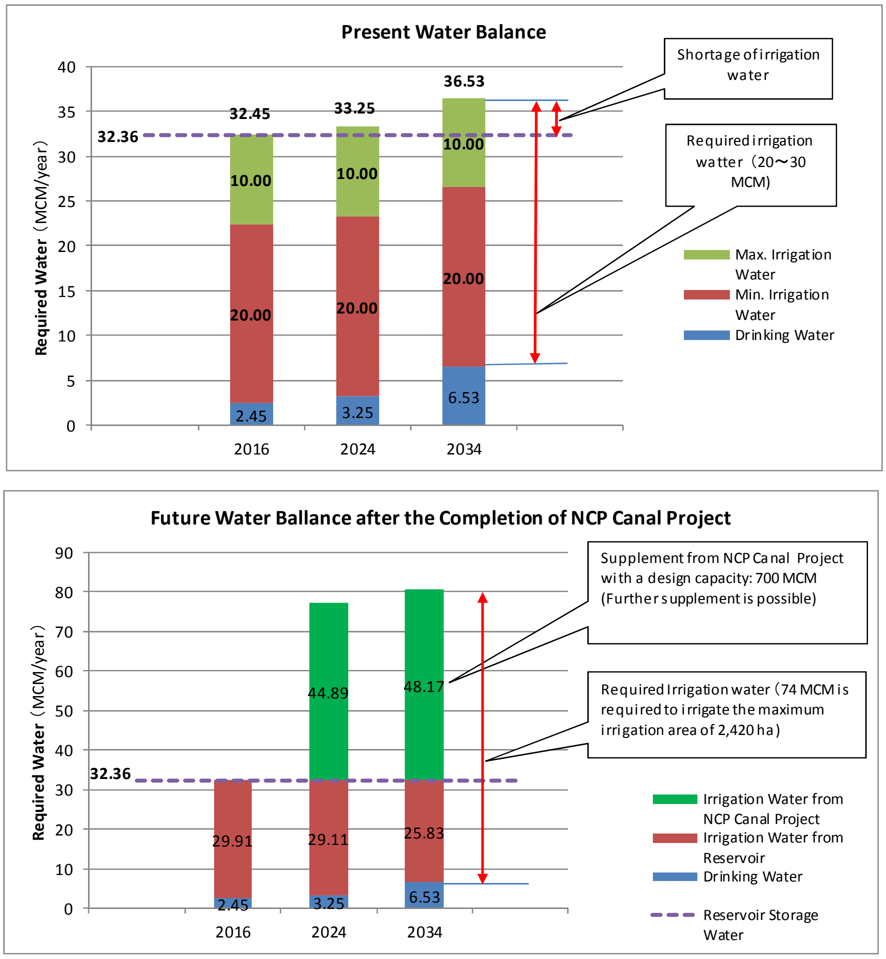


Figure 4.9 Water Availability in the Mahakanadarawa Wewa

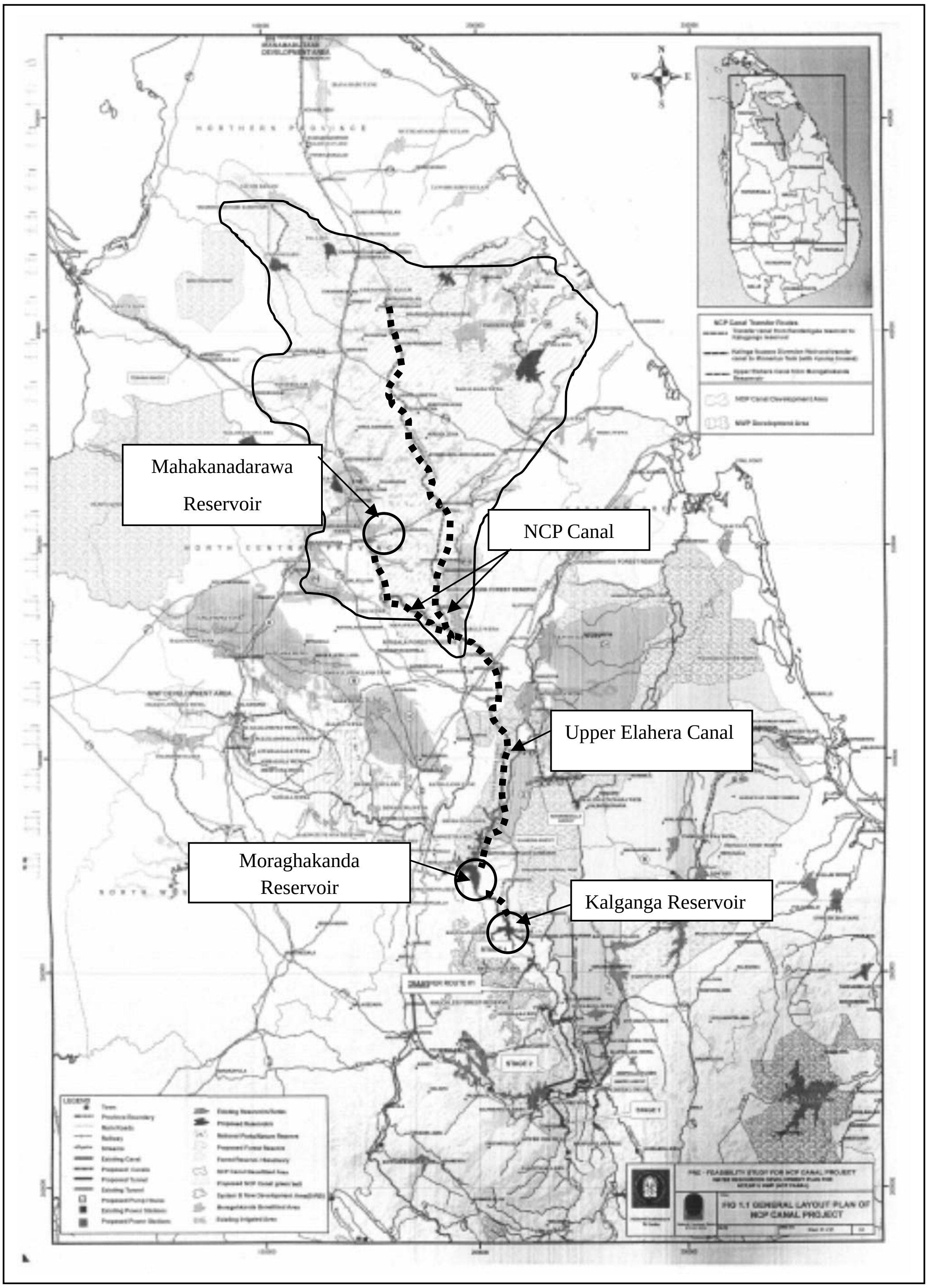


Figure 4.10 NCP Canal Development Project Location Map

(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) 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 4.11.**

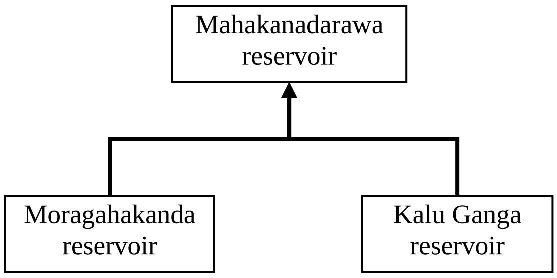


Figure 4.11 Water Flow from Both Reservoirs to Mahakanadarawa

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.

Water quality results of the two water resources and the drinking water standards in Sri Lanka were compared. For Moragahakanda: a colour sample exceeded the desirable level, and turbidity, taste and nitrite samples exceeded the permissible level of the Sri Lankan standards. For Kalu Ganga: a colour sample exceeded the desirable level and a taste sample exceeded the permissible level 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 4.13 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

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.

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, 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 4.12**. This figure shows the water balance of the existing irrigation scheme of 800 ha because 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 4.13**. Therefore, the storage water will be enough for water supply and irrigation even in 2034.

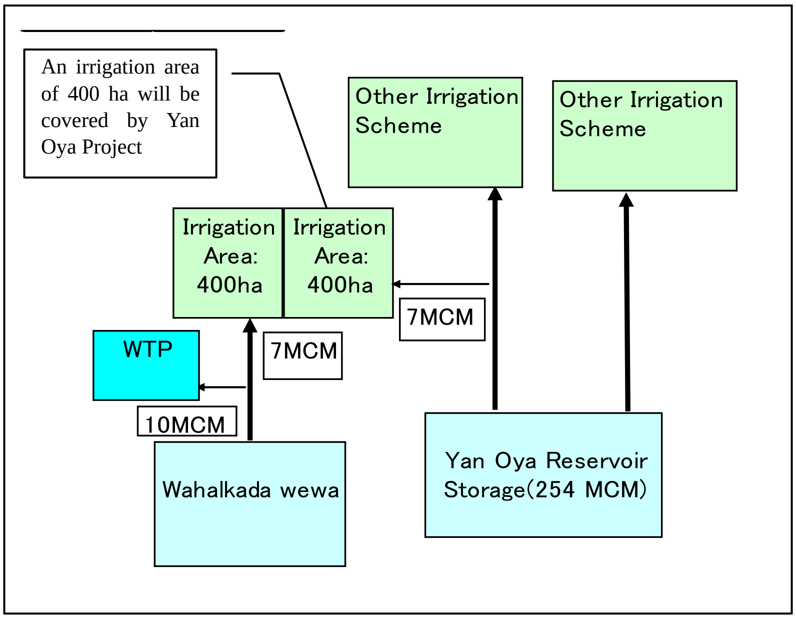


Figure 4.12 Image of Assumed Additional Water from Yan Oya Project

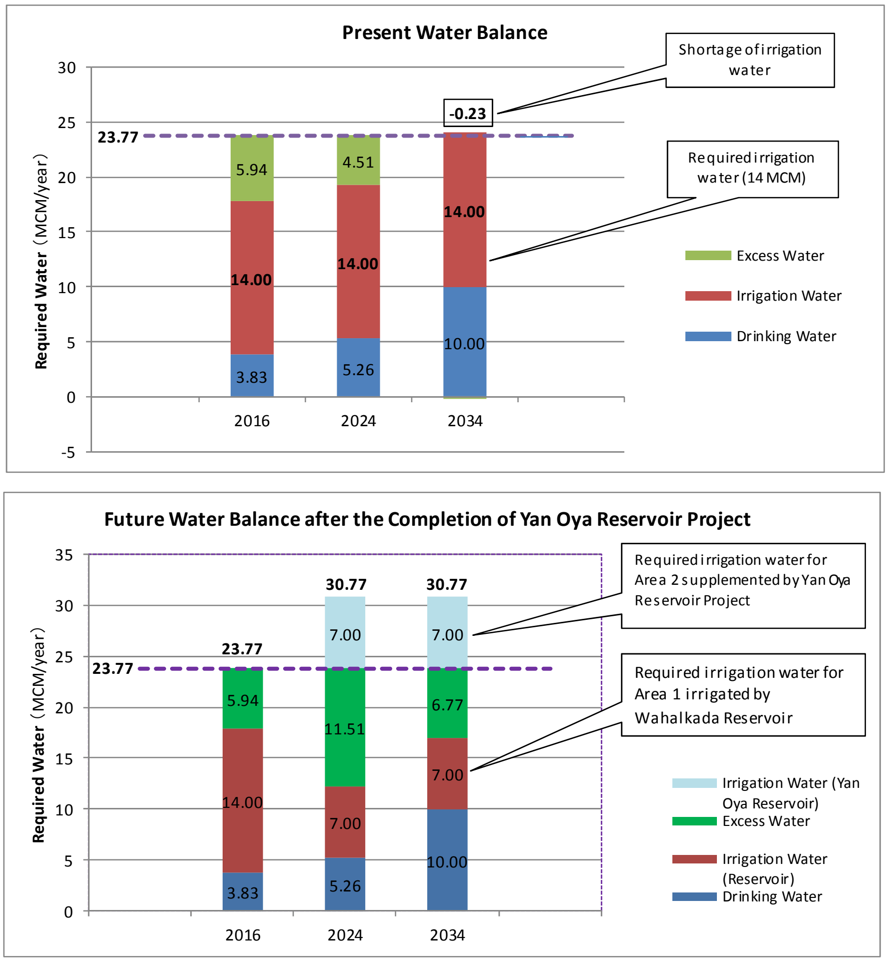


Figure 4.13 Water Availability in the Wahalkada Wewa

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. 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.

4.3.7 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

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 Rs..200 million is losing by this situation.

Kotmale:	35%
Victoria:	14.7%
Randenigala:	18.4%
Castlereeigh:	14.0%

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 1-2 m & 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.

(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

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.

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.

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. Although the 32 dams are designated to be rehabilitated by responsible organization, Mahakanadarawa Wewa and Wahalkada Wewa are not included therein. 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 5.1**.

Table 5.1 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.

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.

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

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.

Table 5.2 Design Criteria for Intake Facilities

	Mahakanadarawa	Wahalkada
Max. irrigation discharge	3.4 m^3/sec	2.0 m^3/sec
Max. intake discharge for drinking water	0.22 m^3/sec (18,800 m^3/day in 2034)	0.34 m^3/sec (28,800 m^3/day in 2034)
Canal discharge in irrigation period	0.62～3.62 m^3/sec	0.7～2.34 m^3/sec
Width of existing irrigation canal at intake point	3.5 m	4.5 m
Height of existing canal	2.2 m	2.1 m
Max. water depth in canal	1.45 m	0.91 m
Water depth just for drinking water in 2034	0.22 m	0.32 m
Design height of lower portion of the canal	0.30 m	0.40 m
Max. water level for irrigation and drinking water	1.51 m	1.00 m

Figure 5.1 and **Figure 5.2** shows the outline of intake facility for Mahakanadarawa and Wahalkada Systems, respectively.

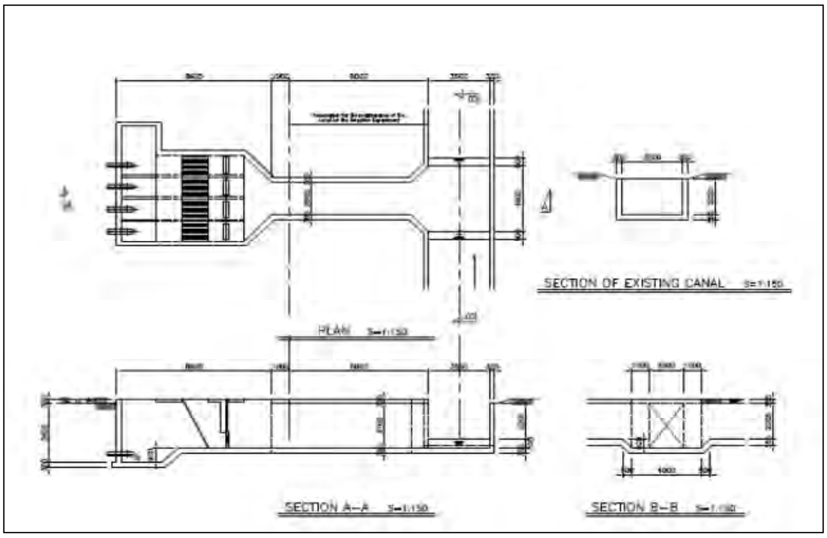


Figure 5.1 Outline of Intake Facility in Mahakanadarawa Wewa

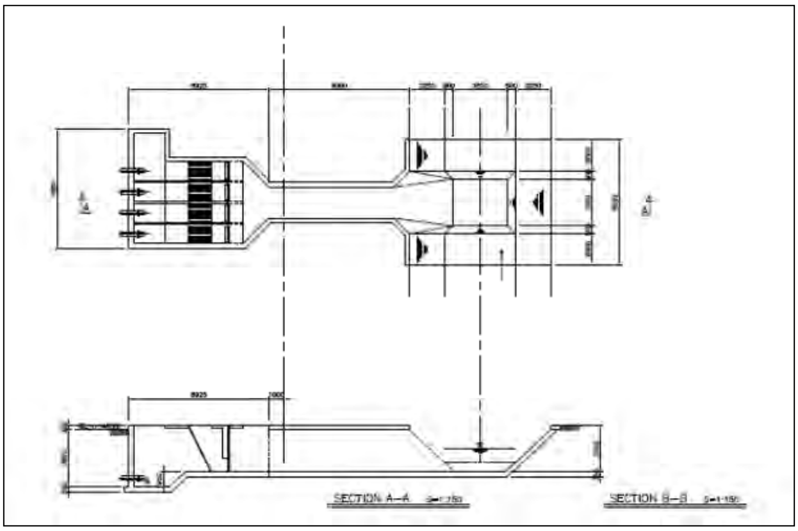


Figure 5.2 Outline of Intake Facility in Wahalkada Wewa

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.

100 persons/km^2 = 1 person/ha = 4 persons/4 ha = 1 HU/4 ha

(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 5.3**.

Table 5.3 FIRR Comparison between Stage and Full Constructions

(1) Stage Construction						(2) Full Construction (10% Reduction)				
Year	Investment	Revenues	Expenditures	Cash flow		Year	Investment	Revenues	Expenditures	Cash flow
2012	0.0			0		2012	0.0			0
2013	82.2			-82.2		2013	81.8			-81.8
2014	437.5			-437.5		2014	437.2			-437.2
2015	1,093.1			-1,093		2015	1,126.9			-1,127
2016	3,508.7			-3,509		2016	3,645.1			-3,645
2017	3,641.5			-3,642		2017	3,777.9			-3,778
2018	960.1	56	34	-938.1		2018	994.0	56	34	-972
2019	14.9	78	46	17.1		2019	14.6	78	46	17.4
2020		82	48	34		2020		82	48	34
2021		86	49	37		2021		86	49	37
2022		90	51	39		2022		90	51	39
2023		94	53	41		2023		94	53	41
2024	786.5	98	54	-742.5		2024		98	54	44
2025		108	66	42		2025		108	66	42
2026		117	71	46		2026		117	71	46
2027		127	76	51		2027		127	76	51
2028		137	80	57		2028		137	80	57
2029		147	85	62		2029		147	85	62
2030		157	90	67		2030		157	90	67
2031		167	95	72		2031		167	95	72
2032		177	100	77		2032		177	100	77
2033		187	104	83		2033	786.5	187	104	-703.5
2034		197	109	88		2034		197	109	88
2035		207	114	93		2035		207	114	93
2036		217	119	98		2036		217	119	98
2037		227	124	103		2037		227	124	103
2038		237	128	109		2038		237	128	109
2039	-4,674	247	133	4,788		2039	-4,950	247	133	5,064
FIRR				-2.65%		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) Raw water quality

The water quality of Mahakanadarawa and Wahalkada irrigation tanks is shown in **Table 5.4** and **Table 5.5**. 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 5.4 Raw Water Quality

	Date	Water Temperature (℃)	Dissolved Oxygen [1] (mg/L)	pH	Turbidity (degree)	Color (degree)	Odor
Wahalakada Tank							
Surface water	17/05/2012	30.1	8.3	8.89	12.4	26.5	None
Bottom water	Ditto	30.0	7.2	-	-	-	ditto
Mahakanadarawa Tank							
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

Table 5.5 Odor of Raw Water

	04/07/2012	08/07/2012	17/07/2012	25/07/2012	28/07/2012
Wahalakada	Muddy or musty			No odor	No odor
Mahakanadarawa		No odor			
Thuruwila			Strong muddy		

(2) Selection of the water treatment process

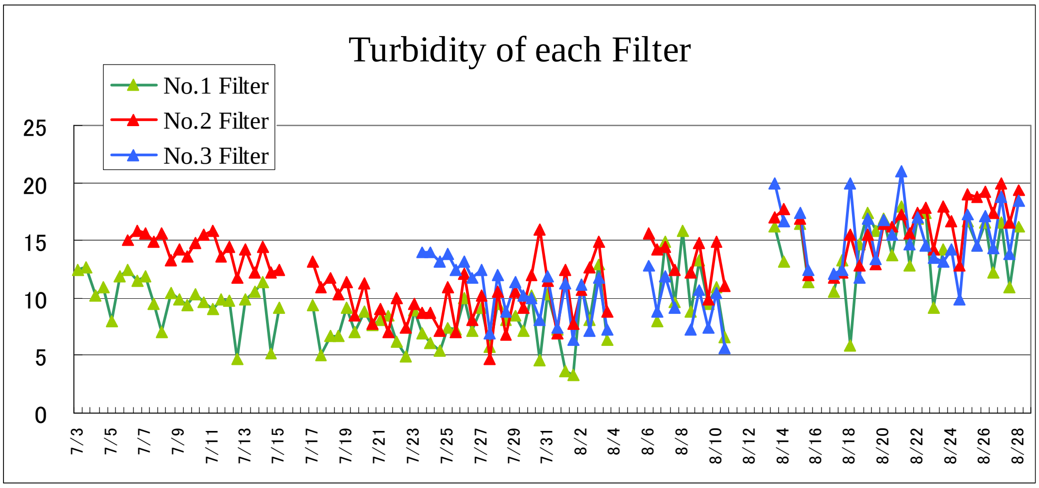
There are two major treatment processes to select: slow sand filters and rapid sand filters.

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 as shown in **Figure 5.3**.

The rapid sand filter can remove the turbidity and color as confirmed by a jar test. 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.



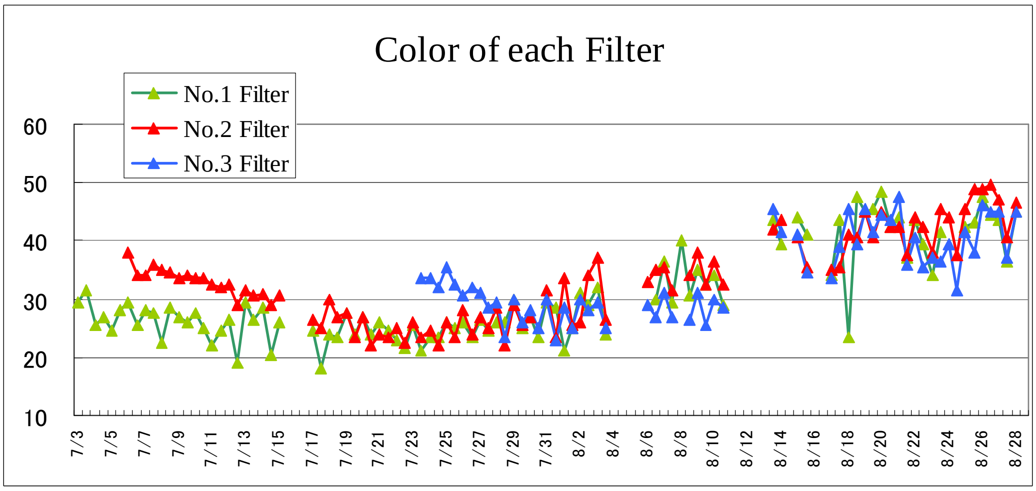


Figure 5.3 Treated Water Quality in Each Sand Filter at the Pilot Plant

Table 5.6 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

5.2.3 Design Criteria

The design criteria of the facilities are shown in **Table 5.7**.

Table 5.7 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

5.2.4 Mahakanadarawa WTP

(1) Flow diagram

The flow diagram of Mahakanadarawa WTP is shown in **Figure 5.4**.

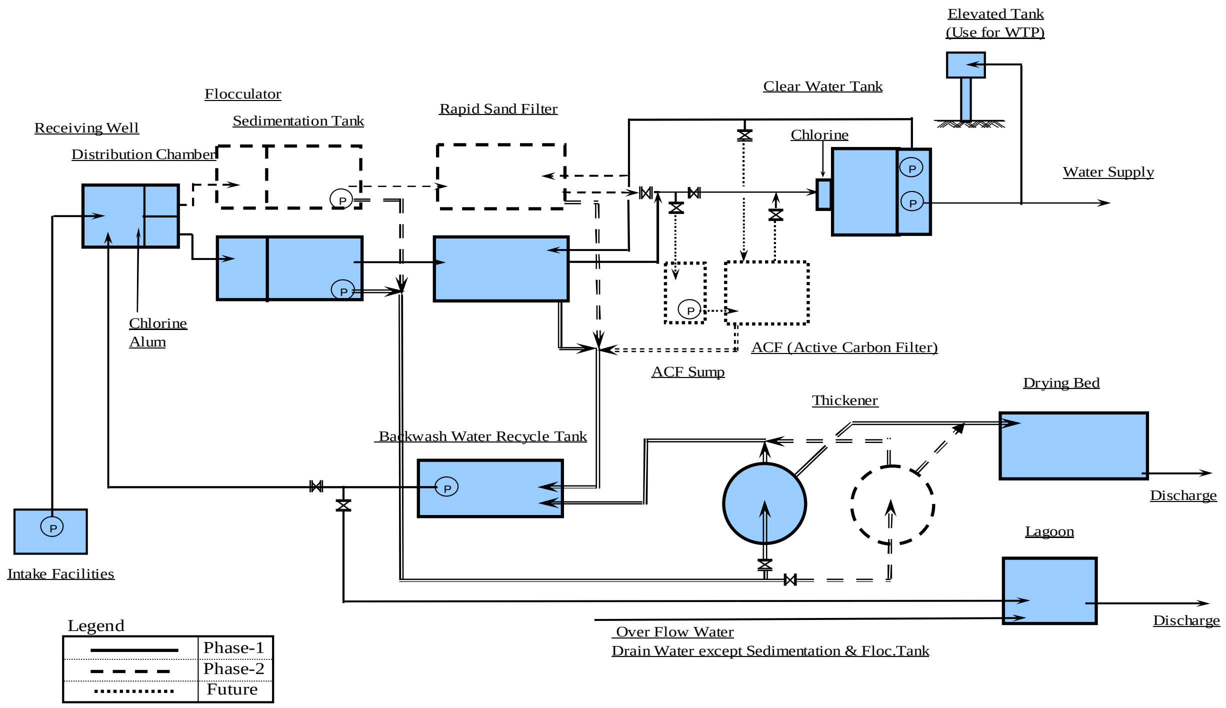


Figure 5.4 Flow Diagram of Mahakanadarawa WTP

(2) Layout

The layout of the facilities in Mahakanadarawa WTP is shown in **Figure 5.5. Figure 5.5.**

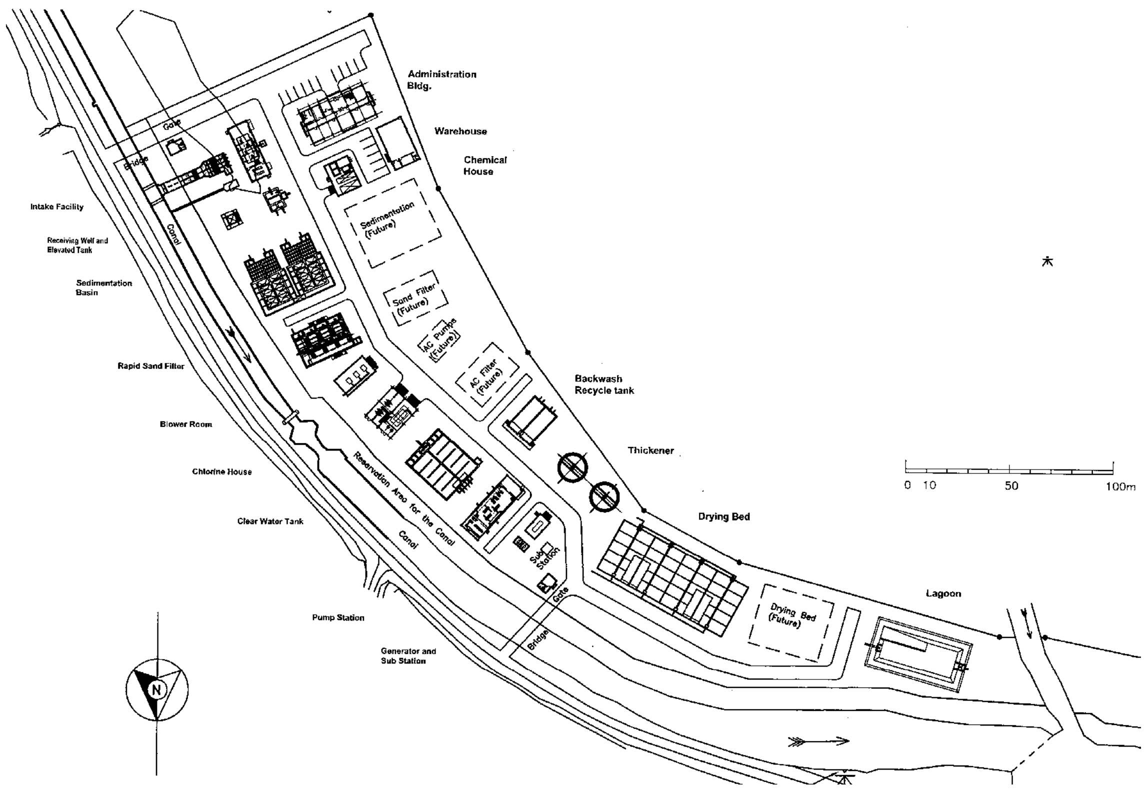


Figure 5.5 Layout of Mahakanadarawa WTP

(3) Outline of Mahakanadarawa WTP

Mahakanadarawa WTP takes water from an irrigation canal from Mahakanadarawa Tank at approximately 120 m 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 5.8**.

Table 5.8 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 Stage-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 Stage-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.

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 5.9**.

Table 5.9 Detail of Mahakanadarawa WTP

Facility	Stage-1	Strage-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	-	*
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.

5.2.5 Wahalkada WTP

(1) Flow diagram

The flow diagram of Wahalkada WTP is the same as in **Figure 5.4**.

(2) Layout of the facilities

The layout of the facilities in Wahalkada WTP is shown in **Figure 5.6**.

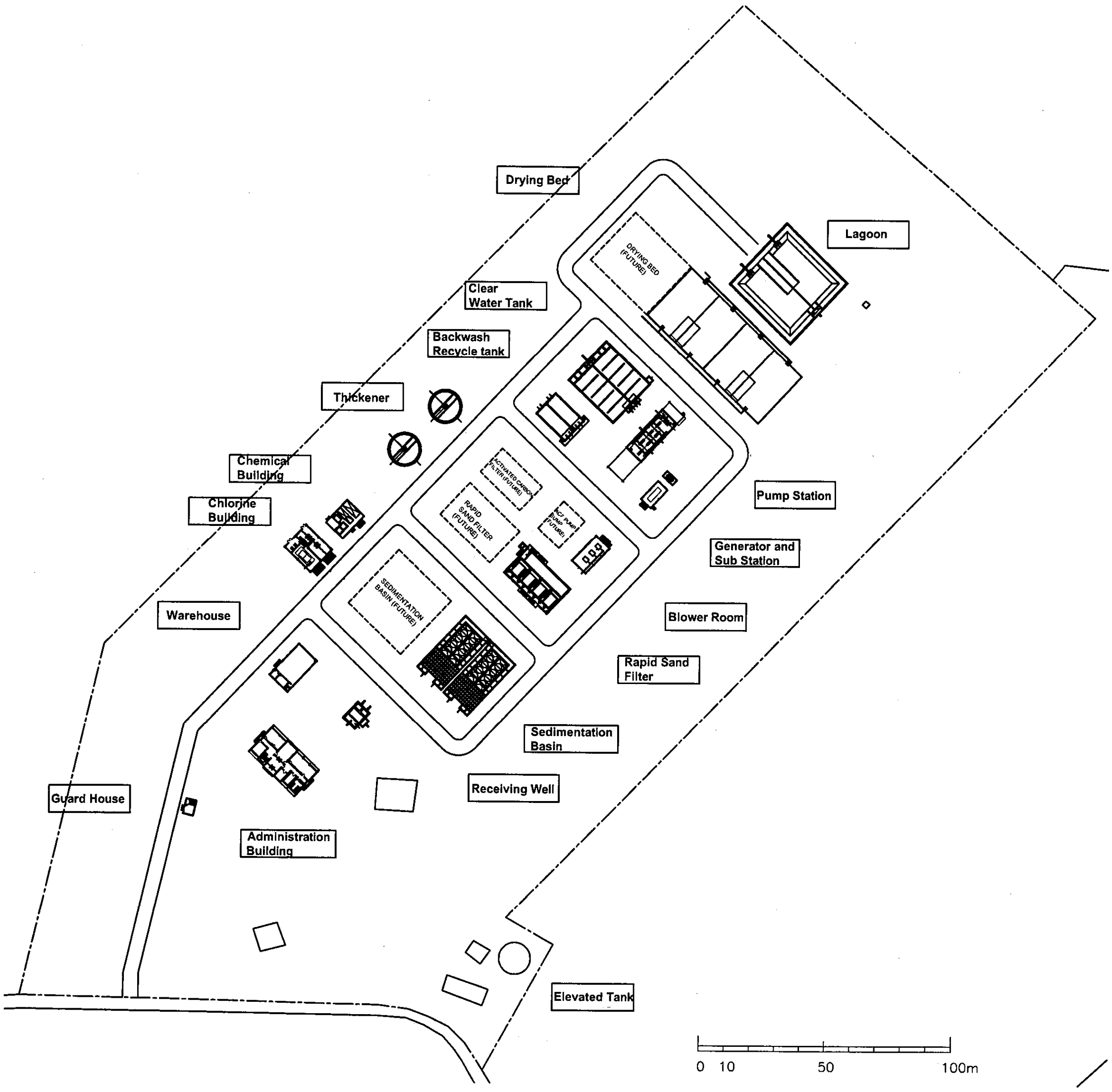


Figure 5.6 Layout of Wahalkada WTP

(3) Outline of Wahalkada WTP

Wahalkada WTP takes water from an irrigation canal from Wahalkada Tank at approximately 420 m 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 5.21**.

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 5.10 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 5.11**.

Table 5.11 Detail of Wahalkada WTP

Facility	Stage-1	Strage-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		*

Facility	Stage-1	Strage-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	
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 5.7**. 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 5.7**. 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.

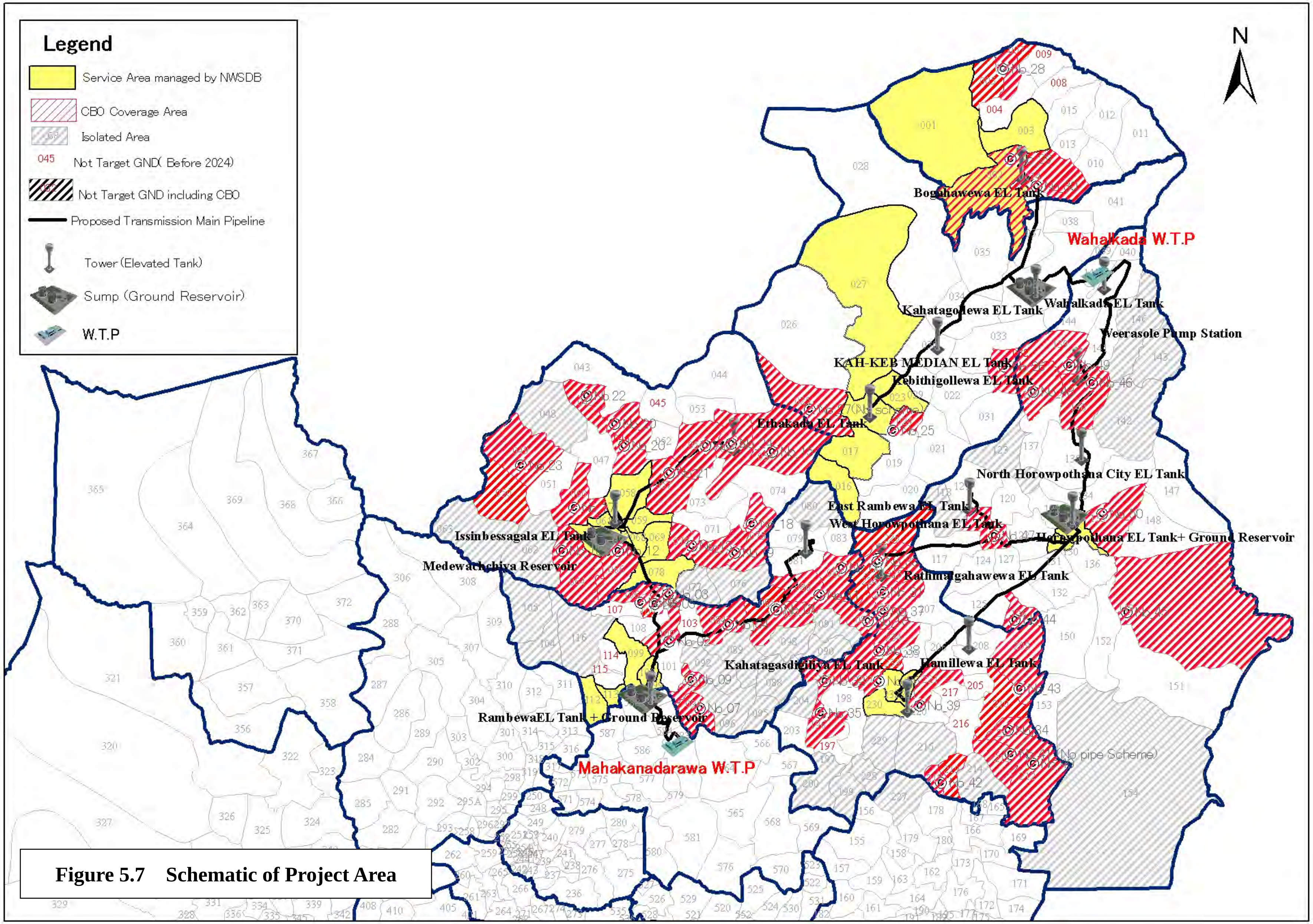


Figure 5.7 Schematic of Project Area

5.3.2 Planning Concept of the System

(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 are 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 5.12 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 5.8 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.

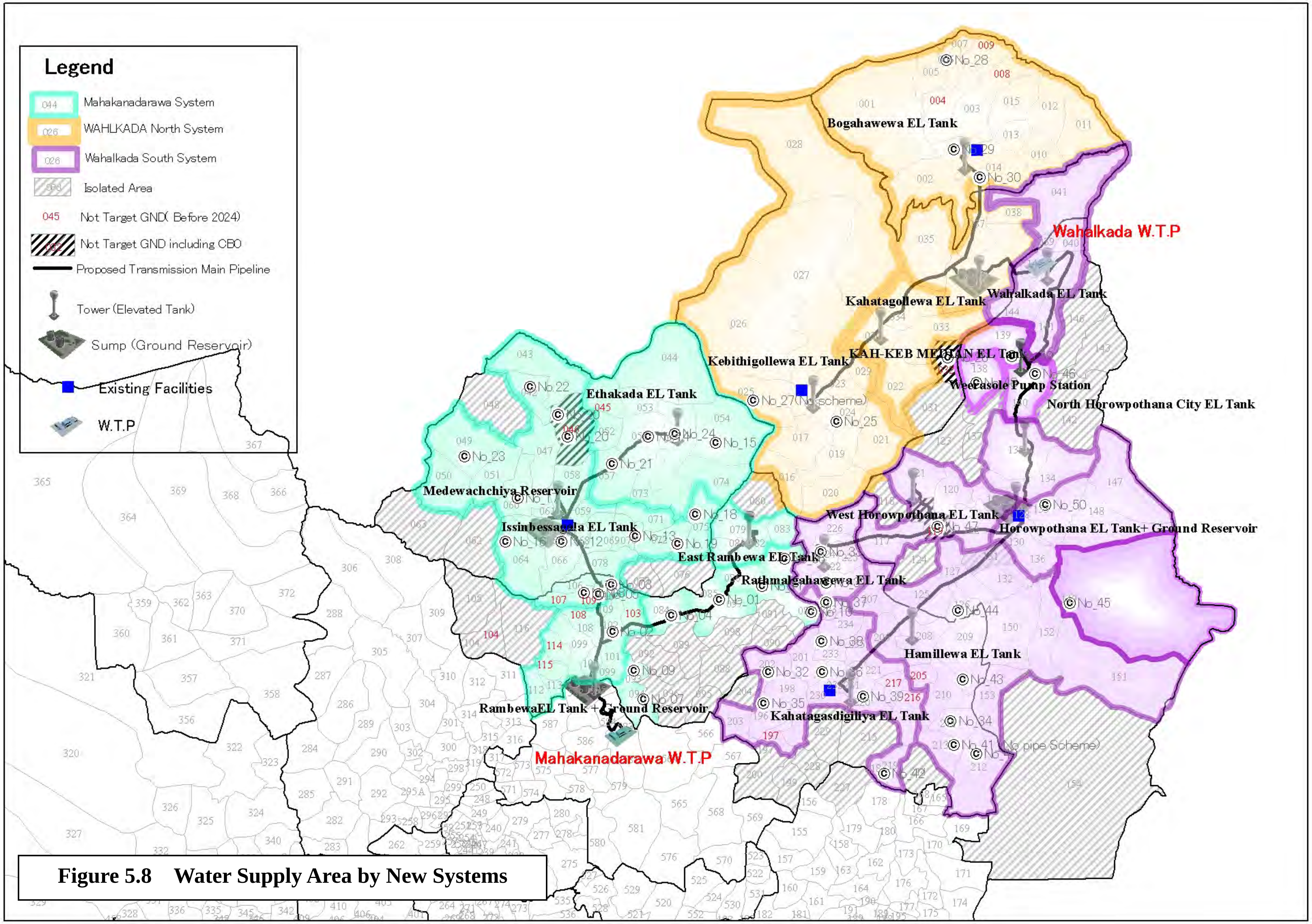


Figure 5.8 Water Supply Area by New Systems

Fifteen elevated tanks, four in the Mahakanadarawa system and 11 in the Wahalkada system, are strategically positioned to cover the entire service area. **Table 5.13** shows the area covered by each elevated tank.

Table 5.13 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 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 5.14**.

Table 5.14 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

5.3.4 Mahakanadarawa System

A schematic flow diagram of the Mahakanadarawa System is shown on **Figure 5.9**.
The Mahakanadarawa system for transmission main is composed of four (4) sections as shown on **Table 5.15**.

Table 5.15 Mahakanadarawa Transmission System

Span		Route	Dia. (mm)	Length (km)
1	Mahakanadarawa WTP～Rambewa Service Centre	Local road	450	7.1
2	Rambewa Service Centre ―～Medawachchiya PS	Route A9	450 / 400	15.8
3	Medawachchiya PS～Issinbassagala Elevated Tank	Route A9/A14 Bypass	350	3.1
4	Medawachchiya PS～Ethakada Elevated Tank	Route B211	300 / 250	14.4

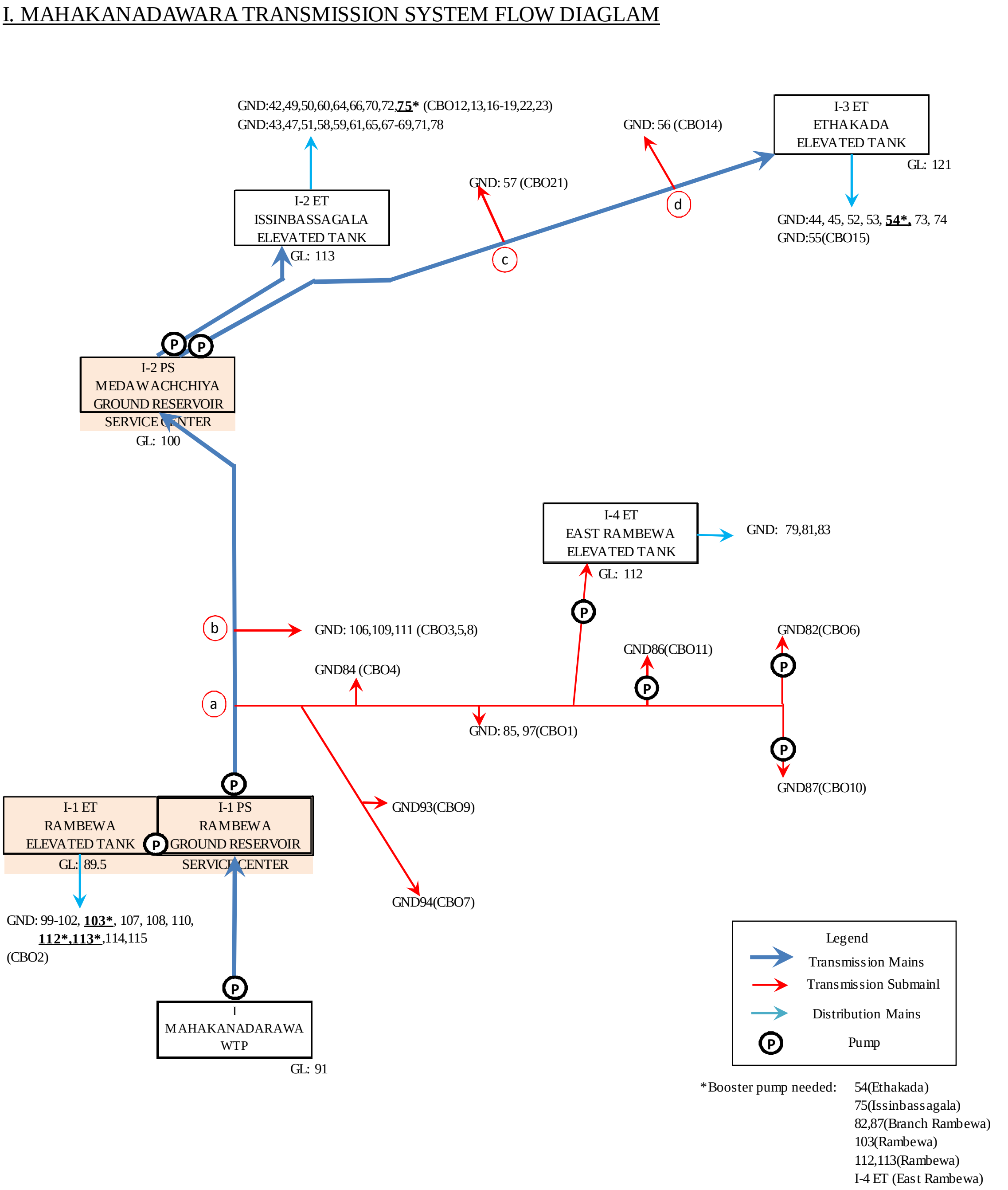


Figure 5.9 Schematic Flow Diagram of the Mahakanadarawa System

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 5.10**.

Table 5.16 Wahalkada Transmission System

Span		Route	Dia. (mm)	Length (km)
Wahalkada Systen IIA				
1	Wahalkada WTP～Kahatagollewa PS	Local road	400	7.8
2	Kahatagollewa PS～Bogahawewa Elevated Tank	Route B211	350	12.0
3	Kahatagollewa PS～Kebithigollewa Service Centre	Route B211	350	20.1
Wahalkada Syatem IIB				
1	Wahalkada WTP～Weerasole PS Weerasole PS～Horowpothana Service Centre	Local road Local road	450 450	14.7 15.5
2	Horowpothana Service Centre－～Kahatagasdigiliya Service Centre	Route A12	450	22.4
3	Horowpothana Service Centre－～Rathmalgahawewa Elevated Tank	Route B282	300	19.2

II. WAHALKADA TRANSMISSION SYSTEM FLOW DIAGLAM

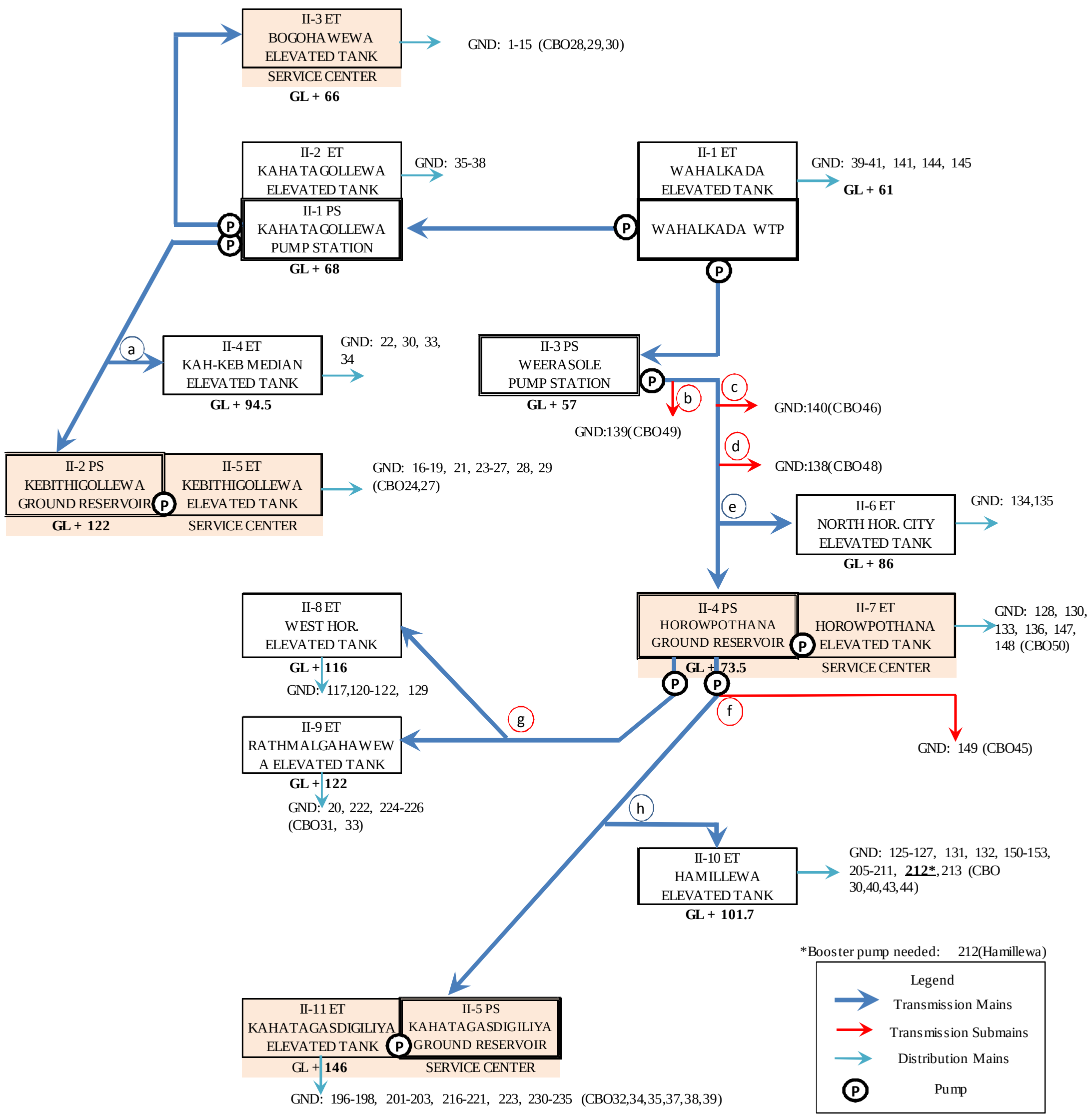


Figure 5.10 Schematic Flow Diagram of the Wahalkada System

5.3.6 Distribution System

(1) Method of Estimate

Distribution system, as mentioned earlier, is composed of distribution main and distribution sub-system. **Figure 5.11** illustrates definitive plan of the distribution system.

As shown on **Figure 5.11**, 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.

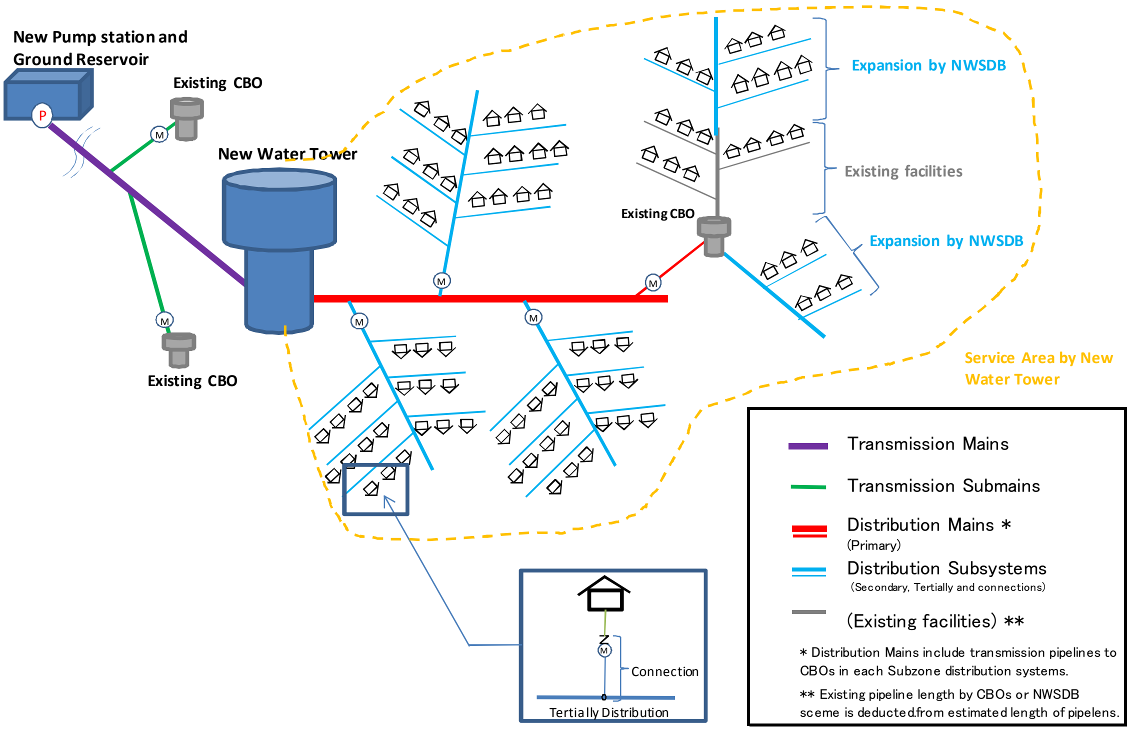


Figure 5.11 Definitive Diagram of Distribution Systems

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.

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 5.17**.

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 Phase I requirement are summarized in **Table 5.33** also. It should be noted that the length in the table is for a year 2024 requirement which corresponds to the project implementation period.

5.3.7 Major Facilities of Transmission and Distribution System

The summary of major facilities of transmission and distribution system is presented in **Tables 5.17** and **Tables 5.18** and **Figure 5.12**.

Table 5.17 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

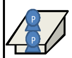
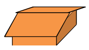
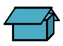
[1) ~ 3)]**:** HDPE, [4)-1~2]**:** PVC

* 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 5.18 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**
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

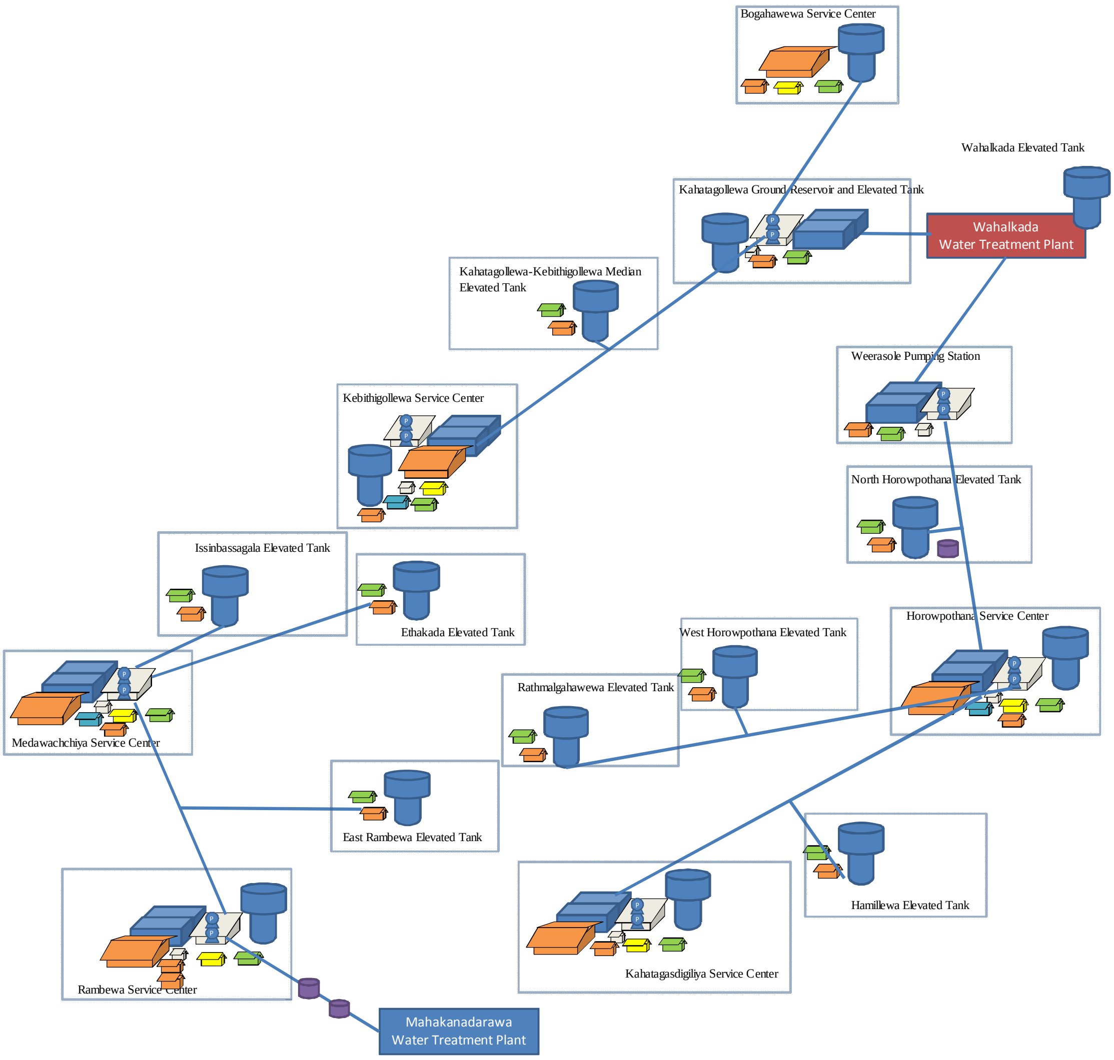


Figure 5.12 Summary Diagram of the Facilities to be Constructed

Table 5.19 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

DS Division	Land Location	Facilities to be constructed
		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 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

DS Division	Land Location	Facilities to be constructed
		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 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

(2) Easy operation and maintenance

(3) Measure of discharging the sand/silt deposit on intake waterways

(4) Water Hammer

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.

5.4.4 Pump

(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.

All essential pump systems include one standby pump/motor set to provide.

(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".

5.4.6 Other Equipment

The following equipment is installed in each pump station.

(1) Overhead traveling crane
(2) Flow control valve
(3) Valves for suction and discharge of pump
(4) Indoor piping
(5) Drain pumps in pump room

5.4.7 Measures against Water Hammer

The general features of the different surge protection measures are shown in **Table 5.20.**

Table 5.20 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.

5.5 Electrical Equipment

5.5.1 Electricity Power Supply

In Sri Lanka, electricity power generating, transmission, and distribution are managed by Ceylon Electricity Board (hereinafter: CEB). No grid-station of CEB is furnished in North Central of Anuradhapura area, and 33 kV power transmission lines are supplied by overhead 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. So, all facilities except for elevated tank sites 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.

5.5.2 Power Generator

Electricity power reliability at the North Central Area is low. 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 Treatment Plant at Wahalkada Proposed by NWSDB, 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.

As same as transformer, these generators will also cover the ultimate phase power demand from the beginning.

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.

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

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.

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.

5.6 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.

Figure 5.13 shows the concept of water supply system in the isolated area.

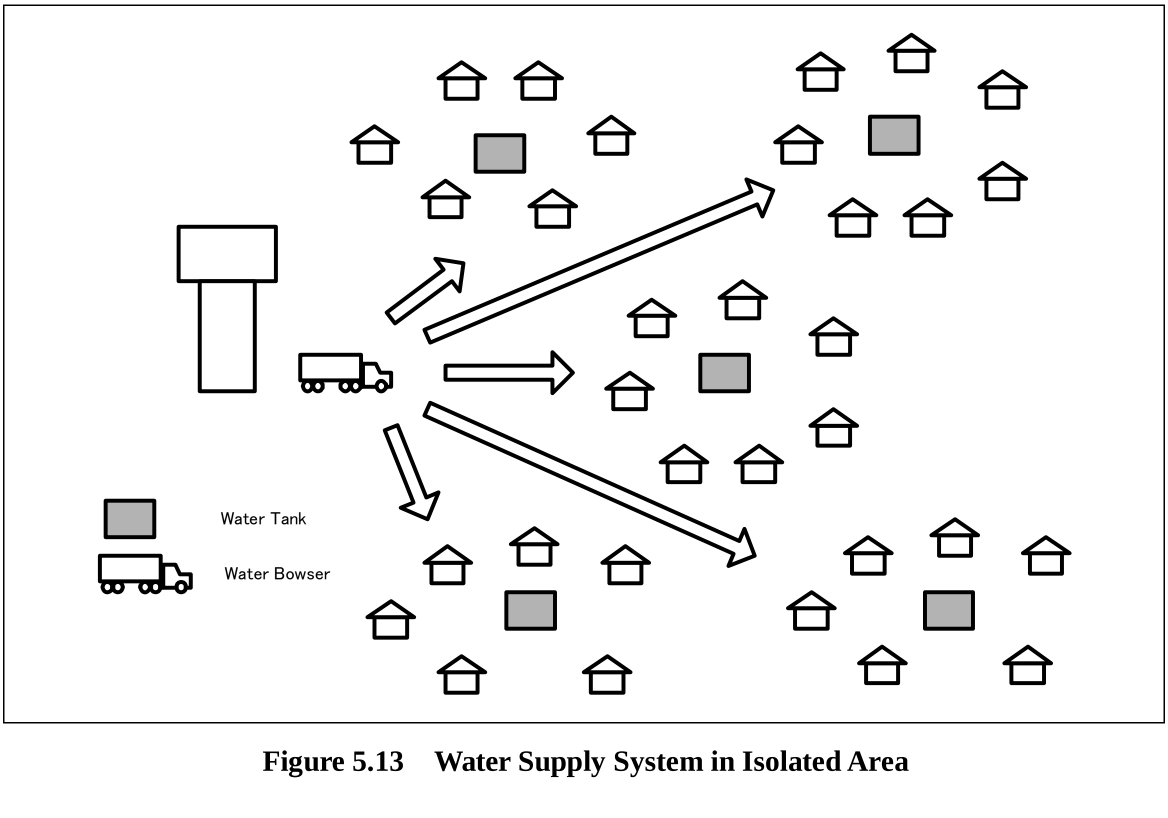


Figure 5.13 Water Supply System in Isolated Area

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.

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

This chapter provides a brief background of NWSDB as an institution and examines its current organization structure, focusing on the organization and operating structure of the NWSDB RSC(N/C), which stands to benefit from the implementation of this Project. It assesses the capacity of the RSC(N/C) and proposes capacity building programmes to enhance organisational skills and improve individual and staff competencies to manage, operate and maintain the new facilities / system. It also assesses the organizations concerned in project implementation; then defines, describes and delineates the sharing of the roles and responsibilities among these organizations to mitigate managerial, financial and technical problems may arise in the case of the Project's implementation.

After an examination of the current O&M organisation, a strengthened O&M organisation is proposed to ensure the sound operation and maintenance of the facilities after its completion, and develop rapid response capability not only to resolve technical issues, but also to achieve the highest level of customer service and satisfaction.

Finally, the section examines the modes by which water supply services can be distributed to the RSC(N/C) service area, which also consists of CBOs. It proposes strategies and approaches that include 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. It also examines the tariff system of the CBOs, which have varied tariff structures and charges. The examination of these tariff systems will keep the RSC(N/C) 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 Organisation

6.1.1 The National Water Supply and Drainage Board

The project implementation organisation is the NWSDB, which is the centralised water supply and sewerage organisation / utility in Sri Lanka providing 40% of the island population with access to safe piped borne water supply. 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 11 regional support centres which are fully operational. 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 (WSS). There are currently 312 WSS operating in the NWSDB RSCs. The NWSDB Approved Cadre (2011) provides for 10,119 personnel covering 246 Categories and spread over 15 Board Grades. Actual number of personnel stood at 9,193, as of July 2012.

6.1.2 The NWSDB RSC(N/C)

The current total approved cadre of NWSDB RSC(N/C) is composed of the *NWSDB RSC(N/C) Approved Cadre* (2011) of 441 personnel, plus the O&M cadre of 44 personnel, approved by the Department of Management Services in July 2012, bringing to **485 the total number of personnel in the Approved Cadre**. There are five sections in the RSC(N/C), as shown in the table below, together with its current number of personnel:

Table 6.1 Current Number of NWSDB RSC(N/C) Personnel according to Section

	Office /Section	Number of Staff
1	Office of the Deputy General Manager	04
2	Development Section	66
3	Finance and Commercial Section	03
4	Human Resources Section	10
5	Information Technology Section	02
6	Operations Section	307
	Total	**392**

Source: HR Section, as of 15 September 2012.

With the completion of the Project, the staff numbers are set to increase by **63 personnel** who will be assigned to manage, operate and maintain new facilities / water supply schemes. The recruitment of the new staff must adhere to the official approval process, and is recommended to commence at least a year before the projected date of the Project's completion. Also, two new units are proposed – the Area O&M (Satellite) Office and the Training Unit / Centre, in addition to three new water supply schemes (Rambewa, Mahakanadarawa and Wahalkada) and the expansion of three existing water supply schemes in the Project area (Kahatagasdigiliya, Kebithigollewa, and Medawachchiya).

6.1.3 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 unit (PMU), to be headed by a Project Director, will be created under the Office of Water Supply Projects, but will be physically based in the RSC(N/C). 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 RSC(N/C) 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.

Table 6.2 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	National Water Supply and Drainage Board	Project Management, Field Supervision, Monitoring and Coordination	General
			Project Management
	NWSDB RSC(N/C)	Coordination	Coordination of Implementation Issues
Project Coordination Committee	Key Stakeholders	Coordination	Coordination of Implementation Issues

6.1.4 Capacity Development of the Implementation Organisation

Training and development – planning, developing and implementing the *Staff Training Plan* – is centralised in the NWSDB Head Office through its Manpower Development and Training Office. This unit conducts technical, non-technical, and computer courses not only for the internal participants, but also for external institutions. It also sends employees to in-country external training programmes categorised into graduate, postgraduate degree courses, and diploma and other short courses, as well as sends key personnel to receive training overseas. For 2012, the NWSDB is conducting around 154 training courses, equivalent to 15,000 training hours.

It is recommended that training be regionalised not only for RSC participants to save on travel time and accommodation, or to maximise training benefits to cover other staff; but more so in having the programmes effectively address the actual training needs of RSC's staff. Towards this end, the organisational capacity of RSC(N/C) should be enhanced to a level that it can plan, develop and implement its own training programs for its own staff, the staff of neighbouring RSCs and also that of external institutions. This entails the development of a North Central Training Plan, organising a regional-level training unit / centre, and staffing it by seven personnel to implement the training plan by 2018.

As to enhancing staff capacity, the following capacity development activities and outputs are recommended:

Table 6.3 Proposed Capacity Development 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 RSC(N/C), 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 RSC(N/C) top management	• Conduct of Overseas Training on Water Utility Best Practices

6.2 Operation and Maintenance Organisation

Figure 6.1 shows the operation and maintenance organisation after the project completion and the supporting system by the existing organizations.

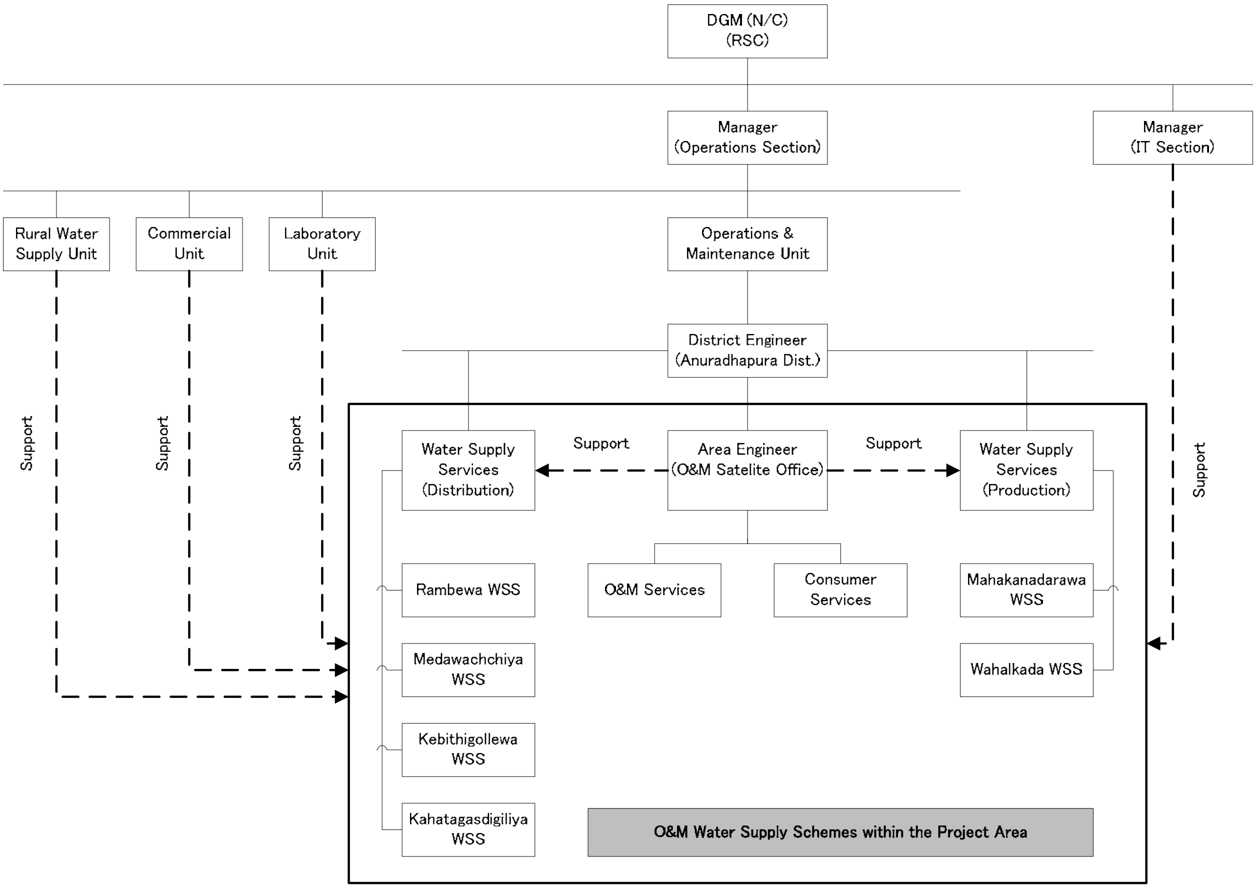


Figure 6.1 Operation and Maintenance Organisation after the Project Completion

The staff requirement for operation and maintenance after the project completion is shown in **Table 6.4**.

表 6.4 Staff Requirement for Operation and Maintenance after the Project Completion

	Saterite Office (Medawachchiya)	WTP		Service Centre (Transmission / Distribution)			
		Mahakanadarawa	Wahalkada	Rambewa	Medawachchiya	Kebithigollewa (Padaviya)	Kahatagasdigiliya (Horowpothana)
Area Engineer	1						
Electrical Engineer	1						
Mechanical Engineer	1						
Engineer Assistant (WTP)		**1**	**1**				
Engineer Assistant (O&M)				1	**1 (1)**	**1 (1)**	1 (1)
Engineer Assistant (Mnechanical)	1						
Engineer Assistant (Electrical)	1						
Consumer Relation Assistant	1						
Plant Technitian		3	3				
Pump Operator Mechanic		1	1	1	4 (3)	7 (6)	3 (1)
Electrician	2	1	1				
Mechanics	2						
Lab Attendant		1	1				
Meter Reader					1 (1)		
Pipefitter		1		2	2 (1)	3 (1)	3 (1)
Driver	1				1	1	1
Caretaker		1	1	1	2	3	4
Labourer	2	1	2	1	3 (1)	9 (4)	6 (4)
Total	13	10	10	6	14 (6)	24 (16)	18 (9)

Bold number shows the Officer-in-Charge (OIC).
The figures in parenthesis show the number of present staff.

6.2.1 Additional O&M Staff/Cadre for the Existing WSS in the Project Area

There are three 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.

6.2.2 New O&M Cadre for 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.

6.2.3 Proposed 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.

6.2.4 Enhancing Other Sections / Units in Support of O&M

There are other sections and units in the RSC(N/C) 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.

6.2.5 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

6.3.1 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.

6.3.2 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 due to a low level of fluoride for (i) and (ii) and the location far away from the proposed transmission pipeline route for (iii), as described in **Section 4.2.5**.

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 RSC(N/C) 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 in which 60 households have indivdual collection systems but CBO is willing to connect to a new pipe borne water supply system. Three CBOs (six percent) have been excluded from the study.

6.3.3 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 6.5 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***

It must be emphasized that CBOs are composed of beneficiary households, 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, 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.

Table 6.6 Manner of Providing Water Supply Services

DISTRIBUTION METHOD	By Existing CBO	By Direct Distribution			By Water Tankers
OVERVIEW	Bulk supply to CBO by RSC(N/C)	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

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 (i) replacement cost (ii) future rehabilitation cost (iii) capital investment (iv) O&M cost, including staff salary. All tariff systems are presented and accepted by the CBO in a general meeting, with a required minimum participation / presence of two-thirds of its membership.

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. In addition, 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 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 21 to 27 per unit.

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.

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 6.7 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 NWSDB RSC(N/C) 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 consumerable 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 6.8**, 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 6.8 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				Profit/Loss (Rs./year)
							Total (Rs./year)	Personnel (Rs./year)	Consumables (Rs./year)	Maintenance (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 Environmental and Social Consideration

7.1 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.

[Environmentally 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.

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.

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.

7.2 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%.

7.3 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.

7.4 Scoping

The results of scoping are shown in **Table 7.1**.

Table 7.1 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.
	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.

	Item	Impact	Description
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

7.5 Mitigation Measures

The adverse impacts and its mitigation measures are listed in **Table 7.2**. The column of Impact shows the evaluation of potential impact after taking mitigation measures.

Table 7.2 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	Minor	NWSDB RSC	PMU DS CEA

		secured.			
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, Regional Support Centre
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. ● 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	Minor	Contractor	PMU

Impact		Mitigation measures	Impact	In charge or implemented by	Supervising
		● 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.			
	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	Minor	Contractor	PMU

Impact		Mitigation measures	Impact	In charge or implemented by	Supervisin g
		peak hours to prevent road traffic blocks ● Public notice prior to construction			
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 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

7.6 Environmental Check List

The evaluation with the JICA checklist is shown in **Table 7.3**.

Table 7.3 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	

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
	(2) Water Quality	(a) Do pollutants, such as SS, BOD, COD contained in effluents discharged by the facility operations comply with the country's effluent standards?	(a) Y	(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.
	(3) Wastes	(a) Are wastes, such as sludge generated by the facility operations properly treated and disposed in accordance with the country's regulations?	(a) Y	(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.

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 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 $7m^{-1}$ $5m^{-1}$ $2m^{-1}$
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}

<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 environme	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 boundar 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

<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></td><td></td><td></td><td>Monitoring plan of resettlment
Preparation of resettlement site
<table>
<tr><th>No</th><th>Explanation of the site (e.g. Area, etc.)</th><th>Status (Completed (date) / not complete)</th><th>Details (e.g.Site selection, identification o candidate sites, discussion with PAPs, Development of the site, etc.)</th><th>Expected Date of Completion</th></tr>
<tr><td>1</td><td></td><td></td><td></td><td></td></tr>
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Public Consultation
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<tr><th>No</th><th>Date</th><th>Place</th><th>Contents of the consultation / main comments and answers</th></tr>
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<tr><th rowspan="2">Resettlement activities</th><th rowspan="2">Planned Total</th><th rowspan="2">Unit</th><th colspan="3">Progress in Quantity</th><th colspan="2">Progress in %</th><th rowspan="2">Expected Date of Completion</th><th rowspan="2">Responsible Organization</th></tr>
<tr><th>During the Quarter</th><th>Till the Last Quarter</th><th>Up to the Quarter</th><th>Till the Last Quarter</th><th>Up to the Quarter</th></tr>
<tr><td>Preparation of RAP</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Approval of RAP</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Finalization of PAPs List</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Progress of Compensation Payment</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Progress of Land Acquisition (All Lots)</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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<tr><td>Lot 2</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Progress of Relocation of People</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table></td></tr>
<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>
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CHAPTER 8 FINANCIAL AND ECONOMIC ANALYSIS

8.1 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). 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 this 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. 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 and discounted annually. The cost is the same as the FIRR calculation. 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. 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.

8.2 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.

After the project completion, 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 NWSDB tariffs. 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. On the other hand, if this project is completed, the NWSDB will supply the CBOs with water. NWSDB has tariffs for supplying bulk water to rural water supply schemes maintained by the CBOs. 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. The CBO survey also questioned about the model charge for a supposed $18m^3$ monthly use based on the CBO tariffs and charges per unit can be obtained.

The water sales per unit (m^3) of the CBOs range from 4.7 Rs./m^3 to 44.5 Rs./m^3 and the average of which is 19.6 Rs./m^3. NWSDB's average overall charge in 2011 is 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 21.0Rs./m^3. Therefore, while some CBO's 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 30Rs./ m^3, but most answers were 25Rs./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).

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. 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 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. However, most users accept the charges if they are set relevantly according to the social economic survey.

8.3 Financial Analysis

8.3.1 Preconditions and Methods

The preconditions and methods of 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 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./ 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. 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.”

8.3.2 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./m^3) 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.

8.4 Economic Analysis

8.4.1 Preconditions and Methods

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

- The 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.

8.4.2 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.

The WTP amounts are set based on the new users (No Supply) group as lower amount of either actual payment per m^3 or 4% income per m^3 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.

8.4.3 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 8.1 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%.

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.

8.5 Toward Sustainability of Operation and Maintenance and What Water Supply Management Should Be

In both cases for Mahakanadarawa and Wahalkada, 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 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 9 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 9.1** and **Table 9.3**, respectively.

9.1 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.

Table 9.1 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 9.1 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)

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.

- 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 9.2 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%	

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 9.3 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	41%	58%	64%		Status of risk avoidance being suffered from fluorosis and CKD through shifting of water source from well water to tap water
		(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%		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)	96 Lpcd	101 Lpcd	103 Lpcd		Shifting of water source from well water to tap water
		Per capita daily average consumption = (Daily average domestic consumption) / (Served population)	80 Lpcd	84 Lpcd	86 Lpcd		

Source: Prepared by the Study Team

Table 9.3 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 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

CHAPTER 10 Project Risk

10.1 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.

10.2 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.