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SOUTH HILLS

GEOHYDROLOGICAL REPORT

Compiled by

K. Sami

September 2009

APPROPRIATE SOLUTIONS FOR DEVELOPMENT IN AFRICA

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1 INTRODUCTION

1.1 BACKGROUND

An open plot of land in South Hills, Johannesberg called Moffat Park is to be investigated for mixed income housing development. The property consists of Erf 1202 South Hills, Holding 88 Klipriviersberg Estate, and Portion 65 of the farm Klipriviersberg No 106 IR.

The area is 204 ha in size.

Current land use is empty undeveloped parkland, illegal dumping of building and domestic waste, two soccer sports grounds, a swimming pool, a garden refuse disposal site, a car wash, off road quad bike trails and squatters.

The property lies in the Upper Vaal catchment, which has been experiencing salinity problems due to extensive urban, industrial and mining development within the catchment. The Upper Vaal is considered to be the most important water resource system in South Africa.

This property lies in the catchment that feeds into the Vaal barrage which is of strategic importance. The Vaal barrage has been experiencing increasing salinity and eutrophication, hence any development in this catchment area must be assessed in terms of potential impacts on the Vaal Barrage. Further declines in the water quality of the Vaal Barrage will lead to further ecological impacts, and an increase in the cost of water purification of water drawn from the barrage. Hence salinity and nutrient loads generated by any development in the catchment should be a pivotal consideration in planning and development.

1.2 TERMS OF REFERENCE

WSM Leshika was appointed by the City of Joburg Property Company Ltd on 15 July 2009

The brief included undertaking a geohydrological survey of the property.

2 SITE DESCRIPTION

2.1 LOCATION

The property is located at South Hills in Johannesberg at approximately 26 15 S, 28 05 E (figure 1), on topographic sheet 2628AA and 2628AC.

It is accessed via southern Klipriviersberg Rd, or South Rand Rd (figure 2).

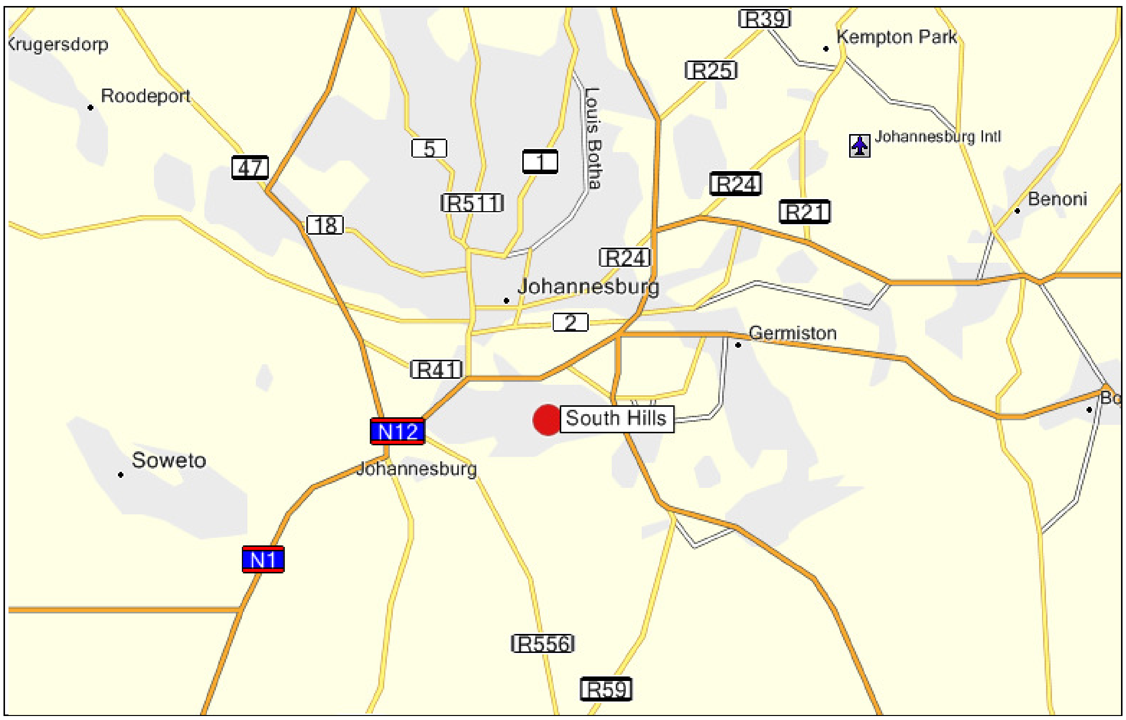


Figure 1. Locality of South Hills

Figure 2 Road network and development in the vicinity of South Hills.

2.2 PHYSIOGRAPHY AND HYDROLOGY

Relief varies from 1688 mamsl in the north, to 1787 mamsl in the south. The terrain rises to the south, with the highest point being the southeast corner. The terrain slopes steeply towards a first order stream that runs northwards through the middle of the property. This stream is ephemeral, except in its lower reach.

The property is part of Quaternary catchment C22B, which drains southwards via the Klipspruit, which enter the Vaal river at Vereeniging.

Historically, the biggest impact in the C22B catchment were from mine discharges. These peaked around 1980 and have diminished to approximately 8.6 Mm^3/a as the mines shut down. Treated urban domestic and industrial effluent point source discharges increased from 1920 and are now over 60 Mm^3/a. In addition, with urban expansion, increasing storm water runoff has contributed to the hydrological regime of the catchment. This has resulted in constantly increasing runoff from the catchment (figure 3). Natural virgin runoff is 12.4 Mm^3/a, but now reaches up to 140 Mm^3/a, with a mean of 95 Mm^3/a.

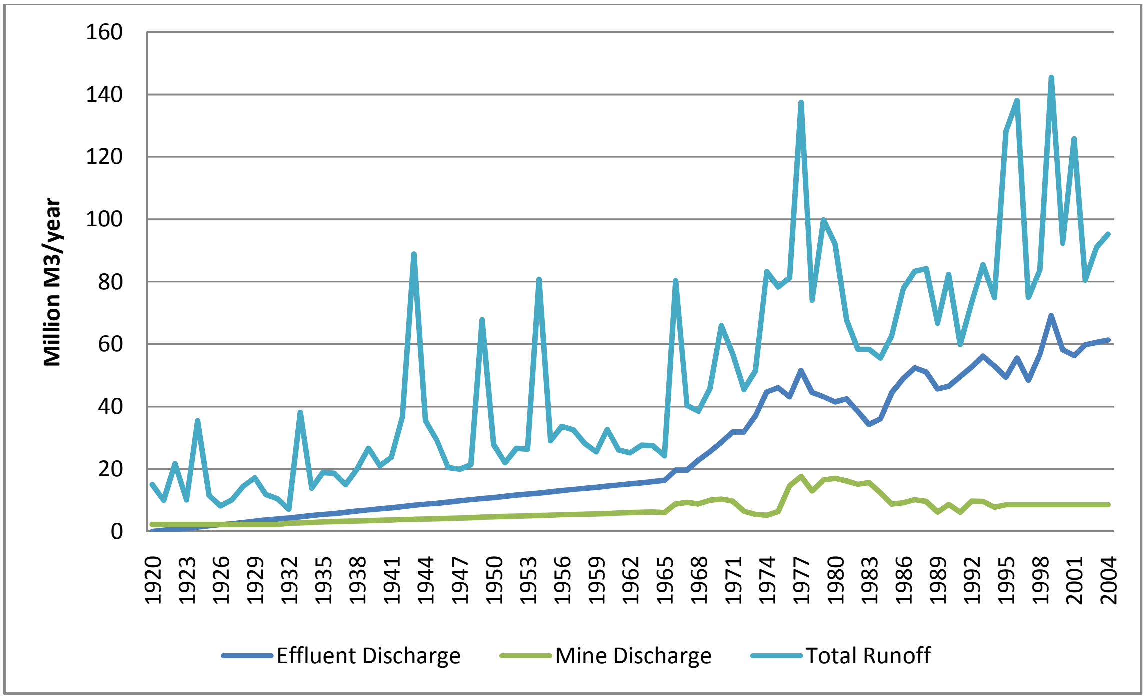


Figure 3 Hydrograph of C22B

2.3 SURFACE WATER QUALITY

The main contaminant sources within the catchment are point source discharges from sewage and effluent treatment works and from mines, and diffuse untreated contamination from urban areas, which can include sewage overflows or leaks, runoff from impervious areas, leaking slime dams, storm runoff, unsewered sanitation etc. To a far lesser extent, irrigation return flows also occur.

The TDS of effluent from treatment works has historically declined from 750 mg/l to less than 550 mg/l (figure 4). The TDS of mine charges declined from a peak of nearly 6000 mg/l in the 1970s to about 2500 mg/l as pumping from deep levels was terminated. This has resulted in a long term improvement of water quality in the Klip from about 1500 mg/l in the 1960s to between 500-600 mg/l in the present day.

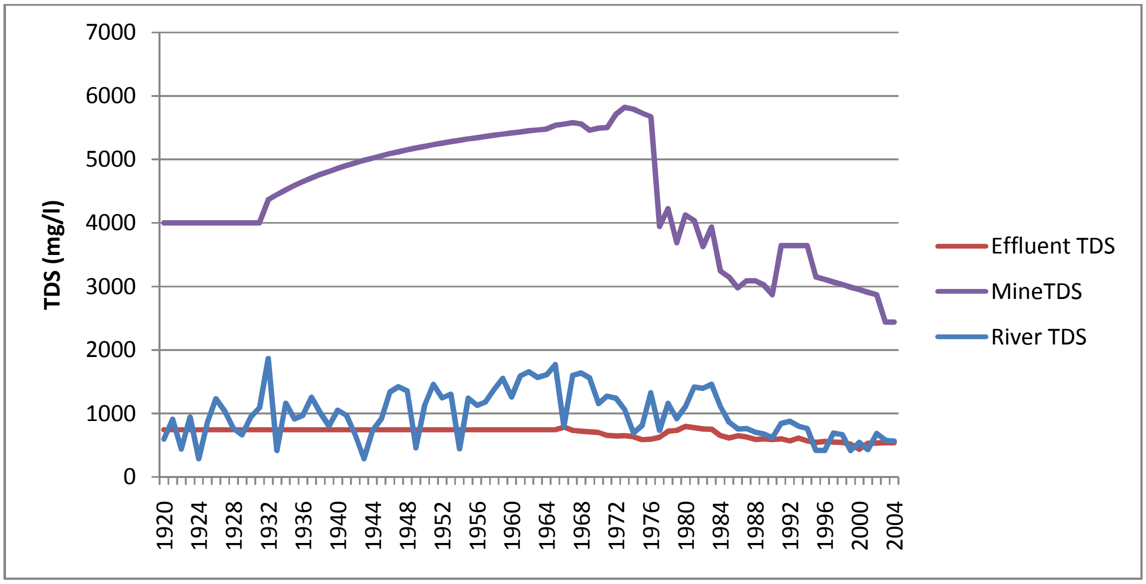


Figure 4 TDS of discharge in C22B

However, due to the increasing effluent discharges, the improvement in the quality of discharges has not resulted in a reduction in the total salt loads from point source discharges (figure 5). Total point source salt loads from the catchment are nearly 60 000 tonnes/a, and effluent discharges now contribute more salts than mine discharges.

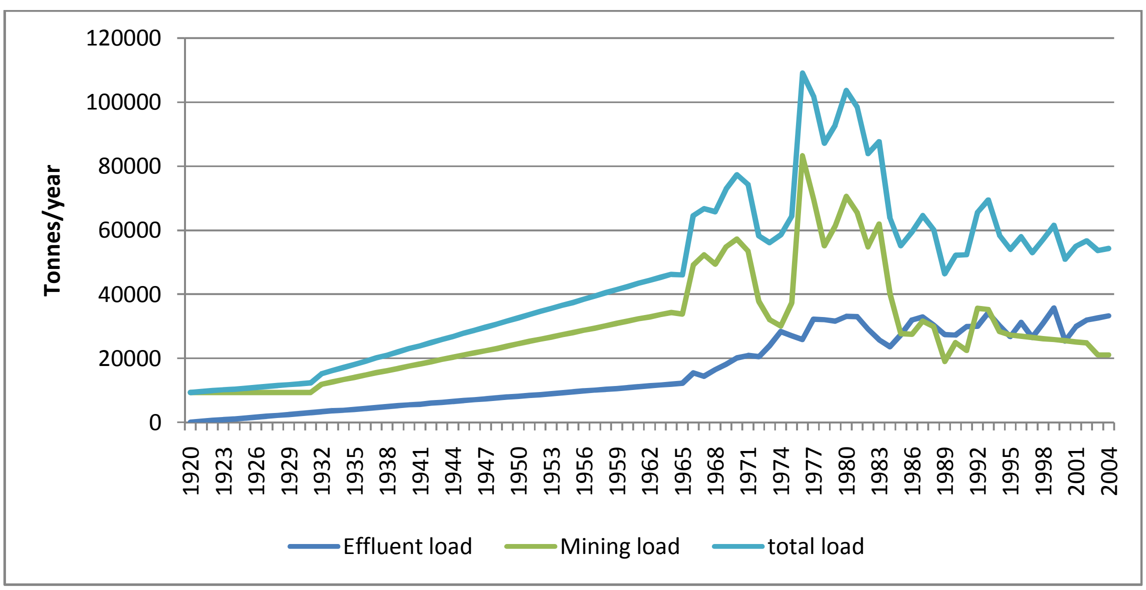


Figure 5 Salt load in C22B

A salt balance was calculated for 2004 to determine the origin of salts in the catchment (table 1). Actual point source discharge and TDS values were utilised. The TDS of natural runoff was assumed to be 113 mg/l, which is the background in similar undisturbed catchments. Urban TDS was calibrated to achieve a salt balance between stream discharge and point source loads. The total salt load has increased from 1400 tonnes/a under virgin conditions to over 78000 tonnes/a under current conditions. 42% of the salt load is from effluent discharge and 29% from diffuse urban discharge.

Table 1 Salt balance for C22B in 2004

		C22A	C22B		C22C	C22D	Total
				%			
Mining Discharge	Mm^3/a	0.084	8.635	9.07	0	0	8.719
TDS	mg/l	3845	2436.3				
Salt load	tonnes/a	322.98	21037.45	26.69	0	0	21360.43
Effluent	Mm^3/a	200.606	61.369	64.45	49.271		
TDS	mg/l	335.3	542.3		591.3		
Salt load	Tonnes/a	67263.19	33280.41	42.22	29133.94	0	129677.5
Natural Runoff	Mm^3/a	17.3	12.4	13.02	14.3	11.3	
natural TDS	mg/l	113	113		113	113	
Salt load	Tonnes/a	1954.9	1401.2	1.78	1615.9	1276.9	6248.9
urban runoff	Mm^3/a	13.598	14.168	14.88	3.064	0.804	31.634
urban TDS	mg/l	1600	1600		1600	1600	
Salt load	Tonnes/a	21756.8	22668.8	28.76	4902.4	1286.4	50614.4
Irrigation	Mm^3/a	2.22	1.48		1.85	1.26	
return flow	Mm^3/a	0.222	0.148		0.185	0.126	
TDS	mg/l	3000	3000		3000	3000	
Salt load	Tonnes/a	666	444	0.56	555	378	2043
Total Runoff	Mm^3/a	229.59	95.24		160.21	240.56	400.77
total load	Tonnes/a	91963.87	78831.86		36207.24	2941.3	209944.3

The volume of urban runoff generated as stormflow, and expected mean water quality based on generated salt loads is shown in table 2. It is calculated that C22B generates salt loads of over 800 mg/l.

Table 2 Estimated TDS values in runoff

		C22A	C22B	C22C	C22D	Total
Urban area	Km^2	169	147.6	33	40.9	
Urban runoff	mm/a	80.46154	95.98916	92.84848	19.6577	
River water	Mg/l	400.557	827.718	557.2917	268.1222	523.8523

To verify the calculated salt balance, the results were compared to existing water quality data. Surface water quality data is available at 3 measuring points (figure 6): the first station is in the klipspruit within C22B (1-519), south of the site but upstream of the discharges of 3 effluent treatment works (179329, 179330, and 179321); the second is at the outlet of C22B (1-523), and the third is a regular DWAF monitoring station that monitors C22A-D (C2H141), which drains a region from Soweto to the East Rand.

Figure 6 Water quality monitoring points and the location of effluent treatment works

Measuring station 1-519 includes urban diffuse discharge and mine discharges. 1-523 includes discharges from Boskburg, Rondebult, Dekima and Vlakplaats sewerage works. C2H141 is on the Klip river at Witkop bridge.

The total dissolved solids increase from an average of 410 mg/l to about 712 mg/l from station to 519 to 523 near the outlet of C22B (figure 7). Since 712 mg/l is higher than the TDS of effluent discharges from the treatment works, this increase cannot be attributed solely to effluent discharges, and must be related to diffuse contamination from urban areas. At the outlet of C22A-C22D, water quality improves by dilution to 550 mg/l. This is similar to the water quality estimate in table 2 generated from the salt balance. The management target for the Vaal barrage is 195 mg/l, and above 455 mg/l is considered unacceptable.

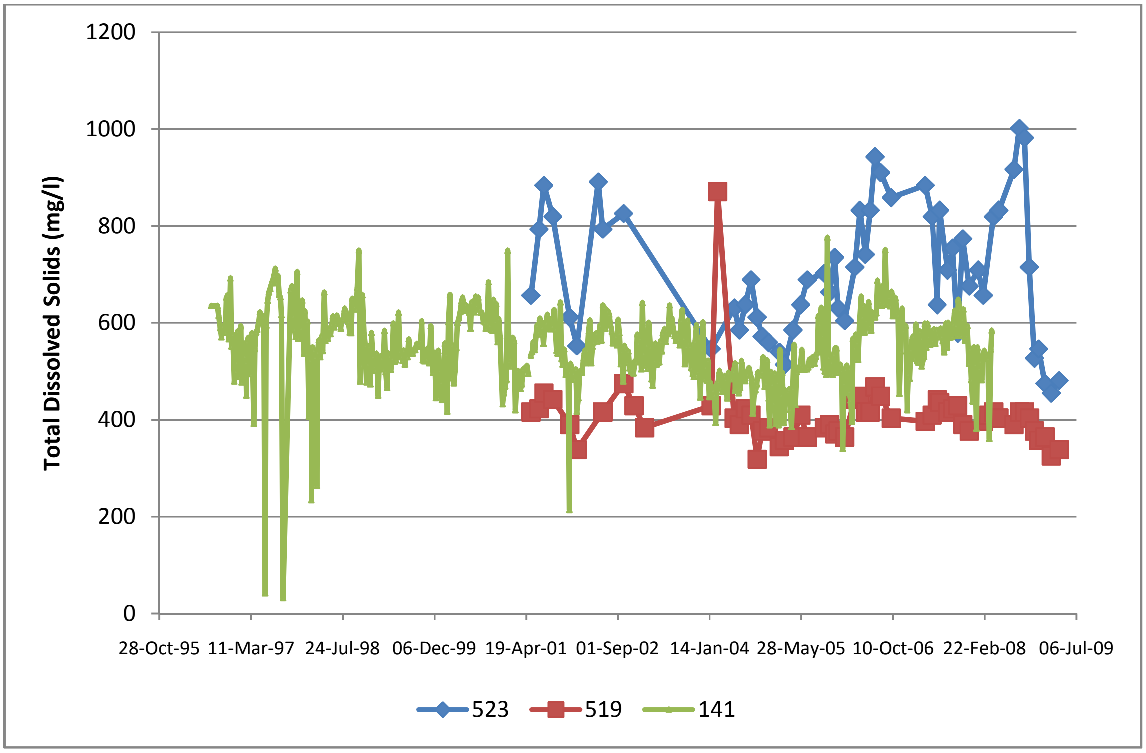


Figure 7 Observed TDS values

In addition to salt loads generated from urban areas, the shedding of nutrients is also of concern due to their role in eutrophication in dams. The key nutrients of concern are nitrates and phosphates. Currently, nitrates are below 5 mg/l (figure 8), with a target of 3 mg/l and 6 mg/l being considered unacceptable. Phosphates are generally below 1 mg/l (figure 9).

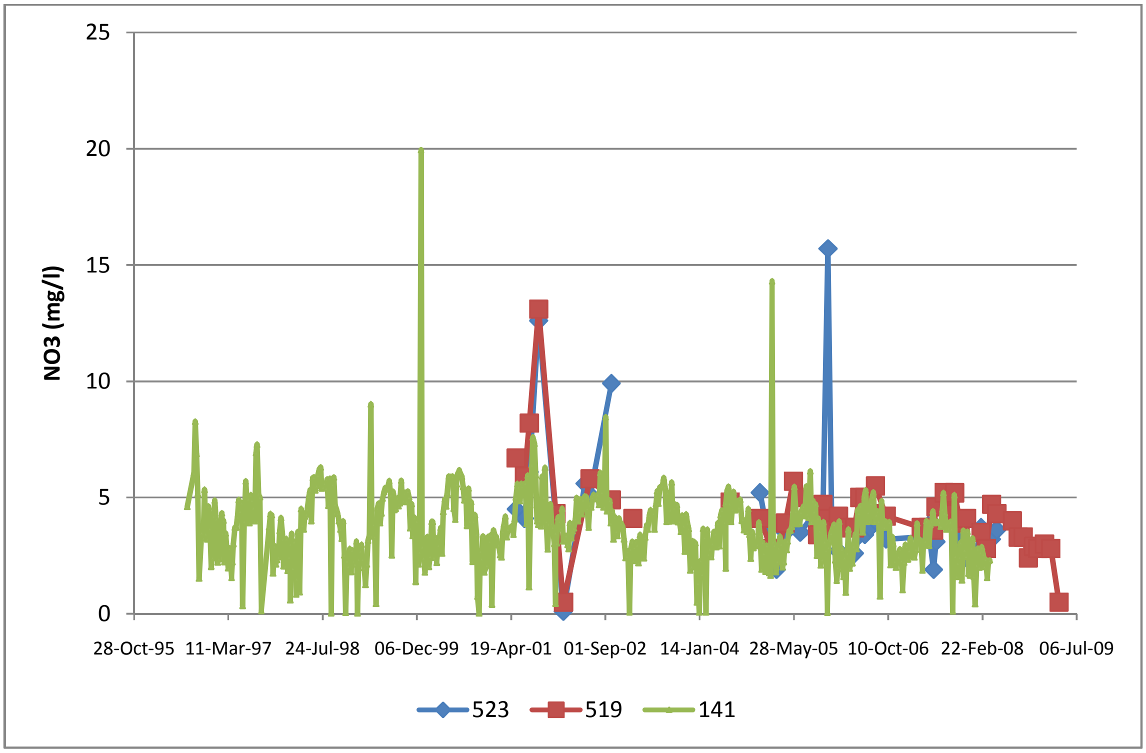


Figure 8 Observed nitrate concentrations

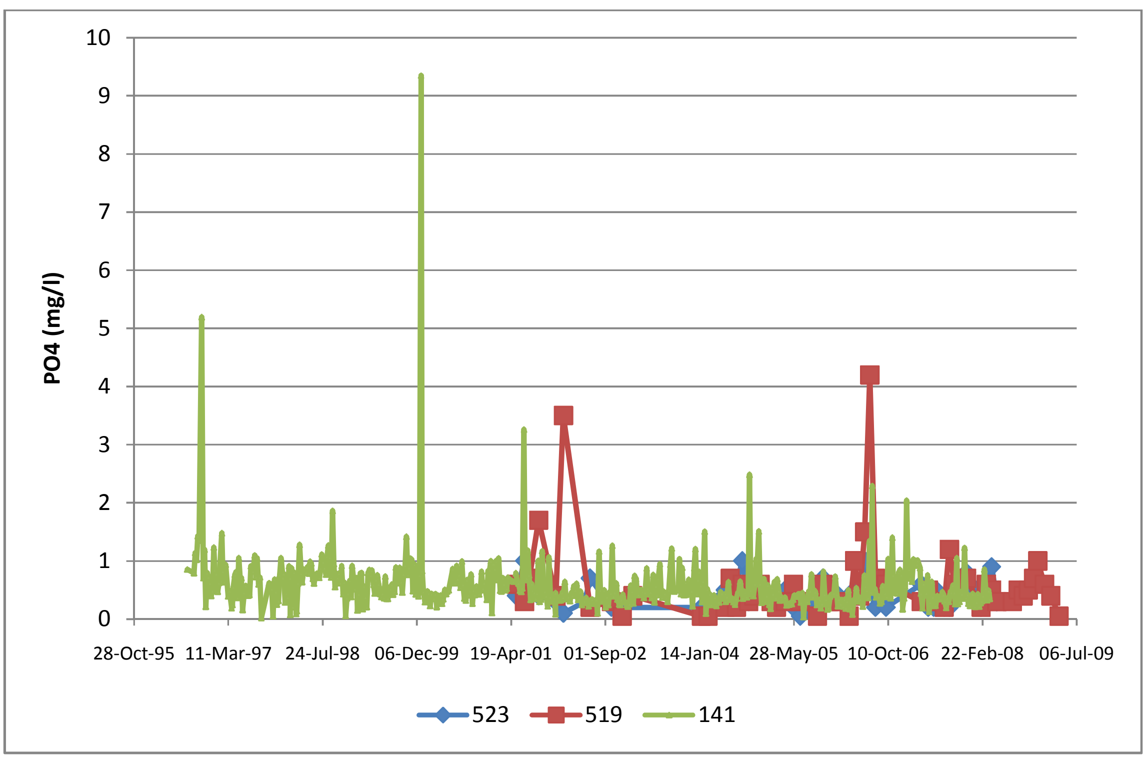


Figure 9 Observed phosphate concentrations

Target water quality guidelines are shown in table 3. More than 50% of the time, water quality exceeds target guidelines for nitrates, sulphates and total dissolved solids at C2H141, with TDS being unacceptable more than 50% of the time. This indicates the already stressed condition of the catchment.

Insufficient data exists to perform this analysis for stations 519 and 523, but conditions at 523 are generally worse. Plots of water quality for these stations are shown in appendix 1. At 519, water quality is acceptable 90% of the time. At 523 TDS exceeds 897 mg/l 90% of the time and sulphates are unacceptable more than 50% of the time.

Table 3 Water quality at C@H141Q01 with values below 50% of the time (P50) and 95% of the time (P95)

pH			NO3+NO2-N (mg/l)		NH4-N (mg/l)		F (mg/l)		PO4-P (mg/l)		SO4 (mg/l)		TDS (mg/l)	
P5	P50	P95	P50	P95	P50	P95	P50	P95	P50	P95	P50	P95	P50	P95
7.5	7.8	8.1	3.72	5.92	0.20	0.94	0.26	0.31	0.45	1.07	163	213	519	608
		pH	NO3+NO2-N (mg/l)		NH4-N (mg/l)		F (mg/l)		PO4-P (mg/l)		SO4 (mg/l)		TDS (mg/l)	
Target		6.5-8.5		3		0.5		0.7				100		195
Unacceptable		<6->9		>6		>1		>1				>200		>455

2.4 CLIMATE

Rainfall data for the following rainfall station is available:

Rosherville - POW (0476/163) 26 13 S 28 06 E 740. 3 mm/a

Rainfall is predominantly in the summer months with 83% of rainfall between October and March.

The nearest evaporation station is at Jan Smuts (A2E009), with has an annual S-pan evaporation of 1765 mm/a.

2.5 GEOLOGY AND HYDROGEOLOGY

The geology consists of argillaceous quartzite, conglomerate and sandy shale of the Turfontein SubGroup of the Central Rand Group. (figure 10). These beds dip moderately to the south at 20 degrees.

South Hills lies on 2 Formations of this Subgroup, the Mondeor Conglomerate, which has conglomerate interbedded with quartzite, and the Elsberg Quartzite. This was confirmed by drilling 3 x 80 m boreholes from North to South Across the site (figure 11). The drill logs are shown in appendix 2. These were used to develop a hydrogeological model of the site (figure 12).

BH1 near the south boundary encountered 3 metres of alluvial sand before penetrating Elseberg quartzite and a band of shale. BH2 encountered quartzite and conglomerate of the Mondeor Formation before entering Elsberg quartzite. BH3 near the northern boundary encountered conglomerate and quartzite of the Mondeor Formation. The southern margin of the property is capped by a coarse conglomerate layer of the Mondeor Formation, which overlies the Elsberg quartzite Formation.

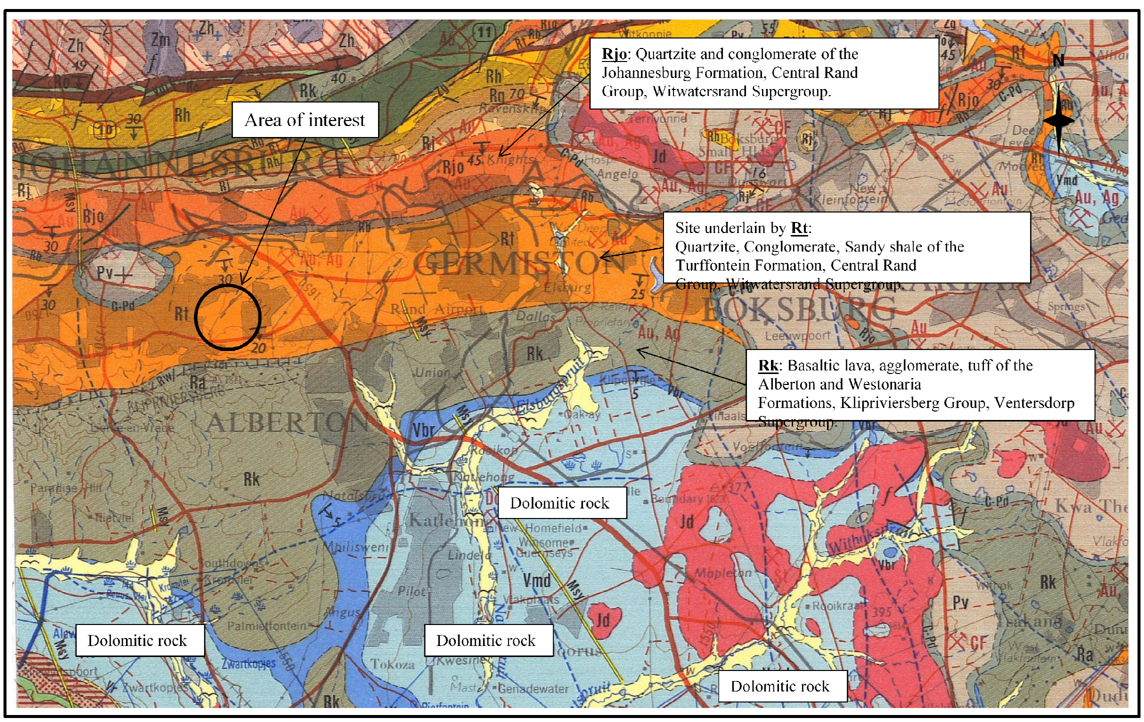


Figure 10 Geological Map

Figure 11 Location of boreholes

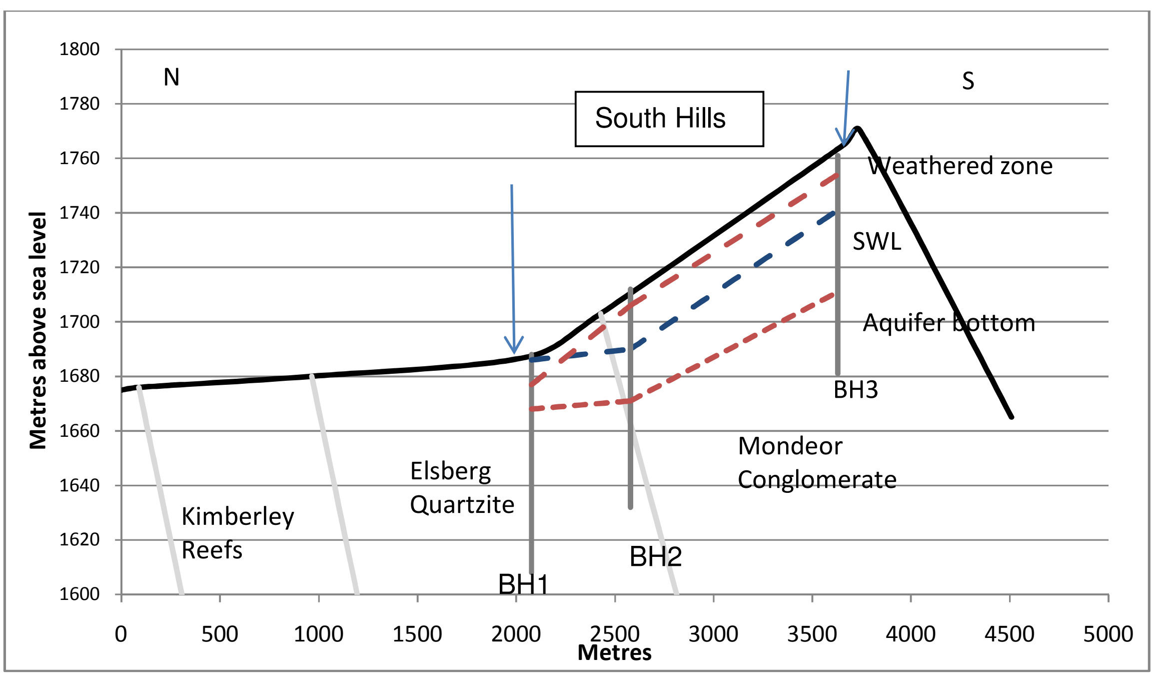


Figure 12 N-S cross section at South Hills

The Central Rand Group forms a fractured aquifer of generally hard compact formations, in which groundwater is restricted to fractures, fissures and joints. Groundwater is generally encountered below the weathered zone. 5% of boreholes yield less than 0.1 l/s, 20% yield between 0.1-0.5 l/s, 57% of boreholes yield 0.5-2 l/s, 12% yield between 2-5 l/s, and only 7% yield above 2 l/s. Groundwater is generally encountered 10-25 m below surface. Groundwater quality is variable but is generally of good quality, with a maximum recorded TDS values of 611 mg/l and a mean of 207 mg/l.

The three boreholes drilled had yields of 2.5, 0.6 and 0.15 l/s from north to south. The aquifer is unconfined in the south, and the static water level is approximately equal to the first water strike. Downgradient to the north the aquifer becomes confined, with static water levels above the water strike depth.

The aquifer is therefore recharged in the south and groundwater flow is northward. The northern borehole had a static water level above the eleveation of the northward flowing stream, implying groundwater discharges into the stream. The presence of pools of water in the stream confirms this. Much of the aquifer discharge is used by the extensive and dense riverine vegetation.

In the Mondeor Conglomerate, water strikes are in the conglomerate at the contact with quartzite layers. In the Elsberg quartzite water strikes are in fracture zones in the quartzite. Water strikes and water levels are generally below the weathered zone (figure 12), except in BH1 where groundwater discharges at surface, implying that the aquifer is of the purely fractured type

3 GROUNDWATER RESOURCES EVALUATION

3.1 GROUNDWATER RESOURCES

The Groundwater Harvest Potential for C22B is 39.2 mm/a, or 79 968 m^3/a for a 204 ha area. This is equivalent to 219 m^3/d.

Harvest Potential is defined as the maximum volume of ground water that may be abstracted per area without depleting the aquifers. It is based on estimated mean annual recharge and a rainfall reliability factor, which gives an indication of the possible drought length.

The Harvest Potential represents a synthesis of the amount of groundwater in storage in an aquifer system, the recharge and the time span between these recharge events.

It is however not possible to abstract all the groundwater available. This is mainly due to economic and/or environmental considerations. The main contributing factor is the hydraulic conductivity or transmissivity of the aquifer systems. Based on average borehole yields, harvest potential is reduced by an exploitation factor to derive the exploitation potential, which is considered to be a conservative estimate of the groundwater resources available for exploitation.

The exploitation potential is 27.4 mm/a, or 55 896 m^3/a, or 153 m^3/d.

Average recharge from rainfall is estimated at 40 mm/a, 0r 81 600 m^3/a, of which approximately 13 mm/a contributes to river baseflow. Much of the recharge sustains riverine alien vegetation. Approximately 13 hectares of riverine bush exists. Le Maitre et al. (2000), estimated that aliens invaders in Gauteng utilise about 414 mm/a of water. 13.5 ha would therefore utilise 55 890 m^3/a of water, or 68% of the recharge to the property. This is equal to 27 mm of recharge to the site.

Existing groundwater use in the Quaternary catchment is largely from private domestic and industrial boreholes for garden irrigation. Estimated use is approximately 0.96 Mm^3/a, which is only about 2.7 mm/a.

The aquifer can be classified as a poor aquifer, which is insignificantly yielding but of good quality, that will never be utilised for water supply and that will not contaminate other aquifers.

The property lies in the headwater of the catchment and no current abstraction exists in the catchment.

3.2 GROUNDWATER QUALITY

Samples were collected from the newly drilled boreholes. Borehole has a water Quality of Class according to the Department of Water Affairs Standards for Dometsic Water Quality, which is...

Both boreholes have c…..water according to the Ryznar corrosivity index (figure 6), hence steel pipes are to be avoided. Such water will cause a premature replacement of geysers and household utensils.

Table 4 Water Quality

Figure 13 Ryznar Corrosivity index

3.3 GROUNDWATER VULNERABILITY

Groundwater vulnerability is defined as the tendency and likelihood for general contaminants to reach the water table after introduction at the ground surface, or through leaking pipes. It is affected by travel time of a contaminant, the attenuation capacity of the environment, and recharge acceptance of the aquifer.

Several factors determine how vulnerable an aquifer is to contamination: the thickness and material of the unsaturated zone, the presence of confining units above the aquifer, the permeability and type of flow in the aquifer, the recharge rate and the location of the contaminant source along the flow path.

In general, the greater the depth to groundwater static water level, the less vulnerable an aquifer will be to contamination. Groundwater on the property is approximately 20 m deep, except near the northern boundary. However, since the overburden is generally less than 1 m thick and the unsaturated zone is largely fractured rock, and percolation is via fractures, travel time is too short to allow any attenuation to take place. Hence the depth to the water level is less relevant, and the aquifer is very vulnerable to contamination. Where the groundwater is shallow, it is upwelling, hence not likely to be contaminated.

Since both the aquifer and the unsaturated zone are of the fractured type, and covered only by a thin layer of permeable sand, generally less than a metre thick, they do not provide any degree of attenuation of contaminants. The shallow and coarse permeable sandy nature of the overburden does not provide any significant residence time for attenuation of microbial contaminants.

The high recharge rates also result in the aquifer being vulnerable to contamination, however, the low permeabilities in the aquifer suggest that transport rates for teh spread of contamination are slow.

The aquifer can be considered highly vulnerable to most pollutants with rapid impact in many scenarios. Contaminants are likely emerge at the northern boundary, where the aquifer discharges into the stream. These contaminants would be introduced into the Klip river system.

3.4 POTENTIAL IMPACTS

3.4.1 Groundwater Abstraction

Due to the low borehole yields and steep slopes, it is unlikely that the development will have a large number of private boreholes for garden watering. The potential for groundwater abstraction exists only in the northern portion adjacent to the stream. Since the development will be mixed housing, and largely low income, it is unlikely that a proliferation of boreholes will occur; hence baseflow depletion is not expected.

3.4.2 Groundwater Recharge

The provision of water supply via pipelines, sanitation and drainage of stormwater can impact on groundwater. Leaking pipes directly recharge groundwater, since losses are not subject to evaporation.

Recharge patterns can also be affected by modifications to the natural sources and routes of infiltration. The construction of roads, down pipes from buildings, and car parks alter natural drainage by the concentration of rain water to produce locally-concentrated infiltration, increasing recharge. Garden watering can also increase recharge. In general, the reduction of recharge by the construction of impermeable surfaces is more than offset by the enormous volumes of water circulating through and lost from the water and wastewater infrastructure, especially where garden and amenity watering takes place.

Due to the very thin soils, steep slopes, and low permeability rock, it is probable that concentrated recharge will not percolate to the aquifer and fill flow downgradient along the bedrock contact as interflow, resulting in increased baseflow.

Increased baseflow is seen as a benefit to the Vaal river system, since it would dilute the high salt load in the catchment. However, due to the small size of the catchment, increased flow in unlikely to have any significant impact.

3.4.3 Increased Discharge

Urban development leads to increased runoff due to storm runoff from impervious areas. In table 2 it was shown that urban areas in C22B generate 96 mm/a of runoff, where as natural runoff is 32 mm/a. From a 204 ha area, an additional 130560 m^3/a of storm runoff would be generated.

Sewered waste water will be treated and returned to the Vaal system through an existing water treatment facility, increasing the load to this facility. Since it will use Rand Water imported from outside the catchment, discharge will increase flow in the system, and the salt load of the already stressed Vaal catchment.

Assuming an equal volume of treated effluent to storm runoff, a total of about 391 000 m^3/a would be added to the discharge of the Klip.

3.4.4 Impacts on Water quality

Most of the increased recharge in urban environments is of poor quality (Table 5).

Unsewered domestic waste, or leaking sewage pipes can result in salts, pathogens and nitrates entering the groundwater. Leaking pipes discharge below the soil, bypassing the attenuation capacity of the soil, introducing contaminants directly to the aquifer.

Unplanned disposal of solid and liquid domestic wastes into the street, stream channel and onto disused land can contribute to the pollution load to the aquifer and stream channels. In table 1 it was shown that diffuse urban runoff has a TDS of 1600 mg/l. 204 ha generating 96 mm/a of runoff would add 313 tonnes/a to the salt load of the catchment. Assuming an equal volume of treated effluent, 420 tonnes/a of salts would be added to the Klip which is a 0.5% increase in the salt load.

Paved surfaces create runoff during rainstorms. This runoff picks up oil, chemicals, and gravel from the pavement and grass. These chemicals would usually be filtered out of the water as its passes through the ground, however, from impervious services it can concentrate and seep into the ground in localised areas.

Fertilizers from gardens can run off into streams and seep into the aquifer, increasing nitrate, phosphate and salt levels.

Since the Vaal is already a stressed catchment due to salt loads, any additional salt concentrations in excess of those currently existing are of concern. Due to the small size of the development, its impact in itself is insignificant on the drainage region, but if seen as a cumulative impact resulting from all developments in the area, the impact significance may become high.

Table 5 Impacts on water resources

Activity	Water Quantity	Water quality	Pollutants
Leaking mains/water lines	Major	Excellent	None

Abstraction	Minor	None	None
Storm runoff	Minor	Poor	Hydrocarbons, chemicals, N, Cl, coliforms, DOC
Informal sanitation and dumping	None	Minor Poor	N, Cl, coliforms, DOC
Leaking waste water	Minor to major	Poor	Hydrocarbons, chemicals, N, Cl, coliforms, DOC
Leaking sewers	minor	Poor	N, B, Cl, coliforms, SO4, chemcals
Pluvial drainage by soakaway	Major	Good to poor	N, Cl, coliforms, hydrocarbons, DOC, chemicals
Seepage from drainage channels	Minor	Moderate to poor	N, Cl, coliforms, SO4, DOC, chemcials
Garden and lawn watering	Minor to major	Good to moderate	N, PO4

3.4.5 Ground Water Risk and Impact Assessment

Risk is based on the combination of the probability, or frequency of occurrence of a hazard and the magnitude of the consequence of the occurrence. Risk estimation is concerned with the outcome, or consequences of an intention, taking account of the probability of occurrence and can be expressed as P (probability) x S (severity) = Risk

Risk evaluation is concerned with determining significance of the estimated risks and also includes the element of risk perception. Risk assessment combines risk estimation and risk evaluation.

The potential impacts to groundwater were assessed by considering the risk evaluation criteria as outlined in table 6 and the risk evaluation criteria in table 7. The risk assessment evaluation is shown in table 8.

Table 6 Risk evaluation criteria

DURATION		
Short term	6 months	1
Construction	36 months	2
Life of project	+/- 50 years	3
Post rehabilitation	Time for re-establishment of natural systems	4
Residual	Beyond the project life	5
EXTENT		
Site specific	Site of the proposed development	1
Local	Surrounding areas	2
District	Johannesburg Municipality	3
Regional	Southern Gauteng	4
Provincial	Gauteng	5
National	Republic of South Africa	6
International	Beyond RSA borders	7

PROBABILITY		
Almost Certain	100% probability of occurrence – is expected to occur	5
Likely	99% - 60% probability of occurrence – will probably occur in most circumstances	4
Possible	59% - 16% chance of occurrence – might occur at some time	3
Unlikely	15% - 6% probability of occurrence – could occur at some time	2
Rare	<5% probability of occurrence – may occur in exceptional circumstances	1
SEVERITY		
Catastrophic (critical)	Total change in area of direct impact, relocation not an option, death, toxic release off-site with detrimental effects, huge financial loss	5
Major (High)	> 50% change in area of direct impact, relocation required and possible, extensive injuries, long term loss in capabilities, off-site release with no detrimental effects, major financial implications	4
Moderate (medium)	20 – 49% change, medium term loss in capabilities, rehabilitation / restoration / treatment required, on-site release with outside assistance, high financial impact	3
Minor	10 – 19% change, short term impact that can be absorbed, on-site release, immediate contained, medium financial implications	2
Insignificant (low)	< 10 % change in the area of impact, low financial implications, localised impact, a small percentage of population	1

Table 7 Risk estimation criteria

RISK ESTIMATION (Nel 2002)					
	SEVERITY				
PROBABILITY	Insignificant (1)	Minor (2)	Moderate (3)	Major (4)	Critical (5)
Almost certain (5)	H	H	**E**	**E**	**E**
Likely (4)	M	H	H	**E**	**E**
Possible (3)	L	M	H	**E**	**E**
Unlikely (2)	L	L	M	H	**E**
Rare (1)	L	L	M	H	H

E	Extreme risk – immediate action required, detail considerations required in planning by specialists – alternatives to be considered	4

H		High risk – specific management plans required by specialists in planning process to determine if risk can be reduced by design and management and auditing plans in planning process, taking into consideration capacity, capabilities and desirability – if cannot, alternatives to be considered, senior management responsibility	3
M		Moderate risk – management and monitoring plans required with responsibilities outlined for implementation, middle management responsibility	2
L		Low risk – management as part of routine requirements	1

IMPACT SIGNIFICANCE	
Negligible	The impact is non-existent or insubstantial, is of no or little importance to any stakeholder and can be ignored.
Low	The impact is limited in extent, even if the intensity is major; whatever its probability of occurrence, the impact will not have a significant impact considered in relation to the bigger picture; no major material effect on decisions and is unlikely to require management intervention bearing significant costs.
Moderate	The impact is significant to one or more stakeholders, and its intensity will be medium or high; therefore, the impact may materially affect the decision, and management intervention will be required.
High	The impact could render development options controversial or the entire project unacceptable if it cannot be reduced to acceptable levels; and/or the cost of management intervention will be a significant factor in project decision-making.
Very high	Usually applies to potential benefits arising from projects.

Table 8 Risk assessment

Impact	Duration	Extent	Probability	Severity	RE	Significance
Leaking mains/water lines	3	2	2	1	1	Low
Abstraction	3	2	3	1	1	Negligible
Storm runoff	3	4	5	1	3	Low
Informal sanitation and dumping	3	2	4	1	2	Moderate
Salt generation	3	4	5	2	3	Moderate
Leaking waste water	3	2	3	2	2	Moderate
Leaking	3	2	2	2	1	Moderate

sewers						
Pluvial drainage by soakaway	3	2	5	1	3	Negligible
Seepage from drainage channels	3	2	5	1	3	Negligible
Garden and lawn watering	3	2	5	1	3	Negligible
Sewered waste water	3	4	5	2	3	Low

4 CONCLUSIONS AND RECOMMENDATIONS

The property lies in the Upper Vaal catchment, which has been experiencing salinity problems due to extensive urban, industrial and mining development within the catchment. The Klip is one of the most heavily impacted catchments of the Vaal system. The catchment is already highly stressed and has been heavily impacted by increasing discharges and deteriorating water quality. Water entering the Vaal barrage from this catchment is already below target levels. Consequently, any impacts from development must be seen not just in isolation but in terms of the cumulative impact of all developments.

The property lies on quartzites and conglomerates of the Central rand Group. These form a fractured low yielding aquifer of good quality. The aquifer can be classified as a poor aquifer, which is insignificantly yielding but of good quality, that will never be utilised for water supply and that will not contaminate other aquifers.

The property lies in a headwater region of the catchment and no current abstraction exists. No upgradient contaminant sources exist. The aquifer is recharged in the south of the site and discharges in the north via a perennial spring, and through evapotranspiration by alien vegetation that runs along a drainage channel running through the site.

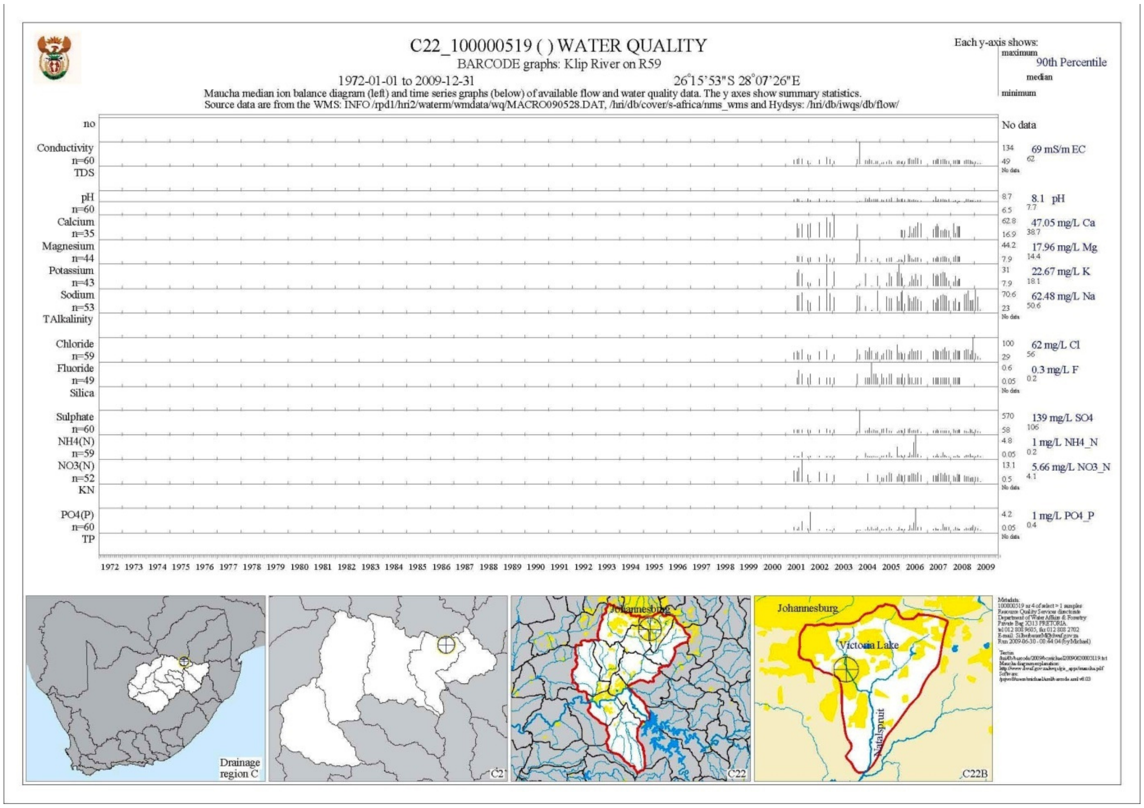
The groundwater exploitation potential of the property is 27.4 mm/a, or 55 896 m^3/a, or 153 m^3/d.

Due to its fractured nature and sandy shallow overburden, the aquifer is highly vulnerable to contamination. Since groundwater discharges within the property, contamination will not extend to any great distance, but will impact on surface water. The impacts of the development will be negligible to moderate and impact on an already highly impacted catchment.

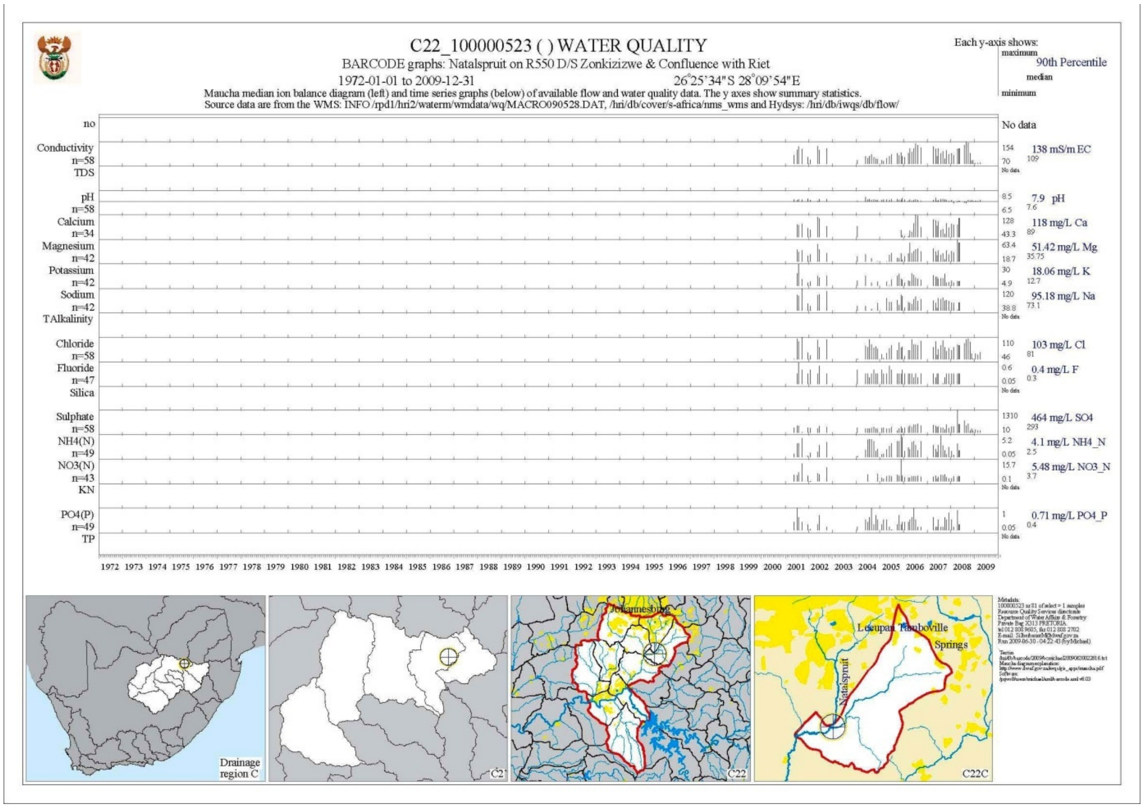
It is recommended that the impacts of developments in this catchment be evaluated in terms of cumulative impacts on the catchment and downstream areas, rather than in isolation.

K. SAMI M.Sc, Pr Sci. Nat

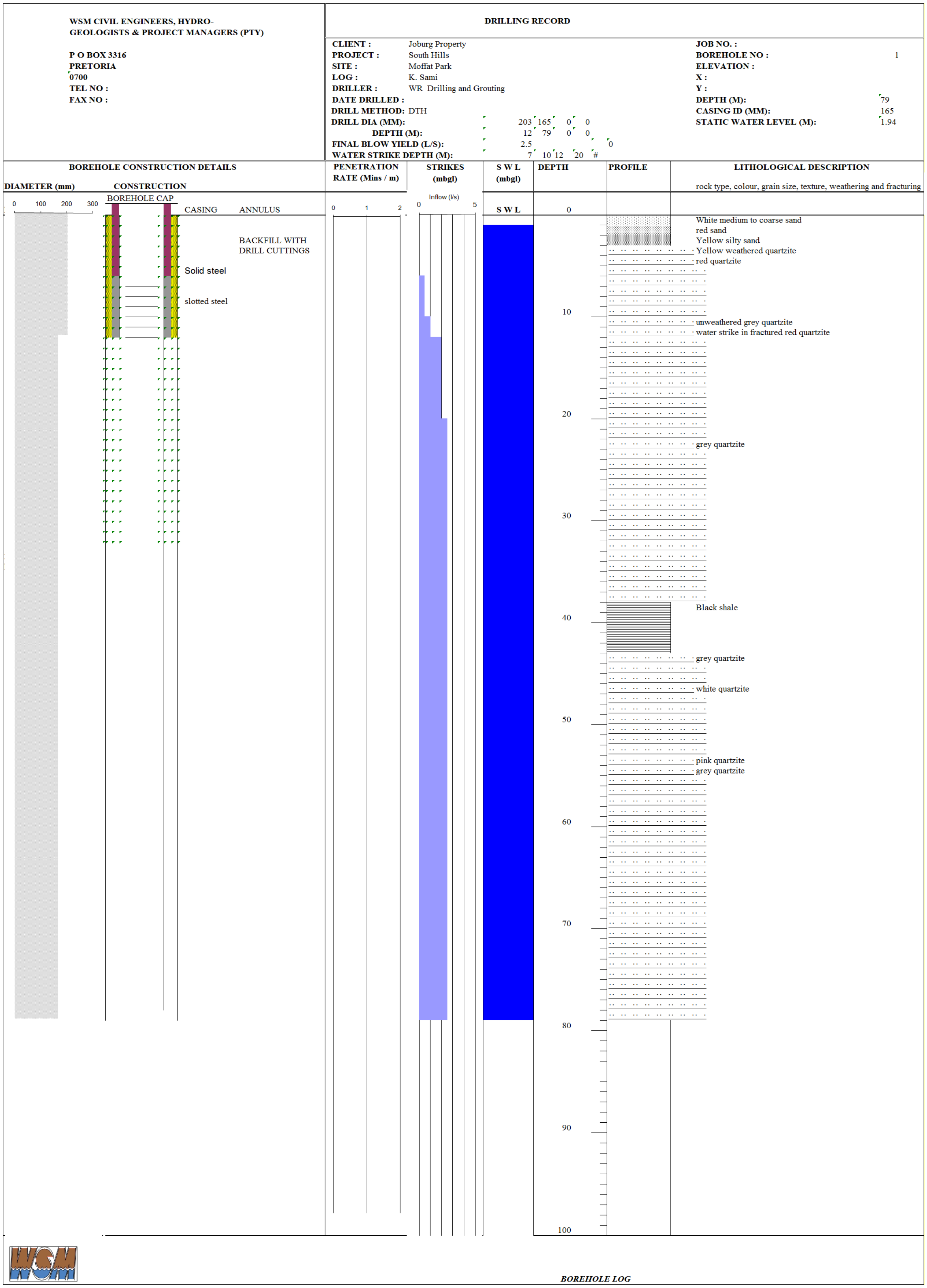
APPENDIX 1



C22_100000519 ( ) WATER QUALITY
BARCODE graphs: Klip River on R59
1972-01-01 to 2009-12-31
26°15'53"S 28°07'26"E
Maucha median ion balance diagram (left) and time series graphs (below) of available flow and water quality data. The y axes show summary statistics.
Source data are from the WMS: INFO /rpd1/hri2/waterm/wmdata/wq/MACRO090528.DAT, /hri/db/cover/s-africa/nms_wms and Hydsys: /hri/db/iwqs/db/flow/
Each y-axis shows:
maximum
90th Percentile
median
minimum
no
No data
Conductivity n=60
69 mS/m EC
TDS
pH n=60
8.1 pH
Calcium n=35
47.05 mg/L Ca
Magnesium n=44
17.96 mg/L Mg
Potassium n=43
22.67 mg/L K
Sodium n=53
62.48 mg/L Na
TAlkalinity
Chloride n=59
62 mg/L Cl
Fluoride n=49
0.3 mg/L F
Silica
Sulphate n=60
139 mg/L SO4
NH4(N) n=59
1 mg/L NH4_N
NO3(N) n=52
5.66 mg/L NO3_N
KN
PO4(P) n=60
1 mg/L PO4_P
TP
1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009
Drainage region C
C21
Johannesburg
C22
Johannesburg
Victoria Lake
Natalspruit
C22B


C22_100000523 ( ) WATER QUALITY
BARCODE graphs: Natalspruit on R550 D/S Zonkizizwe & Confluence with Riet
1972-01-01 to 2009-12-31
26°25'34"S 28°09'54"E
Maucha median ion balance diagram (left) and time series graphs (below) of available flow and water quality data. The y axes show summary statistics.
Source data are from the WMS: INFO /rpd1/hri2/waterm/wmdata/wq/MACRO090528.DAT, /hri/db/cover/s-africa/nms_wms and Hydsys: /hri/db/iwqs/db/flow/
Each y-axis shows:
maximum
90th Percentile
median
minimum
no
No data
Conductivity n=58
138 mS/m EC
TDS
pH n=58
7.9 pH
Calcium n=34
118 mg/L Ca
Magnesium n=42
51.42 mg/L Mg
Potassium n=42
18.06 mg/L K
Sodium n=42
95.18 mg/L Na
TAlkalinity
Chloride n=58
103 mg/L Cl
Fluoride n=47
0.4 mg/L F
Silica
Sulphate n=58
464 mg/L SO4
NH4(N) n=49
4.1 mg/L NH4_N
NO3(N) n=43
5.48 mg/L NO3_N
KN
PO4(P) n=49
0.71 mg/L PO4_P
TP
1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009
Drainage region C
C2
Johannesburg
C22
Lesupas
Rynboville
Springs
Natalspruit
C22C

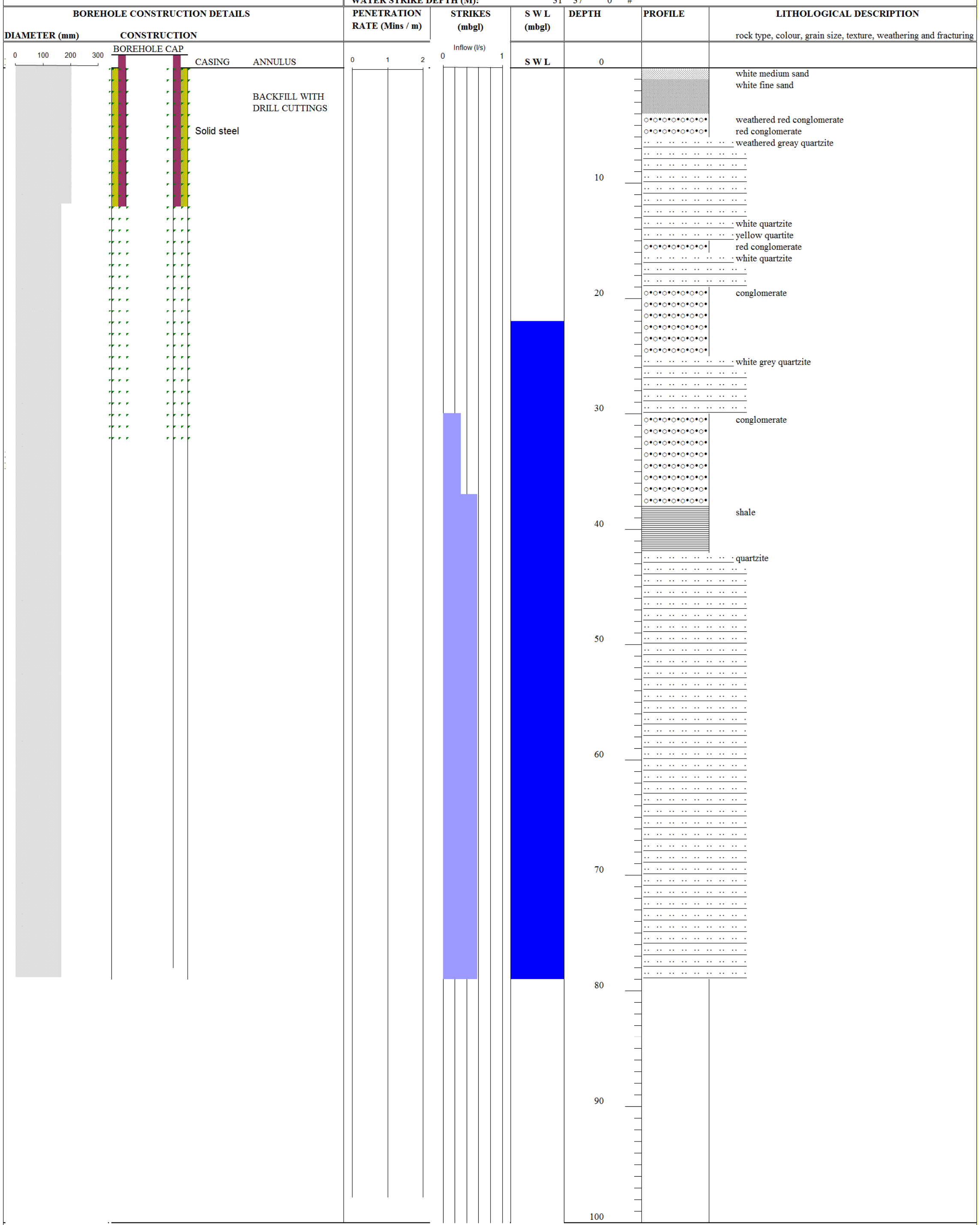
APPENDIX 2


WSM CIVIL ENGINEERS, HYDRO-
GEOLOGISTS & PROJECT MANAGERS (PTY)
P O BOX 3316
PRETORIA
0700
TEL NO :
FAX NO :
DRILLING RECORD
CLIENT : Joburg Property
PROJECT : South Hills
SITE : Moffat Park
LOG : K. Sami
DRILLER : WR Drilling and Grouting
DATE DRILLED :
DRILL METHOD: DTH
DRILL DIA (MM): 203 165 0 0
DEPTH (M): 12 79 0 0
FINAL BLOW YIELD (L/S): 2.5 0
WATER STRIKE DEPTH (M): 7 10 12 20 #
JOB NO. :
BOREHOLE NO : 1
ELEVATION :
X :
Y :
DEPTH (M): 79
CASING ID (MM): 165
STATIC WATER LEVEL (M): 1.94
BOREHOLE CONSTRUCTION DETAILS
DIAMETER (mm)
CONSTRUCTION
BOREHOLE CAP
0 100 200 300
CASING
ANNULUS
BACKFILL WITH
DRILL CUTTINGS
Solid steel
slotted steel
PENETRATION
RATE (Mins / m)
0 1 2
STRIKES
(mbgl)
Inflow (l/s)
0 5
S W L
(mbgl)
S W L
DEPTH
0
10
20
30
40
50
60
70
80
90
100
PROFILE
LITHOLOGICAL DESCRIPTION
rock type, colour, grain size, texture, weathering and fracturing
White medium to coarse sand
red sand
Yellow silty sand
Yellow weathered quartzite
red quartzite
unweathered grey quartzite
water strike in fractured red quartzite
grey quartzite
Black shale
grey quartzite
white quartzite
pink quartzite
grey quartzite
BOREHOLE LOG

WSM CIVIL ENGINEERS, HYDRO-GEOLOGISTS & PROJECT MANAGERS (PTY)
P O BOX 3316
PRETORIA
0700
TEL NO :
FAX NO :

DRILLING RECORD

CLIENT :	Joburg Property	JOB NO. :	
PROJECT :	South Hills	BOREHOLE NO :	2
SITE :	Moffat Park	ELEVATION :	
LOG :	K. Sami	X :	
DRILLER :	WR Drilling and Grouting	Y :	
DATE DRILLED :		DEPTH (M):	79
DRILL METHOD:	DTH	CASING ID (MM):	165
DRILL DIA (MM):	203 165 0 0	STATIC WATER LEVEL (M):	22.7
DEPTH (M):	12 79 0 0		
FINAL BLOW YIELD (L/S):	0.58 0		
WATER STRIKE DEPTH (M):	31 37 0 #		



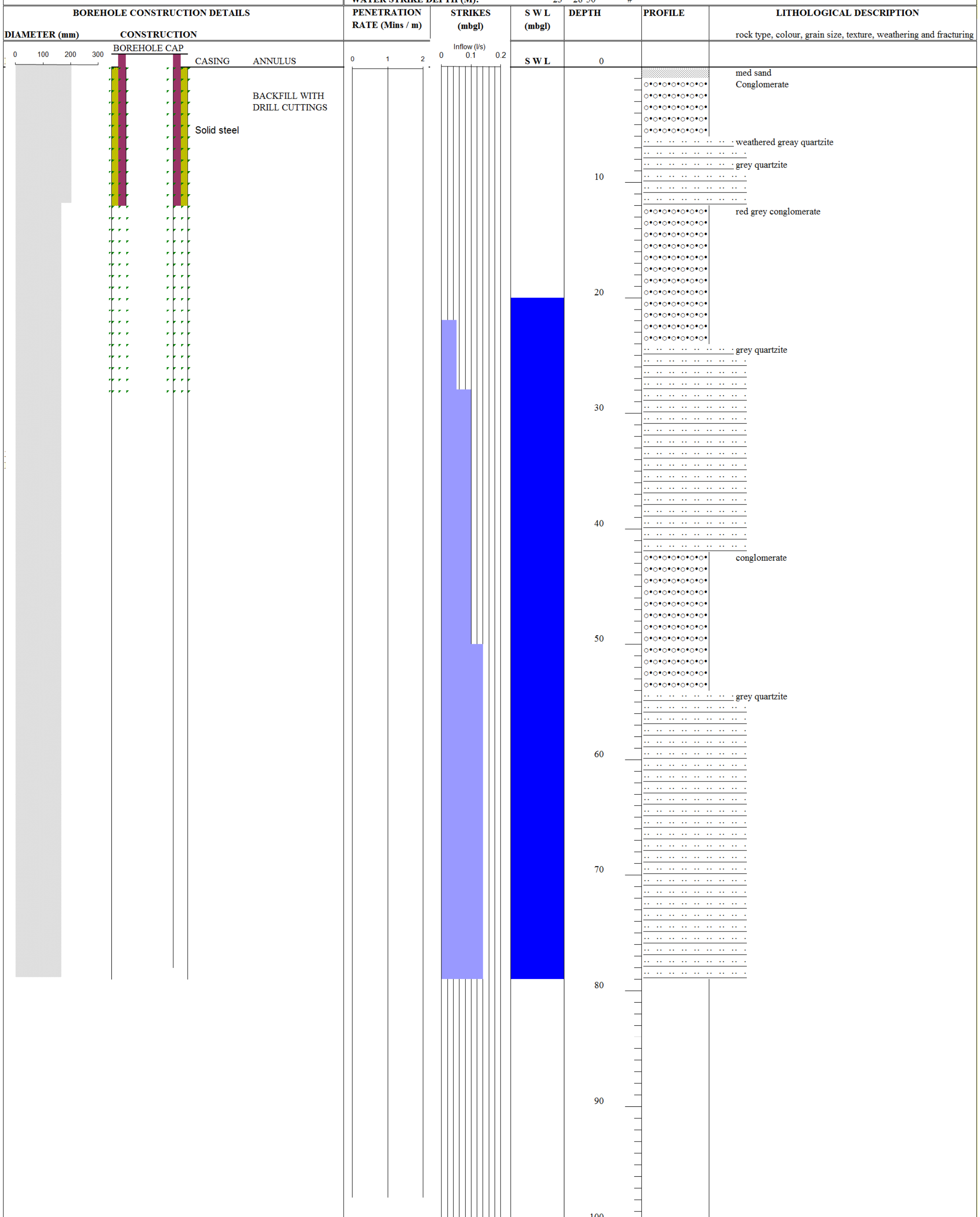
BOREHOLE LOG

WSM CIVIL ENGINEERS, HYDRO-GEOLOGISTS & PROJECT MANAGERS (PTY)

P O BOX 3316
PRETORIA
0700
TEL NO :
FAX NO :

DRILLING RECORD

CLIENT :	Joburg Property	**JOB NO. :**	
PROJECT :	South Hills	**BOREHOLE NO :**	3
SITE :	Moffat Park	**ELEVATION :**	
LOG :	K. Sami	**X :**	
DRILLER :	WR Drilling and Grouting	**Y :**	
DATE DRILLED :		**DEPTH (M):**	79
DRILL METHOD:	DTH	**CASING ID (MM):**	165
DRILL DIA (MM):	203 165 0 0	**STATIC WATER LEVEL (M):**	20.3
DEPTH (M):	12 79 0 0		
FINAL BLOW YIELD (L/S):	0.14 0 0		
WATER STRIKE DEPTH (M):	23 28 50 #		



BOREHOLE LOG