Lüderitz Town Council

Water and Wastewater Infrastructure Masterplan

2024 and beyond

bicon
namibia

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TABLE OF CONTENT

1 INTRODUCTION

The Lüderitz Town Council sourced engineering services through bid documentation and Bicon Namibia Consulting Engineers and Project Managers (Pty) Ltd was successful. This assignment for the Water and Wastewater Master Plan (WWMP) is one of six components within the above-mentioned appointment.

This master plan forms part of the greater master plan development of the Lüderitz Town Council (TLC) and it is required that this report be considered in parallel to t he proposals of the companion master plans.

During the contract negotiations, the general approach to the implementation of the projects was adopted as per the original proposal and to follow the following process for this assignment:

1. Stage 1 : Capturing As Built	90%
2. Stage 2 : Modelling of Network	85%
3. Stage 3 : Operational Plan	25%
4. Stage 4 : Intervention Plan	25%
5. Stage 5 : Adoption of Plan	

The Inception Report was developed over time and the general outline as proposed adopted early in 2023 and captured in general the arrangements, processes, and final terms of reference for the execution of the project.

Since the adoption of the Inception Report a few interactions and presentations discussed and mapped the interventions to be adopted. It is therefore necessary to outline the two broad infrastructure development focus areas:

- Upgrade, rehabilitation and routine maintenance to ensure infrastructure upkeep.
- Planning and strategizing for the future developments required to accommodate new developments and expansion infrastructure.

This report deals with the listing and the outline of the intervention scope in respect of these two areas of infrastructure development areas. The details of the interventions are also summarized in broad terms to provide the required terms of reference for the development of the detail intervention strategies.

2 TERMS OF REFERENCE

2.1 Scope of Services

2.1.1 Water Infrastructure

The outline of the scope of services is the following:

- ➢ Determine water demand
- ➢ Investigate and asses existing pump stations
- ➢ Assess quality of water
- ➢ Do full as built record of water infrastructure
- ➢ Do full calibration and modelling of existing water network
- ➢ Compile as built records of existing model
- ➢ Advise on improved efficiency of existing infrastructure
- ➢ Advise on upgrade and extensions to the existing infrastructure
- ➢ Advise on and provide preliminary design on additional future storage (Cost excluded from current bid price)
- ➢ Do required further development of distribution network

2.2 Deliverables

2.2.1 Water Infrastructure

- ➢ Investigation report
    - Records of existing water infrastructure
- ➢ Calibration and Modelling Report
    - Modelling of existing systems
    - Calibration of system
    - Analysis results
    - Gap analysis Identification of shortcomings
- ➢ Intervention Plan
    - Based on modelling and gap analysis
    - Propose and model rehabilitation of existing failed infrastructure
    - Propose and model upgrades for improved efficiencies
    - Propose and model extensions to additional users
- ➢ Preliminary design (not part of current bid price)Technical Proposal 19
    - Future storage
    - Future distribution system

2.2.2 Sewerage Infrastructure

- ➢ Investigation report

  - Records of existing water infrastructure

- Calibration and Modelling Report
  - Modelling of existing systems
  - Calibration of system
  - Analysis results
  - Gap analysis Identification of shortcomings
- Intervention Plan
  - Based on modelling and gap analysis
  - Propose and model rehabilitation of existing failed infrastructure
  - Propose and model upgrades for improved efficiencies
  - Propose and model extensions to additional users

3 PROJECT ENVIRONS

It is inevitable that the proposals for infrastructure development would require context to those interested parties that have not been involved in the conceptualization and development of the proposals from the onset. This section intends to provide a high level overview of the

3.1 Location

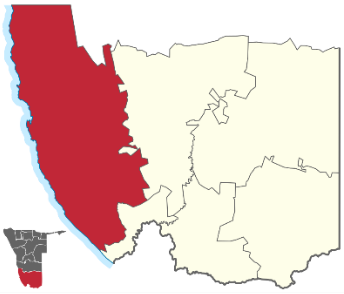
Lüderitz is a coastal town located on the west coast of Namibia, at about 26°39’ latitude south.

The town is about 125km from the nearest other residential settlement, being Aus Village and about 340km from the nearest town of Keetmanshoop, both to the east of Lüderitz.

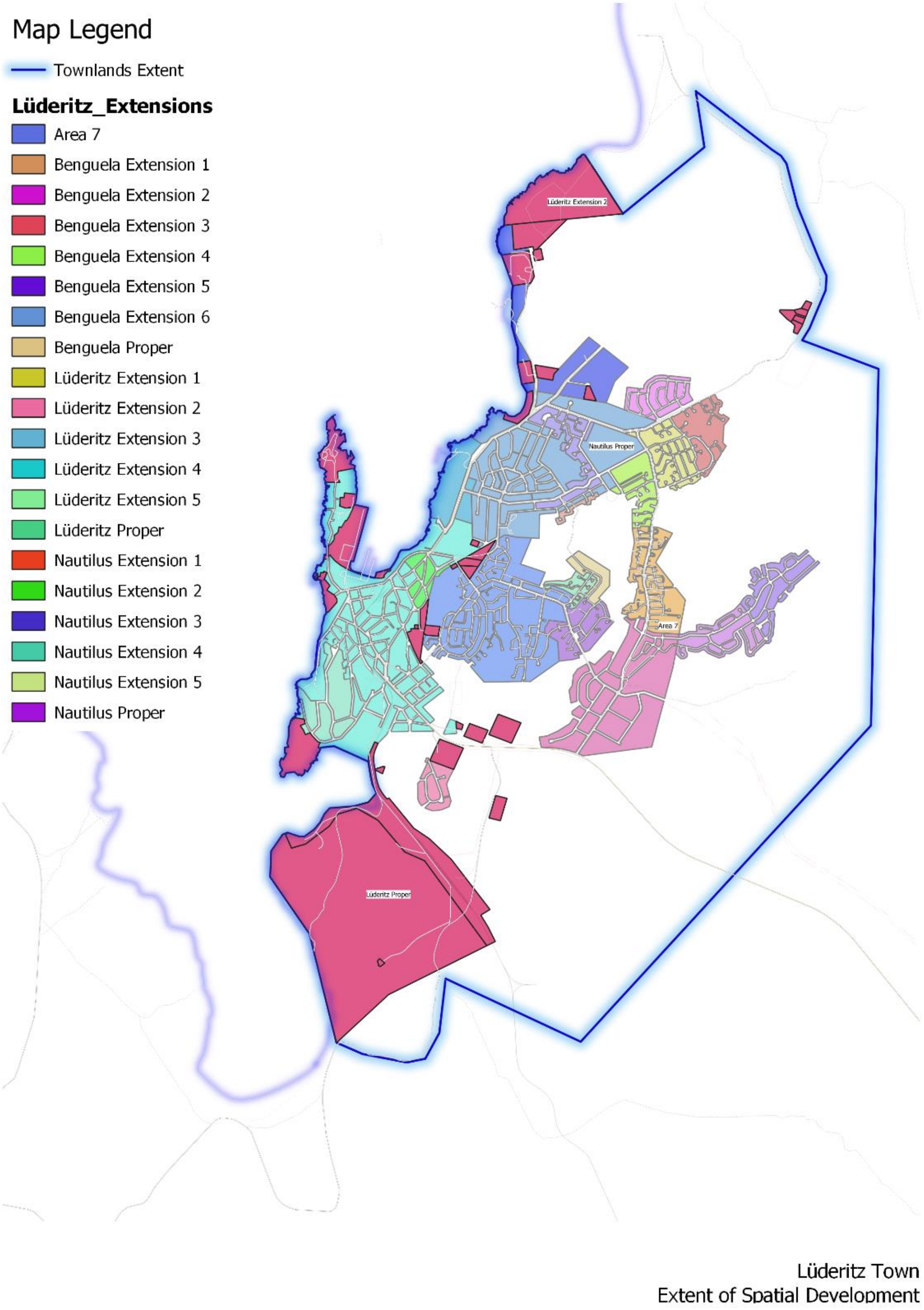
Lüderitz is reach by road from all directions via the village of Aus, and the surfaced link road between Aus and Lüderitz is the only public road access to the town. The town can also be reached via air transport to the Lüderitz Airport (FYLZ) some 12km outside of town (east).

The town of Lüderitz forms part of the //Kharas Regional Council area of jurisdiction and also falls within the constituency of !Nami‡Nûs.

The town is surrounded by restricted area access.

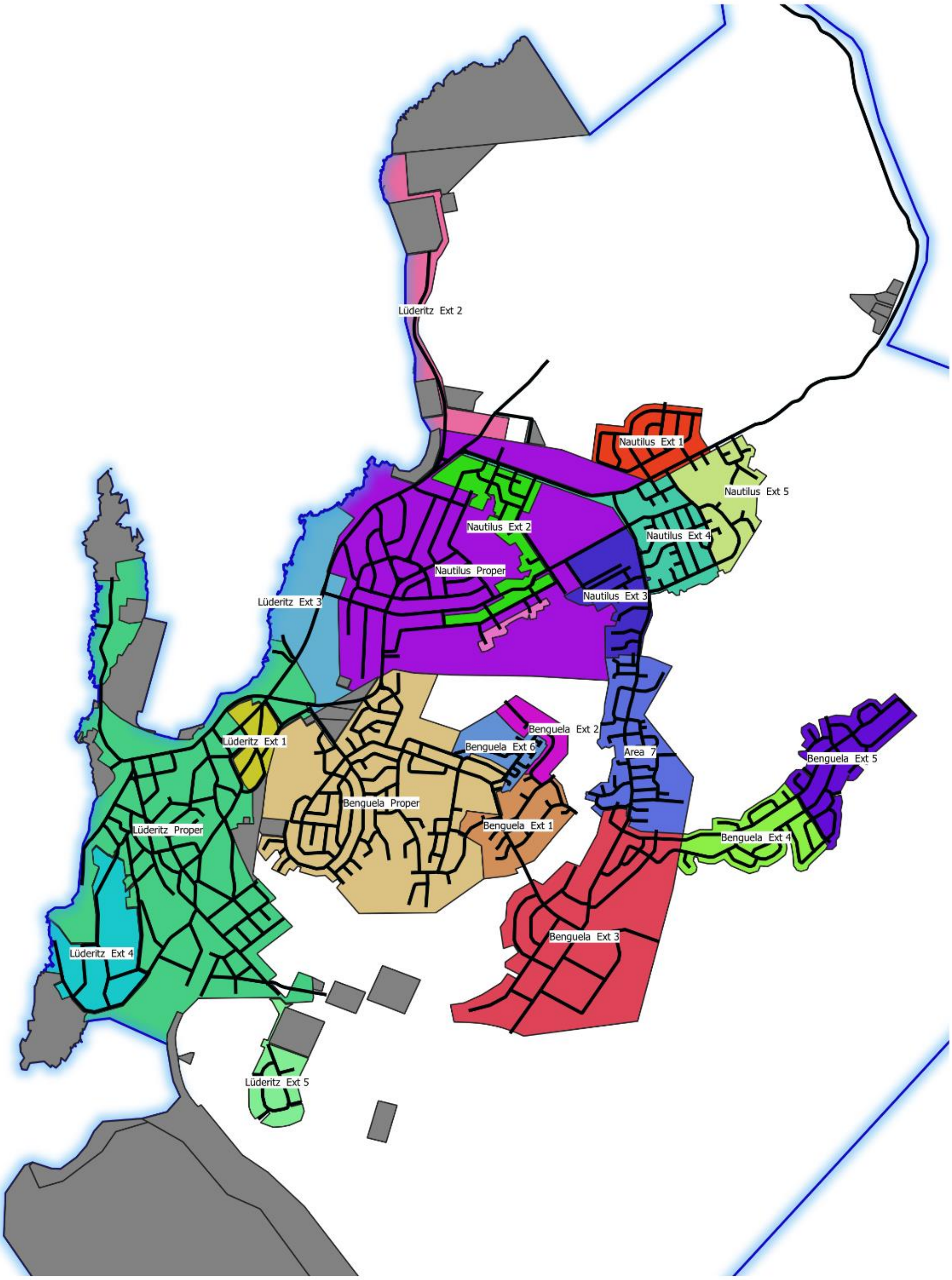


The current extensions of the town is presented in the map below.



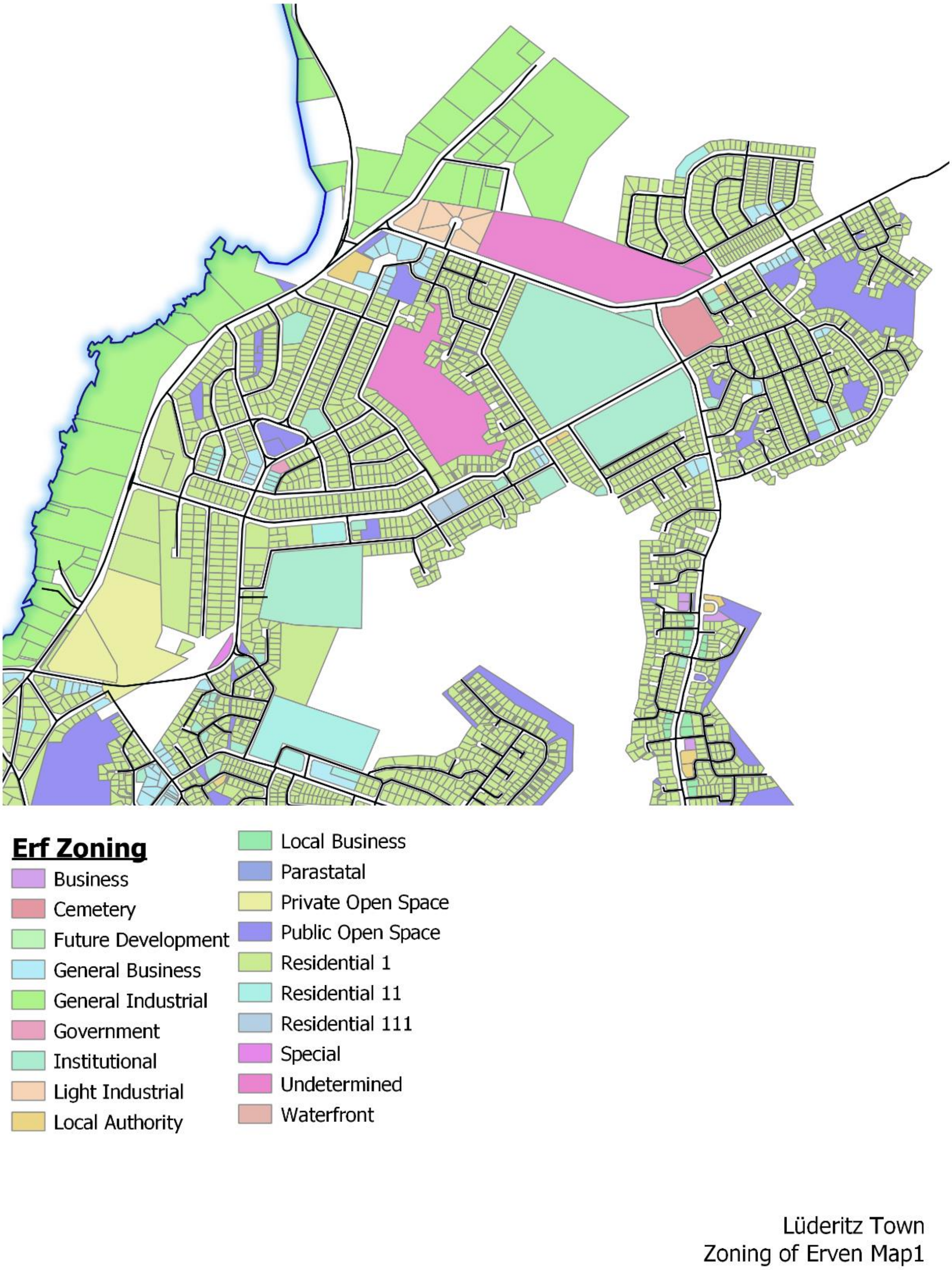
3.2 Town Layout

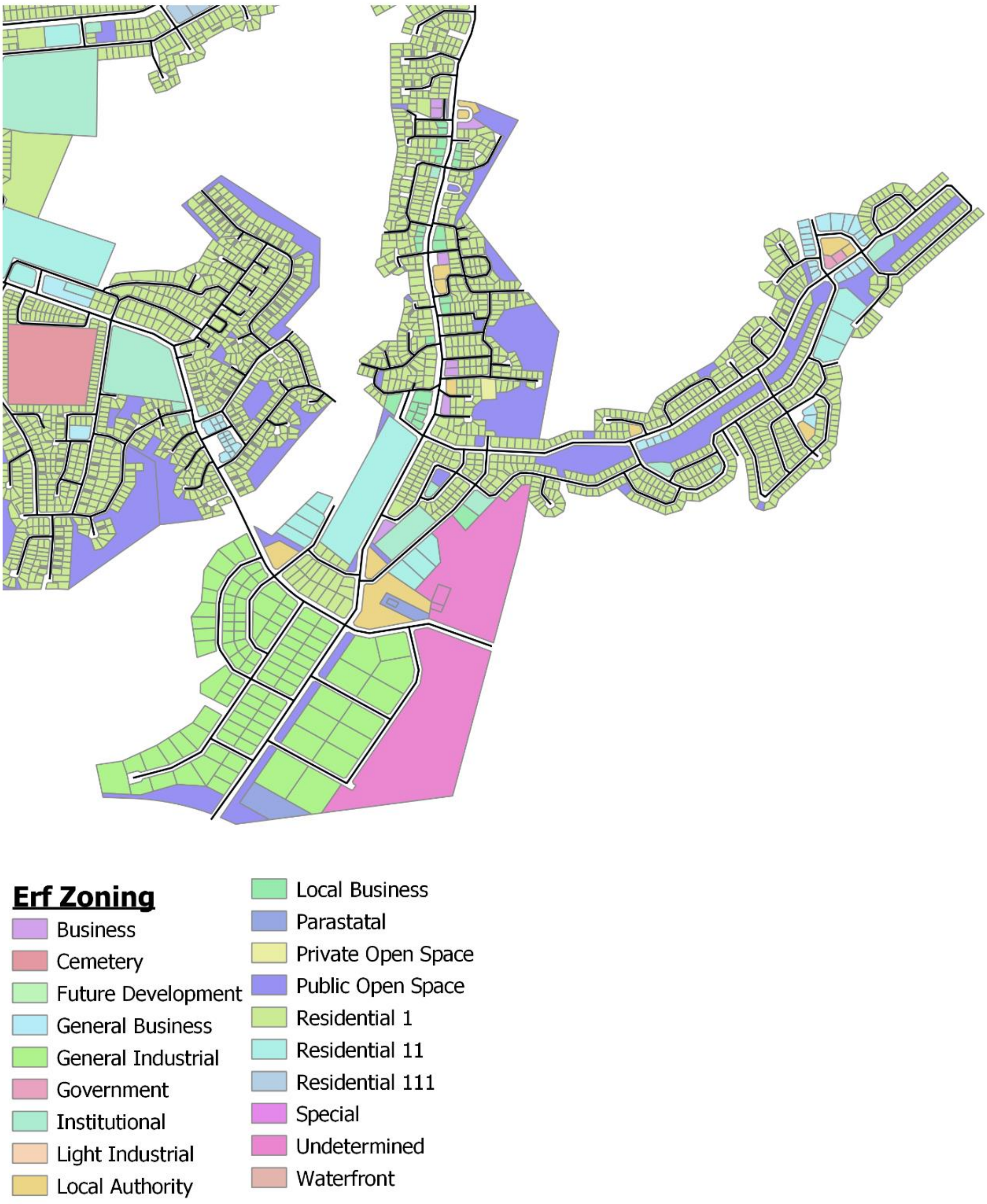
The town consist of about 3 major extensions, namely Lüderitz, Nautilus, Benguela. The area of town to the south-east is Benguela and to the north-west is Nautilus. Each of the major extensions also have further minor extensions.



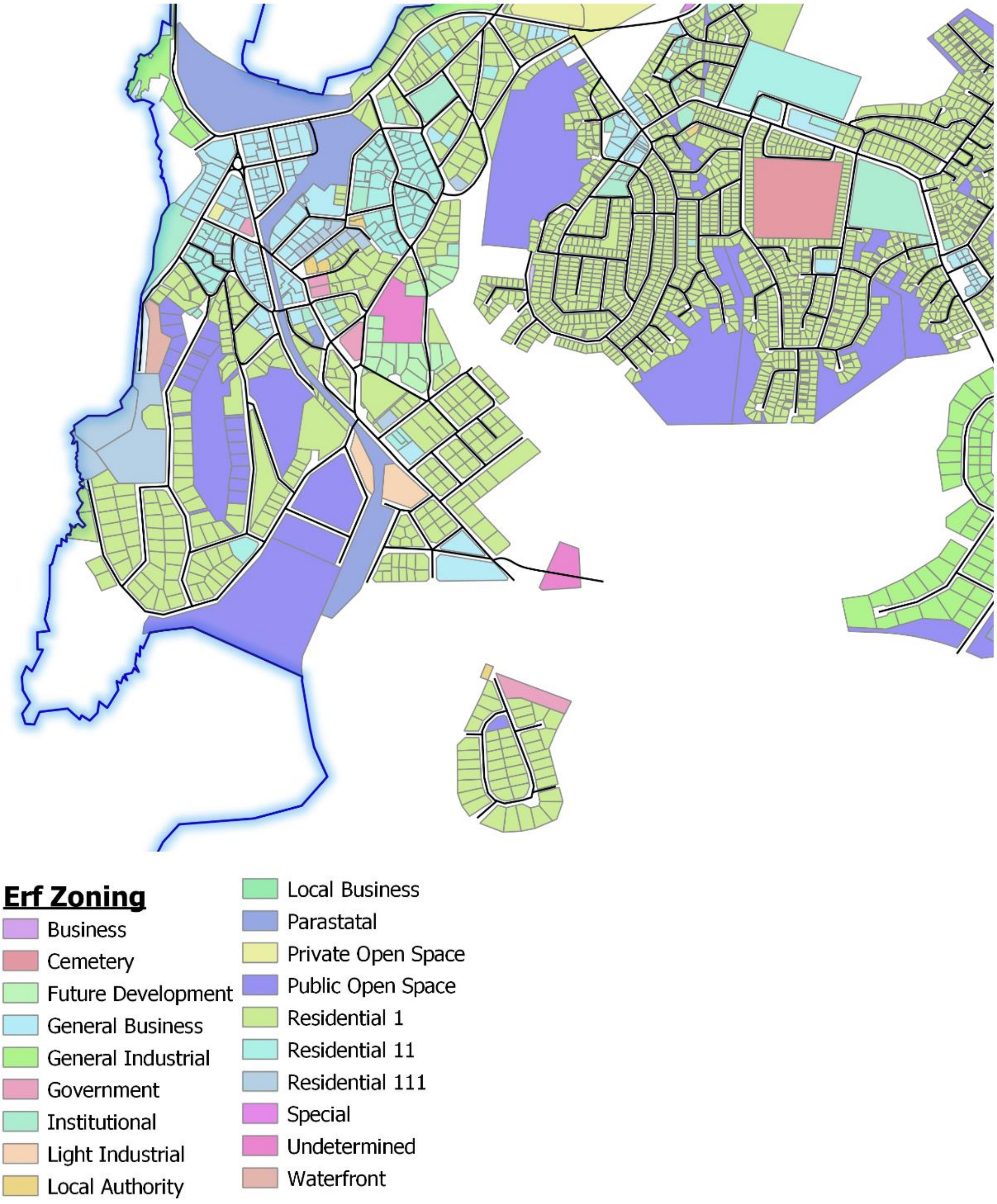
Lüderitz Town
Development Extensions

A few closer views of the town layout indicating the existing erven to be serviced is presented below.



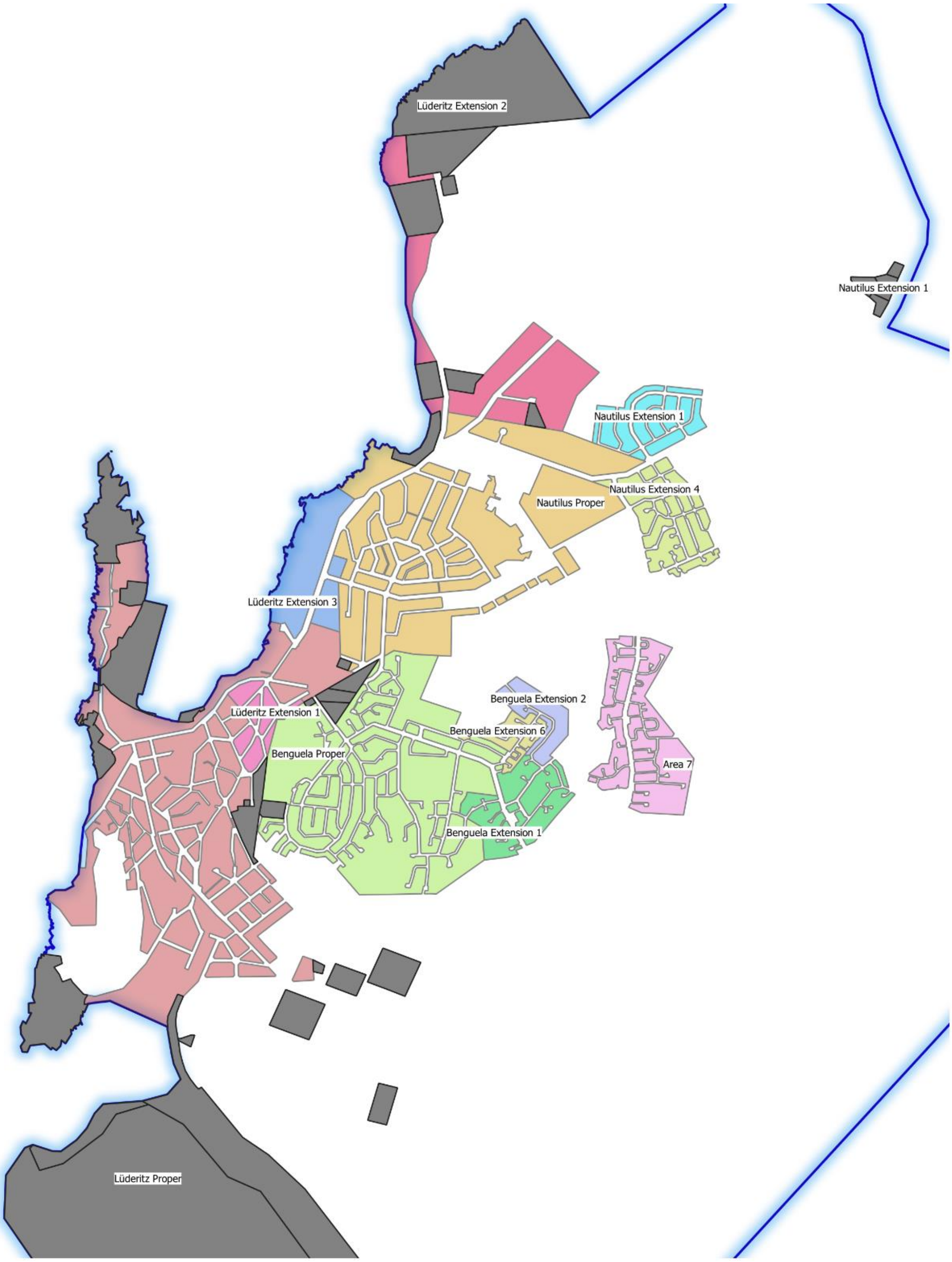


Lüderitz Town
Zoning of Erven Map 2



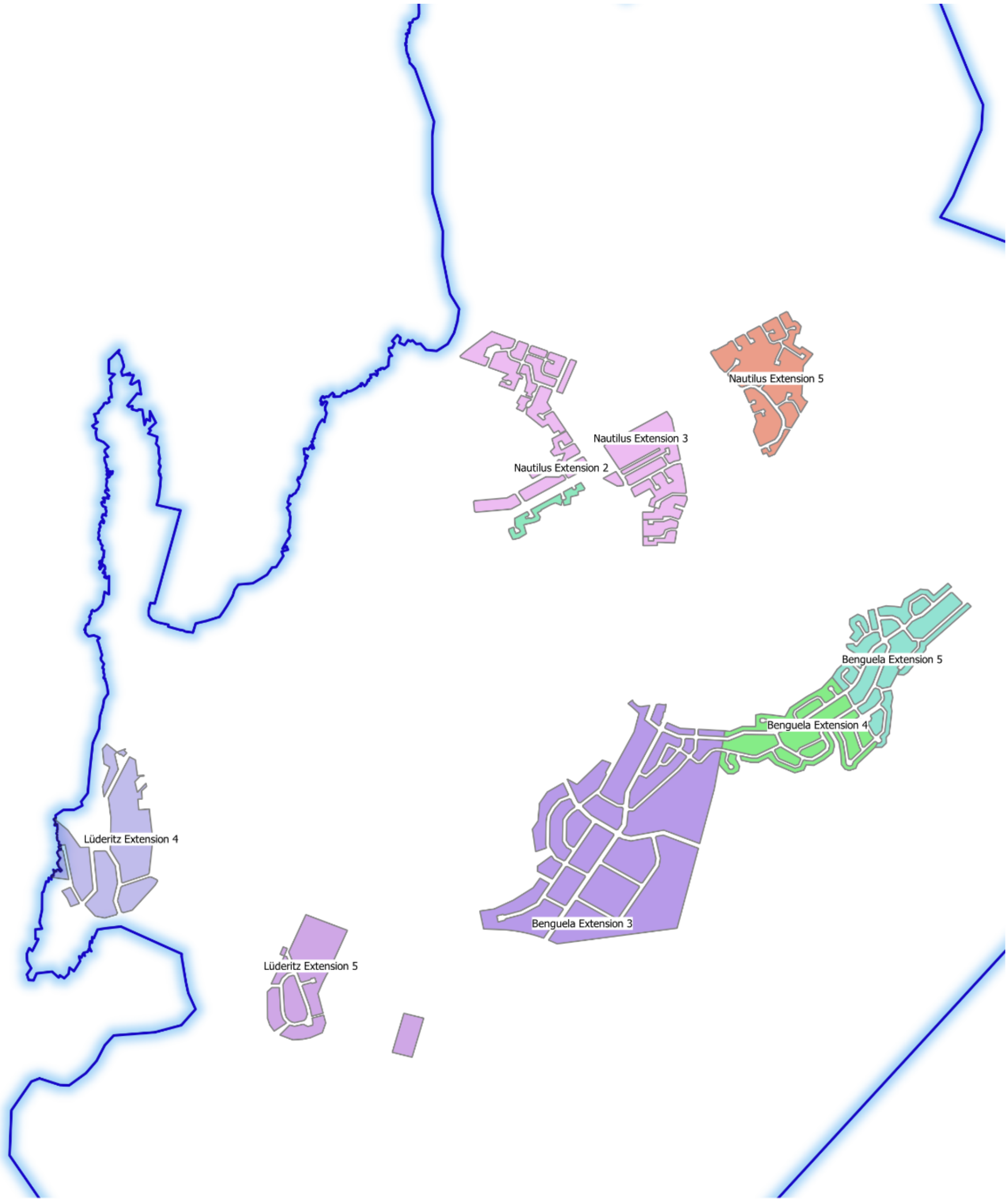
Lüderitz Town
Zoning of Erven Map 3

Of these developments, the following are existing populated areas.



Lüderitz Town
Current Development Extensions

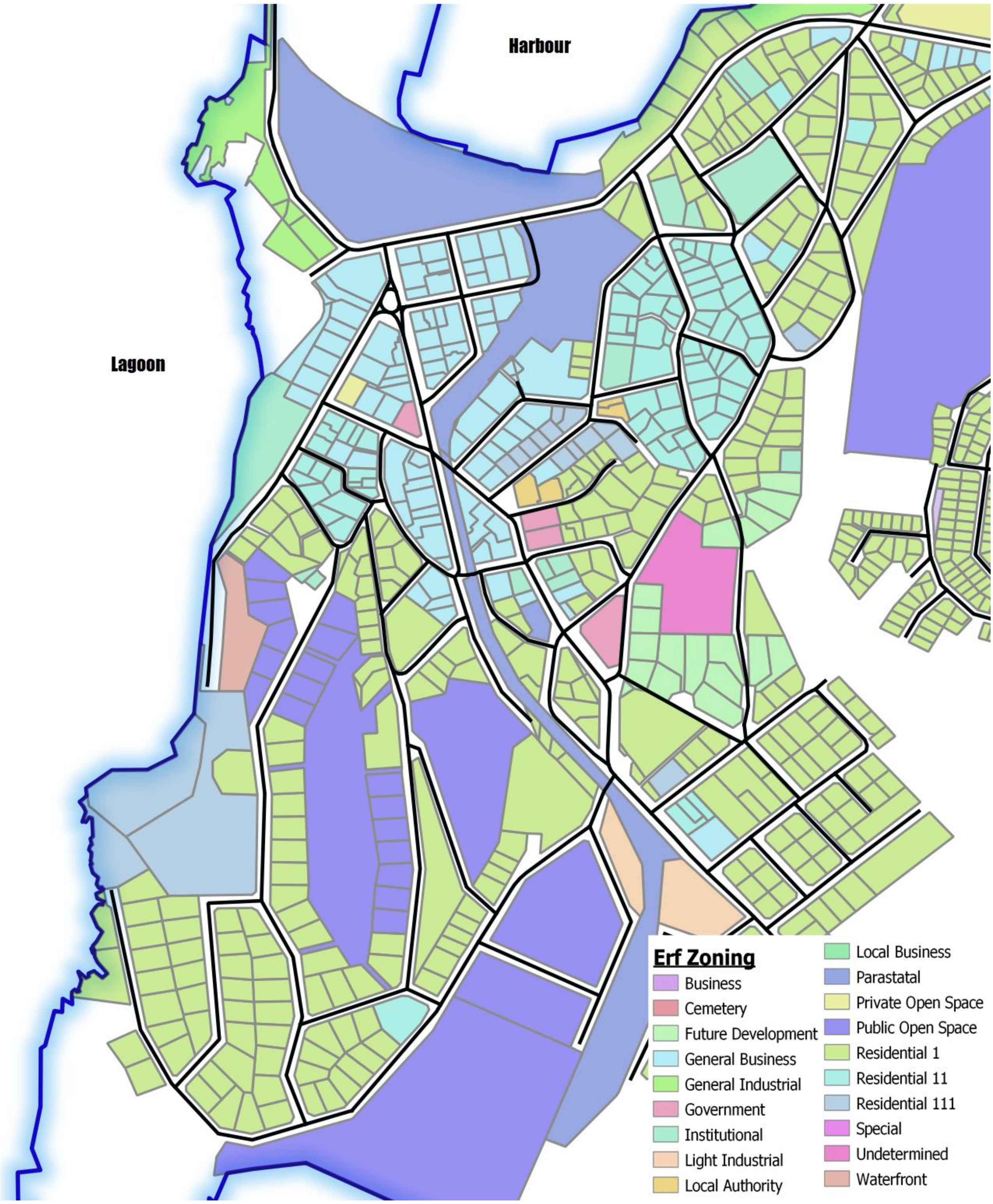
The planned future development areas are indicated below.



Lüderitz Town
Future Development Extensions

3.3 Townlands Spatial Development

The central business district (CBD) of the town is located directly to the south of the harbour.



Most industrial activity is located in and around the harbour, with significant fish processing related industries located along the coast to the north-east of the harbour.

Most residential erven are located within the Benguela and Nautilus extensions, and consequently also most of the schools and sports facilities.

The area of development per zoning is summarized in the table below.

Ref	***Zoning***	***Projected***		***Present***		***% Coverage***
		Area	***Number***	***Area***	***Number***	
1	Business	8 676	8	6 943	7	0.1%
2	Cemetery	66 774	2	66 774	2	1.1%
3	Future Development	33 587	19	33 587	19	0.6%
4	General Business	192 371	197	149 217	146	3.3%
5	General Industrial	799 610	150	553 469	52	13.6%
6	Government	73 552	12	63 449	9	1.2%
7	Institutional	363 142	56	289 168	43	6.2%
8	Light Industrial	38 508	9	38 508	9	0.7%
9	Local Authority	49 215	23	12 086	14	0.8%
10	Local Business	19 320	26	9 987	17	0.3%
11	Parastatal	147 608	7	129 442	4	2.5%
12	Private Open Space	87 582	5	87 582	5	1.5%
13	Public Open Space	753 458	107	524 436	57	12.8%
14	Residential 1	2 576 610	4815	1 829 552	3344	43.8%
15	Residential 11	217 098	107	137 065	95	3.7%
16	Residential 111	67 883	19	56 020	16	1.2%
17	Special	8 362	3	8 362	3	0.1%
18	Undetermined	375 561	9	198 817	5	6.4%
19	Waterfront	8 620	2	8 620	2	0.1%

4 NATURAL ENVIRONMENT

This section of the report provides a high level overview of the natural environment of the town.

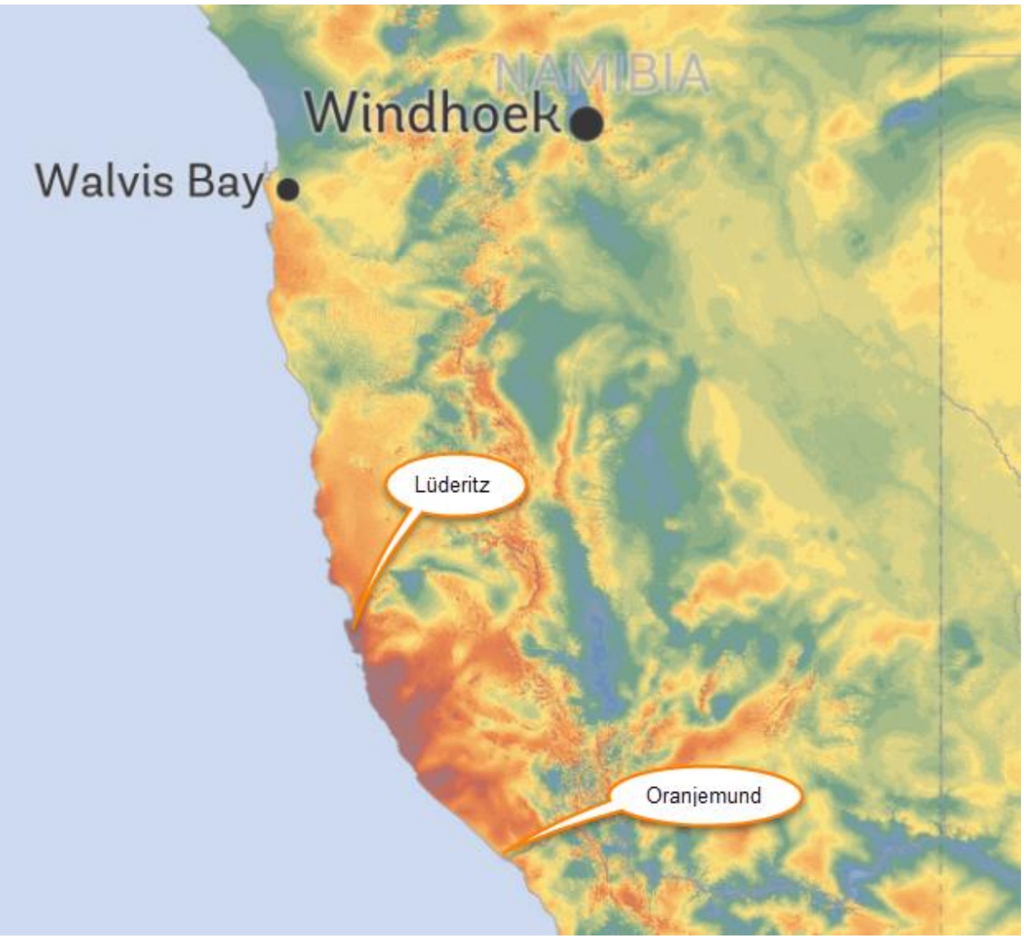
4.1 Climate

The general climate is that of coastal desert environment as Lüderitz is located within the Namib Desert. According to Wikipedia the climate is described hence:

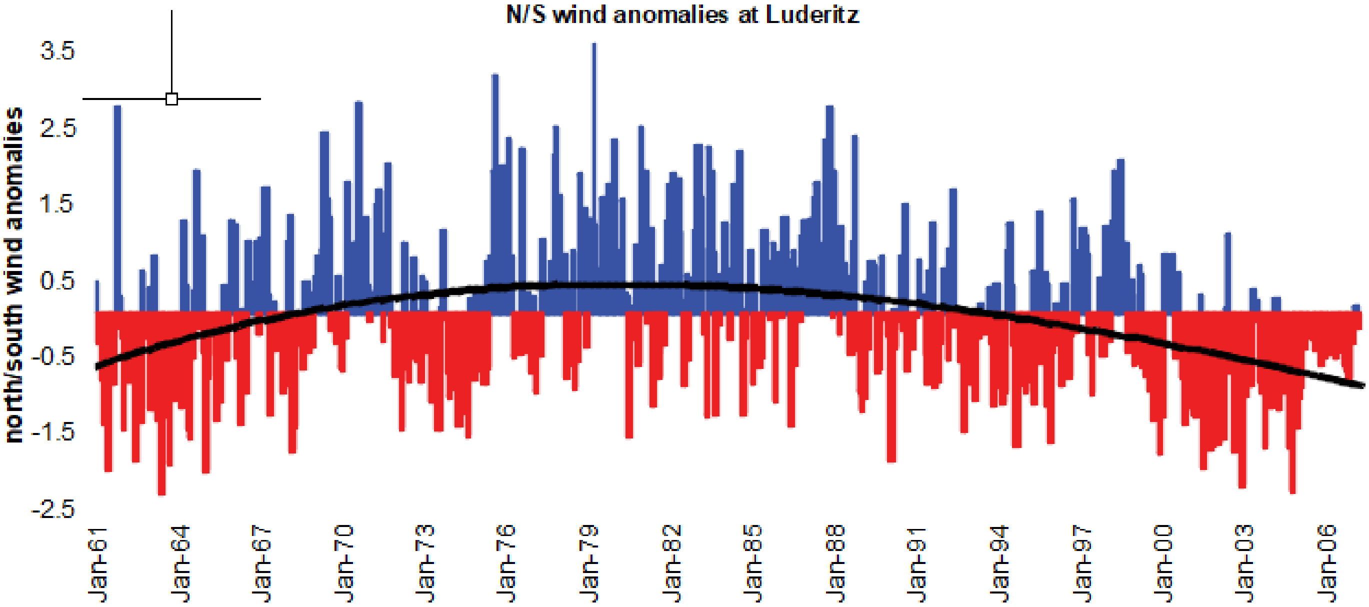
> *Lüderitz has a desert climate (BWk, according to the Köppen climate classification), with moderate temperatures throughout the year. The average annual precipitation is 17 millimetres (0.67 inches). Windy and cold conditions can occur due to the cold South Atlantic current on the coast.*

It is a well known fact that the wind speeds around Lüderitz is very high which can be attested by the world championships for board sailing, the “Luderitz Speed Challenge” event, held annually during November.

The World Wind Atlas indicates that a high wind speed profile at 10m elevation is maintained off the coast around Lüderitz as per the below map. The green areas in the map indicate low wind speeds with the read colouring indicating high wind speeds.



The predominant wind direction for Lüderitz is north-south. According to National Marine Information and Research Center in Swakopmund, north-south wind anomalies were recorded between 1961 and 2006 at the light house and a graph of the data is presented below



The main factors influencing the rainfall pattern are the cold ocean current offshore (the Benguela current) and the prevailing winds (western and eastern winds). The annual median rainfall ranges between 15 and 70 mm, is highly unpredictable and rainfall events are equally likely in all months of the year. Much of the small amount of rain comes in the southwest of Namibia as cold fronts from the Cape in winter. This results in the vegetation being dominated by succulents which are also adapted to the foggy conditions.

As noted, the annual average rainfall is 17 mm. The highest rainfall recorded over a 24-hour period is 31 mm (Enviro Dynamics/Interconsult, Update 2018). Today, the only run-off that could occur would be from the rocky faces of exposed gneiss and granites, which will quickly be absorbed into the sandy inlays or sand filled drainage channels. The time span required for the surface transport of contaminants from the study area to surrounding pans may exceed the natural breakdown.

The general climatic statistics are given below as extracted from Wikipedia.

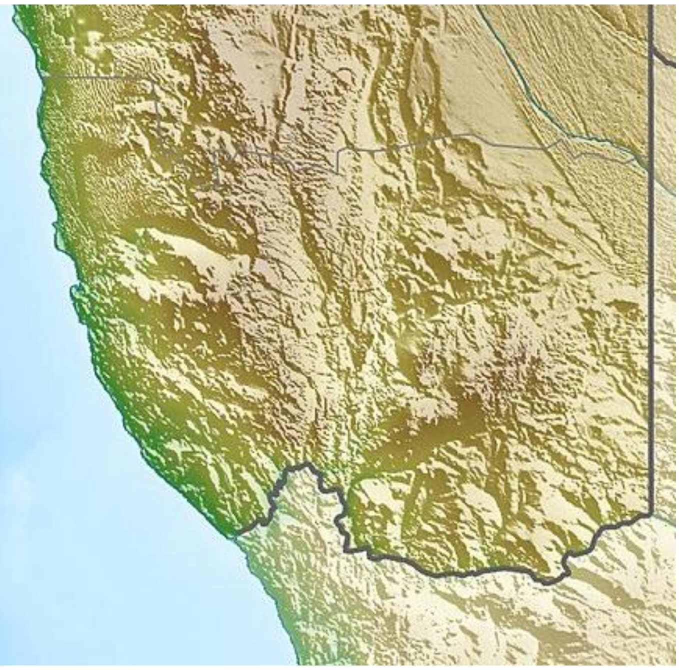
Climate data for Lüderitz

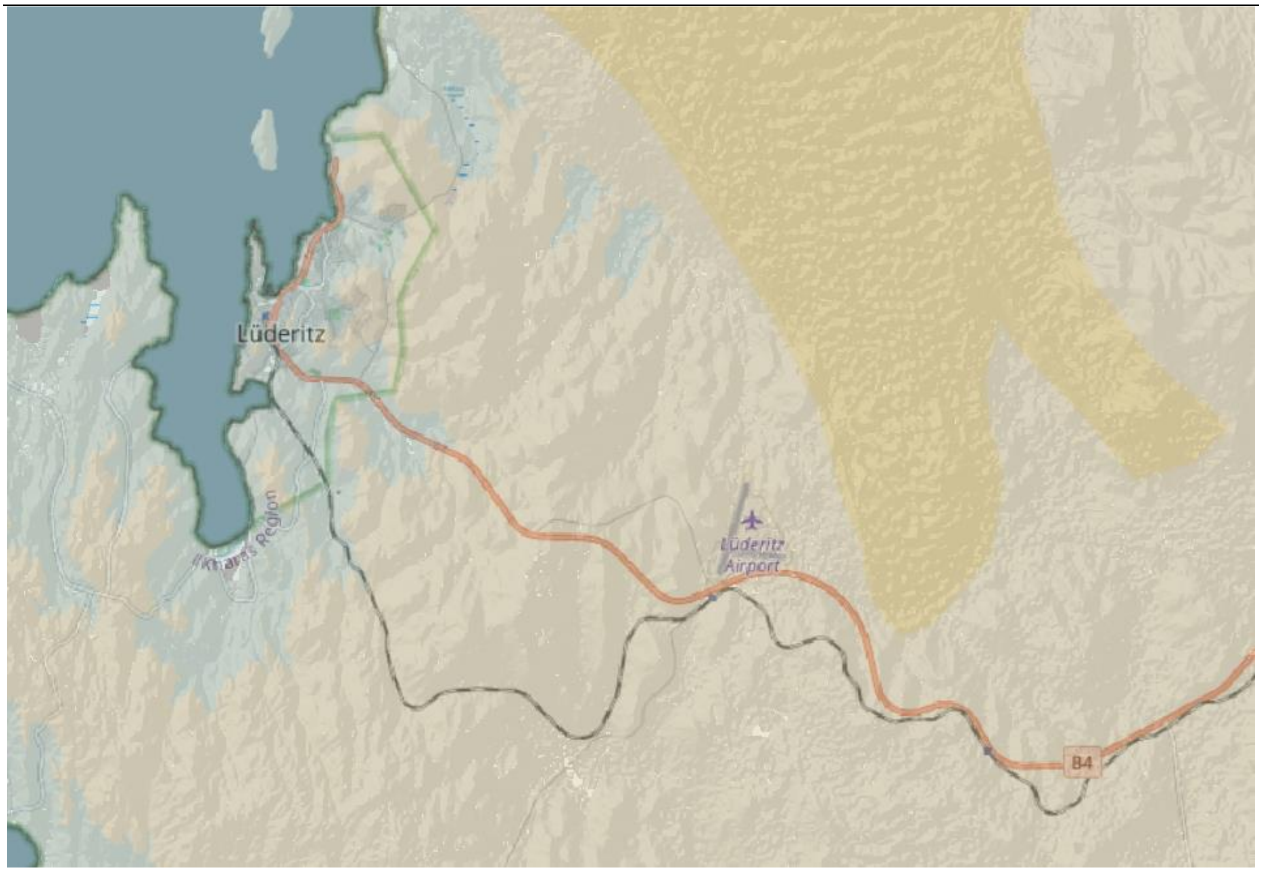
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Record high °C (°F)	32.5 (90.5)	30.0 (86.0)	34.1 (93.4)	36.5 (97.7)	33.0 (91.4)	31.6 (88.9)	30.7 (87.3)	33.0 (91.4)	35.1 (95.2)	35.0 (95.0)	37.5 (99.5)	30.6 (87.1)	37.5 (99.5)
Average high °C (°F)	21.4 (70.5)	21.3 (70.3)	21.1 (70.0)	19.9 (67.8)	19.2 (66.6)	19.0 (66.2)	17.9 (64.2)	17.2 (63.0)	17.3 (63.1)	18.0 (64.4)	19.2 (66.6)	20.5 (68.9)	19.3 (66.7)
Daily mean °C (°F)	17.7 (63.9)	17.8 (64.0)	17.4 (63.3)	16.3 (61.3)	15.5 (59.9)	15.1 (59.2)	14.1 (57.4)	13.7 (56.7)	13.9 (57.0)	14.7 (58.5)	15.8 (60.4)	17.0 (62.6)	15.7 (60.3)
Average low °C (°F)	14.0 (57.2)	14.3 (57.7)	13.8 (56.8)	12.6 (54.7)	11.7 (53.1)	11.2 (52.2)	10.4 (50.7)	10.2 (50.4)	10.5 (50.9)	11.4 (52.5)	12.3 (54.1)	13.5 (56.3)	12.1 (53.8)
Record low °C (°F)	5.5 (41.9)	5.0 (41.0)	6.0 (42.8)	5.5 (41.9)	3.3 (37.9)	0.2 (32.4)	3.0 (37.4)	4.8 (40.6)	3.4 (38.1)	3.4 (38.1)	4.9 (40.8)	3.9 (39.0)	0.2 (32.4)
Average precipitation mm (inches)	0 (0)	1 (0.0)	2 (0.1)	2 (0.1)	3 (0.1)	3 (0.1)	1 (0.0)	2 (0.1)	1 (0.0)	0 (0)	0 (0)	0 (0)	17 (0.7)
Average precipitation days (≥ 0.1 mm)	1.0	1.0	1.0	0.9	1.4	1.4	1.0	0.7	0.5	0.5	0.5	0.7	10.6
Average relative humidity (%)	82	81	82	80	79	72	74	78	80	80	80	80	79
Mean monthly sunshine hours	198.4	203.4	257.3	216.0	213.9	144.0	170.5	201.5	216.0	201.5	189.0	176.7	2,388.2
Mean daily sunshine hours	6.4	7.2	8.3	7.2	6.9	4.8	5.5	6.5	7.2	6.5	6.3	5.7	6.5

Source: Deutscher Wetterdienst[16]

4.2 Topography

The coastal belt indicated by green in the below map is bounded to the east by the Namib Desert which stretches to the east up to the Kuibis escarpment some 20km east of Aus.



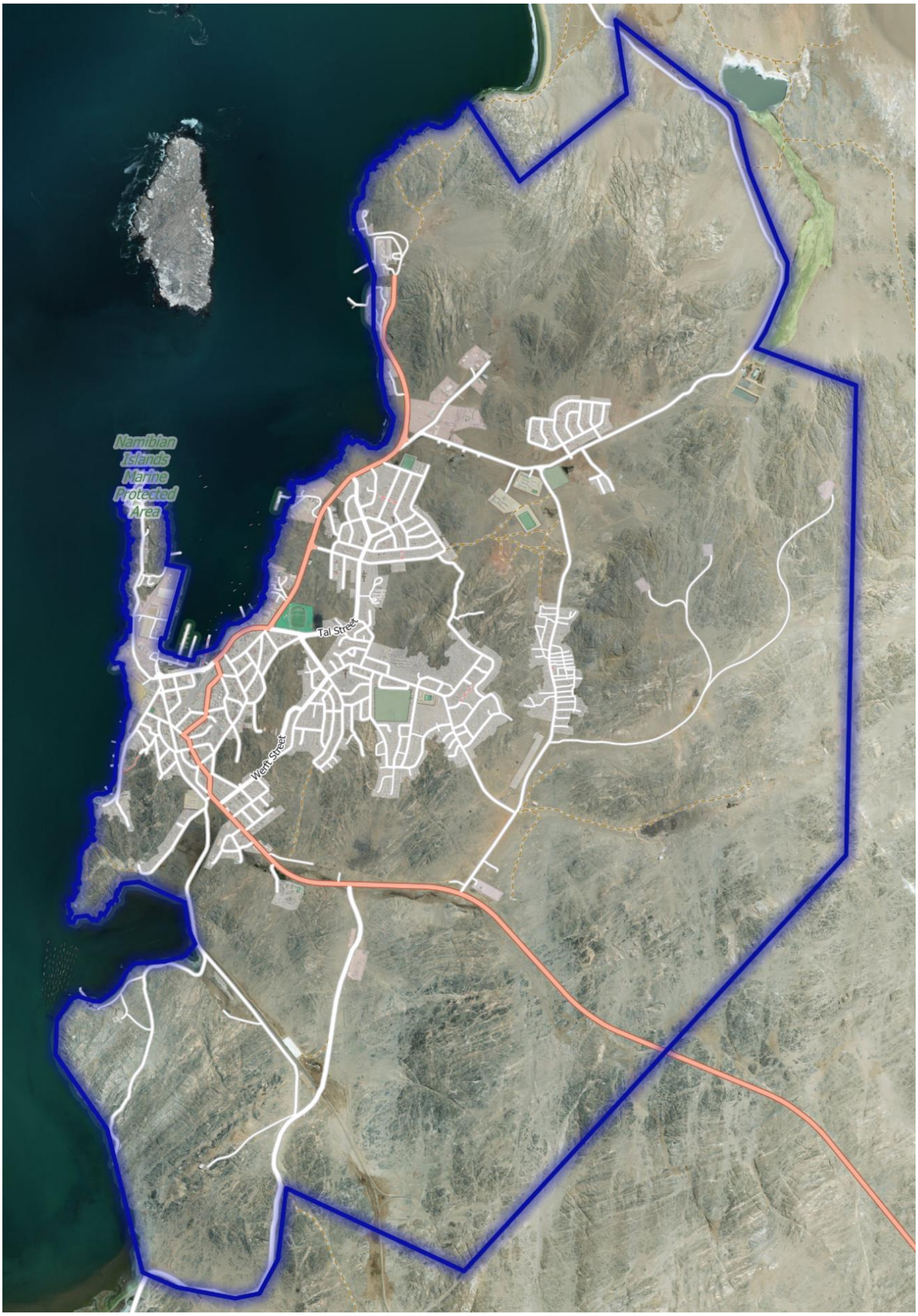


The above relief map indicates the lower lying areas around town in light green shading with the sand desert in brighter brown and the balance of the area rough rolling rocky landscape.

5 SPATIAL DEVELOPMENT

5.1 Existing Developed Townlands

The below ortho image with overlay of developed areas provides context for the intended expansions planned as discussed below.



5.2 Structure Plan

A structure plan for Lüderitz was adopted in 2015, which was compiled by Messrs Stubenrauch and titled "Lüderitz Structure Plan : Towards A Model Town". The purpose of the structure plan is stated in the document to be:

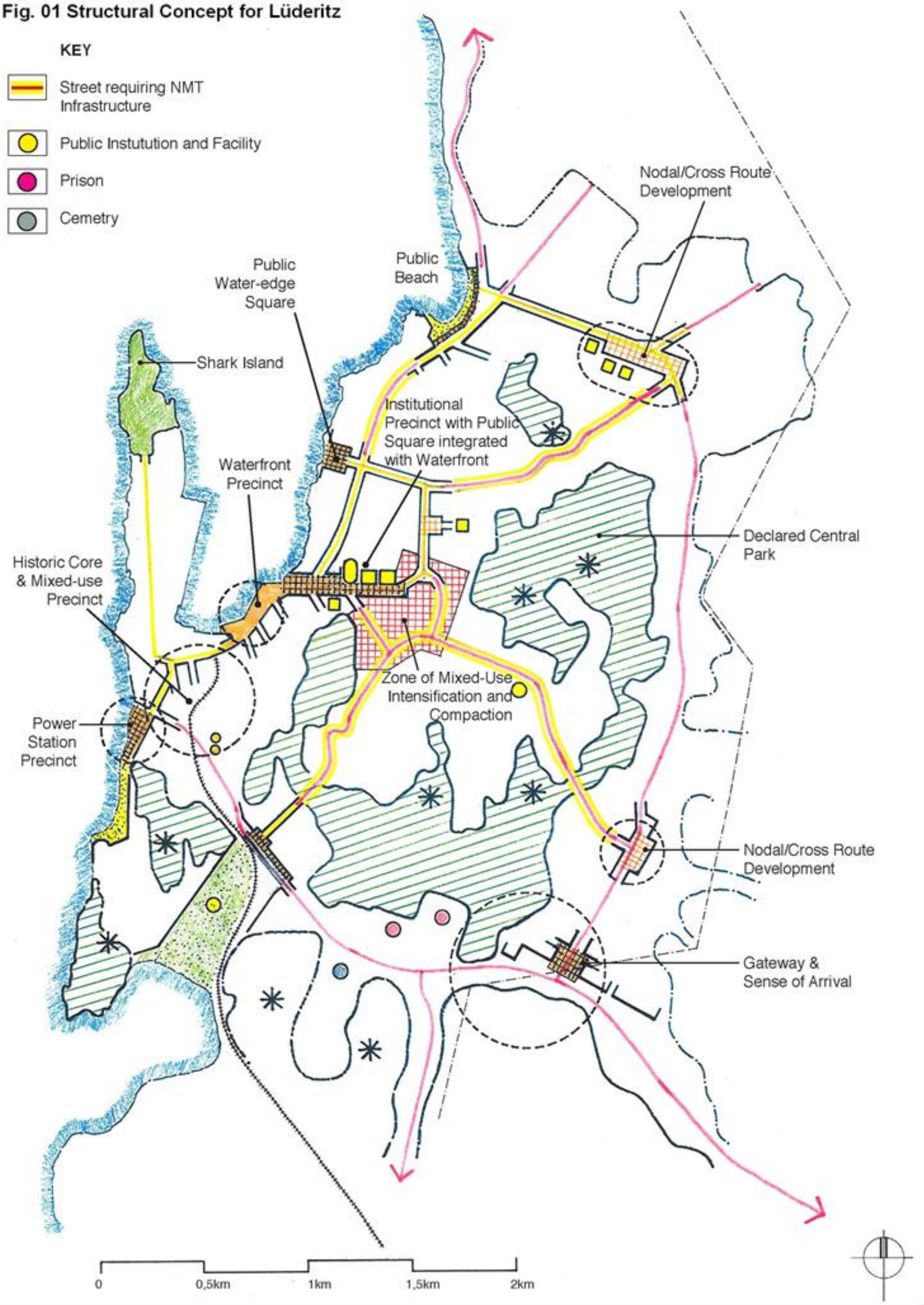
> *The purpose of the Structure Plan is to guide and organise the various forms of land-use, and to respond to the existing natural and man-made environments in such a way as to optimise the living conditions of the residents of Lüderitz, and provide a clear development strategy over the long term.*
>
> *In the absence of a Structure Plan, it can be very difficult for Local Authorites to make informed decisions when planning applications are presented to the Council, particularly in the context of rezoning applications on land, applications for densification and increases in height, and for applications for the development of land that does not currently have a determined zoning.*
>
> *The Structure Plan should be used to make these decisions. Each new development, no matter how small should always be seen as part of the bigger picture of long term development.*

This approach is supported and the structure plan should be consulted during the planning for water and wastewater services.

5.2.1 General Spatial Development as Proposed

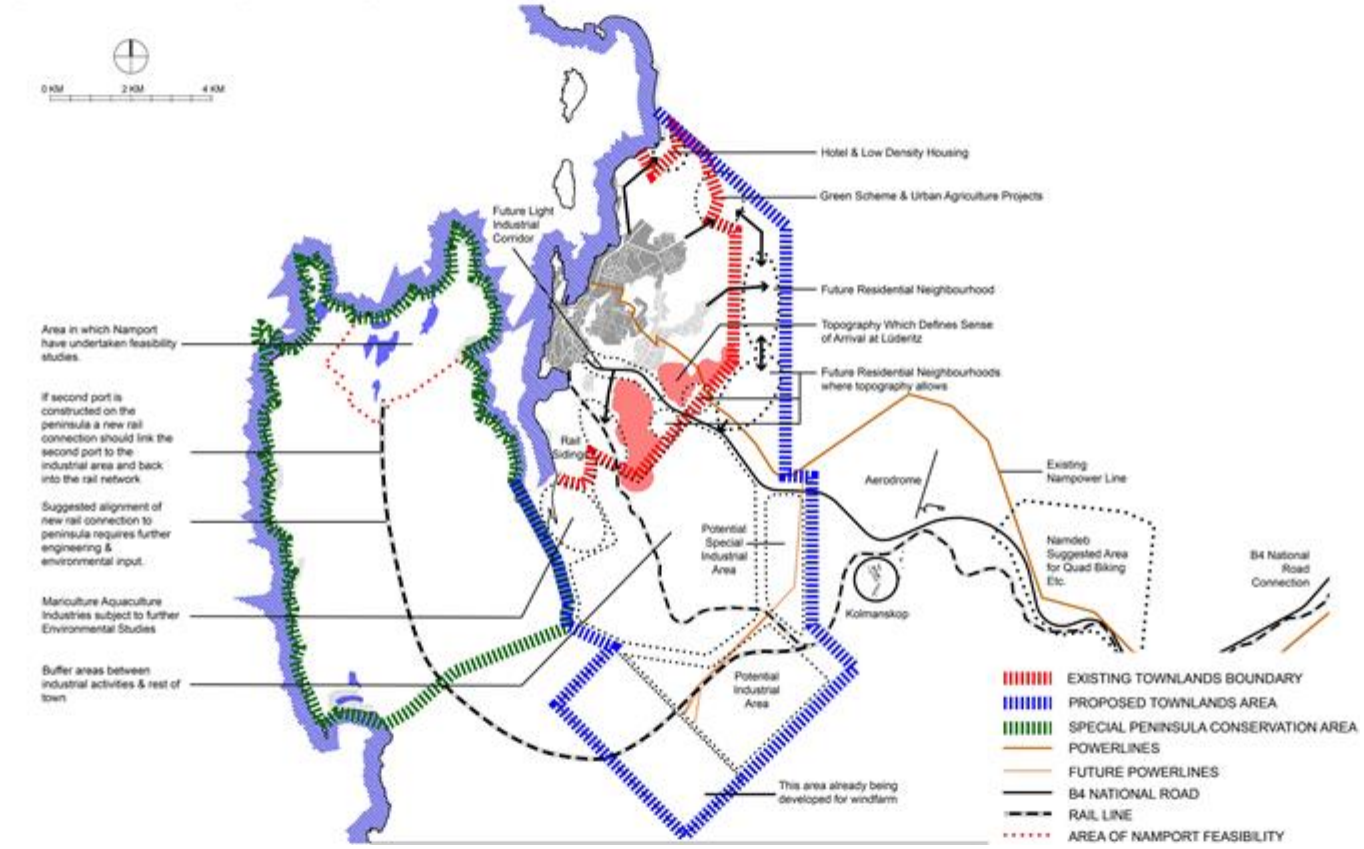
The overall spatial development of the town is presented by the structure plan as indicated by the map out below. Most of the development seems to be restricted to the existing townlands extent with the major through routes already established.

Fig. 01 Structural Concept for Lüderitz



The greater environs beyond the town development is also presented by the structure plan with the map below. This concept also indicates that residential, commercial, industrial and port developments outside of the current townlands area. This planning is, however, still some time in the future and not covered under this master plan.

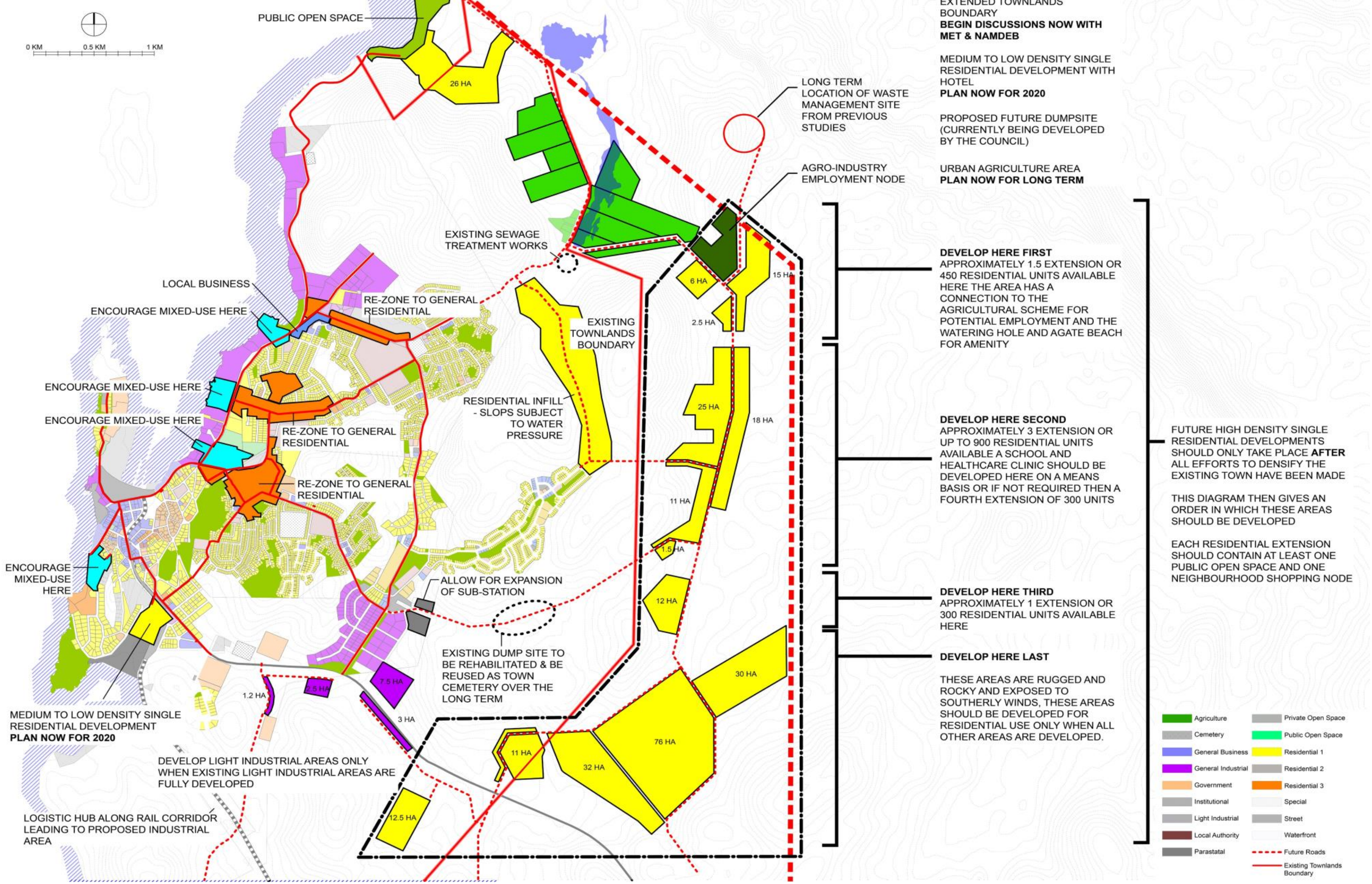
Fig. 08 Structural Concept for Sub-Region



The resolution in respect of further development is stated by the structure plan, is to densify existing developments to capacity prior to expansion of residential developments beyond the existing footprint. The extent of future developments as proposed by the structure plan is presented on the next page.

This concept will be considered where bulk infrastructure is planned, but would not be used to dictate the extent of such infrastructure.

Fig. 15 Indicative Land Uses



EXTENDED TOWNLANDS BOUNDARY
BEGIN DISCUSSIONS NOW WITH MET & NAMDEB

MEDIUM TO LOW DENSITY SINGLE RESIDENTIAL DEVELOPMENT WITH HOTEL
PLAN NOW FOR 2020

PROPOSED FUTURE DUMPSITE (CURRENTLY BEING DEVELOPED BY THE COUNCIL)

URBAN AGRICULTURE AREA
PLAN NOW FOR LONG TERM

DEVELOP HERE FIRST
APPROXIMATELY 1.5 EXTENSION OR 450 RESIDENTIAL UNITS AVAILABLE HERE THE AREA HAS A CONNECTION TO THE AGRICULTURAL SCHEME FOR POTENTIAL EMPLOYMENT AND THE WATERING HOLE AND AGATE BEACH FOR AMENITY

DEVELOP HERE SECOND
APPROXIMATELY 3 EXTENSION OR UP TO 900 RESIDENTIAL UNITS AVAILABLE A SCHOOL AND HEALTHCARE CLINIC SHOULD BE DEVELOPED HERE ON A MEANS BASIS OR IF NOT REQUIRED THEN A FOURTH EXTENSION OF 300 UNITS

DEVELOP HERE THIRD
APPROXIMATELY 1 EXTENSION OR 300 RESIDENTIAL UNITS AVAILABLE HERE

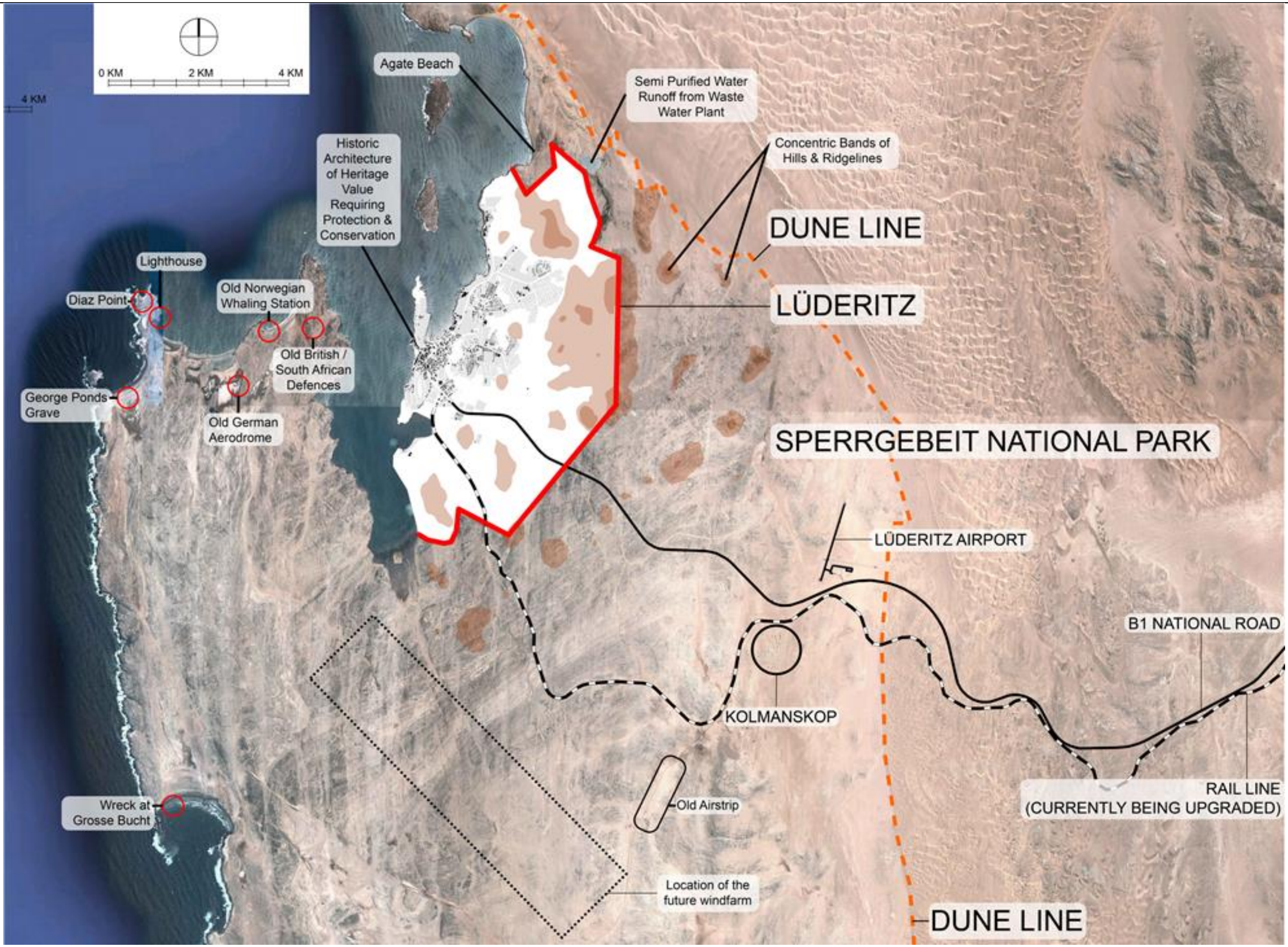
DEVELOP HERE LAST

THESE AREAS ARE RUGGED AND ROCKY AND EXPOSED TO SOUTHERLY WINDS, THESE AREAS SHOULD BE DEVELOPED FOR RESIDENTIAL USE ONLY WHEN ALL OTHER AREAS ARE DEVELOPED.

FUTURE HIGH DENSITY SINGLE RESIDENTIAL DEVELOPMENTS SHOULD ONLY TAKE PLACE **AFTER** ALL EFFORTS TO DENSIFY THE EXISTING TOWN HAVE BEEN MADE

THIS DIAGRAM THEN GIVES AN ORDER IN WHICH THESE AREAS SHOULD BE DEVELOPED

EACH RESIDENTIAL EXTENSION SHOULD CONTAIN AT LEAST ONE PUBLIC OPEN SPACE AND ONE NEIGHBOURHOOD SHOPPING NODE


0 KM
2 KM
4 KM
4 KM
Agate Beach
Semi Purified Water Runoff from Waste Water Plant
Concentric Bands of Hills & Ridgelines
Historic Architecture of Heritage Value Requiring Protection & Conservation
DUNE LINE
Lighthouse
Diaz Point
Old Norwegian Whaling Station
LÜDERITZ
Old British / South African Defences
George Ponds Grave
Old German Aerodrome
SPERRGEBEIT NATIONAL PARK
LÜDERITZ AIRPORT
B1 NATIONAL ROAD
KOLMANSKOP
RAIL LINE (CURRENTLY BEING UPGRADED)
Wreck at Grosse Bucht
Old Airstrip
Location of the future windfarm
DUNE LINE

5.2.2 Demography and Socio-Economic Data

It is stated in the structure plan that historic population growth of Lüderitz is not linear and the long-term compounded annual growth rate is about 2,1%. It was also proposed that the actual population growth might be between the experienced 2,1% and the lower national ‘natural growth rate’ of the population of 1.4%.

It is also stated that the household population of Lüderitz as measured in the census of August 2011 was 12,232 persons split between 4,044 households, with an average household size of approximately 3.02 persons per household.

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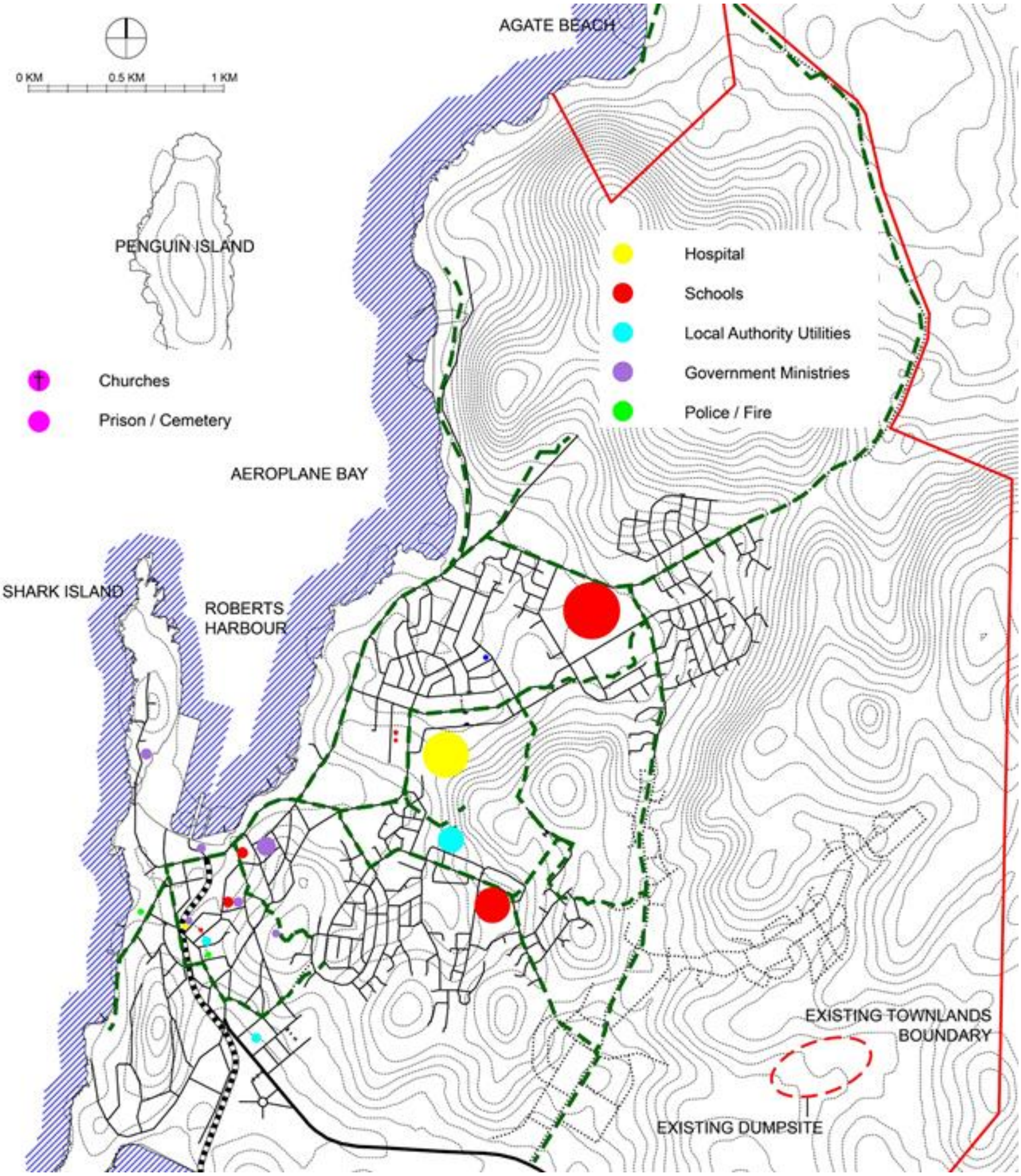
The 2020 population figure was estimated in 2015 to be between 15,057 and 14,208 people.

Social challenges stated by the structure plan include:

- Unemployment is seen as a major problem.
- In terms of quality of life, the population views the fishing industry, the mining industry, the harbour, and the waterfront as the major assets. People like the weather, the peacefulness, and the scenery.
- The population is not expanding at the same rate as other towns in Namibia, this is partly because of Lüderitz’ isolation, and partly because there is not a big enough employment draw.
- The cost of living is identified as a major problem, particularly the cost of food water and electricity.
- Living conditions for residents in the poorest neighbourhoods are as bad as anywhere in Namibia, but this is exacerbated by the climactic conditions. Care needs to be taken on provision of low-income housing in the future.

5.2.3 Major Non-Residential Zoning



5.2.4 Water and Wastewater Infrastructure

The structure plan provides quite an extensive overview of the exsing water infrastructure as background information and is extensively quoted below.

A *Water*

Water for Lüderitz is pumped from the Koichab Pan, via a well-field of 8 boreholes. The aquifer below the pan is a fossil reserve, and is therefore recharged at a slow rate. Water is abstracted from 8 boreholes in the Koichab Pan Aquifer and is collected in a reservoir. Water is transferred from the collector reservoir to the Lüderitz terminal reservoir by means of a 120 km long gravity pipeline and 5 booster stations along the route. The capacity is 200 m^3 per hour (Namwater.com.na, 2014).

The Koichab well-field is situated 120 km north-east of Lüderitz at the foot of a massive dune formation up to 200m high. The Koichab area was proposed as early as 1914 as the most suitable source of water supply for the growing town of Lüderitz, however a water supply scheme was only established in 1968.

The Koichab well-field covers an area of 20 x 3 km^2 with an average aquifer thickness of 50m and water level at 16m. Radio carbon analyses show that the groundwater in the Koichab River aquifer is fossil water some 5000 - 7000 years old. It is of Group A quality and one of the best waters found in Namibia.

There is conflicting information on the water recharge of the Koichab Aquifer.

The sustainable yield of the Koichab Aquifer was estimated at $2m^3$ million a year, although hydrologists admit that the aquifer’s recharge system is not entirely understood it is considered that the current abstraction rate is

sustainable, but this cannot be guaranteed over the long term.

The water use of the Town is 1.043 million m^3 (August 2012 to July 2013; Source: Ignatius Tjipura, LTC). 99.3% of the Lüderitz residents have access to safe water and 90.5% have access to water-borne toilet facilities.

Nationally an average it is only 80% of Namibians that have access to safe water and 51% to toilet facilities.

In view of the uncertainty on the sustainable extraction of water from the Koichab Pan, and due to the fact that it is good environmental practice to consider alternative sources of water in a desert environment, alternative solutions will need to be developed over the long term, such as desalination.

The process of developing a desalination plant requires a number of detailed engineering studies however the a general area has been identified for the potential location of a plant. (as per comms Venter Willem Venter Namwater 10/04/14)

Water reclamation or desalination has to be considered.

In case desalination is an option, additional power needs to be supplied, possibly using a renewable, off-grid technology.

In case water reclamation is considered, the sewerage plant infrastructure needs to be expanded. The European Union funded the sewerage plant in 2008. Although the installation was planned up to a stage where water would be fit for human consumption, high costs prevented the construction of the second phase of the facility. In any event, NamWater recommend demand management before any costly alternative to obtain water is considered.

Given the climatic conditions that prevail in Namibia, and considering the fact that the recharge of the Koichab Aquifer still needs to be fully understood, it is important that large water consuming economic activities should as a rule not be encouraged in the areas that either relay solely on groundwater or that are not in the vicinity of one of Namibia's few permanent water-bearing rivers.

> *According to Namibian policy, water is for human consumption first, followed by serving the needs of animals. The provision of water for industrial purposes is at the bottom of the priority list.*

B Sewerage

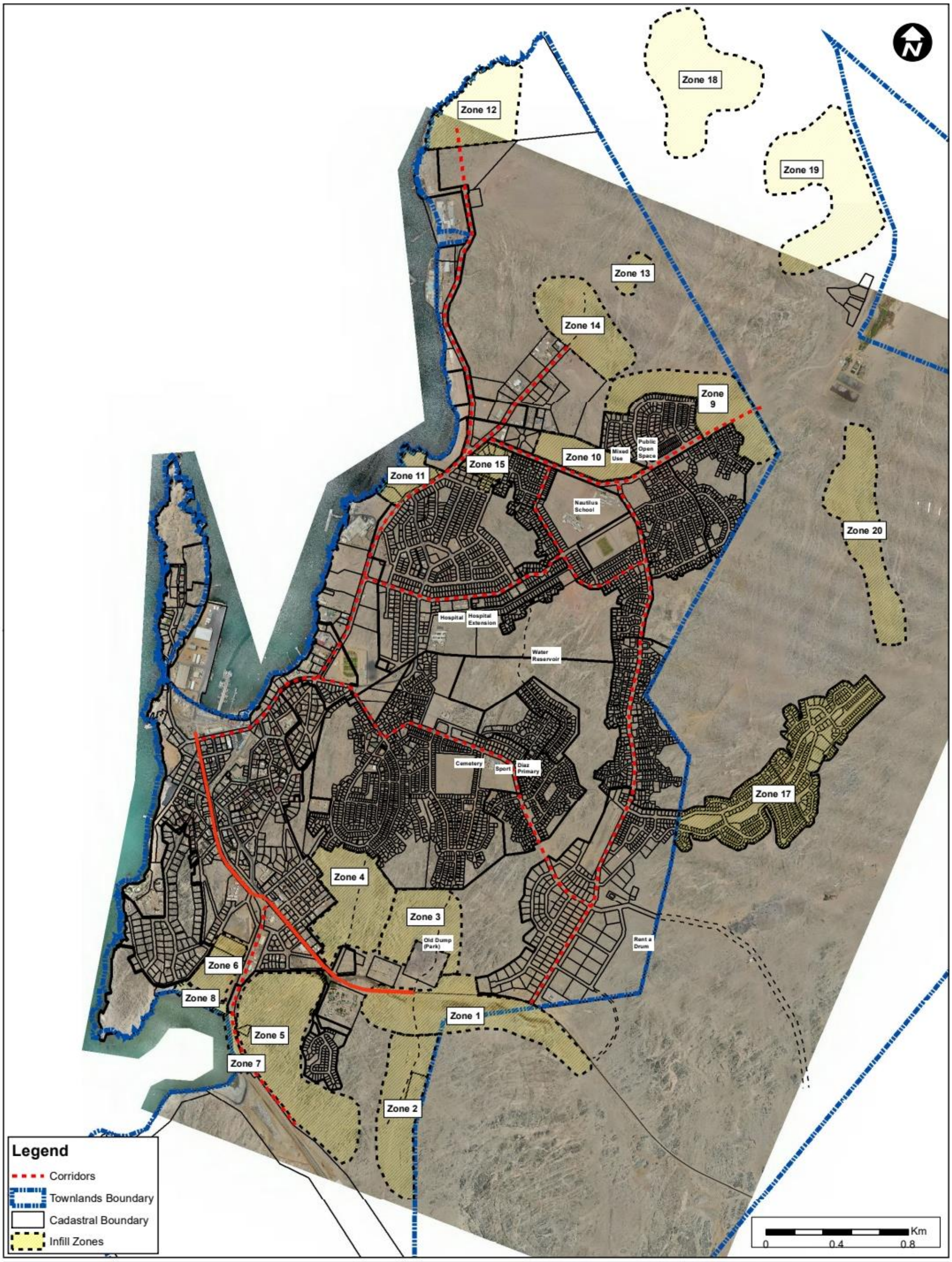
As far as the Town's capacity to treat sewerage is concerned, the sewerage ponds have a capacity to handle 2,000 m³ of drain water per day. Currently, there is an inflow of 1,300 m³ per day. There is sufficient land to the north of the sewerage ponds in case the plant needs to be expanded. Given a population growth of 2.05% per year, an expansion of the facility may only be needed after 2031, when population levels could reach 18,834 inhabitants (an increase of 33% over the 2011 population figure of 12,537 people, which is proportionately equal to the 35% spare capacity of the sewerage works).

C Electricity

On average, the electricity consumption of Lüderitz was close to the 7.5 kVa per month (the figure for June 2013 has approached 7.45 kVa) that has been contractually agreed on with NamPower (as per comments: NamPower, Keetmanshoop, Hans Peens, 16 September 2013). The supply contract with NamPower will be increased to 15 kVa by 2015 (as per comments: LTC, Mr. Langer, 16 September 2013). The additional capacity will be sufficient for Lüderitz for the duration of the implementation period of the Structure Plan (2041).

5.3 Other Development Initiatives

Several expansion and densification areas have been identified for immediate development.

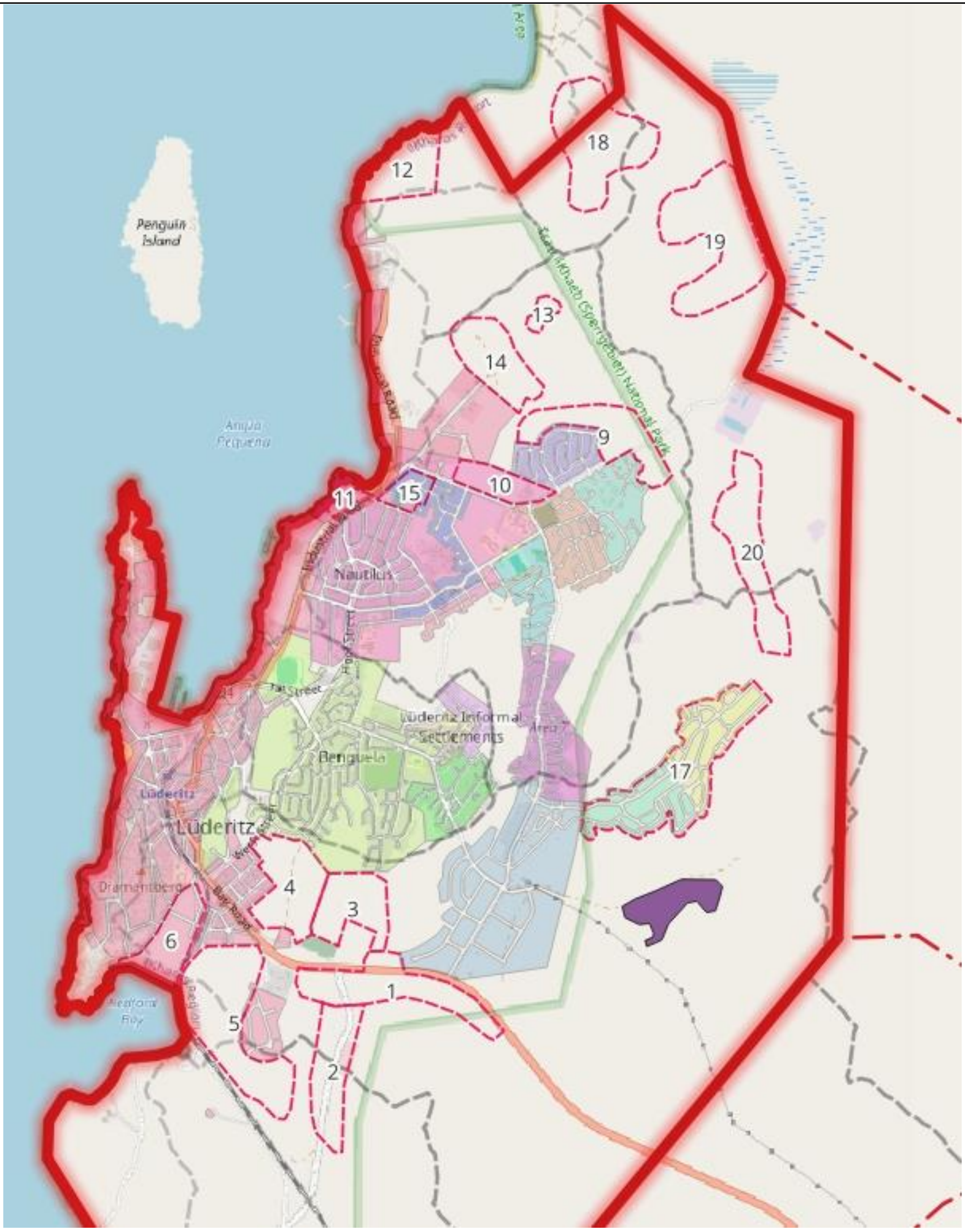


Stubenrauch Planning Consultants SPC

LÜDERITZ

Densification Map

January 2024



The above layout indicates the planned development areas for immediate development with red outline and numbers from 1 to 20.

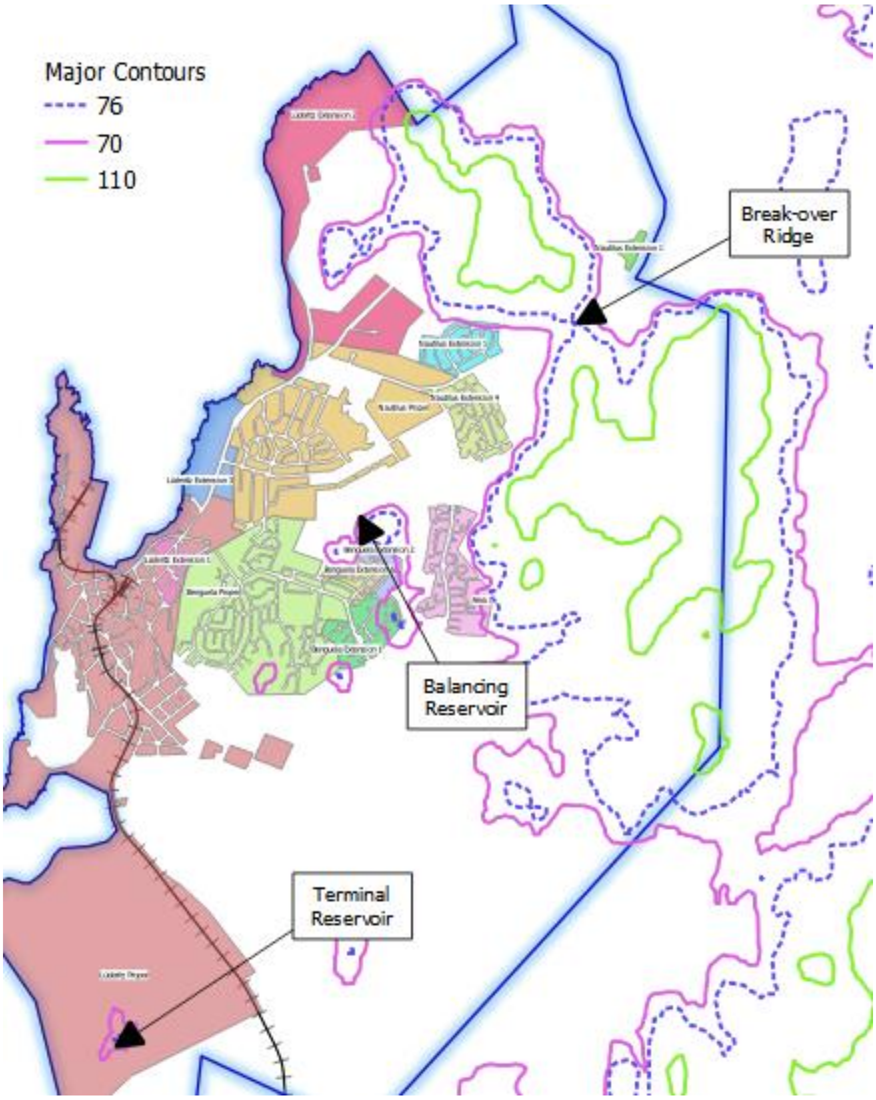
These areas were identified as available land to be developed without high impact on town planning requirements. As discussed later in this report, the impact the planned development has on existing and expansion infrastructure planning is significant enough to reconsider the suitability of all of the areas for development.

In principle, the topography has a huge impact on the design of both water as well as sewer infrastructure and the town planning should take cognisance of the economies of scale of water and sewer infrastructure development with topographical constraints.

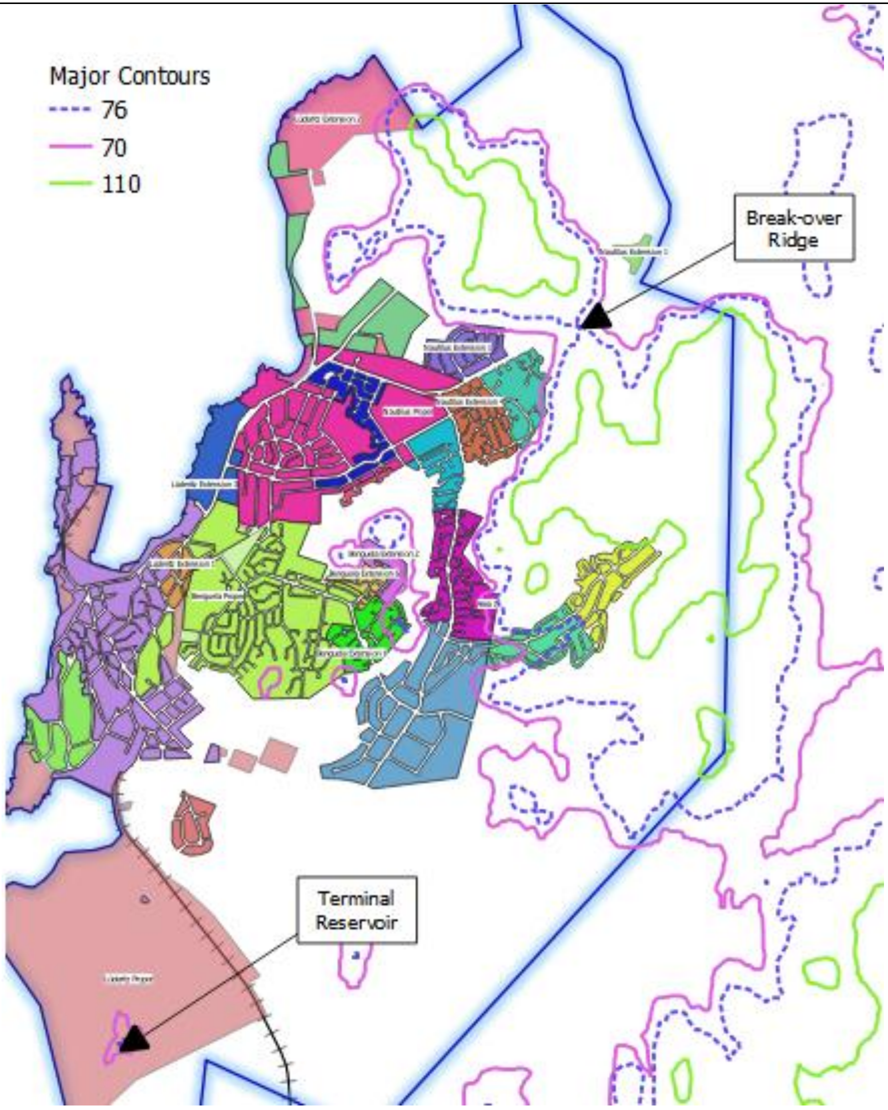
6 BASIC TERRAIN ANALYSIS

The terrain within the townlands area is dominated by rolling terrain with abundant granitic outcrop, and with gravel valleys in between of shallow gravel depths. A number of development extensions exists with minimal topsoil depth.

6.1 Major Contours



Existing Development Extent



Projected Future Development Extent

It is by coincidence that the NamWater Terminal Reservoir (Bulk Supply Reservoir) is at a natural ground elevation of 75 mAMSL as is the break-over ridge elevation near the wastewater treatment works. The 76m contour is thus a major contour indicating the extent of the static pressure envelope of the terminal reservoir.

The balancing reservoir near Benguela Ext 2 (mid-town) is also at an elevation of 75m.

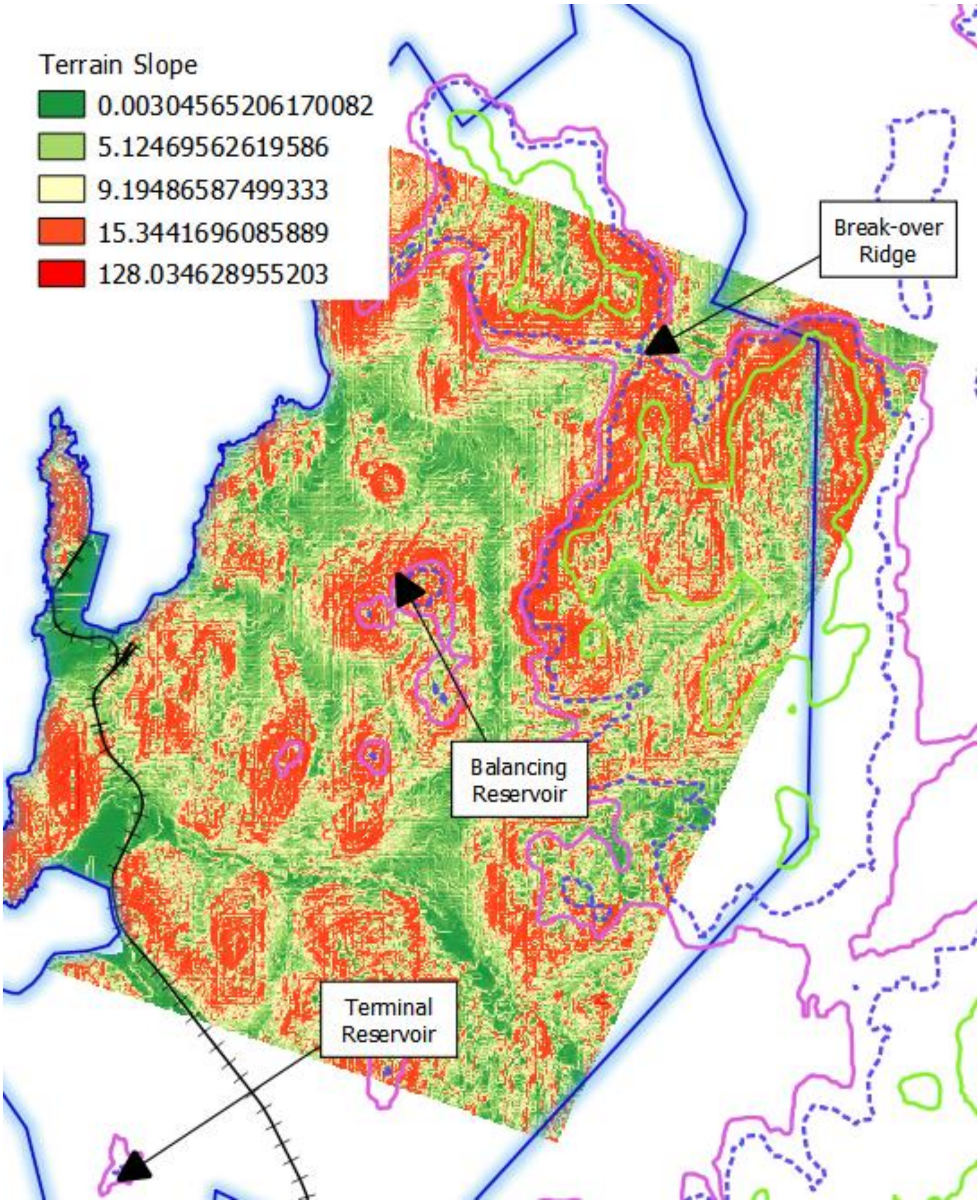
All of the existing development falls below and to the west of the 76m contour with only a portion of the future planned development falling above this contour (eastern: Benguela Ext 4 and Ext 5). These two extensions rise from 76m to 110m at the highest point, a difference in elevation of some 34m. To ensure adequate water pressure for Ext 4 and Ext 5, an additional bulk reservoir is required at significant pumping energy.

From a topographical stand point, Benguela Ext 4 and Ext 5 is not economical in respect of water supply.

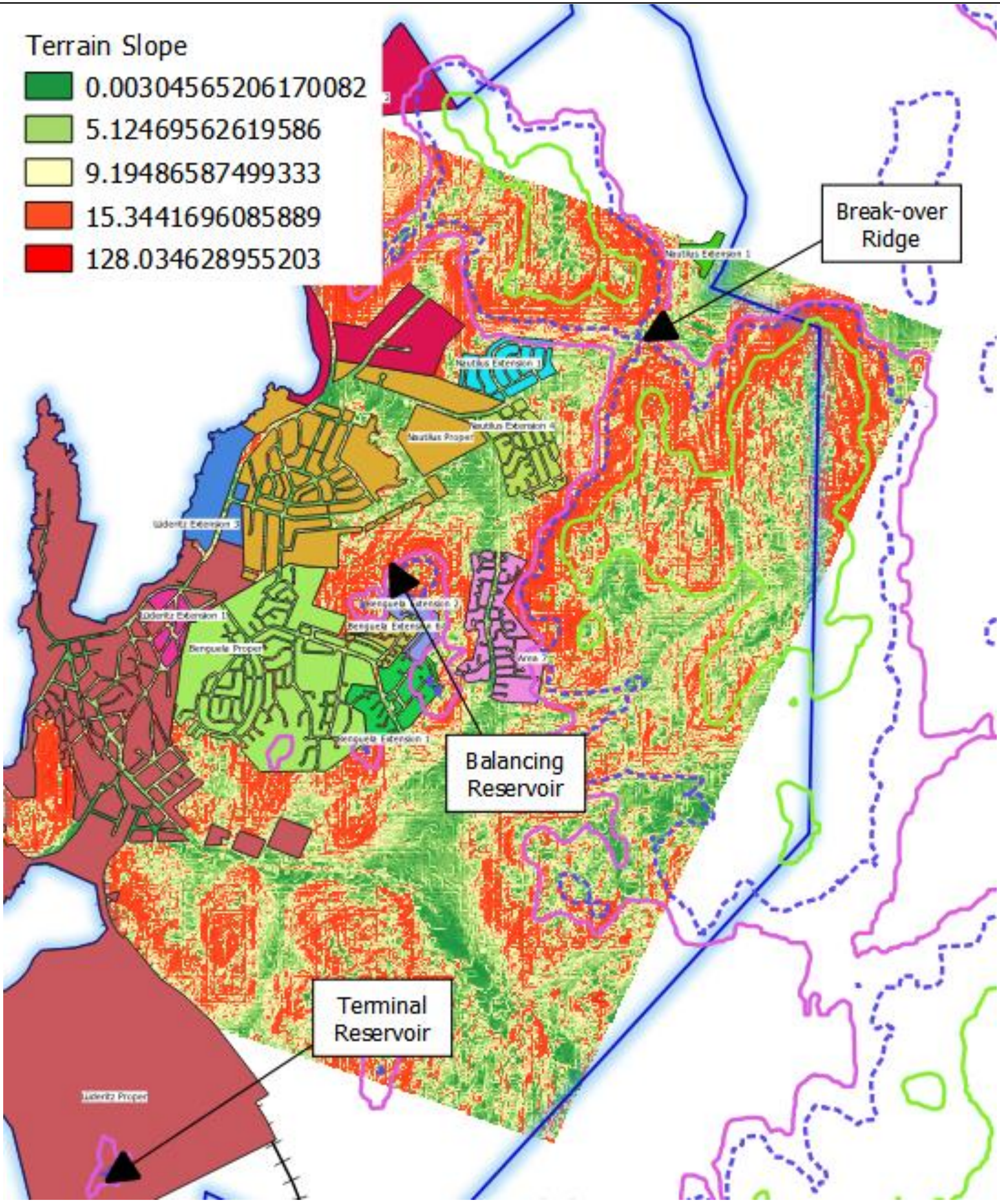
All wastewater to the existing wastewater treatment plant has to be pumped in order to breach the break-over elevation of the 76m contour.

6.2 Topography

The terrain slopes that are regarded as viable to develop are presented below in the green colours. The red colours are not considered to be viable for development.



The current development extent as it relates to slope is presented below.



6.3 Natural Drainage Basins

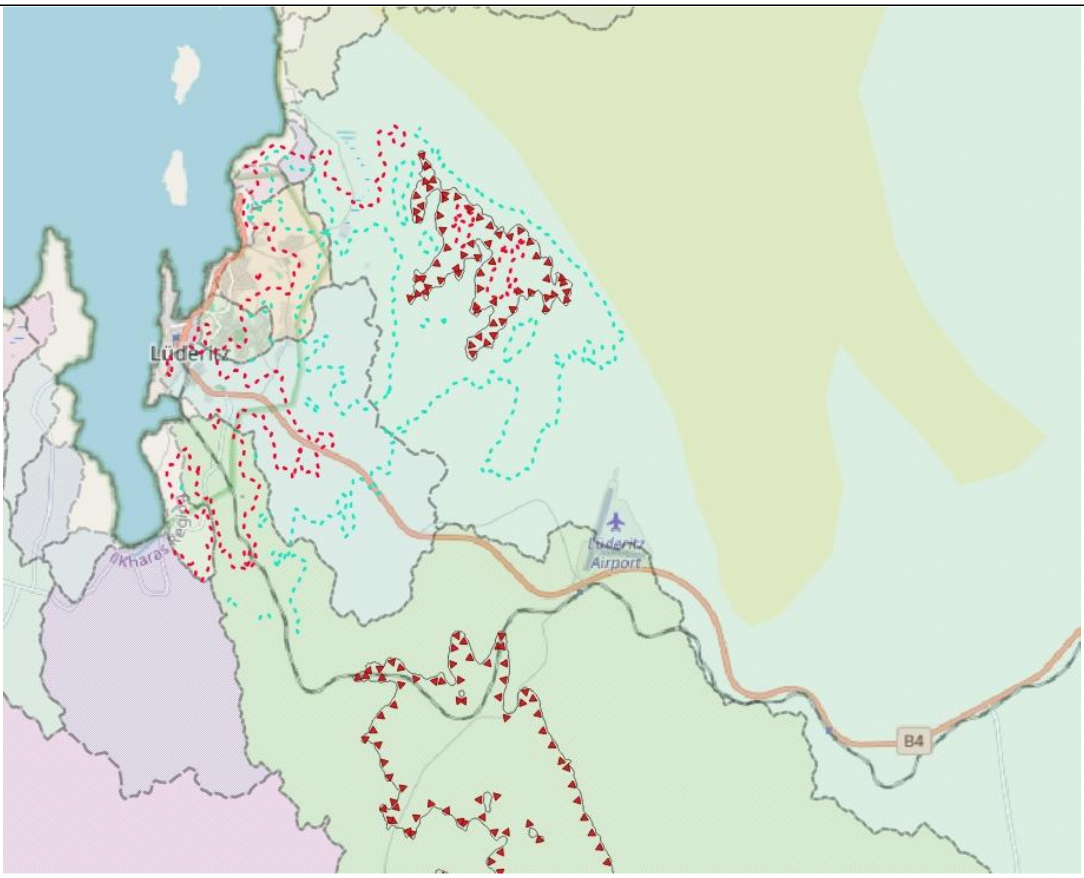
The environs around Lüderitz have a very low average annual precipitation and major drainage features are not known for the area. However, the natural artesian seepage along the south of the B4 road as it enters the Town is an indication of subterranean water features.

Although drainage basins are less significant for storm run-off purposes, it are the prime indicators of natural gravitational flow in a sewer system.

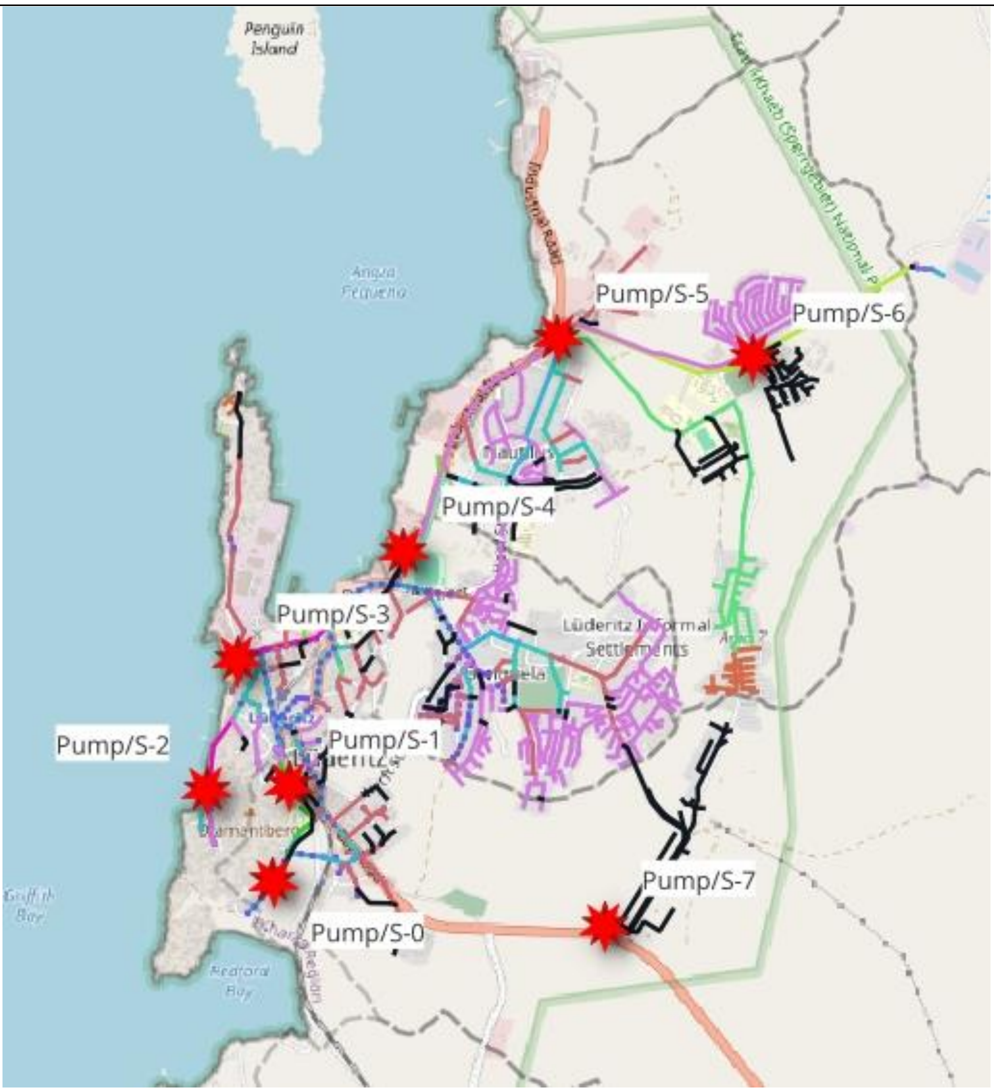
It is therefore always of benefit to follow the topography in developing townlands in order to reduce the complexity of pumped sewer systems. It should be appreciated that the existing system of pumped sewer system is a great burden on the Town Council and a similar situation should be avoided as far as possible.

New developments ought to take benefit of the topography and to shape new townlands extension in such a manner as to take cognizance of the natural flow pattern to be mimicked by the sewer system.

The below image indicates the main drainage basins of the town and environs.



The image to the top indicates the main drainage basins and the one to the bottom is a clearer indication of the basins affecting the townlands and environs.



The outlines of the drainage basis as it affects the current sewer pump system is highlighted in the above map.

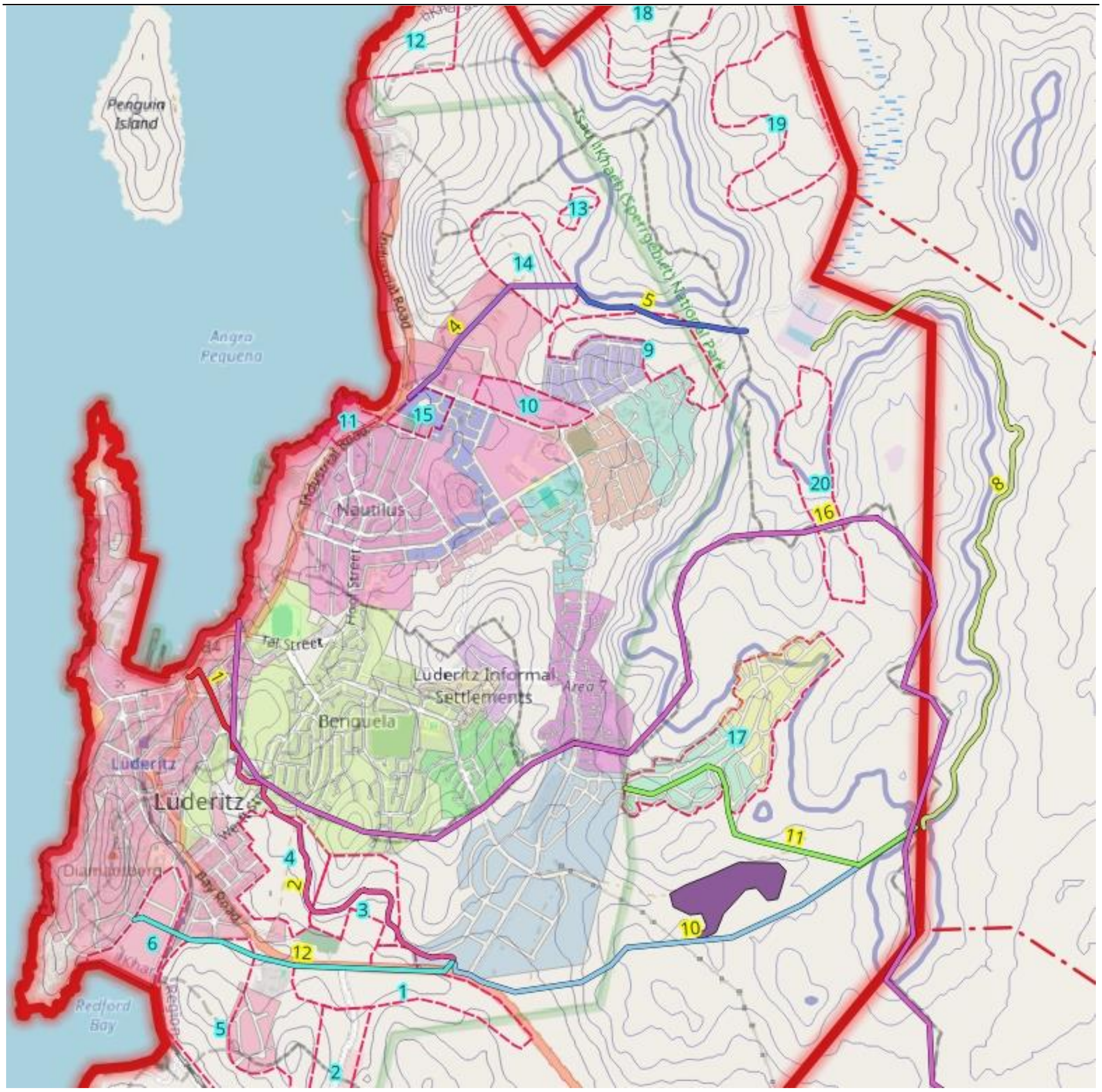
An improved system can be developed to eliminate the multiple successive pump systems that are dependent on downstream pumps to be operational not to cause a through flow blockage as is regularly experienced in the town.

It should, however, be noted that it would not be possible to avoid any pump system as the topography does not allow gravity only due to the fact that the existing sewer treatment is situated beyond watershed boundaries.

It is however possible to minimize the sewer pump system to a minimum by dividing the townlands into two major sewer catchment areas. The existing pump stations 4 and 5 would continue to discharge to the northeast. There is a proposal to also reduce the complexity of the existing pumping arrangements with a new line that would also cover the intended developments in areas 9, 13 and 14.

The existing sewer catchment areas serviced by pumpstations 1, 2, 3 and 7 as well as the future developments of 1, 3, 4, 6 and 17 is proposed to be services by a set of existing pumpstations but to realigned pipe system.

The above arrangements are indicated on the below map.



The new development areas are indicated by a number on a cyan background and the proposed new pumped sewer pipe system legs are indicated with number on yellow background.

The division of the townlands is indicated by line 16 (not a pump line).

The southern townlands are drained naturally to the basin low point and sewer is returned by pump along lines 1, 2, 12 10 and 11 to a high lying point near the townlands boundary. From here pipe no 8 gravitates towards the existing treatment works.

The above arrangement eliminates much of the complexity of the existing system. The northern drainage areas serviced by pumpstation 4 and 5 (also being the largest sewer collection volume) only depends on two pumpstations and not the four current arrangements.

It is thus imperative that the townlands layout consider the natural drainage of sewer system and be guided by the drainage basins as well as the most suitable sewer reticulation system.

7 DESIGN NORMS AND STANDARDS

This section provides the context for adoption of the parameters to develop the assessment and analysis criteria determining the status quo infrastructure performance and identification of gaps in performance as well as determining the future benchmark requirements.

7.1 Reference Norms and Standards

The LTC proposed that the design should be based on "*Guidelines for Human Settlement Planning and Design*" published by CSIR (Red Book, or HSP&D) which will be adopted. We were also issued with the water and sewer guidelines of the LTC, which are appended hereto under ANNEX A.

Guidelines as to the Level of Service differ amongst the various services, and therefore a common Level of Service that is considered applicable to all the services is presented under section 6.3 below, and further discussions of such follows under the various different sections below.

Development of infrastructure for future use is done premised on certain design intent and user expectations or demands. The future is uncertain, and this uncertainty issue is covered by the various guidelines for specific user environments.

7.1.1 Potential Growth in Demand

Anticipated future development extent and growth should be considered in any development. The capacity of Infrastructure should be able to cope with changes in demand over the adopted period of design life as above. However, sound economic principles restrict over capacity. Therefore, phasing of infrastructure capacity should be a parameter to be considered. Phasing of capacity is determined on economic principles, but is dependent on the type of infrastructure.

It can be readily appreciated that it would be more costly to phase pipeline capacity than for instance storage capacity. To increase storage on available land is about adding additional units which are then determined by the growth rate of demand and economic factors.

Due to the geometry of pipelines, to divide a suitable pipe in two, is not merely to half the numeric value of the diameter. The reduced geometric formula for the ratio between a single pipe versus equivalent of two equal diameter pipes is $D_{small} = D_{large} / \sqrt{2}$. Thus, the diameter for two pipes having the same area capacity than a single 100 ND, is 70 ND. (The hydraulic equivalence is slightly more complicated, but not subject to discussion here).

The same principles apply to other infrastructure where the capacity constructed initially should be cognisant of the future growth in demand.

In respect of roads, some of the aspects to be considered is the growth in traffic that is affected by many factors, some not immediately evident. Due to the nature of the current development, it can be expected that initially most of the generated traffic are commercial transport suppliers, such as taxis and busses. However, over time it is most likely that gradual car ownership would increase as the access to title deeds make it more possible for individuals to secure loans. This subject is, however, outside of the scope of this report and it suffice to make mention of the dynamics that would influence a design of this nature.

A Infrastructure Capacity Growth Predictions

It is quite intuitive to regard the growth of infrastructure capacity to be a simple extension of population growth. The most obvious case where population growth would be close to the growth in demand for infrastructure capacity, is in remote urbanized areas where the number of people and not the broader economy is the only determinant of infrastructure capacity.

However, in terms of the growth in demand for infrastructure development in general has many drivers and is a complicated model to simulate. The complexity of such a model is outside of the application to this type of development, as the land use is generally residential with limited and dispersed business and industry allocations.

The potential growth in demand for the current project is many driven by the town planning scheme and the extents of the development that is largely known and defined. The total future area of development is some 1 200 ha, or about 10 times the Phase 1 development. However, some of the infrastructure is not affected by the future expansion to the development.

Once a water reticulation zone has been installed, it would remain serving only that area that is connected to the reticulation. Some future changes in land use, for instance densification from detached dwellings to high rise dwellings on the same property (or same water connection) is usually unlikely, but does happen, and for such circumstances it would be on a small scale that would not materially change the level of service provided for the specific reticulation. This is due to the ability of a well designed network to balance flows and pressures within the network to accommodate the increase in use on a specific node, pipe and sub-skeleton of the network.

On the other hand, due to the arrangement of the layout for this development, the design of some of the roads is affected by the future development. Access to the regional roads network is to the north of the development and those roads leading onto and intersect with the access roads require to be designed in cognisance of the future development and traffic generated from it over the design period of such roads.

B Future Demand Growth: Water

The water reticulation is divisible by extension and associated with the proposed elevated tank, and as the reticulation area is not subject to change, no growth in demand is applicable, in as far as size is concerned. There is also not a change in terms of Level of Service anticipated as the Level of Service for the end of design life is applicable for reticulations.

The correct Level of Service selection would sustain the above premise, however, if a lower Level of Service is selected than that anticipated for the end of design life, might cause the reticulation to become redundant and to be replaced in the future, which is not an economical approach.

For the bulk and internal bulk infrastructure a different approach would be followed and such future development that would have an influence on the bulk infrastructure would be considered for final capacity determination.

C Future Demand Growth: Sewer

Sewer is a return flow of the water consumed and therefore the growth in sewer loading is driven by the growth in water demand and therefore the same argument as for anticipated water demand growth applies to the growth in sewer loading.

7.1.2 Level of Service

It is our opinion that the Level of Service for the development be as follows

Table 1 : Level of Services (LoS) Matrix

Ref	***Service***	***Description of Level of Service (LoS)***	***LoS Requirements***
1	Water : Supply average annual daily demand	Moderate to High (HSP&D Tbl 9.11)	Available water supply, but at 90 l/capita/day
2	Water : End user demand for sizing of reticulation pipe mains	Middle Income (HSP&D Tbl 9.14)	600 to 1000 l/property/day Or 200 l/capita/day
3	Water : Residual Pressures	House connections and Low Risk – Group 3 (HSP&D Tbl 9.17 to 9.21)	Maximum – Limit to 60m Minimum – 24m peak flow without fire water Minimum : 15m peak flow with fire water from 1 hydrant
4	Sewer : Type	Group 3 : Water Borne House Connection (HSP&D Page 8)	No sewer retention within development – full reticulation with flushing toilets
5	Sewer : reticulation pipe sizing as well as cumulative sewer production	Middle Income Group (HSP&D Tbl C.1)	750 l/property/day
6	Streets and Stormwater	LoS = 3 (HSP&D Tbls 8.1 to 8.3)	Lined channel on shoulder or on street, street category as per use
7	Electricity	Medium : as per CSIR Red Book	1,5 to 3 kVA ADMD per customer

These various LoS standards are thus used to comply with due diligence in respect of technical design.

7.2 Full Water Reticulation with Erf Connections

Full services for water in respect of pipes, valves, fire hydrants and erf connections are required.

7.2.1 General

It is fundamental to the design of water reticulation to manage the overall pressure zones. The zones are determined from the supply area of a reservoir and the topography of the supply area.

There is a legacy acceptance of a limit to the maximum static pressure in a reticulation pf 9 Bar (900 kPa). This legacy pressure limit is also stated in the guidelines. The rational for adopting this pressure as appose to any other pressure is not well documented, but it is assumed to be a pressure that is just below the minimum pressure commercially available for appurtenances of 10 Bar (1 MPa). Although this pressure of 1 MPa is also used to demarcate low and medium pressure water infrastructure, there is no rational premise for adoption of this specific pressure as the maximum low-pressure value. It would be expected that the adopted maximum low-pressure value would be due to reasons of a practical nature such as the supply pressure requirements of user fixtures.

The counter argument for the minimum pressure in reticulations during peak demand should be higher than 2 Bar (200 kPa), which is a very sensical limit as most residential fixtures provide a good level of services at this pressure. Thus, the adoption of this pressure has the benefit that the level of service of the residential fixtures are still within good operating conditions during the peak demand period of the day when the overall reticulation pressure is at its lowest.

Adopting the same logic associated with the selection of the low-pressure limit for adopting the maximum pressure value, the limit of user fixtures pressure rating is that of the average household geyser of between 400 to 600 kPa. It would thus be a rational decision to select the maximum pressure in a reticulation at static conditions to be 600 kPa.

It is therefore appropriate to install water infrastructure with a pressure rating of PN 6 (600 kPa) as a maximum value, except where individual water reticulation component minimum pressure ratings are higher, such as valves that are only available with a minimum pressure of PN 10 (1 MPa). It is a significant cost saving to have the reticulation pipes of a maximum pressure of PN 6, over a pressure of PN 9.

7.2.2 Layout Design

Table 2 : Water Reticulation Layout Design

Ref	***Aspect***	***Positioning***	***Comments***
1	Reticulation Pipes	Pipe Centre Line 1,6 m from erf boundary in road reserve Generally, only one pipe along a road reserve, with house connections on other side of road to cross road with HDPE 40 ND. Layout arrangement to avoid cross-connections – at such locations T-connections should be staggered with minimum distance of 2m apart – preferably, place T-connections on opposite sides of road reserve Pipes to be placed along the erf boundaries with the least number of connections crossing over a road Avoid non-standard bends (Standard bends 11¼°, 22½°, 45° & 90°) or combination of sequential bends – develop change in direction over distance	Layout determination based on cadastral information and coordinates of changes in direction to be reported Each junction of more than one pipe (not bends) to be numbered A schedule of all connections and fittings to be provided, ordered as type of connection with all nodes of type listed
2	Pipe Trench	<u>Trench width:</u> Minimum 600 mm at house connections For reticulation pipes – minimum width as per SANS 1200 LB Preferred 800 mm wide standard for pipe 50 to 200 ND pipe	

Ref	***Aspect***	***Positioning***	***Comments***
		Trench depth: 1,0 m cover over pipe maximum under road crossing 800 mm cover along road reserve Extent depth past pipe to underside of bedding as per SANS 1200 LB	
		Bedding to Pipe: As per SANS 1200 LB for flexible pipes	
3	Fire Hydrant Placement	To be along routes accessible to fire fighting vehicles Opposite erf pegs At distances of not more than 240 m apart measured along road reserve	Pillar type Placement at dead-ends (for souring purposes) and high points (for air release on filling) to be checked once initial position was done
4	Thrust Restraint	For pipes not having restrained couplings, at all change in flow direction For restrained (flanged) connections, where pipes enter or exit structures or at places where maintenance would cause a section to have high differential pressure – check differential pressure difference for all operational conditions and anchor as needed At valves and other fittings not restrained – spigot and socket valves	Require Geotech information (lateral bearing resistance of soil) to determine block size Constructed from 20 MPa mass concrete

Ref	***Aspect***	***Positioning***	***Comments***
5	Valves: Isolating	Placed such as to avoid closing more than four valves to isolate a section of main Pipe sections between isolating valves should not exceed a length of 600 m – investigate to mitigate situation Located at street corners opposite erf corner boundary (splay) pegs, and intermediate valves opposite the common boundary peg for two erven At junctions of multiple pipes, installed in the smaller-diameter branches For larger mains (> 200 ND) valve diameter may be reduced by one Nominal Diameter size, as long as velocity is lower than 1,5m/s through open valve.	Tapered square cap for key
6	Valves: Air	No air valves are used as supply connections (and fire hydrants) function as air release	
7	Valves: Scour	Limited scour valves are used as fire hydrants should also function as scour release At strategic low points and dead-ends, scour valves should be placed with outlet sump such that reticulation can be drained by pumping sump empty. External drainage of scoured water to be controlled and contained in order not to pond water, erode soil or damage anything else	
	Valves: Chambers	Valve chambers of various sizes, depending on use, will be employed Isolating valve chambers are essentially a small masonry opening around the valve with a tubular extension to surface (200 ND uPVC pipe) terminating at NGL in a concrete surround with small valve lid Scour valve chambers are designed for in situ conditions with dry void access to valve body partitioned into a wet well area for receiving mobile drainage pump and equipment	In paved environment, valve lid to be at finished level In un-paved or gravel surrounds, lids to protrude at least 150 mm above NGL.

7.2.3 Basic Planning and Design Analysis Criteria

Water use is dependent upon the land use. The values of Fig 9.9 and Tbl 9.14 were used to determine water use, which results are summarized below

Table 3 : Water Use Demand

Ref	***Land Use***	***l/m²/erf***	***Min l/day***	***l/100m²bld***
1	Agricultural	1	600	
2	Business : General	2.4	600	400
3	Business : Local	2.4	600	400
4	Government	2.4	600	400
5	Institutional	3	600	500
6	Municipal	2.4	600	400
7	POS	1	200	
8	Residential	1.05	450	
9	Residential : General	1.4	600	
10	Utility Services	0.4	200	

Erf density ratio *0.6*

Criteria to be used during analysis of water networks and appurtenances.

Table 4 : Water Infrastructure Design Criteria

Ref	***Aspect***	***Description***
1	Design Horizon: Years after commissioning	Bulk supply pipelines and reticulation: 25 Mechanical and electrical equipment: 10-15
2	Growth in Demand	No adjustment to the Level of Service as selected for both reticulation as well as elevated storage.
3	House occupancy:	5 persons
4	Design Water Usage:	As per table above
5	Provision of Fire Flow	900 l/min (15 l/s) Single simultaneous hydrant discharge
6	Pipe Flow Friction Factors	Darcey-Weisbach flow equation with Moody Chart friction factor as predicted by Swamee-Jane formula Pipe Roughness : 0,1mm which includes fitting losses in reticulations
7	Design Loss Factors (LF):	i)Water treatment works, $LF_w = 10\%$ ii)Total conveyance losses, $LF_r = 10\%$
8	Gross Average Annual Daily Demand (GAADD):	$GAADD = (1 + LF_r) * AADD$

Ref	***Aspect***	***Description***
9	Summer Peak Factor:	SPF = 1,2
10	Summer Daily Demand (SDD_{ww})	SDD_{ww} = SPF * GAADD * (1 + LF_w) Design Pumping Period = 20 hrs/day Water treatment mechanical equipment as well as raw water and clean water pumps.
11	Summer Daily Demand, (SDD_{pl}):	SDD_{pl} = SPF * GAADD Bulk supply pipelines
12	Storage Reservoirs: (Total Storage, i.e. Regional and Service Reservoirs combined, but **<u>excluding</u>** elevated tank volume)	Pumped from One Source : 48 Hrs * AADD Pumped from Multiple Sources: 36 Hrs * AADD Gravity from Source: 24 Hrs * AADD Recommended to split volumes roughly equal between Regional and Service storage's for new reservoirs. A maximum of 24 hours and a minimum of 16 hours is required at Service storage.
13	Elevated Tank/Tower: (Only required to provide reticulation pressures)	4 Hrs * AADD (only for area to be served by tank)
14	Design for pipeline flow between Main Storage and Elevated Tank:	2 * GAADD (Gravity) 2 * GAADD (Pumped: 20hrs/day)
15	Design Peak Factor (DPF)	Reticulations DPF = 3
16	Design Peak Flow Rate (DPFR)	Reticulations DPFR = DPF * GAADD
17	Residual Pressures in Reticulations (above NGL)	25 m minimum at supply point under Peak Flow conditions without fire flow. 15 m minimum at supply point under Peak Flow with fire flow conditions
18	Restriction to Velocities	DPFR for Reticulations: Min 0,2 m/s & Max 1,5 m/s

7.2.4 Use of Material

Table 5 : Water Infrastructure Material Specifications Summary

Ref	***Type***	***Description***	***Rating***	***Size/Capacity***
1	Reticulation pipes	HDPE (SANS 533)	PE 100 PN 6	50 & 63 ND
		uPVC (SANS 966 or ISO 4422)	PN 6 (Class 6)	Min 75 ND Max 250 ND
		GRP	PN 6	Min 200 ND Max 800 ND
		Galvanised Mild Steel (SANS 62)	Medium Duty	15 - 150 ND
		Steel Min. API 5L Grade A	Min. wall thickness t = 4,5 mm Slenderness, D/t < 120	> 200 ND
2	House Connections	HDPE (SANS 533)	PE 100 PN 16	25 ND – single house 32 ND – double house
3	Fire Hydrants	SANS 10105-2:2010 Right Angle, tamper proof – 80mm Brass sluice-valve type		80 ND and larger mains connection
4	Valves	Cast Iron : SABS 1034 Gr 250 Spigot and socket, Flanged or Screwed for suitable application	PN 10	50 – 250 ND

7.2.5 Assembly and arrangement

The water infrastructure assembly and arrangement drawings are attached as Annex E. These are mostly typical details from which design decisions are made, as well as used for measurement and costing purposes.

7.3 Full, Waterborne Sewage Reticulation with erf connections

Full services for waterborne sewage system in respect of pipes, manholes, pump lifting stations and erf connections that are required.

7.3.1 Layout Design

Table 6 : Layout Design : Sewer

Ref	***Aspect***	***Positioning***	***Comments***
1	Reticulation Pipes	Pipe Centre Line 2,5 m from erf boundary in road reserve House connection link pipes to serve 4 erven Generally, only one pipe along a road reserve, with house connections on other side of road to cross road with 110 ND. Pipes to be placed along the erf boundaries with the least number of connections crossing over a road	Layout determination based on cadastral information and coordinates of changes in direction to be reported Each lateral connection serving more than one erf to be numbered A schedule of all connections to be provided, ordered as type of connection with all nodes of type listed
2	Pipe Trench	<u>Trench width:</u> Minimum 600 mm at house connections for shallow depth For reticulation pipes – minimum width as per SANS 1200 LB Preferred 800 mm wide standard for pipe 110 to 200 ND pipe	When the sewer is to be located in a trench by itself, the minimum clear width to be allocated to it in the road reserve should be 1,5 m
		<u>Trench depth:</u> 1,4 m cover over pipe minimum under road crossing Extent depth past pipe to underside of bedding as per SANS 1200 LB Variable to a maximum of 3,0m as per SANS 1200 LD	
		<u>Bedding to Pipe:</u> As per SANS 1200 LB for flexible pipes Drawing LB-2 of SABS 1200 LB	
3	Manhole Placement	At horizontal distances of not more than 60 m apart measured centre line Consideration should be given to spacing of not more than 100 m	

Ref	***Aspect***	***Positioning***	***Comments***
4	Thrust Restraint	For steep pipes of grade in excess of 1:10.	Require Geotech information (lateral bearing resistance of soil) to determine block size Constructed from 20 MPa mass concrete
5	Curved alignment	minimum radius of curvature is 30 m	
6	House connections	In special residential areas, where an erf extends for a distance of more than 50 m from the boundary to which the connecting sewer is laid, provision need only be made to drain the area of the erf within 50 m of this boundary. The sewer connection should be provided at the lowest suitable point on the erf. On street boundaries the connection should be located either at a distance of 1,15 m or at a distance of 5 m or more from a common boundary with an adjacent erf, unless a local authority has already an accepted standard location. To be in accordance with SABS 1200 LD Figure LD-7 In very flat terrain, and where the house drains may be laid as an integral part of the engineering services, flatter minimum grades than 1 in 60 for the house drains may be considered. Minimum grades of 1 in 40 for house connections are proposed	
7	Junction with main sewer	A plain 45º junction should be used at the point where the connecting sewer joins the main sewer. Details of the connecting sewer should be in accordance with one of the types shown in Figures LD-7 and LD-8 of SABS 1200LD	

Table 7 : Sewer Basic Planning Design Criteria

<table>
<tr><th>Ref</th><th>Aspect</th><th>Description</th></tr>
<tr><td>1</td><td>Design Horizon:
Years after commissioning</td><td>Bulk pipelines and reticulation : 25
Mechanical and electrical equipment : 10-15</td></tr>
<tr><td>2</td><td>Growth in Demand</td><td>No adjustment to the Level of Service as selected for both reticulation as well as elevated storage.</td></tr>
<tr><td>3</td><td>House occupancy:</td><td>5 persons</td></tr>
<tr><td>4</td><td>Design Sewer Effluent Discharge:
Average Annual Daily Flow
(AADF)</td><td>Taken as 80% return flow from water supply</td></tr>
<tr><td>5</td><td>Pipe Flow Friction Factors</td><td>Chezy flow equation with Moody Chart friction factor as predicted by Swamee-Jane formula
Pipe Roughness : 0,6mm which includes fitting losses in reticulations</td></tr>
<tr><td>6</td><td>Extraneous inflow</td><td>15%</td></tr>
<tr><td>7</td><td>Design Peak Factor (for Reticulations):</td><td>DPF = 2,5</td></tr>
<tr><td>8</td><td>Design Peak Flow Rate (DPFR for Reticulation):</td><td>DPFR = DPF * AADF</td></tr>
<tr><td>9</td><td>Minimum self-cleaning velocity</td><td>0,7 m/s</td></tr>
<tr><td>10</td><td>Minimum longitudinal slopes</td><td>
<table>
<tr><th>SEWER DIAMETER (MM)</th><th>MINIMUM GRADIENTS</th></tr>
<tr><td>100</td><td>1 : 120</td></tr>
<tr><td>150</td><td>1 : 200</td></tr>
<tr><td>200</td><td>1 : 300</td></tr>
<tr><td>225</td><td>1 : 350</td></tr>
<tr><td>250</td><td>1 : 400</td></tr>
<tr><td>300</td><td>1 : 500</td></tr>
</table>
</td></tr>
<tr><td>11</td><td>Restriction to Velocities</td><td>DPFR for Reticulations: Min 0,2 m/s & Max 1,5 m/s</td></tr>
</table>

7.3.2 Use of Material

Table 8 : Sewer Infrastructure Material Specifications Summary

Ref	***Type***	***Description***	***Rating***	***Size/Capacity***
1	Pipes	uPVC Sections 3.1 and 3.2 of SABS 1200 LD.	400 kPa	Min 110 ND Max 250 ND

Ref	***Type***	***Description***	***Rating***	***Size/Capacity***
2	Manholes	All materials used for manholes should be in accordance with Section 3.5 of SABS 1200 LD.		

8 EXISTING WATER AND WASTEWATER INFRASTRUCTURE

8.1 Bulk Water Supply

8.1.1 Historic Water Supply to Lüderitz

According to CuveWaters Papers presenting results from ongoing research work in the project 'Integrated Water Resources Management' (2008), the historic picture is as follows:

> Sea water desalination was introduced in Lüderitz in 1897, using a submerged tube evaporator condensing plant [Wipplinger, 1963]. Prior to this the reception of this plant, fresh water had been imported, mostly by ship from Cape Town. Since coal was the thermal energy source, the tube evaporator plant and subsequent plants built in 1906 and 1912, were closely integrated with the operation of the railway system, and were managed by the railway authorities.
>
> In 1914 a 6-effect submerged tube evaporator with a capacity of about 150 m³/day, coupled to 600 m³ storage reservoirs for distilled water was installed. During 1941, it was replaced by a similar plant. In 1954, the Lüderitz Municipality completed a coal-fired power station with an adjoining 200 m³/day tubular evaporator plant.
>
> In 1962, the Municipality added a 24-stage multistage flash plant with a capacity to produce some 550 m³/day. Unlike the earlier plants, the latter two were not independent units, but worked in conjunction with the Lüderitz power station. Water consumption in Lüderitz in 1962 was 70,000 m³, and both plants jointly had a capacity of 225,000 m³ (300 days per annum). The excess fresh water supply meant that the 1962 plant operated below capacity, and thus below cost effectiveness, which prompted the Municipality to put measures in place to increase the water consumption of residents and industry. Today, Lüderitz drinking water is supplied from an aquifer, piped from the Koichab Pan some 120 km inland.

8.1.2 Current Bulk Water Supply

Bulk water supply to the town of Lüderitz is provided by NamWater through the Koichab Pan Bulk Supply Netwerok.

A *Source*

The source is fossil water reserves in the Koichab paleo-channel of the Koichab Pan aquifer. The Koichab wellfield, consisting of eight boreholes, is situated 100 km north-east of Lüderitz.

According to the "TECHNICAL SUMMARY OF WATER ACCOUNTS" by the Department of Water Affairs Ministry of Agriculture, Water and Forestry (2006), the Koichab resource potential was estimated at 1,19 Mm³/a.

In "Groundwater assessment and sustainable management of the coastal alluvial aquifers in Namib Desert, Namibia: Omdel Aquifer as case study" (Matengu, 2020), it is stated that the latest water quality chemical analysis for the production boreholes of Koichab Pan Aquifer is classified as Group A. The average actual abstraction (2015-2020) and the total recommended abstraction of production boreholes at Koichab Pan Aquifer is 1,1 Mm³/a and 2,23 Mm³/a respectively.

Estimated groundwater stored reserves amount to 1 600 Mm³ and 150 Mm³ for the entire aquifer and the well field respectively (van Vuuren 2000).

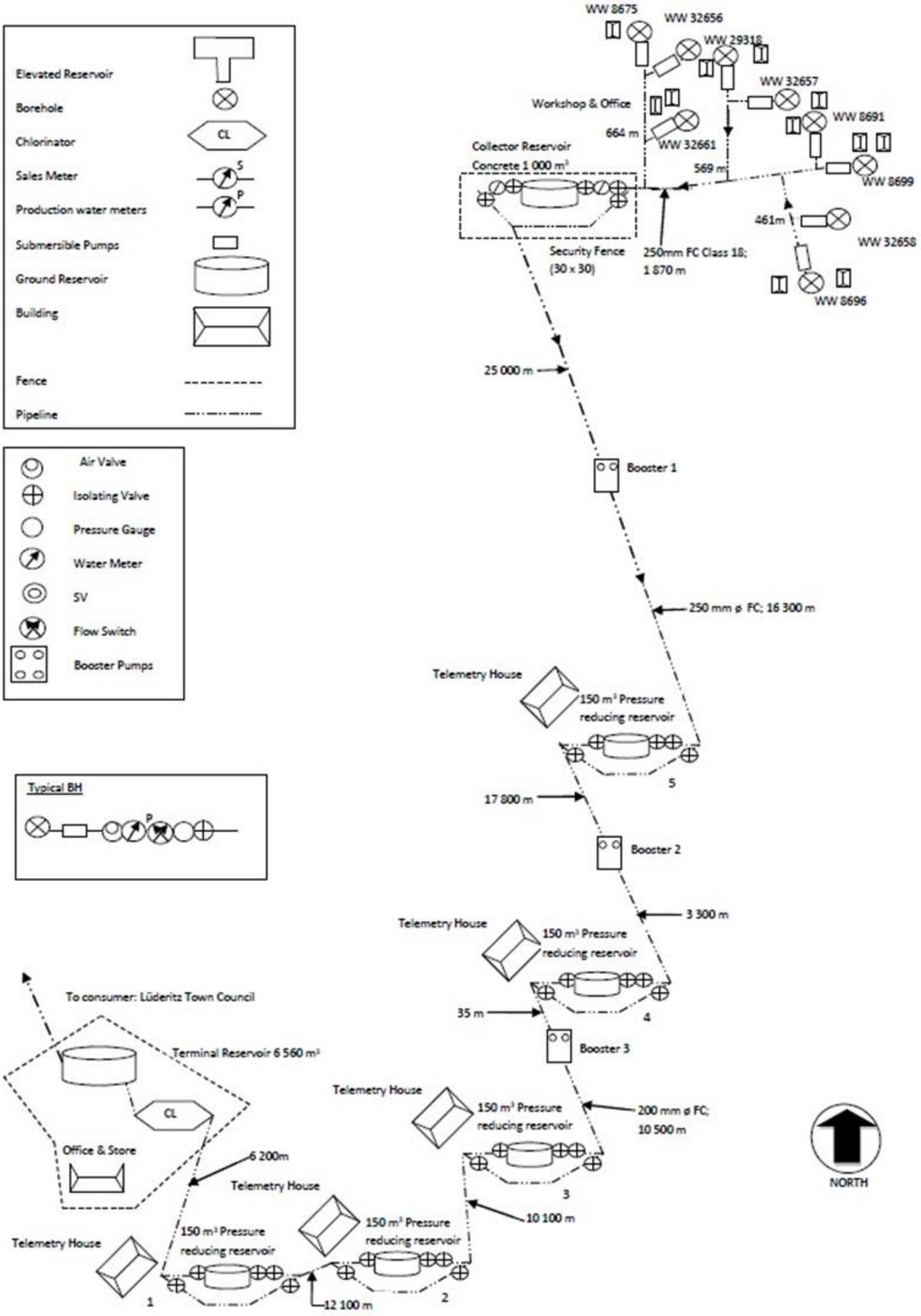
The information below is extracted from the ENVIRONMENTAL MANAGEMENT PLAN for the LÜDERITZ WATER SUPPLY SCHEME (NamWater, 2019).

B Water Quality and Disinfection

The production source of water from boreholes in Koichab Pan to Lüderitz falls in Group B, but after chlorination, the water quality falls in Group A.

At present chlorination takes place via the Alldos gas chlorinator, situated in a building at the terminal reservoir. A total of 24 500 m3/day of water can be disinfected at 2 g/m³.

C Schematic Layout of the Bulk Supply Scheme



D Pipe Work

A 200 mm diameter, 14 km long, Class 18 AC pipeline connects the boreholes and conveys the water to the collector reservoir. The design capacity of this pipeline is 3 000 m3/day and appears to be in a good condition as no problems with pipe breakages or leakages are being experienced.

From the collector reservoir the water flows under gravity towards the Lüderitz terminal reservoir through a 100 km long asbestos cement pipeline with diameters of 250 mm, 200 mm and 150 mm, and pipe classes that vary between 36 and 18 bar. Under normal gravity conditions without bypassing the pressure break tanks, the main pipeline can convey water at a rate of 2 060 m3/day and 2 800 m^3/day when pumped. During the site inspection it was observed that several of the valves were leaking and the pipe is exposed at three places.

A 4.5 km long, 200 mm diameter, Class 36 AC bypass has been constructed 770 m downstream of pressure break tank 5 to avoid the dune area and reduce the impact of potential pipe breaks. It was observed on site that a portion of this new pipe has already been covered by dunes.

E Reservoirs

The circular concrete ground reservoir receiving the water from the production boreholes is located at Koichab Pan. It has a capacity of 1 000 m^3 and is in good condition. The collector reservoir can be bypassed if required.

Located next to the pipeline are 5 circular concrete pressure break reservoirs of 150 m^3 each. The pressure breaks can also be bypassed.

The 6 560 m^3 ground steel terminal reservoir is located on the Radford Hill at Lüderitz.

F Power Supply and Control System

Electricity is supplied through NamPower by means of a 22 kV overhead bulk supply line that feeds transformers situated at the boreholes, pressure break reservoirs, booster station and terminal reservoir. The transformers supply 400 V to the different components of the scheme.

The control system consists of a PLC controlled control valve on the inlet of each of the reservoirs which closes if the level of the tank rises beyond a certain level. The borehole pumps are fitted with timers and manual start/stop buttons for the motors. The telemetry system sends level and flow information to the master station from where the valves can also be opened or closed.

G Scheme Operation

The scheme is run by a permanent operator and two assistants. Temporary labourers are appointed as and when required. The operation of the scheme is carried out automatically by means of a telemetry and control system that has been installed at the terminal reservoir, pressure break reservoirs and the master station and boreholes at Koichab Pan.

The system is monitored from a control centre situated in an office at the terminal reservoir that relays the data to NamWater in Keetmanshoop.

H Maintenance

Remedial maintenance is carried out by the operator and assistants, while the maintenance of the mechanical and electrical equipment, buildings, pipelines and installations is carried out by NamWater from the Keetmanshoop office.

8.1.3 Bulk Supply Terminal Reservoir

The 6 560 m³ ground level terminal reservoir of steel is located on the Radford Hill at Lüderitz, at about 80 mAMSL.

The reservoir volume of 6,56 Ml is 1,19 times more than the 3 Ml/day design capacity of the pipeline, which results in an effective storage capacity of about 52 hr in respect of supply capacity.

However, the present average annual daily demand (AADD) of all municipal users is estimated to be some 4,2 Mℓ/day. The current daily storage of the terminal reservoir is thus more likely to be 37 hr, whereas a 48 hour storage would be regarded the minimum.

The current storage capacity at the terminal reservoir seems to be inadequate.

8.1.4 Incorporation into Maser Plan

The information as set out above will be used during the development of the Master Plan as summarized herewith:

As set out under Section 8.1.2A "Source", the medium term average abstraction per annum is about 1,1 Mm³/annum, or about 3 Mℓ/day. As the recommended abstraction is stated variously in different references, together with the pipe system being restricted to 3 Mℓ/day, the overall system is thus restricted to the smaller of the capacity values. The system is thus restricted by the capacity of the pipeline to an average supply of 3 Mℓ/day.

Water source from NamWater with available supply at3 Mℓ/day or 3 000 m³/day with Group A water quality.

8.2 Bulk Internal Network

The bulk internal network consists of

- Bulk gravity main from NamWater Terminal Reservoir
- Booster pumps at southern boundary of Nautilus Proper, supplying Balancing Reservoir located near Benguela Ext 2 at about 75 mAMSL.

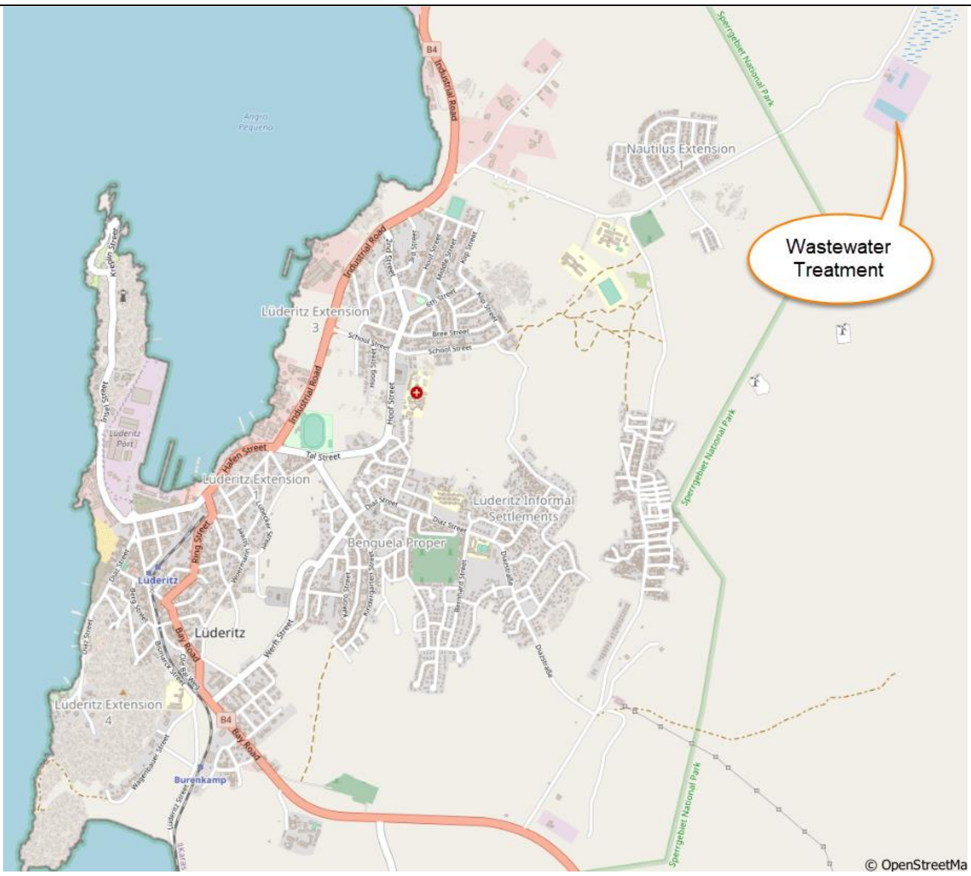
8.3 Reticulation Network

The data of the reticulation network was received as CAD drawings with limited information as to pipe type, diameter, pressure rating and pipe fixtures. The extent of the reticulation is presented in the map below.

8.4 Wastewater Outfall and Treatment

8.4.1 General

The existing wastewater treatment is performed through a biological nutrient removal activated sludge system based upon a 3-Stage Phoredox process. The plant is located to the north-east of the town and within a catchment area separate from any of the town catchment areas. This catchment is draining to the north towards the Agate Beack area.



Wastewater Treatment

8.4.2 Capacity

The treatment works has a hydraulic load of

Average	2 Mℓ/day – Average Daily Wet-weather Flow
Peak daily	3 Mℓ/day – Peak Factor of 1,5
Peak hourly	5 Mℓ/day – Peak Factor of 2,5

8.4.3 Process Layout

The plant schematic layout is presented below.

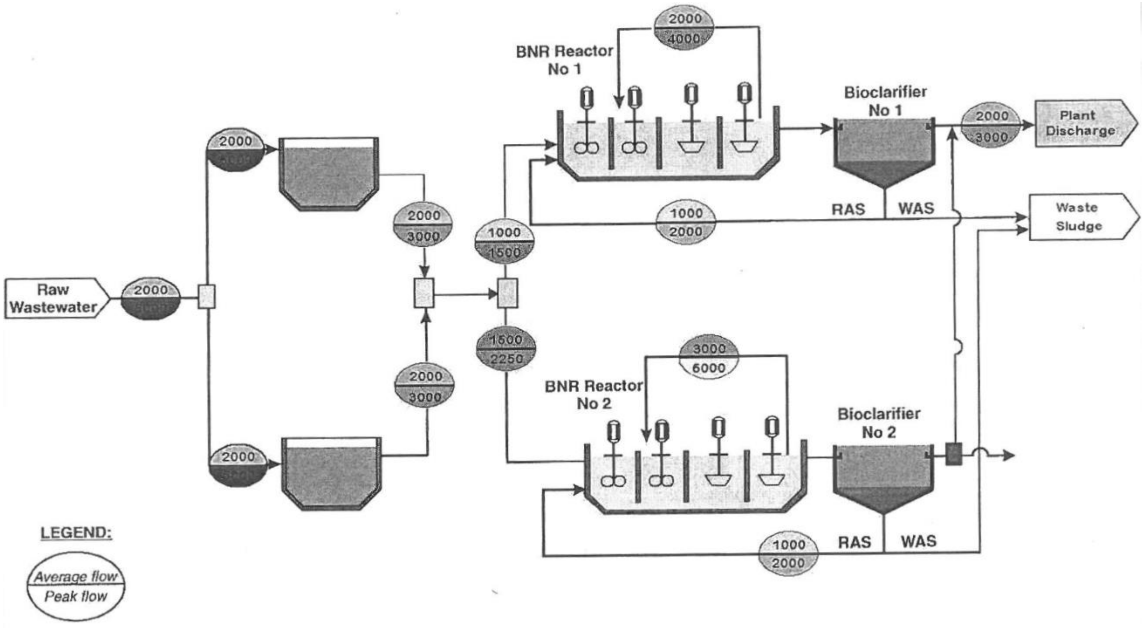


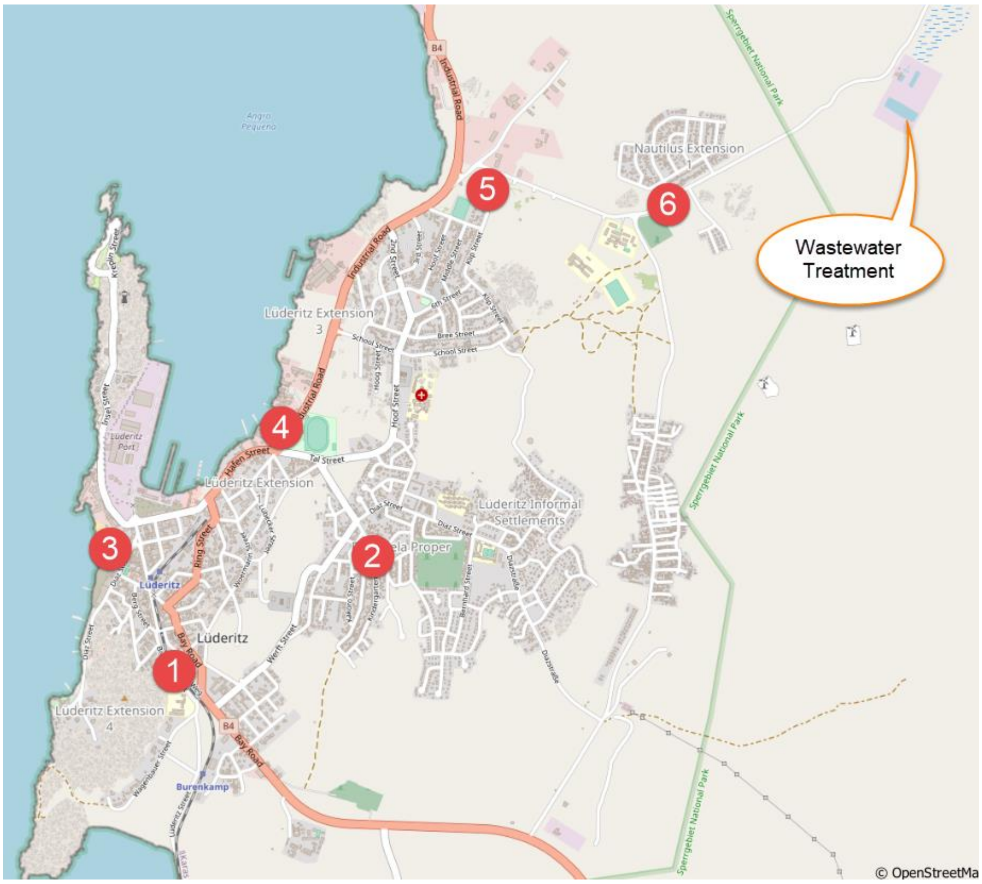
Figure 2 : Schematic Plant Flow Diagram - Phase 1

8.4.4 Secondary Wastewater Network

The treatment plant receives raw sewage exclusively from pumped systems. At present there are 6 pumpstations, with one main pump station (No 5) receiving most of the town wastewater and pumping directly to the treatment works with another minor pump station (No 6) also feeding directly to the treatment works.

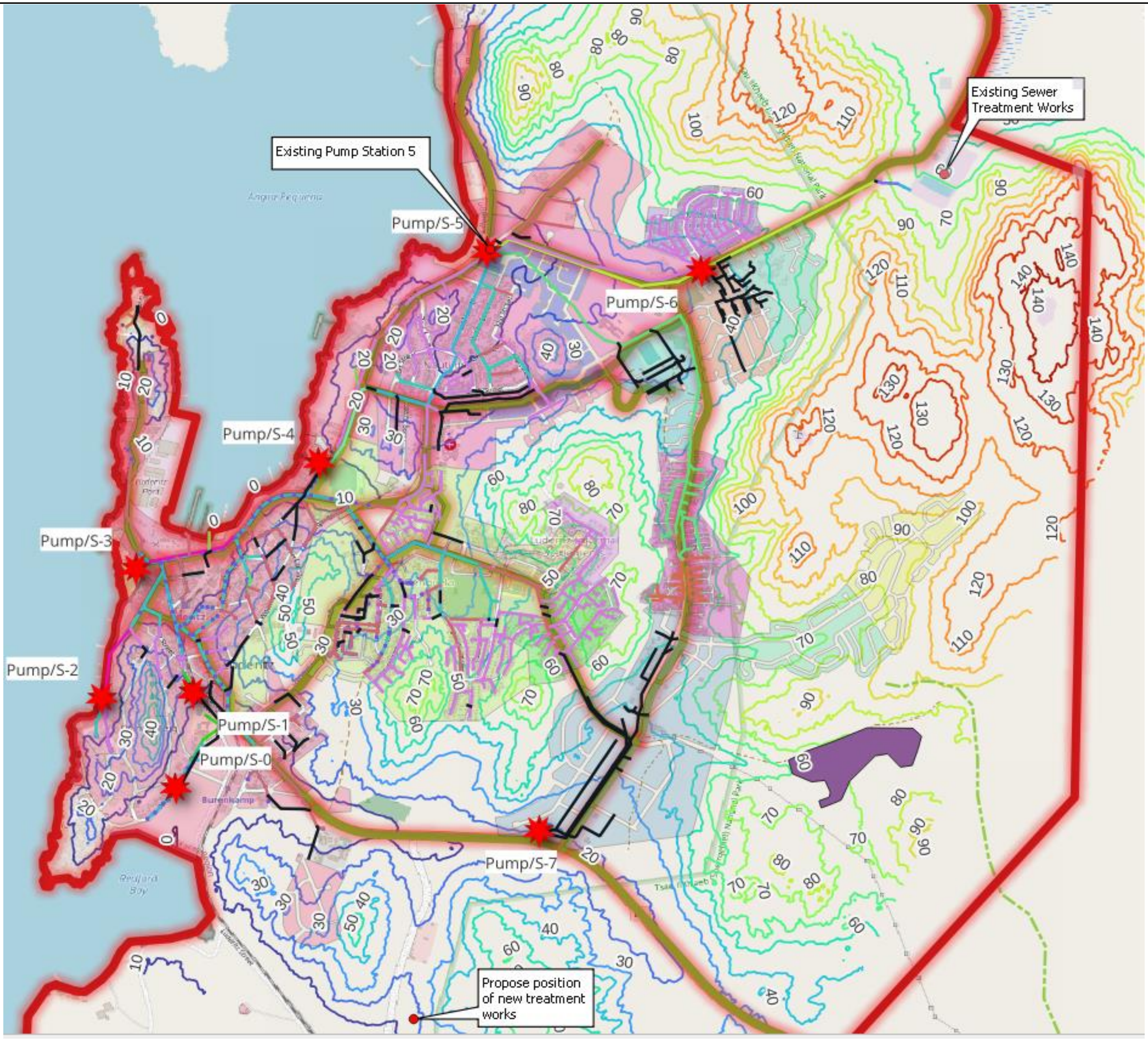
The other four pump stations are intermediary pump stations that act as high lift stations that cascade until reaching the catchment area of pump station No 5.

The red and white numbers in the sketch below indicates the positions of the pump stations.



8.4.5 Primary Wastewater Network

The primary wastewater network consists mainly of house connections onto basic gravity based piped reticulation draining towards pump stations.


Existing Pump Station 5
Existing Sewer Treatment Works
Pump/S-5
Pump/S-6
Pump/S-4
Pump/S-3
Pump/S-2
Pump/S-1
Pump/S-0
Pump/S-7
Propose position of new treatment works

9 DEMAND ASSESSMENT

9.1 Water Demand Derived from Spatial Arrangement

Making use of only the summarized information in respect of erf zoning and size, the estimated water demand is summarized in the below table.

Lüderitz Water Master Plan Demand Calculations

Baseline Demand Allocation

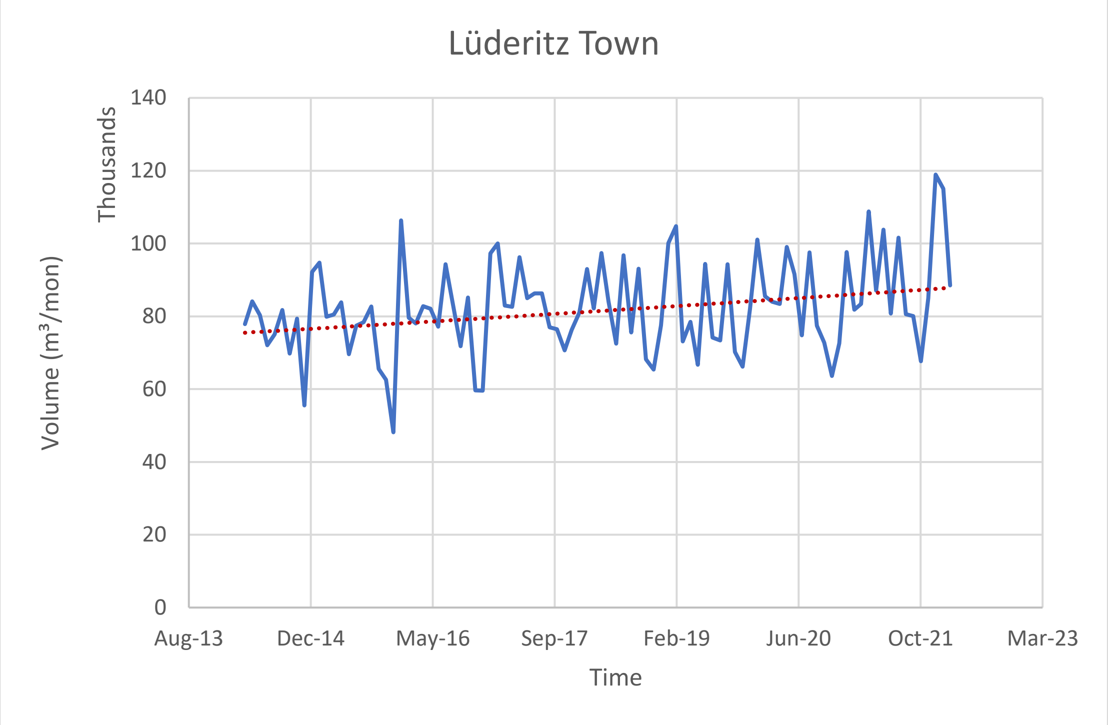
Zoning	Property Area m^2	Average Demand m^3/hr	% of Tot Demand	Group %
Residential 1	1479169	71.326	51.0%	81.6%
Residential 11	827820.3	4.988	3.6%	
Residential 111	1156058.5	3.521	2.5%	
Bld_Inf	4695624.3	34.229	24.5%	
Business	3479.8	0.084	0.1%	2.4%
General Business	190285.3	3.233	2.3%	
General Industrial	658487.1	15.756	11.3%	12.6%
Light Industrial	36233.6	1.813	1.3%	
Institutional	1172183.9	1.769	1.3%	2.1%
Parastatal	209953.7	0.633	0.5%	
Government	59651.5	0.326	0.2%	
Local Authority	19698.6	0.231	0.2%	
Cemetery	85606.1	0.15	0.1%	1.0%
Private Open Space	40670.9	0.108	0.1%	
Public Open Space	240384.3	1.201	0.9%	
Undetermined	67925.7	0.415	0.3%	
Future Development	20105.1	0.45	0.3%	
Special	11210.1	0.047	0.0%	
Total	***10 974 548***	***140***	***100%***	
Property Total Area	1 097.45	ha		

Total consumption per day 3360 m^3/day

Number of Residential Properties	2773
Number of Informal Households	2633
Total Residential Households	5406
Average size of Household	3.02
Estimated Total Population	16326
Total Residential Consumption	2737536
Average consumption per capita	168

9.2 Recorded Sales Data

According to sales data at the terminal reservoir the periodic monthly sales for the town is graphically indicated by the below graph.



The median sales over the period is 81,750 m^3/month (2,73 Ml/day), however, the long term trend has a compounded growth rate of about 0,6% per annum. The standard deviation is about 12,850 m^3/month, and of the 95 months on record for the above graph, a total of 18 months exceeded 1 standard deviation and 12 months were lower than 1 standard deviation.

The data for determining the statistics can therefore be accepted as significantly falling within the normal distribution and is sufficiently representative of the actual draw downs in order to draw conclusions from.

9.3 2023 Census

The preliminary population figure for Lüderitz indicates a total estimated population of 16,125 people.

The previous estimated population of 16,326 remains valid as well as the calculations premised on it.

The average daily consumption per capita is about 170 l/c/day should the full average sales figure be considered as domestic use. However, it is known that there is substantial commercial activity requiring water and it would thus not be reasonable to assign all water supplied by NamWater to the Town as domestic use.

Using the consumption figure of 130 l/c/d as an average domestic use, the total domestic use per day is in the order of 2,1 Ml/day and other use to be as high as 0,63 Ml/day.

Comparing this calculation with the figures of Section 9.1, Water Demand Derived from Spatial Arrangement, the 2,7 Ml/day is a good average figure for mixed use and that the difference between the average consumption based on guidelines and the actual average can be attributed to higher than normal personal consumption. The higher than norma per capita use of 170 l/d/d, is still within acceptable limits (200 l/c/d considered high) and within the normal planning level of service.

Should the latest average monthly consumption based on a steady 0,6% compounded growth be considered, then the average daily consumption per capita increases to about 180 l/c/d, which remains under the threshold of being considered high unit consumption of 200 l/c/d.

For planning purposes, it might be prudent to adopt an average consumption rate of 200 l/c/d.

9.4 Water Demand

The anticipated future water demand for the extent of development as set out in Section 5.2.1 "General Spatial Development as Proposed" is estimated at about 6 Mℓ/day and the present estimated demand is about 2,9 Mℓ/day.

9.5 Wastewater Effluent

At a sewer return flow of 80% of the water demand, the future effluent produced is estimated to be about 4,8 Mℓ/day and the present at about 2,3 Mℓ/day.

These figures are at the boundary of the unsustainable high daily peaks, and it is confirmed that the current wastewater treatment facility has run out of capacity.

It has become sufficiently clear that the existing wastewater treatment facility is undersized for daily flows and expansion of wastewater treatment capacity has become critical.

10 INFRASTRUCTURE STATUS QUO ANALYSIS

The information of the existing systems is varied in terms of detail. Much of this data is still at consultants and therefore not readily available. Requests for information was sent to the consultants and being followed up.

10.1 Base Data

10.1.1 Cadastral Data

Cadastral data was also received in various formats and various sources.

It should be noted that any development should take full cognisance of the cadastral data in order to plan projects where the infrastructure does not encroach upon the properties of others.

The coordinate system of the cadastral information received from the various sources does not align well with the satellite positioning systems and maps. In order to have the information sensibly overlaying with the satellite data, a shift on the Namibian National System Lo22/15 was required.

This shift is for purposes of a Master Plan good enough, however, for project implementation it is not.

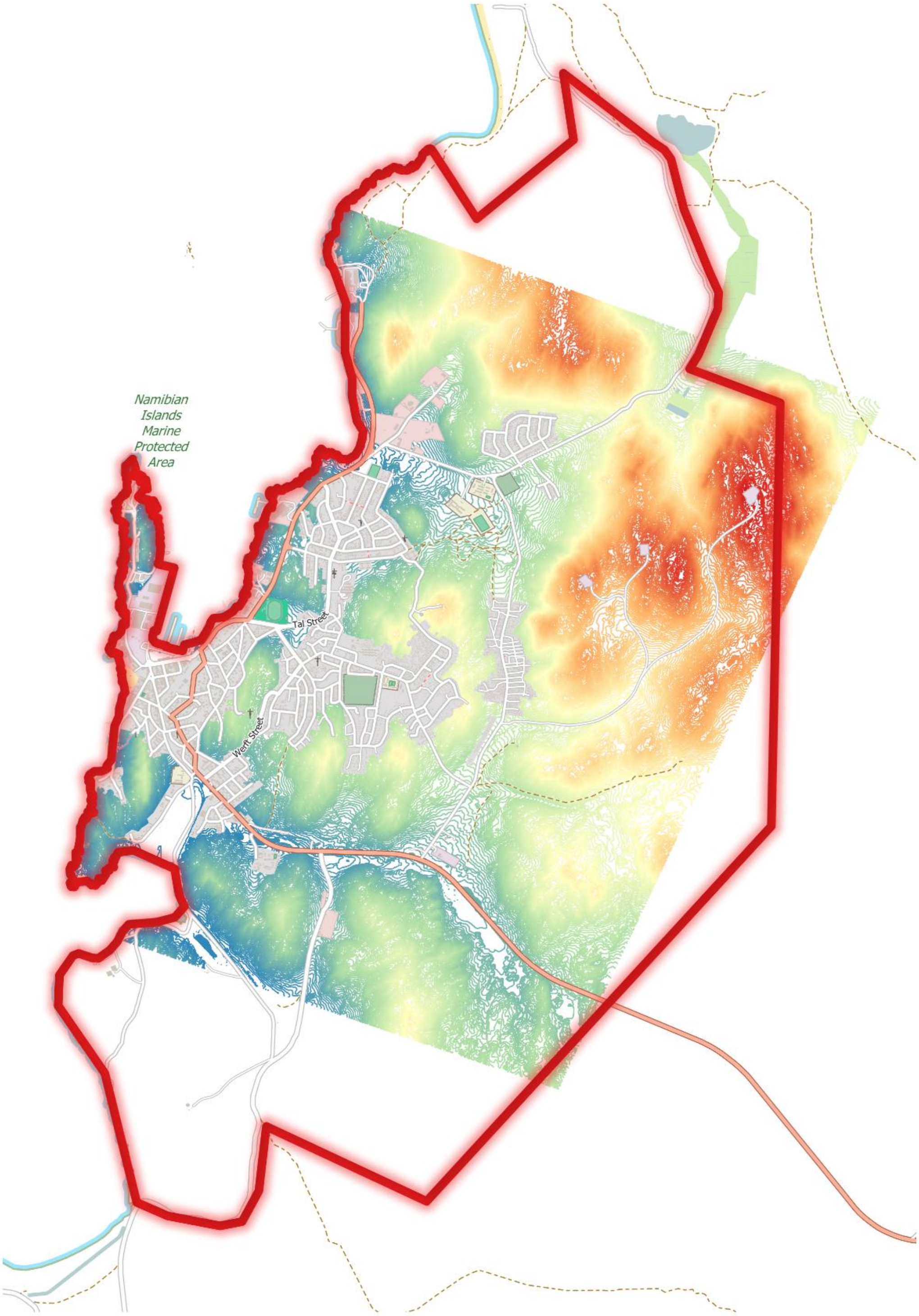
Proper geo-orientated cadastral information is invaluable for the proper geo-location of infrastructure. It is proposed that all the cadastral information at the Surveyor General is sourced and used in officially firm up the cadastral information used.

10.1.2 Topographical Data

Topographical data was received in the form of CAD polylines with elevation representing height contours. The contours were determined from aerial imagery captured by unmanned aerial vehicle (UAV) photography.

The contour data was used to develop a digital elevation model (DEM) with a 5m grid of points. This DEM was then used to interpolate elevations of points and profiles of lines.

The extent of the topographical data does not cover the entire development area as set out by the Townlands Scheme. Where elevations are required outside of the area covered by the UAV imagery, the 30m grid DEM from satellite information suppliers was used.



Extent of the Topographical Information from UAV imagery

The map above shows the range in topographical elevations from the high lying topography in red with the near sea level in blue.

It is evident from the map that the natural tendency of the initial town planners was to develop within the many valleys as the grey areas indicate build up areas which falls within the generally blue to green areas depicting the valleys.

10.1.3 Orthophoto Imagery

Of great assistance in determining existing development levels is the use of recent satellite imagery, such as what is found on the Google Earth data. Although not accurate beyond about 1x1m pixel resolution, the extent of development is quite visible. This report is based on imagery dated from June 2020 to present.

10.2 Water Reticulation

10.2.1 Bulk Water Supply to Reticulation

Information in respect of the bulk water supply is discussed under Section 5.2.4 "Water and Wastewater Infrastructure" as well as Section **Error! Reference source not found.** "**Error! Reference source not found.**".

> *The daily bulk water supply capacity was taken as 136 m^3/hr and 3 000 m^3/day. The Terminal Reservoir full supply level is taken as 78 mAMSL.*

10.2.2 Source of Reticulation Information

Information is used from CAD drawings received from the LTC. The information consists of more than one drawing and some drawings are not geo-orientated and therefore external references were used to orientate the drawings to scale and geo-location.

The information is not exactly dated and does not distinguish clearly on the overall age of the infrastructure. The pressure rating of the pipes is also not stated and therefore the exact internal diameter of the pipelines cannot be determined. For purposes of the high-level information used in the Master Plan, the nominal diameters would suffice. However, the detail analysis needs to be done with the exact internal diameters as well as using the actual pressure classes of pipes to manage the pressure zones.

The various CAD files were consolidated into a single file that was superimposed on the cadastral data.

10.2.3 Modelling of the Network

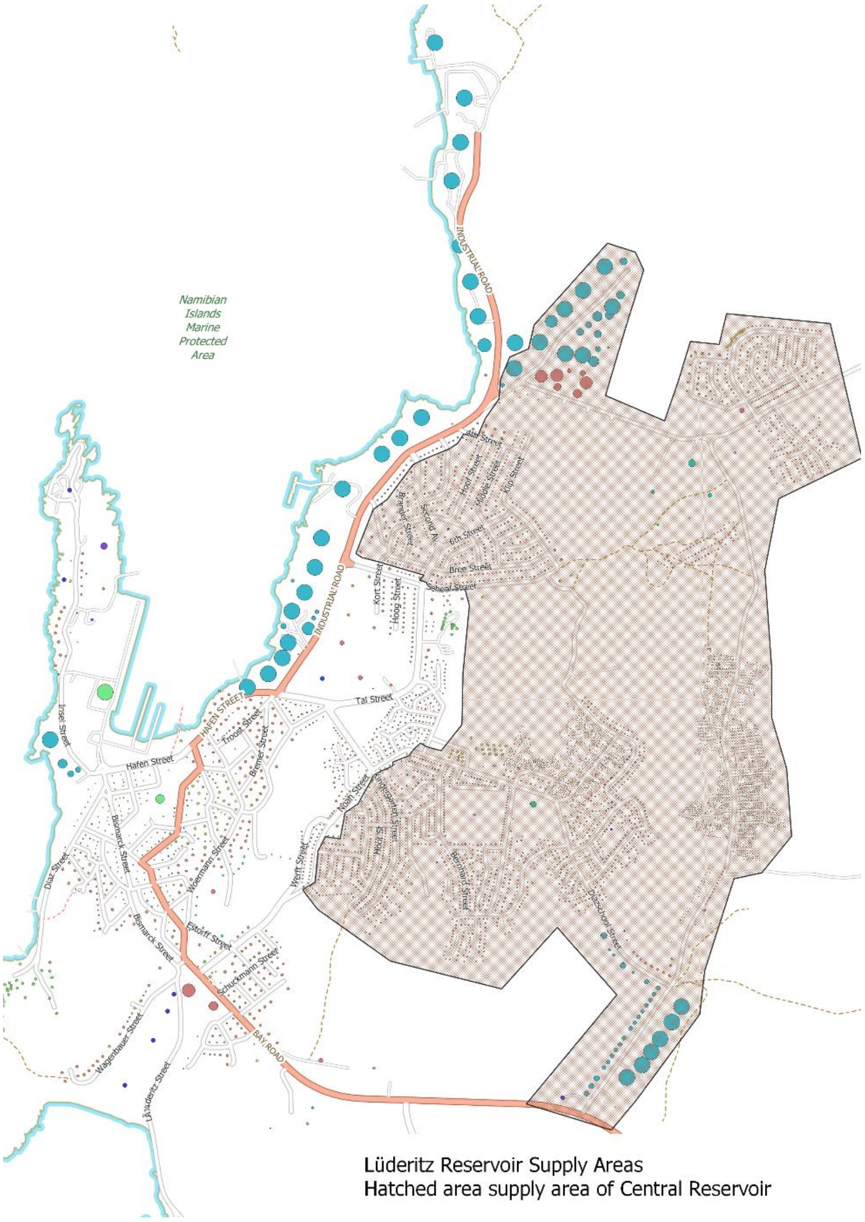
The base data in respect of cadastral and pipe network as geo-located was used to develop a reticulation representative of the information received. Analysis of the network is based on

- Pipe information as determined from the CAD file layouts was used to develop a reticulation network
- Two reservoirs were inserted into the reticulation network
- Demands were determined from cadastral information and inserted into the pipe network
    - The zoning presented in various pdf maps were transferred to the CAD layout
    - Erven were then differentiated based on use
    - The property use was used to determine the typical expected daily demand (Average Annual Daily Demand AADD)
    - Once the AADD per erf was established, the erf level AADD was transferred to the closest pipe
    - Multiple erven would be assigned to a given pipe and the cumulative AADD determined for a pipe
    - Such cumulative AADD's were inserted as nodes along a pipe
- The geometrical and hydraulic information was used to develop a model of the reticulation network in EPANET
- The base line analysis of the reticulation network was done in EPANET
    - The base line analysis indicated incorrect topology of the network, which topological errors were corrected
    - Basic evaluation of high and low values for the following parameters was done

    - At nodes: Pressure
    - For pipes: Velocity
  - Where extreme anomalies were identified, the network was adjusted to perform within tolerance
  - The network as corrected to successfully analyse for the base line forms the basic network for analysis on a broader approach

Two crucial aspects of the topology of the reticulation network is the area of supply assigned to the Central Reservoir should be noted. Firstly, the layout of the pipes requires dedicated pipe closures to prevent the booster pump being supplied by the Central Reservoir (recirculated flow), and secondly, the supply area ought to be in proportion to the storage capacity of the Central Reservoir.

For purposes of evaluation analysis with the least amount of adjustment to the network to ensure non-recirculation the following Central Reservoir supply area was used.



Lüderitz Reservoir Supply Areas
Hatched area supply area of Central Reservoir

The corrected base line reticulation network was adopted for further analysis.

10.2.4 Basic Analysis

A Demands

The demands were calculated and applied as set out under Section **Error! Reference source not found.** " **Error! Reference source not found.**".

Lüderitz Water Master Plan Demand Calculations

Baseline Demand Allocation

Zoning	Property Area m^2	Average Demand m^3/hr	% of Tot Demand	Group %
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Government	59651.5	0.326	0.2%	
Local Authority	19698.6	0.231	0.2%	
Cemetery	85606.1	0.15	0.1%	1.0%
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Property Total Area	1 097.45	ha		

Total consumption per day 3360 m^3/day

Number of Residential Properties	2773
Number of Informal Households	2633
Total Residential Households	5406
Average size of Household	3.02
Estimated Total Population	16326
Total Residential Consumption	2737536
Average consumption per capita	168

A(i) Base Line Scenario

The table to the left indicates the average consumption of properties along existing pipelines.

There are some properties that are not yet developed but included in this scenario as developed properties.

The scenario depicted here is thus of the future situation when all properties along existing pipe routes have been developed. Therefore, the current situation would result in a total consumption that is less than what is presented here.

A(ii) Composition of Total Demand

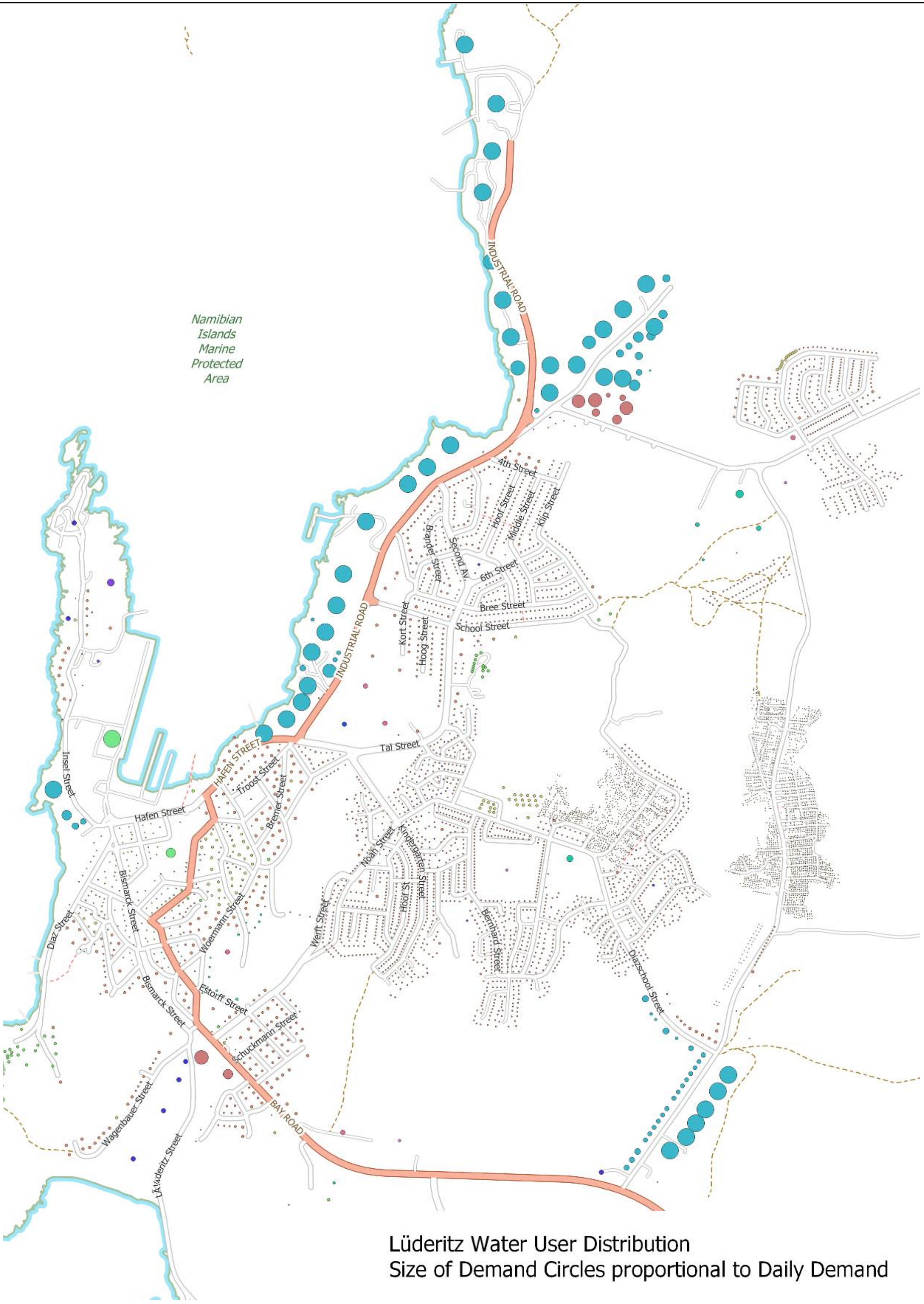
Combining the cadastral information with the observed development extents the composition of the water indicate that the residential demand is about 82% of the total daily demand.

The second largest user group is the industrial users at about 13%.

The business users at 2% and institutional users also at about 2% accounts for the third largest users.

The total water demand is thus primarily driven by residential users with a significant industrial user demand.

The distribution and relative demand volume of above scenario is presented graphically by the below map.



Lüderitz Water User Distribution
Size of Demand Circles proportional to Daily Demand

A(iii) Estimated Population

From the number of residential properties and informal households identified on satellite imagery as compared with the cadastral layouts, a total of 5 406 households were counted.

The 2011 census indicated that the average size of households in Lüderitz is about 3,02 persons. Using this statistic of average household size and applying it to the physically identified households of 5 406, the total estimated population for the base line scenario would be 16,326 persons.

When applying the 2011 census data parameters to the 5 406 identified households, the total estimated 2011 population of 12,232 should have grown with about 2,1% on average. Thus, over a period of 11 years, the total estimated population would be 15,374 persons.

A close correlation exists when comparing the statistical estimate based on the 2011 census data (15,374) with the estimated population (16,326) determined by physically identified households.

For this base line scenario, the average consumption per capita per day is about 168 l/capita/day. This is considered to be a high level of service and might not be a representative average consumption per capita per day.

It should be noted that the total daily consumption of this base line scenario exceeds the Bulk Water System capacity (3 000 m^3/day) by about 360 m^3/day.

A(iv) Reduced Base Line Scenario

A sensitivity analysis was done with a reduced level of service, reducing the estimated average daily per capita consumption of 168 litre to a more realistic 120 litre.

This scenario is referred to as Base Line 70.

The average annual daily demand for this scenario for all users totals to 2 400 m^3/day, or 100 m^3/hr. The total average consumption for this scenario is more in line with the current reported total consumption. However, this figure must be confirmed by evaluating the most current consumption figures from NamWater as well as the Council records.

B Analysis of Reticulation Pipe Network

The reticulation pipe network has to perform to the required minimum pressures at peak flow conditions. From Section **Error! Reference source not found.** "**Error! Reference source not found.**", it is required that the minimum pressure at peak flow conditions at any one user connection should not be lower than 25m.

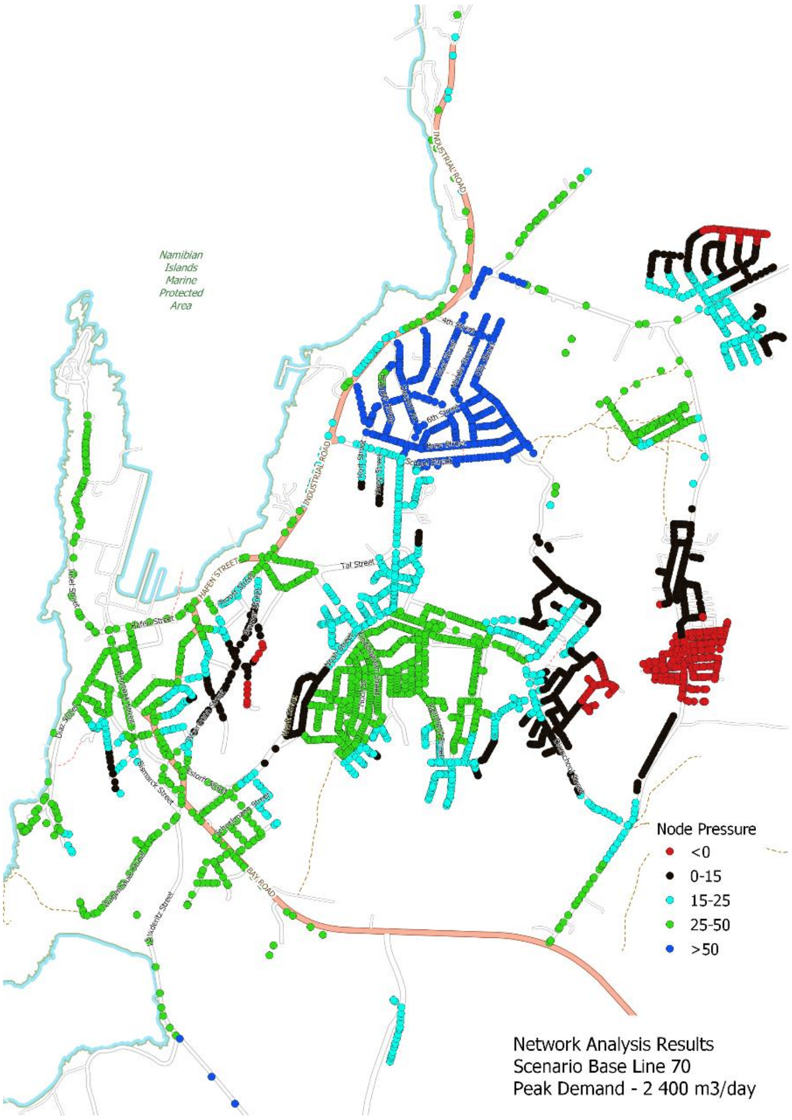
The peak flow condition is determined by applying the reticulation Design Peak Factor (DPF) of 3 to the average daily demand.

The overall peak flow for the Base Line 70 scenario is 100 x 3 = 300 m^3/hr.

C Nodal Residual Pressure

The analysis indicates negative pressures (the red circles) at peak demand conditions. It should be noted that in normal circumstances open user connections during such conditions causes air to be sucked into the system, which air is released during conditions of low demand.

There is also significant areas with low pressure (the black circles with pressure between zero and 15m) during peak demand.



C(i) Peak Flow Conditions

It should also be observed that the analysis of the system is "forcing" demand beyond what would be physically possible in all circumstances. What would happen in real life is that the demand will diminish with diminishing pressure and the areas with pressure below 15m would thus experience lower tap flow and in rare instances, pressure would become negative with associated air being sucked into the system.

C(ii) Present Network Assessment

The network as analysed is insufficient to provide an average level of service.

C(iii) Network overall performance

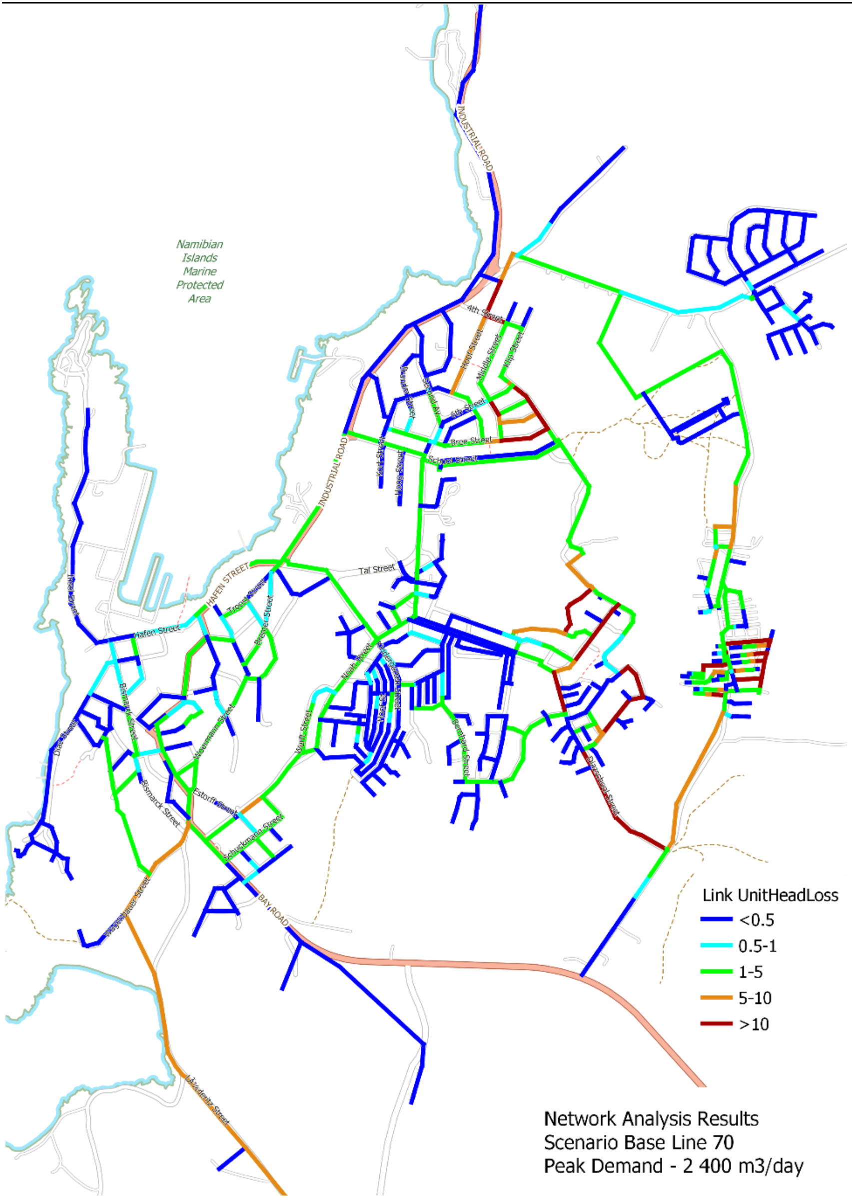
The analysis of the existing pipe network in respect of anticipated pressure during peak demand seems to suggest that the network is able to provide supply to most of the end users, although at a reduced level of service.

D Pipe Loss Gradient

The pipe gradient head loss is a gradient in m/km indicating the relative friction losses in a pipe. When graphically inspected, a pipe with significantly different friction loss gradient as compared to the neighbouring pipes, can be identified and flagged as a pipe with unacceptable losses.

Assessment of acceptable friction losses are measured in relation to pipe diameter. For smaller pipes, even low velocities would have high gradient losses. Acceptable gradient of friction losses for reticulations is 5 m/km. This limit applies to pipe internal diameters up to about 350mm. Thereafter a limit of 1,5m/s would regulate the allowable friction losses.

For the current network all internal pipe diameters are less than 350mm and therefore all pipes are assessed on gradient head loss only.



D(i) Peak Flow Conditions

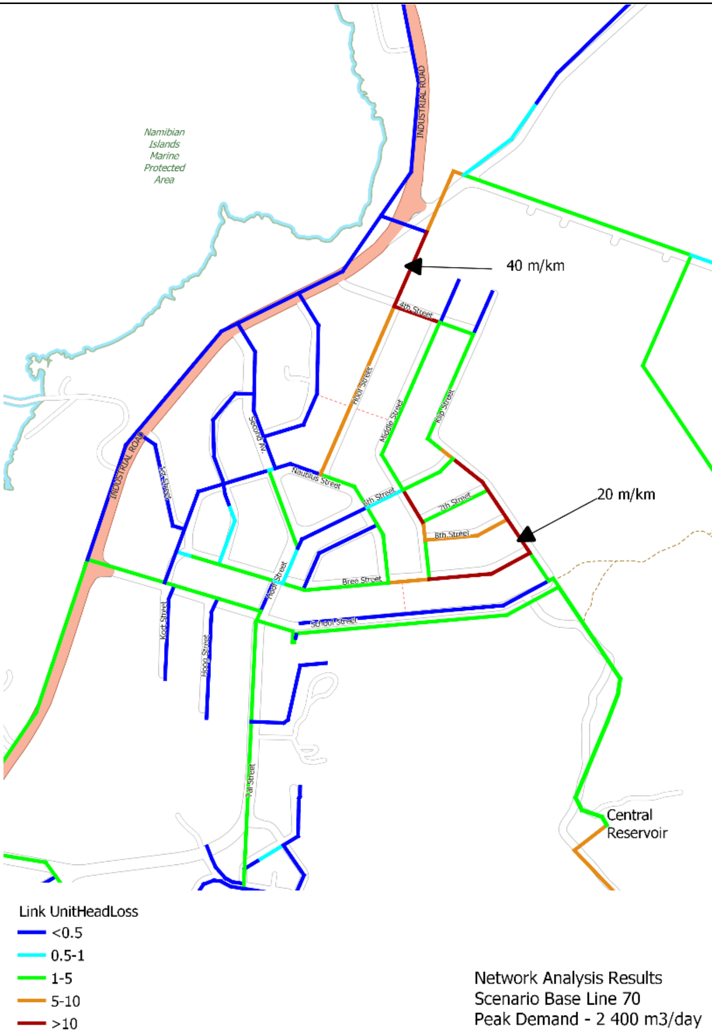
During peak flow conditions, several critical pipes indicate to have gradient head losses in excess of 5 m/km.

The most critical pipe where the gradient head loss exceeds 5 m/km is the pipeline from the NamWater Terminal Reservoir, with a head loss gradient of 8,3 m/km and velocity of 1,32 m/s.

A few other critical pipes exceed the 5 m/km gradient, such as the southern outlet to the Central Reservoir as well as a few pipes north of the Central Reservoir.

Other pipes where the head loss gradient exceeds 10 m/km are required to be totally undersized for the typical application.

More specifically, in the northern supply area of the Central Reservoir, there are pipes that drastically reduce the static head due to adverse and unacceptably high head loss gradients. These pipes are shown in the next map.



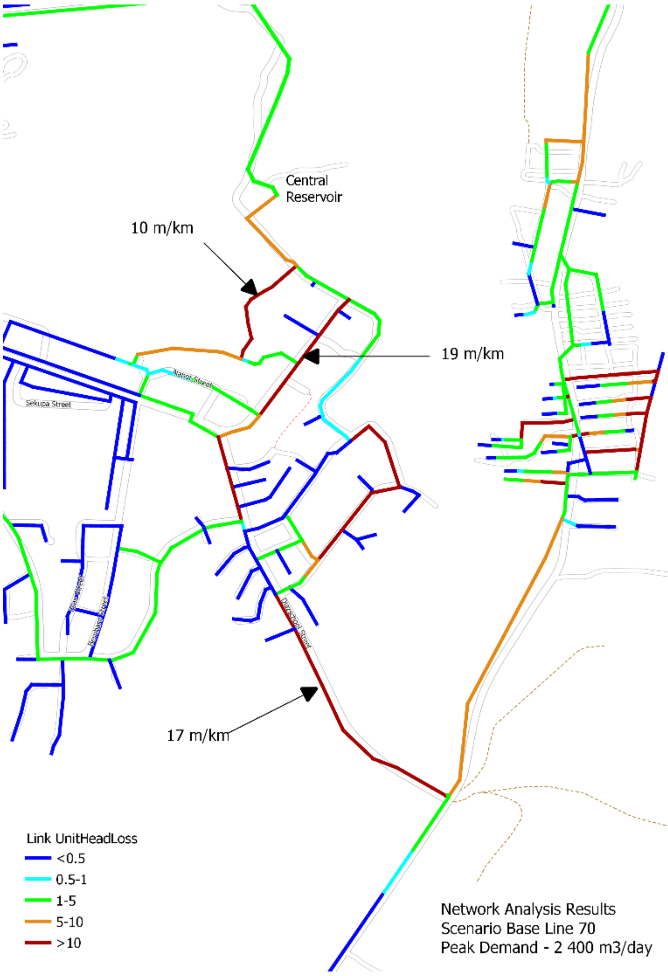
The most critical of these adverse head loss gradients is the pipe indicated with an arrow next to the 40 m/km gradient.

This pipe is the main and only link pipe to the northern and eastern supply zones and acts like a constriction to pressure to these supply areas.

Furthermore, the outlet of the Central Reservoir to the north divides into two pipes (one indicated by arrow and 20 m/km gradient) that also dramatically reduces the available static head.

These two pipe groups are primarily the cause of poor residual pressures in the supply areas as set out in 10.2.4C "Nodal Residual Pressure" above.

A similar condition also appears in the southern outlet of the Central Reservoir as set out in the below map.



10.2.5 Verification of Network Data

It is necessary to ensure that the pipes that are indicated herewith to be critical pipes that underperform, are verified on site as to be correct.

As these pipes have been identified to have adverse effects on the performance of the network in total, every effort should be made to ensure that the pipe data as well as the network connectivity is correct.

A Central Reservoir Supply Zone

It is of first importance to ensure that the topology and connectivity of the network supplied by the Central Reservoir is indeed correctly modelled.

The supply zone of Central Reservoir as indicated above in Section 10.2.3 "Modelling of the Network" should thus be confirmed.

It should also be confirmed that this supply zone is properly isolated from the network that supplies the Booster Pump in order to prevent inadvertent recirculation of the Central Reservoir water.

The effect of the size of the Central Reservoir and the size of the area supplied should also be considered. Due to the apparent function of the reservoir in providing elevated pressure to the higher lying areas, the intention of this reservoir is as a balancing reservoir and not a storage reservoir. The storage function of the system should be fully catered for by the NamWater Terminal Reservoir.

The size of the Central Reservoir should also be confirmed accurately together with the operating levels as well as the operational control.

B Pipe Data

It is proposed that the pipes that were identified as having head loss gradients exceeding 10 m/km should be investigated in detail.

10.3 Bulk Water Supply

10.3.1 Existing Information Pertaining to Bulk Water Supply

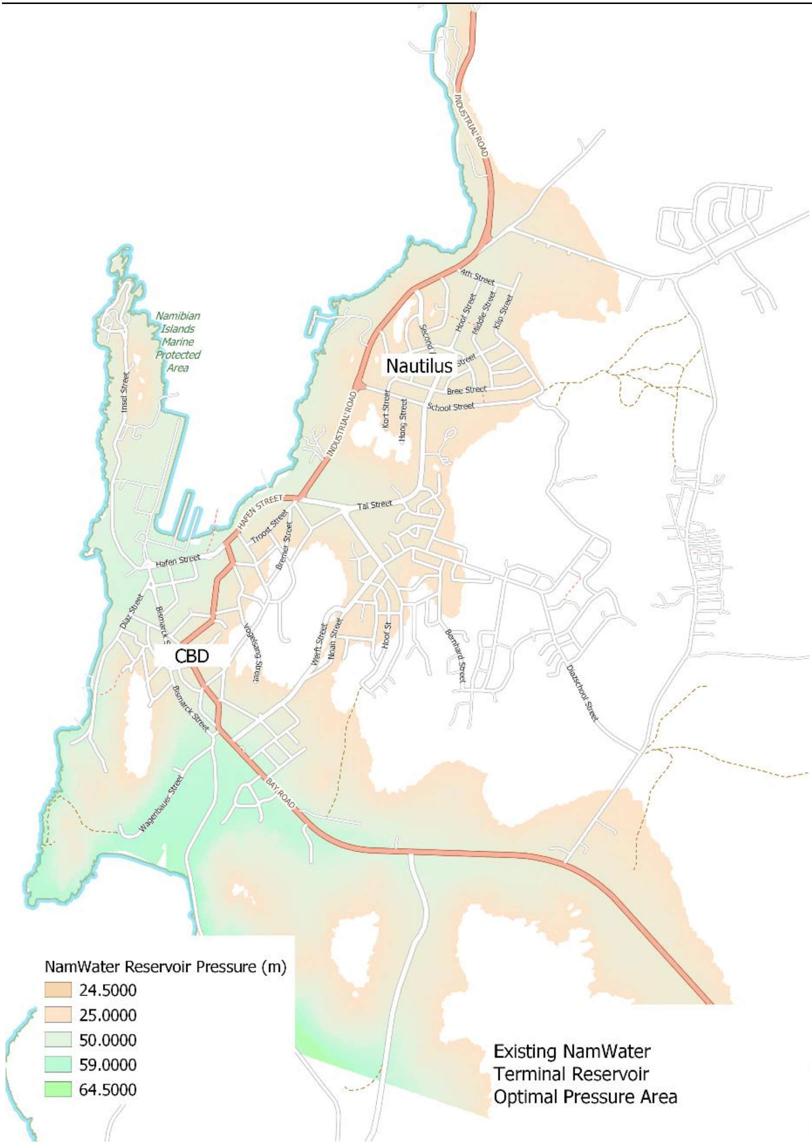
The daily capacity of the Bulk Water Supply as discussed under Section **Error! Reference source not found.** "**Error! Reference source not found.**" is estimated at 3 Ml/day (3 000 m³/day), whereas the Scenario Base Line 70 requires a daily supply of 2,4 Ml/day. The Scenario Base Line 70 is a scenario that reduces the Base Line demand from 168 l/capita/day to 120 l/capita/day and the overall daily demand from 3 360 m³/day to the 2 400 m³/day.

Thus, depending on a slight change in actual per capita water used per day, the overall bulk supply is at present very sensitive to exceed the Bulk Water Supply System.

However, indications are that the bulk water supply to Lüderitz is close to, if not already exceeding, the existing full capacity of the NamWater Bulk Water Supply System.

10.3.2 Extent of NamWater Terminal Reservoir Optimal Pressure Area

Extending the available static head at the NamWater Terminal Reservoir (78 mAMSL) at a head loss gradient of 5 m/km an optimal pressure area can be determined. The pressure area for this arrangement is provided below



It should be noted that the situation as presented to the left is on an idealized basis and does not accommodate the pipelines that have been identified having high head loss gradients. However, the arrangement herewith is handy in identifying areas that cannot be supplied from the NamWater Terminal Reservoir, even on idealized arrangement.

It is therefore unavoidable that additional reservoirs be used to be able to supply to the higher lying areas, such as the Central Reservoir currently employed.

A CBD High Lying Areas

Noticeable areas of low residual pressures under peak flow conditions are experienced in two areas of the CBD.

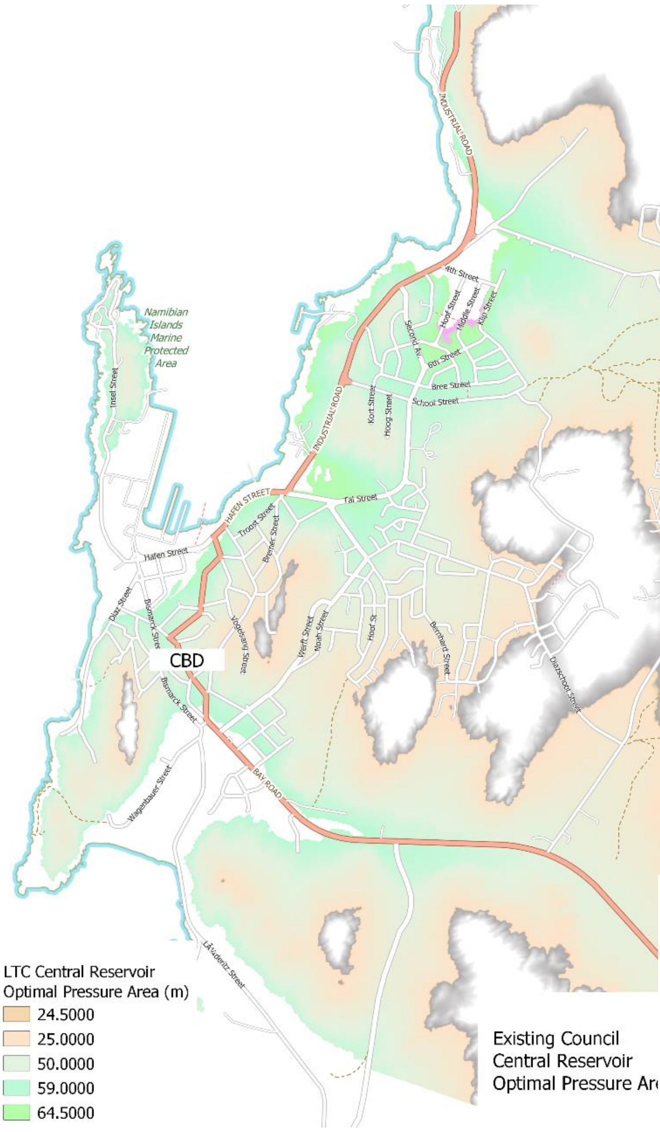
10.3.3 Extent of Central Reservoir Optimal Pressure Area

The same principle used to determine the optimal pressure area for the Terminal Reservoir can be used to determine the extent of the optimal pressure area for the Central Reservoir.

It should, however, be noted for the preparation of the optimal pressure area of the Central Reservoir a maximum pressure cut-off is also determined, where any pressure exceeding 65m static be seen as too high pressure.

From most of the design guidelines, including the CSIR Red Book adopted here, the maximum pressure is extended to 90m maximum static. However, as indicated under Section **Error! Reference source not found.** “**Error! Reference source not found.**”, a maximum static pressure of 60 m accommodates geysers commonly available in the marketplace.

The optimal pressure area for the Central Reservoir is indicated with the below map



It should be noted that the two high lying areas in the CBD can also not be sufficiently covered by the Central Reservoir at 10m higher elevation than the NamWater Terminal Reservoir.

A CBD High Lying Areas

Special arrangements ought to be considered to cater for the high lying areas in the CBD area.

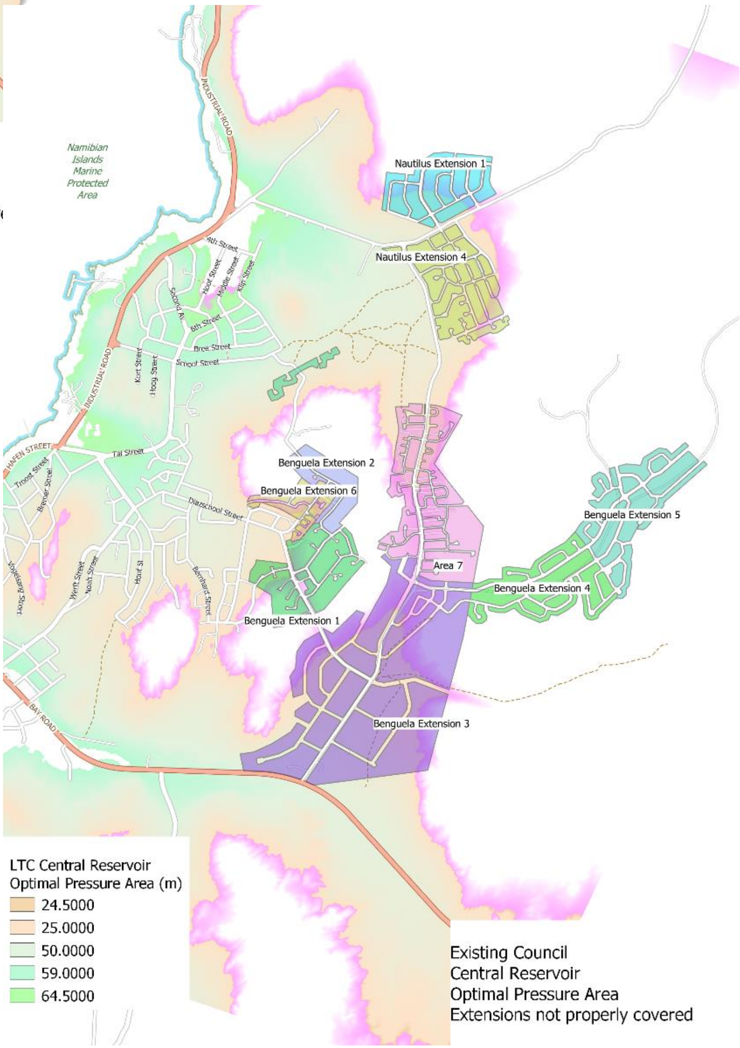
B Other High Lying Areas

The extensions to the east of Lüderitz are generally higher lying areas and are poorly serviced by the Central Reservoir.

The idealized and optimal pressure area of the Central Reservoir confirms the results of the hydraulic analysis discussed under Sections 10.2.4C “Nodal Residual Pressure” and 10.2.4D “Pipe Loss Gradient”.

An area that is especially poorly serviced is the proposed most easterly extensions of Benguela Ext 4 and Ext 5. For these areas to be developed a dedicated reservoir needs to be provided.

The map to the right indicates the extensions poorly serviced by the Central Reservoir.

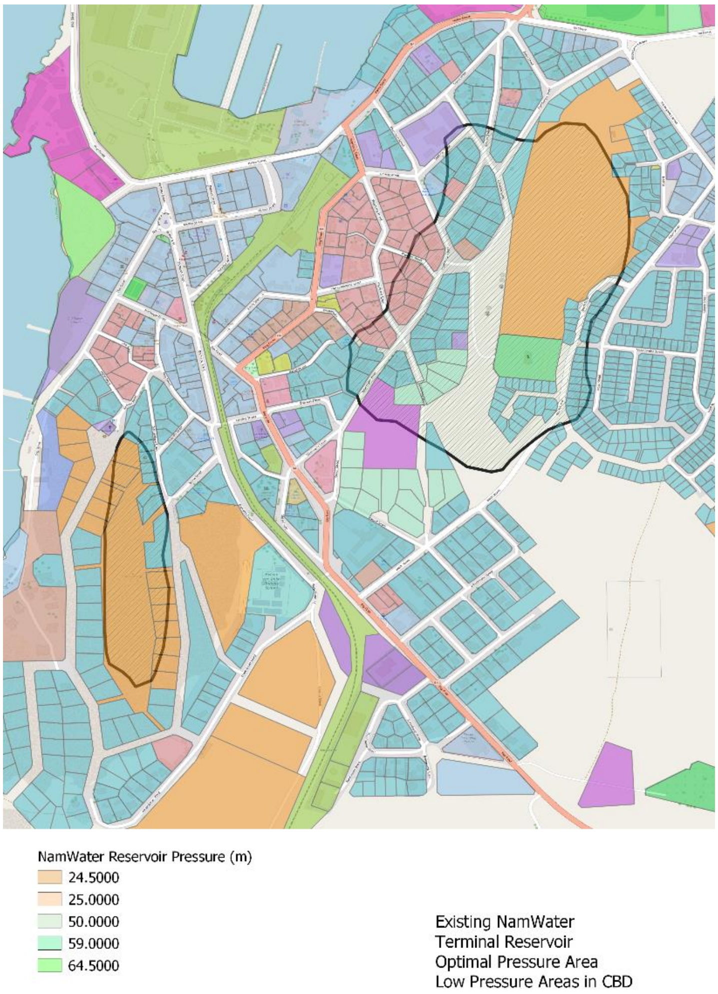


10.3.4 Need for Additional Service Reservoirs

The optimal pressure area for the highest lying reservoir (Central Reservoir) indicated the need for additional service reservoirs to service the higher lying areas, especially in the east of the development, however, two areas in the CBD also suffers from poor supply.

A Additional Service Reservoir for CBD

It is proposed that dedicated elevated service reservoirs be provided to service the low pressure areas to ensure that the minimum standards in terms of residual pressure can be achieved in the whole CBD area.



B Additional Service Reservoir for Eastern Extensions

It was indicated in Section 10.3.3B "Other High Lying Areas", that the existing Central Reservoir is not able to service all the eastern extensions to the required minimum standards.

It was also shown that these areas are partially serviced by the existing Central Reservoir with the balance of the extensions not receiving sufficient residual pressure during peak demand times.

B(i) Area 1

Area 1 indicated on the below map is bounded by the fringes of Benguela Proper. The core of this area seems not to have been considered for development.

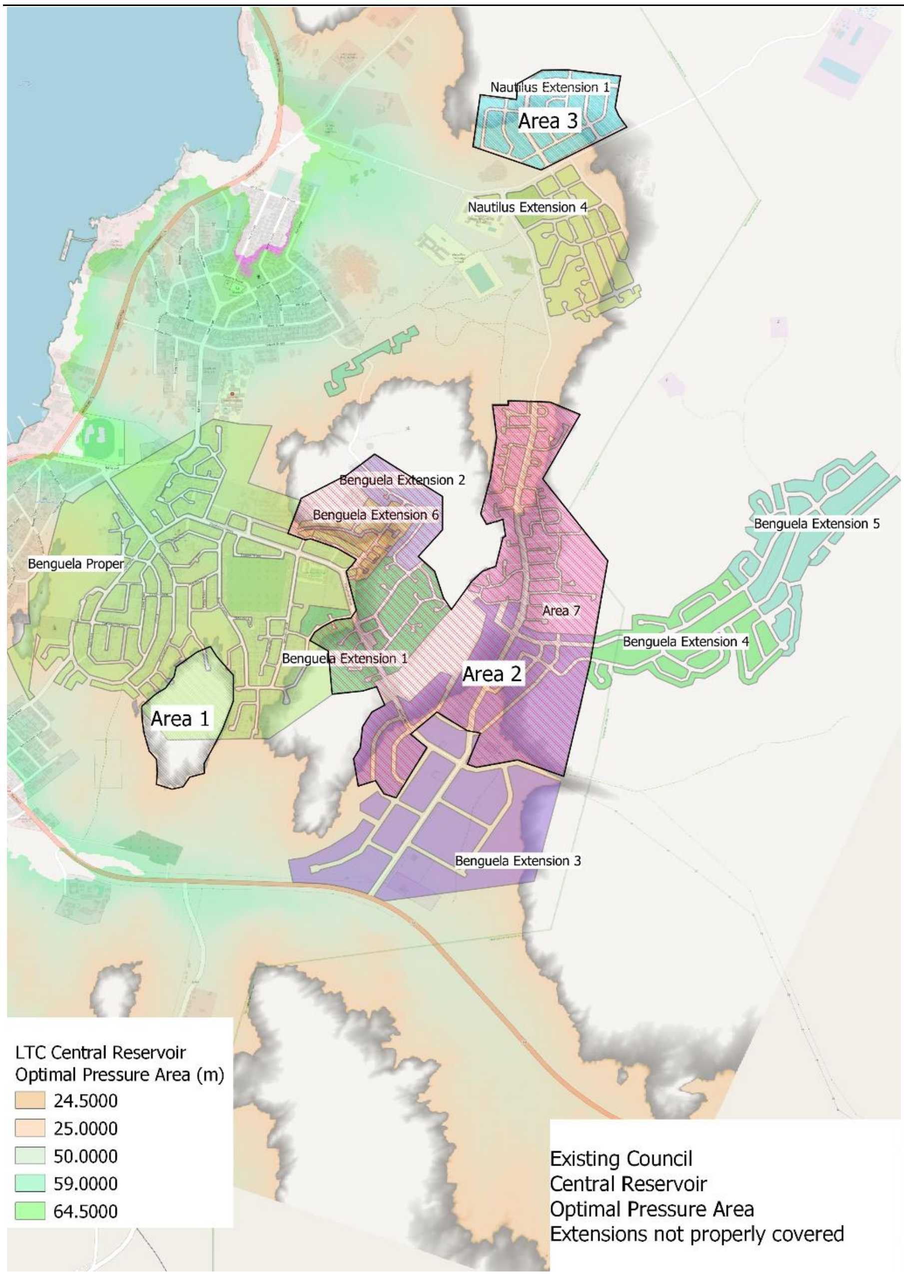
Due to planned and existing development on the fringes of Area 1 being marginally below minimum standards, no additional service reservoir is required. However, this area covered by Area 1 should be formally excluded from any future development.

B(ii) Area 2

Area 2 on the below map is a substantial part of the eastern development extensions and should be considered for servicing by a dedicated service reservoir.

B(iii) Area 3

Area 3 is substantially half of the Nautilus Extension 3 (existing NHE housing development) and ought to have a dedicated service reservoir to ensure minimum standards for residual pressure can be achieved.



Existing Council
Central Reservoir
Optimal Pressure Area
Extensions not properly covered

B(iv) Balance of Eastern Extensions

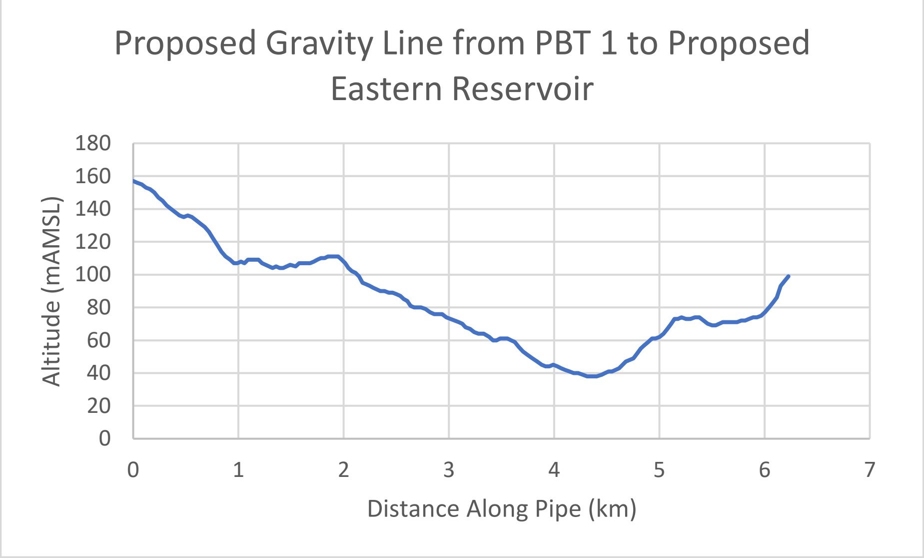
The development as proposed by the Structure Plan to the east as proposed for Benguela Extension 4 and 5 is considered to be uneconomical to develop in respect of water supply. The reasons for this would become apparent in the discussions of the next section.

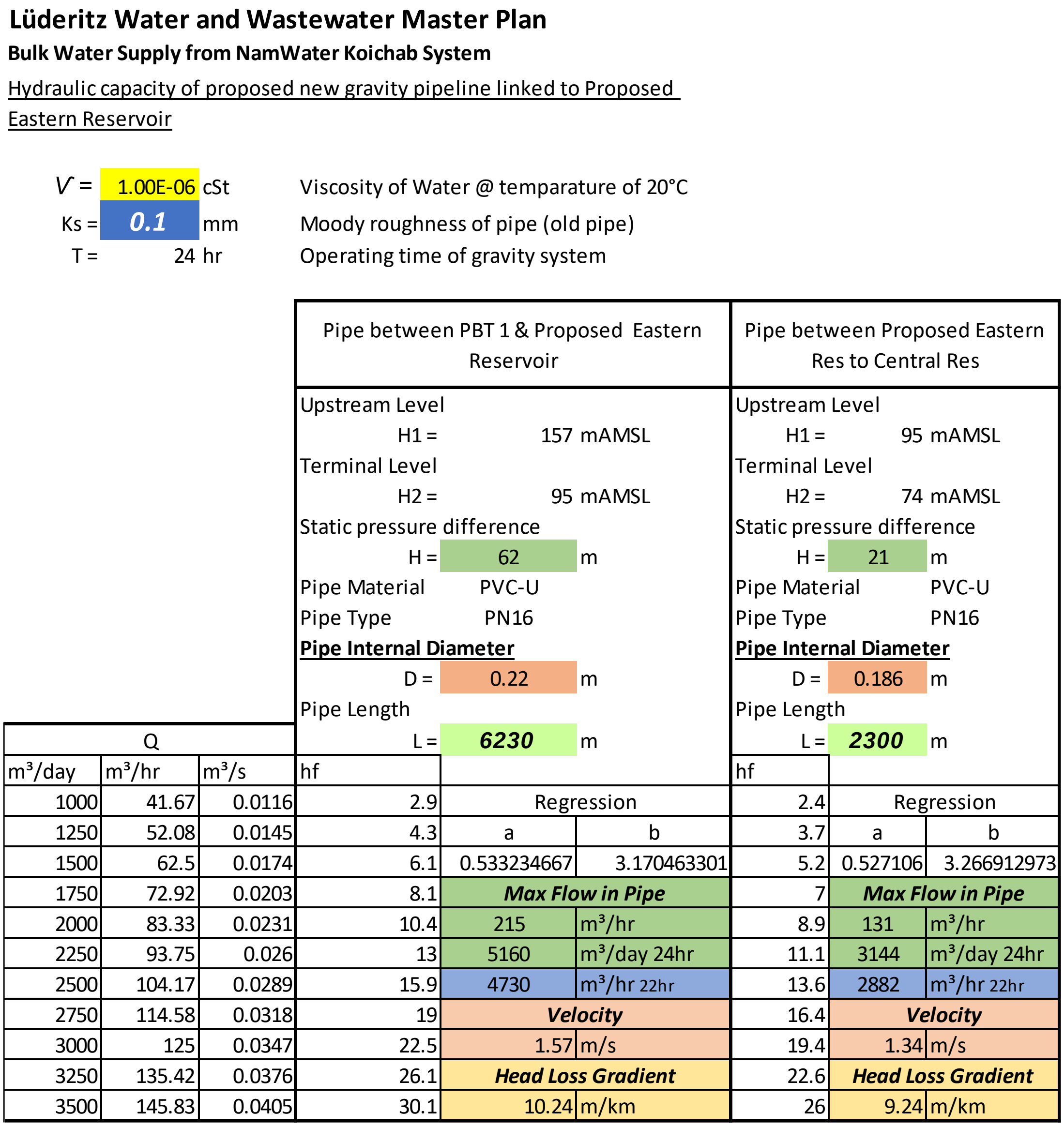
10.4 Proposed Additional Water Storage Reservoirs

It is herewith proposed to provide an additional reservoir on the eastern extents of the Lüderitz Townlands. The primary function of such a reservoir is to provide adequate pressure to the higher lying areas within the Townlands development.

The maximum elevation of the reservoir was determined by applying the general principle of a 5 m/km head loss gradient from the areas ill supplied by the existing reservoirs to a point most common to these areas. The required elevation of such a storage structure was determined to be in the order of 95 m and the only available natural elevation of this magnitude is located to the east.

A point closest to the NamWater Bulk Supply line with an elevation of 95 m was selected. It is proposed that this reservoir be supplied from PBT 1 via a pipe of 200 ND. The daily capacity of the proposed pipe is in the order of 2,6 Ml/day.





Lüderitz Water and Wastewater Master Plan

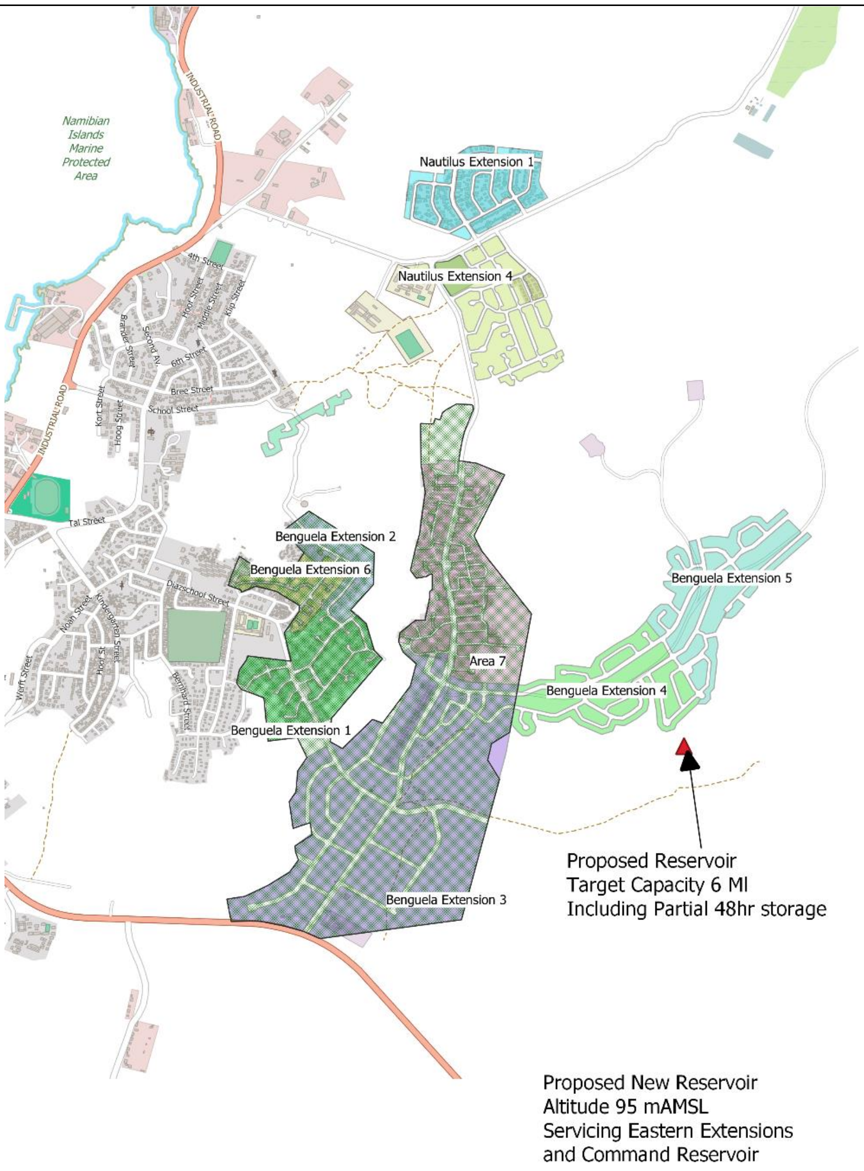
Bulk Water Supply from NamWater Koichab System

Hydraulic capacity of proposed new gravity pipeline linked to Proposed Eastern Reservoir

V =	1.00E-06	cSt	Viscosity of Water @ temparature of 20°C
Ks =	**0.1**	mm	Moody roughness of pipe (old pipe)
T =	24	hr	Operating time of gravity system

	Pipe between PBT 1 & Proposed Eastern Reservoir	Pipe between Proposed Eastern Res to Central Res
Upstream Level H1 =	157 mAMSL	95 mAMSL
Terminal Level H2 =	95 mAMSL	74 mAMSL
Static pressure difference H =	62 m	21 m
Pipe Material	PVC-U	PVC-U
Pipe Type	PN16	PN16
Pipe Internal Diameter D =	0.22 m	0.186 m
Pipe Length L =	***6230*** m	***2300*** m

Q			Pipe between PBT 1 & Proposed Eastern Reservoir			Pipe between Proposed Eastern Res to Central Res		
m^3/day	m^3/hr	m^3/s	hf			hf		
1000	41.67	0.0116	2.9	Regression		2.4	Regression	
1250	52.08	0.0145	4.3	a	b	3.7	a	b
1500	62.5	0.0174	6.1	0.533234667	3.170463301	5.2	0.527106	3.266912973
1750	72.92	0.0203	8.1	***Max Flow in Pipe***		7	***Max Flow in Pipe***	
2000	83.33	0.0231	10.4	215	m^3/hr	8.9	131	m^3/hr
2250	93.75	0.026	13	5160	m^3/day 24hr	11.1	3144	m^3/day 24hr
2500	104.17	0.0289	15.9	4730	m^3/hr 22hr	13.6	2882	m^3/hr 22hr
2750	114.58	0.0318	19	***Velocity***		16.4	***Velocity***	
3000	125	0.0347	22.5	1.57	m/s	19.4	1.34	m/s
3250	135.42	0.0376	26.1	***Head Loss Gradient***		22.6	***Head Loss Gradient***	
3500	145.83	0.0405	30.1	10.24	m/km	26	9.24	m/km



Proposed Reservoir
Target Capacity 6 Ml
Including Partial 48hr storage

Proposed New Reservoir
Altitude 95 mAMSL
Servicing Eastern Extensions
and Command Reservoir

The proposed reservoir can function in various combinations. It is, however, proposed that this reservoir is sized to be the primary storage reservoir for the town and that the existing NamWater Terminal Reservoir to act as secondary storage.

It is further proposed that this reservoir would supply the Central Reservoir without the need to pump to the Central Reservoir, and thus, the bulk supply of water to be reliant only on gravity.

> *The benefit of the proposed pipeline to the proposed Eastern Reservoir is that the reliability of supply to the entire town is improved, the higher lying areas are sufficiently serviced, and new developments can benefit from supply from both the existing NamWater Terminal Reservoir as well as from the proposed Eastern Reservoir. In addition, the proposed Eastern Reservoir would immediately relieve the burden on the existing gravity supply main from the Terminal Reservoir that is working at above capaciy at present.*

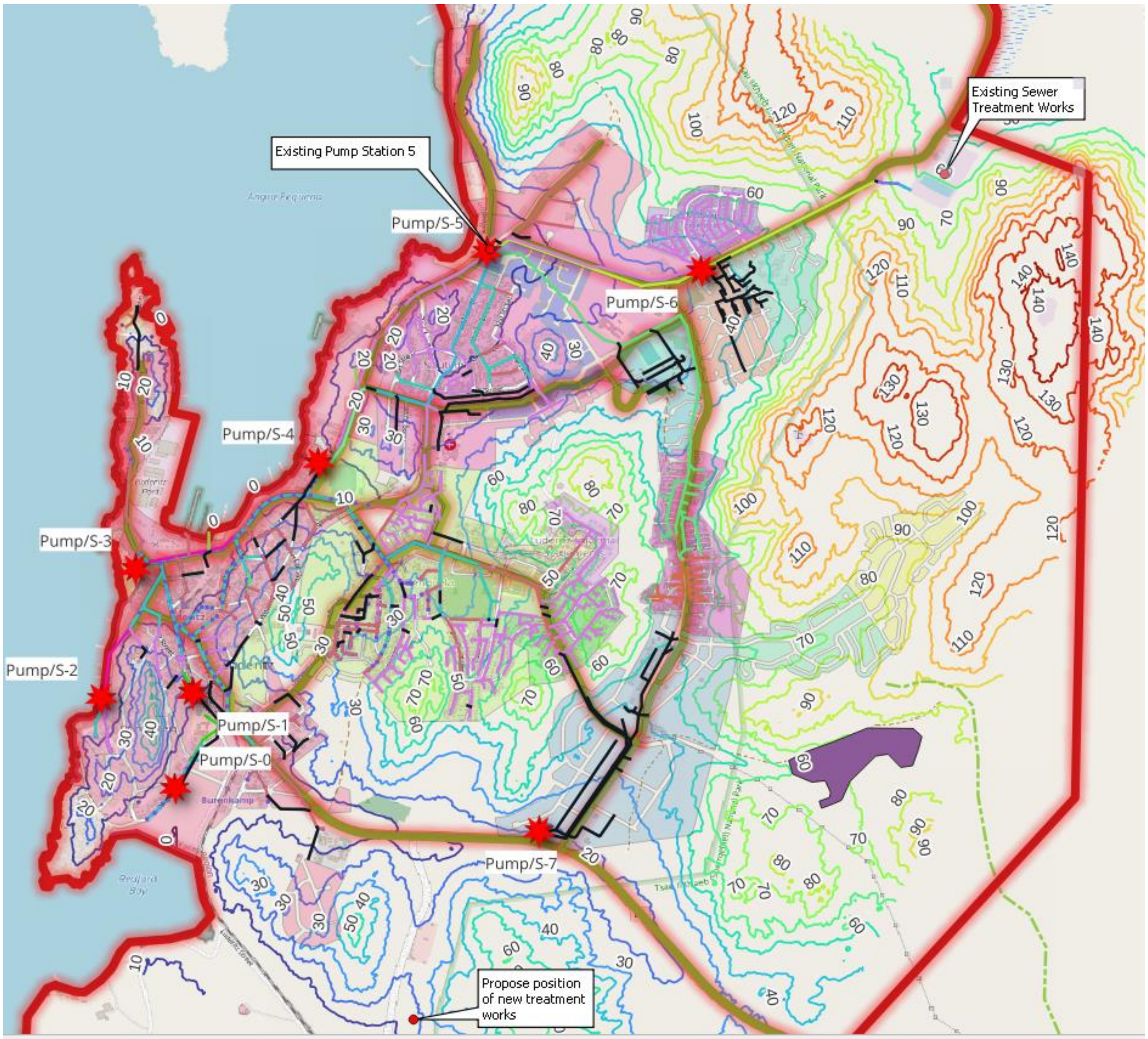
10.5 Wastewater Treatment

A report received from the LTC and prepared by Aqua Utilities Corporation (Pty) Ltd (now Aqua Services) of Windhoek was consulted in this respect.

Based on the existing information and the capacity analysis, it would seem that the existing treatment plant is already close to maximum capacity. Any further development would increase the burden on this treatment plant.

There were concerns raised about the limit of treated effluent discharged and a possibility of having an alternative treatment facility was raised.

From a hydraulic engineering perspective, the most suitable location of an additional plant is suggested to be to the south of the town as indicated in the map below.



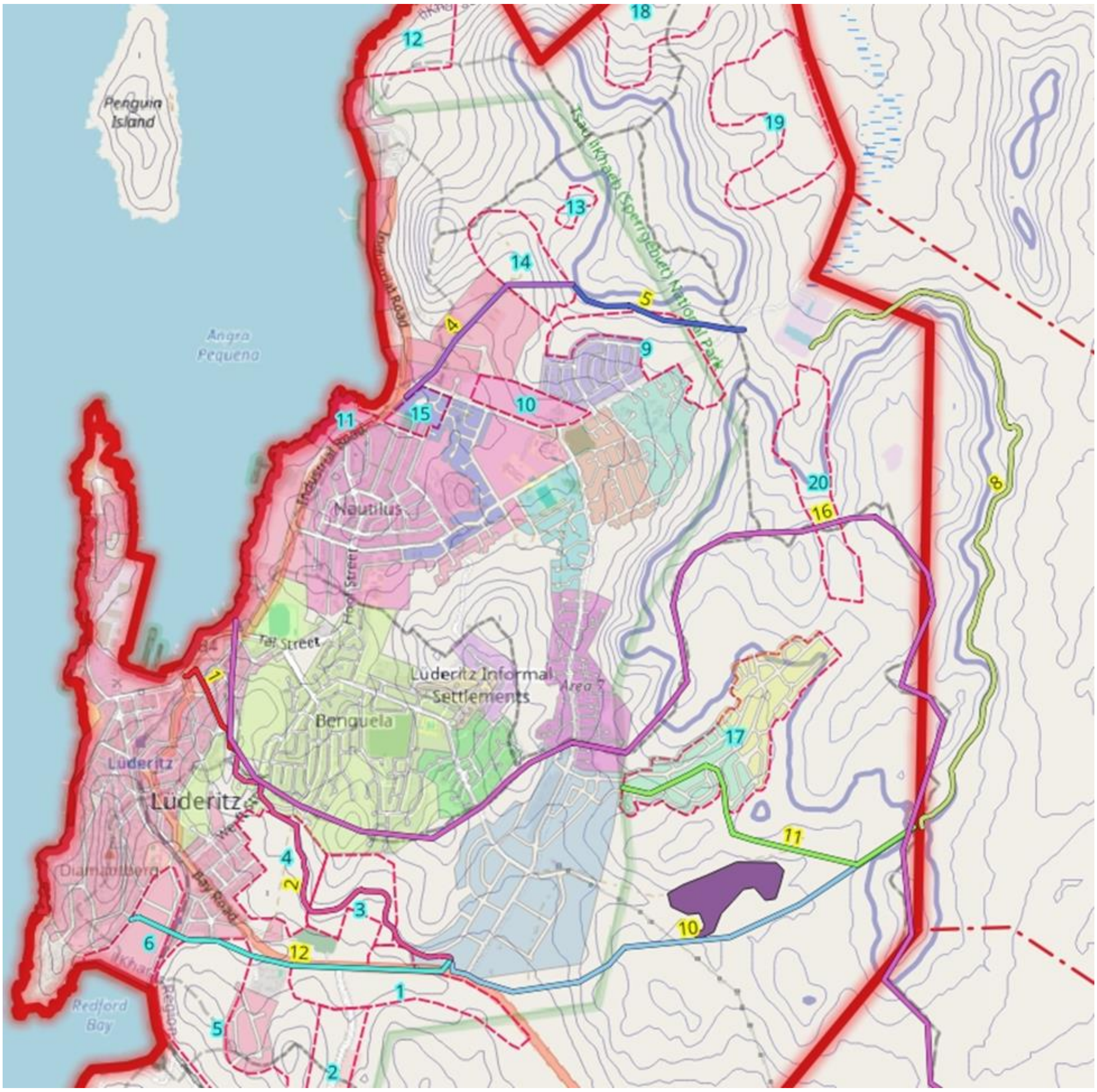
10.6 Bulk Pumped Sewer Network

As indicated in the above map, the discharge of sewer for the entire town is dependent on an intricate network of pumped sewer network. The discharge received by Pumpstation Pump/S-0 in the map above, is pumped to a crest before Pump/S-1 from where gravity flow discharges to Pump/S-1, the combined effluent at Pump/S-1 is again lifted to a crest from where gravity feeds Pump/S-3, with the same situation repeating until Pump/S-5 finally pumps the water over the ridge before the treatment works, and gravity thereafter feeds the treatment works.

There are thus five times that the effluent reaching Pump/S-0 is pumped and gravitated before it reaches the treatment plant. The risk of the effluent not being conveyed continually becomes exponentially more with each additional pump and gravity system is required.

The main vulnerability of this network is that all the sewer of the town accumulates at Pump/S-5 and any breakdown here exacerbates risk of overflow at the pumpstation with the health and environmental issues associated therewith.

To minimize the risk of the network not performing to standard as well as to cater for expansions to the sewer effluent capability of the Town, a refurbishment of the network is proposed and entails the following.



The above arrangement is also discussed under the town planning proposals as the effective bulk sewer network remains a fundamental operational challenge if the town layout is not beneficial thereto.

An improved bulk sewer network can be developed to eliminate the multiple successive pump systems that are dependent on downstream pumps to be operational not to cause a through flow blockage as is regularly experienced in the town.

It should, however, be noted that it would not be possible to avoid any pump system as the topography does not allow gravity only due to the fact that the existing sewer treatment is situated beyond watershed boundaries.

It is however possible to minimize the sewer pump system to a minimum by dividing the townlands into two major sewer catchment areas. The existing pump stations 4 and 5 would continue to discharge to the northeast. There is a proposal to also reduce the complexity of the existing pumping arrangements with a new line that would also cover the intended developments in areas 9, 13 and 14.

The existing sewer catchment areas serviced by pumpstations 1, 2, 3 and 7 as well as the future developments of 1, 3, 4, 6 and 17 is proposed to be services by a set of existing pumpstations but to realigned pipe system.

The above arrangements are indicated on the above map.

10.7 Conclusions and Recommendations

The foregoing section outlines the interventions required to bring the existing system to an acceptable level of service and adopts to the changing environment. It remains a challenge to keep old infrastructure to continue being useful in the present sense as well as to cater for some future date.

The above discussions are premised on the integration of the status quo situation with the demands of the foreseeable future.

There are two main future expectations to manage:

- The upkeep of the existing infrastructure for user expectations where no expansion depends on the existing infrastructure.
- The upgrade of existing infrastructure to expansion demands.

The two scenarios are interrelated, and the one cannot be considered without having consideration of the other. However, for purposes of practical management and best utilization of resources, the general approach would be to prioritize the upkeep of existing infrastructure as an ongoing rollout and to supplement the infrastructure implementation with the expansion demands.

Therefore, any list of infrastructure development work will include both aspects of upkeep and upgrade infrastructure, the one not overshadowed by the other.

The balance of this subsection is devoted to summarizing the proposed development aspects, first for water infrastructure and then for sewer infrastructure.

The subsections for water and sewer infrastructure will address projects categorized under:

- Investigations
    - Where anomalies or uncertainties exist regarding the infrastructure performance, the cause should be investigated.
    - These investigations are focused on resolving a specific challenge only.
    - A terms of reference report is developed on which planning can be premised.
- Operational
    - These operational interventions are related to improvements to the management aspect of infrastructure control and operations.
    - These interventions typically retrofit or modify control instrumentation of mechanical or electrical equipment.
    - The challenges causing the need for operational interventions are known yet need to be formalized and can involve in situ investigations or measurement recordings.
    - A terms of reference report is developed on which planning can be premised.
- Rehabilitation
    - Rehabilitation interventions seek to rehabilitate existing infrastructure to original design intent.
    - Rehabilitation interventions are premised on already known challenges with mature conceptual resolutions.
    - The terms of reference report is developed on which design can be premised.
- Improvements
    - Improvement interventions seek to augment or alter the original design intent.

  - Rehabilitation interventions are premised on already known challenges with mature conceptual resolutions.
  - The terms of reference report is developed on which design can be premised.
- Expansion
  - Expansion interventions seek to expand existing services delivery.
  - These interventions can be expansions of existing reticulations or the addition of new reticulations.
  - These interventions are identified and conceptually developed with this master plan development.
  - The terms of reference report is developed on which design can be premised.

10.8 Water Services Intervention Projects

10.8.1 Investigations

A Central Reservoir Supply Zone

The extend of the existing reticulation that is connected to the central reservoir is unclear and there is according to the modelling of the existing reticulation a possibility that a circular feed loop is present. If so, the booster pumps supplying the central reservoir is re-circulating water which is wasteful.

It is required that a in situ investigation to flow and pressure be recorded by employing sensors that can present data in real time.

The result of the investigation should:

- Confirm supply reticulation to Central Reservoir
- Confirm isolation of Central Reservoir Supply Zone
- Isolate booster pump circulation

10.8.2 Operational

A New Pulse Output meters at the reservoir and main inlet

This initiative is to improve the capability of accurate recording bulk flow and to monitor in real time the fluctuations in flow.

B Integration of Water Booster stations to the Scada Network

This initiative is to automate and better control the operational performance of the booster pumps to the Central Reservoir. This work might be affected by the Central Reservoir Supply Zone Investigation.

C Installation of pulse output Bulk meters and integration to Scada

This initiative is to improve the capability of accurate recording bulk flow and to monitor in real time the fluctuations in flow.

D Installation of solenoid valves at bulk users and integration to Scada

This initiative is to improve the capability of controlling bulk flow and to monitor in real time the fluctuations in flow.

E Installation of flow meters in the water network

This initiative is to improve the capability of accurate recording operational flow and to gain insight into the operational conditions of the reticulations.

F Pressure control system.

There is a need to improve the pressure within the system and to manage pressures to protect user equipment. This intervention is to be coordinated with the Central Reservoir Supply Zone Investigation.

10.8.3 Rehabilitation

A Replacement of Manhole covers

This is a routine maintenance initiative to replace unserviceable equipment and is managed by the Town Council internally.

B Replacement of Valves

This is a routine maintenance initiative to replace unserviceable equipment and is managed by the Town Council internally.

C Cleaning of water reservoir- Central

This is a routine maintenance initiative to replace unserviceable equipment and is managed by the Town Council internally.

D Repair of chlorination room

This is a routine maintenance initiative to replace unserviceable equipment and is managed by the Town Council internally.

E Replacement of Booster pumps

This initiative should be coordinated with the Central Reservoir Supply Zone Investigation.

F Repair of pumphouse building, Fencing and construction of perimeter wall for the central reservoir

This is a routine maintenance initiative to replace unserviceable equipment and is managed by the Town Council internally.

G Shack dwellers site

This is a routine maintenance initiative to replace unserviceable equipment and is managed by the Town Council internally.

10.8.4 Improvements

A Replacement of Asbestos pipelines in Town (Program)

This initiative is an ongoing effort to replace asbestos pipes having an adverse health risk with suitable pipe material.

B Replacement of asbestos pipeline from main inlet and rerouting thereof.

This initiative is an ongoing effort to replace asbestos pipes having an adverse health risk with suitable pipe material.

C Rerouting of main supply pipeline from railway siding

This is to replace the existing pipework with improved supply to the town reticulation.

This initiative should be coordinated with the expansion project for an additional command reservoir.

D Rerouting of Midblock reticulation in Benguela

This initiative is to address the difficulties of maintaining the reticulation that is inaccessible due to it being within the erven and not at street front.

E New Booster line for Area 2

This initiative is to improve the pressure within the reticulation of Area 2.

This initiative should be coordinated with the expansion project for an additional command reservoir as well as with the Central Reservoir Supply Zone Investigation.

10.8.5 Expansion

A Additional Command Reservoir

The conceptual development of the need to provide additional command reservoir capacity is required to take the concepts developed with this planning.

10.9 Sewer Services Intervention Projects

10.9.1 Investigations

A Possible New Effluent Plant

A concern was raised about the limitations to the expansion of the existing effluent treatment plant and treated discharge to cater for the future growth of the Town. Along this concern the possibility of an alternative treatment plant was raised as a planning initiative. Thus, the greatest constraint on expansion is an environmental issue which needs to be confirmed as this has a great impact on the balance of design around the sewer outfall and delivery to the correct point of treatment.

Under this investigation are the following initiatives:

- New Effluent treatment Plant and/or
- New Industrial Effluent Plant / Combined
- Rerouting of sewer pipelines to proposed effluent plant.
- New Effluent plant- Industrial area - Peninsula - options to be investigated.

10.9.2 Operational

A *Integration of pumpstations to Scada*

This initiative is to improve the capability of accurate recording bulk flow and to monitor in real time the fluctuations in flow, and to use such data to improve the atomization of the sewer pumpstations.

B *Procurement of a vacuum truck (Combination)*

This is an operational issue to be able to address temporary overflows more quickly and effectively to reduce the negative impact of inadvertent overflows at pumpstations when pump operations are interfered with.

10.9.3 Rehabilitation

A *Reinstatement of Sand Trap*

The effectiveness of a sewer pumpstation is heavily dependent on the effectiveness of reducing high loads of sand in sewage that impacts negatively on the pump performance.

B *Remediation work at the Effluent treatment plant*

The mechanical and electrical installations and equipment is not performing to standard and has a direct influence on the effectiveness of the treatment plant as a whole.

This initiative is to restore the original design intent.

C *Replacement of Existing Pipe Network to Original Design intent.*

There are a number of network collapses in the area and can only be addressed by the replacement of infrastructure. The following are areas that need attention:

- Replacement of Sewer pipelines in Benguela
- Replacement of sewer mains from Diaz School to Pumpstation 4
- Replacement/ Repair of Manholes and manhole covers.
- Repair of sewer pipelines and installations of Build Together erven Area 4

10.9.4 Improvements

A *Improvements to Sewer Pumpstation Operations*

The inadvertent out of service conditions at pumpstations 4 and 5 and the long lead time to repairs cause regular overflow at the pumpstations. In order to improve the lead time requirements and contain any overflows it is proposed to increase the retention storage at the pumpstations.

This initiative should also be coordinated with the proposed re-ordering of the pumpstation layout and discharge points.

Included in the proposal are the following subprojects:

- Additional Retention system at Pumpstation 4 & 5
- Construction of New Sewer Mains From Pumpstation 5 to treatment Plant
- Upgrading of Pumpstation1 (Sumps, Buildings, Electricity, Pumps, efficiencies)

- Upgrading of Pumpstation2
- Upgrading of Pumpstation3
- Upgrading of Pumpstation4
- Upgrading of Pumpstation5
- Upgrading of Pumpstation6
- Upgrading of Pumpstation7
- Upgrading of Pumpstation8
- Upgrading of Pumpstation9

B Improvements to Bulk Sewer lines

The bulk sewer lines that require improvement are listed below:

- New Sewer mains for erf 1014-1013 and 1012
- Rerouting of Sewer in Area 2- Natalia
- Upgrading of sewer pipeline at erf 1739 Area 2
- Construction of inline Grinders- North of Area 7
- Construction of Sewer main lines in Jakkalsdraai (Eliminate Midblock)
- Construction of Bulk sewer in Spokiesdorp- (Eliminate midblock)
- Upgrading of Area 7 Main sewer pipeline to Pumpstation 5

10.9.5 Expansion

A Increasing and/or expanding the existing bulk pumped sewer network.

The proposed re-organization of the existing bulk pumped sewer network that would resolve most of the existing operational challenges as well as addressing the expansion of the system as an integrated system that is robust and economically operated includes the following subprojects:

- Replacement of Pump rising mains from Pumpstation 1- 1A
- Replacement of rising mains from Pumpstation 3 to sand trap
- Repair of Pumpstation Buildings 1-7
- Replacement of rising mains between pumpstation 5 and 6

B Construction of new pumpstations

The driving force behind the proper refurbishment of the bulk pumped sewer network would be the optimal design of the pump positions and associate d pumpstations.

11 IMPLEMENTATIONPLAN

The work for execution as identified by the master plan and operational issues experienced by the Town Council, the below scope of work is submitted for consideration.

11.1 Summary of Scope of Work

Section 10 above discusses the intervention initiatives identified to address the status quo requirements. The status quo requirements also consider the expansion requirements, and the proposals are thus integrated to address both status quo as well as expansion requirements.

11.1.1 Sewer Scope of Work

Intervention Type	***Line Ref***	***Scope of Work***	***Planning Cost Estimate (N$ Million)***	***Construction Cost Estimate (N$ Million)***
Investigations	3	New Effluent treatment Plant	0.79	TBD
	4	New Industrial Effluent Plant / Combined		
	64	Rerouting of sewer pipelines to proposed effluent plant		
	65	New Effluent plant- Industrial area - Peninsula - options to be investigated		
Operational	34	Integration of pumpstations to Scada	0.79	TBD
	62	Procurement of a vacuum truck (Combination)	Internal	Internal
Rehabilitation	25	Reinstatement of Sand Trap	Internal	Internal
	27	Remediation work at the Effluent treatment plant	1.5	TBD
	31	Replacement of Sewer pipelines in Benguela	Internal	Internal
	32	Replacement of sewer mains from Diaz School to Pumpstation 4	Internal	Internal
	33	Replacement/ Repair of Manholes and manhole covers	Internal	Internal
	35	Repair of sewer pipelines and installations of Build Together erven Area 4	Internal	Internal
Improvements	5	Improvements to Sewer Pumpstation Operations	To coordinate with Line Ref Item 63	
	55	Improvements to Bulk Sewer Lines	1.17	TBD
Expansion	28	Increasing and/or expanding the existing bulk pumped sewer network.	To coordinate with Line Ref Item 63	
	63	Construction of new pumpstations	2.76	28.2
	65	New Effluent plant- Industrial area - Peninsula - options to be investigated	3.1	35.0

Please note the line references are internal references for coordination and will be removed once the discussion stage is completed.

The wording "Internal" under the costing column refers to work executed by the Town Council on the operations budget. The acronym "TBD" is an item that requires investigation prior to be able to finally cost construction for same.

11.1.2 Water Scope of Work

Intervention Type	***Line Ref***	***Scope of Work***	***Planning Cost Estimate (N$ Million)***	***Execution Cost Estimate (N$ Million)***
Investigations	New	Investigate Central Reservoir Supply Zone	0.5	TBD
Operational	43	New Pulse Output meters at the reservoir and main inlet	Internal	TBD
	46	Integration of Water Booster stations to the Scada Network	Internal	TBD
	69	Installation of pulse output Bulk meters and integration to Scada	Internal	TBD
	70	Installation of solenoid valves at bulk users and integration to Scada	Internal	TBD
	71	Installation of flow meters in the water network	Internal	TBD
	74	Pressure control system	Internal	TBD
Rehabilitation	40	Replacement of Manhole covers	Internal	TBD
	42	Replacement of Valves	Internal	TBD
	47	Cleaning of water reservoir- Central	Internal	TBD
	48	repair of chlorination room	Internal	TBD
	50	Replacement of Booster pumps	Internal	TBD
	51	Repair of pumphouse building, Fencing and construction of perimeter wall for the central reservoir	Internal	TBD
	73	Shack dwellers site	Internal	TBD
Improvements	41	Replacement of Asbestos pipelines in Town (Program)	0.84	TBD
	44	Replacement of asbestos pipeline from main inlet and rerouting thereof.	0.84	TBD
	45	Rerouting of main supply pipeline from railway siding	0.41	TBD
	49	Rerouting of Midblock reticulation in Benguela	0.51	TBD
	72	New Booster line for Area 2	0.32	TBD
Expansion	2	Bulk Water Terminal Storage	2.9	36.5

Please note the line references are internal references for coordination and will be removed once the discussion stage is completed.

The wording “Internal” under the costing column refers to work executed by the Town Council on the operations budget. The acronym “TBD” is an item that requires investigation prior to be able to finally cost construction for same.

11.2 WAY FORWARD

The proposed interventions should be workshopped for approval and the strategy for implementation adopted.

On approval of the proposals as set out herewith, this report should be updated to reflect such discussions and approvals as well as developing the associated terms of references in accordance with the approvals received.

The individual terms of references should then be workshopped for acceptance and the project implementations should then be commenced in accordance with the said terms of reference.