APPENDIX 4.8.2

SHORT
GROUNDWATER DESCRIPTION
FROM SAL CONSULT LIMITED
HYDROGEOLOGY REPORT

HYDROGEOLOGICAL CONDITIONS OF THE AREA

GROUNDWATER OCCURRENCE

The project area is underlain by the Birimian metasediments whose permeability is highly dependent on the secondary permeability obtained from fractures, quartz stringers, stockworks, veins and shear zones which have improved groundwater transmission and storage. The development of aquifers in these rocks is therefore dependent on the nature, length, density, thickness and the degree of interconnection of the fractures, stringers, stockworks and veins and also on the in-filling of the fractures as well as on the extent of weathering in the area.

For substantial amounts of groundwater to occur in these rocks, the fractures should be many and interconnected causing enough porosity and permeability for groundwater transmission and accumulation. The mode of occurrence of groundwater is thus basically linked to the nature and thickness of the decomposed zones and their interconnection to rock fractures, joints, quartz-veins and pegmatites that occur in these rocks. Quartz veins and pegmatites in the area are fractured and to some extent brecciated due to brittle deformational activities which may have affected them.

GROUNDWATER FLOW DIRECTION

In the study area, due to the heterogeneity of the aquifers and their dependence on secondary permeability, such as fractures and quartz veins among others, flow of groundwater within aquifers occurs predominantly in the fractures and other discontinuities rather than as intersticial flow. There are many barriers to continuous groundwater flow laterally as well as with depth. The rock types are varied and as such, weather to different depths. The nature and degree of weathering also varies spatially. Similarly, unfractured rocks are very common giving credence to lateral barriers to groundwater flow.

The determination of groundwater flow direction in any geologic formation is very complex and depends upon a variety of factors. The presence of geological structures such as faulting, folding and jointing constitute important controlling factors. Groundwater movement is in accordance with the hydrostatic gradients, where the difference in pressure heads between any two points is a prime motivating factor.

Coffey, 2007 assumed the direction of groundwater flow towards the Offin River to the north, based on terrain analysis (Regional topography).

To confirm this, static water levels for twenty-five (25no) inclined exploration holes from Perseus Mining limited were analysed. Geological sections with plot of static water levels were prepared for selected profiles within the concession. From the sectional maps, the difference in hydraulic heads was used to determine the flow directions. Flow is generally in the direction of low hydraulic gradient. The results showed that groundwater flow is radial within the project area.

DETERMINATION OF RECHARGE AREAS AND RATE OF RECHARGE

The study area is in a moist semi-deciduous forest with rainfall of between 951.2 mm to 1829 mm and it is characterized by seasonal rainfall, high evapo-transpiration rate and medium surface runoff. Infiltration of rainwater and subsequent percolation into the groundwater system as baseflow also depends on the aperture, density and degree of interconnection of the fractures and the permeability of the weathered rock.

Topographic highs are normally considered as areas of groundwater recharge and topographic lows as areas of groundwater discharge, especially in a terrain in which the occurrence of groundwater is controlled by the geomorphology, geology and tectonic setting.

Recharge of an unconfined aquifer occurs at the ground surface directly above the aquifer. In contrast, recharge to a confined aquifer may occur many kilometres away, typically at a higher elevation where the aquifer is no longer confined; that is, where the overlying material are permeable and allow percolating rainfall to reach the confined aquifer. Once recharged, the groundwater flow downgradient to where it is confined.

The occurrence of groundwater and the subsequent sustained withdrawal of water from an aquifer depend essentially on the amount of recharge that reaches the aquifer. This in turn is dependent, to some extent, on the soil moisture deficit, soil texture, soil structure, amount of vegetation cover, and the extent of lateral and vertical soil and aquifer parameter variation. Other critical inputs to groundwater recharge include the amount of precipitation, the extent of evapotranspiration, rock type, topography, permeability of aquifer, and surface runoff.

The rate of recharge to the aquifers in the study area will require a continuous data gathered over a period of years to be estimated. Generally, about 15% of the total precipitation ends up as groundwater, but this varies locally and regionally from 1 to 20%. Previous work carried by Jay Minerals Services Limited on the Ayanfuri concession estimated the recharge from 3 to 5% of the total annual rainfall.

AQUIFER CHARACTERISTICS

Aquifer types

Aquifers are geologic layers that are filled with water and that can transmit enough water to supply a well under normal hydraulic gradient. Both confined and unconfined aquifers exist in the study area. Flow of groundwater occurs in three distinctly different but hydraulically interconnected aquifers namely:

Weathered rock aquifers
Fractured quartz vein aquifers
Fractured rock aquifers

Aquifers in the area are highly heterogeneous with limited areal extent. Their characteristics change rapidly due to the nature of the topography, weathering conditions, geology and the secondary structural features necessary for the development of high permeability in the rock.

Depth to Aquifer

The depth to transition zones (moderately weathered zones) from drill logs was generally considered as the depth to the aquifer in this study. The transition zones are known to be good aquifers, especially when fractures and quartz veins crosscut them. The ability of moderately weathered zones and the fractured basement rocks to bear and yield water depend on the number and size of interstices created during weathering, fracturing and the extent to which they are interconnected.

A similar assessment of groundwater in the region carried out by Water Resources Research Institute (WRRI,1996) reported a variation in depths to which aquifers were intercepted from 6-69m with a mean of 37m for borehole logs. Coffey, 2007 on the other hand, reports the depth to aquifer from a range of 13-60m on the regional water bores.

As part of this study, drill logs of exploration holes were examined and the depth to the transition zones which are normally considered as the water bearing zones varied between 6 and 92m with a mean of 22.4m. This is indicative on both shallow and deep seated aquifers in the study area.

Yield (flow)

No yield measurements were carried out on the existing boreholes and no data was available in the study area but earlier assessment by the WRRI, 1996 recorded borehole yield in the range of 0.6-8.2m^3/hr and averaged 2.7m^3/hr.

Coffey, 2007 study on the regional boreholes in the area recorded borehole yields in the range of 0.7-10.79m^3/hr with a mean of 2.7m^3/hr.

The variations in yields may be due largely to weathering and fracturing. The borehole tapping water from relatively thick layers of unconsolidated and quartzite fragments derived from sandstones and quartzites as well as fractures in these rocks, were found to be relatively high yielding according to the WRRI report.

Static Water Level

The depth to static water levels recorded at the time of pump installation during the WRRI assessment in the region varied between 1 and 19m with a mean of 7.5m. Coffey, 2007 on the other hand, recorded static water level in the range of 1.7 to 23.3m with a mean of 9.16m.

For this study, data was obtained for groundwater levels in inclined exploration holes at the mine site. The groundwater levels were then projected to the vertical plane for analysis. The static water levels ranged from 1.7 to 26.6m with a mean of 12.62m in the inclined holes. However, it ranged from 123.534-133.883m (MSL). A summary of static water levels projected to the vertical and reduced to MSL is presented in Table 1

Table 1: Static water levels projected to the vertical and reduced to MSL

BHID	E -UTM	N – UTM	RL	Dip	Azm	SWL in inclined holes (m)	SWL Projected vertical and Reduced to MSL (m)
ABDD088	617,019.13	658,286.08	134.979	-60	NW	1.762	128.423
ABRC 051	617,132.47	658,441.19	134.974	-50	NW	11.351	126.278
ABRC144	617,035.65	658,609.14	141.639	-50	SE	14.421	130.592
ABRC146	617,088.75	658,549.52	139.773	-50	SE	8.632	133.161
ABRDD155	617,011.81	658,575.34	147.173	-70	SE	17.768	130.476
ABDD091	617,113.17	658,288.32	133.757	-50	SE	1.066	132.940
ABRDD286	617,022.16	658,563.91	147.187	-70	SE	19.911	128.477
ABRDD302	616,937.25	658,539.05	148.303	-70	SE	20.117	129.399
ABRDD306	616,962.42	658,570.08	149.196	-75	SE	18.272	131.547
ABRDD308	617,099.47	658,305.55	133.6	-50	NW	12.897	123.721
ABRDD316	616,965.68	658,627.00	146.796	-70	SE	13.741	133.883
ABRDD324	617,061.17	659,310.33	154.443	-60	NW	14.162	142.178
AFRC018	617,891.18	659,646.60	142.123	-60	SE	5.929	136.989
AFRDD070	617,818.05	659,728.43	139.981	-60	SE	14.322	127.578
AFRDD071	617,991.77	659,924.91	130.438	-50	SE	9.013	123.534
AFRDD072	618,035.03	659,935.81	131.428	-50	SE	9.085	124.468
AFRDD073	618,061.28	659,905.74	131.107	-50	SE	9.818	123.586
AFRDD078	617,729.75	659,646.96	156.339	-70	SE	26.573	131.368
AFRDD080	618,004.66	659,909.38	130.615	-50	SE	4.515	127.156
AFRDD081	618,058.53	659,968.89	141.272	-50	SE	20.089	125.883
AFRDD082	617,841.96	659,701.00	139.724	-60	SE	14.264	127.371
FBDD016	617,894.63	659,702.66	141.106	-60	SE	15.512	127.672
FBDD032	617,779.97	659,680.40	131.065	-50	SE	8.134	124.834
FBDD033	618,007.77	659,965.90	130.207	-50	SE	6.628	125.130
AFRDD90	617,779.97	659,680.40	149.13	-50	SE	25.886	129.303