APPLICATION OF LIFE CYCLE COST ANALYSIS IN SELECTION OF BEST TECHNO-ECONOMICAL WATER SUPPLY SYSTEM

A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT FOR THE

AWARD OF THE DEGREE OF

MASTER OF ENGINEERING

IN

CIVIL ENGINEERING

(ENVIRONMENTAL ENGINEERING)

UNDER THE GUIDANCE OF
DR. S.K.SINGH
PROFESSOR AND HEAD

SUBMITTED BY
MANENDER MAHOUR
(ROLL NO: 13994)

DEPARTMENT OF CIVIL & ENVIRONMENTAL ENGINEERING
DELHI COLLEGE OF ENGINEERING
DELHI UNIVERSITY, DELHI

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(Manender Mahour)
Roll No 13994

CANDIDATE'S CERTIFICATION

I hereby certify that the work presented in this dissertation entitled **'APPLICATION OF LIFE CYCLE COST ANALYSIS IN SELECTION OF BEST TECHNO-ECONOMICAL WATER SUPPLY SYSTEM"** in partial fulfillment for the award of the degree of **MASTER OF ENGINEERING** in Civil Engineering, with specialization in **ENVIRONMENTAL ENGINEERING**, submitted to the department of Civil and Environmental Engineering, Delhi College of Engineering, Delhi is an authentic record of my own work, under the supervision of **Dr. S.K.SINGH, Professor and Head**, Department of Environmental Engineering, Delhi College of Engineering, Delhi.

The matter embodied in this dissertation has not been submitted by me for the award of any other degree.

Date: **(MANENDER MAHOUR)**
Place: Delhi **Roll No: 13994**

CERTIFICATE

Certified that the work presented in this dissertation entitled **"APPLICATION OF LIFE CYCLE COST ANALYSIS IN SELECTION OF BEST TECHNO-ECONOMICAL WATER SUPPLY SYSTEM"** in partial fulfillment of the requirements for the award of the degree of **MASTER OF ENGINEERING** in Civil Engineering, with specialization in **ENVIRONMENTAL ENGINEERING**, submitted to the Department of Environmental Engineering, Delhi Technical University, Delhi (Formerly Delhi College of Engineering) is an authentic record of the work done by **Mr. MANENDER MAHOUR (R.No.13994)**, under my supervision.

Dr. S.K.SINGH,
Professor & Head,
Department of Environmental Engineering
Delhi Technical University
(Formerly Delhi College of Engineering)

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CHAPTER 1

INTRODUCTION

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INTRODUCTION

1.1 INTRODUCTION

Water is rapidly becoming a scarce resource in all cities of Republic of India with growing population on the one hand, and fast growing economies, commercial and developmental activities on the other. This scarcity makes water both a social and an economic good. Its users range from poor households with basic needs to agriculturists, farmers, industries and from commercial undertakings with their needs for economic activity to rich households for their higher standard of living. For all these uses, the water supply projects being proposed either new water supply scheme or for extension and augmentation.

Water supply schemes may comprises of components, but not limited to, as follows

a. Intake Structure
b. Raw Water Pumping Station
c. Raw Water Channel or Conveyance
d. Water Treatment Works and Main pumping Station
e. Clear Water Transmission Main System
f. Pumping Stations
g. Mass Balancing Reservoir
h. Distribution Main and System

Rehabilitation and augmentation depends on the various factors like service area of project, water demand to meet, pressure requirement, physical condition of the water supply component structure etc.

As water supply systems play an important role in the infrastructure development, in spite of the fact cost that its development puts enormous financially burden. One of the most challenging aspects in today's time is to design a water supply system which is technically feasible and most economical over the project horizon. This involves analysis and selection of an appropriate alternative of water supply system capable of meeting the project requirements in an economic way.

1.2 LIFE CYCLE COST ANALYSIS (LCCA)

Application of Life Cycle Cost Analysis (LCCA) is recognized as a decision making tool in selection of a suitable alternative which could suit case specific requirements of the project. The methodology of LCCA for the selection of most techno-economical water supply system design generally includes several evaluation steps that will vary depending upon the complexity of the project.

The selection of water supply system has to take into account an understanding of the variability of various parameters viz. number of source and its location, type of raw water and clear water transmission main system and its route alignment, water treatment plant system, size of treatment, land availability and its cost, energy and recurring charges and other capital investments involved in the water supply system.

This dissertation work focus on application of life cycle cost analysis for selection of water supply system among the various alternatives developed.

1.3 OBJECTIVES OF PRESENT STUDY

Objectives of the present study work are as follows

- Review of literature and past studies carried out with regard to Life Cycle Cost Analysis (LCCA).
- Study of General Methodology for carrying out Life Cycle Cost Analysis (LCCA).
- Study of various economic indicators of Life Cycle Cost Analysis.
- Study Various Parameters for Alternatives of Water Supply System.

- Application of LCCA for selection of best techno-economical water supply system, a case study.

1.4 ORGANISATION OF DISSERTATION

This present dissertation has been undertaken to arrive at an understanding on life cycle cost analysis and its application in water supply sector for selection of best techno-economical system so that financial burden on user can be alleviated for use of water.

Chapter 2 defines LCCA, literature reviews describing historical background and earlier studies. Also delineates the economic indicators that affect the LCCA and basic procedure of LCCA.

Chapter 3 delineates methodology of carrying out LCCA along with the various project alternatives along with its components and its effect, design criteria and development of various alternatives.

Chapter 4 presents the application of LCCA for water supply system for the selection of water supply system with a case study.

Chapter 5 narrates the result of the case study and its analysis.

Chapter 6 delineates the conclusions drawn from present dissertation work and also recommendations are made.

CHAPTER 2

LITERATURE REVIEW

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Definition of Life Cycle Cost Analysis (LCCA) has been refined over the time since the idea was first introduced by the work of economist Winfrey in 60's and the American association of state highway official (AASHO's) "Red Book" in the transportation domain. Following are few definition of life cycle cost analysis said so far.

"The total discounted cost of owning, operating, maintaining, and disposing of a building or a building system over a period of time" by The National Institute of Standards and Technology (NIST) Handbook 135, 1995 Edition,

"Life Cycle Cost Analysis is an economic evaluation technique that has been particularly valuable when there is a need to compare competing alternatives for projects with entailing costs and benefits that stretch over long spans of time."

In simple words "Life Cycle Cost Analysis is an indispensable technique used as decision making tool to evaluate long term performance of various alternatives to achieve a common goal i.e. selection of best techno-economical alternative".

2.2 TECHNO-ECONOMICAL ANALYSIS

It is an evaluation technique by which technical aspect of all the project's alternative such as appropriateness of technical standard adopted, reality of the implementation and its schedule, likely hood of achieving the expected result can be analyzed to arrive at an economical alternative of project.

Such analysis is necessary to carried out to ensure that project is formulated in sound manner as least cost solution following all the accepted engineering norms. Life cycle cost analysis is used as decision taking tool in the techno-economic analysis.

2.3 HISTORICAL BACKGROUND OF LCCA

Literature review of various documents reveals that concept of life cycle cost analysis was introduced by economist Winfrey in the 60's and the American Association of State Highway Officials (AASHO's) "Red Book" of 1960 in transportation sector. At that time, the available information was not sufficient to perform a comprehensive and reliable LCCA that truly summarizes all the components of the analysis. Extensive research started as a result. World Bank in Brazil in the 1960s developed an empirical models based on the research.

Later on the concept of LCCA was taken up by U.S. Department of Defence to implement the idea in various programs in 1970's. After implementation of LCCA in military, other sectors like aviation, power, oil and chemical, and railways system came under the preview of LCCA.

With aim of promoting LCCA, National Cooperative Highway Research (NCHRP) in 1984 started project number 20-5 FY 1983. In 1983 and 1993, The American Association of State Highways and transportation officials (AASHTO) endorsed the use of LCCA, as for economic evaluation and as a decision support tool, in their Pavement Design Guides.

The Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 called for "the use of life cycle costs in the design and engineering of bridges, tunnels, or pavement," both for metropolitan and statewide planning. Subsequently, the National Highway System (NHS) Designation Act of 1995 mandated the States to perform LCCA on NHS projects costing $25 million or more. In 1996, the Federal Highway Agency released its Final Policy statement on LCCA. In the year 2000, LCCA came under the charge of Asset Management.

2.4 INDIAN SCENARIO

Implementation of LCCA in infrastructure service like transportation sector was first introduced by the National Highway Authority of India (NHAI) in 1990. Later, LCCA widely adopted for all international and bilateral funded projects viz. World Bank, ADB, JBIC etc. literature review reveals use of LCCA by various authorities particularly pertaining to water and wastewater services is not a common practice. However, these days project funded by the foreign agencies like World Bank, ADB, JBIC etc. involves LCCA application. However, great efforts are required to establish standard procedure for carrying out LCCA in all the water and waste water authorities before finalizing a particular project alternative.

2.5 PARAMETERS FOR LCCA

Analysis of Life Cycle Cost is primarily based on various economic parameters, as discussed in the below. As mentioned above that LCCA technique is used for comparing total cost incurred during the project horizon i.e. cost involved from owing to disposing, for the various alternative developed giving same benefit or output. There are various economic indicators or variables by which economic comparison can be carried out, those are as follows

a) Cost of the Project
b) Study Period
c) Net present Value
d) Inflation
e) Discount rate

a) **Cost of the Project:** Cost of the project can be defined as total expenditure incurred during the project horizon i.e. from construction cost, rehabilitation cost, operation and maintenance cost, salvage cost up to disposal of a project facility. Cost of project can be divided into in two categories on which project's alternatives to be evaluated in a LCCA.

I. **Initial Expenses:** Initial Expenses are all costs incurred prior to occupation of the facility i.e. construction cost and rehabilitation expenses, if any.

II. **Future Expenses:** Future Expenses includes all costs incurred after occupation of the facility i.e. operation and maintenance cost, rehabilitation cost, salvage cost etc.

For LCCA study, cost of alternatives, all alternative giving same benefits, is to be worked out for comparison.

b) **Study Period:** The second variable of the LCC equation is Study Period or Life Time. Period of time over which operation and maintenance expenditure is to be evaluated is known as Study Period. This study period generally varies from two to four decades, depending upon intended useful life of the facility considered under the project. Study period can be categorized into two phases: 1. Planning and construction period i.e. from designing of project on paper to commencement and 2. Service period. The service period is the time period from date the facility becomes operational to the end of the study.

c) **Net Present Value (NPV):** As the name indicates, net present value is defined as the time equivalent value of past, present or future expenses as of the beginning of the project i.e. base year. The present value of all expenses must first be determined to accurately combine initial expenses with future expenses.

In order to determine the net present value of the cost of project in base year, discount rate and time period play an important role. As most of the initial expenses of project occur at time of base year of the study period. Thus, estimation of present value of these initial expenses is not required as both will be same i.e. net present value is equal to their actual cost.

Whereas net present value of future expenses is time dependent. Future expense can be incurred at any time between year of commencement (i.e. base year) and project horizon. The present value calculation is the equalizer that allows the summation of initial and future costs.

There are two type of future expenses, one time and recurring cost. As most of the operation and maintenance cost are recurring type. Recurring costs are costs that occur every year over the span of the study period. Most operating and maintenance costs are recurring costs. One-time costs are costs that do not occur every year over the span of the study period as these are mostly replacement costs.

To simplify the LCCA, all recurring costs are expressed as annual expenses incurred at the end of each year and one-time costs are incurred at the end of the year in which they occur. To determine the Net Present Value of future investment, the following formula is used:

$$NPV = \sum_{t=0}^{T} (B_t - C_t) / (1+d)^t \quad \text{..........Equation A}$$

Where NPV = Net Present Value
Bt = Benefits to be gained at time t

Ct = Costs to be incurred at time t
d = Discount Rate
t = Time of incurrence (years)
T = Life time of the project

d) Inflation: Expenditures typically occur at various points in the past or future and are therefore measured in different value units because of changes in price. A general trend toward higher prices over time is called inflation. All the expenditure must be converted to today's value by "inflating" them. This can be done by multiplying the "dated" price by the relative increase in the price index between the date of the price and the present.

e) Discount Rate: The discount rate is "the rate of interest reflecting the investor's time value of money." Basically, it is the interest rate that would make an investor indifferent as to whether he received a payment now or a greater payment at some time in the future.

Accounting for the future expenses is one of the key features and is based on the well-established principle in economics according to which money has time value. This means a rupee today is worth more than a rupee tomorrow. Therefore, all future costs and benefits must be converted to a common time dimension, which assist in making decisions regarding investments with different long-term time-lines, this procedure is referred to as discounting.

Discounting is performed by employing a discount rate that represents the percent change in the value of the rupee per period of time.

Pertaining to life cycle cost analysis, the discount rate can be defined as a value in percent used as a mean for comparing the alternative uses of funds and costs over a period of time by reducing the future amounts to present worth. In that manner the economics of the different alternatives can be compared on a common basis.

The real discount rate is generally approximated by subtracting the inflation rate from the nominal rate for simpler calculation. It should be noted that in any economic analysis, nominal and real costs and discount rates must not be combined in the same analysis. Logical consistency requires that analysis be performed either in real or nominal values.

2.6 METHODOLOGY LIFE CYCLE COST ANALYSIS

For establishing the best techno-economical among all alternative of project to be executed, all alternative should be accounted for all financial equivalency of costs and benefits resulting from project implementation.

It comprises of the comparison of revenues and expenses (initial investment, operation and maintenance costs in terms of energy consumption) in each project alternative and working out the corresponding technical and financial benefits.

2.6.1 THE SYSTEMS METHOD

LCCA leads to establishment of the best techno-economical alternative among the various available alternatives of the project to be implemented. The system method provides the proper framework for structuring LCCA efficiently. It is a comprehensive process that involves handling a number of interlinked problems and/or tasks on a global basis to achieve the maximum utilization and benefits. **Figure 2.1** describes the major phases and components of the systems method.

2.6.2 ANALYSIS STAGES

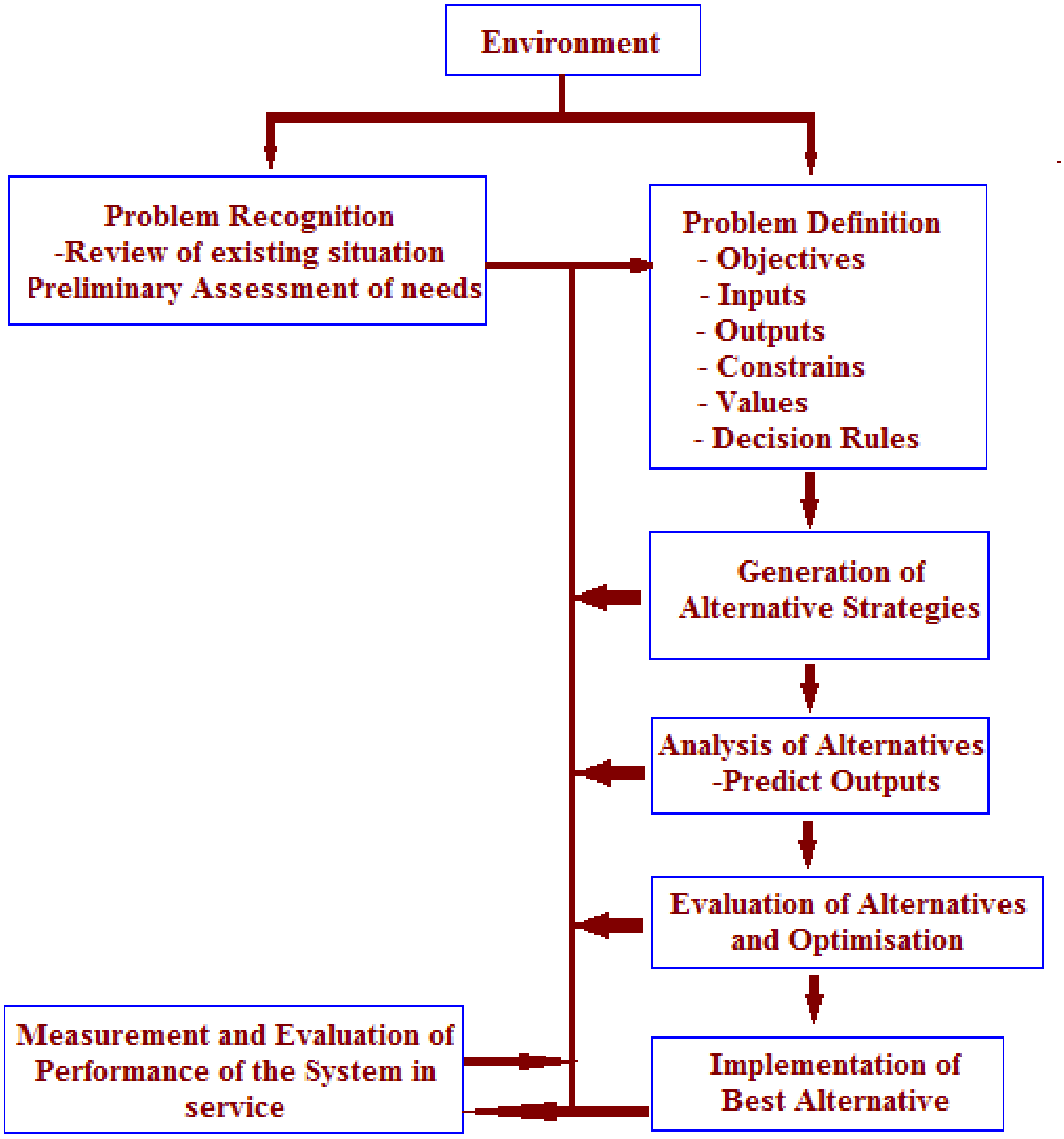
Evaluation of project is performed at various stages of analysis. Analysis stages can be categorized based on the perspective why and what to evaluate

Primary categorizations for level of analysis is based on perception "Why are we Evaluating" Two types of analysis are identified, the primary and secondary analysis:

(i) The primary analysis aims at establishing the economic feasibility of the project. If the anticipated benefits cover the estimated costs, the project is worthwhile in principle. The results of the primary analysis determine whether the project should be constructed in the first phase. Furthermore, the analysis results can be used to prioritize and rank other feasible projects.

(ii) The secondary analysis is executed after the project is chosen for implementation. Its purpose is to decide on the optimum lifecycle strategy between competing alternatives. Life cycle strategies may differ in their initial designs, type and timing of rehabilitation, and maintenance activities, however they must yield equal benefits.

Figure-2.1: Major Phases and Components of Techno-Economic Analysis



The second question, “What are we evaluating?” generates the second categorization

(i) ***The Project Level Analysis*** is a bottom up approach, involves evaluation of competing alternatives for one project. In this analysis, optimum life cycle strategy is explored that achieves the maximum economy without taking funding availability or other policy considerations into account.

(ii) ***The Network Level Analysis*** is *a* top-down approach in which number of projects considered that constitute the network simultaneously. This level of analysis is mainly concerned with finding the best utilization of the network as a whole under various resource constraints and taking into consideration possible political factors. Normally, the main constraint that drives this level of analysis is the financial resources. The input information required is less detailed than that of the project-level. The output of network-analysis provides a program of projects to be constructed for the whole network, and such analysis may provide policy analysis under different scenarios, like the effects of decreased budget on the level of serviceability of the network.

Even though the objectives, level of information, components, and approach may vary in the different types of analysis, the results and decisions attained at each level must interface with each other continuously in order to obtain efficient management.

2.6.3 BASIC PROCESS FOR LIFE CYCLE COST ANALYSIS

Many procedures of LCC analysis have been proposed as the analysis procedures are not completely the same due to differences among the systems analysed. However, some common basic steps, which seem to be essential, in all of the proposed procedures are summarised below.

a) Define Project and Its Alternatives
b) Choose Economic Indicators
c) Establish Expenditure Stream for Each Alternative
d) Computing Net Present Value for Each Alternative
e) Compare and Interpret Results

The LCCA structured approach can be outlined in the following steps:

a) Define Project and its Alternatives

First step in the LCC Analysis procedure is Define Project Alternatives. This is the first step in the LCCA procedure. Each project alternative is carried out initial process design including estimation of cost for each components for example water supply system cost, energy requirement cost and chemicals required at various stage of water treatment plant etc. At this stage, common costs between different alternatives can be identified. For example, in evaluating new treatment plant and energy costs are common to all alternatives. Marginal costs, especially those occurring in the future, can be insignificant with respect to the total value of the project; thus, it is helpful to identify such costs beforehand.

b) Choose Economic Indicators

General economic parameters considered as economic indicator are as follows

- Project's Alternative Cost including Capital and Operational Cost under,
- Discount Rate
- Analysis periods

Except cost of project's alternative, both parameters should be equal for all options.

c) Inventory of Expenditure for Each Alternative

Next step in carrying out LCCA, an inventory of Expenditure is to be established as shown below in **Figure 2.2.** This inventory list out the cost of various components of the project in each alternative like land cost, cost of construction from pipe to concrete, rehabilitation cost, recurring expenditure such operation &maintenance and other associated life cycle cost of each project alternative over the project study period.

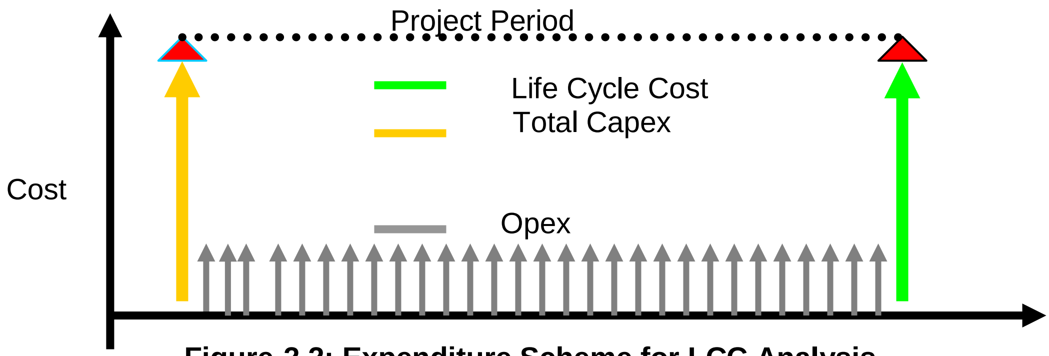


Figure-2.2: Expenditure Scheme for LCC Analysis

d) Computing Net Present Value for Each Alternative

Once the expenditure stream is established, computing the Net Present Value of each alternative becomes a straightforward calculation using formula mentioned in Equation A earlier in this section. For example it is advisable to compute the land cost, cost of construction of Water supply system from pipe to WTP, treatment and pumping cost, annual operation and maintenance cost (including saving) for each alternative separately, in order to better understand the exact contribution of each cost category to the total final worth.

e) Compare and Interpret Results

After calculating net present value for each alternative, interpretation of these results can be made. Generally, an alternative is preferred if its NPV is a minimum than the NPV of other competing alternatives.

CHAPTER 3

METHODOLOGY

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METHODOLOGY

3.1 INTRODUCTION

The LCCA process enables the comparison of total cost (capital and recurring) of all the alternatives, which can be implemented, the alternative that yield the maximum gains is considered the optimal option.

There are various Components, which have potential to effect on the capital cost and operation & maintenance cost of the system and should be taken into account while carrying out the LCCA of the project.

All the prevailing appropriate components in project's alternatives for obtaining the best techno-economical option are presented along with a brief description for each of them and how it can affect the cost analysis.

The present study is focused on application of LCCA to a water supply and finding out the best techno-economical alternative out of various alternatives available. In the following section the various components which may be considered for LCCA analysis of a water supply system are discussed. Later methodology for the development of the water supply system along with various design criteria has been briefed.

3.1.1 SOURCE UTILIZATION

Type of Source: Source is the most important component of the project in water supply sector as its type, surface or ground, decides the whole structure of water supply system.

If water source is underground for e.g. tube well, only small tube well pump house and chlorination system is required before pumping water into clear water system and distribution system, except special treatment for example removal of fluoride, hardness etc. In case, surface water source, water supply system comprises of components like intake structure, raw water system includes pumping system, water treatment plant and main pumping stations followed by clear water transmission and distribution system.

Surface water supply schemes always incur greater capital and recurring cost as compared to schemes due to involvement of provision of various components like intake and conveyance of raw water including pumping station and major treatment facilities.

Availability of water at source: Available water quantity at source to meet the water demand of project area plays an important role in water supply system planning, capital cost and operational cost. Depending upon water availability at source, water supply scheme can be a single source or multi source scheme and hence capital and recurring cost varies from system to system. Life Cycle Cost of a single source water supply scheme may be economical than multi-source scheme as it involves intake structure, pumping station, conveyance main and also man month required is lesser.

Elevation of Water Source: location of water source at higher elevation is always beneficial to water supply system as it leads to make a gravity system, whereas, if the elevation of water source is lower than the project area, pumping facilities will be required to pump water to project area which leads to more capital and operational & maintenance cost.

Water Quality: Raw water from the surface source requires treatment to make is potable for drinking purpose. Degree of treatment varies depending upon quality of water. Usually ground water sources need less treatment including filtration and disinfection. Sometime underground strata impart taste or color or metals in water, which need special treatments for removal and again incur more capital cost and O & M cost.

Distance of Source from Project Area: Distance of project area from water sources is also important criteria as it decides the capita cost and operation & maintenance cost of the system. If the water source is in the vicinity of project area, life cycle cost will be less as it will involve less capital and O&M cost due to involvement of small conveyance main length and small pumping facilities, where as if the project area is location far away from the water source, transportation of water leads to high life cycle cost analysis due to involvement of more conveyance mains length, pumping and other associated components. Also during useful life of the conveyance main, cost for operation and maintenance, rehabilitation results in higher recurring expenditure.

3.1.2 SYSTEM CONFIGURATION

System configuration delineates the type of system, Centralized or Decentralized system. i) A centralized system with water works located at one point in the project area and distribution of treated water to consumption points by a transmission system. ii) A decentralized system with multi-water works each dedicated for feeding a particular zone.

Each system has its advantages and disadvantages and affects capital and recurring cost of the system.

Centralized System usually leads to the following:

- Centralized system involves Raw Water Pumping from water source (e.g. reservoir or intake) to centralized water treatment plants in project area. This system does not have any advantage over the decentralized system expects raw water transmission main in decentralized system, would be shorter and incur less capital cost. This saving in life cycle cost of water supply system overcome by cost incurred in huge extra length of clear water transmission main and pumping station.

- If huge raw water storage is created at one place, it leads to involvement of huge cost for acquisition of land and structure construction.
- As the water to be distributed from centralized WTP, Huge length of bigger size of clear water transmission main emanating from WTPs will be required as conveyance main carry entire quantity of clear water to feed scattered service zones of project area.
- The system may require crossing of higher number of physical barrier likes road crossing, river crossing and rail crossing.
- In case of emergency shutdown of water treatment plant, supply to the whole service area will be cutoff till the breakdown can be made up. Hence entire project area will affect due to shut down.

Minimum operating points like pumping station appear to be the only merit with centralized system. Less number of operation and maintenance points helps in good system management.

From the above, it seems that centralized system configuration leads to involvement of huge additional length of pumping main, bigger sizes of pipes, extra pumping cost, more numbers of crossing of physical barrier (like national highways, state highways, rail crossing and river crossing). Collectively all these leads to enormously high cost of the project and time consuming also as this involve getting permissions for crossings as well.

Decentralized System Configuration has the following favorable points over the demerits enlisted above for centralized system.

- In case of decentralized system, comparatively smaller sizes and length of raw water transmission main (water source to WTPs) and Clear Water Main from (WTPs to MBR) are involved as each WTP will have to feed different zones.
- Lesser numbers of crossings of roads, railway lines, rivers etc as no duplication of pipe lines is involved.
- As the different water works serve to different area and comparatively lesser length of transmission main.
- Small service area will be affected in case of emergency shutdown of water works.

However, the only demerit to decentralized system is greater operation and maintenance cost at each proposed WTP.

3.1.3 TRANSMISSION MAIN – RAW WATER AND CLEAR WATER

Raw water transmission mains transport water from source to water treatment plant and later clear water transmission mains transport water to clear water reservoir such as ground reservoir or elevated reservoir. This component of the system involves pumping stations, pipe lines and other apparentness, water treatment plants and reservoirs (ground level or elevated).

Routing of transmission mains (clear and raw water) plays an important role in keeping a control on the capital cost. Routing should be carefully chosen taking topography, access road, service zone area (of WTP and Reservoir) and length of the pipe network into account. This results in reducing the capital and recurring cost of water supply project. Alternatives can be developed in a project for the following components

- Raw Water Conveyance System and its alignments
- Site of Water Treatment Plant and capacities
- Clear water Transmission Main and its alignments
- Raw water and Clear Water Pumping Stations location
- Service zone of WTP and Clear Water Reservoir (based on Geographical Proximity, Topography, Interference with Physical Barriers, Existing Water Supply Infrastructure, Administrative Boundaries, Spread of Area, Demand)
- Distribution System

Life Cycle Cost Analysis can give design engineers a better representation of the comparison, and it can rule out biasness towards certain alternative to a great extent.

3.2 METHODOLOGY FOR DEVELOPING WATER SUPPLY SYSTEMS

Any water supply scheme, existing or in design, need to follow some basic steps, but not limited to, while formulation of water supply system. These results in establishing the best techno-economical water supply scheme. Given below is the basic procedure.

- Identification of project Area describing geographical details with reference to map and special features, if any, which may affect the project design, implementation and operation.
- Coverage of water supply system including the extent to which water supply scheme will provide services like components of water supply scheme to be included in the water supply schemes from intake to house hold connection.
- Assessment of Population to be served in future, based on the base present population through population projection.
- Estimation of water demand considering the rate of water supply in the project area along with Raw Water requirement.

- Conditional assessment of existing water supply infrastructure i.e. to study whether existing system can meet the future water demand requirement.
- Identification of Improvement areas in the water supply system like water requirement, transmission main and distribution rehabilitation and extension, if old, pumping capacities
- Identification of Suitable Water Sources which provide sufficient quantity and Quality.
- Development of various feasible alternative of Water Supply System, designing including integrated with existing water supply system, if any.

Also system should be matched with the demand of the project area to determine the area that could be covered under the selected source for a sustainable drinking water supply system.

- Estimation of Cost for all alternatives and comparison
- Recommendation of best techno-economical water supply system among various alternatives.

The various alternatives of water supply system were evaluated on the following parameter

1. Capital Cost
2. Operation & Maintenance Costs

Usually the capital cost includes cost to be incurred in constructing the major components of a water supply schemes like raw water intake structure, raw water system including pumping station and transmission main, water treatment plant including clear water reservoir, clear water transmission main including pumping station and service reservoirs etc. Operation and maintenance cost includes money to be spent for keeping the above mentioned systems in running conditions.

All these factors have been converted to a “Rupee” cost for the purpose of arriving at the ranking of the technology under LCCA.

3.3 DESIGN NORMS AND ASSUMPTION

For designing a water supply system, some engineering design criterion, norms and guidelines are to be followed. In general, the guidelines as laid down in the CPHEEO Manual on Water Supply and Treatment, Ministry of Urban Development, Government of India and relevant IS codes are followed. If not available in the above references, some norms and criteria may also be taken from other acceptable standards. A few important parameters / considerations are discussed below.

3.3.1 DESIGN PERIOD

The Manual of Water Supply published by Government of India lays down general guidelines for design periods of Water Supply Systems. It recommends a general design period of 30 years from the date of commissioning of that particular scheme. For this study, year 2010 and 2040 has been considered as base year of commissioning and ultimate planning horizon respectively. Intermediate years have been considered as 2025.

3.3.2 WATER SUPPLY RATE

Drinking water should be provided at the rate of 135 lpcd in the urban area like cities and towns, whereas 70 lpcd in rural areas.

3.3.3 SYSTEM LOSS

Allowances for system loss are provided over theoretical water demand to determine the actual water demand as below:

i)	Raw water transmission and treatment	-	5%
ii)	Clear water transmission and distribution	-	15%
iii)	Seepage and evaporation loss in reservoir, if any	-	25%

3.3.4 DESIGN LIFE OF VARIOUS UNITS

The design life of the various units is considered as:

i)	Civil structures and pipeline works	-	30 to 35 Years
ii)	Mechanical and electrical items	-	15 Years

3.3.5 DURATION OF PUMPING

It depends upon the power situation in the project area. For this dissertation work, all pumping operations are assumed to be carried out for 20 hours a day.

3.3.6 STANDBY FOR PUMPING MACHINERY

In case one set is suggested	-	100%
In case more than one pump set is to work	-	50%

3.3.7 DESIGN FORMULA

Hazen-Williams formula is used for hydraulic design of the pipeline which is given below

$V = 4.567 \times 10^{-3}\ C\ d^{0.63}\ S^{0.54}$ and $Q = 1.292 \times 10^{-5}\ C\ d^{2.63}\ S^{0.54}$

Where, Q is discharge in m^3/hr
V is velocity of flow in m/s
d is the diameter of pipe in mm
S is the slope of hydraulic gradient
C is the Hazen-Williams Co-efficient

3.3.8 "C" VALUE ADOPTED

The recommended value of Hazen-Williams coefficient as per the CPHEEO Manual / IS Code is used in the hydraulic design as given below:

S. No	Conduit Material	Recommended value of C	
		For New Pip	For Design Purpose
1	Cast Iron, Ductile Iron and Mild Steel Pipes lined cement mortar or epoxy	140	140

Source: CPHEEO's Manual on Water Supply and Treatment

3.3.9 PIPE MATERIALS - TRANSMISSION AND DISTRIBUTION SYSTEM

Transmission of water from source to house hold through transmission and distribution system can be done only through pressure conduits or by gravity system. Following conduits are generally available for transmission and distribution system. Choice of the pipe material usually depends on mutual understanding with executing agency.

1. Ductile Iron
2. Cast Iron
3. M.S. Fabricated Pipe
4. Pre-stressed Concrete
5. P.V.C/ HDPE Pipes

For this study, Ductile Iron and PVC pipes has been considered.

3.3.10 HEAD LOSS AND TERMINAL PRESSURE

Besides Head Loss through pipeline due to friction the system design has to take into account residual pressure at terminal points and also losses due to fittings, valves etc. which are essential component in water supply network.

Minimum residual pressures at terminal points considered are:

- **On Distribution Main**
  - 7m residual pressure for single story
  - 12m residual pressure for double story
  - 17 m residual pressure for three story building
- **On Transmission and Sub Transmission Main**
  - At inlet to Reservoir and WTP – 5 m
  - At peak of pumping main – 5 m.

CHAPTER 4

APPLICATION OF LIFE CYCLE COST ANALYSIS FOR WATER SUPPLY SYSTEM

CHAPTER 4

APPLICATION OF LIFE CYCLE COST ANALYSIS FOR WATER SUPPLY SYSTEM

4.1 APPLICATION OF LIFE CYCLE COST ANALYSIS FOR WATER SUPPLY SYSTEM

As mentioned in earlier section, application of life cycle cost analysis for the selection of best techno-economical water supply scheme can leads to minimum capital investment and subsequent least operation and maintenance cost among the various feasible alternatives for a water supply scheme. For the purpose of this study, a water supply scheme has been designed for a project area, details of which is delineated later in this section, and application of LCCA with its parameter like time, capital cost and operation and maintenance cost leads to selection of best techno-economical alternative among the various feasible alternatives.

4.2 PROJECT AREA

Chitradurga district, located in southern region of Karnataka around 200 km from state capital. Total area of project area is around 8449 Sq. Km which is approximately 4.4 % of the state area. Chitradurga district has Vedavathi River passing through the district and flowing in north-east direction. Two reservoirs namely Tungabhadra and Bhadra Reservoir, located in Krishna River basin, have been considered as main source of water for the project area for the drinking water purpose. **Figure 4.1** depicts the location of project area.

This project area comprises of 6 nos. of Taluk which are as follows

a. Hiriyur
b. Chitradurga
c. Challakere
d. Hosodurga
e. Molakalmuru
f. Holalkere

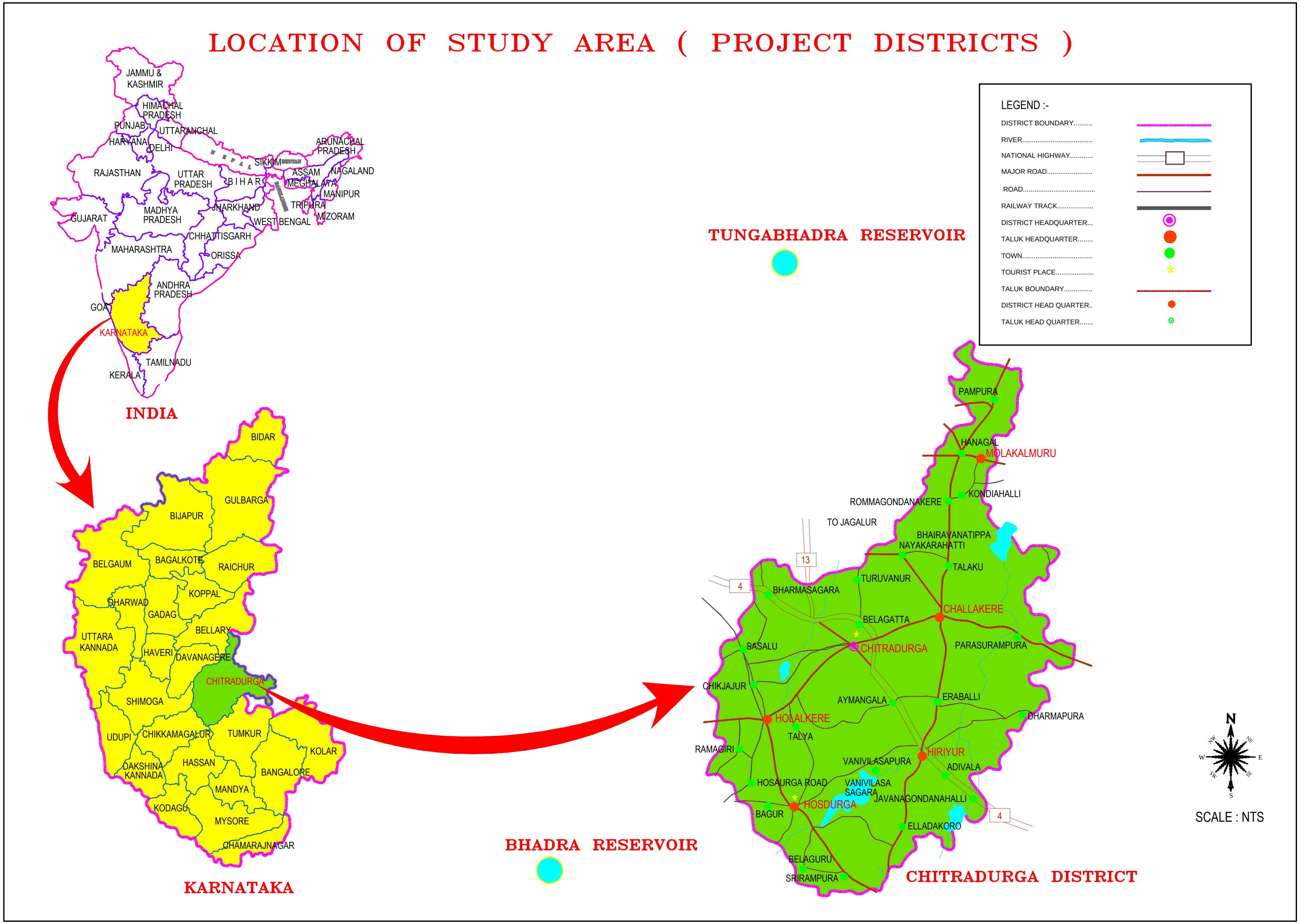


Figure No 4.1 : Location of Project Area

4.3 COVERAGE OF COMPONENT WATER SUPPLY SYSTEM

As mentioned in the Section 3, water supply system comprises of various components including intake system, raw water supply system, water treatment plants, clear water transmission main system and distribution system, pumping stations, mass balancing reservoir and service reservoir.

The overall plan includes bringing raw water from identified surface water sources i.e. reservoir to water treatment plants located in the different parts of district for treating raw water. Service area of water treatment plants has been decided by dividing the whole district divided into zones and further into sub-zones depending upon topography, its proximity to possible water sources, physical constraints, administrative boundary such as Taluk, municipal councils.

4.4 APPROACH AND METHODOLOGY

For planning purpose, system is analyzed with respect to the following feasible criterion before recommending the best techno-economical feasible option based on Life Cycle Cost Analysis.

1. Centralized and Decentralized system.
2. Raw Water Transmission Main with respect to its route alignment and source of water. Total of four alternatives for raw water transmission main have been considered, which are briefly described later in this section.
3. Whole project district has been divided into number of service zones of WTPs. Service zones of each WTP has been worked out based on the existing treatment capacities of WTPs, topography, proximity of habitations,

administrative boundary such as Taluk, municipal councils, physical constraints like river, railway crossing and NH Crossing and other factors.

4.5 POPULATION PROJECTION

Projection of population for project district, up to project horizon 2040, has been done by the various methods like Arithmetic Increase Method, Incremental Increase Method and Geometric Progression Method as stipulated in CPHEEO Manual on Water Supply and Treatment, MOUD. Figures established by these methods is enclosed in **Appendix 4.1.**

However, considering population growth pattern in Chitradurga district, final figures had been established by using State Decadal Growth Rate of 17% for Rural and 32.5% for Urban Areas which are very close to the population figures established from Geometric Progression Method. Summary of projected populations is presented in the **Table 4.1.** These populations have been used for formulation of water supply scheme for study under this dissertation.

Table 4.1: Population Projection

Chitradurga District	**Base Population**	**Population Projection**		
	YR-2001	**YR-2010**	**YR-2025**	**YR- 2040**
Hiriyur	264719	311559	410630	544551
Chitradurga	374038	447552	607438	831338
Challakere	332718	389923	509870	670303
Hosodurga	216858	252837	327504	425937
Holalkere	197766	229762	295658	381608
Molakalmuru	126742	147913	191909	250083
Total	1512842	1779546	2343009	3103820

4.6 PROJECTED WATER DEMAND

Water demand has been estimated based on the Design criterion and assumptions mentioned in section 3 i.e. Water Supply at the rate 135 lpcd and 70 lpcd in urban and rural area for the year 2025 and 2040 and assumed losses in distribution system, WTP, transmission system etc. Detailed estimation for raw and clear water demand has been enclosed in the **Appendix 4.2**

4.6.1 CLEAR WATER DEMAND

To meet water requirement of population of 2343009 and 3103820 in year 2025 and 2040 respectively, approximately 198.705 MLD and 270.207 MLD of clear water is required. Summary of the clear water demand, Taluk wise break up, is presented in the **Table 4.2**

Table 4.2: Clear Water Demand

Chitradurga District	**Clear Water Demand (in MLD)**		
	Year 2010	**Year 2025**	**Year 2040**
Hiriyur	25.892	34.976	47.622
Chitradurga	41.607	58.188	82.097
Challakere	31.404	41.956	56.480
Hosodurga	19.574	25.792	34.195
Holalkere	17.300	22.559	29.556
Molakalmuru	11.538	15.234	20.257
Total	147.315	198.705	270.207

4.6.2 RAW WATER DEMAND

It is established that 245.421 MLD and 333.803 MLD of raw water is required to meet the clear water demand including losses**.** Summary of the Raw Water Demand, Taluk wise break up, is presented in the **Table 4.3**

Table 4.3: Raw Water Demand

Chitradurga District	**Raw Water Demand (in MLD)**		
	Year-2010	**Year-2025**	**Year-2040**
Hiriyur	31.982	43.197	58.842
Chitradurga	51.408	71.891	101.426
Challakere	38.800	51.820	69.793
Hosodurga	24.176	31.856	42.240
Holalkere	21.337	27.835	36.472
Molakalmuru	14.256	18.822	25.030
Total	**181.959**	**245.421**	**333.803**

4.7 EXISTING WATER SUPPLY INFRASTRUCTURE ANALYSIS

There are about ten water supply schemes in the Chitradurga District. Out of which seven are existing water supply schemes and the remaining three schemes are on-going schemes/proposed. The demand and supply gap in these existing/ongoing schemes are also carefully examined and enclosed in **Appendix 4.3**. It is established that all these schemes, serving small parts of the project area, have inadequate existing water supply infrastructure specially water source to meet the future demand of their respective service area. Therefore all the existing infrastructure upto water treatment plant has not been considered for this study. Service area of these WTPs i.e. zones have been redefined with provision of deficit treatment capacities. WTPs will not be taken into account for comparison as it will be same for all the developed alternatives.

4.8 RAW WATER SOURCES

Tungabhadra and Bhadra Reservoir have been considered as primary water source for water supply schemes (various alternatives) due to availability of adequate quantity of raw water to match up water demand. Distance of Tungabhadra and Bhadra Reservoir from project area is approximately 125 km and 85 km. Location of Tungabhadra and Bhadra reservoir is depicted in the **Figure 4.1**

Maximum of approximately 245.421 MLD and 333.803 MLD of Raw Water are to be drawn from primary sources in year 2025 and 2040 depending up on system planning. Raw water will be conveyed from Take-off point at Bhadra Dam and Tungabhadra reservoir to the various existing and proposed water treatment plant considered in water supply schemes.

4.9 SYSTEM CONFIGURATION

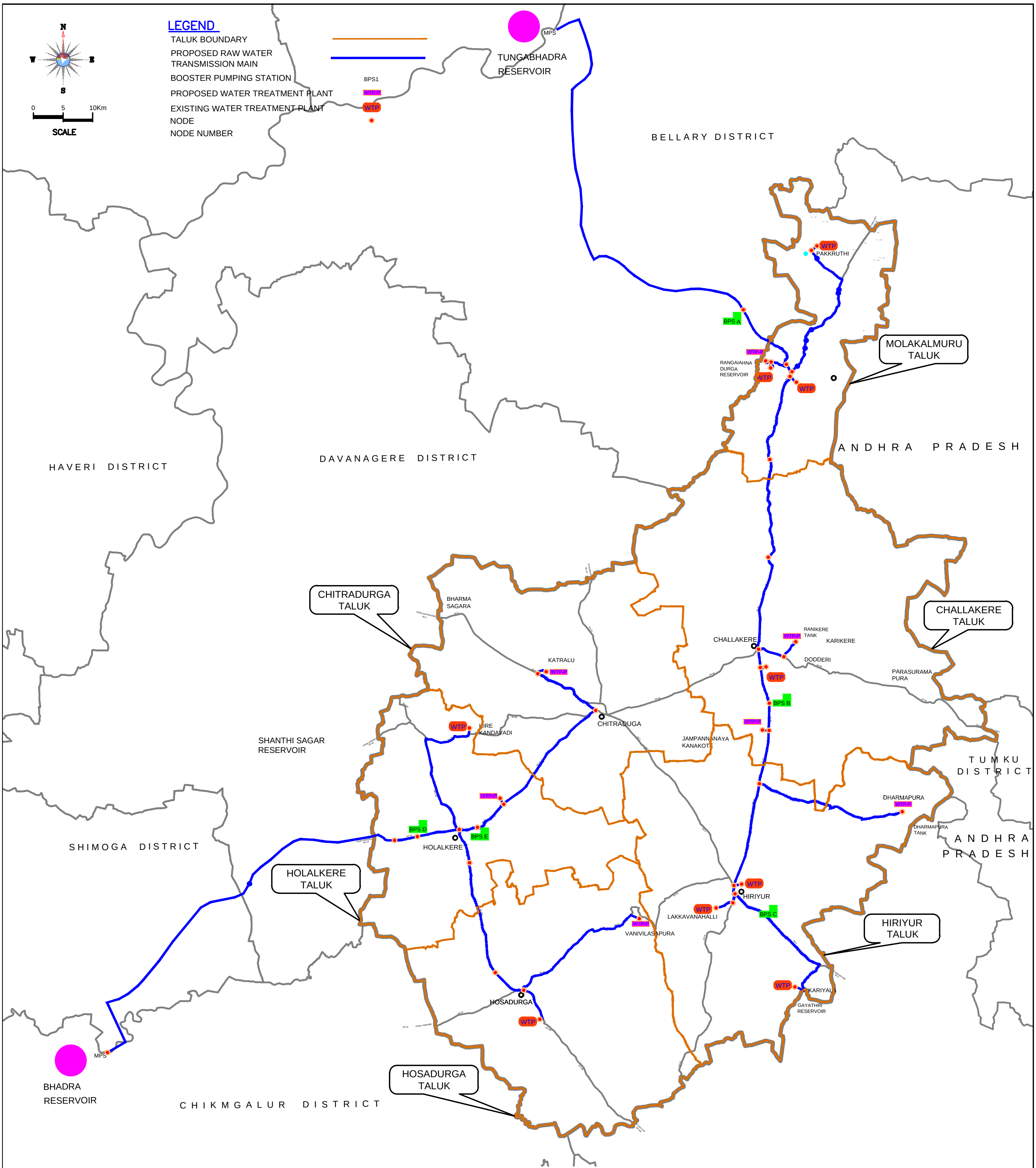
Service area of the clear water system has been restricted to Taluk level instead of district level taking into account various factors like project coverage area and its topography, operation & maintenance and administrative control of system. In order to ensure that system will be best techno-economical and simple in operation and maintenance; system has been studied with 2 different approaches which are as follow

- A centralized system with water works located at one point in the taluk and distribution of treated water to consumption points by a transmission system.
- A decentralized system with multi-water works each dedicated for feeding a particular zone.

Based on preliminary study and in order to compare between the two systems configuration alternatives, Layouts for centralized and decentralized system have been developed and are presented in **Figure 4.2 and Figure 4.3.**

It is observed that for a centralized system, huge length of bigger sizes of transmission main, duplicating of transmission mains (raw water and clear water) and more numbers of crossing of physical barrier like road and river crossing etc are among the few demerits. Association of these demerits leads to the cost intensive proposals. Hence decentralized system has been recommended in spite of the fact that operation and maintenance of the water supply system will be easier in the centralized system due to the less number of the operating points.

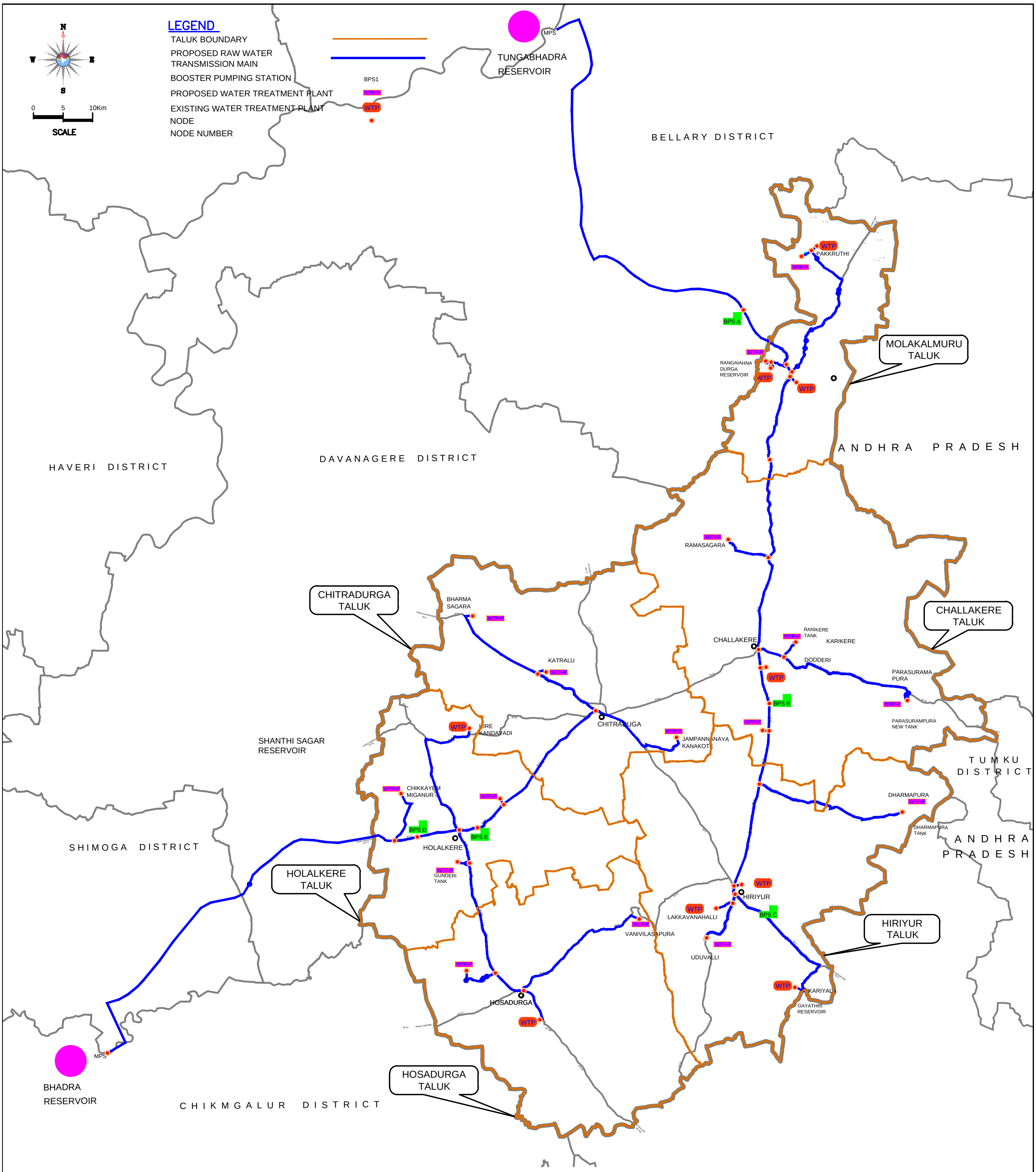
Figure 4.2 : Centralised System for Water Supply System



Centralised System

RAW WATER TRANSMISSION MAIN ALTERNATIVES

Figure 4.3 : Decentralised System for Water Supply System



Decentralised System

RAW WATER TRANSMISSION MAIN ALTERNATIVES

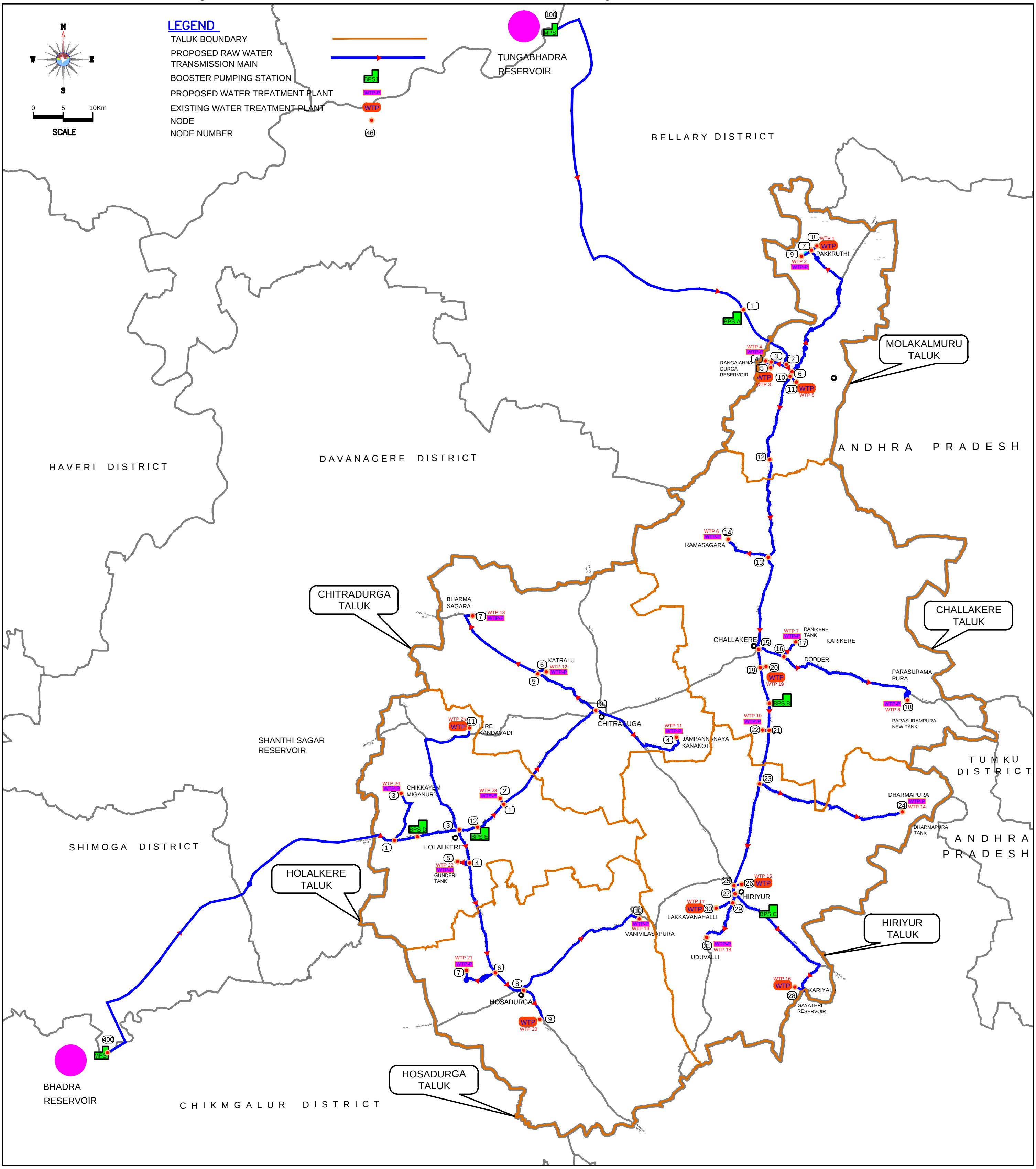
4.10 RAW WATER TRANSMISSION ALIGNMENT (RWTM) OPTIONS

Four Alternatives had been developed for conveyance of raw water from surface water source to various existing and proposed WTPs; a brief description of all alternatives has been discussed below along with service area conveyance main under various alternatives emanating from the identified water sources i.e. reservoir to various WTPs (Existing and proposed) considered under this dissertation work.

4.10.1 ALTERNATIVE A OF RAW WATER TRANSMISSION SYSTEM

In alternative A of the raw water transmission main, 3 Talukas namely Molakalmuru, Hiriyur and Challkere were proposed to be feed from Tungabhadra Reservoir while the other 3 Talukas namely Chitradurga, Holalkere and Hosadurga will be feed from Bhadra Reservoir. **Figure 4.4** shows service area covered under each water sources along with the route alignment of raw water transmission main considered under **Alternative A.**

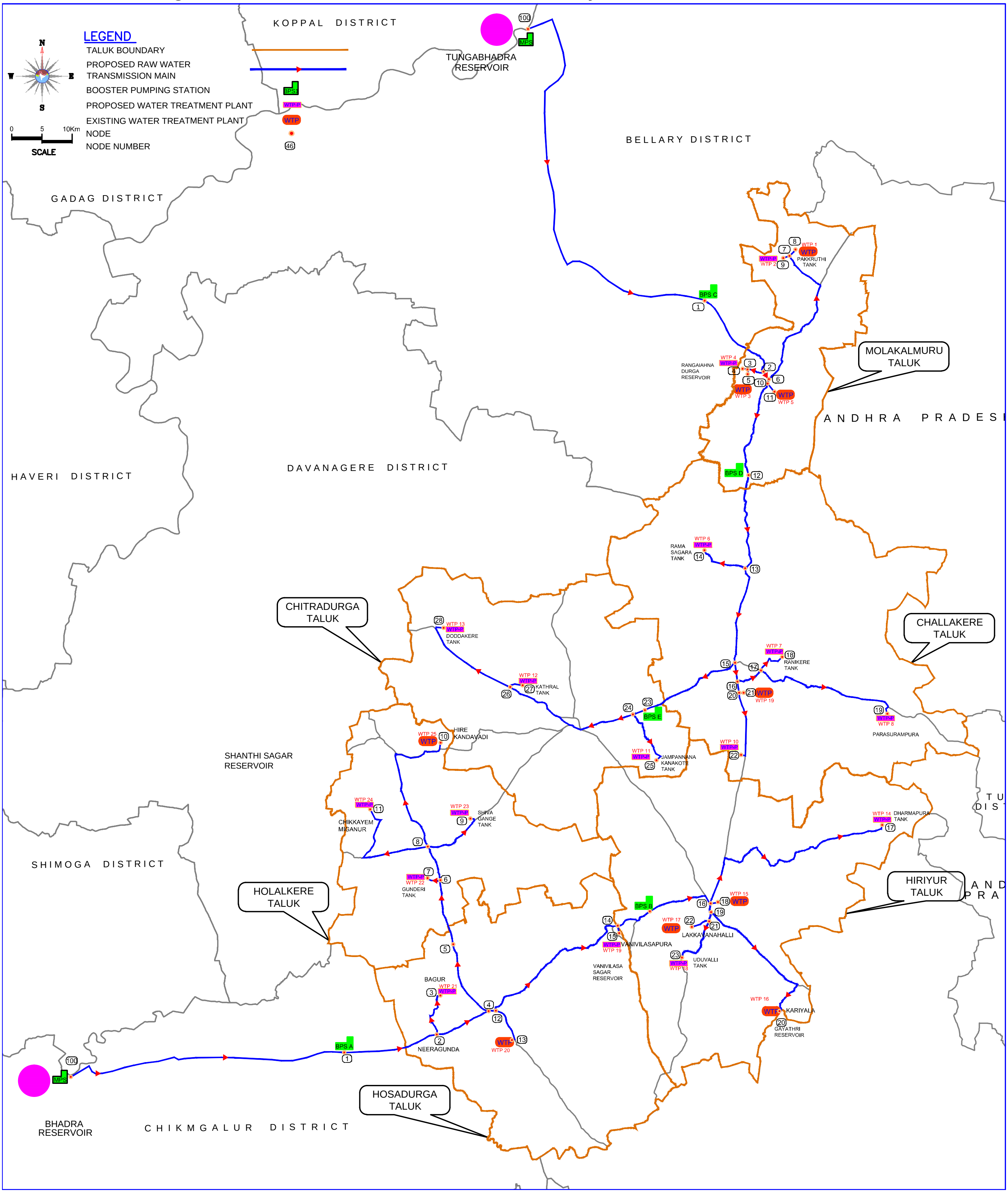
Figure 4.4 : Raw Water Transmission System for Alternative A



4.10.2 ALTERNATIVE B OF RAW WATER TRANSMISSION SYSTEM

In this Alternative, 3 Talukas in northern part namely Molakalmuru, Chitradurga and Challakere were considered to be feed from Tungabhadra Reservoir. While the other 3 Talukas namely Hosadurga, Holalkere and Hiriyur from BhadraReservoir.**Figure 4.5** shows service area covered under each water sources along with the route alignment of raw water transmission main considered under **Alternative B.**

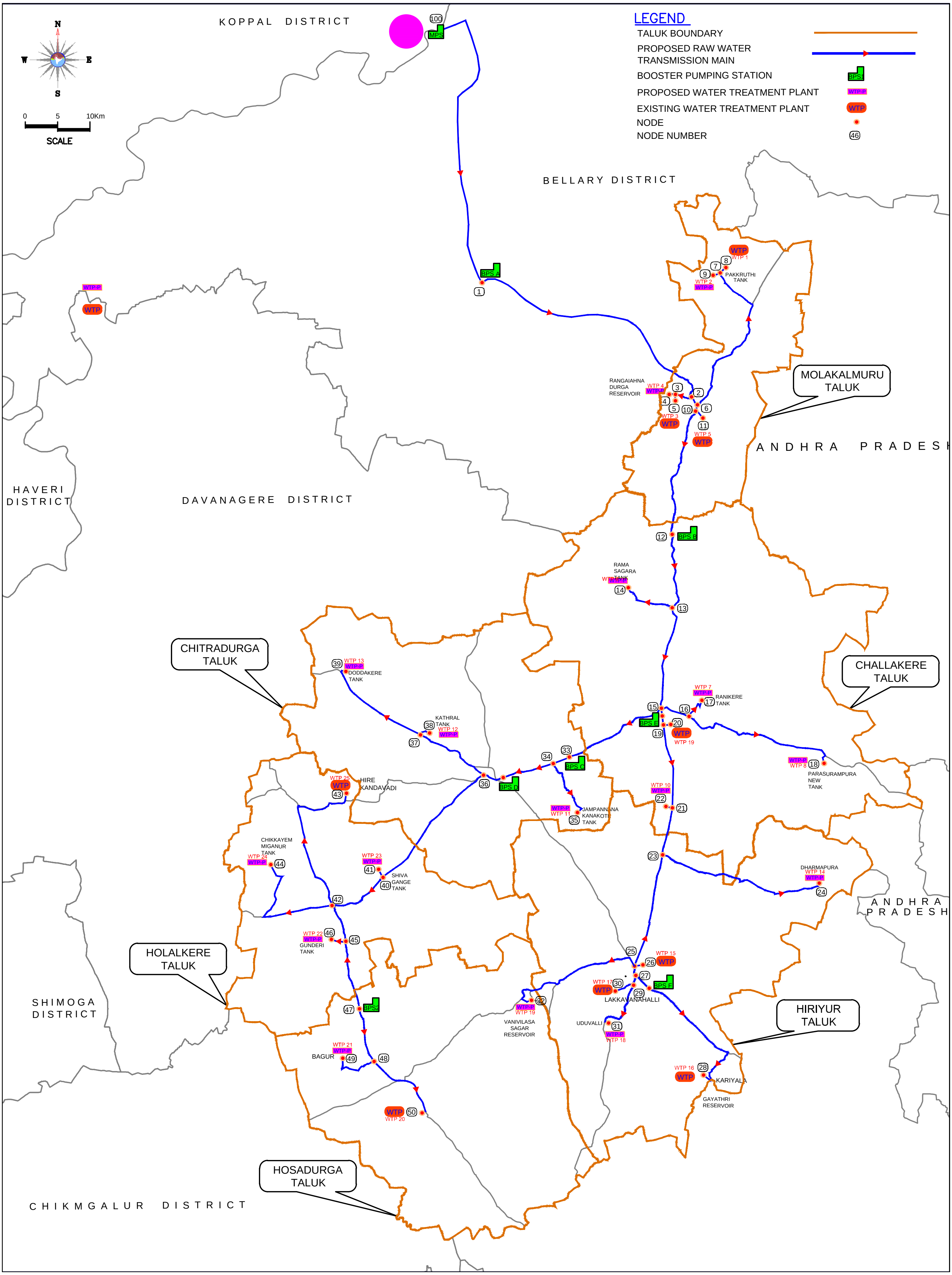
Figure 4.5 : Raw Water Transmission System for Alternative B



4.10.3 ALTERNATIVE C OF RAW WATER TRANSMISSION SYSTEM

All six taluks are considered to be feed from Tungabhadra Reservoir. Raw water from reservoir is pumped to various selected WTPs (Existing and Proposed). **Figure 4.6** shows service area covered under each water sources along with the route alignment of raw water transmission main considered under **Alternative C.**

Figure 4.6 : Raw Water Transmission System for Alternative C



4.10.4 ALTERNATIVE D OF RAW WATER TRANSMISSION SYSTEM

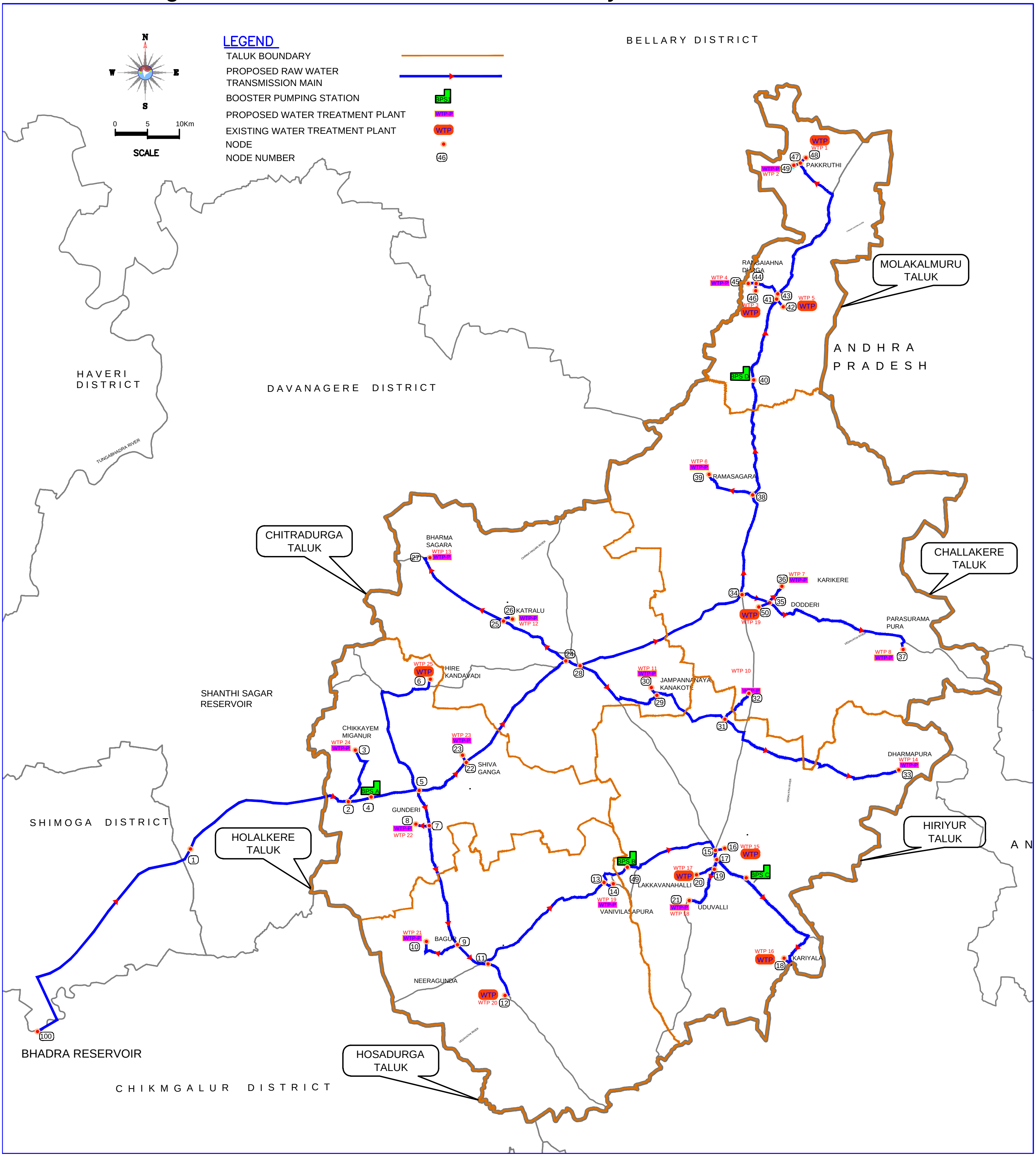
All six taluks are considered to be fed from Tungabhadra Reservoir. Raw water from reservoir is pumped to various selected WTPs. (Existing and Proposed) **Figure 4.7**shows service area covered under each water sources along with the route alignment of raw water transmission main considered under **Alternative D.**

Salient features established from preliminary study of raw water supply system in all the four alternatives is presented below in **Table 4.4**

Table 4.4: Silent features of four alternatives of RWTM System

Features in proposed RWTM system	Alternative A	Alternative B	Alternative C	Alternative D
Raw water Transmission Main Length (in km)	611	608	550	552
Proposed Diameter Range (in mm)	150 - 1400	150 - 1400	150 - 2000	150 - 2000
Road Crossing is	14	13	15	15
Rail Crossing	9	10	7	7
River Crossing	15	15	14	14
Main Pumping Station	2	2	1	1
Booster Pumping Station	5	6	6	4

Figure 4.7 : Raw Water Transmission System for Alternative D



4.11 HYDRAULIC DESIGING OF RAW WATER TRANSMISSION SYSTEM

Based on the various design criterions, norm and guidelines mentioned earlier, hydraulic design of raw water transmission main has been carried out and results have been provided in the **Table 4.5, 4.6, 4.7 and 4.8** for alternative A, B, C and D respectively including pumping head and length for economic system for each of the alternative of raw water transmission main system. Hydraulic designs of the entire alternatives have been carried out considering the same design criterion and norms so that all alternatives can be compared at a common platform.

Table 4.5. :Alternative A – Hydraulic Design Output of Raw Water Transmission Main (From Bhadra Reservoir and Tungabhadra Reservoir)

S. No.	Node		Location	Length	Flow	Designed	Ground Level(m)		Head (m)		
	From	To		(m)	(MLD)	Dia mm	U/S	D/S	Ist Phase U/S	2nd Phase U/S	D/S
Source : Bhadra Reservoir											
1	400	1		71442	180.138	1400	690	660	89.01	136.84	58.4
2	1	BPS D		10795	161.627	1400	660	700	52.48	58.4	5
3	1	2	WTP 24	10037	18.511	450	660	640	13.08	34.43	5
4	BPS D	3		500	161.627	1400	660	700	153.24	153.51	112.89
5	3	4		6048	46.613	800	700	700	108.88	112.89	102.9
6	4	5	WTP 22	2092	4.373	200	700	700	28.89	41.96	5
7	4	6		19489	42.24	700	700	740	81.97	102.9	11.48
8	6	7	WTP 21	7426	10.571	400	740	720	3.14	8	5
9	6	8		5936	31.669	700	740	720	7.58	11.48	22.29
10	8	9	WTP 20	6551	27.438	450	720	660	17.2	11.86	5
11	8	10	WTP 19	31628	4.231	250	720	560	40.52	22.29	5
12	3	11	WTP 25	26625	1.88	200	700	680	49.05	83.52	5
13	3	12	BPS E	135	113.134	350	700	700	39.9	69.58	5
14	BPS E	1		9163	113.134	1000	700	760	129.88	142.01	55.63
15	1	2	WTP 23	1009	11.708	250	760	760	29.07	42.25	5
16	1	3		22658	101.426	1000	760	720	30.52	55.63	42.35
17	3	4	WTP 11	18556	6.413	300	720	640	15.28	17.46	5
18	3	5		12162	95.013	1000	720	680	30.22	19	57.01
19	5	6	WTP 12	1603	87.722	600	680	680	22.73	39.68	5
20	5	7	WTP 13	17439	7.291	350	680	680	38.58	57.01	5
Source : Tungabhadra Reservoir											
1	100	1 (BPSA)		75100	153.665	1400	498	550	105.73	141.93	5
2	1 (BPSA)	2		13052	153.665	1400	550	560	138.11	144.4	119.64
3	2	3		2821	10.005	250	560	540	76.58	104.09	46.25
4	3	4	WTP 4	765	7.989	200	540	540	31.67	46.25	5
5	3	5	WTP 3	725	2.016	150	540	540	13.02	17.39	5
6	2	6		1543	143.66	1400	560	560	118.98	119.64	118.1
7	6	7		27113	7.96	400	560	560	61.31	78.91	29.26
8	7	8	WTP 1	1250	1.535	200	560	580	27.05	28.18	5
9	7	9	WTP 2	1807	6.425	350	560	580	27.75	29.26	5
10	6	10		706	135.7	1400	560	560	99.649	118.1	117.65
11	10	11	WTP 5	1671	7.065	200	560	540	17.84	56.77	5
12	10	12		16251	128.635	1300	560	558	111.97	117.65	106.43
13	12	13		17702	128.635	1300	558	555	100.25	106.43	95.03
14	13	14	WTP 6	8176	11.328	350	555	580	65.64	85.15	5
15	13	15		16251	117.307	1300	555	580	88.05	95.03	54.04
16	15	16		4667	28.555	600	580	560	49.57	54.04	61.41
17	16	17	WTP 7	3351	18.131	350	560	560	39.89	59	5
18	16	18	WTP 8	25324	10.424	400	560	540	34.26	61.41	5
19	15	19		3141	88.752	800	580	590	46.07	53.96	26.86
20	19	20	WTP 9	730	24.526	400	590	600	19.92	25.74	5
21	19	BPS B		10005	64.226	900	590	595	19.62	26.86	5
22	BPS B	21		1005	64.226	900	595	600	147.25	147.97	141.28
23	21	22	WTP 10	1046	5.384	150	600	600	76	115.27	5
24	21	23		8875	58.842	900	600	600	135.74	141.28	128.56
25	23	24	WTP 14	26282	15.739	450	600	580	46.81	80.84	5

Table 4.5. :Alternative A – Hydraulic Design Output of Raw Water Transmission Main (From Bhadra Reservoir and Tungabhadra Reservoir)

S. No.	Node		Location	Length	Flow	Designed	Ground Level(m)		Head (m)		
	From	To		(m)	(MLD)	Dia mm	U/S	D/S	Ist Phase U/S	2nd Phase U/S	D/S
26	23	25		17574	43.103	700	600	600	106.23	128.56	80.43
27	25	26	WTP 15	1253	24.588	300	600	600	39.51	80.21	5
28	25	27		1778	18.515	500	600	600	78.58	80.43	75.19
29	27	BPS C	BPS A	8543	2.529	200	600	615	55.55	74.74	5
30	27	29		1636	15.986	500	600	620	73.89	75.19	51.51
31	29	30	WTP 17	3148	8.694	300	620	620	22.85	32.56	5
32	29	31	WTP 18	8887	7.292	350	620	640	42.08	51.51	5
33	BPS C	28	WTP 16	18000	2.529	200	615	640	104.9	145.34	5

Table 4.6 : Alternative B - Hydraulic Design Output of Raw Water Transmission Main (From Bhadra Reservoir and Tungabhadra Reservoir)

S. No.	Node		Location	Length	Flow	Designed	Ground Level (m)		Head (m)		
	From	To		(m)	(MLD)	Dia mm	U/S	D/S	Ist Phase U/S	2nd Phase U/S	D/S
Source : Bhadra Reservoir											
1	100	1		47819	137.554	1400	680	660	10.73	29.05	5
2	1 (BPS)	2		15625	137.554	1400	690	680	137.74	143.72	139.33
3	2	3	WTP 21	8468	10.571	300	720	690	43.8	81.46	5
4	2	4		9676	126.983	1000	720	690	124.81	139.33	134.83
5	4	5		3553	36.472	700	740	720	120.35	134.83	118.06
6	5	6		10808	36.472	700	720	700	109.5	118.06	116.33
7	6	7	WTP 22	2092	4.373	200	700	720	48.89	61.96	5
8	6	8		6048	32.099	700	700	720	112.5	116.33	86.73
9	8	9	WTP 23	10307	11.708	450	700	760	79.04	86.73	5
10	8	10	WTP 25	26625	1.88	200	700	680	49.05	83.52	5
11	8	11	WTP 24	22332	18.511	500	700	680	22.4	50.83	5
12	4	12		1062	90.511	900	640	720	129.87	131.33	47.95
13	12	13	WTP 20	6551	27.438	450	720	660	17.2	11.86	5
14	12	14		30420	63.073	700	720	560	24.64	47.95	39.33
15	14	15	WTP 19	1208	4.231	200	560	560	17.96	25.08	5
16	14	BPS B		10000	58.842	900	560	580	33.09	39.33	5
17	BPS B	16		7789	58.842	900	580	600	129.19	134.05	102.89
18	16	18	WTP 14	40262	15.739	500	600	610	71.68	102.89	5
19	16	17	WTP 15	1253	24.588	300	600	580	19.51	60.21	5
20	16	19		1778	18.515	500	600	600	78.58	80.43	75.19
21	19	20 (BPS A)	WTP 16	8543	2.529	200	600	615	55.55	74.74	5
22	19	21		1636	15.986	500	600	620	2	75.19	51.51
23	21	22	WTP 17	3148	8.694	300	620	620	2	32.56	5
24	21	23	WTP 18	8887	7.292	350	620	640	42.08	51.51	5
25	20 (BPS A)	20	WTP 16	18000	2.529	200	615	640	104.9	145.34	5
Source : Tungabhadra Reservoir											
1	100	1 (BPS C)	BPS C	77150	196.249	1400	498	540	122.9	184.23	5
2	1 (BPS C)	2		11000	196.249	1400	540	560	120.84	129.59	90.02
3	2	3		2821	10.005	300	560	540	38.58	49.9	37.87
4	3	4	WTP 4	1807	7.989	250	540	540	26.25	37.87	5
5	3	5	WTP 3	1250	2.016	150	540	540	18.83	26.37	5
6	2	6		1543	186.244	1400	560	540	88.9	90.02	107.53
7	6	7		27113	7.96	400	540	560	78.89	96.49	26.84
8	7	8	WTP 1	725	1.535	200	560	580	26.19	26.84	5
9	7	9	WTP 2	765	6.425	350	560	580	26.17	26.81	5
10	6	10		706	178.284	1400	540	580	107.05	107.53	66.48
11	10	11	WTP 5	1671	7.065	200	580	560	17.84	56.77	5
12	10	12(BPS D)	(BPS D)	31251	171.219	1200	580	550	25.11	66.48	5
13	12(BPS D)	13		2702	171.219	1400	550	558	150.46	152.14	140.41
14	13	14	WTP 6	8176	11.328	300	558	555	77.51	118.83	5
15	13	15		13114	159.891	1400	558	580	133.09	140.41	102.45
16	15	16		3137	58.465	900	580	580	100.51	102.45	98.01
17	16	17		4667	28.555	600	580	590	93.54	98.01	75.38
18	17	18	WTP 7	3351	18.131	350	590	560	9.89	29	5

Table 4.6 : Alternative B - Hydraulic Design Output of Raw Water Transmission Main (From Bhadra Reservoir and Tungabhadra Reservoir)

S. No.	Node		Location	Length	Flow	Designed	Ground Level (m)		Head (m)		
	From	To		(m)	(MLD)	Dia mm	U/S	D/S	Ist Phase U/S	2nd Phase U/S	D/S
19	17	19	WTP 8	23324	10.424	400	590	590	50.37	75.38	5
20	16	20		3141	29.91	500	580	600	79.44	90.94	48.43
21	20	21	WTP 9	730	24.526	350	600	600	14.42	25.58	5
22	20	22	WTP 10	12051	5.384	300	600	600	32.97	48.43	5
23	15	23(BPS E)	BPS E	17666	101.426	1000	580	635	81.96	101.54	5
24	23(BPS E)	24		1842	101.426	1000	635	640	140.61	142.65	133.32
25	24	25	WTP 11	10175	6.413	350	640	640	84.59	128.2	5
26	24	26		23346	95.013	1000	640	700	110.03	133.32	24.67
27	26	27	WTP 12	1603	87.722	600	700	680	2.73	19.68	5
28	26	28	WTP 13	17439	7.291	350	700	680	18.58	37.01	5

Table 4.7 Alternative C : Hydraulic Design Output of Raw Water Transmission Main (From Tungabhadra Reservoir)

S. No.	Nodes		Location	Length	Flow	Designed	Ground Level (m)		Head(m)		
	From	To		(m)	(MLD)	Dia mm	U/S	D/S	Ist Phase U/S	2nd Phase U/S	D/S
1	100	1 (BPS A)		46817	333.803	2000	498	540	69.18	86.2	5
2	1 (BPS A)	2		41335	333.803	2000	540	560	120.06	135.09	80.48
3	2	3		2821	10.005	250	560	540	49.24	76.75	18.91
4	3	4	WTP 4	765	7.989	250	540	540	13.99	18.91	5
5	3	5	WTP 3	725	2.016	150	540	540	13.02	17.39	5
6	2	6		1543	323.798	1900	560	560	79.79	80.48	78.91
7	6	7		27113	7.96	400	560	560	61.31	78.91	29.26
8	7	8	WTP 1	1250	1.535	200	560	580	27.05	28.18	5
9	7	9	WTP 2	1807	6.425	350	560	580	27.75	29.26	5
10	6	10		706	315.838	1200	560	560	52.42	55.23	48.81
11	10	11	WTP 5	1671	7.065	250	560	540	-3.92	9.21	5
12	10	12(BPS B)		5251	308.773	1200	560	558	28.83	48.81	5
13	12(BPS B)	13		28702	308.773	1900	558	555	136.83	148.48	124.77
14	13	14	WTP 6	8176	11.328	350	555	580	65.64	85.15	5
15	13	15		16251	297.445	1900	555	580	118.57	124.77	85.66
16	15	16		4667	28.555	500	580	560	61.23	72.11	61.41
17	15	33(BPS C)		17666	175.907	1400	580	635	74.29	85.66	5
18	15	BPS E		2641	92.983	600	580	585	44.56	73.64	5
19	16	17	WTP 7	3351	18.131	250	560	560	39.18	46.96	5
20	16	18	WTP 8	25324	10.424	400	560	540	34.26	61.41	5
21	BPS E	19		500	92.983	1000	585	590	152.82	153.28	147.28
22	19	20	WTP 9	730	24.526	250	590	600	63.5	120.98	5
23	19	21		11005	68.457	1000	590	600	141.97	147.28	124.78
24	21	22	WTP 10	1046	5.384	250	600	600	63.5	120.98	5
25	21	23		8875	63.073	900	600	600	118.55	124.78	110.31
26	23	24	WTP 14	26282	15.739	450	600	580	46.81	80.84	5
27	23	25		17574	47.334	800	600	600	96.72	110.31	80.43
28	25	26	WTP 15	1253	24.588	300	600	600	39.51	80.21	5
29	25	27		1778	18.515	500	600	600	78.58	80.43	75.19
30	27	(BPS F)	WTP 16	8543	2.529	200	600	610	50.55	69.74	5
31	27	29		1636	15.986	500	600	620	73.89	75.19	51.51
32	29	30	WTP 17	3148	8.694	300	620	620	22.85	32.56	5
33	29	31	WTP 18	8887	7.292	350	620	640	42.08	51.51	5
34	25	32	WTP 19	18997	4.231	250	600	560	33.76	71.49	5
35	(BPS F)	28	WTP 16	18000	2.529	200	610	640	109.9	150.34	5
36	33(BPS C)	34		1842	175.907	1400	635	640	137.18	148.02	78.56
37	34	35	WTP 11	10175	6.413	300	640	640	37.75	55.7	5
38	34	(BPS D)		10000	169.494	1400	640	700	72.51	78.56	5
39	(BPS D)	36		1184	169.494	1400	700	720	152.34	153.06	131.45
40	36	37		12162	95.013	800	720	700	56.17	92.14	37.01
41	37	38	WTP 12	1603	87.722	600	700	680	2.73	19.68	5
42	37	39	WTP 13	17439	7.291	350	700	680	18.53	37.01	5
43	36	40		22658	74.481	1400	720	760	119.31	131.45	61.37
44	40	41	WTP 23	1009	11.708	250	760	760	29.07	42.25	5
45	40	42		9298	62.773	900	760	700	55.18	61.37	106.35
46	42	43	WTP 25	26625	1.88	200	700	680	49.05	83.52	5

Table 4.7 Alternative C : Hydraulic Design Output of Raw Water Transmission Main (From Tungabhadra Reservoir)

S. No.	Nodes		Location	Length	Flow	Designed	Ground Level (m)		Head(m)		
	From	To		(m)	(MLD)	Dia mm	U/S	D/S	Ist Phase U/S	2nd Phase U/S	D/S
47	42	44	WTP 24	22322	18.511	450	700	640	7.45	54.92	5
48	42	45		6048	42.382	700	700	700	99.82	106.35	90.29
49	45	46	WTP 22	2092	4.373	200	700	700	28.89	41.96	5
50	45	47		10808	38.009	700	700	700	2	90.29	66.84
51	47	48		8681	38.009	700	700	740	2	66.84	8
52	48	49	WTP 21	7426	10.571	400	740	720	-0.14	8	5
53	48	50	WTP 20	12487	27.438	500	740	660	-31.87	1.29	5

Table 4.8 : Alternative D - Hydraulic Design Output of Raw Water Transmission Main (From Tungabhadra Reservoir)

S. No.	Nodes		Location	Length	Flow	Designed	Ground Level (m)		Head (m)		
	From	To		(m)	(MLD)	Dia mm	U/S	D/S	Ist Phase U/S	2nd Phase U/S	D/S
1	100	1		43429	333.803	2000	660	660	109.25	125.04	88.68
2	1	2		28012	333.803	2000	660	660	78.5	88.68	65.23
3	2	3	WTP 24	10039	18.511	450	660	640	13.09	34.44	5
4	2	4 (BPS A)		8231	315.292	1400	660	685	49.93	65.23	5
5	4 (BPS A)	5		3064	315.292	1400	685	700	145.75	151.44	123.33
6	5	6	WTP 25	26625	1.88	200	700	680	49.05	83.52	5
7	5	7		6048	89.716	900	700	700	114.36	122.54	103.61
8	7	8	WTP 22	2092	4.373	200	700	700	28.89	41.96	5
9	7	9		19489	85.343	900	700	740	79.36	103.61	8
10	9	10	WTP 21	7426	10.571	400	740	720	-0.14	8	5
11	9	11		5639	74.772	900	740	720	-1.18	4.46	11.86
12	11	12	WTP 20	6551	27.438	450	720	660	-17.2	11.86	5
13	11	13		30420	47.334	700	720	560	-53.57	-8.52	52.39
14	13	14	WTP 19	1208	4.231	200	560	560	17.96	25.08	5
15	13	BPS B		10000	43.103	700	580	600	39.68	52.39	5
16	BPS B	15		7789	43.103	700	580	600	136.24	146.14	84.81
17	15	16	WTP 15	1253	24.588	300	600	600	39.51	80.21	5
18	15	17		1461	18.515	500	600	600	83.29	84.81	80.5
19	17	BPS C	WTP 16	10221	2.529	200	600	610	57.53	80.5	5
20	17	19		1590	15.986	500	600	620	74.13	75.39	51.82
21	19	20	WTP 17	3124	8.694	300	620	620	22.72	32.35	5
22	19	21	WTP 18	8991	7.292	350	620	640	42.28	51.82	5
23	5	22		9298	223.696	1400	700	760	114.14	123.33	42.25
24	22	23	WTP 23	1009	11.708	250	760	760	29.07	42.25	5
25	22	24		22658	211.988	1400	760	720	45.37	65.84	59.35
26	24	25		12162	95.013	900	720	700	38.48	59.35	37.01
27	25	26	WTP 12	1603	87.722	600	700	680	2.73	19.68	5
28	25	27	WTP 13	17439	7.291	350	700	680	18.58	37.01	5
29	24	28		2137	116.975	1000	720	720	56.63	59.3	52.76
30	28	29		15237	27.536	500	720	640	19.49	52.76	39.05
31	29	30	WTP 11	1182	6.413	250	640	640	14.25	19.31	5
32	29	31		13826	21.123	600	640	620	31.45	39.05	37.64
33	31	32	WTP 10	6010	5.384	250	620	600	3.081	37.64	5
34	31	33	WTP 14	31752	15.739	500	620	580	9.7	34.31	5
35	28	34		28533	89.439	900	720	580	-27.44	10.21	61.41
36	34	35		4667	53.081	700	580	560	50.64	59.01	60.21
37	35	50	WTP 9	730	24.526	300	560	560	24.96	48.61	5
38	35	36	WTP 7	3357	18.131	350	560	560	39.95	59.1	5
39	35	37	WTP 8	25324	10.424	400	560	540	34.26	61.41	5
40	34	38		16251	36.358	700	580	555	40.94	53.7	46.22
41	38	39	WTP 6	8176	11.328	450	555	580	40.48	46.22	5
42	38	40 (BPS D)		1702	25.03	400	555	558	23.34	34.01	5
43	40 (BPS D)	41		32251	25.03	600	558	560	120.12	148.17	77.77
44	41	42	WTP 5	1671	7.065	200	560	540	17.84	56.77	5
45	41	43		706	17.965	500	560	560	77.07	77.77	75.8

Table 4.8 : Alternative D - Hydraulic Design Output of Raw Water Transmission Main (From Tungabhadra Reservoir)

S. No.	Nodes		Location	Length	Flow	Designed	Ground Level (m)		Head (m)		
	From	To		(m)	(MLD)	Dia mm	U/S	D/S	Ist Phase U/S	2nd Phase U/S	D/S
46	43	44		4364	10.005	300	560	540	58.29	75.8	46.25
47	44	45	WTP 4	765	7.989	200	540	540	31.67	46.25	5
48	44	46	WTP 3	725	2.016	150	540	540	13.02	17.39	5
49	43	47		27113	7.96	400	560	560	61.31	78.91	29.26
50	47	48	WTP 1	1250	1.535	200	560	580	27.05	28.18	5
51	47	49	WTP 2	1807	6.425	350	560	580	27.75	29.26	5
52	BPS C	18	WTP 16	16000	2.529	200	600	640	111.57	147.53	5

4.12 WATER TREATMENT PLANTS

Existing water treatment plants has been proposed to be utilized to the extent possible along with the required rehabilitation and extension in treatment capacities, where ever required to meet deficit. Service area of the existing WTPs has been reorganized as these WTPs are serving small part of the project area scattered over the project area. In addition, around 15 Nos. of New WTPs proposed to meet the clear water demand with Conventional treatment process with cascade aeration has been proposed. **Table 4.9** below provides details of the WTPs, (15 Nos. Proposed and 10 Nos. Existing) with capacities considered in the proposal of this study under each Taluk.

Table 4.9: Details of Water Treatment Plant

WTP No.	WTP Capacities			
	Year 2010	Year 2025	Year 2040	Status
WTP 1	0.77	0.98	1.24	Existing WTP
WTP 2	3.25	4.11	5.20	New WTP
WTP 3	1.02	1.29	1.63	Existing WTP
WTP 4	4.04	5.11	6.47	New WTP
WTP 5	2.83	3.75	5.72	Existing WTP
WTP 6	5.72	7.24	9.17	New WTP
WTP 7	9.17	11.59	14.67	New WTP
WTP 8	5.26	6.66	8.44	New WTP
WTP 9	9.82	13.02	19.85	New WTP
WTP 10	2.72	3.44	4.36	New WTP
WTP 11	3.24	4.10	5.19	New WTP
WTP 12	37.91	49.43	71.00	New WTP
WTP 13	3.68	4.66	5.90	New WTP
WTP 14	7.95	10.05	12.74	New WTP
WTP 15	9.87	13.07	19.90	Existing WTP
WTP 16	1.28	1.62	2.05	Existing WTP
WTP 17	4.39	5.57	7.04	Existing WTP
WTP 18	3.68	4.65	5.90	New WTP
WTP 19	2.13	2.70	3.42	Existing WTP
WTP 20	12.68	16.32	22.21	Existing WTP
WTP 21	5.34	6.76	8.56	New WTP
WTP 22	2.21	2.80	3.54	New WTP
WTP 23	5.91	7.49	9.48	New WTP
WTP 24	8.58	11.04	14.98	New WTP
WTP 25	0.95	1.21	1.52	Existing WTP

4.13 COSTING

Costing has been worked out for all four Alternatives i.e. Alternative A, Alternative B, Alternative C and Alternative D of raw water supply system. Costing has been done based on schedule of rates, market prices and guidelines.

Tentative cost for all four raw water supply systems has been presented in the next Chapter.

Cost of laying of raw water transmission main system and pumping stations have considered for comparison, whereas cost for the intake structure and rehabilitation and extension of existing WTP, construction of new WTPs is not taken into account while estimation of the capital cost and operation& maintenance cost.

CHAPTER 5

RESULT AND ANALYSIS

CHAPTER 5

RESULT AND ANALYSIS

5.1 RESULTS

As mentioned in the chapter 4, block cost of pipe network, pumping station and associated machineries has been worked out for four alternatives for comparison of life cycle cost on the parameters like capital cost and operation and maintenance cost of raw water transmission main and using Life Cycle Cost Analysis (LCCA) as a decision making tool for selection of best techno-economical alternative.

5.2 CAPITAL COST

Following cost has been considered for the comparison of capital cost in all the four alternatives of raw water supply system.

a. Cost of Pipe Length
b. Cost of Pumping Station and associated machineries

Cost for the following components has not been taken in to account while life cycle cost assessment as cost for these components will marginal difference in all alternative.

a. Intake structure
b. Water Treatment Plant
c. Crossing of physical barrier like river, national & state highways etc.

5.2.1 COST OF PIPE LENGTH

For all the alternatives, pipe sizes calculated based on the hydraulic design carried out and delineated in earlier section. Costing of these pipe length for all alternatives, diameter wise, has been calculated based on the unit cost inclusive of laying jointing, testing and commissioning of pipe network along with the cost of pipe specials like bends, tees etc., air valves, sluice valves and other apparentness. Unit Costs worked out is shown in the **Appendix 5.1**. Costing for each alternative is presented in the **Table 5.1.** It is established that alternative A, B, C and D of the raw Water transmission Main System incur approximately Rs. 1185.74 Crores, Rs. 1133.57 Crores, Rs. 1435.05 Crores and Rs. 1095.08 Crores respectively.

5.2.2 COST OF PUMPING STATIONS

Block Cost of pumping stations has been worked out for civil structure construction, electrical component and pumping machineries and is presented in the **Table 5.2**. Block cost has been worked out based on the thumb rules based on pump cost.

Table 5.1 : Cost of Pipe Length for Various Alternatives

Diameter (mm)	Material	Unit Cost Rs/m	Alternative A		Alternative B		Alternative C		Alternative D	
			Length (m)	Total Cost (INR)	Length (m)	Total Cost (INR)	Length (m)	Total Cost (INR)	Length (m)	Total Cost (INR)
150	DI	1776	1771	3145296	1250	2220000	725	1287600	725	1287600
200	DI	2276	58946	134161096	58864	133974464	56510	128616760	59832	136177632
250	DI	3024	35458	107224992	1807	5464368	30390	91899360	8201	24799824
300	DI	3816	22957	87603912	35917	137059272	14576	55622016	9471	36141336
350	DI	4713	39795	187553835	41347	194868411	36309	171124317	31594	148902522
400	DI	5679	60593	344107647	50437	286431723	59863	339961977	61565	349627635
450	DI	6767	42870	290101290	16858	114078086	48604	328903268	24766	167591522
500	DI	7837	3414	26755518	69149	541920713	20568	161191416	50746	397696402
600	DI	10332	6270	64781640	6270	64781640	4244	43849008	47680	492629760
700	DI	13285	42999	571241715	50829	675263265	25537	339259045	69127	918352195
800	DI	16068	9189	147648852	0	0	29736	477798048	0	0
900	DI	19511	19885	387976235	21988	429007868	18173	354573403	71871	1402275081
1000	DI	23568	43983	1036591344	52530	1238027040	11505	271149840	2137	50364816
1200	MS	27138	0	0	31251	848089638	5957	161661066	0	0
1300	MS	33210	50204	1667274840	0	0	0	0	0	0
1400	MS	39282	173138	6801206916	169659	6664544838	53350	2095694700	43251	1698985782
1900	MS	64584	0	0	0	0	46496	3002897664	0	0
2000	MS	71751	0	0	0	0	88152	6324994152	71441	5125963191
Total	INR		611472	11857375128	608156	11335731326	550695	14350483640	552407	10950795298
Total	**Crores**			**1185.74**		**1133.57**		**1435.05**		**1095.08**

Table 5.2: Cost of Pumping Station and pumps

Pumping Station Name	Pumping Head		KW		Pump Cost (in Lacs)		Civil Cost	Electrification cost	Other Appurtenances	Total Cost (Rs. Lacs)		Total Cost (Rs.) (Crores)		
	Ist phase	2st phase	Year 2025	Year 2040	Year 2025	Year 2040	1.5 time of pump cost	10 % of Civil Cost		Year 2025	Year 2040	In Ist Phase	In 2st Phase	Total in 2040
Alternative A														
Bhadra Reservoir MPS	89.01	136.84	3035.73	5445.28	1062.51	1905.85	2858.77	285.88	142.94	4064.22	1905.85	40.65	19.06	59.71
BPS D	153.24	153.51	4682.56	5478.57	1638.89	1917.50	2876.25	287.63	143.81	4658.96	1917.50	46.59	19.18	65.77
BPS E	129.88	142.01	2725.56	3521.79	953.95	1232.63	1848.94	184.89	92.45	2895.33	1232.63	28.96	12.33	41.29
Tungabhadra Reservoir MPS	105.73	141.93	3123.80	4846.67	1093.33	1696.33	2544.50	254.45	127.22	3765.06	1696.33	37.66	16.97	54.63
1(BPSA)	138.11	144.4	4082.29	4931.01	1428.80	1725.85	2588.78	258.88	129.44	4147.02	1725.85	41.48	17.26	58.74
BPS B	147.25	147.97	1812.40	2109.31	634.34	738.26	1107.39	110.74	55.37	1797.10	738.26	17.98	7.39	25.37
BPS C	104.9	145.34	54.82	84.08	19.19	29.43	44.14	4.41	2.21	65.54	29.43	0.66	0.30	0.96
					6831.01	9245.85	13868.78	1386.88	693.44	21393.22	9245.85	213.98	92.49	306.47
Alternative B														
Bhadra Reservoir MPS	10.73	29.05	286.74	891.65	100.36	312.08	468.12	46.81	23.41	591.88	312.08	5.92	3.13	9.05
1 (BPS)	137.74	143.72	3680.84	4411.30	1288.30	1543.95	2315.93	231.59	115.80	3720.02	1543.95	37.21	15.44	52.65
BPS B	129.19	134.05	1446.83	1746.11	506.39	611.14	916.71	91.67	45.84	1468.93	611.14	14.69	6.12	20.81
20 (BPS A)	104.9	145.34	54.82	84.08	19.19	29.43	44.14	4.41	2.21	65.54	29.43	0.66	0.30	0.96
Tungabhadra reservoir MPS	122.9	184.23	4536.92	7967.47	1587.92	2788.62	4182.92	418.29	209.15	5979.99	2788.62	59.80	27.89	87.69
1 (BPS C)	120.84	129.59	4460.88	5604.43	1561.31	1961.55	2942.33	294.23	147.12	4650.75	1961.55	46.51	19.62	66.13
12(BPS D)	150.46	152.14	4818.15	5727.99	1686.35	2004.80	3007.20	300.72	150.36	4843.91	2004.80	48.44	20.05	68.49
23 (BPS E)	140.61	142.65	2609.44	3156.18	913.30	1104.66	1656.99	165.70	82.85	2653.15	1104.66	26.54	11.05	37.59
					7663.12	10356.23	15534.34	1553.43	776.72	23974.17	10356.23	239.77	103.60	343.37

Pumping Station Name	Pumping Head		KW		Pump Cost (in Lacs)		Civil Cost	Electrification cost	Other Appurtenances	Total Cost (Rs. Lacs)		Total Cost (Rs.) (Crores)		
	Ist phase	2st phase	Year 2025	Year 2040	Year 2025	Year 2040	1.5 time of pump cost	10 % of Civil Cost		Year 2025	Year 2040	In Ist Phase	In 2st Phase	Total in 2040
Alternative C														
Tungabhadra Reservoir	69.18	86.2	4402.52	6373.71	1540.88	2230.80	3346.20	334.62	167.31	5054.39	2230.80	50.55	22.31	72.86
1 (BPS A)	120.06	135.09	7640.46	9988.69	2674.16	3496.04	5244.06	524.41	262.20	8180.42	3496.04	81.81	34.97	116.78
12 (BPS B)	136.83	148.48	8038.20	10147.57	2813.37	3551.65	5327.48	532.75	266.37	8407.22	3551.65	84.08	35.52	119.60
BPS E	152.82	153.28	2643.20	3127.73	925.12	1094.70	1642.06	164.21	82.10	2649.28	1094.70	26.50	10.95	37.45
(BPS F)	109.9	150.34	57.43	86.98	20.10	30.44	45.66	4.57	2.28	68.05	30.44	0.69	0.31	1.00
33 (BPS C)	137.18	148.02	4557.44	5747.04	1595.10	2011.46	3017.19	301.72	150.86	4763.16	2011.46	47.64	20.12	67.76
(BPS D)	152.34	153.06	4859.57	5718.45	1700.85	2001.46	3002.19	300.22	150.11	4853.15	2001.46	48.54	20.02	68.56
					11269.59	14416.56	21624.84	2162.48	1081.24	33975.67	14416.56	339.81	144.20	484.01
Alternative D														
Bhadra Reservoir MPS	109.25	125.04	6952.53	9245.58	2433.38	3235.95	4853.93	485.39	242.70	7530.01	3235.95	75.31	32.36	107.67
4 (BPS A)	145.75	151.44	8759.88	10576.05	3065.96	3701.62	5552.43	555.24	277.62	8896.01	3701.62	88.97	37.02	125.99
BPS B	136.24	146.14	1083.65	1378.27	379.28	482.39	723.59	72.36	36.18	1139.05	482.39	11.40	4.83	16.23
BPS C	111.57	147.53	545.89	825.86	191.06	289.05	433.58	43.36	21.68	646.32	289.05	6.47	2.90	9.37
40 (BPS D)	120.12	148.17	62.77	85.72	21.97	30.00	45.00	4.50	2.25	69.22	30.00	0.70	0.31	1.01
					6091.65	7739.02	11608.53	1160.85	580.43	18280.61	7739.02	182.85	77.42	260.27

5.3 OPERATION ANDMAINTENANCE COST

Operation and Maintenance for the 30 years has been worked out after taking the following cost into considerations

a. Cost for Man power
b. Energy Cost
c. Capital Maintenance
d. Repair Cost etc.

Comparison of Operation and maintenance cost for all the alternatives for the designed system is presented in the **Table 5.3.**

It is established that Rs. 3542.1 Crores, Rs. 3959.27 Crores, Rs. 5481.14 Crores and Rs. 2975.55 Crores of Operation and Maintenance cost will incur for Alternative A, Alternative B, Alternative C, and Alternative D respectively. Hence it is established that Alternative D will incur Least Cost.

Table 5.3 : Operation and Maintenance Cost for the year 2025 & 2040

Sl No.	Particulars	2025	2040	2025	2040	2025	2040	2025	2040
	Preliminary data								
1	Population :	2343009	3103820	2343009	3103820	2343009	3103820	2343009	3103820
2	Forecast Population	2343009	3103820	2343009	3103820	2343009	3103820	2343009	3103820
Sl No.	**Particulars**	**Alternative A**		**Alternative B**		**Alternative C**		**Alternative D**	
	Expenditure :								
	Man power (Establishment)								
1	**Pump operator at Head works**								
	No. of Head Works	2	2	2	2	1	1	1	1
	a) Nos. @ 3 persons	3	3	3	3	3	3	3	3
	b) Salary per month Rs.	3000*	5250*	3000*	5250*	3000*	5250*	3000*	5250*
	c) Expenditure per month	18000	31500	18000	31500	9000	15750	9000	15750
2	**Pump Operator at BPS**								
	No. of BPS	5	5	6	6	6	6	4	4
	a) Nos. @ 3 persons	3	3	3	3	3	3	3	3
	b) Salary per month	3000	5250	3000	5250	3000	5250	3000	5250
	c) Expenditure per month	45000	78750	54000	94500	54000	94500	36000	63000
3	**Pump Operator at WTP**								
	No. of WTPs (Proposed)	16	16						
	a) Nos. @ 3 persons	3	3						
	b) Salary per month	3000	5250						
	c) Expenditure per month	144000	252000	144000	252000	144000	252000	144000	252000

Table 5.3 : Operation and Maintenance Cost for the year 2025 & 2040

Sl No.	Particulars	2025	2040	2025	2040	2025	2040	2025	2040
4	**Valve man for Raw water Rising Main maintenance**								
	No. of Head Works + BPS	7	7	8	8	7	7	5	5
	a) Nos.	1	1	1	1	1	1	1	1
	b) Salary per month	3000*	5250*	3000*	5250*	3000*	5250*	3000*	5250*
	c) Expenditure per month	21000*	36750*	24000*	42000*	21000*	36750*	15000*	26250*
5	**Energy Cost**								
	a) Raw Water Pumping Station								
	(i) KW Consumed (For Running Pumps)								
	Total	13011	17611	14596	19726	21466	27460	11603	14741
	(ii) Pumping Hours	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
	(iii) Energy Consumption per month	7806863	10566688	8757847	11835687	12879533	16476065	6961890	8844596
	(iv) Energy rate Rs/unit	5	8.75*	5	8.75*	5	8.75*	5	8.75*
	(v) Energy cost per month(Crores)	3.90	9.25	4.38	10.36	6.44	14.42	3.48	7.74
6	**Chemical Experts**								
	If Disinfections done at WTP								
	(a) Consumption of Water per month (MLD)	7362.6	10014.09						
	(b) Dosage	2.0mg/lit	2.0mg/lit						
	(c) Chemical require per month (Kg)	14725.26	20028.18		Same for all the Alternatives				
	(d) Total quantity of Bleaching Power Required with 25% Cl_2 require per month	58901.04	80112.72						
	(d) Rate of material per kgs	12	21						
	(e) Cost of material (Crores)	**0.07**	**0.17**	**0.07**	**0.17**	**0.07**	**0.17**	**0.07**	**0.17**
7	**Capital M & R cost (Crores)**								
	Capital cost								

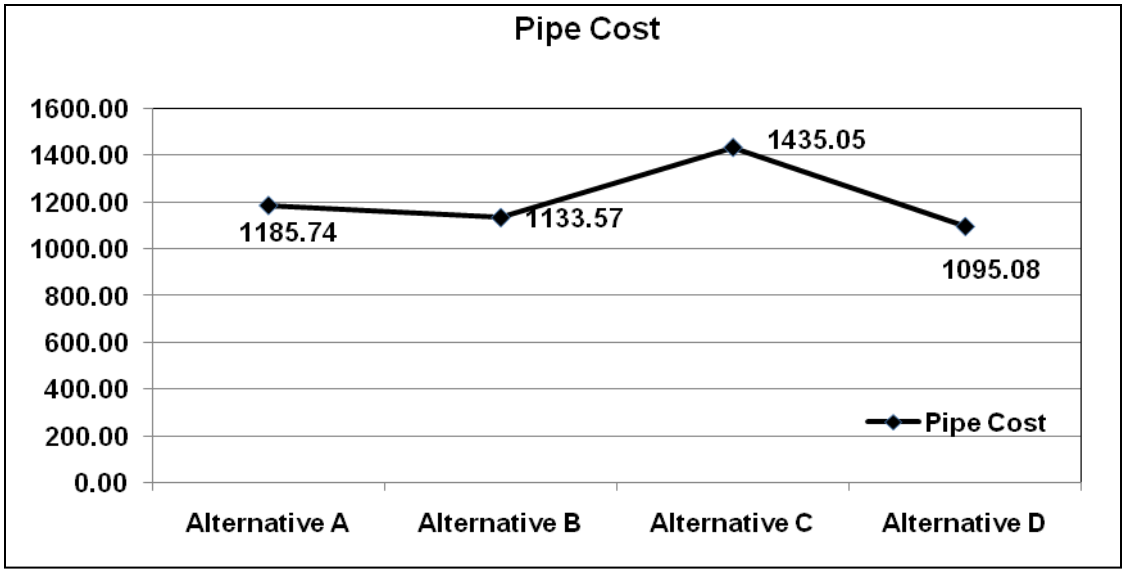
Table 5.3 : Operation and Maintenance Cost for the year 2025 & 2040

Sl No.	Particulars	2025	2040	2025	2040	2025	2040	2025	2040
	a) Capital cost other than pumping machinery	159.49		178.64		248.69		133.50	
	b) Rate of M & R **1% per year for Civil Works**	1%	1%	1%	1%	1%	1%	1%	1%
	c) M & R cost per Month	0.13	0	0.15	0	0.21	0	0.11	0
8	**Capital cost (Crores) of**								
	a) Machinery and Electrification	68.31	92.46	76.63	103.56	112.70	144.17	60.92	77.39
	b) Rate of M & R **5% per year for Mechanical Works**	5%	5%	5%	5%	5%	5%	5%	5%
	c) M & R cost per month	0.28	0.39	0.32	0.43	0.47	0.60	0.25	0.32
	Total O&M cost (Crores)	**4.41**	**9.84**	**4.94**	**11.00**	**7.21**	**15.23**	**3.94**	**8.27**
9	**O&M charges per Year**	**52.94**	**118.07**	**59.31**	**131.98**	**86.55**	**182.70**	**47.23**	**99.19**
	O&M charges for 30 years	**1588.15**	**3542.12**	**1779.44**	**3959.27**	**2596.61**	**5481.14**	**1416.9**	**2975.55**

5.4 ANALYSIS

5.4.1 PIPE COST

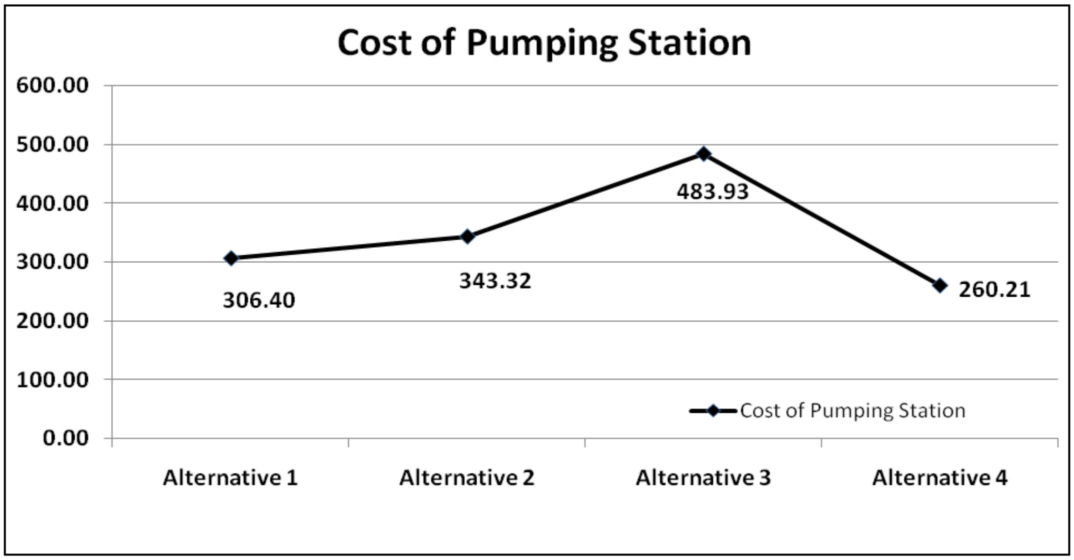
Graph presented below in **Figure 5.1**depicts the comparison of capital cost of pipe length, one of the parameter of life cycle cost analysis, for four alternatives.



As it is clear from graphical presentation that Alternative D incur least capital cost for pipe network comparison to other alternatives of raw water transmission main system. In Alternative A and Alternative B, additional cost of pipe for bringing raw water to the project area is leading to higher cost compared to Alternative D, whereas Alternative C higher cost is due to more length of bigger sizes of pipe. Hence cost of capital cost in alternative D is least plays a significant role in deciding the project system based on the capital cost investment.

5.4.2 PUMPING STATION AND PUMP COST

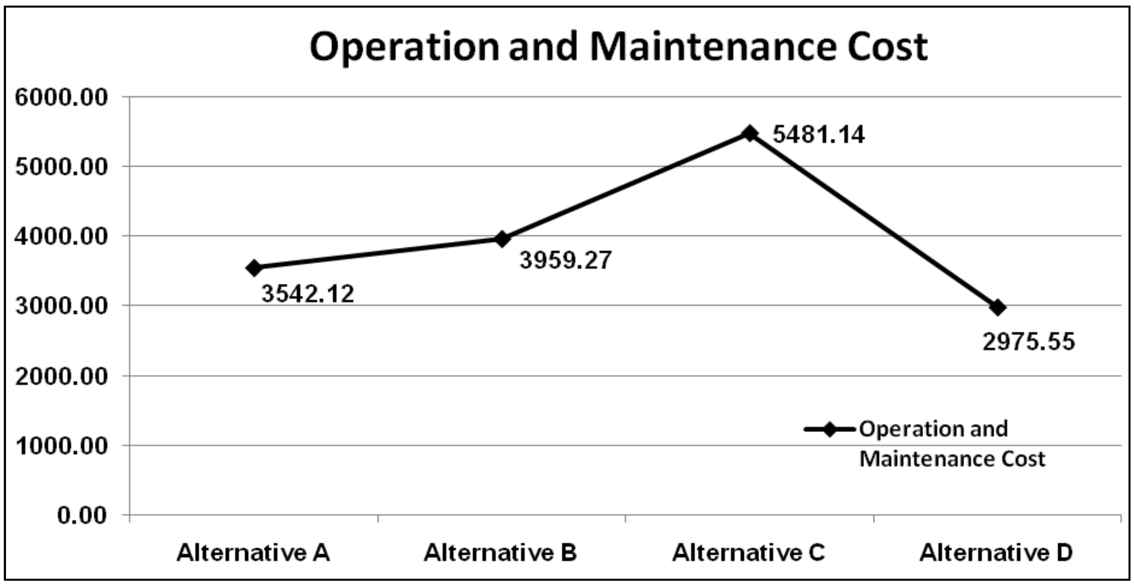
Graph presented in **Figure 5.2** depicts the comparison of capital cost for pumping stations and machineries for four alternatives of Water Supply System.



As it is clear from the comparison that Alternative D of raw water system will leads to least capital investment due to minimum nos. of pumping stations and minimum pumping head of machineries is required.

5.4.3 OPERATION AND MAINTENANCE COST (O & M)

Operation maintenance cost of the system including the various cost like energy consumption, remuneration of staff, chemicals, and repair work etc., As O&M cost gives overall of cost to be incur throughout the project horizon, it plays an important role in section. Alternative D will incur least operation and maintenance cost in comparison to other alternatives. It is observed that due to higher elevation of Bhadra Reservoir which results in designing a raw water system with less pumping station and pumping head to serve the whole project area, which subsequently leads to less operating cost i.e. less O&M cost. **Figure 5.3** shows the comparison of operation and maintenance cost of all the alternatives.



CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

Following are the inference drawn from the present dissertation work

1. Life Cycle Cost analysis verified that its application in water supply sector leads to selection of best techno-economical water supply system which will be more efficient and incur least project cost i.e. Capital and Operation & Maintenance cost.
2. Four alternative of water supply system has been selected i.e.
    - Alternative A: 3 taluks namely Molakalmuru, Hiriyur and Challakere feed from source Tungabhadra Reservoir and 3 taluks i.e. Chitradurga, Holalkere and Hosadurga from Bhadra Reservoir.
    - Alternative B: Water supply system with 3 taluks (Molakalmuru, Chitradurga and Challakere) with Tungabhadra reservoir as source and 3 taluks (Hiriyur, Holalkere and Hosadurga) from Bhadra Reservoir.
    - Alternative C: Water supply system with source Tungabhadra Reservoir.
    - Alternative D: Water supply system with source Bhadra Reservoir.
3. It is established in this dissertation, with the application of LCC analysis, Alternative D i.e. water supply system with source Bhadra Reservoir only, is best techno-economical water supply system.
4. LCCA's parameters like project cost, study period etc. plays an important role in the selection of best techno-economical water supply system, which incurs least capital

and operation & maintenance cost in comparison to other alternatives of water supply system.

6.2 RECOMMENDATIONS

1. Out of four alternatives. Alternative D of water supply system is best techno-economical water supply system and hence concept of LCC Analysis should be applied for the selection of most economical water supply system.

2. In addition, this study also depicts fundamental information like consideration of water source at higher elevation among various available water sources, leads to less operation & maintenance cost and should be preferred. Similarly, distance of water source from the project area plays significant role in deciding capital cost of project which ultimately lead to selection of best techno-economical water supply system and hence water source in vicinity should be preferred over the other.

6.3 SCOPE OF FURTHER STUDY

Similar to this dissertation work, where LCC analysis has been applied for the selection of raw water supply system, application of Life Cycle Cost Analysis leads to the selection of other components of water supply scheme for example, clear water transmission main system from Water treatment plant to service reservoir and then for distribution system i.e. from service reservoir to household.

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APPENDICES

Appendix 4.1: Population Projection

Population for Year 1971 to 2001 has been taken from the Census for the Projection

Year	Population		Increment		Incremental Increase	Growth Rate (R)
1971	887849					
1981	1096745		208896			0.235
1991	1312717		215972		7076	0.197
2001	1505428		192711		-23261	0.147
Total			617579		-16185	
Average		A=	205860	B =	-8093	0.190

Geometric Mean (Rg) → 0.190

Arithmetic Progression Method

Pop(f) = Pop(p) + A x N

Year 2010 :	1505428 + 205860 X 0.9	=	1690702
Year 2025 :	1505428 + 205860 X 2.4	=	1999492
Year 2040 :	1505428 + 205860 X 3.9	=	2308282

Incremental Increase Method

Pop(f) = Pop(p) + A x N +(n x (n+1) x B)/2

Year 2010 :	1505428 + 205860 X 0.9 + (0.9 X (0.9 + 1) X -8093)/2	=	1683782
Year 2025 :	1505428 + 205860 X 2.4 + (2.4 X (2.4 + 1) X -8093)/2	=	1966473
Year 2040 :	1505428 + 205860 X 3.9 + (3.5 X (3.5 + 1) X -8093)/2	=	2230953

Geometrical Progression Method

Pop(f) = Pop(p) X (Rg +1)^^{n}

Year 2010 :	1505428 X (0.19+1)&^"0.9	=	1760566
Year 2025 :	1505428 X (0.19+1)&^"2.4	=	2285455
Year 2040 :	1505428 X (0.19+1)&^"3.9	=	2966833

Where
Pop(f) = Future Population
Pop(p) = Present Population
A = Average Increase
B = Average Incremental Increase
n = Difference of decades between Present and Future year

Appexdix 4.2 : Detailed Water Demand Estimation for Raw and Clear Water Demand

S.No.	Cluster No.	Taluk	Village with Highest Elevation Level	Served with WTP	Population 2001	Population Projection			Demand at Consumer End in MLD			Demand from OHSR Outlet (Losses-14% in DS) in MLD			Demand at WTP Outlet (1% losses-CWTM) in MLD			Demand at WTP Inlet (2% losses-WTP) in MLD			Demand at DAM Outlet (3% losses-RWTM) in MLD		
					Village	2010	2025	2040	2010	2025	2040	2010	2025	2040	2010	2025	2040	2010	2025	2040	2010	2025	2040
TALUK : HIRIYUR																							
1	Cluster 1	HIRIYUR	Chikka Siddavvanahalli	WTP 17	25021	28820	36475	46159	2.015	2.553	3.231	2.342	2.968	3.755	2.363	2.998	3.794	2.412	3.059	3.870	2.484	3.156	3.989
2	Cluster 2	HIRIYUR	Palavvanahalli	WTP 17	29506	33985	43016	54434	2.377	3.011	3.808	2.766	3.503	4.427	2.793	3.538	4.471	2.850	3.610	4.562	2.935	3.721	4.705
3	Cluster 3	HIRIYUR	Belenahalli	WTP 14	21171	24384	30859	39052	1.706	2.159	2.733	1.983	2.510	3.180	2.003	2.535	3.212	2.044	2.585	3.278	2.107	2.664	3.380
4	Cluster 4	HIRIYUR	Benkanahalli	WTP 14	32222	37112	46970	59441	2.599	3.288	4.162	3.022	3.823	4.839	3.052	3.861	4.890	3.116	3.939	4.989	3.212	4.060	5.146
5	Cluster 5	HIRIYUR	venukalagudda	WTP 14	27780	33502	42396	53655	2.344	2.966	3.756	2.725	3.448	4.365	2.753	3.483	4.409	2.809	3.554	4.499	2.896	3.661	4.637
6	Cluster 6	HIRIYUR	Bharmagiri	WTP 18	8538	9834	12445	15749	0.689	0.871	1.102	0.801	1.013	1.282	0.810	1.022	1.295	0.826	1.043	1.322	0.851	1.074	1.363
7	Cluster 7	HIRIYUR	Paremenahalli	WTP 18	21088	24286	30740	38897	1.700	2.153	2.723	1.975	2.503	3.167	1.995	2.528	3.199	2.036	2.577	3.265	2.099	2.656	3.366
8	Cluster 8	HIRIYUR	Seshappanahalli	WTP 18	16067	18506	23419	29639	1.295	1.638	2.074	1.506	1.904	2.413	1.521	1.924	2.437	1.554	1.962	2.487	1.603	2.021	2.563
9	Cluster 9	HIRIYUR	Kasturirangappenahalli	WTP 16	17162	18264	23114	29250	1.278	1.619	2.047	1.487	1.883	2.380	1.502	1.903	2.402	1.532	1.943	2.451	1.579	2.003	2.529
10	Cluster 10	HIRIYUR	Kasavanahalli	WTP 14	16156	18608	23549	29802	1.304	1.649	2.086	1.515	1.917	2.426	1.530	1.936	2.450	1.561	1.974	2.499	1.609	2.035	2.576
11	Cluster 11	HIRIYUR	Hiriyur (Rural)	WTP 15	50008	64258	97647	148473	8.585	13.069	19.900	9.983	15.196	23.139	11.591	15.349	23.373	11.827	15.662	23.850	12.192	16.146	24.588
Total					264719	311559	410630	544551	25.892	34.976	47.622	30.105	40.668	55.373	31.913	41.077	55.932	32.567	41.908	57.072	33.567	43.197	58.842
TALUK : CHITRADURGA																							
1	Cluster 1	CHITRADURGA	Sevapura	WTP 11	18790	21642	27390	34662	1.515	1.916	2.428	1.762	2.227	2.824	1.781	2.249	2.851	1.817	2.296	2.910	1.873	2.368	3.000
2	Cluster 2	CHITRADURGA	Kallenahalli	WTP 12	19321	22322	28249	35751	1.561	1.977	2.504	1.814	2.299	2.913	1.834	2.323	2.942	1.871	2.370	3.001	1.929	2.444	3.093
3	Cluster 3	CHITRADURGA	Turuvanur	WTP 12	24404	28040	35485	44907	1.964	2.484	3.143	2.284	2.887	3.654	2.307	2.916	3.691	2.355	2.976	3.767	2.428	3.068	3.884
4	Cluster 4	CHITRADURGA	Megalahalli	WTP 12	32954	37956	48035	60789	2.658	3.363	4.253	3.091	3.910	4.944	3.124	3.948	4.994	3.189	4.030	5.096	3.287	4.155	5.254
5	Cluster 5	CHITRADURGA	Kenchavvanagatihalli	WTP 13	16062	18501	23413	29630	1.295	1.638	2.075	1.505	1.904	2.412	1.522	1.924	2.436	1.552	1.964	2.485	1.601	2.025	2.562
6	Cluster 6	CHITRADURGA	Yemmehatti	WTP 13	29638	34134	43199	54671	2.389	3.022	3.827	2.778	3.513	4.452	2.805	3.546	4.497	2.863	3.619	4.587	2.950	3.732	4.729
7	Cluster 7	CHITRADURGA	Doddiganahal	WTP 12	27424	31587	39973	50590	2.211	2.800	3.543	2.573	3.253	4.119	2.600	3.284	4.162	2.654	3.352	4.246	2.737	3.454	4.377
8	Cluster 8	CHITRADURGA	Megalahalli	WTP 12	31178	35909	45446	57514	2.515	3.183	4.026	2.921	3.702	4.680	2.949	3.742	4.727	3.010	3.816	4.823	3.100	3.934	4.972
9	Cluster 9	CHITRADURGA	Siddapura	WTP 12	30191	34774	44007	55694	2.436	3.079	3.897	2.835	3.579	4.528	2.861	3.616	4.572	2.918	3.688	4.664	3.007	3.802	4.808
10	Cluster 10	CHITRADURGA	Kakkeharavu	WTP 11	21374	24618	31156	39430	1.724	2.180	2.761	2.004	2.535	3.213	2.025	2.562	3.246	2.065	2.615	3.313	2.129	2.697	3.413
11	Cluster 11	CHITRADURGA	Chitradurga (Town)	WTP 12	122702	158069	241085	367700	21.339	32.546	49.640	24.813	37.844	57.721	28.852	38.226	58.304	29.441	39.006	59.494	30.352	40.212	61.334
Total					374038	447552	607438	831338	41.607	58.188	82.097	48.380	67.653	95.460	52.660	68.336	96.422	53.735	69.732	98.386	55.393	71.891	101.426
TALUK : CHALLAKERE																							
1	Cluster 1	CHALLAKERE	Chowlkere	WTP 6	29755	34272	43371	54891	2.400	3.036	3.842	2.790	3.529	4.467	2.815	3.565	4.513	2.874	3.637	4.602	2.960	3.751	4.743
2	Cluster 2	CHALLAKERE	Hirehalli	WTP 7	30037	34597	43781	55410	2.422	3.065	3.879	2.816	3.564	4.511	2.846	3.600	4.557	2.903	3.674	4.650	2.993	3.789	4.794
3	Cluster 3	CHALLAKERE	Pagadalabande	WTP 8	27133	31252	39549	50052	2.187	2.768	3.504	2.542	3.218	4.076	2.568	3.250	4.117	2.620	3.315	4.199	2.700	3.416	4.330
4	Cluster 4	CHALLAKERE	Doddachellur	WTP 8	38164	43957	55627	70402	3.074	3.894	4.930	3.576	4.526	5.735	3.610	4.571	5.791	3.685	4.666	5.912	3.801	4.808	6.094
5	Cluster 5	CHALLAKERE	Chikkahalli	WTP 10	33714	38835	49146	62198	2.720	3.440	4.354	3.161	4.000	5.063	3.194	4.037	5.114	3.257	4.119	5.220	3.357	4.245	5.384
6	Cluster 6	CHALLAKERE	Ramajogihalli	WTP 7	33800	38932	49270	62354	2.725	3.449	4.366	3.170	4.008	5.079	3.204	4.050	5.133	3.269	4.130	5.239	3.370	4.256	5.401
7	Cluster 7	CHALLAKERE	Hirekere	WTP 6	41256	47519	60139	76104	3.326	4.208	5.328	3.868	4.892	6.197	3.907	4.942	6.261	3.987	5.043	6.390	4.110	5.198	6.585
8	Cluster 8	CHALLAKERE	Budnahatti	WTP 7	33229	38271	48434	61297	2.680	3.391	4.291	3.117	3.942	4.986	3.151	3.982	5.034	3.215	4.061	5.137	3.314	4.186	5.296
9	Cluster 9	CHALLAKERE	Karikere	WTP 7	16563	19078	24146	30556	1.337	1.690	2.136	1.555	1.965	2.484	1.572	1.987	2.509	1.602	2.026	2.561	1.652	2.090	2.640
10	Cluster 10	CHALLAKERE	Challakere (Town)	WTP 9	49067	63210	96407	147039	8.533	13.015	19.850	9.922	15.134	23.081	11.537	15.287	23.314	11.772	15.599	23.790	12.136	16.081	24.526
Total					332718	389923	509870	670303	31.404	41.956	56.480	36.517	48.778	65.679	38.404	49.271	66.343	39.184	50.270	67.700	40.393	51.820	69.793

Appexdix 4.2 : Detailed Water Demand Estimation for Raw and Clear Water Demand

S.No.	Cluster No.	Taluk	Village with Highest Elevation Level	Served with WTP	Population 2001	Population Projection			Demand at Consumer End in MLD			Demand from OHSR Outlet (Losses-14% in DS) in MLD			Demand at WTP Outlet (1% losses-CWTM) in MLD			Demand at WTP Inlet (2% losses-WTP) in MLD			Demand at DAM Outlet (3% losses-RWTM) in MLD		
					Village	2010	2025	2040	2010	2025	2040	2010	2025	2040	2010	2025	2040	2010	2025	2040	2010	2025	2040
TALUK : HOSODURGA																							
1	Cluster 1	HOSODURGA	Goolihatti	WTP 21	18983	21865	27671	35017	1.531	1.934	2.451	1.779	2.249	2.849	1.796	2.269	2.877	1.832	2.316	2.936	1.890	2.389	3.026
2	Cluster 2	HOSODURGA	Burudekatte	WTP 21	25770	29683	37564	47540	2.077	2.629	3.326	2.417	3.057	3.866	2.439	3.088	3.904	2.488	3.152	3.985	2.565	3.249	4.108
3	Cluster 3	HOSODURGA	Channasamudra	WTP 20	15190	17496	22142	28019	1.223	1.549	1.961	1.423	1.800	2.281	1.438	1.818	2.303	1.468	1.855	2.350	1.512	1.911	2.420
4	Cluster 4	HOSODURGA	Bommenahalli	WTP 20	14577	16790	21247	26889	1.175	1.487	1.882	1.365	1.728	2.187	1.379	1.745	2.210	1.409	1.779	2.255	1.453	1.832	2.325
5	Cluster 5	HOSODURGA	Tandaga	WTP 20	21047	24239	30680	38827	1.693	2.147	2.715	1.968	2.495	3.155	1.990	2.519	3.185	2.031	2.571	3.250	2.094	2.650	3.354
6	Cluster 6	HOSODURGA	Kudurekanive Forest	WTP 20	23715	27312	34569	43747	1.910	2.421	3.062	2.219	2.816	3.556	2.242	2.844	3.593	2.289	2.900	3.667	2.361	2.988	3.779
7	Cluster 7	HOSODURGA	Doddabyladakere	WTP 20	27058	31164	39439	49909	2.183	2.760	3.496	2.535	3.208	4.065	2.559	3.243	4.106	2.611	3.308	4.190	2.690	3.413	4.319
8	Cluster 8	HOSODURGA	Ramajjanahalli	WTP 19	26487	30507	38607	48861	2.134	2.703	3.422	2.482	3.142	3.980	2.504	3.175	4.022	2.555	3.240	4.105	2.631	3.341	4.231
9	Cluster 9	HOSODURGA	Galabenahalli	WTP 21	21543	24811	31401	39738	1.737	2.197	2.782	2.020	2.554	3.234	2.039	2.578	3.267	2.081	2.632	3.335	2.147	2.713	3.437
10	Cluster 10	HOSODURGA	Hosadurga (Town)	WTP 20	22488	28970	44184	67390	3.911	5.965	9.098	4.548	6.936	10.579	5.288	7.006	10.686	5.396	7.149	10.904	5.563	7.370	11.241
Total					216858	252837	327504	425937	19.574	25.792	34.195	22.756	29.985	39.752	23.674	30.285	40.153	24.160	30.902	40.977	24.906	31.856	42.240
TALUK : HOLALKERE																							
1	Cluster 1	HOLALKERE	Gollarahalli	WTP 23	15248	17563	22226	28132	1.228	1.555	1.970	1.429	1.808	2.290	1.442	1.825	2.312	1.471	1.863	2.360	1.518	1.922	2.434
2	Cluster 2	HOLALKERE	Ghatti hosahalli	WTP 23	23219	26741	33844	42831	1.873	2.370	2.998	2.178	2.757	3.485	2.200	2.786	3.520	2.246	2.841	3.592	2.317	2.929	3.704
3	Cluster 3	HOLALKERE	Mahadevapura	WTP 23	24669	28412	35957	45507	1.988	2.516	3.185	2.310	2.898	3.668	2.309	2.926	3.701	2.356	2.986	3.775	2.428	3.077	3.893
4	Cluster 4	HOLALKERE	Davanahalli	WTP 23	10498	12092	15302	19365	0.847	1.072	1.358	0.983	1.246	1.579	0.993	1.257	1.594	1.013	1.283	1.626	1.045	1.321	1.677
5	Cluster 5	HOLALKERE	Hirekandavadi	WTP 25	11785	13574	17179	21739	0.950	1.203	1.523	1.105	1.400	1.771	1.116	1.415	1.789	1.138	1.445	1.825	1.173	1.490	1.880
6	Cluster 6	HOLALKERE	Sringeri-Hanumanahalli	WTP 24	24354	28047	35502	44927	1.962	2.487	3.146	2.279	2.892	3.657	2.301	2.919	3.692	2.346	2.978	3.767	2.418	3.073	3.885
7	Cluster 7	HOLALKERE	Dummi	WTP 24	17063	19654	24873	31474	1.377	1.741	2.203	1.600	2.023	2.562	1.615	2.042	2.588	1.648	2.082	2.640	1.698	2.147	2.722
8	Cluster 8	HOLALKERE	Singenahalli	WTP 24	28120	32385	40986	51873	2.264	2.868	3.632	2.632	3.335	4.224	2.655	3.369	4.266	2.711	3.438	4.353	2.796	3.542	4.489
9	Cluster 9	HOLALKERE	Viswanathanahalli	WTP 22	27420	31579	39965	50581	2.210	2.798	3.540	2.569	3.253	4.115	2.595	3.283	4.158	2.646	3.350	4.242	2.729	3.455	4.373
10	Cluster 10	HOLALKERE	Holalkere (Rural)	WTP 24	15390	19715	29824	45179	2.601	3.949	6.001	3.025	4.592	6.978	3.506	4.638	7.048	3.578	4.733	7.192	3.688	4.879	7.415
Total					197766	229762	295658	381608	17.300	22.559	29.556	20.110	26.204	34.329	20.732	26.460	34.668	21.153	26.999	35.372	21.810	27.835	36.472
TALUK : MOLAKALMURU																							
1	Cluster 1	MOLAKALMURU	Santhegudda	WTP 1	9610	11070	14008	17727	0.774	0.981	1.241	0.899	1.142	1.444	0.908	1.152	1.459	0.927	1.176	1.489	0.957	1.211	1.535
2	Cluster 2	MOLAKALMURU	Vaderahalli	WTP 2	19750	22749	28787	36432	1.592	2.013	2.550	1.852	2.340	2.964	1.871	2.364	2.992	1.907	2.413	3.055	1.968	2.489	3.150
3	Cluster 3	MOLAKALMURU	Yerajinnenahalli	WTP 3	12641	14559	18425	23317	1.020	1.290	1.631	1.184	1.502	1.897	1.195	1.516	1.916	1.220	1.547	1.956	1.259	1.594	2.016
4	Cluster 4	MOLAKALMURU	Surammanahalli	WTP 4	17050	19638	24852	31453	1.376	1.738	2.199	1.598	2.021	2.556	1.613	2.041	2.581	1.645	2.084	2.634	1.695	2.148	2.716
5	Cluster 5	MOLAKALMURU	Marlahalli	WTP 4	20283	23362	29565	37417	1.635	2.069	2.620	1.901	2.407	3.045	1.920	2.431	3.076	1.959	2.480	3.138	2.019	2.557	3.235
6	Cluster 6	MOLAKALMURU	Molkalamuru (Town)	WTP 5	14133	18207	27769	42352	2.458	3.749	5.718	2.858	4.359	6.649	3.323	4.403	6.716	3.391	4.493	6.853	3.496	4.632	7.065
7	Cluster 7	MOLAKALMURU	Guddadahalli	WTP 4	12766	14704	18608	23550	1.029	1.301	1.650	1.198	1.513	1.919	1.211	1.529	1.938	1.238	1.559	1.978	1.277	1.607	2.038
8	Cluster 8	MOLAKALMURU	Bommadevarahalli	WTP 2	20510	23624	29895	37835	1.654	2.093	2.648	1.923	2.434	3.081	1.943	2.457	3.112	1.982	2.507	3.177	2.044	2.584	3.275
Total					126742	147913	191909	250083	11.538	15.234	20.257	13.413	17.718	23.555	13.984	17.893	23.790	14.269	18.259	24.280	14.715	18.822	25.030

APPENDIX 4.3 : EXISTING SYSTEM CAPACITY ANALYSIS														
			Design Parameters			**Population**			**Clear Water Demand in MLD**		**Net Clear Water Requirement after Deducting the Existing Infrastrure in MLD**		**Total Raw Water Requirement at the Source Point in MLD**	
S.No	**Water Supply Scheme**	**No of Habitations**	**Design Period (Ultimate)**	**Existing WTP (MLD)**	**Base Year**	**Base Year 2001**	**Year 2025**	**Year 2040**	**Year 2025**	**Year 2040**	**Year 2025**	**Year 2040**	**Year 2025**	**Year 2040**
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	1A Existing / On Going Schemes (Rural)													
	MOLAKALMURU													
1	16 Villages Scheme	16	2027	1.8	2001	20534	29931	37879	2.10	2.65	0.30	0.85	0.37	1.06
2	11 Villages Scheme	11	2027	1.35	2001	33912	49432	62558	3.46	4.38	2.11	3.03	2.64	3.79
	HIRIYUR													
3	Javanagondahalli and other 38 Villages Schemes	39	2029	2.23	2001	30376	44277	56035	3.10	3.92	0.87	1.69	1.09	2.12
4	Aimangala and other 38 Villages Schemes	39	2031	3.05	2001	34555	50369	63744	3.53	4.46	0.48	1.41	0.59	1.77
	1B Existing / On Going Schemes (Urban)													
	MOLAKALMURU													
5	Town Scheme	1	2031	1.6	2001	14131	27765	42347	3.75	5.72	2.15	4.12	2.69	5.15
	CHITRDURGA													
6	Town Scheme	1	2041	43.16	2001	132103	259556	395872	35.04	53.44	-8.12	10.28	-10.15	12.85
	CHALAKERE													
7	Town Scheme	1	2041	17.59	2001	61667	121164	184797	16.36	24.95	-1.23	7.36	-1.54	9.20
	HOLALKERE													
8	Town Scheme	1	2031	2.02	2006	16500	32420	49446	4.38	6.68	2.36	4.66	2.95	5.82
	HIRIYUR													
9	4.54 MLD Town Schemes	1	2041	4.54	NA	39800	78199	119269	10.56	16.10	6.02	11.56	7.52	14.45
10	12.54 MLD Town Schemes	1	2041	12.54	2001	63182	124140	189337	16.76	25.56	4.22	13.02	5.27	16.28
	HOSODURGA													
11	Town Scheme	1	2031	4	NA	22488	44185	67390	5.96	9.10	1.96	5.10	2.46	6.37
	Sub Total (1A + 1B)	**112**	**22371**	**93.88**		**469248**	**861438**	**1268674**	**104.98**	**156.96**	**11.10**	**63.08**	**13.88**	**78.85**

APPENDIX 5.1 : Unit Cost for Water Supply Pipe

Analysis of Rates of Providing and Laying MS Pipes

	Unit	1000		Metres															
Sr No (1)	**Dia In mm (2)**	**Thickness as per IS**	**Cost of Supply, Laying, Jointing per metre Rate (3)**	**Cost of Supply, Laying, Jointing per Km Rate (4)**	**Trench Width**	**Excavation Quality In Cum (5)**	**Rate Of Excavation per Cum (6)**	**Cost Of Excavation (7)**	**Quantity of Refilling (8)**	**Rate Of Refilling per Cum (9)**	**Cost of Refilling (10)**	**Cost of Supplying and Fixing of CI Sluice Valves (11)**	**Cost of Supplying and Fixing of Air Valves (12)**	**Cost of Specials 2% (4) (13)**	**Cost of Thrust Block (14)**	**Unit cost of Valve Chamber (15)**	**Net rate Per Km, 4+7+10+11+12+13+14+15 (16)**	**Rate Per (17)**
1	323.9	4	2707	2707000	0.72	953.21	81	77210	870.85	24	20900.4	33745	17298	54140	4518.84	10000	2924812.2	2925
2	355.6	4	2975	2975000	0.76	1030.26	81	83451	931	24	22344	60477	17298	59500	4928.62	10000	3232998.6	3233
3	406.4	4	3405	3405000	0.81	1139.18	81	92274	1009.53	24	24228.72	72901	34259	68100	5634.3	10000	3712397	3712
4	457	4	3833	3833000	0.86	1253.02	81	101495	1089.07	24	26137.68	91412	34259	76660	6399.4	10000	4179363.1	4179
5	508	5	5320	5320000	0.91	1372.28	81	111155	1169.7	24	28072.8	134628	34259	106400	7235.95	10000	5751750.8	5752
6	610	5.8	7413	7413000	1.01	1626.1	81	131714	1334	24	32016	168738	34259	148260	9116.37	15000	7952103.4	7952
7	711	6.3	9391	9391000	1.11	1899.21	81	153836	1502.38	24	36057.12	202486	34259	187820	11267.69	15000	10031726	10032
8	813	7.1	12103	12103000	1.21	2193.73	81	177692	1674.87	24	40196.88	242983	34259	242060	13753.13	15000	12868944	12869
9	914	8	15331	15331000	1.31	2507.34	81	203095	1851.55	24	44437.2	291580	34259	306620	16544.25	15000	16242535	16243
10	1016	8.8	18748	18748000	1.42	2862.72	81	231880	2052.4	24	49257.6	349896	34259	374960	19716.91	15000	19822970	19823
11	1067	8.8	19697	19697000	1.47	3038.49	82	249156	2144.78	25	53619.5	419875	34259	393940	21443.07	20000	20889293	20889
12	1118	8.8	20646	20646000	1.52	3219.36	83	267207	2238.17	26	58192.42	503850	34259	412920	23265.92	20000	21965694	21966
13	1219	10	25573	25573000	1.62	3594.78	84	301962	2428.3	27	65564.1	604620	34259	511460	27171.35	20000	27138036	27138
14	1422	12.5	37267	37267000	1.82	4408.04	85	374683	2820.7	28	78979.6	725544	34259	745340	36280.06	20000	39282086	39282
15	1626	14.2	48411	48411000	2.03	5330.78	86	458447	3255.34	29	94404.86	870653	34259	968220	47265.28	20000	50904249	50904
16	1829	14.2	54508	54508000	2.23	6308.67	87	548854	3682.66	30	110479.8	1044784	34259	1090160	60183.6	20000	57416720	57417
17	2032	16	68227	68227000	2.43	7367.76	88	648363	4126.48	31	127920.9	1253741	34259	1364540	75247.9	20000	71751072	71751
18	2235	17.5	82081	82081000	2.64	8540.4	89	760096	4619.15	32	147812.8	1504489	34259	1641620	92621.78	20000	86281899	86282
19	2540	20	106604	1.07E+08	2.94	10407.6	90	936684	5343.09	33	176322	1805387	34259	2132080	123426.4	20000	111832158	111832

Water Supply

Analysis of Rates of Providing and Laying DI Pipes																
	Unit	1000	Metres													
Sr No (1)	Dia In mm (2)	Cost of Supply, Laying, Jointing per metre Rate (3)	Cost of Supply, Laying, Jointing per Km (4)	Trench Width	Excavation Quality In Cum (5)	Rate Of Excavation per Cum (6)	Cost Of Excavation (7)	Quantity of Refilling (8)	Rate Of Refilling per Cum (9)	Cost of Refilling (10)	Cost of Supplying and Fixing of CI Sluice Valves (11)	Cost of Supplying and Fixing of Air Valves (12)	Cost of Specials 2% (4) (13)	Cost of Thrust Block (14)	Unit cost of Valve Chamber @ Rs. 3620 per cum (15)	Net rate Per Km, 4+7+10+11+12+13+14+15 (16)	Rate Per (17)
B- Class -k9																
1	100	1114	1114000	0.6	660	81	53460	660	24	15840	6485	14832	22280	2236.36	10000	1239133	1239
2	150	1633	1633000	0.6	690	81	55890	690	24	16560	9954	14832	32660	2658.94	10000	1775555	1776
3	200	2112	2112000	0.6	720	81	58320	720	24	17280	17893	14832	42240	3129.6	10000	2275695	2276
4	250	2829	2829000	0.65	812.5	81	65813	812.5	24	19500	25123	14832	56580	3650.79	10000	3024499	3024
5	300	3584	3584000	0.7	910	81	73710	910	24	21840	33745	17298	71680	4224.96	10000	3816498	3816
6	350	4426	4426000	0.75	1012.5	81	82013	1012.5	24	24300	60477	17298	88520	4854.55	10000	4713463	4713
7	400	5332	5332000	0.8	1120	81	90720	1120	24	26880	72901	34259	106640	5542	10000	5678942	5679
8	450	6368	6368000	0.85	1232.5	81	99833	1232.5	24	29580	91412	34259	127360	6289.76	10000	6766734	6767
9	500	7362	7362000	0.9	1350	81	109350	1350	24	32400	134628	34259	147240	7100.28	10000	7836977	7837
10	600	9742	9742000	1	1600	81	129600	1600	24	38400	168738	34259	194840	8919.36	15000	10331756	10332
11	700	12449	12449000	1.1	1870	81	151470	1870	24	44880	330552	34259	248980	11018.8	15000	13285160	13285
12	800	15037	15037000	1.2	2160	81	174960	2160	24	51840	440487	34259	300740	13418.16	15000	16067704	16068
13	900	18316	18316000	1.3	2470	81	200070	2470	24	59280	498984	34259	366320	16137	20000	19511050	19511
14	1000	22157	22157000	1.4	2800	81	226800	2800	24	67200	600735	34259	443140	19194.88	20000	23568329	23568