RAVENSTHORPE GOLD PROJECT

HYDROGEOLOGICAL SETTING, DEWATERING REQUIREMENTS, AND NATURE OF MINE VOIDS

REPORT FOR
ACH MINERALS PTY LTD

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Rockwater
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1. BACKGROUND

ACH Minerals Pty Ltd (ACH) is planning open-pit and underground mining at its Ravensthorpe Gold Project (RGP) located at Kundip, on the eastern side of Hopetoun Road, 16 km south of Ravensthorpe (Fig. 1). Open pits are planned at the Flag, Harbour View, Kaolin and Hillsborough deposits, and underground mining is also planned at the Flag and Harbour View deposits.

Rockwater was engaged to conduct additional testing of four existing shafts at Kundip; and to update the investigations conducted in 2004 to 2011 and an earlier report (Rockwater, 2011). The results of the previous and new investigations and the hydrogeological assessment are the subject of this report.

1.1. CLIMATE

The Ravensthorpe area has a Mediterranean-type climate with cool winters and warm to hot summers. Mean monthly minimum temperatures at Ravensthorpe range from 6.7 ^{o}C in July and August, to 14.6 ^{o}C in February; and mean monthly maximum temperatures range from 16.3 ^{o}C in July, to 29.0 ^{o}C in January.

The average annual rainfall at Carlingup (BoM Stn. 010869) located 10.6 km north-east of Kundip is 427 mm (1997 to 2017), and average annual dam evaporation at Ravensthorpe is 1,644 mm (Luke, Burke and O'Brien, 1988). Average dam evaporation exceeds average rainfall in every month of the year (Table 1). Monthly-average rainfalls at Carlingup range from 28.9 mm (January) to 46.7 mm (July). Although there is generally more rainfall in winter, the weather is quite dry throughout the year.

Table 1: Average Monthly Rainfall (Carlingup) and Dam Evaporation (Ravensthorpe)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rainfall (mm)	28.9	31.5	30.5	24.9	41.9	41.1	46.7	41.5	40.5	34	30.5	30.1	426.9
Dam Evap. (mm)	260	194	169	118	77	55	65	73	93	135	179	226	1,644

1.2. GEOLOGICAL SETTING

The project area has been geologically mapped at 1:100,000 scale by the Geological Survey of Western Australia (Witt, 1996). The Kundip deposits lie within the Annabelle Volcanics of Archaean age that are mainly andesite and dacite, which have been intruded by a granitic pluton to the west. The upper reaches of the Steere River follows the contact between the granitic and the volcanic rocks.

2. HYDROGEOLOGY, KUNDIP DEPOSITS

2.1. LOCAL GEOLOGY OF DEPOSITS

The local geology of the Kundip deposits is given in Marston (1979), and in a geological summary prepared by Tectonic Resources.

Host rocks for the mineralised zones include acid volcanics – fine to medium grained dacite and andesite, feldspar porphyry (intrusive or extrusive), crystal tuffs, and intrusive granodiorite.

2.1.1. KAOLIN AND HILLSBOROUGH DEPOSITS

These deposits are within fine-medium grained dacite intruded by granite or granodiorite sills. The Hillsborough deposit is separated from Kaolin deposit by an interpreted fault-offset. In the upper parts of the deposits there is strong kaolin alteration that has probably resulted from the intrusion of the Kundip Granodiorite.

Mineralisation is in a series of south-dipping pyrite-rich veins.

The area is deeply weathered with the base of complete oxidation generally at 30-35 m vertical depth. The top of fresh rock is 50-65 m deep.

Mineralised zones at Kaolin strike at about 030 degrees and dip at about 22 degrees to the east-south-east. Historic underground mining, and trial open pit mining in 1997, indicated minor displacement of the main lode. Small northerly dipping faults which trend 245 degrees displaced the lodes by up to one metre.

The Hillsborough mineralised zone is characterized by a series of stacked, discontinuous lodes defined by surface drilling, mapping and underground mining. They extend over 280 m strike. The strike direction ranges from 090 to 050 degrees with an average dip of 50 degrees to the south.

2.1.2. HARBOUR VIEW DEPOSIT

The Harbour View deposit comprises two main lodes known as the Harbour View and Harbour View North, extending over a strike length of about 950 m in a north-easterly direction.

Dacite is the main rock type, along with common andesite. Bedding in the volcanics trends north-west to south-east and dips steeply to the north-east. Granitic rocks have been intersected at depth in drillholes located south of Harbour View.

Weathering is relatively shallow: the base of complete oxidation is 1-10 m vertical from ground surface, with fresh rock typically at depths of about 50 m.

The ore structures strike north-north-east to south-south-west with steep dips to the west (70 to 75 degrees).

Most of the gold occurs at the boundary of sulphide zones. Copper content in these zones average between 1 and 3 % (Tectonic Resources) although Marston (1979) reports that Harbour View shear was the major copper producing structure in the area, with up to 5.47% copper. The vein system is controlled by a series of intersecting shears and faults. Individual veins/ore shoots are discontinuous and may be en-echelon in nature.

2.1.3. FLAG DEPOSIT

The Flag mineralisation (gold and copper) extends east-west over 820 m at the southern end of the Kundip mining field.

The central and eastern parts of the deposits are hosted by dacitic lavas, tuffs and agglomerates, whereas the western part is within granite. It is uncertain whether the contact is intrusive or faulted.

Shallow Proterozoic sediments unconformably overlie the mineralisation, in part.

The oxidation profile varies substantially, depending on the host rock and the surface topography. In the granite, the top of fresh rock is as shallow as 25 m and is rarely deeper than 40 m. The base of complete oxidation is mostly very shallow, generally less than 5 m deep. In the volcanics the base of oxidation is typically 45 to 50 m below the surface.

The strike of the Flag lodes ranges from 090 to 050 degrees and the dip is to the south at between 35 and 70 degrees. The lodes are cut by four north-north-westerly trending faults which offset mineralisation by up to 3 m, and one major north-east trending structure which displaces mineralisation by up to 15 m.

2.2. MINING HISTORY, AND HYDROGEOLOGICAL INVESTIGATIONS

2.2.1. RECORDS FROM MINING

The Kundip mining area is described as having "minor local aquifers" (Johnson, 1998). The volcanic rocks are generally of low permeability. Fractures and joints in the rocks, and in mineralised shear zones and quartz veins, can be moderately permeable.

Drainage lines may follow zones of weakness such as fractures in the underlying rocks.

The old mine workings are reported to have intersected water-bearing fractures, and there are significant volumes of water stored in the workings. Anecdotal evidence (R Walker) suggests that Flag is one of the wettest mines, with inflows possibly in the order of 400 to 500 m^3/d; one report (Lea, 1989) indicated that "the heavy inflow of water at the face of the No. 3 level east drive had caused the cessation of operations because the existing pumps were totally inadequate to cope with the volume". The mine has stoping from levels at 15.2 m, 30.5 m, 45.7 m, 61 m, and 91.4 m depth (Marston, 1979). Noldart (1958) reported a water flow of 60,000 gallons (273 m^3) (per day?) from the 61 m level, with a salinity of 15,000 mg/L TDS. There was underground mining at Flag in 1987 to 1989 (Tectonic Resources).

The Harbour View workings were also reported to be 'wet', and apparently, a large Flygt pump was run continuously during periods of mining in the 1970's and 1980's to keep them dry (at about 2,600 m^3/d?). Inflows to Harbour View in 1903 required pumping rates of only 5,000 gallons per day (about 25 m^3/d) for a main shaft depth of 160 ft (about 50 m) (Montgomery, 1903). Conversely, Marston (1979) reported that the workings were down to 42.7 m depth and mining was confined to oxidised material above the water table (the water table is now about 30 m deep). It is likely that the workings were deepened in the 1970's and 1980's, and during that period there were reported to be high pumping rates (G Walker).

The Beryl workings (adjacent to Kaolin) were said to have yielded moderate amounts of water (less than 250 m^3/d), which were used as a water source for tailings re-treatment; although no water was intersected to 51.8 m depth (Noldart, 1958). Water was cut at 58 m depth at Two Boys (adjacent to Kaolin, Noldart 1958). Hillsborough had workings down to 50.3 m depth; and Beryl to 127.1 m (Marston, 1979). More recently there was trial mining at Kaolin in 1993, and underground and open-pit mining there and in adjacent deposits in 1987 to 1989 (Tectonic Resources).

Apart from the Montgomery report and a few mentions in the Noldart report, there is no written record of dewatering rates for the Kundip mining area. The inflow rates indicate that even the mineralised zones generally have relatively low permeability, except possibly at Flag and Harbour View.

2.2.2. GROUNDWATER EXPLORATION DRILLING

Six groundwater exploration/test holes were drilled in the Kundip area and were completed as monitoring bores (Rockwater, 2004). Two holes (KMB1 & KMB4, Fig.2) were planned to intersect the Harbour View mineralised zone. The others were designed as regional exploration holes/monitoring bores and included two sites at the intersection of linear drainages that might follow fracture zones. An existing exploration hole was also cased for groundwater monitoring (Bore KMB7).

The bore details are summarised in Table 2.

Only trace amounts of water were intersected during drilling, with the exception of KMB6, which is situated in a drainage line along-strike of the Harbour View workings: a small flow of 60 m^3/day was measured from that hole.

The results show that in general, rocks in the area are of low permeability, even within some sections of the Harbour View mineralised zone. A very small proportion of the rainfall, probably around 0.1 percent based on the groundwater salinity, infiltrates the ground to recharge the groundwater that seeps slowly through the rocks, eventually discharging to low-lying areas in the south, possibly along Kuliba Creek.

Groundwater in the area is generally saline, with salinity ranging from about 20,000 to 40,000 mg/L TDS. The pH is near neutral at 6.8.

Static groundwater levels measured in May 2017 ranged from 120.9 m AHD in KMB7 to 148.1 m AHD in Bore H in the area of the planned Kaolin Pit, with a hydraulic gradient trending downwards to the south (Fig. 3). The shape of the water table is somewhat irregular, and does not closely reflect the topography, as would be expected. In particular, the water table south from bore KMB2 has a low gradient falling to the south, whereas the topography falls to the south and west. The low hydraulic gradient in this area may reflect increased permeability resulting from mine voids at the water table in the Harbour View and Flag workings.

Water levels in the north-east at Kaolin and Beryl are 20 m higher than those in the deposits to the south, indicating there is likely to be a hydraulic barrier to the south of Kaolin.

Groundwater levels in the bores have risen significantly, by between 3.2 m (KMB7) and 5.4 m (KMB2), since 2004 (Figs 4 to 6). The rise is attributed to the slow recovery following drilling of the bores and previous mining at Kundip; and/or some very high daily and monthly rainfalls (and infiltration) since 2006, including:

- 102 mm July 2006;
- 114 mm January 2007;
- 122 mm October 2008;
- 101 mm May 2010;
- 171 mm December 2011;
- 125 mm March 2013;
- 146 mm March 2016; and
- 249 mm February 2017.

Table 2: Summary of Kundip Drilling Results, 2004

Bore	ACH Hole No.	mE (GDA)	mN (GDA)	Elevation (m AHD)	Depth Drilled (m bgl)	Slotted Interval (m bgl)	Lithology	Static Water Level (m btc)*	Static Water Level (m AHD)	Maximum Airlift Yield (m^3/d)	Final Salinity (mg/L TDS)
KMB1	RC04KP111	240118	6269727	158.4	70	52 - 70	Mafic, some Ultramafic minor BIF	36.75	121.65	Trace	N/A
KMB2	RC04KP112	240541	6270160	180.44	76	58 - 76	BIF, Interm. Volcanic Below 38m	58.04	122.4	Dry	N/A
KMB3	RC04KP113	240130	6269214	142.18	70	46 - 70	Ultramafic	21.28	120.9	Trace	N/A
KMB4	RC04KP114	240233	6269906	163.93	76	52 - 76	Mafic, minor porphyry	41.82	122.11	Trace	21,800
KMB5	RC04KP115	239368	6269954	132.85	70	45 - 63	Felsic volcanic, mafic below 48m	4.08	128.77	Dry	N/A
KMB6	RC04KP116	239727	6269468	145.71	70	46 - 70	Mafic, minor porphyry	23.56	122.15	57	37,200
KMB7^	RC03KP067	240308	6268738	143.41	106	76 - 106	Phyllite, Conglomerate, felsic volcanic	25.85	117.56	N/A	N/A

*below top of surface casing (23/1/2004)

^old exploration, hole cased

2.2.3. TEST-PUMPING MINE SHAFTS

Constant-head pumping tests were to be conducted on four shafts at Kundip in January 2018 to determine the magnitude of groundwater flows to underground workings, and the range of hydraulic conductivities for rocks around the workings and in the area of the planned open-cut pits.

The testing was conducted by Western Irrigation, under the direction of Rockwater. Details of the shafts tested, from information provided by ACH Minerals, are given in Table 3; locations are shown in Fig. 2.

Table 3: Details of Shafts Tested at Kundip

Shaft	Location		Collar RL	Dimensions	Depth	SWL*	EC (mS/cm)	pH
	mE (GDA)	mN (GDA)	(m AHD)	(m)	(m)	(m b collar)	@ T^oC	(Field)
Beryl	240409	6270396	176	3.5 x 1.5	129	31.15	21.88 @ 23.9	7.77
Flag	240540	6269226	160	3.1 x 1.4	131	38.16	23.85 @ 18.6	6.99
Hillsborough	240128	6270308	172	2.6 x 1.1	67	34.66	ND	ND
Harbour View	240127	6269770	160	2.6 x 1.7	69	33.44	ND	ND

* = Static Water Level (2018)

Beryl and Flag shafts were initially pumped at the capacity of the pump (about 16 L/s) to lower the water level as fast as practicable over a period of 35 minutes to nine hours. The water level in the shaft was then held constant by gradually reducing the pumping rate, which was recorded initially at one-minute intervals, and then at increasing intervals for the remaining period of the test (around 24 hours in total).

The test data were analysed using AQTESOLV Pro (Duffield, 1996–2007) and the method of Jacob and Lohman (1952) for the interpretation of constant-head pumping tests. The analyses are included in Appendix I.

Hillsborough and Harbour View shafts were found to be blocked, and could not be tested.

2.2.3.1. Beryl

The water level in the shaft was lowered by about 5.7 m over 35 minutes before the constant-drawdown phase of the test was commenced. Initially, some difficulty was experienced in maintaining a constant water level, but from 30 minutes to the end of the test (24 hours) good data were obtained. During that period, the pumping rate decreased from 4.5 L/s to 1.8 L/s (435 to 174 m^3/d) indicating relatively low rates of groundwater inflow.

The analysis indicates an aquifer transmissivity 10 m^2/d, and an average hydraulic conductivity of 0.1 m/d over the 98 m of the shaft that is below the water table.

2.2.3.2. Flag

There were evidently extensive workings at the water table in Flag shaft: The water level was lowered to only 3.57 m below the static water level after pumping for 8.75 hours at 16.5 to 17 L/s. In the subsequent constant drawdown phase of the test, the pumping rate gradually decreased from 15.7 L/s at the start to 6.1 L/s after 660 minutes. The pumping rate decline was then significantly greater – the rate falling to 3.3 L/s after 900 minutes. This change is attributed to the dewatering of a permeable fracture or workings near the water table, and less permeable rocks below.

From the test results, groundwater inflows are expected to be low (less than 200 m^3/d) during dewatering. The test results indicated an aquifer transmissivity of about 100 m^2/d from the early data; but this decreased markedly to about 4 m^2/d from the late-time data, giving an average hydraulic conductivity over the recorded depth of the shaft of 0.04 m/d.

2.2.3.3. Hillsborough

There were found to be obstructions in the shaft about two metres below the water table, preventing the pump from being lowered far enough for testing.

2.2.3.4. Harbour View

The Harbour View shaft was full of sludge to the water table, and so it too could not be tested.

2.3. PLANNED MINE PITS AND UNDERGROUND WORKINGS

Pits are planned at four deposits at Kundip (Fig. 2), three of which (Kaolin, Hillsborough, and Flag) will extend up to 17 m (Flag east) to 83 m (Kaolin) below the water table.

At Harbour View there are to be three pits: the north-eastern will be above the water table but will capture, contain, and allow some rainfall-runoff to infiltrate to the groundwater, probably resulting in local groundwater level rises and lower groundwater salinities. The pit will, therefore, act as groundwater source. The other two pits will contain up to 2 m depth of water (southern pit), and 9 m (western pit).

Underground workings beneath Harbour View and Flag will also be extended, from portals within the pits.

The pits extending deep below groundwater level will range in depth from about 56 m (Flag east) to 135 m (Kaolin); their characteristics with respect to groundwater levels and quality are described below.

2.3.1. DEWATERING FLOWS

Estimates of average peak dewatering flows for each pit are given below (Table 4), based on reports of historical flows and the results of test-pumping of the shafts. There is considerable uncertainty in these estimates, and there will be higher flows during dewatering of old underground workings, and short-term additional flows when the underground workings intersect open joints and fractures.

Average flows to the underground workings are also uncertain, but they are likely to be greater than those to the pits – perhaps up to 1,500 m^3/d (Harbour View) and 400 m^3/d (Flag).

2.3.2. CHARACTERISTICS OF FINAL VOIDS

The characteristics of the final voids that will extend below the water table have been assessed by simple water balances to determine whether they will act as groundwater sources, sinks, or flow-through lakes.

It is estimated that about 60 percent of rain falling within the pit perimeters, i.e. 256 mm/a, will report to the bases of the pits. Evaporation from the pit lakes would be at a rate similar to that for agricultural dams (1.64 m/a). Groundwater inflows for various pit inflows were estimated using hydraulic conductivity values determined from the results of the constant-head tests on the shafts (Section 2.2.3), and simple numerical groundwater models. For Harbour View, where the shaft could not be tested, hydraulic conductivity values were adjusted until the end-of-mining flows were 1,000 m^3/d (based on anecdotal evidence of historically high water inflows).

Other details used in calculating the pit water balances are included in Table 4.

Table 4: Details of Planned Pits, Kundip

Pit	Ground Level (m AHD)	Pit Area (m^2) at Ground Surface	Base of Pit (m AHD)	Initial GWL (m AHD)	Est. Max. Inflow (m^3/d)	Final Pit Water Level (m AHD)
Hillsborough	165-180	70,312	81	140-145	500	131.8
Kaolin	190-200	182,188	65	148	800	132.6
Harbour View NE	170	4,125	154	126	0	Dry
Harbour View S	160	14,313	123	125	10	127
Harbour View W	155	12,813	118	127	50	127
Flag W	145-160	42,063	87	125	150	117.3
Flag E	155	28,438	109	126	50	129.2

Water balance calculations are given in Table 5 below. The balance points, equivalent to the final pit water levels (m AHD), are where the flows given in the last column of Table 5 are equal to zero.

Table 5: Water Balance Calculations, Kundip

Hillsborough					
RLWL (m AHD)	Area (m^2)	Inflows (m^3/d)	Rainfall (m^3/d)	Evap. (m^3/d)	Balance (m^3/d)
Perimeter Bund	70,312		49.3		
140	36,313	0	49.3	163	-114
130	27,563	100	49.3	124	25
120	19,688	200	49.3	89	161
110	15,188	300	49.3	68	281
100	9,625	400	49.3	43	406
90	2,813	500	49.3	13	537

Kaolin					
RLWL (m AHD)	Water Area (m^2)	Inflows (m^3/d)	Rainfall (m^3/d)	Evap. (m^3/d)	Balance (m^3/d)
Perimeter Bund	182,188		127.7		
140	93,625	94	127.7	421	-200
130	77,438	293	127.7	348	72
120	62,875	468	127.7	283	313
110	47,188	621	127.7	212	536
100	34,063	749	127.7	153	723
90	20,625	803	127.7	93	838

Flag West					
RLWL (m AHD)	Water Area (m^2)	Inflows (m^3/d)	Rainfall (m^3/d)	Evap. (m^3/d)	Balance (m^3/d)
Perimeter Bund	42,063		29.5		
120	18,813	14	29.5	85	-41
110	11,875	80	29.5	53	56
100	5,750	130	29.5	26	134

Flag East					
RLWL	Water Area	Inflows	Rainfall	Evap.	Balance
(m AHD)	(m^2)	(m^3/d)	(m^3/d)	(m^3/d)	(m^3/d)
Perimeter Bund	28,438		29.5		
130	7,000	0	29.5	32	-2
125	5,250	5	29.5	24	11
120	3,500	14	29.5	16	28
110	813	66	29.5	4	92

Harbour View South					
RLWL	Area	Inflows	Rainfall	Evap.	Balance
(m AHD)	(m^2)	(m^3/d)	(m^3/d)	(m^3/d)	(m^3/d)
Perimeter Bund	14,313		10.0		
125	875	10	10.0	4	16

Harbour View West					
RLWL	Area	Inflows	Rainfall	Evap.	Balance
(m AHD)	(m^2)	(m^3/d)	(m^3/d)	(m^3/d)	(m^3/d)
Perimeter Bund	12,813		9.0		
125	1,688	5	9.0	8	6
120	813	50	9.0	4	55

The calculated final pit water levels (Table 4) indicate that Hillsborough, Kaolin and Flag West pits will be groundwater sinks. The Flag East and Harbour View pits are indicated to be groundwater sources, although at times the Harbour View West lake could be a flow-through feature, and so it is likely that water from these three pits will flow out to groundwater, with the potential to impact groundwater quality.

2.3.3. IMPACT OF MINE WORKINGS ON GROUNDWATER FLOW SYSTEM

Evaporation from the lakes in the Hillsborough, Kaolin and Flag West pits will cause the salinity of the water to increase; but the water will not move into the groundwater flow system if the pits remain as groundwater sinks as indicated. The lower groundwater levels in these pits and underground workings will, however, cause localised lowering of groundwater levels.

Rainfall accumulation and infiltration to groundwater from the Harbour View and Flag East pits will introduce fresh water to the aquifer, and localised rises in groundwater level.

The effect of any groundwater level changes would be undetectable at more than 300 m to 500 m down-gradient of the pits, because of the low permeability of rocks in the area. There are no groundwater users or groundwater-dependent ecosystems near the Kundip project that could be impacted by the changes described above.

Geochemical characterisation of rocks from Kundip by Graeme Campbell and Associates (2018) has provided indications on the chemistry of water in the final pit voids (Appendix II). The potential impacts of water quality for each pit are described below. Underground workings will become submerged after the completion of mining and so not subject to the processes of oxidation and evaporation.

2.3.3.1. Kaolin Pit

Water in the pit should remain circum-neutral, with metals at low concentrations (Appendix II). As the pit will become a groundwater sink, salinity will gradually increase due to evapo-concentration: calculations indicate that salinity could increase from about 22,000 mg/L TDS initially, to 120,000 mg/L TDS after 100 years.

There will be no movement of water from the pit into the surrounding rocks.

2.3.3.2. Hillsborough Pit

Hillsborough pit is immediately adjacent to the Kaolin pit, and although not reviewed by Graeme Campbell and Associates, the geochemistry of the pit lake should be very similar to that described above.

Calculations indicate that salinity could increase from around 22,000 mg/L TDS initially, to 120,000 mg/L TDS after 100 years.

2.3.3.3. Harbour View and Flag East Pits

Water in these pits should also remain circum-neutral, with metals at low concentrations (Appendix II).

The pits are indicated to be sources of groundwater recharge or flow-through features, and so any change in salinity is likely to be a decrease. Flow from the pits will be towards Flag West pit, which will be a groundwater sink.

2.3.3.4. Flag West Pit

Water in Flag West pit is likely to become moderately acidic (pH ~4) because of oxidation of sulphides in the pit walls, causing copper, iron and aluminium to occur at multi-mg/L levels in the pit lake. Iron and aluminium concentrations might be reduced by the presence of silicates in the wall rocks (Appendix II).

The pit will be a groundwater sink, and so salinity could gradually increase: from about 37,000 mg/L TDS initially, to possibly 250,000 mg/L TDS after 100 years.

There will be no movement of water from the pit into the surrounding rocks.

2.3.4. CONCLUSIONS ON FINAL VOIDS, KUNDIP

Archaean volcanic rocks in the Kundip area are of low permeability, as shown by the dewatering pumping rates during previous mining in the area (except possibly at Harbour View), and the low airlift rates from groundwater exploration holes. Of six holes drilled at Kundip, only four intersected permeable zones; the maximum airlift yield was 60 m^3/day.

The groundwater has salinities of about 22,000 mg/L to 37,000 mg/L TDS, and a near-neutral pH.

Pits are planned at four deposits at Kundip, and all except Harbour View NE will extend below the water table. Harbour View NE as well as Flag East and Harbour View South will capture, contain, and allow rainfall-runoff to infiltrate to the groundwater, resulting in a local groundwater level rise and lower groundwater salinity.

The Hillsborough, Kaolin and Flag West pits will be groundwater sinks. Water levels in the pits will remain below current static groundwater levels, with groundwater inflows and rainfall accumulation balancing evaporation losses.

Evaporation from the Hillsborough, Kaolin and Flag West pits will cause increases in salinity in the pit lakes, and moderately acidic conditions are expected in the Flag West pit resulting in elevated metal concentrations. However, the water will not move into the groundwater flow system if the pits remain as permanent groundwater sinks as indicated. It is unlikely that the rate of salinity increase will be as high as predicted, as the increasing salinity will result in lower evaporation rates. There will be localised lowering of groundwater levels around the pits.

The effect of any groundwater level changes would be undetectable at more than 300 to 500 m down-gradient of the pits, because of the low permeability of rocks in the area. There are no groundwater users or groundwater dependent ecosystems near the Kundip project that could be impacted by any changes to the groundwater flow system.

3. OTHER POTENTIAL WATER SOURCES

Water for dust suppression and processing ore will be drawn from dewatering facilities in operating pits and underground workings. If additional water is required, the most prospective source is probably the Mount Desmond main shaft, on M74/163 which is held by ACH Minerals, and is located 8 km north of Kundip.

The Mount Desmond and Elverdton workings are connected by drives at 59.4 m, 91.4 m and 181.7 m depth (Marston, 1979), and were used by Central Norseman as a source of water for processing ore. Probert (1966) reported a yield of 400 kL/d at Elverdton – from depths of up to 24 m – of water with salinity 13,300 mg/L TDS. The water is acidic (pH 4.4) and has elevated metal concentrations.

Sofoulis (1958) reported a similar yield of 409 kL/d when the Elverdton workings were 152 m deep, with salinity about 19,000 mg/L TDS. The workings were deepened to about 260 m? to 1971 and so might now yield higher rates of flow.

As well as groundwater inflows, there could be about 700,000 kL of water stored in the Desmond and Elverdton workings that could be utilised.

Dated: 22 August 2018

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REFERENCES

Duffield, G. M., 1996-2007, AQTESOLV Copyright HydroSOLVE Inc.

Graeme Campbell & Associates, 2018, Ravensthorpe Gold Project: Review of assays from geological database in conjunction with historic GCA-reports – Geochemical character of mining/processing streams and implications for mine-waste, LG-ore and tailings management (Harbour View, Flag, and Kaolin deposits. Report to ACH Minerals Pty Ltd.

Jacob, C. E, and Lohman, S. W., 1952, Non steady flow to a well of constant drawdown in an extensive aquifer. Am. Geophys. Union Trans., V.33, p. 559 569.

Johnson, S.L., 1998, Hydrogeology of the Ravensthorpe 1:250 000 sheet. Geological Survey of W.A. and Water and Rivers Commission.

Luke, G.J., Burke, K.L., and O'Brien, T.M., 1988, Evaporation data for Western Australia. Tech. Report No. 65 (2nd Ed), W.A. Dept. of Agriculture.

Marston, R.J., 1979, Copper mineralisation in Western Australia. Geological Survey of W.A. Mineral Resources Bulletin 13.

Montgomery, A., 1903, The Phillips River Field. Report by the State Mining Engineer. Albany Advertiser June 24 1903.

Noldart, A.J., 1958, Report on the Kundip Mining Group. In Geological Survey of W.A. Bulletin 110 – The Geology of the Phillips River Goldfield, W.A.

Probert, D. H., 1966, An appraisal of the groundwater sources in the Ravensthorpe district: Western Australia Geological Survey, Annual Report for 1965, p. 27-28.

Rockwater, 2011, Kundip copper and gold project – impact of final mine voids on groundwater flow system. Report to Phillips River Mining NL.

Sofoulis, J., 1958, The Geology of the Phillips River Goldfield, W.A. Geological Survey of W.A. Bulletin 110.

Witt, W. K., 1996, Ravensthorpe, W.A. Sheet 2930: Western Australia Geological Survey 1:100 000 Geological Series.

FIGURES

APPENDIX I: TEST-PUMPING PLOTS AND ANALYSES

APPENDIX II: GRAEME CAMPBELL & ASSOCIATES MEMO ON INDICATIVE PIT WATER QUALITY