Auroville

Study on Sustainable Waste Water Management for the Residential Zones I and II

Part Four

Comparison and discussion of viable waste water treatment technologies and sewer network design

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Preliminary Note

This study was commissioned in April 2012. Part 1-3 completed in April 2014. In the meeting November 10th 2014 Part 4 was presented to the review board (L'Avenier, Water Cell and others).
The summary of Part 4 was released so that the preparatory work for implementation could be started.

In January 2016 the proposals were finalized and published in the Auroville News and Notes.
Following the feed back received, a study group was set up to see how concerns of the residents could be met. From February onwards the group met on several occasions.

Since then various changes occurred, in particular to the planned capacity of the plant and the location. These effect the design and layout of the sewage network and treatment plant.

In July 2017 the design of the sewer network was finalized and the construction of the 1st phase of the sewer and waste water treatment plant is under way.

Part 4 is now presented in a revised version where these changes have been incorporated.

Contents:

Introduction

The Residential Zones I and II in Auroville have been identified as the primary residential development zone for the next few years.
At his point a population density has been reached, were the un-controlled release of semi-treated waste water from a multitude of different septic tanks is not supportable any more. And an organized approach for the proper waste water management has to be found.
In a time when water becomes more and more scarce the concept of "waste" water has undergone a transformation and it is now viewed as a potentially valuable resource for agriculture and industry. Likewise the target of treatment has shifted from safe disposal to re-use. In tropical-dry countries like Tamil Nadu, India the location of the Study Area, this concept gains even more importance.
A multitude of treatment technologies exist, each with advantages and disadvantages. These are mostly expressed in terms of treatment efficiency, retention time, reliability, foot print and capital and operational cost. For different types of waste water some treatment methods can be more, others less beneficial. Similarly geographic location, climate and other factors play a role. In April 2012 L'Avenier commissioned this study to provide a sustainable concept for waste water management for the Residential Zone I&II in Auroville.

Note on the structure of this study

The study is comprised of four major sections. Each section describes an independent activity that builds up on the previous section and forms the basis of the subsequent section.

Part 1. - Surveys and Analysis (completed January 2013)
In this part the base parameters for dealings with waste water in the Study Area were established. The existing communities were surveyed. National and international norms researched and assessments were made in regard to
a. quantity and quality of wastewater to be treated
b. re-use of recycled water
c. treatment, re-use or disposal of sludge
d. performance of existing treatment plants

Part 2. – Design Parameters and Recommendations (comp. September 2013)

In this section the findings of the previous chapters are reviewed to formulate the design parameters for the
a. New treatment plant
b. Sewage pipe systems
c. Other machinery, pumps
e. Recommendations for upgrading existing plants

Part 3. – Design Concepts (completed April 2014)

This section provides conceptual designs and cost estimates of different choices of treatment systems and system components
a. Treatment plant(s)
b. sewer pipe network
c. and other machinery

Part 4. – preliminary summary *(submitted in November 2014)*

Part 4. – reviewed with full text, *current volume*

Chapter 1 – Discussion on the criteria for evaluation

Chapter 2 – Common features of the proposal

Chapter 3– Assessment of each proposal (validation)

Chapter 4 – Details of the new location for the treatment plant

Chapter 5 – Detailed design of the sewer network

Chapter 6 – Environmental considerations

Annexure

Several Annexure are given, these refer to adjustments that have been made in the course of this study, such as the choice of location for the plant and in regard to the design size of the plant. The sewage system has been re-designed to suit the new chosen location of the plant.

File Sharing

All Files drawings and presentations that were produces under this study, and many research articles and manuals are available on DVD appended to this book and on a shared Cloud Drive. Access to these files can be given on request by L'Avenier. The current file structure is shown below.

File Structure

- Study on Waste Water Managment RZ
  - Additional notes
  - Literature
    - composting
    - DEWATS
    - exampel small treatment plants
    - Gas turbine
    - Indian Manual on water supply
    - Lab
    - New Indian Manual on Waste Water Managment
      - Part A Engineering
    - Products
    - pumps
    - Re-use of waste water
      - EU richtliniene
      - US EPA
    - sewage design guide
  - Presentations
    - Part 1 Dec 2012
    - Part 2 Luly 2013
    - Part 3 May 2014
  - Reports Part 1 2 3
  - Survey AV existing plants

Summary of preceding Parts of this Study

In April 2012 L'Avenier commissioned this study to provide a sustainable concept for waste water management for the Residential Zone I&II in Auroville.
The study is structured into four parts and although each part forms an independent activity, the four parts are built-up logically upon each other.
After completion of each part the findings were presented to L'Avenier for discussion. Based on this approval the procedures for the following part were decided.
In the following a brief summary of the findings is give.

In Part 1 of this study the population distribution and development in the area was analyzed and projections for immediate and mid-term requirements were computed. The Residential Zone 1 and 2 cover an area of 60 hectare and currently about 600 people live there. The final population target is 3500 residents.
The existing waste water treatment plants in the area were surveyed and it was found that

- most of them are not working satisfactorily in regard to achieved treatment level and nuisance control (odor, mosquitoes and flies)
- they require a lot of maintenance
- only a fraction of the water that enters the plant is available for re-use after treatment
- they occupy a large space

It was found that in many cases there is no schedule to remove the sludge that accumulates in the settlers of the treatment plants. Frequently the sludge builds up to the point that it overflows from the settler into the following treatment structures, blocking the system. This leads to major fault of the plant.
There is currently no satisfying method in place for treating the sludge once it is removed from the plants and disposing of it.
An assessment was made between the options of continuing the current practice of building multiple small on-site treatment plants, repairing and upgrading the existing plants, or, creating a canalization network and a state-of-the-art single treatment plant. Although building up a canalization network poses considerable investment, there are several benefits. In larger plants the cost of water treatment per capita, in terms of investment, operation and maintenance is significantly reduced compared to small plants. A further advantage is that a large plant can be equipped with a hygienic sludge processing unit located on site. This is not feasible in smaller plants
Based on these findings it was decided to design a single community treatment plant along with a canalization network. The treatment plant would initially be sized for 1000 PE(1) and should be expandable to meet the projected end-requirement of 3500 PE. The plant should also be capable of processing the sludge from other small treatment plants from outlying communities so that it could be brought there for processing.

Footnote (1): During the period since this study was started until it was completed, some of the base parameters were re-adjusted. For example the initial design size of the treatment plant was down sized from 1000 PE to 300 PE and similarly the final built out size was reduced from 5000 PE to 3500 PE. Since earlier Parts 1-3 have already been submitted the changes that this implies are annexed here.

Water usage patterns in the communities were analyzed and it could be shown that about 50% of the drinking water which is currently drawn from the fresh water supply system is used for watering the gardens and other non-residential purposes. The survey showed that there is a high level of awareness amongst community members towards the need of saving water and a willingness to use re-cycled waste water for gardening.

It stands therefore to reason that if the re-cycled waste water would be brought back into the communities for watering the gardens, then an almost equal amount of valuable drinking water would be freed and be available for domestic purposes and other higher uses.
Hence it was decided that the waste water would have to treated to a level to render it safe for irrigation and, in the case of percolation, it should be ground water neutral. The parameters for the treatment goal were set accordingly. EU norms and WHO guidelines were adopted for this purpose.

In Part Two of this study a multitude of different treatment technologies were examined. The area in which the project is to be located is situated in rural Tamil Nadu, South India. There are frequent power fluctuations and outages and the plant and machinery needs to be able to accommodate this. The level of education, training and capacity of local staff has to be taken into account and their ability to repair faults. Replacement machinery has to be readily available.
The plant needs to be able to handle fluctuating inflow quantities and should be easily expandable to accommodate the growing demand
Out of the compilation of different technologies four types of systems were selected to be compared against each other in more detail.
These are:

- Anaerobe Baffle Reactor
- Activated Sludge System
- Activated Sludge System with bio media
- Trickling Filter

Different methods for sewage evacuation were considered and it was found that a system could be implemented based on gravity flow, that would avoid the need of any pumping station.
Classical sewage system design, based on an alignment along other existing infrastructure routes was compared to “simplified sewerage”. A variety of commercial sewer pipe systems and materials were studied.

Based on these findings a basic sewer system network was designed, that would allow all communities to be connected. A phased approach for the implementation was suggested.
The trunk sewers are equipped with inspection man holes at 100 m distances and provision for ventilation was made.

The return pipe for the treated water distribution system was designed and dimensioned, and recommendations were made to avoid accidental mix-up with the drinking water supply

Methods to further process the sludge were discussed and it was recommended to sun-dry the digested sludge and then compost it. Co-composting with shredded plant matter would provide additional carbon and further improve the end product. The resulting product can be used in gardens and parks as valuable fertilizer.

Based on these design considerations the requirements for the location of the treatment plant were formulated.

In Part Three commercial offers were sought for the first three of the short listed systems and a detailed design and cost estimation was prepared for the forth system, an optimized waste water treatment plant based on the trickling filter technology.

Summary

In this current Part Four of the study, the designs developed in Part Three are evaluated against each other.
It could be shown that for this particular project the waste water treatment system based on trickling filter technology bears significant advantages over the other systems:

Cost	It requires the lowest initial capital investment. It is significantly cheaper in any of the expansion phases than the other systems
Simplicity of technology	The required materials and workmanship are locally available
Variation in flow	The system can manage large inflow variation
Operation and maintenance	The system operation and maintenance is easy and straight forward
Expansion	The system expansion can be managed flexibly to accommodate increasing population and changing requirements, while the other systems can only be expanded by duplication
Emergency operations	In the event of a major fault, like a disruption in the flow path within the plant, or a lasting power outage, the system offers alternative treatment routes so that it can continue to perform with very little additional input
Sludge management	the system offers fully integrated, hygienic sludge processing were the operating staff has no contact with the raw sludge.
Power	power consumption is low and, power outages can be easily bridged with a UPS or small generator
Interim solution	By February 2016 a number of new residential projects in the study area have almost been completed. They do not have access to waste water treatment. The proposed system is well suited to be built in stages so that an interim solution for waste water treatment can be provided in a very short time. The interim treatment plant would consist of pre-treatment followed by ground filtration and shallow percolation and would be fully integrated into the final design. This system

could be operational within a much shorter period than it would take to built a complete three-stage treatment plant.

Parameters were formulated for the **location of the treatment plan**t.

The chief criteria to select a suitable location for the plant are:
- elevation (gravity flow in the sewer pipe can be maintained)
- access during construction and later-on for the delivery of sludge by truck
- passage for the sewer pipe and the return pipe for irrigation water and electrical line
- closeness to exit point of the main sewer (Vikas Radial)
- sufficient large plot size to accommodate the treatment plant and the extension phases
- sufficient distance from existing residences to minimize impact
- the land should preferably already be owned by Auroville

Based on this the general area for the treatment plant was placed on the border of the Residential Zone II, to the Green Belt.
Out of various possibilities two particular options(2) for the location were identified. The first option is a plot bordering onto Sangha Community. While this plot would be ideally suited, it needs to be purchased.
An other possible location is a plot a bit further to the east.. This land belongs to Auroville but is not directly connected, hence passage rights need to be negotiated. The trunk sewer distance and return pipe are about 80 m longer.

Footnote (2): Since it has not been possible to acquire either of the relevant plots, an alternative location has been identified. Details are given in the annexure

A gravity flow sewage collection system was designed. A sewer gradient of 0.5% should be provided to maintain a minimum velocity of 0.4 m/s at ¼ filling. The pipe should run at a depth of 1.2 – 2.5 m below ground. The trunk sewer is dimensioned 400 mm dia, so that it can accommodate the final expansion phase of the system. Branch sewer diameter is 220 mm. A variety of different pipe and manhole materials were compared. HDPE was found to be the best choice for trunk and branch sewer. The manholes are to be executed in pre-cast concrete elements.
In the first phase it is proposed to implement a trunk sewer along the Vikas Radial and connect the projects Arati and Metreye etc via branch sewers. This takes into account the priority of residences that need to be connected most urgently.
Once the treatment plant is operational to it's full extend, connections can be offered to the other communities as well. The trunk sewer is equipped with level-ground manholes at the end points and midpoint of the Radial. At each junction with a branch sewer, a provision for access is provided at entry level (buried access).

The return pipe system for the recycled water was designed. A low-pressure system is proposed with an end-of-line pressure of 0.5 bar. The pipes should be laid alongside the sewage lines. Pipes and taps should receive distinct markings so that they can not be mistaken for drinking water supply lines.

Clear and consequent marking of the pipe and valves for the return water is imperative to prevent accidental mix-up with drinking water supply. (see Parts 2, page 50)

A **leach field** was designed at the treatment plant site. Through this field the water can be percolated into the ground during times of low demand for irrigation water (monsoon time).

Chapter 1

Qualifiers for evaluation

During finalization of Part 2 a set of criteria had been defined which would help to evaluate the proposals and different technologies. This list was circulated to the manufacturers along with the request for proposals.
The evaluation criteria were divided into four categories, design, operation, cost and management. A fifth heading was provided addressing additional benefits that a design might offer.

Design

As a foremost qualifier, the plant should meet the required treatment standards in regard to quantity and quality as defined in Part 2.

This should be supported either in an existing demonstration plant, or by control calculations of plant size, retention time and other process parameters from renown sources of international literature.
The plant should be expandable (1000 - 3000 – 5000 PE)
The plant should be able to handle large variations in inflow (initially much less quantity than design)
The sludge processing at site should be adequate for safe disposal or use (as compost).
The plant should be able to handle additional sludge from outlying communities.
Treated waste water is free from odour and discoloration and can be stored for 24 h

Operations

This includes all parameters which are to considered for the smooth running of the plant. Foremost the required level of education/training needed for staff is to be considered and to what extend a regular maintenance schedule is to be followed.

The manufacturer should provide a prediction analysis of possible faults and prescribe emergency operations.
Environmental concerns such as noise, smell, mosquitoes and visual impact should be addressed. How these effect the operating staff and the residents in the immediate surroundings. Some of these effects may not be of much concern during normal operations, but may be aggravated during certain maintenance tasks. For example the nuisance of odours during removal of sludge.

The level of technology has to be assessed keeping in mind that Auroville is still a rural area, with limited availability of skilled labour and spare parts.
The run-in time is a period during which the bacteria responsible for the treatment processes build up. This time will vary with the choice of technology. An aerobe system usually requires a much shorter run-in time than an anaerobe system. During run-in time the plant functions at a reduced level, with usually higher environmental impact. The effluent will not be usable for irrigation during this time. After a major break down of the plant a fresh run-in time is required.

Repairs

In case of a break down are there should be provisions to by-pass faulty system components so that the plant can operate at reduced level. The level of technology plays an important role in can execute these repairs and how difficult it is to get the required spare parts.

Cost

The cost of the plant should be seen at different levels:

Initial capital cost
Additional cost in expansion phases
Plant design life
Operational/running cost/year
Energy consumption kwh/m3
Space requirement

Recycled waste water

Auroville lies in a semi arid region. The primary source of drinking water is groundwater. During the dry summer month more than half of the water pumped from the community wells is used for irrigation. Hence the re-cycling of waste water for gardening purposes was set as a priority. Any design to be considered under this study should meet the prescribed requirements and provide an effluent quality acceptable and suitable for irrigation.
The system should provide 24 hour storage for treated waste water and for the rainy seasons and alternative means of disposal.

Additional benefits

Additional benefits of each design should be considered in the choice of the system.

These can be for example:

The plant offers intermediate treatment solution.

Utilization of sludge for farming

Utilization of biogas

Remote monitoring

Local supplier

And others

Chapter 2 – Common features of the proposals

Overview of the proposals and technologies

The table below shows the different designs that were received under part 3 of this study.

	Company offering the system	**System process overview**
System "A"	**Sharpenn Industries**	Screen – grease separation – flocculation – activated sludge treatment – sand filter - activated carbon filter
System "B"	**Akar Impex PvtLtd**	Screen – grease separation – activated sludge process with bio media – settling in lamella settler - chlorination - sand filter - activated carbon filter
System "C"	**Centre For Scientific Research (CSR)**	Screen – grease separation – primary settler – anaerobe baffle reactor –aeration – activated carbon filter
System "D"	**Indus Ecowater**	Screen – grease separation – preliminary settler – activated sludge process with bio media – settling in lamella settler - chlorination - sand filter - activated carbon filter
System "E"	**System designed under this study**	Screen– two preliminary settler cum digester– trickling filter- secondary settler - polishing pond

Detailed write up and drawings of each proposals are given in Pat 3. In order to simplify referring to the offers, in the following they are referred to with the abbreviation "A" through to "E"

Comparison and evaluation of common system components

Some features of the treatment methods which are here under evaluation are quite similar, other vary significantly from each other. In the following a step by step comparison of different technologies at each treatment stage is given, starting from the point were the waste water enters the plant up to the exit point.

Screening

Screening of the inflow is a component offered in all the system. This process removes flotsam in the sewage such as toilet paper, sanitary napkins, diapers etc. These objects could otherwise cause blockage in the system. For reasons of hygiene the removal of the raking goods should preferably be automatic – this has not been provided for in any of the offers.

Oil/Grease trap

Grease trap is common to all systems. Grease and fats have to be skimmed off manually from time to time.

Flow equalization

A flow equalization chamber is provided in all systems. The purpose is to even-out the peak daily flow and provide constant flow through the plant. Some settling will occur in the equalization chamber. The sludge has to be removed or it will undergo anaerobe processes (odor). In system "A" an aeration system is provided to prevent settling.

It is preferable to use the primary settler as equalization chamber and size it sufficient large so that even at peak flow the retention time is sufficient long to provide desired purification.
Further flow equalization, if required, can be provided in a second tank after the primary settler. At this point no, or only marginal settling can be expected.

Flocculation

System "A" offers flocculation before the primary settler. This is achieved by adding aluminum salts. This facilitates increased removal of pollutants and the following stage can be built out smaller.
The cost of Aluminum salt (Aluminum Chloride) has to be added to the running expenses.
A drawback is that aluminum salt limits the usability of the sludge as compost and would possibly reach the ground water. Hence it is suggested to eliminate the flocculation stage.

Settler

All systems offer a simple primary settler with a conic floor. The sludge accumulates in the cone and is pumped from the lowest point. This has to be done at regular intervals because the sludge draws on the oxygen reserve of the water and if the sludge is not removed the system will turn septic.
In case of fault in the sludge pump or in the power supply the system operation would be immediately disrupted and undesirable amounts of sludge would accumulate.

Hence it is proposed to use a system that is less prone to faults. This is a two storied settler cum digester. In this system the sludge digester is located directly under the settler. The settleables sink through slots in the floor of the settler into the digester. The floor of the settler is formed in the shape of conic baffles. When gas or sludge particles rise again, they are deflected sideways and prevented to re-enter the settler. The sludge remains in the digester chamber until it is fully stabilized (30 days). It is then moved (by hydraulic pressure) onto the dewatering and drying beds. At this point the sludge is uniform in consistency and neutral in smell. This system is completely independent of pumps and power supply.
While the settler is in operation, fresh sludge is continuously added to the digester lying below.
Once the digester is full, the waste water flow through the above lying settler should be switched off. Then the entire volume of sludge should be digested for further 30 days before it is moved onto the dewatering bed. Hence it is indicated that two settler/digester should be operated in sequence.
The digesters should be sized sufficiently large so that they can also accommodate the sludge from outlying communities. The sludge brought to site by a sludge tanker can simply be emptied into the digester. A dosing tank regulates the sludge inflow and prevents shock load in the plant.

Secondary treatment

A feed-pump draws water from the primary treatment (settler) stage into the next tank for secondary treatment.

System “C” offers an anaerobe baffle reactor followed by anaerobe filter chambers. If the system is sized to provide a retention time of 18-20 hours it can achieve BOD/COD reduction 50-60% (RWWM Part 2 page 23). Advantage of the system is that it can be built in a manner that it functions entirely on gravity flow and then does not require any pumps to maintain operation.
The tanks have to be rather large and by the nature of the treatment process the outflow is entirely deprived of oxygen and oxygen-loving bacteria. This can cause problems further downstream of the process, such as eutrophication in the polishing pond.

System “A”, offers activated sludge treatment (SWWM Part 2, page 20) . In this treatment method the incoming waste water is agitated and air is blown into the water. This enhances rapid bacteria growth. In the following chamber the water is allowed rest and the bacteria sludge settles. Part of this sludge is re-circulated as “feed bacteria” into the previous chamber, the other part of the sludge is pumped off and moved towards sludge processing.
This process is the most widely used technical in waste water treatment plants of medium to large scale. Re-circulation of sludge and air blower rates can be adjusted to match the water inflow and level of pollution, this allows to optimize the operation parameters.

This method offers good purification rate and end-result (80-90 % BOD and COD removal can be achieved).

System “B” and “D” offer Moving Bed Biofilm Reactor (MBBR) systems (SWWM part 2 page 22). This is a combination of the activated sludge treatment with attached film process. Small plastic capsules (bio media) are added to the waste water in the tank. After some time a bio-film develops on the capsules.
The advantage of the MBBR towards the activated sludge process is that the sludge is retained in the reaction chamber along with the bio media by means of a screen. This simplifies the process because recirculation of sludge is not necessary.
This of course also implies that the system lacks the control possibility of adjusting the re-circulation of sludge and thus respond to changes in inflow loading rates, which is important to maintain good plant performance/efficiency. (SWWM part 2 page 21)

Both system types depend on constant aeration to provide oxygen for the bacterial process.
A blower is required to operate continuously and agitate the waste water, sludge and as the case may be the bio-media mix. At the given quantity of waste water a blower with a rating of 4-5 kW would be required to ensure sufficient oxygen supply.
In the case that the blower operation is interrupted due to a fault / power-cut, the purification process is discontinued. If the fault duration is less than 30-60 ‘ the operation can be resumed normally once the system is restored.
However during such faults the aerobe bacteria are deprived of oxygen and during longer power outages they start dying off and the sludge turns septic. In the case the operation is resumed after a long-lasting fault the plant would be functioning with limited performance until new bacteria have grown (new run-in) this can last several days/weeks.

Hence it is proposed to use a low rate trickling filter as secondary treatment stage.
The trickling filter operates with attached growth process. A surface tank is filled with growth media (slack or granite stone) and the waste water is sprinkled over the media. After some time the media is covered with a bacteria slime layer. Openings at the bottom of the tank allow air-circulation through the media. The water is collected at the bottom of the tank and channeled into a clarifier.

This system offers the same high purification rate as the activated sludge process, but does not require the powerful air blower. Air circulation is maintained by natural convection. A much smaller pump is used to sprinkle the water over the filter media. The system is very flexible to adjust to changing load rate, very robust and easily maintained. Tens of thousands of these systems are successfully operating the world over.

The drawback is that the trickling filter requires about double the tank volume of the activated sludge process. This is compensated to an extend due to the more favorable diameter to height ratio.
The power consumption is about 1/3-1/4 compared to the activated sludge process.

Post processing

After secondary treatment the System “C” offers a vortex stage. This is a cylindrical tank in which the treated water is subjected to a strong circulating flow (by pump). This serves as aeration of the water and is indicated after the anaerobe treatment.
The vortex systems are energy-intense. 2/3 of the entire power consumption of the system can be attributed to this pumps. In this manner the major advantage of the anaerobe system, being low in power consumption, is lost.

System “A”.“B” and “D” offer pressure sand filtration to reduce dissolved solids and remove bacteria.
This is followed by disinfection through chlorination (“B” and “D”) or UV treatment (system “A”).

The chief concern at this point is to achieve a reduction of pathogens in the treated water, to a level that it is safe for irrigation.

Chlorination and UV treatment, while useful to reduce bacteria and viruses have very little effect on Helminthes eggs. In addition the chlorination might cause undesirable chlorine residue for irrigation water.
The Sand filtration achieves a reduction of Helminthes eggs by log 1-3. A polishing pond achieves a similar reduction in Helminths eggs and protozoa (ascaris, giardia, amoeba) and provides good reduction of bacteria and viruses. Hence a polishing pond as tertiary stage is a good solution.

Provisions can be made to install an additional sand filtration. Once the plant has been run-in it can be decided if this additional stage is needed.

Space requirement

For comparison of space requirements of the different treatment plant options the space occupied by structures (tanks, basins, buildings) was taken as per blueprint provided in the design. In some cases it was required correct this by a linear scaling factor to achieve that all designs offer a unified capacity (flow rate).
The storage volume of the tanks was when necessary corrected to match international recognized parameters for retention time
Space requirement was estimated for different build-out phases as well as during the construction period and for maintenance requirements.

Minimum required distances where added around buildings and tanks:
1 meter safety distance towards each structure.
4 meter carriage way width around and between structures.

Operation:

Power requirements:

Various pumps and blowers are operated.

This covers only the treatment process. Additional power for re-circulation of waste water and site maintenance has to be considered.

The operation of all the proposed systems depends on a reliable power supply (back-up).

Requirements, operators input:

Supervision and monitoring of the entire process.

Manual operation

Removal of raking goods,
Skimming off the grease,

Transfer of sludge into drying bags.

Sludge transfer to further processing place,.

Staff: Operation of any of the systems in the final build out stage would require 1-2 staff, during a single day shift and one night watchman.

Maintenance: Since the life expectancy of pumps, blowers and dosing equipment in this environment is not more then 2-3 years, the turnover in these items has to be taken into account

Sludge management:

Unfortunately none of the commercial proposals "A,B,C and D" fulfilled the design requirements. In all four designs the sludge management was incomplete and non of the designs provide a means to accommodate sludge form outlying communities.

The proposal "E" prepared under this study offers both options. It proposes to use two two-storied settler/digester alternating, so that each settler can undergo a resting period during which the sludge is fully digested. This is accompanied by sludge de-watering. The sludge liquor is directed back into the operating primary settler. The sludge chamber of the "resting" settler can then be emptied and the sludge dried. The sludge is then composted.

Emergency Operations

There is very little scope for emergencies operation in the systems "A"-"D" in the case of major system failure. Power outages have to be bridged by diesel generator or similar means .
In the case that the treatment process is interrupted due to any fault, the only viable option to ensure continuous flow of sewage is to create a retention tank that will receive the waste water during the time it takes to restore normal operation.
Once the plant operation can be resumed, the accumulated waste water is pumped into the system and undergoes the usual purification process.
Hence duplication of major system components such as pumps, blowers, pipes etc is recommended so that in case of a fault the second unit can be activated in a short time span.

In comparison, the system "E" with two settler operated in sequence offers a considerable advantage, because in the case of a failure in one settler one can resort to the second settler.
In this manner pre-treatment can be kept operational even in the case of a system failure. Once the water has undergone pretreatment the water can, for a limited time as emergency solution, be percolated into the ground.

Expansion of system into Phase II and Phase III

Capacity expansion of the systems "A"-"D" for phase 2 and phase 3 is only possible by duplicating the treatment stages. This however leads to reduced efficiency in terms of power consumption and manpower for operation. An other option is to rebuilt the system components in a larger scale. Either method is not very efficient.

The proposed design "E" with two settlers and the trickling filter offers a number of possibilities for dynamic expansion. For example the two settlers that are operated during phase 1 in sequence can in the third phase be operated in parallel.
The low rate trickling filter is very flexible in loading rates and can accommodate increased waste water quantities.

Chapter 3– Assessment of each proposal (validation)

Evaluation of System "A" Sharpenn Industries

System process overview
Screen – grease separation – flocculation – activated sludge treatment – sand filter - activated carbon filter

Details of Company offering the system

Sharpenn Industries

The company is company based in Mumbai,

Besides their business in waste water treatment plants, they offer a variety of filters, centrifuges and dryers and other oil/chemical machinery.

Proposal

Quality of proposal: Their offer was presented in a comprehensive format, included are process schematics, layout and section drawings of the system.

Scope: Their offer is restricted to machinery and plant control components. The construction of basin's and tanks is left to the customer and would need to be sub-contracted.

Training: Their offer includes training of our staff in operating the plant.

Repair and Maintenance
Maintenance and replacement of parts would be organized through their Mumbai office.

Deliver time 3 month (excluded are civil works)

Guarantee 15 month

Compliance to the brief. The system is designed as per our brief

The system process steps

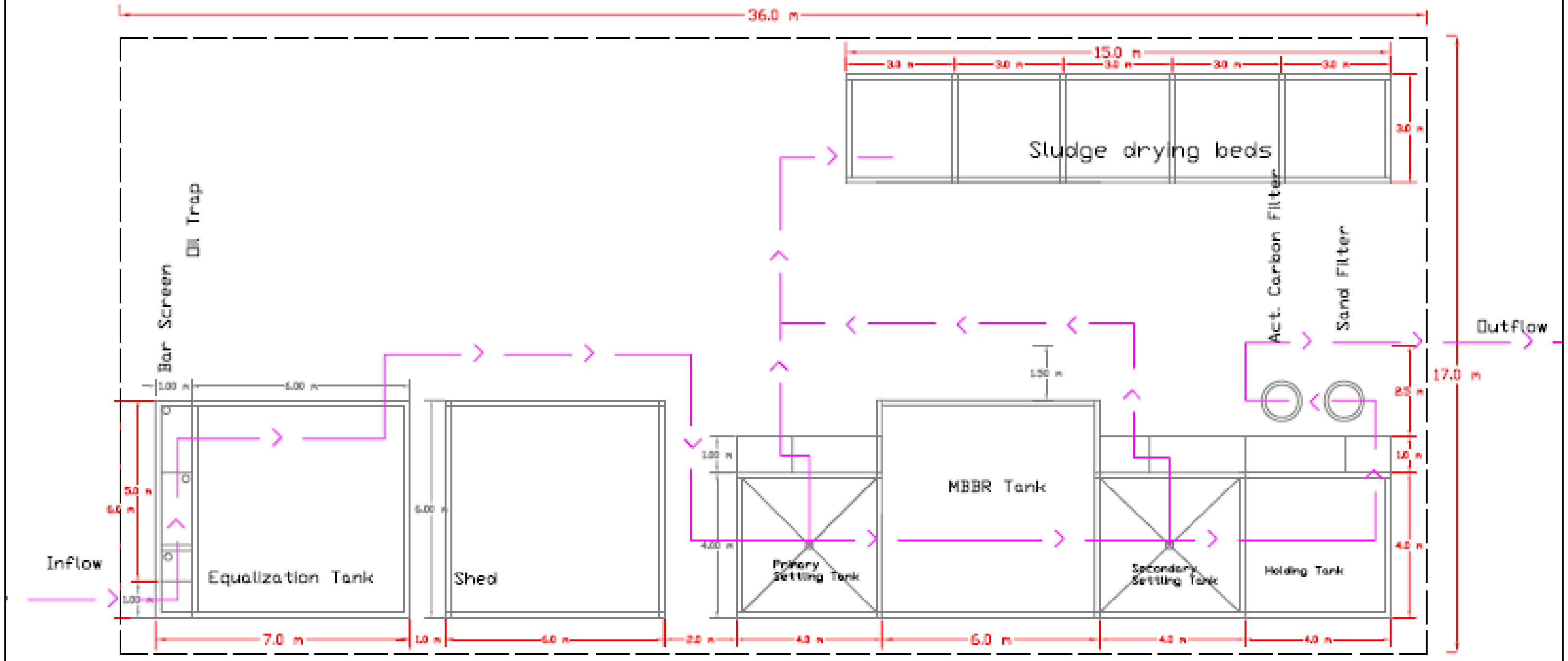
Screening
Oil/grease trap
Flow equalization with aeration to prevent settling
Coagulation and flocculation PAC solution and Poly electrolyte solution
Settler - Sludge removal - Digester - Drying beds
Activated sludge process
Secondary settler / clarifier - Sludge removal; part of the sludge is re-circulated
Pressure sand filtration
Active carbon filtration
Disinfection through UV

Operation:

Consumables: Flocculation:

Poly Aluminum Chloride	0.2 kg/cu.mt.
Poly electrolyte	0.05 kg/cu.mt.
Lime	0.2 kg/cu.mts

Carbon filter needs to be replaced periodically



Aerobe treatment Plant for Domestic Waste Water "Sharpen Industries"

Dimensioned for 1000 PE
175 k liter per day

—› —› — Flow path through plant

Scale NS , 14th December 2013

Activated sludge system

Space requirement 612 m2

Sludge is dried and can be composted

No provision to handel sludge from outlying comunities

Power requirements:

Various pumps and blowers are operated intermittently the power usage is given with 1.50 KWH/m3. This corresponds to about 262 kWh per day at full capacity. This covers only the treatment process. Additional power for re-circulation of waste water and site maintenance has to be considered.

The operation of the plant depends on a reliable power supply (back-up).

Requirements operators input:

Supervision and monitoring of the entire process.

Manual

- Removal of raking goods,
- Skimming off the grease,

- adjustment
  - flocculation dosing
  - air-blower rate.

Start stop

- operation of sludge pumps
  - re-circulation of sludge
  - transfer into digester.

- Sludge transfer from digester to drying place,

- Composting process.

Back washing

- Sand filter

Maintenance: Since the life expectancy of pumps, blowers and dosing equipment in this environment is not more then 2-3 years, the turnover in these items has to be taken into account

Staff: Operation would require continuous presence of 2 staff, in a single day shifts and one night watchman.

Sludge management:

The system offers a sludge digester that is capable of digesting the sludge of 1000 PE for 30 days, after this period the sludge would be dried and composted.

Emergency Operations There is very little scope for emergencies operation incase of major system failure. Power outage are bridged by diesel generator.

In the case that the treatment process is interrupted due to any fault, the only viable option to ensure continuous flow of sewage is to create a retention tank that will receive the waste water during the time it takes to restore normal operation.

Once the plant operation can be resumed, the accumulated waste water is pumped into the system and undergoes the usual purification process.

Hence duplication of major system components such as pumps, blowers, pipes etc is recommended so that in case of a fault the second unit can be activated in a short time span.

Suitable fault alarms, with remote notification should be installed.

Expansion of system into Phase II and Phase III

The system can not be up-graded, hence once the capacity of the plant is reached a duplication is required of most system components.

General evaluation:

Level of technology: high

Level of automation: medium

Assessment if the treatment method and sizing of the plant is capable to achieve desired treatment result (effluent parameters)

Reaction chamber

	Length (m)	width (m)	height (m)	freeboard (m)
Reaction chamber size prefab	6	6	2.5	0

PE	1000					
Volume of the reactor chamber is		V=	216	m3		
Basin loading			4.6	PE/m3	<	25PE/m3
					reference: [1] page 180	

Basin is well sized

BSB Load after flocculation

Volume	175	l
BSB5	229	mg/l
or	40	gr/PE/d

Oxygen/Air demand

		reference: [1] page 221
1	kg BSB load	requires 2.5 kG O2

As per offer: blower has "oxygenation capacity" of	1.2	kg O2 per hour
This is sufficient for	0.48	kg BSB per hour
mean BSB at 1000 PE	1.67	kg BSB per hour

Blower is sized too small

Settler:

			Length (m)	width (m)	height (m)		
			4	4	2		
Size	32	m3					
Retention time					t=	4.4	hours

is sufficient

Disinfection

Treatment goal	Probable achievement
E. coli < 103 count/100 ml *	Flocculation, no influence AST 1-2 log UV treatment 2-4 log sand filtration 1-3 log Combined effect ~ log 5 reduction
Helminthes eggs < 1 per liter. *	Flocculation, no influence AST 1-2 log UV treatment, no influence sand filtration 1-3 log Combined effect ~ log 3 reduction
BOD5 < 25 mg/l	Yes
COD < 125	Yes
TSS < 35.0 mg/l	Yes
Turbidity < 2 NTU	Yes

taken from [2]

The sum of the processes should provide adequate level of disinfection, so that the recycled waste water can be used for watering of gardens

Advantages of the chosen technology:

Low space requirement, good treatment result

Drawbacks / Disadvantages:

The process has a high power consumption.

Due to rather high level of complexity and mechanization, there are increased number of possibilities of malfunctioning.

In the case of a major fault occurring, there is little scope for emergency operation to keep up the flow of waste water in the sewer pipe.

The system can not be expanded. Once the plant capacity of the first phase (1000 PE) has been reached, the entire plant has to be duplicated.

Short comings:

Sludge volume in the digester as offered is only sufficient for digestion of 30 days. Since the drying of the sludge has to be suspended during the monsoon time, sludge container has to be larger.

Fresh sludge is being added into the digester on a daily basis. With one single unit the proper digestion of the most recently added sludge is not achieved. In order to digest the entire sludge volume for 30 days it would require two digester to be operated in sequence.

No provisions in the plant to accommodate sludge from outlying communities.

Environmental concerns:

The additions of Al-Cl flocculants may not be desirable as this restricts the usage of the digested sludge as compost for agricultures. Aluminum salts in drinking water can also be a health concern. (WHO/SDE/WSH/03.04/53)

Proposed Modifications:

Provision for site development, store room cum office and back-up power supply have to be added.

Substitution of the primary stage (flocculation) with conventional settler or settler /digester is suggested. This would eliminate the need of flocculants and improve the reduction in helminthes eggs.

One additional digester unit for sludge management is indicated if the plant is operated autonomously.

Two digester units have to be added to accommodate the sludge generated within the plant if the plant is to accommodate the sludge from outlying communities.

A retention tank for emergency operations, that will receive the waste water during the time it takes to restore normal operation should be added.

Evaluation of System "B" Akar Impex PvtLtd

System process overview
Screen – grease separation – activated sludge process with bio media – settling in lamella settler - chlorination - sand filter - activated carbon filter

Details of Company offering the system

Akar Impex PvtLtd

The company is company based in Mumbai,

They offer a wide range of waste water treatment plants in all sizes and using different treatment methods.
.

Proposal

Quality of proposal: Their offer was presented in a comprehensive format, included are process schematics, layout and section drawings of the system.

Scope: Their offer is restricted to machinery and plant control components. The construction of basin's and tanks is left to the customer and would need to be sub-contracted.

Training: Their offer includes training of our staff in operating the plant.

Repair and Maintenance
Maintenance and replacement of parts would be organized through their Mumbai office.

Deliver time 3 month (excluded are civil works)

Guarantee 15 month

Compliance to the brief. The system is designed for a daily flow of 150 m3 the brief specified 175 m3. The system needs to be up scaled accordingly.

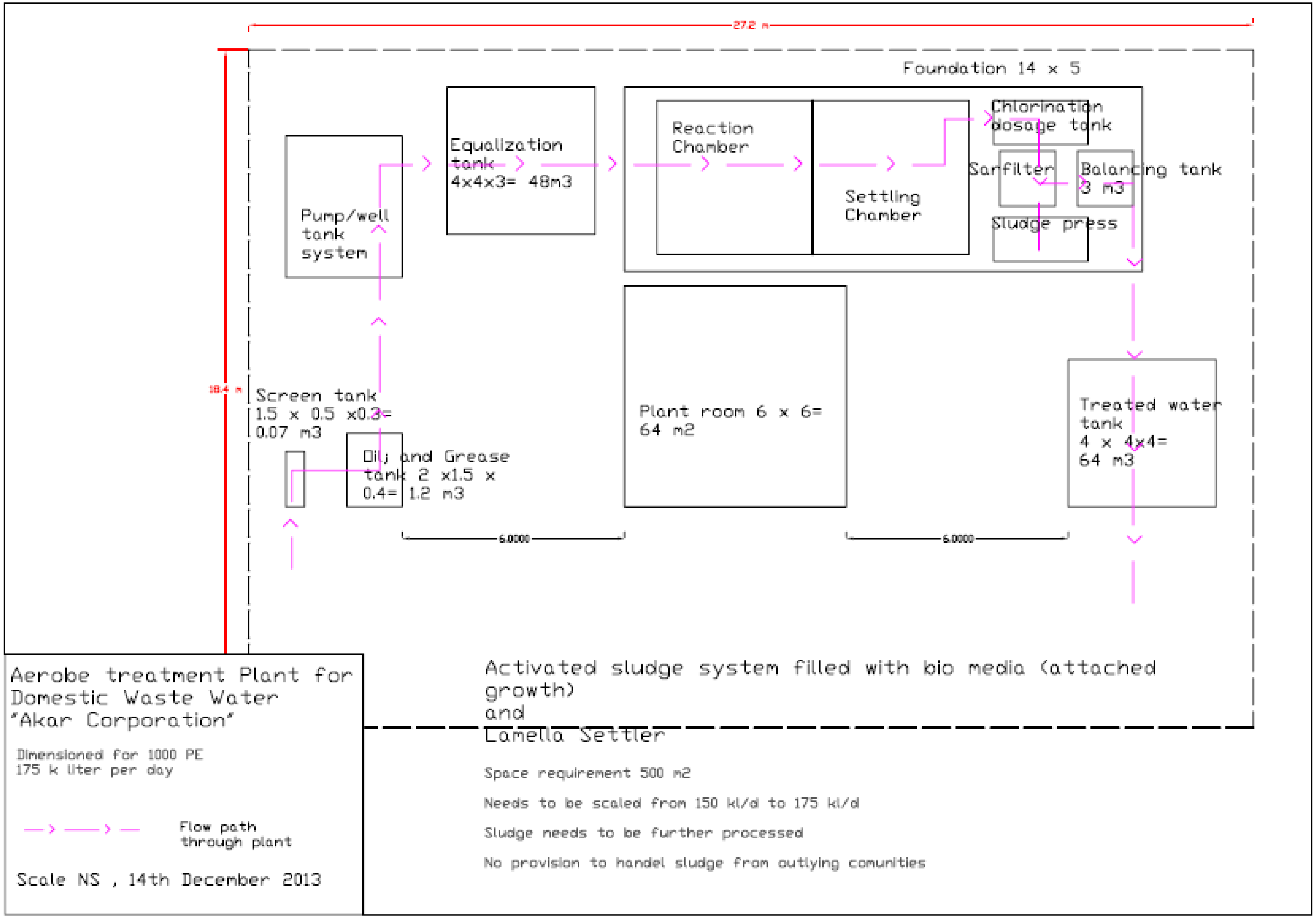
The system process steps

Screening
Oil/grease trap
Flow equalization with level activated pump – air blower
Activate sludge process with bio carrier.
Secondary settler with lamella tubes - Sludge removal
Chlorination
Pressure sand filtration Removes TDS
Active carbon filtration to remove *organics* odors, chlorine, fluorine or radon
Disinfection through UV

Operation:

Consumables:

Carbon filter needs to be replaced periodically


27.2 m
18.4 m
Foundation 14 x 5
Pump/well tank system
Equalization tank 4x4x3= 48m3
Reaction Chamber
Settling Chamber
Chlorination dosage tank
Sarfilter
Balancing tank 3 m3
Sludge press
Screen tank 1.5 x 0.5 x0.2= 0.07 m3
Oil and Grease tank 2 x1.5 x 0.4= 1.2 m3
Plant room 6 x 6= 64 m2
Treated water tank 4 x 4x4= 64 m3
6.0000
6.0000
Aerobe treatment Plant for Domestic Waste Water "Akar Corporation"
Dimensioned for 1000 PE
175 k liter per day
Flow path through plant
Scale NS , 14th December 2013
Activated sludge system filled with bio media (attached growth)
and
Lamella Settler
Space requirement 500 m2
Needs to be scaled from 150 kl/d to 175 kl/d
Sludge needs to be further processed
No provision to handel sludge from outlying comunities

Power requirements:

Various pumps and blowers are operated intermittently the power usage is not given. Continuously operated are the blower rated at 3.7 kW, the sewage centrifugal pump at the balancing tank is rated at 2.2 kW and can be assumed at 50% operation time. The (sand and carbon) filter feed pump is rated at 2.2 kW and operating continuously. The sludge pump rated at 2.2 kW and is assumed to operate 5 minutes every hour. The crating of the hydraulic filter press is not given, but is assumed at 2.2 kW and operating 10 minutes every hour.. Total power requirement is estimated at with 1.50 KWH/m3. This corresponds to about 180 kWh per day. This covers only the treatment process. Additional power for re-circulation of waste water and site maintenance has to be considered.

The operation of the plant depends on a reliable power supply (back-up).

Requirements operators input:

Supervision and monitoring of the entire process.

Manual

Removal of raking goods,
Skimming off the grease,

adjustment

air-blower rate.

Start stop

operation of sludge pumps

transfer into press.

Sludge transfer from press to further processing place,.

Back washing

Sand filter

Maintenance: Since the life expectancy of pumps, blowers and dosing equipment in this environment is not more then 2-3 years, the turnover in these items has to be taken into account

Staff: Operation would require continuous presence of 2 staff, in a single day shifts and one night watchman.

Sludge management:

The system offers a sludge digester that is capable of digesting the sludge of 1000 PE for 30 days, after this period the sludge would be dried and composted.

Emergency Operations There is very little scope for emergencies operation incase of major system failure. Power outage are bridged by diesel generator.
In the case that the treatment process is interrupted due to any fault, the only viable option to ensure continuous flow of sewage is to create a retention tank that will receive the waste water during the time it takes to restore normal operation.

Once the plant operation can be resumed, the accumulated waste water is pumped into the system and undergoes the usual purification process.

Hence duplication of major system components such as pumps, blowers, pipes etc is recommended so that in case of a fault the second unit can be activated in a short time span.

Suitable fault alarms, with remote notification should be installed.

Expansion of system into Phase II and Phase III

The system can not be up-graded, hence once the capacity of the plant is reached a duplication is required of most system components.

General evaluation:

Level of technology: high

Level of automation: medium

Assessment if the treatment method and sizing of the plant, whether it is capable to achieve desired treatment result (effluent parameters)

Verification of sizes and capacities

	Length	width	height	freeboard
Reaction and settler chamber	(m)	(m)	(m)	(m)
prefab	8	2.4	2.6	0.2

assume activated sludge compartment and settling compartment at each half volume

Volume reactor	23.04	m3
Volume settler	23.04	m

Reaction chamber reference: [1] page 180

Load (from brief)

BSB5	300	mg/l
or	60	gr/PE/d
PE	1000	

Loading of basin

43.4	PE/m3	>>	25 PE/m3	*Basin is undersized*

Required	**Basin size:**					
	Permissible load:				reference: [1] page 223	
	without nitrification	1000	gr/m3/d			
	with	500				
	OxygenAir demand					
	Air blower	type of diffuser Fine	Air requirements m3/kg BSB5 60-100			
	required air					
	80	m3/kg BSB5				
	60	kg BSB5/d		required blower capacity:		
	4800	m3/d	efficiency 80%	6000	m3/d	
	Proposed blower capacity					
	100	m3/h				
	24	H				
	2400	m3/d	*<u>Blower is under dimensioned</u>*			

Settler:

Retention time	at Vmax	6.25	m3/h	t=	3.7	hours

is sufficient

Disinfection

Treatment goal	Probable achievement
E. coli < 103 count/100 ml *	AST 1-2 log chlorination 2-6 log sand filtration 0-3 log Combined effect ~ log 5 reduction
Helminthes eggs < 1 per liter. *	AST 1-2 log chlorination 0.5 log sand filtration 1-3 log Combined effect ~ log 3 reduction
BOD5 < 25 mg/l	Yes
COD < 125	Yes
TSS < 35.0 mg/l	Yes
Turbidity < 2 NTU	Yes

taken from [2]

The sum of the processes should provide adequate level of disinfection, so that the recycled waste water can be used for watering of gardens

Advantages of the chosen technology:

Low space requirement, good treatment result

Drawbacks / Disadvantages:

The process has a high power consumption.

Due to rather high level of complexity and mechanization, there are increased number of possibilities of malfunctioning.

In the case of a major fault occurring, there is little scope for emergency operation to keep up the flow of waste water in the sewer pipe.

The system can not be expanded. Once the plant capacity of the first phase (1000 PE) has been reached, the entire plant has to be duplicated.

Short comings:

Raw sludge has to be pumped into filter press and handled manually. Concerns of hygiene have to be addressed.

Disinfection through chlorination is efficient against viruses and bacteria, but has only limited effect against protozoa ad helminthes eggs. (WHO - World Health Organization (2006): Guidelines for the safe use of wastewater, excreta and grey water, Volume 2: Wastewater use in agriculture, World Health Organization, Geneva, 2006, ISBN: 92-4-154683-2)

Press-filtering of sludge in raw state reduces the volume but has little other advantage the sludge has to undergo full treatment.

No provisions in the plant to accommodate sludge from outlying communities.
.

Environmental concerns:

-

Proposed Modifications:

Provision for site development, store room cum office and back-up power supply have to be added.

Two digester units have to be added to accommodate the sludge generated within the plant and for the sludge from outlying communities.

A retention tank for emergency operations, that will receive the waste water during the time it takes to restore normal operation should be added.

Evaluation of System "C" from CSR

System process overview
Screen – grease separation – primary settler – anaerobe baffle reactor –aeration – activated carbon filter

Details of Company offering the system

Centre For Scientific Research (CSR)

The company is based in Auroville,

Besides their business in waste water treatment plants, they offer a variety of ferro cement elements such as water tanks and bio gas plants.

Proposal

Quality of proposal: Their offer was presented in a comprehensive format, included are process schematics, layout and section drawings of the system.

Scope: Their offer is on turn-key basis (includes machinery and civil work of tanks).

Training: – not mentioned

Repair and Maintenance – not mentioned

Deliver time – not mentioned

Guarantee – not mentioned

Compliance to the brief. The system is designed for 108 m3 per day. The requirement as per brief is 175 m3 per day. The system offers no sludge processing.

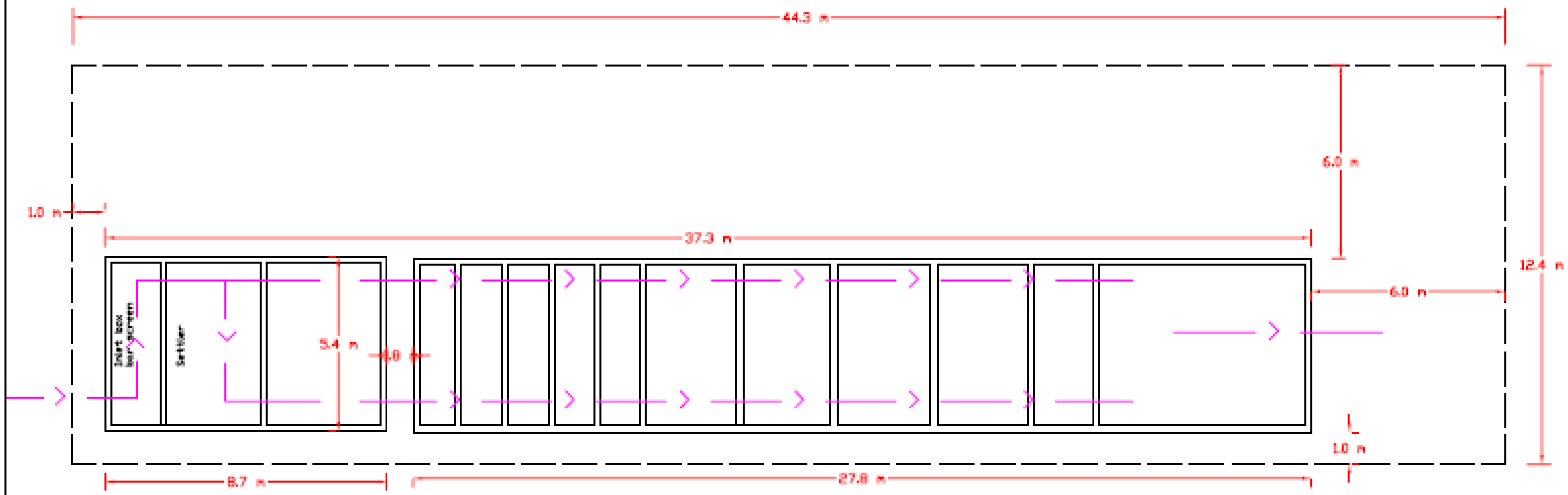
The system process steps

Screening
Oil/grease trap
Flow equalization and primary settling
Secondary settler / anaerobe baffle reactor - Sludge removal
Anaerobe filter reactor - Sludge removal
Vortex 1st and 2nd
Active carbon filtration

Operation:

Consumables:

Carbon filter needs to be replaced periodically



Anaerobe treatment Plant for Domestic Waste Water "CSR"

Dimensioned for 1000 PE
108 k liter per day

Flow path through plant

Scale NS , 14th December 2013

Series of anaerobe settlers and filters followed by airation system

Space requirement 550 m2

needs to be scaled to match 175 kl/d

Sludge needs to be further processed

No provision to handel sludge from outlying comunities

Expansion by doublicating the battery

Power requirements:

Various pumps and blowers are operated intermittently the power usage is given with 4 Hp (3.20 KW). This corresponds to about 77 kWh per day at full capacity. This covers only the treatment process. Additional power for re-circulation of waste water and site maintenance has to be considered.

The operation of the plant depends on a reliable power supply (back-up).

Requirements operators input:

Supervision and monitoring of the entire process.

Manual

Removal of raking goods,
Skimming off the grease,
Occasional cloning of vortex

Sludge management

De-sludgeing / operation of sludge pumps

transfer into digester.

Sludge transfer from digester to drying place,

Composting process.

It is essential that the system is regularly desludged

Maintenance: Since the life expectancy of pumps, blowers and dosing equipment in this environment is not more then 2-3 years, the turnover in these items has to be taken into account

Staff: Operation would require 1 operator, half time for water treatment and occasional presence of staff for de-sludgeing and processing of sludge. One night watchman.

Sludge management:

The system assumes that sludge is removed (77 m3 per year) and processed under a separate scheme.

Emergency Operations

In case of (lasting) power failure the system could continue to run with limited output if the single pump in the balancing tank (2 HP) can be kept operational. Vortex and activated carbon filter could be bypassed.
In the case of a blockage occurring in any of the tanks, it would not be possible be to maintain operation. The entire battery would have to be by-passed.
A viable option to ensure continuous flow of sewage is to create a retention tank that will receive the waste water during the time it takes to restore normal operation.
Once the plant operation can be resumed, the accumulated waste water is pumped into the system and undergoes the usual purification process.

Hence duplication of major system components such as pumps, is recommended so that in case of a fault the second unit can be activated in a short time span.

Suitable fault alarms, with remote notification should be installed.

Expansion of system into Phase II and Phase III

The system can not be up-graded, hence once the capacity of the plant is reached a duplication is required of most system components.

General evaluation:

Level of technology: low

Level of automation: medium

Assessment if the treatment method and sizing of the plant is capable to achieve desired treatment result (effluent parameters)

Primary settler sludge storage volume			reference:	CSR offer
V=	34.76	m3		layout page 22
				Typical section of settler Page 9
Sludge volume before de-watering				
l/p/day	0.3			
Pe	1000			
days	365			
V=	109.5	m3	settler is too small for annual de-sludging	

Net retention time for anaerobic baffle reactors should be 1-2 days
(reference Study WWM Part 2 page

Size of baffle rector and filter

combined length	28.7			
12 walls at 0.2m	26.3	net length		
width	5			
depth	3.3			
available net volume	86.79	m3		
max daily volume			175	m3
net ret time			11.9	h

Retention time is too short to achieve desired BOD/COD reduction

Disinfection

Treatment goal	Probable achievement
E. coli < 103 count/100 ml *	Primary settler, 1-2 log Baffle 1-2 log Filter 0.5-1.5 log Vortex no effect Combined effect ~ log 3.5 reduction
Helminthes eggs < 1 per liter. *	Primary settler, 1-2 log Baffle 1-2 log Filter 0-1 log Vortex no effect Combined effect ~ log 3.5 reduction
BOD5 < 25 mg/l	No
COD < 125	No
TSS < 35.0 mg/l	-
Turbidity < 2 NTU	-

taken from [2]

After treatment the effluent has to undergo further treatment to eliminate E.coli and helminthes so that the recycled waste water can be used for watering of gardens

Advantages of the chosen technology:

Low level of mechanization, low power demand.

Drawbacks / Disadvantages:

The treatment result is questionable for intended purpose.

The process is space intensive.

Anaerobe processes are slow and requires a long run-in period.

The system can not be expanded. Once the plant capacity of the first phase (1000 PE) has been reached, the entire plant has to be duplicated.

Short comings:

Fresh sludge is being added into the digester on a daily basis. With one single unit the proper digestion of the most recently added sludge is not achieved. In order to digest the entire sludge volume for 30 days it would require two digester to be operated in sequence.

No provisions in the plant to accommodate sludge from outlying communities.

Environmental concerns:

Due to the choice of anaerobe process there is a risk of strong odors emitting from the plant. The effluent may remain odorous and not be readily accepted by the community as substitute for irrigation water.

Proposed Modifications:

Provision for site development, store room cum office and back-up power supply have to be added.

Two digester units have to be added to accommodate the sludge generated within the plant if the plant is to accommodate the sludge from outlying communities.

The effluent needs to undergo further treatment polishing pond / slow sand filtration to reduce bacteria and helminthes (log 1-3).

Evaluation of System "D" Indus Ecowater

System process overview
Screen – grease separation – preliminary settler – activated sludge process with bio media – settling in lamella settler - chlorination - sand filter - activated carbon filter

Details of Company offering the system

Indus Ecowater
The company is company based in Hyderabad,

They offer a wide range of waste water treatment plants in all sizes and using different treatment methods.
.

Proposal

Quality of proposal: Their offer was presented in a comprehensive format, included are process schematics, layout and section drawings of the system.

Scope: Their offer is restricted to machinery and plant control components. The construction of basin's and tanks is left to the customer and would need to be sub-contracted.

Training: Their offer includes training of our staff in operating the plant.

Repair and Maintenance
Maintenance and replacement of parts would be organized through their Hyderabad office.

Deliver time 3 month (excluded are civil works)

Guarantee 15 month

Compliance to the brief. The system is designed according to the brief. However no provision of sludge treatment fo r sludge from outlying communities is given. The system needs to be expanded accordingly.

The system process steps

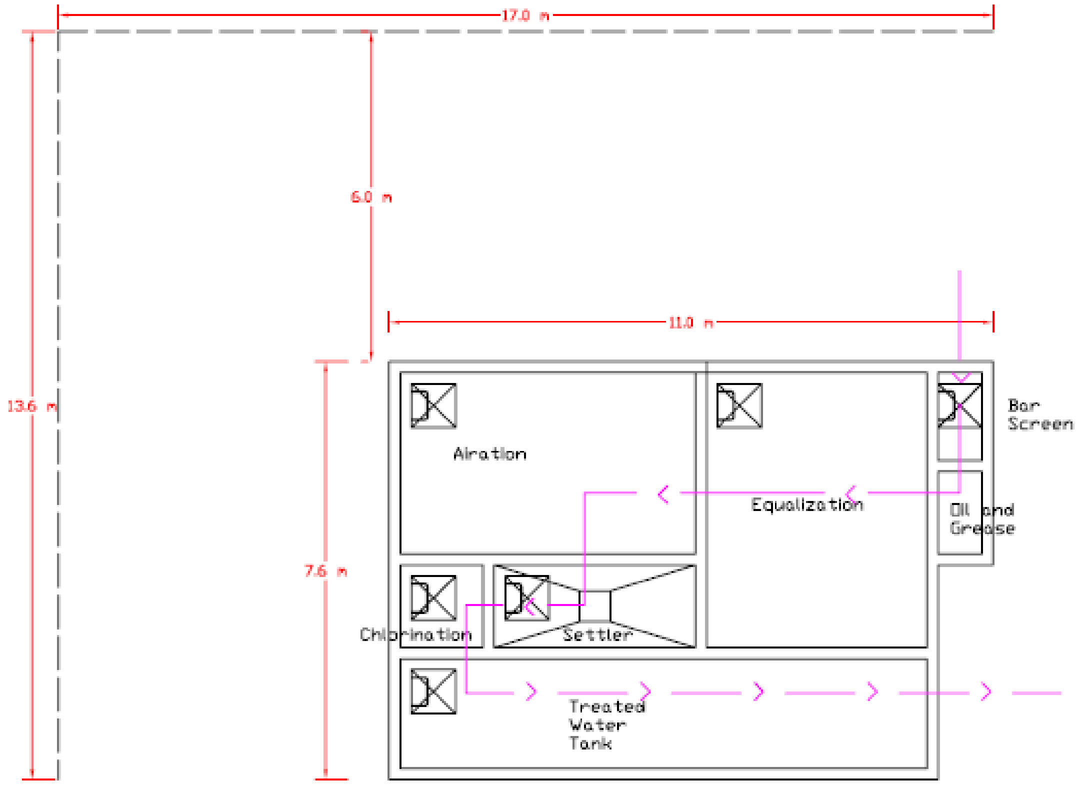
Screening
Oil/grease trap
Flow equalization with level activated pump – air blower
Activate sludge process with bio carrier.
Secondary settler plate settler - Sludge removal
Chlorination
Pressure sand filtration Removes TDS
Active carbon filtration to remove *organics* odors, chlorine, fluorine or radon
Disinfection through UV

Operation:

Consumables:

Chlorine (Sodium Hypochlorite), 5 ppm = 0.0005% ~ 175 ml chlorine per day

Carbon filter needs to be replaced periodically



Aerobe treatment Plant for
Domestic Waste Water
"Indus Ecowater"

Dimensioned for 1000 PE
175 k liter per day

Flow path
through plant

Scale NS , 14th December 2013

Activated sludge system filled with bio media (attached growth)
and
Plate Settler

Space requirement 231 m2

Sludge needs to be further processed

No provision to handel sludge from outlying comunities

Power requirements:

Various pumps and blowers are operated the mean daily power usage is given with 171 kWh/day.
This covers only the treatment process. Additional power for re-circulation of waste water and site maintenance has to be considered.

The operation of the plant depends on a reliable power supply (back-up).

Requirements operators input:

Supervision and monitoring of the entire process. However since the process is mostly automated, continuous presence of staff is not required.

Manual

Removal of raking goods,
Skimming off the grease,

transfer of sludge into drying bags.

Sludge transfer to further processing place,.

Maintenance: Since the life expectancy of pumps, blowers and dosing equipment in this environment is not more then 2-3 years, the turnover in these items has to be taken into account

Staff: Operation would require1 staff, in a single day shifts and one night watchman.

Sludge management:

The raw sludge from the settler is pumped into during bags and then moved onto drying beds.

Emergency Operations There is very little scope for emergencies operation incase of major system failure. Power outage are bridged by diesel generator.
In the case that the treatment process is interrupted due to any fault, the only viable option to ensure continuous flow of sewage is to create a retention tank that will receive the waste water during the time it takes to restore normal operation.
Once the plant operation can be resumed, the accumulated waste water is pumped into the system and undergoes the usual purification process.

Hence duplication of major system components such as pumps, blowers, pipes etc is recommended so that in case of a fault the second unit can be activated in a short time span.

Suitable fault alarms, with remote notification should be installed.

Expansion of system into Phase II and Phase III

The system can not be up-graded, hence once the capacity of the plant is reached a duplication is required of most system components.

General evaluation:

Level of technology: high

Level of automation: high

Assessment if the treatment method and sizing of the plant, whether it is capable to achieve desired treatment result (effluent parameters).

All components seem to be sized adequately.

Disinfection

Treatment goal	Probable achievement
E. coli < 103 count/100 ml *	AST 1-2 log chlorination 2-6 log sand filtration 0-3 log Combined effect ~ log 5 reduction
Helminthes eggs < 1 per liter. *	AST 1-2 log chlorination 0.5 log sand filtration 1-3 log Combined effect ~ log 3 reduction
BOD5 < 25 mg/l	Yes
COD < 125	Yes
TSS < 35.0 mg/l	Yes
Turbidity < 2 NTU	Yes

taken from [2]

The sum of the processes should provide adequate level of disinfection, so that the recycled waste water can be used for watering of gardens

Advantages of the chosen technology:

Low space requirement, good treatment result

Drawbacks / Disadvantages:

The process has a high power consumption.

Due to rather high level of complexity and mechanization, there are increased number of possibilities of malfunctioning.

In the case of a major fault occurring, there is little scope for emergency operation to keep up the flow of waste water in the sewer pipe.

The system can not be expanded. Once the plant capacity of the first phase (1000 PE) has been reached, the entire plant has to be duplicated.

Short comings:

The sludge is moved directly from the settler to the drying beds. This will probably be a cause of nuisance (odor, flies) and concerns of hygiene.

Disinfection through chlorination is efficient against viruses and bacteria, but has only limited effect against protozoa ad helminthes eggs. (WHO - World Health Organization (2006): Guidelines for the safe use of wastewater, excreta and grey water, Volume 2: Wastewater use in agriculture, World Health Organization, Geneva, 2006, ISBN: 92-4-154683-2)

Press-filtering of sludge in raw state reduces the volume but has little other advantage the sludge has to undergo full treatment.

No provisions in the plant to accommodate sludge from outlying communities.
.

Environmental concerns:

-

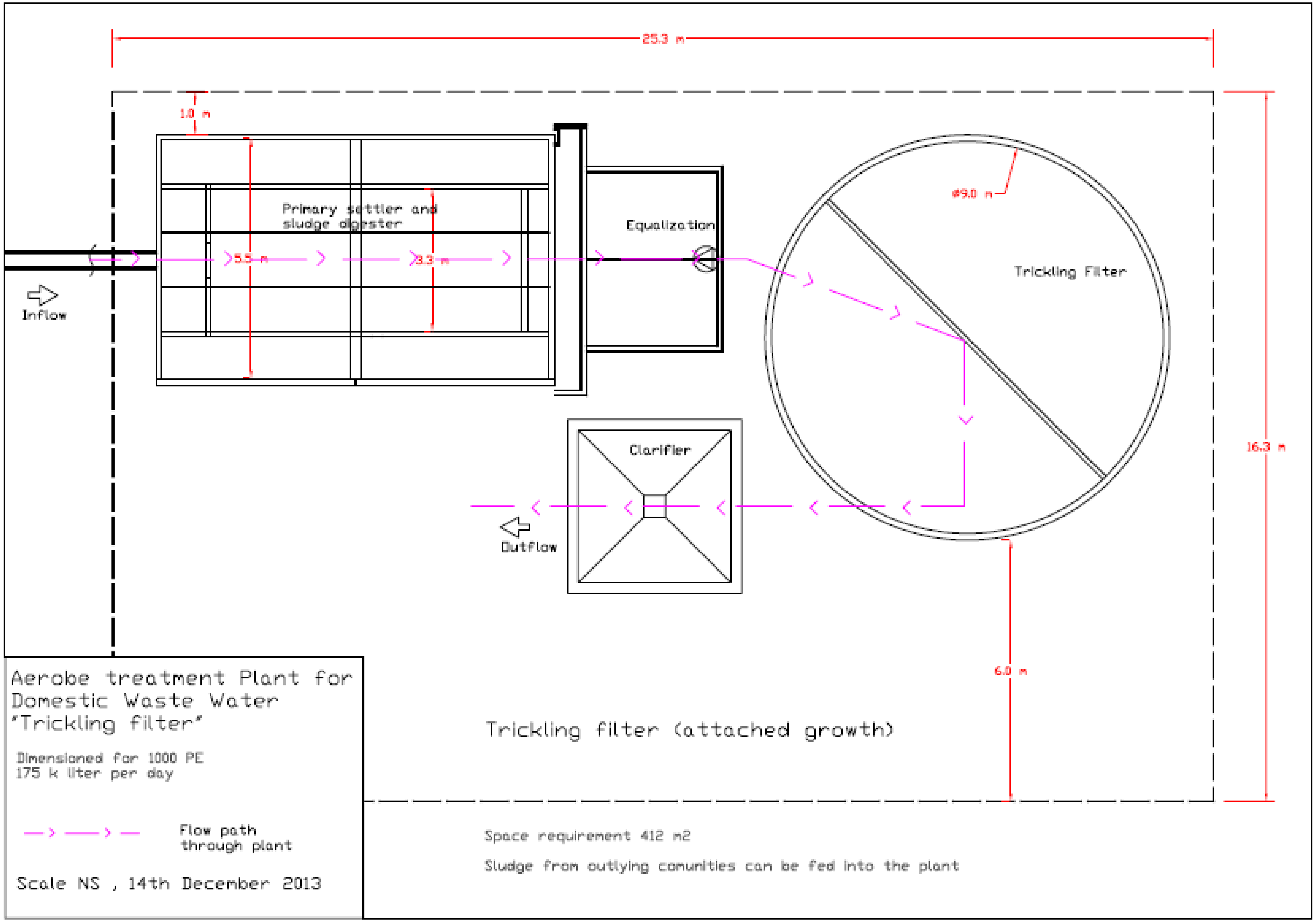
Proposed Modifications:

Provision for site development, store room cum office and back-up power supply have to be added.

Two digester units have to be added to accommodate the sludge generated within the plant and for the sludge from outlying communities.

A retention tank for emergency operations, that will receive the waste water during the time it takes to restore normal operation should be added.

System “E” **Low rate trickling filter** (for design details see Part 3 of the study)
Screen– two preliminary settler cum digester– trickling filter- secondary settler - polishing pond.



Tabular comparison of features

Cost comparison Ph1

Cost comparison off all plants
(Phase 1)

Supplier		Sharpenn/Reliance	Indus	Akar	CSR	Study WWM
Quantity of waste water		175 m3/d	175 m3/d	150 m3/d	108 m3/d	175 m3/d
Warranty		-	15 month	15 month	-	-
Offer by supplier		₹ 3,304,500	₹ 1,675,000	₹ 2,600,000	₹ 6,200,000	₹ 3,500,000
Installation		₹ 300,000	₹ 167,500	₹ 225,000		
Additional civil works (scope of client)		₹ 1,219,500	₹ 838,963	₹ 886,524		
Sludge management						
	digester	₹ 192,500	₹ 192,500	₹ 192,500	₹ 192,500	
	drying	₹ 120,000	₹ 120,000	₹ 120,000	₹ 120,000	
	composting	₹ 50,000	₹ 50,000	₹ 50,000	₹ 50,000	
	Sludge from outlying communities	₹ 192,500	₹ 192,500	₹ 192,500	₹ 192,500	
Polishing pond / storage re-distribution		₹ 100,000	₹ 100,000	₹ 100,000	₹ 100,000	
percolation		₹ 75,000	₹ 75,000	₹ 75,000	₹ 75,000	
Site development		₹ 1,600,000	₹ 1,600,000	₹ 1,600,000	₹ 1,600,000	₹ 1,600,000
Total (excluding taxes)		₹ 7,154,000	₹ 5,011,463	₹ 6,041,524	₹ 8,530,000	₹ 5,100,000
Shipping		₹ 25,000	x	₹ 25,000		
packaging*	1.5%	x	x	x		
Excise*	12.4%	₹ 408,436	₹ 207,030	₹ 321,360		
CST*	2%	₹ 66,090	₹ 33,500	₹ 52,000		
VAT	5%					
Service tax*	12.36%	₹ 37,080	₹ 20,703	₹ 27,810		
GRAND SUM		₹ 7,690,606	₹ 5,272,696	₹ 6,467,694	₹ 8,530,000	₹ 5,100,000
Compare		151%	103%	127%	167%	100%

Cost comparison expansion phases

	Cost comparison off all plants (Phase I, II and III)				
Supplier	**Sharpenn/Reliance**	**Indus**	**Akar**	**CSR**	**Study WWM**
Quantity of waste water	175 m3/d	175 m3/d	150 m3/d	108 m3/d	175 m3/d
Warranty	-	15 month	15 month	-	-
Basic system description					
type of bacteria	aerobe	aerobe	aerobe	anaerobe	aerobe
primary treatment	coagulation settler	settler	settler	settler	settler / digester
secondary treatment	activated sludge	MBBR	MBBR/Lamella settler	baffle reactor/filter	low rate trickling filter
tertiary treatment	sand filtration	sand filtration	sand filtration	Vortex	polishing pond
	chlorination	chlorination	chlorination	*optional	
	activated carbon filtration	activated carbon filtration	activated carbon filtration	*optional	
Additional features		remote monitoring			
Phase 1 cost	**₹ 7,690,606**	**₹ 5,272,696**	**₹ 6,467,694**	**₹ 8,530,000**	**₹ 5,100,000**
Additional cost Phase 2* (expansion to 3000 PE)	**₹ 4,824,000**	**₹ 2,681,463**	**₹ 3,711,524**	**₹ 4,500,000**	**-**
Additional cost Phase 3* (expansion to 5000 PE)	**₹ 4,824,000**	**₹ 2,681,463**	**₹ 3,711,524**	**₹ 4,500,000**	**₹ 1,162,000**
Sum	**₹ 17,338,606**	**₹ 10,635,622**	**₹ 13,890,742**	**₹ 17,530,000**	**₹ 6,262,000**
Compare	**277%**	**170%**	**222%**	**280%**	**100%**

*aproximate values as per offer at todays rate

Space requirements	Phase 1	Phase 2	Phase 3
Sharpenn Industries	612 m2	duplication	
Akar Impex PvtLtd	500 m2	duplication	
CSR	550 m2	duplication	
Indus Ecowater	231 m2	duplication	
Trickling filter expansion	412 m2	dynamic	

Level of Technology

Akar Impex PvtLtd	medium to high
Indus Ecowater	medium to high
Sharpenn Industries	medium to high
CSR	low to medium
Trickling filter	medium

Revised proposal CSR April 2016

Evaluation of the offer from CSR June 2016 – Baffled Reactor with Vortex

System description:

CSR's offers a multi chamber anaerobe baffled reactor (ABR). Followed by an aerobe treatment stage with and aeration device (Vortex).
The sequence of treatment is

settler
|
Balancing / equalization
|
anaerobe treatment
baffled compartments
|
filter (attached growth)
|
Aeration chamber (Vortex)

The system is to be built in pre-fabricated ferro-cement elements.
It is equipped with 2 electric pumps, one at the balancing tank and one at the aeration stage.

As per CSR's offer their scope is:

"Vortex-Dewats STP for Residential Zone 1&2 will be build, calibrated, connected and commissioned by CSR at the end of the sewage line in the allocated space agreed by TDC and CSR".
General comments

The revised offer from CSR follows closely the original design presented two years earlier. The plant has been downsized to accommodate 300 PE. Hence the earlier assessment (see Part Three) in regard to plant performance stands unchanged.
It remains doubtful that the plant will achieve the desired treatment result, especially in regard to odor of the effluent and discoloration. Literature review supports this skepticism. For example KM Foxon et al. (1) find that :

"…the ABR (is) not able to treat wastewater to an acceptable chemical and microbiological standard alone. There must be some post-treatment step and appropriate reuse or discharge method implemented with the ABR as an integrated sanitation system, since unpolished ABR effluent is not fit for discharge to surface or groundwater or for direct use in agriculture…"

CSR offers an aerobe treatment phase with a "Vortex" system as post treatment stage to solve the shortcomings of the ABR.
Five basic parameters have to be fulfilled in order for an aerobe treatment stage to run efficiently.
Inoculation with suitable aerobe bacteria. (especially important when the water has previously undergone anaerobe treatment).

Supply with adequate amounts of oxygen. (the water arrives from the anaerobe treatment stage completely depleted of oxygen)
Constant stirring, or an other means of ensuring good contact between water, bacteria and oxygen.
Sufficient retention time
Secondary settler to remove excess sludge. The excess sludge is still very active if it remains in the treatment tank it will draw on the oxygen reserve of the water.

Although CSR have installed several “Vortex” devices on treatment plants in and around Auroville, they have not been able to show that the technology can achieve the desired result. This may be due to the fact that at some of the basic parameters above are not, or only insufficiently met by the “Vortex”

If the system fails to reach the desired treatment level, then this would put at risk one of the chief parameters to be accomplished by this new treatment plant, that is the re-use of waste water for gardening purposes. In case the quality of the treated water does not convince the end user, because of bad odor or discoloration, then the acceptance of projects of this kind will rapidly fade away.

Further points are discussed here under.

Evaluation of the structural integrity of the plant.

CSR proposes to deliver the tanks for the treatment plant in pre-fabricated ferro cement elements. This option makes the manufacturing easier because it can be done at the factory. CSR also argues that in case that the plant is to be dismantled at a later point, the tanks can be removed and used at an other location.
As per their drawing the tanks are geometrical rectangular shaped.
The depth of the tanks is not indicated in the offer.
As a reference the offer from 2014 is taken. Here the depth of the tanks is given as 3.5 m (5.4 x 37.2 x 3.5 m for 1000 PE, 108 m3 per day).

Ferro cement is a composite material that shows very good tensile and compressive strength, the ability to absorb bending stress is very limited. Ferro cement is also vulnerable to point-impact or -loads.
Due to this mechanical properties ferro cement it is preferably used to build spherical, cylindrical or conical shaped elements. (round water tanks, boat hulls, tubes etc.)
In the proposal the largest tank, the balancing tank, is rectangular and has the horizontal dimensions of approximately 4.8 x 2.4 m.
The pre-fabricated tank has to be designed to withstand the additional loads of transport (lifting and lowering by crane).
After having been lowered into the ground there is a possibility of un-even settling which will create forces in the base plate. Once filled with water further settling will occur. Depending on soil conditions the settling can amount to 2-3 cm during the first year. When in operation the tank has to absorb the forces of daily variation of water level, this is overlaid with forces through the outer soil pressure.

Given the less than optimal geometry of the tank (flat long elements) it is doubtful that the tank will withstand these changing loads without developing cracks.
Waste water contains and generates corrosive substances which react with the cement and the steel. In the case that the tanks develop cracks, these substances will cause accelerated internal corrosion in the composite material.

The design life of the sewage pipe system is 40 years. The design life of the treatment plant should be similar.

It is also doubtful that the tanks could, at a later point, successfully be removed from their location without damage and re-used at an other site.

Recommendations
It is recommended that all underground tanks of the treatment plant should be manufactured in reinforced concrete with adequate concrete coverage of reinforcement against corrosion (aggressive substances). Spacing and size of the rebars should be chosen to minimize cracks.
Pipes and machinery

CSR's offer includes the use of high-end pumps by Grunfos. The quality is very good, the price is accordingly high. Nonetheless these pumps have to be replaced at regular intervals this should be kept in mind.
The pipe material is given as nPVC. This is suitable, provided that adequate protection is provided against mechanical damage. Buried pipes have to be protected against vehicle load and pipes interconnecting the tanks should be bedded flexibly against uneven settling of the tanks.

Design

Emergency operation and bypass

The system is designed as a single string process. Any fault in any one of the processes will lead to a failure of the entire system.
If for example a blockage would occur in the primary settler or the anaerobe filter has to be replaced then the entire system is dysfunctional which could last several days. In this situation there would be 40 m3/day of untreated waste water to be dealt with.
Provisions should be made to by-pass individual tanks, so that in case of failure of one component the plant it still remains functional at a reduced level.

No provision for power back up has been made.

The trunk sewer arrives at the site at a level of 1.5 m below ground. It can be assumed that the water level will fall by 10-15 cm when flowing through the system. The outflow level of the treatment plant should be above ground. The natural surface gradient of the site is not sufficient to achieve a level outflow.

The offer by CSR provides for two pumps to manage the hydraulic head.
pump installed at the 1st equalization tank.
pump installed at the outflow (Vortex)

For both pumps a power back up is required to ensure evacuation of the treated water during extended times of power shut down.

The "Vortex" system uses aerobe bacteria one objective is to eliminate the odor that originates from the previous anaerobe treatment.
Aerobe bacteria require a constant supply of oxygen for their metabolism. In the absence of oxygen they die off.

Hence if the plant would experience an extended power failure (for example during the one-day-long monthly TNEB service shut down), the bacteria colony in the Vortex sump would be severely reduced or completely die off. As a consequence the vortex part of the system would have to undergo a fresh run-in period.

Recommendation:
Power backup minimum capacity for all pumps essential for the operation of the plant, minimum reserve 12 h.

Expansion

The plant is not expandable. If in future it is decided to connect more communities to the sewer network, an entire second plant has to be built in parallel.

Completeness of the offer

Storage and return pump for treated water are missing.

The brief for the design of the treatment plant specifies that the recycled water should be pumped back into the communities for gardening purposes.

An adequate intermediate storage space for the treated water has to be provided (24 hours) at site. A pressure controlled pump has to be installed to re-circulate the water. This has been omitted in the offer.

Evacuation of excess of treated water

During the monsoon time the demand for irrigation water will be low. Hence the water has to be percolated into the ground. An adequately sized drain field has to be provided. This has been omitted in the offer.

Run-in of the plant and training:

After completion of the civil work, CSR proposes to hand over a manual for operation and maintenance.

This is insufficient
The running-in of the plant should be under the scope of the contractor.
Handing over of the plant should be scheduled after the plant has reached acceptable performance level.

During this period adequate training of personnel to operate, monitor and maintain the plant has to be provided.

A monitoring schedule should be established and budgeted.

Baffled reactors typically have a rather long run-in time of 4-12 month until sufficient bacteria have developed to achieve the desired treatment level.
This can be accelerated by inoculation the tanks with bacteria from other treatment plants.

Standard performance parameters (see Part 3) should be regularly monitored, to determine if the treated water can be offered to the communities for re-use in their gardens.

De-sludging and time interval:
Sludge has to be removed from all chambers in the ABR. While the extraction from the primary settler with suction pump may be straight forward, the extraction from tanks filled with filter material such as rocks might be somewhat difficult. The staff has to be trained to perform this task properly.

Extraction of excess sludge is essential for the good performance of the plant.
On the other hand the removal by suction pump and truck and disposing it off site is costly.
The recommendation for the time interval in the offer are theoretical figures. The actual requirements should be established by monitoring. Only then a realistic and cost effective schedule can be made.

Warranty:

No warranty is given against structural manufacturing faults (for example cracks developing in the course of time in the ferro cement treatment tanks).
It is recommended to assert a 10 year warranty for all structural components against design/manufacturing faults.

No warranty on installed machinery, pipes and valves is given.
Although it is assumed that machinery such as the pumps for example are supplied under a manufactures warranty of 1-3 years, this usually only covers the repair of the pump at the factory of the manufacturer. Removing the pump, installing a temporary substitute and subsequent re-installation are not covered.

Recommendation: 5 years maintenance contract for all machinery should be given.

Conclusion

It is doubtful that this design will meet the prescribed requirements and provide an effluent quality acceptable and suitable for irrigation.
If the system fails to reach the desired treatment level and the quality of the treated water does not convince the end user, because of bad odor or discoloration, then one of the chief parameters, the re-cycling of waste water for gardening purposes will be put at risk and the acceptance of other projects of this kind will rapidly fade away.
In all probability the plant will require an additional treatment level to achieve the desired results. Additional space requirements for an upgrade should be taken into account when the final layout is decided.

The supplier should provide the offer as "turn key" complete in all aspects.

The choice of building material and quality of all components should meet the desired life expectancy of 40 years.

There should be adequate guarantees form the supplier in regard to performance of the system and against manufacturing faults.

The supplier should accompany the run-in time and provide adequate training before the system is handed over.

Footnote (1)

From "THE EVALUATION OF THE ANAEROBIC BAFFLED REACTOR (ABR) FOR SANITATION IN DENSE PERI-URBAN SETTLEMENTS KM Foxon • CA Buckley • CJ Brouckaert P Dama • Z Mtembu • N Rodda • M Smith S Pillay • N Arjun • T Lalbahadur • F Bux WRC Report No. 1248/1/06
Water Research Commission P 190-191"

Chapter 4 - New Location for the treatment plant 2016

Parameters were formulated for the **location of the treatment plan**t.

The chief criteria to select a suitable location for the plant are:
- elevation (gravity flow in the sewer pipe can be maintained)
- access during construction and later-on for the delivery of sludge by truck
- passage for the sewer pipe and the return pipe for irrigation water and electrical line
- closeness to exit point of the main sewer (Vikas Radial)
- sufficient large plot size to accommodate the treatment plant and the extension phases
- sufficient distance from existing residences to minimize impact
- the land should preferably already be owned by Auroville

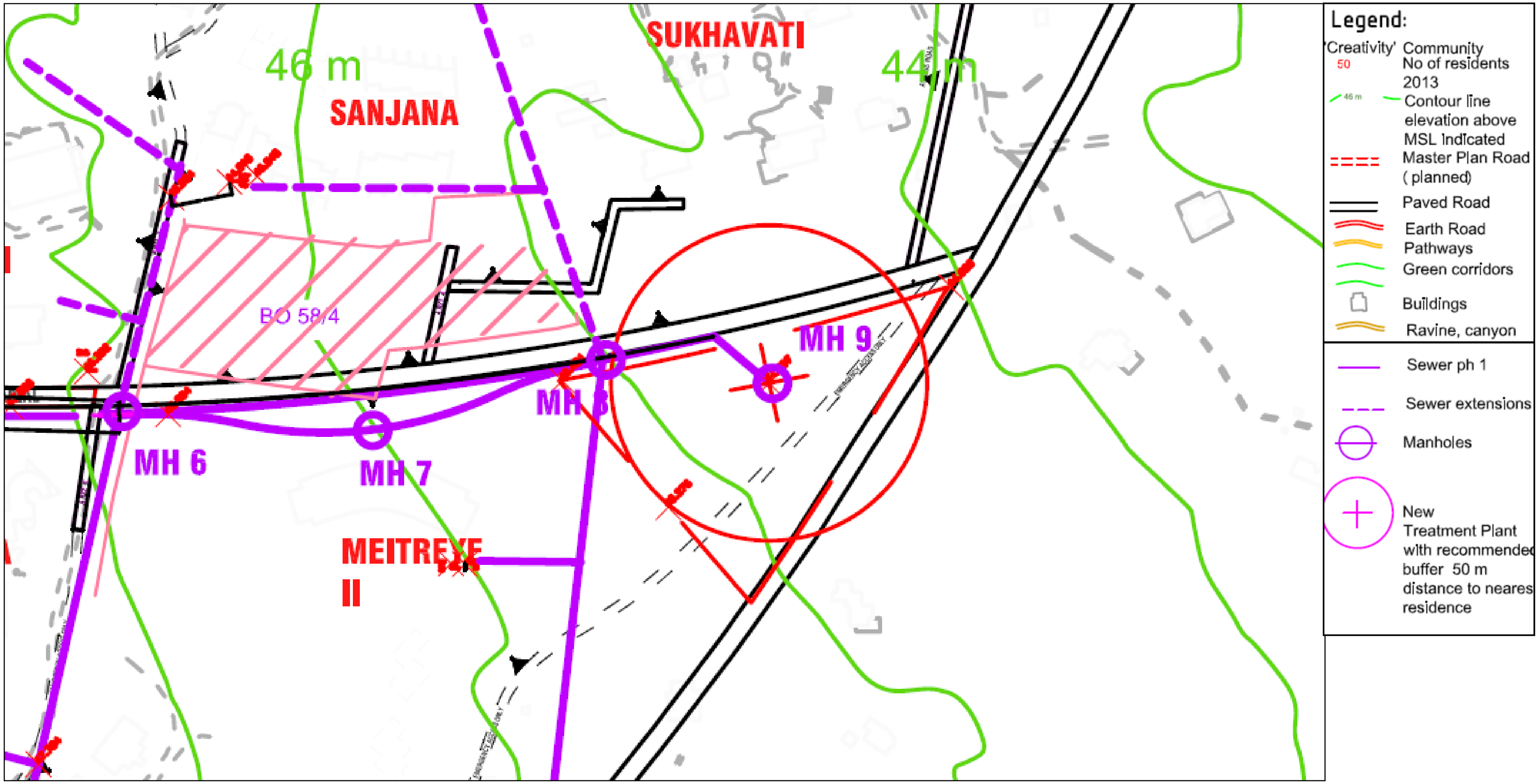
Based on this the general area for the treatment plant was placed on the border of the Residential Zone II, to the Green Belt.
Out of various possibilities two particular options(2) for the location were identified. The first option is a plot bordering onto Sangha Community. While this plot would be ideally suited, it needs to be purchased.
An other possible location is a plot a bit further to the east.. This land belongs to Auroville but is not directly connected, hence passage rights need to be negotiated. The trunk sewer distance and return pipe are about 80 m longer.

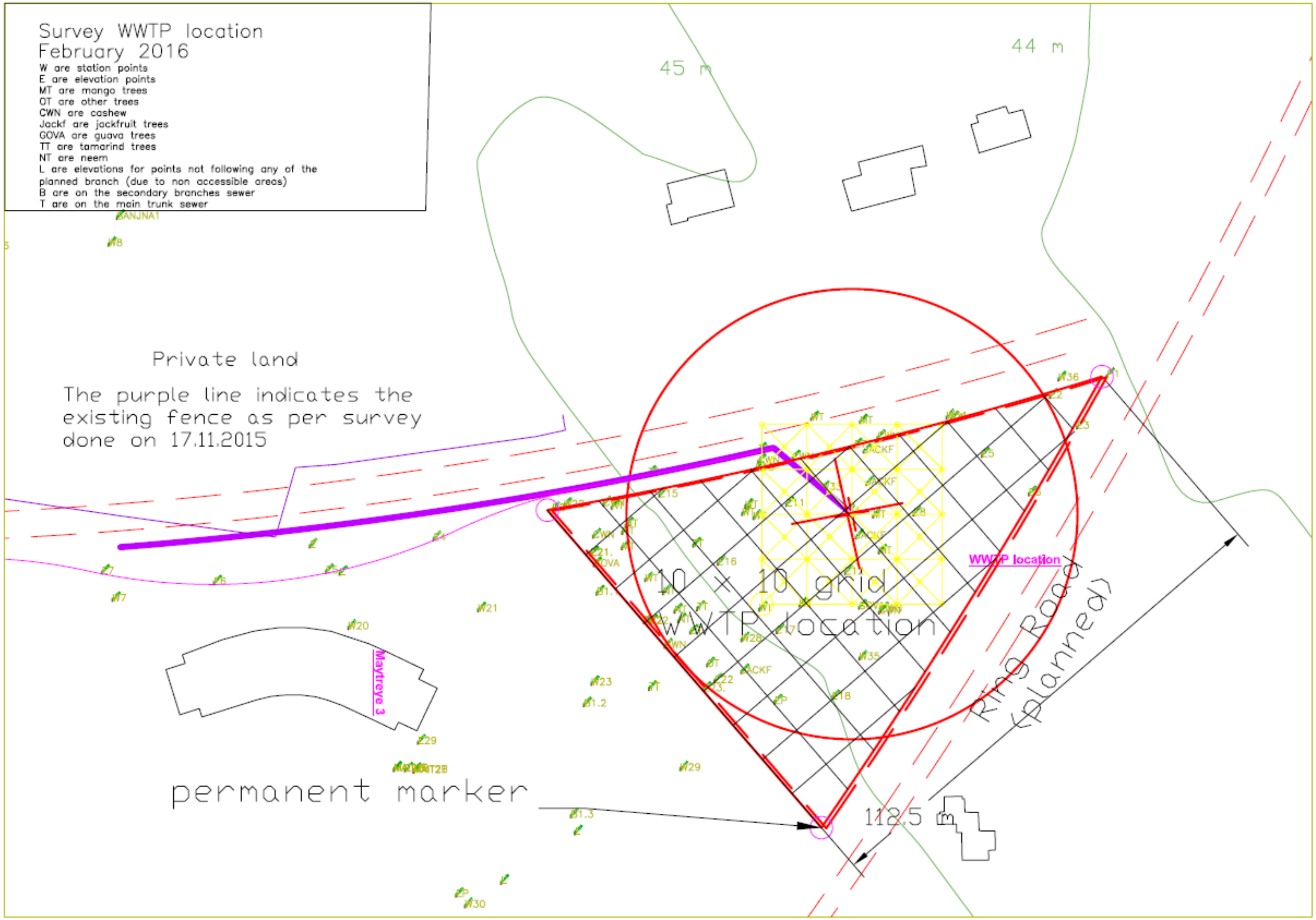
Since during the course of this study it has not been possible to acquire either of the relevant plots suggested above, an alternative location had to be identified.
The new feasible location has been determined as being in the triangle formed by the Ring Road , the Vikas Radial and Maitreye (see attached map). The location has been decided based on an adequate (and equal) buffer distance to all residences in the area.

Initial survey of new site and the sewer alignment showed that a gravity fewer network was feasible.
In a further survey the existing sewer inflow pipes of the treatment plants in the communities in the study area where surveyed and mapped.

Based on this the sewer alignment was re-designed.

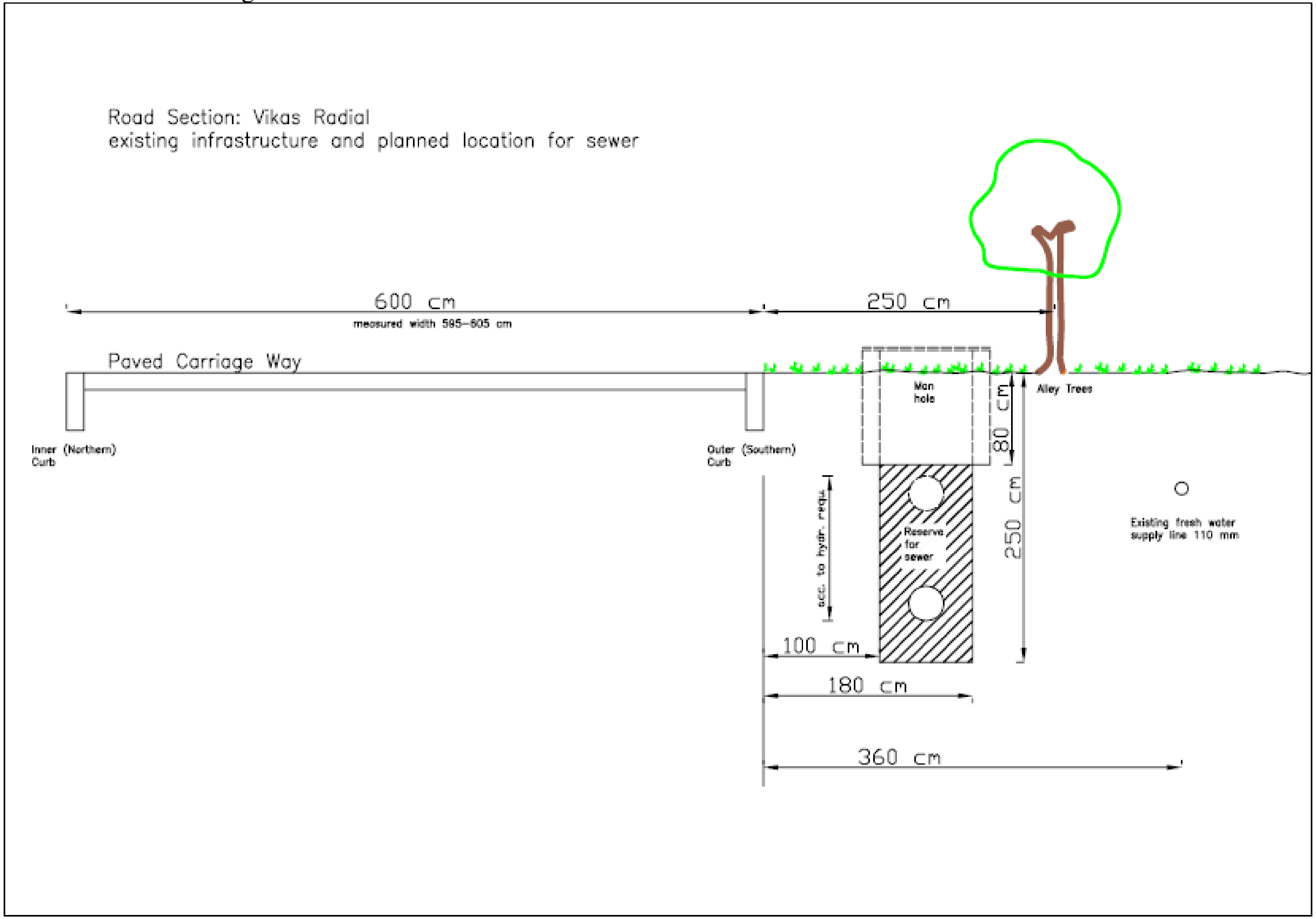
Site of the new location of the waste water treatment plant





Grid survey and permanent markers on the new location of the waste water treatment plant

Section sewer - road alignment



Chapter 5 – Detailed design of the sewer network

A minimum sewer gradient of 0.5% is recommended. This will maintain a minimum velocity of 0.4 m/s at ¼ filling. The maximum gradient should not exceed 4% in order to ensure that solids are transported along the pipe.
The pipe should run at a depth of 1.2 – 2.5 m below ground. The depth of 1.2 m minimizes the risks of the pipe being accidentally damaged through digging work as is common to plant bushes and trees in gardens and parks. The prevailing laterite soil has good adhesion and the depth of 2.5 m is considered the safe maximum depth to carry out trench work in an unsecured trench. This depth should only be exceeded if absolutely necessary and the trench has to be secured adequately. The sewer lines run as far as possible along existing infrastructure corridors at fixed horizontal distance from other infrastructure.
The trunk sewer is dimensioned 400 mm dia, so that it can accommodate the final expansion phase of the system. Branch sewer diameter is 220 mm. A variety of different pipe and manhole materials were compared in Part 3. HDPE was found to be the best choice for trunk and branch sewer. The manholes are to be executed in pre-cast concrete elements.
In the first phase it is proposed to implement a trunk sewer along the Vikas Radial and connect the projects Arati and Metreye etc via branch sewers. This takes into account the priority of residences that need to be connected most urgently.
Once the treatment plant is operational to it's full extend, connections can be offered to the other communities as well. The trunk sewer is equipped with level-ground manholes at the end points and midpoint of the Radial and at each junction with a branch sewer.
At each manhole four branch sewer entry points are provided, the entry points which are currently not used will be closed with a dummy cover. This allows for easy extension of the network in future.

Procedure

In the following the procedure to arrive at the correct elevation level of the sewer design is described.
The depth of the trunk sewer is decided by the required depth of the incoming branch sewers.
The sewer design starts at the top of the line, the sewer depth at the outlet (treatment plant) is decided by the up-hill requirements.

The trunk sewer is aligned along ROW of Vikas Radial. Branch sewers run into the communities and connect more or less perpendicular to trunk sewer.
Branch sewers run along existing roads and pathways as far as possible. The minimum bending radius of HDPE pipe has to be observed. Branch sewers can branch into sub-branches if required.
Depth of the sewer pipe is measured inside the bottom of the profile.
Sewer wall thickness and bedding has to be added at time of excavation
The minimum depth of both sewers is 120 cm below ground level.
In special cases exception can be made, but in this case the sewer has to clearly be marked above ground.

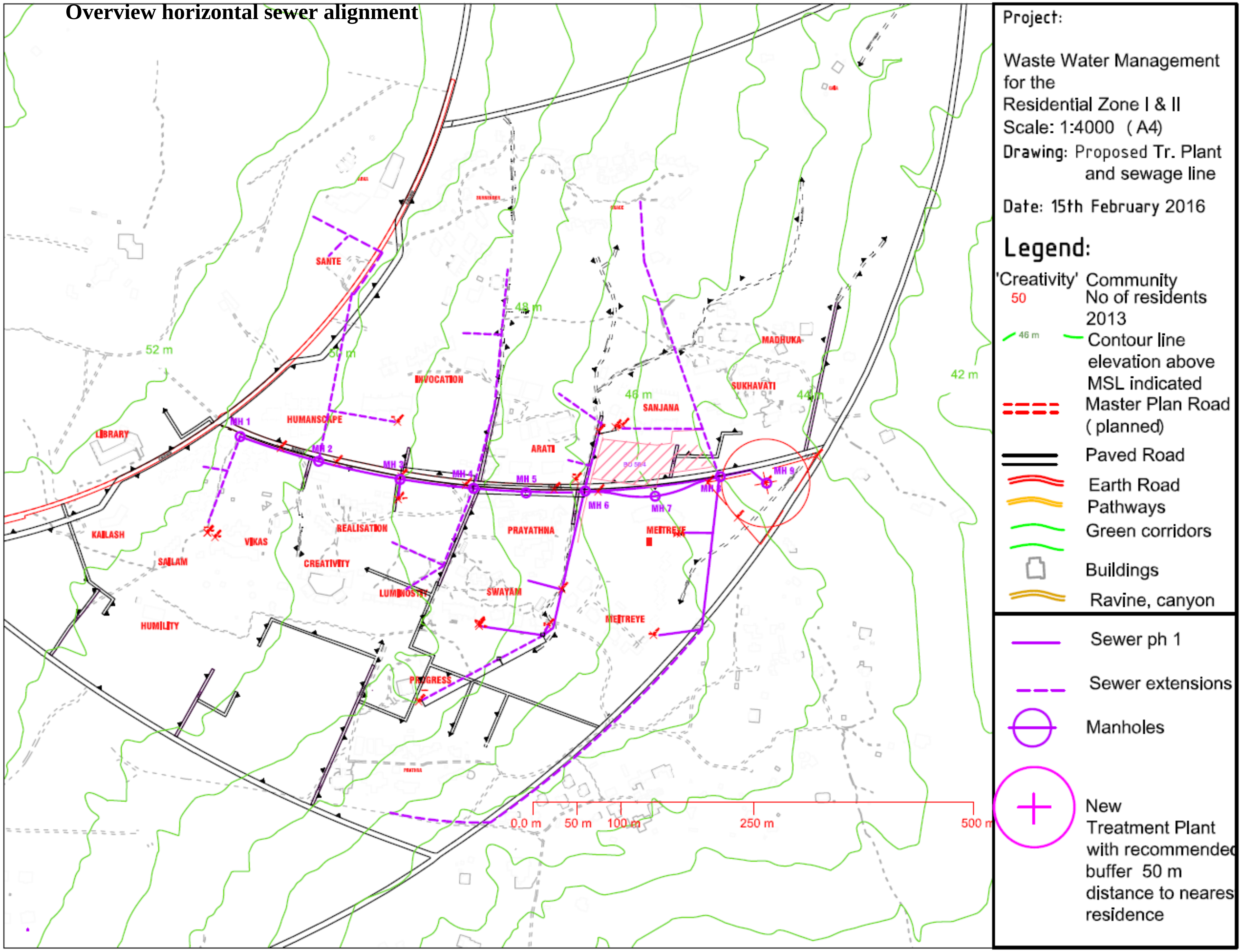
For those communities that have not yet been surveyed, but that might potentially be connected, a sewer connection depth of 1.20 m below ground level is assumed.
Sewers pipe should be laid, as far as possible at minimum depth.
The maximum depth of any sewer is 3.0 m below ground
Down hill pipe slope of 0.50% has to be maintained
Maximum pipe slope of 4% should not be exceeded. If the lay of the land require a steeper slope, a "fall out" in manhole is recommended.
The branches enter the manholes at "1/2" height of trunk sewer + 0.16 m.
Manholes are to be provided at every branch and sharp bend.
Maximum distance between manholes should not exceed m100 m.
Manholes extends minimum 20 cm above ground to ensure that storm water can not enter.
Manholes have to be placed well aside any road or pathways.

The manufacturer specific minimum permissible bending radii have to be observed for example: A 400 mm diameter HDPE pipe should not be bend beyond the minimum radius of 16 m. The maximum deflection Δ v over 10 m length is 80cm.

Before the construction begins the following points have to be verified:
Verify that the endpoint of the sewer and the inlet of the treatment plant match.
Existing underground infrastructure has to be studied to determine if there are conflicts with the sewer alignment.
A minimum horizontal distance to water supply main should be 3 m.
It should be verified that other existing over and underground structures, trees, buildings etc are not in conflict with alignment.
The horizontal alignment should be marked at 10 m interval by means of a new survey.
Vertical alignment and required minimum slope between each marker has to be verified.
The required minimum depth of sewer pipe below ground level has to be verified on each marker
Sewer pipe should cross under water main at a minimum vertical distance 30 cm
Manholes or pipe joints should not be installed in the vicinity of a water mains crossing
If necessary the sewer has to be re-aligned

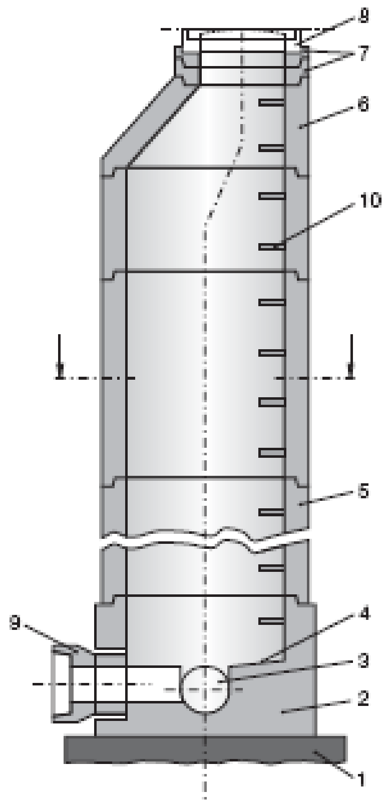
In each community the branch sewer terminates in a connection box. The house sewer lines can be connected in this box.

Overview horizontal sewer alignment

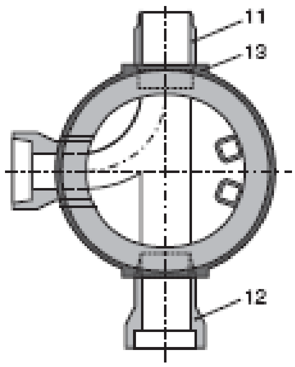


Manhole design

Manhole pre-fabricated RCC (height 0.8-2.5 m) Straight through pipe dia 450 mm, branch 225 mm on two sides



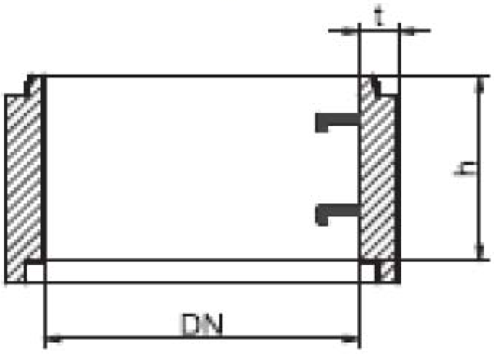
1. PCC
2. Foot piece
3. Formed channel
4. platform
5. Extension ring
6. End piece
7. Cover frame
8. Cover (cast iron, bolted)
9. Connection coupling to HDPE
10. Climbing rung
11. Cast iron rubber ring “inner”
12. Cast iron rubber ring “outer” (muff
13. Sealant



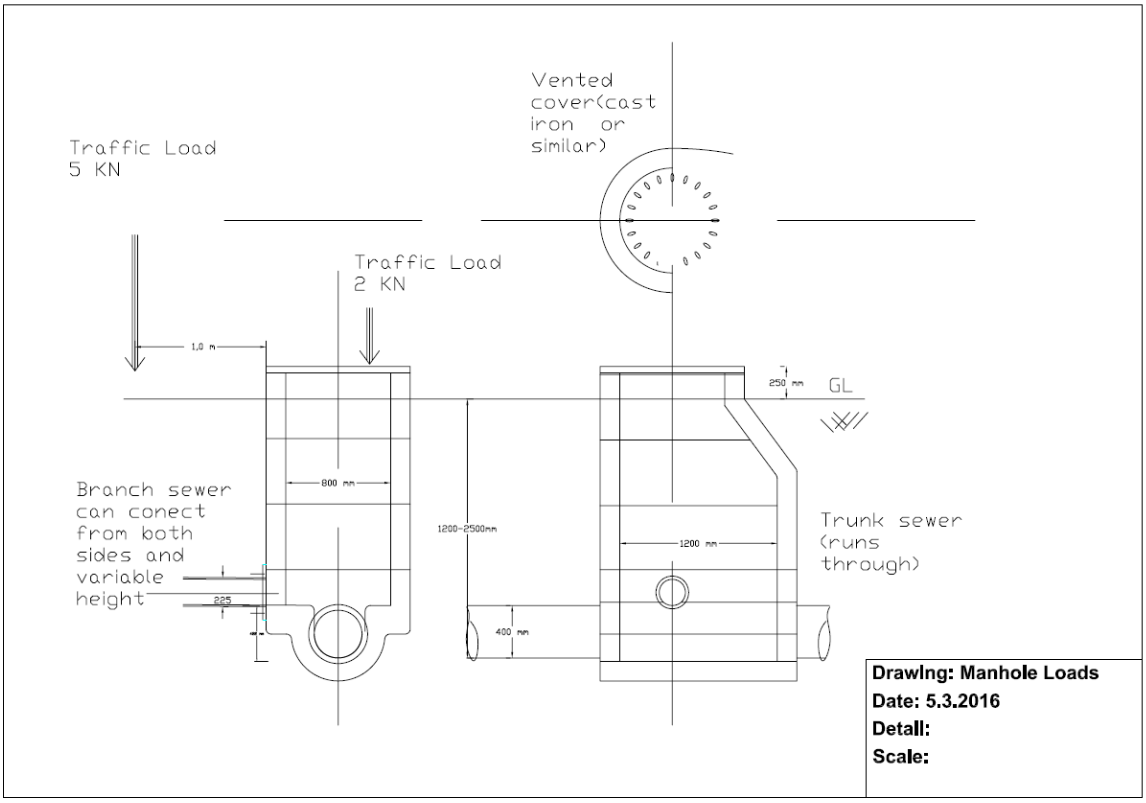
Alternative to 11. and 12 is bolt flange

Extension piece
DN=800 mm; h = 500 mm; t = 120 mm

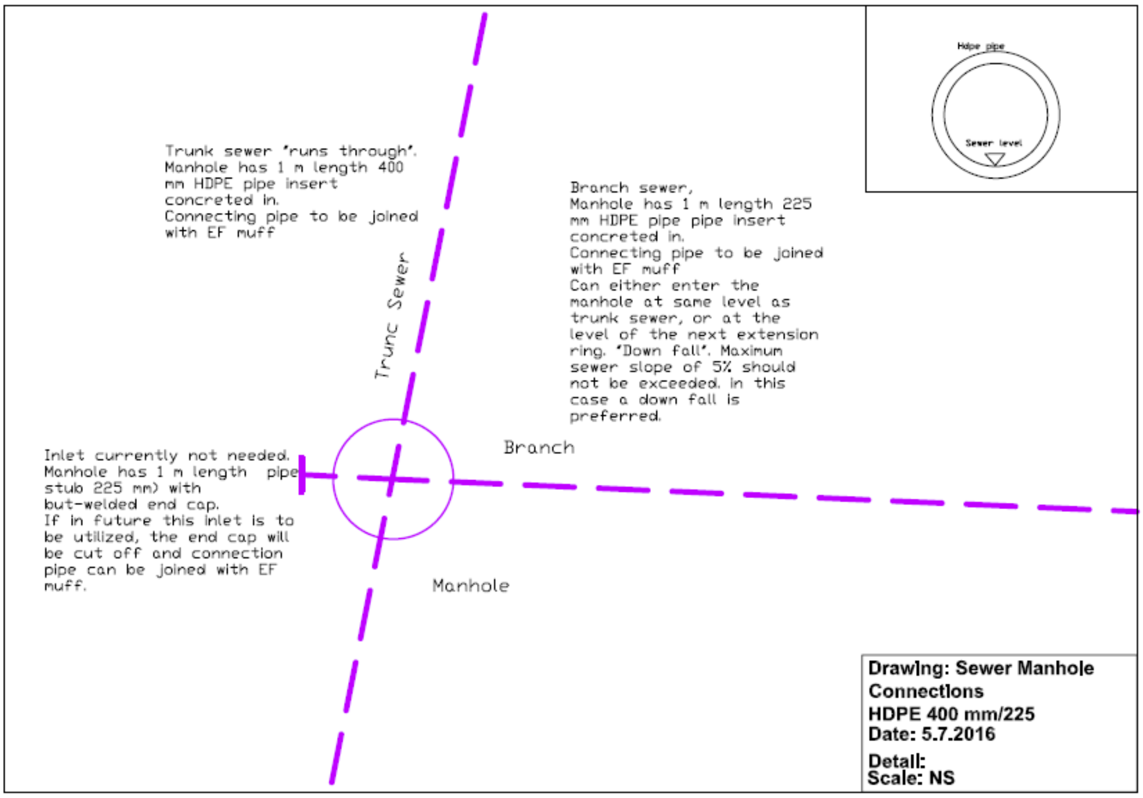
Provision should be made that branch pipe can connect in extension piece at higher level than trunk sewer.



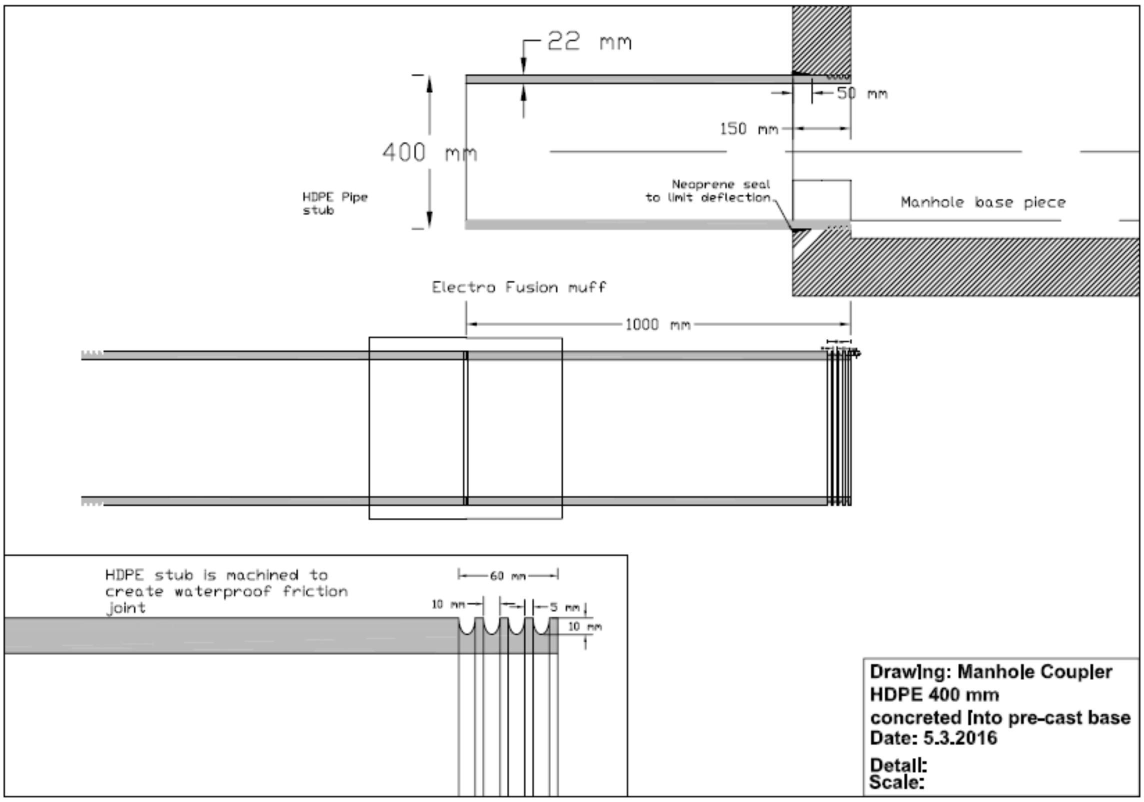
Manhole design loads



Manhole – Sever pipe connection.
The inner walls of the sewer should be free of obstruction. This has implication on the jointing technology that can be applied. For pipe to pipe connection electro fusion couplers are recommended. In the case of pipe to end cap jointing but welding can be used.

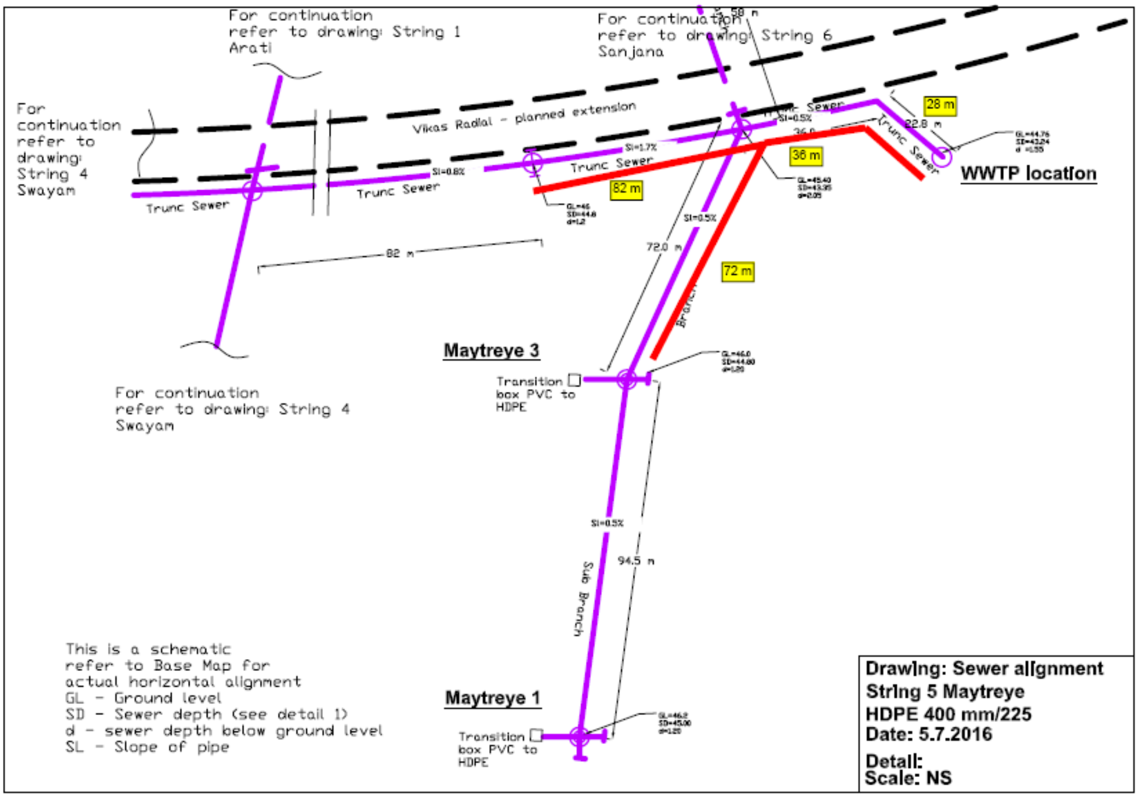


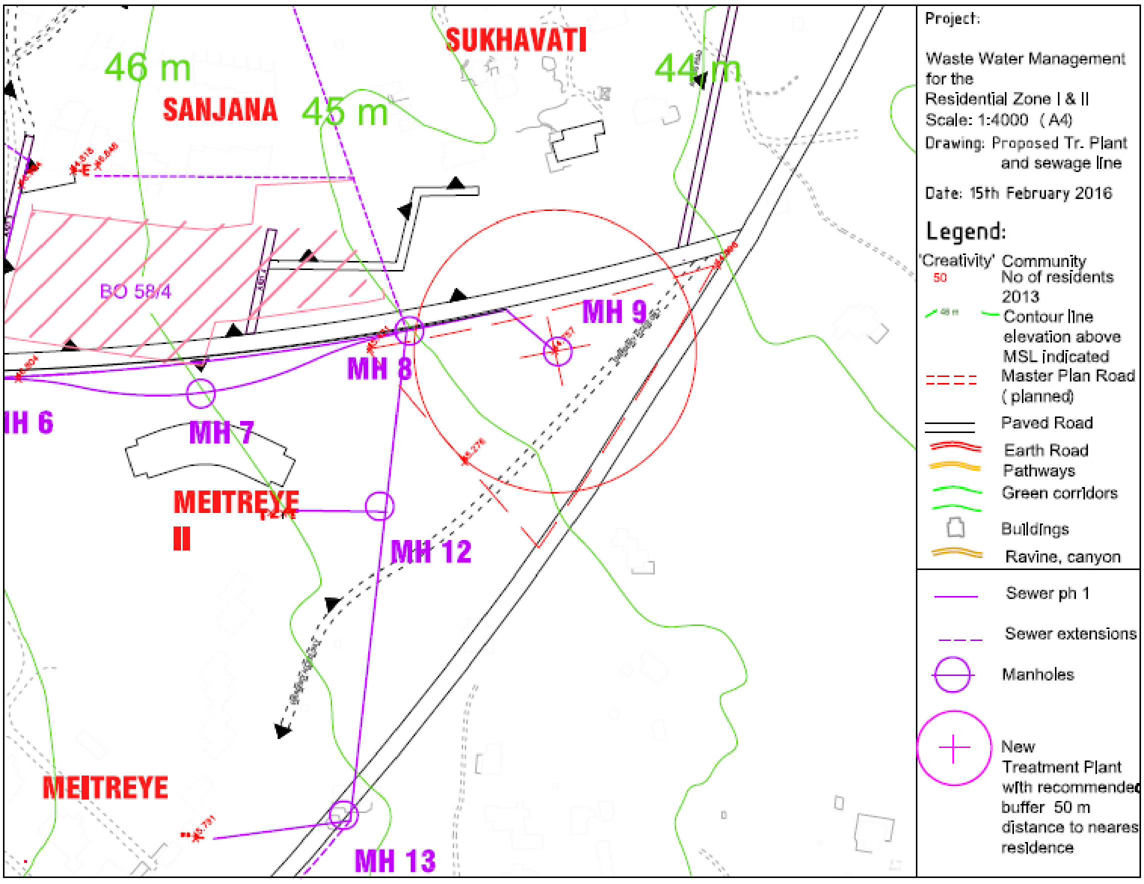
Manhole – pipe connector



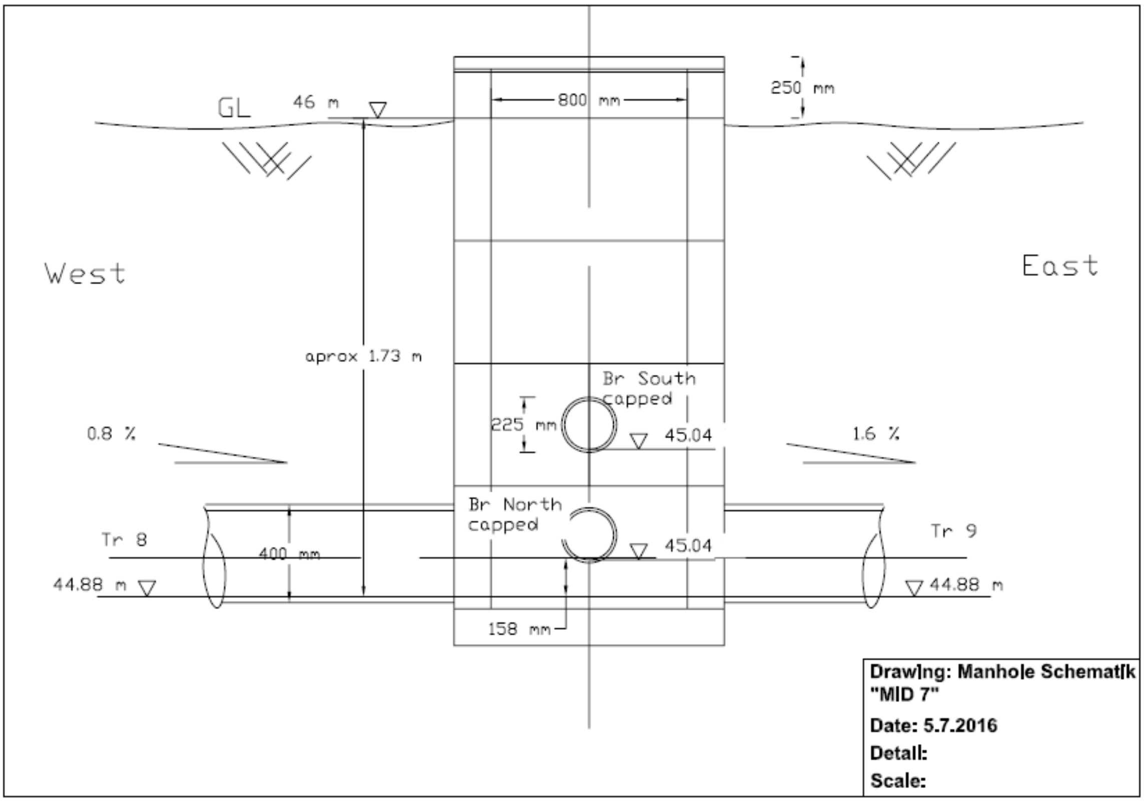
WWTP and sewer, residences to connect 2016 - Phase 1

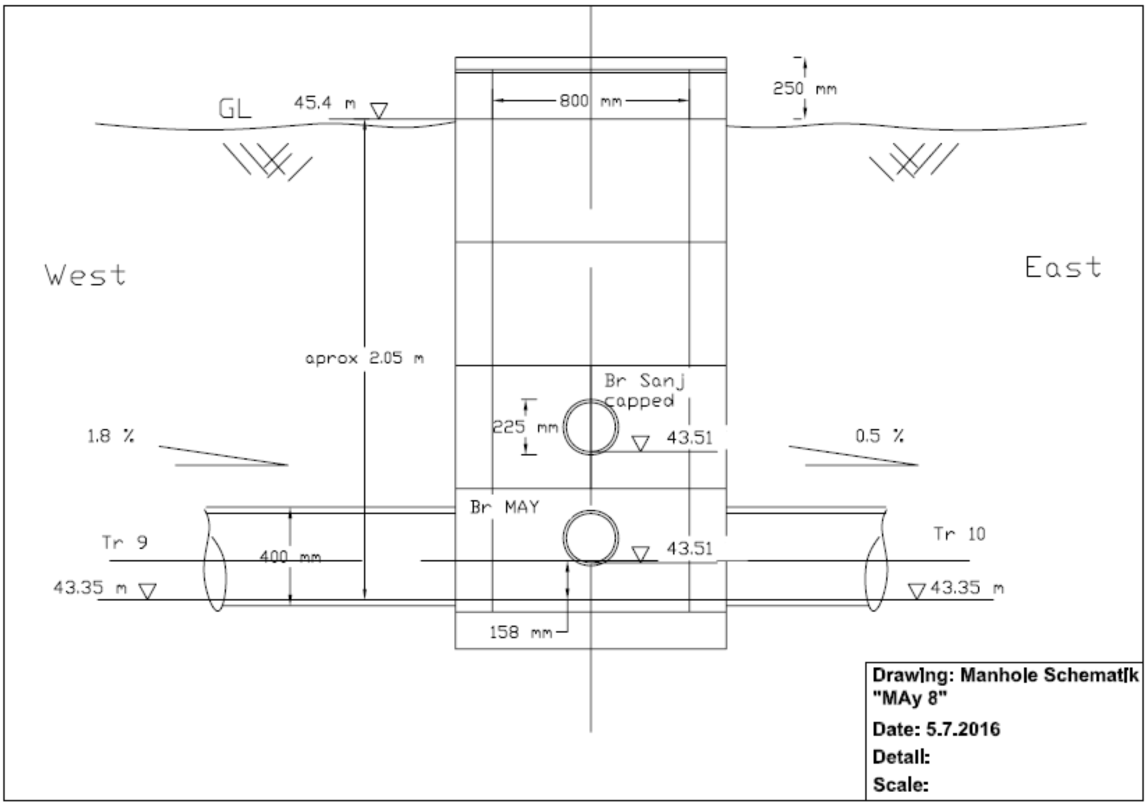
In June 2016 it was decided to implement the sewer network in phases. In the first instance the community Meytreye 3 will be connected. The detailed horizontal and vertical alignment is given here under.



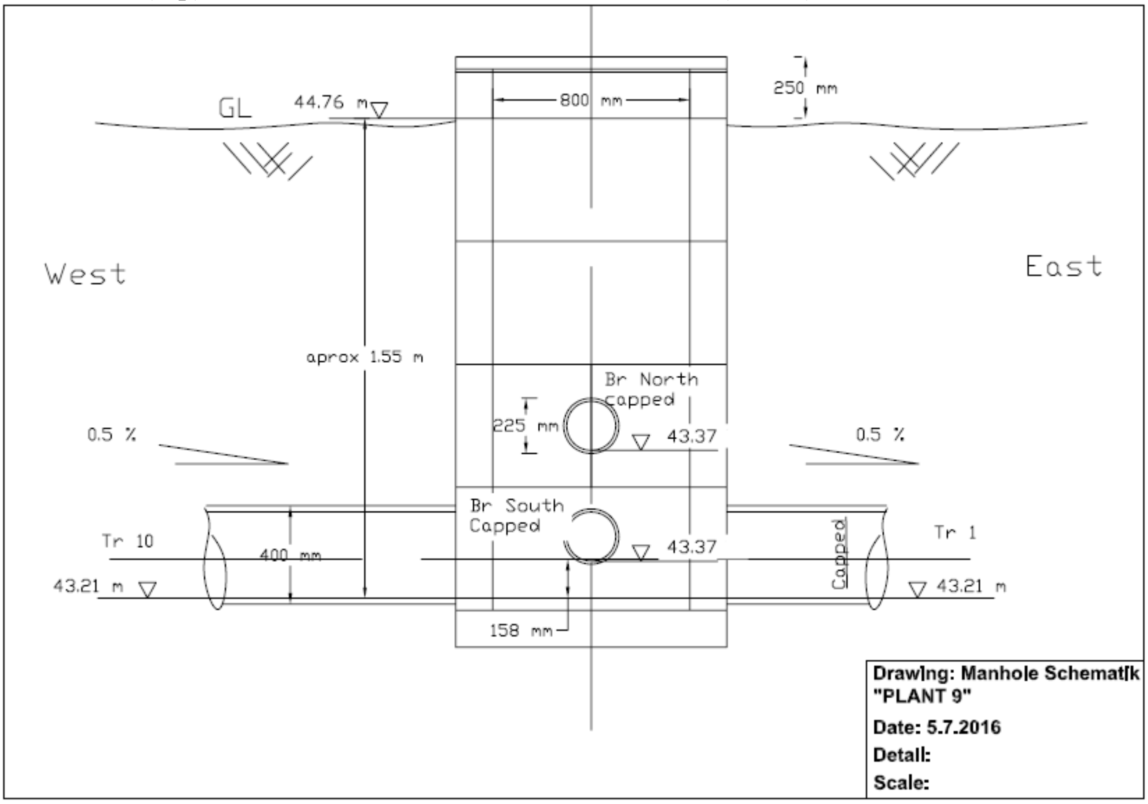


Manhole numbering (top) *Manhole 7 levels (below)*

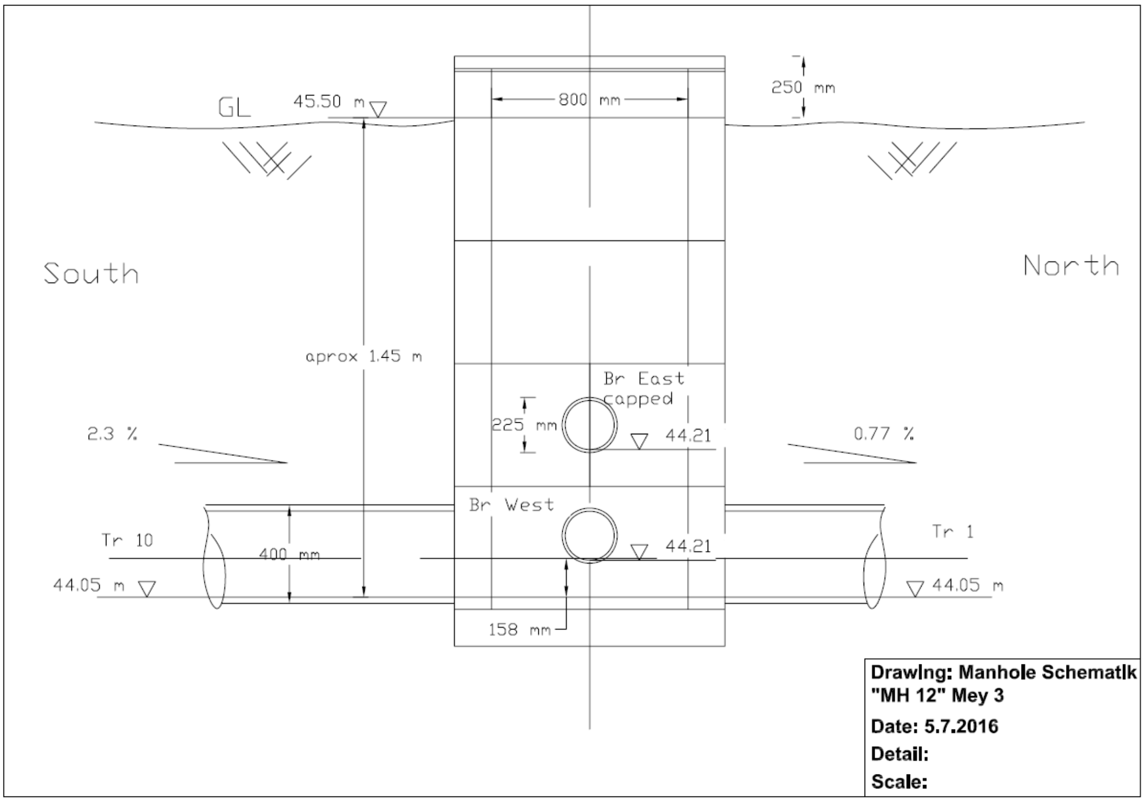




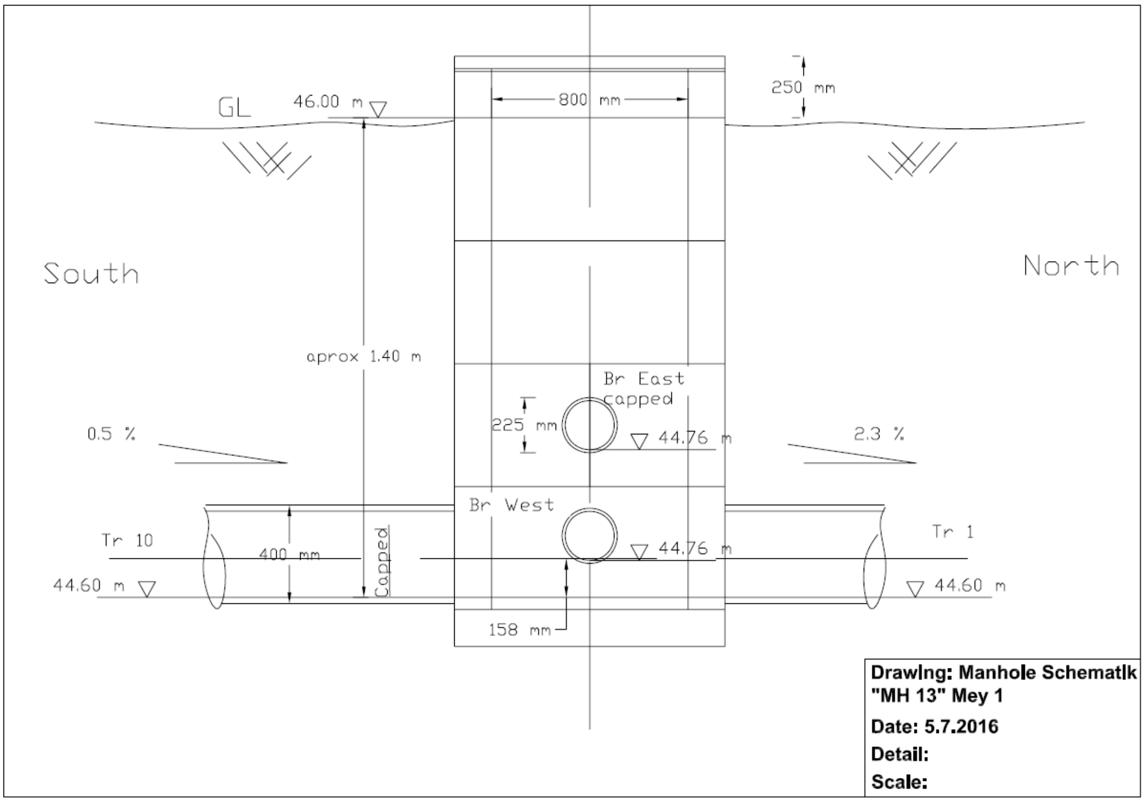
Manhole 8 (top) *Manhole 9 (below)*



Manhole 12 (remark: MH 10 and 11 are located on the Grace Branch)



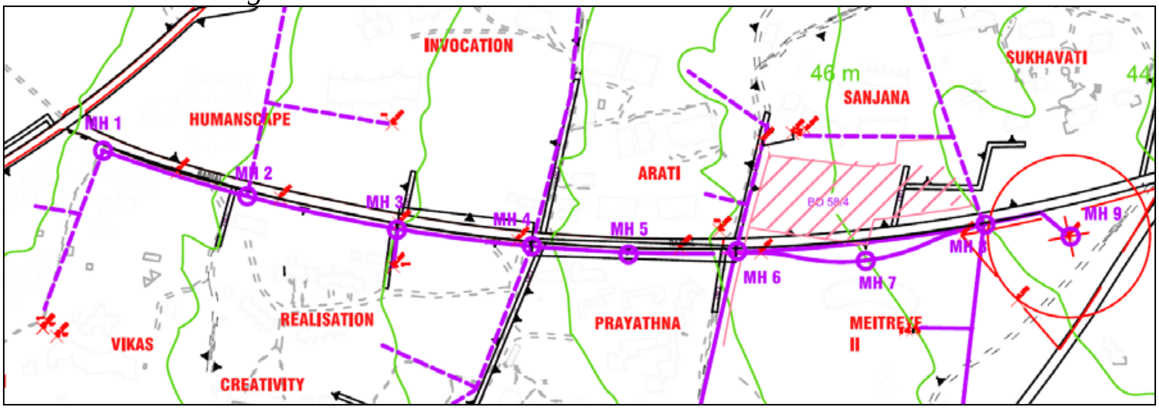
Manhole 13



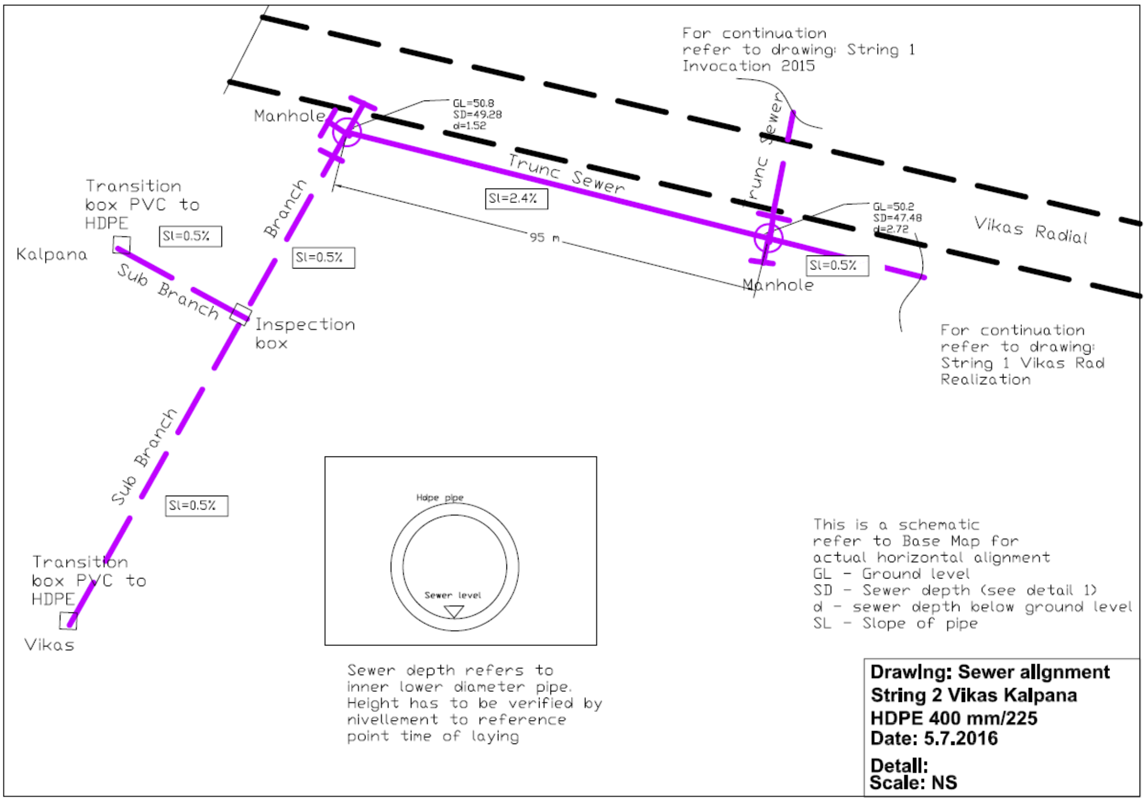
Extension of sewer network

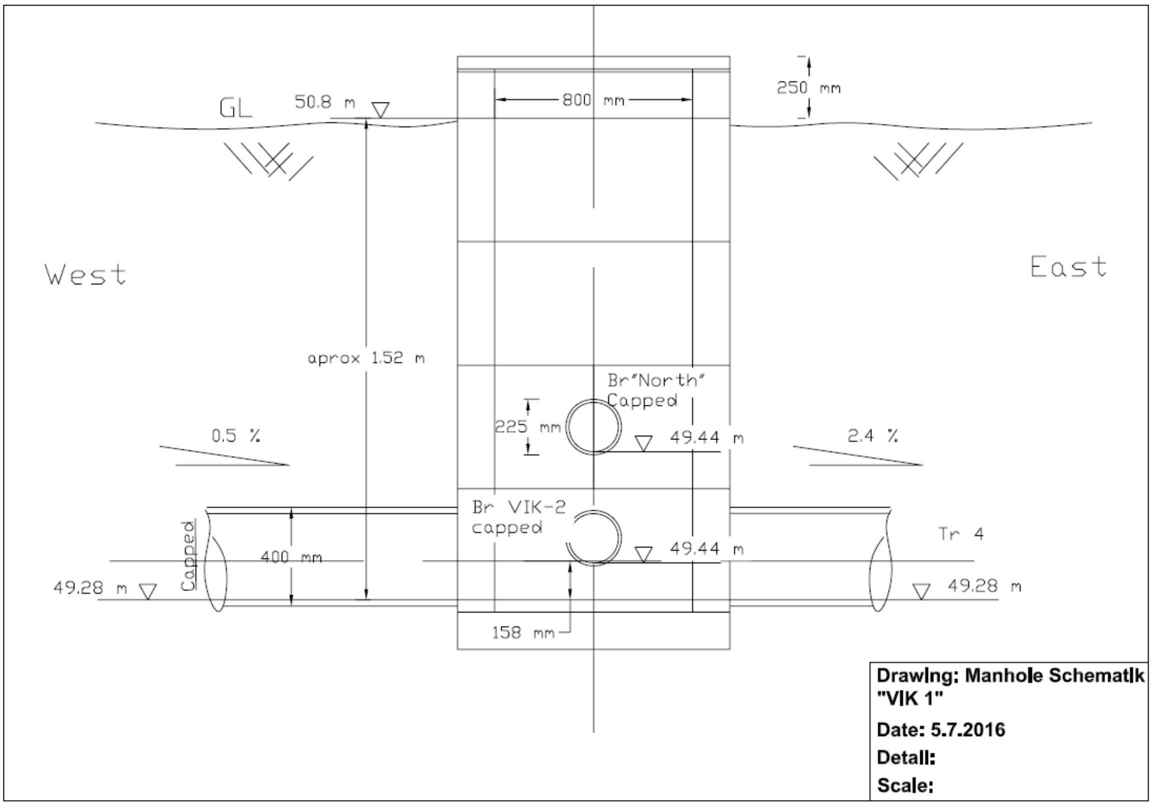
In the next phase the sewer will be extended along the Vikas Radial up to Vikas.
The horizontal and vertical alignment is given here under.
Sewer alignment and manhole position overview.

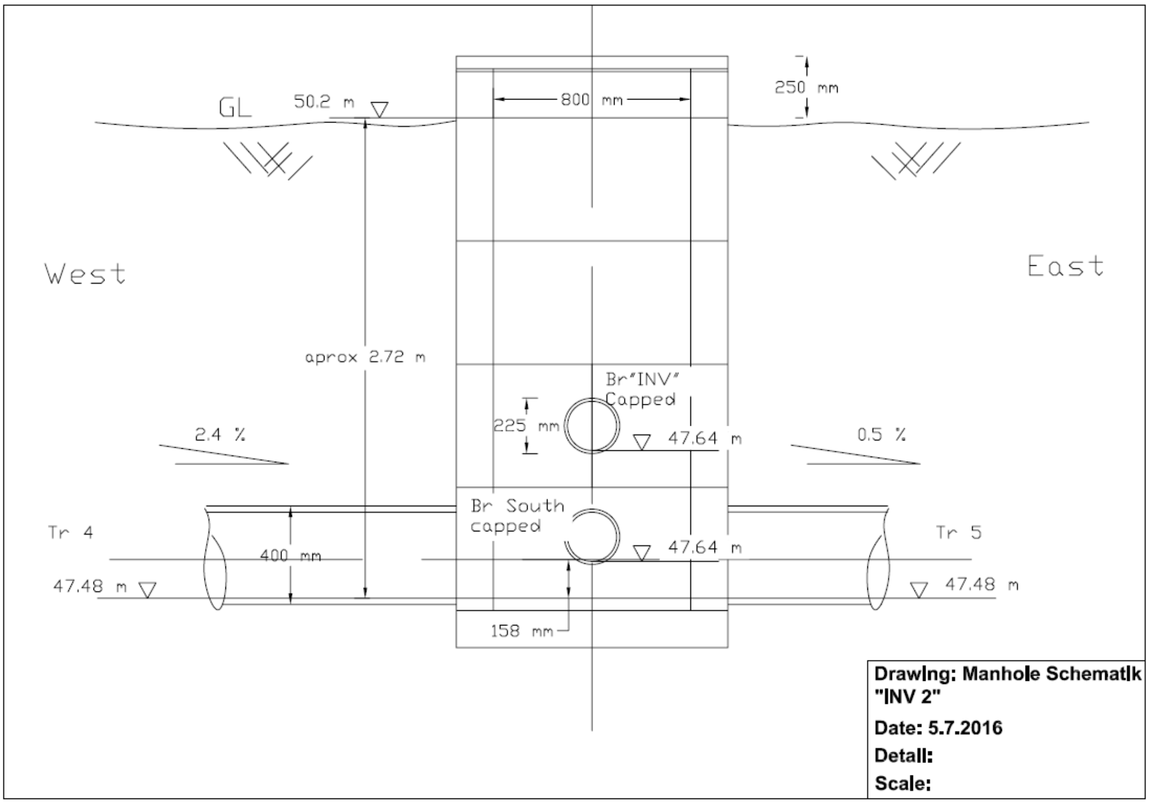
Manhole numbering



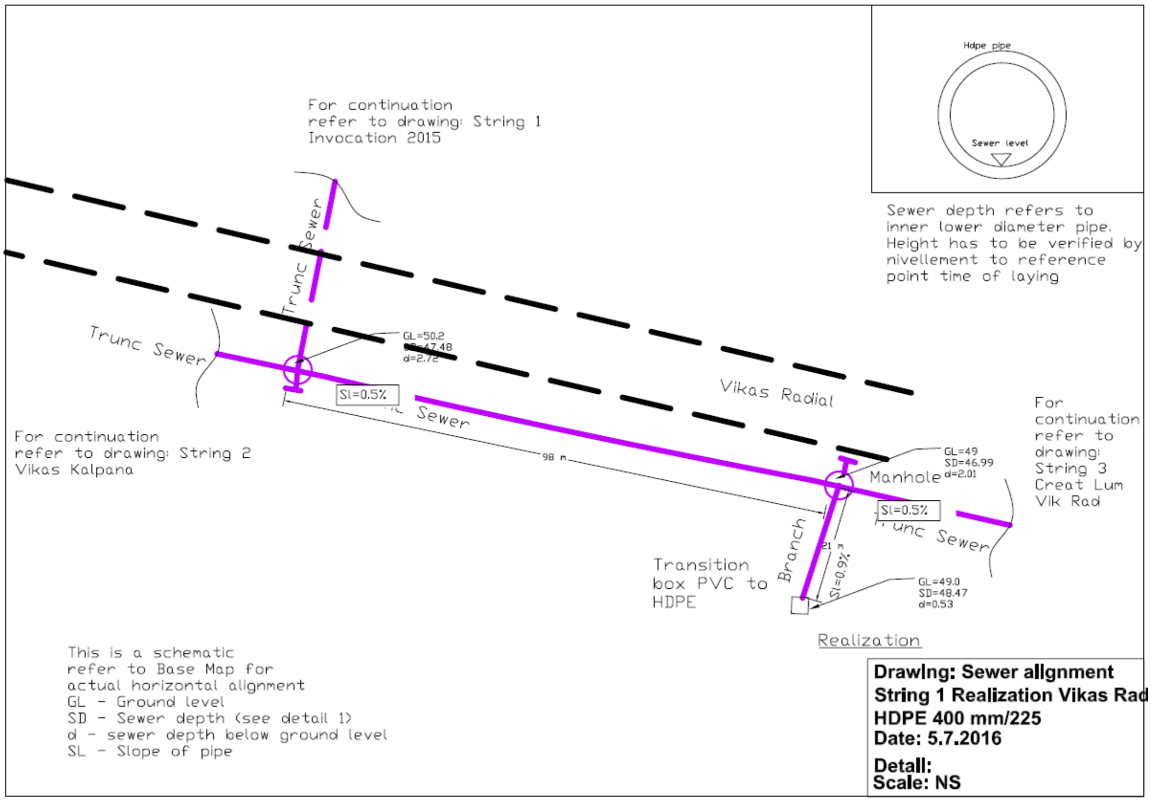
Manhole 1 and 2

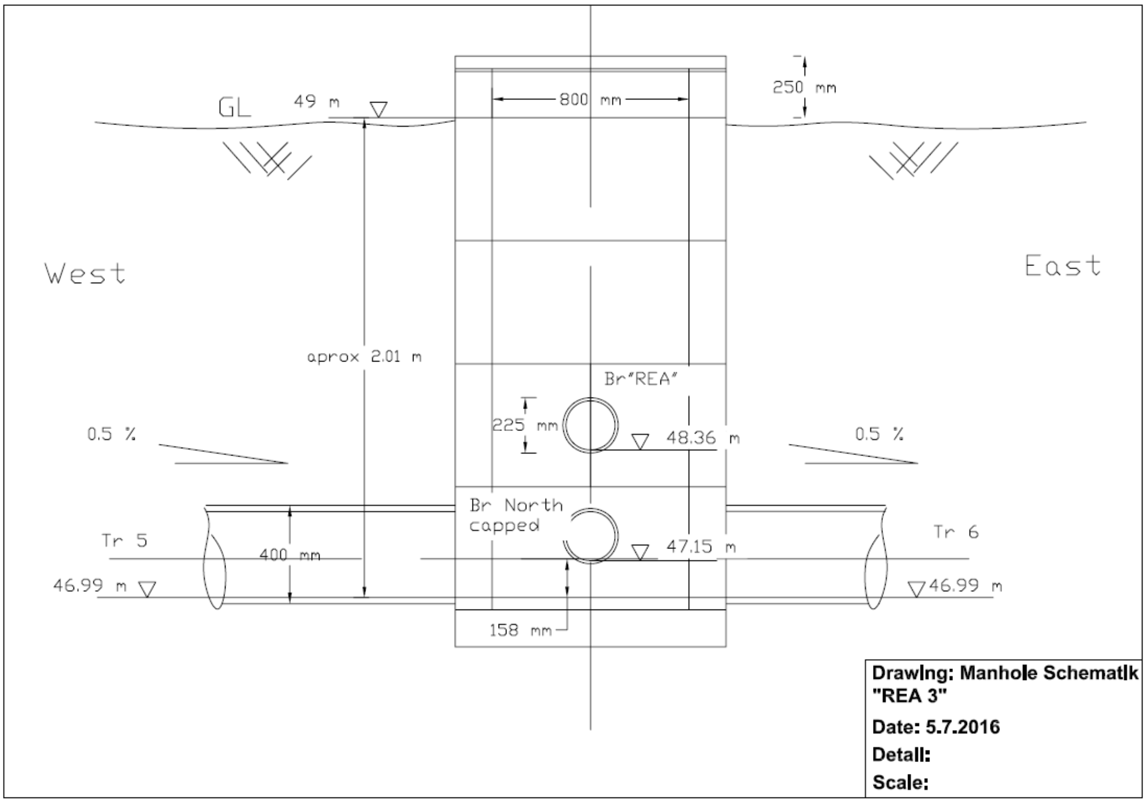




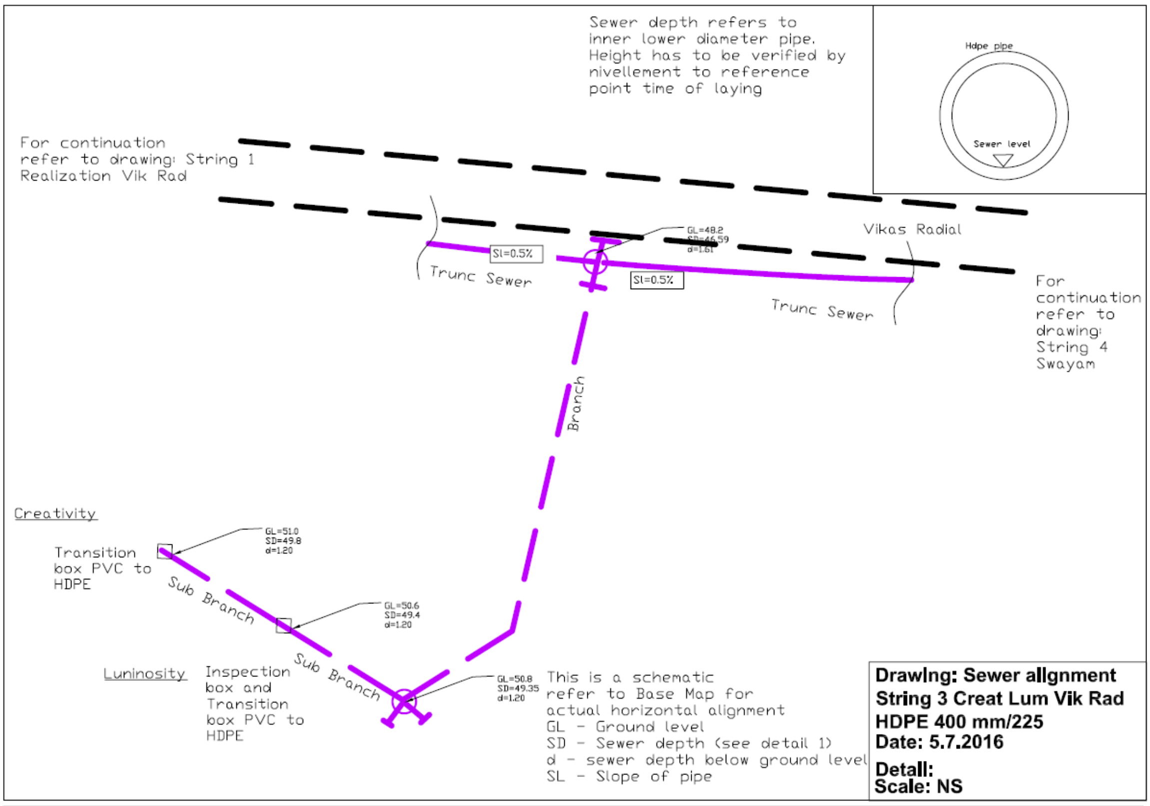


Manhole 2 (details previous page) and 3

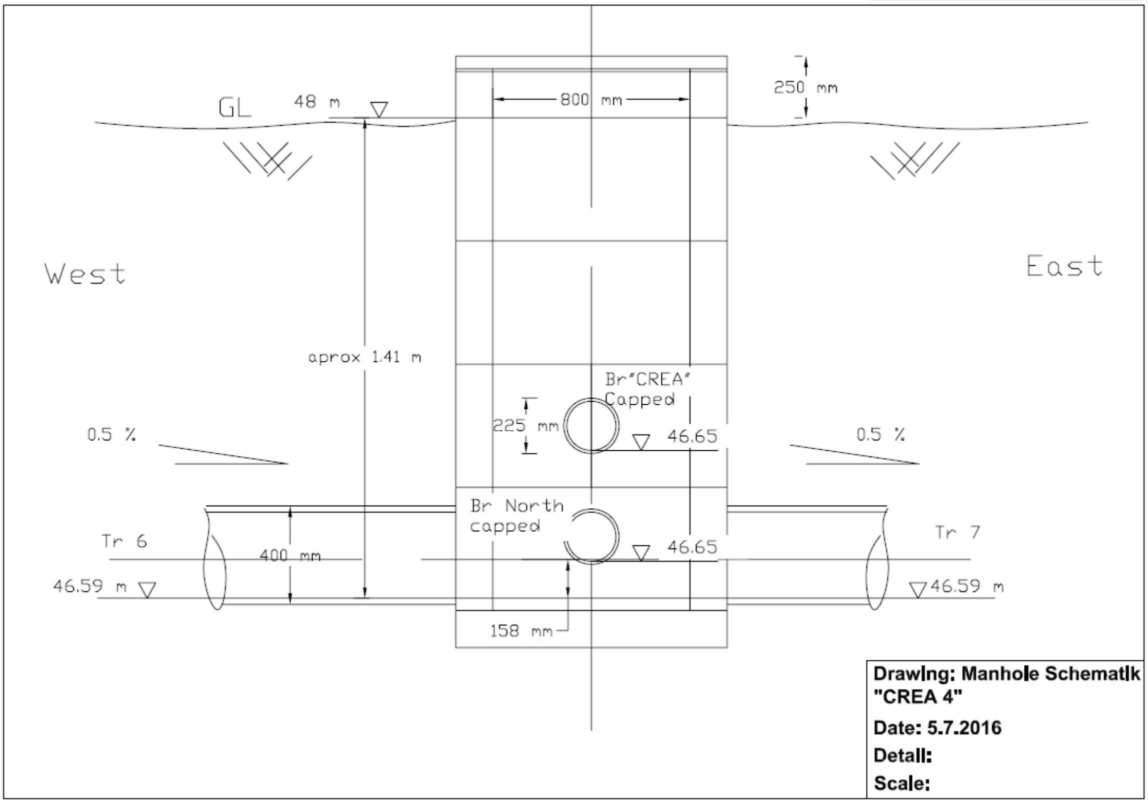

Hdpe pipe
Sewer level
Sewer depth refers to inner lower diameter pipe. Height has to be verified by nivellement to reference point time of laying
For continuation refer to drawing: String 1 Invocation 2015
Trunc Sewer
Trunc Sewer
GL=50.2
SD=47.48
d=2.72
Sl=0.5%
Sewer
98 m
Vikas Radial
For continuation refer to drawing: String 2 Vikas Kalpana
For continuation refer to drawing: String 3 Creat Lum Vik Rad
GL=49
SD=46.99
d=2.01
Manhole
Sl=0.5%
Trunc Sewer
Branch
Sl=0.9%
GL=49.0
SD=48.47
d=0.53
Transition box PVC to HDPE
Realization
This is a schematic refer to Base Map for actual horizontal alignment
GL - Ground level
SD - Sewer depth (see detail 1)
d - sewer depth below ground level
SL - Slope of pipe
Drawing: Sewer alignment
String 1 Realization Vikas Rad
HDPE 400 mm/225
Date: 5.7.2016
Detail:
Scale: NS


GL 49 m
800 mm
250 mm
West
East
aprox 2.01 m
Br"REA"
225 mm
48.36 m
0.5 %
0.5 %
Br North capped
47.15 m
Tr 5
400 mm
46.99 m
Tr 6
46.99 m
158 mm
Drawing: Manhole Schematik "REA 3"
Date: 5.7.2016
Detail:
Scale:

Manhole_4

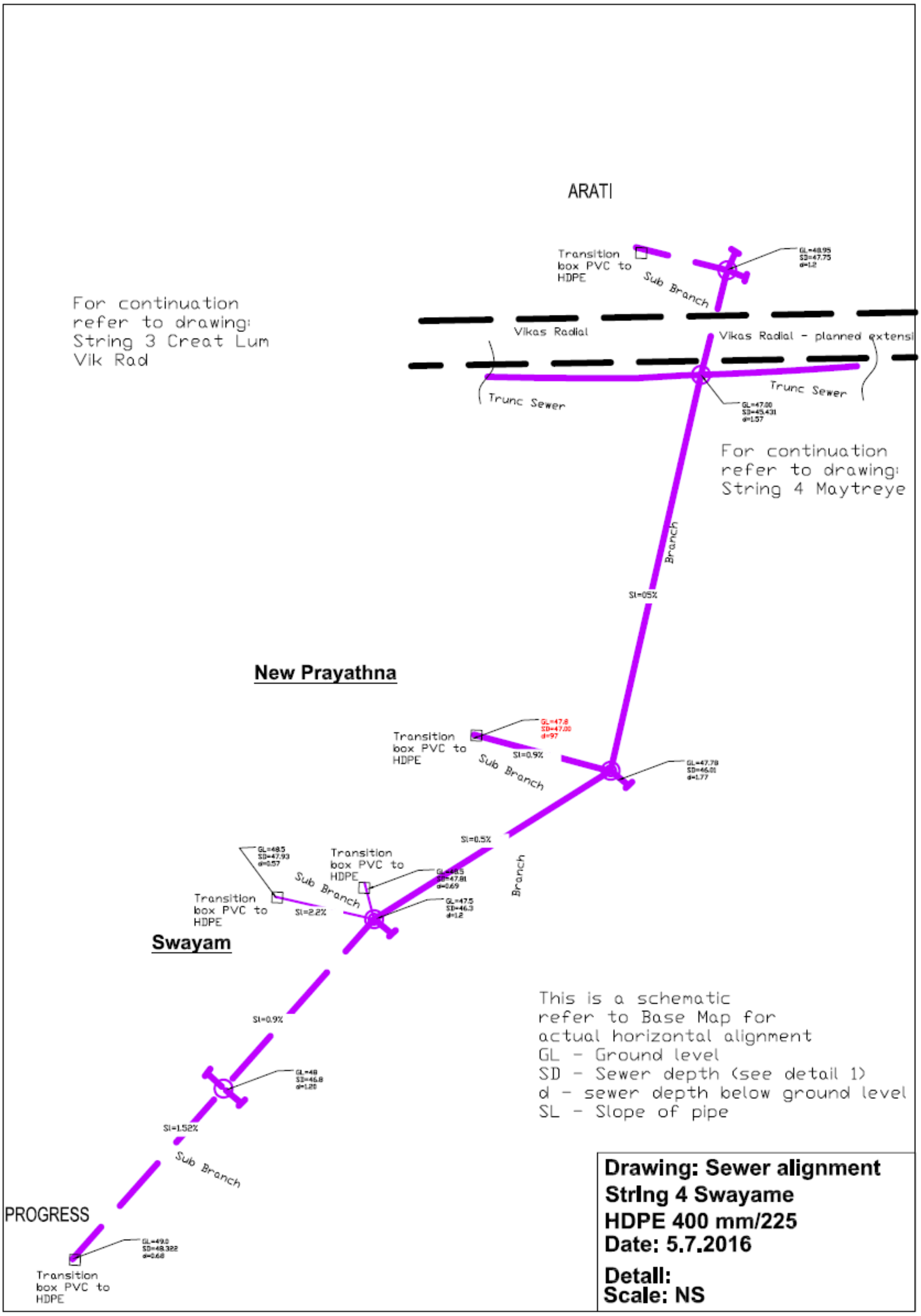


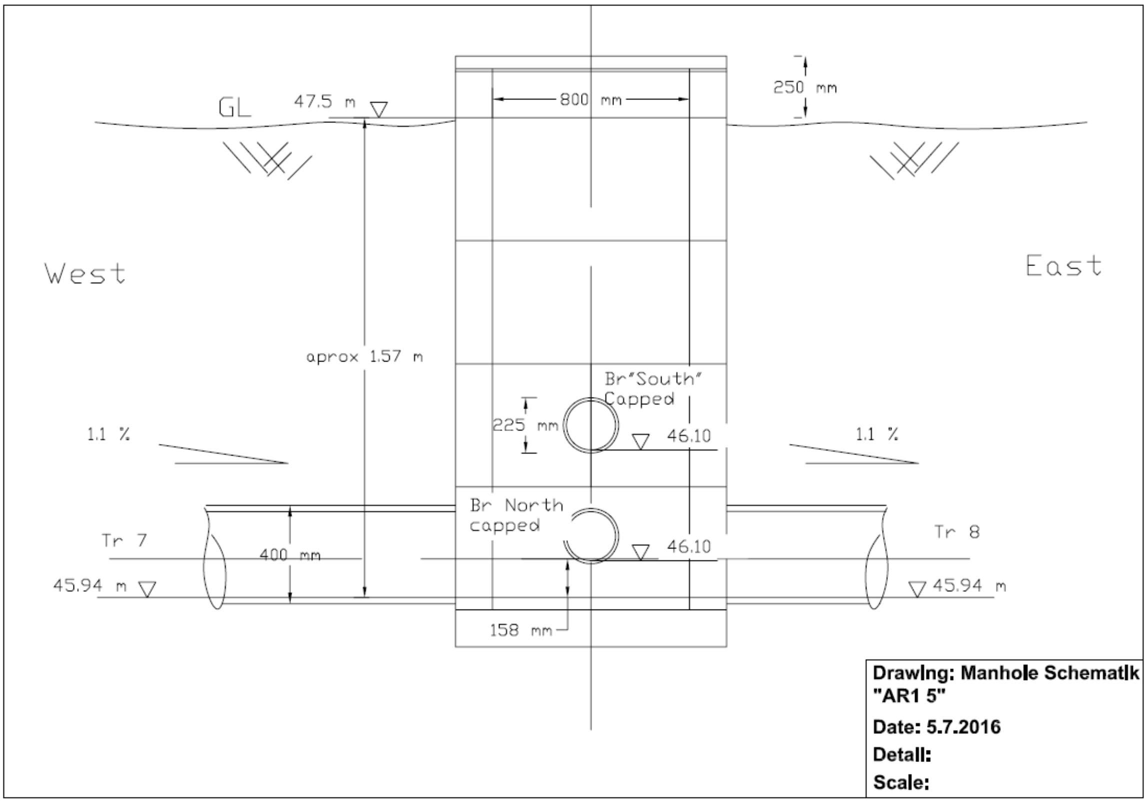
Sewer depth refers to inner lower diameter pipe. Height has to be verified by nivellement to reference point time of laying
Hdpe pipe
Sewer level
For continuation refer to drawing: String 1 Realization Vik Rad
SI=0.5%
GL=48.2
SD=46.59
d=1.61
Vikas Radial
Trunc Sewer
SI=0.5%
Trunc Sewer
For continuation refer to drawing: String 4 Swayam
Branch
Creativity
Transition box PVC to HDPE
GL=51.0
SD=49.8
d=1.20
Sub Branch
GL=50.6
SD=49.4
d=1.20
Luninosity
Inspection box and Transition box PVC to HDPE
Sub Branch
GL=50.8
SD=49.35
d=1.20
This is a schematic refer to Base Map for actual horizontal alignment
GL - Ground level
SD - Sewer depth (see detail 1)
d - sewer depth below ground level
SL - Slope of pipe
Drawing: Sewer alignment
String 3 Creat Lum Vik Rad
HDPE 400 mm/225
Date: 5.7.2016
Detail:
Scale: NS



GL 48 m
800 mm
250 mm
West
East
aprox 1.41 m
Br"CREA" Capped
225 mm
46.65
0.5 %
0.5 %
Br North capped
46.65
Tr 6
400 mm
46.59 m
Tr 7
46.59 m
158 mm
Drawing: Manhole Schematik "CREA 4"
Date: 5.7.2016
Detail:
Scale:

Manhole 5

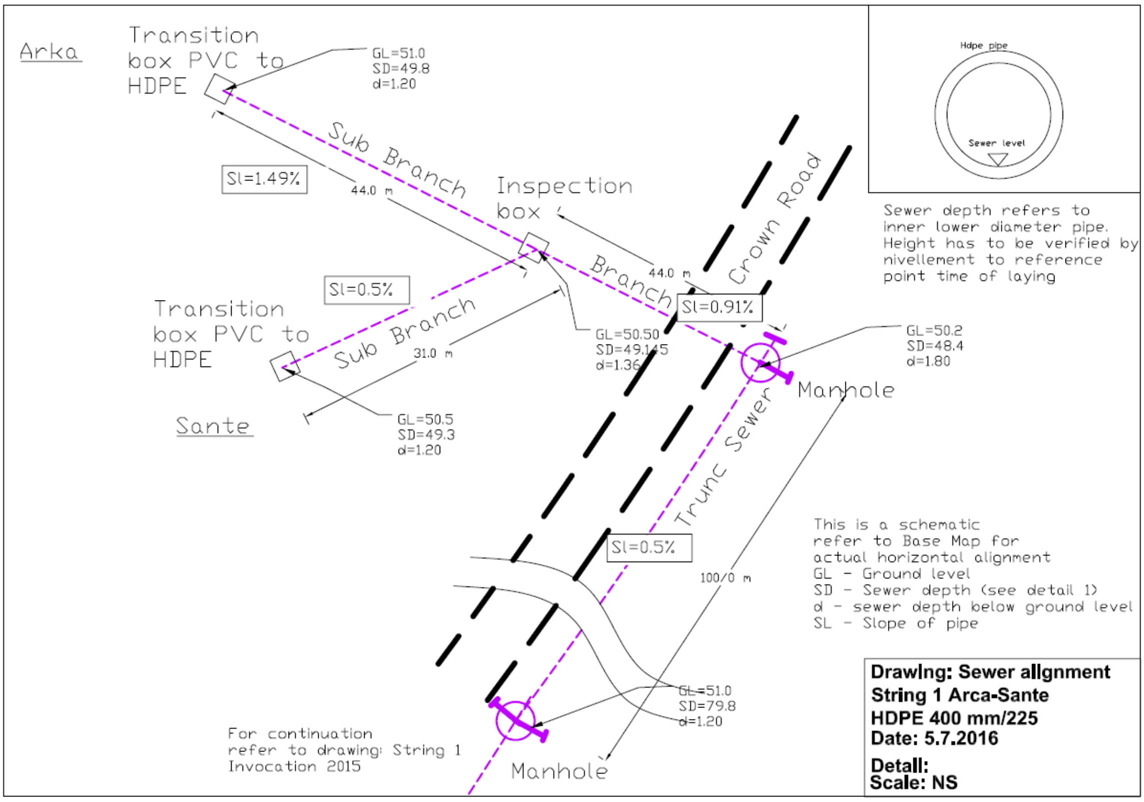

ARATI
Transition box PVC to HDPE
Sub Branch
For continuation refer to drawing: String 3 Creat Lum Vik Rad
Vikas Radial
Vikas Radial - planned extensi
Trunc Sewer
Trunc Sewer
For continuation refer to drawing: String 4 Maytreye
Branch
New Prayathna
Transition box PVC to HDPE
Sub Branch
Branch
Transition box PVC to HDPE
Sub Branch
Transition box PVC to HDPE
Swayam
This is a schematic refer to Base Map for actual horizontal alignment
GL - Ground level
SD - Sewer depth (see detail 1)
d - sewer depth below ground level
SL - Slope of pipe
Sub Branch
PROGRESS
Transition box PVC to HDPE
Drawing: Sewer alignment
String 4 Swayame
HDPE 400 mm/225
Date: 5.7.2016
Detail:
Scale: NS


GL
47.5 m
800 mm
250 mm
West
East
aprox 1.57 m
Br"South"
Capped
225 mm
46.10
1.1 %
1.1 %
Br North
capped
46.10
Tr 7
Tr 8
400 mm
45.94 m
45.94 m
158 mm
Drawing: Manhole Schematik
"AR1 5"
Date: 5.7.2016
Detail:
Scale:

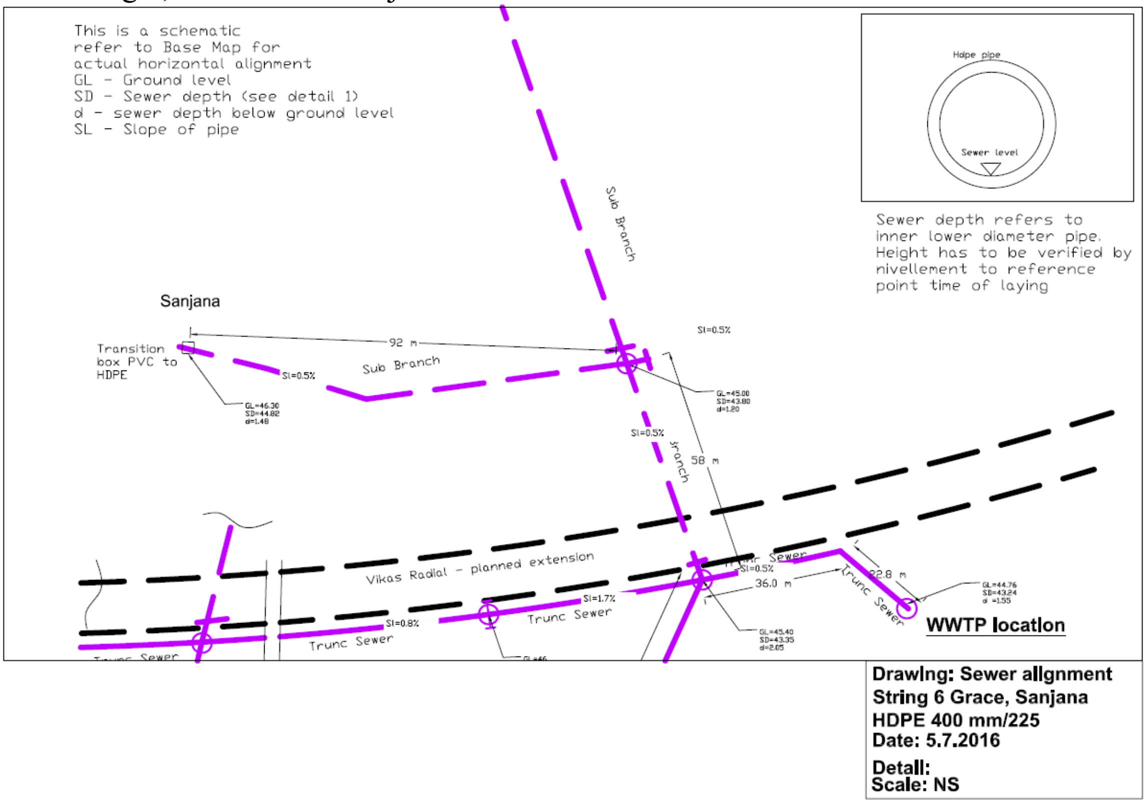
Future Extensions

Further extensions are possible so that most of the residences in RZ1 and RZ 2 can be connected. Example:

String 1 – extended to Arka and Sante



And String 6, extension to Sanjana and Grace



Recycled water return pipe and distribution system

The return pipe system for the recycled water is laid alongside the sewer pipe. It can be laid at constant depth of 80 cm below ground.
A low-pressure system is proposed with an end-of-line pressure of 0.5 bar.
The main pipe should be dia 110 mm HDPE, the branch pipes should be dia 63 mm HDPE. A valve is to be installed at each junction. The valve can be used to switch off the supply of the branch and also serves the purpose to limit the flow (partially closed) to communities closer to the supply so that the pressure at end-of line communities is maintained.
The branches and reducers of the return pipe follow the same concept as the sewer line.
When the sewer mains is a trunk sewer (dia 400 mm), the return pipe is a main supply of 110 mm.
When the sewer is a branch sewer (225 mm) the return pipe is a branch 63 mm
When the sewer terminates in a transition box at the community, the supply line is reduced to 40 mm with a tap as community outlet.
Valves are fitted at each branch (after the reducer) along the main supply line (Vikas Radial).
All connections for the return pipe can be "butt weld"

Pipes and taps should receive distinct markings so that they can not be mistaken for drinking water supply lines.
Clear and consequent marking of the pipe and valves for the return water is imperative to prevent accidental mix-up with drinking water supply. (see Parts 2, page 50)

The available quantity of recycled water is limited. When the reservoir (polishing pond) is empty, there will be no more water until it has refilled (say 12 hours).
It should be considered to supplement the recycled water with drinking water to ensure availability.
This would be applicable especially at the beginning, when :
a) sewage treatment plant has not completed "run in period" and water is not usable
b) quantity of recycled water is low because communities are only gradually connected

Acceptance and usage of the recycled water by end-user will depend on quality, but also availability when required.
Pressure valves to regulate the flow, as commonly used in drinking water supply will probably not work well in the media. Due to residue impurities that remain in the water they will tend to clog.

Hence the flow has to be regulated, by other means:

- variable frequency supply pump, to maintain pressure
- reducer at end user's outlet (40 mm)
- scheduled supply at different branches, for example every second day
- reducing the flow in a particular branch by only partially opening the branch valve

Typically watering in gardens will take place during morning hours, assume 8-11 am and afternoon 2-6 pm. Total 7 hours
Watering in the garden will mostly be done by hose pipe (assume 1 1/2') or drip irrigation
Minimum water pressure at the outlet of 0.5 bar should be maintained (design 1 bar)

Each community outlet should have a proper sign board indicating that this is non-potable water

Chapter 6 **- Environmental Considerations.**

The proposed treatment plant will considerably improve the waste water scenario in the Study Area. The effluent quality of the plant will be much better than those of the multiple existing small plants currently in use and treatment result will be well above any of the Indian Norms. The treated water will be used for gardening purposes and accomplish major savings in fresh water.
The effect of percolating the excess water after treatment into the ground was analyzed. It was found that the ground water table at the proposed location is sufficiently deep so that the natural bacterial action in the ground will remove remaining impurities from the water to the point were negative effects on the soil and groundwater are eliminated.
Measures to control development of vectors such as flies, mosquito etc. have been incorporated into the design of the plant and the sewer system.
During normal operation the aerobe processes in the plant cause no, or very little odor nuisance. The anaerobe processes happen in closed tanks and ventilation points will be equipped with an air scrubber. Provision for a stand-by aeration system have been made for the polishing pond.

Note on disposal of treated waste water by ground percolation

The waste water will be treated at the plant to a degree that it is safe for use as gardening water (see Part 2). The prevailing EU norms which are very similar to the guidelines that the WHO adopted were applied.
At times the demand for irrigation water may be less than the water that is available at the plant. This will almost certainly be the case during the monsoon time. Hence there has to be an alternative means of disposing of the treated water.
At full capacity (1st phase) the plant will treat 175 m3 water daily. The polishing pond offers intermediate storage over 24 hours. Although it might be feasible to provide larger surface storage tanks that can cover for example one entire week, it is not practical beyond a certain size. There are only limited other options for the disposal, such as discharge into a canyon or into the sea.
Ground percolation was chosen because it bears several advantages:
At the time when the water is released from the plant it has already been treated to be safe for irrigation. Pathogens have been eliminated and BOD and COD are greatly reduced. Small quantities of phosphorous and nitrate remain.
(3) names soil filtration as a very efficient means of further purification. The filter action of the earth retains bacteria, viruses and hemlines and bacterial action along the filter path eliminates phosphor and nitrates.
Hence by the time the water reaches the deeper ground levels it would have an excellent quality.
Infiltration into the soil will mostly take place during the monsoon time and go hand in hand with heavy rainfalls. This leads to a very good dilution ratio.
The water is partially stored in the ground and is available for the biosphere during the dry season

In order to asses if shallow ground percolation is a viable method to dispose of the treated waste water two aspects are of concern:
- the permeability of the soil has to be sufficient so that it can absorb the water and no ponding or clogging occurs.
- at he same time the draining water should move through the soil layers sufficiently slow so that bacterial action can eliminate residue pollutants.

The treatment plant is set in a rural environment surrounded by large open areas were life stock (cows and goats) and wild animals freely roam. Hence typically the surface soil layers are heavily contaminated by feces. During rains the microbes are washed into the deeper soil layers.
Especially during the first rains after a long dry spell (summer) the surface water that percolates into the ground carries a heavy organic load.
Interestingly, the analysis of ground water samples rarely show a contamination of the groundwater with e-coli. This is due to the above mentioned fact, that soil filtration effectively eliminates the bacteria.
The proposed waste water treatment plant is located on the eastern edge of the “Auroville Plateau” at an elevation of 50-52 m above mean sea level. The plateau is inclined along the west-east axis sloping downwards to the sea.
(4) identifies the sub surface geological layers as result of Quaternary (time span reaching from today – 2,6 mil. years back), Tertiary (2.6 mil – 66 mil years) and Mesozoic (66 mil – 252 mil years) sedimentation on the crystalline base rock that is found 300-400 m below ground level. The result is a 8-layered geological system with alternating sandstone and clay layers with 3 distinct water bearing layers (aquifers).

The subsurface geological formations follow approximately the same west-east inclination of the surface terrain.
Several bore wells have been drilled in the nearby community "Sharanga" which lies about 200 m towards the south-west of the proposed site. The records of these drill sites are available and serve as basis for the following lithology.

Layer description	*depth below ground level "from – to"*
Lateritic top soil	0-6 m
Fine to coarse grained sand stone	6-30 m
Clay and siltstone	30 -38m
Lime stone	38-60m

The layers below this level are of lesser importance for these considerations

In 1984 the static ground water level was recoded at 21 m below ground level. Although the water level varies during the seasons of the year, a constant decline has been observed over the years and it is now considerably deeper than in 1984.

Important for the assessment is chiefly the thickness and conductivity of the upper most layers along with the depth to groundwater.

(4) gives a mean conductivity of the upper layer as k= 10-2 – 10-3 cm/s. Taking the higher value as a reference, water percolated into the ground would reach the ground water level after about 4 days.
(5) gives a value of surface infiltration rate for the area of 10-15 cm/h. This shows that the infiltration capacity of the ground is sufficient. An area of 72 m2 for the leach field would be sufficient to infiltrate the water that is treated in phase 1 at maximum capacity.

Part of the water from the plant should be percolated through the leach field throughout the year to help maintain beneficial bacteria blanket.

(4) Hydrological conditions in Auroville, Central Ground Water Board, May 1984

(6) Surface water potential for Auroville, March 2013, CSR

Noise emission

During normal operation the main sources of noise at the plant are the electrical pumps. During power outages the diesel generator would run. The sound emission can be reduced by proper sound insulation. It is estimated that maximum noise emission will be limited to 45-50 dB.

Legal – environmental clearance

Legal requirements for the construction and operation of this project were researched.

Waste water treatment plants do not generally need environmental clearance. Only public plants which are set up and managed by the State Industrial Infrastructure Corporation require prior environmental clearance.
In the current project, all aspects of the operation, including the sewage line and the treatment plant will be physically connected and under the ownership and operation of the Auroville Foundation. Hence there is no obligation to seek environmental clearance.
Building application should be filed for at L'Avenier Planning Office.

Annexure :

All annexure are available in "soft copy" on the l'avenir's google drive

Sources:

[1] Imhoff, Taschenbuch der Stadtentwaesserung
[2] Indian Manual on Waste Water
[3] Ireland EPA Water Treatment Manual
[4] US EPA 2000
[5] Agences de l'Eau, France
[6] EM Water
[7] BORDA, DEWATS Handbook
[8] Performance evaluation of integrated treatment plant of trickling filter and constructed wetland, Jan 2012
[9] Various publications listed below
[10]
[11]
[12]
[13]

Publications:

Indian Standards

Indian Manual on Water Supply and Treatment, 1999

Manual on Sewerage and Sewage Treatment Systems, Ministry of Urban Development, 2013

National Urban Sanitation Policy
Ministry of Urban Development, Government of India

Ministry Of Urban Development
Recent Trends In Technologies In Sewerage System, 2012,
Government Of India

Guidelines For Water Quality Management, Central Pollution Control Board, 2008

Surface Water Quality Standards IS: 2296

Simplified sewerage manual

WHO

Safe reuse of WW WHO Vol 1
Safe reuse of WW Agriculture WHO Vol 2
Safe reuse of WW Agriculture and excreta WHO Vol 3
Safe reuse of WW excreta and greywater WHO Vol 4

International Standards

Composting dewatered sewage sludge, U.S. Department Of Health, Education, And Welfare/

Use of Municipal Solid Waste Compost and Waste Water Biosolids with Co-Composting Process, M.H. Hasanimehr, H. Amini Rad, V. Babaee and M. Sharifzadeh ,2011

European Union

91271EEC Communication From The Commission To The European Parliament And The Council

Developing a New Bathing Water Policy, 2000

Revised by Directive 2006/7/EC of the European Parliament management of bathing water quality

US

Guidelines for Water Reuse U.S. Environmental Protection Agency, 2004
California: Health and Safety Code, Title 22

Company Brochures and leaflets (see annexed DVD)

Sewerage

Underground-drainage-system
Lakshmi-corporations
Nu-DrainUDS system
UPVC pressure pipes and fittings
SWRMultiPage

Gas Turbines

CR30 MicroTurbine Renewable Fuels