109899/GW1/2013

GODS WINDOW SKYWALK FINAL GEOHYDROLOGICAL REPORT

Report no 109199-GW1/2013

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Original

FINAL REPORT

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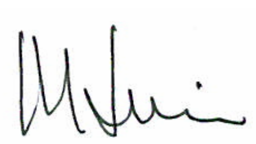
Signed on behalf of Aurecon:	 **M Levin**
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EXECUTIVE SUMMARY

Aurecon was appointed by Strategic Environmental Focus to do a geohydrological study of the potential environmental impact of the development and construction of the Gods Window Skywalk near Graskop, Mpumalanga. As stated in the TOR the objectives are to:

- Undertake and complete environmental assessments that will serve the Department of Economic Development, Environment and Tourism's (DEDET) decision on the environmental acceptability of the proposed development.
- Inform the applicant's understanding of the environmental implications of the various project alternatives and;
- The range of mitigation measures available, leading to an enhanced project and minimizing risks and delays and associated costs.

This study forms part of the environmental impact assessment (EIA) undertaken and includes the collection all the available information regarding the site to compile a geohydrological report. This information is pertinent to understand the hydrological characteristics of the site and assists in the requirements for the development.The objective is to identify any issues that may require addressing. The scope of this report is to:

- Collect and evaluate all available information
- Process and interpret the information
- Discuss the results
- Make recommendations that must be considered for site development

Based on the desk study, site visit & hydrocensus, the following can be concluded:

- Rainfall, run-off and groundwater recharge in the site area control existing environmental conditions and if not taken into consideration during development may have undesirable impact on the ecology.
- No other groundwater users are present in the area.
- Seepage spring flow was heard down in the gorge but the general groundwater flow on the site is in a westerly direction towards drainage.
- The tourist site use fountain water piped by gravity flow to the site, however, the volumes used is not known.
- The water volumes required during construction and operation is not known and the supply source must still be decided.
- Re-testing and refurbishing the existing borehole GBH1 is possible as well as exploring for more groundwater.
- Borehole GBH2 is blocked and not accessible and cannot be considered for refurbishment.
- The soil profile was not investigated but is considered sandy based on the geological formations present.
- Due to the shallow rock in the area the presence of a perched water level during the wet season is possible and must be considered during construction.

- The groundwater quality is not known and could be corrosive.
- The aquifer system in the study area can be classified as a "Major Aquifer System" which is described as follows: "An aquifer which is used to supply 50% or more of domestic water for a given area, and for which there is no reasonably available alternative sources should the aquifer be impacted upon or depleted. Aquifer yields and natural water quality are immaterial."
- The ratings for the Aquifer System Management Classification and Aquifer Vulnerability Classification yield a Groundwater Quality Management Index of 8 for the study area, indicating that a high level of groundwater protection may be required.
- The development site is located in quaternary catchment B60B of the Olifants River Catchment.
- Should the groundwater resource be used and the volume required for use determined then the geohydrological report must be updated for WULA.
- Due to the shallow soil and hard rock a sanitary package plant would be required for the development.
- Solid waste must be collected and managed to ensure a clean environment.

The following recommendations are made:

- The possible existence of a shallow water table during the wet season must be considered when planning and designing basement levels in the development.
- The development must not rely on the fountain and it is therefore recommended that the existing borehole GBH1 be retested and that if required exploration for new borehole(s) be considered.
- It is recommended that groundwater and surface water samples be taken for base line quality and to identify possible future pollution to this water.
- The groundwater is possibly of corrosive nature and must be tested.
- The presence of a major aquifer and high soil permeability pose a high risk to the groundwater users around the site and a comprehensive management and monitoring program must be implemented to ensure zero pollution impact on the sole source aquifer.
- It is recommended that a pollution control storage pond be constructed at down-gradient to capture and treat polluted water from parking areas or workshop areas etc. if necessary.
- No septic tank system must be considered for the development but a package plant must be considered
- The solid waste must be collected, managed and disposed at the permitted site at Graskop.
- It is recommended that for the WULA a new proposal must be prepared for updating the geohydrological report.

1 INTRODUCTION

Aurecon was appointed by Strategic Environmental Focus to do a geohydrological study of the potential environmental impact of the development and construction of the Gods Window Skywalk near Graskop, Mpumalanga. As stated in the TOR the objectives are to:

- Undertake and complete environmental assessments that will serve the Department of Economic Development, Environment and Tourism's (DEDET) decision on the environmental acceptability of the proposed development.
- Inform the applicant's understanding of the environmental implications of the various project alternatives and;
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This study forms part of the environmental impact assessment (EIA) undertaken and includes the collection all the available information regarding the site to compile a geohydrological report. This information is pertinent to understand the hydrological characteristics of the site and assists in the requirements for the development. The objective is to identify any issues that may require addressing. The scope of this report is to:

- Collect and evaluate all available information
- Process and interpret the information
- Discuss the results
- Make recommendations that must be considered for site development

2 AVAILABLE INFORMATION

The following information was available and relevant to the study:

- 1:250 000 Geological Map Pelgrim's Rest 2430
- 1:500 000 Hydrogeological Map Phalaborwa 2330
- 1:50 000 Topographic map Graskop 2430
- Vegter J R (1995) Groundwater Resources of the Republic of South Africa.
- Vegter J R (1995) An Explanation of a set of National Groundwater Maps. WRC Report TT74/95.
- DWS (2000) Policy and Strategy for Groundwater Quality Management in South Africa. Report First Edition 2000.
- AECOM (2013) Skywalk at Gods Window. Project No 602882248 dated April 2013
- Campbell Scott and Quinton (2009) Skywalk Complex and Skylift at Gods Window – Blyde River Canyon Nature Reserve. December 2009.
- ARQ (2013) God's Window Preliminary Geotechnical Assessment Based on a Visual Inspection. Report No. 6640/13554 dated 30 August 2013.
- Dept of Water Affairs & Forrestry (2003) A Protocol to Manage the Potential of Groundwater Contamination from on Site Sanitation. Edition 2 March 2003.

- Parsons R (1995) A South African Aquifer System Management Classification. Report KV 77/95.
- DWS (1998) Minimum Requirements for Waste Disposal by Landfill. Second Edition 1998.

3 SITE LOCALITY

The site as indicated in Figure 1 is located about 10km from Graskop in the Mpumalanga Province and is a very popular tourist attraction. The site is located on the edge of the escarpment with a view to the east over the Blyde River Canyon. The plateau on which the site is located slopes to the west into a south flowing drainage.

4 GEOLOGICAL SETTING

Based on the 1:250 000 geological map (Pilgrim's Rest 2430), the study area is underlain by sedimentary rocks upper and lower parts of the Wolkberg Group belonging to the Transvaal Sequence (Figure 2). The upper part of the Wolkberg Group consists of the following formations:

- Sadowa consisting of dark-grey to brown, well-bedded, micaceous shale with lenticular quartzite layers.
- Mabin consisting of white, grey to reddish brown, medium- to fine-grained quartzite with pebble fans and interlayered shale layers.
- Selati consisting of laminated micaceous and graphitic shale, locally interlayered with sandy shale, flagstone and quartzite.

As stated in the site visit and assessment geotechnical report (ARQ, 2013) the upper and lower undifferentiated Wolkberg Groups consist predominantly of conglomerates, quartzite and shale. The report further assumes a shallow soil profile with rock close to surface. Based on the rock types present in the formations it can be assumed that the soil profile consist of sandy soil. It is recommended that this be confirmed during the geotechnical investigation.

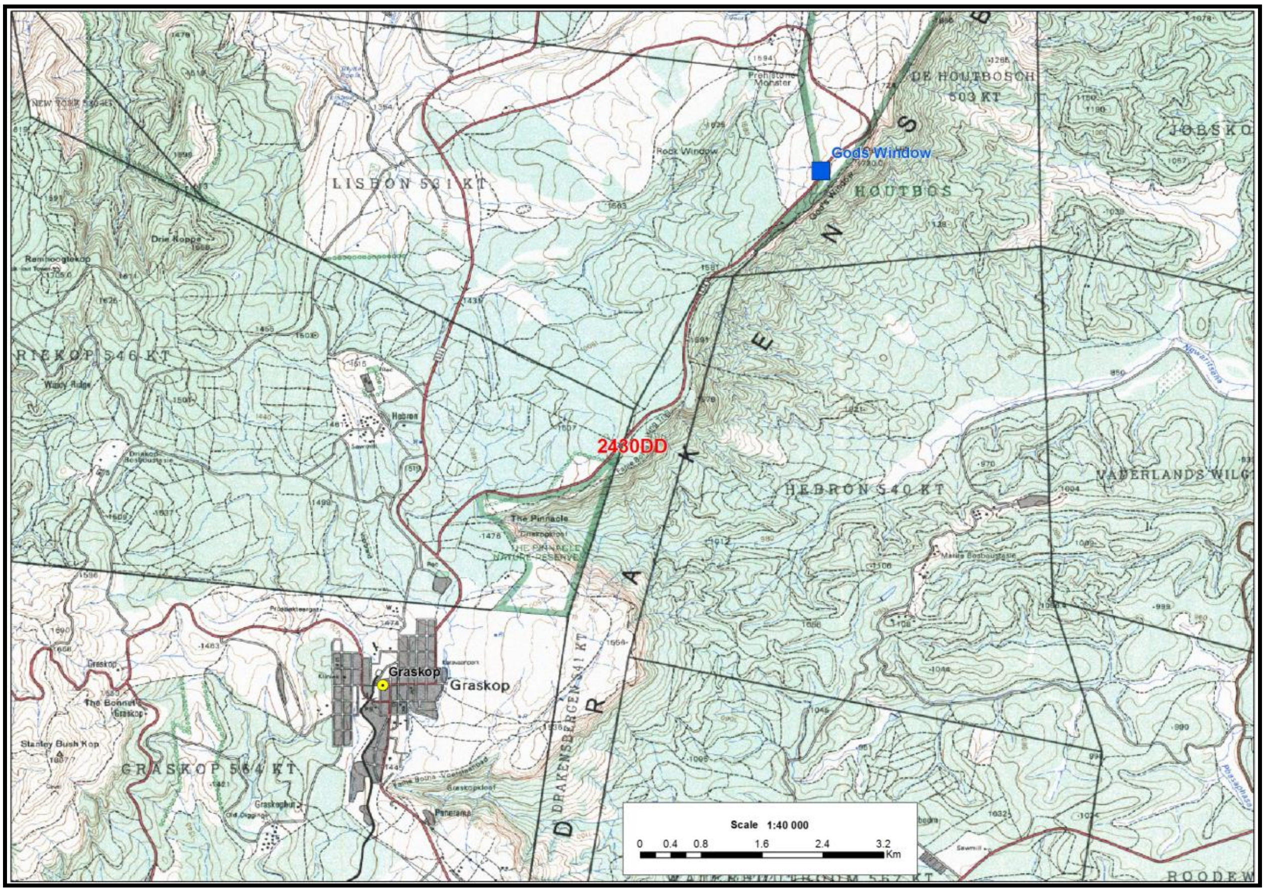


Figure 1: Locality map of the project area.

5 GEOHYDROLOGICAL SETTING

Groundwater movement in the undifferentiated sedimentary rock is along secondary structures, such as fractures, cracks and joints in the hard sedimentary rock. It should be emphasised that not all secondary structures are water bearing. Many of these structures are constricted because of compressional forces that act within the earth's crust. The probability of intersecting a water-bearing fracture by drilling may decreases rapidly with depth. Scientific siting of production boreholes is necessary to intersect these fractures. According to the 1:500 000 Hydrogeological map the aquifer in this area is low and only yield between 0.1 to 0.5 l/s. However, Vegter (1995) indicated on his map that the probability to drill a successful borehole yielding more than 0.1 l/s is between 40 and 60% and the probability of drilling a borehole yielding more than 2 l/s is 40 to 50%.

The presence of shallow rock may result in a shallow perched aquifer in the soil zone during the rainy season. This must be taken in consideration during the structural design in the site area. The movement of groundwater on top of the hard rock is lateral and in the direction of the surface slope. Rain water recharged to the soil zone eventually emanates downstream while the remaining water is evapotranspirated or drained by some other means. This is especially true of the perched groundwater that because of shallow hard rock base depth does not seep vertically and moves horizontal. The evapotranspiration process is enhanced by vegetation.

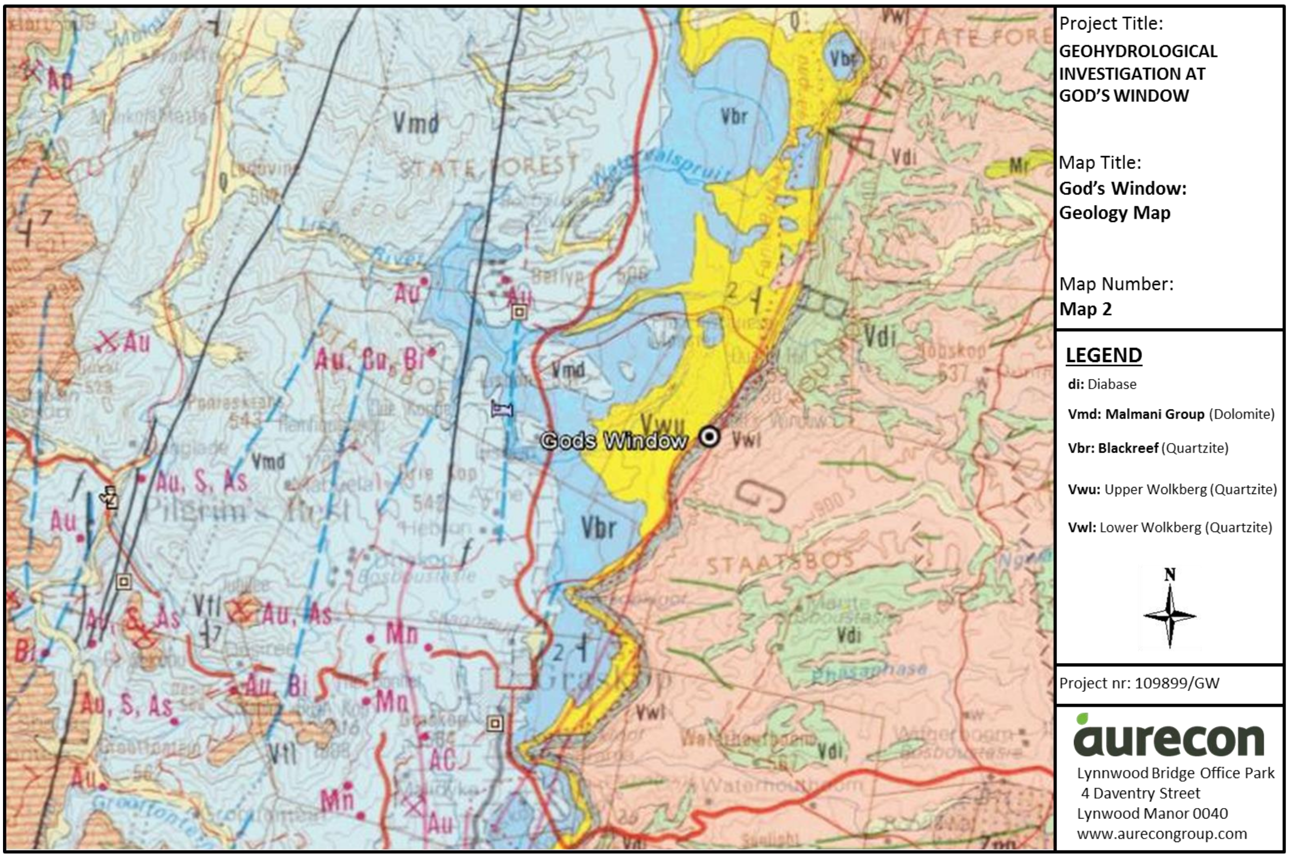


Figure 2: Geological map of the area.

6 SITE GEOHYDROLOGY

The aim of the site visit on 6 August 2013 was to verify the published information and collect site specific data. During the site visit a hydrocensus was carried out on the property earmarked for development as well as the adjacent area of about one kilometre radius to identify any legitimate groundwater users. Two boreholes were identified in the area and the locality of the boreholes is shown on the map in Appendix A and its coordinates in Table 1. Borehole GBH1 is not in use and a pump is stuck inside the borehole but no water level could be measured as shown in Figure 3. It is understood that this borehole was previously used for water supply to the Gods Window tourist site. About 8 metres away a second borehole GBH2 (shown in Figure 4) is located and a water level was measured. The static water level is 20.41 metres below ground level (mbgl).

During the site visit the water supply to the site was investigated. The water is piped by gravity flow from a tank filled by a fountain in the rocks. The locality of the fountain is shown in Figure 6 and the locality map in Appendix A. Seepage spring flow of groundwater is occurring in the Gods Window gorge (Appendix A) and although the exact source and flow cannot be seen from above the sound of flowing water is clear. It is concluded that shallow groundwater is present in the escarpment area and this needs to be protected as it is essential for the ecology of the area.

Table 1. Coordinates of localities recorded at Gods Window.

Locality	Lat	Long	GPS Elevation (masl)
Gods Window	24.87663098	30.88883903	1653
Borehole GBH1	24.86900504	30.88585499	1621
Borehole GBH2	24,86903333	30.88580000	1621
Seepage	24.87640500	30.88905100	1658
Fountain	24.87123303	30.89193496	1695

Coordinates in decimal degrees (WGS84).

Figure 3: Borehole GBH1 previously used for water supply to Gods Window.

The quality of groundwater in the area is shown on the Hydrogeological map to be below 70 mS/m which is perfect for human consumption. However once the supply sources are established samples must be taken after reticulation and tested for both the chemical and bacteriological parameters.

No information regarding the existing old boreholes could be obtained from the Management. The source that will be used for water supply is also still unknown.

7 AQUIFER CLASSIFICATION

The aquifer(s) underlying the subject area were classified in accordance *with "A South African Aquifer System Management Classification, December 1995"* by Parsons. Classification has been done in accordance with the following definitions for Aquifer System Management Classes:

- Sole Aquifer System: An aquifer which is used to supply 50% or more of domestic water for a given area, and for which there is no reasonably available alternative sources should the aquifer be impacted upon or depleted. Aquifer yields and natural water quality are immaterial.
- Major Aquifer System: Highly permeable formations, usually with a known or probable presence of significant fracturing. They may be highly productive and able to support large abstractions for public supply and other purposes. Water quality is generally very good (Electrical Conductivity of less than 150 mS/m).
- Minor Aquifer System: These can be fractured or potentially fractured rocks which do not have a high primary permeability, or other formations of variable permeability. Aquifer extent may be limited and water quality variable. Although these aquifers seldom produce large quantities of water, they are important for local supplies and in supplying base flow for rivers.
- Non-Aquifer System: These are formations with negligible permeability that are regarded as not containing groundwater in exploitable quantities. Water quality may also be such that it renders the aquifer unusable. However, groundwater flow through such rocks, although imperceptible, does take place, and needs to be considered when assessing the risk associated with persistent pollutants.

Table 2. Ratings for the Aquifer System Management and Second Variable Classifications:

Aquifer System Management Classification		
Class	Points	Study area
Sole Source Aquifer System:	6	
Major Aquifer System:	4	4
Minor Aquifer System:	2	
Non-Aquifer System:	0	
Special Aquifer System:	0 – 6	
Second Variable Classification (Weathering/Fracturing)		
Class	Points	Study area
High:	3	
Medium:	2	2
Low:	1	

Based on information collected during the hydrocensus it can be concluded that aquifer system in the study area can be classified as a "Major Aquifer System". The local population is solely dependent on groundwater and no alternative source of water is available at present. In order to calculate the Groundwater Quality Management Index, a points scoring system as presented in Table 3 and Table 4 was used.

Table 3. Ratings for the Groundwater Quality Management (GQM) Classification System:

Aquifer System Management Classification		
Class	Points	Study area
Sole Source Aquifer System:	6	
Major Aquifer System:	4	4
Minor Aquifer System:	2	
Non-Aquifer System:	0	
Special Aquifer System:	0 - 6	
Aquifer Vulnerability Classification		
Class	Points	Study area
High:	3	
Medium:	2	2
Low:	1	

The occurring aquifer(s), in terms of the above definitions, is classified as a sole aquifer system. The vulnerability, or the tendency or likelihood for contamination to reach a specified position in the groundwater system after introduction at some location above the uppermost aquifer, in terms of the above, is classified as **medium**. A shallow water table (~7 mbgl) underlies the site. The level of groundwater protection based on the Groundwater Quality Management Classification:

GQM Index = Aquifer System Management x Aquifer Vulnerability
= 4 X 2 = 8

Table 4. GQM index for the study area

GQM Index	Level of Protection	Study Area
<1	Limited	
1 – 3	Low Level	
3 - 6	Medium Level	
6 - 10	High Level	8
>10	Strictly Non-Degradation	

7.1 Aquifer Susceptibility

Aquifer susceptibility, a qualitative measure of the relative ease with which a groundwater body can be potentially contaminated by anthropogenic activities and which includes both aquifer vulnerability and the relative importance of the aquifer in terms of its classification, in terms of the above, is classified as **high level**.

7.2 Aquifer Protection Classification

The ratings for the Aquifer System Management Classification and Aquifer Vulnerability Classification yield a Groundwater Quality Management Index of 8 for the study area, indicating that **high level groundwater protection** may be required.

Due to the high level GQM index calculated for this area, a strictly high level of protection is needed to adhere to the Department of Water Affair's (DWS) water quality objectives. Reasonable and sound groundwater protection measures are recommended to ensure that no cumulative pollution affects the aquifer, even in the long term.

In terms of DWS's overarching water quality management objectives which is (1) protection of human health and (2) the protection of the environment, the significance of this aquifer classification is that if any potential risk exists, measures must be taken to limit the risk to the environment, which in this case is the (1) protection of the Secondary Underlying Aquifer and (2), the limited number of external users of groundwater in the area.

8 QUATERNARY CATCHMENT

The Gods Window site is located in the B60B Quaternary Catchment of the Olifants River Catchment as shown on the map in Appendix B. WARMS at DWS was contacted to obtain data of water users and usage downstream of Gods Window in the B60B quaternary catchment. Data for the three farms BERLYN 506KT, QUARTZKOP 533KT and LISBON531KT was obtained and the important aspects are shown in the WARMS Data table in Appendix C. There is only one borehole registered for groundwater use while the rest of the usage is surface water.

Under the National Water Act (Act No. 36 of 1998) the water use at the proposed Gods Window Development must be authorised. No information on the water source that will be used at Gods Window was available and if a decision is made to use groundwater as the source a Rapid Reserve Determination must be done. The Reserve determined is the quantity and quality of water required to supply basic needs of people to be supplied with water from that resource and to protect aquatic ecosystems in order to secure ecologically sustainable development and use of water resources. This will be a requirement for a Water Use License Application (WULA). The available groundwater will have to be established by pump testing existing and newly explored boreholes. Once that information is available it is recommended that the geohydrological report be updated for the WULA.

9 RAPID RESERVE DETERMINATION

9.1 Introduction

Definition of Reserve: *"The quantity and quality of water required to supply basic needs of people to be supplied with water from that resource and to protect aquatic ecosystems in order to secure ecologically sustainable development and use of water resources".*

To be able to quantify the groundwater component of the Reserve, the following relationship has to be solved:

$$\mathbf{GW_{allocate} = (Re + GW_{in} - GW_{out}) - BHN - GW_{Bf}}$$

where:	$GW_{allocate}$	=	groundwater allocation
	Re	=	recharge
	GW_{in}	=	groundwater inflow
	GW_{out}	=	groundwater outflow
	BHN	=	basic human needs
	GW_{Bf}	=	groundwater contribution to baseflow

Under the National Water Act (Act No. 36 of 1998) the water use at God's Window must be authorised. The water will be abstracted from a borehole(s), stored in a reservoir and used for domestic and industrial purposes. Under these circumstances, the following (ground) water use is recognised as being relevant to the licence application:

- Section 21 (a) – taking water from a resource.

9.2 Approach

The assessment was done on a "rapid" level using the software GRDM version 4.0.0.0 (2010). The data used for the calculation was derived from the WRC90 dataset contained in the "GRDM" software driven by the Resource Directed Measures from the Department of Water Affairs. The local catchment falls within quaternary catchment B60B. The default values were used in the assessment in order to develop some guidance on the potential impact of the proposed abstraction on the overall groundwater use in the catchment.

9.3 Description of the Study Area

The property hereafter referred to as Gods Window falls within quaternary catchment B60B. The quaternary catchment B60B has a total area of 305km2 of which 15.5 km2 is protected (Blyde River Canyon), leaving an effective area of 289 km2. The study area falls in the Olifants Water Management Area.

The dominant vegetation type is North Eastern Mountain Grassland. The area has a sloping topography and is drained by surface runoff towards the Blyde River which flows in a northerly direction which eventually flows into the Olifants River.

It can be assumed that groundwater elevations mimic surface topography, and groundwater flows from higher lying ground towards lower lying springs or valleys (drainage lines). Based on this observation, as well as the presence of fractured secondary aquifers, surface water catchment boundaries may be used as surrogate for groundwater divides. Using GIS software & Digital

Elevation Model (DEM) data, a local groundwater catchment for the project area was created. It can be assumed that abstraction at Gods Window will be limited to this local groundwater catchment which has a total area of 4.071 km^2 (407.1 ha).

Figure 4. Local Groundwater Catchment Area for God's Window

9.4 Present Water Demand

No facilities other than ablution blocks and water taps currently exist on the property of the study area. The amount of water currently used is unknown by probably fairly low. The DWS categorises the water use licence applications in 3 categories based on the amount of recharge that is used by the applicant in relation to the specified property:

- Category A: Small scale abstractions (<60% recharge on property)
- Category B: Medium scale abstractions (60-100% recharge on property)
- Category C: Small scale abstractions (>100% recharge on property)

The recharge on the actual area of the registered property is not indicative of the volume of groundwater available for abstraction. Property boundaries does not reflect aquifer boundaries, therefore the area of the local groundwater catchment as described in section 9.3 was used to categorise the abstraction/recharge percentage.

9.5 RDM Assessment

The following table summarises the most salient parameters relevant to this catchment (B60B):

Table 5. Most salient parameters relevant to catchment B60B.

Area km²	Population	General Authorisation (m³/ha/a)	Rainfall (mm/a)	Current use (Mm³/a)
302.2	500	75	1026	0

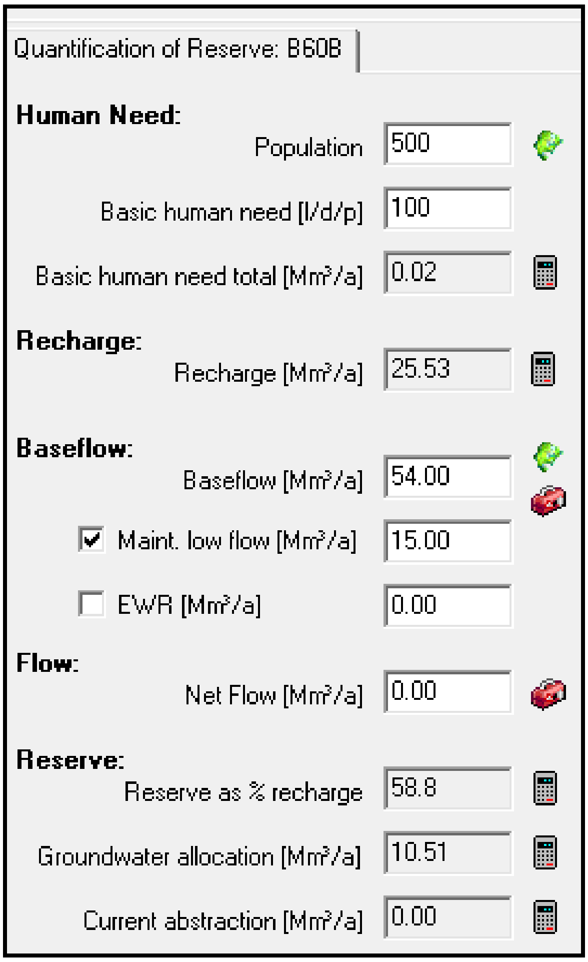
9.6 Classification

Groundwater classification is currently based on a Stress Index which relates water use to recharge. The study area is classified as category B, which indicates unstressed or low levels of stress in terms of abstraction/recharge. The resource is still being used sustainably. At this stage Classification is not directly linked to potential abstraction, but is only indicative of the current situation. A category C classification still implies that ~25.5 (Mm³/a) can still be abstracted from the quaternary catchment before very detailed studies will be required.

9.7 Reserve

The following table summarizes the Reserve for the catchment.

Table 6. A summary of the Reserve for the catchment.



The allocatable portion is still very high, with the greatest impact coming from base flow. Baseflow/Ecological Water Requirement (EWR) totals 58.8% of recharge to the quaternary catchment. If this calculation is done based on the actual area of the local catchment, the following emerges:

Table 7. Recharge to Local Groundwater Catchment at God's Window

Catchment	Actual area (ha) of local catchment	Recharge in Quartenary Catchment (mm/a)	Recharge on property	
B60B	**407.1**	**83.75**	340946.25	**m^3/a**
Total	***407.1***		***340946.3***	**m^3/a**
			0.341	**Mm^3/a**
			934099	**l/day**
			10.8	**l/second**

From this it is evident that local recharge (340 946 m^3/annum) will not supply in the allocatable portion (10.51 Mm^3/annum) for the quaternary catchment B60B. **The local recharge on the local catchment will allow for abstraction of ~ 340 946 m^3/annum.** God's Window could easily apply for 78 840 m^3/a (2.5l/s). The recharge calculations (abstraction being 23% of the local recharge) places the application in Category A (small scale abstractions (<60% recharge on local catchment) (see section 9.4).

9.8 Resource Quality Objectives

Maintain regional groundwater table to:

- Ensure that Schedule 1 water users adjacent to the site have adequate water supply to sustain the basic human need.
- Ensure that adequate water is available to maintain base flow in rivers and streams.

10 DEVELOPMENT IMPACT ASSESSMENT

The underlying geological and geohydrological character of the site is important aspect that has to be considered when developing the site. Rainfall, run-off and groundwater recharge in the site area control existing environmental conditions and if not taken into consideration during development may have undesirable impact on the ecology. The potential impact on the groundwater regime by the development will be assessed during the construction and the operational phases. The impacts considered include water supply, sanitation and waste disposal.

Figure 5: Unused borehole GBH2 close to the previously used borehole GBH1.

Figure 6: The fountain use to pipe water to Gods Window

10.1 Water supply

10.1.1 Construction Phase

No estimate of the volume of water required during construction is available. The present supply from the fountain may not be enough and it is recommended that the existing borehole be retested and refurbished to supply water. Alternately groundwater exploration for siting new additional borehole(s) can be initiated. Such exploration must be done west away from the tourist escarp area. There are no other groundwater users in the one kilometre surveyed area that will impact on the borehole(s). A water supply borehole in the tourist area and to close to the gorge may impact on the groundwater spring seepage flow down in the gorge and shown on the map in Appendix A.

Water levels in the project area will follow a seasonal trend and shallow perched groundwater level can be expected during the wet season. This needs to be considered if basement levels are to be designed at this depth and below. It must further be stressed that the groundwater in the underlying aquifer could be corrosive and can impact on infrastructure. It is recommended that a corrosivity test be done to establish the potential impact.

10.1.2 Operational Phase

It is understood that a final decision still need to be taken on the bulk water supply to the site from Graskop or from local source. The volume required is not known but must supply the daily requirements and provision must be made for fire fighting. Once the reticulation system is completed sample for chemical and bacteriological testing must be submitted to a accredited laboratory to ensure drinking water quality.

10.2 Storm Water

10.2.1 Construction Phase

Better we recommend that

Polluted run-off must be prevented by storm water control. It is recommended that a pollution control storage pond be constructed at down-gradient to capture and treat polluted water if necessary. During the construction phase large earth moving equipment and trucks will be on site. These vehicles normally may leak oil, fuel and grease and a workshop area may be established and fuel storage etc. The selected area should have a berm to keep storm water from rain out of the area. The run-off from the selected area should be controlled and if necessary collected and cleaned to prevent impact on the environment and pollution of groundwater that may be used as supply to the site.

10.2.2 Operational Phase

During the operational phase it will mainly concern the run-off from the parking area. Oil leakage and grease from vehicle collect on the site and it is presumed it will be a paved site sloping slightly to the main road. Storm water must be diverted around the parking area and the run-off from the parking area must be controlled and channelled to a point where it can pass through a grease filter if necessary.

10.3 Sanitation

10.3.1 Construction Phase

It is understood that the present sanitary system consist of a septic tanks that is emptied from time to time. It is not known if the existing system will be sufficient and if it will exist during construction.

It is further unsure where the construction camp will be located. However, no septic system that allow overflow into the subsoil must be installed. During construction a septic system that can be emptied or chemical toilets should be used. The shallow soil profile and sandy nature of the soil makes it vulnerable to pollution from a poorly operated septic system.

10.3.2 Operational Phase

The planned development will need a system to cater for office and restaurant staff as well as tourists and therefore will possibly require a Package plant. However, should a septic sanitary system or French drains be considered on the site, a sanitation protocol study will be required (Dept Water Affairs & Forestry, 2003).

10.3.3 Solid Waste Disposal

It is assumed that solid waste will be collected and disposed at the permitted site at Graskop during the construction and the operational phases. During the site visit it was noted that food, cans, cigarette buds etc. were disposed in the environment. Management of solid waste will have to be attended to during both construction and operational phases.

11 CONCLUSIONS

Based on the desk study, site visit & hydrocensus, the following can be concluded:

- Rainfall, run-off and groundwater recharge in the site area control existing environmental conditions and if not taken into consideration during development may have undesirable impact on the ecology.
- No other groundwater users are present in the area.
- Seepage spring flow was heard down in the gorge but the general groundwater flow on the site is in a westerly direction towards drainage.
- The tourist site uses fountain water piped by gravity flow to the site, however, the volumes used is not known.
- The fountain is located in a protected area.
- The water volumes required during construction and operation is not known and the supply source must still be decided.
- Re-testing and refurbishing the existing borehole GBH1 is possible as well as exploring for more groundwater.
- Borehole GBH2 is blocked and not accessible and cannot be considered for refurbishment.
- The soil profile was not investigated but is considered sandy based on the geological formations present.
- Due to the shallow rock in the area the presence of a perched water level during the wet season is possible and must be considered during construction.
- The groundwater quality is not known and could be corrosive.

- The aquifer system in the study area can be classified as a “Major Aquifer System” which is described as follows: “An aquifer which is used to supply 50% or more of domestic water for a given area, and for which there is no reasonably available alternative sources should the aquifer be impacted upon or depleted. Aquifer yields and natural water quality are immaterial.”
- The ratings for the Aquifer System Management Classification and Aquifer Vulnerability Classification yield a Groundwater Quality Management Index of 8 for the study area, indicating that a high level of groundwater protection may be required.
- The development site is located in quaternary catchment B60B of the Olifants River Catchment.
- Should the groundwater resource be used and the volume required for use determined then the geohydrological report must be updated for WULA.
- Due to the shallow soil and hard rock a sanitary package plant would be required for the development.
- Solid waste must be collected and managed to ensure a clean environment.

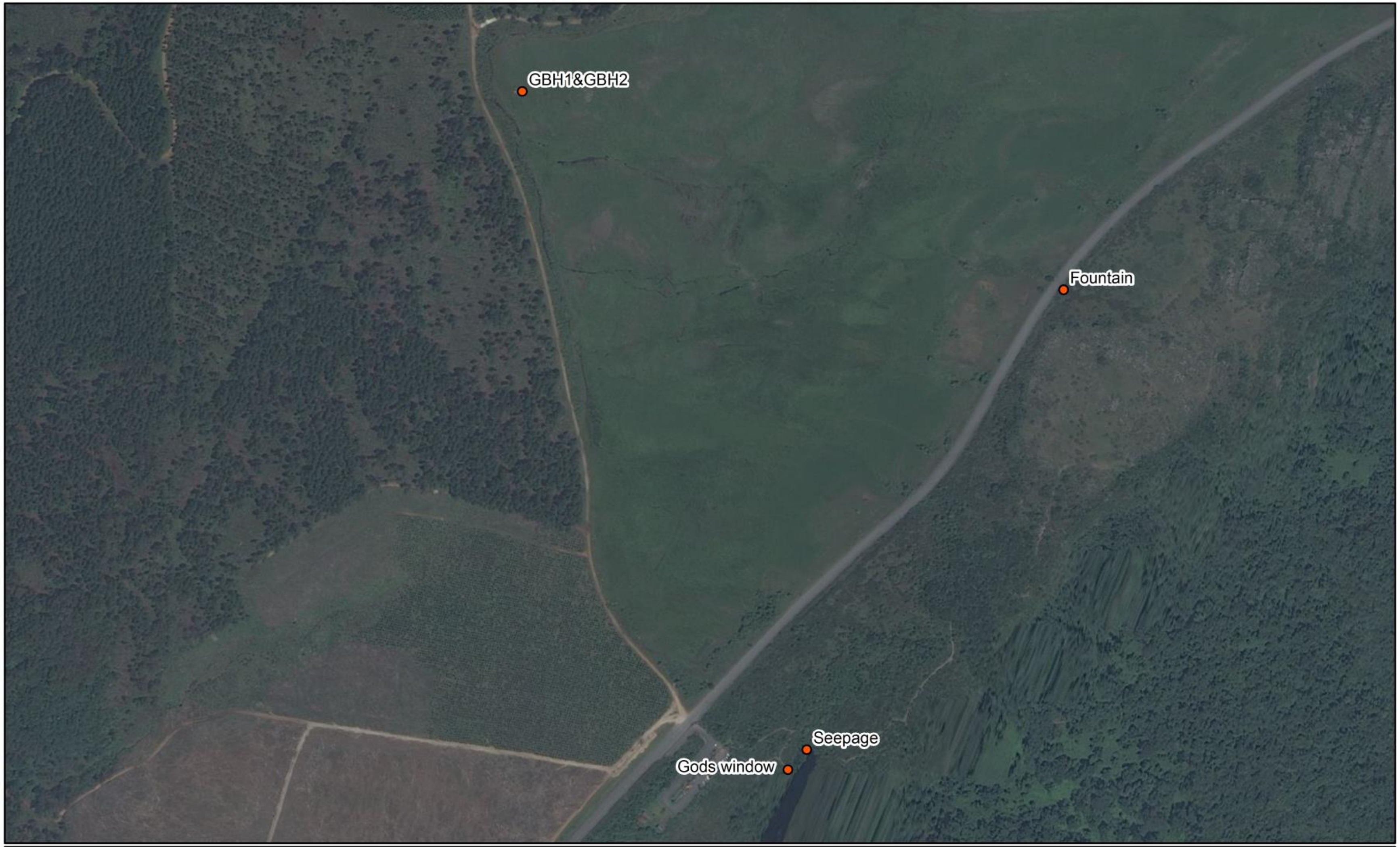
12 RECOMMENDATIONS

The following recommendations are made:

- The possible existence of a shallow water table during the wet season must be considered when planning and designing basement levels in the development.
- The development must not rely on the fountain and it is therefore recommended that the existing borehole GBH1 be retested and that if required exploration for new borehole(s) be considered.
- It is recommended that groundwater and surface water samples be taken for base line quality and to identify possible future pollution to this water.
- The groundwater is possibly of corrosive nature and must be tested.
- The presence of a major aquifer and high soil permeability pose a high risk to the groundwater users around the site and a comprehensive management and monitoring program must be implemented to ensure zero pollution impact on the sole source aquifer.
- It is recommended that a pollution control storage pond be constructed at down-gradient to capture and treat polluted water from parking areas or workshop areas etc. if necessary.
- No septic tank system must be considered for the development but a package plant must be considered
- The solid waste must be collected, managed and disposed at the permitted site at Graskop.
- It is recommended that for the WULA a new proposal must be prepared for updating the geohydrological report.

APPENDIX A

LOCALITY MAP



Legend

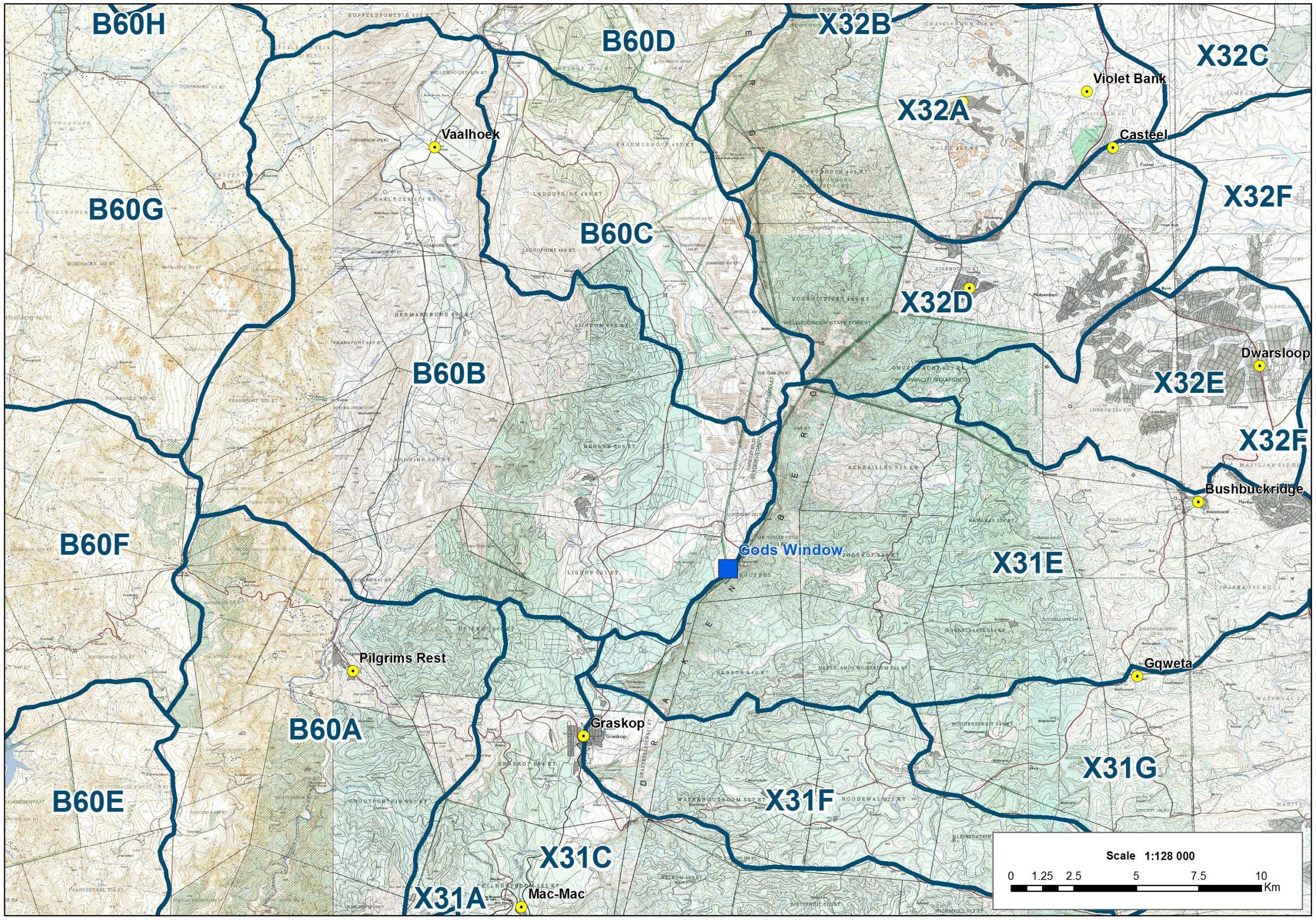
Points

GODS WINDOW

aurecon

APPENDIX B

QUATERNARY CATCHMENTS MAP



GODS WINDOW QUATERNARY CATCHMENT B60B

APPENDIX C

WARMS DATA

PROPERTY	WATER USE	NRWU Licence No	Licence Status	Drainage Region	Water Use Sector	Resource Type	Resource Name
LONDON	REGISTERED			B60B	WATER SUPPLY SERVICE	RIVER/STREAM	BRON2
BLACKHILL	INCOMPLETE	24083171/1	Under Assessment	B60B	MINING	RIVER/STREAM	Molotse River Tributary
HERMANSBURG	INCOMPLETE	24083199/1	Under Assessment	B60B	MINING	RIVER/STREAM	Molotse River Tributary
BERLYN 506 KT 0	REGISTERED			B60B	INDUSTRY (NON-URBAN)	RIVER/STREAM	BERLIN
BERLYN	REGISTERED			B60B	SCHEDULE 1	RIVER/STREAM	DAM / LAKE
WILLEMSOORD	REGISTERED			B60B	AGRICULTURE: IRRIGATION	RIVER/STREAM	BLYDE RIVER
BERLYN 506 KT 0	REGISTERED			B60B	SCHEDULE 1	RIVER/STREAM	BERLIN
BERLYN	INCOMPLETE	24085160/1	Under Assessment	B60B	MINING	BOREHOLE	GROUNDWATER

WARMS DATA