Sugave Water Scheme

Multi-village drinking water scheme analysis

September 2011

CENTRE FOR TECHNOLOGY ALTERNATIVES FOR RURAL AREAS (CTARA)

INDIAN INSTITUTE OF TECHNOLOGY BOMBAY

Reference

The scope of this work includes a technical, economic and social analysis of the Sugave multi-village drinking water scheme with reference to the technical sustainability of the scheme. Detailed analysis on aspects such as institutional arrangement, paying capacity and water users' association (WUA) have not been part of this analysis and must be a subject for a future paper.

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Executive summary

The Sugave rural regional pipeline scheme was proposed by Maharashtra Jeevan Pradhikaran (MJP) to provide drinking water to 15 habitations in Karjat taluka, Raigad district, Maharashtra. The scheme was sanctioned in 1998 with the original cost of Rs 234 lakhs and was designed to provide 55 litres per capita per day (LPCD) of water to a design population of 8835 souls (year 2030). The source of water for this scheme is the perennial Pej River. However, as of September 2011, the scheme remains incomplete and is yet to be handed over by MJP to the people.

The goal of this project, undertaken by CTARA, IIT Bombay, is to understand the challenges faced by this scheme from technical, social, operational and organisational standpoints. The Sarpanch of Borivali Gram Panchayat, which is one of the largest beneficiaries of the scheme, requested CTARA to advise their people in the capacity of a social as well as technical organisation to ensure that the scheme is completed successfully and run in a sustainable manner. In this light, students and faculty from CTARA have studied the history of the scheme, performed site visits, interviewed villagers, organised multi-stakeholder meetings and conducted technical simulations to analyse various aspects of this scheme.

It was found that while the work order was issued in 1999, the scheme was downgraded in priority in 2000 and funds were frozen for work on the scheme. By the time the scheme was upgraded again in 2004, raw material prices had escalated and it was no longer possible to complete the work within the original sanctioned cost. A revised design was approved in 2010 and additional 96 lakhs were sanctioned. As of September 2011, the construction of the scheme is about 85% complete. The water treatment plant and one storage reservoir are yet to be completed.

To address the severe scarcity of water in the beneficiary villages, since 2007 the scheme is being operated during summer months to provide raw water using the partially completed infrastructure. Study of the impact of this operation shows a low degree of acceptance of the scheme by the people due to difference in quality of service across different beneficiaries, poor water quality, absence of tertiary network and irregular and unreliable supply. Due to poor water quality most beneficiaries struggle to meet their drinking water needs. While some of them have started their own private schemes and no longer wish to be part of the Sugave scheme, others travel large distances to fetch drinking water from different sources.

Simulation and technical analysis performed by IIT Bombay students have revealed problems in the design of the scheme which are responsible for low water pressure in tail ending hamlets like Kalyachiwadi. Wrong entries made by MJP in distance and elevation data have compromised the design and performance of the scheme. Particularly, we point out the problem with the Naldhe reservoir which if constructed up to the proposed staging height will not only cause higher cost of construction but will also result in long fill-up time for the reservoir. In general, we found that the weak technical analysis of the scheme has been compensated by over-provisioning in the physical implementation by way of keeping large buffer capacity and using bigger pipes.

Anger and frustration abounds in the people when it comes to discussing their water issue. They feel that MJP has not been transparent in the design process or in updating them on the

status of the scheme. For example, standposts were placed at inconvenient locations without any inputs from the people. Their demand is to have a functional and reliable scheme providing safe drinking water by January 2012.

Many lessons have been learnt through this study. The unilateral downgrade of the scheme in 2000 with no consultations with the beneficiaries was the biggest stumbling block for the scheme which caused inordinate delay and expense. The ground reality of the beneficiaries changed so much during this time that a re-calibration of the scheme design is now needed. While a revised report was submitted by MJP and approved in 2010, it primarily addressed the price escalation and did not redesign the scheme based on the fact that some habitations now have private water schemes and want to opt-out of the multi-village scheme (MVS).

Our recommendation is to form a Water Users' Association (WUA) to represent the interest of the beneficiaries. MJP must partner with the WUA to understand current requirements of the people and reassess the feasibility of the present infrastructure. It must resolve technical issues raised in this report and create a supply schedule by simulating the scheme based on the current demand. Together with the WUA, MJP must evaluate tertiary network and metering options with the people and perform a revised financial analysis of the scheme. The handover protocol and agreement must be jointly developed by the WUA and MJP and they must co-run the scheme for 6 months to enable proper knowledge transfer, documentation and training. But before any of this can happen, MJP must first acknowledge the current problems with the scheme and change its approach from "business as usual" to a more creative approach. A detailed project plan with deliverables and timeline has been proposed in this report that may be followed by MJP to revive the scheme.

1 Introduction

This report presents an analysis of a multi-village drinking water scheme in Sugave and six other villages in Karjat taluka of Raigad district in Maharashtra. The motivation for the study was to understand the challenges involved in implementing and sustaining a multi-village scheme. The objectives of this study are as follows:

- To study the history of the scheme and understand the reasons contributing to the delay in implementing it
- To analyse the technical, social, organisational and operational issues being faced by the scheme
- To suggest interventions for reviving this scheme and to present recommendations for better implementation and sustainable operation of multi-village schemes (MVS)

This work is a follow up of the initial analysis performed by two students from IIT Bombay, Mridul Joshi and Nikhil Goyal[1]. Appendix A provides a list of students who made significant contributions to this project.

The first chapter of this report is an introduction to the beneficiary villages and other stakeholders of this scheme. Chapter 2 and 3 describe the design and history of the scheme and explain the factors that were responsible for a delay of more than 10 years in the implementation of the scheme. Chapter 4 describes the current situation of the scheme in terms of its construction status, operational status as well as financial status. A big component of the analysis of this project was the technical analysis of the design of the scheme. Chapter 5 goes over the findings from this technical analysis. Chapter 6 provides various financial, social, operational and organisational challenges that are being faced by the scheme. Finally, Chapter 7 contains recommendations and scope for future work.

1.1 Location

The Sugave rural regional pipeline scheme was proposed for 7 villages and 8 wadis in Karjat taluka, Raigad district of Maharashtra state. This location is about 100 km from Mumbai and lies in the foothills of the Bhimashankar hills. The villages and their wadis lie along the Shilar River, which is a seasonal river. The nearest railway station is Neral at a distance of about 10 kms.

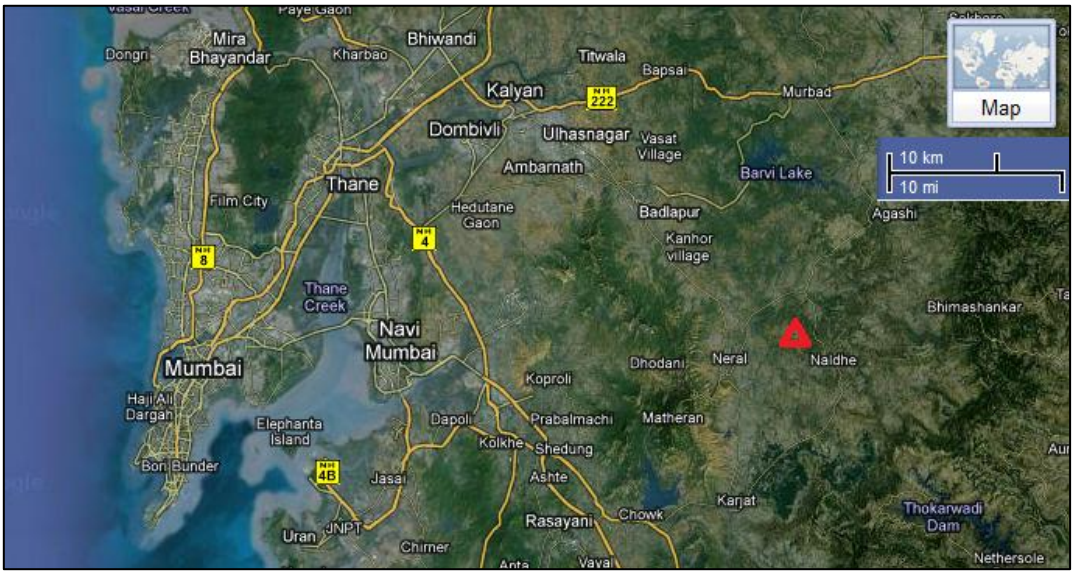

Figure 1: Map showing position of the target area (marked by triangle) with respect to major landmarks

1.2 Census data

Following table shows the population and area of the villages as per Census 2001. The numbers include the population of the wadis for each village. The source for latitude/ longitude information is Google Earth.

Village	Wadis	Latitude/ Longitude (degree)	Area of village (Hectares)	Households	Total Population	Male	Female	SC	ST
Anjap		19.002, 73.385	622	176	901	484	417	7	19
	Ramachiwadi	19.010, 73.400							
Antrad-t-need		19.017, 73.378	324	109	660	325	335	0	250
	Dharyachiwadi	19.017, 73.391							
Antrad-t-waredi		19.028, 73.375	340	164	925	472	453	0	193
	Kalyachiwadi	19.033, 73.363							
Borivali		19.027, 73.400	379	77	447	236	211	0	180
Gudvan		19.028, 73.395	490	104	642	334	308	0	233
	Gudhvanwadi	19.041, 73.385							
Naldhe		19.028, 73.412	393	90	438	216	222	0	212
	Naldhewadi	19.034, 73.426							
Sugave		19.032, 73.406	586	239	1195	596	599	0	532
	Saraiwadi	19.039, 73.417							
	Pingalewadi	19.040, 73.407							
	Lobhyachiwadi	19.033, 73.427							
Total			**3134**	**959**	**5208**	**2663**	**2545**	**7**	**1619**

Table 1: Census 2001 data for beneficiary hamlets

The primary occupation of the villagers is agriculture. The main crop that they grow is paddy during monsoon. At other times, some villagers from the villages and wadis look for alternative employment in nearby towns. The villages are connected to Karjat and Neral through state transport bus service. Electricity and primary schools are available in each village and wadi.

The 15 beneficiary hamlets fall under 3 different group Gram Panchayats (GP). Most of the villages and their wadis are part of the Borivali GP. The only exceptions are Antrad-t-waredi and Kalyachiwadi that are part of Pimploli GP and Lobhyachiwadi, which is part of Patraj GP. Hence, this multi-village scheme (MVS) being studied has beneficiaries in three different GPs.

1.3 Water availability

The nearest rain gauge station for this area is at Karjat. As indicated by the Department of Agriculture, Govt of Maharashtra website[2], the average rainfall between the months of June to October (week 21 to week 44), recorded in Karjat over the past 76 years is 3553.7mm.

In spite of good rainfall, this area faces severe water scarcity during the summer months. The Shilar River, which fills up during the monsoons, is a seasonal river and it dries completely during the summer months.

Figure 2: Dry Shilar river on 31/5/2011

Most villages and wadis also have wells and borewells. However, most of them dry up between months of March and June. Recently, some of the villages and wadis have started their own small-scale private schemes with

standposts, but many of these too face shortage of water in summer months due to collapse of groundwater. The table below provides more information on the water sources that are used by the villagers. The source for this data is field visits and field report by Siddhartha Sohoni[3].

Hamlet	Water source
Anjap	1 well, multiple borewells, standposts of private water scheme that draws from Pej river
Ramachiwadi	2 wells, 2 borewells
Antrad-t-need	1 well, 2 borewells
Dharyachiwadi	2 wells
Anrad-t-waredi	Standposts of private water scheme that draws from a jackwell in Shilar river
Kalyachiwadi	1 well
Borivali	2 wells, 1 borewell
Gudvan	1 well, 1 borewell, villagers go to Borivali borewell to fetch drinking water
Gudvanwadi	2 wells, 1 boring and 1 check dam
Naldhe	2 wells, 2 borewells
Naldhewadi	2 wells (1 of which is a hole in the Shilar river), 2 borewells, standposts of private water scheme (shared with Lobhyachiwadi) that draws from a well
Sugave	2 wells, many borewells.
Saraiwadi	1 well (a hole dug up in the Shilar river)
Pingalewadi	1 well
Lobhyachiwadi	2 wells, 2 borewells, standposts of private water scheme (shared with Naldhewadi) that draws from a well

Table 2: Available water sources

In most of the villages and wadis the current available sources of water are not sufficient to provide enough water during summer months. In most cases the wells and bore wells are located far from the village and require women to travel considerable amount of distance to fetch water. Moreover, the quality of water available from these sources is also questionable. So while the water available may be good enough to be used for washing and cleaning purposes, it is often not fit for drinking. For all these reasons, a rural pipeline scheme that can provide regular and clean drinking water is very desirable for these villages and wadis.

1.4 Stake-holders and our interaction

The people: The primary stakeholders in this project are the people of the 7 villages and 8 wadis. CTARA's team visited the beneficiary hamlets multiple times to interview the villagers. CTARA students performed Participatory Rural Analysis (PRA) activities in two of the villages. We also participated in a Gram Sabha organised

Figure 3: Gram Sabha in Borivali GP

by the Borivali GP to discuss the scheme with the people. The Sarpanch of the Borivali GP, in a letter, requested CTARA to work on behalf of the people to ensure that the scheme is implemented successfully and run sustainably. Borivali GP's Upsarpanch Mr. Sunil Mhase has been an active participant in all our stakeholder meetings.

Maharashtra Jeevan Pradhikaran (MJP): MJP is responsible for conceiving, preparing and implementing water supply and sewerage schemes both in urban and rural areas in the state of Maharashtra. It was formed in 1997 after restructuring and renaming of the Maharashtra Water Supply and Sewerage Board (MWSSB) which itself had been operational since 1979. MJP also acts as an advisor to the Government in respect of planning, operation, training, etc. MJP acts under the aegis of the Water Supply and Sanitation Department[4].The primary objective of the Pradhikaran is to promote potable water supply and satisfactory sanitation facilities so as to achieve and maintain clean environment.

MJP has its central office in Mumbai and Navi Mumbai and has field offices in the entire state. This scheme has been designed and implemented by MJP's Karjat office. Mr. Nivdange, Deputy Engineer at MJP Karjat office has been our primary contact from MJP. The other stakeholders from whom we have had much cooperation are Junior engineers Mr. Ghule, Mr. Sagalgile and Mr. S. Ali.

Contractor: Mr. Chauhan of Paramount Construction New Panvel is the current contractor who has been contracted by MJP to complete the construction of this rural pipeline scheme. The original contractor that had been awarded the tender was Mr. Zagade from Pune. Mr. Chauhan took over the project from him in 2005.

Disha Kendra: Disha Kendra[5] is a local NGO active in the Karjat area that works on issues relevant to women. Leela tai from Disha Kendra helped in the mobilization of women and giving voice to their points of view.

Figure 4: Stakeholder meeting in MJP's Karjat office

Karjat Engineering College: Prof. Kashinath Patil and Prof. Praful Bhoir from Konkan Gyanpeeth College of Engineering took interest in the conduct of the study and partnered with us on field trips and stakeholder meetings.

Elected representatives and policy makers: Sustainable implementation of MVS schemes, reasons for their failures and recommendations for reviving these schemes are of particular interest to elected representatives at the state and central level. Through this report, our hope is to communicate the lessons learned from this rural pipeline scheme and create an impact in policy and decision making.

2 Description of the scheme

This section describes the original approved scheme as it was designed by MJP. Not all parts of it have been constructed yet.

2.1 Scheme Facts

The scheme was designed to supply drinking water to 7 villages and 8 wadis described in the last section. The total population of these villages was 4290 souls in 1991 census and 5208 in 2001 census. The scheme as designed for the year 2030 (ultimate stage) for a design population of 8835 souls.

The scheme was designed to provide 55 litres per capita per day (LPCD) to the beneficiaries. For the year 2030, this translates to a daily demand requirement of 0.583 million litres per day (MLD) (assuming 20% losses).

The source for this scheme is Pej River that flows about 2 kms away from the closest village Anjap. This river is perennial as it receives the tail water discharge of about 1000 MLD from the Bhivpuri dam (Tata Hydro-electric project).

Figure 5: Satellite image of the beneficiary villages

2.2 Description of physical design

The proposed rural pipeline scheme includes a jackwell and pumping station at the lift-up point, a water treatment plant (WTP), one Main Balance Reservoir (MBR) and two elevated storage reservoirs (ESRs). The distribution network includes primary and secondary network ending in standposts in every village and wadi.

- Jackwell and raw water pumping: A jackwell of 6m diameter and 7.5m depth has been designed at the Pej River close to the Anjap bridge. The pump house is designed above

the well. A submersible pump of 22.5HP is designed to pump raw water against a head of 87m from the pump house up to the WTP. Pumping of raw water to the WTP is designed to be carried out for 16 hours per day at the rate of 36,500 litres/hr.

- WTP and pure water pumping: The water from the Pej River is not fit for drinking and hence requires to be treated before it can be distributed for drinking purpose. An unconventional type of WTP with a capacity of 0.874MLD has been proposed for this scheme. The WTP is located at the Anjap crossing at about 2.5km from the lift up point.
- Pure water pumping machinery is required to pump the purified water from the WTP into the MBR which is also located next to the WTP at the Anjap crossing. A 7.5HP pump is designed to operate for 16 hours/day to pump pure water against a head of 27m from the WTP to the MBR.

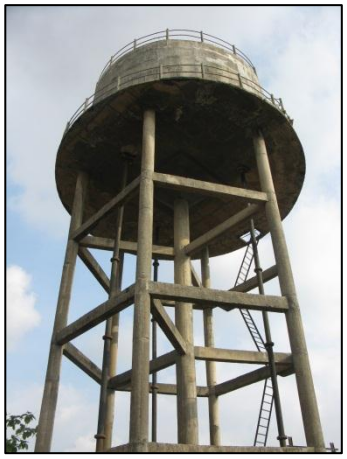

Figure 6: MBR for this scheme

- MBR: The MBR is designed to have a capacity of 2,00,000 litres. The MBR is expected to directly distribute water to Anjap, Antrad-t-need and their wadis. Additionally, the MBR would be used to fill up the two ESRs. The capacity has been designed to hold up to 12 hours of daily water requirement for Anjap, Antrad-t-need and their wadis and up to 2 hours of demand of the remaining villages and wadis. The staging height of the MBR has been designed at 15m.
- ESRs: Two ESRs are proposed in this scheme:
    - Borivali ESR: This is a 1,02,000 litres capacity ESR which would be used to distribute water to Borivali, Gudvan and Antrad-t-waredi, along with their wadis (with ultimate stage population of 3,220 souls). It has been designed to hold 12 hrs of demand. The staging height for the ESR is 12m.
    - Naldhe ESR: The Naldhe ESR is a 1,02,500 litres capacity reservoir designed to distribute water to Sugave, Naldhe and their wadis with an ultimate stage population estimated to be 3,239 souls. The ESR has also been designed to hold up to 12 hours of water requirement. The proposed staging height for this ESR is 10m.
- Gudvanwadi pump: The pipeline scheme is designed to supply water to all the villages and wadis purely by gravity once pure water is pumped into the MBR. The only exception to this is Gudvanwadi, which is at an elevation and requires pumping machinery to pump water to this wadi. A separate sump well, pump room, rising main, pumping machinery and Sintex tank for storage at Gudvanwadi is proposed in the scheme. The designed capacity of the sump well is 4,200 litres and a 2HP pump is proposed to pump water against a total head of 65m from the sump well to the Sintex tank in Gudvanwadi. The Sintex tank has a storage capacity of 4,000 litres.
- Distribution system: The distribution system consists of the following sub systems:
    - Raw water rising main: This is a 150mm diameter pipeline of type D.I. K-9 which is approximately 2,766m long. It runs from the jackwell to the WTP.
    - Pure water rising main: This is a 150mm diameter C.I. pipe of LA class which is about 100m long running between the WTP and the MBR.

- Pure water gravity main: This is the length of the pipeline that runs from the MBR to the two ESRs and two villages and their wadis carrying water only by gravity. Proposed pipes vary between 50mm to 150mm dia of C.I., A.C.P. or G.I. type. The proposed length for the gravity main is 8,982 m.
- Pipeline network from ESRs: A variety of pipes (C.I./A.C.P./G.I. type with diameters ranging from 50mm-150mm) is proposed for carrying water from the two ESRs to the standposts situated in villages and wadis. A total length of 11,314.05m is proposed for the network originating from the two ESRs.
- Pipelines for internal distribution within the villages and wadis were not part of the original scheme. However, 3,510m of pipeline was subsequently added for internal distribution in the revised scheme. The following map provided by MJP shows the network and the assets proposed in this scheme.

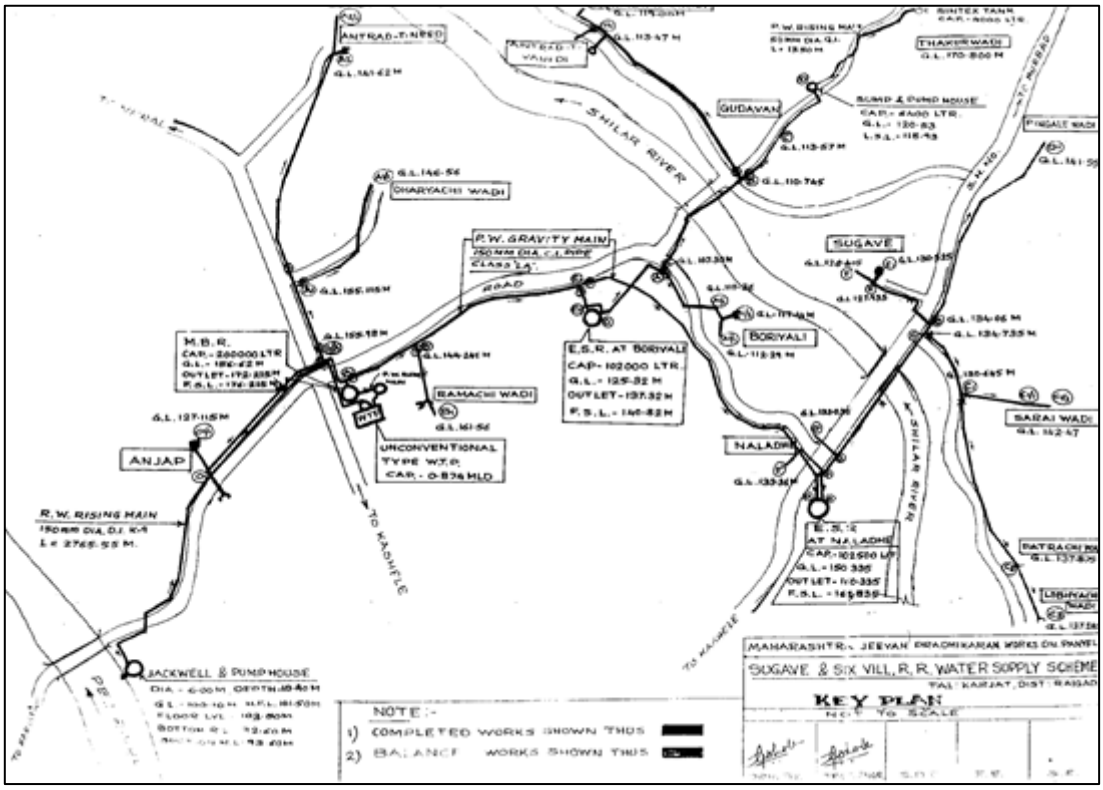

Figure 7: Design of assets for the scheme; Source: MJP

2.3 Proposed cost

The gross cost for the original scheme was Rs 234 lakhs (based on MJP DSR 1996-97). The sources for these funds were Rs 176.3 Lakhs from Govt of India Aid and the remaining Rs 57.7 lakhs from the Government of Maharashtra Aid[6]. The scheme was revised as per DSR 2007-08 and the revised sanctioned cost is Rs 331 lakhs. At the revised cost, the expected cost per 1000 litres is Rs 3.50 and the per capita investment is Rs 3745.

3 Project history

This project originated due to acute shortage of drinking water during summer months in the beneficiary villages. As per MJP documentation, 4 villages and 3 wadis received tanker water in summers before the scheme was proposed. The villages expressed a need for a drinking water scheme. Copies of these Gram Panchayat resolutions are available with MJP[7]. This prompted an investigation from MJP. They performed surveys to determine source of water, and created a preliminary design along with cost estimation for this MVS scheme. Administrative approval was obtained for the scheme on 11/3/1998. The scheme received a technical sanction by MJP engineers on 22/6/1998. Tenders were invited from contractors and the contract for the scheme was awarded on 14/5/1999 to contractor Mr. R. V. Zagade from Pune. The expected completion of the scheme was November 2000. The expected tender cost was Rs 182.21 lakhs and the sanctioned scheme cost was Rs 234 Lakhs.

An archive of documentation and correspondence related to this project that is available in the MJP Karjat office indicates how the work progressed once the contract was awarded. The contractor started placing orders for the required material soon after the contract was awarded. A request to purchase pipes was placed on 21/9/1999. An order for purchasing valves was submitted in February 2000. The contractor regularly submitted a running account bill (RA bill) stating the work completed and the amount due to him. The 3rd RA bill was dated July 2000. At that time, a request for extension of the project up to May 2002 was made by the contractor and approved by MJP. The reason cited in the correspondence was that the 150mm D.I. pipes required for rising main and gravity main were not available.

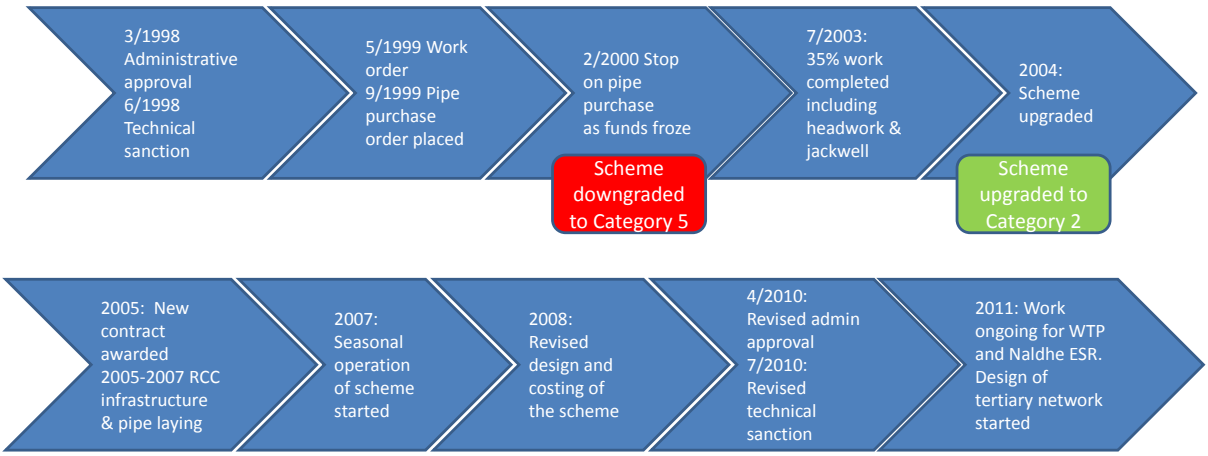

Figure 8: Historical timeline of the scheme

In 1999 there was a change in the ruling party at the state level after which many on-going MJP projects were reviewed. As a result, this project was downgraded in priority to the lowest level (5th category) in terms of financial fund availability. A letter was issued by the Member Secretary (Technical) instructing that no purchase of any new pipes be made for the scheme[8]. This was a major stumbling block for the project. In a letter dated 19/10/2001 addressed to MJP, the contractor had reported that his bills were not being paid due to the acute shortage of funds that MJP was facing. He requested that he be paid regularly or he would have to withdraw from the project. Little progress was made thereafter on the project

as all funds froze. In July/August 2003, local newspapers Dainik Sakal and Raigad Times reported that only 35% work had been completed on the scheme by then and that the contractor had stopped all work on the project. They quoted an MJP engineer saying that MJP was imposing a fine of Rs 500 per day on the contractor due to the delay. The only work completed by this point was the jackwell and pumphouse at the lift up point and laying of some pipes.

In the year 2004 the scheme was raised back in priority to category 2 and funds were made available[9]. In 2005, a new contractor, Mr. Chauhan of Paramount Construction- New Panvel, applied to take over this scheme. A three-party contract was created between MJP, Mr. Zagade and Mr. Chauhan and the work resumed once again. Pipes that were left over from other schemes in the region were directed to this scheme for use[10]. Most pipes were laid by the new contractor in 2005-2006. Other work like construction of RCC infrastructure and MBR construction also continued. However, prices of steel, cement, pipes and other materials had escalated during this time. Moreover, the original tender clause limited the price escalation that could be paid for the scheme; hence progress on the scheme became very slow. Thus, a revised scheme was proposed which sanctioned additional 96 lakhs bringing the total sanctioned cost for the scheme to 331 lakhs. The administrative approval for the revised scheme was received[4] on 27/4/2010. It received a revised technical sanction[11] on 20/7/2010. The revised scheme accounted for some of the shortfalls in the original design and provided for an internal distribution system (tertiary network). It did not, however, re-examine the scope of the scheme, given that some of the original beneficiaries had by now started their own water schemes and did not want to opt-in to the MVS. The revised cost of the scheme was based on the published schedule of rates (DSR) of 2007-2008.

Key Reasons for delay

- ***Unilateral downgrade of scheme priority and fund unavailability between 2000-2004***
- ***Pipe purchase restricted due to funds scarcity***
- ***Steep escalation in prices of raw material***
- ***Revised scheme submitted for administrative approval***
- ***Slow release of funds to contractor***
- ***Land dispute for Naldhe ESR location***

Starting March 2007, in response to the demand from people the contractor started running the scheme to provide raw water to some of the villages and wadis during the summer months only. By summer of 2007, the jackwell and pump house, raw water pumping machinery, raw water rising main and the MBR were completed. Work on the WTP, ESRs and the distribution pipeline was not complete. Hence, the scheme started supplying only untreated water by bypassing the WTP. Water was supplied directly through the MBR without any ESRs. In subsequent years, as the construction work progressed with the approval of the revised scheme and additional funds being sanctioned, more villages and wadis were added to this seasonal operation.

Antrad-t-need, Dharyachiwadi and Ramachiwadi were the first habitations to start getting seasonal supply through this scheme in 2007. Thereafter, Naldhe, Sugave, Borivali and Gudvan were added in the operation. Saraiwadi, Pingalewadi and Naldhewadi were added to

the seasonal operation in the summer of 2011 but received irregular and sporadic supply. Connectivity to Gudvanwadi and Lobhyachiwadi were tested but they do not receive regular water in the seasonal operation. Anjap and Antrad-t-waredi have opted out of this seasonal operation for now since they have developed private schemes of their own. Kalyachiwadi connection still remains to be tested successfully in this scheme.

As of September 2011, the physical construction of the scheme is estimated to be a little over 85% complete. The expected completion date provided by MJP[6] at this time is 1/3/2012.

4 Current situation

This chapter describes the current status of the scheme in terms of the on-going construction, seasonal operation and financial setup.

4.1 Construction Status

As per the status indicated on the MJP website[6], Rs 268.09 lakhs of the sanctioned Rs 330.8 lakhs have been spent on the scheme up till September 2011, which makes it 81% complete from financial standpoint. According to the same website, the physical construction of the scheme is 80% complete but the construction milestones on the website were last updated on 21/5/2010. Since then, progress has been made on the two ESRs (Borivali ESR has been completed and work on Naldhe ESR is ongoing), Gudvanwadi pumping machinery and the distribution system which is not reflected on the MJP website. Hence, the physical progress is realistically a little over 85% complete at this time. The table below indicates the status of each physical part of the scheme. The % complete status has been obtained from MJP's website[6]. Where the status on the website was out-dated, a conservative estimate has been made based on the status observed during field visits.

Table 3: Construction status based on MJP website[6] and observations in the field

Work	Subwork	% Completed	Remarks
Headworks			
	Jackwell	100%	Installed and commissioned
	Pumphouse	100%	Installed and commissioned
Pumping Machinery			
	Raw Water Pumping	100%	Installed and commissioned
	Pure Water Pumping	85%	Pump installed. Electricity connection awaited
	Pure Water Pumping for Gudvanwadi	85%	Pump installed. Electricity connection awaited
Raw Water Rising Main		100%	Major work completed. Installed and commissioned. Construction of chambers remaining
Water Treatment Plant (WTP)		55%	RCC structure completed, procurement and installation of mechanical works yet to be done
Pure Water Rising Main			
	PWRM from WTP sump well to MBR	95%	Minor work such as cross connection, chamber construction etc remains
	PWRM from Gudvanwadi sump	100%	
MBR		100%	Constructed and commissioned
Pure Water Gravity Main		95%	95% commissioned (connection to Naldhe ESR remains)
ESR at Borivali		100%	Constructed and commissioned
ESR at Naldhe		25%	Construction ongoing - columns raised, base slab yet to be constructed
Distribution system		95%	Pipe laid and tested. Mostly commissioned (except Kalyachiwadi)

As indicated above, the major work that is still outstanding includes WTP and Naldhe ESR and setting up electrical connection for pure water pumping at WTP and at the Gudvanwadi sump.

4.2 Operations status

In 2007 the scheme was partially commissioned and has since been used for supplying raw water during summer months. As of 2011, 11 of the 15 habitations are supplied water

seasonally using this scheme. The quality of service varies significantly with some habitations getting adequate water regularly and others receiving water for a very short duration and in a highly irregular manner. The following table provides information on the status of the scheme that was collected during field visits to each of the habitations.

Table 4: Habitation wise scheme status

Hamlet	Scheme connected and tested?	Frequency of supply (ONLY during Apr-Jul 2011 No supply for other months)	Tertiary network
Anjap	Opt out	Opt out	They have a private scheme and have opted out of the MVS
Dharyachiwadi	Yes	Everyday regularly (8-9:45am) except Sundays	Water is supplied to a standpost (with two taps) and an extension has been made up to a standpost attached to a 2000L school tank.
Antrad-t-need	Yes	Everyday regularly (8-9:45am) except Sundays	Water is supplied through 2 standposts. One has 3 taps, the other has 4 taps
Ramachiwadi	Yes	Everyday regularly (8-9:45am) except Sundays	Water is provided to 1 standpost (2 taps) and 1 school tank
Naldhe	Yes	Everyday except Sunday but time is not fixed	Scheme provides water to 1 standpost (4 taps) and extension has been made to 1 school tank and 1 anganwadi tank
Saraiwadi	Yes	Irregular supply with no fixed time	Scheme provides water to 1 standpost (4 taps) and is extended to 1 school tank (~1000L) and one other tank.
Naldhewadi	Yes	Infrequent	They have 2 standposts (2 taps and 3 taps) for the MVS scheme. They also run a private scheme for which they have 3 separate standposts.
Lobhyachiwadi	Testing has been done; They may decide to opt-out	Pipeline has been tested but water is not supplied	Pipe extends till the hamlet but no standposts has been provided yet. They run a private scheme (same as Naldhewadi) for which they have 3 standposts.
Pingalewadi	Yes	Irregular supply with no fixed time	Water supplied to 1 standpost (3 taps) ; school tank is not connected by the scheme
Sugave	Yes	Everyday except Sunday	Water is let into a well as requested by the village. No standposts have been provided
Borivali	Yes	Everyday except Sunday usually afternoons	Water is provided to 2 Standposts (2 taps each) + 1 school tank (currently taping has come off so not being filled)
Gudvan	Yes	Everyday except Sunday usually afternoons	The scheme water is let into a 15000 liter open tank. No standposts have been provided.
Gudvanwadi	Yes	Rarely	A 4000L Sintex tank is provided with 3 outlet taps
Antrad-t-waredi	No/Opt-out	NA	They have a private scheme and currently do not receive water from the MVS
Kalyachiwadi	No	NA	Yet to be commissioned

Four of the 15 habitations currently do not receive any water from the scheme. Their situation is described below.

- **Anjap**: Anjap village has opted out of the scheme since it has implemented its own private scheme. Anjap is located close to the Pej River, which is the same source as that of the MVS scheme. With support from the Rotary club of Switzerland, Anjap residents constructed a jackwell in the river. Water is pumped from this jackwell into a tank and raw water is supplied through standposts.

Figure 9: Standpost at Anjap; Photo Courtesy: Siddhartha Sohoni

- **Kalyachiwadi**: There is currently no alternate water scheme in Kalyachiwadi. A pipe from the MVS scheme runs up to this village, but there are no standposts or storage tanks provided yet under the scheme. According to the contractor, this habitation has been the most difficult to supply water to. The contractor claims that testing has been performed and that it will be possible to supply water to Kalyachiwadi, but currently no water is being supplied under the scheme. The wadi faces acute shortage of water and the polluted river water is used for drinking water in absence of a better choice.

- **Lobhyachiwadi**: As of now, there are no standposts constructed in this wadi under the MVS scheme. A pipe runs up to the village and water supply has been tested here, yet water is not provided through the scheme. Lobhyachiwadi runs a private scheme together with Naldhewadi in which water is pumped from a well into a storage tank and then supplied through standposts constructed in both wadis. This private scheme provides them with sufficient water for 9 months of the year. However, during summer months, the water table recedes and they are able to supply water only once in 3 days. This scheme was initially implemented by the GP through its funds. However, proper handover was not done to the hamlet. The pump failed and the scheme stopped working. The people of the village then took charge and collected money from everyone including Naldhewadi to restart the scheme by replacing the pump. One person was appointed for running the daily operations, keeping a log of the operations and collecting monthly dues (Rs 30 per family). During summer, when the private scheme water comes once in 3 days, women have to walk long distances to fetch water from wells. The people of this village are tentative about opting in to the MVS scheme. They have more confidence in their private scheme (this hamlet is the only one from Patraj GP in this scheme) and hope that in case Naldhewadi parted with their scheme and joined the MVS scheme instead, there would be sufficient water in their scheme to provide for Lobhyachiwadi all year round.

- **Antrad-t-waredi**[3]: A private scheme has been set up here by an internal village co-operative called Jan Seva Mitra Mandal, a group of twenty five odd youth of the village. They received financial support from a Mumbai club for their scheme. The scheme uses the polluted Shilar River as the source. A jackwell has been constructed in the bed of

Shilar River. Water from this fifteen feet deep well is pumped up to the village in a tank. Taps attached to the tank provide water. The pump is fit with an electricity bill meter. The monthly bill amount and maintenance cost is shared equally by all the villagers which amounts to roughly Rs 50 a month. Since this private scheme provides them with adequate water, the village has asked to not be included in the Sugave MVS.

Figure 10: Antrad-t-waredi tank; Photo courtesy – Siddhartha Sohoni

4.2.1 MVS Operation

The scheme is being operated by the contractor and his team of valvemen, pump operators and supervisor that have been employed by him. Since the construction of the scheme is incomplete, the operation is being performed using the current infrastructure available.

Raw water is pumped for 16 hours/day from the lift up point directly into the MBR, bypassing the yet-to-be-completed WTP. A log book is maintained in the pump house to log the pumping hours. According to the contractor, 8 hours of pumping is done at night, usually between the hours of 7 pm and 3 am. This is to fill up the MBR, which takes 5 hours and the Borivali ESR, which takes 3.5 hours to fill up. However, the actual number of pumping hours depends on the electricity availability. Pumping is resumed again at 8am when the water supply is started to the villages and continues as long as the supply runs.

Schematic of infrastructure currently used for seasonal supply

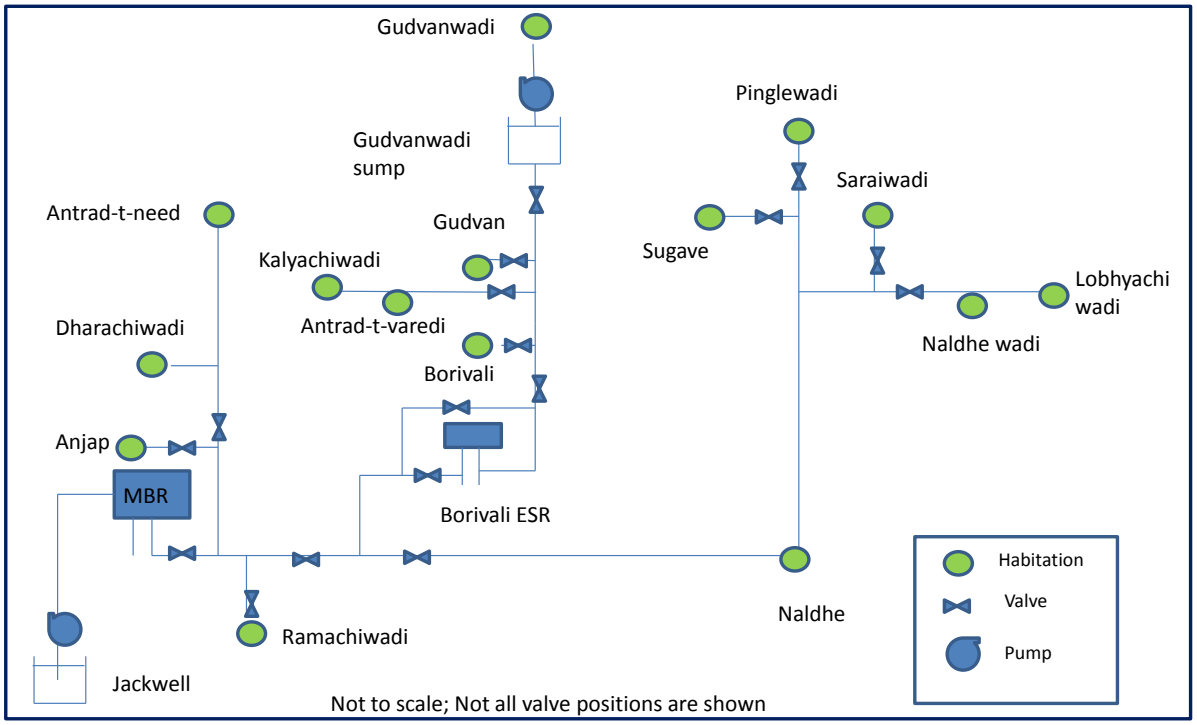

Figure 11: Schematic of distribution network

Appendix B provides a detailed operation schedule for one day along with the positions of all the valves that need to be operated in the network. This was developed by observation during field visit. No such document was available with MJP or with the contractor.

Water is supplied to participating hamlets in four different "batches". These are described below.

1- Ramachiwadi, Antrad-t-need and Dharyachiwadi: These are the first three habitations to receive water every morning. Their water is supplied directly from the MBR. This is usually supplied between 8am- 9:45am everyday (except Sunday). The flow to all other habitations is kept closed during this time. The water supply is regular and the pressure is very good. These are the only habitations which receive water consistently and predictably from the scheme. In general, people in these villages are happy about the scheme and are also heavily dependent on it. In Ramachiwadi, drinking water is obtained from a borewell and the scheme water is only used for washing purposes. In Antrad-t-need and Dharyachiwadi, the scheme water is used for both drinking and washing purposes.

Figure 12: Water supply for Dharyachiwadi, Antrad-t-need and Ramachiwadi

2- Borivali, Gudvan, sump of Gudvanwadi: Water is supposed to be supplied to these two habitations and the Gudvanwadi sump through the Borivali ESR. In practice, many times the Borivali ESR is bypassed and water is supplied directly from the MBR instead. This happens when the Borivali ESR is not filled up during the night due to electricity cut or unavailability of pump operator. If the ESR is used to supply water then it can be supplied at any time of the day since this branch can be operated in parallel with any other branch that receives water directly from the MBR. But usually, the ESR is bypassed and the MBR is used to supply water to these two villages only after water has been supplied to Naldhe, Sugave and their wadis. Borivali and Gudvan receive water every day, for about an hour usually in the afternoons, but the timing can vary considerably depending on where the water is being supplied from. The sump of Gudvanwadi takes about 30 mins to fill up after which

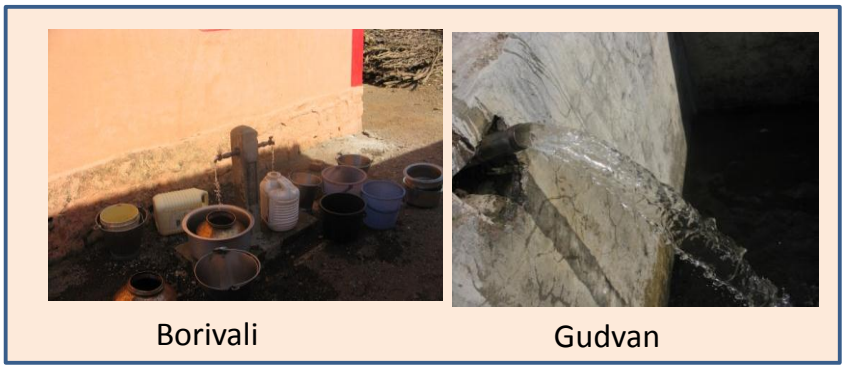

Figure 13: Water supply at Borivali and Gudvan

the valve for incoming water must be shut down or water starts to overflow. However, the sump is filled up rarely as water to Gudvanwadi is supplied very infrequently.

In both Borivali and Gudvan, people complain about the quality of the water and do not use it for drinking. Both villages draw water from a borewell situated in Borivali for drinking purposes. For residents of Gudvan, it implies crossing over to the other side of Shilar River to fetch drinking water.

3- Naldhe, Sugave, Saraiwadi, Naldhewadi, Pinglewadi: Water to all these habitations is supposed to be provided through the Naldhe ESR. However, in absence of the ESR, water is currently provided directly from the MBR. The supply to the villages (Naldhe and Sugave) is regular but the wadis do not receive the water supply regularly. Currently, there is no valve to regulate supply to Naldhe standpost, hence it receives water for as long as water is being supplied to all habitations downstream. The supply to Pinglewadi, Saraiwadi and Naldhewadi is irregular and the timing of the supply is erratic. Residents claim that water is supplied for a very short duration (20 mins to 45 mins). The pressure of water at the standpost varies, and is very low in Naldhewadi. The water quality is a major concern of the people in these habitations and they do not use this water for drinking. Both Naldhe and Sugave get their drinking water from borewells. In Sugave, it is a private borewell belonging to a family which allows free access to villagers to use water from their borewell.

Figure 14: Water supply at Naldhe, Sugave and their wadis

4- Gudvanwadi: Water is supplied from the Gudvanwadi sump using a submersible pump after the Gudvanwadi sump has been filled up. There is no

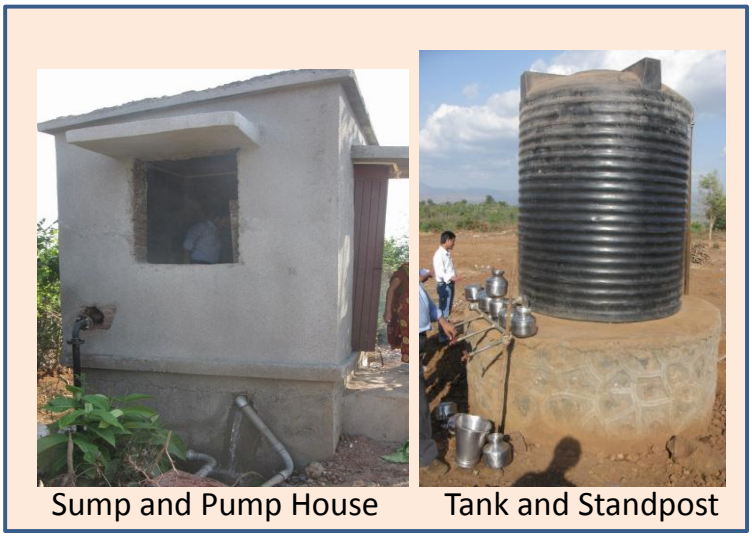

Figure 15: Gudvanwadi sump and tank

electricity connection at the sump. Currently an application has been submitted to Maharashtra State Electricity Board (MSEB) to provide an electrical connection. In the meantime, a diesel generator is provided. However, there are no arrangements to maintain and pay for regular supply of diesel to run the generator; hence water supply to Gudvanwadi from the scheme is a rarity.

4.3 Current financial setup

The cost of running the scheme operationally is currently borne by the contractor (except electricity cost), who has employed manpower for operating the scheme. The contractor, in turn, bills MJP for this trial run through the running accounts bill. MJP is responsible for paying for the cost of electricity required for pumping. It has authorized the contractor to collect this money from the people of the beneficiary villages to pay the electricity bill. The collection has been done irregularly and in an inconsistent manner.

Table 5: Habitation wise water cess (Source: Report by Siddhartha Sohoni and interviews)

Hamlet	Water cess paid per household per month of scheme operation (excludes 2011)	Number of years since receiving seasonal water under this scheme
Anjap	NA	NA
Dharyachiwadi	Rs 20	4 years
Antrad-t-need	Rs 80	4 years
Ramachiwadi	Rs 30	4 years
Naldhe	Rs 50	4 years
Saraiwadi	Rs 20	1 year
Naldhewadi	NA	None
Lobhyachiwadi	NA	None
Pingalewadi	NA	None
Sugave	Rs 50	4 years
Borivali	Rs 50	3 years
Gudvan	Rs 10, Rs 30	3 years
Gudvanwadi	NA	None
Antrad-t-waredi	Rs 50 in the past before the private scheme started	NA
Kalyachiwadi	0	NA

The contractor claims that he decided not to collect any cess from the villagers for the summer of 2011. However, during site visits it was found that Rs 50 was collected by operators from each family in Gudvan, Ramachiwadi and Saraiwadi. No money was collected from other hamlets. The MSEB bill is of the order of Rs 8000 per month[12] which the MJP is liable for during the trial period.

4.4 Estimate of Operations and Maintenance charges after hand over

An estimate of the operations and maintenance charges has been made by Mridul Joshi and Nikhil Goyal in their report[1] and has been summarised below. Their estimate amounts to Rs 12.5 lakhs annually.

This estimate assumes the following

- Establishment charges incudes wages for manpower. It was assumed that the manpower requirement will be same as estimated by MJP in the General Report
- Rates are based on DSR 2010
- 16 hrs of pumping at current electricity rate per unit
- Chemical requirement and raw water tax based on water demand of 0.583MLD
- Depreciation value based on MJP's General Report

Table 6: Estimated operations cost[1]

No.	Charges	Total Amount (Rs. Annual)
1	Establishment Charges	7,48,200
2	Electrical Energy Charges	2,26,720
3	Chemical Consumption Charges	17,100
4	Raw water Charges	85,074
5	Miscellaneous Charges	4,000
6	Depreciation (Repair & Maintenance)	1,71,000
	Total	12,52,094

The operations and maintenance cost per 1000 litres of water comes to Rs 5.90. This cost turns out to be Rs 142 per capita per year (for the design population of 8835). This does not take into consideration any changes to the actual count of beneficiary population due to villages opting out or new private connections.

For these numbers, based on informal surveys and the potential for private connection seekers in this area, it may be concluded that the scheme can be financially sustainable once handed over to the people. The determination of the amount of cess to be collected per household or per private connection will need to be determined after an analysis of the paying capacity of the beneficiaries. This has been suggested as item 5.2 in Table 10 which addresses various actions required for the scheme handover.

5 Technical analysis of the scheme

The technical design is a critical component of implementing a MVS scheme. Problems in technical design can cause service issues, time delays and significant cost impact. Various simulation packages (including open source) are now available to simulate or optimize a pipeline scheme. For example, BRANCH software is used to find the optimal diameter of pipes from a list of user-fed commercial pipes that would minimize the purchasing cost of pipes while still meeting the design parameters of flow rate and minimum residual head. EPANET software is a user friendly simulation package that can be used to simulate an existing network, perform sensitivity analysis and try various what-if scenarios.

The General Report for the Anjap Sugave MVS, available in the MJP office includes documents[13] showing the BRANCH optimization that was performed by MJP for this scheme. Nikhil Goyal and Mridul Joshi analysed the data used by MJP and performed a technical analysis using BRANCH[1]. They prepared a list of technical issues (copy of letter included in Appendix C), and sent it to MJP office in Karjat on March 24th 2011, a formal response for which is awaited. Further, a simulation of the current physical network was performed using EPANET the results of which are included in Appendix F.

This section includes details on the technical issues uncovered in the analysis of the scheme. Please refer to Appendix E for a concise summary of the technical issues along with relevant reference information

1. Incorrect elevation data in Gravity Main simulation: Correct elevation data is very important in designing a gravity-based pipeline system. However, an incorrect entry was found in the Naldhe ESR elevation data used in the simulation of pure water gravity main. In the gravity main simulation, FSL (163.85m) should be used as elevation for the ESR, however, the outlet level (160.34) has been used as elevation instead. The impact of this error is that the pipe types and diamaters chosen by the simulation will not be sufficient to meet the head requirements at the top of Naldhe ESR. Re-simulating[1] the network using the correct elevation (with no other changes) raises the cost of the distribution network from 45.12 lakhs to Rs 48.27 lakhs.

Table 7: Elevation data used in Gravity Main simulation[1]

Storage Reservoir	FSL (in meters)	Outlet (In meters)	Height used in simulation (in meters)
MBR (Inlet)	176.2	172.2	172.2
ESR at Borivali (outlet)	140.82	137.32	140.82
ESR at Naldhe (outlet)	163.84	160.34	160.34

2. Incorrect elevation data in secondary network simulation: The elevation data used for Borivali ESR in the simulation of the downstream distribution network from Borivali ESR has a discrepancy of 1.24m. In simulation of this network, the outlet level of the ESR (137.32m) should be used. However, MJP's simulation files show that the FSL (marked as 138.44) was used instead. MJP's simulation results show that with the incorrect height of the ESR, the residual head at Kalyachiwadi will be exactly 5m. However, since the actual height is lower by more than a meter, the residual head at Kalyachiwadi is expected to be even lower than 4m and hence, does not meet MJP norms.

3. Incorrect pipe length data: In addition to elevation, pipe length is another important data that needs to be provided accurately in simulations. The pipe length data used by MJP in their simulation was validated by comparing it against the straight line distance between nodes as calculated by Google Earth. While most distances were within ballpark, two major discrepancies were observed. The distance of Antrad-t-waredi and Kalyachiwadi from the node where they connect to the main line coming downstream from Borivali ESR has been grossly underestimated in MJP simulations.

a. The length of pipe between node 57 (page 85 General Report) which is the trisection just before Gudvan and Antrad-t-waredi used by MJP is 1830m compared to Google Earth estimate of more than 2500m.

b. Similarly, the distance between Antrad-t-waredi and Kalyachiwadi as used by MJP is 420m, but the Google Earth estimate is at least 1000m.

It is worth noting that the Google Earth distance is the straight distance between the two nodes, hence the real pipe length would have to be even more than the Google Earth estimate. The impact of this discrepancy is that the head loss due to friction has been underestimated in design. Also, the cost of pipes has been underestimated by approximately Rs10 lakhs[1].

4. Pipe diameter: BRANCH software was used by MJP to optimize and select pipe diameters for the network. However, the output of the simulations was disregarded and a different set of pipe types and diameters were used. It is not clear what the basis was for the choice of pipe types and diameters used. This approach undermines the use of simulation. Moreover, the actual physical network has not been simulated by MJP and therefore, there is a risk of not being able to meet the required head, which can lead to poor service, higher cost and time delays (as it has in this case). Appendix D shows the pipe types that resulted from the optimization, the pipe types that were documented as being used and the actual physical pipes used in the field as described by the contractor. The difference in all three can be seen clearly in the table, however there is no explanation for the variations.

5. Naldhe elevation issue: The Naldhe ESR is a critical and sensitive component of the Sugave scheme which is currently under construction. The accuracy of its design height is critical because even an error of a couple of meters can have a significant impact on the performance of the scheme. The Naldhe ESR is being constructed on a sloping ground, which makes it more susceptible to elevation related issues.

The ground level for Naldhe ESR is 150.34m (per MJP). The proposed height by MJP is 10m (as illustrated in point1 above, this is based on an error in the assumption of the elevation of the ESR). For a 10m height, the Outlet is at 160.34m and FSL would be at 163.84m.

Table 8 below shows the results of simulating the actual physical network using appropriate Hazen constants according to the types of pipe being used. The results below have been simulated using EPANET (results validated with BRANCH). The correct elevation of the Naldhe ESR has been used in this simulation (as opposed to the incorrect values used in MJP simulation). The first table corresponds to the upstream flow to the Naldhe ESR and the second table is for the downstream flow from the ESR.

Table 8: EPANET simulation of physical network for Naldhe ESR

Gravity Main Simulation

Naldhe ESR Height = 10m				
Names	Nodes	Demand LPS	Head m	Pressure m
MBR	51		172.22	
	52	0	172.16	15.54
	53	0	172.14	16.16
Anjap	54	1.32	170.31	43.2
Anjap	55	0.15	170.27	43.16
	56	0	171.68	16.56
Dharyhachiwadi	57	0.34	170.47	23.91
Antrad-t-need	58	1.31	166.46	24.84
Antrad-t-need	59	0.87	166.35	24.35
	60	0	171.4	27.16
Ramachiwadi	61	0.34	171.28	9.72
	62	0	169.34	24.46
Borivali ESR	63	3.36	167.95	27.13
Naldhe ESR	64	4.48	167.91	4.07

Naldhe Branch Simulation

Naldhe ESR Height = 10m				
Names	Nodes	Demand LPS	Head m	Pressure m
Naldhe ESR	51		160.34	
	52	0	160.26	25.77
Naldhe	53	1.09	160.08	26.72
	54	0	159.81	30.07
Naldhe	55	1.29	159.57	26.53
	56	0	157.7	22.96
	57	0	157.27	23.21
	58	0	157	29.07
Sugave	59	0.88	156.64	26.12
Sugave	60	0.81	156.57	30.17
Pinglewadi	61	0.73	156.8	15.25
	62	0	156.78	26.13
Saraiwadi	63	0.6	156.69	14.22
Patrachiwadi	64	0.81	155.89	18.01
Lobhyachiwadi	65	0.89	155.76	18.47

As shown above, for the proposed height of 10m, the head at Naldhe ESR would be 4.07m when being filled up from the MBR. This is lower than the minimum residual pressure requirement of 5m in MJP's simulation and will result in a longer time for the ESR to fill up from the MBR. Moreover, if the inflow rate for the ESR is not controlled effectively, the head at the inlet of Naldhe ESR will drop even further. E.g. head will drop to 2m, if inflow rate for Naldhe is changed from design flow rate of 4.48 LPS to 6 LPS keeping everything else constant. Hence, is can be seen that at the proposed height of 10m, filling up the ESR will be slow and highly sensitive to operational parameters.

For this height, when water flows downstream from Naldhe ESR, the lowest head is found to be at Saraiwadi of ~14.22m, which is an acceptable head. If we lower the height of the ESR, keeping all other things constant, the following effect is seen at Saraiwadi.

Table 9: Sensitivity Analysis

Naldhe ESR height	Head at Naldhe ESR	Downstream head at Saraiwadi
m	m	m
10	4.07	14.22
9	5.07	13.22
8	6.07	12.22
7	7.07	11.22
6	8.07	10.22
5	9.07	9.22
4	10.07	8.22

Hence, if a 5m min head requirement is to be enforced, then the Naldhe ESR should not be any higher than 9m, and it will still provide sufficient head downstream from Naldhe.

6. Kalyachiwadi head issue – According to the contractor who is currently running the scheme, one of the biggest challenges of the scheme is to provide water to Kalyachiwadi. This issue could be easily predicted from simulating the network had the simulation been

done correctly.
In MJP's general report (Pg 83), the simulation showed that the head at Kalyachiwadi will be the minimum required head of 5m. However, as mentioned in point 2 above, there is an error in the elevation used for the Borivali ESR which over-estimates the head at Kalyachiwadi. Moreover, as stated in point 3 above, the data used in the simulation underestimates the distance of Kalyachiwadi from the main line. Correcting for these errors shows that the head at Kalyachiwadi will only be 2m, which will be insufficient (See Appendix F for details). In physical implementation, the diameter of the pipe going up to Kalyachiwadi was increased from 50mm (as per simulation) to 65mm to achieve better head. However, since the operation usually by-passes the Borivali ESR and delivers water directly from the MBR, the head is found to be insufficient even with the change in the diameter.

6 Issues with the scheme

6.1 Financial issues

The primary issue with the scheme has been unavailability of funds for implementation.

a. Delayed and incomplete payments to the contractor: Due to the delay in implementation of the scheme, cost of all raw materials increased significantly. Hence, the sanctioned cost had to be revised to adjust for this price escalation. The cost was revised in 2010, and additional funds of Rs 96 lakhs were granted. Until then the contractor had to submit his bills per the old rates of DSR 1996-97 and payment for price escalation had to be requested separately which required many approvals and caused significant delay. Therefore, the contractor has a lot of money invested in the scheme while the compensation made to him has been irregular. This limits his ability to speed up the construction as he does not have the required funds to be able to do this.

b. WTP: Even though the scheme is now operational seasonally, it only provides untreated water to the villages. Most villagers only use this water for washing and other household purposes and look for other sources for drinking water. If the water treatment plant was operational, then the scheme would find much more acceptance from the people. Currently only the RCC structure of the WTP is complete. The contractor is currently awaiting the mechanical works for which a verbal order has been placed. The contractor claims that the mechanical works would cost up to Rs 10 lakhs of investment. However, he does not have that required amount available to him to make the purchase as he has not received his due payments in a timely manner from MJP.

Figure 16: Scheme provides untreated water

c. The tremendous delay in the scheme caused due to unavailability of funds has created its own set of issues which has made the problem even more serious.
    a. Competing schemes: Over time, some of the villages (Naldhewadi, Lobhyacihwadi, Antrad-t-waredi, Anjap) devised their own schemes to solve their drinking water problem. These habitations now have a low level of interest in the multi-village scheme.
    b. Aged infrastructure: Since the construction has drawn out for more than a decade, people are apprehensive about the state of the pipes and other infrastructure. They have a concern that the pipes would have degraded and will cause maintenance issues once the scheme is taken over by them.

6.2 Social concerns related to the scheme:

The people under this scheme have been largely kept out of the design and implementation of this scheme. This lack of transparency has resulted in many issues

Figure 17: Ill-positioned standpost at Saraiwadi

a. The standposts provided by the scheme are located in inconvenient places like in Naldhe and Pinglewadi where they are at the edge of the village, or in Saraiwadi where there is not sufficient space for women to queue up and a fight often breaks out. Appedix G includes Google Earth images of all the habitations with the positions of the standposts marked on them.
b. During laying of pipes at road crossings, some parts of the roads were dug out by MJP without taking consent from the people. This caused a lot of anger in the villagers.
c. There was a land dispute related to the land on which Naldhe ESR was to be constructed and that caused delay in the construction of the ESR. Working with the stakeholders from the onset of the project could have mitigated such an issue.
d. There is anger in the people for not being updated on the status of the scheme and the reason for various delays. When they organised a Gram Sabha to discuss the scheme and invited MJP, at least 2 times MJP representatives did not attend the meeting, or did not send the right person for the meeting. We also found promises being made to the people (in gram sabha held on June 14th, 2011) by MJP officials with no follow through. This fuels anger and frustration in the people.
e. Since people are kept out of the process, there is little feeling of ownership towards the assets on the ground. There have been instances when villagers gave vent to their anger by vandalizing the assets e.g. breaking air valves or removing taps from standposts.

Figure 18: Broken air-valve

f. These are some of the statements made by the villagers in the gram sabha organised in Borivali Gram Panchayat on June 14, 2011 which shows the anger and frustration of people
    i. We want the scheme water in Gudvanwadi by January 2012 or we will remove and throw all the pipes out of the village.
    ii. They have now constructed a bridge in the ocean, but you have not even been able to bring water to Gudvanwadi.
    iii. When a farmer applies for an electrical connection and pays for it, he receives the connection within weeks. MJP claims it has made the payment 2 years ago to MSEB and has still not got the connection –

how is that possible?

iv. We will not discuss metering unless you first start supplying regular water.

6.3 Operational issues

The contactor currently runs the scheme in summer months and the villagers see this trial run as an example of how things would work when the scheme is commissioned and fully operational. However, there are currently many issues with the way in which the scheme is operated, thereby increasing the villagers concerns about the scheme.

a. Lack of schedule – There is no set schedule of operations and most villages are left guessing if, when and for how long they will receive water on any given day. Other than Antrad-t-need, Dharyachiwadi and Ramachiwadi which receive their water supply usually between 8am-11am, most other villages do not have a fixed time. The supply depends on variables such as electricity outage, whether the ESR was filled up during the night and even on the whims and personal schedules of pump operators and valve-men. The operators have not received appropriate training and are not disciplined in maintaining a log book (except the log book at the pump house).

b. The water pressure and hours of supply at the standposts varies significantly from village to village. The 3 habitations that are first to receive water from the MBR get good pressure and so much quantity that water is often wasted. On the other hand, villages at the tail end of the covered area face the problem of getting water for inadequate amount of time and that too at very low pressure. Moreover, the scheme does not provide any meters to measure actual water usage for payment purposes.

c. The scheme operators are not fully trained and/or disciplined in the operations. Overflow of water from tanks happens sometimes when valves are not operated in a timely manner. For example, water was found to be overflowing from the Gudvanwadi sump during demonstration of the infrastructure.

Figure 19: Water overflow from Gudvanwadi sump

d. Currently there is no electrical connection at the sump of Gudvanwadi to be able to operate the pump. A generator has been placed to run the operation, but there is no clarity on who is responsible for bringing and paying for the diesel which is required to run the generator. Hence, even though the infrastructure is in place, the water supply to Gudvanwadi is rare.

e. The Borivali ESR has been commissioned, yet is often bypassed during operations and water is supplied directly through the MBR. This purportedly happens when there have not been enough pumping hours at night to fill up both the MBR and ESR completely – which is usually due to electricity outage, or due to unavailability of pump operator. If the ESR is utilized, water can be supplied to Borivali, Gudvan and their wadis in parallel with water supply to other villages which receive water directly from the MBR. However, when the ESR is bypassed, it results in inefficient use of the

infrastructure and leaves little time in the day for all villages to receive water directly from the MBR.

f. The contractor has collected money from the villages to pay for the electricity charges of the seasonal operation. However, this collection has not been consistent. The amount collected per household varies by villages. For 2011 summer, money has been collected from some villages and not from others.
g. The scheme has not implemented the tertiary network yet. The current standposts are not located ideally, and there are many families that would like to have private connections and are willing to pay a higher charge for that convenience.

6.4 Multi-village scheme organisational issues

a. Multiple GPs: This scheme has beneficiaries across 3 GPs. While 12 of the 15 habitation are in the Borivali GP, 2 habitations (Antrad-t-waredi and Kalyachiwadi) are in Pimploli GP and 1 (Lobhyachiwadi) is in Patraj GP. Currently, the three habitations outside of the Borivali GP do not receive any water from the seasonal scheme operation. Lobhyachiwadi has its own private scheme which they share with Naldhewadi and may choose to opt out of this MVS. Similarly, Antrad-t-waredi too has a private scheme. As for Kalyachiwadi, the contractor claims that there may be a technical issue in being able to provide water through this scheme. Thus, the habitations outside of the Borivali GP have been side-lined in the implementation and running of the scheme.
b. The normal practice by MJP is to hand over a multi-village scheme to the zilla parishad. In this case, the Borivali GP is keen to take the scheme over from MJP after it is completed since the majority of the beneficiaries are part of it. However, MJP's mandate is to ensure that the other 3 habitations are also beneficiaries of the scheme.
c. Metering – The current scheme does not have provisions for any metering. This becomes an issue in the current scenario where the quality of service varies significantly across habitations.

6.5 Technical issues

The technical issues observed in this scheme have been discussed in the previous section and a summary has been included in Appendix E.

7 Recommendations and Future work

This section includes our learnings and recommendations based on the analysis of the Sugave multi-village scheme. It also outlines the scope for future work.

7.1 Recommendations

A. Stakeholder involvement for better acceptance of the scheme: One primary concern that emerges from the study of this scheme is the poor state of consultations between MJP and the beneficiaries. This is evident from (i) the fact that the scheme could be unilaterally downgraded in priority in 2000, (ii) little concern for the locations of standposts and the tertiary network, (iii) absence of any schedule of operations for the seasonal operation, (iv) MJP's ignorance about the actual status of water supply to various wadis and (v) the existence of parallel schemes and its impact on the Sugave scheme sustainability.

- We recommend the formation of a Water Users' Association (WUA) as an important step at the scheme conception stage. This may be constituted from members of the Village Water Committees, elected representatives and members of all beneficiary habitations. This WUA would represent the interests of the beneficiaries throughout the course of the project, during handover and thereafter.
    - The WUA will help in the design of the financial, institutional and engineering aspects of the scheme. The design of the scheme should be approved by the WUA.
    - Training of the WUA should be done in the initial stages of the project so that it can perform its role effectively.
    - Regular meetings must be held between MJP and the WUA with discussion on progress of the scheme, financial status and any challenges being faced. Copies of any correspondence between MJP and other bodies like MSEB should also be marked to the WUA so that it is well informed.
    - An acceptance of the scheme from the WUA must be a pre-condition for initiating handover of the scheme from the implementing agency to the people.
- The training and capacity building of the WUA will be crucial for its proper functioning. As done in Jal Swarajya, a local NGO or Social Organisation (SO) may be used as a partner for this purpose. The SO would also assist in collection of user requirements and various engineering parameters from the people using activities such as participatory rural analysis (PRA). A PRA exercise performed in two of the beneficiary villages by CTARA students was found to be very useful in the understanding of local requirements.

B. Technical aspects of scheme design: It has been observed that a thorough technical analysis of the Sugave scheme was not performed by MJP before designing the scheme and this was later compensated by over-provisioning in the physical infrastructure. As detailed in Section 5 of this report and summarised in Appendix E, wrong entries made by MJP in distance and elevation data compromised the original design of the scheme. At the same time, this design (in terms of pipe diameters) was not used in the physical implementation at all. Instead, a different set of pipe types and diameter was used with no sound technical basis which rendered the exercise of the initial design useless. In Appendix D comparison of columns "Simulation Output" with "Physically used" demonstrates how the physical infrastructure was over-provisioned compared to initial design.

- MJP should modify its design methodology to ensure a thorough technical analysis of

the scheme. While MJP already uses open source optimization software like BRANCH and LOOP, care should be taken in designing inputs to these modules to arrive at optimal diameters in order to make the outputs more trustworthy and actionable, thereby reducing cost. Abhishek et al[14] have shown how optimal staging height of a reservoir can be designed by minimizing the total cost of pipes and reservoir construction. It is strongly recommended that such an approach be adopted to develop an optimal design which can minimize the total cost of implementing a scheme. Sufficient buffer or margin of error may be placed for scalability as part of the design methodology, but once the capacity or residual head constraints are defined, the goal must be to design an optimal network that minimizes cost.

- It is recommended that MJP utilize GIS (Geographical Information Systems) technology to eliminate user-errors in distance and elevation data used for design. MJP should create and maintain its own database of relevant geographical and water related data through physical surveys in order to become more effective in designing water schemes.
- Simulation software such as EPANET (open source) may be used by MJP to predict the water pressure at all points of delivery in a given pipeline network. The most updated simulation model of a scheme should be maintained by MJP at all times. This will help MJP be agile in responding to changes such as villages deciding to opt-out or requesting for new connections. MJP should also use simulation to develop operation schedules to run the scheme by efficiently utilizing the scheme assets.

C. Project Management
   - MJP has been slow in adapting to the changing requirements of the project. In 12 years since the project was sanctioned, requirements of the people have changed significantly as some of the original beneficiaries under the scheme have made alternate arrangements and are no longer interested in the scheme. In such a scenario, it is important for MJP to respond quickly by revising design with the approval from the WUA. MJP should be empowered with the authority to make such decisions and execute them.
   - MJP engineers should be incentivized to attend trainings and workshops to sharpen their technical skills and learn project management techniques. Use of latest technology in GIS and modelling of schemes will help in quick modification of designs. Effective project management skills will allow MJP to recognize changes in requirements and respond to them.

D. Hand over requirements: After delays, the next big reason for failure of multi-village schemes is improper handover and insufficient hand holding during the initial months of handover. Proper documentation and training is of primary importance in a successful hand over.
   - To ensure that the scheme is able to run sustainably after hand-off MJP should provide an operations "manual" with well-defined standard operating procedures that addresses questions like – what manpower is needed to operate the scheme? What should be the schedule of operations? What should be the sequence of valve operation based on the proposed schedule? What are the regular maintenance activities that must be performed?
   - A document should be developed by MJP that describes the organisational structure and the required roles and responsibilities of the body that will take over the scheme

on behalf of the people. This is of special importance in handover of a multi-village scheme so that it can be ensured that interests of all beneficiary villages are being looked after. This document should address issues such as: Who will employ and pay labour required to run the scheme? Who will pay the electricity bills? Who is responsible for implementing metering and keeping accounts? Who will collect the money? Who will authorize and be responsible for repair and maintenance work? Who will authorize new connections (home/private/commercial?), etc.

- The handover documents should contain information on all assets being handed over along with the operation and maintenance manual for each asset (e.g. What regular maintenance and servicing must be performed for the pumpsets, WTP, reservoirs, pipelines, valves etc.). The documents must provide detailed maps with location of the assets along with their specifications and date of purchase and installation so that the age of the assets can be determined for servicing.
- Scheme operators must be trained by MJP to operate the scheme and perform regular maintenance tasks.
- The formal handoff document must be signed by all stakeholders including the WUA and maintained in records to ensure accountability.
- Appendix G provides a list of requirements that should be met for a successful hand over of the scheme from MJP to the people.

E. Recommended next steps for the Sugave MVS: In order to revive the scheme and make it acceptable to the people, MJP must acknowledge the current problems and change its approach from "business as usual" to a more creative approach. It should partner with a social organisation (SO) to start engaging with the beneficiaries and form a WUA which will represent the interest of the people and interface with MJP. A project plan should be developed detailing deliverables, timeline and milestones which must be followed for a successful handover. Such a plan has been proposed in Table 10 which includes recommended steps to be followed for a successful implementation and handover of the scheme. Some of the main requirements in the recommended project plan are highlighted below:
   - A WUA should be formed and engaged with to enable stakeholder participation and buy-in.
   - The scheme should be re-calibrated based on the current requirements of the beneficiaries. This will require a survey of opt-in/opt-out decision from each habitation.
   - Verification of survey data for elevation and distances must be done, especially where anomalies have been pointed out in this report.
   - A feasibility analysis of the current infrastructure should be performed based on new inputs from survey and opt-in/opt-out decisions by the people. The staging height of Naldhe ESR must be reviewed as part of this exercise. Where needed, re-design may need be done to ensure good water pressure in all wadis including Kalyachiwadi.
   - A financial analysis of the scheme should be performed with inputs from the WUA on the paying capacity and potential for home connections. Various options of tertiary

network and metering may be considered and discussed with the people. E.g. individual home connections, common connections for 3-4 homes, wadi level metering etc.

- The WTP should be completed before January 2012 so that it can be commissioned and used for providing safe drinking water for the 2012 seasonal supply.
- Network simulation should be performed to create supply schedules. Detailed documentation will need to be developed detailing the sequence of valve operations to run the scheme according to proposed schedule(s). Bringing transparency to the operations by adhering to a set schedule of operations and pasting the schedule in public places will increase the user confidence in the scheme.
- The WUA and MJP must work together to develop the handover protocol by identifying issues to be address in the handover agreement.
- During the handover phase, MJP should provide thorough training and detailed documentation to the WUA. MJP and the WUA should jointly run the scheme for 6 months. After a successful trial period, the final agreement and sign-off of must be obtained from all parties including MJP, the WUA, TSP (if any), all GPs and the ZP.

7.2 Future Work

Work on the Sugave scheme and, in general, on the study of drinking water schemes needs to continue. Specifically, following are some of the activities that CTARA will engage in:

- It is our goal to ensure that the Sugave MVS is completed successfully and run sustainably in the future. To this end, we will continue partnering with the stakeholders of this project and will assist in the resolution of the issues identified in this report.
- An analysis of the criteria for prioritization of schemes needs to be done. We want to review how stakeholders such as MJP and the beneficiary villages can have an impact on the process of downgrading or upgrading a project. Ultimately, it needs to be studied how the prioritization can be more transparent and how the implementing agencies can be held accountable for project delays.
- We would like to hold workshops for engineers from implementing agencies such as MJP and the Minor Irrigation (MI) departments to provide technical inputs and training in the area of GIS and simulation software such as EPANET.
- CTARA will continue to study and analyse other drinking water schemes including groundwater based schemes and surface water based schemes. We look forward to building partnerships with other GPs and ZPs to broaden our understanding of drinking water supply issues in rural India.

Table 10: Sample Project Plan for Sugave Scheme

Activity	Party responsible	Oct-11	Nov-11	Dec-11	Jan-12	Feb-12	Mar-12	Apr-12	May-12	Jun-12	Jul-12	Aug-12	Sep-12	Oct-12	Nov-12	Dec-12	Jan-13	Feb-13	Mar-13	Apr-13	May-13	Jun-13	Jul-13
1. Completing Physical Infrastructure																							
1.1 Complete WTP	MJP	x	x	x																			
1.2 Commission WTP	MJP				x																		
1.3 Complete Naldhe ESR	MJP							x	x	x													
1.4 Commission Naldhe ESR	MJP									x													
1.5 Valve boxes, air valves, painting work etc.	MJP				x	x	x																
2. Formation of the WUA	SO																						
2.1 Opt-in/out decisions for every habitation	SO		x	x	x																		
2.2 Selection of representatives	SO		x	x	x																		
2.3 Training, empowerment and Terms of Reference	SO				x	x																	
3. Interim Water Supply	MJP																						
3.1 Interim supply feasibility	MJP				x																		
3.2 Interim supply schedule (with interim assets) and training	MJP				x																		
3.3 Interim financial setup	MJP and WUA					x																	
3.4 Interim supply operation	MJP					x	x	x	x	x													
4. Technical Re-evaluation	MJP																						
4.1 Verification of survey data	MJP					x	x																
4.2 Assessment of demand from various class of users	MJP and WUA					x																	
4.3 Design verification of existing design and re-design	MJP						x	x	x														
4.4 Determination of optimal height for Naldhe ESR	MJP							x															
4.5 Supply schedule -primary and secondary network operations	MJP								x	x													
4.6 Development of design base and documentation	MJP						x	x	x	x	x												
5. Financial Analysis	MJP																						
5.1 Estimate operations and maintenance cost	MJP								x														
5.2 Assessment of paying capacity and home connections	WUA						x	x															
5.3 Tertiary network supply options	MJP + WUA							x	x														
5.4 Fixing tariffs	MJP + WUA								x	x													
6. Tertiary Design and Asset Creation	MJP + WUA																						
6.1 Tertiary design and metering	MJP + WUA									x	x												
6.2 Asset creation	MJP											x	x										
7. Supply Schedules and Training	MJP																						
7.1 Simulation of supply schedules (with all physical assets)	MJP											x	x	x									
7.2 Creation of logs	MJP											x	x	x									
7.3 Documentation and training kits	MJP											x	x	x									
8. Handover Preparations	MJP + WUA																						
8.1 Check-list of requirements from WUA	WUA											x	x	x									
8.2 Collaborative design of handover protocol	MJP + WUA													x	x	x							
8.3 Identification of issues to be outlined in hand over agreement - financial, institutional, operational	MJP + WUA														x	x							
8.4 Determine Technical (ops) provider (GP or outside TSP)	WUA															x							
9. Handover Phase																							
9.1 Hiring and training of staff	MJP + WUA+TSP														x	x	x	x	x				
9.2 Putting financial and institutional cycle in place	MJP + WUA+TSP														x	x	x	x	x				
9.3 Handover of all scheme related documentation	MJP														x	x	x	x	x				
9.4 Co-running of scheme	MJP + WUA+TSP																x	x	x	x	x		
9.5 Final agreement and sign off from all parties	ZP+GP+MJP+WUA+TSP																						
10. Sustenance Phase	WUA + TSP																					x	x

x MJP
x WUA/SO
x MJP+WUA
Handover completed

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Appendix A: Student contribution

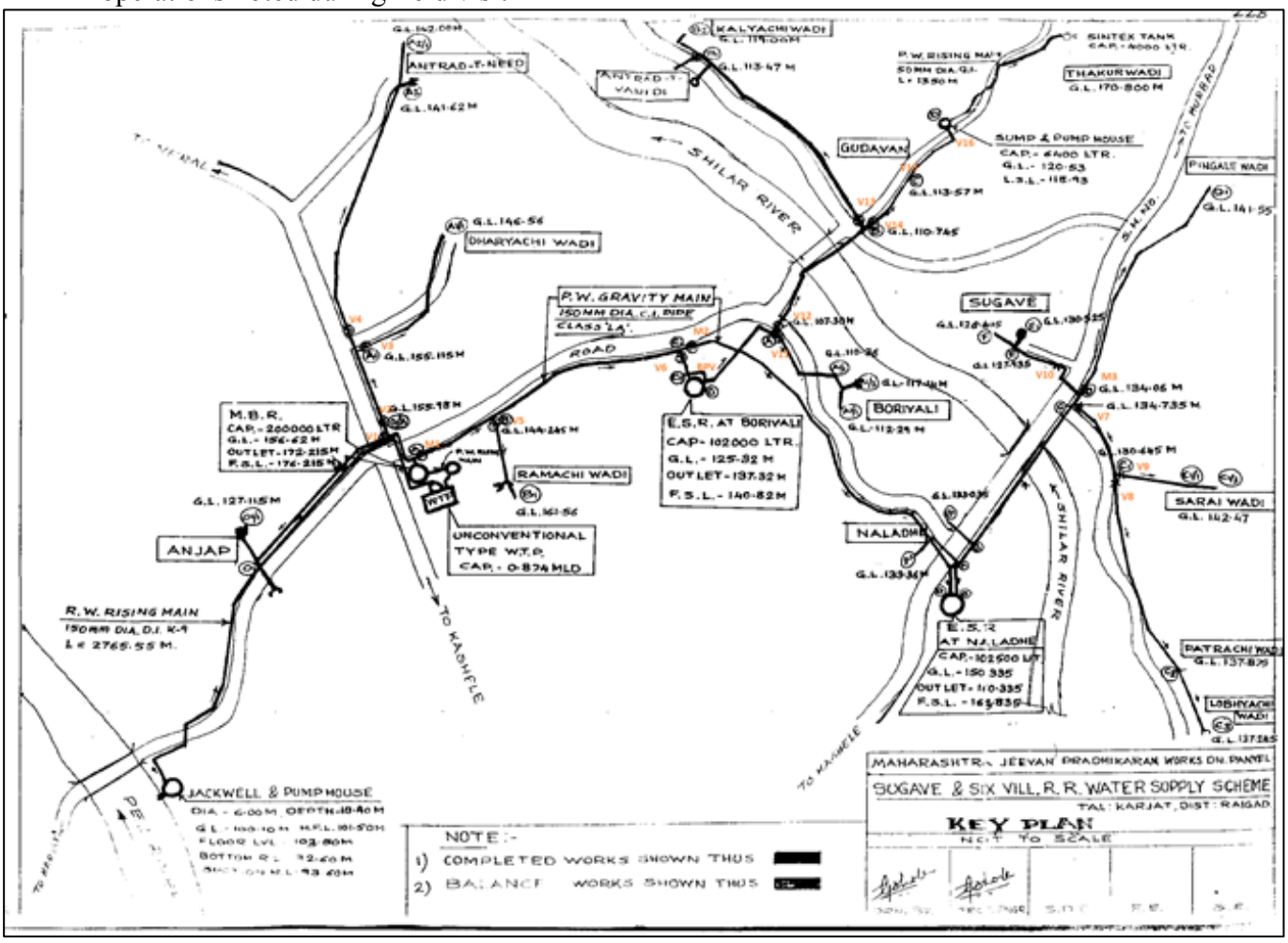
Mridul Joshi and Nikhil Goyal, students of IIT Bombay, participated in a participatory rural analysis (PRA) activity from 4/3/2011 to 6/3/2011 in two of the beneficiary villages for this scheme. They performed the initial analysis (technical and financial) of this MVS as part of a 4 month project as a "Technology and Development Supervised Learning" course under the guidance of Prof. Milind Sohoni.

Siddhartha Sohoni, a 10th standard student from Kendriya Vidyalaya, IIT Powai, stayed in the beneficiary villages for 3 days and wrote a report on the current status of the drinking water situation in all the villages and wadis in this scheme. He reported on the operational status of the MVS scheme and provided many photographs.

Vikram Vijay, Vikas V and Abhishek Sinha, all students of IIT Bombay, provided valuable technical inputs for running simulation models using EPANET and BRANCH.

Appendix B: Valve positions and operations schedule

Map showing valve positions used to currently operate the scheme followed by a schedule of operations noted during field visit



Step	Time	Action	Notes
1	08:30	Opened MBR outlet valve	The valve to Anjap remains closed (V1). No water is being provided by the scheme to Anjap
		Opened the valve to Dharyachiwadi and Antrad-t-need (V2)	
		Opened mainline valve next to MBR (M1)	The mainline valve M2 next to the Borivali ESR remains closed at this time
		Opened the valve to Ramachiwadi branch (V5)	
2	09:45	Closed MBR outlet valve shutting all supply	
		Closed valve to Dharyachiwadi and Antrad-t-need (V2)	
		Closed valve to Ramachiwadi (V5)	
		Opened MBR outlet valve again	
3	10:00	Ensure valve to Sugave branch is closed (V10)	Valve V7 to Saraiwadi, Naldhewadi & Lobhyachiwadi is already closed at this time
		Ensure that the mainline valve (M3) to Pingalewadi is closed	
		Opened mainline valve (M2) next to the Borivali ESR	This starts supply to Naldhe since there is no separate valve to control flow to Naldhe
	10:45	Open the valve to Saraiwadi, Naldhewadi & Lobhyachiwadi branch (V7)	The individual valve for Saraiwadi (V8) and the other one for Naldhewadi and Naldhewadi (V9) are both always left open. The supply is controlled through the upstream valve close to the main line.
4	1pm	Close the main valve to Saraiwadi, Naldhewadi & Lobhyachiwadi (V7)	Supply to Naldhe is still on
	1:45pm	Open the mainline valve to Pinglewadi (M3)	Sugave branch was not opened at the same time as Pinglewadi. The reason given was that it takes about 15 mins for the water to start at Pinglewadi and the contractor waits till that happens before starting Sugave. The pressure of water supply at Pingleadi drops significantly after Sugave valve is opened
	2:15pm	Open the valve to Sugave branch (V10)	
5	3:30 PM	Opened the Borivali ESR bypass valve (BPV)	Borivali ESR could not be filled last night because of electricity failure. Hence it is being bypassed and the MBR is being used to supply water to Borivali/Gudvan area
		Opened inlet valve into Borivali ESR (V6)	The individual valves one for Borivali branch (V11) and one for main Gudwan branch (V12) are always kept open
			The downstream valve V13 to Antrad-t-varedi and Kalyachiwadi branch is kept closed. The scheme doesn't currently supply water to them.
			Valve V14 on the branch towards Gudvan and Gudvanwadi is kept open
			A small valve V15 on the taping for Gudvan is kept closed at this time. So water is being supplied to Borivali and the G.wadi sump at this time.
			There is an inlet valve V16 to the Gudvanwadi sump that remains open.
		Closed the mainline valve (M2) next to the Borivali ESR to stop flow	This stops the flow to Naldhe, Sugave and Pingalewadi. The individual valves for Sugave and Pinglewadi are not closed since closing the valve on the mainline stops the flow upstream
6	4:15pm	Opened the small taping valve at Gudwan to start flow into Gudwan tank	It takes about 30 mins for the gudwanwadi sump to fill up. The gudwan flow is started after the sump gets filled
7	4:30pm	Started the generator to start the pump to supply water from the sump to the Gudvanwadi tank	There is no outlet valve from the sump. It takes about 30 mins after starting the pump for the water to start coming into the tank at Gudvanwadi
			Takes 3 hrs to fill up the Sintex tank in Gwadi
8	~6:45pm	Close the outlet from MBR	
		Close the bypass valve at the Borivali ESR	
	7pm	Open MBR outlet	Even if MBR outlet is closed, the overflow pipe connects after the outlet valve so that if the MBR overflows, it starts filling up the Borivali ESR (assuming ESR inlet is open)
		Open Borivali ESR inlet	ESR outlet and ESR bypass are closed
		start pumping from the main pumphouse	
	3am	Stop pumping	Takes about 8 hrs for the MBR and ESR to fill up together

Appendix C: Copy of letter sent to MJP from IITB students

March 24th, 2011
To:
Shri Nivdange,
Deputy Engineer,
Karjat Subdivision,
Maharashtra Jeevan Pradhikaran,
Karjat, Dist. Raigad, Maharashtra

Dear Shri Nivdange,
You may recall the ongoing IIT-Bombay analysis of the Sugave multi-village drinking water scheme. As a part of this, we have analysed the initial documents supplied by your office and have consulted various stake-holders from MJP, local NGO (Disha Kendra) and the residents of Naldhe, Gudwan and Anjap. We conducted a Participatory Rural Analysis (PRA) during our stay in these three villages from 4/3/2011 to 6/3/2011 (formal report will be submitted shortly). Additionally, we performed a technical analysis of the pipeline network using computer simulation. Based on the analysis so far, we have the following points which we would like your office to help us with in order for us to complete our study.

1. **Working Survey**: Was an initial working survey [Ref1, Pgs 99,102] conducted before the construction started? If so, can you please provide the detailed documents from this survey? This will help us understand many of the discrepancies that we notice between our estimates and the data used by you.
2. **Land Ownership:** We understand that Naldhe ESR is locked in a land ownership issue. This was stated as a reason for delay [Ref2]. Can you please explain if an NOC was obtained or an alternate agreement made with the land owner before the construction was started?
3. **Road crossings**: Another mention for delay was permission and payments for road crossing [Ref1, Pg31]. Was this road crossing required in a new design?
4. **Jackwell & Pump House**: We believe that one reason for the construction delay is that hard rock strata that was expected to be met after 4.5m was actually met after 1m [Ref1, Pg 30]. Can you please help us understand the basis for the initial estimate of 4.5m? Our own visual inspection of the site seems to indicate hard strata rather immediately.
5. **Pipe specifications:**
   a. In the Branch Simulation performed by MJP, [Ref1, Pg82] the following commercial diameters have been used:

Pipe Diameter(mm)	Hazen's Constant
50	100
65	100
80	100
100	100
150	100
200	100

However, the material which is used during implementation [Ref1, Pg91] are pipe diameters of three types (ACP, CI ,GI) of diameters 50mm , 65mm, 80mm, 100mm, 125mm,150mm. Is there a reason to not input the actual pipe-set in the simulation?

(E.g. 125 mm pipe has been used in the physical construction but was not used as input in the simulation). Also, for the pipe-set used, what are the Hazen constants?

b. Assuming that the Hazen constants are the same and that the simulation is valid, we also see many discrepancies in the pipe-dimensions between the simulation output [Ref1, Pgs 70,82,83,88] and the one physically used [Ref1, Pgs 90, 91] in the implementation (see examples below). Is there any reason to deviate from the simulated dimensions?

Location of pipe	According to simulation	Implemented
From ESR Naldhe Across Shilar River	100 ACP	125 CI
From ESR Naldhe branch towards Sugave	80ACP	100 CI
From ESR Borivali towards Gudwan	150 ACP	150CI+150ACP+150GI
In MRB branch , connecting Dharyachi wadi	50GI	50GI +65GI

6. **Length between nodes**: We found significant discrepancy in length of two pipe sections (part of Boriwali ESR sub-network).
   a. Length between Antrat-T-Waredi and node 57 (trisection just before Gudwan) – The length used by MJP in simulation is 1830 meters [Ref1, Pgs 81,85] whereas estimate from Google Earth is atleast 2500 meters.
   b. Length between Antrat-T-Waredi and Kalyachiwadi – Reported length is 420 meters [Ref1, Pgs 81,85] whereas estimate from Google Earth is atleast 1000 meters.

   Can you please validate our understanding? Because of huge increase in length of the pipes, simulation shows that cost of Boriwali pipeline subnetwork would go from INR 12.09 lakhs to 22.5 lakhs. One of the reasons for increased cost would be the need of larger diameter pipes to lower down the increased head requirement.
7. **Elevation**: The elevation difference between Lobhyachiwadi and ground level of ESR at Naldhe taken in your simulation is 8.78m (150.33m - 141.55m) (node 61 and node 51) [Ref1, Pgs 87,89]. Our estimate [Ref3] based on Google Earth[Ref4], is around 1m (89m – 88m), which is substantially lower than the elevation difference in your calculations. Can you please verify the actual height and location of Lobhyachiwadi?
8. **Naldhe ESR height**: Assuming that the Lobhyachiwadi elevation is indeed 141.55m, there seems to be no reason to have Naldhe ESR at the current designed height of 10m. In fact, we performed an exercise to optimize the ESR height by minimizing the total cost of pipe network and ESR construction cost [Ref5]. For ESR at Nahlde we found that the optimal height was 6 meters instead of the current design of 10 meters and by using optimal pipe diameters, there is a potential to save upto INR 2.5Lakhs. Similar analysis may also be done to optimize the height of Boriwali ESR.
9. **ESR elevation:** At Nahlde, the ESR outlet is reported at 160.34 meters with Full Supply Level (FSL) of 163.85 meters [Ref1, Pgs 69, 72]. In simulation of Gravity Main (GM) pipeline network, FSL should be used as the elevation at ESR, but outlet level has been used instead. Re-simulating the GM network with FSL as the elevation being the only change, the network cost changes from INR 45.12 lakhs to INR 48.27 lakhs. Can you please validate this dost differential?

Storage Reservoir	FSL (in meters)	Outlet (In meters)	Height used in simulation (in meters)
MBR (Inlet)	176.2	172.2	172.2
ESR at Borwali (outlet)	140.82	137.32	140.82
ESR at Naldhe (outlet)	163.84	160.34	160.34

10. Operation Log: Can you please provide the daily operation schedule for the network? What are the control points in the network?

11. Operation & Maintenance:

a. The cost of electricity reported [Ref1, Pg 95, Statement no. 21] is Rs 550 per BHP per year. Can you please provide a breakdown of this cost? Our estimate is Rs17,400 per BHP per year (assuming 0.746kW/BHP for 16 hours pumping per day, 365 days per year and a rate of Rs 4 per kWhr)

b. Upon examining RA bill [Ref6, Pg15], we notice that there is a bill for the delivery of water for every summer starting 2007 as follows:

Quantity executed	Item of work	Rate	Unit	Payment up-to date	Payment since prev bill
	1. Commissioning , running & maintaining the scheme to quantities ,rated capacity				
	A) For 10th March2007 to Jul 2007 -4months				
4	a) For upto first 3 villages	1008.3	month	40333.32	40333.32
14	b)Add for every villages or part there of	2420	month	33880	33880
	B) For 15th Jan 2008 to Jun 2008 -6months				
5.5	a) For upto first 3 villages	13108.33	month	72095.82	72095.82
43.6	b)Add for every villages or part there of	3190	month	139084	139084
	C)For 1st March 2009 to Jul 2009 -5 months				
4.5	a) For upto first 3 villages	15711.67	month	70702.52	70702.52
44	b)Add for every villages or part there of	4345	month	191180	191180
	D)Proposed For 1st Mar-Jul				

	2010-5 months				
3.6	a) For upto first 3 villages	186068.4	month	65046.31	65046.31
36	b)Add for every villages or part there of	4997.3	month	179902.8	179902.8
1500	2.Providing TCL powder while running scheme	16.2	Kg	24300	24300

We would like to have a more detailed explanation of the above entries, such as list of wadis served, annotations by gram-sewak, gram panchayat, members etc., and other supporting documents, such as collection of water-cess from the wadis, tariff charged and actual electricity bills. Also, can you please explain the first column above which is titled in the table as "Quantity executed upto date as per measurement book"?

12. **Observations from PRA and related questions**: During our interaction with the residents, we made the following observations [Ref7]
    a. Anjap village already has a private pipeline. Hence the residents seem unwilling to subscribe to the MVS scheme. All other villages also expressed scepticism about the scheme. Their apprehension about the condition of the infrastructure that was installed 10 years ago is a big reason for their unwillingness to subscribe to the scheme. Based on this, we would like to understand if there was any survey or agreement performed with the villages initially. Also, is there any procedure in place for handing over the scheme to them?
    b. Currently the scheme only provides raw water to the villages. We believe that if treated water is provided instead of raw water, there is likely to be better acceptance of the scheme. Additionally, since the construction of WTP is independent of other sub-works, can its construction be prioritized so that the villages and wadis get treated water?
    c. In light of the current reservations about the scheme, was there a formal expression of demand received from the villages at any stage in the project?
    d. We would like to understand the historical timeline of this MVS scheme. Can you please provide information regarding this? It will help us understand the major milestones in the project. Can you also explain what resulted in the lack of funding for the project between 2002 and 2007?
13. **MBR:** It appears that the MBR construction has some minor work including installation of safety equipment remaining. Considering the comparatively low cost of installation of a lightening conductor, is it possible to prioritize its installation to avert risk? Also, please share what insurance policies, if any, are in place to cover the pipeline network.
14. **Pipe strength**: Since the ACP pipes have now been banned, GI pipes have been physically used in the network. However, the revised design continues to show ACP pipes in the network design. Can you please send us the latest design with this change?

Please let us know if you need clarity on any of the above questions. Attached with this letter you will also find a CD containing data used in our technical analysis. We would like to propose a meeting on Saturday, April 3rd to discuss your response. Thank you for your help and support in our analysis.

Best regards,

Mridul Joshi
Senior Undergraduate Student
I.I.T. Bombay

Nikhil Kumar Goyal
Senior Undergraduate Student
I.I.T. Bombay

References for the letter

1. General Report, Revised Addition, obtained from MJP's Karjat office
2. Conversation with Mr. Sunil Mhase, Sarpanch, GP Boriwali
3. Appendix 1
4. Attached map from our technical analysis
5. Appendix 2
6. Current RA bill (30) obtained from MJP Panvel office
7. Discussions with residents during the PRA visit

Appendix D: Simulation output vs. Physical design

Reference for simulation output: output data file SUGAVEMB.OUT (23rd Feb 2008, Pg 68 of revised general report), SUGAVEBO.OUT (19 Apr, 2007, Pg 84 of revised general report), SUGAVENA.OUT (19 Apr, 2007, Pg 87 of revised general report). Reference for revised documentation: Statement No. 18 and 19, pgs 90, 91,92 of revised general report). Reference for physical pipes used: Verbal discussion with contractor

MBR

					Simulation Output	Revised documentation		Physically used	
Pipe#	Start Node	End Node	End Node	Length	Dia	Dia Type	Type	Dia Type	Type
1	51	52		15	200	150	CI	150	CI
2	52	53		40	80	150	CI	150	CI
3	53	54	Anjap	1300	65	80	ACP	80	ACP
4	54	55	Anjap	115	50	65	GI	65/50	ACP
5	53	56		120	80	80	ACP	100	ACP
6	56	57	Dharyachiwadi	980	50	50	GI	50	GI
7	56	58	Antrad-t-need	1780	65/80	80	ACP	80	ACP
8	58	59	Antrad-t-need	60	65	65	GI	65	GI
9	52	60		420	150/200	150	CI	150	CI
10	60	61	Ramachiwadi	350	50	65	GI	65	GI
11	60	62		1220	150	150	CI	150	CI
12	62	63	Borivali ESR	160	80	80	CI	80	GI
13	62	64	Naldhe ESR	2400	150	150	GI	150	ACP

Nahlde ESR Branch

					Simulation Output	Revised documentation		Physically used	
Pipe#	Start Node	End Node	End node	Length mm	Dia mm	Dia mm	Type	Dia mm	Type
1	51	52		60	100	150	CI	150	CI
2	52	53	Naldhe	60	75	65	GI	-	-
3	52	54		60	100	100	CI	100	ACP
4	54	55	Naldhe	60	75	65	GI	-	-
5	54	56		510	100	100	ACP	100	AC
6	56	57		120	75	80	ACP	100	ACP
7	57	58		150	75	80	ACP	80	ACP
8	58	59	Sugave	180	75	65	GI	65	GI
9	58	60	Sugave	180	75	65	GI	65	GI
10	57	61	Pingalewadi	1230	75	80	ACP	80	ACP/GI
11	56	62		840	80/100	100	ACP	100	ACP
12	62	63	Saraiwadi	350	80	80	ACP	100/80	ACP/GI
13	62	64	Nahldewadi	1440	80	100	ACP	100	IC
14	64	65	Lobhyachiwadi	220	75/80	80	ACP	80/65	ACP/GI

Borivali ESR Branch

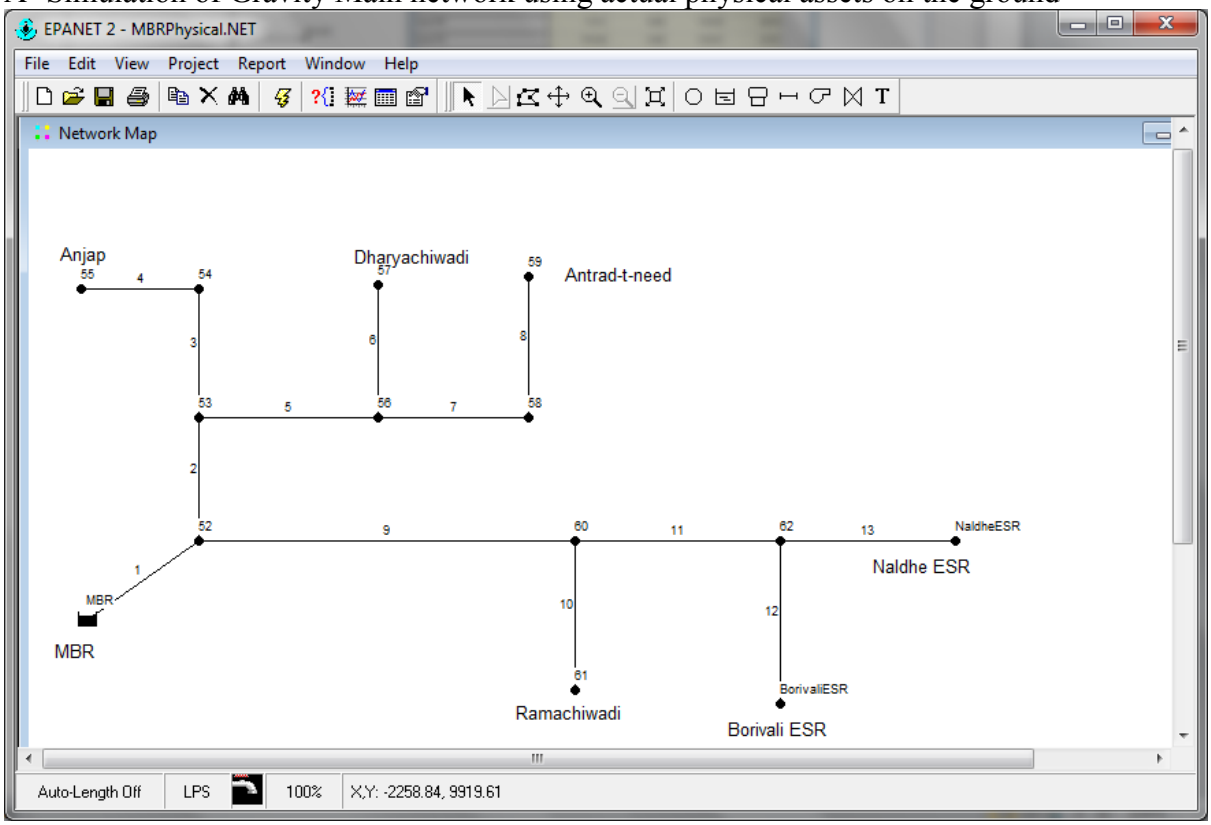
					Simulation Output	Revised documentation		Physically used	
Pipe#	Start Node	End Node	End node	Length	Dia	Dia Type	Type	Dia Type	Type
1	51	52		350	150	150	ACP	150	ACP
2	52	53		180	50	65	GI	65	GI
3	53	54		30	50	65	GI	65	GI
4	54	56	Borivali	30	50	65	GI	65	GI
5	54	55	Borivali	90	50	50	GI	65	GI
6	52	57		390	150	150	ACP	150	CI/GI
7	57	58	Antrad-t-wared	1830	80/100	100	ACP	100	ACP/GI
8	58	59	Kalyachiwadi	420	50	65	GI	65	GI
9	57	60	Gudvan	290	80	100	CI	100/65	CI/GI
10	60	61	udwanwadi Sun	820	50	65	GI	65	GI

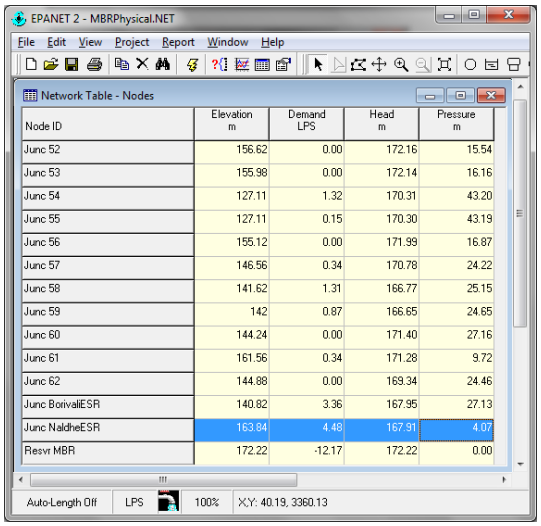
Appendix E: Summary of technical issues

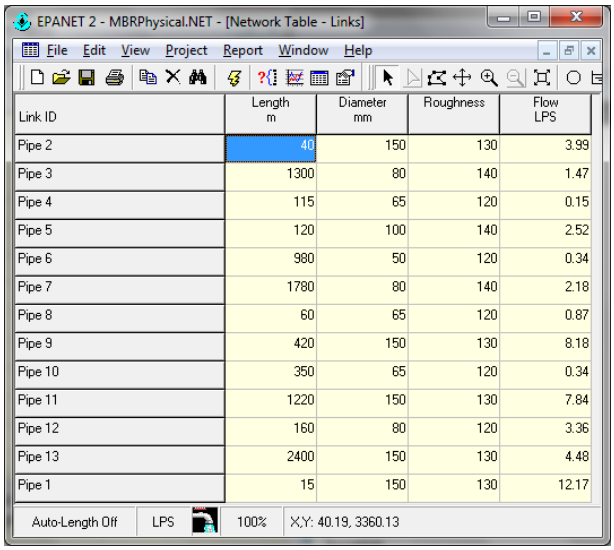
No	Reference Page (General Report)	Reference (detail)	Error	Impact of error	Impact High/Medium /Low
1	Pg 70	Last row in last table	Node 64 (Naldhe ESR) elevation is taken as 160.34m instead of 163.84m	Required head will not be achieved on top of Naldhe ESR with the pipes reommended by the simulation results. Simulation underestimates the optimal network cost by 3.15 lakhs (6.5%)	High
2	Pg 83	Node 51S	HGL for Node 51S (Borivali ESR) should have been137.32 instead of 138.44. FSL was used as the head for instead of the outlet level for downstream network from Borivali ESR.	Heads are overestimated for all points of delivery. Cost of the network is underestimated.	High
3	Pg 83	Pipe 7 data	Simulation pipe 7 and pipe 8 lengths are incorrect when compared with Google Earth. Simulation data - node 57 to 58 : 1830m, node 58 to 59: 420m. GE estimates are 2500m and 1000m for these lengths of pipe going to Antrad-t-waredi and Kalyachiwadi (straight line estimates, actual road length would be even more)	Simulation shows a difference of ~Rs 10L due to additional length (and higher dia of pipe required due to increased head requirement)	High
4	Simulation: Pg - 71, 84,88 Pipe requirement documentation: Pg - 90, 91	Pipe dia tab	Output of simulation was not used in the physical network. The basis of the choice of physical pipes is unclear.	The network cost has not been optimized. Insufficient head achieved at some delivery points	High
5			Proposed height (10m) of Naldhe ESR is not optimal. It should not be higher than 9m to achieve desirable head at the top of the ESR	Higher construction cost Longer time needed to fill up the ESR from MBR through gravity flow	High
6	Pg 83		Insufficient head at Kalyachiwadi due to points 2 and 3 above. Correct simulation shows that water supply to Kalyachiwadi will only have at most 2m head	Service issue for Kalyachiwadi	High
7	72, 54	D.wadi & Antrad LPS(0.34+.87+1.31), population data on Pg 54	LPS for Antrad-t-need calculation assumes 1147 to be the population instead of 1047.	Total LPS for Antrad-t-need and dharyachiwadi should be 2.30. But due to incorrect population input, 2.52lps has been used (minor impact)	Low
8	Pg 65	Point 3	Capacity for 2 hours calculated incorrectly to be 36,437 instead of 48583	Total required capacity of MBR will come out to 218,891instead of 206760 (6% higher)	Medium

Appendix F: EPANET simulation

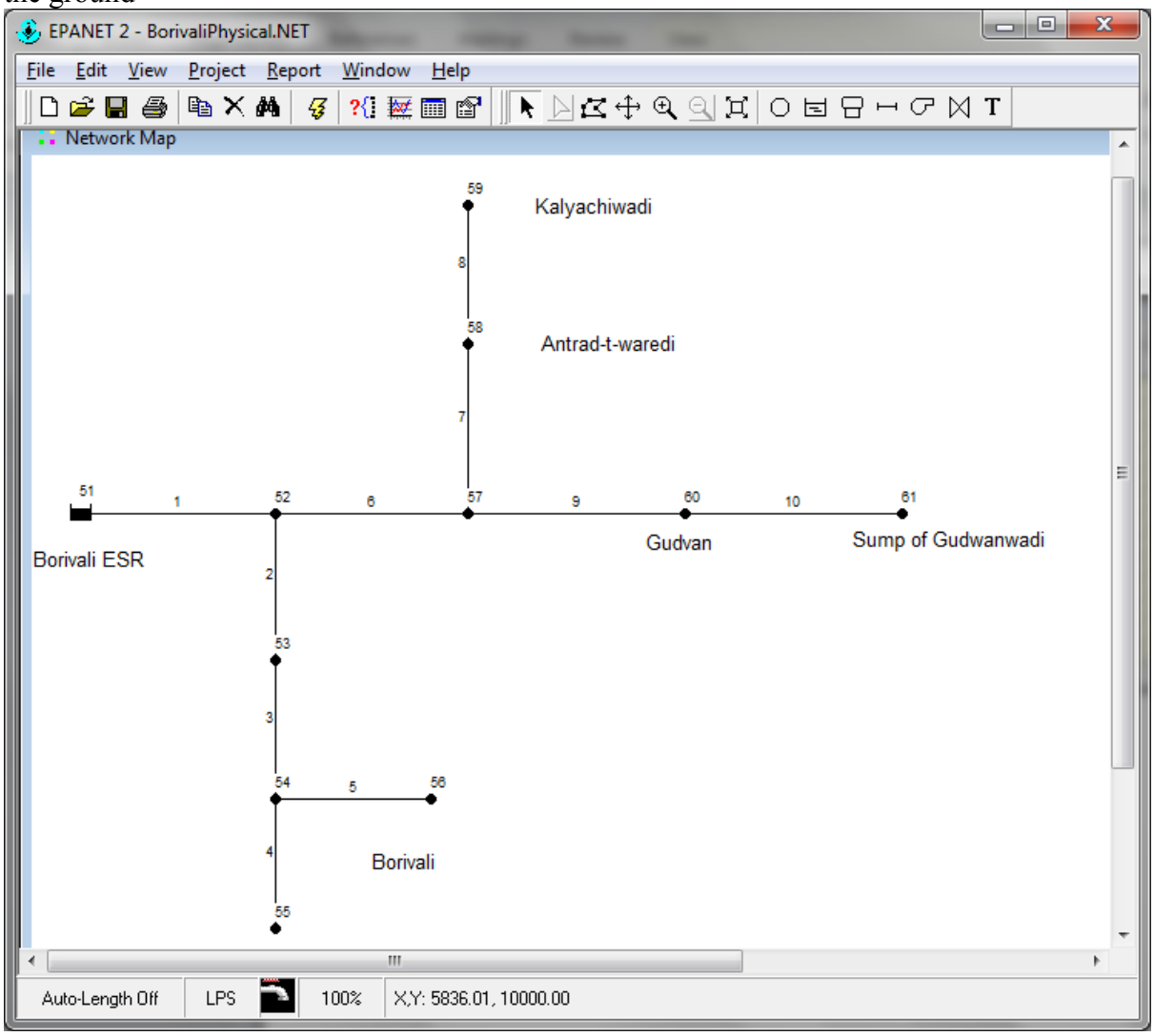
A- Simulation of Gravity Main network using actual physical assets on the ground

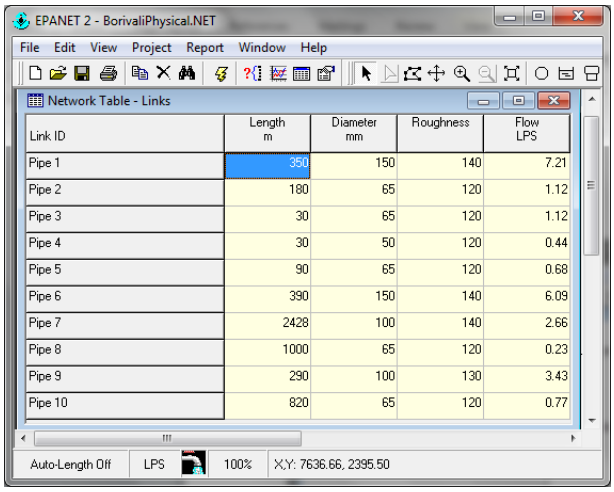


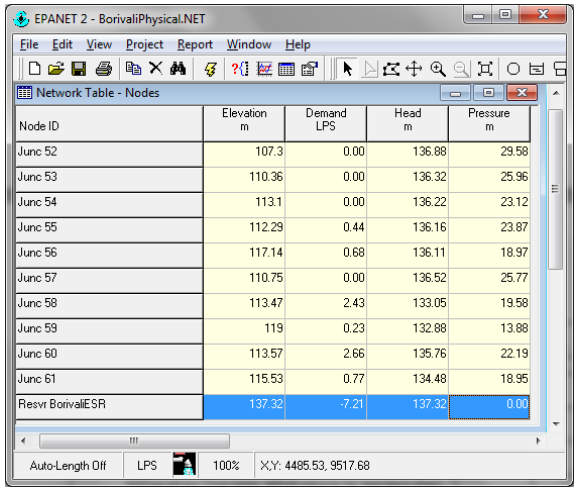




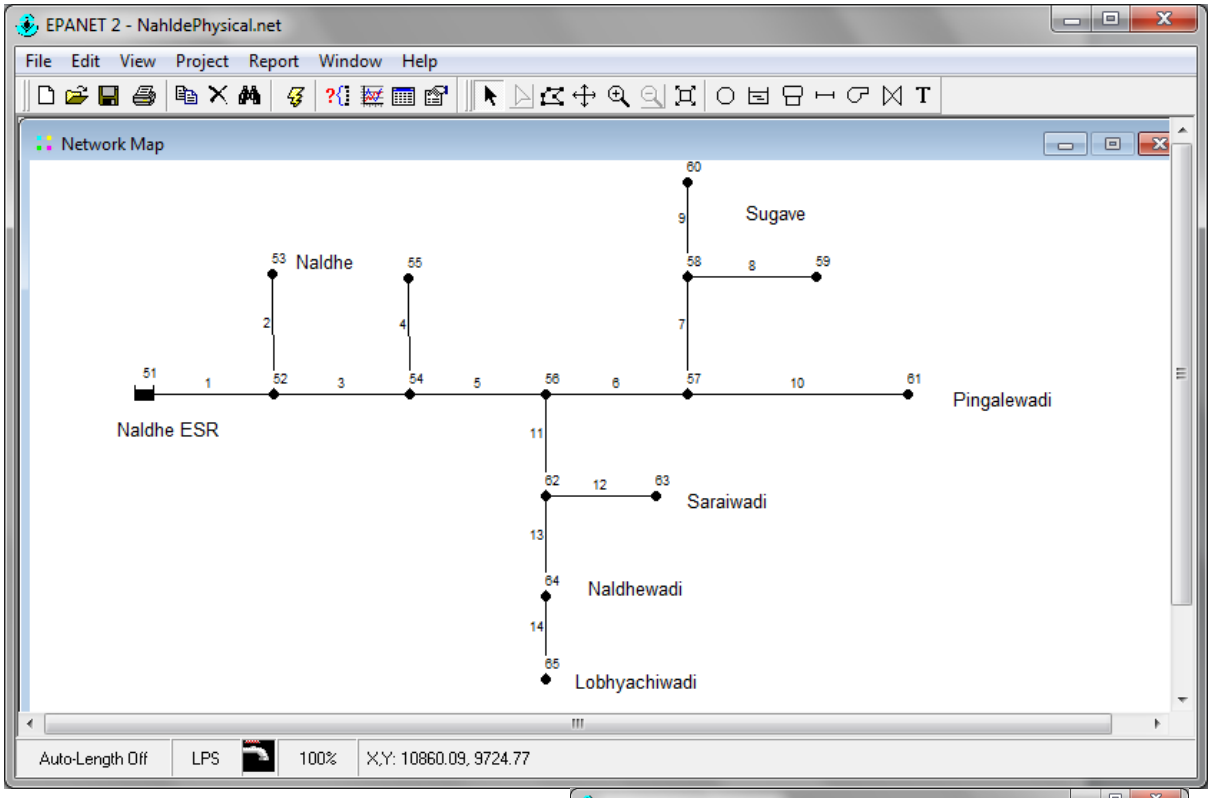
B. Simulation of downstream network from Borivali ESR based on actual physical assets on the ground

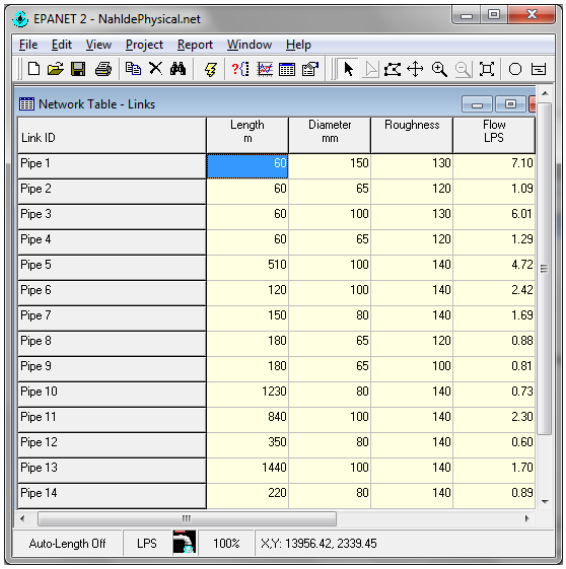


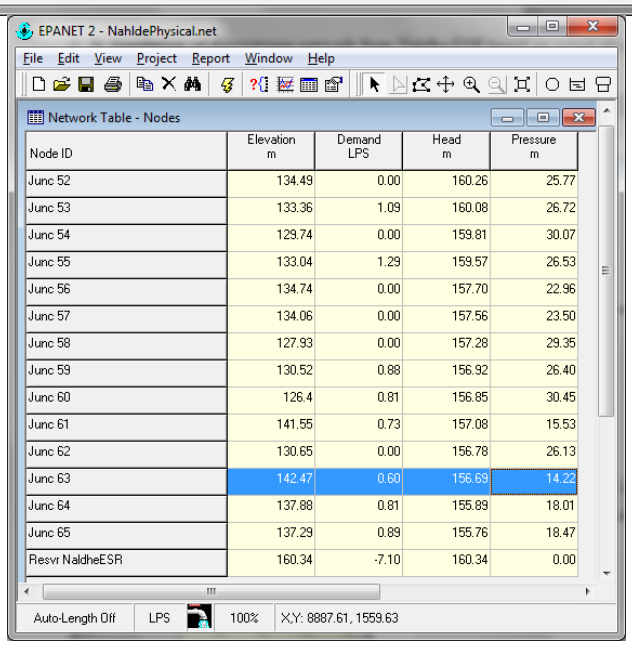




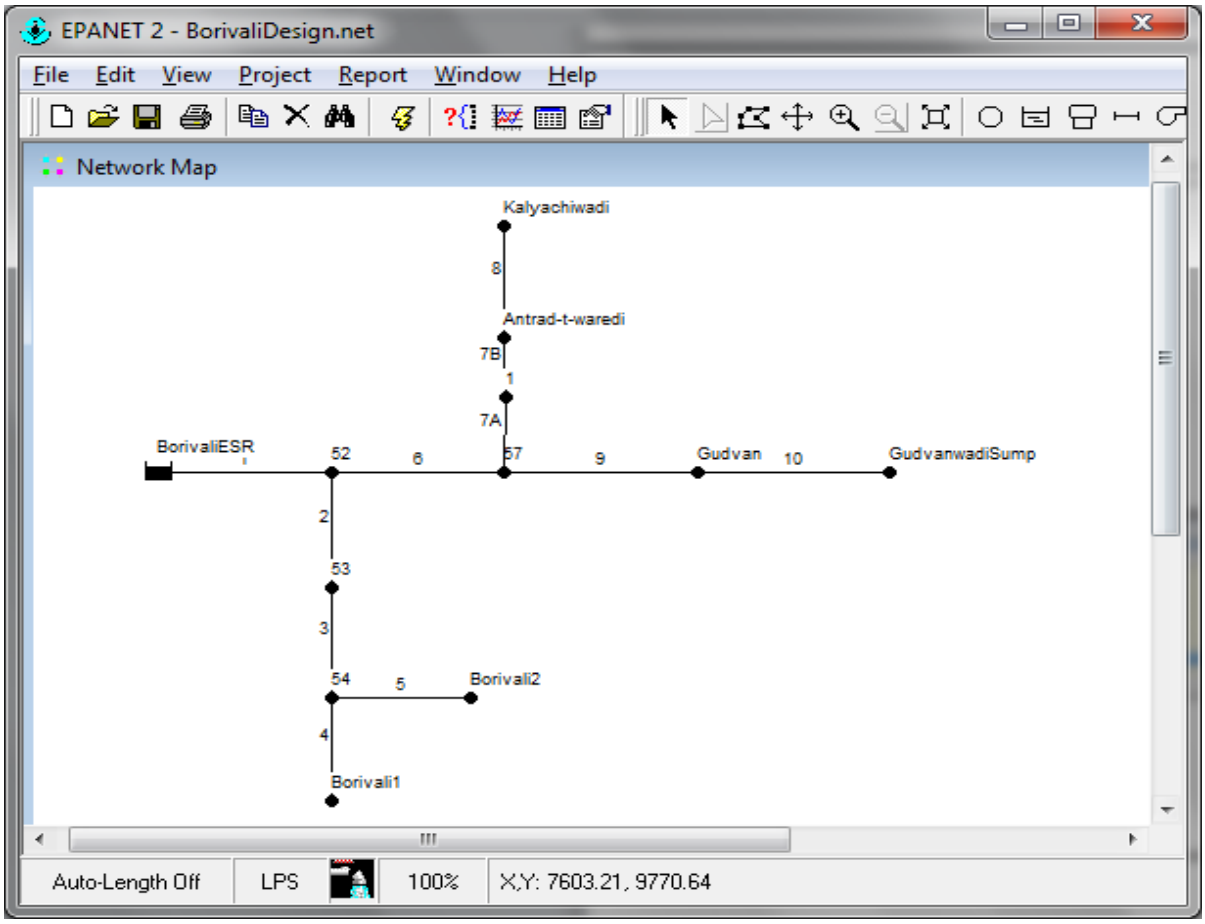
C. B. Simulation of downstream network from Naldhe ESR based on actual physical assets on the ground

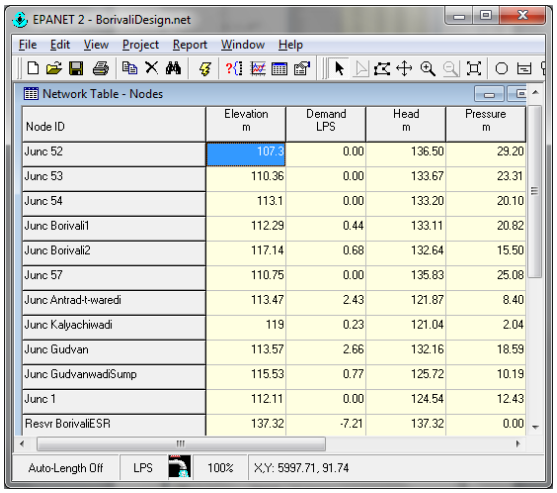


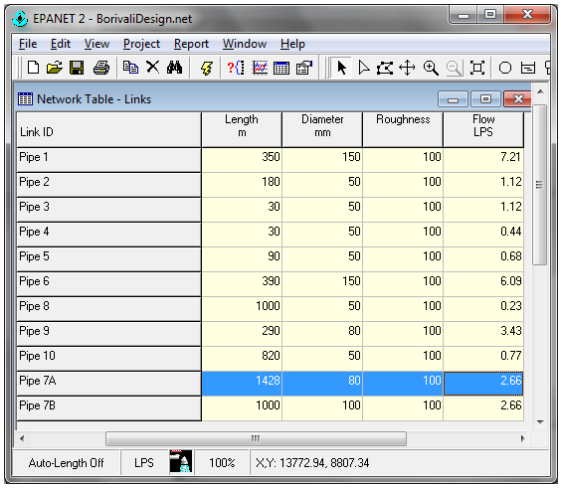




D. Simulating the design of network downstream from Borivali ESR (network based on initial design and not the actual physically used) indicating the low pressure to be expected at Kalyachiwadi







Appendix G: Sample handover documents checklist

No	Requirement for hand-off	Responsible Party	Status	Date
Documentation to be handed off				
1	Distribution network map with all assets marked on it (pumps, MBR, ESRs, WTP, valves, standposts etc)	MJP		
2	Inventory of assets along with specifications , capacity, age of pipes	MJP		
3	Operations Manual describing how the network should be operated	MJP		
3A	Operations Time table: Which valve to be operated when			
3B	Description of labour required to run the scheme - how many valvemen, pump operator, supervisor etc, how many shifts, should be placed at which locations			
3C	Maintenance manual: What actions need to be performed for regular maintenance and at what frequency			
4	Map of tertiary network	MJP		
5	Simulation model of current physical network (input files showing all nodes with elevation data & LPS, pipe lengths, types and output file showing expected head at each node)	MJP		
6	Proposal for amount of water cess to be collected from the people to sustain the scheme	MJP		
Physical completion of work				
1	All assets including WTP and ESRs must be completed and functional	MJP		
2	Tertiary network design and construction completed	MJP		
3	Trial period demonstrating that water can be supplied regularly to all beneficiaries at a reasonable pressure	MJP		
4	Implement a log book for all valvemen and at pump house and enforce daily entry of all tasks performed	MJP		
Training				
1	Ensure that the valvemen are well trained in running the operations and that the supervisor is trained in the O&M needs	MJP/GP		
2	Train all operators to make entries in the log book	MJP		
3	Train account-keeper on maintaining account book for cess collection	GP		
Handshake Documents				
1	A formal hand-off documentation signed by the GP/ZP that the scheme has met all their requirements and is being taken over by them, also mentioning what roles will be played by MJP going fwd	Joint between MJP and GP/ZP		
2	A document describing the organizational structure with roles and responsibilities (Who will employ and pay labour required to run the scheme?Who will pay the electricity bills? Who is responsible for implementing metering and keeping accounts? Who will collect the money? Who will authorize and be responsible for repair & maintenance work?)? Who will authorize new connections (home/private/commercial?)	GP/ZP		

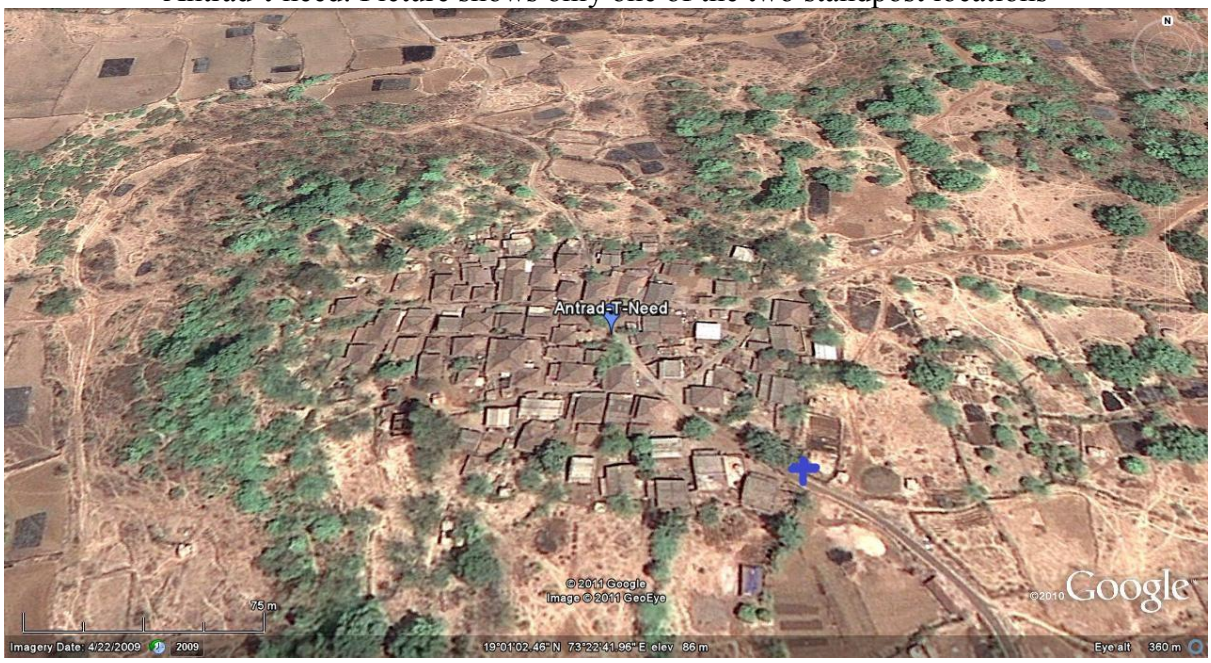
Appendix H: Satellite images of habitations

This Appendix includes the satellite images of habitations taken from Google Earth. In habitations where water is provided through the MVS, current standpost locations have been marked with a blue cross. Wells, and school or anganwadi tanks which are filled by the scheme water are also marked. Note that the blue coloured tear shaped mark at the centre of each habitation denotes the point of latitude/longitude that was used in the data set. It does not mark the position of a standpost or any other physical asset.

Dharyachiwadi – 1 standpost and 1 school tank

Ramachiwadi – 1 standpost and 1 school tank

Antrad-t-need: Picture shows only one of the two standpost locations

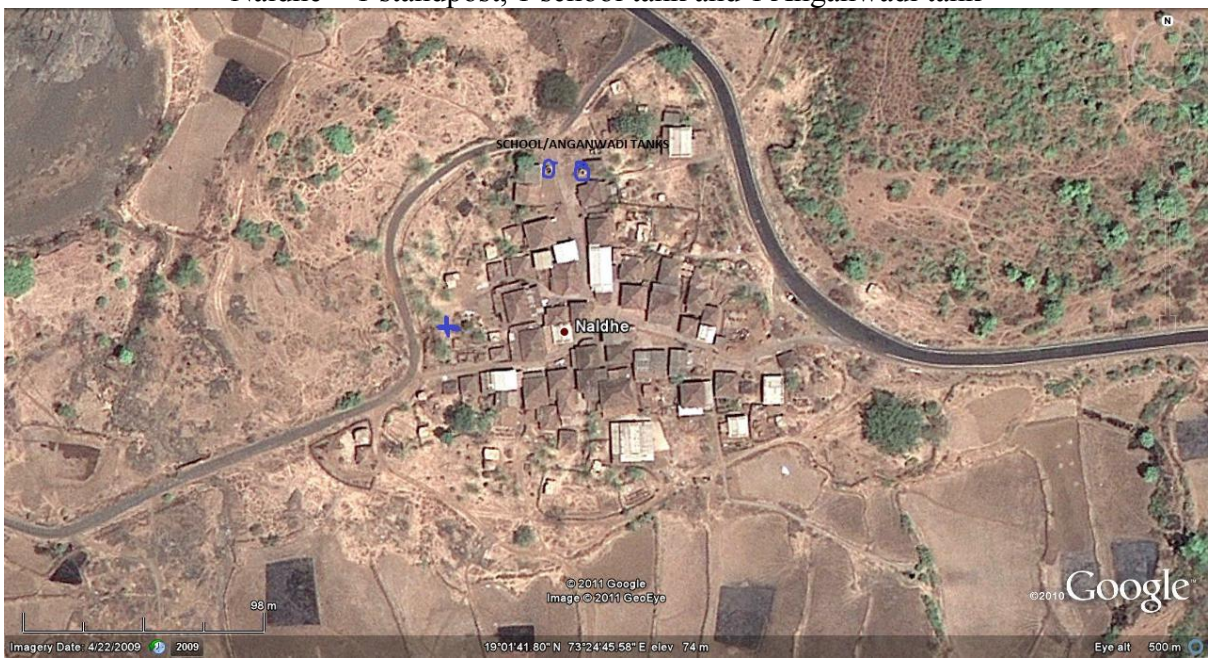


Borivali – 2 standposts

Gudvan- water supplied to one open tank

Gudvanwadi – Water supplied to one Sintex tank

Naldhe – 1 standpost, 1 school tank and 1 Anganwadi tank



Sugave – Water supplied to a well

Pingalewadi – 1 standpost

Saraiwadi – 1 standpost and 1 school tank

Naldhewadi (Patrachiwadi) – 2 standposts and Lobhyachiwadi (no standposts)