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REPORT

Hartebeestpoort Housing Development - Water and Sanitation Feasibility Study

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EXECUTIVE SUMMARY

This report is a desktop study of the technical feasibility regarding water and sanitation provision of the proposed Hartebeestpoort Development. The site being located within a well built-up area, connection to existing bulk infrastructure should not be problematic.

From this study it was determined that the size of the development in terms of number of housing units is too high to rely solely on the municipality for provision of their water and sanitation demands. *Only half the number of units may be developed based on the provisions made for water supply in the region.* Alternative water sources were explored such as groundwater and rainwater harvesting, while alternative wastewater treatment include on-site modular WW treatment plants, and greywater recycling systems.

If the City of Tshwane were to expand their services to accommodate the new development fully, an estimated capital cost of R51m should be allowed for water and sanitation. This excludes water and sanitation related to plumbing inside the buildings.

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LIST OF ACRONYMS

ADD	Average Daily Demand
HDA	Housing Development Agency
WwTW	Wastewater Treatment Works

1 INTRODUCTION

The Housing Development Agency (HDA) intends to develop a site as an inner-city project for integrated human settlement. Portion 237 of Farm Hartebeesport 328 JR 772 JR was identified as the site for this development. The site is in Jan Niemand Park and is bound by Stormvoel Road on the northern boundary, Derdepoort Road on the eastern boundary and a railway line on the southern boundary. There is no defined feature on the western boundary, but the closest developed area is Lindopark. A full feasibility study is underway to determine the best direction in which the site should be developed.

This report will cover the technical feasibility of the water and sanitation provision for the development. This study includes the calculation of the expected demand; the assessment of current municipal capacity regarding water and sanitation; and possible alternatives that can assist or replace municipal supply. Results of the aforementioned exercises and recommendations have been presented in this report study.

2 BACKGROUND

The area of the proposed development is located within a built-up area therefore most of the bulk services are already in place. Once the housing layout options have been confirmed, the ability for these bulk services to accommodate the new development may be determined. At this stage, the estimated number of units will be used to determine the water and sewer demand. No new pipelines outside the footprint, apart from short connections to the municipal pipelines traversing adjacent to the site, will be required. There will, therefore, be no impact on servitudes, graves, streams, wetlands, etc. are envisaged.

The site falls within the Municipality's current master plan as part of future development for Koedoespoort Station. The land use stated in the master plan is residential densification with approximately 935 dwelling units.

However, the proposed number of housing units to base calculations on was taken as 2207 residential dwelling units, 1.2 hectares of commercial development and a small portion (358 m^2) allowed for social facilities. This was based on preliminary calculations of available land of residential use.

3 OBJECTIVES

A feasibility study is a tool used to assess the value, plausibility and potential of the project. A feasibility study involves an in-depth exploration of all aspects of the project to determine an objective idea of the costs, benefits and risks involved. It must be thorough, unbiased and objective to determine that the project is realistic and has potential.

The five key areas of a feasibility study are technical, economic, legal, operational and scheduling feasibility.

- Technical feasibility focuses on the technical resources available and the hardware, software and other technology requirements of the proposed project, for example, service delivery, proximity to transportation nodes.
- Economic feasibility focuses on the cost-benefit analysis of the project, helps determine the viability, cost and benefits associated with the project before financial resources are allocated.
- Legal feasibility investigates to ensure no aspects of the project are conflicting with legal requirements such as zoning laws.
- Operational feasibility studies analyse how the project plan satisfies the requirements identified in the requirements analysis phase of system development.
- Scheduling feasibility looks at the estimated time the project will take to complete.

When these areas have been examined, the feasibility study will identify constraints to the proposed project such as technical, budget, laws and regulations.

This report focuses solely on the technical feasibility of the water and sanitation amenities needed for the development. The technical feasibility contained in this report addresses the municipality's existing infrastructure and capacity to support the expected demand of the development and the feasibility of alternative water sources and wastewater treatment to augment the existing services.

4 DESIGN GUIDELINES

The water supply and sewerage system workstreams will commence once the Town Planners and Architects have shortlisted the site layout options to three (3) and this has been approved by the client.

The following infrastructure guidelines and design philosophy will be followed:

The design philosophy assumes that services would be provided at a level and cost that would be affordable to the beneficiaries, while taking cognisance of the life cycle cost of the infrastructure (i.e. the relationship between capital and maintenance costs). Therefore, the levels of service that will be proposed is based on current guideline documents, which include the following:

Table 1: Design Guidelines

Reference	Service	Design Guideline Document
A	Water	City of Tshwane: Water Services Guidelines
B	Sewer	City of Tshwane: Sewerage Reticulation and Links Guidelines

The design guidelines for each of the services are presented below.

4.1 Water Supply

- Level of service: Water supply will be provided by means of a metered water connection to each housing unit, with a waterborne sanitation system;
- Design Criteria: The proposed design criteria for this development have been extracted from the City of Tshwane design guideline documents referred to earlier;
- Water demand: Water demand figures for the proposed shortlisted site layout options will be informed by the guideline documents (references A and B);
- The following technical design guidelines will be followed:

Table 2: Water Design Guidelines

No.	Parameter	Description	Design Guideline
1	Pressure (head)	Maximum (static)	90m
		Minimum (at peak flow)	10m
2	Flow Velocity	Network pipe maximum	2,0 m/s
		Network pipe recommended	0,6 m/s
3	Peak Factor	Design Peak flow	2,2
		Unaccounted for water	20%
4	Fire Conditions	Risk Category	Category C
		Risk Category Flow	20 l/s, min 10m residual head in system
		Hydrant spacing	240m maximum
		Min pipe size for hydrant	110mm
5	Capacity	Reservoir / Supply line	Supplied by others
6	Hydraulic design	Darcy-Weisbach formula	k-value (mm)
			PVC-U Pipes k = 0,03
			AC Pipes k = 0,025

No.	Parameter	Description	Design Guideline
			Steel Pipes k = 0,02
7	Pipe Materials	Larger than 50mm dia	PVC-U Class 12 (minimum)
		50mm dia and smaller	HDPE Class 12 with approved compression fittings
8	Cover to Pipes	Minimum Cover	1 000mm in all areas
		Maximum Cover	1 500mm in all areas
9	House connections	Adjacent and across road	1 stand 40mm reducing to 25mm at erf
			2 stands 40mm branching to 2 * 25mm at erf
10	Location of Pipes		1,0m from stand boundary
			0,5m from other services in road reserve
11	Valves	Type	RSV's
		Closing	Counter clockwise, non-rising spindle
		Spacing	Max 600m, max 4 valves to isolate a section

The proposed water reticulation system for each site layout options will be shown on an A1 drawing. Positions of isolation valves, water meters as well as pressure reducing/sustaining valves will be proposed on this drawing.

4.2 Sewerage

- Design Criteria: The design criteria for the sewerage collection system will be informed by the design guidelines (references A and B). The interpretation and application of those guidelines are discussed below;
- Design Flow: The design sewer flows will be informed by form the design guidelines. Conservatively, the sewer outflow will be taken as equal to the water demand;
- The technical design guidelines have been obtained from references A and B, and are summarized below: -

Table 3: Sewerage Design Guidelines

No.	Parameter	Description	Design Guideline
1	Minimum pipe diameter	Gravity sewers	160mm
2	Min. velocity at full flow	Gravity sewers	0.7 m/s
3	Peak Factor	Internal Sewers	2.5
4	Infiltration	160mm dia Sewers	15%
5	Pipe Capacity	Flow level in pipe	70% of flow depth
6	Minimum slope for pipes	160mm dia	1 : 80
7	Pipe Material	All diameters	PVC-U Heavy Duty Class 34
8	Locations of Sewers	In Road Reserves	1.2m offset from boundary
9	Minimum Cover over pipe	In Road Reserves	1.5m
		Other areas	1.2m
10	Manholes	Spacing	80m maximum
		Fall across the MH	100mm

The proposed sewer collection system for each site layout options will be shown on an A1 drawing. Positions of manholes and connection to the municipal sewer will be proposed on this drawing.

5 WATER SUPPLY AND DEMAND

5.1 Water Demand

The water demand was calculated using the Guidelines for Human Settlement Planning and Design. The water demand is affected by the type of connection, a standpipe expecting a lower demand than a yard connection, which in turn will have a lower demand than house connections. The type of development also affects that water demand, whether a house dwelling, a low- or high-rise dwelling building, a clinic or a church etc. This particular housing development will contain low-rise multiple dwelling unit buildings, with house connections.

From the different methods in the guidelines for determining the average demand per unit, a conservative value of 900l/day per residential unit, 400 l/d per 100 m^2 of commercial development (offices and shops) and 500 l/d per 100 m^2 of social development were used. With the estimate of number of buildings on the site and the daily demand, the total water demand was determined to be 2.04 Ml/day.

5.2 Municipal Capability

There are three (3) reservoirs near the proposed development that may supply the site. These reservoirs are located at Waverley, Moreleta and Eersterust, as shown in Figure 1. It is most likely that the reservoir located at Moreleta will supply water to the proposed development. From a pressure perspective, the difference in elevation between the reservoirs and the new development is more than adequate to provide minimum feed pressure as per the Human Settlement Guidelines. Once the number of housing units and the associated water demand has been confirmed, an assessment on the bulk mains may be done.

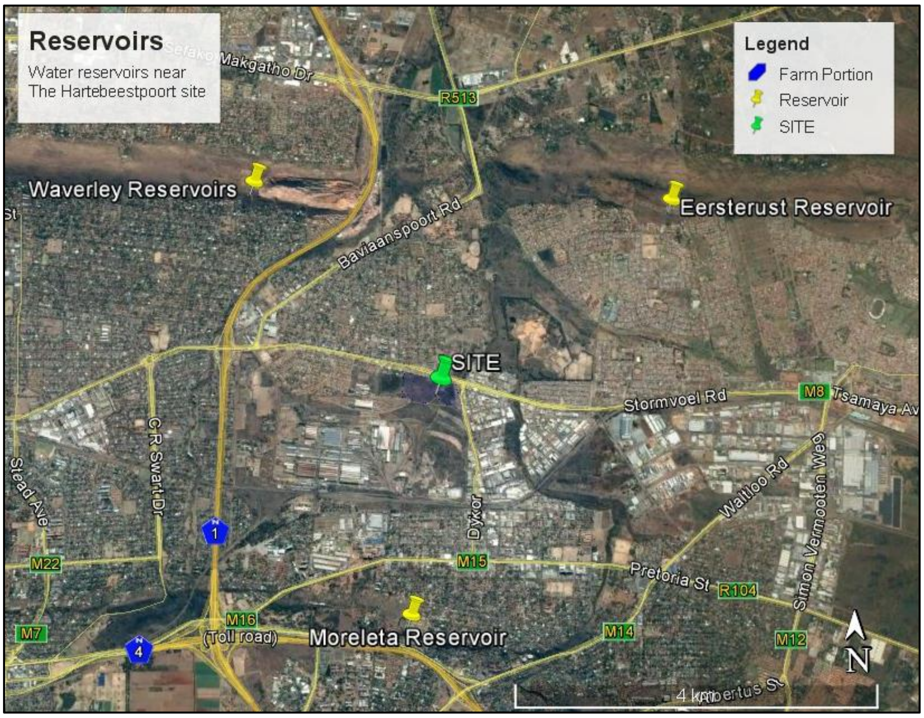

Figure 1: Water Reservoirs near proposed development site

According to provisional communication with the municipality, the master plan's land use for the area was residential densification which aligns with the vision and goals of this project. However, the expected number of the 935 units and the Average Daily Demand (ADD) was calculated as 936 kl/day. This is much lower than what the project anticipates, as it proposed 2207 residential and 5 commercial units with an ADD of 2040 kl/day. The deficit of 1104 kl/day that would have supplied approximately 1227 units. It is recommended that the number of units are reduced or an alternative water supply sources be found.

5.3 Alternatives

South Africa is classified as a water stressed country with an average rainfall of 492mm compared to 985mm received on average in most countries (Water Wise, 2016). By increasing the use of a variety of water sources can help relieve the pressure caused by our current reliance on surface water. These alternative water sources include groundwater, rain water harvesting and water recycling. These alternatives will be explored including their requirements to implement, and their advantages and disadvantages.

5.3.1 Groundwater supply

Groundwater is water located in the saturated zone below the earth's surface (see Figure 2). Ground water is stored in, and moves slowly through, moderately to highly permeable rocks

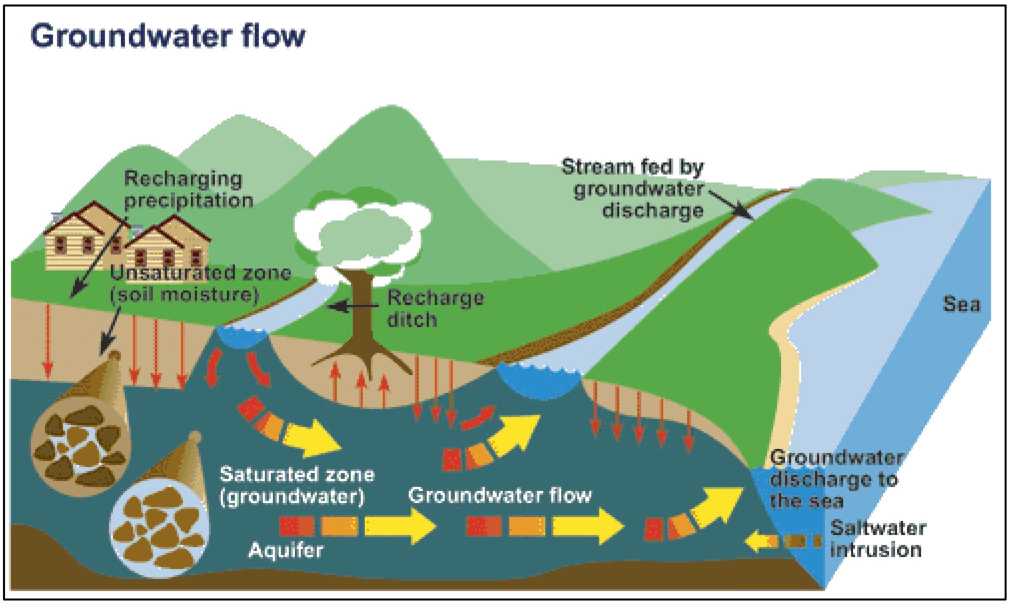

Figure 2: Groundwater Flow

called aquifers (National Centre for Groundwater Research and Training, 2012).

Drilling boreholes will provide access to groundwater that could serve as a potential water source.

Groundwater is acceptable for most uses. It is less susceptible to bacterial pollution than surface water because the soil and rocks act as a filter that screens out most bacteria. However, human activity such as improper disposal of waste etc, that could contaminate groundwater.

Regardless of the quality of the water, before it can be used in the house and deemed fit to drink, a water analysis must be done. This analysis will determine exactly what contaminants need to be treated and removed. Water purification is necessary before human consumption in accordance with the municipal by-laws. (Water Doctor, 2016)

The geotechnical study of the site found that in four (4) of the thirteen (13) test pits, groundwater seepage had occurred, at depths ranging between 0.5m and 1.3m. It was noted that this study was conducted at the beginning of the rainy season and the water table levels could increase during the rainy season.

5.3.1.1 Requirements

The cost of a borehole is largely dependent on its depth and the amount of casing to be used. The type of rock to drill through and the ground conditions also influences the price. Hence a thorough hydrogeological study of the site is needed. This will also determine the probability of finding suitable water, and the quantities that are available for use.

An understanding of the municipal by-laws and regulations regarding water use and environmental factors must be taken into consideration when deciding on groundwater sources. The borehole must also conform to safety regulations.

5.3.1.2 The Benefits

1. **Cost Saving:**

   Using borehole water will save money as it often costs less than the average of municipal water; as the main cost is only the electricity used to pump the water.

   The water is also locally sourced on the site, therefore saving cost and energy in terms of transportation. In addition, there are few ongoing costs associated with the borehole, if it is properly maintained.

2. **Avoid Price Increases:**

   The community will not be as affected by future increases in water prices.

3. **Improved Water Quality:**

   Improved quality of water as derived from a borehole is often of high quality as it does not have chemicals like chlorine and fluoride added to it.

   A quality borehole that is well maintained is an asset that can last up to fifteen (15) years.

4. **Drought Protection:**

   Borehole water supplies are sustainable in even drought conditions. Aquifers provide a large water resource that protects you against municipal water restrictions enforced during droughts.

5.3.1.3 Disadvantages and Concerns

1. The initial costs of drilling and installing pipes and pumps may be high.
2. Whether or not there is water, the client carries the cost of the borehole. Therefore, extensive research on the site is necessary in order to reduce the risk.
3. There are no water or sewerage pipes or electric cables under the ground where the drilling will take place.

5.3.2 Rain water harvesting

Rainwater harvesting is the collection, filtering, storage and distribution of rainwater. This can be used for irrigation of lawns, or as an emergency supply or even as a complete off-the-grid system. Depending on the volumes stored, the water could be collected into water tanks or reservoirs.

The system captures rainwater from the roofs of buildings. The water is then led through gutters to piping that contains a filter to filter the water before it is stored in the water tank. From these storage tanks, the water is pumped into the house for different purposes as demonstrated in Figure 3

The best method to amortize a rainwater system is to ensure the water is being used regularly, filling then effectively emptying the tanks as much as possible. By using the water for indoor purposes in addition to irrigation, the amortization can be reached sooner, and less storage will be needed. It is important that the tanks are never overflowing and that there are no tanks that do not get filled.

The installation would be designed based on factors influencing the household as well as the budget and aesthetics (H2O Harvesting Gauteng and NW Province, 2011).

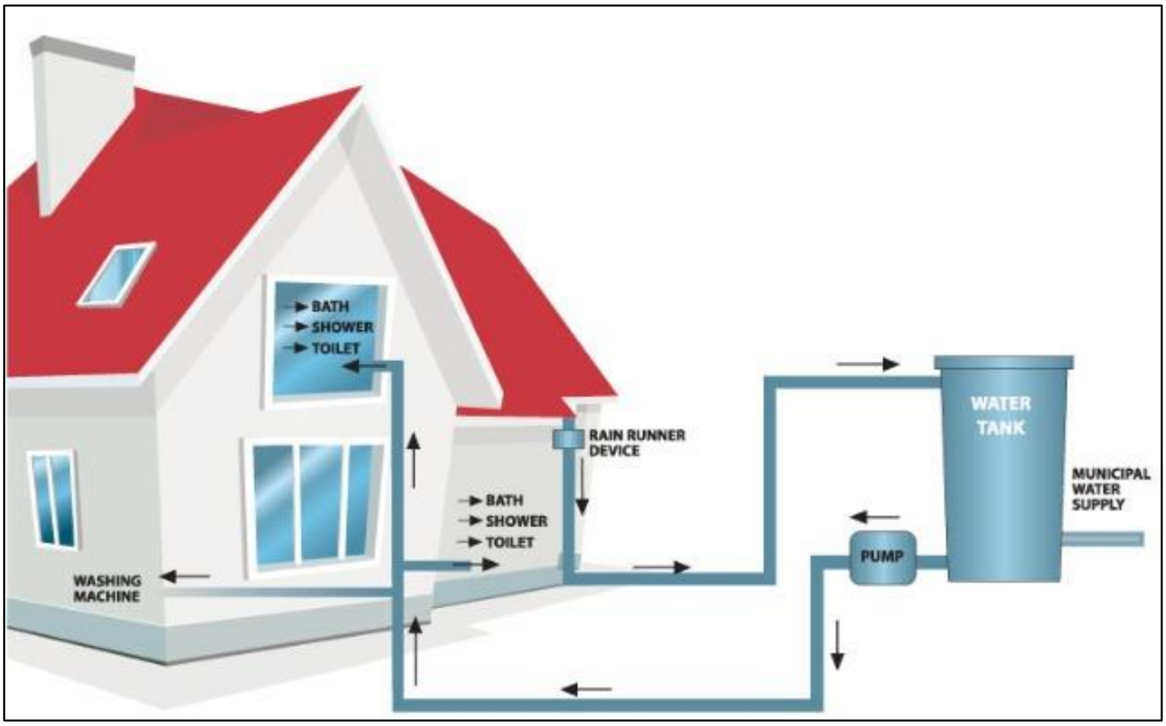

Figure 3: Rainwater Harvesting System

5.3.2.1 The Benefits

Utilizing rainwater harvesting systems provide certain advantages to the community. Firstly, it allows for better utilize an energy resource. It is important to do so since drinking water is not easily renewable, and it helps in reducing wastage. Systems for the collection of rainwater are based on simple technology making it easily accessible. The main advantages are listed below.

5. **Low-cost Maintenance:**

   Once the system is fully operational, not a lot of money needs to be invested in the maintenance of the system. Even less is required if the water collected is not for drinking purposes and does not need to be purified.

6. **Reducing Water Bills:**

   By collecting rainwater, the community would be less dependent on the municipality. If this water is used for multiple purposes, it will significantly reduce the water bill of the residents of the site.

   Most rooftops act as a workable catchment area, which can be linked to the harvesting system, thereby saving money for not having to set-up a catchment. This also lessens the impact on the environment by reducing use of fuel-based machines.

   The combination of all this will help save consumers money in the long run.

7. **Suitable for Irrigation:**

   Rainwater can be used for irrigation and watering of gardens, because it is free of the many chemicals found in groundwater. Therefore, this water can be used to water the lawns on the site.

8. **Reduces Demand on Ground Water:**

With the increased demand for water, a lot of groundwater is extracted to keep up with the demand. This results in low levels of groundwater. By harvesting rainwater, the stress on groundwater as well as surface water supplied by the municipality will be decreased.

9. **Reduces Floods and Soil Erosion:**

   By keeping rainwater from reaching the ground, it is possible to reduce the chances of flooding if carried out on a large-enough scale. Rainwater harvesting also reduces soil erosion and keeps surface water from being contaminated with chemicals from rainwater run-off. The reduced effect of soil erosion allows the land to thrive.

10. **Can be Used for Several Non-Drinking Purposes:**

    Rainwater when collected can be used for several non-drinking functions including flushing toilets, washing clothes, watering the garden, washing cars etc. It is unnecessary to use pure drinking water if all we need to use it for these other purposes, therefore purification can be removed from the process, and thus cutting costs.

5.3.2.2 Disadvantages and Concerns

1. **Unpredictable Rainfall:**

   Rainfall is hard to predict and sometimes little or no rainfall can limit the supply of rainwater. Therefore, it is not advisable to depend solely on rainwater for all your water needs in areas where there is limited rainfall.

2. **Initial High Cost:**

   Depending on the system’s size and technology level, a rainwater harvesting system can be very expensive and benefit from it cannot be derived until it is ready for use. Also, the cost can only be recovered in approximately 10-15 years which again depends on the amount of rainfall and sophistication of the system.

3. **Regular Maintenance:**

   Rainwater harvesting systems require regular maintenance as they may get prone to infiltration by rodents, mosquitoes, algae growth, insects and lizards. They can become as breeding grounds for many animals if they are not properly maintained.

4. **Chemical Seepage from Roofs:**

   Certain types of roofs may seep chemicals, insects, dirt or animal droppings that can be harmful to humans and plant life if it is used for without treatment for domestic use or to water the plants respectively.

5. **Storage Limits:**

   The collection and storage facilities may also impose restrictions as to how much rainwater you can use. During the heavy downpour, the collection systems may not be able to hold all rainwater which ends in going to drains and rivers. Therefore, it is important to tailor the tank capacity to the expected volumes of rainfall.

5.3.3 Greywater Recycling Systems

Greywater is defined as water from baths, showers, hand basins and clothes washing machines or the laundry. On the other hand, water from other household sources, for example, toilet water, and from kitchen and bidets, is considered black water and must be allowed to proceed to the sewer and be treated by sewerage treatment works.

Greywater recycling is the solution to problems relating to demand and supply management of water, not only in South Africa but worldwide.

There are different types of greywater recycling systems, from entry level systems that take greywater from the shower and basins is taken immediately to the garden; to more advanced systems that treat and store the water for re-use in toilets and irrigation.

5.3.3.1 The Benefits

1. **Conservation of water use:**

   Installing greywater systems will reduce the consumption of potable water. Greywater systems used to irrigate gardens or lawns have the potential to save 50 000 to 100 000 litres of drinking water a year (source).

   Less wastewater is generated that would have been taken to plants for treating and disposal. The lower water use would allow for more water to remain in the local watershed, while helping to ensure water demands are met.

2. **Reduces water costs:**

   Consequently, with the reduced water use the households would have reduced water costs.

3. **Brings extra nutrients to plants:**

   The greywater would contain extra nutrients that could benefit plants if the water is used for irrigation. This will also reduce the amount of fertilizer needed.

4. **Environmental benefits:**

   Greywater has environmental benefits such as the reduction of removal of freshwater from sensitive eco-systems; reduction and prevention of pollution from agricultural leachate; and saving of energy by not needing treatment and transportation.

5.3.3.2 Disadvantages and Concerns

1. **Possible diminishing sewage flow**
2. **Less reclaimed water for municipal use**
3. **Health Concerns:**

   There are concerns regarding the quality and health standards of the water. If the water is not filtered properly, it could cause disease or contamination. Greywater may contain fats, oils, grease, hair, lint, soaps, cleansers, fabric softeners, and other chemicals

4. **High initial costs:**

   The implementation of some of these systems can be expensive initially. Especially if the system is to be retrofitted to a house. Greywater systems are most cost effective if they are incorporated into new housing.

5. **Improvement appliances more cost effective:**

   As the efficiency of household appliances improves, there will be less water for re-use. For example, high efficiency clothes washer and water saving toilets, that can decrease water and energy use by 50%. These appliances are probably more cost-effective than a greywater system

6. **Limited storage period:**

   Greywater cannot be stored for more than 24 hours, as it has the potential to harbour undesirable bacteria that could multiple if stored for long periods without being properly being treated.

7. **Limited Functionality**

   Greywater poses a risk to health, therefore cannot be used indoor except for toilet flushing or on food plants when irrigating.

6 SANITATION SUPPLY AND DEMAND

6.1 Sewer Demand

There is no direct way to calculate how much the sewer demand is. Therefore, the expected sewer outfall was taken as 90% of the water demand, which is 1.83 Ml/day.

6.2 Municipal Capability

The closest wastewater treatment works to the proposed site is Baviaanspoort Wastewater Treatment Works (WwTW), located approximately 11km away from the proposed development. However, there is a low difference in elevation means that the outfall sewer gradient to the WwTW is very flat. Two alternative wastewater treatment works may be considered in the feasibility study. These are Zeekoegat WwTW and Rooiwal WwTW however these sites are quite a distance away from the proposed development, 11 and 18 km away respectively. The life cycle costing during the options analysis stage will inform our decision on the preferred WwTW.

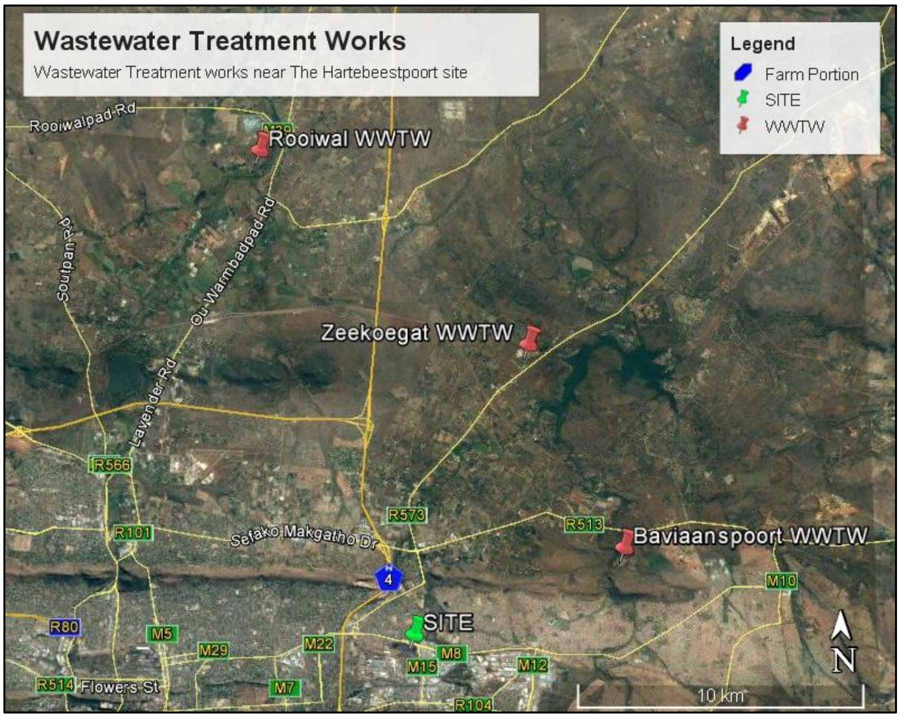

Figure 4: Wastewater Treatment Works near proposed development site

The above portion currently does not have existing sanitation services. However, the portion falls within the Moreleta drainage area and the waste water from this area can be treated at Zeekoegat WwTW and Rooiwal East WwTW.

From the municipality, it was learnt that the capacity of the Rooiwal East WwTW and Zeekoegat WwTW have been exceeded. There are plans to upgrade both plants. Zeekoegat WwTW is expected to increase capacity by 130Ml/d in three phases. Rooiwal East WwTW expects a capacity increase of 45Ml/d. However, no indication was given as to when this would happen.

The estimates of how much the plants would be able to take are not currently available. Therefore, alternative treatment options were investigated in order to alleviate the stress on the wastewater treatment works.

6.3 Alternatives

6.3.1 Package treatment plants

Modular systems take up less space than conventional water plants and contain very few moving parts. The result is an efficient, highly reliable and affordable wastewater treatment plant with low maintenance requirements and low operating costs.

Depending on the site requirements and specific factors unique to that application, the processes used will differ. These processes include clarification, sand filtration, carbon filtration, ion exchange, softening, activated sludge and bio-disk.

6.3.1.1 The Benefits

1. **Ideal for remote locations**
2. **Lower day-to-day maintenance and simple operation**
3. **Relieves the pressure on local municipalities**

   Municipal wastewater treatment plants are over capacity. By treating the wastewater on site, the load at municipal plants is reduced.
4. **Tailored Design:**

   The modules are designed to use the specific requirements of the community.
5. **Flexible:**

   The modules can easily be transported to a different location or extended if need be.

6.3.1.2 Disadvantages and Concerns

1. **Space Limitations**

   Despite the smaller size of modular treatment plants, they still require a considerable amount of land, for the installation of the modules and associated infrastructure.

2. **Noise and Odour Concerns:**

   Having the plant close to residential areas, it is important to ensure that the smell and noise from the plant is unnoticeable, for the comfort of the residents.

6.3.2 Greywater Recycling System

Grey water is the biggest contributor to wastage of water. About 33% of water consumed in the home is normally disposed of. Greywater is very useful for two main purposes: re-use for irrigation or re-use for toilet flushing, and in some special cases for the washing of clothes. Therefore, by recycling greywater, less water is unnecessarily taken to treatment plants

The benefits and drawbacks of a greywater system were discussed in sections 5.3.3.1 and 5.3.3.2 respectively.

7 COSTS

7.1 Capital Cost Estimate

The municipality has indicated that they would not be able to accommodate the entire development based on provision made in their Masterplan. Based on this, no cost was provided for the upgrade of the bulk water supply system. They did indicate though that their water system will need to be modelled fully to understand where changes are required to accommodate the development. In order to undertake this modelling, their consultant will need to be appointed and reimbursed by the developer. Since we did not have the mandate to appoint their consultant, an estimate of R5 million was made here. The cost for the extension of the existing pipeline to the development, the reticulation inside, municipality connection fee (estimated at R3,500 per connection) as well as the provision for the networks upgrades was estimated to be R24.4 million.

At present, the municipality would not be able to cover all the capital costs for the upgrades to the sewer networks. However, the municipality already intends to upgrade most of the system, therefore they will be able to partially fund the costs; the balance would then have to be covered by the developer. An estimate for the upgrade of the sewer system as provided by the municipality was in the region of R1 million. The total costs of sanitation, inclusive of municipality's connection fees (estimated at R7,000 per connection) is estimated to be R26.5 million.

The total cost to be provided for water and sanitation is estimated at R51 million.

7.2 Alternative costs

Capital costs estimated for providing alternative ground water supply could be estimated at R1 million for abstraction and R20 million per megalitre of water treated with an operational cost of

R20 per kilolitre of water treated. A geohydrological study needs to be done to determine if the appropriate yield is available on site.

The cost estimate for providing wastewater treatment is approximately R30 million per megalitre of wastewater treated with an operation cost of R30 per kilolitre of water treated. Treated water may be discharged to the adjacent stream however a Water Use Licence from the Department of Water and Sanitation will be required.

8 LAYOUT

The existing networks of water distribution and sewer systems are Figure 5 and Figure 6. They show that there are no services on the site, as well as south of the site. The 110mm diameter pipe would be extended to connect the site to the water distribution network as shown in red in Figure 5. It was decided to extend the larger pipe, to ensure it can carry the increased capacity. There are manholes, encircled in Figure 6, that can be used for sewer connection. Connection on the west side is preferred as it will not interfere with existing roads. The most probably connection points would be to the west as its piping network is closest.

Without the site layout options, drawings on the internal network could not be prepared. However standard drawings for the water network are attached in Appendix C. These include house connections, water hydrants, standpipes, valves and piping. Standard drawings for the sewer network include sewer house connections, and manholes.

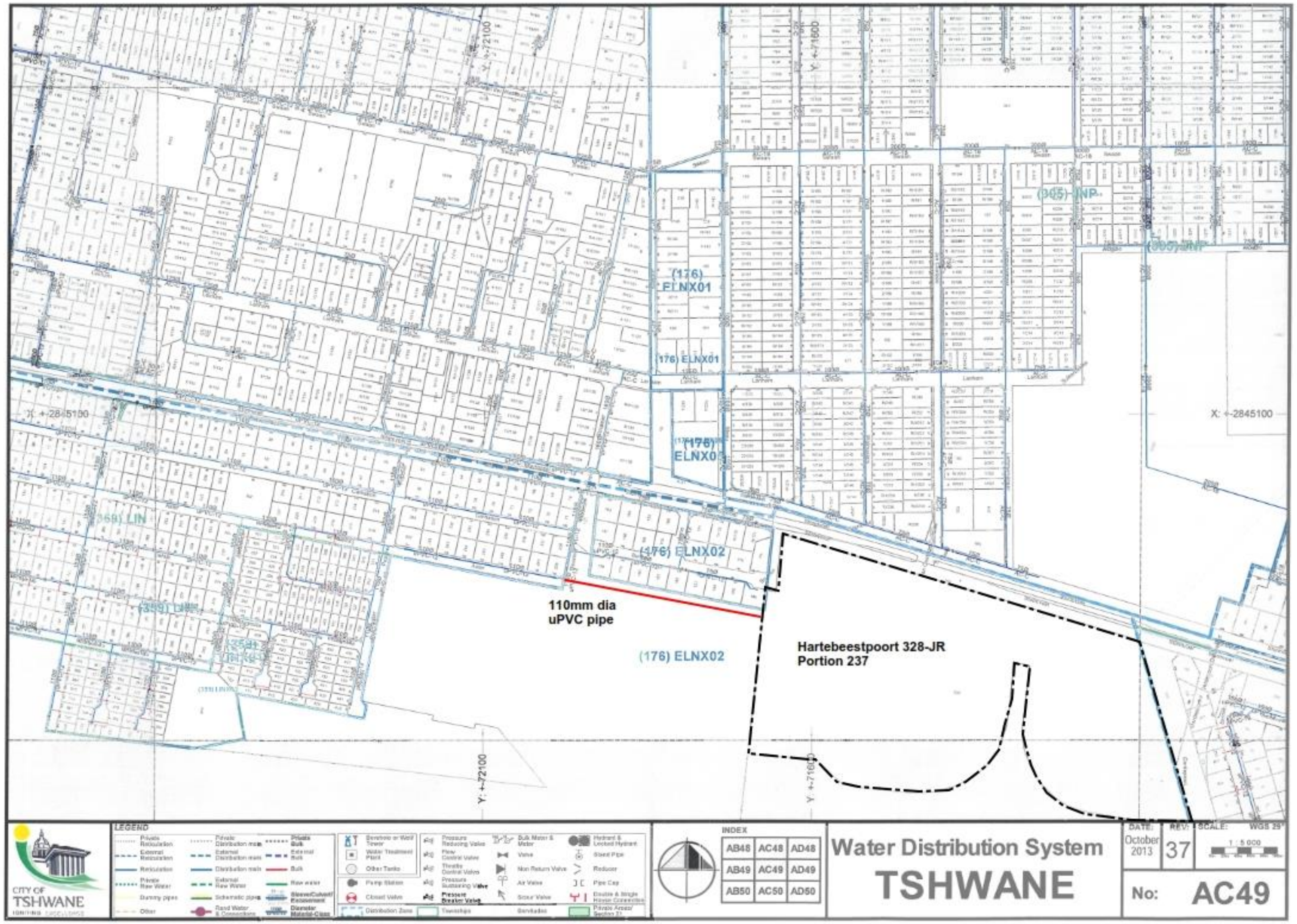

Figure 5: Existing Water Distribution System

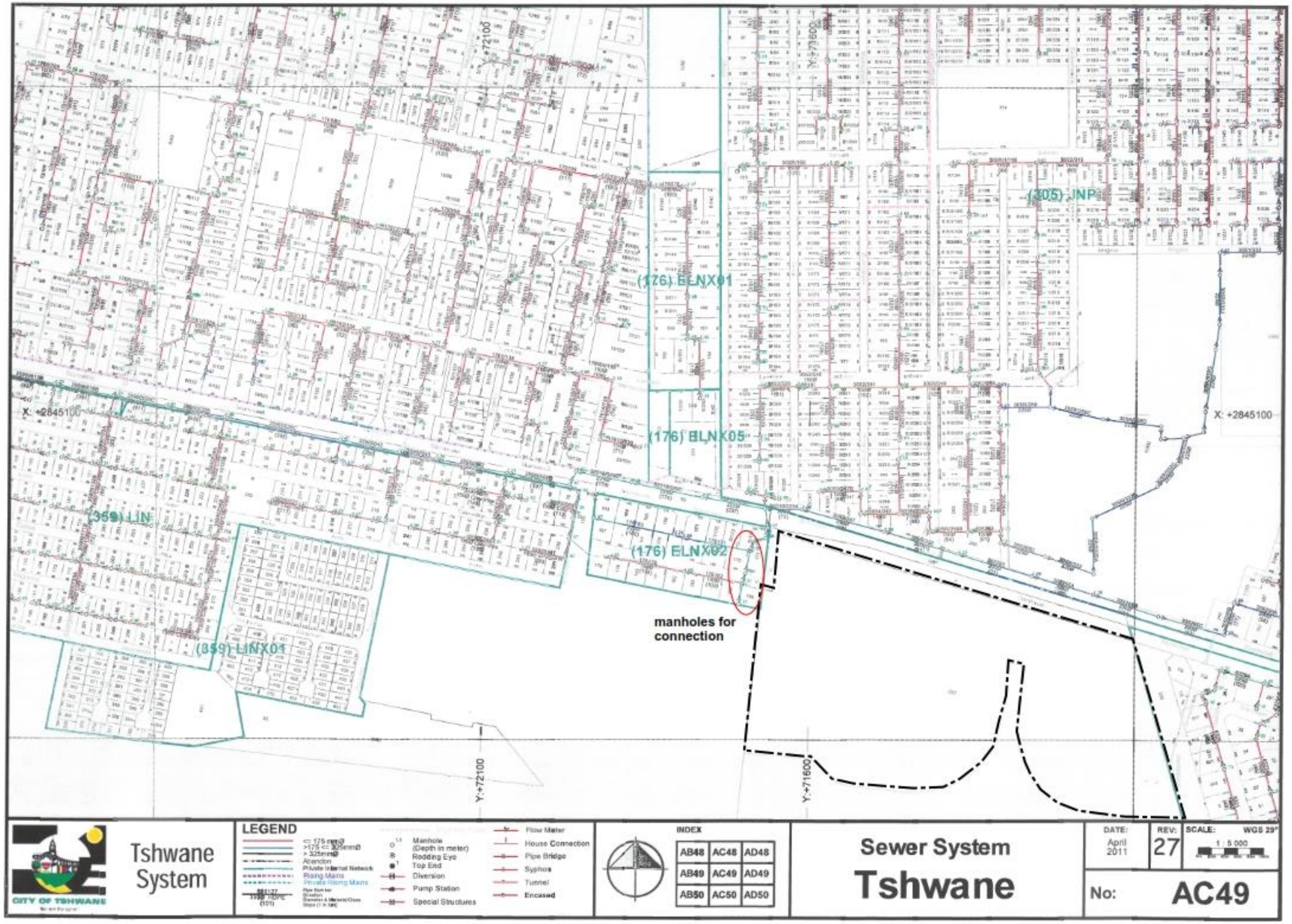

Figure 6: Existing Sewer System

9 RECOMMENDATIONS

Once the water supply demand and sewer flows are known for each of the site layout options, a meeting with the City of Tshwane Water and Sanitation Department will be arranged to discuss whether the existing bulk services will support the proposed development. Once this is established, the project may go ahead as follows:

- Without any changes to the existing bulk services;
- With recommendations for changes to the existing bulk services to support the new demands;
- With recommendations for new bulk services to support the development.

It is therefore recommended that the number of units be reduced if the intent is to rely solely on municipal supply. Otherwise, alternative methods similar to the ones suggested would be needed to supplement or completely take over from the municipality.

From the alternatives expressed in this report, Groundwater is recommended to supplement municipal supply. It is a reliable water source throughout the year. However, a geohydrological study must be undertaken to confirm this.

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APPENDIX A: WATER AND SANITATION DEMAND CALCULATIONS

Total Water Demand (Table 9.13)

(2) Avge. Residential	900	l/day
Total units	2207	units
Demand	**1.99**	**Ml/day**
(4) Avge. Commercial	400	l/day/100m^2
Total Area	12382	m^2
Demand	**0.05**	**Ml/day**
(4) Avge. Social	500	l/day/100m^2
Total Area	358	m^2
Demand	**0.0018**	**Ml/day**

Total Water Demand	**2.04**	**Ml/day**

Total Sewer Outflow (90% of Water Demand)	**1.83**	**Ml/day**

PPENDIX B: STANDARD DRAWINGS FOR WATER AND SEWER INFRASTRUCTURE