CHAPTER 14 OPERATION AND MAINTENANCE PROGRAM FOR SEWERAGE SYTEM

CHAPTER 14 OPERATION AND MAINTENANCE PROGRAM FOR SEWERAGE SYSTEM

14.1 General

The appropriate operation and maintenance (O & M) of the sewerage facilities is vital not only to maintain the performance of the system, but also to prolong its service life.

The O & M program contained in this chapter presents; scope of activities, institutional set-up, task descriptions and O & M procedures. It should be noted that the requirements described in this chapter should be considered as the minimum requirements necessary to attain satisfactory levels of O & M practice and that further development of O & M activities will be subject to the progress of human resource development in this particular field.

14.2 Work Program for Operation and Maintenance

14.2.1 Sewage Collection System

There are four main O & M procedures namely, daily inspection, site investigation, pipe cleaning and rehabilitation of damaged sewers. The work items by O & M procedure are presented in Table 14.1.

Table 14.1 Work Items by Type of O & M of Sewer

O & M Type	Work Items
Daily inspection	- Operation of pumping facilities - Operation of electrical facilities
Site investigation	- Identification of damage and blockage location - Identification of the percolation point of groundwater - Investigation of the overflow point at manhole - Measurement of the volume of settled soil at the sewer bottom
Pipe cleaning	- Removal of settled soil, silt and foreign matter
Rehabilitation	- Replacement/repair of damaged sewer

O & M activities for sewers should be conducted according to the working program outlined below.

(1) Daily inspection

Pumping facilities are operated automatically according to the water level in the pump pits. Daily visiting of the pumping station is required to observe the operation of the pumps and electrical control system.

(2) Site investigation

The site investigation plan by year should be prepared to cover the entire sewered area of the municipality. The actual site investigation should be implemented in accordance with this investigation plan. Safety procedures including "Permit to Work" entry into live manholes will be followed by all staff during the investigation.

This investigation plan will be performed repeatedly and periodically, and the investigation team will describe the site condition in a daily record.

(3) Pipe cleaning program

The pipe-cleaning program by year should be prepared for the entire sewered area in the municipality. A priority action plan will be formulated based upon the results of the site investigation.

Generally, there are four types of pipe cleaning methods available: high pressure jet cleaning machine; vacuum machine; bucket machine; and manual cleaning. High pressure water jetting vacuum removal of waste is recommended.

In order to perform the above activities, it is proposed that the following vehicles and equipment be purchased:

Table 14.2 Vehicle / Equipment

Vehicle/Equipment	Quantity	Purpose
High-pressure Cleaning Car	1	cleaning of sewers
Sludge Vacuum Car	1	cleaning of sewers
High-pressure Cleaning Device	1	cleaning of storm water inlets
Dump Truck	1	transportation of sediments
Pickup Truck	1	control of cleaning works

The pipe cleaning operation for a complete sewage collection system should b performed to a comprehensive maintenance schedule. The pipe cleaning crew should record the volume and quality of the removed sediment, the method of cleaning and cleaning time in order to make improvements in future O&M activities.

(4) Rehabilitation plan

An annual pipe rehabilitation schedule, based upon the results of the investigation survey should be prepared. The rehabilitation work should be prioritized such that the

sewers in most urgent need of repair are rehabilitated first.

Generally there are two types of pipeline rehabilitation, namely the complete replacement of damaged sewers or the partial repair of damaged sewers. Damage to the pipes is caused by environmental or external factors. (damaged/deformed sewer resulting from ground subsidence, adjacent construction works, overweight vehicle, and corrosion by hydrogen sulfide etc.)

Pipe rehabilitation for damaged sewers should be contracted with local contractors according to the Rehabilitation Plan. The engineer responsible for sewer maintenance should instruct the contractors to prepare a report on the extent of damage, probable cause of damage, and suggested methods for pipeline in order to assist with future O&M.

14.2.2 Sewage Treatment Plant

The proposed method of sewage treatment to be used at the sewage treatment plant is the use of an oxidation ditch. This requires relatively simple technology and less manpower for operation and maintenance. Proper operation and maintenance is however indispensable in order to realize the full performance of the equipment and meet the design life of the equipment.

In the plant, there are two type of effluent to be treated namely, sewage and sludge. Sewage is continuously treated by the oxidation ditches, sedimentation basins and by tertiary chlorination, while sludge is treated by seasonal natural drying and removal using a wheel loader and a dump truck.

The O&M for the pump station is classified into two items, daily and periodical working. The working items by O&M types are shown in Table 14.3.

Table 14.3 Work Items of Sewage Treatment Plant by O&M Types

O & M Work	Work Items
Daily work	- Measurement of sewage flow - Removal of screenings at screen - Inspection of operation of aerators - Inspection of operation of sludge collection - Inspection of operation of chlorination facilities - Inspection of operation of electrical facilities - Removal and transfer to the sludge drying beds - Removal of dried sludge
Periodical work	- Removal of grit and sediments at grit chamber (monthly) - Inspection/repair of mechanical/electrical facilities (annually) - Overhaul of mechanical/electrical facilities (every 5 to 10 years)

The O&M for the pump station should be conducted according to the working program outlined below.

(1) Daily work program

The measurement of sewage flow is a significant item for the proper operation of sewerage facilities into the future. The screenings, soil, silt, and other substances collected at the screen and grit chamber have to be removed every day. These substances should be collected at the plant and conveyed to solid waste dumping site for disposal.

The inspection of mechanical and electrical equipment during operation is necessary for the identification of operational problems. Early identification of any problems will help extend the life of the equipment well into the future.

(2) Periodical work program

Two types of maintenance staff are required for periodical working program. The first group is ordinary unskilled workers needed to clean the tanks and basins of the plant. The second are skilled technicians required for the maintenance of the mechanical and electrical establishments.

(3) Sludge disposal

The sludge from sedimentation basins will be thickened and digested at the plant from where it will be treated by natural drying and daily removal using a wheel loader and a dump truck.

In principle, the removed sludge will be disposed of in a solid waste dumping site or

landfill site.

As the sludge may contain toxic substances that originate in industrial wastewater, special attention should be paid to the disposal of sludge in agriculture areas.

(4) Laboratory

The sewage treatment plant will discharge the treated water into Meda Ela, but the treated water will have to comply with strict effluent regulations. Because the quality of the treated water will need to be checked immediately on demand, a laboratory will be facilitated within the plant, staffed by a chemist. Complicated water quality analysis will, however, be conducted by a specialist outside company under contract to the treatment plant. The items to be tested and the required frequency of testing are indicated in Table14.4.

14.3 Organization for Operation and Maintenance

The proposed staffing for operation and maintenance personnel is 8 persons for Phase 1 and 12 persons for Phase 2, as shown in Table 14.5

Table 14.5 Required Number of Staff for O&M of Sewage System

(unit: persons)

Field & Position		Phase 1	Phase 2	Duty
Manager		1	1	Responsible for sewage system
Sewer and Pumping Station				
Sewer	Engineer	-	1	Responsible for cleaning of sewers
	Foreman	1	1	Responsible for site works
	Worker	1	1	1 workers/team
	Driver	-	1	1 workers/team
Vehicle Maintenance*	Mechanic	-	-	Maintenance of vehicles/equipment
Sewage Treatment Plant				
Operation	Engineer	1	1	Responsible for technical matters
	Foreman	1	1	Responsible for operation of each shift
	Operator	1	2	1 operator/shift
Maintenance	Technician	1	1	Responsible for site works
	Worker	-	1	Cleaning
Water Analysis	Chemist	1	1	Water quality control
Total		8	12	

* Vehicle maintenance shall be done by the Municipality workshop.

Table 14.4 Water Quality Examination

Items	Regulations	O&M	Trade effluent	Remarks
(Sewage)				
Air temperature		●		
Water temperature		●	×	
Color		●		
Odor		●		
Transparency by cylinder test		●		
pH		●	×	
DO		●		
BOD	⊙	○		
COD	⊙	●		
SS	⊙	●		
Settleable solids		●	×	
Chlorides		×		by contract
Total solids		×		
Fixed solids		×		
Volatile solids		×		by contract
Dissolved solids		×		by contract
Total nitrogen		×		by contract
Ammonia (Free)		×		by contract
Ammonia nitrogen		×		by contract
Nitrate		×		by contract
Nitrite		×		by contract
Organic nitrogen		×		by contract
Phosphorus (total as P)		×		by contract
Coliform count		●		
Total colonies		●		
Fats			×	by contract
Mineral oils			×	by contract
Organic solvents			×	by contract
Individual heavy metals			×	by contract
Calcium carbide			×	by contract
Bitumen			×	by contract
Cyanides			×	by contract
(Sludge)				
Temperature		●		
pH		⊙		
Moisture content		●		
Hazardous substance		×		by contract

Note: Examination frequency
- ● ; more than once a day
- ○ ; more than once a week
- ⊙ ; more than twice a month
- × ; as required

14.4 Operation and Maintenance Cost

The operation and maintenance program, as stipulated in the preceding sections, requires the following items and annual funds for proper operation of the sewage collection system and the sewage treatment plant. The detailed cost estimate is shown in Appendix 14.1.

Table 14.6 Operation and Maintenance Cost

(Unit: Thousand Rs./year)

Item	Phase 1	Phase 2
Personnel Expenses	840	1,176
Electricity Cost	1,947	2,504
Chemical Cost	27	51
Repair Cost	483	871
Total	3,297	4,602

PART IV ENVIRONMENTAL, INSTITUTIONAL AND FINANCIAL ASPECTS, AND CONCLUSION

CHAPTER 15 ENVIRONMENTAL IMPACT ASSESSMENT

CHAPTER 15 ENVIRONMENTAL IMPACT ASSESSMENT

15.1 Project Presentation

15.1.1 Foreword

(1) Presentation of the EIA

The Environmental Impact Assessment (EIA) is carried out as the second stage of the Environmental Studies proposed under the Greater Kandy and Nuwara Eliya Water Supply and Environmental Improvement Plan.

The need for an EIA has been identified since the beginning by the JICA mission team who visited the area in October 1997, and has been confirmed by the Initial Environmental Examination carried out during the first project phase (January – April, 1998). Conclusions of the IEE are briefly commented hereinafter in paragraph 15.2.

After reviewing the IEE, the Central Environmental Authority of Sri Lanka (CEA), had initially categorized this type of project as a *"Not Prescribed"* project, thus a full Environmental Impact Assessment was not required. Nevertheless, CEA gave a certain number of recommendations, which imposed a requirement for a deeper environmental analysis. Furthermore, the environmental feasibility of the project is a pre-requisite for project implementation with financial assistance under international funding agencies.

To meet all above requirements, a full-scale EIA representing a substantial part of the project. The study was carried out by a team of local consultants, and is presented as a separate report. The present chapter concerns the Environmental Impact of the project in Nuwara Eliya, and has been prepared on the basis of information and data extracted from the local consultants report

The target year for the Study is 2015. However, projections of the served population and water demand will be extended until the year 2020. The target year for the priority projects is set at 2005.

(2) Nuwara Eliya study area

The Nuwara Eliya municipality is located in the Nuwara Eliya District, which is situated

south of Kandy District in the Central Province. The Nuwara Eliya municipality is the capital of the district. (Figure 15.1)

The physiography of the Nuwara Eliya district is characterized by hills, mountain ranges and valleys and high plains. The elevation of the Study Area is in the range 1800-2000m above MSL. The Nuwara Eliya Municipality is located at the foot of Pidurutalagala, the highest mountain in Sri Lanka. A major part of the Municipal area is in the level valley of Nanu Oya.

The underlying geologic formation is mainly high-grade metamorphic crystalline rocks of the Pre-Cambrian era locally classified as rocks of the Highland Series. The soils formed on these rock formations are moderately deep to deep Red Yellow Podzolic soils and Mountain Regosols.

The Nuwara Eliya District is located in the wet zone of Sri Lanka. In the district the annual average rainfall ranges from 2,000 - 2,500 mm, and in the Nuwara Eliya MC area the annual average rainfall is approximately 2,000 mm. In the city, the average temperature varies between 17.4^{0}C and 15^{0}C, with Relative Humidity in the range of 81.2 percent and 88.4 percent. Daily sunshine hours vary between 3.7 hrs and 9.9 hours.

(3) EIA objectives for the Nuwara Eliya area

The Environmental Impact Assessment (EIA) for the Nuwara Eliya Water Supply and Environmental Improvement Project has the following objectives:

1) To assure that the works proposed under the "Nuwara Eliya Water Supply and Environmental Improvement Project" will respect the environment and will comply with the environmental standards required by the Central Environmental Authority (CEA) of Sri Lanka, as well as by the Japanese International Cooperation Agency, JICA;

2) To assure that each of the proposed works will be built and operated in compliance with the same standard and requirements of the above agencies;

3) To assess the major/critical environmental aspects emerging from the Environmental Analysis conducted during the Initial Environmental Examination (IEE) phase and propose adequate mitigation measures;

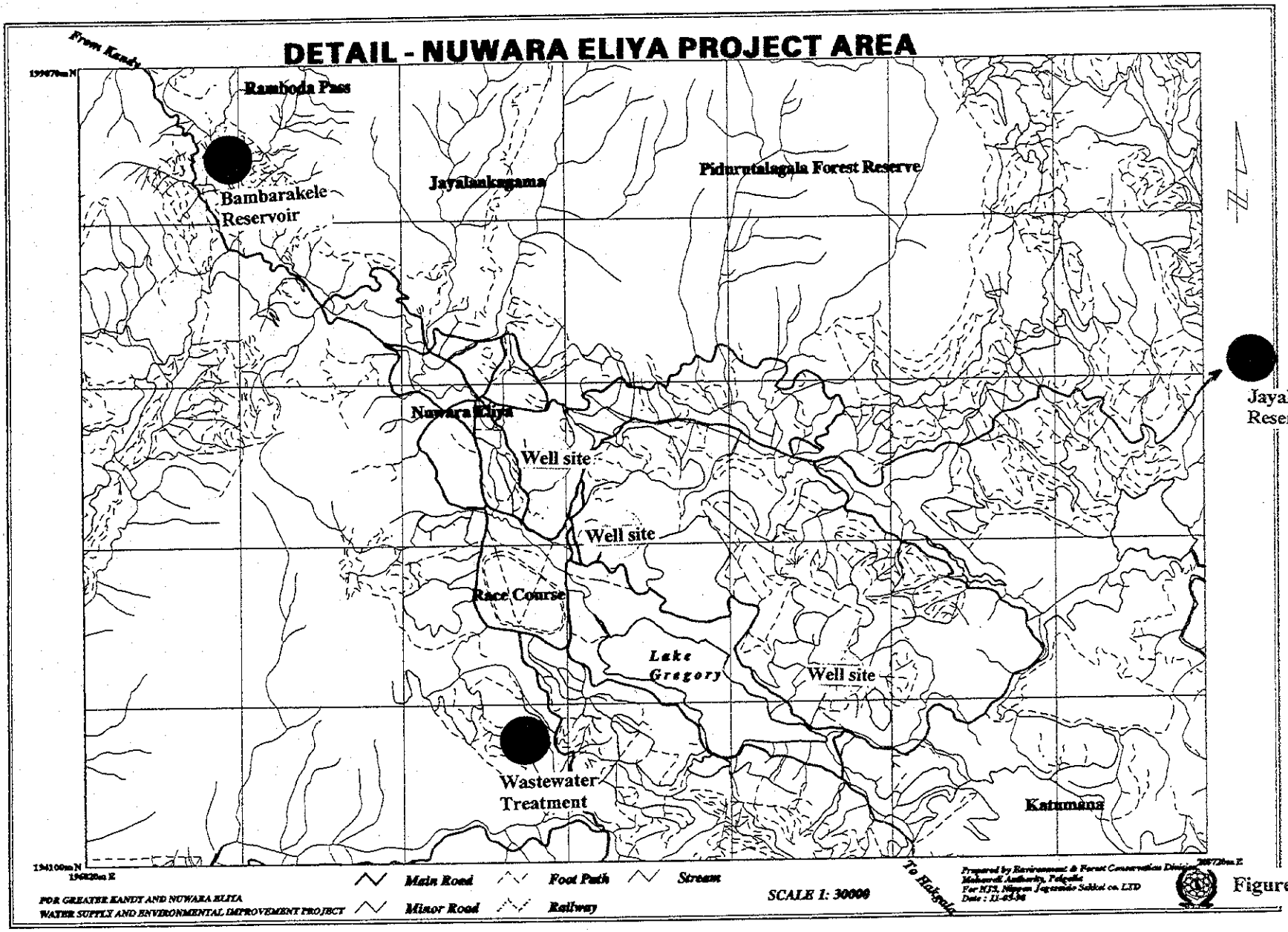

DETAIL - NUWARA ELIYA PROJECT AREA
From Kandy
Ramboda Pass
Bambarakele Reservoir
Jayalankagama
Pidurutalagala Forest Reserve
Jayalanka Reservoir
Nuwara Eliya
Well site
Well site
Race Course
Lake Gregory
Well site
Wastewater Treatment
Katumana
To Haputale
Main Road
Minor Road
Foot Path
Railway
Stream
SCALE 1: 30000
FOR GREATER KANDY AND NUWARA ELIYA WATER SUPPLY AND ENVIRONMENTAL IMPROVEMENT PROJECT

Figure 15.1

4) To identify and assess all other environmental impact which may arise during construction and/or during operation, as a consequence of the specific plant design and/or location;

5) To give guidelines for the implementation of an Environmental Monitoring and Auditing Plan.

The findings and conclusions of the Initial Environmental Examination are taken as a basis for the Environmental Impact Assessment, and are reported in Appendix 15.1 (IEE – Executive Summary). Identified critical impacts are reported hereinafter.

15.1.2 Identification of Critical Impacts

Based on the IEE findings and conclusions, the following aspects have been retained on a priority basis for the Nuwara Eliya present EIA:

(1) Socio –economic impacts in direct impact areas where the construction of treatment plants and dams is proposed;
(2) Land acquisition and compensation to entitled persons or entities that will be subject to involuntary relocation or loss of land or other goods because of the proposed construction;
(3) Environmental feasibility of the proposed Jayalanka Dam and Bambarakele Dam in Nuwara Eliya;
(4) Underground water balance in Nuwara Eliya: its purpose is to assess if exploitation of underground water for water supply might be detrimental for alternative water uses, and particularly for agriculture during the dry season;
(5) Balance of contamination (with - without project comparison) in the major surface water bodies in Nuwara Eliya (Gregory lake, Lover's leap reservoir);
(6) Impact on traffic and transportation during construction in the central areas of Nuwara Eliya;
(7) Transport and disposal of wastes and excavated materials during construction;
(8) Transport and disposal of sludge produced at the wastewater treatment plant;
(9) Noise and odor control (during construction and during operation);
(10) Auditing and monitoring plan (guidelines);
(11) Institutional Assessment of the NWSDB environmental sector.

The water, sewerage and sludge quality survey, carried out as an integral part of this project,

is also part of the Environmental Study and will be briefly commented in the following paragraph.

15.1.3 Water, Sewerage and Sludge Quality Analysis

A water quality examination has been conducted as an integral part of the present project, to collect data on raw water quality of water supply, raw sewage, surface water-bodies (rivers and lakes) and sludge quality.

The water quality examination covers both dry and rainy seasons, including the following specific surveys:

- Water quality survey
- River quality survey
- Sludge quality survey.
- Sewage quality survey
- Lake quality survey;

The first investigation was carried out during the months of March and April 1998. The second investigation, to collect samples for the rainy season, was conducted during the months of July and August 1998. Collected data are reported in Appendices 15.2 and 15.3 (for both Greater Kandy and Nuwara Eliya), while water quality for the Greater Kandy area and the balance of contamination are discussed in the section 15.5.

15.2 Critical Project Components/Activities Affecting the Environment

The proposed Nuwara Eliya Water Supply and Environmental Improvement Project consists of a number of components and activities. Major components are briefly described here for clarity, and to help in the identification of critical impacts arising from the project.

15.2.1 Water Supply

(1) Identification of alternative water sources for the Nuwara Eliya water supply project considering the possibility of exploitation of the following alternative water sources (Figure 15.1):

- Construction of a Reservoir / Dam at Bambarakele and treatment plant;
- Construction of a Reservoir/ Dam at Jayalanka and treatment plant
- Extraction of ground water from Nanu Oya valley within the Municipal area. The water distribution is designed on the assumption that ground water will be extracted on a priority basis.

In the case of surface water (dams), a full treatment will be necessary. In the case of underground water, chlorination will be sufficient. All alternatives require a complex system of transmission and distribution, with trenching and pipe layout covering the whole served area (distribution is mainly in central Nuwara Eliya)

All these alternatives therefore present potential negative environmental impacts, which need to be analyzed.

(2) Jayalanka Reservoir

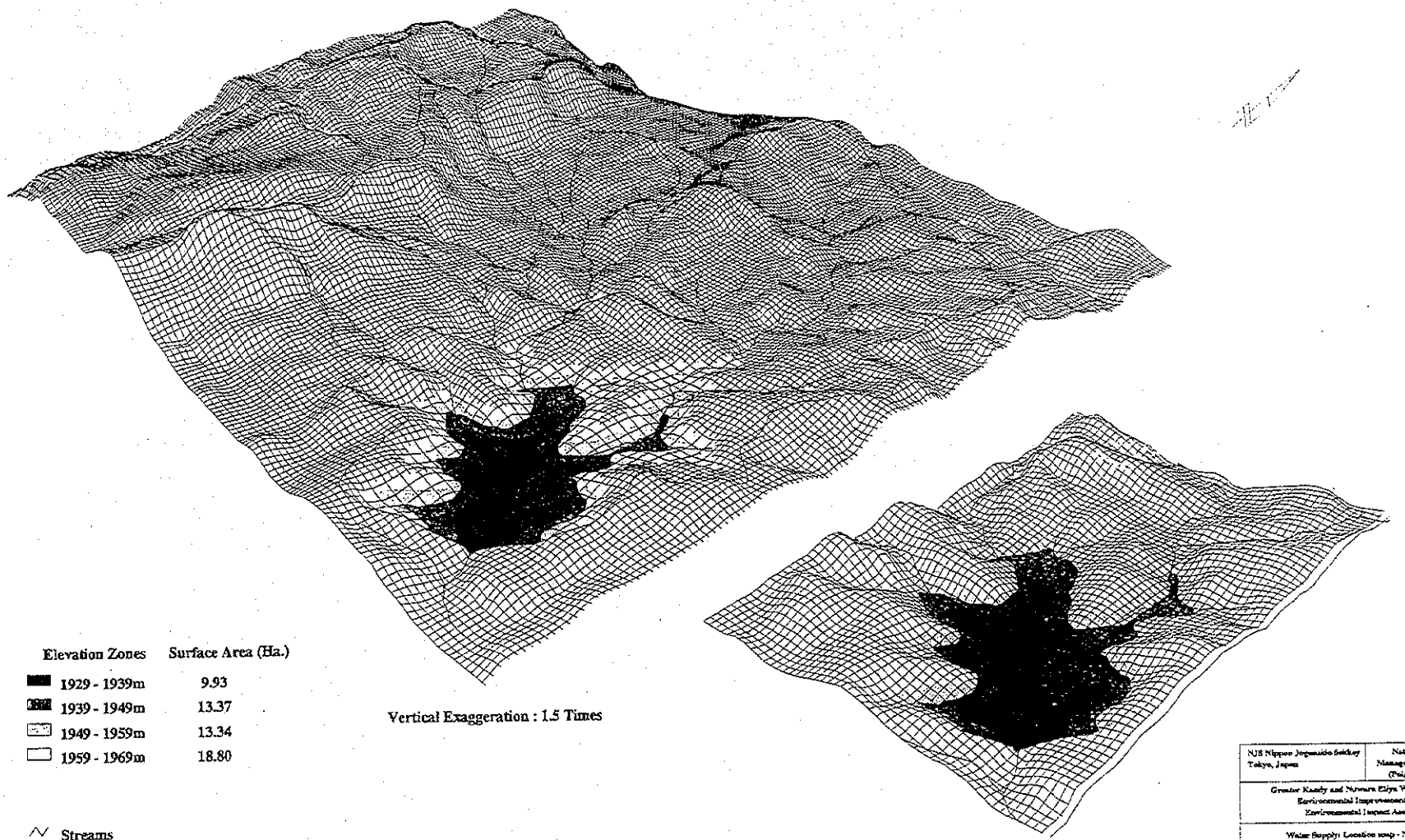
The construction of a 40 m high dam at Jayalanka will create an impoundment of about 20 ha, with a catchment area of 568 ha. A 3D view of the catchment and the flooding area, for different dam heights, is indicated in Figure 15.2-1. The usable storage, for a 40 m high dam, is 1,575,000 m^3; the correspondent approximate water supply is about 6,000 m^3 per day.

A serious problem with Jayalanka reservoir is the presence of a very large area under small holder vegetable plots, which would be submerged. In the catchment, there are vegetable plots and an extensive area under tea plantation (see land use in Figure 15.2-2).

Due to the presence of vegetable plots and tea estates in the catchment area, together with a large population of estate workers and vegetable farmers, the threat of water pollution in the reservoir is very high, requiring the use of advanced and costly water treatment before distribution.

A minimum number of 35 families should be relocated out of the reservoir area. Additionally with the protection needed all around the reservoir, relocation could affect between 50-60 families.

THREE DIMENSIONAL VIEW OF PROPOSED JAYALANKA RESERVOIR & CATCHMENT AREA



NJS Nippon Jogesuido Sekkei, Tokyo, Japan

Natural Resources Management Services - K (Pvt)Ltd., Sri Lanka

Greater Kandy and Nuwara Eliya Water Supply and Environmental Improvement Project - Environmental Impact Assessment

Water Supply: Location map - Nuwara Eliya area

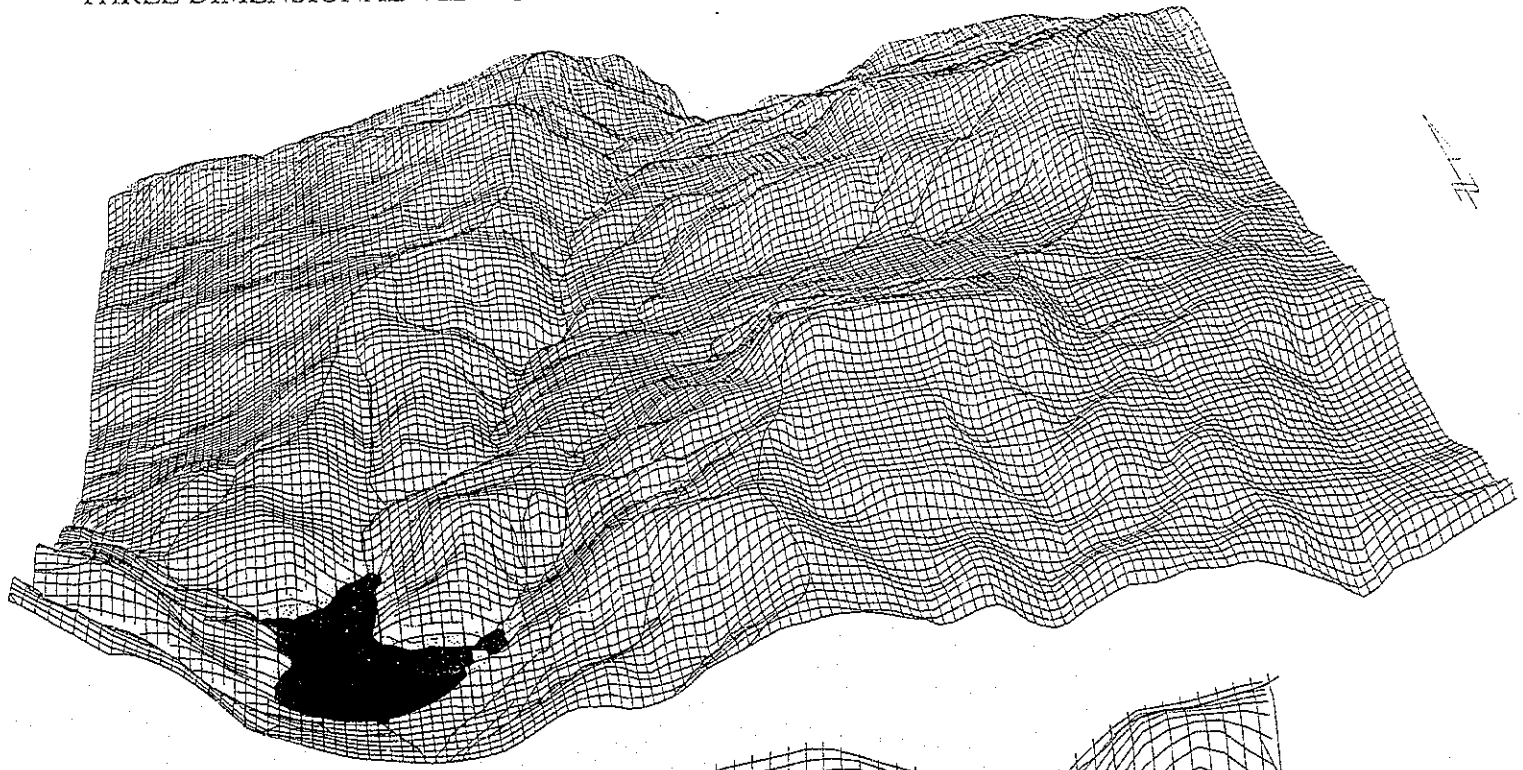
Prepared by : GIS&RS Section

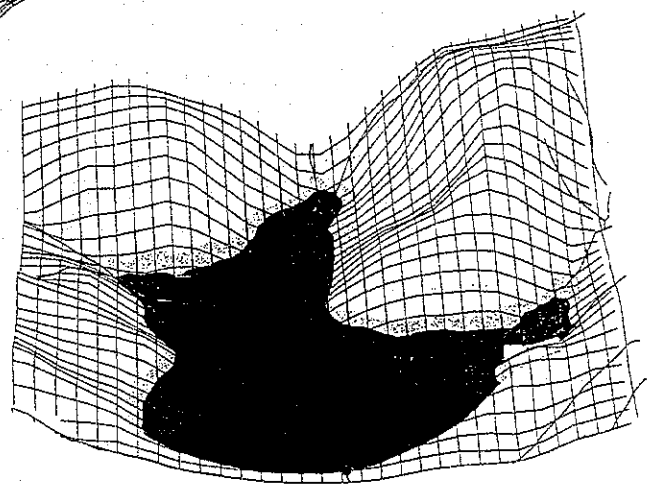
Revised and approved by

September 1998

Figure 15.2-1

THREE DIMENSIONAL VIEW OF PROPOSED BAMBARAKELE RESERVOIR & CATCHMENT AREA





Elevation Zones	Surface Area (Ha.)
1917 - 1927m	3.79
1927 - 1937m	2.83
1937 - 1947m	5.22
1947 - 1957m	2.19
1957 - 1967m	4.29

Vertical Exaggeration : 1.5 Times

Streams

Catchment Boundary

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Greater Kandy and Nuwara Eliya Water Supply and Environmental Improvement Project - Environmental Impact Assessment	
Water Supply: Location maps - Nuwara Eliya area	
Prepared by : GIS&RS Section	Revised and approved by
September 1998	

Figure 15.2-2

(3) Bambarakele dam and reservoir

A 3D view of Bambarakele dam catchment and the impoundment area, for different dam heights, is shown in Figure 15.2-2. An aerial view of the area is given in Figure 15.3

Due to the different topography compared with Jayalanka, the construction of a 50 m high dam will flood a reduced surface area of 6.2 ha, with a correspondent catchment area of 220 ha. The usable storage of the reservoir will be about 412,500 m^3 and the approximate water supply will be 4,250 m^3 per day. Although the yield from Bambarakele is estimated to be 4,250 m^3 per day, a portion of this yield is already in use, therefore, it cannot be counted as new. The lowest flow recorded from some limited measurements is 1,650 m^3/ day, which occurred in 1997. According to 10 year rainfall data, the total rainfall in the dry period was up to 17 percent lower than the dry period total of 1997; therefore, the safe flow rate is estimated to be as low as 1,400 m^3 per day. This shows that construction of a reservoir would increase the safe yield available to the community to about 2,850 m^3 / day.

(4) Ground water extraction

Test wells have been drilled and pump tests have been carried out during the project (see Chapter 5). Suitable well sites have been identified. Based on the estimated unit cost, ground water extraction is shown to be the most attractive alternative compared to exploitation of surface water resources. Facilities to be developed under ground water extraction include the following:

- Extraction and conveyance (drilling of production wells and conveyance pipelines);
- Treatment facility (chlorinating);
- Transmission and Distribution (trenching and laying pipes for transmission, construction of distribution reservoirs and pressure control chambers, trenching and laying distribution pipeline network).

The EIA will focus on potential negative impacts of long term water extraction on alternative water uses (mainly agriculture) in the Nuwara Eliya area. A hydrogeological balance is presented in the following Chapter 4, developed with the help of a specific simulation model.

BAMBARAKELE PROPOSED DAM SITE

(AIR PHOTO - March 1987)

SCALE 1 : 2500

This air photo mosaic is based on the aerial photography of 1987 supplied by the Water Supply & Drainage Board, Kandy.

NJS Nippon Jogesuido Sekkey Tokyo, Japan	Natural Resources and Management Services –Kandy (Polgolla), Sri Lanka
Greater Kandy and Nuwara Eliya Water Supply and Environmental Improvement Project – Environmental Impact Assessment	
Bambarakele Proposed Dam Site –Nuwara Eliya area	
Prepared by	Revised and approved by
September 1998	

Figure 15.3

15.2.2 Nuwara Eliya Wastewater Treatment

This component of the proposed project consists of the following activities:

- Construction of a treatment facility (aerated lagoons) out of town in the Nanu Oya valley;
- Trenching and laying of transmission mains to the treatment plant;
- Construction of secondary transmission lines and connecting system.

The average daily flow of sewage has been estimated to be 2,300 m^3, with a maximum flow of 2,700 m^3/day. A flow of 2,800 m^3/ day is considered for the target year 2010.

Separate systems will be used for collection. The aerated lagoon method is recommended for treatment, because of its advantages in power consumption, construction, operation & maintenance costs, and ease of operation and maintenance. The service area includes the city center, the Lake Gregory area and the Base Hospital (integrated area).

The plant will be formed by a grit chamber, two treatment lines of four aerated lagoons each, with a capacity of 1,400 m^3/day (one complete mixing aerated lagoon and three cells of partial mixing aerated lagoons), and a disinfection tank, designed to reduce bacteria, viruses and ameobic cysts from the effluent by the use of a chlorine solution.

15.2.3 Direct and Indirect Impact Areas (Water Supply and Sewage)

The following Direct impact areas are identified in Nuwara Eliya:

(1) Bambarakele Dam site: 6.2 ha submergence area and dam site;
(2) Fisheries complex at Bambarakele;
(3) Jayalanka Dam site: 20 ha submergence area and dam site;
(4) Ground water well field;
(5) Sewage treatment plant site on Nanu Oya road;
(6) Water supply transmission lines and reservoirs;
(7) Sewage transmission lines.

15.3 Socio-Economic Impacts

15.3.1 Jayalanka Reservoir Site

(1) Project area

The proposed project area is located close to the Kandapola - Nuwara-Eliya road. The geomorphology of the area consists of a flat alluvial plain, mid slopes and upper slopes. The lower portion of the project area is located in the alluvial plain, and is fully cropped. The sloping terrain of the middle portion is on settlement of Jayalankagama. The upper portion of the catchment is managed by the Court-Lodge tea plantation. (see land use in Figure 15.4)

Three major types of land uses are found in the catchment area: forest, tea, and vegetable cultivation. Vegetable cultivation is intensive and at least three crops per year are harvested

(2) Population

The total number of families in the catchment area is about 281, with a population of 1617 people in 3 clusters in the upper catchment area; scattered houses in mid slope, and the lower valley (See Table 15.1).

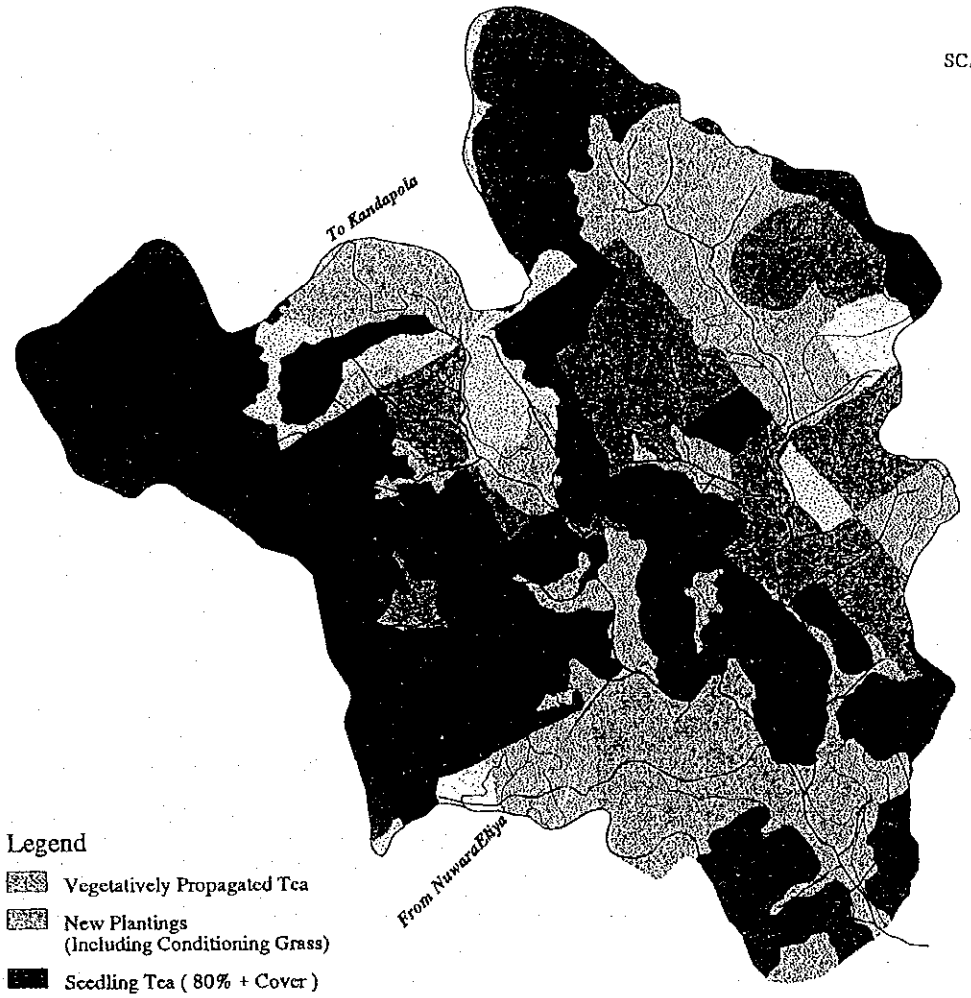
Table 15.1 Population in Jayalankagama Project Site

Area	No. of Families	Total Population	Livelihood
Lower valley	35	205	Vegetable cultivation
Jayalankagama Scattered houses, mid slopes	52	318	Vegetable cultivation
Upper Catchment area (in 3 clusters)	i. upper cluster - 60 ii. middle cluster- 90 iii. mid slope - 44	310 540 244	Tea plantation workers
TOTAL	**281**	**1617**	

(3) Land Acquisition and resettlement

The envisaged dam construction will flood about 20 ha of fertile and almost flat land. The number of persons to be affected by resettlement will be closed to 100 families and a further large number of families - about 200 should be removed from the upper catchment to ensure protection of the reservoir from siltation and pollution.

LAND USE OF PROPOSED JAYALANKA CATHMENT



SCALE 1 : 20000

Legend

- Vegetatively Propagated Tea
- New Plantings (Including Conditioning Grass)
- Seedling Tea (80% + Cover)
- Seedling Tea (60 - 80%)
- Seedling Tea (40 - 60%)
- Seedling Tea (Less than 40% Cover)
- Diversified Tea (Less than 50% Other Crop Cover)
- Vegetables
- Eucalyptus
- Natural Woodland (Open)
- Natural Woodland (Dense)
- Scrub
- Settlement
- Minor Road
- Stream

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Greater Kandy and Nuwara Eliya Water Supply and Environmental Improvement Project - Environmental Impact Assessment	
Land Use of Proposed Jayalanka Catchment	
Prepared by : GIS/RS Section	Revised and approved by
September 1998	

Figure 15.4

Considering the necessary protection or safeguard zone, at least 40 ha need to be acquired for the project, at prices apparently ranging between Rs. 6,400,000 up to 40,000,000[1] per hectare (S 98,000 to 600,000). Vegetable cultivators and casual laborers will lose their source of livelihood, both income and employment opportunities will be at stake. It should also be considered that in Nuwara Eliya non agricultural employment is very hard to find.

Land values in the vegetable growing area are very high. The demand for land is such that one hectare may cost at least Rs. 20,000,000/=. Furthermore, there is strong opposition to the project, and negotiation for compensations will be extremely difficult.

It can be concluded that involuntary resettlement and land acquisition represent a major problem, making the project not feasible from the social/environmental point of view.

15.3.2 Bambarakele Reservoir Site

(1) General

The impacts of the proposed reservoir construction are of two folds. The first is directly related to the inundation, the second will be on the adjoining areas. (see land use in Figure 15.5)

(2) Resettlement

The Dam site is located below the settlement area, and above the plantation settlements. Less than 10 ha will be flooded, and no evacuation will take place. Only the sheds of the Inland Fisheries Department need to be removed. There is no opposition to the project and no social/environmental problems are expected in the area.

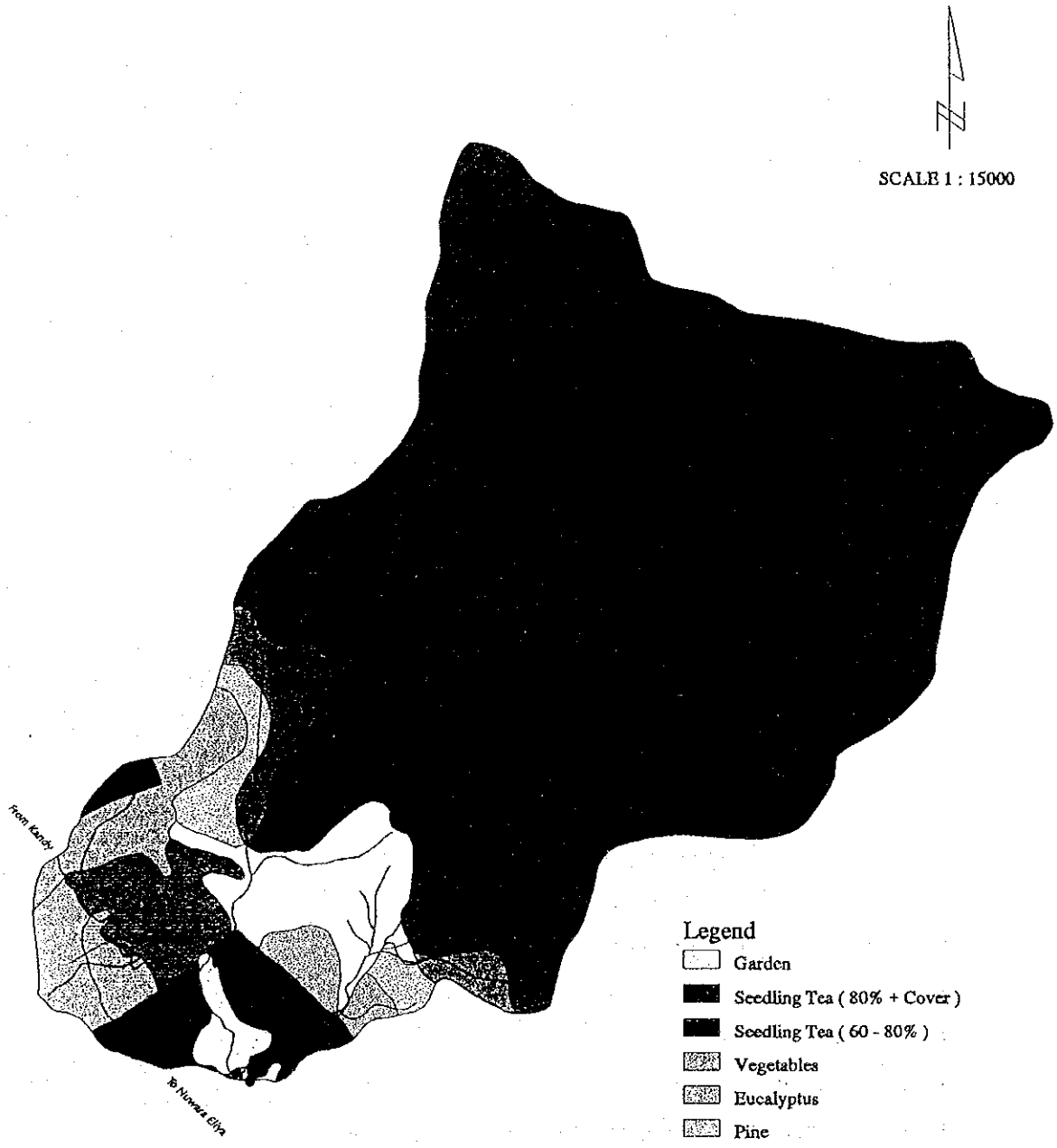
(3) Land Acquisition

The lower segment of the proposed reservoir site includes tea-cultivated land. According to estimates one acre of tea land is valued at about Rs. 4,800,000, while the upper part of the reservoir area is under forest vegetation.

---

[1] *This price is particularly high and needs to be further verified. The information comes from local people, however, there are no reliable market statistics available.*

LAND USE OF PROPOSED BAMBARAKELE CATHMENT



NJS Nippon Jogesuido Sekkey Tokyo, Japan	Natural Resources and Management Services - Kandy (Polgolla), Sri Lanka
Greater Kandy and Nuwara Eliya Water Supply and Environmental Improvement Project - Environmental Impact Assessment	
Land Use of Proposed Bambarakele Catchment	
Prepared by : GIS/RS Section	Revised and approved by
September 1998	

Figure 15.5

(4) Indirect impacts

Bambarakele dam's indirect impact area is characterized by steep slopes. The Nuwara-Eliya - Kandy road runs through the area; the distance from the proposed reservoir to the road is about 150 meters. Land use systems include, tea cultivation, forest, and also a small area under vegetable beds, in addition to the constructed lands. One guest house and six houses are located about 150-200 meters away from the reservoir site. Immediately below the dam site three houses and two sheds - owned by Inland Fisheries Department. Six houses are located above the reservoir site. Of these, two houses are relatively small. 25 people live in the upper area, depending on multiple sources for their livelihood. Two families depend on casual work, while the others depend on non-agricultural sources. Monthly income is in the range of Rs. 1,000 to Rs. 7,000. The total population in this area is about 24 people. The guesthouse functions mainly during the peak season.

Houses located above the reservoir site are scattered, and on private land. Two clusters are located below the dam site. One belongs to the Inland Fisheries Department and the other belongs to the plantation.

Spring water is the main source. Open springs or tentatively connected pipes are used to obtain water for bathing, washing and drinking purposes. Seasonal fluctuations have been reported. All the households have latrines, five of them are water sealed, one is a pit. Waste is poorly managed. An office of CARE is located in the area, but not active.

Compensation to the affected people in the indirect impact area should take into consideration the following concerns:

- Better water supply and service;
- Tourist attraction and possible increase in aesthetic value;
- Increase in land price;
- Loss of cultivated lands;
- Labor opportunities during construction.

(5) Conclusion on social/environmental feasibility

Bambarakele dam, the opposite of Jayalanka, present a positive socioeconomic feasibility: the impoundment area is reduced, land can be easily acquired at convenient prices, and there is no opposition to the project. Nevertheless, people living in the surrounding areas will be affected, since their way of life will be forcibly changed. Compensation should therefore be considered, in a monetary or non-monetary form (recommended).

This should at least include:

- Improvement of waste management and the introduction of a waste collection system;
- Training on soil conservation and the introduction of soil conservation measures.

15.3.3 Sewerage Treatment Plant (Nanu-Oya Road)

(1) Project site

The project site is located in a minor valley close to the Nuwara-Eliya - Nanu-Oya road. Land is owned by a tea plantation.

No houses or other physical structures are located on the proposed site. In the vicinity of the project area (within an 150 meter radius), 12 houses, two shops, one garage, one shrine and one Tea Estate line-room are found. The total affected population has been assessed as 102 persons, who will need to be considered for compensation.

(2) Project Impacts and mitigation measures

No displacements will take place.

Land acquisition will be necessary. The price of one hectare of tea land in this area is about Rs. 12,000,000 (about $ 185,000). Unpleasant odors from the sewerage plant are considered as a main threat by residents, expecting unavoidable problems such as headaches, psychological problems due to the smell of the sludge. A proper information campaign should be carried out to explain the real dangers and threats for human health.

The socio-economic inquiry carried out by the project also revealed some positive aspects, mainly related to employment opportunities and the production of fertilizer suitable for local cultivation. The importance of these positive impacts should be emphasized during the recommended information campaign.

As an additional mitigation measure, it is also recommended to grow a dense hedge of trees around the treatment plant in order to improve visual impact, hiding the plant from outside view, and avoid/mitigate offensive odors.

(3) Alternative site for the Nuwara Eliya WW Treatment Plant

As shown in the previous paragraph, the proposed site close to the Nanu Oya road, even if not completely negative from the socioeconomic point of view, certainly presents some

problems for which finding a solution may not be easy. An alternative site for the treatment plant is therefore proposed by the Municipality in the same valley about 2.5 km downstream. It is a level area with an additional sloping area adjacent to it. Most of land is unused, while the sloping part is under a forest plantation. The whole area appears to a part of State property, and this is an essential point to be considered. No compensations or land acquisition costs will need to be paid for the acquisition of this land. However, it will require additional sewer lines and a considerable amount of earthwork for leveling of the site to obtain the area necessary for plant construction. In addition, measures should be taken against flooding in the valley. Because of its topographical condition the site is not recommendable technically or financially.

15.3.4 Land Acquisition and Compensations Procedures

(1) Legal assessment and responsibility for land acquisition in Nuwara Eliya

Land acquisition and compensation to entitled persons and/or agencies are the primary impacts of the proposed project. However, the secondary impacts (socioeconomic) that occur due to the project deserve major concerns, since they are much harder to mitigate. In fact, a deteriorated socioeconomic environment nearly always adversely affects the physical environment. The correct application of land acquisition procedures will help minimizing both the primary and secondary impacts of the project.

Land acquisitions for public purposes are based on the Land Acquisition Act of 1950. There are two procedures described for land acquisition for a public purpose, namely;

1) when the land acquisition to be undertake under normal conditions and
2) when the land acquisition is urgently required.

These two procedures are described in detail in the Land Acquisition Act of 1950 and subsequent amendments (Appendix 15.3).

The final decision on land acquisition is based on the following:

1) Claimants eligible for compensation;
2) The nature of their claim on the land identified for take over;
3) The total amount of compensation for the entire land area to be taken over by the Ministry or its Agency;
4) According to Section VI of the Regulation under the Land Acquisition Ordinance, the

final amount of compensation that should be paid for the claimants of the land to be taken over;

5) Share of compensation for each claimant.

(2) Compensation for the acquisition of land

Compensation for any land acquired for a public purpose is paid as a measure to reduce socio-economic impacts, which are important factors that affect the immediate environment of the project sites.

Payment of compensation arises at two stages in the process of land acquisition, namely; (i) at preliminary investigation stage and (ii) at the stage of taking over of possession of the land by the State. Compensation is determined by the officer responsible for land acquisition in the district/ Division. The second and the final compensation is determined after considering the claims made by affected persons, current market value, claimant's ownership relation to the land and any other factor that may be required for valuation under Section 17 of the Chapter 460 of the Land Acquisition Ordinance. The value of compensation determined by the acquisition officer is final.

In Nuwara Eliya the authority for land acquisition is the Divisional Secretary of Nuwara Eliya.

15.4 Groundwater Balance in Nuwara Eliya

15.4.1 Technical Approach

(1) Predictable negative impacts

Nuwara Eliya water supply project includes a proposal to extract ground water from the valley of Upper Nanu Oya. Expected negative impacts from groundwater extraction are the following:

- lowering of shallow layers;
- possible impairment of present water uses;
- reduction of soil moisture for the survival of the natural vegetation;
- Possible loss of biodiversity.

It is therefore essential to analyze the water balance in the Upper Nanu Oya catchment and make realistic predictions about the extractable volumes for water supply.

To satisfy the projected water demand for year 2015, five (5) new boreholes are expected

to be developed in the Upper Nanu Oya catchment (within the Gregory Lake hydrological catchment). This water source is considered to be less costly compared to other options, such as proposed Bambarakele and Jayalanka reservoirs, and will also have less negative environmental impacts. It is expected to abstract, on average, about 7000 m^3/d during a period of approximately 120 days during the dry season (from January to April).

To understand the unique environmental value of this area, it should be considered that the highland cloud forest complex[2] which included natural forests in and around Nuwara Eliya are the richest in bio-diversity in Sri Lanka, and only 5 percent of such forests exist in the world. Therefore, the conservation value of these forests, which account for more than 1/3rd of the Upper Nanu Oya catchment, is very high and any development project, which would affect these unique areas, will be detrimental to the whole country.

(2) Methodology

The objective is to quantify the limiting hydrologic yield of the aquifer (or 'water bearing medium'): that means to verify if the *long average recharge, whatever the quantity of water stored in the aquifer, is large enough to balance almost every variation of percolation and abstraction* (Twort et. al. 1974). This is the approach taken in this study to assess the EIA of the proposed abstractions at Nuwara Eliya.

For this purpose, a hydrological simulation model has been used, choosing a model already tested for an environment similar to the Study Area. For the EIA study, this model was modified to provide the necessary information required to assess the possible impacts of ground water abstractions within the Gregory Lake hydrological catchment in Nuwara Eliya. Primary information from the field studies conducted at the Horton Plains and information on rainfall/runoff relations of the Upper Mahaweli catchment was also used to validate the model output, since rainfall/runoff relations were not available for the Upper Nanu Oya catchment.

In addition, the following data were compiled to conduct the water balance study.

- 30 years daily rainfall data from 1964 to 1993 (at Sita Eliya);
- Average monthly evaporation values at Sita Eliya (1985-1993);
- Present land use data in the catchment;
- Information on agricultural practices;
- Information on geology and soils;

- Information on soil physical characteristics of similar soils;
- Information on hydrological model parameters determined from local studies;
- Information on runoff/rainfall relations for the upper Mahaweli catchment.

The modified water balance model provided the daily outputs of hydrological processes, such as evapotranspiration (water use), runoff, ground water recharge, and soil moisture depletion in the root zone for different land use types within the Upper Nanu Oya catchment.

(3) Study Area

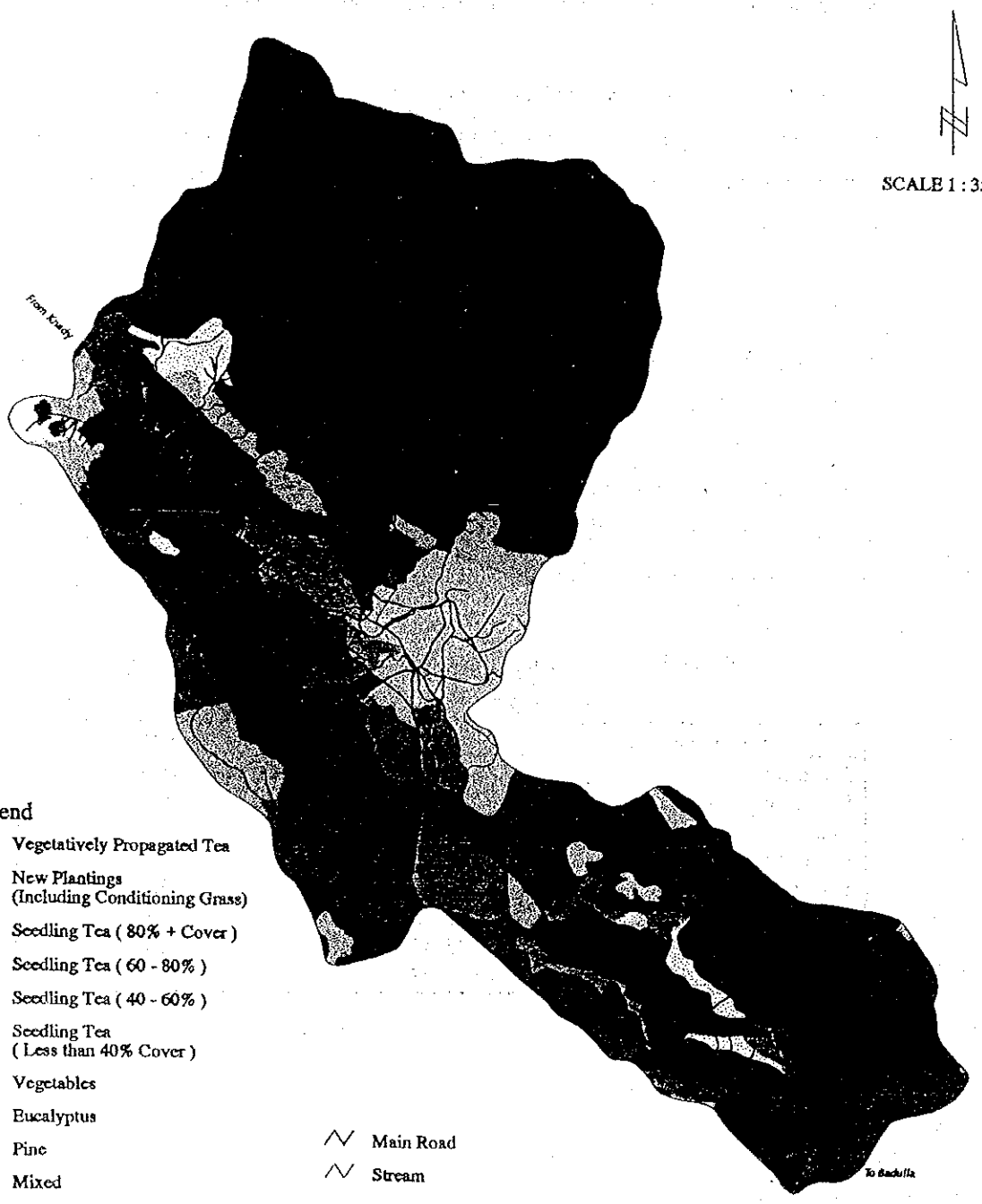
The Study Area is represented by the Upper Nanu Oya or Gregory Lake hydrological catchment (Figure 15.6), located in the highest peneplain of the country. All five boreholes are located within this hydrological boundary. The total area of the catchment is about 1450 ha with a predominant land use of natural forest. These land use types were truncated to seven hydrologically similar units for the water balance model. The extent under each of these units is given in the following Table.

Table 15.2 Hydrological Homogenous Land Use Types in Upper Nanu Oya Catchment

Land Use	Extent (ha)	Percentage
Natural Forest	650.35	41.3
Forest plantations	106.21	6.7
Tea	159.07	10.1
Grasslands	126.33	8.0
Vegetables	395.28	25.1
Urban Area	93.68	5.9
Water	45.43	2.9
Total	1,576.35	100.0

[2] *Cloud forests are above 1,500 m.*

LAND USE OF LAKE GREGORY HYDROLOGICAL CATHMENT



NJS Nippon Jogesuido Sekkey Tokyo, Japan	Natural Resources and Management Services - Kandy (Polgolla), Sri Lanka
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Land Use of Lake Gregory Hydrological Catchment	
Prepared by : OLS/RS Section	Revised and approved by
September 1998	**Figure 15.6**

15.4.2 Water Balance of the Upper Nanu Oya Catchment

(1) Rainfall and Evaporation

The monthly distribution of rainfall and evaporation in the Study Area, given in Figure 15.7-1, shows that the evaporation exceeds rainfall in the months of February and March. Therefore, Nuwara Eliya experiences water shortages just before the holiday season in April. The rainfall throughout the year is fairly distributed with an average of rainy days of 200 which could go down to about 150 in some years (Roche, 1996).

(2) Underground water simulation results[3]

The percentage of rainfall, which contributes to evapotranspiration, runoff and recharge is calculated at 46.4 percent, 45.2 percent and 8.3 percent respectively. The average daily ground water recharge over a period of 30 years is about 7184 m^3/d, a little more than the designed value of 7000 m^3/d. Figure 15.7-2 shows the cumulative recharge and abstraction assuming an extreme situation, where ground water abstraction continues throughout the year at a design rate of 7000 m^3/d. The cumulative recharge line runs fairly above the abstraction line, indicating that the ground water level does not decline over the years.

Figure 15.8-1 shows the probability of having consecutive dry months where recharge is less than abstractions (i.e. .7000 m^3/d), while Figure 15.8-2 shows the probability of having consecutive dry months during which runoff is less than the total abstractions. As we can see, there is about 50 percent probability of having between three and five consecutive dry months per year. During these periods the ground water level will go down, since recharge is less than abstraction. Expected negative implications on natural vegetation will be briefly analyzed in the following paragraph.

15.4.3 Expected Negative Impacts due to Over-Abstraction of Groundwater

Lowering of the water table, which helps to accelerate the soil moisture depletion rate could be considered as the major impact on natural vegetation due to ground water over-abstraction. Trees with deeper roots can absorb soil moisture from deeper layers of soil when surface layers desiccate beyond the permanent wilting point and can still survive.

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[3] *The annual water balance of Upper Nanu Oya catchment from the simulation study for a period of 30 years from 1964 to 1993 is shown in the principal EIA report, Appendix 5.2*

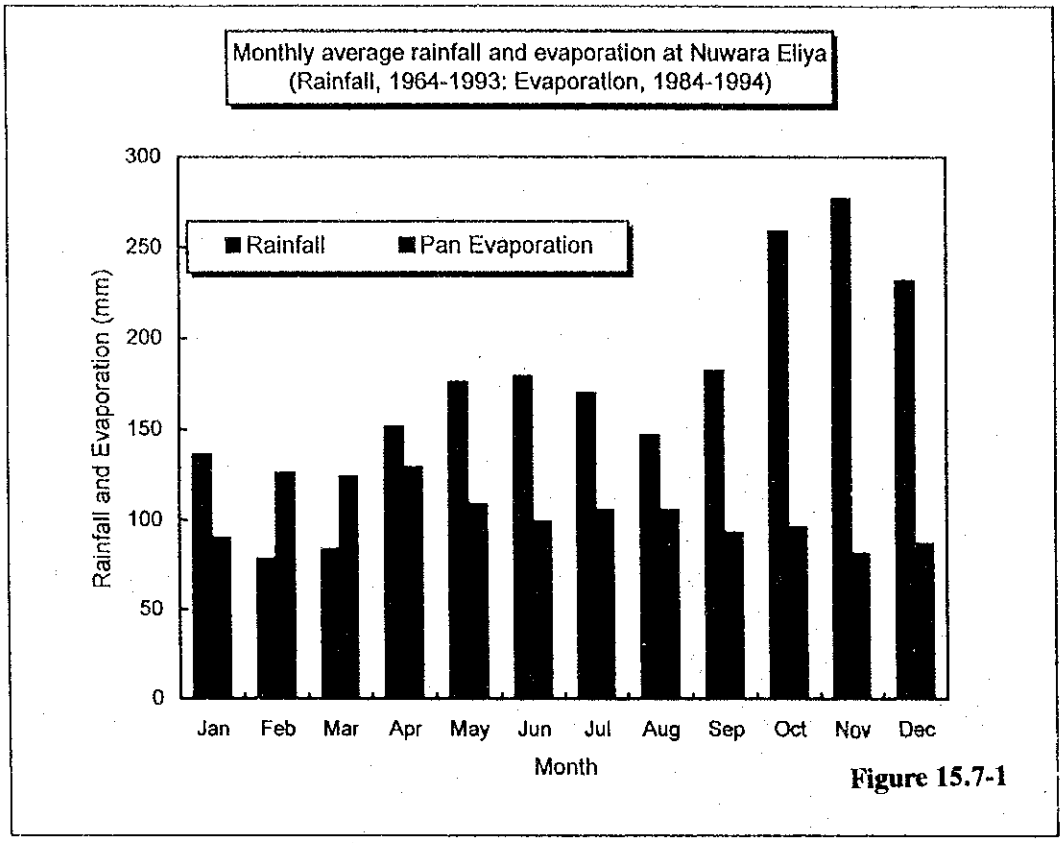


Figure 15.7-1

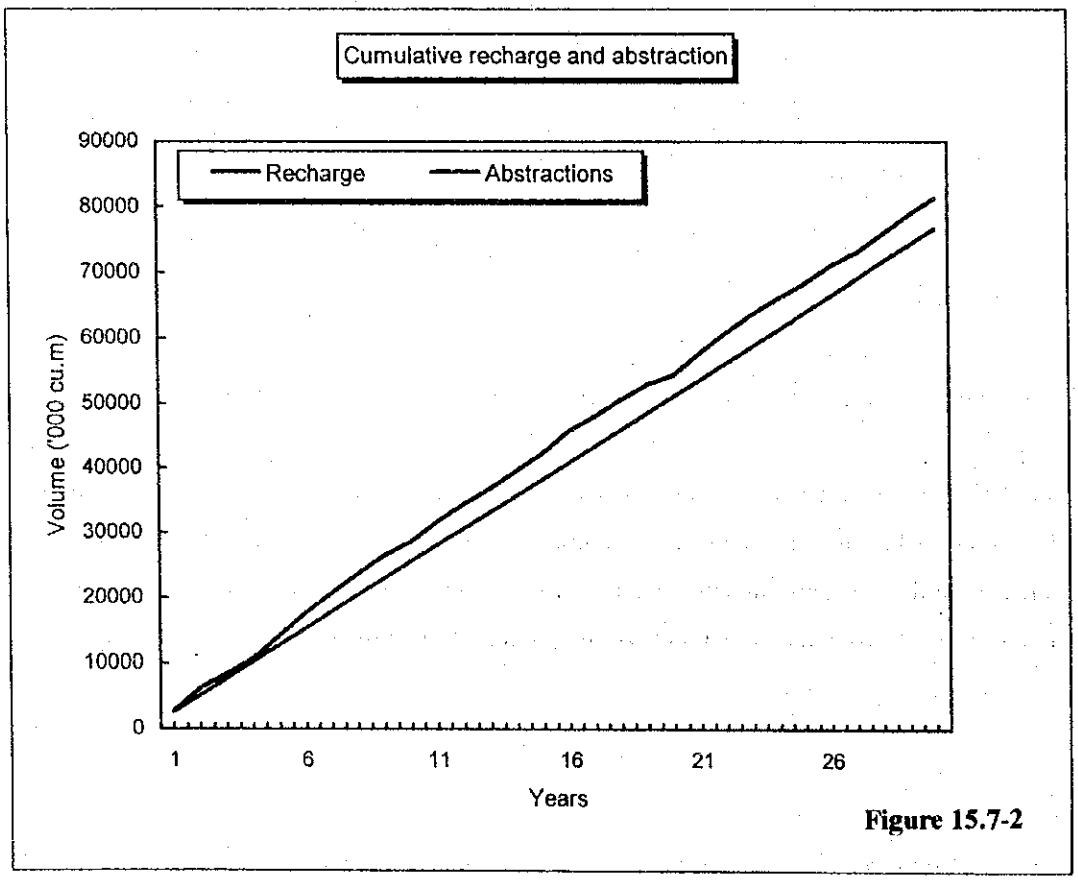


Figure 15.7-2

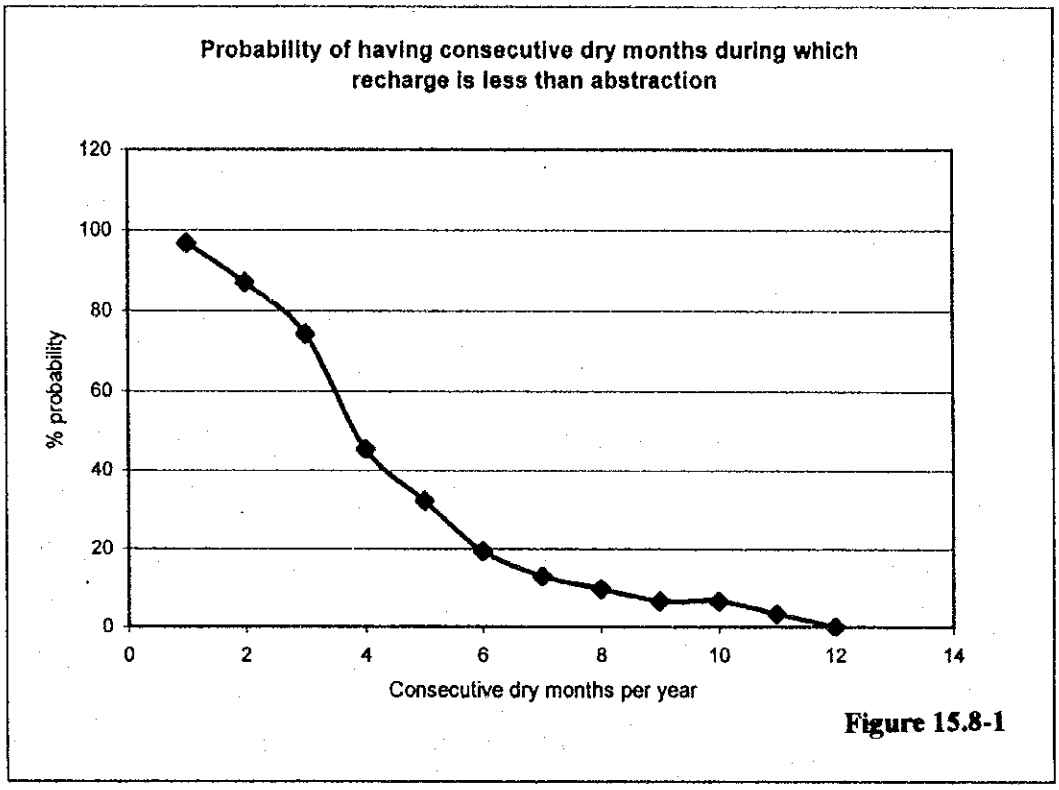


Figure 15.8-1

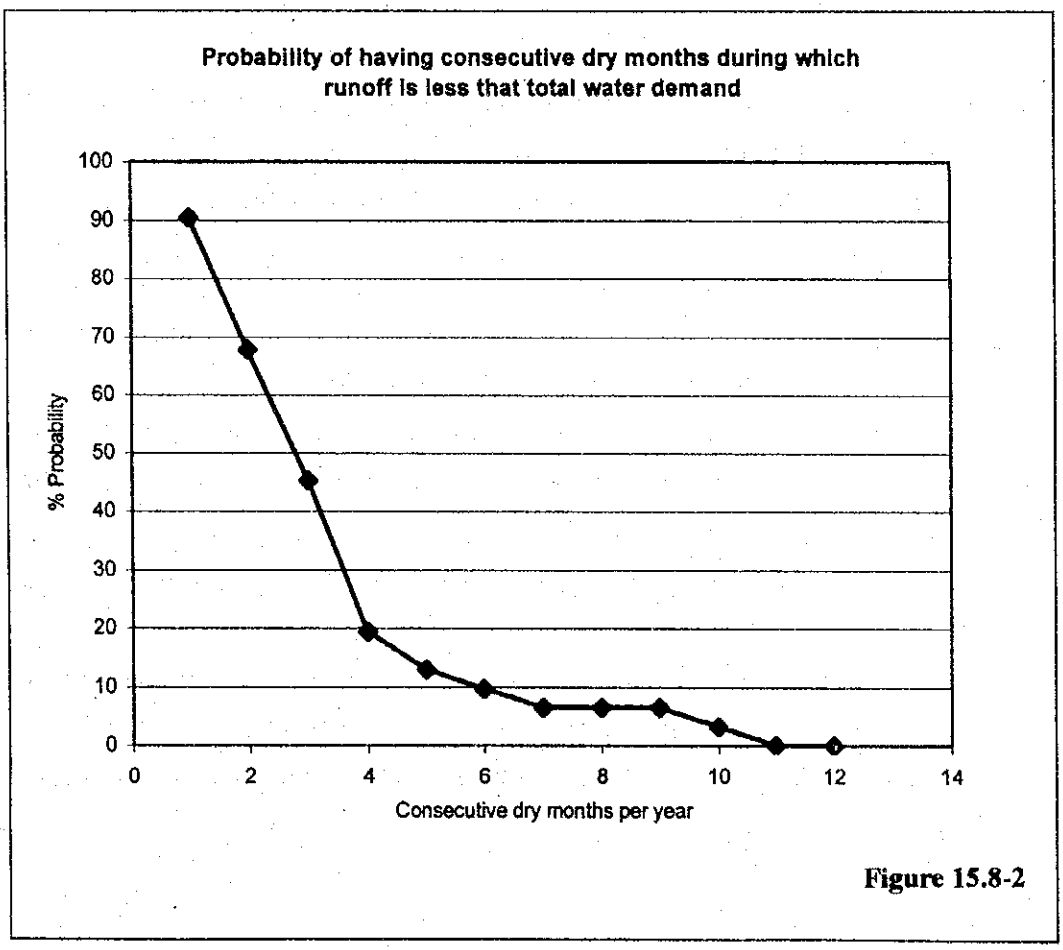


Figure 15.8-2

The simulated monthly average soil moisture content within the root-zone of natural vegetation is shown in Figure 15.9. Soil moisture depletion within the root zone does not exceed half of the available soil moisture at field capacity (200 mm), except during a few months during 1983, which was considered as an extremely dry year. During the rest of the 29 years, soil moisture content maintained at acceptable levels, with no negative impacts expected due of drought. Serious impacts can therefore be expected only in extreme situations, and for short periods of time.

15.4.4 Conclusions

The above analysis indicates that groundwater can be considered as a reliable source for water supply at Nuwara Eliya, since the designed abstraction is less than the long-term recharge.

However, it is considered to be risky relying only on ground water to provide the required projected demand for year 2015, due to the following reasons:

(1) The underground inflow – outflow balance of the upper Nanu Oya catchment has not be studied. The peneplain has two major erosional scarps, one to the west and the other to the east, and the possibility of leakage out of the catchment cannot be excluded. This would negatively affect the overall water balance especially during dry years.
(2) It is assumed that the rootzone is moderately deep and uniform throughout the catchment. However, vegetation located in preferential recharge sites with shallow soils may be affected, with detrimental effects on bio-diversity and natural forest conservation.

The following recommendations are given, to avoid / mitigate possible negative effects:

- It is desirable to develop an alternative surface water source, such as Bambarakele reservoir to supplement the ground water source, if groundwater resource is found scarce. The conjunctive use of these two sources will help to reduce any long-term negative impacts to a minimum. For that purpose, flow measurement should be conducted continuously for a period of at least ten years.
- Monitor the groundwater table to assess the impact of groundwater abstraction in the long term.
- Carry out pumping tests for longer periods, especially during the dry season in February-May, before the wells are further developed for water supply. These tests should also be carried out simultaneously at different wells to assess their performance under such conditions.

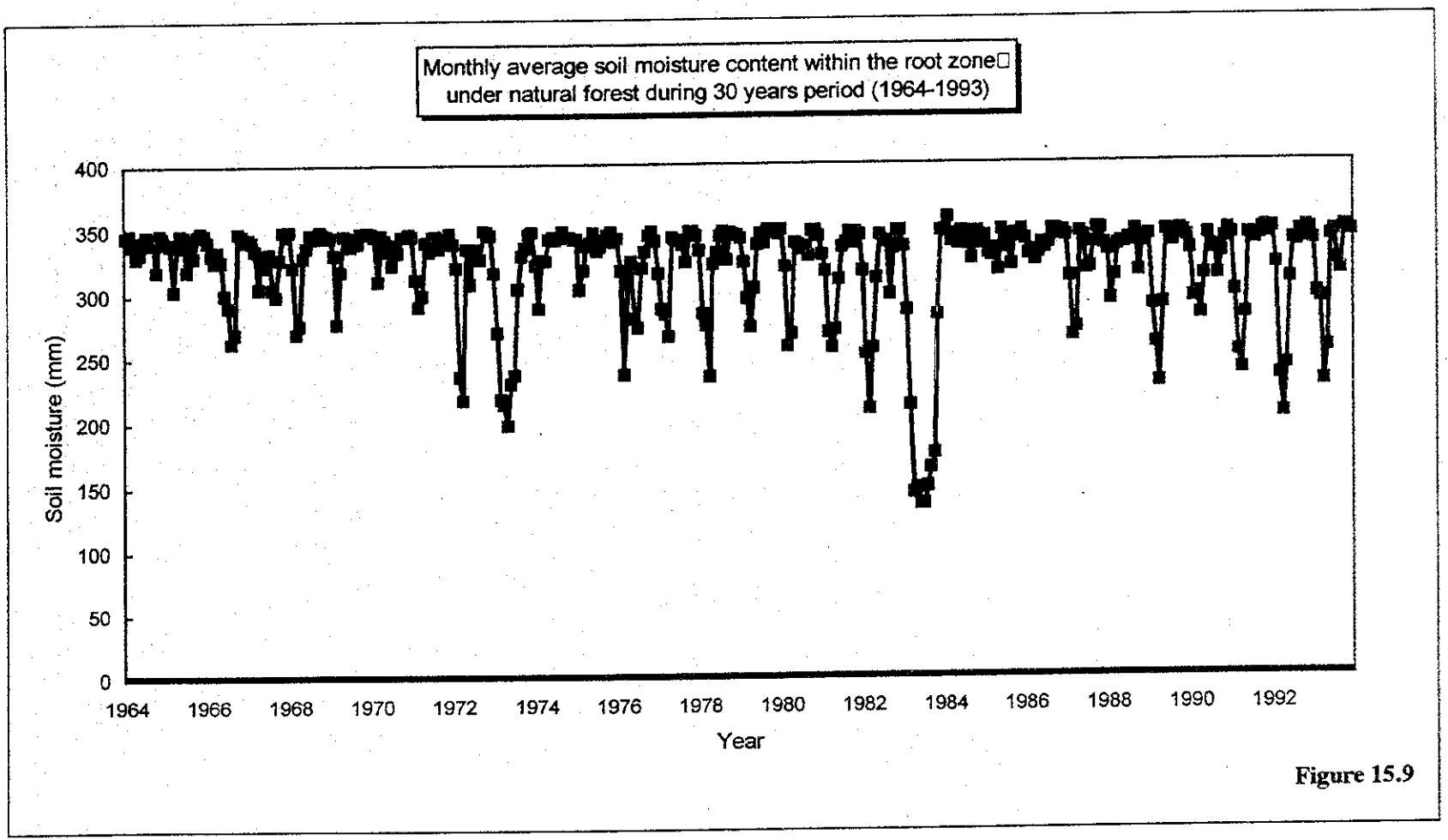

Monthly average soil moisture content within the root zone under natural forest during 30 years period (1964-1993)
Soil moisture (mm)
400
350
300
250
200
150
100
50
0
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
Year

Figure 15.9

- An intensive groundwater development study should be conducted with the collaboration of experienced foreign experts to identify the groundwater yield of deep aquifers which have different recharge mechanisms other than the shallow aquifer discussed above. The groundwater development in the project targets the deep aquifer consisting of fractures in the shear zone which continue 120km beyond the Nuwara Eliya area.

15. 5 Water Quality Assessment and Balance of Contamination in the Major Surface Water Bodies

15.5.1 Water Quality Criteria and National Standards

Descriptions on water quality criteria for surface and groundwater, which are important in water quality assessment, are reported in Table 15.3.

Table 15.3 Surface and Groundwater Criteria for Water Quality Assessment

Water Quality Parameter	Description
pH	The pH of most natural surface water is between 6.0-8.5 although low values can occur in dilute water high in organic content, and higher values in eutrophic waters and ground water
Dissolved Oxygen	In freshwater DO at sea level ranges from 15 mgl^{-1} 0 °C to 8 mgl^{-1} at 25 °C; concentrations in unpolluted waters are usually close to, but less than 10.00 mgl^{-1}
Free Ammonia	Unpolluted water contains about 0.1 mgl^{-1}; total ammonia is less than 0.2 mgl^{-1}, concentrations of 2 - 3 mgl^{-1} indicate high organic pollution
Nitrate	Natural levels of NO_3 seldom exceed 0.1 mgl^{-1}; polluted water contains up to 5 mgl^{-1} but often less than 1 mgl^{-1}; more than 0.2 mgl^{-1} promotes algal blooms; in groundwater it should be around 500 mgl^{-1}; concentrations in ground water is extremely high in areas subjected to intensive agriculture and livestock
Nitrite	Usually less than 0.001 mgl^{-1} rarely reach about 1 mgl^{-1}
Phosphorus	Range in natural surface water 0.005-0.020 mgl^{-1}; average in ground water is 0.02 mgl^{-1}
BOD_5	2 mgl^{-1} in unpolluted surface water; 10 mgl^{-1} in surface water receiving waste-water; average in raw sewage is 600 mgl^{-1} and industrial waste may contain 25,000 mgl^{-1}
COD	Less than 20 mgl^{-1} in less polluted surface waters; exceed 200 mgl^{-1} in surface water receiving effluent; range in industrial effluent is 100 - 60,000 mgl^{-1}
Total Coliform	Counts in rivers and lakes vary from <1 to 3,00 organisms per 100 ml; counts in water bodies in areas of high population densities may increase up to 10 million organisms per 100 ml; natural ground waters should contain no faecal bacteria unless contaminated
Metals	Eight trace elements (viz., Cu , Cd, As,Cr,Pb,Hg,Ni, and Zn) are considered as high priority; Be, Tl, V, Sb and Mo are highly toxic; concentrations of different metals in water varies from 0.001 to 0.1 $\mu g\ l^{-1}$
Pesticides	Most pesticides are compounds which do not occur naturally in the environment and therefore detectable concentration indicate pollution.

(Source: Water Quality Assessment 1992)

15.5.2 Water Quality in Nuwara Eliya (Historical Data)

(1) Lake Gregory and tributaries

The first study on water quality of Lake Gregory, its tributaries and the main stream of Nanu Oya was carried out by NARA from 1989 to 1990 (NARA, 1991). This study recommended dredging the Lake to remove the organic and inorganic bed sediments in order to minimize the growth of floating aquatic plants (e.g., Eichornia, Salvinia and Hydrilla). Table 15.4 summarizes the results of the water quality reported by NARA. In addition, the Urban Development Authority has determined the surface water quality of Nanu Oya, Hospital Stream and the Lake Gregory during the Environmental Study of Nuwara Eliya carried out in 1995.

Table 15.4 Water Quality of the Lake Gregory and its Tributaries

Parameter	Lake Gregory			Tributaries (South Shore)			Tributaries (North Shore)			All Tributaries (LG)			Nanu Oya
	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	
Turb. (NTU)	18	6	54	26	10	47	90	13	236	62	10	236	35
EC (uScm^{-1})	122	11	99	182	152	244	276	175	346	236	152	346	128
Hardness				57	40	75	68	47	98	63	40	98	33
PH	6.3	5.4	6.7	6.5	6.4	6.6	6.6	6.4	6.8	6.5	6.4	6.8	6.5
Nitrite*	0.02	N.D.	0.12	0.14	N.D.	0.6	0.188	0.11	0.270	0.17	N.D.	0.63	0.12
Nitrate*	1.34	0.46	2.01	2.59	1.83	3.890	3.211	1.42	4.560	2.94	1.42	4.56	2.35
Ammonia*	0.27	0.1	0.73	0.61	0.38	0.820	1.575	0.57	3.440	1.16	0.38	3.44	1.03
Phosphate*	10	N.D.	10	0.03	0.01	0.080	0.196	0.02	0.570	0.13	0.01	0.57	0.02
t-Iron (mg/l)	0.11	N.D.	0.69	0.24	0.14	0.460	0.506	0.11	1.180	0.39	0.11	1.18	-
BOD_5*	28.4	16.5	46.4										
Coliform (MPN/100 ml)	869	47	1854	446	6267	85710	166000	11644	468700	114028	6267	468700	

(modified from NARA 1991) (mg/l)*

The study carried out by UDA and ROCHE also reported high organic pollution in Lake Gregory but the situation was not adverse with respect to organic pollution as reported by NARA in 1991 (Table 15.5). Perhaps dredging has resulted in some improvements in the lake water quality.

Table 15.5 Water Quality of Lake Gregory and Tributaries Draining into the Lake

Parameter	Lake Gregory											
	Station 1			Station 2			Station 3			Tributaries		
	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max
SS	9	19	29	11	30	48	22	32	39	5.9	33	94
Turb.(NTU)	0.3	23	49	0.9	32	72	0.9	30	52	5	25.4	82
EC ($uScm^{-1}$)										53	246	380
Color										0	69	134
BOD_5*							1.5	2.47	3.4		1.4	2.9
COD*							5	11.02	13		11.1	23.8
pH	6.7	6.93	7.35	6.94	7.3	7.78	6.94	7.5	8.05	6.04	6.49	6.95
Alkalinity*	14.6	21.6	28.6	15.2	22.8	30.4	18.9	24.1	29.2	6.1	19.2	40.2
Kj-N*	0.521	0.631	0.829	0.54	1.06	1.75	0.658	0.721	0.815	0.17	0.551	1.021
Nitrite*	0.011	0.029	0.038	0.013	0.027	0.036	0.016	0.029	0.037	0.001	0.09	0.211
Nitrate*	0.08	0.351	0.733	0.22	0.382	0.663	0.144	0.407	0.535	0.227	0.929	1.85
T-P*	114	143	220	24	80	110	45	106	140	23	122	471
d-P*	ND	4	10	1	5	9	1	10	20	1	10	39

(modified from UDA & ROCHE 1995) (mg/l)*

(2) Nanu Oya and Hospital Stream

Significantly high organic pollution and fecal contamination have been reported in the main stream Nanu Oya and its tributaries in the Nanu Oya sub-watershed and in the downstream tributaries of the Hawa Eliya sub-watershed (Table 15.6). This was mainly due to the disposal of untreated domestic wastes and sewage and overflow from septic tanks during the rainy period and infiltration of organic wastes from soakage pits located along the course of the stream banks. Relatively high concentrations of nitrite reported from this stream indicate contamination with raw sewage.

Table 15.6 Summary of the water quality of main stream Nanu Oya and its tributaries modified from UDA and ROCHE 1995

Parameter	Sites											
	Nanu Oya			B'kelle			Waterfield			Pedro		
	Min	Avg.	Max	Min	Avg.	Max	Min	Avg.	Max	Min	Avg.	Max
SS *	1.6	24.1	120	1.5	25.4	140	1.6	47.5	144	3	21.6	92
Turb.(NTU)	1	13.3	54	1	9	23	1	17	54	1	9	20
EC (us/cm)	15	50.3	97	15	124	222	14	34	66	13	55	272
Color	17	34	58	51	67	130	28	36	46	25	33	40
BOD_5*	1.3	3.0	4.9									
COD*	10	16.7	30	N.D.	15.7	28	6.2	28.9	94.2	N.D.	43.8	76.8
pH*	5.5	6.3	7.8	5	6.4	7.2	5.6	6.5	7.2	5.5	6.1	6.8
Alakalinity*	6.1	13.3	27.4	4.9	7	9.1	6.7	10.03	17.7	7.9	10.2	12.2
Kj-N*	176	437	826	1.6	0.609	1.64	0.048	0.45	1.74	0.23	0.68	2.1
Nitrite-N*	N.D.	17	53	N.D.	11	53	N.D.	122	817	N.D.	2.5	8
Nitrate-N*	80	449	1113	56	559	1,222	8	244	632	33	399	981
T-P*	N.D.	86	400	7	41	140	N.D.	7	190	5	48	150
D-P*	N.D.	7	21	N.D.	1	19	N.D.	4	14	N.D.	6	24
Iron (mg/l)	130	2.78	6.6									

Note: * mg/l

15.5.3 Water Quality Survey Conducted during the Study

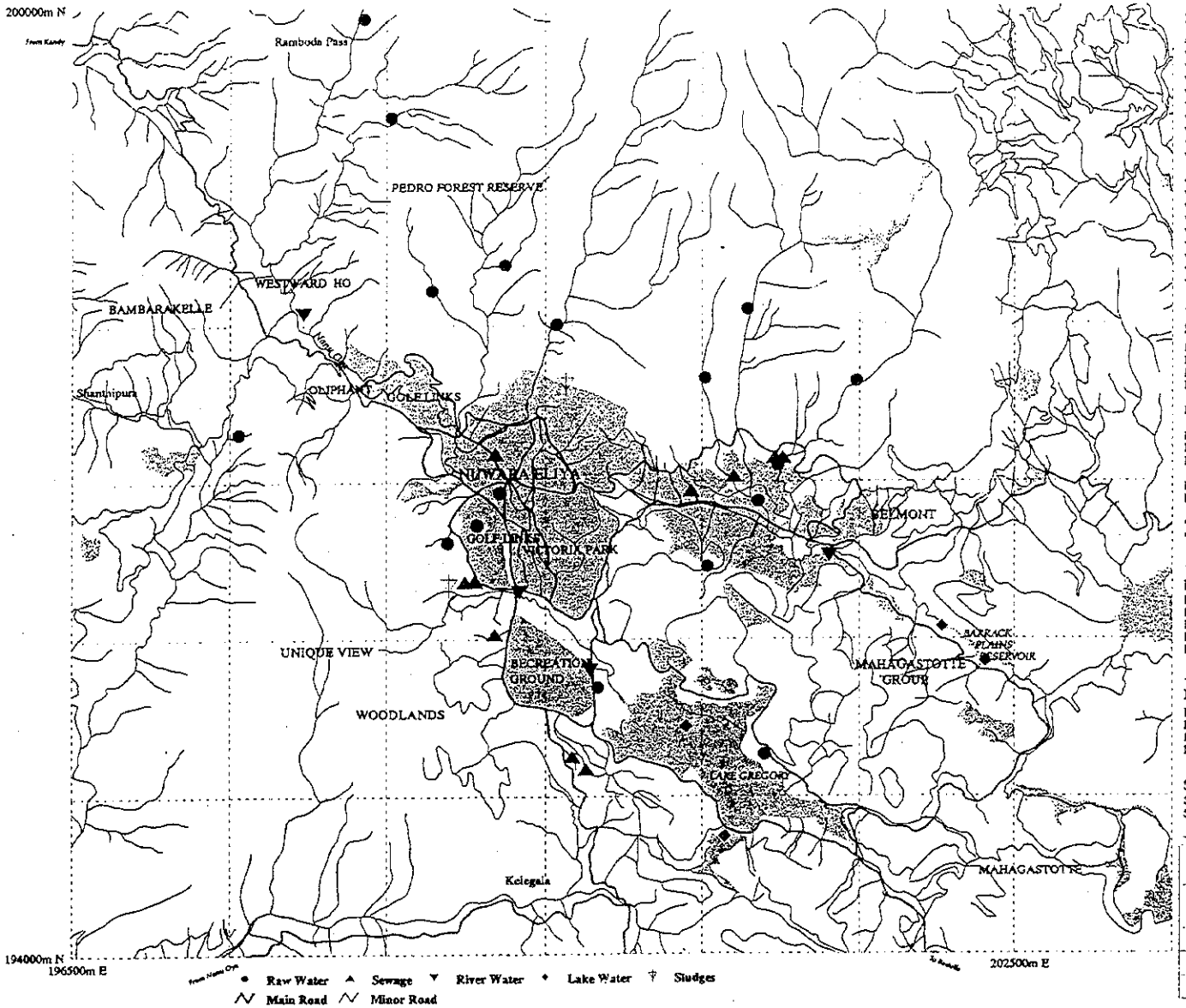
(1) Sampling sites and WQ parameters

A comprehensive survey on surface and ground water quality was carried out by the JICA Study Team to comply with the proposed project activities. During this survey the quality of surface and ground water (e.g., raw water, river water, water from bore holes and lake water) was determined during the dry season (February - March 1998), and during wet season (July - August 1998), at several pre-selected sites (Figure 15.10 and 15.11).

The type of water analyzed and sites where samples were collected from are shown in the following Table 15.7.

WATER QUALITY SAMPLING DRY SEASON - NUWARA ELIYA

Scale 1:25000



Raw water quality

WQ/N/1	Bambarakele
WQ/N/2	Shanthipura
WQ/N/3	Pedro intake
WQ/N/4	Water field(old)
WQ/N/5	Water field(new)
WQ/N/6	Piyatissapura
WQ/N/7	Brewery falls
WQ/N/8	Gamunupura
WQ/N/9	Lovers leap
WQ/N/10	Hill club
WQ/N/11	Old bore hole
WQ/N/12	Upper lake road bore hole
WQ/N/13	Galway forest bore hole
WQ/N/14	Interfasion bore hole
WQ/N/15	Palladium bore hole
WQ/N/16	Golf club bore hole
WQ/N/17	Brewery bore hole

Sewage quality survey

N/1-Domestic sewage(middle income)**
N/2-Domestic sewage(low income)*
N/3-Effluent from septic tank(Cey Bank Rest)*
N/4-Hotel(with treatment facility)-before treatm (grand hotel)
N/5-Hotel(with treatment facility)-after treatmen (grand hotel)
N/6-Hotel(with treatment facility)-Cey Bank Re
N/7-Industrial wastewater-drain(Ceylon Brewer
N/8-Industrial wastewater-effluent after treatme (Ceylon Brewe
N/9-Hospital sewage
N/10-Municipality-Nuwara Eliya*

*no flow
**adequate amount of sample was available only once

River water quality

RWQ/N/1	Upstream of city's borders
RWQ/N/2	Victoria park
RWQ/N/3	Influent point to Gregory lake
RWQ/N/4	Upstream of hospital & Brewery
RWQ/N/5	Influent point to Barrack's plain reservoir

Lake water quality

LWQ/N/1	Gregory lake(near play ground)
LWQ/N/2	Gregory lake(middle of the lake)
LWQ/N/3	Barrack Plains Reservoir(middle)
LWQ/N/4	Barrack Plains Reservoir(end)

Sludge quality survey

SQ/N/1	Ceylon Brewery
SQ/N/2	Grand hotel

NJS Nippon Jogesuido Sekkei Tokyo, Japan

Natural Resources and Management Services - Kan (Pvt)Ltd, Sri Lanka

Greater Kandy and Nuwara Eliya Water Supply and Environmental Improvement Project - Environmental Impact Assessment

Water Quality/Dry : Location map - Nuwara Eliya area

Prepared by : OISWA Section

Reviewed and approved by

September 1998

Figure 15.10

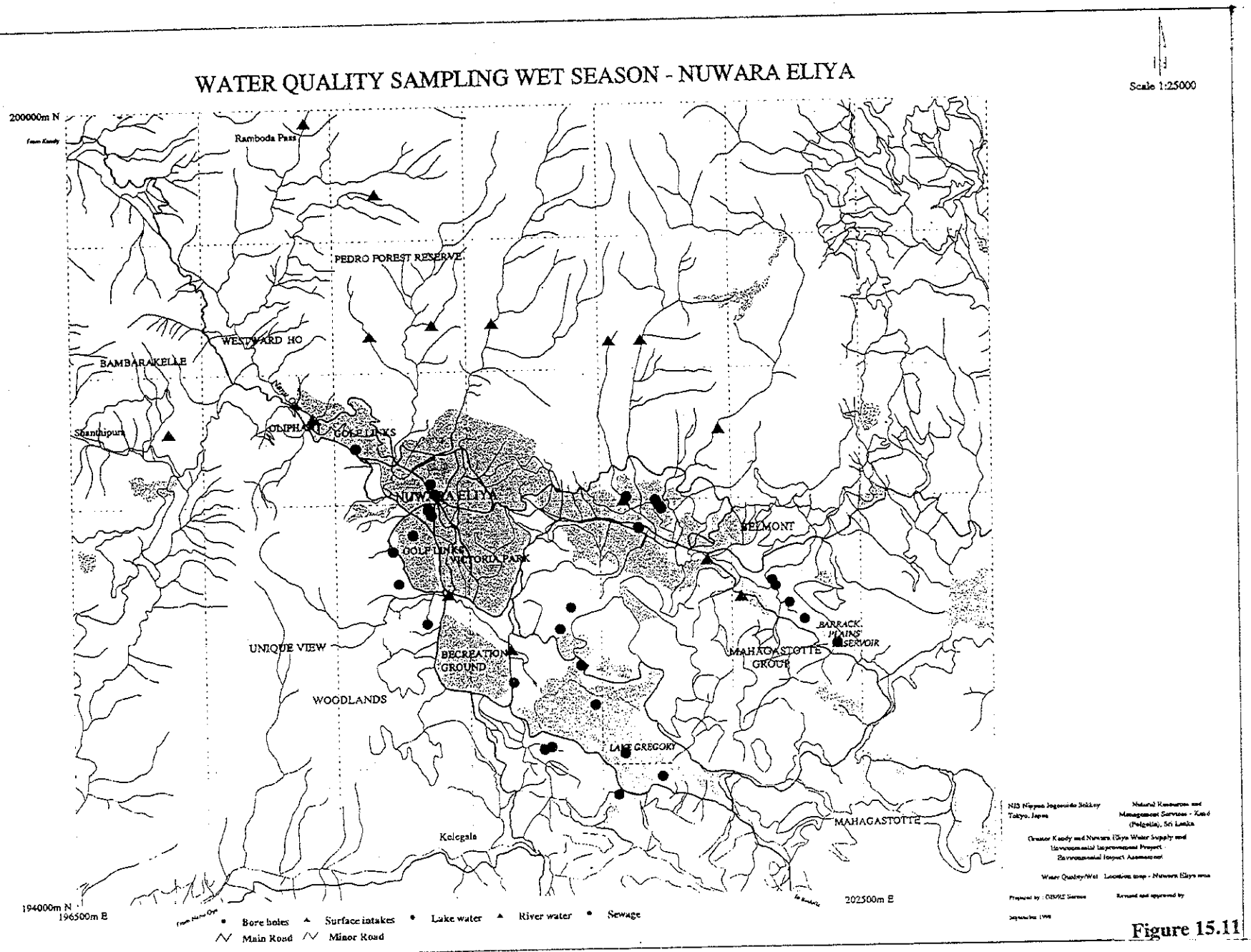

WATER QUALITY SAMPLING WET SEASON - NUWARA ELIYA
Scale 1:25000
200000m N
194000m N
196500m E
202500m E
Ramboda Pass
PEDRO FOREST RESERVE
WESTWARD HO
BAMBARAKELLE
Shanthipura
OLIPHANT
GOLF LINKS
NUWARA ELIYA
GOLF LINKS
VICTORIA PARK
BELMONT
BARRACK PLAINS RESERVOIR
MAHAGASTOTTE GROUP
RECREATION GROUND
UNIQUE VIEW
WOODLANDS
LAKE GREGORY
MAHAGASTOTTE
Kelegala
Bore holes
Surface intakes
Lake water
River water
Sewage
Main Road
Minor Road
NJS Nippon Jogesuido Sekkey
Tokyo, Japan
Natural Resources and Management Services - Kandy (Pelgolla), Sri Lanka
Greater Kandy and Nuwara Eliya Water Supply and Environmental Improvement Project
Environmental Impact Assessment
Water Quality/Wet Location map - Nuwara Eliya area
Prepared by : GIS/RS Section
Reviewed and approved by
September 1998

Figure 15.11

Table 15.7 **Type of Water Analyzed and Sampling Sites in Nuwara Eliya Area**

Type of Water	Nuwara Eliya	
Raw Water	**Surface water intakes** 1) Bambarakele 2) Shallinpura 3) Pedro 4) Waterfield new 5) Waterfield old 6) Piyatissapura 7) Brewery falls 8) Gemunupura 9) Hawaeliya 10) Galna near Golf	**Groundwater (Bore holes)** 11) Hill Club 12) Race Course 13) Upper Lake Rd 14) Galway 15) Interfashion 16) Golf Club 17) Brewery
River Water	**Nanu Oya sub-watershed** 18) Upstream city Border 19) Victoria Park 20) Influent Gregory Lake	**Hawaeliya sub-watershed** 21) Upstream hospital flow 22)Inflow of BP reservoir
Lake Water	22) Lake Gregory 23) Barrack Plains Reservoir	

The following parameters have been determined for different sites during this survey using standard methods:

- **Physico-chemical**: Temperature, pH (=Acidity), Alkalinity, EC (= Electrical conductivity), Chloride, Sulfate, Kjeldhal Nitrogen, total Nitrogen, total Phosphorus, Nitrate, Nitrite, SS, TDS DO, C O D and BOD_5
- **Trace Metals** : Cd, Fe, Pb, Mn, Co, Zn, Cu, As, and Hg
- **Bacteriological:** Total Coliform and *E.coli*
- **Pesticides:** Thirty-four types of commonly used different pesticides in 20 water samples.

(2) Raw Water Quality

Results of raw water quality analysis in Nuwara Eliya are given in Table 15.8. Acid pH of raw water has been shown in the Brewery and Gemunupura intakes during dry weather. Nitrate and phosphorus concentrations are also very high in surface water intakes. All surface water intakes in Nuwara Eliya have been contaminated with Fecal coliform. The analytical results also show high concentrations of iron in the surface intakes of Nuwara Eliya during the rainy season.

Table 15.8 Raw Water Quality of Nuwara Eliya

Parameter	Site								
	BK	SP	PI	WO	WN	PP	BI	GI	LI
Turbidity	2.21	4.41	1.26	0.85	1.32	1.33	2.13	1.29	0.84
(NTU)	11.2	0.75	1.28	1.02	1.5	0.8	1.2	0.89	1.52
pH	6.7	6.6	6.8	6.7	7.5	6.4	5.5	5.9	6.1
	6.9	6.6	7.2	6.7	6.5	6.5	7.5	7.0	6.3
EC	15.8	16.3	15.1	17.4	15.1	14.8	18.9	13.9	15.9
($uScm^{-1}$)	11	15	11	12	11	12	13	12	11
Alkalinity	8.2	3.9	7.3	7.9	7.4	8.2	8.2	7.6	7
(mg/l)	7	5	8	9	6	8	9	8	8
Chloride	1.37	0.92	1.03	1.06	1.36	1.26	1.68	1.61	1.3
(mg/l)	1.0	1.0	0.93	1.04	1.15	1.04	0.95	1.05	1.05
Free NH_3	0	0	0	0	0.11	0.14	0.14	0.27	0.18
(mg/l)	0.93	0.08	0.01	0.14	0.14	0	0.11	0.13	0.20
Nitrite	0.03	0.05	0.05	0.05	0.05	0.03	0.03	0.03	0.03
(mg/l)	0.39	0.53	0.43	0.56	0.58	0.19	0.53	0.48	0.43
Nitrate	0.36	2.34	0.51	0.16	1.43	0.4	1.74	0.49	0.82
(mg/l)	1.12	2.44	1.07	0.55	1.09	1.08	0.69	0.78	1.11
Fluoride	0.03	0.03	0.03	0.03	0.03	0.04	0.03	0.03	0.03
(mg/l)	0.03	0.11	0.02	0.02	0.03	0.02	0.02	0.04	0.04
Phosphate	0.73	1.08	0.71	0.92	0.85	0.89	0.87	0.69	1.32
(mg/l)	2.42	1.3	1.89	1.22	2.93	3.26	2.25	2.52	1.56
Sulfate	0.41	0.69	0.47	0.44	0.54	0.005	0.34	0.33	0.44
(mg/l)	1.20	1.45	1.25	1.50	1.60	1.30	1.30	1.10	1.50
T-coliform	27	60	70	70	540	50	650	450	250
(MPN/100ml)	18	150	1300	28	45	175	40	121	1120
E.coli	14	2	16	0	500	0	300	20	15
(MPN/100ml)	31	55	560	07	18	70	5	41	540
T-iron	0	0	0.1	0	0	0	0.15	0.1	0
(mg/l)	1.80	1.80	0	0.03	0.55	0.11	0.19	0.19	0.18

(BK-Bambarakelle, SP-Shanthipura, PI-Pedro Intake, WO-Water Field Old, WN-Water Field New, PP-Piyatissapura BI-Brewery Intake, GI-Gemunupura Intake, LI-Lover's Leap Intake

(3) Ground Water

Some water samples analyzed from the boreholes in Nuwara Eliya showed acidic pH. The pH was extremely low in the water analyzed from Interfashion, Golf Course and Galway Forest bore holes (Table 15.9). Extremely high concentration of free ammonia have been reported in the water samples analyzed from the Palladium bore hole during the rainy season. Nitrite and nitrate concentrations were also unbelievably high in the same bore-hole. Phosphorus concentrations were also high in most of the bore holes during the rainy season. Fecal contamination had been reported in all bore holes except in the Galway for-est bore hole. In addition, high concentrations of Mn and Fe have been reported in sever-al bore holes in Nuwara Eliya. The highest concentration of iron has been reported from the Palladium bore hole.

Table 15.9 Groundwater Quality (Bore Hole) in Nuwara Eliya

Parameter	Site									
	HC	OD	UL	GF	IF	PD	GC	BR	GN	GG-BH
Turbidity (NTU)	0.8 – 7 36.5-61.1	0.42 - 2.01 1.33-22.4	0.45 - 0.67 0.96-1.45	0.36 - 0.81 0.54-2.18	1.28 - 3.68 1.57-6.9	3.3 – 25.7 120-800	1.2 4.8-22.5	2.3 7.10-29.0	0.2	5.0
pH	5.2 - 7.5 6.8-7.4	7.2 - 7.8 6.8-7.1	6.1 - 6.8 6.0-6.9	5.0 - 6.2 4.9-5.8	4.3 - 6.9 7.0-7.8	5.2 - 6.2 5.2-7.0	4.8 - 7.3 5.0-5.8	4.7 6.3-7.4	6.2	9.4
EC (uS/cm)	220 – 222 220-177	260 – 270 260-250	108 – 134 99-103	142 – 152 176-180	134 – 254 260-250	138 – 143 1000-1020	65 – 110 29-42	220 198-220	50	230
Alkalinity (mg/l)	132 – 138 106-142	162 – 169 165-170	54 – 58 54-81	5.5 – 10.3 11-22	31 – 154 166-171	30 – 44 301-391	8.5 - 12.7 7.9-14.5	122 110-220	27	1.50
Chloride (mg/l)	1.2 - 3.3 1.58-2.19	1.3 - 2.8 1.25-1.62	1.9 - 3.3 1.58-1.81	21.4 - 30.9 15.49-26.91	1.9 - 2.8 1.54-2.04	143 – 155 1.58-1.24	1.6 - 8.1 1.54-2.57	3.9 3.16-2.57	2.63	2.19
Free NH_3 (mg/l)	0 - 0.27 0.09-0.24	0 - 0.08 0.04-0.11	0 0-0.10	0 - 0.26 0.07-0.16	0.2.60 0.01-0.21	0.05 – 5.49 0.16-4.45	0 - 2.339 0.19-0.62	5.03 0.20-0.16	0.04	0.05
Nitrite (mg/l)	0 - 0.05 0.08-0.12	0.05 - 0.06 0.08-0.09	0.0 - 0.05 0.09-0.18	0.0 - 0.05 0.10-0.12	0.0 - 0.04 0.09-0.57	0.0 – 0.26 2.06-14.2	0 0.09	0 0.09-0.16	0.09	0.09
Nitrate (mg/l)	1.27 - 3.31 1.78-2.54	0.59 - 1.99 1.48-4.26	2.00 - 3.75 2.72-4.26	5.04 - 7.08 7.41-9.0	0.76 - 2.17 2.78-3.59	0.16 – 0.56 32.17-97.12	1.78 - 4.49 2.44-3.88	5.03 4.68-6.48	4.28	2.38
Fluoride (mg/l)	0.05 - 0.09 0.04-0.05	0.07 - 0.10 0.02-0.04	0.04 - 0.10 0.02-0.07	0.06 - 0.12 0.04-0.06	0.08 - 0.13 0.04-0.05	0.08 – 0.23 0.02-0.04	0.03 0.02—0.03	0.05 0.03-0.04	0.17	0.18
Phosphate (mg/l)	0.45 - 0.57 3.11-9.02	1.25 - 1.31 2.5-9.45	0.73 - 0.91 2.08-6.21	0.68 - 0.94 1.94-5.77	0.41 - 1.70 1.44-8.20	0.08 – 0.23 2.66-4.4	0.27 - 0.37 2.96-5.11	0.38 3.11-5.69	0.32	0.68
Sulfate (mg/l)	1.68 - 4.06 2.11-2.62	0.78 - 2.18 1.65-3.78	1.86 - 2.13 1.45-5.26	1.63 – 20 .13 3.04-8.83	0.07 - 3.72 2.45-3.37	0.32 – 11.14 1.75-3.56	0.60 - 2.46 1.61-2.65	2.68 1.12-3.02	2.18	1.97
T-coliform (MPN/100ml)	2.0-12 72-140	0 – 10 40-50	0 50-90	0 0	0 –140 90-140	200 – 1000 60-100	0 20-50	0 60-110	20	20
E.coli (MPN/100ml)	0 10-50	0 – 4 0-10	0 10-40	0 0	0 20-60	80 – 1000 20-40	0 0-10	0 0-60	0	0
Mn (mg/l)	0 0.07-0.4	0 0	0 0-0.47	0.20 - 0.24 0-0.15	0 0	0.17 – 0.22 1.62-9.33	0.01 - 0.13 0.07-0.13	0.06 0-0.05	0	0
T-iron (mg/l)	0 1.27-5.19	0.0 - 0.2 0-0.72	0.0 - 0.3 0-1.05	0.0 - 0.2 0.24-1.65	0.1 - 0.3 0-0.44	1.5 – 18 10.20-418.5	0 0.9-2.72	0 0.2-0.57	0	0

(BH- Bore Hole, HC- Hill Club, UL – Upper Lake, GF- Galway Forest, IF – Interfashion, PD –Palladium, GC – Golf Club, BR- Brewery, GN-BH Galway New Borehole, GG-BH New Borehole near Golf Ground

(4) Surface water quality

Surface water in Nuwara Eliya was extremely acidic during the dry season compared to the rainy season. Extremely high BOD_5 has been determined for the water samples collected upstream of the Hospital Stream and Inflow to the Barrack Plains Reservoir. The Barrack Plains Reservoir also had high BOD_5 values during the rainy season. It is interesting to note the very low oxygen in the surface water samples analyzed from Nuwara Eliya Total nitrogen and total phosphorus are also remarkably high in the surface water analyzed from Nuwara Eliya during the rainy season. In addition to fecal contamination, surface water samples in Nuwara Eliya also show relatively high concentrations of Mn and Zn ions. (Table 15.10)

Table 15.10 Surface Water Quality - Nuwara Eliya

Parameter	Site						
	CB	VP	IG	UH	IB	GL	BP
pH	4.0 - 5.6 **6.8 - 6.6**	4.5 - 6.2 **5.8 - 6.6**	4.8 - 5.7 **6.3 - 6.8**	5.9 - 7.5 **6.6 - 6.8**	4.8 - 5.6 **6.5 - 7.3**	4.2 - 7.2 **6.1 - 8.4**	4.2 – 4.9 **6.3 – 6.9**
EC ($uScm^{-1}$)	20 **12 – 15**	190 - 200 **53 – 76**	150 – 230 **66 – 84**	420 – 720 **116 – 144**	370 - 400 **58**	128 – 139 **67 –131**	125-368 **133 – 186**
COD (mg/l)	16 - 24 **12 – 218**	16 - 36 **16 – 291**	24 - 56 **8 - 680**	60 – 416 **81 – 307**	324 - 1084 **61 –154**	8 – 44 **8 – 113**	24 – 152 **8 – 251**
BOD (mg/l)	0.9 - 1.1 **0.5 - 0.6**	5.2 - 8.3 **3.7 - 25.7**	4.1 - 12.1 **0.7 - 21.7**	40.2 – 55.2 **18.7 – 25.2**	75.2 -135.2 **21.7 - 28.5**	3.2 – 6.3 **0.7 - 2.7**	**0.2 – 38.5**
DO (mg/l)	7.0 - 7.8 **7.7 - 8.4**	0.9 - 1.5 **3.5 - 5.5**	2.1 - 7.8 **4.8 - 5.1**	1.9 - 2.3 **3.7 - 5.4**	0 - 0.2 **1.9 - 4.7**	7.0 - 9.4 **6.0 - 10.0**	**0-1.7**
SS (mg/l)	145 - 152 **33 - 50**	124 - 130 **62 - 200**	5 - 98 **30 - 120**	905 –1123 **46 – 620**	315 - 389 **220 - 591**	122 – 150 **17 – 110**	**58-250**
Chloride (mg/l)	1.4 - 1.8 **5.1 - 6.8**	21.4 - 25.6 **10.9 - 17.8**	21.3 – 27.5 **11.2 – 15.8**	6107-158.5 **20 - 26.9**	57.6 - 72.4 **20.9 - 46.8**	9.8 - 14.1 **3.6 - 4.7**	**6.0 – 19.9**
Sulfate (mg/l)	0.1 - 0.2 **1.0 - 1.6**	0.1 - 0.3 **1.1 - 1.2**	0.1 - 1.4 **4.0 - 6.1**	0 - 0.1 **3.6 - 6.0**	0 - 0.6 **8.1 - 16.3**	0.1-0.7	**8.4 – 13.8**
T-N (mg/l)	6.7 - 7.4 **1.3 - 13.4**	8.3 - 8.9 **3.3 - 13.4**	10.1 - 12.0 **0.6 - 20.1**	21.6 – 23.6 **2.6 - 5.9**	20.2 - 28.6 **1.9 - 20.1**	23.0 - 58.0 **2.0 - 13.6**	**0.4 – 15.9**
T-P (mg/l)	0.3 - 0.4 **3.9 - 7.2**	0.4 - 0.5 **2.7 - 10.6**	2.0 - 2.1 **3.4 - 10.9**	0.3 - 0.4 **6.5 - 8.6**	0.4 - 0.5 **4.6 - 7.4**	0.2 - 0.8	
T-coliform x 100 ml	8– 16 **0.7 – 1.2**	>10 **0.2 – 0.4**	>10 **20 - 30**	2.5 – 10 **1.1 – 3.4**	0.8 - 3 **1.2 - 45**	0.7 – 2.3 **1.3 – 16**	**17- 350**
E.coli x 100 ml	120-400 **0-40**	>1000 **20 - 60**	>1000 **600 - 1180**	60 – 1000 **10 – 70**	0 - 40 **10 - 1000**	50 – 80 **<100**	**28 – 140**
Mn (mg/l)	0	2	0.05 - 0.18	0.06 - 0.13	0.11 - 0.20		
Zn (mg/l)	0 **0.03 - 0.21**	0 **0.05 - 0.39**	0 **0.02 - 0.43**	0 **0.10 - 0.69**	0 **0.15 - 0.25**	0.01 - 0.02 **0 - 0.24**	**0 - 0.09**

(CB- Upstream City Boarder, VP- Victoria Park, IG- Inflow to Gregory Lake, UH- Upstream Hospital and Brewery, IB- Inflow Barrack Plain Reservoir, GL- Gregory Lake, BP- Barrack Plains Reservoir)

(5) Synthesis of water quality examination

A Synthesis of water quality examination carried out by JICA Study Team and NWSDB in the Nuwara Eliya area is shown in the following Table 15.11.

Table 15.11 Synthesis of Water Quality Examination Carried out in the Nuwara Eliya Area by JICA Study Team and the NWSDB

Type of Water	Parameter								
	pH	DO	Free NH_3	T-N	T-P	BOD_5	COD	Coliform	Metals
Raw Water									
Bambrakelle	Normal		Normal	High	High			High	ND
Shanthipura	Normal		Normal	High	High			High	ND
Pedro Intake	Normal		Normal	High	High			High	ND
Waterfield Old	Normal		Normal	High	High			High	ND
Waterfield New	Normal		Normal	High	High			High	ND
Piyatissapura	Normal		Normal	High	High			High	ND
Brewary Intake	min. low		Normal	High	High			High	ND
Gemunu Mwth.	min. low		Normal	High	High			High	ND
Lover's Leap	Normal		Normal	High	High			High	ND
Groundwater									
Hill Club	min. low		Normal	High	High			Present	ND
Old Borehole	Normal		Normal	High	High			Present	ND
Upper Lake	Normal		Normal	High	High			Present	ND
Galway Forest	min. low		Normal	High	High			nil	ND
Interfashion	min. low		Normal	High	High			Present	ND
Palladium	min. low		Normal	High	High			Present	ND
Golf Club	min. low		Normal	High	High			Present	ND
Brewary	min. low		Normal	High	High			Present	ND
Galway New	Normal		Normal	High	High			Present	ND
Golf Club New	max. low		Normal	High	High			Present	ND
Surface Water									
City Boarder	min. low	Normal		High	High	Normal	max. high		High*
Victoria Park	min. low	min. low		High	High	High	max. high		High*
Inflow G Lake	min. low	min. low		High	High	High	max. high		High*
Hawa Eliya	min. low	Low		High	High	High	max. high		High*
Inflow BPR.	min. low	Low		High	High	High	max. high		High*

15.5.4 Sewage, Industrial Effluent and Sludge Quality

The JICA Study Team also examined the quality of various type of sewage (i.e., different socioeconomic classes), effluents from septic tanks, hospitals, the brewery and some industries located in Greater Kandy and Nuwara Eliya areas. Irrespective of the category raw sewage contains a large amount of BOD_5, SS, T-N and T-P (Table 15.12). The effluent from different septic tanks also contained usual amounts of the above mentioned, organic wastes. However, BOD_5, SS, T-N, and T-P values of effluent released from both Kandy and Nuwara Eliya hospitals and several industries were relatively low compared to standard values. This may be attributed to specific conditions registered at the date and time of analysis, and cannot be con-

sidered as indicative of a permanent situation. Therefore standard values are used for the computation of contaminant loads in this environmental assessment. Sludge quality is given in Table 15.13.

Table 15.12 Sewage and Industrial Effluent Quality in Nuwara Eliya Area

Type	Parameter			
	BOD_5 (mg/l)	TSS (mg/l)	T-N (mg/l)	T-P (mg/l)
Sewage Quality				
Lower income	160	317	48.8	6.24
Middle income	250	414	75.2	16.2
High income				
Office sewage	55.2	88	64.1	7.62
Hotel sewage	752	148	21.7	7.84
Effluent/ Septic Tanks				
Lower income	130	182	62	180
Middle income	132	197	55.7	11.6
High income	135	340	49.1	21.1
Office	218	102	81	66
Hospital Effluent	22.0	142	21.7	7.84
Industrial Effluent				
Brewery	175	88.4	88.4	5.00

Table 15.13 Sludge Quality in Nuwara Eliya

Site	Parameter					
	Water Content (mg/g)	TSS (mg/g)	VSS (mg/kg)	T-P (mg/kg)	T-N (g/kg)	Zn (mg/kg)
Ceylon Brewery	67.53	4.96	0.73	11.86	11.32	
Grand Hotel	93.99	4.06	0.29	13.5	9.88	
Middle income House	547.7	320.2	10.5	7.5	8.7	0.22
Public toilets	476.2	410.14	14.5	8.5	8.1	0.12

15.5.5 Contaminant Balance and Impact Assessment

(1) Water quality modeling

The impacts of the implementation of the proposed project on major surface water resources in Nuwara Eliya have been quantified using a water quality modeling. Contaminant concentration, (BOD_5, DO, T-N and T-P) in Nanu Oya and Gregory lake were computed for above different phases using one-dimensional (linear) modeling approach. Concentrations in Gregory Lake were computed using the complete mixed system approach.

The general mass balance equation under steady condition together with the single first order kinetic equation for the decay process of the constituents are the governing equations of the models. The saturated dissolved oxygen in water is based on Henry's equation. Details of the models and the validations are given in the main EIA report prepared by local consultants (Appendix 6.3.1)

(2) Water bodies considered in the present analysis

The following water bodied have been considered in the present analysis for the Nuwara Eliya area:

- **Nanu Oya : 3.3 km,** from upstream to its inflow to the Lake Gregory
- **Hospital Stream: 3.0 km,** from upstream to its inflow to the Barrack Plains Reservoir
- **Lake Gregory:** considered as well mixing surface water body;
- **Barrack Plains Reservoir:** at present, the Barrack Plains Reservoirs has converted into a swamp, therefore only contaminant loads are computed but water quality modeling was not attempted.

(3) Computations of contaminants load

A comprehensive survey was conducted in both Greater Kandy and Nuwara Eliya, during the month of September 1998, to identify the various sources of contaminants with respective location and type, and the quantity of contributing waste water and drainage flows[1] into the water bodies directly or through infiltration. For the streams, the contaminant loading rates and water flows rates were considered as continuous point sources at 30m intervals. For lakes, the contaminant loads from the streams flowing into them and from the direct and infiltration flows from the perimeter were used.

The following information was collected during this survey:

- Type of building: house, office, school, hospital, and hotel, restaurant public latrine
- Type of disposal: septic tank, pit latrine, direct, treatment plant
- Number of inhabitants: during the daytime. during day and night
- Type of water used: municipal, dug well , stand post

Quantification of contaminant discharge flow rates into respective water bodies was based on the standard rates and the proportion given in the Table 15.14.

Table 15.14 Rates of Drainage Flow and the Quantities and Proportions of Contaminants Used in the Computation of Contaminant Balance

Type	Flow Rate (l/capita/day)	Quantity of Contaminant (g/capita/day)		
	Q	N	P	BOD_5
Day time occupant	60	2.5	0.5	15
Day & night occupant	120	7.0	1.0	40
% infiltration from pits				
within 0 – 15 m	90	20	20	10
within 15 – 30 m	60	05	05	00
Public latrine				
Excretion (g/capita/day)	30	2.0	0.2	20
Urination (g/capita/day)	15	0.4	0.005	05
Waste water drains mg/l	-	04	01	30
Stream drainage mg/l	-	0.5	0.1	02

(4) Simulated scenarios

The following scenarios are considered to explain the impact of the implementation of the proposed project on surface water resources in Greater Kandy and Nuwara Eliya.

Phase 0 : present status of water quality

Phase 1 : **30 percent** of the population and all wastewater inflows public latrines and the other direct connections are connected to the sewer system

Phase 2 : Phase 1 plus another **60 percent** of the population (i.e., **90 percent** of the total population) is connected to the sewer system

Predictions are based on the above specified Water Quality Modeling. Concentrations of **BOD_5, DO, T-N and T-P** were computed using one-dimensional modeling approach for the Nanu Oya and Hospital stream, and complete mixed system approach for Lake Gregory.

(5) Modeling results and prediction of water quality improvement

Nanu Oya

Average dry weather flow in Nanu Oya is shown in Figure 15.12-1 This steam will be rehabilitated with the implementation of the water supply system and sewage treatment facility since it will totally reduce the direct discharge of sewage and domestic water in to the stream system. However, nitrogen and phosphorus concentrations in the stream system may remain at a higher level since the stream is receiving nitrogen and phosphorus compounds washing off vegetable plots. Figure 15.12-2 and 15.13-1,2,3 show the improvement of T-N, T-P, BOD_5 and DO respectively in the Nanu Oya with the implementation of the project.

Hospital Stream

There will be a greater improvement in the water quality of the hospital stream (Figure 15.14 and 15.15) since the implementation of the proposed project will not allow untreated hospital waste and brewery effluent to reach the stream directly.

Lake Gregory

There will be a certain improvement in the water quality of Lake Gregory with the implementation of the proposed project. However, there is no substantial big difference in values computed for T-N, T-P, DO for the present and after implementation of the phase 2. This is mainly due to the good mixing behavior and small retention time of Lake Gregory.

Table 15.15 Changes in T-N, T-P and DO in Lake Gregory after Project Implementation

Parameter	Wet Weather		Dry Weather	
	Present	Phase 2	Present	Phase 2
T-N (mg/l)	8.5	6.2	14.7	14.2
T-P (mg/l)	0.06	0.04	0.043	0.003
DO (mg/l)	6.5	6.57	8.3	8.5

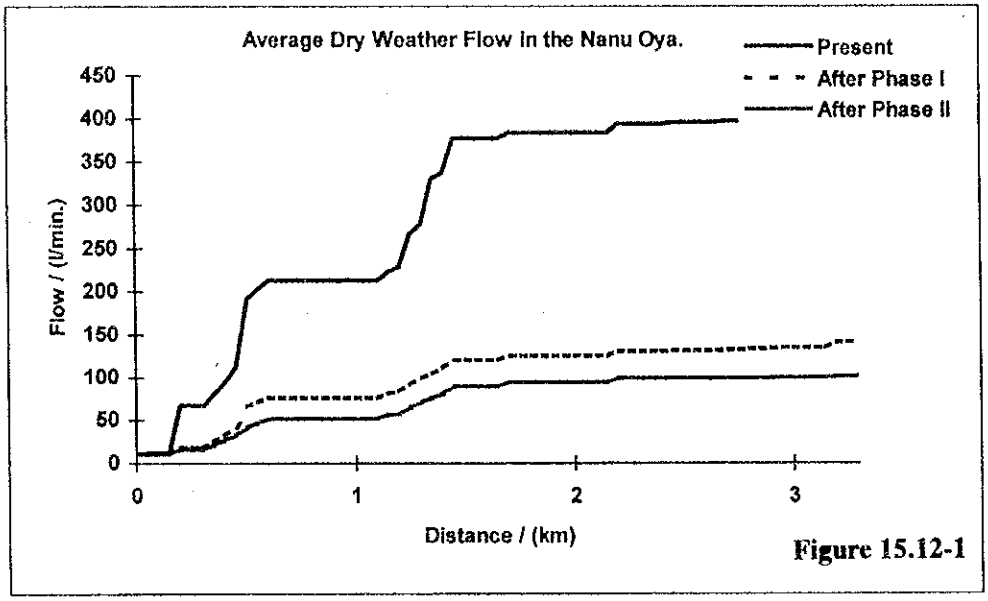


Figure 15.12-1

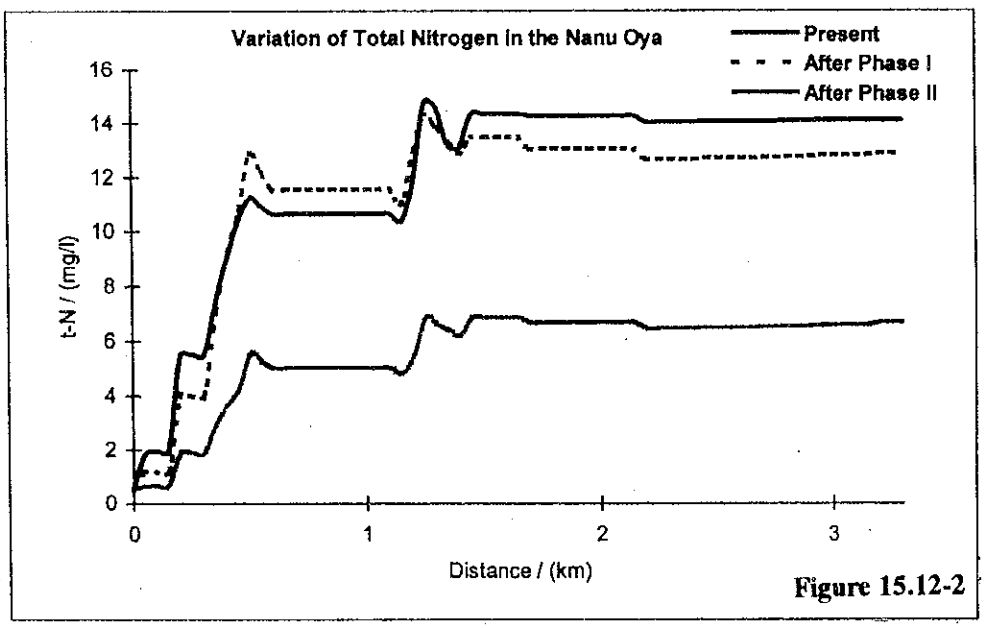


Figure 15.12-2

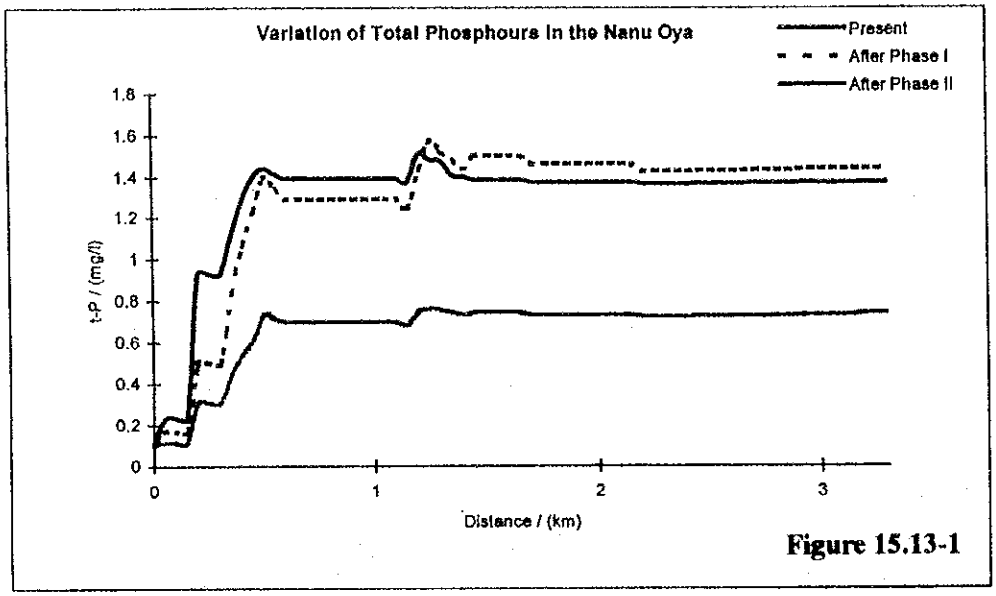


Figure 15.13-1

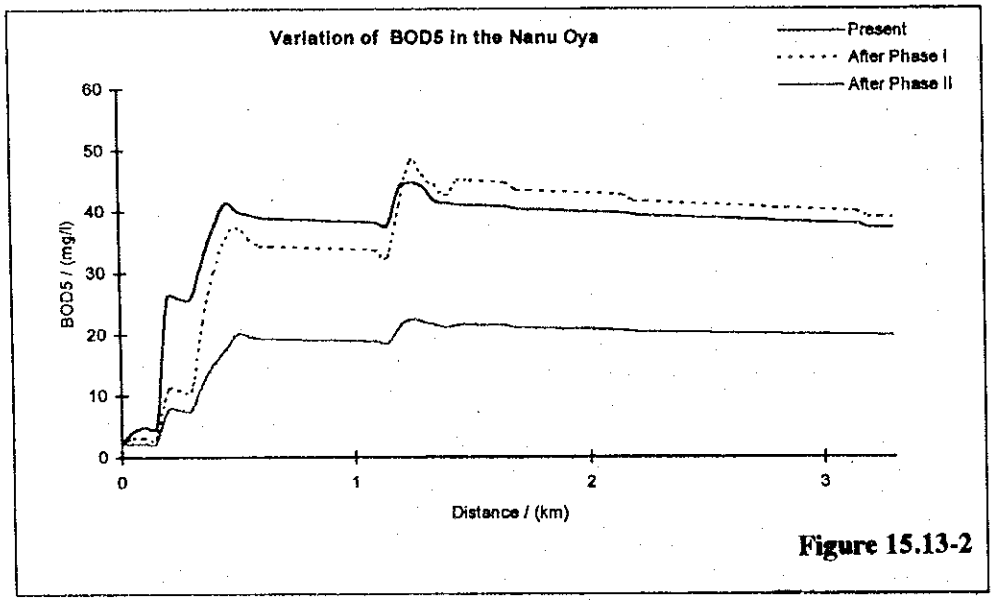


Figure 15.13-2

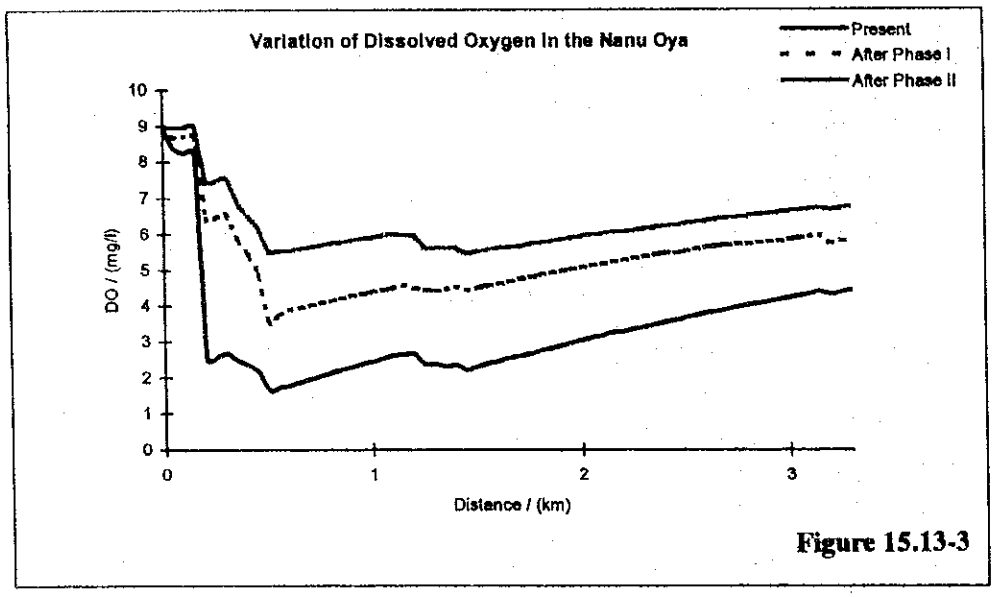


Figure 15.13-3

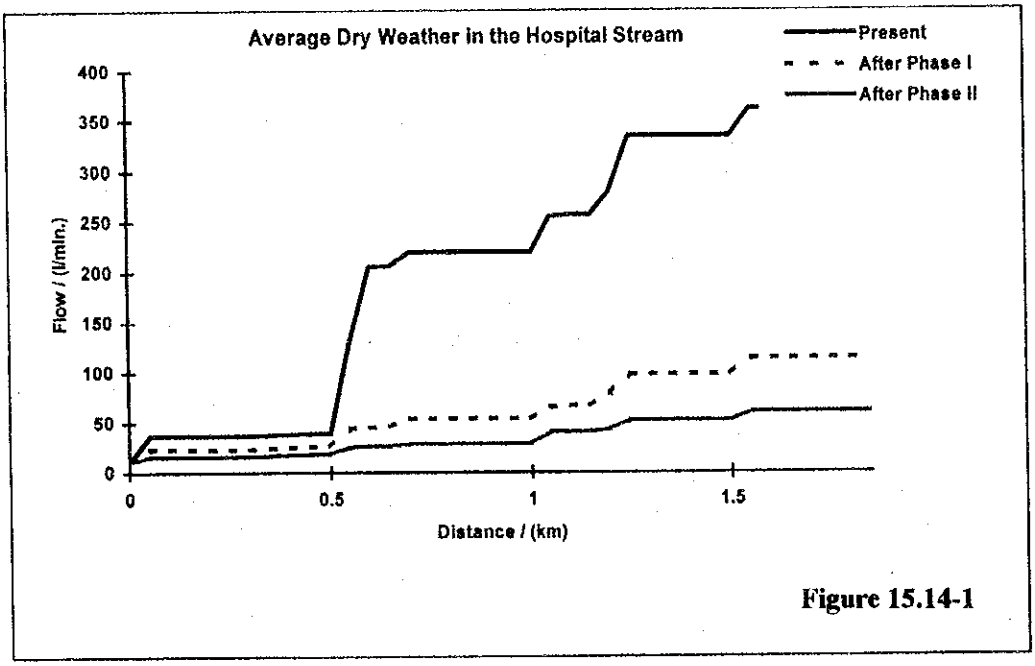
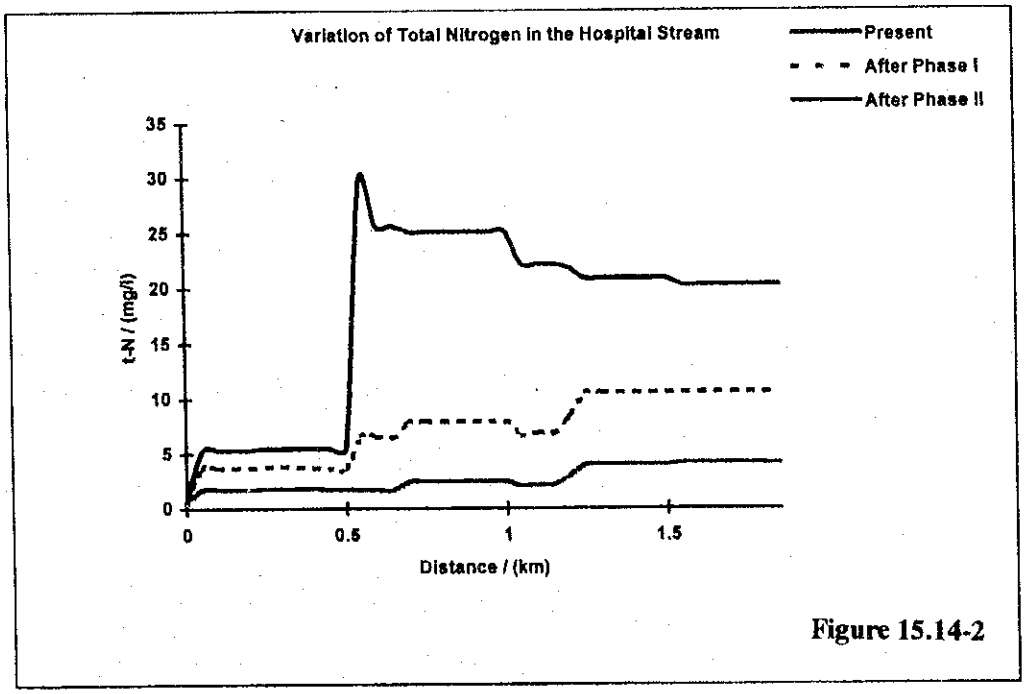


Figure 15.14-1



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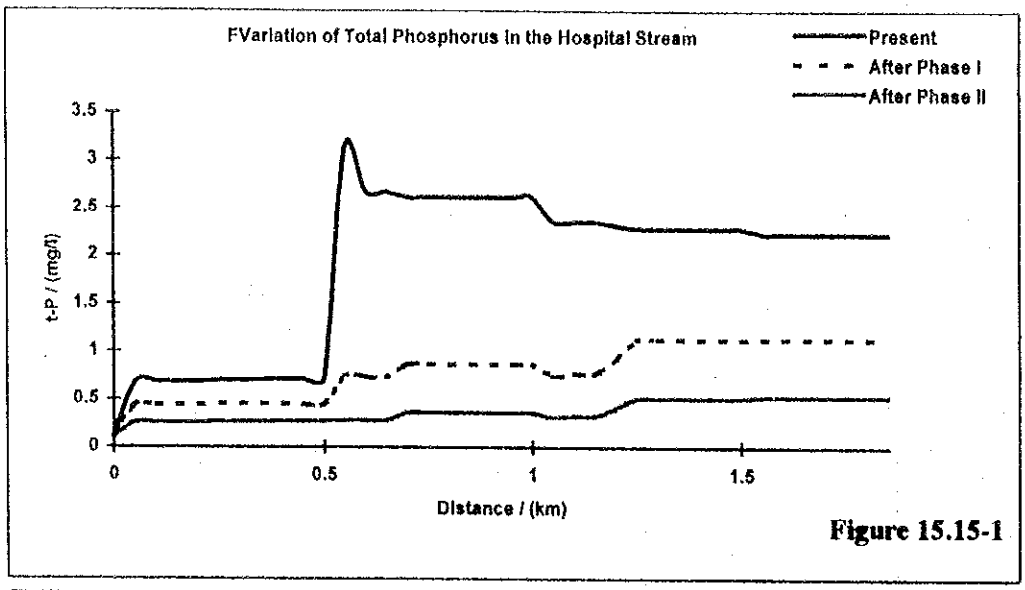

Figure 15.15-1

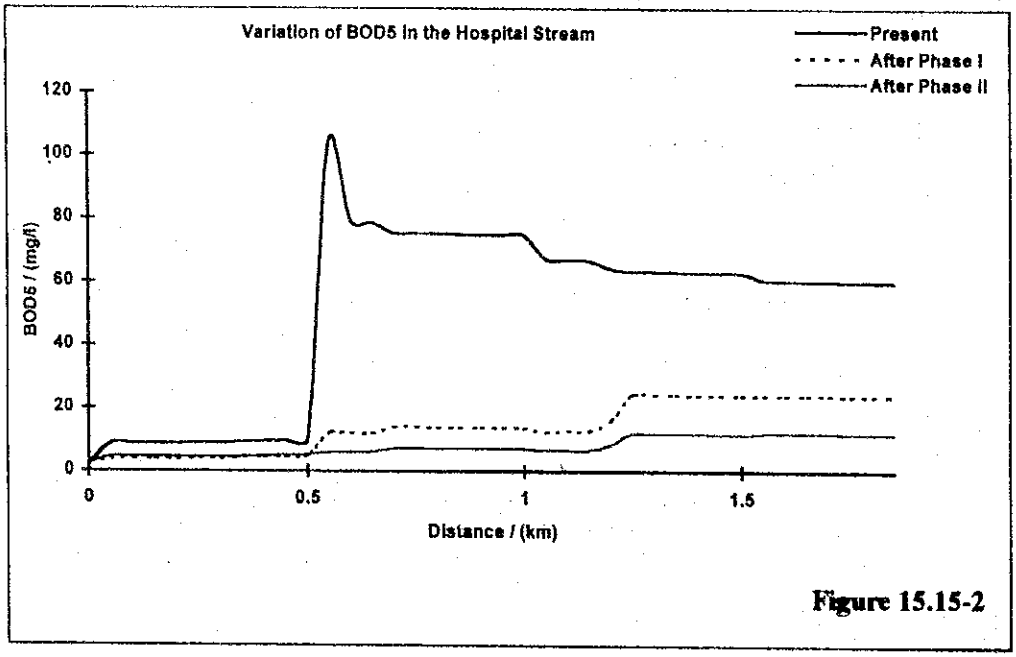

Figure 15.15-2

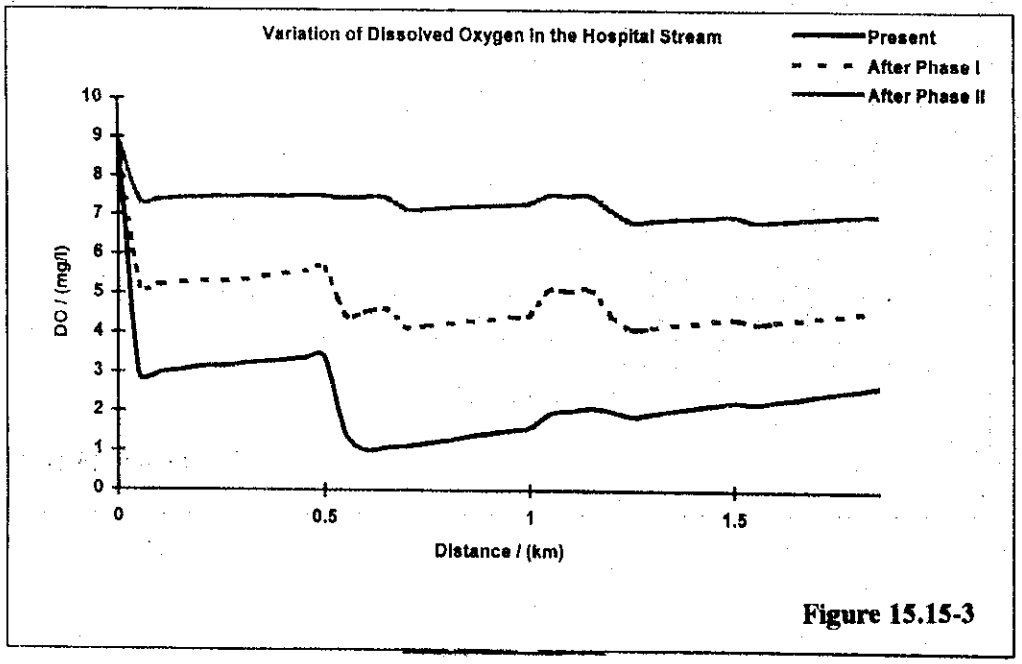

Figure 15.15-3

15.6 Impact on Traffic and Transportation during Construction

15.6.1 General Impacts

The proposed project involves additional vehicle movements to the construction sites, the possible closure of at least one traffic lane due to trenching for pipeline laying activities and stationing of equipment and machinery at the work sites. All these will obstruct traffic movement, and heavy traffic delays can be expected during the construction phase due to the restriction of space on roads. Even if the negative effects in Nuwara Eliya are minor compared with the expected effects in Kandy, re-arrangement of traffic moving directions along principal roads will be required.

The Figure 15.16 shows the recommended alternative roads for traffic diversion in Nuwara Eliya. It must be stressed that not all selected roads are presently in a condition to absorb the new traffic load, and should therefore be improved to ease transit of vehicles. Specific recommendations are given hereinafter.

15.6.2 Specific Recommendations to Ease Traffic within Construction Zones

(1) Improvement of roads and park areas

Similar to Kandy, Nuwara Eliya also will need some improvements along roads required for traffic diversion during the construction period. The most important are listed below, while details are given in the principal EIA report:

- Lady Mccullums drive ('B' class road; to be widened).
- Jayathilaka Mawatha (surface upgrading);
- Moonpalace road (surface upgrading).

In addition to above, following car parks should be improved to move roadside-parking during the construction:

- Cargill's ground;
- New market main car park;
- New market rear car park;
- Parking space on park road opposite old Kachcheri building.

According to the parking survey carried out, all the above places can be used for more traffic than presently used. Hence those using roadside parking should be able to relocate to one of those car parks.

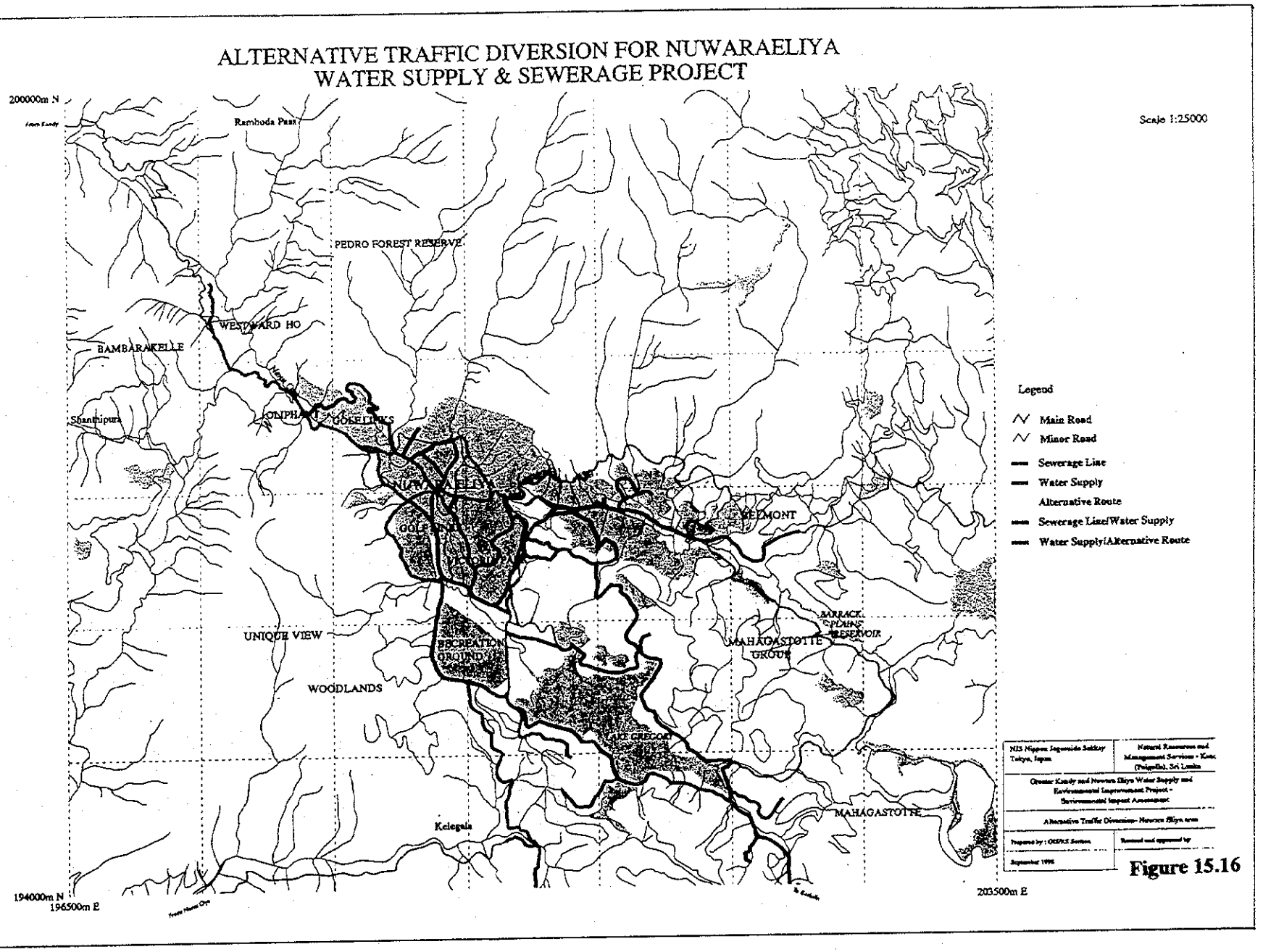
ALTERNATIVE TRAFFIC DIVERSION FOR NUWARAELIYA
WATER SUPPLY & SEWERAGE PROJECT
200000m N
194000m N
196500m E
203500m E
Scale 1:25000
Ramboda Pass
PEDRO FOREST RESERVE
WESTWARD HO
BAMBARAKELLE
Shanthipura
OLIPHANT
GOLF LINKS
VELMONT
UNIQUE VIEW
WOODLANDS
RECREATION GROUND
BARRACK PLAINS RESERVOIR
MAHAGASTOTTE
Kelegala
Legend
Main Road
Minor Road
Sewerage Line
Water Supply
Alternative Route
Sewerage Line/Water Supply
Water Supply/Alternative Route
Alternative Traffic Diversion- Nuwara Eliya area
September 1996

Figure 15.16

(2) Reduce number of vehicles entering the construction area

Other recommended interventions, specifically aimed to reduce the number of vehicles entering the construction zone, are:

- During trenching of first section: to move the private bus terminal in Badulla road to the car park in front of the post office;
- During construction in the central town area: to shift the Sunday fair to the vacant space between the Police station and the RRDP office or to locate it by the side of the park road.

- Display at the city's entrance and in central / tourist areas project information/notice boards showing relevant roads, roads being closed for traffic or allowing only one way traffic; construction schedule including dates of commencement and completion of works on each road. Recommended places are: top pass - Kandy road, Moon Planes road junction, Hawaeliya - Udapussellawa road, Mahagastota road junction, Seethaeliya - Badulla road, Blackpool junction, Nanu Oya - Talawakelle Road;

- In addition to notice boards, information leaflets should be distributed to the general public and made available to people at bus depots, private bus operators, and other concerned entities.

(3) Improve traffic management and control in sensitive areas

During construction, specific traffic management/control is needed in sensitive areas of the following roads/squares/places in Nuwara Eliya[4]

- **Queen Elizabeth drive** : sensitive locations are identified at Queens lodge (Presidents Bungalow), SSP's office and the Bank
- **Badulla Road**: "A" class road. Sensitive locations are the Private bus terminal, the Botanical Garden, the School and the Hotel
- **Udupussellawa Road:** 'B' class road. Sensitive locations are Kachcheri, Bus depot, Hospital, school and garment factory
- **Park road**: this road is not used by public transport. Sensitive locations are Kachcheri and the Courts;
- **Police Avenue**: presently this is not use for public transport. Sensitive locations are the Police station and the Divisional Secretaries office;

[4] *Details are given in the principal EIA report, Chapter 7.*

- **Jayathilake Mawatha**: this road is used only for light traffic. Sensitive locations are the Police station., Technical college and the Hotel;
- **Old Bazar Road**. 'A' class road. Sensitive locations are the Municipal council office and the School;
- **Lowson street.** This is a one way traffic road used by delivery vehicles. Sensitive locations are the Bank and the Shopping center;
- **New Bazaar road**: 'A' class / one way road. Sensitive locations are the Bus stand and the Market.

15.6.3 Safety during Construction

Safety should be the primary concern of any construction site. If safety conditions are improved, this will have an automatic effect on the ease of movement of traffic. Safety during construction can be improved in the following ways.

- Properly barricading the construction sites;
- Proper fencing along trenches. These should be illuminating to ensure safety during night;
- Night bulbs, lights at all barricades and safety fences;
- Direction signs for vehicle movement as well as pedestrian movement;
- Flagmen at construction sites to warn drivers and pedestrians;

Details of service lines along the construction sites should be made available for contractors to avoid possible damage. The work force should be informed about the importance of their own safety as well as the safety of other road users. Suitable methods of punishing those who are violating the minimum safety conditions should be implemented.

15.7 Other Environmental Impacts

15.7.1 General

Other than major impacts, already discussed in the previous sections of the EIA, the construction and operation of works planned under the present project will involve the following:

- Offensive odors, mainly due to emissions of hydrogen sulfide (H_2S) and the presence in the sewage of organic rotten compounds;
- High noise levels during construction, due to engines operation, power generators, pumps, etc.;
- Impacts on air quality, due to plant emissions during operation, or emissions of equipment during construction;

- Additional production of solid wastes, collected in grit chambers at entrance of wastewater treatment plant, and to be properly collected and disposed;
- Security and hygiene of workers and the general public, especially during construction;
- Accident risks for workers and the general public, especially during construction;

All negative effects associated with these impacts can be effectively mitigated by including in the Project Specifications an Environmental Action and Management plan. This should include specific environmental control and mitigation measures to be adopted, and limits to be observed by the contractor(s) and the plant operator(s)[5]. Odor, noise impacts and disposal of contaminant materials are of major importance and will be briefly discussed in the present section.

15.7.2 Odors

(1) General concepts Offensive odors are either the consequence of decomposition of organic matter, or may be produced by other organic substances usually present in the wastewater. Raw sewage present a characteristic displeasing odor, sometime irritating, which is not as offensive as the odor of sewage after anaerobic decomposition processes have taken place.

The most penetrating odor is generally due to Hydrogen Sulfide (H2S), produced as a result of bacterial reduction of sulfur anhydrides SO2 and SO3. Other offensive or disturbing odors may also result from the presence of different chemical substances originated from hospitals or industrial sources (as is the case of the brewery in Nuwara Eliya).

Offensive odors coming from wastewater treatment plants, represent one of the most important concerns of public opinion, and are usually the principal cause of public nuisance.

The key point to reduce or possibly avoid public complains, is to perform a periodic monitoring of offensive odors, involving representatives of the potentially affected communities.

(2) Characterization of odors

The following four parameters are suggested to characterize offensive odors:

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[5] *This document should not be confused with the Environmental Monitoring and Auditing Program, which will be discussed in the Paragraph 8.*

Table 15.16 Characterization of Odors

Category	Description
Character	It is relevant to the mental association of the subject who perceives the odor. It is therefore a subjective parameter, which may vary from individual to individual.
Perceptibility	It is the number of dilutions necessary to reduce an odor to the minimum detectable level.
Hedonic	Relating to, or marked by pleasure: it is relative level of pleasure or repulsion of an individual perceiving a certain odor. It is also a subjective parameter.
Intensity	It is the most objective parameter. It is normally measured with an olfactometer, or it may be measured through "perceptibility", once the basic relation (number of dilutions up to the lower limit of perceptivity) has been established.

(3) Evaluation of odor intensity

An odor can be measured using odor-sensitive instruments, which provide "objective" values, or through the "sensorial method" (organoleptic) , which leads to subjective values.

The sensorial method, based on the human capacity of detecting offensive odors, is usually preferred. According to this method, groups of persons are exposed to odors which have been diluted with non contaminated air, taking note of the number of dilutions necessary for the odor not to be perceived by the majority of exposed persons. This value is called " *Minimum Detectable Threshold of Odor Concentration - MDTOC".*

An alternative accepted terminology for the sensorial method is *ED50,* which measures the number of dilutions necessary for an odor to be detected with difficulty by an "average person" (50^{th} percentile) . That means that if the *ED50* is increased one point, the odor is no longer detectable. To avoid inevitable errors direct touch *olfactometers* have been developed permitting sensorial measurement of odors at the same site where odors are generated.

For detection of Hydrogen Sulfide gas diffused portable meters are available, capable of detecting concentrations of less than 1 ppb/volume.

(4) Specific recommendations

Mitigation

Offensive odors will represent a minor problem in Nuwara Eliya, considering the relatively isolated location of the plant. Tree planting (double row) all around the plant area is

recommended to mitigate the effect, avoid complains from neighboring people and improve visual impact.

Monitoring

Monitoring is also essential to avoid people nuisance. The recommendation is to monitor the odors using the "*sensorial*" method. An evaluation group composed of seven persons should be formed, including three representatives of public institutions (Water Board, Municipality Health Office, local CEA representative), and four representatives of potentially affected families or communities. This group will be requested to detect offensive odors at different distances from the plant (or from the point where odors are more detectable), determining the minimum distance, in different geographical directions, where the majority of people do not detect the odor any more.

15.7.3 Noise and Vibrations

(1) General

Noise is usually defined as an unwanted sound that affects everyone in the environment. People's reaction to offensive noises is similar to their reaction to odors. Most people express an opinion about offensive noises, the threshold of sensitivity is different for different persons, and continuous noises may have negative effects on physiological, psychological, communication, performance and social behavior, not only upon human beings, but also upon animals.

Sounds are measured by Decibel scale (dB)[6], i.e. by use of sound-level meters. This is an objective measure of sound pressure levels, and not a measure of "loudness", which describes the pressure amplitude of sound vibration in the air, and is related to the stress imposed to the ear.

An essential parameter to be considered is the length of time a person is exposed to an offensive noise. This will be of particular concern during construction activities, when highly noisy equipment will be working simultaneously. Table 15.17 below reports the criteria adopted by the US Environmental Protection Agency and the State of California concerning the maximum exposure time to offensive (high level) noises, and Table 15.18 reports the average noise emission level for some construction equipment.

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[6] *The "dB" is a non-dimensional unit defined as 10 times the logarithm of the rate between two selected values (dB=10log*q1/q2).*

Table 15.17 Maximum Admissible Time of Exposure to Offensive (High Level) Noises

Noise Levels (dB)	Maximum Time of Exposure (Residential Areas) (Hours)	Maximum Time of Exposure (Industrial or Commercial Areas) (Hours)
70	16-24 (hours)	
75	8 (hours)	
80	4 (hours)	
85	2 (hours)	
90	1 (hours)	8
95	0.5 (hours)	4
100	15 minutes	2 (hours)
105	8 minutes	1 (hours)
110	4 minutes	30 minutes
115	2 minutes	15 minutes or less

Table 15.18 Average Noise Emissions of Most Common Construction Equipment[7]

Construction equipment	Noise Level at 16.5 m (dB)
Tracked excavator	88
Water Truck	87
Compactor	82
Bulldozers	86
Road roller	74
Asphalt spreader	91
Cement lorry	85

(2) Sri Lanka regulations

Sri Lanka regulations about noise control have been established by the Ministry of Transport, Environment and Women's affairs, under Section 23P, 23Q and 23R of the National Environmental Act No. 47 of 1980, read with section 32 of that act.[8]

These regulations include VIII "Schedules", each one of them fixing specific limits to be respected. Maximum permissible noise levels at boundaries of L_{acq},T[9] are established under Schedule I, as reported in the following Table 15.19.

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[7] *Noise emission of a specific construction equipment must be indicated by the contractor.*
[8] *See Extraordinary gazette 924/12, 1996, 05, 23*
[9] $L_{Acq}T$ *means the equivalent continuous, A-weighted sound pressure determined over a time interval T (dB).*

Table 15.19 Sri Lankan Regulations: Maximum Permissible Noise Level at Boundaries $L_{acq}T$

Area	Day Time (dB)	Night Time (dB)
Low noise	55	45
Medium noise	63	50
High noise	70	60
Silent zone	50	45

Where:

- **Low noise area**: means an area located within any Pradeshiya Sabha area;
- **Medium noise area**: means an area located within any municipal Council or Council Urban Area;
- **High noise area**: means any export processing zone established by the board of Investment or industrial estate approved under part IV of the National Environmental Act;
- **Noise sensitive area**: includes any area in which a courthouse, hospital, public library, school, zoo, sacred areas set a part for recreational or environmental purposes are depicted in a noise zone map (see Figure 15.17 for the Nuwara Eliya area)

For construction activities, the maximum permissible noise levels at boundaries of the land in which the source of noise is located in $L_{acq}T$, is fixed at 75 dB during day time and 50 dB during night time (Schedule III, Regulation 4).

Maximum permissible noise levels at boundaries in $L_{Acq}T$, for industrial activities (plant construction can be included in this category), are established as follows (Schedule IV, and V, Regulations 7(a) and 7)b):

Table 15.20 Sri Lankan Regulations: Industrial Activities: Maximum Permissible Noise Level at Boundaries $L_{acq}T$

Areas	Day Time (dB) (Sched. IV)	Night Time (dB) (Sched. IV)	If Background Noise Exceed Given Levels (Sched. V)
Rural residential areas	55	45	+ 3 dB
Urban residential areas	60	50	+ 3 dB
Noise sensitive areas	50	45	+ 3 dB
Mixed residential	63	55	+ 3 dB
Commercial areas	65	55	+ 3 dB
Industrial areas	70	60	+ 3 dB night + 5 dB day

SENSITIVE AREAS IN CENTRAL NUWARA ELIYA

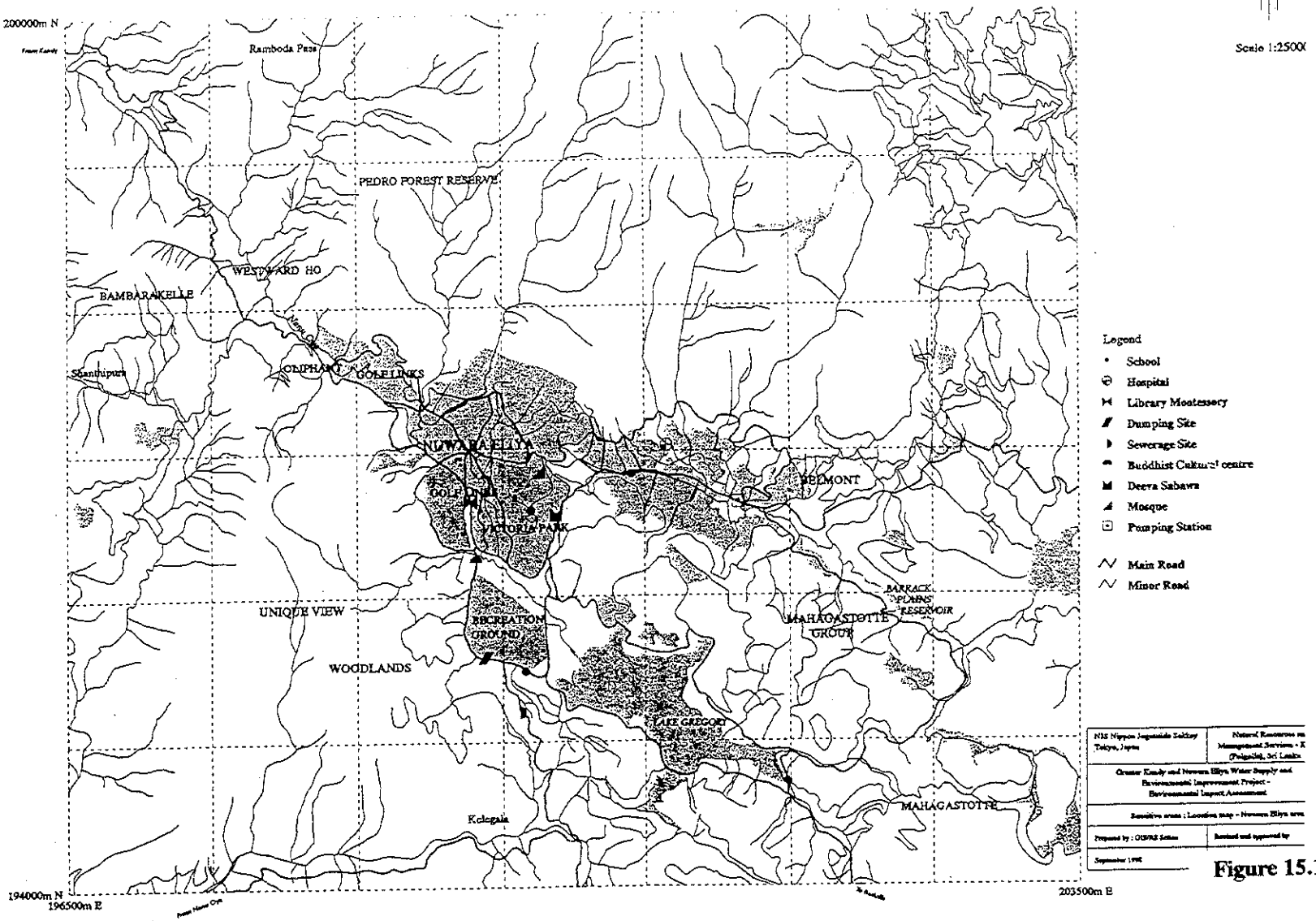

Figure 15.17

Schedule VI concerns Industrial/Commercial and Urban/Rural/Mixed residential areas, and reads as follows:

Table 15.21 Sri Lankan Regulations: Mixed Areas: Maximum Permissible Noise Level at Boundaries $L_{acq}T$

Areas	Day Time (dB)	Night Time (dB)
Industrial/Commercial	75	60
Urban/Rural/Mixed Residential	65	50

(3) Unavoidable environmental impacts

During operation

During normal plant operation, noise is minimal and will not be detectable outside plant area. The only exception will be during periods when the emergency power plant is operated, because of power failure or low voltage of public power supply. In this case, especially if the power plant is not underground, noise in the immediate vicinity of the plant can easily pass the threshold of 70 dB, and will be audible outside the plant up to a distance ranging from 50 to 100 m, depending on wind direction and obstacles to noise transmission.

Considering the relatively isolated location of the plant and the exceptional nature of this impact, noise during plant operation is not expected to represent a problem either for plant workers or for neighboring communities. The following specific recommendations are anyhow given to minimize this impact:

During construction

Noise impacts will be relatively important and unavoidable only during the construction period, both at plant sites and for the layout of main transmission lines.

Noise levels to be respected will depend upon the classification of the area where the specific work is carried out. Considering the location of the works, the following classification is given.

Table 15.22 Noise Levels to be Respected at the Different Work Sites

Site	Classification	Noise Levels to be Respected Day/Night
Nuwara Eliya WWT Plant	Rural/Mixed Residential ❑ Operation ❑ Construction	 63/50 75/50
Nuwara Eliya Central Area	Medium Noise Urban / Residential Sensitive Area (see map) ❑ During Construction	 60/50 50/45 75/50
Nuwara Eliya Peripheral	Medium Noise Urban/Rural/Mixed Residential ❑ Construction	65/50 75/50*

The following actions are important to avoid public nuisance and repeated interruption to work:

- Thoroughly inform the local population and surrounding communities about the works to be done, period of execution, and noise inconvenience which will be suffered;
- Avoid operation of highly noisy equipment (like jack hammers) in particularly sensitive areas during specific hours (i.e. during school hours if works are close to a school, or during religious functions if works are close to a temple or cult site);
- In any case avoid the use of highly noisy equipment in hospital zones, even for short periods of time, employing alternative low-noise techniques;
- In any event avoid the use of highly noisy equipment in residential areas at night;
- In any case limit the period of time during which highly noisy works are carried out, considering the limits given in Table. 15.17 above.
- Ensure that the contractor employs the use of as much low noise emission equipment as possible.

15.7.4 Removal, Transport and Disposal of Contaminant Materials

Removal, transport and disposal of contaminant material mainly concern:

- Materials generated during construction (temporary impact);
- Sludge produced at the wastewater treatment plant site (permanent impact).

(1) Excavation and construction material

The problem could arise only at the wastewater treatment plant. The proposed site for the plant construction is a minor valley, with negligible vegetative cover. During construction,

land leveling to some extent will be inevitable with important earth movements. The "cut and fill" process will be anyhow used, causing minimal or no evacuation of waste materials.

If the suggested alternative for the Nuwara Eliya sewage treatment site is adopted, this is partly a level grassland and part a forest plantation area. Vegetative matter is more important than in the previous location, but remains negligible. Land leveling will also be important, and possibly the "cut and fill" methodology will not avoid transport of residual material out of the area. A secure land fill must therefore be located before starting the construction, and material must be disposed in a proper manner, to prevent erosion and mud transport during the rainy season.

(2) Sludge

Estimates of quantities of sludge to be transported ranges between **9 and 10 m^3/day.** Considering the use of **4 m^3** load capacity trucks to collect and dispose of the sludge, a minimum of three runs per day will be required. Considering the location of the plant, this operation will have minor negative impacts on the surrounding population. It is therefore recommended that peak traffic times and night times are avoided in order to mitigate any nuisance.

15.8 Environmental Auditing and Monitoring

15.8.1 Responsibilities

In the case of WS or WW treatment plants, environmental auditing and monitoring will be necessary either during construction and operations stages. Responsibilities will be as follows:

- Environmental monitoring and reporting: NWSDB / WWTP;
- Environmental auditing: CEA, or the entitled Project Approving Agency.

15.8.2 Environmental Auditing and Monitoring during Construction

The main components of the project are designed to improve the quality of the environment and the well being of the population of Nuwara Eliya. Specific monitoring is required as an environmental control measure in situations where the environmental impacts of the project appear as critical and adverse. After the review of the IEE and the comments received from the Central Environmental Authority the following areas are critical:

(1) Disposal of solid material generated during construction
(2) Solid waste associated with the work force should be collected and disposed
(3) Routes for the transport of material and transport to be carried out in consultation with the local authorities
(4) Action to be taken to minimize dust
(5) During construction measures to be taken to reduce disturbance due to noise
(6) Proper surface drainage systems to be maintained during construction
(7) Restore or rehabilitate the temporarily used areas to initial state

Of these specific recommendations of the CEA, the last is the most important item that needs regular Monitoring and Auditing on a long-term basis. The other recommendations are valid for the construction period. Nevertheless all of them should be monitored and corrective measures adopted where necessary.

The other specific areas to be monitored are:
(1) Water quality of Nanu Oya after discharging of treated wastewater;
(2) Health hazards in the vicinity of the wastewater discharge area,
(3) Health hazards due to toxic gases at the treatment plants soil erosion during construction,
(4) Public health hazards from sewer outflows,
(5) Air pollution/ odors and noise,
(6) Traffic disturbance during construction,
(7) Ground water contamination and water disease vector at sludge dumping area.

15.8.3 Environmental Auditing and Monitoring during Operation

(1) Need for an auditing and monitoring activity

As already mentioned, environmental auditing and monitoring during operation is a routine activity, to be performed by the Environmental Section active at the Plant. The target is to ensure, through periodic sampling, analysis and reporting, that in no case will the environmental quality parameters established by the CEA and accepted by the NWSDB be exceeded.

The Water Supply and Drainage Board apply for the Environmental Protection License for the Wastewater treatment plant in accordance with the requirements of the National Environmental (protection and quality) Regulation No: 1 of 1990 published in the Gazette Extra Ordinary No:595/16 of 2nd February 1990.

Environmental auditing and monitoring is expected to be of particular importance for the Wastewater Treatment Plant, because of the nature of the Plant itself, and because of the lack of experience existing in the Country. The treated wastewater from the treatment plant should meet the relevant CEA standards as stipulated in Gazette Extra Ordinary No:595/16 of 2nd February 1990.

A general monitoring and reporting program should be agreed between the NSWDB and the CEA. It will concern:

(2) General monitoring and reporting provisions

- Procedures for collection of samples and measurements;
- Procedures for flow measurement, devices and methods to be applied;
- Analyses to be performed, detection methods, list of certified laboratories (including a quality assurance (QA) plan for laboratory analyses).
- Frequency of monitoring;
- Reporting of monitoring results;
- Frequency of reporting.

(3) Influent sampling and analysis required

Parameter, units, sample type, sample frequency, report frequency);

(4) Sludge monitoring requirements

1) General requirements;
   - Sludge removal;
   - Sludge handling, storage, use or disposal;
   - Sludge management practices;
   - Sludge operation and maintenance facilities;
2) Monitoring: sampling, testing for pollutants, sludge quality analysis.
3) Notification and reporting.

(5) Effluent monitoring

- Location of effluent sampling stations;
- Periods of monitoring;
- Effluent sampling and analysis requirements.

A proposal for a " Sewage Treatment Plant Monitoring and Reporting Program" suitable for

application to the NWSDB for the present Kandy WWT Project, is given in Appendix 15.

15.9 Institutional Setting

15.9.1 Specific Project Requirements

The NWSDB does not have, at this time, an internal environmental organization, able to perform all environmental activities usually requested to correctly engineer, build and operate all owned production, transmission and distribution structures.

For the accomplishment of the environmental tasks requested under the present project, the CEA ask the NWSDB to set up the following environmental units:

- **A Project Environmental Unit (PEU),** in charge for environmental management, monitoring and reporting, as above specified;
- **An Environmental Auditing Commission (EAC),** in charge of Environmental Auditing, i.e. exerting a direct control over the PEUs activities and environmental impacts of the project, either during construction or during operation.

These units, to operate correctly, need to be inserted in an organized institutional scheme, where tasks, responsibilities and hierarchical dependencies are clearly defined. Even if it is not a task of the present project to discuss in any detail the Institutional Arrangements of the NWSDB, it is necessary to draft a full environmental organization for the Water Board, as a recommendation to the General Management.

15.9.2 Proposed Environmental Setting for the NWSDB

The proposed environmental setting for the NWSDB includes the following structures:

(1) A **Central Environmental Division (CED),** to be created in Colombo, as an additional staff function of the General Management office. This Division is responsible for:

- Setting the general environmental policies and regulations, to be applied by the NWSDB at national level;
- Coordination of environmental activities at national level;
- Preparation of all required environmental studies (Initial Environmental Examination, Environmental Impact Assessment, Environmental Management and Monitoring Plan), in collaboration with Regional Offices and project units.

(2) A **Regional Environmental Unit (REU),** to be established in the Regional WB office in

Kandy, in charge of the general coordination of all environmental activities directly or indirectly concerning the NWSDB Getambe Regional Office. This office will operate a laboratory for non-routine analysis, to be performed quarterly or yearly, or for special analysis which may be requested if particular problems occur.

(3) Two **Project Environmental Units (PEUs)**, to be established in Kandy and Nuwara Eliya, in charge for the Environmental Management and Monitoring of the specific projects. These Units will operate local laboratories for routine water quality and sludge quality analysis.

The **PEUs** will be hierarchically dependent to the **REU** in Kandy, even if physically located within the plant areas. Each PEU will be composed of at least two specialists, as described hereinafter. These Units will prepare reports on environmental quality, to be forwarded to the Regional Environmental Office in Getambe, and through this, after approval, channeled to the Environmental Auditing Commission.

The REU will, in its turn will formally report to the Environmental Division in Colombo, but will operate in strict coordination and under the direct control of the General Manager of the Central Region in Kandy.

- The **Environmental Auditing Commission: does** not formally belong to the NWSDB. It will be created as an independent institution, or - as recommended by the CEA, within the Municipalities of Nuwara Eliya, and will be tentatively composed by **five members**:
- Municipal Council; 2) NWSDB; 3) Mahaweli Authority; 4) CEA - Local Office or Central Office; 5) CEA nominated independent consultant;
- The **EAC** will decide a schedule of site inspections and meetings (say quarterly), to assess the state of the environment and audit the job performed by the Project Environmental Units. The Commission, if needed, will report directly to the CEA, for the necessary environmental permits.

Figure 15.18 shows the Environmental Organization recommended for the NWSDB, applicable to all projects and plants developed and/or operated by the Board.

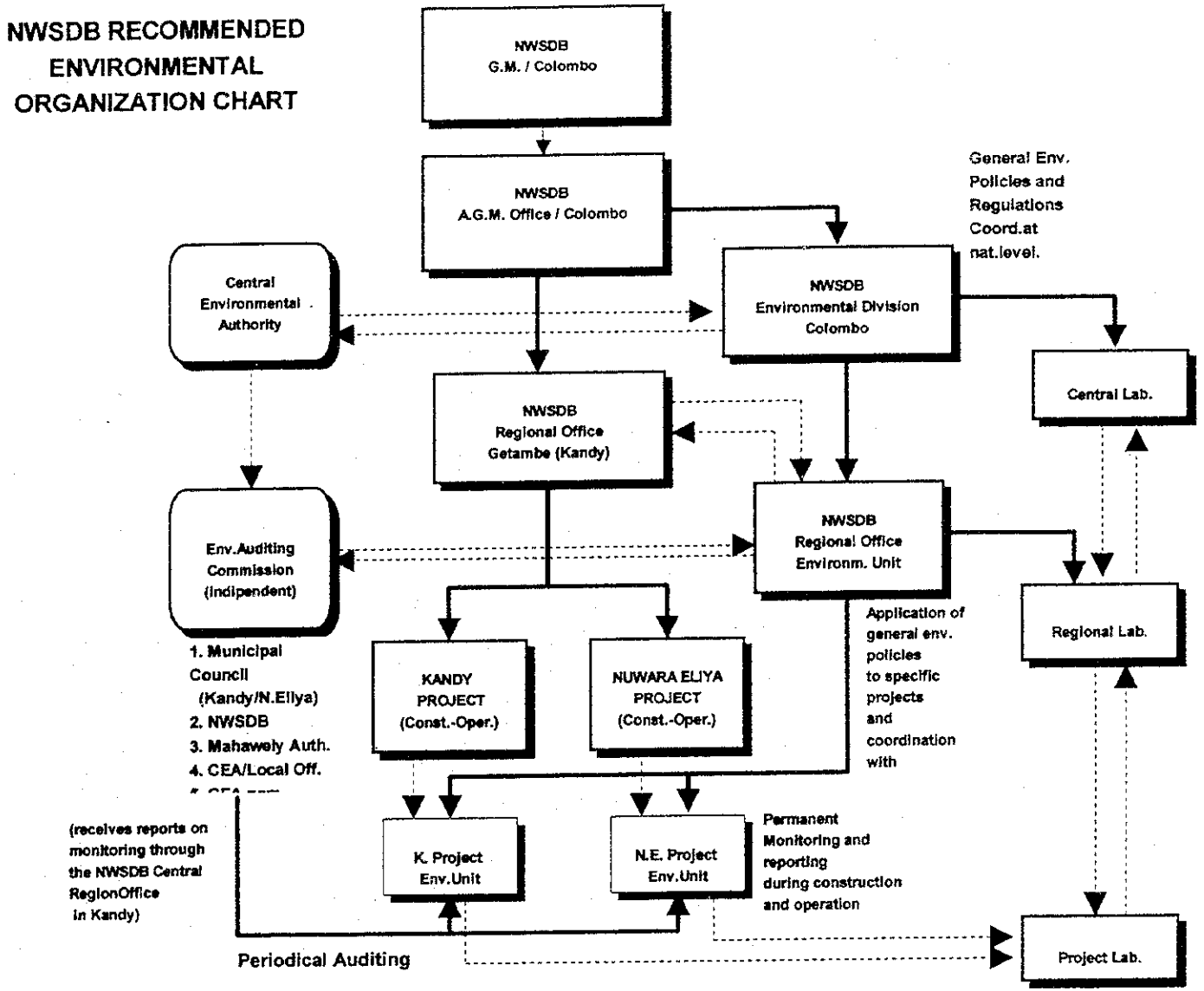
NWSDB RECOMMENDED ENVIRONMENTAL ORGANIZATION CHART
NWSDB G.M. / Colombo
NWSDB A.G.M. Office / Colombo
General Env. Policies and Regulations Coord.at nat.level.
Central Environmental Authority
NWSDB Environmental Division Colombo
Central Lab.
NWSDB Regional Office Getambe (Kandy)
Env.Auditing Commission (Indipendent)
NWSDB Regional Office Environm. Unit
Regional Lab.
1. Municipal Council (Kandy/N.Eliya)
2. NWSDB
3. Mahawely Auth.
4. CEA/Local Off.
KANDY PROJECT (Const.-Oper.)
NUWARA ELIYA PROJECT (Const.-Oper.)
Application of general env. policies to specific projects and coordination with
(receives reports on monitoring through the NWSDB Central RegionOffice in Kandy)
K. Project Env.Unit
N.E. Project Env.Unit
Permanent Monitoring and reporting during construction and operation
Project Lab.
Periodical Auditing

Figure 15.18