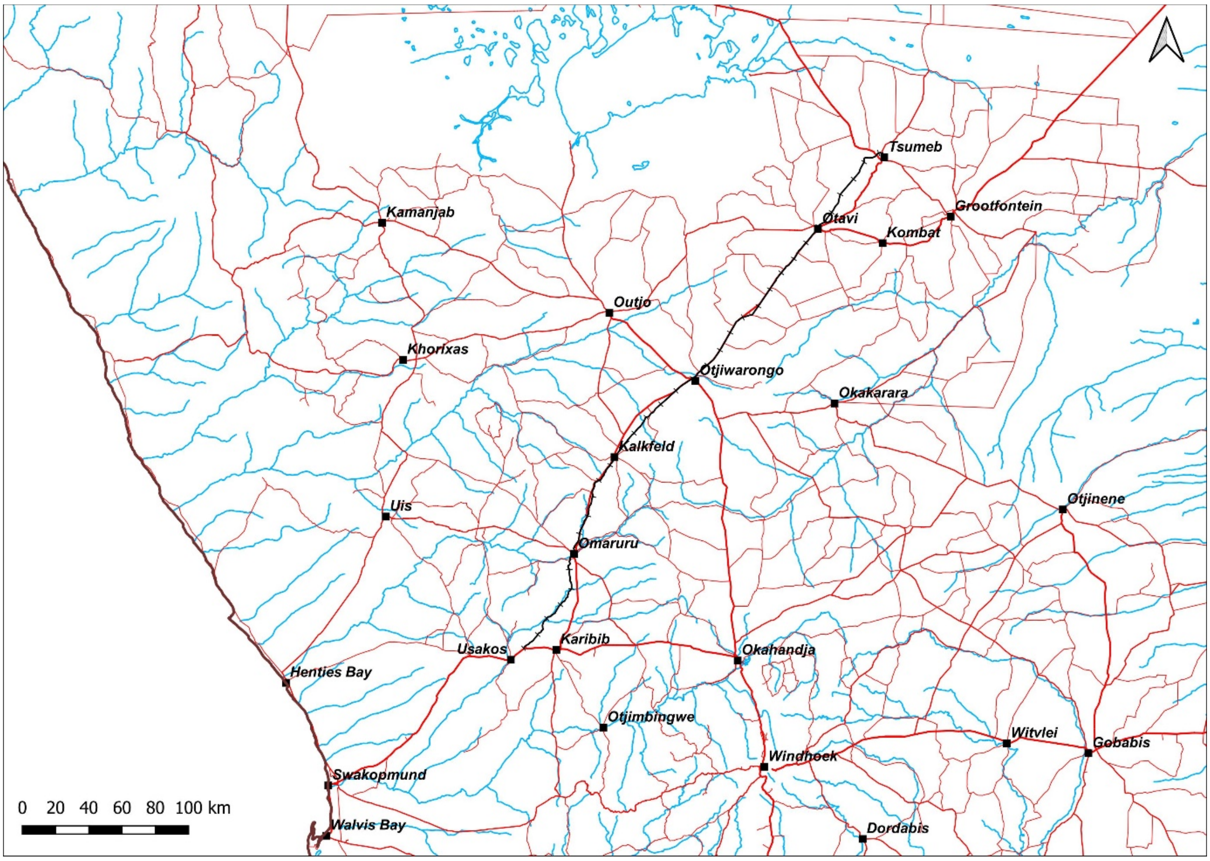
HYDROGEOLOGICAL INPUT AND ASSESSMENT OF THE GROUNDWATER POTENTIAL FOR THE WATER SUPPLY TO THE KRANZBERG TO TSUMEB RAILWAY LINE
PHASE ONE: KRANZBERG TO OTJIWARONGO



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CONTENTS

INTRODUCTION

Urban Green cc appointed Dynamic Water Resources Management (**DWRM**) to conduct an assessment of the groundwater potential to supply in the water demand of the Kranzberg to Tsumeb railway line project, and to consider the potential impact of groundwater abstraction on the environment.

The project will be completed in two phases:

- Phase 1 – Kranzberg to Otjiwarongo
- Phase 2: Otjiwarongo to Tsumeb

This report is submitted for Phase 1 of the project.

Objectives

The works shall cover, but is not necessarily limited to the following:

- To investigate the groundwater potential based on existing boreholes located in close proximity to the railway line;
- To investigate the groundwater potential based on the prevailing geology and associated hydrogeology in close proximity to the railway line;
- To consider the potential impact of groundwater abstraction on the environment, and to propose mitigation measures to negate these impacts;
- To compile a written report on the findings.

APPROACH AND METHODOLOGY

A short narrative of the approach and methodology followed are as follows:

- Desktop study, evaluating the groundwater potential from existing boreholes and based on the prevailing geology;
- Identify and recommend most viable areas to be investigated for establishing groundwater abstraction points;
- Identify and recommend existing boreholes that could possibly be used to supply water [note that the use of such boreholes will eventually depend on negotiations for the use with the borehole owner(s)];
- Assess the potential impact of groundwater abstraction on the environment and propose mitigation measures;
- Compilation and submission of a report.

DESKTOP STUDY

Information required to complete the groundwater potential assessment were:

- Railway centreline (already provided);
- Water demand;
- Minimum water quality standard for the required water use;
- Maximum distance from the railway centreline that must be assessed in terms of the groundwater potential.

The railway centreline was provided, but none of the other required information were given to **DWRM**. It was therefore considered reasonable to assume that the groundwater potential as determined during this study should rather inform the demand-side, while a general overview of the groundwater quality is given to possibly exclude specific areas of poor water quality.

The groundwater potential was assessed within a distance of 10 km either side of the railway line, i.e., all boreholes captured in the GROWAS database and located within 10 km from the railway centreline were included in the evaluation.

Boreholes

The desktop study evaluated the groundwater potential along the railway line, based on available information from the DWA database, relating to the following parameters:

- Borehole yields
- Rest water levels
- Groundwater quality (TDS, sulphate, nitrate)

It must be emphasised that the database is not complete, i.e., not all existing boreholes are captured in the database; hence an evaluation based on the database boreholes may not give an accurate reflection of the true situation. It was also realised that the information captured in the database are not accurate, and ***DWRM*** does not take responsibility for incorrect data. For example, for many boreholes where no rest water levels were recorded, it is captured as 0 m; similarly, depths of some boreholes are obviously incorrect. These obviously incorrect data were not used in the evaluation, especially in contouring the rets water level. The borehole data are summarised in **Appendix 1**.

All boreholes recorded in the database that fall within 10 km either side of the railway centreline were filtered, and further grouped in terms of their yield to give a clear indication of the groundwater potential in terms of the yield distribution that can be expected along the railway line. The locations and yields of these boreholes are shown in **Maps 1 to 3**.

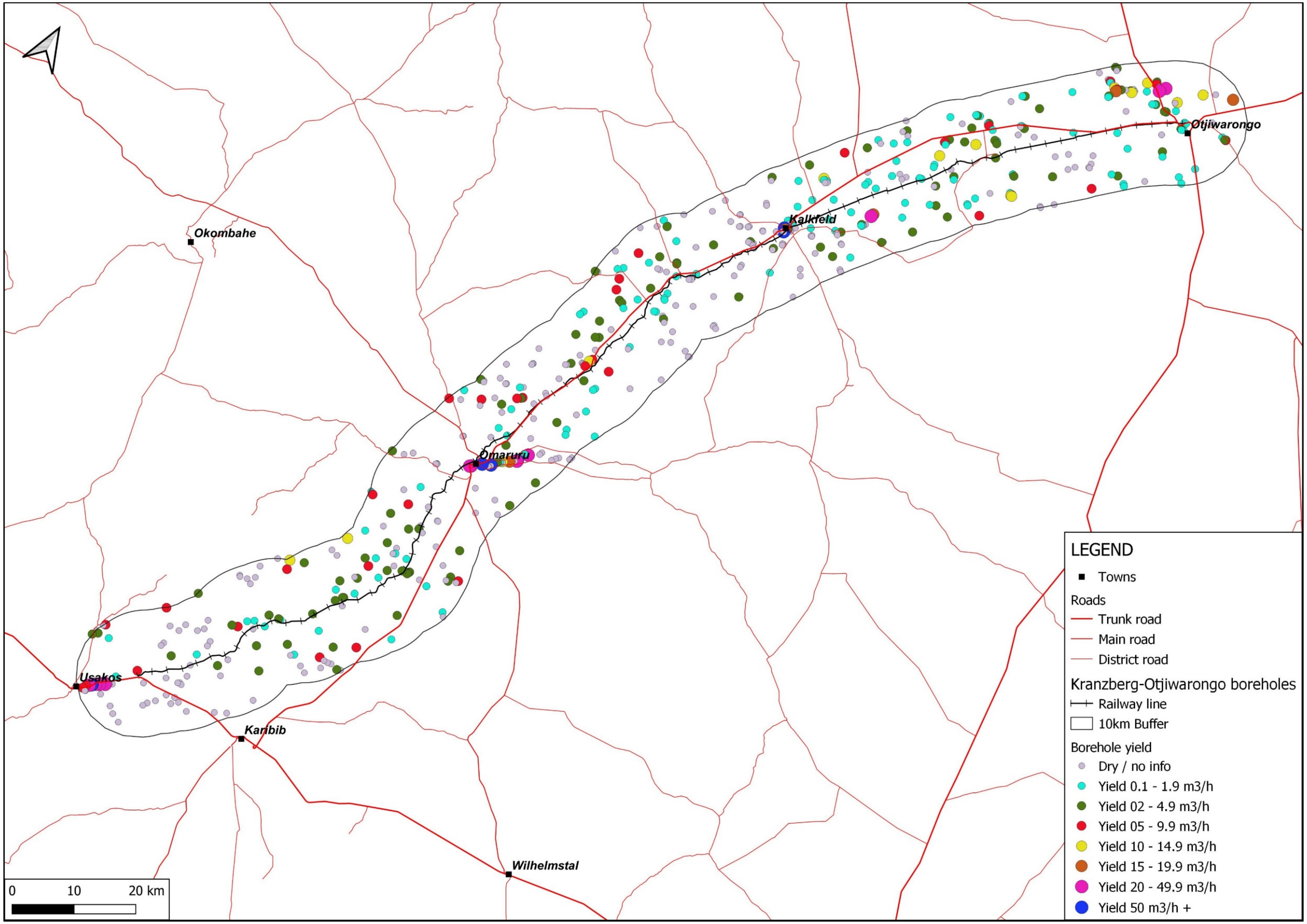
It must also be borne in mind that, if boreholes are in existence for a long period of time, or has not been in operation for some time, the captured borehole data may not reflect the actual and current borehole capacities.

A statistical analysis of the borehole yields is shown in **Table 1** below.

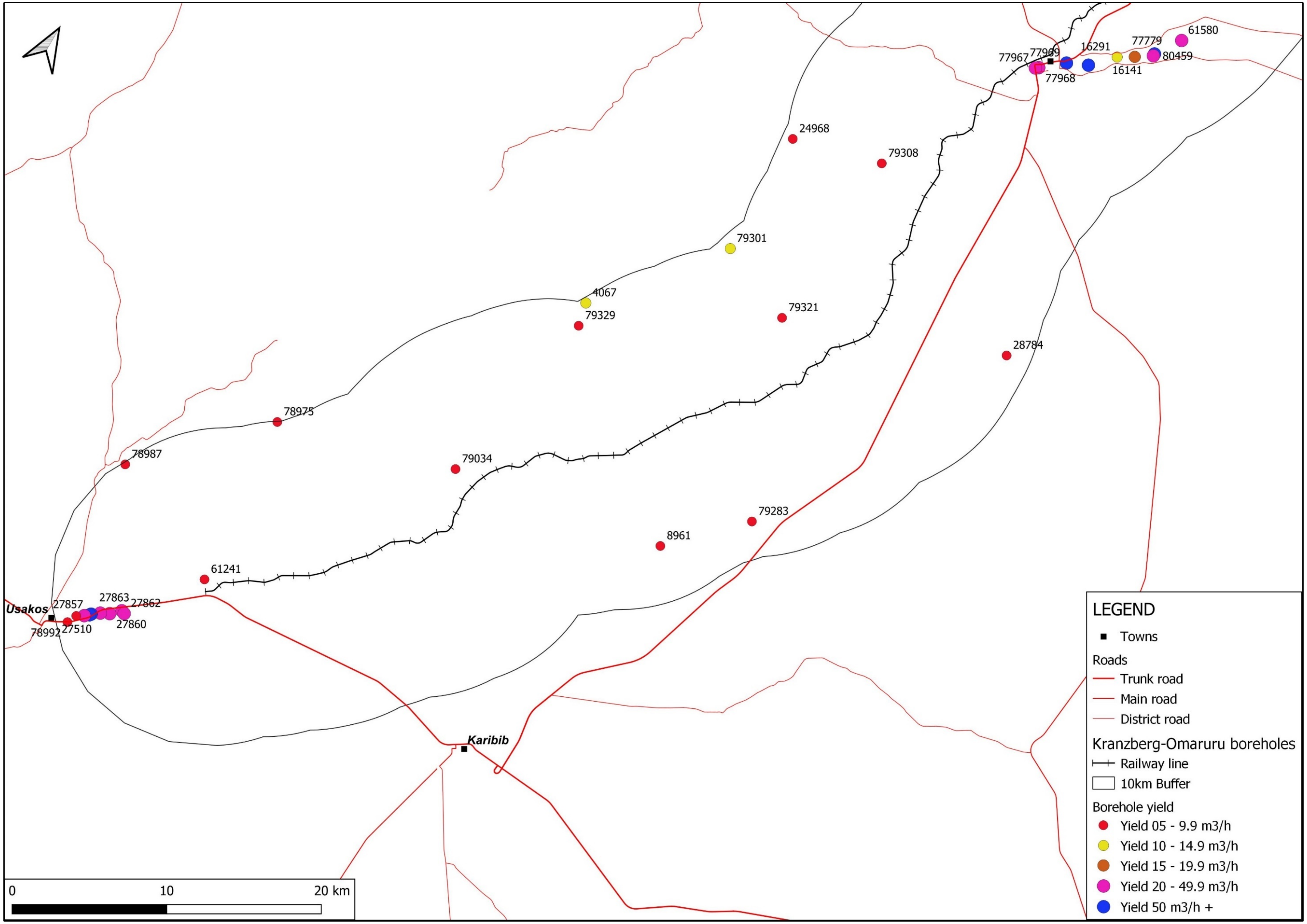
Table 1 Borehole yield statistics: Kranzberg to Otjiwarongo

	Numbers	**Percentage**
Number of boreholes	**593**	**100.0%**
Yield >10m^3/h	38	**6.4%**
Yield >5m^3/h and <10m^3/h	37	**6.2%**
Yield <5m^3/h	233	**39.3%**
No yield recorded	285	**48.1%**
Totals	**593**	**100.0%**

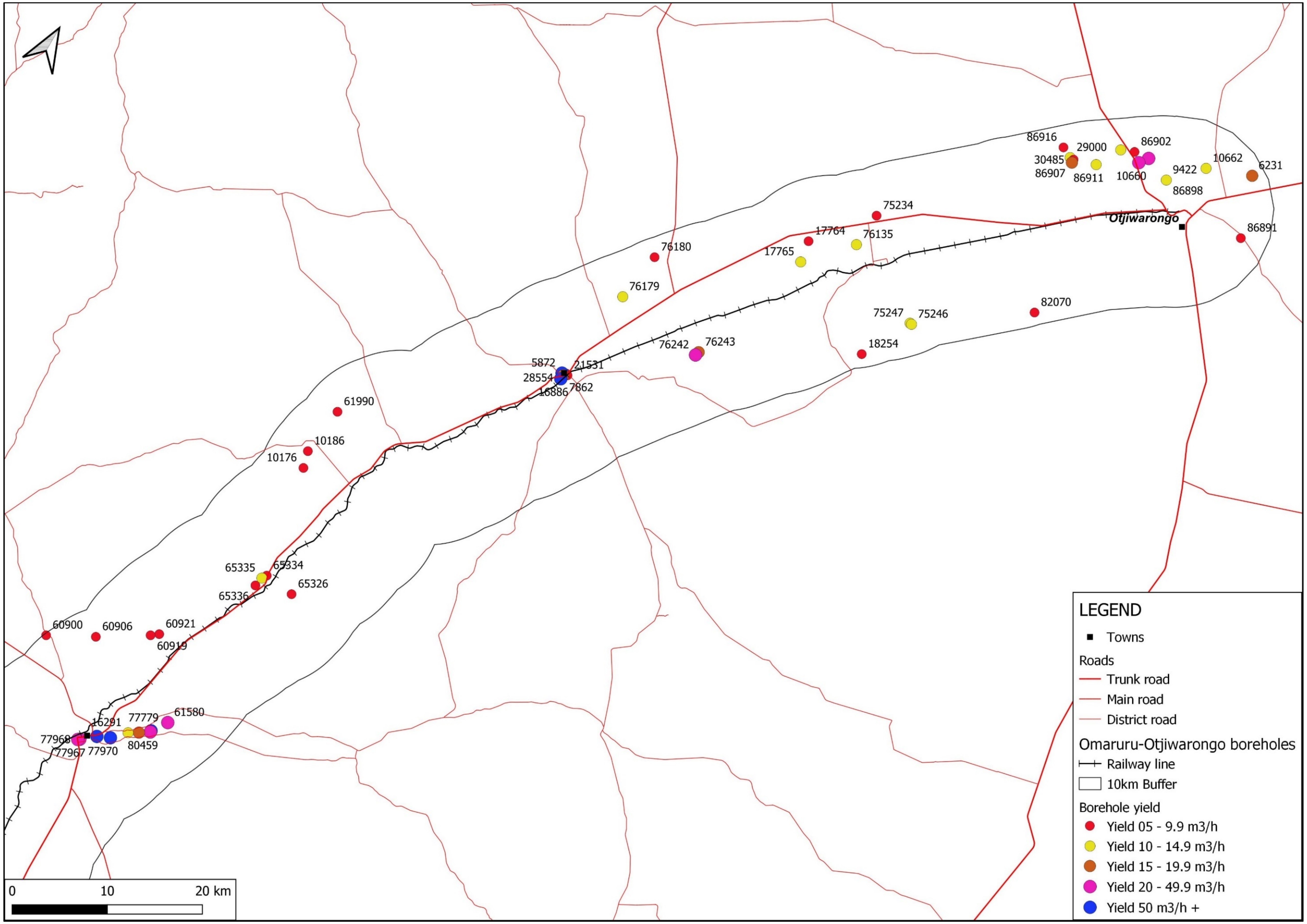
An overview of the yields already gives an indication of the generally low groundwater potential to supply in construction water, where high yielding boreholes are required to supply in large volumes of water on a daily basis. Only 12.6% of the database-recorded boreholes yield more than 5 m^3/h, suggesting that a large number of boreholes will be required (in a small area) to supply in the water demand.



MAP 1 **Locations and yields of all the database-recorded boreholes located between Kranzberg and Otjiwarongo and within 10 km from the railway centreline**



MAP 1 **Locations and yields of all the database-recorded boreholes located between Kranzberg and Omaruru and within 10 km from the railway centreline**



MAP 3 **Locations and yields of all the database-recorded boreholes located between Omaruru and Otjiwarongo and within 10 km from the railway centreline**

Aquifers exploited for bulk groundwater abstraction

A few well-studied aquifers are present in the study area that either supplied water in the past, or are still supplying water, for bulk abstraction to supply in municipal water demands. These aquifers are shortly discussed below.

Kranzberg Aquifer

Public streams are considered water protection areas (previously referred to as water control areas), and groundwater abstraction from water protection areas is regulated by the Water Act of 1956. The Kranzberg Aquifer is therefore in a water protection area, and according to the Water Act any person abstracting groundwater from a water controlled area needs to apply for a permit to abstract water and must comply with the permit conditions as specified.

To the northeast of Usakos, an extensive calcrete plain has developed towards Karibib. Typically, a thin cover of oxidised alluvium obscures the solid geology across a gently undulating inter-mountain plain. The Khan, Aroab and Kranzberg Rivers are incised into this plain and contain a variable thickness of alluvium representing the weathering products of surrounding areas of high relief. The calcrete plain immediately to the northeast of Usakos has been shown to be underlain by a paleo river channel running sub-parallel to the existing course of the Kranzberg River, the so-called Kranzberg Aquifer (see **Figure 1**).

The calcrete-capped, alluvium filled paleo-river channel striking northeast from the confluence of the Aroab and Kranzberg Rivers differs from the aquifer hosted in the Khan River alluvials in the sense that the alluvium is partially cemented. Intergranular cementation by calcium carbonate has taken place in distinct, discrete horizons intercalated with completely unconsolidated layers.

The unconsolidated alluvial layers are capable of containing and transmitting significant quantities of groundwater. Due to the layered nature of the aquifer system the groundwater is semi-confined. The aquifer is reportedly separated by a hydraulic discontinuity into two compartments, i.e., Compartment A and Compartment B. The alleged compartmentation is however neither supported by the existence of a lithological barrier nor a geophysically proven structural feature, and it is therefore doubted if this discontinuity really exists. Water level graphs of a number of monitoring and production boreholes penetrating both “compartments” of the Kranzberg Aquifer show almost identical behaviour, which is further indication that there is only one, hydraulically connected, Kranzberg Aquifer.

The combined groundwater reserves of Compartments A and B in the Kranzberg Aquifer were calculated as 0.649 Mm^3. A recharge figure could not be calculated due to a lack of runoff data. A re-evaluation of previous studies concluded that the Municipal sources tap the same aquifer as the NamWater Kranzberg boreholes, therefore the two borehole groups should be treated as one. The sustainable yield of the Municipal and Kranzberg sources combined is approximately 0.270 Mm^3/a, with the Kranzberg Aquifer’s sustainability estimated at 0.108 Mm^3/a.

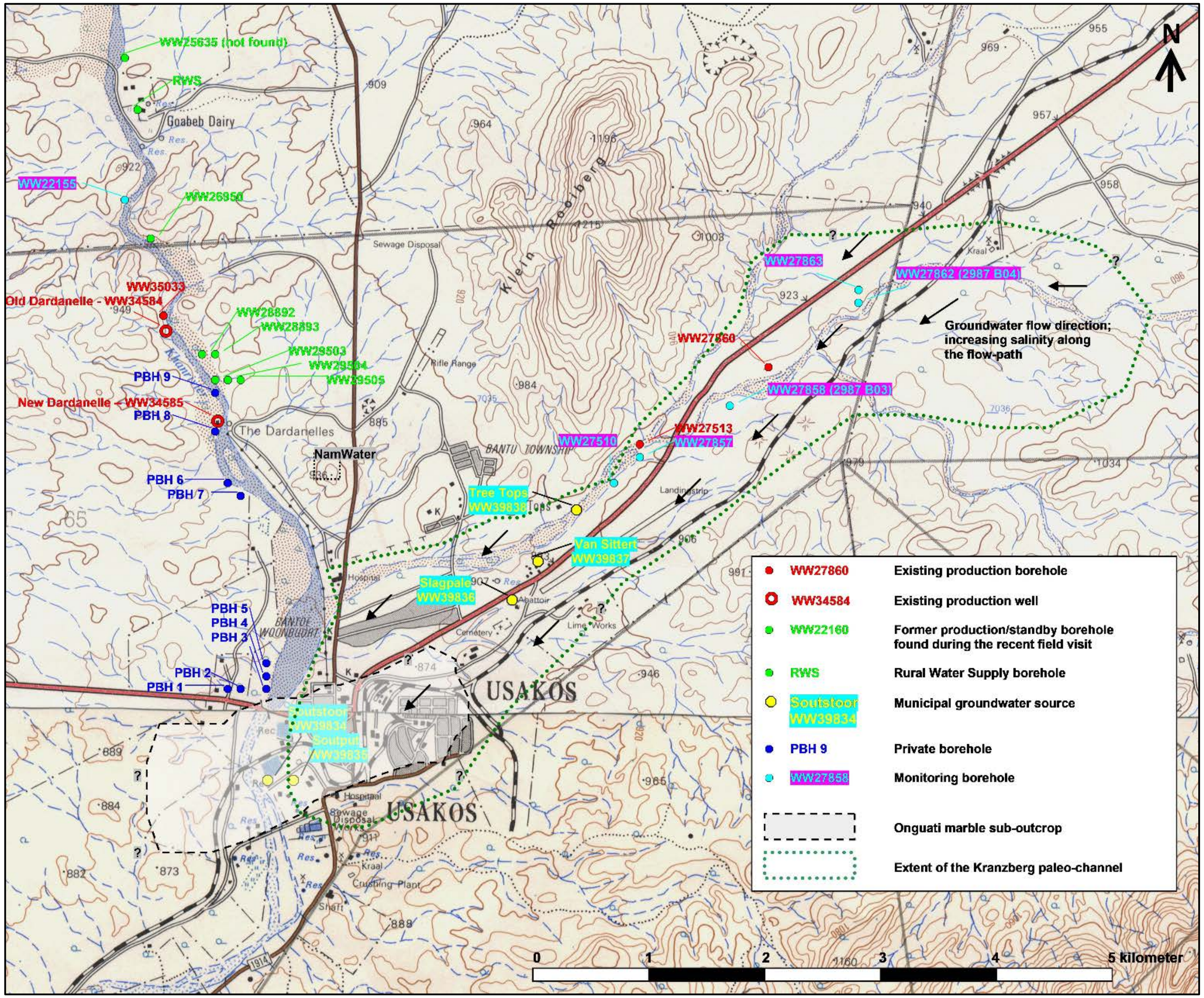


Figure 1 Lay-out of the Kranzberg Aquifer, including the Usakos municipal boreholes (adapted from NamWater, 2000)

Spes Bona Aquifer

Public streams are considered water protection areas (previously referred to as Groundwater Control Areas), and groundwater abstraction from Water protection areas is regulated by the Water Act of 1956. The Seps Bona Aquifer is located in the Khan River some 30 km north of Karibib, and in a Water protection area. According to the Water Act any person abstracting groundwater from a water controlled area needs to apply for a permit to abstract water and must comply with the permit conditions as specified.

The scheme consisted of 6 production boreholes drilled in 1966, but it was decommissioned around 2003 when the Swakoppoort Dam became the source of its water supply, and water was piped in from the Swakoppoort Dam.

Due to a water supply shortfall experienced at the Karibib Water Supply Scheme, caused by a significant drop of the water level and the deterioration of water quality of the Swakoppoort Dam, five replacement boreholes were drilled in the Spes Bona wellfield at the end of 2016. *Drilling of the replacement boreholes in the Spes Bona wellfield was unsuccessful, as all but one of the boreholes were dry.* Alluvial sediments were intercepted in all the boreholes drilled, comprising medium to coarse grained sand.

As with most alluvial aquifers, aquifer recharge depends largely on flood events. During and immediately after flooding water levels rise rapidly, and then decrease steadily, but continuously, until the next flood event.

Omaruru River Aquifer (ORA)

The Omaruru River Aquifer is proclaimed as a Water Control Area and according to the Water Act any person abstracting groundwater from a water controlled area needs to apply for a permit to abstract water and must comply with the permit conditions as specified.

The only exploited groundwater resources in the immediate area of Omaruru for large-scale abstraction such as municipal or irrigation water supply, are the alluvial beds of the ephemeral Omaruru River. The alluvium deposits form a phreatic aquifer, the dimensions of which are controlled by the configuration of the river channels.

The Omaruru Municipality operates its own bulk water supply scheme. All of its water is abstracted from the Omaruru River by means of borehole installations. Water is abstracted from four boreholes in the immediate vicinity of Omaruru, and also from the three boreholes of the Kranzberg scheme east of the town.

In general, it is known that bedrock rises immediately below the road bridge at Omaruru town. From this bedrock high the Omaruru River Aquifer (ORA) stretches upstream for a distance of about 30 km, with a second rise in bedrock at a distance of about 600 m upstream from section 6C. A bedrock high is also noted at a distance of about 3 000 m upstream of section 3D, and these two geohydrological compartments are referred to as Compartments 1 and 2 (see **Figure 2**). The ORA was previously divided into 4 compartments, namely compartments A, B, C & D. The Municipality abstracts groundwater from compartments A & B only (i.e., the downstream portion or Compartment 1). In this report, reference is made to Compartments 1 and 2, as well as to compartments A, B, C and D.

Previous hydrogeological studies concluded that the total volume of groundwater stored in the alluvium of the ORA at full capacity (assuming that the average water level is approximately 2 m below surface) is about 5.78 Mm^3. Due to dead storage in the aquifer, it is assumed that only 80% of the water can be effectively abstracted, which reduces the total water available for abstraction to 4.62 Mm^3. *This volume of stored reserves is the total for the aquifer upstream of Omaruru over a stretch of 30 km and is only available when the aquifer is at full capacity, which is assumed to be at a regional water level of 2 m below surface.* The stored reserve is extremely sensitive, and the volume of groundwater changes significantly during any one year. From **Figure 2** it can be seen that, in the rainy season (January to April or quarter 1), the aquifer is replenished during runoff events. During the rest of the year groundwater is utilised and lost *via* subsurface throughflow, and the reserves decrease accordingly.

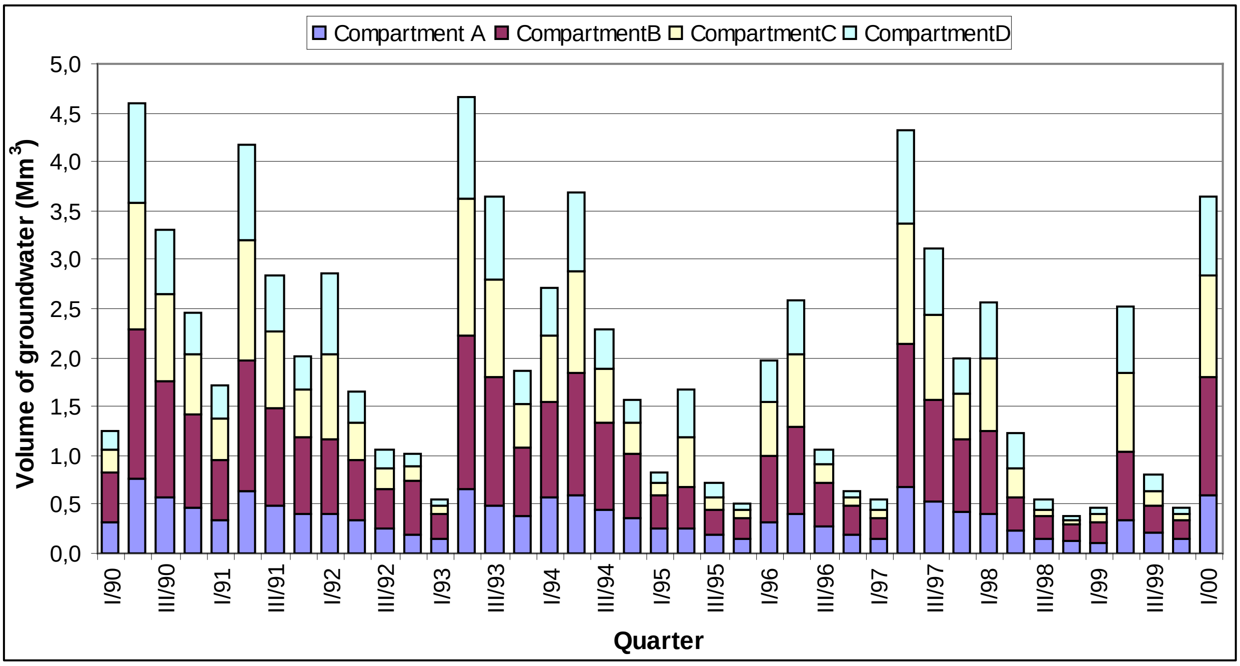


Figure 2 Total volume of groundwater available, and changes in stored reserves, in the Omaruru River Aquifer (Alexander and Becker, 2000)

The average recharge calculated for Compartment 1 (Compartments A and B), which is being exploited by the Omaruru and Kranzberg boreholes, is in the order of 1 Mm^3/a, which is also an estimate of the long-term sustainable yield of this part of the aquifer. The recharge in the upstream Compartment 2 (Compartments C and D), which is utilised by various other permit holders was calculated to be in the order of 1.5 Mm^3/a. *The total recharge to the ORA, which can be regarded as an estimate of the sustainable yield of the aquifer, was thus calculated to be 2.5 Mm^3/a.*

A study by NamWater in 2000 found that, based on available groundwater abstraction permit data, a total of 2.61 Mm^3/a was allocated for abstraction from the ORA: 1.0 Mm^3/a to the Municipality and 1.61 Mm^3/a other persons amounting to the 2.61 Mm^3/a, thus exceeding the estimated annual recharge.

The extent of the Omaruru River Aquifer is shown in **Figure 3**.

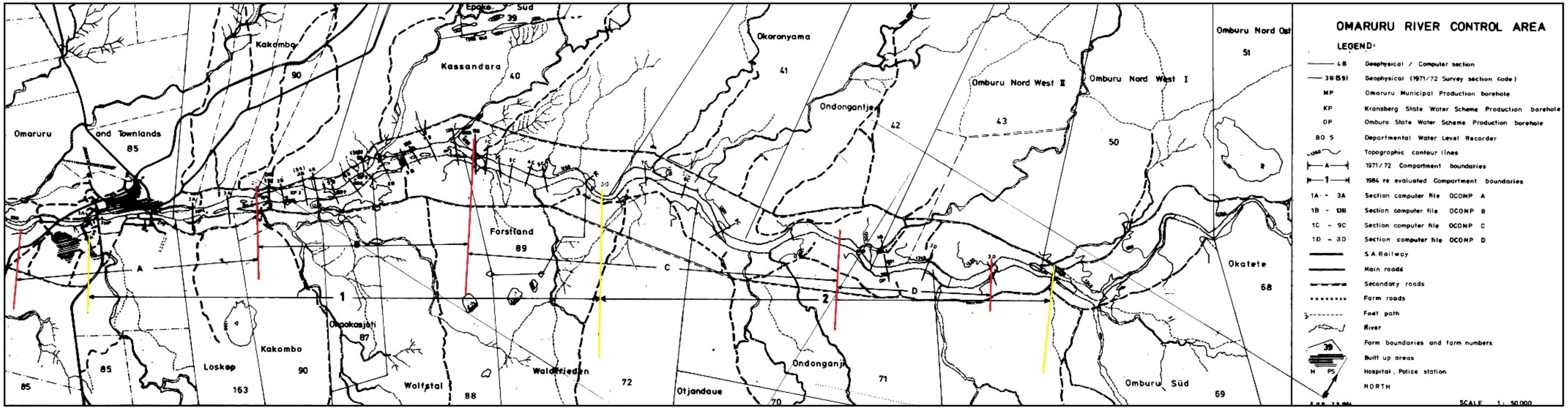


Figure 3 Location and Extent of the Omaruru River Aquifer (Red Shows Compartments A to D; Yellow Shows Compartments 1 and 2)

Otjiwarongo Marble Aquifer (OMA)

Prior to 1991, Otjiwarongo was supplied with water from boreholes drilled in the so-called Omatjenne aquifer compartment. As the water demands of the town increased, the sustainable yield of the Omatjenne compartment was exceeded and water levels dropped sharply. Groundwater investigations were undertaken in the north easterly extensions of the OMA and further reserves, classified as 6 additional aquifer compartments were identified, and the wellfield was extended. The sheme lay-out is shown in **Figure 4**.

The aquifer extends from Omatjenne, 20 km to the west of Otjiwarongo, to some 100 km in a north easterly direction towards Otavi. This area is generally of low relief. The marble formation forms low, linear ridges. Surface drainage is poorly developed and nowhere deeply incised, and drains into the Ugab River. The area is underlain by schists, marbles and other carbonate formations of the Swakop Group of the Damara Sequence. The groundwater potential of fractured aquifers in the Swakop Group is generally low. However, the carbonates (marbles and limestones) have a moderate groundwater potential and *at properly selected targets such as fracture zones and karstified contact zones, even high yields can be encountered*. The fractured and karstified marble band of the Karibib Formation comprises the OMA, which occurs as a gently lunging synclinal structure, closing at Omatjenne and plunging to the northeast, forming two sub-parallel, steeply dipping limbs, some 10 to 15 km apart. The OMA is a well-defined geological and hydrogeological unit, with little leakage across the marble-schist contacts into the largely impermeable surrounding schist. Water is contained in solution cavities which are developed in the marble adjacent to the contacts and in faulted and fractured zones. Away from these features, the transmissivity and storativity are very low. These also decrease with depth below the vertical interval where fluctuations in the water table have enhanced solution effects.

The Omatjenne – Otjiwarongo Scheme is the only part of the ORA that fall within the scope for the Kranzberg-Otjiwarongo portion of the greater project. It consists of 9 boreholes (as well as an earth dam), with the boreholes located either side of the C38 Otjiwarongo – Outjo tar road. The recommended yield of the 9 boreholes of the Omatjenne – Otjiwarongo Scheme, which are between 30 m and 210 m deep, vary between 10 m^3/h and 45 m^3/h, with a total recommended yield of 205 m^3/h.

For completes sake, the Omarassa-Otjiwarongo Scheme is shortly discussed as well. The scheme consists of two parallel pipeline arms with a northeast – south west orientation linking up boreholes in the OMA, corresponding with the two sub-parallel limbs of the OMA. The scheme is supplied from 13 boreholes which are between 63 m and 126 m deep, and the yields vary between 2.5 m^3/h and 25 m^3/h, with a total recommended yield of 205.5 m^3/h. Due to scheme insufficiency, the water supply scheme was again extended through the so-called Phase 5 extension. The Omarassa Phase 5 investigations culminated in the successful completion of three production boreholes, increasing the total abstraction with another 120 m^3/h.

The Bulk Water Master Plan for the North West of Namibia (completed in 2009) determined that the peak month demand of consumers in the Otjiwarongo area already exceeds the recommended borehole yield of the Omatjenne and Omarassa Schemes.

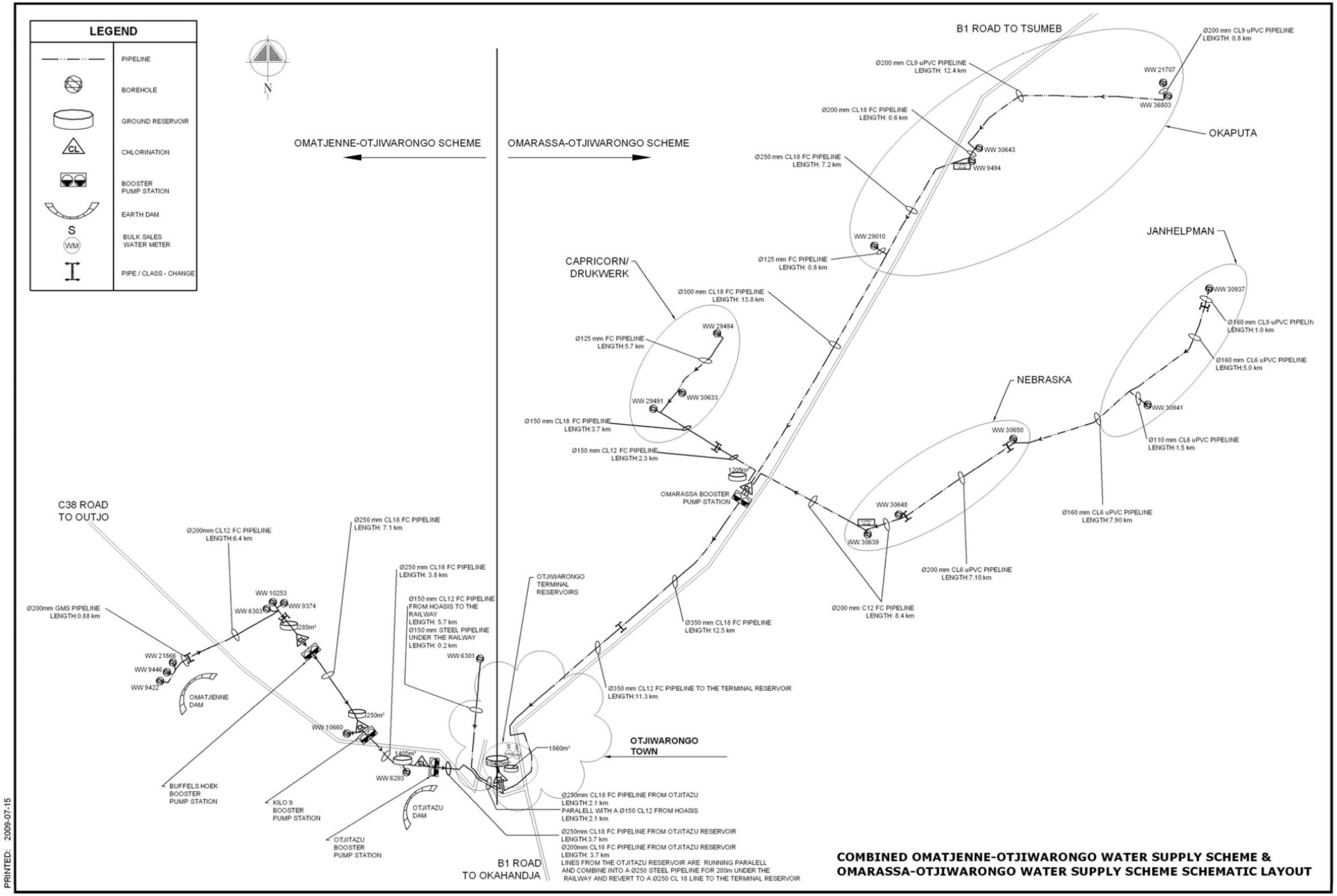


Figure 4 Layout of the Omatjenne – Otjiwarongo and Omarassa – Otjiwarongo Schemes (NamWater, 1998)

Aquifer summary

In summary it can be stated that, of the four aquifers discussed above, the Spes Bona Aquifer is unsustainable, Kranzberg and Omaruru Aquifers are used to its maximum capacity, while the Otjiwarongo Aquifer may have potential for additional groundwater abstraction.

Kranzberg Aquifer

The Kranzberg Aquifer has an estimated stored reserve of 0.649 Mm^3, while its sustainable yield was estimated at 0.270 Mm^3/a. (0.090 Mm^3/a for the Kranzberg Aquifer and 0.179 Mm^3/a for the Municipal sources). NamWater abstraction form the Kranzberg Aquifer is in excess of 0.1 Mm*3*/a.

There is thus no surplus groundwater available from the Kranzberg Aquifer.

Spes Bona Aquifer

The latest drilling results proved to be unsuccessful as all but one of the boreholes were dry. The scheme was decommissioned and is currently not used for bulk water supply.

Despite the unsuccessful drilling, the Spes Bone Aquifer do have potential to supply in construction water. However, borehole yields are generally less than 5 m^3/h, and a number of boreholes will be required to supply construction water.

Omaruru River Aquifer

The total recharge to the ORA, which can be regarded as an estimate of the sustainable yield of the aquifer, was calculated to be 2.5 Mm^3/a. A study by NamWater in 2000 found that, based on available groundwater abstraction permit data, a total of 2.61 Mm^3/a was allocated for abstraction from the ORA: 1.0 Mm^3/a to the Municipality and 1.61 Mm^3/a other persons amounting to the 2.61 Mm^3/a, thus exceeding the estimated annual recharge.

Otjiwarongo Marble Aquifer

The Omatjenne – Otjiwarongo Scheme is the only part of the ORA that fall within the scope for the Kranzberg-Otjiwarongo portion of the greater project.

The recommended yield of the Omatjenne – Otjiwarongo Scheme is 205 m^3/h, with individual borehole yields varying between 10 m^3/h and 45 m^3/h.

It appears that the OMA is thus capable to host high-yielding boreholes that can supply in the construction water demand. However, the Bulk Water Master Plan for the North West of Namibia determined that the peak month demand of consumers in the Otjiwarongo area exceeds the recommended borehole yield of the Omatjenne and Omarassa Schemes.

All four of these aquifers are located within either proclaimed water protection areas, or exploit river alluvials, thus in public streams and law also water protection areas. The proclaimed water protection areas are shown in **Figure 5** on the next page.

According to the Water Act, permits are therefore required to 1) drill boreholes, and 2) abstract groundwater for any use other than domestic use.

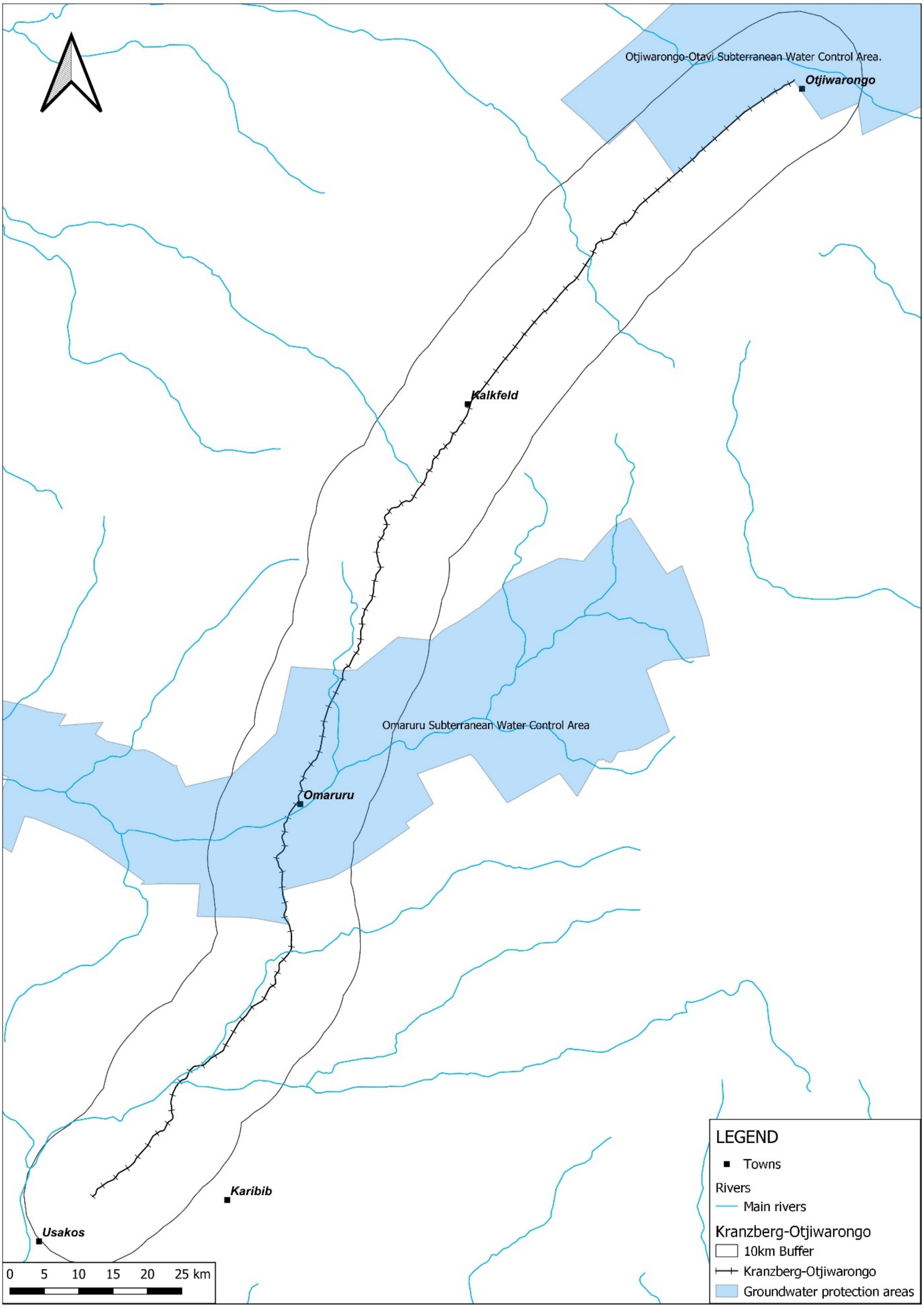


Figure 5 Proclaimed water protection areas between Kranzberg and Otjiwarongo. Note that all rivers are by law also water protection areas.

Other groundwater abstraction

Other than groundwater abstraction to supply water to municipalities, groundwater is used for domestic and stock watering purposes on commercial farmland.

These “farm boreholes” are, with exception, mostly low yielding, tapping localised secondary aquifers in hard rock environments. In many cases, these boreholes are also located close to ephemeral rivers, and the isolated aquifers tapped by these boreholes are dependent on flooding during rainy seasons to provide recharge and maintain the sustainability to these boreholes.

Where these aquifers hosting farm boreholes are not dependent on river run-off for recharge, percolation during rainfall events and subsurface flow and leakage from adjacent hard rock provides the recharge water.

The characteristics and behaviour of the prevailing geohydrological environment is hugely influenced and dictated by the geology, and the predominant rock types determine a geological formation’s capacity to host groundwater. It also determines if groundwater can move “easily” through the rock types or not, i.e., it determines the presence and yield of a groundwater resource. The matrix rock or host rock type thus plays a very significant role in the presence and rate of groundwater flow. Unless the host rock possesses good (secondary) porosity, the recharge will be limited. To understand the occurrence of groundwater it is therefore necessary to understand the prevailing geohydrological characteristics associated with the geology.

Certain geological processes could change a geological environment to enhance the hydrogeological characteristics of the geological environment by creating secondary porosity. For example, fracturing of a totally impervious rock can result in very porous fractures, which could host large and high-yielding aquifers; impervious rock that is well-jointed, or possesses solution features, can similarly host large and high-yielding aquifers. It is however very important to bear in mind that such high-yielding aquifers will not be sustainable, often even in the short term, if they are not regularly recharged, and / or if they are not “large in size”.

A rock is aquiferous, i.e., it can contain a groundwater resource, when:

- it has voids (the porosity of the rock);
- these voids are of sufficient size (at least a few fractions of millimetres thick or in diameter) and are connected to each other (the rock is then permeable);
- these voids contain water (they are said to be saturated with water), generally provided by percolation of precipitation, or by means of sub-surface throughflow.

As a result of the complexity of any hydrogeological environment, it is often found that adjacent aquifers are hydraulically poorly linked to one another, or not linked at all, meaning that the effect of abstraction on the groundwater reserve stored in the other, is only noticed after a while (which can in time be from days to years), or there is no effect at all. On the other hand, abstraction form an aquifer that is hydraulically well-connected to another aquifer may result in an almost immediate water table reaction in the other.

Due to a lack of knowledge and understanding of the hydrogeological processes, there is often a high level of animosity and opposition from farmers when it comes to abstraction of groundwater on their properties by an "outside party", and more so if large quantities of water is needed over a short time period, such as construction water.

Rest water level

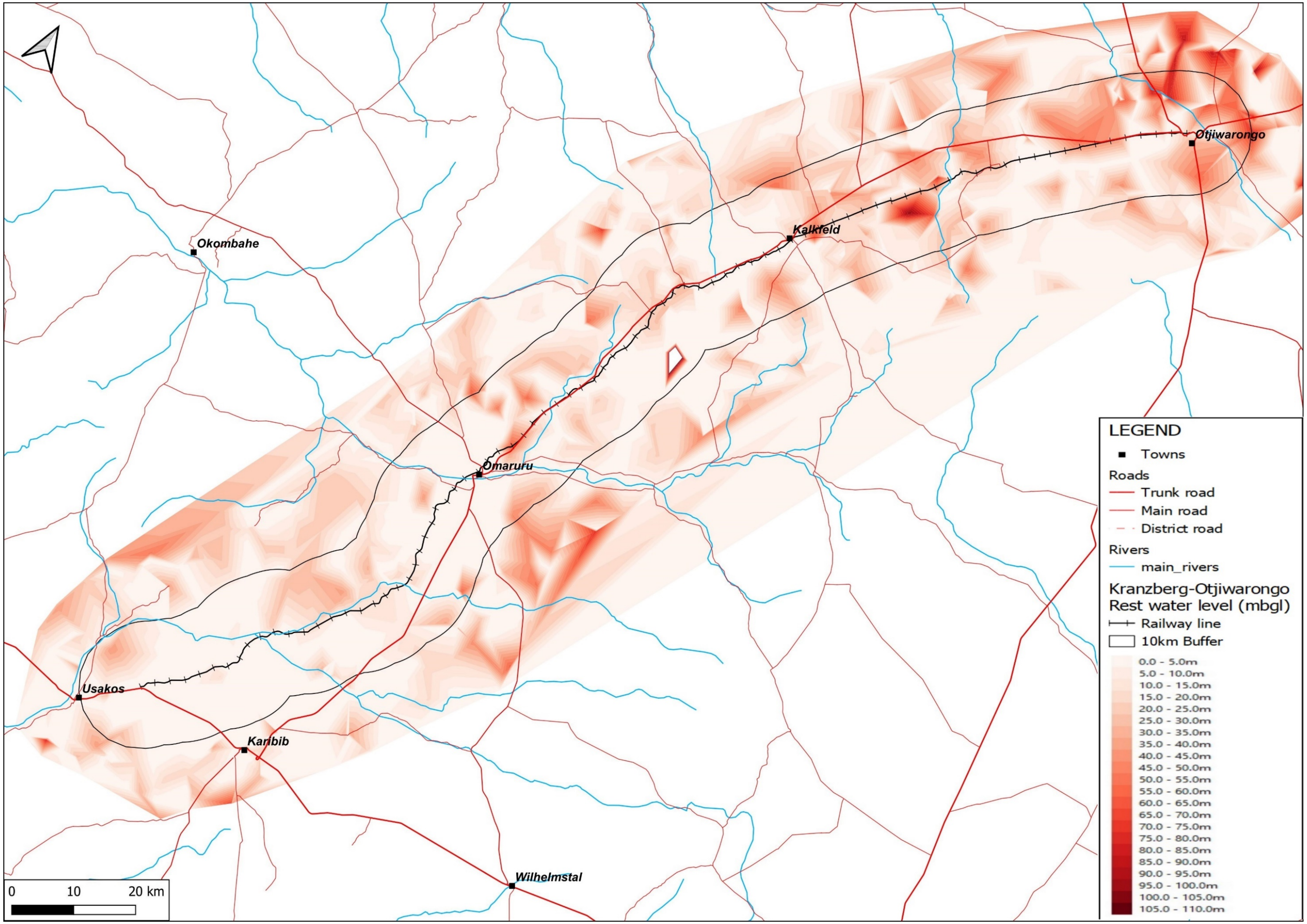
Of the 593 boreholes recorded in the database that is located within 10 km of the railway centre line, the water level of 297 boreholes (50.1%) is recorded as "0". Many of these are dry boreholes where there actually is no water level, but for many the water level is simply not available. For the remaining 296 boreholes (49.9%), water levels were recorded. It must be borne in mind that these water levels were taken at the time of drilling, and do not necessarily represent the current situation.

The deepest water level recorded is 100 m below ground level (mbgl). The borehole is located on farm Rodenhof some 20 km east-northeast of Kalkfeld, and is 139 m deep with a recorded yield of 1.3 m^3/h.

The shallowest water level recorded is 0.6 mbgl. The borehole is located in the Omaruru River some 5.5 km east of Omaruru, and is 16.4 m deep with a recorded yield of 18 m^3/h.

The average water level (excluding al the zero-values) is 23.64 mbgl.

Map 6 shows the depth to the groundwater table is shown on the next page.



MAP 6 Depth to groundwater table / rest water level

Water Quality Analyses

Figures 6 to 8 below show water quality in terms of total dissolved solids (TDS), sulphate and nitrate respectively. The figures were scanned from the 1980 1:1 000 000 water quality maps of Namibia.

Areas where the water quality is poorer, are just south of Okanono siding, south and west of Norman siding, and between Avond- Erundu- and Paresis sidings. The TDS-value gets into the range from 3 001 ppm to 5 000 ppm.

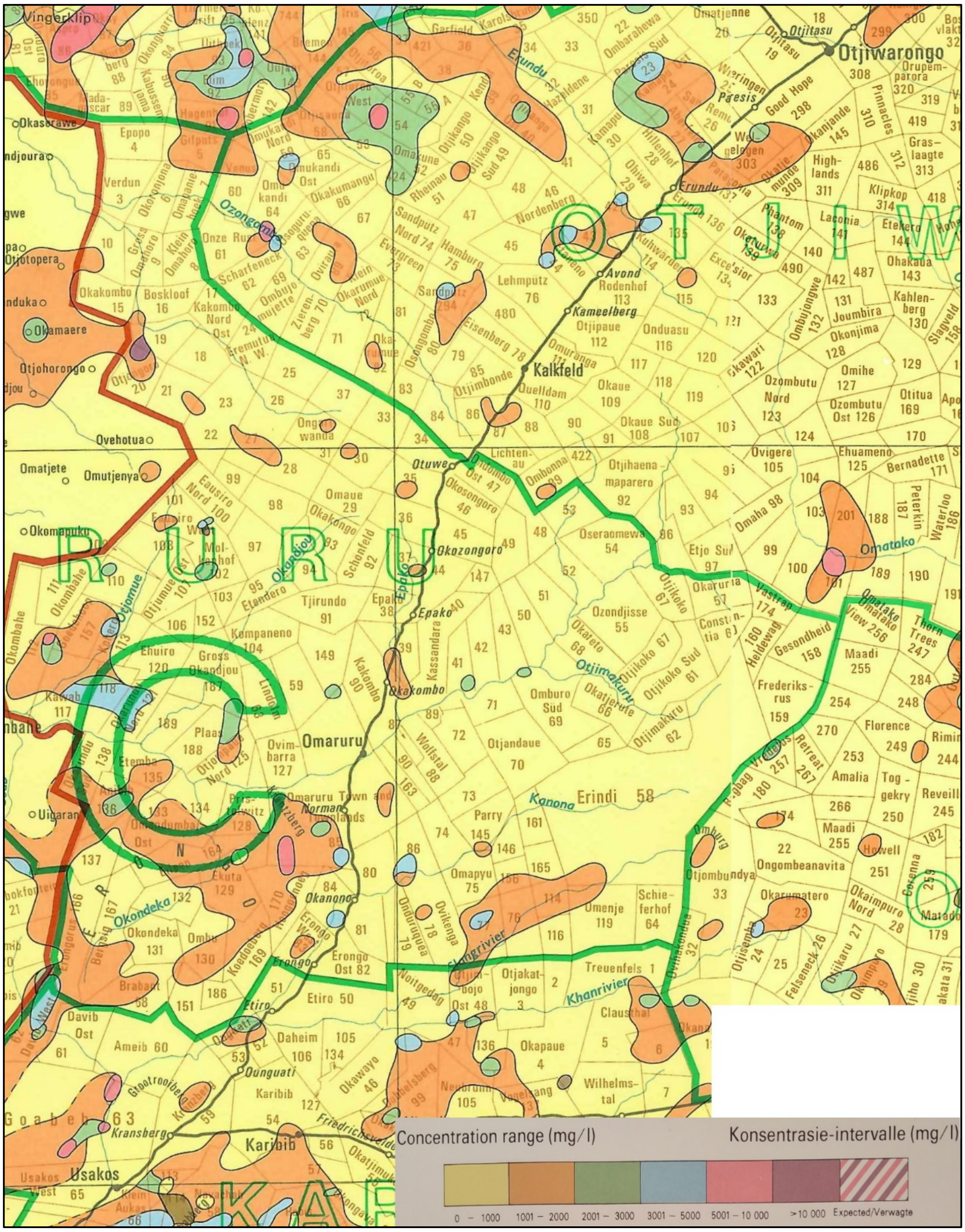


Figure 6 Groundwater quality: Total Dissolved Solids along the railway line between Kranzberg and Otjiwarongo

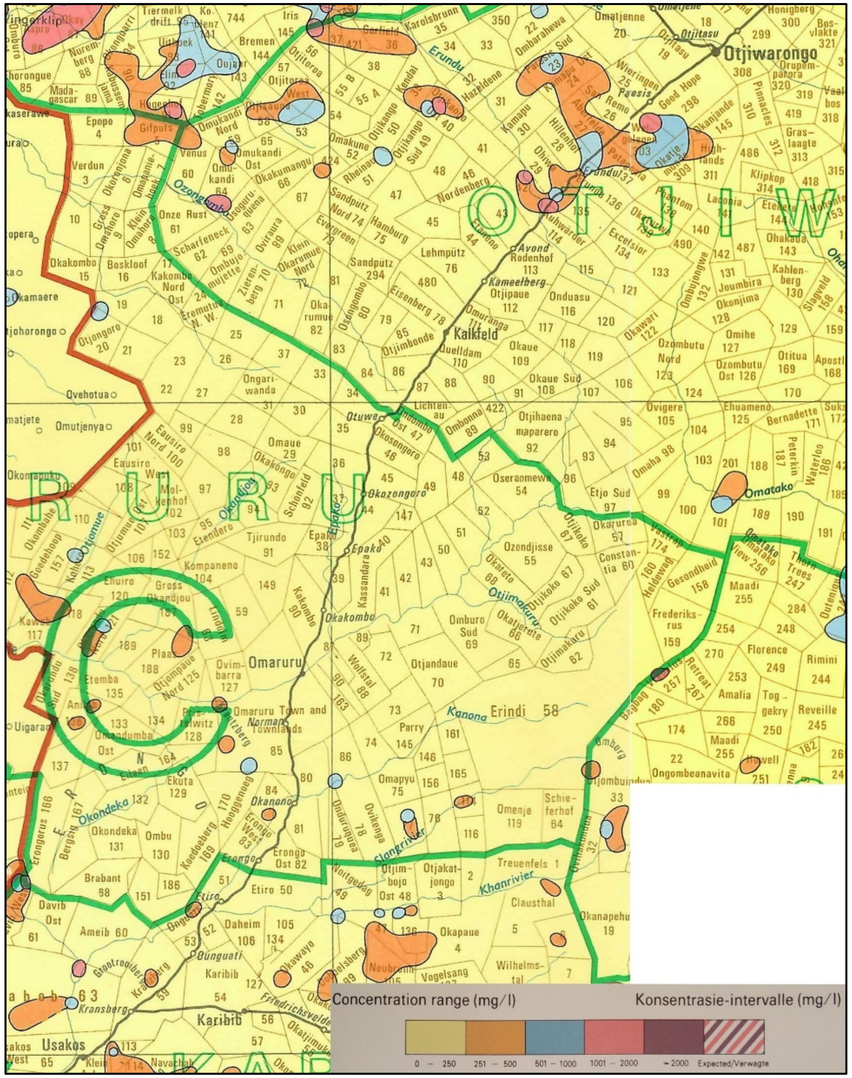


Figure 7 Groundwater quality: Sulphate concentrations along the railway line between Kranzberg and Otjiwarongo

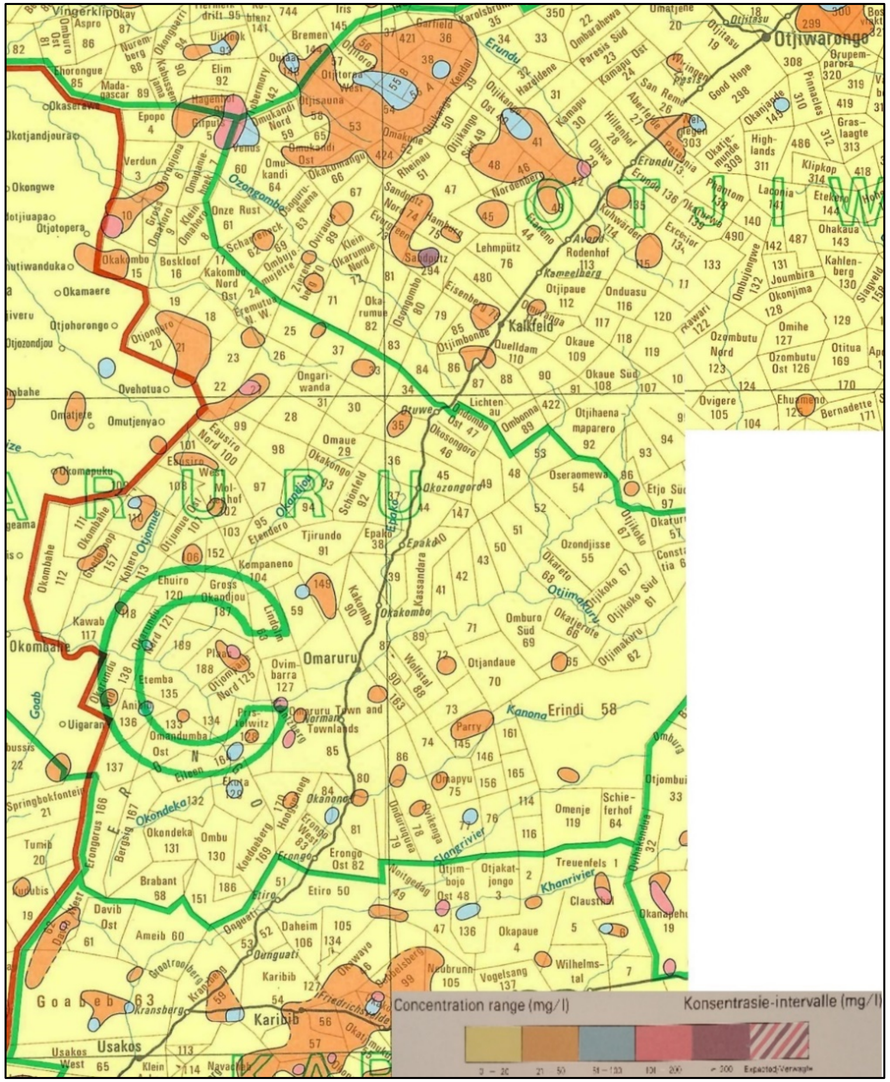


Figure 8 Groundwater quality: Nitrate concentrations along the railway line between Kranzberg and Otjiwarongo

Geology

The assessment of the geological environment to identify the regional geology, and particularly relating to the groundwater potential, the 1:1 000 000 geological map of Namibia was used. In order to show it clearer, the geology is presented in two maps for the sections Kranzberg to Omaruru and Omaruru to Otjiwarongo respectively.

As stated earlier, the geology is one the most significant the determining factors relating to the occurrence of groundwater. The predominant rock types are:

Sedimentary rock: sand (alluvium), sandstone

Sand or alluvium possesses primary porosity, while sandstone can possess both primary and secondary porosity. The alluvium occurs in riverbeds, while sandstone is present in the Etendeka and Omingonde Formations just to the north of the Etiro siding. Sedimentary rocks generally have high groundwater potential

Igneous rock: granite

Granite possesses secondary porosity, and unless it is fractured and / or deeply weathered, it has very low groundwater potential. Granite is present over most of the area, but diminishes closer to Otjiwarongo.

Metamorphic rock: schist and limestone (marble)

Schist and marble possess secondary porosity. Schist has very low groundwater potential, even when fractured, as it weathers to clay, which has a very good water retention capacity and as a result do not transmit groundwater easily. If intruded by extensive vein quartz, which are fractured, schist can however yield quite productive aquifers, but sustainability is a real concern.

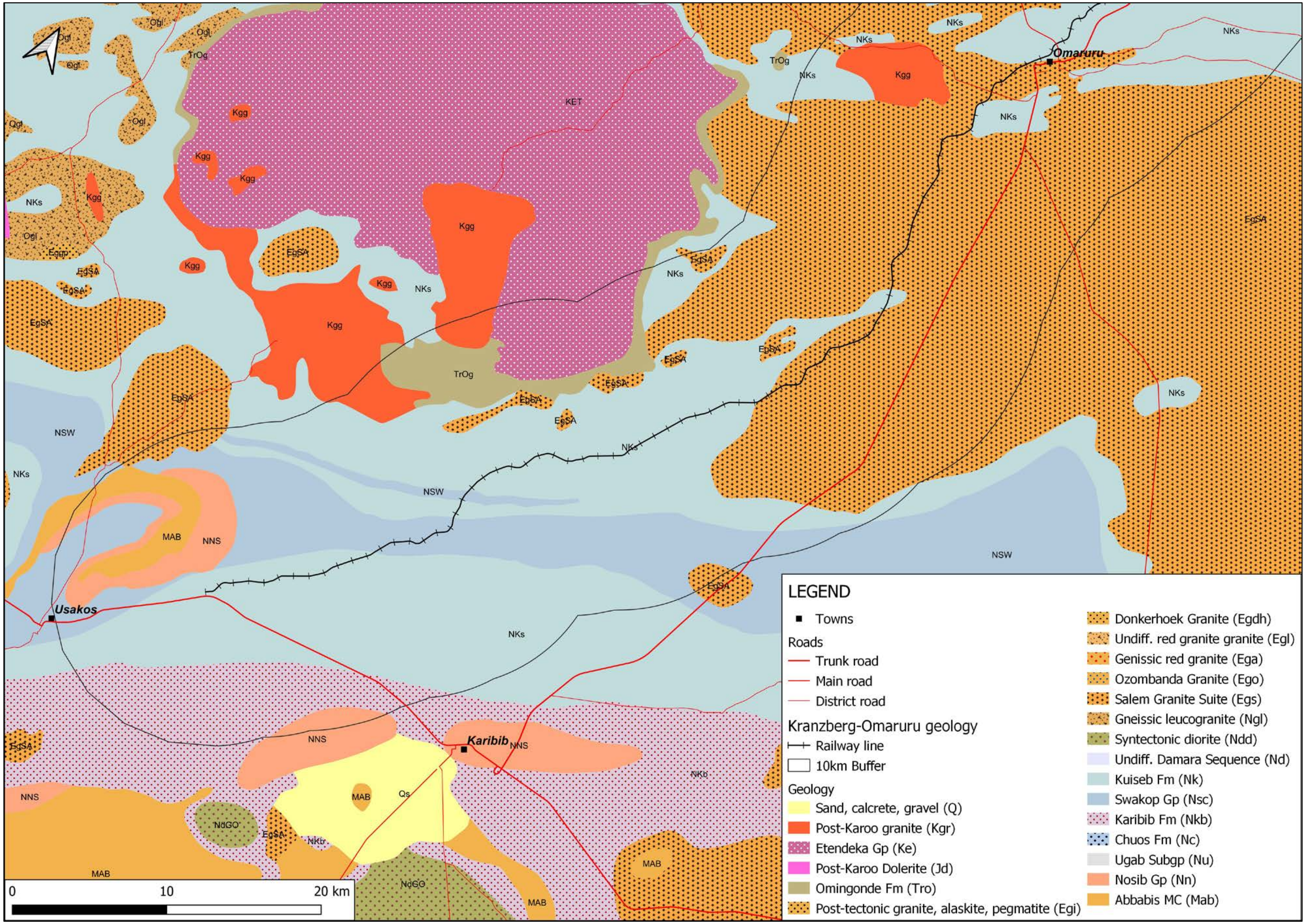
Inherently marble also has very low groundwater potential. However, if fractured or dissolution of the rock took place, marble can host moderate to very productive aquifers.

Schist is present extensively over most of the area, while marble is mostly limited to the Swakop Group between Kranzberg and Karibib, to the north of Omaruru and around Kalkfeld, while there is also some marble present in the Otjiwarongo area.

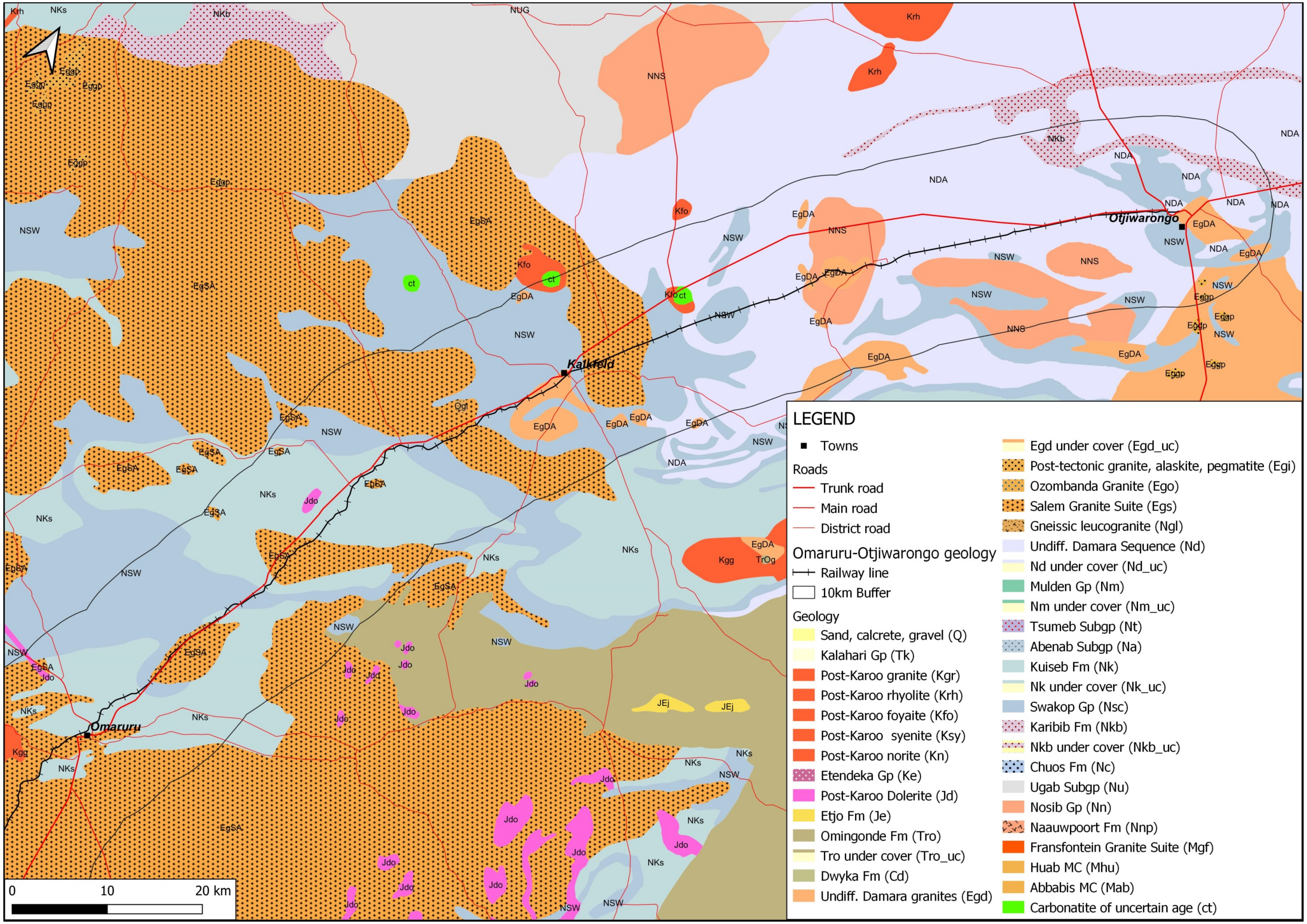
The nature of the geology suggests that groundwater abstraction from secondary aquifers in the hard rock may not have a major impact on the regional groundwater table, as most of the rock comprise of low porosity matrix rocks. The impacts will mostly be concentrated in the immediate vicinity of abstraction points. However, if there is hydraulic connectivity between different aquifers caused by fracturing, weathering or even jointing, preferential groundwater flow paths are created along which negative impacts of abstraction can migrate.

The alluvials are however a very sensitive geological environment with good hydraulic connectivity within layers, and extreme care must be taken when these are exploited for groundwater abstraction.

Map 7 and **Map 8** show the geology between Kranzberg and Omaruru, and between Omaruru and Otjiwarongo respectively.



MAP 7 Geology between Kranzberg and Omaruru



MAP 8 Geology between Omaruru and Otjiwarongo

HIGH RISK POLLUTION AREAS

Considering the hydrogeological environment, and more specifically the nature of the aquifers in the study area, there are three main types of areas that are prone to high pollution risk, namely:

- primary alluvial aquifers
- secondary aquifers where high-transmissivity preferential flow paths have been created through fracturing
- secondary limestone (marble) aquifers with solution features

The first two aquifer types are rather easy to identify as the rivers alluvials can be clearly seen and the fractures are mostly mapped and / or visible where it manifests on the ground. Although the marble itself is easily identifiable, those parts of marble formations that are actually good aquifers caused by solution features are unfortunately not that easily identifiable due to the lack of available hydrogeological information and the insufficiency of recorded borehole information.

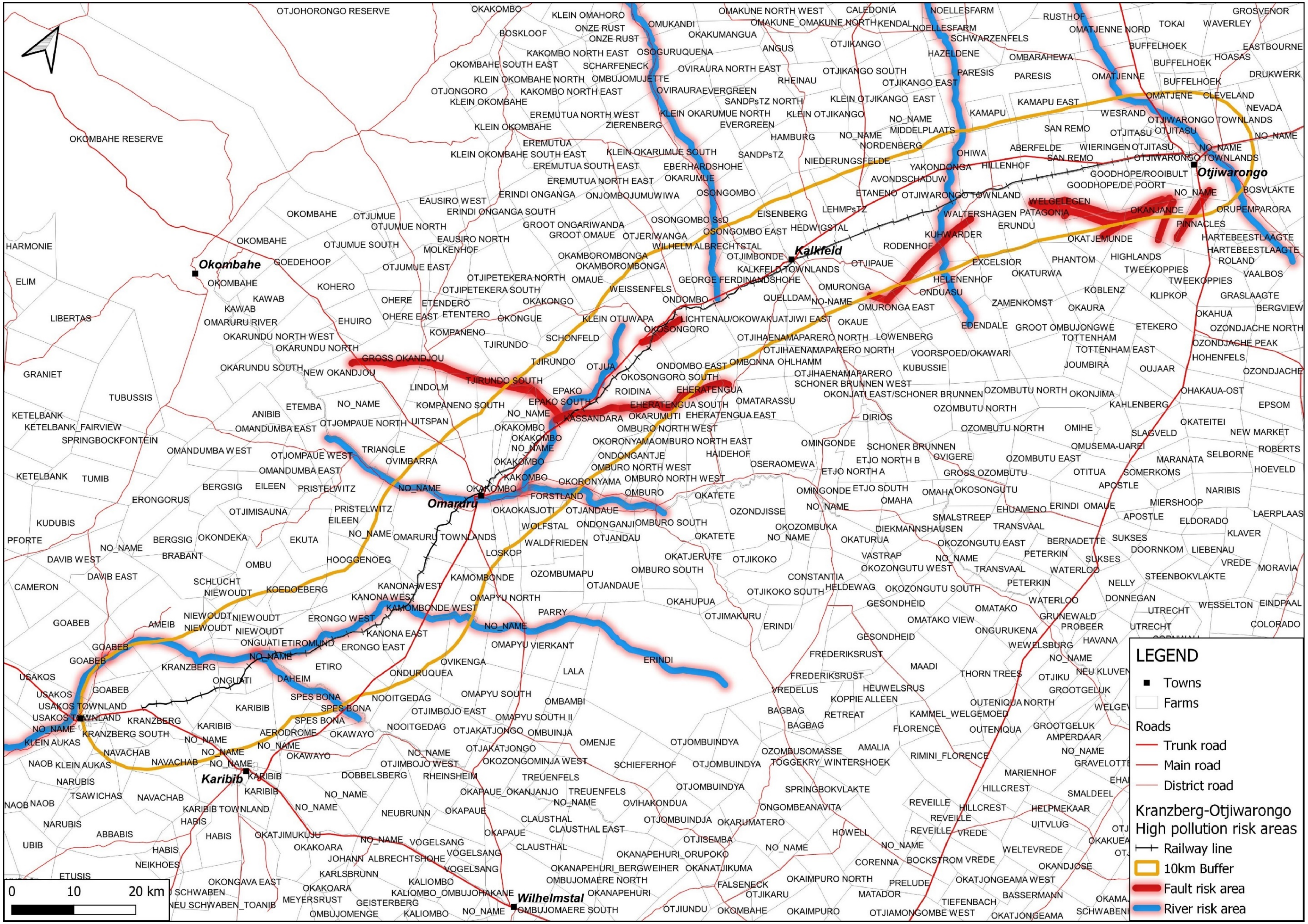
The hydrogeological characteristics of these environments are a) usually high transmissivities and b) high storativity, i.e., in laymen's term, groundwater flows at a high rate through these aquifers, and the percentage of the rock volume available to store water in is high respectively.

The biggest concern is that, once a pollutant enters the groundwater in such aquifers, it spreads very rapidly through the aquifer, and it becomes almost impossible to remove such pollutants.

Where the above hydrogeological environments prevail, utmost care must therefore be taken to prevent and avoid causing pollution, or any negative impacts for that matter, to occur. Even more so, where a river flows over or along a fracture, extra care must be taken to prevent and avoid causing pollution.

The areas where primary river alluvial aquifers and fractures have been mapped are shown in **Map 9** on the next page.

NOTE: The rivers shown in **Map 9** are only those mapped on the 1:1 000 000 scale geological map of Namibia, and *it does not show all the rivers, irrelevant of their size*. **All rivers must be treated as potential high-risk pollution areas.**



MAP 9 Areas with high pollution risk based on mapped rivers and fractures

POTENTIAL IMPACTS

The prevailing groundwater environments and its characteristics comprise:

Primary alluvial aquifers

- shallow, fresh water aquifer(s) in the active river channels;
- bounded mostly by impermeable rocks;
- recharged continuously through subsurface groundwater throughflow and sporadically through direct recharge during flooding, and;

Secondary fractured aquifers

- groundwater discharging as springs or recharging adjacent aquifers;
- confined groundwater originating at distant recharge areas;
- seasonal direct recharged of fractures during and after rainfall events, and minimally through subsurface groundwater throughflow / leakage from adjacent groundwater sources in the host rock, and;

The potential negative impacts of construction work on the hydrogeological environment are related to either:

- Unsustainable use of groundwater sources (over-abstraction)
- Deterioration in the ambient groundwater quality
- Reduction of the infiltration capacity of the alluvial sediments

Unsustainable use of groundwater sources

The tell-tail sign of unsustainable groundwater use is a lowering of the water table over an aquifer. This is relatively easily identified in an alluvial aquifer that is rather homogenous within different layers where the hydraulic connectivity is high, but it is not that easily identified in hard rock (secondary) aquifers that are heterogeneous, and adjacent, close-by aquifers may not at all be hydraulically connected. In the former, if groundwater abstraction causes a drop in the water level, it is safe to conclude that the aquifer is unsustainably used (or mined). However, a drop in the water table in a secondary aquifer may only reflect what is happening in a small, localised area, possibly without having any impact on an adjacent, close-by aquifer.

Anticipating the effect of groundwater abstraction on the greater, regional groundwater environment is not possible considering the prevailing hydrogeological conditions, specifically the relevance of the prevailing geology and unknown-of geological structures such as possible fractures and / or joint systems (that have not been mapped) creating preferential groundwater flow paths; the distribution of boreholes within the hard rock areas, and; the lack of previous hydrogeological studies within the hard rock areas to derive baseline conditions from.

Deepening of water levels may lead to the drying up of boreholes and fountains, and the loss of organisms that lives in the groundwater. Vegetation may also be impacted through increased water stress, or even vegetation die-off, where such vegetation depends on groundwater.

In terms of direct groundwater-related impacts, over abstraction may result in any, or all, of the following:

- Groundwater level drawdown and subsequent deepening of the water table.
- Reduction of natural groundwater discharges.
- Changes in groundwater flow patterns that can affect groundwater quality distribution in the subsurface.

There is a low probability of negative impacts being caused by over-exploitation (over-pumping) on the groundwater environment. Any such impacts will:

- be of medium-term extent;
- in all likelihood have low intensities;
- be of short to medium term duration, and;
- be of low to medium significance, even without mitigation measures.

Deterioration in the ambient groundwater quality

Groundwater pollution can be defined as the direct or indirect alteration of the physical, chemical or biological properties of a water resource so as to make it:

- less fit for any beneficial purpose for which it may reasonably be expected to be used, or
- harmful or potentially harmful –
  - to the welfare, health or safety of humans and animals;
  - to any aquatic or non-aquatic organisms;
  - to the resource quality; or
  - to property.

Potential pollution sources could arise from:

- construction activities,
- spillage of hazardous substances,
- through leakage of sewage.

Groundwater may become polluted through point source and / or diffuse discharges such as dust, fuel or chemical spills. Petroleum products released to the environment general migrate through the soil *via* two pathways; bulk flow (infiltrating the soil under gravity) or capillary action (individual compounds dissolving into air or water). As the products migrate through the soil, small amounts thereof can be retained by soil particles, known as residual saturation. Residual saturation can potentially reside in the soil for years and act as a continuing source of contamination. Environmental waste protection protocols must be implemented to ensure that no environmental harm is caused, and that appropriate action is taken in any event of a point source and / or diffuse discharges occurring.

Construction activities will generate different types of solid wastes which can end up polluting run-off water if not properly managed. Additionally, spills and leaks may also occur from vehicles and heavy equipment used during the construction operations, which may result in soil contamination. The principal direct environmental impact of soil quality associated with the construction phase is the potential contamination from the following sources:

- spills or leaks from construction machinery
- waste generation / management
- accidental leaks

Although the above impact (i.e., soil contamination) will be localised within the spillage area, the potential migration of such contamination to aquifers may represent significant environmental risks. Considering the general high transmissivity of an alluvial aquifer in particular, it can unambiguously be stated that any surface pollution resulting in any pollutant ending up in the river sediments will enter the aquifer as soon as recharge water is available.

However, with proper waste management and spill prevention / control measures, these impacts could be controlled and minimized during the construction phase.

There is a low to medium probability of negative impacts being caused by the construction works on the groundwater environment, and more specifically on the groundwater quality. Any such impacts will, depending on the type of pollutant:

- be of immediate to local extent;
- in all likelihood have low to medium intensities;
- be of medium to long term duration, and;
- be of medium to high significance.

Hazardous pollutants such as hydrocarbons from fuel or oil spillages will:

- be of immediate to local extent;
- in all likelihood have medium to high intensities;
- be of long-term duration, and;
- be of high significance, even without mitigation measures,

as it can render part of an aquifer unsuitable for domestic consumption.

Reduction of the infiltration capacity of the alluvial sediments

During construction certain activities, such as grading, creates pollutants that can leave the site and harm the receiving environment. Sediment is one of the main pollutants of concern. Over a short period of time, construction sites can contribute more sediment than can be deposited naturally over several decades. The resulting siltation, along with the contribution of other pollutants from construction sites, can cause physical, biological, and chemical harm to catchments.

Erosion is a degenerating process that very often goes hand-in-hand with construction activities. Apart from the aesthetical aspects associated with erosion, it can cause indirect negative impacts where the eroded material is deposited. The best way to minimize the risk of creating erosion and sedimentation problems during construction is to disturb as little of the land surface as possible. Other effective erosion control measures include preserving existing vegetation where feasible and stabilising and re-vegetating disturbed areas as soon as possible. Disturbed and exposed areas are subject to wind erosion, sediment tracking and dust generation by construction equipment.

Dust generated during construction will result from clearing and earthworks, including trenching, levelling, bund construction (if / when applicable) and rehabilitation operations. The major dust sources will be from the movement of vehicles over the cleared work areas and from vehicles transporting equipment to the work areas.

The occurrence and significance of the dust generation will depend upon meteorological and ground conditions at the time and location of activities. However, under normal meteorological conditions, dust impacts will be limited to within several hundred meters of the respective construction areas.

Large volumes of dust settling in river beds *may* result in the reduction of the infiltration capacity, especially through the top layer of the alluvial. This affect will be enhanced if the volume of recharge water is small, i.e., the flowing water does not have the energy to remove the dust layer.

There is a low probability of negative impacts being caused by (significant) dust generation on the groundwater environment. Any such impacts will:

- be of immediate extent;
- in all likelihood have low intensities;
- be of short term duration, and;
- be of low significance, even without mitigation measures.

MITIGATION MEASURES

Reducing groundwater availability due to over abstraction

Groundwater over abstraction can be defined as abstracting more than the natural inflow / recharge to the aquifer, thus groundwater outflow is greater than groundwater inflow. In order to prevent potential accusations of unsustainable groundwater use and associated depletion of groundwater reserves used for farming activities, hydrocensuses in every area targeted for establishing groundwater abstraction points for supply of construction water should be done. The locations of boreholes used for water supply must be surveyed, and the rest water levels in these boreholes must be measured and recorded.

Since *in situ* groundwater is an invisible source, sustainable exploitation thereof can only be observed through monitoring groundwater levels in conjunction with monitoring abstraction volumes and -rates. Water level reaction to both abstraction and possible direct recharge from percolation of rainfall and / or run-off in rivers must be monitored in order to provide early warning of impending impacts, in this instance both negative and positive impacts.

Unless a groundwater balance is established, thus providing an accurate estimation of the surplus volume of groundwater available for abstraction, managing groundwater's sustainable use is reactionary, i.e., one will only realise over-abstraction occurs once the rest water levels start deepening. Therefore, in order to properly manage the groundwater abstraction to ensure sustainable use, the following measures must be implemented:

- A groundwater monitoring program whereby water levels and abstraction volumes and rates are measured and recorded frequently
- Manage demand and abstraction

- Reduce abstraction if over-abstraction becomes evident
- Implement water conservation measures
- Limit groundwater use to essential needs and improve efficiency in the use of groundwater to minimise effect on local availability
- Implement water conservation measures
- Regularly inspect all installations associated with groundwater abstraction and distribution to eliminate leaks which are wasting water

Deterioration in the ambient groundwater quality

To limit the potential for spills or leaks from construction machinery and its resultant potential impact on the water quality, the following mitigation measures should be implemented:

- All reasonable measures must be taken to prevent spillage and leakage of materials likely to pollute any aquifer.
- Site storage and service areas in areas away from the alluvial sediments and / or drainage channels, or where fractures are known / mapped to occur.
- Storage areas for hazardous materials such as fuel and oil must be bunded.
- If a spill occurs, the contaminated soil must be removed immediately and disposed of at an appropriate disposal site.

To limit the potential for waste generation and its resultant potential impact on the water quality, the following mitigation measures should be implemented:

- Appropriate measures should be taken for the transportation, handling, storage and disposal of ALL waste.
- Provision must be made for adequate sanitary facilities and the workforce should not be allowed to discharge any untreated sanitary waste into the groundwater or any surface water course.

Reduction of the infiltration capacity of the alluvial sediments

Dust and erosion control include practices that protects the soil surface and prevents soil particles from being detached. The best way to minimize the risk of creating erosion and sedimentation problems during construction is to disturb as little of the land surface as possible. Other effective erosion control measures include:

- Limit on-site vehicle speed
- Apply dust suppression to unpaved areas
- Limit or even prohibit activities during high winds
- Capture run-off water from the work area and adjacent lands where practical and possible
- Ensure adequate water flow by diverting flood prone watercourses for the duration of the work if needed during the rainy season
- Areas disturbed as part of construction activities (e.g., temporary access routes and vegetation clearing) should be protected from erosion and returned to a protected state after the disturbing activity is completed
- Temporary runoff and erosion control management plans should be created and implemented during construction phases

Table 2 Summary of potential negative impacts and the proposed mitigation measures

Potential impact		Level of significance	Mitigation measures	Implementation		
				Who	**How**	**Monitoring**
Unsustainable use of groundwater sources	- Groundwater level drawdown and subsequent deepening of the water table. - Reduction of natural groundwater discharges. - Changes in groundwater flow patterns that can affect groundwater quality distribution in the subsurface	- **low to medium significance**, even without mitigation measures medium-term extent; - in all likelihood have low intensities; - short to medium term duration.	- A groundwater monitoring program whereby water levels and abstraction volumes and rates are measured and recorded frequently - Manage demand and abstraction - Limit groundwater use to essential needs and improve efficiency in the use of groundwater to minimise effect on local availability - Implement water conservation measures - Regularly inspect all installations associated with groundwater abstraction and distribution to eliminate leaks which are wasting water	- Environmental officer - Site engineer - Appoint and train a water works clerk who reports directly to a foreman or site engineer	- Identify monitoring boreholes - Equip abstraction boreholes with flow meters - Reduce abstraction if over-abstraction becomes evident	- Measure water levels accurately and weekly in both monitoring and abstraction boreholes - Measure abstracted volumes accurately and weekly - Present data graphically
Deterioration in the ambient groundwater quality	- Alteration of the physical, chemical or biological properties of a water resource so as to make it: • less fit for any beneficial purpose for which it may reasonably be expected to be used, • harmful or potentially harmful o to the welfare, health or safety of humans and animals; o to any aquatic or non-aquatic organisms; o to the resource quality; o to property.	- **medium to high significance** in all likelihood have low to medium intensities; - medium to long term duration.	- All reasonable measures must be taken to prevent spillage and leakage of materials likely to pollute any aquifer. - Site storage and service areas in areas away from the alluvial sediments and / or drainage channels, or where fractures are known / mapped to occur. - Storage areas for hazardous materials such as fuel and oil must be bunded. - If a spill occurs, the contaminated soil must be removed immediately and disposed of at an appropriate disposal site. - Appropriate measures should be taken for the transportation, handling, storage and disposal of all waste. - Provision must be made for adequate sanitary facilities and the workforce should not be allowed to discharge any untreated sanitary waste into the groundwater or any surface water course.	- Project Management - Site engineer - Environmental officer - Appoint and train a water works clerk who reports directly to a foreman or site engineer	- Ensure vehicles, equipment and machinery are in good working order to minimize leaks of contaminants - Keep spill kits at the work site to accelerate intervention in the event of spills or leaks - Ensure trained personnel are available to intervene immediately in the event of accidental spills or leaks	- Conduct regular inspections of construction site for spills or leaks - Analyse water quality of all nearby water sources after spills or leaks occurred
	- Spillage of hazardous substances • spills or leaks from construction machinery • waste generation / management • accidental leaks - Improper maintenance of vehicles, machinery and other motorised equipment	- **high significance**, even without mitigation measures immediate to local extent; - in all likelihood have medium to high intensities; - long-term duration.				

Reduction of the infiltration capacity of the alluvial sediments	- Dust generation - Erosion	- **low significance**, even without mitigation measures. - immediate extent; - in all likelihood have low intensities; - short term duration.	- Limit on-site vehicle speed - Limit or even prohibit activities during high winds - Capture run-off water from the work area and adjacent lands where practical and possible - Ensure adequate water flow by diverting flood prone watercourses for the duration of the work if needed during the rainy season	- Site engineer - Environmental officer - Appoint and train a water works clerk who reports directly to a foreman or site engineer	- Apply dust suppression to unpaved areas - Areas disturbed as part of construction activities (e.g., temporary access routes and vegetation clearing) should be protected from erosion and returned to a protected state after the disturbing activity is completed - Temporary runoff and erosion control management plans should be created and implemented during construction phases	- Conduct regular inspections of construction site for signs of erosion or soil degradation

AREAS WITH POTENTIAL TO DEVELOP FOR GROUNDWATER ABSTRACTION

The areas with the highest potential to supply in the construction water demand and develop for groundwater abstraction, and which can be identified from a "bird's-eye view", are unfortunately also the same areas with high risk to be polluted, namely the river alluvials and the fractures shown in **Map 9** on page 24.

However, these are not necessarily the only areas with good potential to host high-yielding boreholes, **BUT *extensive hydrogeological remote sensing and field investigations, both reconnaissance and geophysical investigations, will be required to identify specific locations where new boreholes can be drilled.***

Access onto privately owned land, and drilling boreholes on private property for groundwater abstraction, will require negotiations and agreements with individual land owners.

Where high-yielding boreholes are existing, use of such boreholes can also be negotiated with respective owners.

Another alternative is to obtain water from NamWater schemes, but this will most likely be a very expensive alternative.

ADMINISTRATIVE, LEGAL AND REGULATORY REQUIREMENTS

To protect the environment and achieve sustainable development, projects, plans, and programmes considered to potentially have adverse impacts on the environment require an environmental assessment. The following legislation and agreements govern environmental assessment processes in Namibia and / or are relevant to the development.

Laws and key aspects

The Namibian Constitution

- Promote the welfare of people
- Incorporates a high level of environmental protection
- Incorporates international agreements as part of Namibian law

Environmental Management Act

Act No. 7 of 2007, Government Notice No. 232 of 2007

- Defines the environment
- Promotes sustainable management of the environment and the use of natural resources
- Establishes a process of assessment and control of activities with possible significant effects on the environment

Environmental Management Act

Government Notice No. 28 to 30 of 2012

- Commencement of the Environmental Management Act
- List activities that require an environmental clearance certificate
- Provide Environmental Impact Assessment Regulations

Nature Conservation Ordinance 4 of 1975

Including all amendments of Government Notices: 117 of 1976; 115 of 1978; 77 of 1985; 75 of 1987; 90 of 1988; 131 of 1996.

- Nature Conservation Amendment Ordinance 4 of 1977; 16 of 1980; 27 of 1986
- Nature Conservation Amendment Act: 6 of 1988; 17 of 1988; 31 of 1990; Act 5 of 1996.
- Consolidating and amending laws relating to the conservation of nature; the establishment of game parks and nature reserves; the control of problem animals; and to provide for matters incidental thereto
- Provides list of specially protected game, protected game (including birds) and huntable game (including birds)
- Provides a list protected species in annex 243.

Petroleum Products and Energy Act

Act No. 13 of 1990, Government Notice No. 45 of 1990

- Regulates petroleum industry
- Makes provision for impact assessments
- Petroleum Products Regulations (Government Notice No. 155 of 2000)
- Prescribes South African National Standards (SANS) or equivalents for construction, operation and decommissioning of petroleum facilities (refer to Government Notice No. 21 of 2002)

The Water Act

Act No. 54 of 1956

Remains in force until the new Water Resources Management Act comes into force.

- Defines the interests of the state in protecting water resources
- Controls water abstraction and the disposal of effluent
- Numerous amendments

Water Resources Management Act

Act No. 11 of 2013.

Not in force yet.

- Provide for management, protection, development, use and conservation of water resources, including the role and function of basin management committees
- Prevention of water pollution and assignment of liability

Public and Environmental Health Act

Act No. 1 of 2015, Government Notice No. 86 of 2015

- Provides a framework for a structured public and environmental health system, and for incidental matters
- Deals with Integrated Waste Management including waste collection, disposal and recycling; waste generation and storage; and sanitation.

Labour Act

Act No 11 of 2007, Government Notice No. 236 of 2007

- Provides for Labour Law and the protection and safety of employees Labour Act, 1992: Regulations relating to the health and safety of employees at work (Government Notice No. 156 of 1997).

National Heritage Act 27 of 2004

- Ensures the protection of cultural and archaeological sites.
- The Act requires the identification of cultural and archaeological sites within the study area, and registration and protection thereof.

Hazardous Substances Ordinance

Ordinance No. 14 of 1974

- Applies to the manufacture, sale, use, disposal and dumping of hazardous substances as well as their import and export
- Aims to prevent hazardous substances from causing injury, ill-health or the death of human beings.

Soil Conservation Act

Act No. 76 of 1969

- Aims to combat and prevent soil erosion, the conservation, improvement and manner of use of the soil and vegetation, and the protection of the water sources in Namibia

Water and Sanitation Policies

The existing water and sanitation policies in place are:

National Water Policy (NWP) adopted in 2000

Water Supply and Sanitation Sector Policy (WSASP) which was adopted in 2008

- Take steps to prevent "any public or private water on or under that land, including rainwater that falls on or flows over or penetrates such land" from being polluted.
- Require a permit for the disposal of effluent and industrial wastewater.
- Of particular concern is the prevention of surface- and groundwater pollution, therefore the collection, storage, disposal and re-use of sewage- and storm water is of utmost importance.

National Sanitation Strategy of 2009, which is based on this WSASP policy.

In terms of the National Sanitation Strategy 2010/11 – 2014/15, a developer must put in place strategies:

- Guaranteeing safe and affordable sanitation, encouraging decentralised sanitation systems where appropriate.
- That should promote recycling through safe and hygienic recovery and use of nutrients, organics, trace elements, water and energy, and the safe disposal

of all human and other wastes, including sewage and industrial effluent, in an environmentally sustainable fashion.

BASIN MANAGEMENT COMMITTEES

In terms of the Water Resources Management Act, Act No. 11 of 2013, Government may "recognise a group of representatives of such institutions, stakeholders and persons who are organised or associated for the purpose of organising, planning or dealing with matters relating to the development, management, protection and enhancement of water resources in the basin or part of the basin, to be a basin committee for the purposes of this Act in furtherance of the Government's objective in achieving an integrated management of water resources."

The Omaruru River basin is one of the first in Namibia to establish a basin management committee, with a difficult balancing act to perform in a water resource that's already being utilised to its maximum. While the river basin itself is only forty to eighty kilometres wide, its aquifers are the main source of water for most of the 63 720 square kilometre Erongo Region, that contains one of the world's prime uranium deposits.

To balance water use, the basin committee is structured to represent all stakeholders such as local or regional authorities, conservancies, the business community, the mines, the farmers, the ministries and NamWater.

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for Dynamic Water Resources Management — **Date**

APPENDIX ONE

BOREHOLE DATA AS CAPTURED IN THE GROWAS DATABASE

Map number	Latitude (°S)	Longitude (°E)	Borehole status	Location	Diameter (mm)	Depth (m)	Rest water level at time of drilling (m)	Initial yield (m^3/h)	Elevation (masl)
6231	-20.399	16.6827	not known		150	103.6	55.9	18.2	1580
86889	-20.4055	16.6554	not known		150	110	55	0	1453
6301	-20.4123	16.6407	not known	Hoasas	0	0	0	0	1462
68769	-20.4125	16.641	drilled	Hoasis	0	0	66.85	0	1458
40414	-20.413	16.639	drilled	Hoasis	200	92.5	0	0	0
10662	-20.4152	16.6389	not known		200	143	66	10	1465
86901	-20.4321	16.5671	not known		150	91	68	1.8	1412
86900	-20.4335	16.567	not known		150	91	47	3.6	1412
16507	-20.4348	16.584	not known	Buffelshoek	200	186	80	30	1420
86902	-20.4363	16.5684	not known		0	128	73.15	8	1412
40413	-20.438	16.574	drilled	Otjitazu - Kilo 9	110	142.58	0	0	0
68770	-20.4391	16.579	drilled	Kilo 9 - Otjitazu	0	0	38.4	0	1416.94
37524	-20.44132	16.5554	drilled	Farm Otjitazu	165	125	82	10	0
10660	-20.443	16.5776	not known		203	150	45	27.3	1407
80544	-20.4434	16.6725	not known		0	0	0	0	1335
86898	-20.444	16.6104	not known		150	60	0	9.1	1440
9422	-20.444	16.6104	not known	Omatjenne	200	96.4	7	10.2	1440
22115	-20.4454	16.5002	not known		153	59.4	22.8	4.1	1378
29837	-20.4455	16.503	drilled	Omatjenne	164	102	52.57	2.4	1378
86899	-20.4464	16.6081	not known		0	91	0	0	1440
29838	-20.4488	16.5044	not known	Omatjenne	160	90	34.47	0	1377.89
86906	-20.4527	16.5611	not known		150	110	36	1.4	1409
86892	-20.4543	16.6979	not known		150	73	37	0.5	1490
86891	-20.4555	16.7048	not known		150	107	21	9	1490
86890	-20.4557	16.7032	not known		150	71	0	4.2	1490
86897	-20.4557	16.6152	not known		150	76	0	1.8	1445
30484	-20.4599	16.5415	not known	Wesrand	150	75	0	0	1400
86513	-20.4599	16.5415	not known	Wesrand	150	65	0	0	1400
30483	-20.4613	16.5446	not known	Wesrand	150	95	0	0	1403
86512	-20.4613	16.5446	not known	Wesrand	150	90	0	0	1403
86903	-20.4624	16.5833	not known		150	63	27	2	1415
86904	-20.4633	16.5815	not known		150	49	36	1.4	1415

80542	-20.4639	16.6359	not known		150	152	27	0.8	1325
80543	-20.4641	16.6389	not known		150	30	12	1.1	1325
86910	-20.4641	16.5386	not known		150	122	49	4.5	1401
86912	-20.4641	16.603	not known		150	60	0	2.3	1434
29833	-20.4644	16.483	not known	Omatjenne	257	66	40.41	0	1392.73
6293	-20.4647	16.6002	not known	Otjitazu	0	0	0	4.5	1434
86905	-20.4647	16.5784	not known		150	116	49	0.1	1415
86911	-20.4652	16.5416	not known		0	52	30	13.8	1402
68768	-20.4663	16.4999	not known	Wieringen	0	0	0	0	0
86909	-20.4663	16.532	not known		150	116	49	0	1400
86916	-20.4669	16.5044	not known		150	40	30	9	1405
86913	-20.4684	16.5055	not known		150	76	0	0.9	1408
73833	-20.4691	16.5113	not known		0	0	0	0	1210
86908	-20.4696	16.5255	not known		150	192	58	4	1400
29000	-20.472	16.5154	not known	Wieringen	206	100	50.09	10	1396.59
30485	-20.472	16.5194	not known	Wesrand	150	85	0	5	1398
30636	-20.4738	16.5167	not known	Wieringen	164	90	54.69	0	1396.09
80546	-20.4739	16.6406	not known		0	105.2	27.4	0.5	1315
86895	-20.4744	16.6361	not known		150	63	24	4.1	1458
86894	-20.4753	16.6376	not known		150	76	24	1.4	1458
86907	-20.4753	16.5195	not known		150	122	55	18	1399
86914	-20.4864	16.5139	not known		150	62	27	2.2	1420
86915	-20.4882	16.5139	not known		150	61	43	0.2	1420
30486	-20.4931	16.5489	not known	Wesrand	150	85	0	0	1428
86896	-20.4962	16.6149	not known		0	0	0	0	1473
75237	-20.5087	16.4621	not known		150	91	20	1.8	1410
78720	-20.5144	16.6866	not known		150	111	55	1.3	1521
82055	-20.5169	16.6293	not known		150	53	24	4.1	1480
82054	-20.5232	16.6334	not known		150	76	24	1.4	1485
76308	-20.5268	16.5543	not known		150	50	34	1.9	1461
82057	-20.5367	16.6714	not known		150	34	12	1.4	1530
82051	-20.539	16.5804	not known		0	58	0	0.8	1520

82075	-20.5429	16.6798	not known		150	24	9	0.8	1535
75241	-20.5489	16.4023	not known		150	49	24	2	1389
75243	-20.5509	16.3985	not known		0	40	31	0.9	1389
75242	-20.5539	16.4312	not known		0	112.8	46	2.3	1405
75238	-20.5589	16.4953	not known		150	69	52	0.4	1453
26152	-20.5661	16.3874	not known		0	0	0	0	1391
82062	-20.5675	16.6292	not known		0	0	0	0	1540
82064	-20.5735	16.5397	not known		0	0	0	0	1500
82053	-20.5806	16.5888	not known		150	110	45	2.3	1528
82052	-20.5832	16.5794	not known		150	91	37	1.6	1523
82065	-20.5853	16.5438	not known		0	0	0	0	1499
82063	-20.5865	16.6029	not known		0	30.5	9.75	0.1	1549
29540	-20.5883	16.4205	not known	Aberfelde 27	150	63.3	0	0	1422
11702	-20.589	16.4262	not known		0	106.7	0	0	1421
82059	-20.589	16.6053	not known		150	46	18	0.7	1549
75239	-20.5892	16.4231	not known		150	76	52	0.4	1420
75240	-20.5897	16.4201	not known		150	82	52	1.1	1419
82069	-20.5901	16.5059	not known		0	0	0	0	1549
11703	-20.5902	16.4264	not known		0	152.4	37	2.5	1421
29542	-20.5908	16.42	not known	Aberfelde 27	150	49.6	0	0	1420
82067	-20.5914	16.5433	not known		0	14	8	0	1500
82066	-20.5916	16.5447	not known		0	0	0	0	1501
75244	-20.5938	16.4465	not known		0	0	0	0	1445
82068	-20.6014	16.5248	not known		0	0	11	0	1545
29541	-20.6028	16.4233	not known	Aberfelde 27	150	74	0	0	1425
75245	-20.6028	16.49	not known		0	0	0	0	1500
76133	-20.6074	16.3575	not known		0	21	20	0.4	1391
80864	-20.6087	16.3536	not known		150	85	24	2.7	1396
76134	-20.6089	16.3515	not known		0	21	20	0.4	1388
28144	-20.6094	16.5172	not known		0	0	0	0	1528
26078	-20.6099	16.3753	not known		150	95.2	20.4	4.8	1402
75233	-20.6115	16.374	not known		0	0	15	0.5	1400

75234	-20.6129	16.377	not known		150	67	19	5.4	1400
9423	-20.6156	16.3854	not known		0	68.1	20	0.3	1410
82070	-20.616	16.5639	not known		150	44	11	6	1528
75235	-20.6263	16.3997	not known		0	21	15	0.5	1421
75236	-20.627	16.3965	not known		150	67	14	3.2	1420
18791	-20.6285	16.3559	not known		0	76.2	22.9	4	1410
11037	-20.6298	16.4016	not known		0	53.6	16.46	3.2	1420
78751	-20.63	16.5023	not known		150	103	37	4.1	1510
18790	-20.6303	16.3397	not known		0	87.8	22.9	0	1429
80863	-20.6306	16.3186	not known		150	40	31	0.7	1390
76135	-20.6463	16.3743	not known		150	91	46	13.6	1445
75252	-20.6486	16.4113	not known		150	60	24	3.6	1435
76136	-20.6513	16.3573	not known		150	100.6	45.7	2	1447
75251	-20.6564	16.4471	not known		0	21	0	0.5	1445
75250	-20.658	16.4501	not known		150	30	0	4.1	1445
80862	-20.6597	16.3351	not known		150	86	46	4.5	1415
78741	-20.6639	16.5264	not known		0	122	0	0	1550
80861	-20.6665	16.3335	not known		0	24	0	0.3	1415
17764	-20.6666	16.3309	not known		0	25.3	19.2	7.7	1415
78566	-20.6681	16.2624	not known		150	61	0	0	1394
80860	-20.6691	16.3337	not known		0	24	0	0.4	1415
78740	-20.6767	16.509	not known		0	91	0	0	1518
78739	-20.6778	16.5106	not known		150	110	14	0	1518
76145	-20.68	16.2714	not known		0	62.2	0	2.7	1403
75249	-20.6819	16.4583	not known		0	18	0	0.5	1490
75248	-20.6829	16.4623	not known		0	18	0	2	1490
30994	-20.6842	16.2665	not known		0	81	0	0	1415
75247	-20.6848	16.4612	not known		0	0	0	11.4	1490
75246	-20.685	16.463	not known		150	35	0	11.4	1490
30993	-20.6859	16.2766	not known		0	91	0	0	1411
17765	-20.6873	16.3347	not known		0	32.1	14.6	10.1	1420
76142	-20.6942	16.2808	not known		150	81	49	1.4	1418

80854	-20.6961	16.3609	not known		0	37	0	0	1435
80853	-20.6974	16.4317	not known		0	0	0	0	1475
80866	-20.7025	16.3349	not known		150	93.9	24	0.3	1445
75255	-20.7031	16.3703	not known		150	76	14	4.1	1430
76141	-20.7058	16.2636	not known		150	62	46	1.8	1419
80865	-20.706	16.3357	not known		0	117.7	76.2	0.2	1445
80855	-20.7069	16.3725	not known		0	25	0	0.7	1440
78544	-20.7129	16.2402	not known		150	54	18	0.3	1418
75256	-20.7148	16.4158	not known		150	91	0	1.4	1473
72595	-20.7155	16.2461	not known		0	5	4	0	1421
76140	-20.7259	16.2809	not known		150	56	24	0.2	1440
80859	-20.7278	16.4099	not known		150	97	30	1.6	1470
80857	-20.7284	16.3532	not known		150	91	0	2.3	1451
80858	-20.7292	16.4114	not known		150	91	0	1.1	1471
76137	-20.7298	16.3288	not known		150	40	24	1.4	1460
80856	-20.73	16.3516	not known		0	18	16	0	1450
76138	-20.7303	16.3254	not known		150	47	24	1.8	1460
72594	-20.7308	16.2316	not known		150	24	14	4.5	1427
18254	-20.7334	16.435	not known		150	138.4	38.71	9.3	1494
76146	-20.7392	16.3067	not known		0	91.4	0	0	1472
76143	-20.74	16.296	not known		0	93	0	0	1461
76144	-20.745	16.3027	not known		0	85.3	0	0	1469
76139	-20.748	16.287	not known		150	44	18	1.8	1461
76259	-20.7529	16.369	not known		0	0	13	4.5	1470
76180	-20.7538	16.2051	not known		150	97	24	6.8	1434
76238	-20.7565	16.3601	not known		150	82	64	0.5	1472
76307	-20.7587	16.3933	not known		150	140.8	27.7	4.1	1480
76237	-20.7614	16.2513	not known		0	60	0	0	1472
76239	-20.7723	16.3256	not known		150	139	100	1.3	1491
76236	-20.7733	16.2597	not known		150	91	35	0.9	1540
76234	-20.7759	16.2751	not known		150	42	0	0.5	1475
76235	-20.779	16.258	not known		150	91	35	0.9	1519

76241	-20.793	16.3333	not known		150	61	15	0.5	1510
76194	-20.7952	16.1677	not known		150	41	24	3	1444
20304	-20.8012	16.2036	not known		0	76.2	27	0	1470
76179	-20.8015	16.1976	not known		150	46	0	13.6	1460
76184	-20.8028	16.2003	not known		150	60	0	0.3	1465
76183	-20.8035	16.2042	not known		150	24	15	0.9	1470
76240	-20.8035	16.3586	not known		150	185	9	3.2	1520
76185	-20.8036	16.1987	not known		150	67	21	0.5	1465
76181	-20.8047	16.2052	not known		150	64	46	0	1470
76182	-20.8063	16.2025	not known		0	23	22	0	1469
76243	-20.8104	16.2921	not known		0	17	5	15	1539
76244	-20.8124	16.2921	not known		150	14	5	4.5	1539
76242	-20.8142	16.2908	not known		150	37	5	45	1550
76186	-20.8211	16.2275	not known		150	48.9	18.29	0.5	1485
76196	-20.8235	16.1655	not known		0	25	21	0.9	1458
10106	-20.8241	16.2607	not known		150	71.3	16.76	0.5	1515
30663	-20.8289	16.2897	not known		160	97	25	0	0
76250	-20.8316	16.2845	not known		150	70	37	2.5	1581
76247	-20.8318	16.2878	not known		0	177	25	0	1575
76248	-20.8334	16.2858	not known		150	60	18	1.5	1570
76249	-20.8334	16.2845	not known		150	70	18	1.5	1580
76187	-20.8374	16.199	not known		150	38	35	0.3	1485
76246	-20.8377	16.3274	not known		0	8	5	0	1550
76192	-20.8385	16.1272	not known		150	73	55	3	1470
76245	-20.8396	16.3252	not known		150	70	0	2	1550
76191	-20.8433	16.1288	not known		0	13	7	0	1470
76199	-20.8497	16.2365	not known		0	15	14	0.1	1509
76251	-20.8566	16.2626	not known		150	66	15	4.5	1524
76188	-20.8567	16.1846	not known		0	16	15	0.2	1489
76252	-20.8592	16.254	not known		150	46	16	0.1	1517
76257	-20.8606	16.258	not known		150	46	16	0	1520
76253	-20.863	16.2601	not known		0	15	14	0	1526

76258	-20.8714	16.2719	not known		0	0	0	0	1530
76255	-20.8719	16.2733	not known		150	46	15	0	1533
76198	-20.8741	16.2191	not known		150	98	64	0.1	1527
76174	-20.8753	16.1399	not known		0	45	0	0	1485
76173	-20.8781	16.142	not known		0	45	0	0	1490
76189	-20.8808	16.1833	not known		0	25	24	0.2	1503
76190	-20.8814	16.1825	not known		150	46	24	0.5	1503
76254	-20.8818	16.2953	not known		150	82	34	0.1	1553
61467	-20.8823	16.2263	not known		0	0	0	0	1542
62214	-20.8832	16.1911	not known		0	0	0	0	1512
61465	-20.8837	16.2256	not known		0	0	0	0	1542
61466	-20.8837	16.227	not known		0	0	0	0	544
9346	-20.8843	16.1945	not known		150	62.8	0	1.1	1520
31503	-20.885	16.1862	not known		200	100	23.94	0	1512
9355	-20.8853	16.1984	not known		150	32.6	0	0	1521
76197	-20.8907	16.2471	not known		150	42	16	4	1568
32408	-20.8913	16.1915	not known		200	100	22.68	0	1520
5865	-20.8916	16.1875	not known		150	185.7	23.1	5.6	1522
21531	-20.8925	16.1897	not known		200	68	22	6	1519
2999	-20.8925	16.1945	not known		0	0	0	0	1523
3125	-20.8925	16.1945	not known		0	0	0	0	1523
7257	-20.8925	16.1897	not known		200	65	4.9	4.5	1519
5872	-20.8933	16.1838	not known	Kalkfeld	152	184	22.86	73.6	1520
76256	-20.8936	16.2707	not known		150	58	18	4	1578
33217	-20.8945	16.186	not known	Kalkfeld	200	132	0	15	1505
7862	-20.896	16.1862	not known	Kalkfeld	0	0	12.2	6.8	1518
20099	-20.8966	16.1858	drilled		150	9	0	0	1518
28554	-20.8967	16.1865	not known		200	100	10.5	7.2	1519
20100	-20.8971	16.1863	drilled		250	19	9.7	0.8	1516
16875	-20.8975	16.1899	not known		200	103	17	0.4	1523
16886	-20.8985	16.1856	not known	Kalkfeld	200	100	7	54.5	1519
76233	-20.8989	16.1859	not known	Kalkfeld	0	0	0	0	1519

61464	-20.899	16.1838	not known		0	0	11.5	0	1535
34586	-20.8991	16.1863	drilled	Kalkfeld - Put 2	0	0	0	0	1519
24100	-20.9021	16.0827	not known		0	0	0	0	1450
76207	-20.9026	16.2449	not known		0	0	0	0	1590
76175	-20.9042	16.1754	not known		0	45	0	0	1549
76302	-20.9048	16.291	not known		0	0	0	0	1580
76301	-20.9069	16.2938	not known		0	0	0	0	1580
76172	-20.9089	16.114	not known		0	45	0	0	1492
76171	-20.9097	16.1136	not known		0	45	0	0	1492
76170	-20.9127	16.1566	not known		0	45	0	0	1550
76169	-20.9135	16.1574	not known		0	45	0	0	1550
76203	-20.9146	16.1952	not known		150	88	0	0	1549
76204	-20.9146	16.1934	not known		150	76	0	0	1548
76202	-20.9165	16.1942	not known		0	30	0	0	1550
76168	-20.9174	16.1353	not known		0	0	0	0	1540
76167	-20.9188	16.134	not known		0	45	0	0	1540
76166	-20.9238	16.1233	not known		0	45	0	0	1500
76165	-20.9249	16.1221	not known		0	45	0	0	1500
76176	-20.9249	16.1066	not known		0	0	0	0	1482
76222	-20.9255	16.074	not known		0	0	0	0	1451
76200	-20.9272	16.185	not known		0	30	0	3.6	1552
76201	-20.9295	16.185	not known		0	30	0	0	1554
76205	-20.9333	16.2373	not known		150	76	15	0	1670
76218	-20.9355	16.1539	not known		0	10	0	0	1560
76214	-20.9357	16.1487	not known		0	15	0	4.5	1549
76217	-20.9375	16.1499	not known		0	13	0	0	1550
76216	-20.9376	16.1464	not known		0	14	0	0	1550
76219	-20.9384	16.1549	not known		0	13	0	0	1570
76209	-20.9413	16.1587	not known		0	14	0	0	1585
76206	-20.942	16.2429	not known		150	91	0	0	1660
76221	-20.9508	16.0381	not known		0	0	0	0	1500
76210	-20.9604	16.1993	not known		150	116	47	0.3	1610

76215	-20.967	16.1019	not known		150	55	0	2	1509
76212	-20.9719	16.1552	not known		0	0	0	0	1572
29992	-20.9728	16.0158	not known		150	110	40	0.1	1485
76208	-20.974	16.2496	not known		0	0	30	0	1640
76211	-20.9753	16.1552	not known		0	0	0	0	1572
76230	-20.9766	16.0252	not known		0	52	9	1.9	1491
76231	-20.9783	16.0251	not known		0	52	27	4.5	1490
76220	-20.9831	16.0802	not known		0	35	0	0	1500
29994	-20.9854	16.0116	not known		150	52	0	0	1486
76232	-20.9898	16.049	not known		0	39.6	0	0.3	1508
76213	-20.9907	16.1539	not known		0	0	0	0	1540
29993	-20.9995	15.9899	not known		150	54	0	0	1478
61775	-21.0123	16.178	not known		0	0	0	0	1578
61776	-21.0141	16.1767	not known		150	140.8	49.68	2	1578
79064	-21.0162	16.1016	not known		150	37	9	1.5	1551
22974	-21.0168	16.0668	not known		150	88	29	2.9	1539
79063	-21.0183	16.0675	not known		0	91	21	4.5	1535
79062	-21.0218	16.039	not known		0	18	8	4.5	1515
61764	-21.0243	16.0978	not known		0	18	0	0	1555
61763	-21.0269	16.0996	not known		0	51	0	0	1552
61765	-21.0288	16.0962	not known		0	52	24	0	1553
12244	-21.0321	16.1427	not known		0	100	0	0	1570
61990	-21.0329	16.0077	not known		150	61	12	5.5	1518
13099	-21.0343	16.0766	not known		150	99	30.4	0.9	1544
79069	-21.0359	16.0601	not known		0	50.3	0	0	1526
79066	-21.0372	16.0293	not known		150	61	24	0.5	1531
79068	-21.0382	16.0493	not known		0	50.3	0	0	1529
79067	-21.0384	16.0456	not known		0	71.6	0	0	1530
61475	-21.0476	15.9751	not known		0	20	5	0	1510
61760	-21.0597	16.1229	not known		0	20	0	0	1540
61757	-21.0624	16.0783	not known		150	99	23	0.5	1532
61474	-21.0626	15.9992	not known		150	45	9	1.5	1510

61762	-21.0681	16.166	not known		0	38	0	0	1503
79065	-21.0682	16.0516	not known		150	46	21	3	1520
61482	-21.0683	15.992	not known		0	18	3	0.3	1501
61761	-21.0699	16.1655	not known		0	7	0	0	1503
61756	-21.0707	16.0778	not known		150	73	27	0.5	1537
61785	-21.0712	16.1708	not known		0	0	0	0	1502
61758	-21.0715	16.0989	not known		0	74.7	0	0	1542
61759	-21.0725	16.0794	not known		0	64	0	0.1	1537
10186	-21.0794	16.002	not known		150	49	14	5.3	1520
61483	-21.0866	15.968	not known		0	0	0	0	1468
61478	-21.0877	15.9637	not known		150	34	15	2.1	1460
13095	-21.0921	16.043	not known		150	70.7	15.8	0.8	1492
61771	-21.0939	16.0773	not known		0	93.3	24	0.4	1505
61770	-21.0942	16.0896	not known		0	20	0	0	1476
61772	-21.0948	16.0744	not known		0	85.6	26.8	1	1503
10176	-21.0953	16.0067	not known		150	50	18.28	5.4	1496
61766	-21.0976	16.0932	not known		0	93	0	4	1470
61767	-21.1014	16.0966	not known		0	22	0	0	1470
61773	-21.1064	16.0193	not known		150	83	14	3	1474
61769	-21.1069	16.1153	not known		0	12	0	0	1478
13094	-21.1079	16.0243	not known		150	83	15	3	1474
61774	-21.1134	16.0307	not known		150	46	11	0.4	1470
29392	-21.1217	16.1213	not known		160	54	24.3	0	1270
65314	-21.122	16.1477	not known		0	0	0	0	1458
65315	-21.1259	16.1577	not known		0	0	0	0	1441
61794	-21.1272	16.1561	not known		0	0	0	0	1441
61768	-21.128	16.1082	not known		0	28	0	0	1454
61493	-21.1473	15.98	not known		150	70	55	1.3	1459
65332	-21.1474	16.0088	not known		150	30	8	2	1430
61989	-21.1496	16.0311	not known		0	0	0	0	1428
61494	-21.1533	15.9771	not known		150	72	0	0.9	1440
65327	-21.1579	16.0698	not known		150	70	0	0.5	1408

65329	-21.1615	16.0693	not known		0	0	0	0	1408
65331	-21.1684	16.0212	not known		150	30	10	2	1418
65330	-21.171	16.0157	not known		150	30	10	2	1411
65325	-21.1759	16.138	not known		0	61	0	0	1428
61496	-21.1817	15.9874	not known		150	30	15	2	1420
61985	-21.187	16.0259	not known		0	0	0	0	1392
65334	-21.2012	16.0298	not known		0	45	16	5	1380
65326	-21.2045	16.061	not known		0	19	0	6	1380
65337	-21.205	16.0095	not known		0	34	27	0	1370
65335	-21.2056	16.0268	not known		0	59	9	11	1378
61988	-21.2102	16.1031	not known		0	0	0	0	1391
65339	-21.2132	16.0182	not known		0	187	0	0	1361
65333	-21.2136	16.0204	not known		0	45.4	0	0	1360
65336	-21.2147	16.0249	not known		0	34	9	5	1361
65338	-21.2218	16.0037	not known		0	76	24	3	1356
61497	-21.2264	15.9994	not known		0	0	0	0	1365
61499	-21.2269	15.9489	not known		0	34	27	0	1430
61498	-21.2275	15.9973	not known		0	46	27	0	1375
65328	-21.2343	16.0348	not known		0	21	0	4	1359
61986	-21.2361	16.0563	not known		50	40	21	1	1350
61987	-21.2392	16.0544	not known		150	37	22	1	1350
61500	-21.2499	15.9531	not known		0	0	0	0	1385
29365	-21.2501	15.9998	drilled	Nei Neis	50	8	0	0	705
60910	-21.2504	15.9526	not known		0	0	0	0	1380
26433	-21.2522	15.952	not known		0	0	0	0	1390
18319	-21.2706	15.9176	not known		0	110	22	0	1340
5426	-21.2715	16.0619	not known		0	55	12.2	1.4	1325
60909	-21.2782	15.9932	not known		0	15	11	0	1309
60908	-21.281	15.9968	not known		0	10	0	0	1312
29313	-21.2828	16.0517	not known		150	87	30	0	0
60913	-21.2872	15.9587	not known		150	162	58	0	1323
30461	-21.29	15.9541	not known		0	0	50	0.5	1326

60907	-21.2928	15.9203	not known		0	0	0	0	1315
93356	-21.2951	15.9331	not known		0	0	0	0	1230
30460	-21.2957	15.9319	not known		0	0	0	0	1329
64921	-21.2966	16.0933	not known		0	46	18	1.4	1309
60926	-21.3002	15.9856	not known		0	0	0	0	1345
60921	-21.3008	15.9658	not known		150	91	18	5	1338
22390	-21.3028	15.9641	not known		150	150	28	4.1	1340
60919	-21.3059	15.9588	not known		150	34	22	5.4	1345
64918	-21.3068	16.0314	not known		0	76	0	2	1300
60911	-21.3078	15.9	not known		0	90.8	0	0	1310
18321	-21.3086	15.895	not known		0	87	37	2.4	1302
5124	-21.3087	16.0501	not known		0	62	0	0.9	1291
17679	-21.3097	15.9011	not known		0	77.7	0	0	1311
5425	-21.3161	16.0529	not known		150	67	18	1.4	1302
60925	-21.3193	15.997	not known		0	0	21	0	1290
60912	-21.3217	15.9285	not known		0	134	52	0	1315
60918	-21.3238	15.9595	not known		130	41	18	0.5	1299
60924	-21.3246	15.9427	not known		150	24	0	3	1290
60906	-21.3334	15.9117	not known		150	107	18	6.8	1318
60899	-21.3345	15.8813	not known		150	62	12	1	1295
60923	-21.3348	15.9494	not known		0	0	0	0	1284
61575	-21.3404	16.0793	not known		0	5	2	0	1267
60929	-21.3422	15.9146	not known		0	0	0	0	1290
61574	-21.3444	16.0779	not known		0	7	2	0	1266
64920	-21.3464	16.0088	not known		0	0	0	0	1265
60902	-21.349	15.8839	not known		0	0	0	0	1279
27178	-21.3503	16.062	not known	Stinzinghof	0	0	2.82	0	1260
61576	-21.3538	16.0583	not known		0	0	3.4	0	1258
60900	-21.356	15.8674	not known		150	47	21	5.5	1263
64919	-21.3562	16.035	not known		0	0	0	0	1250
60922	-21.3567	15.9574	not known		150	137	0	1.5	1265
28451	-21.3587	16.0539	not known		260	38	8	0	1255

80462	-21.36	16.0336	not known		0	0	1.89	0	1250
60917	-21.3601	15.9747	not known		150	117	61	0.7	1267
61580	-21.3692	16.0186	not known		0	0	2	30	1240
16359	-21.3703	16.0122	drilled	Omaruru	150	13	6.61	0	1240
16360	-21.37049	16.01223	drilled	Omaruru	150	10	4.5	0.3	1255
60920	-21.3732	15.9808	not known		0	113	35	3.2	1265
60914	-21.3742	15.9542	not known		0	0	0	0	1264
14003	-21.3772	16.0081	not known		0	0	3.17	0	1239
16358	-21.38221	16.00577	drilled	Omaruru	150	9.4	3.93	1	1232
77779	-21.384	16.0082	drilled	Okaokasjoti 87	0	0	4.15	50	1229
80459	-21.3853	16.0082	drilled	Okaokasjoti West 87	0	0	3.59	20	1230
16357	-21.3868	16.005	drilled	Omdel	150	13	2.5	0	1230
80464	-21.3883	15.9969	not known		0	0	2.4	0	1226
16141	-21.3913	15.9985	not known	Omaruru - Kranzberg	250	16.4	0.6	18	1242
60927	-21.393	15.9164	not known		0	0	0	0	1238
60928	-21.3936	15.9155	not known		0	0	0	0	1238
27172	-21.3951	15.9879	not known	Kakombo	0	0	4	0	1221
16291	-21.3966	15.9891	not known	Omaruru - Kranzberg	250	12.4	1.8	10	1235
80463	-21.3973	15.9843	not known		0	0	3.53	0	1220
60930	-21.3979	15.9901	not known		0	6	2	0	1220
40144	-21.39871	15.98605	In Use	Omaruru	0	0	0	0	0
61577	-21.3988	16.0503	not known		150	133	32	3.2	1262
60884	-21.3995	15.9865	not known		150	14	2	1	1219
60916	-21.401	15.9793	not known		0	7	2	0	1223
16305	-21.40132	15.98276	drilled	Omaruru	150	13	2.96	4	1217
80461	-21.408	15.9789	not known		0	0	2.22	0	1216
60915	-21.4089	15.9731	not known		0	0	0	0	1223
77970	-21.4092	15.9762	not known		0	9.1	0	70	1217
80460	-21.4104	15.9766	not known		0	0	3.05	0	1215
60879	-21.4128	15.9742	not known		0	0	0	0	1216
60877	-21.4131	15.9743	not known		0	5	0	0	1216
60878	-21.4131	15.9742	not known		0	5	1	0	1216

77969	-21.4146	15.9637	not known		0	0	2.58	70	1219
77968	-21.4251	15.9502	not known		0	7.6	0	40	1214
40139	-21.42592	15.94772	In Use	Omaruru	0	0	0	0	0
77967	-21.4263	15.9485	not known		0	7.6	0	40	1214
61581	-21.4465	16.0336	not known		150	67	46	3	1261
60881	-21.4473	15.9024	not known		0	4.6	0	0	1183
60883	-21.4476	15.9026	not known		0	0	0	0	1185
60882	-21.4478	15.9029	not known		0	6.4	0	0	1185
60880	-21.4485	15.901	not known		0	5.5	0	0	1185
77954	-21.45	15.9735	not known		0	0	0	0	1256
61582	-21.4506	16.0092	not known		0	0	0	0	1253
77962	-21.4515	15.8619	not known		0	0	0	0	1200
77961	-21.4599	15.8507	not known		0	0	0	0	1158
26087	-21.4641	15.8323	not known		150	53	8.5	4.8	1163
61583	-21.4669	16.0243	not known		0	0	0	0	1270
77955	-21.4811	15.9934	not known		0	0	0	0	1288
29229	-21.4889	15.8988	not known		160	80	40	0.1	1240
29604	-21.5048	15.8783	not known		160	115	0	0	1228
29602	-21.5084	15.9249	not known		160	74	0	0	1244
79312	-21.5192	15.9479	not known		0	0	0	0	1235
79313	-21.5195	15.9493	not known		0	0	0	0	1235
79308	-21.5198	15.8958	not known		150	52	0	8	1235
26021	-21.5305	15.8349	not known		150	104	17	0	1208
79281	-21.5314	15.8379	not known		0	0	0	0	1228
20265	-21.5318	15.837	not known		0	91.4	0	0.9	1228
24968	-21.5337	15.8401	not known		150	69	9	5.4	1229
29231	-21.5379	15.9294	not known		165	62	0	0	1231
62241	-21.5405	16.0018	not known		150	76	0	2.3	1236
79306	-21.5429	15.9296	not known		150	131	0	2	1229
79309	-21.5443	15.8792	not known		150	146	0	2	1270
79311	-21.5455	15.9373	not known		0	0	0	0	1260
79307	-21.5508	15.9158	not known		150	134	0	4	1215

24350	-21.5528	15.9669	not known		0	43.3	0	0	1230
79310	-21.5658	15.8795	not known		0	0	0	0	1320
61983	-21.5715	15.9909	not known		0	0	0	0	1229
28784	-21.5799	16.0238	not known		150	80	57	5.5	1215
62242	-21.5804	16.0103	not known		150	49	0	4.5	1215
65286	-21.5836	16.0222	not known		0	0	0	0	1218
79322	-21.5838	15.8979	not known		0	91	11	2.4	1175
79327	-21.5839	15.9147	not known		0	94	0	0	1195
79302	-21.5848	15.8585	not known	Hoogenoeg-170	150	37	18	1.8	1439
62243	-21.5875	16.0101	not known		150	76	0	2.3	1210
28783	-21.5881	16.0068	not known		0	0	0	0	0
79316	-21.5902	15.9365	not known		150	82	10	1.5	1187
79328	-21.5915	15.9173	not known		150	137.2	10.66	0.6	1185
79317	-21.5934	15.9142	not known		0	0	0	0	31
390	-21.6044	15.9511	not known		150	27.4	19.8	2.2	1181
79325	-21.6064	15.95	not known		150	30	18	2.3	1181
61982	-21.607	15.9704	not known		0	33.5	0	0	1187
79301	-21.6075	15.841	not known	Hoogenoeg-170	150	20	9	11	1425
79315	-21.6082	15.9252	not known		0	0	20	0	1171
79324	-21.6083	15.9491	not known		150	30	3	2.3	1182
79326	-21.6085	15.94	not known		0	65	0	3	1175
79285	-21.6098	15.985	not known		0	20	0	1.8	1201
79318	-21.6118	15.8946	not known		150	63	0	1.5	1170
79319	-21.6169	15.9196	not known		0	27	15	0	1165
79320	-21.619	15.9196	not known		0	59	0	2.1	1167
22369	-21.6194	15.88	not known		150	79	32	2.5	1190
79321	-21.6272	15.8908	not known		150	64	22	5.1	1171
17280	-21.6307	16.0273	not known		150	67	37	1.6	1230
79305	-21.6337	15.8289	not known	Hoogenoeg-170	0	0	0	0	1555
79314	-21.6345	15.9135	not known		150	37	15	1.5	1152
17299	-21.6363	16.0319	not known		0	39.6	0	0	1230
79304	-21.6369	15.84	not known	Hoogenoeg-170	0	0	0	0	1510

79288	-21.6508	15.8856	not known		150	33	18	2.5	1159
30271	-21.6513	15.881	not known		150	50	10	0	0
79289	-21.6669	15.864	not known		150	76	37	3	1159
79323	-21.6683	15.9686	not known		150	30	9	2.3	1192
9926	-21.6703	15.8016	not known		150	114	29	3.2	1625
79294	-21.6722	15.8939	not known		0	76	15	1.3	1125
4067	-21.6776	15.7802	not known		150	78	22.86	10.9	1540
79290	-21.6811	15.8655	not known		0	46	33	1.5	1159
61235	-21.6846	15.7624	not known		0	0	0	0	1545
79292	-21.6852	15.8823	not known		150	27	15	2	1118
79291	-21.686	15.8808	not known		0	0	15	2	25
79329	-21.6912	15.7835	not known		50	114	30	6.7	1585
79293	-21.6951	15.8733	not known		0	30	10	4	1118
79287	-21.6969	15.8871	not known		0	0	0	0	1130
5607	-21.7028	15.9798	not known		150	36.9	9.1	1.4	1190
61940	-21.7072	15.7446	not known		0	0	0	0	1475
79286	-21.7095	15.9365	not known		0	0	0	0	1170
61941	-21.7249	15.7471	not known		0	0	0	0	1478
79284	-21.7287	15.8533	not known		0	46	15	2	1108
61943	-21.7325	15.7371	not known		0	0	0	0	1520
61942	-21.7336	15.7244	not known		0	70	0	0	1515
61945	-21.7351	15.7257	not known		0	0	0	0	1519
61944	-21.7366	15.7455	not known		0	0	0	0	1534
79283	-21.7389	15.9389	not known		0	0	0	5	1161
79282	-21.7456	15.875	not known		0	0	0	1.4	1123
79043	-21.7555	15.9073	not known		0	0	0	2.7	1127
79040	-21.7597	15.8146	not known		0	122	0	1.5	1075
79039	-21.76	15.8113	not known		0	0	0	4	1075
79036	-21.7624	15.7954	not known		150	79	24	2	1070
8962	-21.778	15.9001	not known	Spes Bona	100	31	0	0	969.1
8928	-21.7782	15.9176	not known	Spes Bona	120	75.3	21.35	0	1000.9
8961	-21.7783	15.8972	drilled	Spes Bona - Khan river	203	76.2	27.97	6.8	969.1

9036	-21.7791	15.9357	not known	Spes Bona	200	73.2	13	0	1020.7
78997	-21.7793	15.9057	not known		0	0	0	0	981.7
78998	-21.7793	15.9119	not known		200	68.3	0	0	998.5
7990	-21.7793	15.9054	not known	Spes Bona	200	32	8.5	0	982.3
79032	-21.7798	15.7986	not known		0	31.4	0	1.8	1071
79037	-21.7803	15.7802	not known		0	35.1	0	0.7	1054
8960	-21.7812	15.93	not known	Spes Bona	200	74.7	0	3.6	1128
79041	-21.7858	15.8433	not known		0	0	0	3.2	1088
79033	-21.7863	15.7708	not known		0	9.8	0	1.4	1054
78976	-21.7871	15.6826	not known		150	55	0	2	1090
26946	-21.791	15.9069	not known		0	100	0	0	1145
79059	-21.7916	15.7849	not known		0	0	0	0	1070
79042	-21.7938	15.8606	not known		0	0	0	1.4	1118
79058	-21.7974	15.8561	not known		0	0	0	0	1115
79034	-21.7999	15.7622	not known		0	30.5	0	9.1	1044
79035	-21.8023	15.7532	not known		150	32	7	4	1044
29603	-21.8034	15.878	not known		160	74	0	0	1229
79001	-21.8091	15.8887	not known		150	76.2	0	0	1148
79038	-21.8103	15.8026	not known		0	58.5	0	3.6	1117
78955	-21.8139	15.7171	not known		0	0	0	0	1021
78952	-21.8275	15.7187	not known		0	0	0	0	1035
78975	-21.8286	15.651	not known		150	43	6	8	987
78953	-21.8347	15.7109	not known		0	0	0	0	1148
78954	-21.836	15.6903	not known		0	0	0	0	1068
78951	-21.839	15.7366	not known		0	0	0	0	1051
79030	-21.8404	15.8258	not known		150	54.9	0	2.7	1101
78956	-21.8467	15.7364	not known		0	0	0	0	1080
78963	-21.8483	15.6858	not known		0	0	0	0	1056
78949	-21.8491	15.6703	not known		0	0	0	0	1025
79031	-21.8491	15.775	not known		0	0	0	0	1085
18324	-21.8641	15.7657	not known		0	43	15.8	2.7	1064
61243	-21.8654	15.7288	not known		0	85.3	0	1.3	1044

18196	-21.8748	15.7777	not known		0	47.5	0	0	1075
78964	-21.8751	15.675	not known		0	0	0	0	1060
78965	-21.8803	15.6735	not known		0	0	0	0	1048
79061	-21.8818	15.8413	not known		0	80	0	0	1129
78943	-21.8838	15.7286	not known		0	0	0	0	1033
61242	-21.8859	15.6953	not known		0	91.4	0	2	1016
78987	-21.8948	15.5821	not known		0	29	0	5.4	922
14792	-21.8973	15.5796	not known		0	93.9	0	0	922
78950	-21.9001	15.7328	not known		0	0	0	0	1055
78981	-21.909	15.5741	not known		0	12	8	0	913
78966	-21.9095	15.5969	not known		150	90	40	0.4	974
78982	-21.911	15.5784	not known		150	31	12	4.5	919
78961	-21.9136	15.7283	not known		0	0	0	0	1052
78960	-21.9149	15.7316	not known		0	0	0	0	1052
78962	-21.9153	15.7254	not known		0	0	0	0	1048
22160	-21.91661	15.5713	drilled	Usakos - Khan river	200	21.3	6.4	2.3	907.9
18325	-21.9174	15.8156	not known		0	74	0	0	1133
78948	-21.9177	15.7059	not known		0	0	0	0	1034
18194	-21.9256	15.7983	not known		0	64	0	0	1126
61241	-21.9296	15.6613	not known		0	85.3	0	6.8	971
78945	-21.936	15.733	not known		0	0	0	0	1076
78947	-21.9391	15.7195	not known		0	0	0	0	1057
78944	-21.9393	15.7418	not known		0	0	0	0	1082
78957	-21.9406	15.6793	not known		0	0	0	0	1011
79002	-21.945	15.7597	not known		150	67	0	0	1095
78946	-21.9466	15.7326	not known		0	0	0	0	1074
61240	-21.9527	15.6367	not known		0	106.7	0	1.8	952
78995	-21.9543	15.7095	not known		200	37	0	0	152
78958	-21.9631	15.7001	not known		0	0	0	0	1028
61239	-21.9649	15.638	not known		0	0	0	0	911
27861	-21.9664	15.6305	drilled	Usakos	200	24	0	0	933
27865	-21.9672	15.6341	drilled	Usakos	200	30	0	0	928

78959	-21.9693	15.696	not known		0	0	0	0	1064
27863	-21.96977	15.62645	drilled	Usakos - Kranzberg river	150	49	26.54	20	920
27862	-21.9705	15.6286	drilled	Usakos - Kranzberg river	150	48	24.15	25	919
27859	-21.9732	15.6207	drilled	Usakos	200	40	0	0	923
27860	-21.9748	15.6208	drilled	Usakos	150	45	25.01	21	913
27858	-21.9773	15.61552	drilled	Usakos - Kranzberg river	164	36	15.3	36	908
27513	-21.9805	15.6109	not known	Usakos	200	32	5	51	892
27857	-21.98132	15.61029	drilled	Usakos - Kranzberg river	150	42	11.32	55	896
27510	-21.9833	15.60764	drilled	Usakos - Kranzberg river	200	96	4.1	28	886
78993	-21.9858	15.6034	not known		0	0	0	5	886
78996	-21.9862	15.63	not known		0	0	0	0	896
78992	-21.9915	15.6006	not known		0	0	0	6.4	883
78989	-21.9932	15.6067	not known		0	0	0	0	900
78990	-21.9934	15.6059	not known		0	0	0	0	897
61238	-21.9942	15.6522	not known		0	0	0	0	1074
61679	-22.002	15.6619	not known		0	0	0	0	1160
81826	-22.0087	15.676	not known		0	31	28	0	1065