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# BASIC DESIGN STUDY REPORT
# ON
# THE PROJECT FOR THE IMPROVEMENT
# OF
# WATER SUPPLY FACILITIES IN URBAN AND SEMI-URBAN CENTRES
# IN
# THE KINGDOM OF NEPAL

March 2006

JAPAN INTERNATIONAL COOPERATION AGENCY

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| 06-045 |

# PREFACE

In response to a request from His Majesty's Government of Napal, the Government of Japan decided to conduct a basis design study on the Project for the Improvement of Water Supply Facilities in Urban and Semi-Uraban Centres and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Napal a study team from 12th June to 9th July 2005 for Phase.1 and from 13th September to 28thSeptember 2005 for Phase.2.

The team held discussions with the officials concerned of His Majesty's Government of Napal, and conducted field study in the study area. After the team returned to Japan, further studies were made. Then, a mission was sent to Napal in order to discuss a draft basic design, and as this result, the present report was finalized.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countriris.

I wish to express my sincere appreciation to the officials concerned of His Majesty's Government of Napal for their close cooperation extended to the team.

March 2006

Seiji Kojima
Vice-President
Japan International Cooeration Agency

**March 2006**

# LETTER OF TRANSMITTAL

We are pleased to submit to you the basic design study report on the Project for the Improvement of Water Supply Facilities in Urban and Semi-Urban Centres in His Majesty's Government of Napal.

This study was conducted by NJS Consultants Co., Ltd., associated with Nihon Suido Consultants Co., Ltd. under a contract to JICA, during the period from June 2005 to March 2006. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation in Nepal and formulated the most appropriate basic design for the project under Japan's grant aid scheme.

Finally, we hope that this report will contribute to further promotion of the project.

Very truly yours,

Hiroki Fujiwara
Project Manager,
Basic Design Study Team on the Project for the Improvement of Water Supply Facilities in Urban and Semi-Urban Centres
NJS Consultants Co., Ltd.
Nihon Suido Consultants Co., Ltd.

Basic Design Study on the Project for the Improvement of Water Supply Facilities in Urban and Semi-Urban Centres

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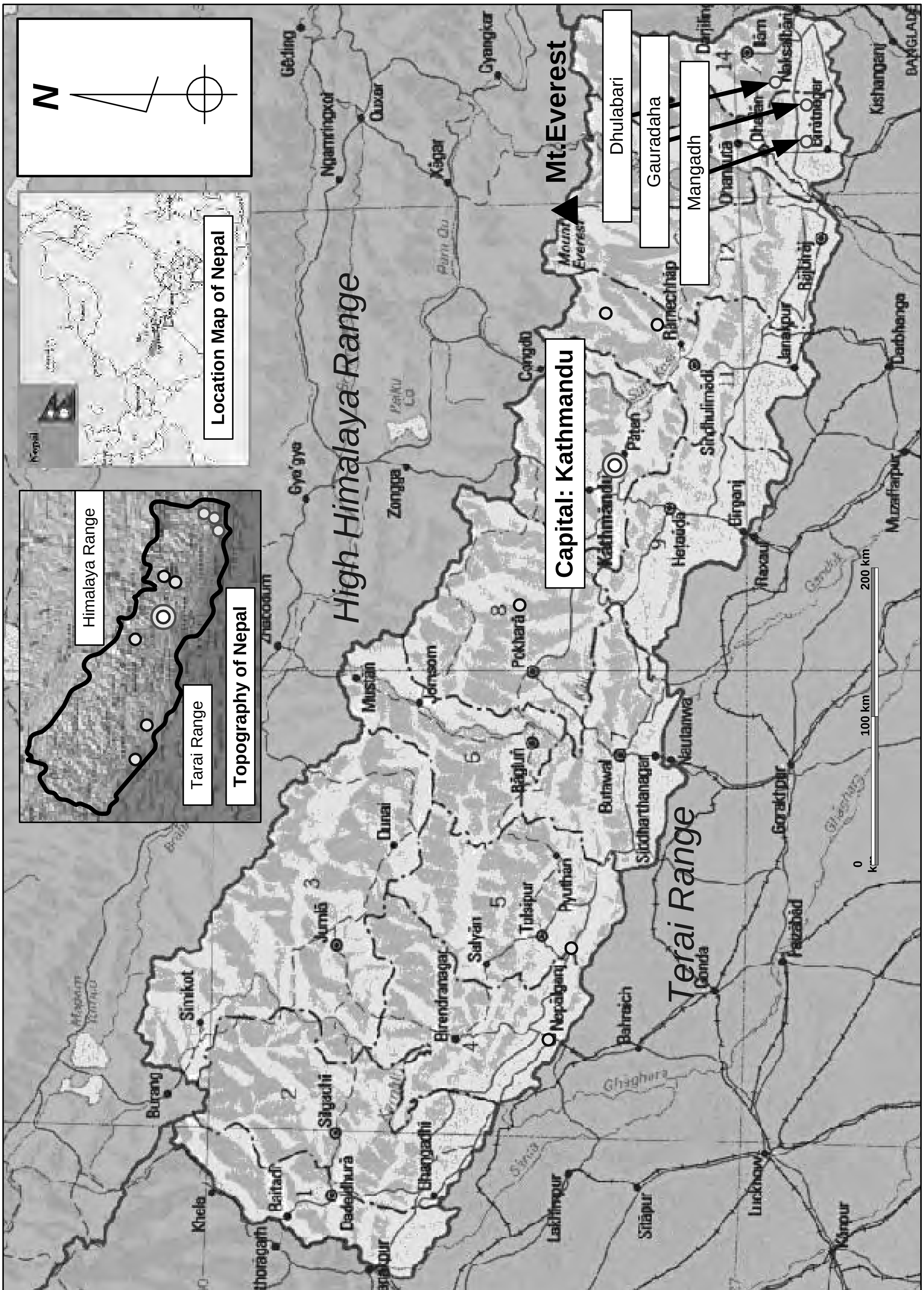
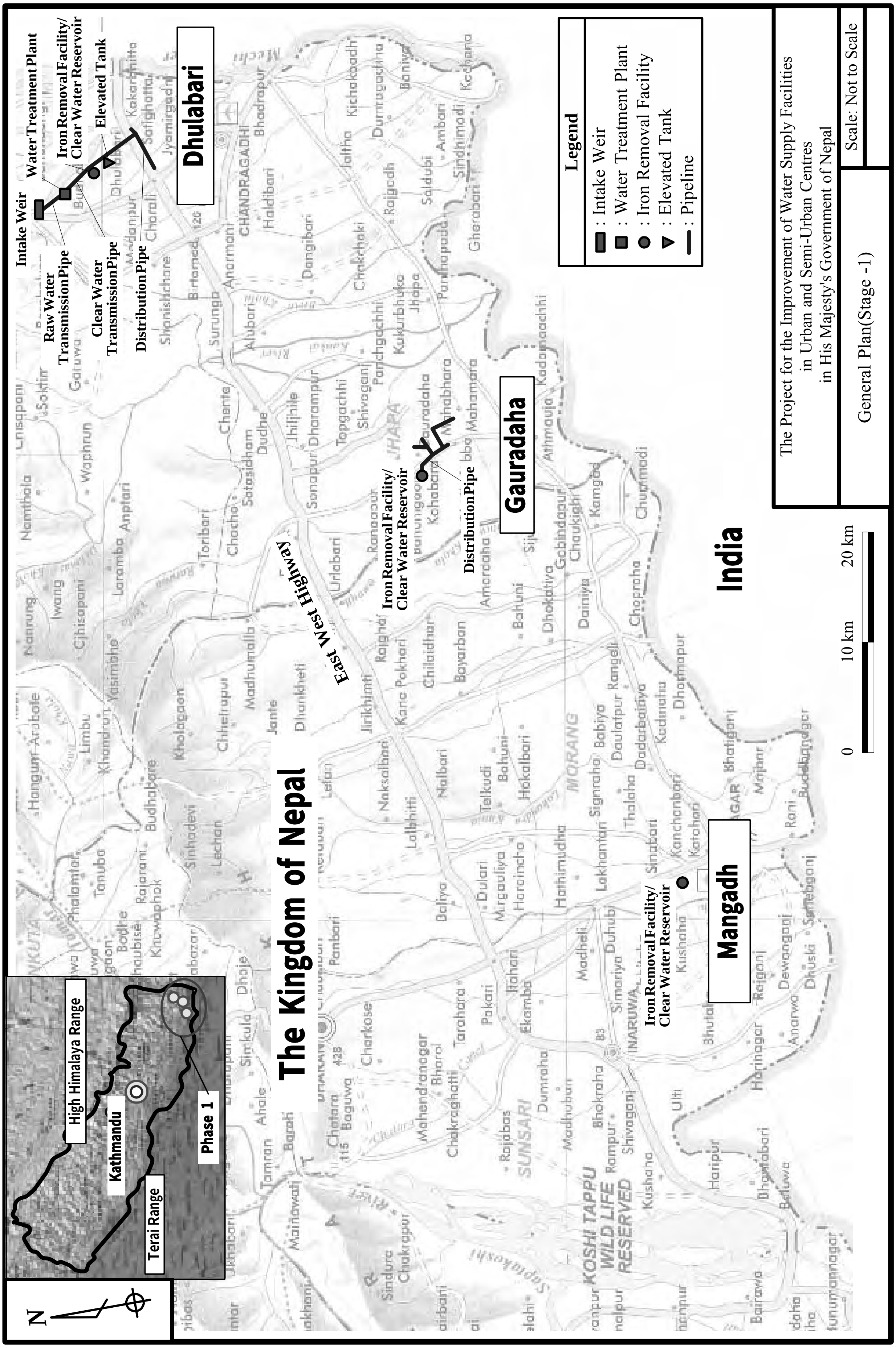
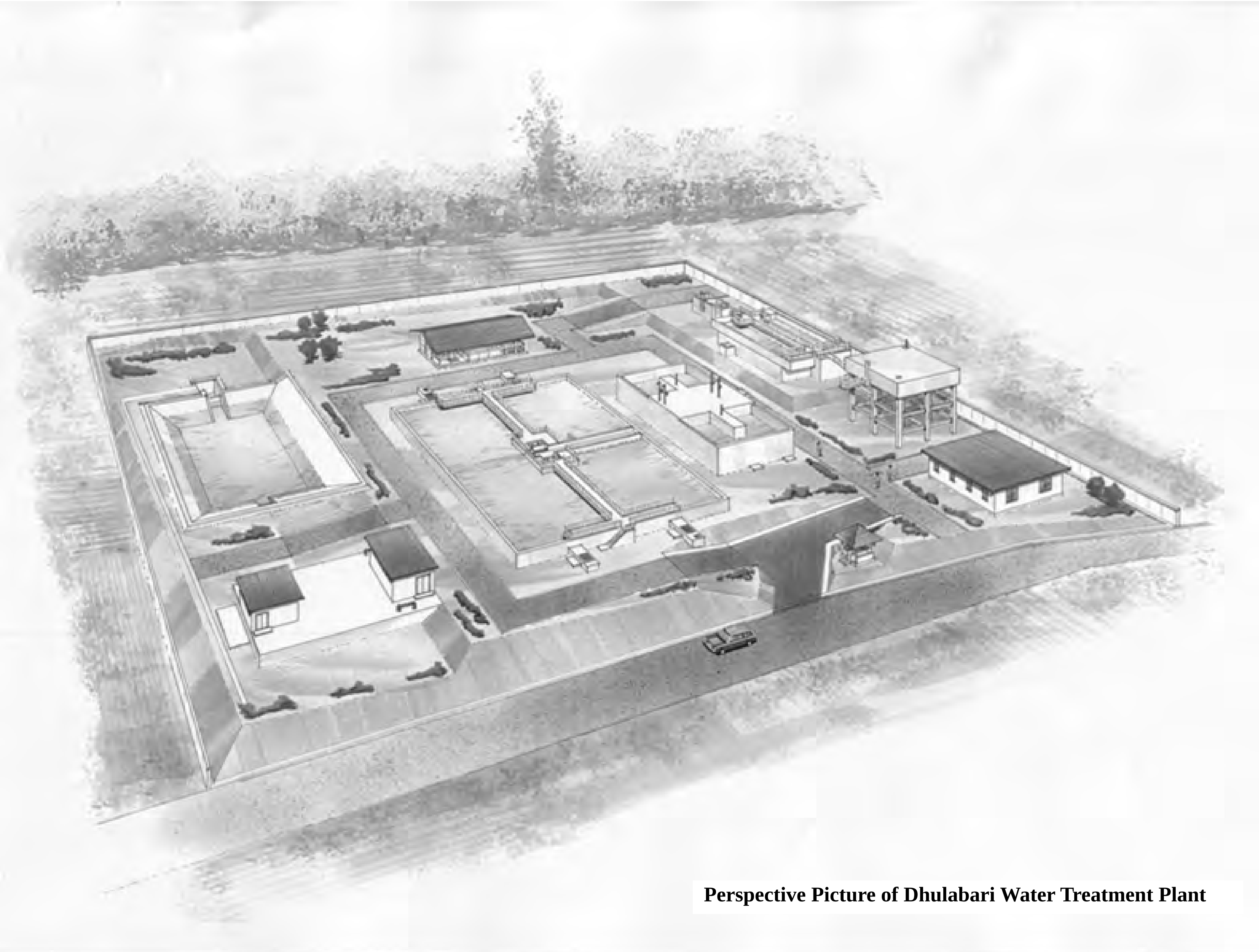
# PART. 1 Phase-1 Basic Design Study



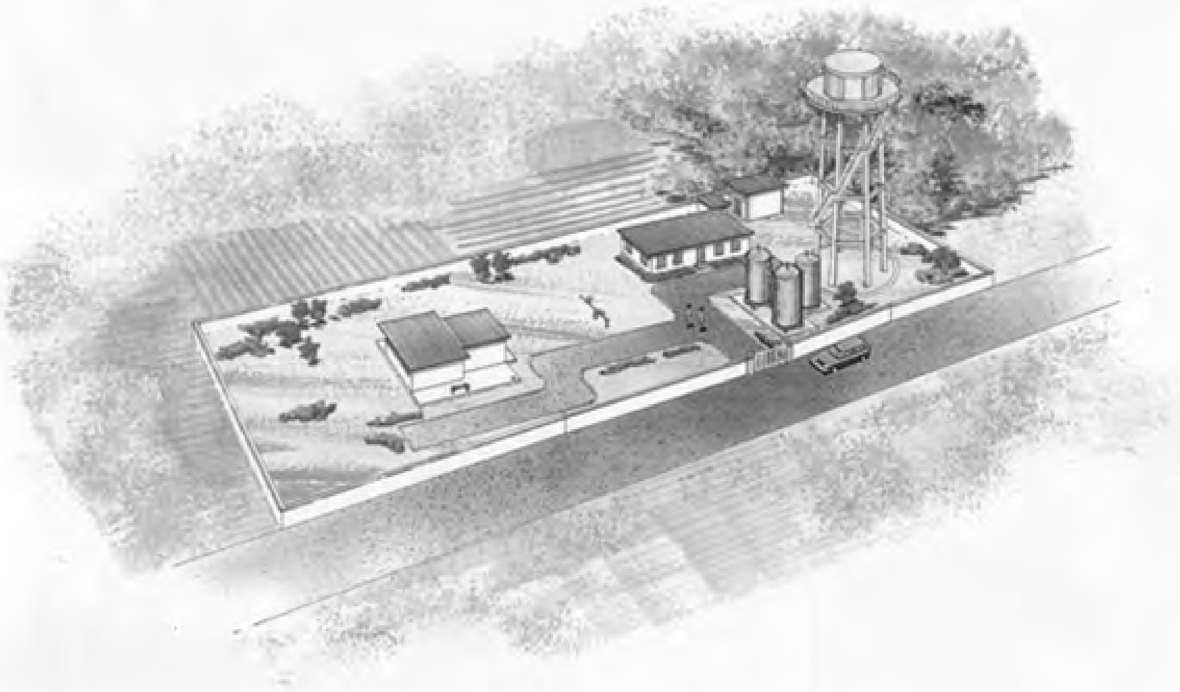

**Location Map of Study Areas**

The Project for the Improvement of Water Supply Facilities in Urban and Semi - Urban Centres in His Majesty's Government of Nepal


Dhulabari
Intake Weir
Water Treatment Plant
Iron Removal Facility/ Clear Water Reservoir
Elevated Tank
Raw Water Transmission Pipe
Clear Water Transmission Pipe
Distribution Pipe
Gauradaha
Iron Removal Facility/ Clear Water Reservoir
Distribution Pipe
Mangadh
Iron Removal Facility/ Clear Water Reservoir
The Kingdom of Nepal
East West Highway
India
High Himalaya Range
Kathmandu
Terai Range
Phase 1
N
0
10 km
20 km
Legend
: Intake Weir
: Water Treatment Plant
: Iron Removal Facility
: Elevated Tank
: Pipeline
The Project for the Improvement of Water Supply Facilities in Urban and Semi-Urban Centres in His Majesty's Government of Nepal
General Plan(Stage -1)
Scale: Not to Scale



**Perspective Picture of Dhulabari Water Treatment Plant**



**Perspective Picture of Gauradaha Water Treatment Plant**

**Perspective Picture of Mangadh Water Treatment Plant**

## Summary（Phase-1）

The Kingdom of Nepal (hereinafter “Nepal”), the country land extends north to south with length of 200km and the climatic streak features diverse from subtropical to polar ones. Gorges from high mountains of Himalaya which run from north to south hinder mountainous areas from construction of infrastructures. The Gross Domestic Product (GDP) per capita is USD 236 and that shows Nepal is one of typical agricultural Least Developed Countries (LDC). The His Majesty’s Government of Nepal is making forceful efforts to keep social order, however, those excretions are suffered by frequent armed Maoist struggles which origin from poverty. Nepal locates geographically as a buffer zone between China and India and this fact means sustainable development of this country is an important factor in the regional security.

His Majesty’s Government of Nepal has tried to extend safe water supply systems which dedicate to secure people live under the Ninth Five Years Development Plan (Target Year 2001/2002). However, the rate of population served of the country is 71.6% by the end of the target year, whereas 28.4% of the people have yet to be served with potable water. Reduction of non served area of water supply is one of the most significant issues to be solved promptly hereafter.

To solve the poor status of water supply at national level His Majesty’s Government of Nepal has organized National Planning Commotion of Nepal and decided Tenth Five Years Development Plan (2002～07). The objectives for water supply under the plan are, (1) to achieve 85% service ration, (2) to improve quality of drinking water suitable for consumption, etc. And under this plan every effort, not only of the nation, local authorities but also Non-government Organizations (NGOs) and community organizations, would be directed to the efforts utilizing supports of all donors.

In this regard, His Majesty’s Government of Nepal requested the Government of Japan to extend a grant aid to water supply system in ten regions outside of the capital area. In response to the request Japan International Cooperation Agency (JICA) conducted an overseas project formulation study in 2003 and in this study eight regions were selected as the priority project area after the evaluation of project factors such as urgency and necessity of the project, accessibility to the sites, political stability, and maintenance capacity of the water supply originations etc. The Basic Design Study of Water Supply Facilities in Urban and Semi-Urban Centers was conducted aiming to improve life environment of the people in the project area

The Basic Design Study is conducted in two (2) Phases, taking project priority, effectiveness and scale into consideration. It was proposed that Phase-1 study covers three (3) areas, namely Dhulabari, Gauradaha and Mangadh while Phase-2 study covers five (5) areas, Manthali, Besisahar, Bhimeswor, Beljhunddi and Nepalgunj. Due to the political instability in the five areas proposed for the Phase-2 study, Birgunj and Janakpur are selected as Phase-2 Study areas instead of above five areas.

The results of the Phase-1 Study are summarized hearinafter.

The original requests by the Nepalese side and the proposed scope of works by this study are summarized in Table-1. Similar to other areas in trouble a lot of people are not served any water supply in the study area and even if they are served from existing water supply facilities the services are very poor affected by scariness of amount of water, temporary water supply and suspended service. Furthermore some waters from existing

facilities are not suitable to drink due to suffering from high turbidity, high ferrous density, or contamination. Those are the most urgent issues to be tackled.

Table-1 The Original Request by the Nepalese side and Proposed Scope of Works by This Study(Phase-1)

| No. | Item | Original Request | Basic Design | Remarks |
|---|---|---|---|---|
| **1. Facilities** | | | | |
| **A** | **Dhulabari** | | | |
| A-1 | Water Intake | Intake Weir x 1 | Intake Weir x 1 | Reconstruction |
| A-2 | Raw water transmission pipeline | HDPE pipes x 10.0km<br>River crossing bridges | Pipe length 11.8km<br>Concrete and mesh cage protection for river crossing pipes. | Due to the results of route survey. |
| A-3 | Water treatment plant | | | |
| | Treatment Facilities | Rapid filter x 1<br>(Coagulant feeders + sedimentation tanks + rapid filters) | Slow sand filter x 1<br>(Sedimentation tank + rough filters + slow sand filters)<br>Capacity: 4,326m$^3$/day | Changed filtration method to slow sand filtration due to its low O&M costs.<br>Proposed supply flow + water loss for treatment. |
| | Clear water reservoir | 500m$^3$x 1 | Approx. 600m$^3$x1 | |
| | Chlorination facility | 1 | 1 | For spring water |
| A-4 | New distribution facility | | | |
| | Elevated tank | 450m$^3$x1 (RC) | Approx.450m$^3$x1 (FRP) | At WUSC office site |
| A-5 | Rehabilitation of the existing distribution facility | | | |
| | Backup generator | ― | 1 unit | For existing tube well pump |
| | Disinfection facility | ― | 1 unit | For existing tube well water |
| A-6 | Distribution pipes | DI/GI pipes x 9.0km | Pipes approx. 6.7km | Due to the results of route survey. |
| A-7 | Flow meter | 4 | 4 | Installed at inlet and outlet of WTP, two outlets of elevated tank. |
| **B** | **Gauradaha** | | | |
| B-1 | Water treatment and distribution facility | | | At WUSC office site |
| | Iron removal plant (IRP) | 1 | 1 (Capacity: 1,100m$^3$/day) | |
| | Clear water reservoir | 300m$^3$x1 | Approx. 300m$^3$x1 | |
| | Lift pumps for elevated tank | ― | 2 (including one stand-by) | |
| | Backup generator | ― | 1 unit | For existing tube well pump |
| | Chlorination facility | 1 | 1 unit | |
| B-2 | Distribution pipes | HDPE x 6.0km | Pipes approx. 6.1km | |
| B-3 | Flow meters | 2 | 2 | Installed at inlet of IRP, outlet of elevated tank |
| **C** | **Mangadh** | | | |
| C-1 | Water treatment and distribution facility | | | At WUSC office site |
| | Iron removal plant (IRP) | 1 | 1 (Capacity: 2,200m$^3$/day) | |
| | Clear water reservoir | 300m$^3$x1 | Approx. 300m$^3$x1 | |
| | Lift pumps for elevated tank | ― | 2 (including one stand-by) | |
| | Backup generator | ― | 1 unit | For existing tube well pump |
| | Chlorination facility | 1 | 1 unit | |
| C-2 | Flow meters | 2 | 2 | Installed at inlet of IRP, outlet of elevated tank |
| **2. Soft Component** | | | | |
| A | | | Technical support for water supply facility operation and | |

| | | | | |
|---|---|---|---|---|
| | | | maintenance | |
| B | | | Support for institutional development of WUSC | |

The project objective is to provide reliable safe drinking water supply to more people in the study area and consequently living environment of the study area will be improved through surplus safe drinking water.

The water demands in the study area in the target year, 2014 are expected 4,200m$^3$/day for Dhulabari, 1,100m$^3$/day for Gauradaha and 2,200m$^3$/day for Mangadh in design maximum daily supply respectively. The capacities of water supply facilities are to be met those requirements. Whereas compared to the ferrous concentration in WHO water quality guidelines is 3mg/L current waters are 2.6～8.64mg/L in Gauradaha, 2.2～5.7mg/L in Mangadh respectively.

In addition to the construction of water supply facilities which will contribute to improve water quality of water from existing facilities and to solve the problem of water shortage in three study areas, another objective of this aid cooperation project is to support human resource development in operation, maintenance and management for the effective water supply operation management. The both sides decided to plan the project in accordance with the following policies on the basis of the requested components and the result of the field study and discussions.

In Dhulabari existing spring water source is not suitable for potable due to high turbidity in rainy season. To improve this issue, constructions of a water treatment plant and disinfection facilities are proposed. Regarding treatment method, the initial requested method was rapid sand filtration which requires coagulation chemicals, however, to reduce cost of operation and maintenance and to relive burden of operation and maintenance slow sand filter was selected considering needless of chemical dosage and reduction of electricity consumption. To retain enough amount of water supply newly water intake weirs are proposed and newly raw water transmission pipes, treated water transmission pipes and elevated tanks are proposed. Furthermore main distribution pipes are proposed to reinforce the function of distribution network.

In Gauradaha iron concentration of existing wells too high for potable water and to solve this issue and supply safe potable water iron removal facilities and disinfection facilities are proposed. For iron removal facilities the method same as the conventional systems in the neighboring areas in Nepal is proposed. And main distribution pipes are proposed to reinforce the function of distribution network.

In Mangadh, similar to Gauradaha, iron concentration of existing wells too high for potable water iron removal facilities and disinfection facilities are proposed.

Over and above, due to frequent occurrences of electric power failure in above three areas backup generators are proposed to secure the water supply.

The components of project of the basic design are shown in Table 2.

Taking into account the dimensions of the construction facilities single fisical year is proposed for implementation of construction. The implementation terms up to construction are; for the detailed design and tendering 5.5 months, and for the construction works 10.5 months are required respectively.

Total project cost is estimated 1,119 million JPY (1,112 million JPY born by the Japanese Government and 7 million JPN born by the Nepalese side respectively)

Table-2 The Components of the Project

| No. | Item | Specification | Quantity | Remarks |
|---|---|---|---|---|
| **1. Facilities** | | | | |
| **A** | **Dhulabari** | | | |
| A-1 | Water Intake | Intake Weir | 1 | Reconstruction |
| A-2 | Raw Water Transmission Pipeline | φ150～225mm | Approx.11.8km | Newly Construction |
| A-3 | Water Treatment Plant | | | |
| | Treatment Facilities | Slow Sand Filter （Sedimentation Tank＋Rough Filter ＋Slow Sand Filter） Design Treatment Flow：4,326m$^3$/day | 1 | Newly Construction |
| | Clear Water Reservoir | RC Approx.600m$^3$ | 1 | Newly Construction |
| | Chlorination Facility | Powdered Chorine Dissolving Tank & Feeding Equipment | 1 unit | Newly Construction |
| A-4 | New Distribution Facility | | | |
| | Elevated Tank | FRP Approx.450m$^3$ | 1 | Newly Construction |
| A-5 | Existing Distribution Facilities | | | |
| | Backup Generator | Building for Backup Generator, Backup Generator | 1 unit | Newly Construction |
| | Chlorination Facility | Powdered Chorine Dissolving Tank & Feeding Equipment | 1 unit | Newly Construction |
| A-6 | Distribution Pipe | φ63～300mm | Approx. 6.7km | Newly Construction |
| A-7 | Flow Meter | Mechanical | 4 | Newly Construction |
| **B** | **Gauradaha** | | | |
| B-1 | Water Treatment and Distribution Facility | | | |
| | Iron Removal Plant(IRP) | Aeration + Filter Design Treatment Flow：1,100m$^3$/day | 1 | Newly Construction |
| | Clear Water Reservoir | RC Approx.300m$^3$ | 1 | Newly Construction |
| | Elevated Tank Lift Pump | | 2 (1for stand-by) | Newly Construction |
| | Backup Generator | Building for Backup Generator, Backup Generator | 1 unit | Newly Construction |
| | Chlorination Facility | Powdered Chorine Dissolving Tank & Feeding Equipment | 1 unit | Newly Construction |
| B-2 | Distribution Pipe | φ63～160mm | Approx. 6.1km | Newly Construction |
| B-3 | Flow Meter | Mechanical | 2 | Newly Construction |
| **C** | **Mangadh** | | | |
| C-1 | Water Treatment and Distribution Facility | | | |
| | Iron Removal Plant(IRP) | Aeration + Filter Design Treatment Flow：2,200m$^3$/day | 1 | Newly Construction |
| | Clear Water Reservoir | RC Approx.300m$^3$ | 1 | Newly Construction |
| | Elevated Tank Lift Pump | | 2 (1for stand-by) | Newly Construction |
| | Backup Generator | Building for Backup Generator, Backup Generator | 1 unit | Newly Construction |
| | Chlorination Facility | Powdered Chorine Dissolving Tank & Feeding Equipment | 1 | Newly Construction |

| | | | | |
|---|---|---|---|---|
| C-2 | Flow Meter | Mechanical | 2 | Newly Construction |
| **2. Soft Component** | | | | |
| A | Technical Support for water supply facility operation and maintenance | | | |
| B | Support for institutional development of WUSC | | | |

Water supply amount is expected to increase and qualities of supplied water are expected to improve by the implementation of the project. Then the water demand of people in the study area will be fulfilled and sustainable safe water supply will be achieved.

Direct and indirect effectiveness of the project are as follows.

(1) Direct Effectiveness

Following effectiveness are expected by implementation of the project.

a) Dhulabari

①Increase of water supply capacity: Current water supply capacity of approx. 700m$^3$/day will increase from to 4,200m$^3$/day

②Increase of water supply hour: Current average water supply hour of 8.6 hours will increase to approx. 15 ～24hours

③Improvement of water quality: Water quality will be improved by the construction of water treatment plant and water supply amount will be secured by the augmentation of clear water reservoir, intake weir and elevated tank.

b) Gauradaha

Improvement of water quality: Water quality will be improved by the construction of iron removal plant from current ferrous concentration (2.6～8.64mg/L) to the required level of WHO guidelines（below 0.3mg/L）.

c) Mangadh

Improvement of water quality: Water quality will be improved by the construction of iron removal plant from current ferrous concentration (2.2～5.7mg/L) to the required level of WHO guidelines（below 0.3mg/L）.

As to operation and maintenance all of the water supply facilities will be operated and maintained with oriented management by the implementation of proposed soft components. And effective operation of implementation organization will achieve water works management and operation and maintenance planning with well understanding of water utility management.

(2) Indirect Effectiveness

Due to the construction of water treatment plant and disinfection facilities water supply facilities will be improved, water supply amount and server population will increase in accordance with improvement of water quality, water borne disease such as diarrhea and typhoid will decrease and consequently health of people will be expected to improve.

In addition to the above mentioned great expected effectiveness the implementation of the project will contribute to improve BHN of people and the necessity of the implementation of grant aid by the Japanese Government is significant.

To achieve the project effectively and efficiently the recipient country government is required following initial involvements.

(a) Currently each WUSC is managing tariff collection and accounting tasks, however, the management is vulnerable. Even though as things are, if they become competent to plan water works management and operation maintenance sustainable management could be achieved. Therefore to organize appropriate tariff system and to restructure organization eligible to sustainable operation and maintenance and collect necessary tariff and run sound management.

(b) Corresponding to the increasing population appropriate water distribution extension scheme should be implemented to uncovered service areas.

(c) Appropriate regulations for illegal encroachment, solid waste disposal and etc. in surrounding peripheral areas of water resources should be taken to prevent contamination.

(d) After the implementation of the project promotion of new house connection supply should be taken utilizing increased water supply amount.

(e) Requirement for the implementation of the project

- The Nepalese side takes appropriate actions to arrange budget for the allocated project cost (regarding land acquisition, fence works for the sites of water intake facility and water treatment plant, power supply line works).
- The Nepalese side takes appropriate actions to arrange regulatory permissions and approvals required fort construction of project components.
- DWSS, WSSD and WUSC involve in the detailed design and understand the planning contents and try to acquire technical skills.

Basic Design Study on the Project for the Improvement of Water Supply Facilities in Urban and Semi-Urban Centres

Phase-1

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## Abbreviations

| | |
|---|---|
| ADB | Asian Development Bank |
| DIP | Ductile Iron Pipe |
| DWSS | Department of Water Supply and Sewerage |
| EIA | Environmental Impact Assessment |
| EOJ | Embassy of Japan |
| GI | Galvanized Iron Pipe |
| GOJ | Government of Japan |
| HDPE | High Density Polyethylene Pipe |
| HMG/N | His Majesty’s Government of Nepal |
| IEE | Initial Environmental Evaluation |
| JICA | Japan International Cooperation Agency |
| MPPW | Ministry of Physical Planning and Works |
| NGO | Non-government Organization |
| NPC | National Planning Commission |
| Nrs | Nepal rupees |
| NWSC | Nepal Water Supply Corporation |
| PVC | Polyvinyl Chloride Pipe |
| RC | Reinforced Concrete |
| SP | Steel Pipe |

| | |
|---|---|
| VDC | Village Development Committee |
| WB | World Bank |
| WHO | World Health Organization |
| WSSDO | Water Supply and Sanitation Division Office |
| WUSC | Water Users and Sanitation Committee |

# 1. Background of the Project

The Kingdom of Nepal (hereinafter "Nepal"), the country land extends north to south with length of 200km and the climatic streak features diverse from subtropical to polar ones. Gorges from high mountains of Himalaya which run from north to south hinder mountainous areas from construction of infrastructures. The Gross Domestic Product (GDP) per capita is USD 236 and that shows Nepal is one of typical agricultural Least Developed Countries (LDC). The His Majesty's Government of Nepal is making forceful efforts to keep social order, however, those excretions are suffered by frequent armed Maoist struggles which origin from poverty. Nepal locates geographically as a buffer zone between China and India and this fact means sustainable development of this country is an important factor in the regional security.

His Majesty's Government of Nepal has tried to extend safe water supply systems which dedicate to secure people live under the 9$^{th}$ Five Years Development Plan (Target Year 2001/2002). However, the rate of population served of the country is 71.6% by the end of the target year, whereas 28.4% of the people have yet to be served with potable water. Reduction of non served area of water supply is one of the most significant issues to be solved promptly hereafter.

To solve the poor status of water supply at national level His Majesty's Government of Nepal has organized National Planning Commotion of Nepal and decided the 10$^{th}$ Five Years Developement Plan (2002〜07). The objectives for water supply under the plan are, (1) to achieve 85% service ration, (2) to improve quality of drinking water suitable for consumption, etc. And under this plan every effort, not only of the nation, local authorities but also Non-government Organizations (NGOs) and community organizations, would be directed to the efforts utilizing supports of all donors.

In this regard, His Majesty's Government of Nepal requested the Government of Japan to extend a grant aid to water supply system in ten regions outside of the capital area. In response to the request Japan International Cooperation Agency (JICA) conducted an overseas project formulation study in 2003 and in this study eight regions were selected as the priority project area after the evaluation of project factors such as urgency and necessity of the project, accessibility to the sites, political stability, and maintenance capacity of the water supply originations etc. The Basic Design Study of Water Supply Facilities in Urban and Semi-Urban Centers was conducted aiming to improve life environment of the people in the project area

The Basic Design Study is conducted in two (2) Phases, taking project priority, effectiveness and scale into consideration. It was proposed that Phase-1 study covers three (3) areas, namely Dhulabari, Gauradaha and Mangadh while Phase-2 study covers five (5) areas, Manthali, Besisahar, Bhimeswor, Beljhunddi and Nepalgunj. Due to the political instability in the five areas proposed for the Phase-2 study, Birgunj and Janakpur are selected as Phase-2 Study areas instead of above five areas.

The results of the Phase-1 Study are summarized hearinafter.

The original requests by the Nepalese side and the proposed scope of works by this study are summarized in Table 1-1.

Table 1-1 The Original Request by the Nepalese side and Proposed Scope of Works by This Study

| No. | Item | Original Request | Basic Design | Remarks |
|---|---|---|---|---|
| **1. Facilities** | | | | |
| **A** | **Dhulabari** | | | |
| A-1 | Water Intake | Intake Weir x 1 | Intake Weir x 1 | Reconstruction |
| A-2 | Raw water transmission pipeline | HDPE pipes x 10.0km<br>River crossing bridges | Pipe length 11.8km<br>Concrete and mesh cage protection for river crossing pipes. | Due to the results of route survey. |
| A-3 | Water treatment plant | | | |
| | Treatment Facilities | Rapid filter x 1<br>(Coagulant feeders + sedimentation tanks + rapid filters) | Slow sand filter x 1<br>(Sedimentation tank + rough filters + slow sand filters)<br>Capacity: 4,326m$^3$/day | Changed filtration method to slow sand filtration due to its low O&M costs.<br>Proposed supply flow + water loss for treatment. |
| | Clear water reservoir | 500m$^3$x 1 | Approx. 600m$^3$x1 | |
| | Chlorination facility | 1 | 1 | For spring water |
| A-4 | New distribution facility | | | |
| | Elevated tank | 450m$^3$x1 (RC) | Approx.450m$^3$x1 (FRP) | At WUSC office site |
| A-5 | Rehabilitation of the existing distribution facility | | | |
| | Backup generator | − | 1 unit | For existing tube well pump |
| | Disinfection facility | − | 1 unit | For existing tube well water |
| A-6 | Distribution pipes | DI/GI pipes x 9.0km | Pipes approx. 6.7km | Due to the results of route survey. |
| A-7 | Flow meter | 4 | 4 | Installed at inlet and outlet of WTP, two outlets of elevated tank. |
| **B** | **Gauradaha** | | | |
| B-1 | Water treatment and distribution facility | | | At WUSC office site |
| | Iron removal plant (IRP) | 1 | 1 (Capacity: 1,100m$^3$/day) | |
| | Clear water reservoir | 300m$^3$x1 | Approx. 300m$^3$x1 | |
| | Lift pumps for elevated tank | − | 2 (including one stand-by) | |
| | Backup generator | − | 1 unit | For existing tube well pump |
| | Chlorination facility | 1 | 1 unit | |
| B-2 | Distribution pipes | HDPE x 6.0km | Pipes approx. 6.1km | |
| B-3 | Flow meters | 2 | 2 | Installed at inlet of IRP, outlet of elevated tank |
| **C** | **Mangadh** | | | |
| C-1 | Water treatment and distribution facility | | | At WUSC office site |
| | Iron removal plant (IRP) | 1 | 1 (Capacity: 2,200m$^3$/day) | |
| | Clear water reservoir | 300m$^3$x1 | Approx. 300m$^3$x1 | |
| | Lift pumps for elevated tank | − | 2 (including one stand-by) | |
| | Backup generator | − | 1 unit | For existing tube well pump |
| | Chlorination facility | 1 | 1 unit | |
| C-2 | Flow meters | 2 | 2 | Installed at inlet of IRP, outlet of elevated tank |
| **2. Soft Component** | | | | |
| A | | | Technical support for water supply facility operation and maintenance | |
| B | | | Support for institutional development of WUSC | |

# 2. Contents of the Project

## 2－1 Basic Concept of the Project

The 10th Five-Year Development Plan (2002 – 2007) devised by The National Planning Commission of Nepal in 2002 has set the following drinking water supply objectives:

1. Achieving 85% service ratio
2. Improving quality of drinking water suitable for consumption.

Through achieving those targets, people could live in improved health and sanitation condition, with lower morbidity by decrease of waterbore infectious diseases and economical growth and development.

To achieve the above water supply objectives, the Nepal Government has requested to the Japanese Government for assistance in the development and improvement of water supply systems for ten (10) sites outside of the capital area. In response to the request, the Japan International Cooperation Agency (JICA) dispatched a project formulation mission to Nepal, and the mission selected eight (8) priority projects (sites) after the evaluation of project factors such as urgency and necessity of the project, accessibility to the sites, political stability, and maintenance capacity of the water supply organizations etc. Among the comppnents of the project, taking considerartion into priorities, effectiveness of the implementation of survey and construction works, three sites, Dhulabari, Gauradaha and Mangadh have been selected for the Phase -1 basic design study.

The existing water supply systems in the study areas only manage to supply drinking water to around 14～34 percent of the population. The current services are hampered by insufficient water production, resulting in service disruption and low water pressure. And there is an urgent need for water quality improvement since the current supplied water has high turbidity, contains high level of iron and even polluted to the level that is not suitable for drinking purposes.

This study proposes construction of water treatment facility and additional water intakes in order to improve the existing water supply system, as well as institutional development plan for efficient operation and management of the Water Users and Sanitation Committee (WUSC). The proposed facilities will meet the water demands in 2014 with safe and reliable supply.

The proposed scopes of works by this study are summarized in Table 2-1.

Table 2-1 The Components of the Project

| No. | Item | Specification | Quantity | Remarks |
|---|---|---|---|---|
| **1. Facilities** | | | | |
| **A** | **Dhulabari** | | | |
| A-1 | Water Intake | Intake Weir | 1 | Reconstruction |
| A-2 | Raw Water Transmission Pipeline | φ150～225mm | Approx.11.8km | Newly Construction |
| A-3 | Water Treatment Plant | | | |
| | Treatment Facilities | Slow Sand Filter （Sedimentation Tank＋Rough Filter ＋Slow Sand Filter） Design Treatment Flow：4,326m$^3$/day | 1 | Newly Construction |
| | Clear Water Reservoir | RC Approx.600m$^3$ | 1 | Newly Construction |
| | Chlorination Facility | Powdered Chorine Dissolving Tank & Feeding Equipment | 1 unit | Newly Construction |
| A-4 | New Distribution Facility | | | |
| | Elevated Tank | FRP Approx.450m$^3$ | 1 | Newly Construction |
| A-5 | Existing Distribution Facilities | | | |
| | Backup Generator | Building for Backup Generator, Backup Generator | 1 unit | Newly Construction |
| | Chlorination Facility | Powdered Chorine Dissolving Tank & Feeding Equipment | 1 unit | Newly Construction |
| A-6 | Distribution Pipe | φ63～300mm | Approx. 6.7km | Newly Construction |
| A-7 | Flow Meter | Mechanical | 4 | Newly Construction |
| **B** | **Gauradaha** | | | |
| B-1 | Water Treatment and Distribution Facility | | | |
| | Iron Removal Plant(IRP) | Aeration + Filter Design Treatment Flow：1,100m$^3$/day | 1 | Newly Construction |
| | Clear Water Reservoir | RC Approx.300m$^3$ | 1 | Newly Construction |
| | Elevated Tank Lift Pump | | 2 (1for stand-by) | Newly Construction |
| | Backup Generator | Building for Backup Generator, Backup Generator | 1 unit | Newly Construction |
| | Chlorination Facility | Powdered Chorine Dissolving Tank & Feeding Equipment | 1 unit | Newly Construction |
| B-2 | Distribution Pipe | φ63～160mm | Approx. 6.1km | Newly Construction |
| B-3 | Flow Meter | Mechanical | 2 | Newly Construction |
| **C** | **Mangadh** | | | |
| C-1 | Water Treatment and Distribution Facility | | | |
| | Iron Removal Plant(IRP) | Aeration + Filter Design Treatment Flow：2,200m$^3$/day | 1 | Newly Construction |
| | Clear Water Reservoir | RC Approx.300m$^3$ | 1 | Newly Construction |
| | Elevated Tank Lift Pump | | 2 (1for stand-by) | Newly Construction |
| | Backup Generator | Building for Backup Generator, Backup Generator | 1 unit | Newly Construction |
| | Chlorination Facility | Powdered Chorine Dissolving Tank & Feeding Equipment | 1 | Newly Construction |
| C-2 | Flow Meter | Mechanical | 2 | Newly Construction |
| **2. Soft Component** | | | | |
| A | Technical Support for water supply facility operation and maintenance | | | |
| B | Support for institutional development of WUSC | | | |

# 2－2 Basic Design of the requested Japanese Assistance

## 2-2-1 Design Policy

### (1) Sector Target and Project Objectives

#### 1) Sector Target and Project Objectives

- Sector target: Improve the living environment of the study area through additional safe drinking water
- Project objectives: Provide reliable safe drinking water supply to more people in the study area

Specifically to extend water supply amount and increase served population with improvement of supply water quality which will meet to the target quality equivalent to the WHO Guidelines for Drinking Water Quality.

#### 2) Target Year

Target year is set at 2014, as proposed by the JICA project formulation study in 2004. The planning period shall be decided considering reliability of population projection and rationality of facility development. DWSS guidelines propose 15 years as planning period for area with annual population increase of more than two percent, and 20 years period for area with annual increase of less that two percent. The guidelines suggest the planning span be decided based on the economic situation and existing development plans.

The previous annual populations of proposed areas increase of 3.1 to 3.8 percent. Due to this high population growth, uncertainty of the future population growth and fear of proposing the excessive facility, the planning span for this study is set at 10 years, up to 2014.

#### 3) Strategy for natural conditions

The weather in the study area is sub-tropic and has monsoon (wet) season from June to September and dry season from October to May. The average annual rainfall differs from 1,500 mm to 3,000 mm. Eighty percent of rainfall occurs in the wet season and causies frequent landslides and flooding.

This weather condition will be taken into account for facility design and implementation schedule planning.

#### 4) Strategy for social conditions

In order to improve the financial satndng of the executing agency, water tariff shall be raised. Appropriate tariff system shall be proposed with due respect to income level and affordability of the residents and possible government subsidies thorough discussion with the executing agency.

#### 5) Strategy for laws, regulations and standards

The Nepal Government has yet to establish drinking water quality standards. Thus, the proposed water treatment facility shall produce drinking water of which quality meet WHO Drinking Water Gguidelines instead.

#### 6) Strategy for hiring local contractors and traded equipment and materials

To use of major local contractors will be considered for construction of water intakes, water treatment plant, water transmission pipelines and treated water reservoirs. Especially in Dhulabari where safety of foreigners is not secured, the maximum use of local contractors will be considered.

For water pipes, commonly used locally made HDPE pipes will be used for water intake pipes and water distribution pipes with less than 50 mm diameters. For larger diameter pipes, use of ductile iron (DI) pipe is proposed due to its durability and ease of installation. DI pipes, which are not manufactured in Nepal, will be imported from third countries.

#### 7) Strategy for operation and maintenance capacity of the executing agency

The proposed facility will be suitable for the executing agency in regard to operation and maintenance capacity, technical expertise and affordability for O&M costs. As the proposed treatment system will be new to the study area, soft component of the project will be proposed to strengthen operation and maintenance capacity of the executing agency.

#### 8) Strategy for grade of facility and equipment

The proposed water treatment plant shall produce good water quality, which meets WHO drinking water guidelines while achieving ease of operation with mainly manual controls.

#### 9) Strategy for construction methods, procurement methods and implementation schedule

Heavy rains in wet season and increased river flow may hamper progress of construction and access to some areas is restricted for Japanese nation. These factors shall be taken into account for implementation schedule and organization for construction and supervision.

## 2-2-2 Basic Design Plan

### 2-2-2-1 Dhulabari

#### (1) Basic Policy for Planning

Basic policies for planning considering natural conditions are enumerated as shown below,

- Since the intake point of surface water and some portions of the transmission pipeline are planned to be located in the mountainous area, structurally sound facilities and appropriate pipe materials will be used. Improvement/reinforcement of access roads for operation and maintenance shall be considered to avoid natural damage caused by land slides and falling rocks.
- Existing water supply is operated by gravity system that gains energy by the difference in elevation between the intake point and elevated tank. The system is connected to a new purification plant. The system has high hydrostatic pressure along the transmission pipeline route with high elevation.

Thus, high pressure pipe materials and valves will be selected. Moreover, countermeasures to release high pressure in the transmission pipeline shall be considered in designing the system.

- In the rainy season, the turbidity of raw water is reported to be high. The purification system shall be designed so as to be able to adopt with the fluctuation of turbidity.
- The Nepal side requests the construction of water bridge for the traverse of the Timai river. In the basic design, the structure for the traverse shall be planned to suit the design such as an inverted siphon which will be based on the result of topographic survey of traverse points.

Basic policies for planning to address social and economical conditions are itemized below,

- There is a refugee camp near the proposed site of a purification plant. The layout plan of the plant shall be designed so as to neither cause disruption nor dispute with refugees during the construction stage and subsequent operation and maintenance activities.
- As the new intake point is located below the cliff on the left side of the Timai River, so that new transmission pipeline is to be located near the cliff and parallel to existing pipeline which locates along the cultivated land in riverbed. Therefore for construction of the new transmission pipeline a temporary access road for pipeline installation shall be considered for security purposes.

Basic policies for construction method of facilities, procurement method of equipment and materials, and construction period are enumerated below,

- Some portions of the existing transmission pipeline are either difficult or not accessible to vehicular traffic. Improvement of existing road such as surface restoration shall be necessary for the construction of a purification plant. In construction sites where access is difficult to trucks and machineries, transportation of equipment and materials shall be done manually or by means of tractors.
- Construction works and mobility/land travel by Japanese personnel may be affected by the fluctuation of the water level of the river due to seasonal rainfall. Thus, the implementation system and schedule of construction activities including allocation and schedule of personnel will be evaluated.

Critical points for the planning in Dhulabari water supply system are as follows:

① Quality of water source is not potable without treatment due to high turbidity during rainy season. Thus, a new treatment facility will be considered to improve the water quality.

② Quantity of water supplied is inadequate to the water demand. It is mainly due to increaseof population which becomes more critical during the dry season. To increase intake volume, improvement of existing intake facility is necessary to be extended together with the expansion of water conveyance and distribution systems.

③ As existing transmission pipelines traversing the river are often damaged due to inappropriate structures and it causes interruption in conveying raw water during rainy season, improvement of the facilities and protective structures shall be considered.

## (2) Basic Items for Water Supply Planning

### 1) Project Area

Project area is Dhulabari in the Jhapa district. The area is mainly formed by Bazar that commercial stores close-set in the centre of the town. Its suburbs are housing area where households are separately distributed and its population has increased yearly. In the future plan, both areas will be able to deal with the same Bazar one due to the same living area.

Service area shall be Dhulabari that is formed by 6 wards. The project area is shown in Figure 2-1.

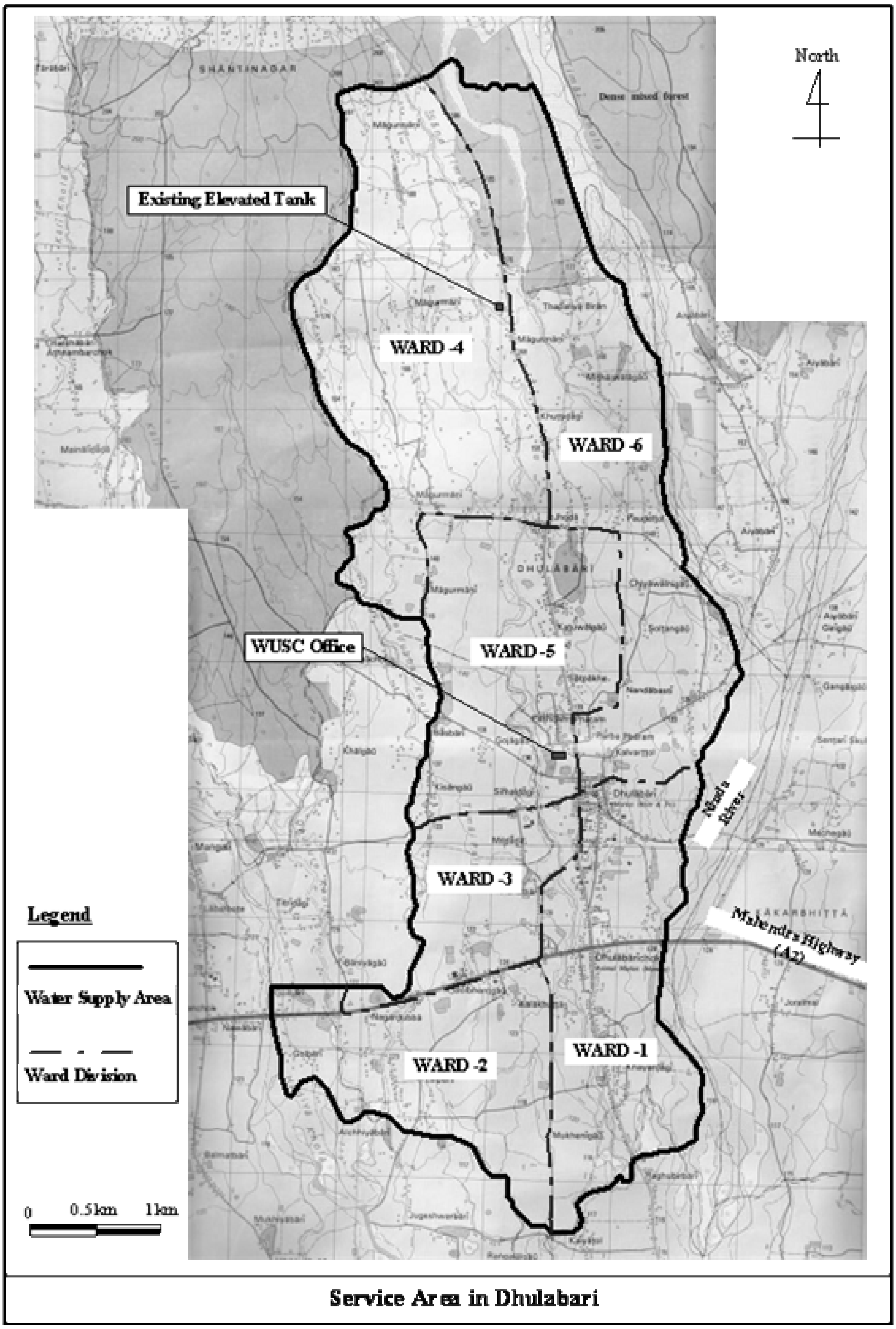


Figure 2-1 The project area in Dhulabari

**2)** Population Projection

Population projection was estimated using the population growth rate based on a 9 year data of the population statistics (1996-2004). Present status and population projection are shown in Table 2-2 and Table 2-3.

Yearly growth rate for the past 9 years ranges from 1.87 % to 3.94 % and after 2001 it has grown with yearly average 3.76 %. Based on actual status of recent 4 years (2001-2004), future growth rate of population was presumed to be 4 %. Based on this assumption, future population projection was carried out. As a result, future population projection in 2014 was estimated at 36,900.

Table 2-2 Population in Dhulabari

| Year | Population | Ratio of population increase (%) | Household |
|---|---|---|---|
| 1996 | 19,760 | | |
| 1997 | 20,130 | 1.87 | |
| 1998 | 20,610 | 2.38 | |
| 1999 | 21,050 | 2.13 | |
| 2000 | 21,500 | 2.14 | |
| 2001 | 22,320 | 3.81 | |
| 2002 | 23,200 | 3.94 | |
| 2003 | 24,040 | 3.62 | |
| 2004 | 24,920 | 3.66 | 3,872 |
| | | | |
| Average | | 3.76 | (2001～2004) |

Table 2-3 Prediction of inside population of water supply in Dhulabari

| Year | Population | Ratio of population increase (%) | Notes |
|---|---|---|---|
| 2005 | 25,918 | 4% | |
| 2006 | 26,955 | | |
| 2007 | 28,033 | | |
| 2008 | 29,154 | | |
| 2009 | 30,320 | | |
| 2010 | 31,533 | | |
| 2011 | 32,794 | | |
| 2012 | 34,106 | | |
| 2013 | 35,470 | | |
| 2014 | 36,900 | | Population Prediction |

### 3) Design Criteria for Water Supply

#### a) Service Connection

Present rate of service connection in Dhulabari was estimated at 34 % of the service area population based on the number of house connection as reflected in the billing and collection documents and the number of existing public taps.

This rate is expected to increase in the target year (2014) by 85 %, with the improvement of the main distribution pipelines and provision of additional water sources. Supply hours are likewise expected to increase. The existing public and community taps are expected to decrease from 30 to 11 taps by 2014.

#### b) Water Demand

Water demand rate to be adopted in the design are as follows;

- Domestic water demand for service connection (Daily average): 100 L/capita/day (DWSS Design Criteria)
- Water demand rate for public taps (Daily average):45 L/capita/day (DWSS Guideline)

#### c) Variation Coefficient

Variation coefficient means magnitude of variation of water demand. It was established based on the actual usage in Biratnagar City.

(Daily maximum value) / (Daily average value) = 1.2

#### d) Leakage Rate

Leakage rate was estimated to be 10 % based on survey results of "Final Report Task-2 for Providing Consulting Services for Development Study on Improvement of Water Supply Facilities in Urban Centres and Kathmandu Valley (March 2004) conducted by JICA Nepal office" and on the assumption that leakage rate is increasing by 1% per year as the system gets older.

#### e) Design Parameters

Design parameters in Dhulabari are shown below.

Table 2-4 Design Water Supply in Dhulabari

| | | Bazar | | Total | Notes |
|---|---|---|---|---|---|
| | | House Connection | Public Taps | | |
| Design Inside Population of Water Supply area | ① | 36,900 | | 36,900 | |
| Design Rate of Service Connection *1) | ② | 85% | | - | |
| Design Population Supplied in each Ward*2) | ③ | 31,365 | | 31,365 | ①×② |
| | | 30,661 | 704 | 31,365 | |
| Design Average Daily Supply per Capita (L/day/capita) *3) | ④ | 100 | 45 | - | |
| Design Average Daily Supply (Accounted-for Water) ($m^3$/day) | ⑤ | 3,066 | 32 | 3,098 | ③×④ |
| Leakage Rate | ⑥ | 10.0% | | - | |
| Design Average Daily Supply ($m^3$/day) | ⑦ | 3,407 | 35 | 3,442 | ⑤/(1-⑥/100) |
| Variation Coefficient *4) | ⑧ | 1.2 | | - | |
| Design Maximum Daily Supply ($m^3$/day) | ⑨ | 4,088 | 42 | 4,130 | ⑦×⑧ |
| Design Facility Water Supply ($m^3$/day) | ⑩ | | | **4,200** | |

*1) Rate of Service Connection：National target can be attained in 2014 based on the improvement conditions of existing distribution pipeline system.

*2) Population Served of Public Taps : 11 places×10 HHs×6.4 persons/family＝704 persons

*3) Design Average Daily Supply per Capita : DWSS Design Criteria

*4) Variation Coefficient (Daily maximum / Daily average) : Practical achievement

### (3) Intake Facilities

The water sources in Dhulabari are mostly springs, which are located approximately 10 km north of Dhulabari VDC and originates from fissures of fault zone located on the left bank steep slope of the Timai River. The JICA Study team confirmed five springs, of which two springs have relatively large capacity. These two spring sources converge with the surface water (streams) before reaching the first water tank. Then, at the second underground water tank located further downstream, some other streams coming from small capacity springs converge with the main stream. From the second underground tank, the water flows down by gravity through a transmission pipe to an elevated tank located at the lowland area.

The Study Team carried out discharge measurement at spring sites and stream channels by different methods depending on the site conditions. At springs/streams with relatively large flow, current meter method is used. However, at springs/streams with small discharge, overflow-weir method or bucket with stopwatch method is used. In addition to the flow measurement mentioned above, additional measurement was also carried out at another spring, which is located upstream side of the two major springs. This spring has not been tapped yet. The result was 0.44 L/s there. It was confirmed that the total capacity of spring sources is more than 10.0 L/s (864 $m^3$/day) in June (beginning of the rainy season).

It is necessary and desirable to carry out the flow measurement throughout the year to establish variations of flow by seasons. Accordingly, the Study Team requested the WSSDO and WUSC staff to conduct periodical measurement (twice a month). Table 2-5 shows the results on the flow measurement at Dhulabari spring sources up to August 2005. The Study Team will carry out more detailed analyses during the next field survey period on the available capacity of the water sources based on additional data of flow measurement.

Table 2-5 Flow Measurement at Dhulabari Spring Source

| No. | DATE | Overflow Depth at Rectangular Weir | | Overflow Coefficient | Discharge | |
|---|---|---|---|---|---|---|
| | | (cm) | (m) | C | ($m^3$/s) | (L/s) |
| 1 | 15 July 2005 | 5.0 | 0.0500 | 1.8400 | 0.1234 | 12.34 |
| 2 | 31 July 2005 | 5.5 | 0.0550 | 1.8330 | 0.1419 | 14.19 |
| 3 | 16 August 2005 | 13.75 | 0.1375 | 1.8178 | 0.5561 | 55.61 |
| 4 | 31 August 2005 | 15.00 | 0.1500 | 1.8220 | 0.6351 | 63.51 |

The Study Team estimated the potential recharge to the groundwater by applying the Tank Model method. For the analyses by simulation of tank model method, four tanks are assumed. As input data, the basin area at the water sources and the daily rainfall data at the Gaida (Kankai) agri-meteorological observatory are used. The results of analyses show that the average recharge capacity is 52.7 L/s (recharge ratio of 7%) during the rainy season (June - September) and 10.3 L/s (recharge ratio of 10%) during the dry season (October - May).

Table 2-6 Groundwater Potential Simulations by Tank Model Method

(Unit: L/s)

| Rainy Season | | Dry season | |
|---|---|---|---|
| Period | Recharge | Period | Recharge |
| Jun - Sep 1988 | 43.8 | Oct 1988 - May 1989 | 11.6 |
| Jun - Sep 1989 | 69.2 | Oct 1989 - May 1990 | 15.4 |
| Jun - Sep 1990 | 59.3 | Oct 1990 - May 1991 | 5.9 |
| Jun - Sep 1991 | 58.6 | Oct 1991 - May 1992 | 8.2 |
| Jun - Sep 1992 | 40.9 | Oct 1992 - May 1993 | 9.5 |
| Jun - Sep 1993 | 53.5 | Oct 1993 - May 1994 | 12.9 |
| Jun - Sep 1994 | 43.6 | Oct 1994 - May 1995 | 6.5 |
| Jun - Sep 1995 | 47.6 | Oct 1995 - May 1996 | 11.4 |
| Jun - Sep 1996 | 53.6 | Oct 1996 - May 1997 | 8.4 |
| Jun - Sep 1997 | 45.8 | Oct 1998 - May 1999 | 8.2 |
| Jun - Sep 1998 | 74.4 | Oct 1999 - May 2000 | 8.0 |
| Jun - Sep 1999 | 54.9 | Oct 2000 - May 2001 | 12.5 |
| Jun - Sep 2000 | 56.9 | Oct 2001 - May 2002 | 9.1 |
| Jun - Sep 2001 | 38.3 | Oct 2002 - May 2003 | 14.8 |
| Jun - Sep 2002 | 41.8 | Oct 2003 - May 2004 | 8.0 |
| Jun - Sep 2003 | 47.6 | Oct 2004 - May 2005 | 14.6 |
| Jun - Sep 2004 | 65.6 | | |
| Average | 52.7 | Average | 10.3 |

Analyzing the present condition of water source mentioned above, basic design for the water source facilities was proposed. With regard to the main water source (springs at Dhulabari), the existing intake weir is small and can only collect very limited discharge from the springs. From the engineering point of view, laying of several collect pipes on the slope and construction of a new intake weir as illustrated in Figure 2-2 Intake Facilitiesis recommended to fully collect the discharge from the fissures. In addition, Table 2-7 shows the outline of water source development project at Dhulabari.

Table 2-7 Outline of Water Source Development Project at Dhulabari

| Project Contents | |
|---|---|
| ① | Remove the existing intake weirs |
| ② | Construction of a new intake weir cross all the slope (Two intake weirs connected by conduit pipes) |
| ③ | Quantity of water intake<br>Rainy season (June - September): 52.7 L/s<br>Dry season (October - May) : 10.3 L/s |
| ④ | Water quality<br>Removing the high turbidity after raining by newly proposed water treatment plant to meet the WHO criteria (< 5 NTU) |

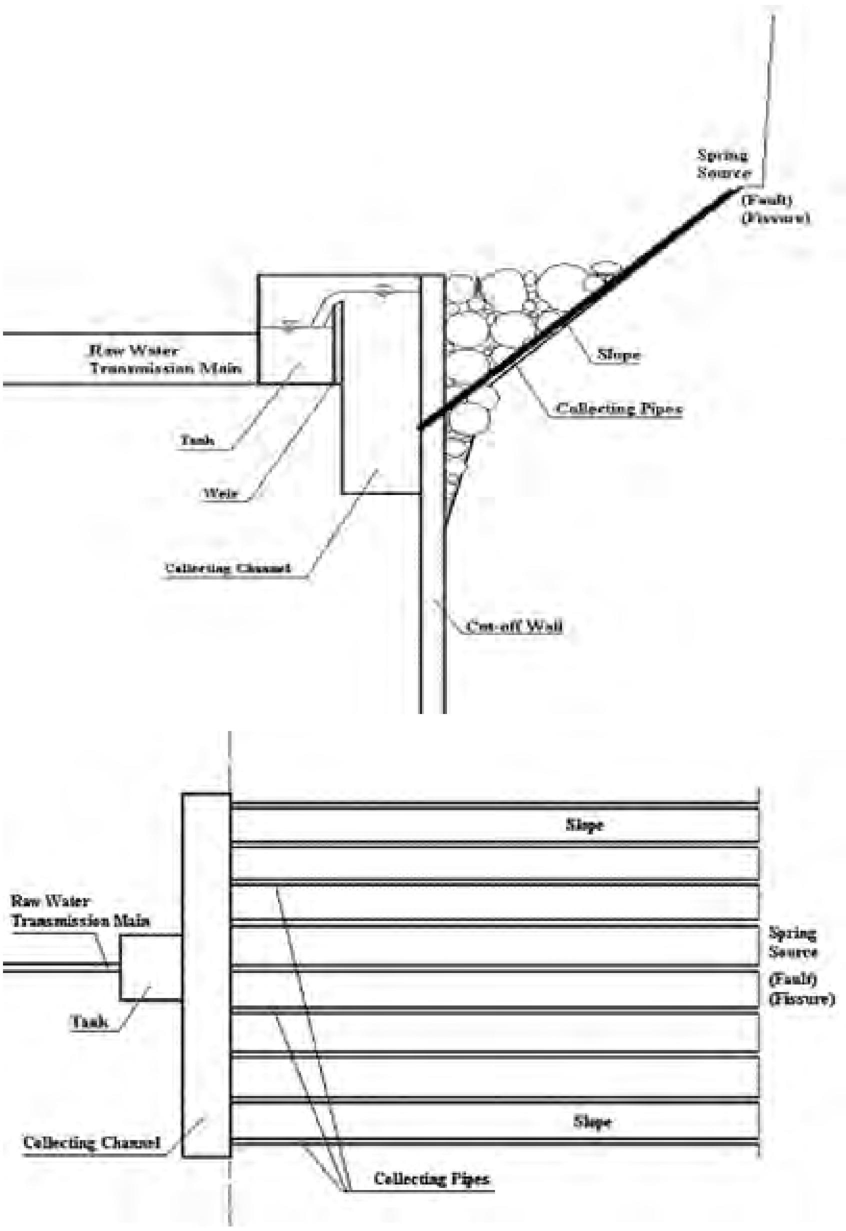


Figure 2-2 Intake Facilities

After completion of the intake facility, collected water in rainy season will meet the demand. However, the flow will drop in dry season. Even if a well near the existing elevated tank is utilized, total water will not meet the demand. The duration of water supply in dry season is more than 15 hours/day, it will be longer than that of the existing condition, and thus, effevtiveness on improvement is high.

- Total anticipated flow of raw water in dry season (1,000m$^3$ /day) plus well water (1,700m$^3$ /day) is 2,700 m$^3$ /day .
- Expected duration of water supply in dry season is 2,700 m$^3$ divided by 4,200 m$^3$ times 24 hours. The result is 15.4 hours.
- According to the result of water quality analysis of well water iron removal plant is not neccssary.

## (4) Plan of Treatment Plant and Distribution Facilities

### 1) Raw Water Transmission Facility

- Extent of the raw water facility: Intake to New treatment plant
- Design Flow: 4,320 m$^3$ per a day including losses in treatment process

A gravity flow system is applied similar to the existing facility for raw water transmission, taking advantage of the topographical feature i.e. 100 meters of water head available between the intake and treatment plant. The existing transmission pipe will be utilized and the new transmission pipe will be designed to accommodate the excess flow. Design flow rate of the new transmission pipe is 33 litre per a second (or 2,850 m$^3$ per a day) including 3 % of losses in treatment process and use in the treatment plant.

The route of the transmission pipe is shown in Figure 2-3 Plan of Treatment Plant and Distribution Facilities. The alignment of the new pipe is in parallel with the existing pipe and its location is river bank side. An alignment of the pipe crossing Timai river is put at right angle to the river flow. Steel pipes jointed by welding and embedded in concrete will cross the river and placed 1.5 meter below the river bed to the top of the pipe. The space in length of the embedded concrete plus 1.5 meter in the both upstream and downstream sides and 1.5 in depth will be filled with gabion to protect the pipe. The capacity of the pipe at the crossing will be designed to carry the total flow rate of the water supply system i.e. 50 liter per a second. (or 4,326 m$^3$ per a day)

Nominal diameter and length of the pipes are summarized in Table 2-8.

Table 2-8 Nominal Diameter and Length

| No. | Site | Flow Rate (l/s) | ND & Pipe Material | Length (m) |
|---|---|---|---|---|
| 1 | Intake to River Crossing | 33 | φ150 HDPE | 1,800 |
| 2 | River Crossing | 50 | φ200 SP | 135 |
| 3 | River Crossing to Treatment Plant | 33 | φ150 HDPE | 895 |

Ground level at the intake and the treatment plant is 380 meter and 280 meter above sea level respectively. Hydrodynamic water head at the receiving well in the plant is approximately 20 meter. Considering the design flow rate of 33 litres per a second, the type of flow control at the intake of the receiving well should be selected to control damage in the pipe lining.

Due to the excessive elevation head, narrow alignment and location of existing utilities, the selection of materials for transmission pipes will take into account the durability for internal pressure and external loads as well as workability. Applicable pipes are Steel Pipe (SP), Ductile Iron Pipe (DIP), and High Density Polyethylene Pipe (HDPE). DIP has disadvantage in weight compared to other pipes. SP requires not only high skill for jointing i.e. welding but also complicated associated works such as trench works, welding works, protection works at welded place, etc. These works requires longer time than jointing works of DIP and HDPE, thus, SP has disadvantage in workability.

The pipe route located near the existing pipe and irrigation channel are the difficult portions of the new transmission pipeline.

Therefore, HDPE is the recommended pipe material (lightweight and flexible) for the transmission pipelines, while SP will be utilized for river crossings.

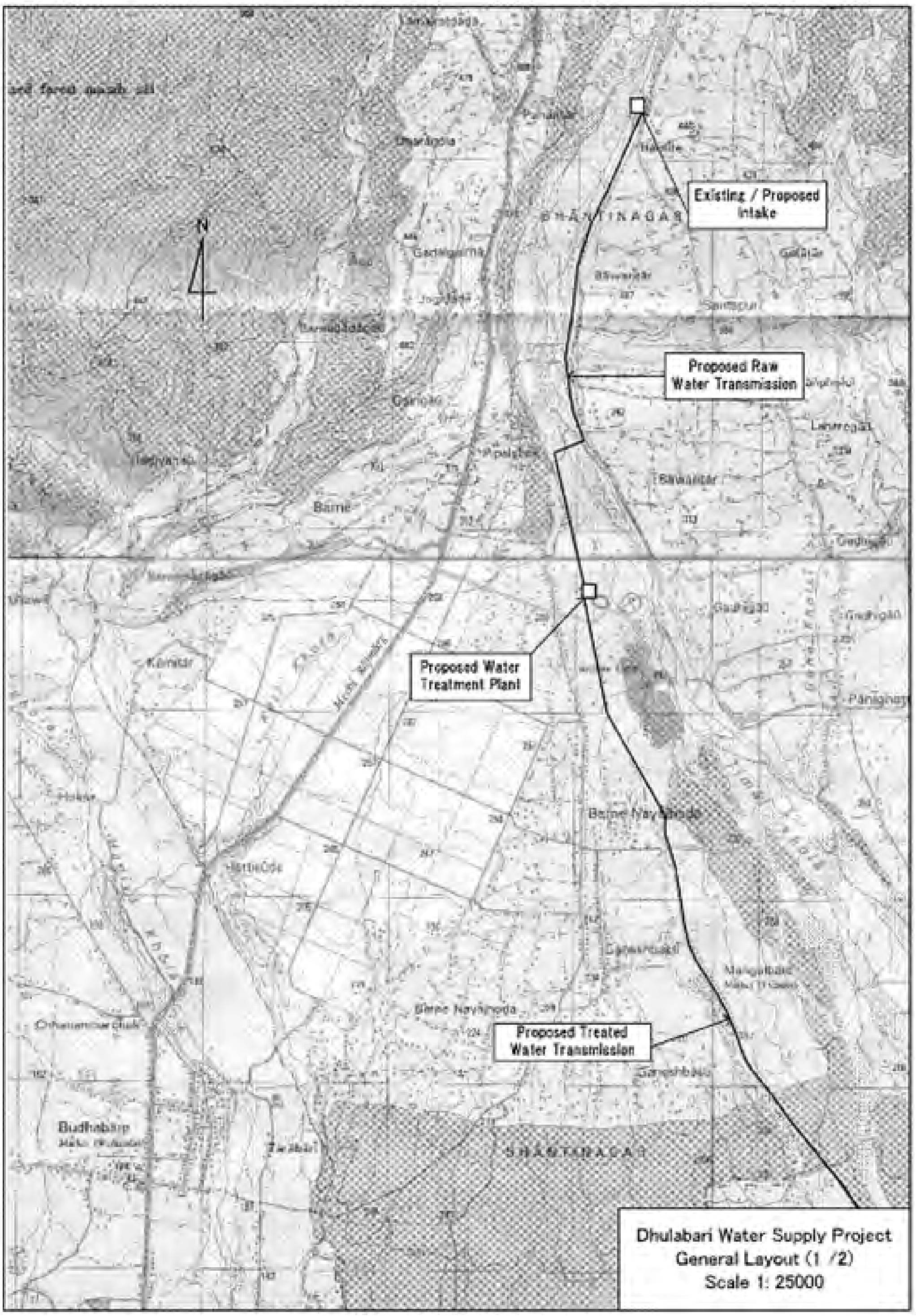


Figure 2-3 Plan of Treatment Plant and Distribution Facilities

## 2) Water Treatment Facilities

The treatment fcility capacity, the dasign maximum daily capacity is 4,326m$^3$/day; this figure includes desisn water supply of 4,200m$^3$/day and loss and consumption of 3 % in the process.

Initial required function of the plant was to remove turbidity, however, due to evade the risk of faces contamination the selection of treatment method should be taken it into consideration. The results of field suvey of raw water qualities show all of indicators do not satisfy WHO Guidelines for Drinking Water Quality except bacterial indicators.

The turdidity of the sample taken in rainy season was 220 NTU (the sample was taken on September 15, 2005 while raining) and two hours after raining it decreased to 38 NTU. The transient high value of turbidity can be assumed as a result of piled earth and sand on the slope above the aquifer flashed, discharged and mixed in water resource. On that account the selection of treatment method is basially focused on removal of undisolved contents (suspended substance, bacteria) and is considred to desin facility which retains capabitility correspodible to the transient high value of turbidity.

Generally filtration is practical method to remove undissolved contents. Two types of filtrations are mainly adopted: slow sand filter and rapid sand filter. Followings are the processes arranged two filtration methods.

Type A: (Slow sand filtration)

Sedimentation basin → Rough filter → Slow sand filter → Chlorination → Clear water reservoir / Transmission regulation reservoir

Type B: (Rapid sand filtration)

Sedimentation basin → Rapid sand filter → Chlorinatio n → Clear water reservoir / Transmission regulation reservoir

The comparision of both methods are shown in Table 2-9.

In consequence of the above comparision analysis there are advantages and disadvantages of both types; A Type is adopted for this project with highlighting following aspects.

- Correspoding to abrupt variation of turbdity, whereas A Type has a difficuty, B Type has an advantage because it is capable to adjust the coagulant quantity in accordance with the turbidity. However it has difficulty with adjusting to high turbidity, it is possible to control this issue by utilizing the sedimentation basin as a buffer basin.
- A Type does not require any chemeical (coagulant), and the electric consumption is less. Decreae in operation and maintenance cost can be achieved.
- Due to unnecessity of burdensome chemical injection control operation and maintenance becomes simmple.
- Compared to B Type A Type requires larger land area, however, all facilities are arranged suitably in acquisited site area.

Process flow diagram is shown in Figure 2-4 Process flow diagram and outline of each facility is as followings.

Table 2-9 Comparision of Type A and Type B

| Item | A Type | B Type | Remarks |
|---|---|---|---|
| Process Compsition | ② Sedimentation basin<br>③ Rough filter<br>④ Slow sand filter<br>⑤ Clear water reservoir / Transmission regulation reservoir<br>⑥ Chlorination | ① Sedimentation basin<br>② Rapid sand filte<br>③ Clear water reservoir / Transmission regulation reservoir<br>④ Chlorination | Both methods require chlorination. |
| Filtration Process | Slow sand filter:<br>Biological film of filter sand separates solids and organic matter, and dissolves them with oxidation biological activity. | Rapid sand filter:<br>Coagulaton treatmented flocs are separated by attaching to and filtration of finter media. | |
| Raw Water Turbidity | Only for slow sand filter up to 10 NTU is acceptable. Rough filter increases allowance up to 20 NTU. | Corresponding to high turbidity chemical dosing rate would be increased. Vulnerability to abrupt variation of turbility of much note. | |
| Dissolved matter removal competence | Possible to accept on condition below allowance limit: higher than rapid sand filter | Lower than slow sand fintrarion | In case good quality and low turbidity of source water, slow sand filtration is substantially adopted. Discolved matter suvh as ammonium nitrogen, odor, iron, manganese, etc., are possible to be removed bellow allowance limits. |
| Pretreatment | In case turbidity excesses 30 NTU coagulation sedimatation is required e.g. sedimatation tank, Rough filter. | Coagulation sedimatation is inevitable. | |
| Facility area | Compared to rapid sanf filter, 30 times of area is required. | Compared to alow sand filter one thirtieth of area is required. | Vast area is required for large-scale water treatement plant. |
| Sand Cleaning | Sand cleaning is not required for slow sand filter but it is required for rough filter. However cleaning frequency is lower than one of rapid sand filter. | Required | Water for cleaning and cleaning facility are required. |
| Filter scraping removal | Required | Required | Scraped sand claning facity is required. |
| Chemical | Not required | Permanent cagulant supply is required. | Generally aluminum sulfate is used for coagulant. |
| Construction cost | Compared to B Type the number of facilities is larger. Easpecially the area of fiter itself turns drastically larger than one of B type. Consequently the consruction cost becomes high. | Compared to A Type the area becomes smaller due to unoccupation of slow sand filter. | |
| Operation and maintenance cost | Costs for rough filter cleaning and sand scraping are required. | In addition to cost for chemical (coagulant) cleaning cost for rapid sand filter is required. | Generally sand scraping removal is required once a week, and cleaning of rapid sand filter is required once a week. |

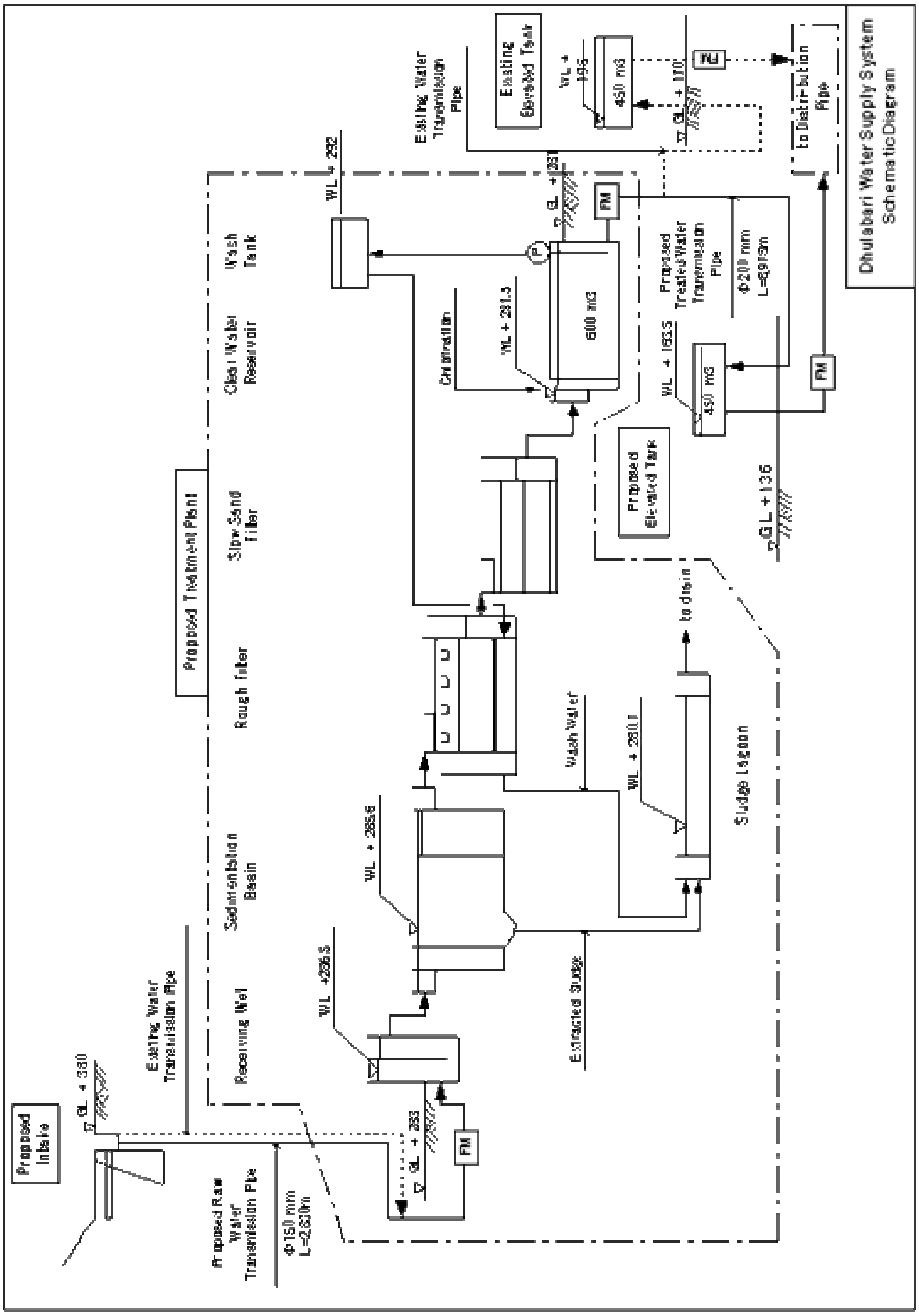


Figure 2-4 Process flow diagram

### 3) Sedimentation Basin

A result of observation on intake site will conclude that erosion of the slope by heavy rain will rise turbidity of raw water. A sedimentation basin or raw water reservoir is recommended to avoid clogging and to prevent high turbid water from entering the treatment facility. Retention time in the sedimentation basin will be 2 hours in consideration of time needed to inform the operator to shutdown the intake facility. Extraction of settled sludge will be done manually after draining the basin.

**4)** Rough Filter

Rough filter will lower the turbidity level by 50%, thus, reducing the load of the slow sand filter. Three types of rough filter are usually applied, i) horizontal flow type: ii) gravity type: and iii) an upward flow type. A horizontal flow type requires more simple structure but flow rate is lower compared with other types. Flow rate applied to an upward flow type is larger than others, but washing and controlling is rather difficult than a gravity flow type. A gravity type with flow rate at 1.5 meter per hour is selected for this project because of easy washing.

**5)** Slow Sand Filter

Design filtration rate for slow sand filter is usually 4 to 5 meter per a day. Design filtration rate is assumed at 5 meter per a day in consideration of turbidity during heavy rain and 8 meter per a day on normal condition when raw water turbidity is low. Filter media, sand and gravel will be supplied from local market or neighboring countries.

**6)** Clear Water Reservoir

Clear water reservoir is provided to make continuous treatment process operation. The reservoir absorbs fluctuation of distribution flow and protects treatment facilities from change of flow. An additional new elevated tank is to be constructed in the city for this project. While volume of the new tank is not enough due to limit land area in the city, the total volume of the clear water reservoir and other elevated tanks is to have 8 hours of the maximum daily supply. Thus the volume of the reservoir should have 3 hours of the maximum daily supply.

**7)** Chlorination

Chlorination is applied in order to protect water from bacteria. No chlorination is applied to the present supply although Escherichia coli were observed in the result of water quality examination. Chlorination system with bleaching powder by gravity drop method which is commonly used in Nepal will be adopted in this project in consideration of rather small flow rate. Feeding ratio of chlorination is assumed at 3 ppm in view of the total length of transmission pipe and volume of reservoir.

**8)** Sludge Lagoon

Sludge lagoon will be provided to: i) dry extracted sludge from sedimentation basin: ii) receive wash water from rough filter: iii) drain water from reservoir and others. The volume of the lagoon will be designed to receive all wash water from rough filters.

**9)** Other Facilities

Water supply will be provided in the plant for dissolving chemical (bleaching powder) and water use in the plant. A washing machine and storage space is provided for scraping/cleaning sand from slow sand filter. An administration builing will be provided to accommodate the control room including quarters for the chief operator, office, storage, kitchen, toilet and space for the standby generator unit that will be provided in case of power failure.

**10)** Access road for Operation and Maintenance

Access road in the plant is necessary for receiving bleaching powder and carrying scraped sand. Likewise, access of heavy truck will be necessary for repair of equipment in the plant. To meet the requirement mentioned above, a 4 meter wide paved access road will be provided.

Specification of the treatment plant is summarized in Table 2-10 and Table 2-11

Table 2-10 Specification of Water Treatment Facility

| | | | | |
|---|---|---|---|---|
| 1 Capacity | Q = | | 4,326 m3／日 | ( 50 lit/s) |
| | | | including loss (3%) in the process and use | |
| 2 Receiving Well | | | | |
| Number of well | N = | | 1 unit | |
| Retantion Time | T = | | 4.5 min | |
| Volume | V = | | 13.5 m3 | |
| Dimensions | Width 1.5m x Length 3.2m x Depth 3.0m x 1unit | | | |
| Incidental Facilities | Weir | | 1 unit | |
| | Overflow Pipe (Φ150mm) | | 1 unit | |
| | Drain Pipe (φ100mm) | | 1 unit | |
| 3 Sedimentation Basin | | | | |
| Type | Rectangular Horizontal Flow | | | |
| Number of basins | N = | | 2 basins | |
| Retantion Time | T = | | 2 hours | |
| Volume | V = | | 210 m3 | |
| Dimensions | Width 5m x Length 13.4m x Depth 3.0m x 2 basins | | | |
| Incidental Facilities | Perforated Buffle Wall | | 1 unit | |
| | Trough | | 1 set | |
| | Deslufging Valve (φ150mm) | | 1 pcs／basin | |
| | Desludging Pipe (φ150mm) | | 1 unit | |
| | Flushing Pipe | | 1 unit | |
| 4 Rough Filter | | | | |
| Type | Gravity | | | |
| Number of filters | N = | | 4 filters | |
| Filtration Rate | V = | | 36 m／day | (1.5 m／hour) |
| Dimensions | Width 4.2m x Length 7m x Depth 1.3m x 4 filters | | | |
| Filter Media | 3 layers | | φ 24～50mm x 50 cm | |
| | | | φ 12～18mm x 30 cm | |
| | | | φ 8～12mm x 20 cm | |
| Underdrain Sysytem | Perforated Slub (RC) | | | |
| Washing | Washing Flow Rate | | 60 cm／min | |
| Piping | Inlet | Main | φ250 mm | |
| | | Branch | φ150 mm | |
| | Outlet | Main | φ250 mm | |
| | | Branch | φ150 mm | |
| | Wash Drain | Main | φ500 mm | |
| | | Branch | φ400 mm | |
| Incidental Facilities | Effuluent Weir | | 2 places | |
| | Wash Drain Pit | | 1 place | |
| | Wash Water Tank | | 150 m3 | |
| 5 Slow Sand Filter | | | | |
| Type | natural equilibrium type | | | |
| Number of Filters | N = | | 4 filters | (one for standby) |
| Filtration Rate | V = | | 5 m／day | (0.2 m／hour) |
| Dimensions | Width 14m x Length 16.5m x Depth 2.2m x 4 filters | | | |
| Filter Sand | Effective Size | | φ0.4 mm | |
| | Uniformity | | Less than 2.0 | |
| | Thickness | | 90 cm | |
| Supporting Gravel | 4 Layers | | φ 60 mm x 15 cm | |
| | | | φ 20～30mm x 10 cm | |
| | | | φ 10～20mm x 10 cm | |
| | | | φ 3～4mm x 10 cm | |
| Underdrain | Maim Pipe | | Φ300mm (PVC) | |
| | Brnch Pie | | φ100mm Perforated Pipe (PVC) | |
| Piping | Inlet | | φ200 mm | |
| | Outlet | | φ200 mm | |
| | Return | | φ100 mm | |
| | Drain | (Drain Pit) | φ100 mm | |
| Incidental Facilities | Inler Weir | | 1 set | |
| | Outlet Weir | | 1 set | |
| | Washing Sand Equipment | | 1 set | |

Table 2-11 Specification of Water Treatment Facility

| | | | |
|---|---|---|---|
| 6 | Clear Water Reservoir | | |
| | Number of Reservoir | N = | 2 reservoirs |
| | Retention Time | T = | 3 hour |
| | Capacity | V = | 625 m3 |
| | Dimensions | Width 10m x Length 20m x Depth 3m x 2 reservoirs | |
| | Piping | Inlet | φ250 mm |
| | | Outlet | φ250 mm |
| | | Overflow | φ150 mm |
| | | Drain | φ100 mm |
| 7 | Chlorination Equipment | | |
| | Chemical | Bleaching Powder | |
| | Dosage Ratio | Max | 3 ppm |
| | | Average | 1 ppm |
| | Feeding Method | Gravity Drop | |
| | Feeding Point | at inlet | |
| | Storage Tank | Number of tanks | 2 units (1standby) |
| | | Capacity | 1 m3 |
| | Feeder | | 2 units (1standby) |
| 8 | Operaton Buildings | | |
| | Structure | RC Width 10m x Length 10m | |
| | | Entrance | 10 m2 |
| | | Chief Iperator Room | 10 m2 |
| | | Officr Room | 30 m2 |
| | | Labolarory | 9 m2 |
| | | Storage | 15 m2 |
| | | Rest Room | 26 m2 |
| 9 | Plant Water Supply | | |
| | Pump | 200 lit/min | 2 units (1standby) |
| | Tank | for 10 persons | 1 unit |
| 10 | Yard Piping | | |
| | Raw Water | | φ250 mm |
| | Flow Meter at Inlet | (Waltman Type) | φ200 mm |
| | Sedimentaion Basins to Rough Filters | | φ250 mm |
| | Rough Filters to Slow Sand Filters | | φ250 mm |
| | Slow Sand Filters to Clear Water Reservoirs | | φ250 mm |
| | Treated Water Transmission Main | | φ250 mm |
| | Flow Meter at Outlet | (Waltman Type) | φ200 mm |
| 11 | Land Scaping | | |
| | Land Scaping | | 1 set |

### (5) Treated Water Transmission / Distribution Pipe Networks

#### 1) Treated Water Transmission Pipe

Extent of pipe: the new treatment plant to the existing and the new elevated tanks.

The total design flow rate is 4,200 $m^3$ per a day or 49 litre per a second. Design flow rate of the new pipe is 32 litre per a second.

The new pipe is ND 150 mm HDPE 8,975 m in length. The pipe alignment will be in parallel with the existing pipe. With gravity flow, an automatic flow control valve will be provided at inflow of the tank.

#### 2) Distribution Facility

The capacity of the existing elevated tank, 450 $m^3$, can only supply the maximum daily requirement for 2.3 hours. The new elevated tank will have a designed volume that will raise the capacity to a minimum of 8 hours supply of maximum day demand. Each reservoir is summarized in Table 2-12 below.

Table 2-12 Reservoir

| Name | Capacity ($m^3$) | Remarks |
|---|---|---|
| New Clear Water Reservoir | 600 | Reinforced Concrete (RC※1) |
| Existing Elevated Tank | 450 | RC |
| New Elevated Tank | 450 | FRP※2 panel with RC foundation |
| Total | 1500 | 8.6 hours |

※1:Reinforced Concrete, ※2:Fiber Reinforced Plastic

Pre-fabricated panels are applied to structure of the new elevated tank in consideration of the following reasons:

・Location of the tank is within the land of the WUSC Dhulabari office.

・The location is near to the congested market place which is located at centre of water supply area.

・The land does not have enough space for preparation and temporary works during construction.

Access to the site passes through the most congested roads in the area.

Taking the above into consideration, pre-fabricated panels will be used to shorten construction time and to mitigate impact on the environment.

In addition, the following facilities are provided for existing well pump which will be utilized in case of water shortage in dry season:

Chlorination facility: for underground water, 1 unit of bleaching powder dissolving tank and feeder

Generator:

・Facilities to be supplied: a well pump, chlorination unit (feeding pump, mixer)

・Purpose: to manage power failure which occurs with increased frequency

・Capacity: 75 kVA, 1 unit

### 3) Distribution Pipe

Principal purpose of this project is to improve distribution pipe networks which should be modified to accommodate increase in water supply production. Distribution pipes excluding main pipes installation works were requested by Nepal side. However, distribution main were selected for improvement in this project as a result of discussion between the study team and concerned parties.

Piping works under this project are summarized in Table 2-13.

(Detail network analysis in accordance with increase of water supply aomount is shown in Appendix 4-1.)

Table 2-13 Piping works in Dhulabari

| Pipe | Route & Location | Material, ND, Length | Remarks |
|---|---|---|---|
| Distribution Main | Dhulabari | - DIP 300 mm x 80 m<br>- DIP 250 mm x 1,520 m<br>- DIP 150 mm x 1,750 m | Addition to the existing pipe networks.<br>To be installed under main road passing from the North to the South direction in Dhulabari in parallel with existing pipe |
| Distribution | Route 1 | - DIP 100 mm x 410 m | In Northeast area, component of a pipe loop |
| Distribution | Route 2 | - DIP 100 mm x 470 m | South side of Mahendra Highway |
| Distribution | Route 3 | - DIP 150 mm x 1,335 m<br>- SP 150 mm x 130 m | Ditto, SP is used at pipe bridge |
| Distribution | Route 4 | - HDPE 75 mm x 1,000 m | Southwest area, component of a pipe loop |
| Total | | 6,700 m | |

### 4) Special Construction

・Timai river crossing

Pipe supports are set on abutments and piers of the existing bridge.

・Mahendra highway crossing

According to DWSS, excavation across the highway will not be allowed by the authority. Pipes are to be installed inside existing culvert crossing along the highway.

Facilities to be cooperated by Japanese Government are shown in Figure 2-5.

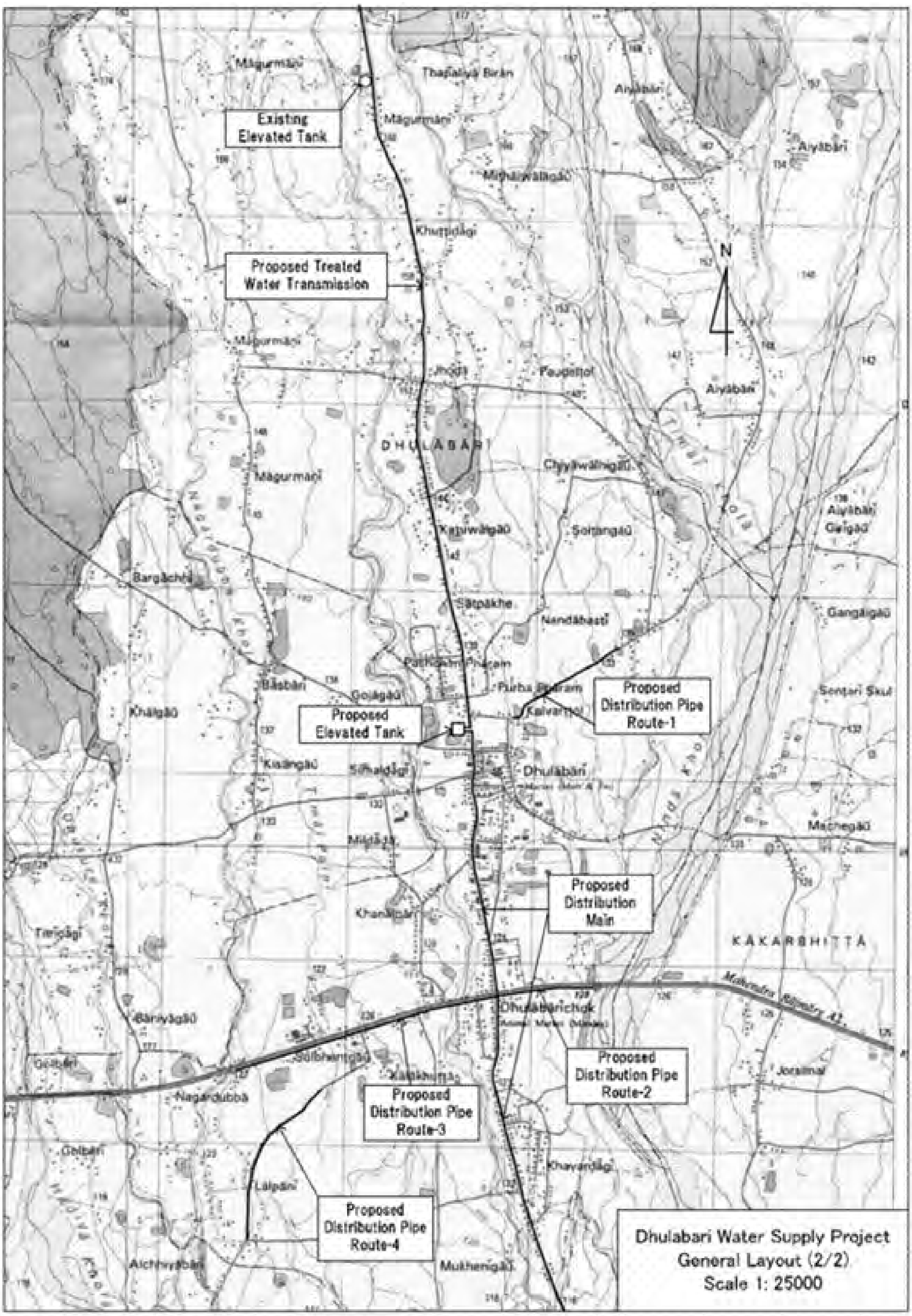


Figure 2-5 Facilities to be cooperated by Japanese Government

### **2-2-2-2** Gauradaha

#### **(1)** Basic Policy for Planning

Critical points for the planning in the Gauradaha water supply system are as follows:

① Water quality of existing wells has high iron concentration ranging from 2.6 mg/L to 8.64 mg/L (WHO drinking water guideline: 0.3 mg/L) and it is not potable. Thus, new purification plant to improve raw water quality is planned.

② There are no distribution pipeline networks in the south-western side of planned service area where population is rapidly increasing. The expansion of main distribution pipeline shall cover that area.

Components of the water supply systems requested by the Nepal government are iron removal system, clear water reservoir, and distribution pipelines. Water sources for water supply system are existing well No.1 and No.3, and existing well No.2 located in the play ground of neighbouring secondary school.

#### **(2)** Basic Items for Water Supply Planning

##### **1)** Project Area

Project area is Gauradaha in Jhapa district. The area consists of Bazar area and Out of Bazar area. In the centre area, commercial stores are densely located. Its suburb is housing area where households are separately distributed and forms different residence area from the Bazar area.

Service areas shall be the Gauradaha that is formed by 5 wards. The project area is shown in Figure 2-6.

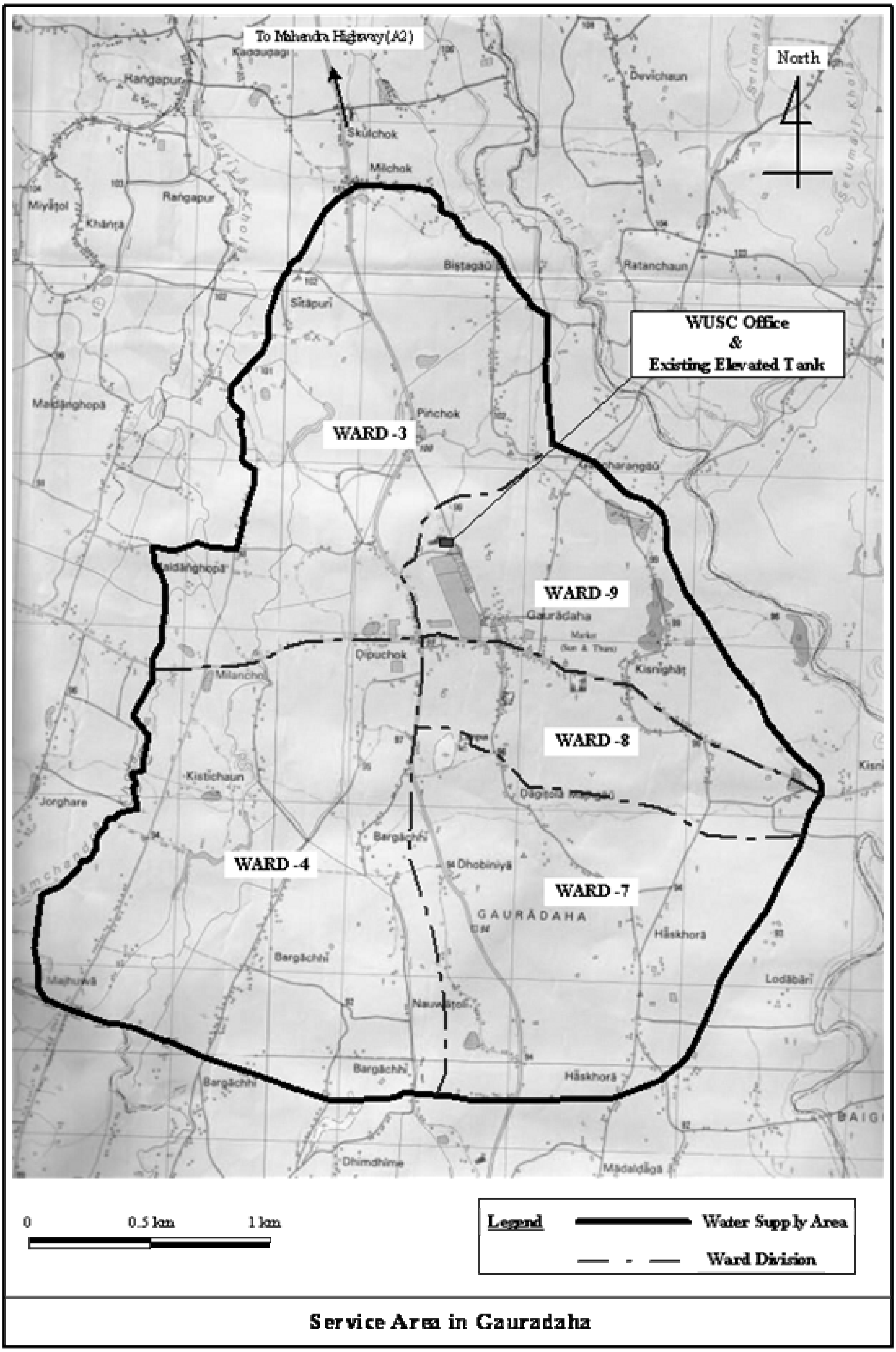


Figure 2-6 The project area in Gauradaha

### 2) Design Population Served

Population projection was estimated based on a two-year data of the population statistics (2002-2004). Present status and projection of population are shown in Table 2-14 Status Population in Gauradaha（2004） and Table 2-15 Prediction of inside population of water supply in Gauradaha.

Yearly growth rate of population for past 2 years is approximately 3.5 % and the same growth rate is presumed to continue. Based on this assumption, population projection was carried out. As a result, projected population in 2014 was estimated to be 13,100.

Table 2-14 Status Population in Gauradaha（2004）

| | Bazar | Out of Bazar | Total |
|---|---|---|---|
| Ward-3 | 481 | 1,123 | 1,604 |
| Ward-4 | 770 | 1,798 | 2,568 |
| Ward-7 | 0 | 1,129 | 1,129 |
| Ward-8 | 1,393 | 0 | 1,393 |
| Ward-9 | 2,598 | 0 | 2,598 |
| Total | 5,243 | 4,049 | 9,292 |

※30% of Ward-3 and 4 is Bazar area

Table 2-15 Prediction of inside population of water supply in Gauradaha

| Year | Bazar | Out of Bazar | Total |
|---|---|---|---|
| 2005 | 5,426 | 4,191 | 9,617 |
| 2006 | 5,616 | 4,338 | 9,954 |
| 2007 | 5,813 | 4,490 | 10,302 |
| 2008 | 6,016 | 4,647 | 10,663 |
| 2009 | 6,227 | 4,809 | 11,036 |
| 2010 | 6,444 | 4,978 | 11,422 |
| 2011 | 6,670 | 5,152 | 11,822 |
| 2012 | 6,904 | 5,332 | 12,236 |
| 2013 | 7,145 | 5,519 | 12,664 |
| 2014 | 7,400 | 5,700 | **13,100** |

### 3) Design Criteria for Water Supply

#### a) Service Connection

Present rate of service connection in 2004 was approximately 14 % of the service area population. The target rate of service connection for the year 2014 is 70% in the Bazar area and 65% in the non-Bazar area. In consideration of the national development plan which is up to 2017, the target rate of service connection is expected to be 85% and 75% respectively.

#### b) Water demand

Water demand rate to be adopted are as follows;

Domestic water demand for service connections（Daily average）:

Bazar area 100 L/capita/day (DWSS Planning Value)

Out of Bazar area 70 L/capita/day (DWSS Design Criteria)

Water demand rate for public taps (Daily average): 45 L/capita/day (DWSS Guideline)

### c) Variation Coefficient

Variation coefficient means magnitude of variation of water demand. It was established based on the actual usage in the Biratnagar City.

(Daily maximum value) / (Daily average value) = 1.2

### d) Leakage Rate

Leakage rate is assumed to increase by 1% every year as the system gets older.

### e) Design Parameters

Design parameters in Gauradaha are shown below:

**Figure 2-7 Design Water Supply in the Gauradaha**

| | | Bazar | | Out of Bazar | | Total | Notes |
|---|---|---|---|---|---|---|---|
| | | House Connection | Public Taps | House Connection | Public Taps | | |
| Design Inside Population of Water Supply area | ① | 7,400 | | 5,700 | | 13,100 | |
| Design Rate of Service Connection *1) | ② | 70.0% | | 65.0% | | - | |
| Design Population Supplied in each Ward*2) | ③ | 5,180 | | 3,705 | | 8,885 | ①×② |
| | | 5,047 | 133 | 3,610 | 95 | 8,885 | |
| Design Average Daily Supply per Capita (L/day/capita) *3) | ④ | 100 | 45 | 70 | 45 | - | |
| Design Average Daily Supply (Accounted-for Water) ($m^3$/day) | ⑤ | 505 | 6 | 253 | 4 | 768 | ③×④ |
| Leakage Rate | ⑥ | 10.0% | | | | - | |
| Design Average Daily Supply ($m^3$/day) | ⑦ | 561 | 7 | 281 | 5 | 853 | ⑤/(1-⑥/100) |
| Variation Coefficient *4) | ⑧ | 1.2 | | | | - | |
| Design Maximum Daily Supply ($m^3$/day) | ⑨ | 673 | 8 | 337 | 6 | 1,024 | ⑦×⑧ |
| Design Facility Water Supply ($m^3$/day) | ⑩ | | | | | **1,100** | |

*1) Rate of service connection : Based on 10th Plan, Bazar wil be 70%, Out of Bazar will be 65% in 2014

*2) Population served of Public Taps : 2 places×20 HHs×5.7 persons/family＝228 persons
Population served of Public Taps of Bazar and Out of Bazal were divided by proportion of population.

*3) Design Average Daily Supply per Capita : DWSS design Criteria

*4) Variation Coefficient (Daily maximum / Daily average) : Practical achievement

## (3) Design of Treatment Plant and Distribution Facilities

A new iron removal facility and a new clear water reservoir are planned in the land of WUSC office in consideration of the existing two wells, No.1 and No.3 and existing elevated tank. Space is available in the vicinity.  Design Treatment Flow Rate: the daily maximum supply, 1,100 $m^3$ per a day

### 1) Iron Removal Facility

The result of resource water quality sampling test shows that manganese content is below the allowance (0.3 mg/L or below in WHO water quality gidelines), however, iron content is in range of from 2.6 mg/L to 8.64 mg/L (0.3 mg/L or below in WHO water quality gidelines). Two types of iron removal methods are mainly adopted. Those are Type A: Pretreatment (aration, chrorination, etc.,) + Filter and Type B: Utilization of iron reducing bacteria.

Type A: After the oxidation dissolved iron dispose as undisolved iron compounds and the flter removes them.

Type B: The process is, similary to slow sand filter, utilizing the iron reducing bacteria.

The advantages of Type B are easiness of operation and maintenance, and suitability for less fluctutiation of water quality.

In consequence of the comparison analysis Type A (basically utilizing atmospheric oxidation and possible utilize chlorinated lime as oxidizer if it is required) is adopted for this project for following reasons.

・Type A is easy to control injection quantity by utlizing oxidizer and makes effective oxidation is possible. Meanwhile, utilizing atmospheric oxidation has been experienced in Nepal numerously and the cost of this method is less than the case of utilizing oxidizer.

・In Nepal chlorinated lime is utilized for disinfection by chlorine, therefore it is easy to utilize chlorinated lime as oxidizer.

・Type B requires to confirm the existence of iron bacteria. In case of non-existence of the bacteria transplantation is required. And it is difficult to measure the effectiveness of removal constantly, then polot testing is necessary to define the effectiveness.

There is of note that dissolving procedure of chlorinated lime should be carefully monitored because there are some operational troubles are reported regarding choke accidents in injection pipe by dissolved chrorinated lime.

### 2) Clear Water Reservoir

The capacity of the existing elevated tank, 100 m3, is not enough for storage in future supply since it can only supply the maximum daily requirement for 2 hours. The total volume of the existing and the new storage should be able to supply the maximum day for a minimum of 8 hours. Each reservoir is summarized in Table 2-16 below.

Table 2-16 Storage Capacity

| Storage Facility | Capacity ($m^3$) | Remarks |
|---|---|---|
| New Reservoir | 300 | Reinforced Concrete Structure |
| Existing Elevated Tank | 100 | ditto |
| Total | 400 | 8.7 hours |

Treatment Process is shown in Figure 2-8.

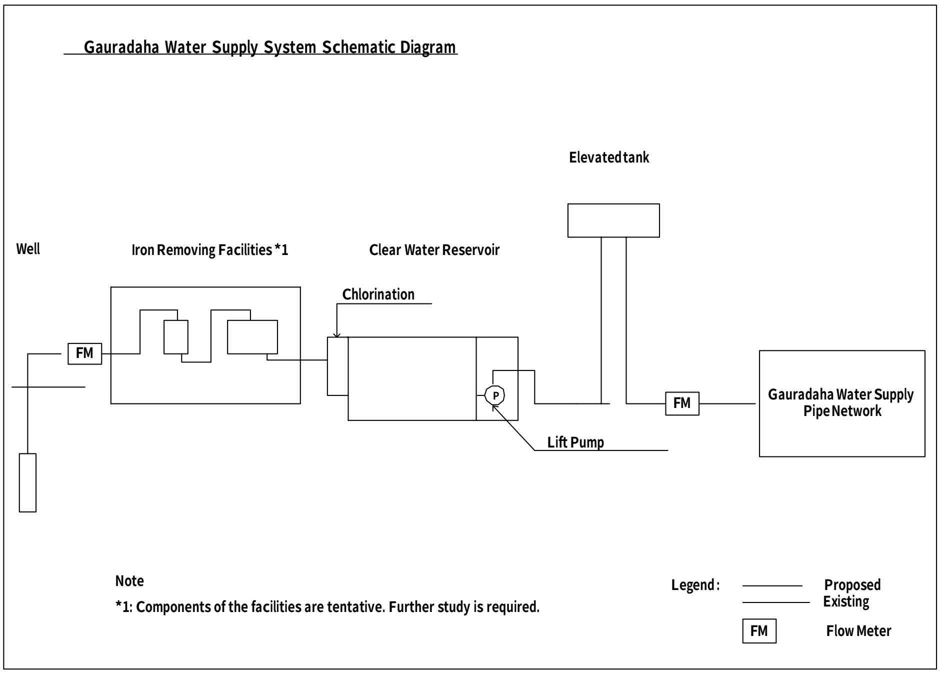


Figure 2-8 Treatment Process

### 3) Generator for Emergency

・Facilities to be supplied: a well pump, chlorination unit (feeding pump, mixer)

・Purpose: to manage power failure which occurs with increased frequency

・Capacity: 65 kVA, 1 unit

## (4) Distribution Pipe Networks

While distribution pipes for supply to expanded area were requested by Nepal side, installation of distribution main for the southwest area and improvement of distribution pipe networks to deal with increase of water were selected as a result of discussion between the study team and concerned parties.

Improvement of distribution pipes are as follows.

(Detail network analysis in accordance with increase of water supply aomount is shown in Appendix 4-1.)

Table 2-17 Improvement of distribution pipes

| Route | Location | ND & Length | Remarks |
|---|---|---|---|
| 1 | Southwest area | HDPE 100mm x 2,700 m | Expansion |
| 2 | ditto | HDPE 50mm x 1,000 m | ditto |
| 3 | ditto | HDPE 50mm x 500 m | ditto |
| 4 | West area | HDPE 75mm x 800 m | ditto |
| 5 | Center area | HDPE 150mm x 470 m | Opposite side of road and in parallel with existing, east to west direction |
| 6 | ditto | HDPE 150mm x 600 m | Opposite side of road and in parallel with existing, north to south direction |
| | Total | 6,070 m | |

Facilities to be cooperated by Japanese Government are shown in Figure 2-9.

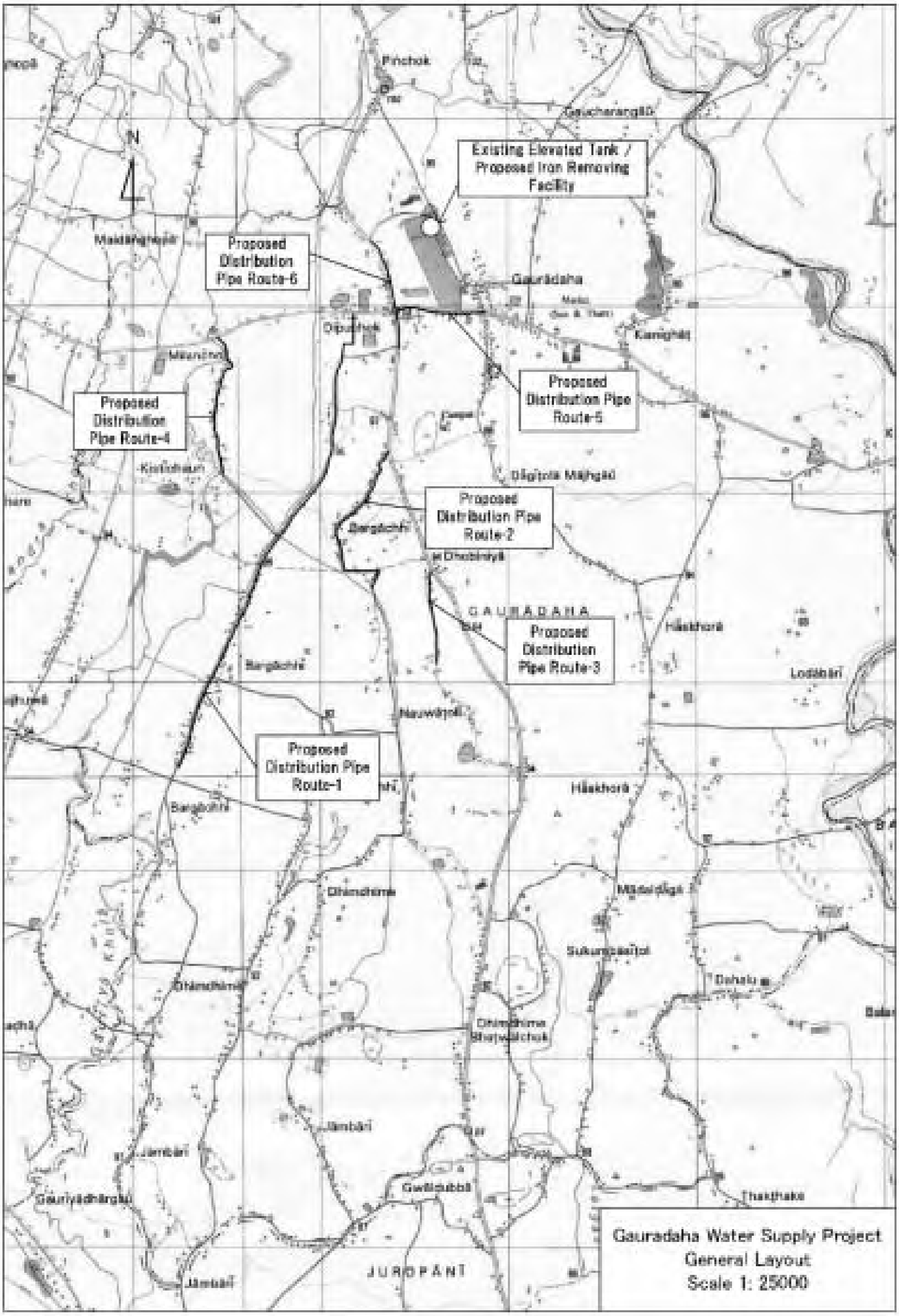


Figure 2-9 Facilities to be cooperated by Japanese Government

### 2-2-2-3 Mangadh

#### (1) Basic Policy for Planning

Critical points for the planning in the Gauradaha water supply system are as follows:

Water quality of existing wells has high iron concentration ranging from 2.2 mg/L to 5.7 mg/L (WHO drinking water guideline: 0.3 mg/L) and it is not potable. Thus, new purification plant is planned to improve raw water quality.

Requested facilities by the Nepal government are an iron removal facility and a clear water reservoir. In the Basic Design Study, an iron removal facility and a clear water reservoir are planned in correspondence with the request, and treated water shall be distributed by natural gravity system that height difference between from existing elevated tank to distribution pipelines cause.

#### (2) Basic Items for Water Supply Planning

##### 1) Project Area

Project area is Mangadh, Morang district. The area is adjacent to the Biratonagar City and is formed by Semi-Bazar area. The Mangadh consists of 4 ward areas and it is planned service areas. The project area is shown in Figure 2-10.

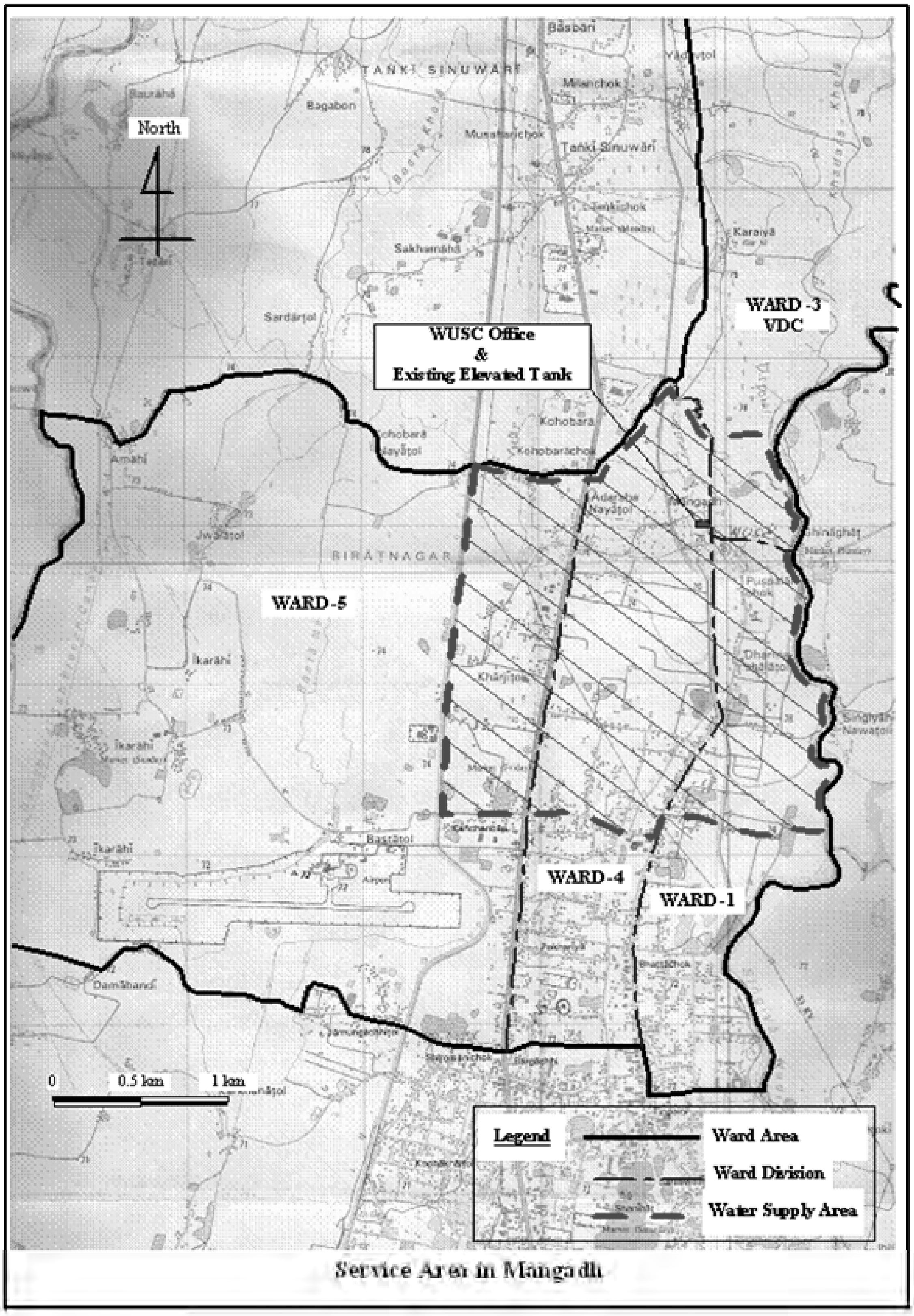


Figure 2-10 The project area in Mangadh

### 2) Design Population Served

Population projection in the future was estimated by the population growth rate based on two years' data of the population statistics (1987 and 2002). Present status and future projection of population are shown in Table 2-18 Status Population in Mangadh, Table 2-19 Status Population in Mangadh and Table 2-20 Prediction of inside population of water supply in Mangadh.

Design service area is a part of 1, 3, 4, 5 ward areas and the inside population of water supply area occupies 60 % to total residential population in each ward area. Population in the area has increased with rate of 46 % in the past 15 years. Thus, yearly average growth rate is estimated to be approximately 3 %. In this Basic Design Study, on assumption that afterwards, population shall increase with the same rate, future population projection was estimated. As a result, population projection value in the year of 2014 was 27,400.

Table 2-18 Status Population in Mangadh

| Ward | 1987※1 | 2002※2 | Ratio of population increse | |
|---|---|---|---|---|
| | | | 1987-2002 | For the year |
| Ward-1 | 4,575 | 9,159 | 100.2% | 6.7% |
| Ward-4 | 8,039 | 10,812 | 34.5% | 2.3% |
| Ward-5 | 8,204 | 10,384 | 26.6% | 1.8% |
| Total | 20,818 | 30,355 | 45.8% | **3.1%** |

※1:National Census

※2:Biratnagar Town Panchayat Land Use Projection 1987-2002

Table 2-19 Status Population in Mangadh

| Ward | Semi-Bazar | Inside population of water supply※ |
|---|---|---|
| Ward-1 | 9,159 | 5,495 |
| Ward-4 | 10,812 | 6,487 |
| Ward-5 | 10,384 | 6,230 |
| Ward-3(VDC) | 1,613 | 968 |
| Total | 31,968 | 19,180 |

※the inside population of water supply area occupies 60 % in each ward area

Table 2-20 Prediction of inside population of water supply in Mangadh

| Year | Semi-Bazar | Inside population of water supply |
|---|---|---|
| 2005 | 34,932 | 20,959 |
| 2006 | 35,980 | 21,588 |
| 2007 | 37,059 | 22,235 |
| 2008 | 38,171 | 22,903 |
| 2009 | 39,316 | 23,590 |
| 2010 | 40,495 | 24,297 |
| 2011 | 41,710 | 25,026 |
| 2012 | 42,961 | 25,777 |
| 2013 | 44,250 | 26,550 |

| | | |
|---|---|---|
| 2014 | 45,578 | 27,400 |

### 3) Design Criteria for Water Supply

#### a) Service connection

Present rate of service connection as of 2005 is 15 % of the service population with 1,000 household connections. The water supply system commenced operation to in 2005. The target rate of service connection in 2017 is 75% for semi-Bazar area, in consideration of the national development plan of Nepal. For a 10 year projection, the expected rate of service connection in 2014 is 65%. The area at present has no public taps.

#### b) Water demand

Domestic water demand rate to be adopted in the design is;

Domestic water demand for service connections（Daily average）:

Bazar area 100 L/capita/day (DWSS Design Criteria)

#### c) Variation Coefficient

Variation coefficient means the magnitude of variation of water demand. It was set up based on the actual usage in Biratnagar City.

(Daily maximum value) / (Daily average value) = 1.2

#### d) Leakage Rate

Leakage rate was assumed to be increasing 1% yearly as the system gets older.

#### e) Design Parameters

Design parameters for water supply system in the Mangadh are shown below,

Table 2-21 Design Water Supply in Mangadh

| | | Semi-Bazar | | Total | Notes |
|---|---|---|---|---|---|
| | | House Connection | Public Taps | | |
| Design Inside Population of Water Supply area | ① | 27,400 | | 27,400 | |
| Design Rate of Service Connection *1) | ② | 60.0% | | - | |
| Design Population Supplied in each Ward | ③ | 16,440 | | 16,440 | ①×② |
| | | 16,440 | 0 | 16,440 | |
| Design Average Daily Supply per Capita (L/day/capita) *2) | ④ | 100 | | - | |
| Design Average Daily Supply (Accounted-for Water) ($m^3$/day) | ⑤ | 1,644 | 0 | 1,644 | ③×④ |
| Leakage Rate | ⑥ | 10.0% | | - | |
| Design Average Daily Supply ($m^3$/day) | ⑦ | 1,827 | 0 | 1,827 | ⑤/(1-⑥/100) |
| Variation Coefficient *3) | ⑧ | 1.2 | | - | |
| Design Maximum Daily Supply ($m^3$/day) | ⑨ | 2,192 | 0 | 2,192 | ⑦×⑧ |
| Design Facility Water Supply ($m^3$/day) | ⑩ | | | **2,200** | |

*1) Rate of Service Connection : Semi-Bazar wil be 60% in 2014 since proportional allotment of 75% in 2017

*2) Design Average Daily Supply per Capita : DWSS design Criteria

*3) Variation Coefficient (Daily maximum / Daily average) : Practical achievement

### (3) Design of Treatment Plant and Distribution Facilities

The two existing pump wells, No.1 and No.2, are located in the land of WUSC office and at 500 m far from the land to the south respectively. A new iron removal facility and a new clear water reservoir shall be installed. Design Treatment Flow Rate: the daily maximum supply, 2,200 $m^3$ per a day

#### 1) Iron Removal Facility

The same reason as mentioned in Section 2-2-2-2, oxidation by air is selected as principal oxidation system. However, chemical feeding system is also provided as standby equipment in case of increase in iron content.

#### 2) Clear Water Reservoir

The capacity of the existing elevated tank, 450 $m^3$, is not enough for storage, providing the maximum day supply for only 4.9 hours. Presented capacities ss below are the details of the reservoirs including a new reservoir needed to increase the maximum day supply to a minimum of 8 hours.

Table 2-22 Storage Capacity

| Storage Facility | Capacity ($m^3$) | Remarks |
|---|---|---|
| New Reservoir | 300 | Reinforced Concrete Structure |
| Existing Elevated Tank | 450 | ditto |
| Total | 750 | 8.2 hours |

Treatment Process is shown in Figure 2-11.

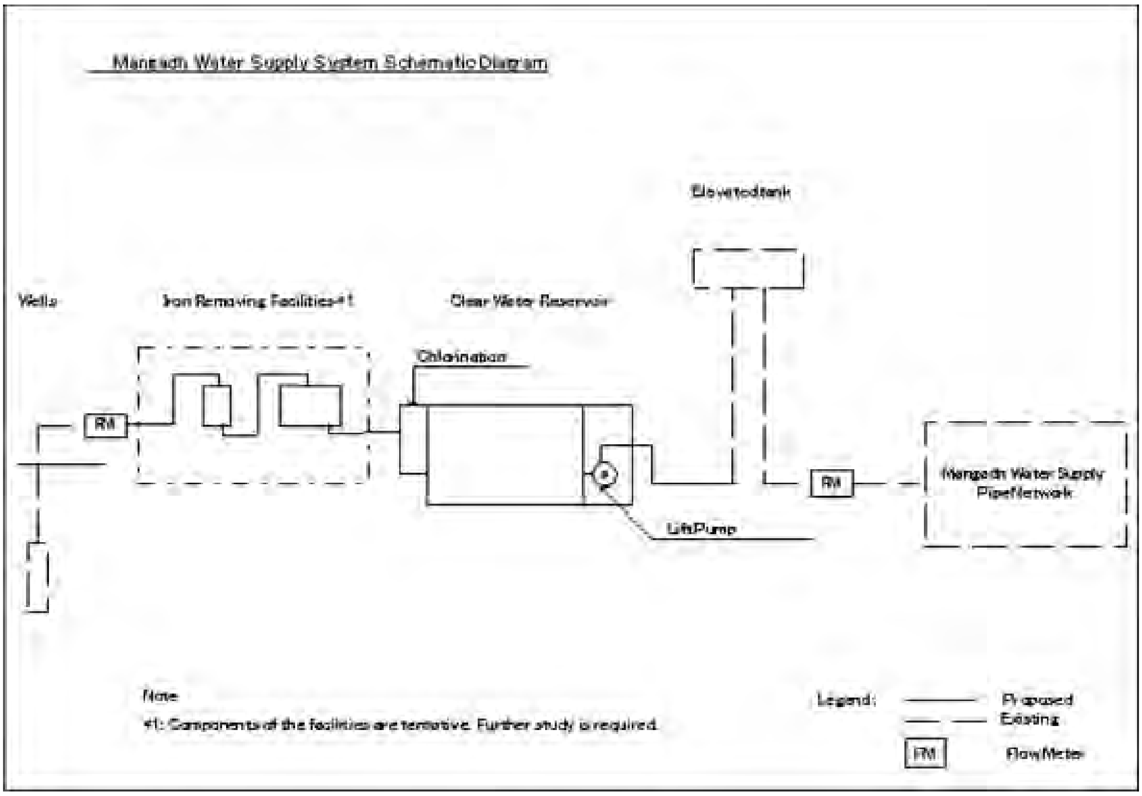

Figure 2-11 Treatment Process

### 3) Generator for Emergency

・Facilities to be supplied: a well pump, chlorination unit (feeding pump, mixer)

・Purpose: to manage power failure which occurs with increased frequency

・Capacity: 150 kVA, 1 unit

## (4) Additional Request for Assistance Regardi ng Distribution Network

Additional component of 4 km DIP pipeline was requested with following reasons in the study period.

・A road expansion schem is planed and if it is implemented existing high density polyethylene (HDPE) pipeline will get influence such as vibration, excess load. As a result it is asuumed that water leakage will deteriorate.

・In addition to the above apprehension connetions of HDPE pipes (butt fusion connections)

After the field suvey the additional requested component has not been taken for following reasons.

・The road expansion scheme has not been defined concretely.

・Only 1 km of pipelines among 4 km of them would be loaded by traffic of heavy vhicles in future. The remaining 3 km of them would be very little to be affected by road expansion due to the lines of roads located in residential areas and the traffic of heavy vehicles would be assumed very few.

・Event ifthe pipeline would be sttled undr the road with the traffic of heavy vehicles , the position of the pipe would be private land side bound by drain gutter, therefore the influence of the traffic load would be very little.

・Any siginificant water leakage is identified so far.