GROUNDWATER MONITORING: GEORGE WWTW SITES

Drilling & Installation of Monitoring Boreholes, Monitoring Programme and Site Hydrogeology

On behalf of:

WPCP
WATER PURIFICATION CHEMICAL & PLANT cc

Prepared for:

GEORGE
THE CITY FOR ALL REASONS

Veltwater
GROUNDWATER SPECIALISTS

SIGN-OFF SHEET

Title of Report:	Groundwater Monitoring: George WWTW Sites – Drilling & Installation of Monitoring Boreholes, Monitoring Programme and Site Hydrogeology
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Document Approval By:

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GEORGE MUNICIPALITY

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Veltwater
GROUNDWATER SPECIALISTS

DISCLAIMER

Report Version	Draft Final		
Title	Groundwater Monitoring: George WWTW Sites Drilling & Installation of Monitoring Boreholes		
Author	Jorette van Rooyen		17 June 2021
Document Reviewer	Sonia Veltman		17 June 2021

QUALIFICATIONS AND EXPERIENCE OF THE AUTHORS

Jorette van Rooyen is a qualified hydrogeologist (M.Sc. Environmental Sciences – Hydrogeology & Hydrology, North-West University) and registered with The South African Council for Natural Scientific Professions: Professional Earth Scientist.

Jorette has 10 years' experience in various aspects of hydrogeology, including mine and smelter related groundwater assessments, routine surface and groundwater monitoring, emergency environmental impact and groundwater risk assessments, groundwater resource assessment, management and planning, site characterisation and development of monitoring networks. Specialist functions include conceptual and numerical modelling of groundwater systems, borehole specific evaluations and sustainable yield recommendations. Field experience in groundwater investigations include hydrocensus, geophysics, aquifer testing, drilling supervision, geological logging, auguring, soil (geotechnical) sampling, groundwater monitoring and sampling, soil vapour surveys, in-situ compaction testing, free phase bail down testing and trial pit design and excavation supervision and profiling.

Sonia Veltman is a qualified principal hydrogeologist (M.Sc. Geohydrology, University of the Free State) and registered with The South African Council for Natural Scientific Professions: Professional Natural Scientist.

Sonia has 20+ years' experience in various aspects of hydrogeology, including groundwater resource assessment, management and planning, site characterisation, environmental impact assessments, monitoring networks and data, geochemical characterisation, and numerical modelling. Field experience in groundwater investigations include remote sensing, ground truthing, sampling, geochemical sampling, geophysical surveys, site selection, drilling support, geological logging, and reporting.

DECLARATION OF INDEPENDENCE

I, Jorette van Rooyen, declare that I am an independent specialist consultant and have no financial, personal, or other interest in the proposed development, nor the developers or any of their subsidiaries, apart from fair remuneration for work performed in the delivery of hydrogeological services. There are no circumstances that compromise the objectivity of my performing such work.

I, Sonia Veltman, declare that I am an independent specialist consultant and have no financial, personal, or other interest in the proposed development, nor the developers or any of their subsidiaries, apart from fair remuneration for work performed in the delivery of hydrogeological services. There are no circumstances that compromise the objectivity of my performing such work.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

LIST OF MAPS

NOTE: All Maps have been included as Drawings in Appendix C.

1 INTRODUCTION

Veltwater Groundwater Specialists (Veltwater) was contracted by Water Purification Chemical and Plant (WPCP) on behalf of George Municipality (hereafter also referred to as the “client”) to assist with the siting and drilling supervision of 12 monitoring boreholes in and around George, Western Cape; commonly referred to as the Outeniqua WWTW’s (Waste Water Treatment Works) project.

The findings and recommendations, based on the results of the hydrogeological work conducted at the George WWTW sites, are contained in this report.

2 TERMS OF REFERENCE

2.1 Deliverables

Veltwater was responsible for the siting and drilling supervision of newly installed monitoring boreholes at appropriate positions at four facilities. The scope was adjusted during the drilling period to fulfil the relevant requirements in the Outeniqua and Gwaing WWTWs Water Use Licenses for:

- Establishing the groundwater monitoring programme, including a typical field form for capturing field data while monitoring and photos for reference how to monitor/sample,
- Describe the site conceptual model (CSM) with flow paths, gradient, and discharge points into surface water bodies,
- Identify the current impacts on the groundwater system and recommendations to address / mitigate (or specify why if not), and
- Discuss the impacts on groundwater users that is in the flow path of potential pollution (however I do believe this to be naught as discussed in Parson document, but it will have to be linked with flow paths).

Chemical analyses performed during the monitoring run included major cations and anions, all relevant metals, and microbial indicators, in accordance with a shortened list of required SANS parameters for groundwater.

A concise stand-alone hydrogeological drilling report, documenting data gathered during the drilling and installation, were the final deliverable.

3 General Site Information

3.1 Location & Topography

The George WWTWs sites comprise of the Outeniqua and Gwaing WWTWs and will hereafter also be referred to as “the George WWTWs”.

The Outeniqua WWTW site is located at Pacaltsdorp, immediately south of the George industrial area, Western Cape Province. Access to the site is obtained via Beach road (see attached Site Locality Map – Dwg No. 1).

The Skaapkop River flows along the eastern boundary of the site and is joined by an unnamed tributary in the south. The site is situated at an elevation ranging between 184 and 197 metres above mean sea level (mamsl) (data obtained from an existing works survey).

Gwaing WWTW site is located to the west of the Tumsui industrial area, George, Western Cape Province. Access to the site is obtained via the R102 (see attached Site Locality Map – Dwg No. 1).

The Gwaing River flows along the western boundary of the site and drains towards the south. The site is situated at an elevation ranging between 184 and 197 metres above mean sea level (mamsl) (data combination of an existing works survey and available SRTM where survey data was incomplete).

3.2 Geology

The published 1: 250 000 Geological sheet 3322 Oudtshoorn, shows that the George WWTWs and surrounding areas are underlain by gneissic granite, granodiorite and albitite of the Maalgaten and related granites of the George batholith. According to the geological map there is no prominent faulting present in the immediate area of the site (see attached Geological Map – Dwg No. 2).

The soil horizons in the area consist of sands and lithosols that are imperfectly and poorly drained to structureless loamy sand and sandy loams. The reported clay content for this area range between 6 and 15%.

3.3 Hydrogeological Environment

The aquifers associated with these deposits are classified as intergranular and fractured and are considered minor (low yielding) to poor aquifer systems with minimal vulnerability of groundwater contamination and variable permeability for groundwater flow (Parsons, 1995). Higher yields are generally expected at intersections of fracture / fault zones or in transition/contact zones between the weathered aquifer and bedrock.

The dominant yield classes range between 0.1 and 0.5 l/s, and the natural quality of the groundwater is reported as variable to poor. Most of the groundwater flow occur in the weathered zone, or in the openings between joints and fractures within the bedrock mass (see attached Hydrogeological Map – Dwg No. 3).

4 Field Results

4.1 Drilling Results & Borehole Construction

Monitoring borehole positions was selected based on available site information, expected groundwater flow pathways (source-pathway-receptor principles) and accessibility of a drill rig to the drill sites.

The monitoring boreholes at the George WWTWs were drilled via conventional air percussion methods at starting diameters of 254 mm (10”) until stable formations were encountered, followed by 203 mm (8”) into competent rock formations to final depths. Thereafter, 140 mm outer diameter (OD) threaded plain, and factory slotted uPVC casing was installed. Following the installation of the uPVC, 3 to 5 mm gravel pack was placed in the annulus between the steel and uPVC casing walls to ensure stability and prevent the entry of fines into the monitoring boreholes.

Centralisers were fitted onto every second length of the uPVC casing, to ensure casing stability within the boreholes. The boreholes were considered to pass the straightness test when the small size drill bit was lowered into the full uPVC column to depth and the airlift yield was attempted and did not shatter the uPVC at depth.

TBC – monitoring borehole headworks to be finalised.

The geological logs are attached to this report as Appendix A, with borehole construction details indicated. A summary of the drilling results is presented in Table 4:1 and photographs of the completed boreholes can be seen in Figure 4:1.

The monitoring borehole locations are shown on the attached Monitoring Boreholes and Groundwater Flow Maps – Dwg No. 4 and DWG No. 5.

4.1.1 Outeniqua WWTW

The OQ (Outeniqua) boreholes were completed to final depths ranging between 30 (OQ 01) and 40 metres below ground level (mbgl) (OQ 03). The completion depth of the uPVC in OQ 03 reached 35 m due to the collapsing clay formations at depth.

Groundwater was not intersected during the drilling process, within the granitic formations, at any of the monitoring boreholes. Boreholes OQ 01 and OQ 03 recovered overnight and were checked for the presence of water prior to borehole development. OQ 02 did not have sufficient water for development after overnight recovery and water was pumped into the borehole to effectively clean and develop the borehole. Due to the minimal amount of water in the columns, accumulative yields of >0.01 l/s were recorded.

4.1.2 Gwaing WWTW

The GN (Gwaing) boreholes were completed to final depths ranging between 27 (GN 02) and 40 metres below ground level (mbgl) (GN 01). The completion depth of the uPVC in GN 01 reached 39.2 m due to the collapsing clay formations at depth.

Groundwater was intersected at 24 m during the drilling process of borehole OQ 02. No further groundwater was intersected at the remainder of the monitoring boreholes. All boreholes could recover overnight and were then checked for the presence of water prior to borehole development. Due to the minimal amount of water in the columns, accumulative yields recorded ranged from >0.01 (GN 01 and GN 03) to 0.03 l/s (GN 02).

Table 4:1 – Monitoring Borehole Installation Details

BH ID	Date		Static Water Level	BH Completion Depth	BH Diameter	219 mm (OD) Casing	140 mm (OD) Casing		Water Strike Depth	Accumulated Yield
	Start	Completed	(mbgl)	(mbgl)	(mm)	Solid (mbgl)	Solid (mbgl)	Slotted (mbgl)	(m)	(l/s)
OQ 01	25/03/2021	26/03/2021	18.66	30	219	12	0 – 12.6	12.6 – 30	none	>0.01
OQ 02	26/03/2021	27/03/2021	30.53	31	219	11	0 – 13.6	13.6 – 31	none	>0.01
OQ 03	27/03/2021	29/03/2021	22.82	40	219	12	0 – 11.8	11.8 – 35	none	>0.01
GN 01	29/03/2021	30/03/2021	23.44	40	219	12	0 – 16	16 – 39.2	none	>0.01
GN 02	30/03/2021	31/03/2021	14.63	27	219	10	0 – 9.6	9.6 – 27	24	0.03
GN 03	31/03/2021	01/04/2021	24.50	35	219	10	0 – 11.8	11.8 – 35	none	>0.01

OQ 01

OQ 02

OQ 03

GN 01

GN 02

GN 03

Figure 4:1 – Images of the Completed Monitoring Boreholes

4.2 Groundwater Monitoring and Sampling

A groundwater monitoring and sampling survey was undertaken by Veltwater on Wednesday 7 April 2021.

4.2.1 Groundwater Monitoring

The recently installed monitoring boreholes were checked with a dipmeter to determine the static water levels (SWLs) and final uPVC (BH) depths.

The results are contained in Table 4:2 below.

Table 4:2 – Groundwater Monitoring Results

Date	***07/04/2021***			
BH ID	**Surface Elevation** (mamsl)	**SWL** (mbgl)	**SWL** (mamsl)	**uPVC Depth** (mbgl)
OQ 01	197	19.83	177	30
OQ 02	188	28.65	159	31
OQ 03	193	22.62	170	35
GN 01	200	23.09	177	39
GN 02	179	14.67	165	27
GN 03	184	24.04	160	34

The static water levels cannot yet be used for trend analyses but was used to generate groundwater flow directions and inferred flow lines (see the attached Monitoring Boreholes and Groundwater Flow Maps – Dwg No. 4 and Dwg No. 5). The calculated groundwater flow gradient for the aquifers across both sites ranged between 0.02 and 0.023.

4.2.2 Water Quality

Groundwater samples were collected during monitoring using disposable bailers, a separate one for each borehole, to avoid possible cross contamination between boreholes and were submitted to a SANAS-accredited laboratory for analyses.

The results were compared to the general standard DWS Wastewater limit values related to discharging waste or water containing waste into a water resource through a pipe, canal, sewer, or other conduit, as stipulated in the Water Use License (WUL) in terms of Section 21 (f) of the National Water Act (Act 36 of 1998), issued to Outeniqua WWTW on 18 December 2015 (License No.: 18/K30C/F/4036) and to Gwaing WWTW on 18 December 2015 (License No.: 18/K30B/FG/4081) (hereafter also referred to as George WULs).

The laboratory analyses results were summarised in Table 4:3, Outeniqua WWTW (OQ) and Gwaing WWTW (GN), and the water quality test certificates were attached to this report in Appendix B.

From the results in Table 4:3, the following non-compliance to the George WULs occur:

- The Electrical Conductivity (EC) and suspended solids exceed the WUL limits in all boreholes except GN 03, for both field and laboratory measurements. The variation between the field and laboratory EC can be attributed to electrons going into solution, in the laboratory, from the suspended solids at 25°C and is likely to stabilise at the next sampling run.
- Manganese (Mn) exceeds WUL limits in all boreholes except GN 03 and OQ 01, fluoride (F) in borehole GN 03 and iron (Fe) in borehole OQ 02.
- Chemical oxygen demand exceeds WUL limits in all boreholes except GN 02 and GN 03, with E.coli only exceeding the WUL limits in OQ 02.

These values should be considered as a baseline situation and trend analyses should only be done after one (1) year of monitoring has been completed. Sampling intervals at three (3) month intervals would suffice, until a good trend has been established, after which sampling intervals can be reduced pending professional evaluation of a hydrogeologist.

However, considering the clayey nature of the weathered granite and slow movement of groundwater through the weathered zone, the widespread occurrence of Total Coliforms and E.coli bacteria indicates long term infiltration from leakages at both facilities from the WWTWs processes.

Parsons (2017) indicated that Outeniqua WWTW was upgraded in 2014 and that the sludge from this facility is transferred to Gwaing WWTW, where it is dried and stored. Borehole GN 03 is the monitoring borehole among the dried sludge beds at Gwaing and overall, the borehole with the least groundwater contamination. This conclusion should be revisited after a year's monitoring data has been gathered.

Table 4:3 – Water Quality Results

Variable	Unit	DWS Wastewater Limits		GN 01	GN 02	GN 03	OQ 01	OQ 02	OQ 03
		General Limit	WUL Limit	07/04/2021 10:50	07/04/2021 11:20	07/04/2021 11:40	07/04/2021 12:15	07/04/2021 12:35	07/04/2021 13:10
Field Measurement EC	mS/m	-	-	350	178	100	303	349	343
pH @ 25°C	-	≥ 5.5 - ≤ 7.5	≥ 5.5 to ≤ 9.5	6.80	7.30	7.70	7.00	6.90	6.90
Electrical Conductivity @ 25°C	mS/m	≥ 50 - ≤ 100	≥ 70 to ≤ 150	1019.00	320.00	144.00	700.00	944.00	839.00
Suspended Solids	mg/l	10	25	59.00	44.00	<18	32.00	1165.00	58.00
Ammonia as N	mg/l	2	6	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Ortho-Phosphate as P	mg/l	≥ 1 - ≤ 2.5	10	<0.1	<0.1	<0.1	0.16	<0.1	<0.1
Total Alkalinity (as CaCO3)	mg/l			191	153	294	235	81	73
Total Hardness	mg/l			930	159	36	430	1718	916
Calcium as Ca	mg/l			174	30	7.89	79	232	93
Magnesium as Mg	mg/l			120	20	4.02	57	276	166
Sodium as Na	mg/l			2225	651	336	1383	1493	1438
Free Chlorine as Cl2	mg/l	0	0.25	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Chloride as Cl	mg/l			2744	639	125	1621	2606	2199
Fluoride as *F	mg/l	1	1	0.50	0.59	2.35	0.71	0.82	0.40
Sulphate as SO4	mg/l			139	65.3	21.3	144	148	166
Nitrate as N	mg/l			0.9	0.86	3.85	0.27	<0.25	0.97
Nitrite as N	mg/l			<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Nitrate / Nitrite as N	mg/l	1.5	15	0.14	0.13	0.41	<0.12	<0.12	0.14
Aluminium as Al	mg/l			0.0480	0.1260	0.1560	0.0810	0.5340	0.1880
Dissolved Copper as Cu	mg/l	0.002	0.01	0.0013	0.0044	0.0012	0.0027	0.0063	0.0027
Dissolved Iron as Fe	mg/l	0.3	0.3	0.174	0.152	0.090	0.041	2.733	0.240
Dissolved Manganese as Mn	mg/l	0.1	0.1	0.765	0.333	0.068	0.044	0.626	1.745
Dissolved Lead as Pb	mg/l	0.006	0.01	0.0032	0.0016	<0.001	0.0021	0.0082	0.0034
*Colour	mg/l Pt			<10	<10	<10	<10	<10	<10
*Turbidity	NTU			6.9	10.0	13	4.2	444	20
Chemical Oxygen Demand as COD	mg/l	30	75	133.00	52.00	32.00	76.00	233.00	80.00
Standard Plate Count	cfu/1ml			>10000	>10000	>10000	>10000	>10000	>10000
Total Coliforms	cfu/100 ml			41060	57940	26130	24196	241960	1986
E. coli	cfu/100ml		150	35.00	3.00	24.00	<1	188.00	10.00

Values highlighted in red exceed the WUL limits of the George WULs. Values highlighted in orange exceed the General standards of the DWS Wastewater limits applicable to discharge of wastewater into a water resource.

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4.3 Conceptual Site Model

Conceptual site models for both Outeniqua and Gwaing WWTWs were presented in Figure 4:2 and Figure 4:3. These are derived from cross-sections of the current sites as understood from drilling logs and monitoring results. See the attached Monitoring Boreholes and Groundwater Flow Maps – Dwg No. 4 and Dwg No. 5 for the position of the cross-sectional lines.

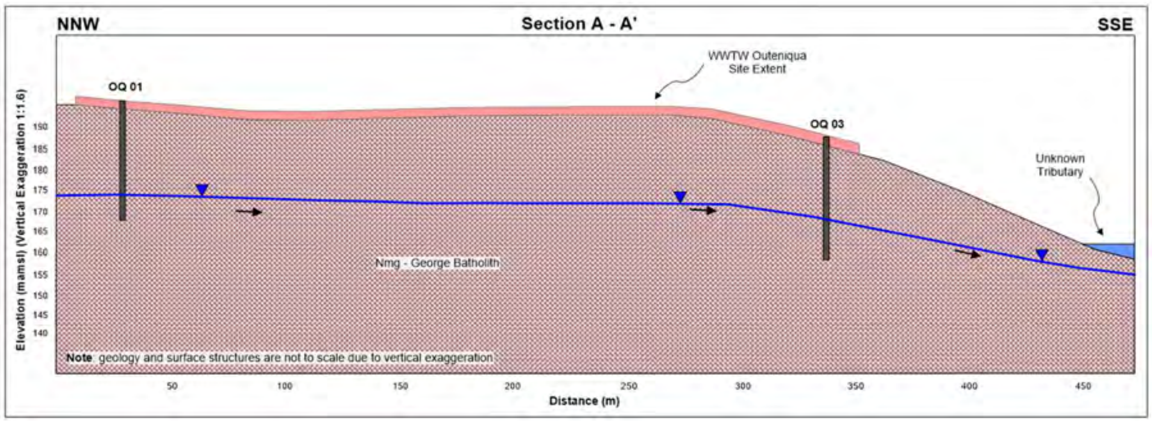

Figure 4:2 – Conceptual Site Model Outeniqua

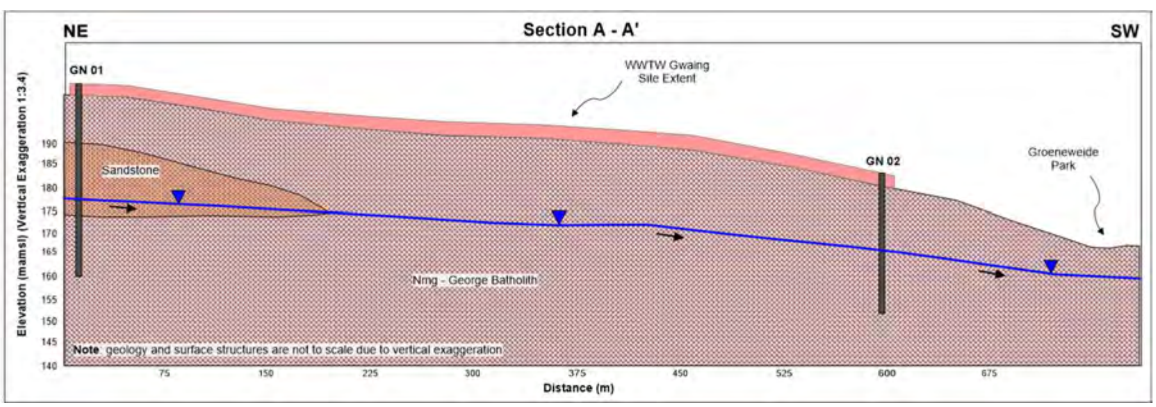

Figure 4:3 – Conceptual Site Model Gwaing

The groundwater flow direction in the weathered granite underlying the WWTW site are in south-easterly and south-westerly directions towards the Skaapkop and Gwaing Rivers, respectively. The saturated water level follows topography, flow occurs above the hard rock contact in the weathered material and slope downwards towards the rivers and lower lying areas, and likely discharges into the surface drainage within the weathered riverbeds.

The water quality results indicate long term seepage into the weathered granite below, from both WWTWs process and containment facilities, with less impact from the dried sludge beds at the Gwaing WWTW.

5 GROUNDWATER MONITORING PROGRAMME

Groundwater monitoring is essential for measuring any changes in water levels and / or chemical indicators to show changes in the groundwater system that should trigger a mitigation response.

The George WULs mandated the development of a groundwater monitoring programme, at each facility, to determine the impacts on the groundwater system. The following section outlines the programme to obtain representative monitoring information taken consistently, with results that are defendable, through adopting the methods and procedures prescribed. Representative consistent information can then be compared and evaluated over time.

5.1 Monitoring Sites

Table 5:1 provided a summary of the monitoring boreholes, the types of monitoring, frequency and evaluation of information that should be implemented. The minimum required parameters for water quality analyses were given in Table 5:2. The monitoring frequency was largely based on the guidelines specified in the George WULs, while the required parameters formed a combination of compliance and impact monitoring as inferred from section 4.2. See the attached Monitoring Boreholes and Groundwater Flow Maps – Dwg No. 4 and Dwg No. 5 for the positions of the monitoring boreholes at Outeniqua and Gwaing WWTWs, respectively.

Table 5:1 – Groundwater Monitoring Programme: Outeniqua (OQ) and Gwaing (GN) WWTWs

Monitoring ID	Lat (S) (WGS84)	Long (E) (WGS84)	Elevation (mamsl)	Monitoring Type	Interval	Evaluation
OQ 01	22.46223	-34.00446	197	Water level measurements, all boreholes	Quarterly	Trends
OQ 02	22.46531	-34.00601	188			
OQ 03	22.46329	-34.00699	193			
GN 01	22.42544	-33.99361	200	Sampling for water quality analysis, all boreholes	Quarterly	DWS Wastewater limit values related to disposal into a water resource
GN 02	22.42222	-33.99801	179			
GN 03	22.41927	-33.99779	184			

Table 5:2 – Groundwater Monitoring Compliance Variables

pH	Sodium (mg/l)	Dissolved Manganese (mg/l)
Electrical Conductivity (mS/m)	Chloride (mg/l)	Dissolved Lead (mg/l)
Suspended Solids	Fluoride (mg/l)	Chemical Oxygen Demand (mg/l)
Chorine as Free Chlorine (mg/l)	Sulphate (mg/l)	Total Coliforms per 100ml
Ammonia as N (mg/l)	Aluminium (mg/l)	E Coli per 100ml
Nitrate/Nitrite as N (mg/l)	Dissolved Cu (mg/l)	Soap, oil and grease
Orthophosphate as P (mg/l)	Dissolved Iron (mg/l)	

*These should be revisited after a year's monitoring and evaluation.

5.2 Procedures

Detailed groundwater monitoring field procedures, checklists, and a borehole monitoring field form were included as Appendix D. Routine groundwater monitoring and sampling of the newly installed monitoring boreholes should include the following:

- On-site monitoring of water levels in the monitoring boreholes, including the date and time of the measurement taken. A manual water level device (dipmeter) is recommended; and
- Groundwater sampling and analyses of groundwater quality, including the date and time of each sample taken. Sampling methods include the following:

  - RECOMMENDED: Sampling utilising disposable bailers to avoid cross contamination.

  OR

  - Water-bearing monitoring boreholes can be purged using a <0.1 litre per second (l/s) pump to remove groundwater, until either three times of the volume of groundwater contained within the monitoring boreholes have been removed, or until the monitoring boreholes are pumped dry. This will aid in the removal of any stagnant water introduced into the boreholes. The sample should be collected prior to the end of pumping. Care should be taken to ensure that all equipment be de-contaminated between boreholes.

5.3 Reporting

The George WULs requires that the monitoring information be made available to the DWS upon written request or inspection.

However, it is recommended that a qualified hydrogeologist evaluate the data and make the necessary adjustments to the monitoring programme after the first year's monitoring data is available.

Reporting of results, including long-term trends, and recommendations of management actions would be to the benefit of the George Municipality for understanding current impacts and where facilities are likely to contribute more to environmental pollution versus other parts of the same facility.

6 Conclusions and Recommendations

Monitoring borehole positions was selected based on available site information, expected groundwater flow pathways (source-pathway-receptor principles) and accessibility of a drill rig to the drill sites.

The monitoring boreholes at the George WWTWs were drilled via conventional air percussion methods and constructed to ensure integrity as monitoring boreholes. The boreholes were subjected to a baseline groundwater monitoring and sampling event and the laboratory results returned indicated long term seepage into the clayey weathered granites that underlies both the George WWTWs process and containment facilities.

Groundwater at the sites flows in a south, south-easterly and south-westerly direction toward the Skaapkop River for Outeniqua WWTW and in a mainly south-westerly direction towards the Gwaing River for Gwaing WWTW. The calculated groundwater flow gradient for the aquifers across both sites ranged between 0.02 and 0.023.

Monitoring Programme

The monitoring programme, as described in section 5 of this report accompanied by detailed groundwater monitoring procedures included in Appendix D, was designed to ensure that the groundwater monitoring and sampling objectives are met as stipulated in the George WULs.

The groundwater monitoring programme should be implemented on a quarterly basis and scheduled accordingly to ensure regular intervals. An example of a schedule is provided in Table 6:1 below.

Table 6:1 – Sampling Schedule Example

Year	Baseline	Quarter 1	Quarter 2	Quarter 3	Quarter 4
1	April 2021	July 2021	October 2021	January 2022	April 2022

The monitoring information should be evaluated after one year's monitoring data is gathered, to adjust the monitoring programme if necessary.

Groundwater Impacts

Parsons (2017) noted, from hydrocensus information, the absence of boreholes actively being used by neighbouring properties in the vicinities of both George WWTWs. The closest boreholes where north of the current site, while groundwater flows to the south. Therefore, no groundwater users exist downstream of the sites that can be impacted.

The main environmental impact from the GWWTWs remains the long-term seepage from the facilities into the sub-surface and discharge in the weathered zone of the nearby rivers.

7 References

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Council for Geoscience. (1978). 1:250 000 Geological Map 3322 Oudtshoorn. The Government Printer, Pretoria.

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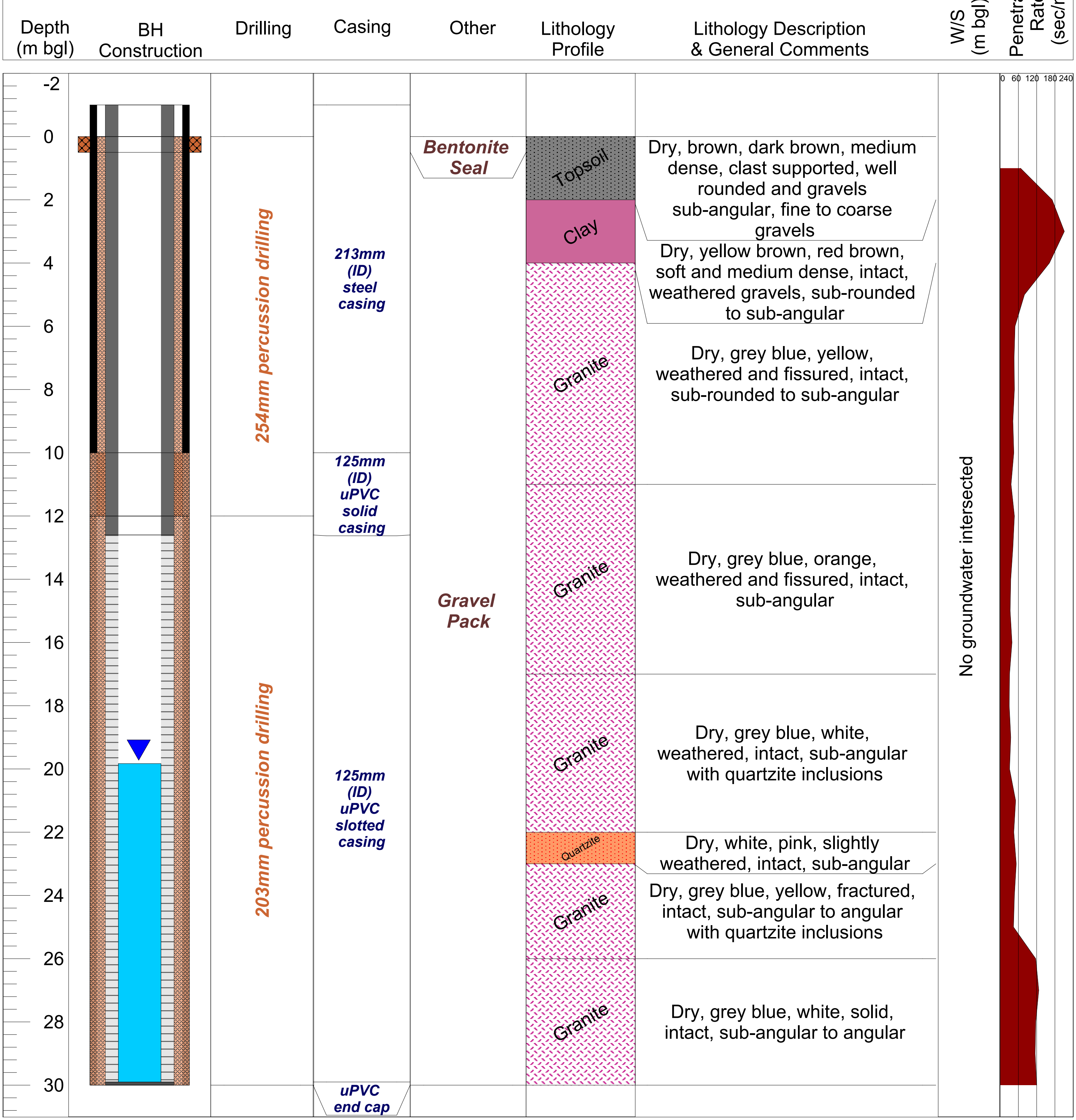
ANNEXURE A

BOREHOLE DRILLING LOGS

BOREHOLE GEOLOGICAL AND CONSTRUCTION LOG



PROJECT: WWTW - Outeniqua

BH NO: OQ 01

DATE COMPLETED: 26 March 2021

BH CO-ORDINATES: -34.00446 / 22.46223

CONTRACTOR: Steyn's Drilling

DRILLER: Oom Johan

DRILLED DEPTH (m): 30

LOGGED BY: JvR

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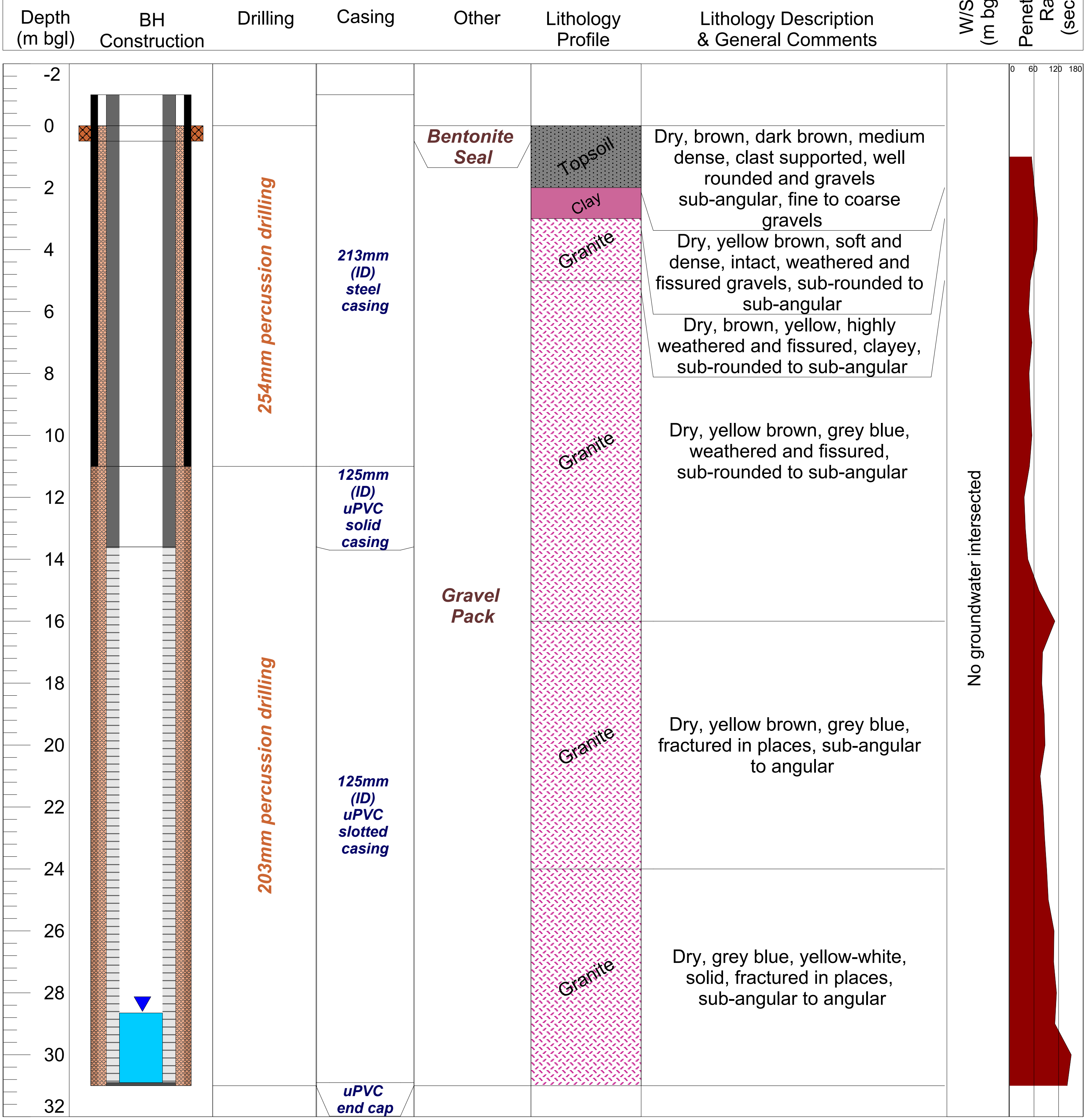
BOREHOLE GEOLOGICAL AND CONSTRUCTION LOG



PROJECT: WWTW - Outeniqua

BH NO: OQ 02

DATE COMPLETED: 27 March 2021

BH CO-ORDINATES: -34.00601 / 22.46531

CONTRACTOR: Steyn's Drilling

DRILLER: Oom Johan

DRILLED DEPTH (m): 31

LOGGED BY: JvR

BOREHOLE GEOLOGICAL AND CONSTRUCTION LOG

Depth (m bgl)	BH Construction	Drilling	Casing	Other	Lithology Profile	Lithology Description & General Comments	W/S (m bgl)	Penetration Rates (sec/min)
0 – 1		254mm percussion drilling (0 – 12)	213mm (ID) steel casing (0 – 12)	Bentonite Seal	Topsoil	Dry, brown, light brown, chocolate brown, medium dense, clast supported, well rounded and gravels sub-angular, fine to coarse gravels	No groundwater intersected	
1 – 5.5					Granite			
5.5 – 12				Gravel Pack	Granite	Dry, grey blue, yellow, soft and dense clays, highly weathered and fractured gravels in places, sub-rounded to sub-angular		
12 – 14		203mm percussion drilling (12 – 40)	125mm (ID) uPVC solid casing		Granite	Dry, blue grey, white, slightly weathered, sub-angular with high mica content		
14 – 17					Granite	Dry, yellow brown, grey blue, clayey, weathered and fractured, sub-rounded to sub-angular		
17 – 26			125mm (ID) uPVC slotted casing		Granite	Dry, grey blue, yellow brown, clayey, weathered and fissured, sub-angular to angular		
26 – 28					Granite	Slightly moist, grey blue, yellow-white, clayey, highly weathered and fractured, sub-rounded to sub-angular, bigger gravels, 25m - unstable horizon		
28 – 35					Granite	Dry, blue grey, white, solid, sub-angular to angular		
35 – 38			uPVC end cap		Granite	Dry, grey blue, white, solid, sub-angular to angular with quartzite inclusions		
38 – 39					Granite	Slightly moist, yellow brown, grey blue, clayey, weathered, sub-rounded to sub-angular		
39 – 40					Granite	Dry, blue grey, white, solid, sub-angular to angular		

Penetration rate scale: 0, 60, 120, 180, 240

Depth scale: 0, 4, 8, 12, 16, 20, 24, 28, 32, 36, 40, 44

PROJECT: WWTW - Outeniqua

BH NO: OQ 03

DATE COMPLETED: 29 March 2021

BH CO-ORDINATES: -34.00699 / 22.46329

CONTRACTOR: Steyn's Drilling

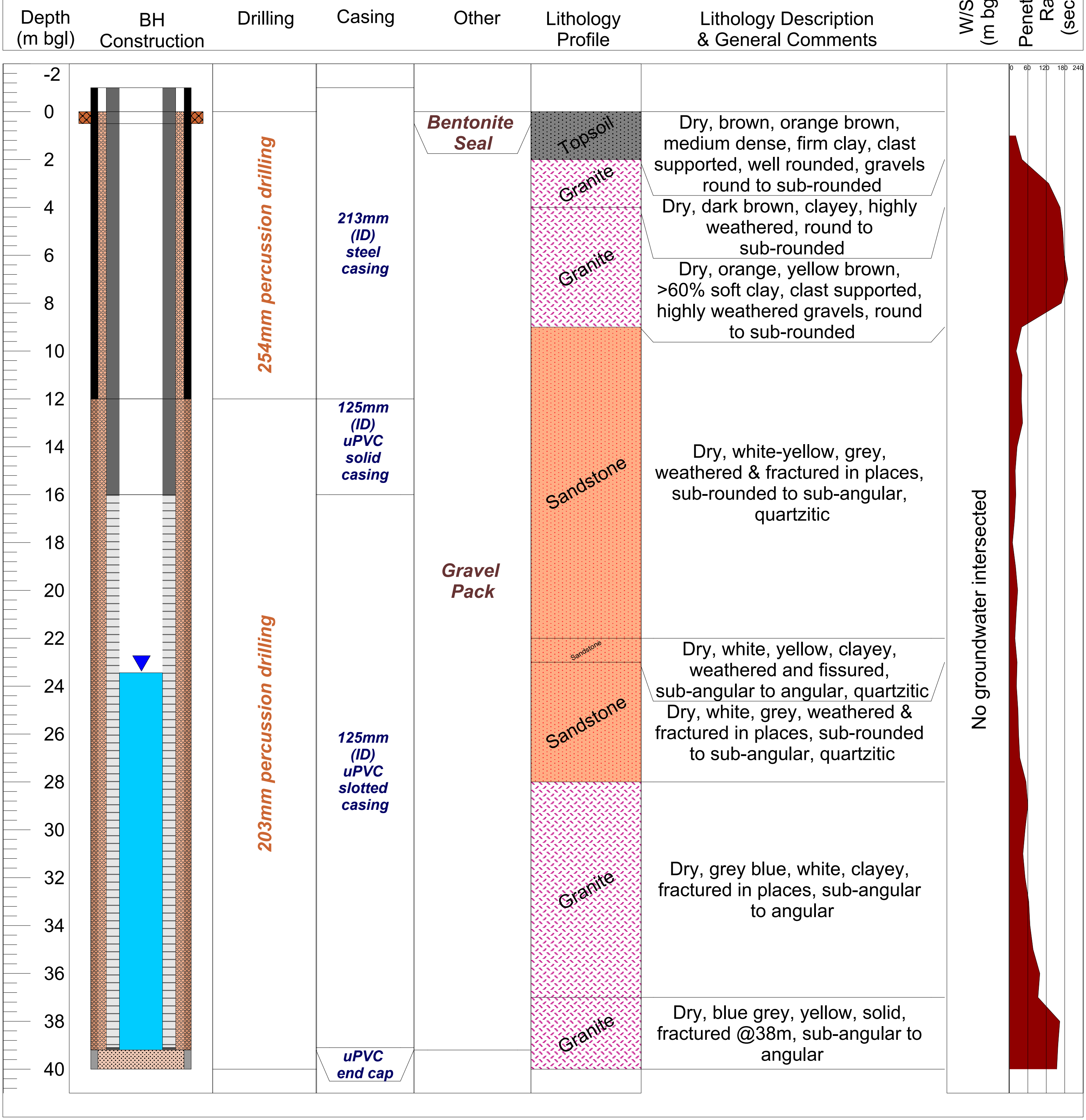
DRILLER: Oom Johan

DRILLED DEPTH (m): 40

LOGGED BY: JvR

Veltwater GROUNDWATER SPECIALISTS

BOREHOLE GEOLOGICAL AND CONSTRUCTION LOG



PROJECT: WWTW - Gwaing

BH NO: GN 01

DATE COMPLETED: 30 March 2021

BH CO-ORDINATES: -33.99361 / 22.42544

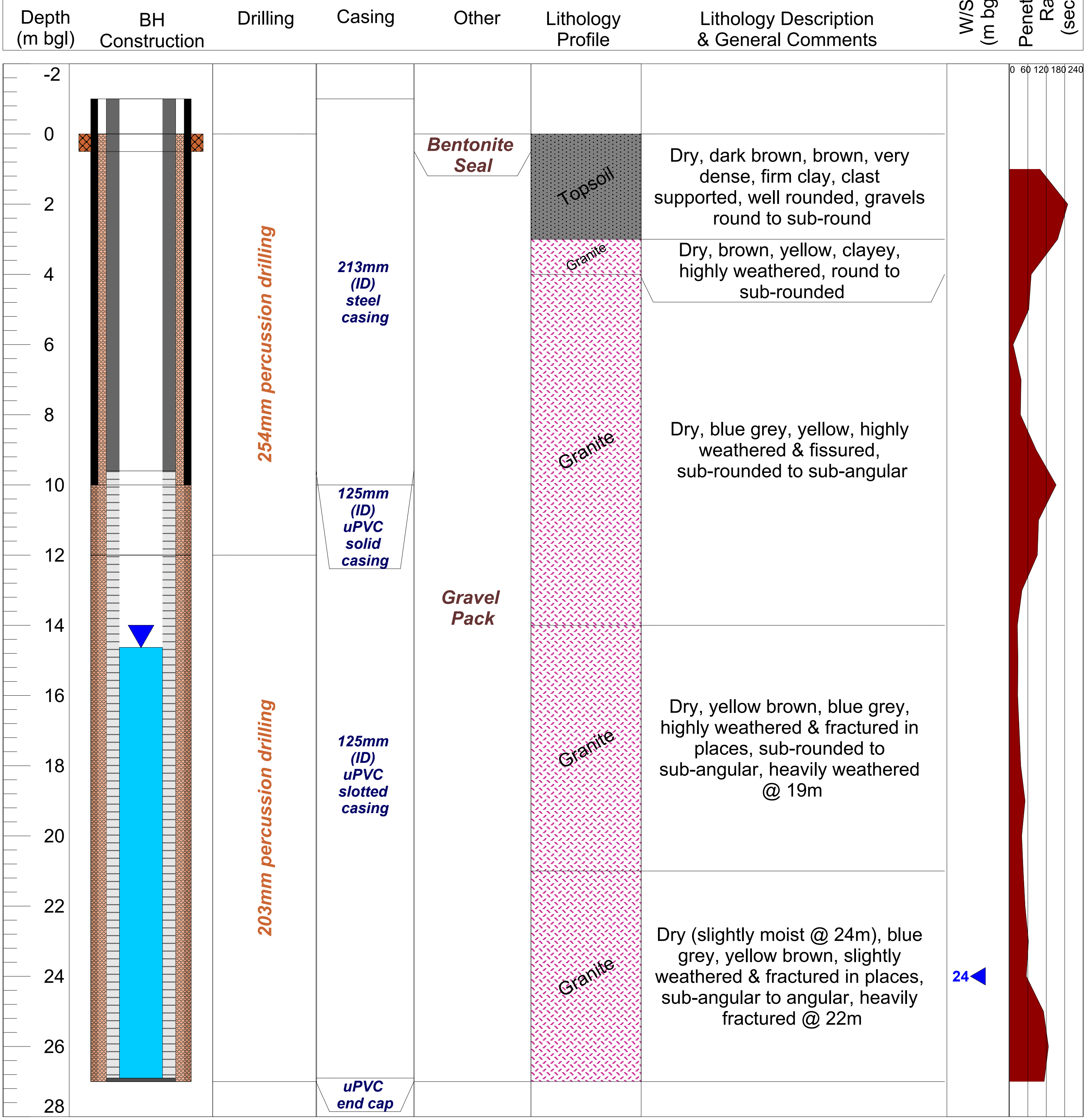
CONTRACTOR: Steyn's Drilling

DRILLER: Oom Johan

DRILLED DEPTH (m): 40

LOGGED BY: JvR

BOREHOLE GEOLOGICAL AND CONSTRUCTION LOG



PROJECT: WWTW - Gwaing

BH NO: GN 02

DATE COMPLETED: 31 March 2021

BH CO-ORDINATES: -33.998017 / 22.422219

CONTRACTOR: Steyn's Drilling

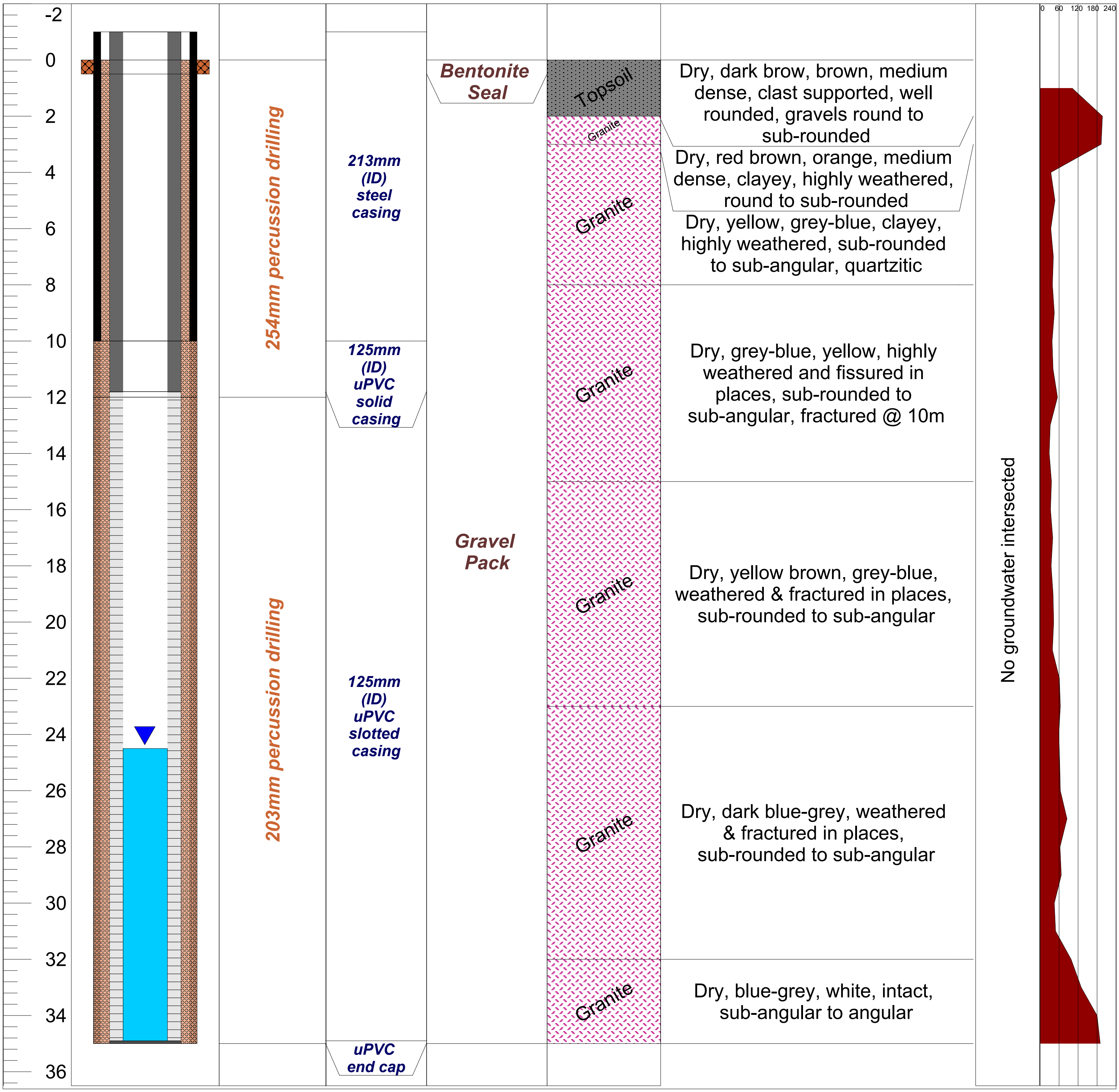
DRILLER: Oom Johan

DRILLED DEPTH (m): 27

LOGGED BY: JvR

Veltwater GROUNDWATER SPECIALISTS

BOREHOLE GEOLOGICAL AND CONSTRUCTION LOG



PROJECT: WWTW - Gwaing

BH NO: GN 03

DATE COMPLETED: 1 April 2021

BH CO-ORDINATES: -33.99779 / 22.41927

CONTRACTOR: Steyn's Drilling

DRILLER: Oom Johan

DRILLED DEPTH (m): 35

LOGGED BY: JvR

Veltwater
GROUNDWATER SPECIALISTS

ANNEXURE B

WATER QUALITY TEST REPORTS

Certificate of Analysis

Project details

Customer Details

Customer reference:	GEORGE WWTW
Quotation number:	Q2102-200_B
Company name:	VELTWATER CC
Contact address:	25 DS DF DU TOIT CRESCENT, GEORGE 6529
Contact person:	SONIA VELTMAN

Sampling Details

Sampled by:	CUSTOMER
Sampled date:	2021/04/07
Additional customer information:	007517/21- SAMPLED BY: S. VELTMAN, 007518/21- SAMPLED BY: S. VELTMAN, 007519/21- SAMPLED BY: S. VELTMAN, 007520/21- SAMPLED BY: S. VELTMAN, 007521/21- SAMPLED BY: S. VELTMAN, 007522/21- SAMPLED BY: S. VELTMAN, 007523/21- SAMPLED BY: S. VELTMAN, 007524/21- SAMPLED BY: S. VELTMAN, 007525/21- SAMPLED BY: S. VELTMAN

Sample Details

Sample type(s):	GROUNDWATER SAMPLES
Date received:	2021/04/12
Delivered by:	COURIER SERVICE
Additional customer information:	STRANGE ODOUR- POSSIBLE ORGANICS
Temperature at sample receipt (°C):	24.1

Report Details

Testing commenced:	2021/04/12
Testing completed:	2021/04/15
Report date:	2021/04/20
Our reference:	002468/21

Analytical Results

Methods	Determinands	Units	007517/21	007518/21
			GEORGE: KK01 07.04.2021	GEORGE: KK02 07.04.2021
Chemical				
85	Dissolved Calcium	mg Ca/ℓ	98	70
85	Dissolved Magnesium	mg Mg/ℓ	11.1	18.2
84	Sodium	mg Na/ℓ	124	133
83A	Aluminium	µg Al/ℓ	37	32
83A	Copper	µg Cu/ℓ	<1	1.304
83A	Iron	µg Fe/ℓ	87	21
83A	Manganese	µg Mn/ℓ	50	25
83A	Lead	µg Pb/ℓ	2.814	1.373
10G	Total Alkalinity	mg $CaCO_3$/ℓ	207	136
16G	Chloride	mg Cl/ℓ	109	112
123	Free Chlorine*	mg Cl_2/ℓ	<0.1	<0.1
122	Monochloramine*	mg/ℓ	<3	<3
3	Chemical Oxygen Demand (Total)	mg O_2/ℓ	40	40
40A	Colour (True)*	mg Pt-Co/ℓ	<10	<10
2A	Electrical Conductivity at 25°C	mS/m	120	117
18G	Fluoride	mg F/ℓ	0.40	0.32
Calc.	Ammonium*	mg NH_4/ℓ	<1.93	<1.93
65Gc	Nitrate	mg N/ℓ	1.7	**16.1**
65Gb	Nitrite	mg N/ℓ	<0.05	0.07
Calc.	Combined Nitrate + Nitrite (sum of Ratios)*	-	0.21	**1.5**
4	Turbidity	NTU	**45**	**12**
1	pH at 25°C	pH units	7.0	7.1
66G	Orthophosphate	mg P/ℓ	<0.1	<0.1
67G	Sulphate	mg SO_4/ℓ	42.8	42.7
5	Suspended Solids at 105°C	mg/ℓ	96	52
Calc.	Total Hardness*	mg $CaCO_3$/ℓ	290	249
Microbiological				
32	*E.coli*	MPN/100mℓ	<1 (Not detected)	**6**
32	Total Coliforms	MPN/100mℓ	**1553**	**1986**
31	Standard Plate Count	colonies/mℓ	**>10000**	**>10000**

Methods	Determinands	Units	007519/21	007520/21
			GEORGE: KK03 07.04.2021	GEORGE: GN01 07.04.2021
Chemical				
85	Dissolved Calcium	mg Ca/ℓ	106	174

Methods	Determinands	Units	007519/21	007520/21
			GEORGE: KK03 07.04.2021	GEORGE: GN01 07.04.2021
85	Dissolved Magnesium	mg Mg/ℓ	19.4	120
84	Sodium	mg Na/ℓ	132	**2225**
83A	Aluminium	µg Al/ℓ	249	48
83A	Copper	µg Cu/ℓ	8.442	1.301
83A	Iron	µg Fe/ℓ	268	174
83A	Manganese	µg Mn/ℓ	31	**765**
83A	Lead	µg Pb/ℓ	3.106	3.153
10G	Total Alkalinity	mg $CaCO_3$/ℓ	196	191
16G	Chloride	mg Cl/ℓ	105	**2744**
123	Free Chlorine*	mg Cl_2/ℓ	<0.1	<0.1
122	Monochloramine*	mg/ℓ	<3	<3
3	Chemical Oxygen Demand (Total)	mg O_2/ℓ	48	133
40A	Colour (True)*	mg Pt-Co/ℓ	<10	<10
2A	Electrical Conductivity at 25°C	mS/m	134	**1019**
18G	Fluoride	mg F/ℓ	0.43	0.50
Calc.	Ammonium*	mg NH_4/ℓ	<1.93	<1.93
65Gc	Nitrate	mg N/ℓ	**24.0**	0.9
65Gb	Nitrite	mg N/ℓ	<0.05	<0.05
Calc.	Combined Nitrate + Nitrite (sum of Ratios)*	-	**2.2**	0.14
4	Turbidity	NTU	**171**	**6.9**
1	pH at 25°C	pH units	7.1	6.8
66G	Orthophosphate	mg P/ℓ	<0.1	<0.1
67G	Sulphate	mg SO_4/ℓ	58.7	139
5	Suspended Solids at 105°C	mg/ℓ	189	59
Calc.	Total Hardness*	mg $CaCO_3$/ℓ	343	930
Microbiological				
32	*E.coli*	MPN/100mℓ	<1 (Not detected)	**35**
32	Total Coliforms	MPN/100mℓ	**2420**	**41060**
31	Standard Plate Count	colonies/mℓ	**>10000**	**>10000**

Methods	Determinands	Units	007521/21	007522/21
			GEORGE: GN02 07.04.2021	GEORGE: GN03 07.04.2021
Chemical				
85	Dissolved Calcium	mg Ca/ℓ	30	7.89
85	Dissolved Magnesium	mg Mg/ℓ	20	4.02
84	Sodium	mg Na/ℓ	**651**	**336**
83A	Aluminium	µg Al/ℓ	126	156
83A	Copper	µg Cu/ℓ	4.419	1.24

Methods	Determinands	Units	007521/21	007522/21
			GEORGE: GN02 07.04.2021	GEORGE: GN03 07.04.2021
83A	Iron	µg Fe/ℓ	152	90
83A	Manganese	µg Mn/ℓ	333	68
83A	Lead	µg Pb/ℓ	1.589	<1
10G	Total Alkalinity	mg $CaCO_3$/ℓ	153	294
16G	Chloride	mg Cl/ℓ	**639**	125
123	Free Chlorine*	mg Cl_2/ℓ	<0.1	<0.1
122	Monochloramine*	mg/ℓ	<3	<3
3	Chemical Oxygen Demand (Total)	mg O_2/ℓ	52	32
40A	Colour (True)*	mg Pt-Co/ℓ	<10	<10
2A	Electrical Conductivity at 25°C	mS/m	**320**	144
18G	Fluoride	mg F/ℓ	0.59	**2.35**
Calc.	Ammonium*	mg NH_4/ℓ	<1.93	<1.93
65Gc	Nitrate	mg N/ℓ	0.86	3.85
65Gb	Nitrite	mg N/ℓ	<0.05	<0.05
Calc.	Combined Nitrate + Nitrite (sum of Ratios)*	-	0.13	0.41
4	Turbidity	NTU	**10**	**13**
1	pH at 25°C	pH units	7.3	7.7
66G	Orthophosphate	mg P/ℓ	<0.1	<0.1
67G	Sulphate	mg SO_4/ℓ	65.3	21.3
5	Suspended Solids at 105°C	mg/ℓ	44	<18
Calc.	Total Hardness*	mg $CaCO_3$/ℓ	159	36
Microbiological				
32	*E.coli*	MPN/100mℓ	**3**	**24**
32	Total Coliforms	MPN/100mℓ	**57940**	**26130**
31	Standard Plate Count	colonies/mℓ	**>10000**	**>10000**

Methods	Determinands	Units	007523/21	007524/21
			GEORGE: OQ01 07.04.2021	GEORGE: OQ02 07.04.2021
Chemical				
85	Dissolved Calcium	mg Ca/ℓ	79	232
85	Dissolved Magnesium	mg Mg/ℓ	57	276
84	Sodium	mg Na/ℓ	**1383**	**1493**
83A	Aluminium	µg Al/ℓ	81	**534**
83A	Copper	µg Cu/ℓ	2.723	6.336
83A	Iron	µg Fe/ℓ	41	**2733**
83A	Manganese	µg Mn/ℓ	44	**626**
83A	Lead	µg Pb/ℓ	2.068	8.198
10G	Total Alkalinity	mg $CaCO_3$/ℓ	235	81

Methods	Determinands	Units	007523/21 GEORGE: OQ01 07.04.2021	007524/21 GEORGE: OQ02 07.04.2021
16G	Chloride	mg Cl/ℓ	**1621**	**2606**
123	Free Chlorine*	mg Cl_2/ℓ	<0.1	<0.1
122	Monochloramine*	mg/ℓ	<3	<3
3	Chemical Oxygen Demand (Total)	mg O_2/ℓ	76	233
40A	Colour (True)*	mg Pt-Co/ℓ	<10	<10
2A	Electrical Conductivity at 25°C	mS/m	**700**	**944**
18G	Fluoride	mg F/ℓ	0.71	0.82
Calc.	Ammonium*	mg NH_4/ℓ	<1.93	<1.93
65Gc	Nitrate	mg N/ℓ	0.27	<0.25
65Gb	Nitrite	mg N/ℓ	<0.05	<0.05
Calc.	Combined Nitrate + Nitrite (sum of Ratios)*	-	<0.12	<0.12
4	Turbidity	NTU	4.2	**444**
1	pH at 25°C	pH units	7.0	6.9
66G	Orthophosphate	mg P/ℓ	0.16	<0.1
67G	Sulphate	mg SO_4/ℓ	144	148
5	Suspended Solids at 105°C	mg/ℓ	32	1165
Calc.	Total Hardness*	mg $CaCO_3$/ℓ	430	1718
Microbiological				
32	*E.coli*	MPN/100mℓ	<1 (Not detected)	**188**
32	Total Coliforms	MPN/100mℓ	**24196**	**241960**
31	Standard Plate Count	colonies/mℓ	**>10000**	**>10000**

Methods	Determinands	Units	007525/21 GEORGE: OQ03 07.04.2021
Chemical			
85	Dissolved Calcium	mg Ca/ℓ	93
85	Dissolved Magnesium	mg Mg/ℓ	166
84	Sodium	mg Na/ℓ	**1438**
83A	Aluminium	µg Al/ℓ	188
83A	Copper	µg Cu/ℓ	2.698
83A	Iron	µg Fe/ℓ	240
83A	Manganese	µg Mn/ℓ	**1745**
83A	Lead	µg Pb/ℓ	3.376
10G	Total Alkalinity	mg $CaCO_3$/ℓ	73
16G	Chloride	mg Cl/ℓ	**2199**
123	Free Chlorine*	mg Cl_2/ℓ	<0.1
122	Monochloramine*	mg/ℓ	<3
3	Chemical Oxygen Demand (Total)	mg O_2/ℓ	80

Methods	Determinands	Units	007525/21
			GEORGE: OQ03 07.04.2021
40A	Colour (True)*	mg Pt-Co/ℓ	<10
2A	Electrical Conductivity at 25°C	mS/m	**839**
18G	Fluoride	mg F/ℓ	0.40
Calc.	Ammonium*	mg NH_4/ℓ	<1.93
65Gc	Nitrate	mg N/ℓ	0.97
65Gb	Nitrite	mg N/ℓ	<0.05
Calc.	Combined Nitrate + Nitrite (sum of Ratios)*	-	0.14
4	Turbidity	NTU	**20**
1	pH at 25°C	pH units	6.9
66G	Orthophosphate	mg P/ℓ	<0.1
67G	Sulphate	mg SO_4/ℓ	166
5	Suspended Solids at 105°C	mg/ℓ	58
Calc.	Total Hardness*	mg $CaCO_3$/ℓ	916
Microbiological			
32	*E.coli*	MPN/100mℓ	**10**
32	Total Coliforms	MPN/100mℓ	**1986**
31	Standard Plate Count	colonies/mℓ	**>10000**

Refer to the “Notes” section at the end of this report for further explanations.

Where the laboratory detection limit for a test is higher than the required specification limit, the raw data is reviewed and the detection limit highlighted in bold font if outside of specification.

Specific Observations

Results that appear in bold do not meet the specification limits in Appendix 1 of this report.

Quality Assurance

Technical signatories

Notes to this report

Limitations

This report shall not be reproduced except in full without prior written approval of the laboratory.
Results in this report relate only to the samples as taken, and the condition received by the laboratory.
Any opinions and interpretations expressed herein are outside the scope of SANAS accreditation.
The decision rule applicable to this laboratory is available on request.
Sample preparation may require filtration, dilution, digestion or similar. Final results are reported accordingly.
Where the laboratory has undertaken the sampling, the location of sampling and sampling plan are available on request. Talbot Laboratories is guided by the National Standards SANS 5667-3:2006 Part 3 Guidance on the Preservation and Handling of Water Samples; SANS 5667-1:2008 Part 1 Guidance on the Design of Sampling Programmes and Sampling Techniques and SANS 5667-2:1991 Part 2: Guidance on Sampling Techniques.
Customers to contact Talbot Laboratories for further information.

Uncertainty of measurement

Talbot Laboratories' Uncertainty of Measurement (UoM) values are:

- Identified for relevant tests.
- Calculated as a percentage of the respective results.
- Applicable to total, dissolved and acid soluble metals for ICP element analyses.
- Available upon request.

Analysis explanatory notes

Tests may be marked as follows:

^	Tests conducted at our Port Elizabeth satellite laboratory.
*	Tests not included in our Schedule of Accreditation and therefore that are not SANAS accredited.
#	Tests that have been sub-contracted to a peer laboratory.
NR	Not required -shown, for example, where the schedule of analysis varied between samples.
σ	Field sampling point on-site results.
a	Testing has deviated from Method.

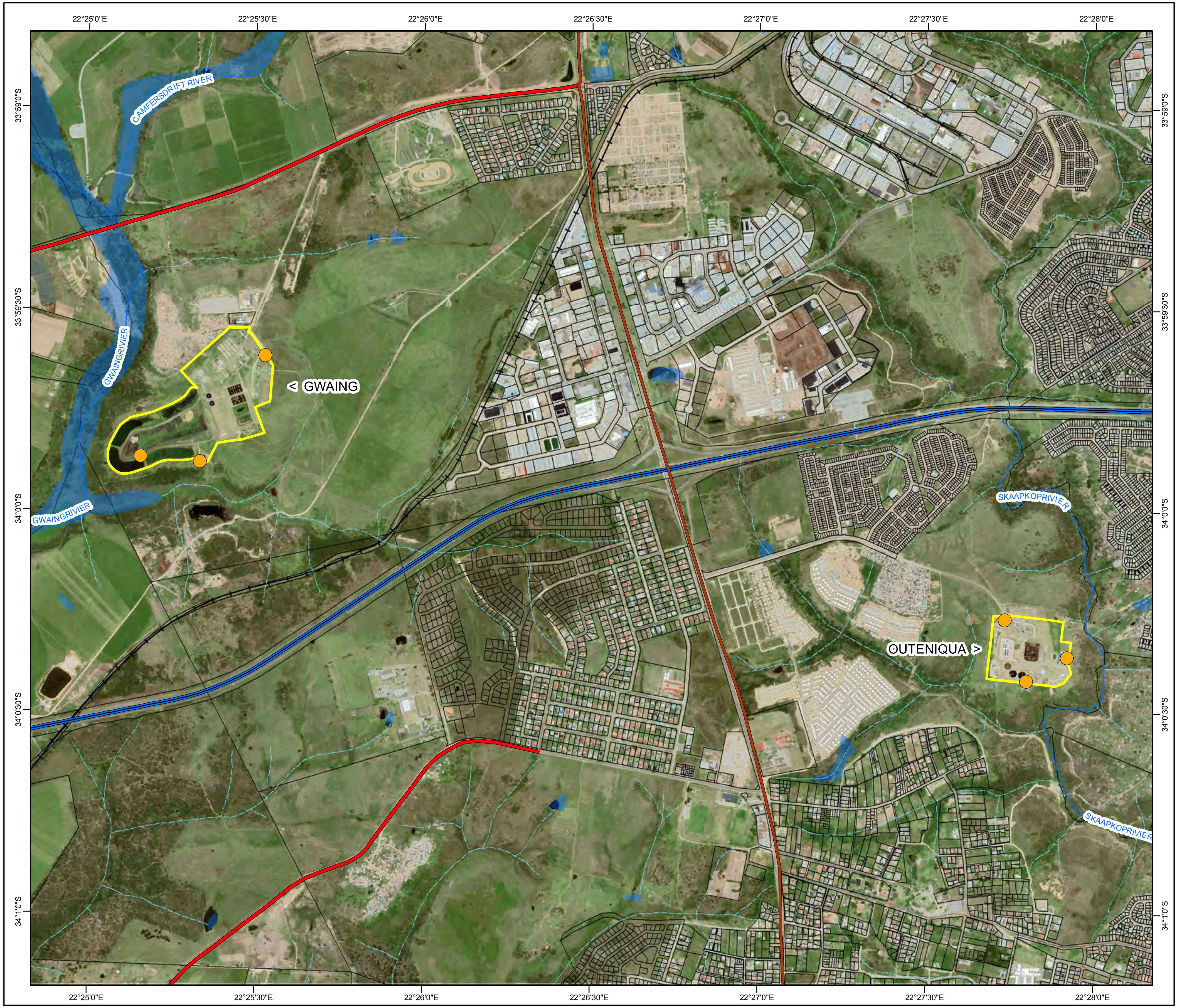
Appendix 1: Specifications - SANS 241-1:2015 RECOMMENDED LIMITS

Reported Determinands	Limits	Reported Determinands	Limits
E.coli	0 Count/100mℓ (0 MPN/100mℓ)	Zinc	≤5000 µg/l (≤5 mg/ℓ)
Faecal Coliforms	0 Count/100mℓ (0 MPN/100mℓ)	Antimony	≤20 µg/ℓ (≤0.02 mg/ℓ)
Cryptosporidium species	Not Detected	Arsenic	≤10 µg/ℓ (≤0.01 mg/ℓ)
Giardia species	Not Detected	Barium	≤700 µg/ℓ (≤0.7 mg/ℓ)
Total Coliforms	≤10 Count/100mℓ (10 MPN/100mℓ)	Boron	≤2400 µg/ℓ (≤2.4 mg/ℓ)
Standard Plate Count	≤1000 Count/1mℓ	Cadmium	≤3 µg/ℓ (≤0.003 mg/ℓ)
Somatic Coliphages	Not Detected	Total Chromium	≤50 µg/ℓ (≤0.05 mg/ℓ)
Cytopathogenic viruses	Not detected	Copper	≤2000 µg/ℓ (≤2 mg/ℓ)
Enteric Virus (Sub#)	Not Detected	Cyanide	≤200 µg/ℓ (≤0.2 mg/ℓ)
Colour	≤15 mg/ℓ Pt-Co	Iron	Chronic: ≤ 2000 µg/ℓ (≤2 mg/ℓ)
Electrical Conductivity	≤170 mS/m	Iron	Aesthetic: ≤ 300 µg/ℓ (≤0.3 mg/ℓ)
Total Dissolved Solids at 180°C	≤1200 mg/ℓ	Lead	≤10 µg/ℓ (≤0.01 mg/ℓ)
Turbidity	Operational ≤1 NTU	Manganese	Chronic: ≤ 400 µg/ℓ (≤0.4 mg/ℓ)
Turbidity	Aesthetic ≤5 NTU	Manganese	Aesthetic: ≤100 µg/ℓ (≤0.1 mg/ℓ)
pH	≥ 5 to ≤ 9.7	Mercury	≤6 µg/ℓ (≤0.006 mg/ℓ)
Odour	Inoffensive	Nickel	≤70 µg/ℓ (≤0.07 mg/ℓ)
Free Chlorine	≤5 mg/ℓ	Selenium	≤40 µg/ℓ (≤0.04 mg/ℓ)
Monochloramine	≤3000 µg/ℓ (≤3 mg/ℓ)	Uranium	≤30 µg/ℓ (≤0.03 mg/ℓ)
Nitrate	≤11 mg/ℓ	Aluminium	≤300 µg/ℓ (≤0.3 mg/ℓ)
Nitrite	≤0.9 mg/ℓ	Total Organic Carbon	≤10 mg/ℓ
Combined Nitrate plus Nitrite (sum of Ratios)	≤1	Chloroform	≤300 µg/ℓ (≤0.3 mg/ℓ)
Sulphate	Acute: ≤ 500 mg/ℓ	Bromoform	≤100 µg/ℓ (≤0.1 mg/ℓ)
Sulphate	Aesthetic: ≤ 250 mg/ℓ	Dibromochloromethane	≤100 µg/ℓ (≤0.1 mg/ℓ)
Fluoride	≤1500 µg/ℓ (≤1.5 mg/ℓ)	Bromodichloromethane	≤60 µg/ℓ (≤0.06 mg/ℓ)
Ammonia	≤1.5 mg/ℓ	Trihalomethanes Ratio	≤1
Chloride	≤ 300 mg/ℓ	Microcystins	≤1 µg/ℓ
Sodium	≤200 mg/ℓ	Phenols	≤10 µg/ℓ (≤0.01 mg/ℓ)

End of Report

ANNEXURE C

MAPS



Outeniqua & Gwaing WWTW

- Site boundary
- Erf boundary
- National road
- Trunk road
- Divisional road
- Main road
- Railway line
- Perennial river
- Non-perennial river
- Water body

N

0 250 500 750 1 000
m

CLIENT:
George Municipality

TITLE:
Drawing 1 : Site locality map

GEORGE
THE CITY FOR ALL REASONS

WPCP
WATER PURIFICATION CHEMICAL & PLANT

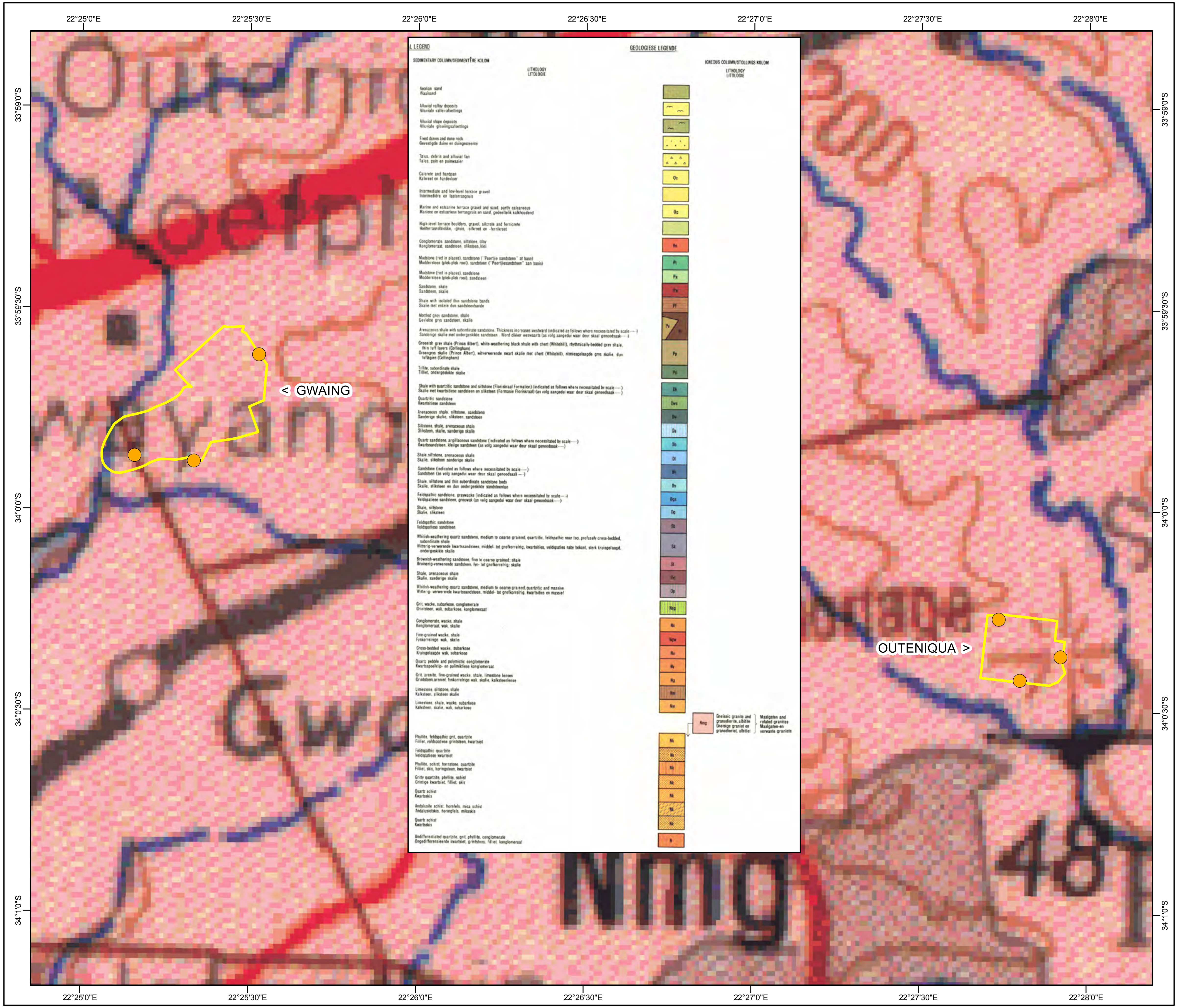
DATE: APRIL 2021	
DRAWN: MV	
CHECKED:	
APPROVED:	
PROJECT:	
SCALE: 1:17 000	
DRAWING: Projects/Marian/MF/SV	REF:

Sonia Veltman • Principal Hydrogeologist • Mobile + 27 74 041 1444
George
South Africa

Veltwater
GROUNDWATER SPECIALISTS

Projection: Geographic. Datum: Hartebeeshoek 1994
Source: Surveyor General
Insert: ESRI Data and Maps, Google Image: Nov 2020
Map design by: Digital Signature, Marian Viljoen, 082 90 33 272

SIZE: A3



Outeniqua & Gwaing WWTW

Site boundary

N

0 250 500 750 1 000
m

CLIENT:
George Municipality

TITLE:
Drawing 2 : Geology map

GEORGE THE CITY FOR ALL REASONS

WPCP WATER PURIFICATION CHEMICAL & PLANT

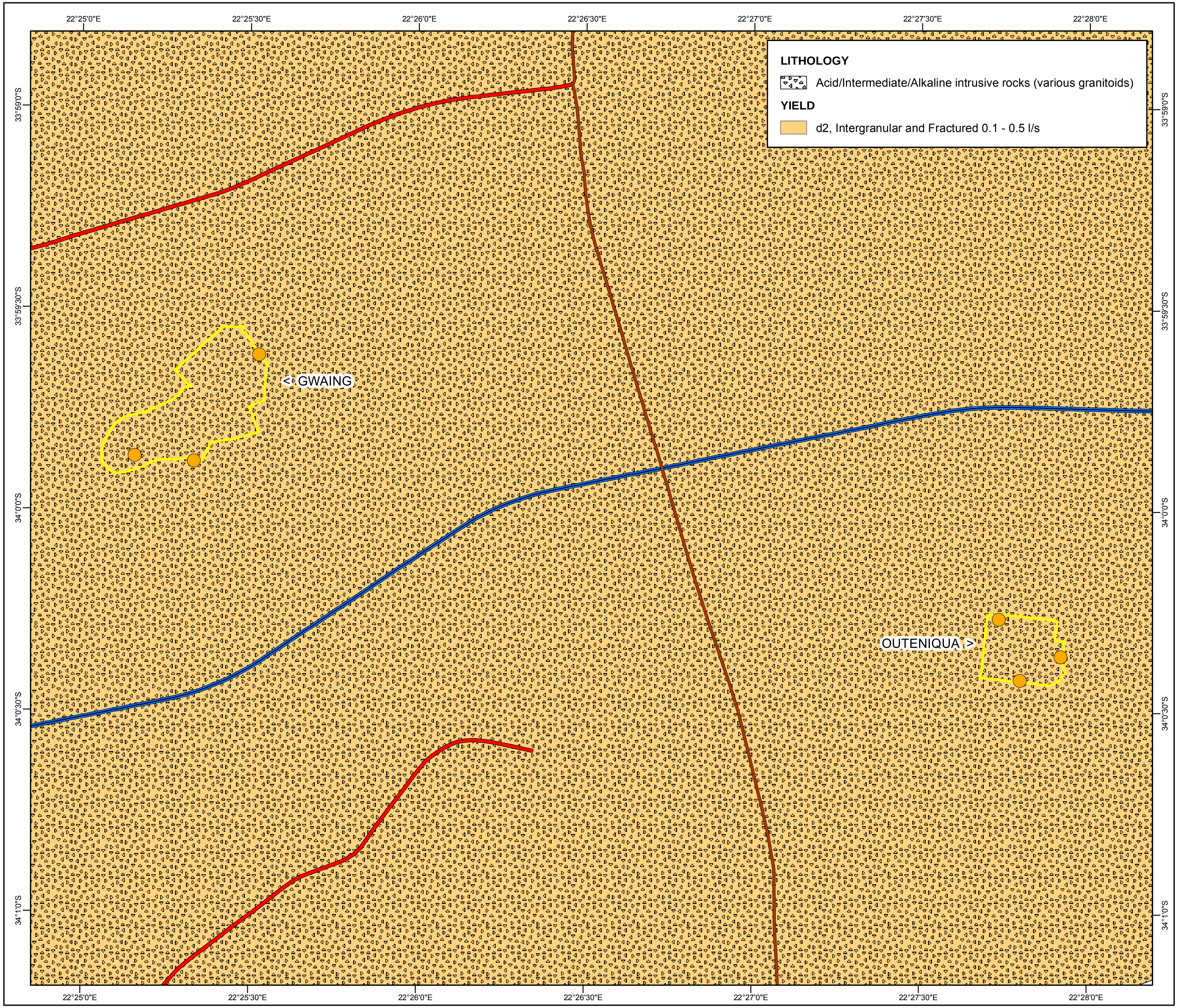
DATE: APRIL 2021	
DRAWN: MV	
CHECKED:	
APPROVED:	
PROJECT:	
SCALE: 1:17 000	
DRAWING: Projects/Marian/MF/SV	REF:

Sonia Veltman ● Principal Hydrogeologist ● Mobile + 27 74 041 1444
George
South Africa

Veltwater GROUNDWATER SPECIALISTS

Projection: Geographic. Datum: Hartebeesthoek 1994
Source: Surveyor General
Insert: ESRI Data and Maps, Google Image: Nov 2020
Map design by: Digital Signature, Marian Viljoen, 082 90 33 272

SIZE:
A3



Outeniqua & Gwayang WWTW

- Site boundary
- National road
- Trunk road
- Divisional road
- Main road

N

0 250 500 750 1 000

m

CLIENT:

George Municipality

TITLE:

Drawing 3 : Hydrogeology map

GEORGE THE CITY FOR ALL REASONS

WPCP WATER PURIFICATION CHEMICAL & PLANT

DATE: APRIL 2021	
DRAWN: MV	
CHECKED:	
APPROVED:	
PROJECT:	
SCALE: 1:17 000	
DRAWING: Projects/Marian/MF/SV	REF:

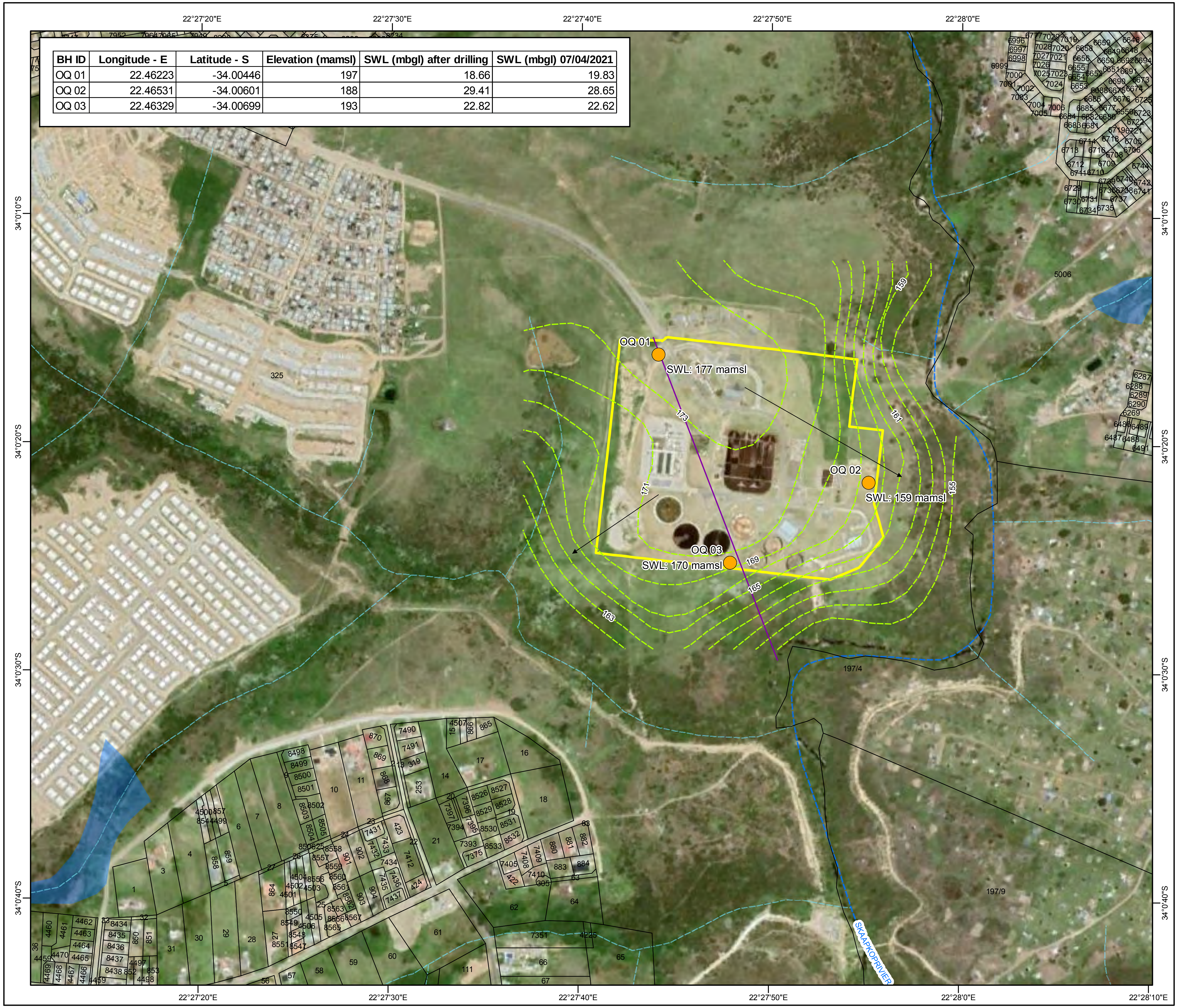
Sonia Veltman • Principal Hydrogeologist • Mobile + 27 74 041 1444
George
South Africa

Veltwater GROUNDWATER SPECIALISTS

Projection: Geographic. Datum: Hartebeeshoek 1994
Source: Surveyor General
Insert: ESRI Data and Maps, Google Image: Nov 2020
Map design by: Digital Signature, Marian Viljoen, 082 90 33 272

SIZE: A3

BH ID	Longitude - E	Latitude - S	Elevation (mamsl)	SWL (mbgl) after drilling	SWL (mbgl) 07/04/2021
OQ 01	22.46223	-34.00446	197	18.66	19.83
OQ 02	22.46531	-34.00601	188	29.41	28.65
OQ 03	22.46329	-34.00699	193	22.82	22.62



Outeniqua WWTW

- Site boundary
- Monitoring BHs
- Flow direction
- Cross-section
- Contours
- Erf boundary
- National road
- Trunk road
- Divisional road
- Main road
- Railway line
- Perennial river
- Non-perennial river
- Water body

N

0 100 200 300
m

CLIENT:
George Municipality

TITLE:
Drawing 4: Monitoring boreholes and groundwater flow - OUTENIQUA

GEORGE THE CITY FOR ALL REASONS

WPCP WATER PURIFICATION CHEMICAL & PLANT cc

DATE: MAY 2021	
DRAWN: MV	
CHECKED:	
APPROVED:	
PROJECT:	
SCALE: 1:5 000	
DRAWING: Projects/Marian/MF/SV	REF:

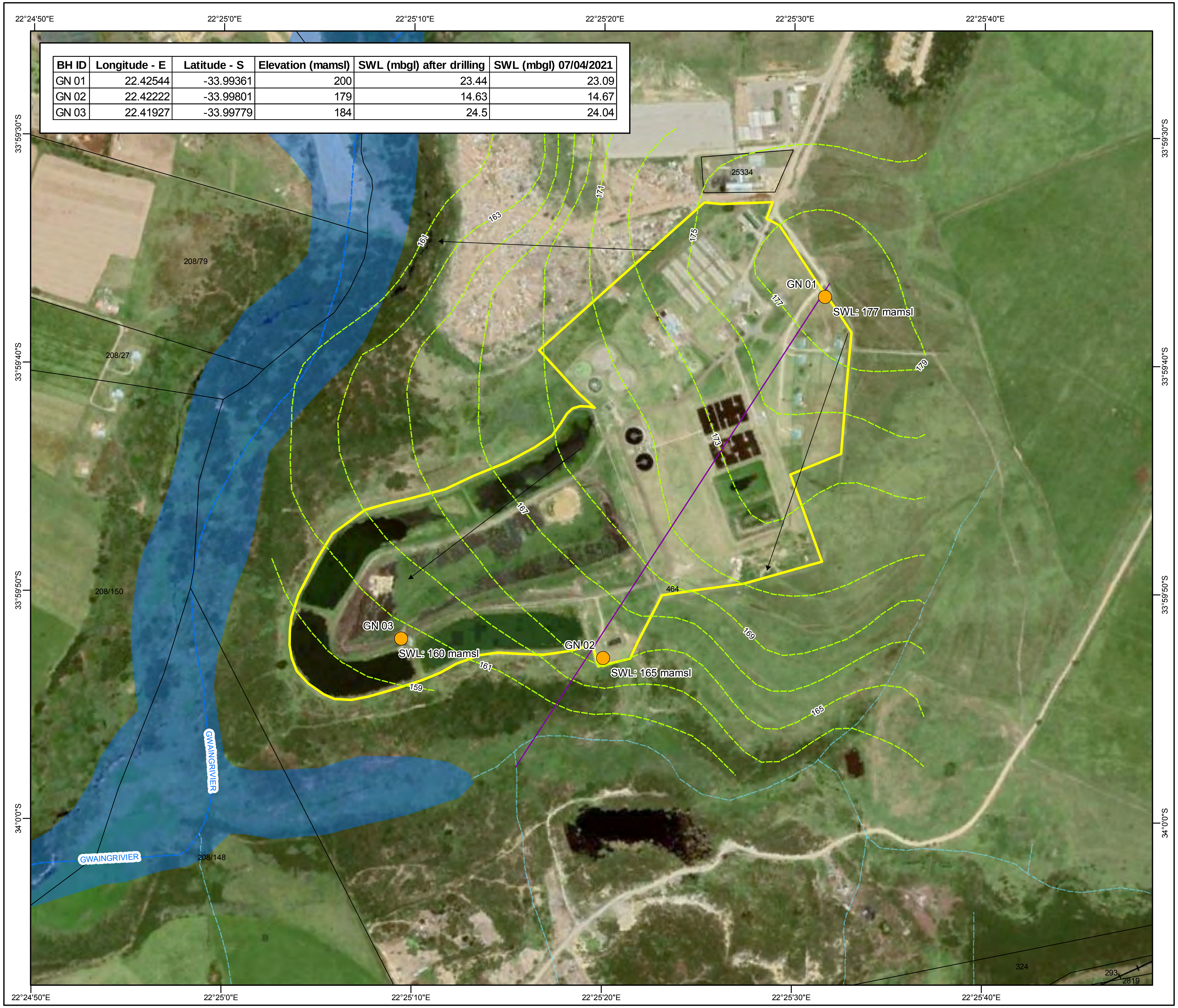
Sonia Veltman • Principal Hydrogeologist • Mobile + 27 74 041 1444
George
South Africa

Veltwater GROUNDWATER SPECIALISTS

Projection: Geographic. Datum: Hartebeeshoek 1994
Source: Surveyor General
Insert: ESRI Data and Maps, Google Image: Nov 2020
Map design by: Digital Signature, Marian Viljoen, 082 90 33 272

SIZE: A3

BH ID	Longitude - E	Latitude - S	Elevation (mamsl)	SWL (mbgl) after drilling	SWL (mbgl) 07/04/2021
GN 01	22.42544	-33.99361	200	23.44	23.09
GN 02	22.42222	-33.99801	179	14.63	14.67
GN 03	22.41927	-33.99779	184	24.5	24.04



Gwaing WWTW

- Site boundary
- Monitoring BHs
- Flow direction
- Cross-section
- Contours
- Erf boundary
- National road
- Trunk road
- Divisional road
- Main road
- Railway line
- Perennial river
- Non-perennial river
- Water body

N

0 100 200 300

m

CLIENT:

George Municipality

TITLE:

Drawing 5: Monitoring boreholes and groundwater flow - GWAING

GEORGE THE CITY FOR ALL REASONS

WPCP WATER PURIFICATION CHEMICAL & PLANT

DATE: MAY 2021

DRAWN: MV

CHECKED:

APPROVED:

PROJECT:

SCALE: 1:5 000

DRAWING: Projects/Marian/MF/SV

REF:

Sonia Veltman • Principal Hydrogeologist • Mobile + 27 74 041 1444
George
South Africa

Veltwater GROUNDWATER SPECIALISTS

Projection: Geographic. Datum: Hartebeesthoek 1994
Source: Surveyor General
Insert: ESRI Data and Maps, Google Image: Nov 2020
Map design by: Digital Signature, Marian Viljoen, 082 90 33 272

SIZE: A3

ANNEXURE D

GROUNDWATER MONITORING PROCEDURES

General

The groundwater monitoring procedures at the George WWTWs include, but is not limited to, the following activities and considerations:

- Sampling equipment required, including field probes, bottles, preservatives, filters;
- Timeframes within which the sample remains viable for analysis of various parameters without jeopardizing data quality (holding times);
- Water level measurements; and
- Templates for recording field data.

Equipment Maintenance and Repair

Prior to sampling, equipment should be checked as follows:

- Check batteries of all meters and replace if necessary. Ensure spare batteries are available;
- Have all meters and electrodes stored in correct storage fluid;
- Check calibration solutions (i.e., if it is necessary to order more, then order well in advance of next sampling event); and
- Check toolbox for all tools and the state of the tools. Clean and repair or replace tools where necessary.

Equipment

The following equipment may be required for groundwater measuring and sampling (if the boreholes are bailed – recommended):

- Keys and/or crowbar (depending on opening mechanism of borehole) to open boreholes;
- Water level recorder (dip meter);
- Single use sampling bailers;
- Additional batteries;
- Sample bottles - 1ℓ (dependent on laboratory requirements);
- Clearly marked bottles containing preservative (nitric acid, 10% concentration) if applicable;
- Filter membranes and syringes (including extras) if applicable;
- Disposable latex gloves (including extras);
- Sealable cooler bags or cool box with cooling mediums (ice-bricks);
- Field notes (log sheets);
- Site map;
- Pens, markers and pencils;
- Personal protective equipment as required per site area;

- Camera if applicable;
- First aid kit;
- Decontamination kit (detergent, buckets, soap, rinse water and PVC pipe);
- Tape measure; and
- Garbage bags for disposables if applicable.

The following equipment may be required for groundwater measuring and sampling (if the boreholes are purged):

- Keys and/or crowbar (depending on opening mechanism of borehole) to open boreholes;
- Water level recorder (dip meter);
- Generator (if necessary);
- Containers for purging boreholes (if no pumps are available) (if required);
- Container to measure pumping rate (25 litre or 10 litre) (if required);
- pH/EC/Temp probe and calibration standards;
- Additional batteries;
- Copies of manufactures manuals for calibrating field instruments;
- Calibration bucket;
- Wash water;
- Stopwatch;
- Sample bottles - 1ℓ (dependent on laboratory requirements);
- Clearly marked bottles containing preservative (nitric acid, 10% concentration) if applicable;
- Filter membranes and syringes (including extras) if applicable;
- Disposable latex gloves (including extras);
- Sealable cooler bags or cool box with cooling mediums (ice-bricks);
- Field notes (log sheets);
- Site map;
- Pens, markers and pencils;
- Personal protective equipment as required per site area;
- Camera if applicable;
- First aid kit;
- Calculator if applicable;
- Decontamination kit (detergent, buckets, soap, rinse water and PVC pipe);
- Tape measure; and
- Garbage bags for disposables if applicable.

Records

During the monitoring procedure the following information must be recorded on the relevant form supplied:

- Name and location of sample point (i.e., borehole name and coordinates);
- Date and time of sample collection;
- Type of sample (e.g., groundwater sample);
- Water level within borehole
- Measurement from ground level to top of borehole collar;
- Depth of borehole to determine siltation levels;
- Method of sample collection (e.g., bailer or purged);
- Sample appearance and olfactory description at the time of collection (e.g., colour, clarity, smell);
- Results of on-site analysis (i.e., pH, EC, temperature);
- Details of any sample preservation techniques employed;
- The name of the sample collector; and
- Field observations (e.g., rural community close by, evidence of livestock using water, high rainfall event previous night).

Groundwater Monitoring Procedures

Borehole Setup

Step	Instruction
1	If required, sampling technicians should introduce themselves to the site management and follow the applicable safety instructions.
2	Find the sampling point.
3	Fill in the sampling sheet (time, date, sample number, etc.).
4	Protect instruments from contamination in the event of it falling to the ground.
5	Put on protective clothing as required. Wear a new set of gloves for each sample.
6	Assemble sample kit at the sample point.
7	Remove the locking cap on monitoring point.

Water-Level Measurements - Pre-sampling Activity

Step	Instruction
1	Lower the sensor of the dip meter down the borehole until the needle deflects, the buzzer or light goes off. Raise it until it stops deflecting or going off. This is the water level.
2	Measure the water level depth using the datum point, which should be marked on the casing, usually the top of the casing. Measure the length from ground level to top of casing, this will be collar height.
3	Re-check the water level and record.
4	Note the lowering to the bottom of the borehole will disturb the water column and dislodge particles that are loosely attached to the sidewall. If the borehole is to be purged this may not affect sample integrity. However, for low-yielding boreholes first collect the water sample before measuring the depth.
5	Remove the cable and clean off properly.

Groundwater Sampling

Sampling is undertaken in accordance with the sampling protocol specifications. Sample preparation will be undertaken according to laboratory requirements (filtration, specific preservative, etc.). Care must be taken to ensure that the samples collected are sufficiently large enough (1ℓ) to allow the laboratory to run duplicate analysis if required. Samples will be stored and transported at cool temperatures.

Field observations for each sampling point will be recorded on field data sheets.

The field technician collecting the water samples will keep a record of the sampling session by filling in a sampling sheet check list form.

The chain of custody form will be completed when the samples are transported and transferred to a SANAS-accredited laboratory for analysis.

General:

- The inner surfaces of sample bottles or caps should not be touched with fingers or other objects. The sample bottle should be stored and transported with caps tightly secured.
- Preservation techniques (including filtering) and laboratory instructions should be followed. It is recommended that two samples are taken, one 1L bottle for inorganic chemical analyses and one 500ml bottle for microbiological analyses. This could vary between laboratories and should be confirmed.
- If groundwater sampling via the purging methodology is considered: in the event of the borehole being pumped dry, a recovery time of approximately 2 weeks should be allowed prior to returning to site for sampling via single use bailers.

NOTE: The preservation methods should be discussed with the laboratory, in some cases filtering and preservation may or may not be required provided the samples are submitted to the laboratory as soon as practically possible.

Bailed sample collection

The samples are taken under ambient temperature and pressure conditions.

Step	Instruction
1	Use a new or decontaminated uPVC bailer and make sure that everything is in working order.
2	Fix a strong light rope to the top of the bailer and lower it to just below static water level in the borehole.
3	Pull the bailer gently upwards until the bailer has sufficient weight, indicating the water filled the void.
4	Pull the bailer up and out of the borehole, gently but not too slow.
5	Decant water into suitable sample bottle.
6	Filtering and preservation should occur according to the laboratory instructions, if required.
7	Measure the pH, EC, and temperature as part of the field measurements and record on sampling sheet.
8	Label bottle clearly and complete field notes.
9	Steps taken in the field should be recorded on the field notes.
10	Keep sample cool in dark clean container (out of direct sunlight) and taken to the laboratory within 7 days of being taken or sooner depending on viability of microbial sample.

Purging procedure (if applicable)

Step	Instruction
1	Measure the water level.
2	Measure the borehole depth.
3	Measure the height of water column = borehole depth – depth to water level.
4	Calculate the pumping time needed to remove three volumes.
5	Install the pump with the inlet above the main water strike or 1.5 to 2 metres from the bottom of the borehole to avoid intake of silt into the pump.
6	Set up the EC, pH metres and stopwatch

7	Start pumping.
8	Measure pumping rates at regular intervals and record in litre per second.
9	Take continuous readings of pH, EC, and temperature from the discharge point.
10	If the field parameters have not stabilised, continue pumping until they do. This will be the purge time at that pumping rate.
11	Record all the above readings.

Purge sample collection (if applicable)

Step	Instruction
1	Rinse all field equipment prior to sampling- e.g., probes rinsed with water between samples. Wear a new set of latex gloves for each sample.
2	At the sampling point remove cap of sample bottle but do not contaminate inner surface of cap and neck of sample bottle with hands.
3	Once the borehole has been purged, with the pump still pumping, lower the pump about 0.5 m and collect the water sample. This is done so that contamination from the stagnant water which is above the pump inlet does not occur.
4	If the site contains hazardous or potentially hazardous groundwater pollution, make arrangements to safely dispose of the purged water which may contain toxic substances. Collect the purged water in the pre-arranged containers and dispose safely (if applicable).
5	Filtering and preservation should occur according to the laboratory instructions, if required.
6	Label bottle clearly and complete field notes.
7	Steps taken in the field should be recorded on the field notes.
8	Keep sample cool in dark clean container (out of direct sunlight) and taken to the laboratory within 7 days of being taken or sooner depending on viability of microbial sample.

Photographic Examples

Water level measurement (dip meter)

Bailed sample

Decant bailed sample into sample bottle

Field EC / pH / Temp measurement

Borehole Monitoring Field Form Example

Veltwater GROUNDWATER SPECIALISTS

BOREHOLE MONITORING FIELD RECORD

PROJECT DETAILS		SAMPLE INFORMATION	
Project:	GEORGE WWTWs	***Number of samples collected:***	12
Purpose of water:	Compliance monitoring	***Method of sample collection (purged / bailed):***	Bailed
Sample preservation:	NONE	***Sample filtration conducted:***	NONE
Access authorisation:	George Municipality	***Type of samples:***	Groundwater
Name of sampler:	S Veltman, J v Rooyen	***Field observations:***	

Borehole ID	Sample Date	Facility ID	Approx. Borehole Depth (m below ground)	Static Water Level (m below ground)	Collar Height (m)	EC (mS/m)	Water Description (colour, inclusions, olfactory)	Current Status & Condition	Remarks / Comments
KK 01	07/04/2021	Kleinkrantz	38	36.07	tbc	78	Pungent smell, clear	New	Headworks incomplete
KK 02	07/04/2021	Kleinkrantz	39	37.00	tbc	76.4	Clear	New	Headworks incomplete
KK 03	07/04/2021	Kleinkrantz	32	31.00	tbc	86.2	Clear	New	Headworks incomplete
HB 01	23/04/2021	Herolds Bay	57	46.94	tbc	142.2	Clear	New	Headworks incomplete
HB 02	19/04/2021	Herolds Bay	57	42.02	tbc	71.3	Clear	New	Headworks incomplete
HB 03	03/05/2021	Herolds Bay	59	47.80	tbc	129.8	Clear	New	Headworks incomplete
GN 01	07/04/2021	Gwaing	39	23.09	tbc	350	Clear	New	Headworks incomplete
GN 02	07/04/2021	Gwaing	27	14.67	tbc	178	Pungent smell, sediment	New	Headworks incomplete
GN 03	07/04/2021	Gwaing	34	24.04	tbc	100	Clear	New	Headworks incomplete
OQ 01	07/04/2021	Outeniqua	30	19.83	tbc	303	Clear	New	Headworks incomplete
OQ 02	07/04/2021	Outeniqua	31	28.65	tbc	349	Pungent smell, sediment	New	Headworks incomplete
OQ 03	07/04/2021	Outeniqua	35	22.62	tbc	343	Clear	New	Headworks incomplete

Final Page