RPS Aquaterra

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GÖKIRMAK COPPER PROJECT, TURKEY
MINE WATER MANAGEMENT

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Our ref: i200\C1\008c
Date: 23 September 2015

Document Status

	Issue Date	Purpose of Document
Revision A	16/09/15	Draft issued for client review
Revision B	18/09/15	Second draft issued for client review
Revision C	23/09/15	Third draft issued for client review

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1. INTRODUCTION

RPS Aquaterra (RPS) was commissioned by AMC Consulting (UK) Ltd (AMC) on behalf of ASYA Maden İşletmeleri A.Ş (AMI) to complete a water management study for AMI's Gökirmak Copper Project (the Project) in province of Kastamanou near the village of Hanönü in Turkey. The Project location is illustrated in Figure 1.

RPS completed a water management review of the project in December 2014. Subsequently, in March 2015, a data gap analysis was completed and a scope of work was devised to raise the level of the water management aspects of the Project up to Feasibility Study level. RPS' Principal Hydrogeologist Paul Heaney completed a site visit of the Project site in April 2015.

The objective of this study was to compile all the key findings of the previously completed water management studies (currently scattered across numerous existing report) into one concise document and to further the hydrological/hydrogeological understanding of the Project as far as possible within a designated two-month period (May and June 2015).

The study focussed on the following key Project features:

- pit
- waste dumps – northern and western waste dumps
- process plant
- tailings disposal facility (TDF) - Kepezkaya and Bağdere.

The location of these key features is illustrated in Figure 2.

The scope of work for this study was based on tasks that could be undertaken, and where maximum value could be added within a two-month period (in line with AMI's project schedule). While the period for the study extended to 4.5 months (during which time a field investigation programme was completed and pits/waste dumps designs were developed) the water management study scope remained the same.

The scope of work for this study focussed on identifying the various water management issues facing the Project and developing practical and cost effective water management approaches to address these aspects.

This water management study addresses the following key aspects:

- hydrology of the Project area
- hydrogeology of the Project area
- mine dewatering and depressurisation
- surface water management – the management of rainfall runoff across the project area
- mine water demand and water supply options
- overall site water balance
- water monitoring programmes.

Assessment of the proposed Gökirmak River diversion infrastructure designs was not part of the scope of this study, but it has been assessed in detail by Hidro Dizayn.

2. HYDROLOGY

2.1 Climate

The Project is located in the Hanönü District, which is situated in the eastern part of the Kastamonü Province, between the Central Anatolia and Black Sea regions. The Project area climate is influenced by the climatic features of these two regions and it can vary on an annual basis depending on which region has the more dominant influence. A characteristic continental climate typical of the Central Anatolia region can be observed at the Project site in some years, while the rainy temperate climate typical of the Black Sea region is observed in other years.

2.1.1 Precipitation

Precipitation data are available for four meteorological stations in the region of the Project and is summarised in Table 2.1.

Table 2.1: Meteorological Station Data in Project Area

	Hanönü	Tasköprü	Kastamonü	Devrekani
Elevation	475	520	800	1,050
Years of Data	1968–1994	1955–1980	1930–Present	1970–2011
Average Annual Precipitation (mm)	492	427	486	523

Average monthly precipitation data for the Hanönü, Kastamonü and Devrekani meteorological stations are presented in Table 2.2.

Table 2.2: Average Monthly Precipitation Values

	Average Precipitation Values (mm)		
Meteorological Station	**Hanönü**	**Kastamonü**	**Devrekani**
Elevation (m)	475	800	1,050
January	38.85	36.85	35.8
February	29.42	30.57	31.4
March	34.11	35.94	37.4
April	54.77	55.33	56
May	66.77	64.15	75.7
June	52.1	49.67	59.8
July	31.22	33.53	32.3
August	29.44	27	34
September	27.41	24.54	35
October	37.99	37.63	44.7
November	39.56	40.6	32.8
December	50.41	50.21	48
Annual Total Precipitation	492.05	486.02	522.9

Two manual read rain gauges were installed at the Project site, in the core shed compound, on 22 May 2015 and daily rainfall totals have been collected from these two rain gauges since. The daily rainfall data collected for the Project site from 22 May to 27 August 2015 is presented in Appendix A and illustrated below in Chart 2.1.

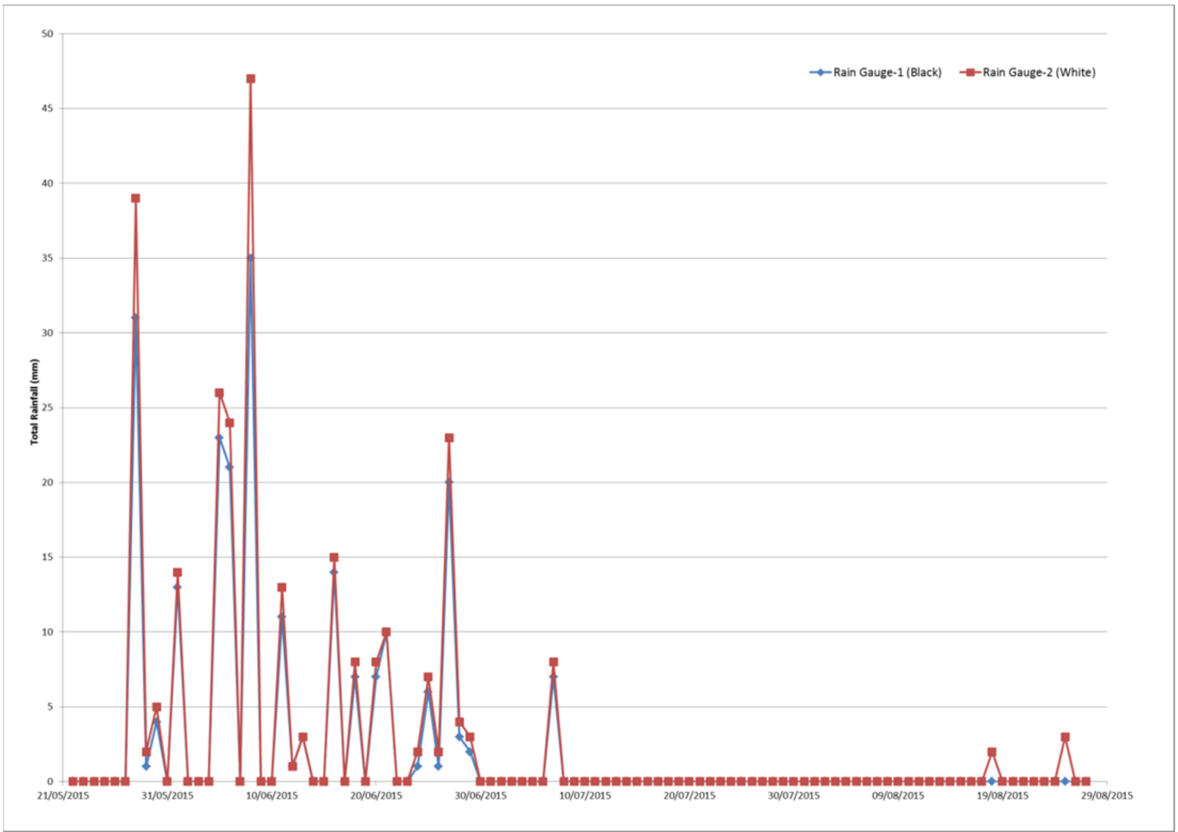

Chart 2.1: Gökirmak Copper Project Site Daily Rainfall Data (May to August 2015)

Daily rainfall data is also available from the Kastamonü meteorological station from 1 January 2011 to 31 May 2015. Thus, it is possible to compare the new daily rainfall data from the Project site with the ongoing long-term rainfall data collected at the Kastamonü meteorological station.

A comparison of the Project site daily rainfall data with the currently available daily rainfall data from Kastamonü meteorological station is presented in Table 2.3. It is too early to draw any conclusions from this short data set but it will be possible to extend this comparison as the data set expands with time.

Table 2.3: Daily Rainfall Comparison – Project Site and Kastamonü Meteorological Station

Date	Rainfall (mm)		Difference (mm)
	Gökirmak Project Site	Kastamonü Meteorological Station	
22/05/2015	0	1	**-1**
23/05/2015	0	0	**0**
24/05/2015	0	4.6	**-4.6**
25/05/2015	0	0.2	**-0.2**
26/05/2015	0	15.4	**-15.4**
27/05/2015	0	3.6	**-3.6**
28/05/2015	39	17.9	**21.1**
29/05/2015	2	0	**2**
30/05/2015	5	9.8	**-4.8**
31/05/2015	0	4	**-4**

2.1.2 Snowfall

There is no site-specific snowfall data available for the Project site. However, now that rain gauges have been installed at site it will be possible to start collected information on snowfall and the potential rate of snow melt.

Regional

The ESIA (ENVY 2014) provides information on the occurrence of snow for the Devrekani Meteorological Station. The Devrekani Meteorological Station is located at a significantly higher elevation (1,050m) than the Project site (Hanönü 492m). However, this information is relevant for the regional setting of the Project area.

Meteorological records for Devrekani Meteorological Station are available for the years of 1970–2011. The data indicates that snow generally occurs between October and April. The average annual number of snowy days is 48.5, as detailed in Table 2.4.

Table 2.4: Snowfall Data, Devrekani Meteorological Station (Days)

Meteorological Parameter	Months												Annual
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
No. of snowy days	10.8	10.1	8.8	3.2	0.3	-	-	-	0	1.0	5.2	9.1	48.5
No. of snow-covered days	16.9	14.3	8.5	0.9	0.1	-	-	-	-	0.2	4.2	11.6	56.7

The average annual maximum snow cover is 73cm, which was observed in December. The distribution of the maximum snow cover values as per months is given in Table 2.5.

Table 2.5: Maximum Snow Cover Thickness, Devrekani Meteorological Station

Meteorological Parameter	Months												Annual
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Maximum snow cover thickness (cm)	67	65	36	30	7	-	-	-	-	8	34	73	73

Project Site

Anecdotal evidence from AMI staff familiar with the Project site has provided the following information regarding local snowfalls in the Project area. Snowfalls occur almost every year, approximately four or five times per winter and generally, snowfalls occur between the months of January and March. Typical snowfall events comprise of approximately 50mm of snow. In general, the accumulated snow melts between each snowfall event. However, in localised pockets the snow can remain for longer periods, thus providing snow the opportunity to accumulate to up to 250 mm to 300mm thickness in these localised areas.

Snow that does not melt and accumulates within the localised pockets will typically melt between March and April. Based on a typical snow to liquid ratio of approximately 10 to 1, any 50mm to 300mm snow accumulations on melting would correspond to 5mm to 30mm rainfall within these localised areas.

These equivalent rainfall values are within the range of the daily rainfall values recorded at the on-site rain gauge between May and August 2015 (illustrated in Chart 2.1) and within the two-year recurrence interval for 24 hour rainfall (illustrated in Table 2.6). However, any 250mm to 300mm snow accumulations (25mm to 30mm rainfall equivalents) are expected to be localised (predominantly in shaded/sheltered area) unlike a standard rainfall event which acts across the entire catchment. Thus, it does not appear that snow makes up a significant proportion of the total precipitation within the Project area and any snow melting in March–April is unlikely to have any significant impact on mine water management.

2.1.3 Rainfall Intensities

A statistical evaluation of precipitation records from the Hanönü meteorological station and a composite from all meteorological stations relevant for the 4,277.2 km² Gökırmak River catchment was completed as part of a flood study completed by Nba Proje Musavirik Muhendislik Ve Egitim Sanayi Ticaret Ltd STI (nbaproje) in 2013 (nbaproje 2013a, also presented in IMC 2014). Table 2.6 presents the results for 24-hour rainfalls evaluated for the Hanönü meteorological station (records from 1968 to 1994) and the composite meteorological stations. The nbaproje 2013a study (also captured in IMC 2014) also presents rainfall intensity values for various recurrence storm events, presented in Table 2.7.

Table 2.6: 24-Hour Rainfall for Various Recurrence Intervals

Recurrence Interval (Years)	2	5	10	25	50	100	Max PP
Meteorological Station	**Total Rainfall within 24 Hours (mm)**						
GÖKÇEAĞAÇ-HANÖNÜ	29.23	39.79	47.32	57.36	65.19	73.31	151.96
GÖKIRMAK catchment composite	31.22	43.17	52.09	64.76	75.39	87.19	189.01

Table 2.7: Rainfall Intensities for Various Recurrence Intervals, Hanönü Meteorological Station

Duration	2 hours	4 hours	5 hours	6 hours	8 hours	12 hours	18 hours	24 hours	24 hours
Conversion coeff.	**0.693**	**0.777**	**0.809**	**0.83**	**0.851**	**0.893**	**0.956**	**1**	**n.a.**
Recurrence (Years)	**Rainfall Intensity in mm/h**								**total in 24 hours**
2	10.1	5.7	4.7	4.0	3.1	2.2	1.6	1.2	29.23
5	13.8	7.7	6.4	5.5	4.2	3.0	2.1	1.7	39.79
10	16.4	9.2	7.7	6.5	5.0	3.5	2.5	2.0	47.32
25	19.9	11.1	9.3	7.9	6.1	4.3	3.0	2.4	57.36
50	22.6	12.7	10.5	9.0	6.9	4.9	3.5	2.7	65.19
100	25.4	4.2	11.9	10.1	7.8	5.5	3.9	3.1	73.31
Max Probable Precipitation	52.7	29.5	24.6	21.0	16.2	11.3	8.1	6.3	151.96

For small catchments the time of concentration (Tc) can be relatively short. The ESIA (ENVY 2014) includes a statistical evaluation of rainfall data from the Devrekani meteorological station which provides rainfall intensities for shorter periods of time (less than two hours). The Devrekani meteorological station is located approximately 50km west of the Project site at an elevation of about 1,050m above sea level. Rainfall intensities appear to be higher at the Devrekani meteorological station than at the Gökçeağaç-Hanönü station but an equivalent statistical evaluation does not appear available for the Gökçeağaç-Hanönü station. The derived shorter duration rainfall intensities for Devrekani meteorological station are provided in Table 2.8. If evaluating shorter rainfall events at the Project site then these numbers should be considered.

Table 2.8: Devrekani Station Statistically Evaluated Short Duration Rainfall Intensities

Duration	5 min	10 min	30 min	60 min
	0.083 hrs	0.167 hrs	0.5 hrs	1.0 hrs
Recurrence (years)	**Rainfall intensity in mm/h**			
2	83	61	33	21
5	112	83	52	33
10	125	100	63	42
25	152	118	80	52
50	175	125	91	61
100	205	135	105	69

2.1.4 Evaporation

The Devrekani meteorological station is the nearest station to the Project site with evaporation data. The mean annual open surface evaporation for the Devrekani meteorological station based on data from 1970 to 2011 is 684.4 mm. The monthly open surface evaporation values (sourced from ENVY 2014) for the Devrekani meteorological station are presented in **Error! Reference source not found.**2.9.

Table 2.9: Open Surface Evaporation Data from Devrekani Meteorological Station

Months	Mean Open Surface Evaporation (mm)	Daily Maximum Open Surface Evaporation (mm)
January	-	-
February	-	-
March	-	-
April	3.6	6
May	99.6	8.5
June	119	8.3
July	152.1	15.2
August	151.7	9.9
September	105.1	8.7
October	52.1	8.5
November	1.2	2.4
December	-	-
Annual	684.4	15.2

Reference: Data from Devrekâni Meteorological Station (1970–2011)

2.2 Surface Water Catchment

The Project site is located within the catchment of the Gökırmak River, the main tributary of the Kizilirmak River that eventually flows into the Black Sea. The Gökırmak River is the recipient of all surface water drainage of the Project area. The Gökırmak River catchment area upstream of the Project site is approximately 4,277km². Further details of the Kizilirmak and Gökırmak River catchment characteristics are provided in nbaproje 2013a and ENVY 2014.

The Gökırmak River flows all year round, while flows within the local surface drainage systems are only intermittent and depend entirely on rainfall and snow melt. The Gökırmak River is used for hydroelectric and irrigation purposes in the immediate vicinity of the Project area.

Surface water levels and flows within the Gökırmak River are currently influenced by the hydroelectric and irrigation projects on the river; this influence will increase with further proposed hydroelectric and irrigation related activities. There is a river diversion weir associated with Demirci Hydro-electric Power Plant (HEPP) Facilities, downstream of the Project site. In addition, the General Directorate of State Hydraulic Works (DSİ) plan to construct the Taşköprü Dam, for irrigation and HEPP purposes, approximately 2km upstream of the Project site.

The proposed open pit corresponds with a section of the Gökirmak River and as a result, it is necessary to divert the Gökirmak River within the vicinity of the pit. In order to facilitate this, upstream and downstream coffer dams, two identical diversion tunnels on the northern bank and a spillway on the southern bank associated with the upstream coffer dam are being constructed. The open pit will be excavated within the area between the upstream and downstream coffer dams. A large amount of work has been completed by Hidro Dizayn on the river diversion works and this work is described in detail in other separate reports.

The smaller scale local ephemeral drainage systems will need to be diverted and managed in the vicinity of Project infrastructure, the key features being the pit, waste dumps, tailings dams and process plant site. The surface water management requirements associated with the local drainage systems is discussed in Section 6 of this report.

2.2.1 Gökirmak River Levels

A temporary surface water monitoring station (R1) was previously installed on the Gökırmak River within the Project site and water level readings were taken twice a day between 10 April and 21 May 2013. A permanent automatic surface water monitoring station (R2) was installed on the Gökirmak River approximately 210m downstream of R1 and hourly readings were recorded between 18 May 2013 and 30 August 2013. The level measurements taken at both stations during this period in April–May 2013 suggest a river water level gradient of approximately 0.35% between the two stations during this period. Average daily Gökirmak River water levels as recorded at R2 are shown in Chart 2.2. The hydrograph presented in Chart 2.2 illustrates varying rainfalls during the months of May and June followed by a typical base flow curve during the dryer period from mid-June to the end of August 2013.

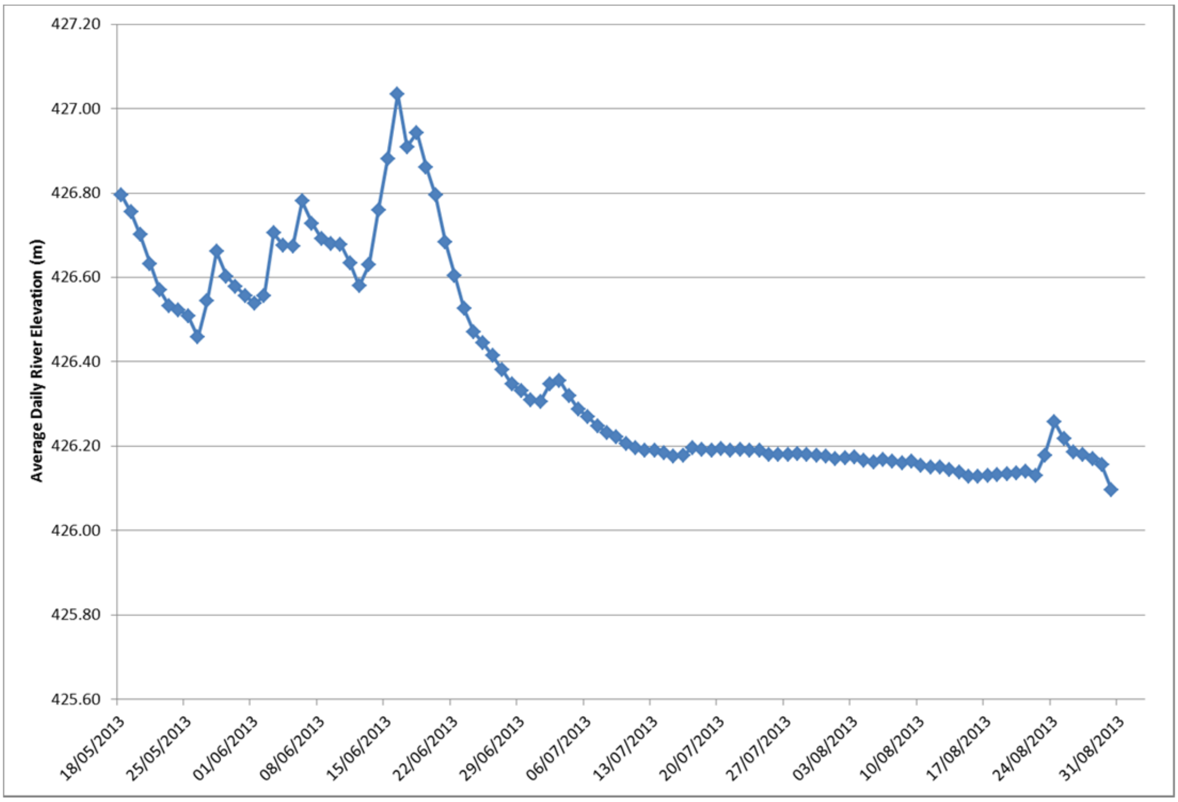

Chart 2.2: Average Daily Gökirmak River Levels (R2) 18 May–30 August 2013

2.2.2 Gökirmak River Flows

The closest official automated river gauging station, on the Gökirmak River, to the Project area is the Gökırmak-Dereköy gauging station. The Gökırmak-Dereköy gauging station is located at the bridge in Dereköy at location 4607991 m N 617888 m E. River flow records exist from this gauging station from 7 November 1953 to present.

The gauging station automatically measures water levels; these levels are then translated into flows using an established river level vs river flow relationship. Average monthly Gökirmak River flows, sourced from Erproje, 2015, from May 2014 to April 2015, are presented in Table 2.10.

Table 2.10: Average Monthly Automated Gökirmak River Flow Data (May 2014 to April 2015)

Month	Flow (m^3/s)	
	2014	2015
January	-	21.89
February	-	36.91
March	-	43.72
April	-	44.40
May	21.00	-
June	28.51	-
July	1.61	-
August	0.75	-
September	4.81	-
October	10.02	-
November	10.39	-
December	17.43	-

Average monthly automated Gökirmak River flows between May 2014 to April 2015 vary between 0.75m^3/s (August 2014) and 44.40m^3/s (April 2015).

Gökirmak River flow analysis was completed for the Project site as part of the nbaproje 2013a study. This study identified that the critical duration event for the Gökirmak River catchment in the vicinity of the Project site (based on a 4,277km^2 upstream catchment area) was the 12-hour event. Maximum Gökirmak River flows derived for various recurrence events (using the Snyder Method, which is the method recommended to be adopted, nbaproje 2013a) are presented in Table 2.11.

Table 2.11: Gökirmak Maximum River Flows in Project Area – Snyder Method (nbaproje 2013a)

Recurrence (Years)	2	5	10	25	50	100	500	1,000	10,000	OET
Max Flow (m^3/s)	144.4	278.6	412.5	639.9	856.6	1,119.0	1,607.9	1,818.4	2,517.8	4,952.0

Gökirmak River flows are measured manually on a monthly basis by AMI within the Project site at monitoring location R2. The monthly Gökirmak River flow data from May 2014 to June 2015 is presented in Table 2.12.

Table 2.12: Monthly Gökirmak River Flow Data collected by AMI (May 2014 to June 2015)

Date	Flow (m^3/s)	Date	Flow (m^3/s)
23/05/14	12.088	26/12/14	12.793
05/06/14	24.670	20/01/15	21.284
15/07/14	0.875	25/02/15	31.774
25/08/14	0.592	19/03/15	45.541
24/09/15	4.373	16/04/15	36.936
17/10/14	7.252	12/05/15	25.223
16/11/14	7.750	21/06/15	89.671

Measured Gökirmak River flows are noted to vary between 0.592m^3/s (August 2014) and 89.671m^3/s (June 2015).

Gökirmak River flows are a critical element of the coffer dam and tunnel design elements of the Project and are discussed in a lot more details in the various reports prepared by Hidro Dizayn.

2.2.3 Surface Water Quality

Surface water quality samples were collected, as part of the ESIA (ENVY 2014), from three different points on the Gökırmak River in May and August 2012, in order to establish a baseline data set. The sampling points were chosen to be approximately 12km apart and were located upstream (SW1 and SW2) and downstream (SW3) of the Project Area. The location of the surface water sampling points and the laboratory results are presented in Appendix B.

The laboratory results suggested that nitrite concentrations (in both May and August 2012) and lead concentrations (in August 2012) were above the relevant surface water quality guidelines placing the Gökırmak River in Water Quality Class IV (very polluted) but all the other parameters analysed are below the guideline values.

3. HYDROGEOLOGICAL INVESTIGATIONS

3.1 Previous Hydrogeological Investigations

3.1.1 Field Investigations

A significant amount of hydrogeological field investigations have previously been completed in the Project Area. The previous hydrogeological field investigations completed include:

- Field investigations completed between 1994 and 1996 by General Directorate of State Hydraulic Works (DSI) as part of investigations associated with the construction of a new hydroelectric dam in the area (Bores SK-3, SK-4, SK-5, SK-12 and SK-14) (ERGIN 1998).
- Hydrogeological and geotechnical investigation completed in November 2012, in which five new boreholes (OW-1 to OW-5) were drilled into the schist at locations within the proposed pit area (referenced in IMC 2014).
- Hydraulic testing of the OW1-OW5 boreholes was completed in February, June and August 2013 by AMI (AMI 2013).
- Hydrogeological and geotechnical investigations undertaken in July 2013 by npaproje, in which four new boreholes were drilled into the alluvium (DH-1 to DH-4) (nbaproje 2013b).
- Hydraulic testing of the DH1-DH4 boreholes was completed in August 2013 by AMI (AMI 2013).
- Geological and Geotechnical investigation undertaken in 2014 by npaproje associated with the proposed new coffer dams and tunnel construction. The investigation included the excavation of trial pits into the alluvium and the drilling, installation and hydraulic testing of 14 new boreholes (DSK1-10 and TSK1-4) predominantly into the alluvium (nbaproje 2014a and 2014b).
- Installation and hydraulic testing in September 2014 of three dug (“caisson”) wells adjacent to the Gökirmak River in the east of the Project area (detailed in Erproje 2015).
- Hydrogeological and geotechnical investigation completed in 2014-2015 in the Kepezkaya TDF area, in which twenty five new boreholes (KSK-1 to KSK-25) were drilled. Hydraulic testing was completed on the first phase of boreholes drilled (KSK1 to KSK14) in 2014 (raw data by AMI).

In addition, groundwater level monitoring has been undertaken intermittently within the Project area since March 2013 and groundwater quality samples were collected from the pit area in 2012, 2013 and most recently in August 2015.

The findings of all these previous investigations are captured within the hydrogeology section of this report (Section 4).

3.1.2 TDF Groundwater Modelling

A numerical groundwater flow and transport model was developed for the Bağdere and Kepezkaya TDFs for the purposes of the SEIA (ENVY 2014). The model domain was defined by the Karaardıç Hill to the north, the Gökirmak River to the south and seasonal streams to the east and west. The model area included both the Bağdere and Kepezkaya TDF areas. The model area was divided into three 100m thick layers with the top of the model equal to ground elevation. The cell sizes were 50m × 50m in the majority of model domain and 25m × 25m in the TDF area. There were no observation wells in the area to facilitate model calibration.

A conservative solute with an initial concentration of 1,000mg/l was set to discharge into the model within the TDF area. Background concentrations elsewhere and recharge outside the TDF footprints were all set to 0mg/l. The adopted bedrock hydraulic conductivity for the model is not stated in the SEIA. The transport model was run for simulated period of 100 years.

The result of the model indicated the sulphate concentration in groundwater adjacent the Gökirmak River increased to 200mg/l, the relevant drinking water standard, within 283 days for the seepage from the Bağdere TDF area and 950 days for the Kepezkaya TDF area.

The groundwater modelling illustrated the requirement that a basal liner system be incorporated in the TDF design in order to protect the groundwater and surface water receptors. A liner is currently included in both Bağdere and Kepezkaya TDF designs.

3.2 2015 Hydrogeological Field Investigations

3.2.1 Drilling Programme

A geotechnical and hydrogeological drilling programme was completed at the Project site between May and August 2015. Boreholes were drilled in the pit and waste dump areas in order to advance both geotechnical and hydrogeological understanding of the Project site.

A total of 12 new boreholes were drilled, nine within the pit area (GT series) and three within the northern waste dump area (WD series). Boreholes GT-007 and GT-013 targeted a significant fault running through the pit area known locally known as the “Dividing Fault”.

The boreholes were cored in order to provide detailed geological and structural information from these locations. Casing was installed in ten of the twelve holes in order to keep these boreholes open, so that they could be used for subsequent hydraulic testing and groundwater level monitoring.

The borehole drilling and construction details are summarised in Table 3.1. The location of the new boreholes is illustrated in Figure 3.

Table 3.1: Borehole Drilling and Construction Details

Borehole ID	Drilled Depth (m)	Static Water Level (mbtoc)	Dip (Degrees)	Total Cased Depth (m)	Slotted Casing (mbtoc)	Plain Casing (mbtoc)
GT-001	100	-	70	No Casing		
GT-002	150	5.4	70	150	3-99	0–3 99–150
GT-003	200	20.67	70	200	3-150	0–3 150–200
GT-007	220	50.51	70	220	3-150	0–3 150–220
GT-009	250	73.6	70	250	4-250	0–4
GT-011	215	19.61	70	9162	3-72	0–3 72–162
GT-013	180	54.72	70	180	3-150	0–3 150–180
GT-014	155	-	70	No Casing		
GT-015	105	7.5	70	105	3-54	0–3 54–105
WD-01	28	5.9	80	28	3-15	0–3 15–28
WD-02	55	16.33	80	54	3-23	0–3 23–54
WD-03	39.2	24.73	80	39.2	3-21.2	0–3 21.2–39.2

3.2.2 Packer Testing

Packer testing was completed in four of the new GT boreholes drilled within the pit area (GT-003, GT-007, GT-013 and GT-014). Packer tests were completed on 2m intervals, where possible, but there was considerable difficulty in completing packer tests as getting a good seal was very difficult due to the highly broken nature of the rock mass. Analysis of the packer tests data and the hydraulic conductivity results derived is discussed in Section 4.4.1.

3.2.3 Hydraulic Testing

An extensive programme of airlift recovery testing was completed across the Project site. Airlift recovery testing was completed on the following boreholes:

- OW-1 to OW-5 – five existing groundwater monitoring boreholes located within the pit area
- GT-002, GT-003, GT-007, GT-009, GT-011, GT-013 and GT-015 – seven of the new boreholes within the pit area
- WD-01 and WD-02 – two of the new boreholes within the northern waste dump area
- KSK-15, KSK-17 and KSK-25 – three existing boreholes within the tailings dam area.

The location of the OW, GT and WD series holes is presented in Figure 3 and the location of the KSK holes is presented in Figure 4.

Airlift testing was selected as the optimum initial hydraulic testing methodology as the majority of the boreholes were inclined, still contained significant quantities of drilling fluids/cuttings and had not been constructed as groundwater pumping wells with gravel packs etc. Airlifting was undertaken by injecting high pressure air into the borehole to a depth of up to 100 metres below ground level. The injected air expelled water out of the borehole. The water discharging at surface was controlled by means of a custom build borehole head works, which funnelled the water through a discrete outlet, allowing the water discharge rate to be measured using a graduated bucket and stopwatch.

Where the water discharge from the borehole was estimated to be less than 10 litres per minute the airlift testing ceased within five minutes and the recovery of the water level was monitored. In this instance, recovery of the water level was analysed as a falling head test using the Bower and Rice method. Where the water discharge from the borehole was sustainable and greater than 10 litres per minute the airlift testing was continued for generally up to one hour. In this instance, recovery of the water level was analysed using the Theis recovery method.

Analysis of the airlift recovery tests data and the hydraulic conductivity results derived is discussed in Section 4.4.

3.3 Ongoing Field Investigation Programme

Two key hydrogeological uncertainties remaining at this time:

1. The hydraulic properties of discrete fault zones.
2. The potential interconnection between the river, alluvium, bedrock and pit.

In addition, to date, no pumping tests have been completed within the Project site (except on the Caisson wells). All hydrogeological investigations completed to date have adopted simple hydraulic testing techniques (e.g. falling head tests, slug tests or airlift recovery tests). Pumping tests provide a higher level of hydrogeological certainty and provide data indicative of more of the rock mass beyond the borehole itself. A programme of pumping test would increase the confidence in the representativeness of the hydraulic parameters used to assess mine water management.

A hydrogeological field investigation programme has been developed and is currently ongoing to address the above uncertainties and to advance the level of hydrogeological insight for the Project.

3.3.1 Fault Zone Hydraulic Properties

To date hydraulic testing has been of holes intersecting a variety of lithologies across the full depth of holes primarily drilled for mineral or geotechnical purposes. Hydraulic testing of these holes completed as part of this study has greatly improved our understanding of the hydrogeology of the Project area, although the results are indicative of bulk parameters of the rock mass intercepted by the hole tested.

It is very important to have a good understanding of the hydraulic properties of discrete fault zones within the Project area as these features have the potential to act as barriers either to groundwater movement or as preferential flow paths for groundwater movement. If the main faults in the Project area are highly permeable and if there is a high degree of hydraulic inter-connectivity within the rock mass then these faults have the potential to transmit significant volumes of water into the pit and at high rates if not dewatered prior to interception by the pit. If this is the case, then dewatering these primary fault zones, prior to intercepting them in the pit will be highly advantageous as it will greatly improve the mine working environment and will have significant economic benefits regarding blasting and tyre wear. If the fault zones can be dewatered using dewatering bores then this would also represent a useful “clean” water supply option for the Project.

Airlift testing of the two GT boreholes which intersected the main Dividing Fault (GT-007 and GT-013) produced a lot more water than most of the other boreholes tested, suggesting that the fault contains significantly more water than the surrounding schist zones and that they may be a target for advanced ex-pit dewatering boreholes.

A hydrogeological investigation programme has been developed and is currently ongoing to investigate further the hydraulic properties of the Dividing Fault zone in the vicinity of GT-007, the results of this investigation may have a significant influence on the mine dewatering approach adopted for the Project.

3.3.2 Alluvium and Bedrock Hydraulic Interconnectivity

The individual hydraulic properties of the alluvium and the bedrock have been explored through numerous previous hydrogeological investigations. However, to date the hydraulic connection between these two formations and with the Gökirmak River has not been specifically assessed.

It will be very important to have a good understanding of the hydraulic interaction/connectivity between the alluvium and the bedrock, particularly in the vicinity of the upstream coffer dam, which is located only 130m from the edge of the final pit.

There is the potential for significant long term groundwater inflows into the pit if there is a high degree of interconnectivity between the alluvium, bedrock and pit in the vicinity of either the upstream or downstream coffer dams. While the presence of effective low permeability cut-off walls extending beneath both of the coffer dams and keyed into the bedrock will significantly reduce lateral groundwater flows through the alluvium at this location, if there is a mechanism for water to move vertically downwards from the alluvium into the underlying bedrock (e.g. through permeable structures) then this could significantly impact mine inflows.

A hydrogeological investigation programme has been developed and is currently ongoing to investigate further the river, alluvium and bedrock interconnectivity, as well as further define the hydraulic properties of the alluvium and bedrock in this coffer dam area. The results of this investigation will greatly further our understanding of the alluvium and bedrock hydraulic properties, the interaction between the alluvium and bedrock, and surface water/groundwater interaction. This additional insight will be greatly beneficial in terms of devising an optimum mine dewatering approach and overall mine water management for the Project.

4. HYDROGEOLOGY

4.1 Geology

4.1.1 Project Area

The regional geology comprises a great variety of different lithologies with numerous and complicated structures throughout, as a result of strong tectonic deformation in the region.

The principal geological formations present across the Project site comprise the following:

- Mesozoic Ophiolites – dominant rocks comprise schists and phyllates
- Akgöl Formation – predominantly metabasic rocks
- Cankurtaran Formation – comprising limestone blocks and intercalation of sandstone, siltstone, claystone, sandy limestone and gravelstone with volcanic intermediates
- Pervaneyaka Formation – pebblestone, pebbly sandstone, sandy limestone and limestone
- Alluvial Deposits – clay, silt, sand, gravel, pebble and well-rounded blocks of various size.

More detailed descriptions of the geology of the region and the Project area is provided in various other reports including nbaproje 2014c.

4.1.2 Pit Area

The pit area comprises primarily of schists, phyllites and metavolcanic rocks belonging to the Akgöl and Mesozoic Ophiolite Formations. In the pit area, the metamorphic rocks are primarily divided into two categories, a mixed schist (schist) and a green schist (metavolcanic). The mixed schist (MSCH) has a foliated and folded texture and consists of quartz, talc, graphite, mica and sometimes, small amounts of chlorite, calcite, chalcopyrite and pyrite. The green schist (GSCH) has a harder and more massive texture than the mixed schist and includes chlorite, calcite, quartz, limonite, rarely chalcopyrite, and pyrite. The distribution of the mixed schist and the green schist in the pit area is illustrated in Figure 5. There is abundant and complex fracturing and faulting throughout the bedrock in the pit area. Alluvium sediments up to 40m thick are also present in the pit area, these alluvial sediments are highly variable in nature and comprise clay, silt, sand, gravel, pebble and well-rounded blocks of various size.

4.1.3 Waste Dump Areas

The northern waste dump is predominantly underlain by the Cankurtaran Formation, a large proportion of which is the Ebonite member of the Cankurtaran formation, which comprises mainly of basaltic-andesitic lava, tuffs and agglomerates. Pervaneyaka formation deposits (gravelstone, pebbly sandstone, and sandy limestone) also underlie a small portion of the northern waste dump area. In addition, there are likely to be thin alluvial deposits in some of the larger drainage channels.

There have been no detailed geological investigations completed yet in the western waste dump area. However, the western waste dump geology is likely to be very similar to that of the pit area, comprising schist, meta-volcanites and phyllites rocks belonging to the Akgöl Formation. While there has been no mapping of the mixed schist and green schist, as yet, it is likely that the lower, smoother and more incised areas (e.g. valleys and stream beds) are underlain by mixed schist, and the higher and sharper levels (e.g. hills) are underlain by green schist.

4.1.4 Process Plant Area

The process plant area is underlain by three different units the metabasic Akgöl Formation (similar to that in the pit and western waste dump area), sedimentary units of the Çağlayan Formation (consisting of sandstone, limestone and mudstone), and Oligocene-Miocene aged limestones and other continental clastic sediments. The average thickness of the sedimentary units in the process plant area is 40 to 50m, these are then underlain by metamorphic rocks.

4.1.5 TDF Areas

The Kepezkaya TDF is predominantly underlain by the Cankurtaran Formation composed of limestone blocks and sandstone, siltstone, claystone, sandy limestone, gravelstone alternation and partially by basaltic-andesitic lava, tuff, and agglomerates (volcanic member). KSK-5 is the deepest hole drilled in this area, it was 360m deep and it intercepted shale, sanstone and agglomerate. Pervaneyaka formation deposits underlie a portion of the south-western area, and predominantly consist of limestone and marl (also gravelstone, pebbly sandstone, and sandy limestone). In the western valley, parts there are localised areas of up to 10m of unconsolidated materials, comprising clayey, silty and sandy deposits.

The Bağdere TDF is predominantly underlain by the Cankurtaran Formation composed of limestone blocks and sandstone, siltstone, claystone, sandy limestone, gravelstone intercalation with volcanic intermediate levels. Pervaneyaka formation limestones underlie a small part of Bağdere TDF in the northern higher topographic elevations.

4.2 Aquifers

There are three different types of aquifers (water bearing rocks) in the Project region:

- Karstic limestone aquifers
- Fractured rock aquifers
- Unconsolidated, porous aquifers.

Limestone mostly exists in the section of the Project area located to the north of the Gökırmak River and beyond the currently proposed pit footprint. Limestone exists in the vicinity of the northern waste dump but limestone aquifers are not considered to be of significance for the Project.

Within the Project area, and particularly within the excavated pit area, it is the presence of fractured rock aquifers and unconsolidated alluvial aquifers associated with the Gökirmak River (and its tributaries) which are likely to be of most significance for the Project.

Fractured Rock Aquifers – The schists, phyllites and metabasic rocks which are present within Project site, and which are abundant within the vicinity of the pit, can exhibit significant secondary permeability at contact zones and where significant fracturing and/or alteration of the rock exits. However, where the rock is fresh and un-fractured, these formations exhibit low permeability. Highly fractured basalt and andesite rocks of the Cankurtaran Formation in the waste dump and TDF areas are classed as semi-permeable aquifers (ENVY 2014).

Unconsolidated Alluvial Aquifers – The alluvial deposits associated with the Gökırmak River and its tributaries can exhibit a significant primary permeability where clean sand, gravel or pebble units are present. In the vicinity of the pit, the width of the alluvium is generally up to 200 metres and thicknesses of up to 40m have been recorded (DH-3 intersected 39m of alluvium; SK-4 and SK-14 intersected 40m of alluvium).

While the fractured rock and coarse grained alluvial sediments have the potential to act as significant aquifers for the Project (especially important with regards estimating groundwater inflows to the pit and designing an appropriate pit dewatering system), a key feature will be the storage properties of these aquifers and the degree of hydraulic continuity/connectivity within the rock mass. While these rocks have the potential for elevated permeability and have the potential to transmit water at relatively high rates, if there is a large degree of compartmentalisation and only limited hydraulic connectivity with other sources of water (e.g. other fracture zones, permeable rock, highly porous rock or water bodies), then any high flow rates might only be short term.

4.3 Groundwater Levels and Flow Direction

Groundwater level monitoring has been undertaken intermittently within the pit area since March 2013 and the Kepezkaya TDF area since August 2014. Groundwater levels have been collected manually from exploration holes, geotechnical investigation bores and designated hydrogeological observation wells. Groundwater levels from August 2014 to August 2015 from the various monitored boreholes across the Project area are provided in the Appendix C.

4.3.1 Pit Area

Automated groundwater level loggers were installed in monitoring boreholes OW-1, OW-2, OW-4 and OW-5 in June 2013 and since this date have been continuously measuring water levels at these four locations. Charts 4.1 and 4.2 provide the level logger results, as groundwater level in meters below ground level (mbgl) and groundwater elevations (mRL), respectively.

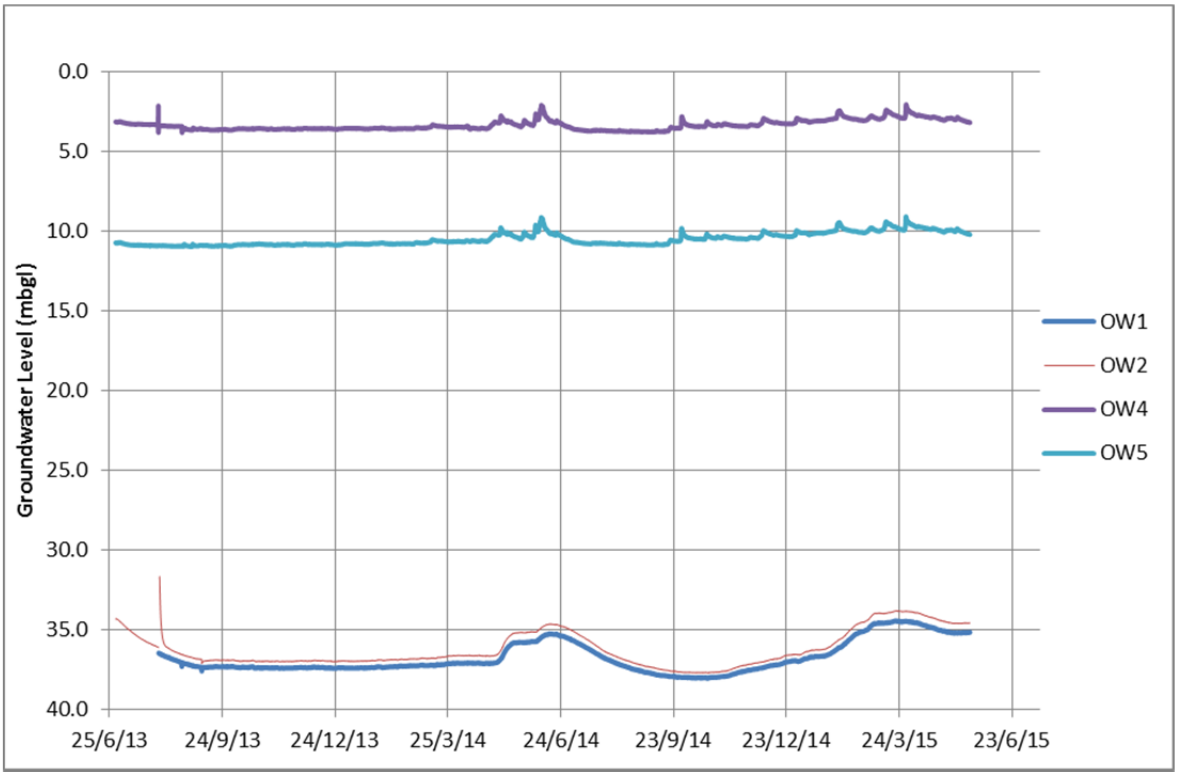

Chart 4.1: OW Monitoring Borehole – Groundwater Depth (mbgl)

Chart 4.1 illustrates that the depth to groundwater at OW-1 and OW-2 is similar and ranges between 33mbgl and 38mbgl. The OW-1 and OW-2 hydrographs are quite subdued; there is a relatively deep water table at these locations, which appears to have a longer response time to rainfall events, as water percolates through the thick unsaturated zone. The groundwater table at OW-4 and OW-5 is much shallow, with depth to groundwater at approximately 3mbgl and 11mbgl, respectively. The OW-4 and OW-5 boreholes are located close to the river (and the associated alluvial deposits) and their hydrographs are flashier, indicative of a more rapidly changing groundwater table, however the magnitude of the groundwater level fluctuations is less than at OW-1 and OW-2.

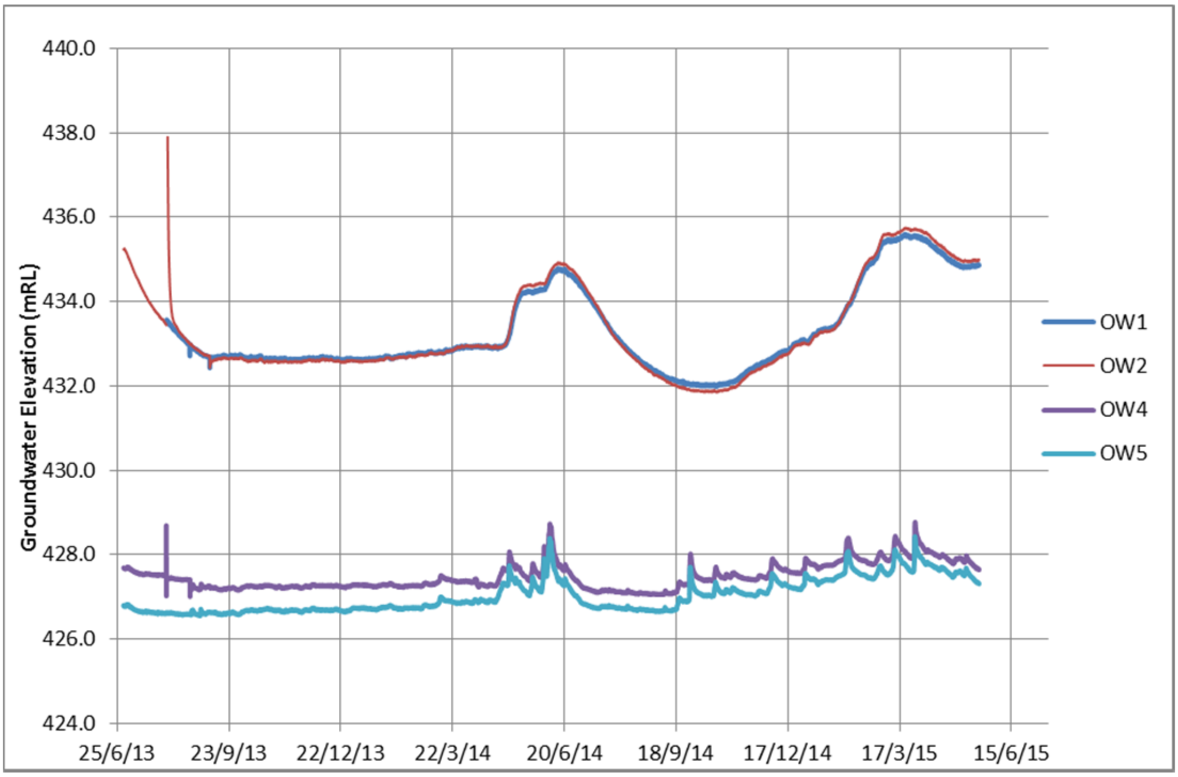

Chart 4.2: OW Monitoring Borehole – Groundwater Elevations (mRL)

Chart 4.2 illustrates that the groundwater elevation at OW-1 and OW-2 is much higher (between 431mRL and 436mRL) than the groundwater elevation at OW-4 and OW-5 (between 427mRL and 429mRL). OW-4 and OW-5 are located close to the Gökirmak River and the groundwater level is very similar to that of the river (average of 427.5mRL). Groundwater elevations in OW-4 and OW-5 appear influenced by the river water level, which is the main groundwater discharge feature in the locality. This would also explain the limited groundwater level fluctuation in response to rainfall. OW-1 and OW-2 are located at a higher topographic elevation and further away from the Gökirmak River and are likely to be more reflective of the in-situ bedrock response to recharge.

Manual groundwater level measurements in the pit area were initiated in the OW-1 to OW-5 in March 2013, DH1 to DH-4 in July 2013 and in an additional 30 boreholes within the pit area in August 2013. Groundwater level measurement has been intermittent within the pit area, with intensive groundwater level monitoring conducted between August and October 2014, there is then a data gap before regular groundwater level monitoring was re-initiated in May 2015. There is currently an ongoing monthly groundwater level monitoring programme incorporating approximately 25 boreholes within the pit area.

Groundwater hydrographs illustrating the depth to groundwater at 26 boreholes across the pit area from August 2014 to August 2015 are illustrated in Chart 4.3. The chart illustrates the wide range in the depth to groundwater across the pit area, with groundwater levels ranging from 2mbgl at OW-4 close to the Gökirmak River to 80mbgl at DG-111, which is located approximately 500m south and up slope from the river.

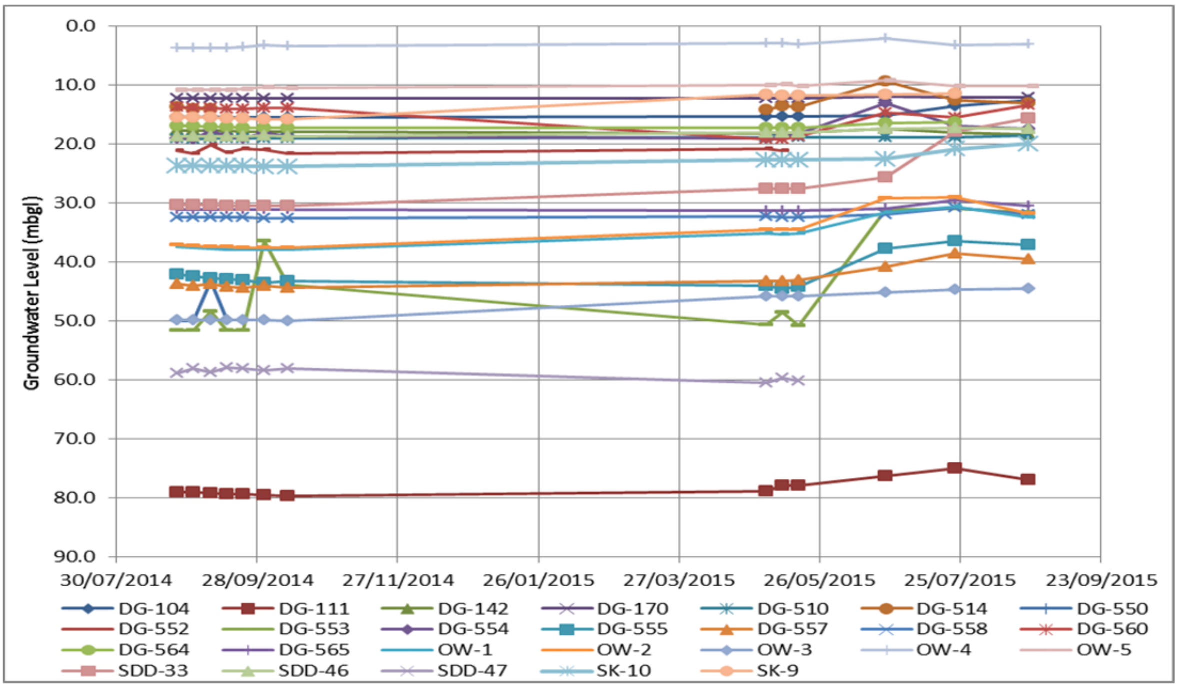

Chart 4.3: Pit Borehole Groundwater Levels (mbgl)

The depth to groundwater table is not directly related to the distance from the Gökirmak River, as some boreholes located further up hill (at a higher topographic elevation) than DG-111 have shallower groundwater levels. Chart 4.4 illustrates the groundwater elevation and ground surface (topographic) elevation for boreholes within the pit area versus their northing coordinate. This chart illustrates that in general, the groundwater elevation remains within 20m of the surface, but there are locations where the groundwater level is deeper. This groundwater table variability possibly relates to the proximity of the borehole to surface water features, the permeability of the rock intercepted channels and geological structures.

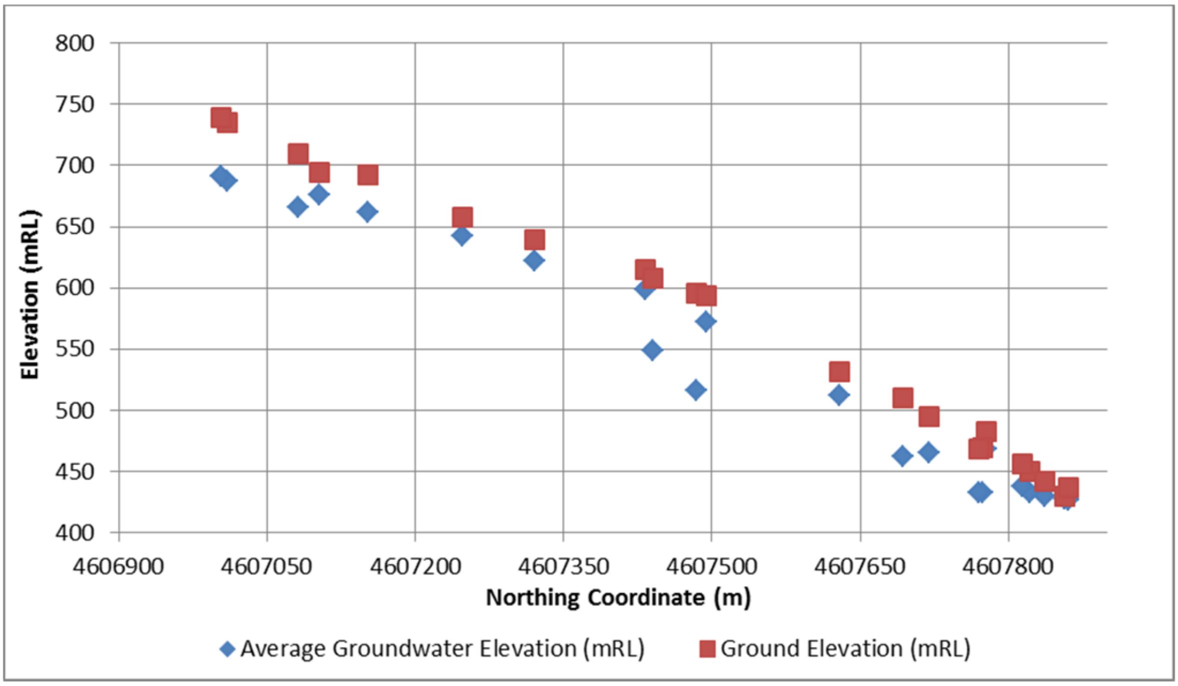

Chart 4.4: Groundwater Table Elevation vs Ground Surface Elevation (mRL)

Groundwater table elevation contours for the pit area (based on the average groundwater level at each monitoring borehole from August 2014 to May 2015) and the groundwater monitoring locations is presented in Figure 6. This illustrates that the groundwater table is generally a reflection of the topography. Groundwater flow direction is from the higher topographic elevations in the south, towards the Gökirmak River (the main groundwater discharge feature) in the south and west. The hydraulic gradient varies across the site with the levels generally steeper in central pit area and flatter at the lower topographic elevations towards the Gökirmak River. The fluctuations in the hydraulic gradient may reflect variations in hydraulic conductivity within the rock, however, caution should be applied in drawing conclusions from the available data, as many of the boreholes are screened over hundreds of metres and therefore the measured groundwater level is an amalgamation of the groundwater pressure (head) acting on the borehole across its full depth.

4.3.2 Kepezkaya TDF Area

Groundwater levels were recorded in the Kepezkaya Tailings Disposal Facility (TDF) area at 10 of the KSK series boreholes between August and October 2014. Chart 4.5 presents the available groundwater level data from the monitoring conducted previously in this area. The Kepezkaya TDF monitoring locations are illustrated in Figure 4.

The data illustrates that groundwater levels are generally between 5m and 20mbgl. The groundwater level at KSK-06 is significantly deeper than at the other locations, up to 37mbgl, which may relate to the fact that this borehole is located adjacent to a relatively steep embankment, whereas the other boreholes are located within the valley. The measured groundwater levels are relatively stable within the two-month period, the only significant variation is observed at KSK-05 where the data indicates generally increasing groundwater levels up to the point where the borehole became artesian during the final monitoring round on 17 October 2014.

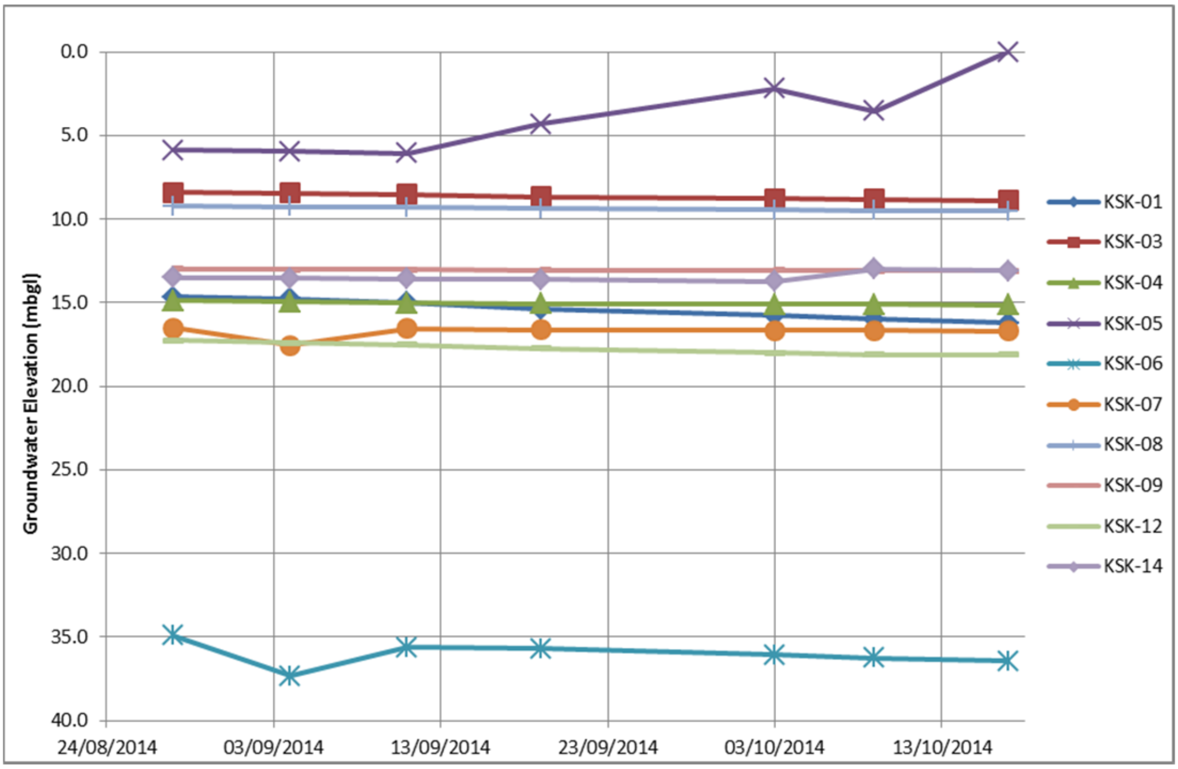

Chart 4.5: Kepezkaya TDF Groundwater Levels (mbgl)

4.3.3 Waste Dump Areas

Three new boreholes were drilled in August 2015, towards the south (WD-01 and WD-03) and west (WD-02) of the proposed northern waste dump; the location of these new boreholes is illustrated in Figure 3. The groundwater level was recorded in WD-01 and WD-02 on 21 August 2015 and in

WD-03 on 22 August 2015. The depth to groundwater in WD-01, WD-02 and WD-03 was 5.7mbgl, 16.13mbgl and 24.58mbgl, respectively. The northern waste dump is an extensive feature; few conclusions can be drawn from these three boreholes except that groundwater levels at the perimeter of the norther waste dump will vary between at least approximately 5 and 25mbg.

There is no groundwater level data currently available from the western waste dump area.

4.3.4 Process Plant Area

There is no groundwater level data currently available from the process plant area.

4.4 Hydraulic Conductivity

Hydraulic conductivity (or permeability) is a key parameter with regards to defining groundwater flow rates and volumes. It is critical in particular in the pit area with regards to predicting potential groundwater inflows and pit dewatering/depressurisation requirements.

A key focus of many of the previous hydrogeological investigations completed (detailed in Section 3.3) was the determination of the hydraulic conductivity of the various lithologies present in the Project area. This study builds upon the previous work completed and focusses on providing additional insight into the hydraulic conductivity of the various lithologies in the pit, northern waste dump and TDF areas.

Current ongoing studies will provide more certainty with regards to hydraulic conductivity in the Project area through the completion of a specific hydrogeological drilling, borehole installation and test pumping programme.

4.4.1 Pit Area Alluvium

An initial investigation completed by DSI (1994 and 1996) as part of investigations associated with the construction of a new hydroelectric dam in the area assessed the hydraulic conductivity of the alluvium within the Gökirmak River valley in the vicinity of the pit (ERGIN 1998). As part of this investigation hydraulic conductivity values were derived from slug testing completed on 6 of the boreholes installed (SK-3, SK-4, SK-5, SK-12, SK-14 and SK-15). The results of the investigation (sourced from IMC 2014) suggested that hydraulic conductivity of the alluvium decreases with depth, the results are summarised in Table 4.1.

Table 4.1: Alluvium Hydraulic Conductivity in Pit Area (DSI 1994/1996 Slug Tests)

Borehole ID	Thickness of Alluvium (m)	Alluvium Average Hydraulic Conductivity (m/s)
SK-3	6	0.3×10^{-5} to 5.0×10^{-5}
SK-4	40	5.0×10^{-5} (0–10.5m) 1.0×10^{-6} (10.5–28m) 1.0×10^{-8} (28–40m)
SK-5	11	1.0×10^{-6} (0–11m) Not Permeable (11–50m)
SK-12	11	0.2×10^{-5} to 7.0×10^{-5}
SK-14	40	1.0×10^{-5} to 1.0×10^{-6}
SK-15	18	1.0×10^{-5}

Four additional boreholes (DH1-DH4) were drilled and installed in the pit area alluvium in July 2013 (nbaproje 2013b). Slug and bail tests were completed on these four alluvial boreholes by AMI staff in August 2013 (AMI 2013). A summary of the hydraulic conductivity values derived from the analysis of the slug and bail tests (sourced from IMC 2014) is presented in Table 4.2.

Table 4.2: Alluvium Hydraulic Conductivity in Pit Area (AMI 2013 Slug and Bail Tests)

Borehole ID	Thickness of Alluvium (m)	Alluvium Hydraulic Conductivity (m/s)	
		Bower and Rice Method	Hvorslev Method
DH-1	34.5	1.47×10^{-4}	1.89×10^{-4}
DH-2	36	1.76×10^{-4}	2.28×10^{-4}
DH-3	38	2.80×10^{-5}	3.58×10^{-5}
DH-4	36	2.72×10^{-4}	3.50×10^{-4}

The hydraulic conductivity of DH-3 is approximately one order of magnitude lower than the other values, which was attributed to the fact that this borehole intersected material with a higher silt content. Based on these results IMC 2014 concluded that the alluvium in the pit area has a relatively high hydraulic conductivity, averaging approximately 2×10^{-4}m/s, although as typical of fluvial deposits the nature of the sediments and thus the hydraulic conductivity is locally variable.

Ten boreholes (DSK-1 to DSK-10) were drilled and installed in the pit area alluvium in 2014 (nbaproje 2014b). Permeability and packer tests were completed on these ten boreholes and the full set of derived hydraulic conductivity values are presented in Appendix D.

The hydraulic conductivity values derived from the permeability and packer testing of the various depth intervals from the ten boreholes tested varied significantly, ranging from 1.97×10^{-4}m/s to 8.78×10^{-7}m/s. The data suggests that the alluvium comprises of zones of significantly different hydraulic conductivity. The median hydraulic conductivity for each of the ten boreholes tested was as follows:

- DSK-1 – 6.1×10^{-5}m/s
- DSK-2 – 1.4×10^{-5}m/s
- DSK-3 – 8.9×10^{-6}m/s
- DSK-4 – 9.0×10^{-6}m/s
- DSK-5 – 2.5×10^{-5}m/s
- DSK-6 – 1.0×10^{-5}m/s
- DSK-7 – 1.1×10^{-5}m/s
- DSK-8 – 3.4×10^{-5}m/s
- DSK-9 – 2.0×10^{-5}m/s
- DSK-10 –1.2×10^{-5}m/s.

The permeability and packer test data suggests that a bulk hydraulic conductivity value of the order 1.0×10^{-5}m/s may be representative of the alluvium in the pit area.

4.4.2 Pit Area Bedrock

Previous Investigations

Five boreholes (OW-1 to OW-5) were drilled and installed in the pit area bedrock (schist and ore) in November 2012. Slug and bail tests were completed on these five bedrock boreholes by AMI staff in August 2013 (AMI 2013). A summary of the hydraulic conductivity values derived from the analysis of the slug and bail tests (sourced from IMC 2014) is presented in Table 4.3.

Table 4.3: Bedrock Hydraulic Conductivity in Pit Area (AMI 2013 Slug and Bail Tests)

Borehole ID	Bedrock – Hydraulic Conductivity (m/s)	
	Bower and Rice Method	Hvorslev Method
OW-1	6.28×10^{-9}	7.39×10^{-9}
OW-2	2.26×10^{-8}	2.84×10^{-8}
OW-3	8.38×10^{-9}	1.01×10^{-8}
OW-4 *	3.27×10^{-7}	4.62×10^{-7}
OW-5 *	2.41×10^{-5}	2.99×10^{-5}

* Borehole casing also slotted through alluvial deposits.

The hydraulic conductivity derived for the bedrock from the five OW boreholes varies significantly. Boreholes OW-4 and OW-5 have slotted casing within the alluvium sequence which explains the higher hydraulic conductivity derived for these two boreholes. OW-1 to OW-3 are located further to the south and did not intercept any alluvial sediments, thus the hydraulic conductivity values derived from these three boreholes are likely to be more representative of the bedrock properties. The average of the hydraulic conductivity for the bedrock, based on analysis of the slug and bail tests completed on OW-1, OW-2 and OW-3 is 1.4×10^{-8}m/s.

Investigations Completed as Part of this Study

Previous hydrogeological investigations had only provided a limited hydraulic conductivity data set over a localised area of the pit, it was therefore necessary to undertake additional investigations to improve our understanding of the hydraulic conductivity of the bedrock in the pit area. As detailed in Section 3.2, an additional nine holes were drilled within the pit are (GT series), with two boreholes (GT-007 and GT-013) specifically targeted a significant fault running through the pit area known locally known as the “Dividing Fault”.

Hydraulic conductivity of the bedrock in the pit area was assessed in two ways:

- packer testing during drilling of new holes in the pit area
- airlift recovery testing – existing and newly installed boreholes.

Packer Testing

As detailed in Section 3.2.2, packer testing was completed in four of the new GT series boreholes drilled within the pit area (GT-003, GT-007, GT-013 and GT-014). Packer tests were completed on 2m intervals, where possible. The packer test data was analysed using standard methodology and the full set of packer test derived hydraulic conductivity values are presented in Appendix E.

The hydraulic conductivity values derived from the packer testing of the various depth intervals from the four boreholes tested varied significantly, ranging from 4.6×10^{-5}m/s to 6.5×10^{-8}m/s. The data suggests that the rock mass comprises of zones of significantly different hydraulic conductivity. The median hydraulic conductivity for each of the four boreholes tested was as follows:

- GT-003 – 2.4×10^{-6}m/s
- GT-007 – 5.2×10^{-6}m/s
- GT-013 – 5.0×10^{-6}m/s
- GT-014 – 1.4×10^{-6}m/s.

The packer tests data suggested that a bulk hydraulic conductivity value of the order 1×10^{-6}m/s to 5×10^{-6}m/s may be representative of the bedrock in the pit area.

Airlift Recovery Testing

As detailed in Section 3.2.3, hydraulic testing using the airlift recovery methodology was completed on five existing groundwater monitoring boreholes located within the pit area (OW-1 to OW-5) and seven of the new boreholes within the pit area (GT-002, GT-003, GT-007, GT-009, GT-011, GT-013 and GT-015).

Details of the airlift recovery tests completed and the monitoring water level recovery for the boreholes tested in the pit area is presented in Appendix F. A summary of the airlift testing completed and the derived hydraulic conductivity results are presented in Table 4.4.

Table 4.4: Bedrock Hydraulic Conductivity in Pit Area (2015 Airlift Recovery Testing)

Borehole ID	Average Flow (m^3/d)	Representative Hydraulic Conductivity (m/s)	Formation
OW-5	183	1.0×10^{-5}	Alluvium/Schist
OW-1	216	2.0×10^{-6}	Schist
OW-2	Mist	2.3×10^{-9}	Schist
OW-3	7	5.8×10^{-8}	Schist
OW-4	47	3.4×10^{-7}	Schist
GT-002	89	6.3×10^{-6} [1]	Schist
GT-003	61	4.6×10^{-7}	Schist
GT-009	3.7	6.8×10^{-9}	Schist
GT-011	<14	2.3×10^{-7}	Schist
GT-015	8	3.0×10^{-8}	Schist
GT-013	17	1.0×10^{-6}	Schist/Fault
GT-007	236	_ [3]	Fault
GT-007 (2) [4]	159	1.2×10^{-5} [2]	Fault

[1] Low certainty in permeability value as limited data.

[2] Low certainty in permeability value as water levels recovered very quickly.

[3] Unable to analyse data as water level recovered too quickly.

[4] Longer duration test – 160 minutes.

The airlift test derived hydraulic conductivity results indicate that the schist bedrock, the primary rock in the pit area, exhibits a wide range of permeability, ranging over four orders of magnitude from 2×10^{-9}m/s to 6 x10^{-6}m/s. In some instances the hydraulic conductivity can be significantly different in boreholes located in very close proximity, for instance the relatively high hydraulic conductivity at OW-1 (6 x10^{-6}m/s) is very different to the low hydraulic conductivity observed at OW-2 (2 x10^{-9}m/s), which is located less than 10m away.

The average hydraulic conductivity of the nine schist only results is 1×10^{-6}m/s and the median hydraulic conductivity of the nine schist only results is 2.3×10^{-7}m/s.

The alluvium and faulted units generally exhibit higher hydraulic conductivity values of the order 1×10^{-6}m/s to 1×10^{-5}m/s.

This variability in hydraulic conductivity is reflective of the mixed geology and complex fracturing observed in the Project area.

4.4.3 Waste Dump Area

No previous hydraulic conductivity testing has been completed in either the northern or western waste dump areas. As detailed in Section 3.2.3, as part of the current study three new boreholes were drilled and installed in the northern waste dump area (WD-01, WD-02 and WD-03). Hydraulic testing, using the airlift recovery methodology, was completed on these three boreholes; although only proved successful for WD-01 and WD-02. Details of the airlift recovery tests completed and the monitoring water level recovery for the two boreholes tested in the northern waste dump area is presented in Appendix F. A summary of the airlift testing completed and the derived hydraulic conductivity results are presented in Table 4.5.

Table 4.5: Hydraulic Conductivity in Northern Waste Dump Area (2015 Airlift Testing)

Borehole ID	Average Flow (m^3/d)	Representative Hydraulic Conductivity (m/s)	Formation
WD-001	5	5.0×10^{-8}	Schist
WD-002	34	2.0×10^{-6} [1]	Schist

[1] Low certainty in permeability value as limited data.

The two hydraulic conductivity values from around the perimeter of the northern waste dump vary over two orders of magnitude.

4.4.4 Tailings Disposal Facility Area

Previous Investigations

Twenty-five boreholes (KSK series) have been drilled throughout the Kepezkaya TDF area. Hydraulic testing was completed on the first phase of boreholes drilled (KSK1 to KSK14) in 2014. The testing comprised falling head permeability tests in the upper unconsolidated and weathered rock sections and packer testing (Lugeon testing) in the fresh rock (test results provided as raw data by AMI). The full set of derived hydraulic conductivity values are presented in Appendix G. The results are illustrated graphically in Chart 4.6.

The testing results indicate that the hydraulic conductivity is very variable and generally ranges from 1×10^{-6}m/s to 1×10^{-4}m/s in the unconsolidated and weathered rock sections. The hydraulic conductivity reduces in the fresh rock (with the exception of KSK-3 and KSK-4), as illustrated by the fact that in most cases there was no measureable response for the packer tests at depth.

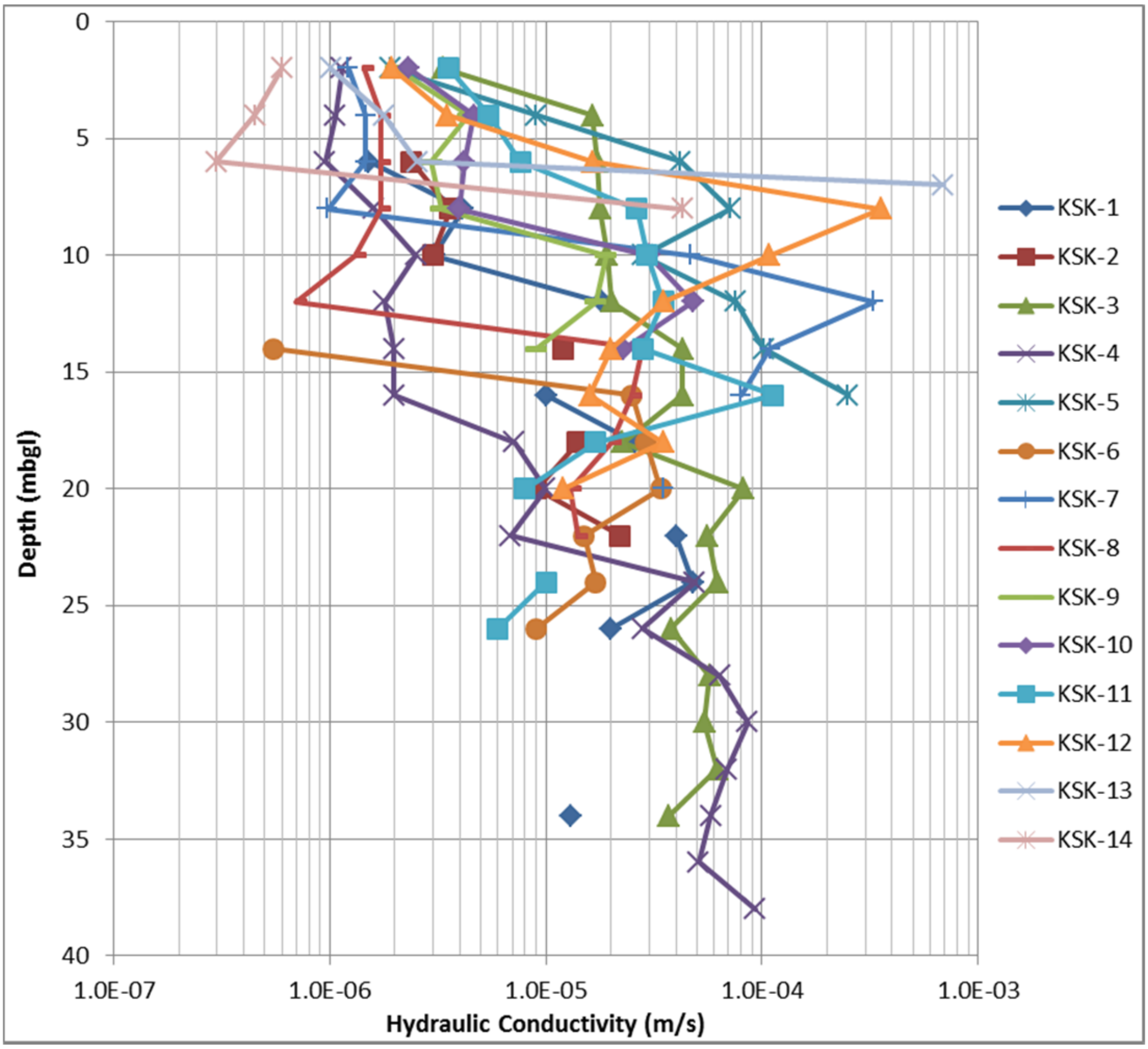

Chart 4.6: Kepezkaya TDF Hydraulic Conductivity

Investigations Completed as Part of this Study

As detailed in Section 3.2.3, as part of the current study three of the existing boreholes within the Kepezkaya TDF area (KSK-15, KSK-17 and KSK-25) were hydraulically tested using the airlift recovery method. Details of the airlift recovery tests completed and the monitoring water level recovery for the three boreholes tested in the Kepezkaya TDF area is presented in Appendix D. A summary of the airlift testing completed and the derived hydraulic conductivity results are presented in Table 4.6.

Table 4.6: Hydraulic Conductivity in Kepezkaya TDF Area (2015 Airlift Testing)

Borehole ID	Average Flow (m^3/d)	Representative Hydraulic Conductivity (m/s)	Formation
KSK-15	367	2.0×10^{-5}	Sedimentary
KSK-17	3	1.8×10^{-6}	Sedimentary
KSK-25	4	1.5×10^{-7}	Sedimentary

The results illustrate the wide range of hydraulic conductivity values observed in the Kepezkaya TDF area. The lower hydraulic conductivity at KSK-25 is representative of the deeper groundwater as the water column extended from 25mbgl to 35mbgl.

The results of the previously completed falling head permeability and packer testing and the airlift testing completed as part of this investigation illustrate that the unconsolidated strata and weathered bedrock in the Kepezkaya TDF area has variable hydraulic conductivity ranging from 1×10^{-7}m/s to 1×10^{-4}m/s, whereas the deeper bedrock generally has a lower hydraulic conductivity.

There is no hydraulic conductivity data available for the Bağdere TDF area.

4.5 Groundwater Quality

4.5.1 Regional Groundwater Quality

Regional groundwater quality samples were collected, as part of the ESIA (ENVY 2014), from three regional groundwater monitoring wells (KS-1, KS-2 and KS-3) in May 2012 and August 2012 in order to establish a background baseline data set. In August 2012, an additional well within the Project area (DG-101) was also sampled. The regional groundwater sampling well, KS-1 is located in 12km south-west of the Project area, KS-2 is located 4km west of the Project area and KS-3 is located 10km east of the Project area. The location of the groundwater sampling points and the laboratory results are presented in Appendix B. These KS-1, KS-2 and KS-3 groundwater quality results do provide some indicative background water quality data form the region but the monitoring points are located too far from the Project area to be directly relevant for this study.

4.5.2 Pit Area Groundwater Quality

Alluvium

Groundwater quality samples were collected from the alluvium within the pit area, from boreholes DH-1 to DH-4 in September 2013. The groundwater quality results are provided in Appendix B.

The groundwater quality data for the alluvial boreholes (DH1 to DH4) from September 2013 is relatively consistent across the four boreholes. However, a high zinc concentration (1.15mg/L) was detected in DH-3 which was approximately two orders of magnitude higher than the zinc concentrations detected in the other boreholes. Higher concentrations of some metals (cadmium, copper, arsenic and manganese) were also detected in the water sample collected from DH-3, relative to the other boreholes. With the exception of the high zinc concentration detected in DH-3 the groundwater quality in the alluvium appears generally good and there is little sign of any significant impact from the mineralisation present in the underlying bedrock.

Bedrock

In the ESIA (ENVY 2014), the August 2012 groundwater quality results for DG-101, located within the pit area, were compared to surface water quality guidelines, as there were apparently no groundwater guidelines within the environmental legislation. The DG-101 groundwater quality results for pH (6.15), conductivity (10,710uS/cm), mercury (0.025mg/L), lead (0.69mg/L), nickel (1.1mg/L) and zinc (4.65mg/L) concentrations were above the surface water guidelines placing it in Water Quality Class IV (very polluted), suggesting that this water could only be used as a process water supply.

Groundwater quality samples were collected from the predominantly schist bedrock within the pit area, from boreholes OW-1 to OW-5 in September 2013. The groundwater quality results are provided in Appendix B. OW-2 and OW-3 exhibited very high zinc concentrations, 13.82mg/L and 8.96mg/L respectively, which IMC 2014 dismiss as most likely being the result of using galvanised steel casing in the boreholes. The overall quality of the groundwater from the OW boreholes is good, with the exception of OW-2 which appears to be strongly impacted by nearby copper mineralization and the infiltration of recent still oxygenated rainwater. The groundwater in OW-2 exhibits high concentrations of sulphates (2,672mg/L), iron (49.54mg/L), manganese (23.98mg/L) and zinc (13.82mg/L), but copper is below the detection limit and the pH is close to neutral (6.83) suggesting a high buffer capacity within the bedrock (also supported by the elevated calcium and magnesium concentrations).

Groundwater quality samples were collected from OW-1, OW-3 and OW-5 in July 2015 and the laboratory results are provided in Appendix B. The groundwater quality of OW-5 is good, although the iron concentration (0.776mg/L) is elevated. Zinc, iron, magnesium and manganese were all detected at elevated concentrations in both OW-1 and OW-3. Zinc concentrations were 11.13mg/L and 10.38mg/L, iron concentrations were 0.466mg/L and 6.96mg/L, magnesium concentrations were 71.47mg/L and 40.34mg/L and manganese concentrations were 0.626mg/L and 0.311mg/L in OW-1 and OW-3, respectively.

Old mine workings in the pit area, where groundwater was emerging, appear heavily stained with iron precipitate and is a likely indication that the water emerging from these old mine workings has a high metals concentration. This could be indicative of acid mine drainage associated with the old workings, which would be relevant for long-term mine closure planning.

4.5.3 Waste Dumps, TDF and Process Plant

There is no groundwater quality data currently available from the waste dump, TDF or process plant areas.

4.6 Groundwater Recharge, Discharge and Abstraction

Groundwater recharge will occur predominantly through the infiltration of rainwater (and any localised snow melt) across the Project site melts. Recharge in the uphill areas of the Project area will drive groundwater flow through the rock mass towards the lower elevation river valleys.

Groundwater discharge will be primarily to the Gökırmak River, with this groundwater flow providing the baseflow component of the river. However, during the generally drier summer months, when there is little recharge, the groundwater table declines and during these periods the Gökirmak River appear to lose water through its riverbed and recharge the underlying rocks.

It is reported that currently there are no groundwater supply wells or other groundwater users within the Project area (IMC 2014).

4.7 Surface Water and Groundwater Interaction

The available groundwater level data from the OW-4 and OW-5 monitoring boreholes suggests that there is a direct hydraulic link between the Gökirmak River and the alluvium in the vicinity of the pit. It is proposed that a low permeability cut-off wall will be installed to the base of the alluvium, under both the upstream and downstream coffer dams, in order to limit lateral groundwater flow through the alluvium towards the pit. If the low permeability cut-off walls are effective then this should significantly reduce the hydraulic link between the river and the alluvium in the vicinity of the pit.

Surface water/groundwater interaction has the potential to influence water management for the Project significantly; however, little specific hydrogeological assessment of this aspect has been undertaken. Thus, as detailed in Section 3.3.2, a hydrogeological field programme is currently being undertaken in order to investigate further the river, alluvium and bedrock interconnectivity, the results of this ongoing investigation will greatly further our understanding of surface water/groundwater interaction in the Project area.

4.8 Conceptual Hydrogeological Model

The conceptual hydrogeology of each of the key Project areas is summarised below.

4.8.1 Pit Area

- Geology – Predominantly green and mixed schist, with up to 40m thickness of alluvium in the Gökirmak River channel. The bedrock is heavily fractured and faulted. One major approximately north-south orientated fault has been mapped, known as the Dividing Fault, but there are also numerous other significant fault zones in the pit area.
- Aquifers – Fractured rock and alluvial aquifers are both present in the pit area.

- Groundwater Levels – In the vicinity of the Gökirmak River groundwater levels are very similar to the river level. Recorded depth to groundwater ranges from 2mbgl (close to Gökirmak River) up to 80mbgl (up slope and 500m south of the Gökirmak River). However, groundwater levels are generally within 20m of the ground surface.
- Groundwater Flow – Groundwater flows northwards towards the Gökirmak River (the primary discharge zone) across the majority of the pit area. Groundwater is likely to flow southwards towards the Gökirmak River in the small northern pit area.
- Hydraulic Properties – Alluvium hydraulic conductivity varies from 1×10^{-4} to 1×10^{-6}m/s (adopted conservative bulk hydraulic conductivity value of 1×10^{-5}m/s). Schist bedrock hydraulic conductivity varies from 1×10^{-6} to 1×10^{-8}m/s (adopted conservative bulk hydraulic conductivity value of 1×10^{-7}m/s). Fault zone hydraulic conductivity varies from 1×10^{-5} to 1×10^{-6}m/s (adopted conservative bulk hydraulic conductivity value of 1×10^{-5}m/s).
- Groundwater Quality – Alluvium groundwater quality is good, although localised elevated metals concentrations may be present. High metals concentrations exist in groundwater associated with the orebody, localised elevated concentrations of zinc, iron, manganese and magnesium exist.
- Surface Water-Groundwater Interaction – The Gökirmak River and alluvium are hydraulically connected in the pit area.

4.8.2 Northern Waste Dump Area

- Geology – Predominantly basaltic-andesitic lava, tuffs and agglomerates, but also areas of limestone blocks and pebbly sandstone, sandstone, siltstone, claystone, sandy limestone, gravelstone. Thin alluvial deposits in the larger surface water drainage channels.
- Aquifers – Semi-permeable aquifers comprising fractured basalt and andesite exist in the northern waste dump area.
- Groundwater Levels – Groundwater levels range from approximately 6mbgl to 25mbgl in the three new waste dump boreholes installed.
- Groundwater Flow – Groundwater flows are likely to mirror topography.
- Hydraulic Properties – Two hydraulic conductivity values are available from the perimeter of the northern waste dump: 1×10^{-8} and 2×10^{-6}m/s.
- Groundwater Quality – No groundwater quality data available.

4.8.3 Western Waste Dump Area

- Geology – Predominantly green and mixed schist.
- Aquifers – Fractured rock aquifers are likely to be present in the western waste dump area.
- Groundwater Levels – No data available.
- Groundwater Flow – Groundwater flow direction is likely to be northwards towards the Gökirmak River.
- Hydraulic Properties – No data available.
- Groundwater Quality – No data available.

4.8.4 Process Plant Area

- Geology – Metamorphic mixed and green schists and sedimentary sandstone, limestone, mudstone and some other continental clastic sediments.
- Aquifers – Fractured rock aquifers are likely to be present in the process plant area.
- Groundwater Levels – No data available.
- Groundwater Flow – Groundwater flow is likely to mirror topography and be in a north to north-eastwards direction towards the Gökirmak River (to the north) and the Gökirmak River tributary located to the east of the process plant site.

- Hydraulic Properties – No data available.
- Groundwater Quality – No data available.

4.8.5 Kepezkaya TDF Area

- Geology – Predominantly sandstone, siltstone, claystone, sandy limestone, gravelstone alternation and occasional basaltic-andesitic lava, tuff, and agglomerates. Unconsolidated clayey, silty and sandy deposits up to 10m thick.
- Aquifers – Semi-permeable aquifers comprising fractured basalt and andesite may exist in the Kepezkaya TDF area.
- Groundwater Levels – Groundwater levels range from approximately 5mbgl to 20mbgl in the ten boreholes monitored in the area.
- Groundwater Flow – Groundwater flows are likely to mirror topography and generally be in a south westerly direction.
- Hydraulic Properties – Unconsolidated material hydraulic conductivity is variable and ranges from 1×10^{-4} to 1×10^{-6}m/s. Bedrock hydraulic conductivity is generally low, while values range from 1×10^{-4} to 1×10^{-7}m/s, a bulk hydraulic conductivity is likely to be predominantly in the 1×10^{-6} to 1×10^{-7}m/s range.
- Groundwater Quality – No data available.

4.8.6 Bağdere TDF area

- Geology – Predominantly sandstone, siltstone, claystone, sandy limestone, gravelstone alternation and occasional basaltic-andesitic lava, tuff, and agglomerates.
- Aquifers – Semi-permeable aquifers comprising fractured basalt and andesite may exist in the Bağdere TDF area.
- Groundwater Levels – No data available.
- Groundwater Flow – Groundwater flows are likely to mirror topography and generally be in a southerly direction towards the Gökirmak River.
- Hydraulic Properties – No data available.
- Groundwater Quality – No data available.

5. MINE DEWATERING AND DEPRESSURISATION

5.1 Mine Plan and Schedule

AMC provided the following information regarding the mine plan:

- pit shells for six phases of pit development - Phases 1 to 5 and Final Phase (27 August 2015)
- a bench schedule (20 August 2015)
- approximate annual pit profiles for the proposed open pit (3 September 2015).

The above data was used as the basis for the prediction of pit inflows.

5.2 Pit Inflows

As the proposed pit develops, water inflows to the pit will comprise:

- Groundwater inflows – through the bulk rock-mass, permeable structures, and alluvium within the river valley.
- Surface water inflows – from rainfall runoff within the pit footprint itself and the immediately adjacent surface catchments which drain towards the pit.

Inflows from both sources have been predicted using standard hydrological and hydrogeological models and using pit areas and depths/volumes based on the provided pit phases, profiles and bench schedule. The estimations of these inflows are presented in the following sections.

In assessing pit inflows, the pit area has been broken down into two sub-catchments based on the 440mRL elevation; water inflows above this elevation can be managed by gravity drainage and channelled laterally out of the pit, while water inflows below 440mRL will need to be pumped out of the pit. Where possible, water inflows are recommended to be captured and managed so that pumping is minimised.

5.3 Groundwater Inflows

Bulk average groundwater inflows to the pit have been predicted using an analytical groundwater flow model. The model makes a number of simplified assumptions; however, it is suitable for conservative groundwater inflow predictions. The predicted inflows represent progressive average inflows from the bulk rock mass, alluvium and fault/fracture zones with time.

It is likely that there will be localised more significant inflows as the mine intersects permeable fracture zones. The magnitude and duration of these enhanced localised flows will depend on the properties of the structure itself (the hydraulic conductivity), the extent of the structures, the storage of these permeable zones and their hydraulic connection to water sources (e.g. shallow perched aquifers or surface water bodies).

Enhanced pit inflows are likely to occur where the pit intercepts the more permeable alluvial deposits in the Gökirmak River valley. The Gökirmak River will be isolated from the pit area, prior to the commencement of mining, by installation of a channel diversion tunnel and coffer dams upstream and downstream of the proposed pit. The alluvium within the proposed pit area will be hydraulically isolated from the alluvium upstream and downstream of the two coffer dams by the installation of a low permeability cut-off wall. If effective these low permeability cut-off walls should restrict the movement of groundwater through the alluvium towards the pit. Groundwater inflows to the pit from the alluvium will be greatest when excavation first commences, when the alluvium is fully saturated (e.g. soon after the coffer dams are installed), however, inflows are likely to reduce over time (assuming successful hydraulic isolation of the alluvium). Long term inflows to the pit from the alluvium will be dependent upon the effectiveness of the low permeability cut-off walls and the groundwater throughflow into the alluvium from the surrounding rock-mass.

A field investigation is currently ongoing to assess the hydraulic properties of the fault zones in the Project area, to confirm the hydraulic properties of the alluvium and underlying bedrock in the upper coffer dam area, and to evaluate the river, alluvium and bedrock hydraulic interconnection. The findings of these investigations are planned to be used to update the pit groundwater inflow predictions.

Subsequently, as the project progresses to engineering design level the development of a numerical groundwater model should be considered in order to provide further confidence in predicted groundwater inflows and to ensure development of an appropriate dewatering system.

5.3.1 Bulk Bedrock Groundwater Inflows

It is proposed that pit groundwater inflows from levels above 440mRL will be collected in bench drains, that these inflows will drain laterally under gravity to the sides of the pit and discharge into a specifically designed perimeter drainage system. This approach minimises the pumping requirements from the pit floor. Groundwater inflows from levels below 440mRL (except alluvial inflows) will drain to the base of the pit, where they will be captured in an in-pit sump and will subsequently be pumped to surface. Groundwater inflows from the alluvium will be intercepted higher up in the pit, just beneath the base of the alluvium, in a separate dewatering system. Groundwater inflows were estimated for each of these individual components in order to provide the necessary data for the three different dewatering systems.

A detailed groundwater inflow assessment has been completed using the annual pit profiles, available groundwater level information and a conservative 1 × 10-7m/s hydraulic conductivity for the bedrock in the pit area, in order to predict groundwater inflows from both above and below the 440mRL elevation. The bench schedule and annual pit profiles illustrate that mining, particularly in the early mine life, will be simultaneously undertaken at numerous different bench levels creating isolated sub-pit excavations within the final pit footprint.

The groundwater inflow assessment suggests that average annual bench inflows (above 440mRL) will generally range from zero up to 15 L/s; with the higher predicted inflows usually being a combined inflow from a number of simultaneously mined sub-pits.

Average groundwater inflows draining to the in-pit sump (from levels below 440mRL) have been estimated on an annual basis and are summarised in Table 5.1.

Table 5.1: Groundwater Inflows to In-Pit Sump Dewatering System (below 440mRL)

End of Year	1	2	3	4	5	6	7	8	9	10	11	12	13
Pit Sump Inflows (L/s)	0	0	10	15	30	25	25	25	20	20	20	15	15

The pit sump inflows are predicted to increase significantly in Year 5, which corresponds to the time when there is a large increase in the percentage of the pit below 440mRL, resulting in a larger proportion of the inflows being managed via the in-pit dewatering system rather than the bench dewatering drainage system.

The pit groundwater inflows predicted as part of this study are approximately an order of magnitude higher than the previous estimations of pit groundwater inflows (nbaproje 2014c). The inflow assessment is very sensitive to hydraulic conductivity and the previous lower inflow estimations (nbaproje 2014c) adopted a hydraulic conductivity of 1×10^{-8}m/s. The hydraulic testing completed as part of this study suggested that the hydraulic conductivity of the bedrock in the pit area varied between 1×10^{-6} and 1×10^{-8}m/s. A median hydraulic conductivity value (1×10^{-7}m/s) has been adopted for this study, in order to adopt a conservative approach and to reduce the risk that pit dewatering requirements are under-estimated. Actual groundwater inflows to the mine may be an order of magnitude lower than those presented in Table 5.1 if a bulk hydraulic conductivity of 1×10^{-8}m/s proves to be more representative of the bedrock hydraulic conductivity in the pit area. To date hydraulic conductivity values have been derived from slug test, falling head tests, packer test and permeability tests, however, a programme of test pumping (which will provide more accurate hydraulic conductivity values) is ongoing which will provide a more in-depth understanding of the bedrock hydraulic conductivity.

5.3.2 Alluvium Groundwater Inflows

As mentioned in Section 5.3 above, it is proposed to hydraulically isolate the alluvium in the pit area from both the Gökirmak River and the upstream/downstream alluvial deposits by the installation of an upstream and downstream coffer dam and the installation of low permeability cut-off walls beneath each coffer dam. It is also proposed that surface water runoff from the area surrounding the pit will be collected in interception drains (where possible) along the valley sides and thus surface runoff will also be restricted from the alluvium in the pit area. If these groundwater and surface water isolation measures are effective, it is expected that this will result in the formation of a discrete alluvial aquifer (the alluvial sediments between the two coffer dams) of known extent (thickness, width and length) with recharge to the alluvium being restricted to incident rainfall onto the alluvium between the two coffer dams and throughflow from the surrounding bedrock.

Immediately following diversion of the Gökirmak River and the installation of the rainfall runoff interception drains, the alluvium in the pit area will be fully saturated. In addition, there is likely to be residual ponds of water along the riverbed and the initial excavations will be through the uppermost coarse-grained high permeable alluvial sediments, it is expected that this will result in very high initial groundwater inflows, the magnitude of which will be primarily dependent on the size of excavation. However, once all the ponded water and upper very coarse alluvial sediments have been dewatered, then the groundwater inflows are expected to reduce and bulk average inflows might be up to 15L/s (although this will depend upon the extent of the excavation). Long-term average pit inflows from the alluvium are likely to be of the order 5L/s, assuming the alluvium is hydraulically isolated by the coffer dams, the low permeability cut-off walls and rainfall runoff interception channels. The alluvial groundwater inflows are likely to be strongly influenced by storm events, which will rapidly recharge the alluvium (even within the discrete zone of alluvium between the two coffer dams), and it is likely that immediately following heavy rainfall events that groundwater inflows from the alluvium will temporarily increase.

5.3.3 Fracture Zones/Faults Groundwater Inflows

As mentioned in Section 5.3 above, it is likely that there will be localised more significant inflows as the mine intersects permeable fractured/fault or contact zones. The magnitude and duration of these enhanced localised flows will depend on the hydraulic properties of these structures and their links to water sources.

A fracture zone groundwater inflow assessment has been completed using an assumed 5-10m thick zone and a conservative hydraulic conductivity of 5×10^{-5}m/s to estimate maximum potential instantaneous initial fracture inflows. The assessment suggested that the initial interception of fully saturated discrete fracture zone might result in groundwater inflows of up to 20L/s. However, these initial fracture inflows might reduce in magnitude rapidly, with modelling suggesting that flows might reduce to 5L/s within 24 hours assuming that there is not a constant supply of water to these fracture zones. While it is predicted that initial fracture inflows might reduce in volume rapidly it is possible that large rainfall events or extended wet periods might re-saturate these fracture zones and that fracture flows could temporarily increase, although these are not likely to exceed these initial maximum predicted 20L/s levels.

Further investigation of the hydraulic properties of the fracture zones is currently being undertaken. The findings of these investigations are planned to be used to update the predictions of inflows from the fracture zones/faults as required. These investigations will also provide insight as to whether groundwater inflow from these zones of significant fracturing is high enough to warrant advanced dewatering with dewatering boreholes.

5.4 Surface Water Inflows

5.4.1 Methodology

The rainfall statistics from the Hanönü Meteorological Station have been adopted for this assessment (see Section 2).

Average annual surface water inflows to the pit have been calculated using the annual average rainfall (492mm) for the Hanönü Meteorological Station.

Storm event surface water inflows to the pit have also been calculated using both the 24 hour storm with a 100 year return period event (73mm) and the 2 hour storm with a 100 year return period event (25.4mm) based on rainfall intensity data from the Hanönü Meteorological Station (Tables 2.4 and 2.5).

A runoff coefficient is applied to the rainfall data in order to represent the proportion of total rainfall that actually runs off as opposed to ground infiltration or evaporation. Runoff coefficients vary dependent on a number of factors including the rainfall intensity, topography and ground characteristics. The runoff coefficients used for this assessment are presented in Table 5.2.

Table 5.2: Runoff Coefficients

Runoff Coefficients	Annual Average Rainfall	Storm Event (24 Hr 100 Yr)	Storm Event (2 Hr 100 Yr)
Pit	0.45	0.7	0.8
External Catchment	0.45	0.7	0.8

The applicable catchment areas for the surface water pit inflows has been based on the six pit development phases (Phases 1-5 and Final) provided and on the surrounding topography which could not be managed as “clean” runoff.

The pit area has been broken down into two sub-catchments for each Phase:

1. The area draining to the in-pit sump, predominantly the pit area below 440mRL, but also including some small external catchments in some instances.
2. The area of the pit wall above 440mRL, but also some small external catchments in some instances. Rainfall runoff from this sub-catchment will be captured on the pit benches and gravity drained laterally east and west to perimeter drains at the pit edge.

Catchment areas for each phase of pit development are provided in Table 5.3 and illustrations of the pit catchments divisions for Phase 1, Phase 3 and Final Phase are presented in Figures 7, 8 and 9.

Table 5.3: Pit Catchment Areas

Pit Phase	Pit Catchment Above 440mRL (hectares)	Pit Catchment Below 440mRL (hectares)
Phase 1	10.8	1.73
Phase 2	27.4	10.8
Phase 3	30.5	21.6
Phase 4	44.8	28.2
Phase 5	56.3	37.0
Final Phase	83.6	44.5

Surface water inflows to the pit have been estimated by applying an appropriate Runoff Coefficient (RoC) to the relevant catchment area (Area) and multiplying by the Rainfall (Rainfall) in the form of:

Inflow Volume (m^3) = RoC * Area (m^2) * Rainfall (m)

5.4.2 Average Annual Surface Water Pit Inflows

Average annual pit inflow rates were calculated using the information and methodology detailed in Section 5.3.1 and the results are presented in Table 5.4. The results are presented separately as the surface water flows reporting to the bench drainage system (above the 440mRL elevation) and the surface water flows reporting to the in-pit sump (below the 440mRL elevation).

Table 5.4: Average Annual Surface Water Pit Inflows

Phase	Bench Drainage Inflows Above 440mRL (m^3/year)	In-Pit Sump Inflows Below 440mRL (m^3/year)
Phase 1	24,000	3,850
Phase 2	60,700	16,750
Phase 3	67,650	47,850
Phase 4	99,300	62,400
Phase 5	124,700	81,850
Final	185,000	98,450

5.4.3 Storm Event Surface Water Pit Inflows

Storm event surface water pit inflows have been calculated using the information and methodology detailed in Section 5.3.1. The 24 hour 100 year return period event rainfall (73mm) has been used for the In-Pit Sump Inflows estimation, as this larger volume event, would be critical in designing an appropriate dewatering system. However, the 2 hour 100 year return period event rainfall (25.4mm) has been used for the Bench Drainage Inflows estimation, as this more intense rainfall event creates higher runoff rates, which is more critical for the design of an appropriate drainage channel network to collect and manage the storms runoff. The peak flow rates for the 2 hour 100 year return period rainfall event were estimated using the rational method and a higher runoff coefficient than the 24 hour 100 year rainfall event due to the higher intensity rainfall over a shorter duration.

The surface water pit inflows for the 24 hour 100 year event in-pit sump catchment (volume in m^3) and the 2 hour 100 year event bench drainage catchment (flow rate in m^3/s) are presented in Table 5.5.

Table 5.5: Storm Event Surface Water Inflow Volumes and Rates

Phase / Year	Bench Drainage Inflows Above 440mRL 2 hr 100 yr Storm (m^3/s)	In-Pit Sump Inflows Below 440mRL 24 hr 100 yr Storm (m^3)
Phase 1	1.89	890
Phase 2	-	3,880
Phase 3	3.07	11,090
Phase 4	-	14,460
Phase 5	-	18,970
Final	4.76	22,820

5.5 Pit Dewatering System Design and Strategy

Pit dewatering will be principally driven by surface water components and predominantly influenced by large storm events. While the groundwater pit inflows are likely to be relatively minor compared to the pit inflows resulting from large rainfall events, the dewatering system will need to consider both elements as groundwater inflows will continue even during extended dry periods and will be locally significant in areas of enhanced permeability.

Pit dewatering is planned to be achieved through a combination of three separate dewatering systems:

- In-Pit Sump Dewatering System – Capturing groundwater and surface water pit inflows below 440mRL. These inflows will gravity drain to an in-pit sump at the base of the pit and will be subsequently pumped out of the pit to a sediment treatment system.
- Bench Drainage Dewatering System - Capturing groundwater and surface water pit inflows above 440mRL. These inflows will collect in bench drains and will gravity drain laterally east and west (along the pit benches) to perimeter drains at the pit edge. Perimeter collector drains will then transfer this water to a sediment treatment system.

- Alluvial Dewatering System – Capturing groundwater inflows from the alluvium intersected in the pit walls. These inflows will collect in bench drains; on the bench below the base of the alluvium, they will drain laterally to an in-pit bench sump from where they will be pumped out of the pit to a sediment treatment system. This system is planned to have the capacity to manage smaller rainfall events. However, runoff from large storm events will by-pass this system and will drain to the in-pit sump dewatering system.

Dewatering boreholes are another possible pit dewatering option. However, at this stage there is insufficient data to confirm whether they would be a feasible option. As described in Section 3.3, there is an ongoing field investigation programme focussed on assessing whether fault zones would have sufficient permeability for them to be a potential dewatering bore target for the mine.

This report presents a viable dewatering approach, however, there is scope to optimise the dewatering design and strategy if required in order to incorporate AMI preferences or any additional data.

5.5.1 Pit Dewatering – Assumptions and Guiding Principals

The following assumptions and guiding principles have been adopted for the dewatering designs developed as part of this study:

- All water derived from rainfall runoff falling on the pit footprint and/or groundwater inflows into the pit will be managed via an isolated "dirty" water system, separate from rainfall runoff from undisturbed catchments.
- All benches above 440mRL will drain laterally and the runoff collected will exit the pit at the point where the pit intersects natural topography. This drainage will be captured by an external drainage system and thus this water will not need to be pumped from the pit.
- The dewatering strategy is designed around the requirements of dealing with the 24 hour 1 in 100 year rainfall event. Rainfall runoff derived from storms will be the critical factor in terms of the dewatering programme design. The proposed system will also be able to manage smaller rainfall events and groundwater inflows.
- The alluvial dewatering system will manage average condition pit inflows; however, for the 1 in 100 year storm it is assumed that the rainfall runoff from this area will be too much for the alluvial dewatering system to manage and that this runoff will also report to the base of the pit.
- Historical rainfall data has been used from the Hanönü Meteorological Station, the degree to which this rainfall data replicates actual rainfall at the pit site is uncertain.
- Conservative storm event runoff coefficients have been adopted for the pit, with a view to producing upper percentile estimates of the storm rainfall reporting to the dewatering system, and thus evaluating worst case water management and pumping requirements.
- Pit inflow estimates are based on phased pit designs provided by AMC on 27 August 2015 and approximate annual pit profiles provided by AMC on 3 September 2015.
- Pump selection is based not only on each individual phase, but also on the pumping requirements for the subsequent phase, with a view to developing a dewatering strategy that is practical while not requiring additional pump purchase too frequently.
- The dewatering system should be able to remove all flooding from the pit floor within a maximum of three days (pers. comm. AMI 24/7/15).
- Sykes pumps (common throughout the mining industry) have been used as indications of the specifications of pumps required, but pumps from other manufacturers with similar specifications would also be appropriate.

5.5.2 In-Pit Sump Dewatering System

It is planned that the in-pit sump dewatering system will capture all surface water and groundwater inflows to the pit below the 440mRL elevation level, excluding the alluvial groundwater inflows that will be captured by an independent system. The 440mRL elevation is the cut-off elevation, above which bench drainage can be managed by gravity (and can be drained laterally out of the pit) and therefore minimise pumping requirements and costs.

The in-pit sump dewatering system is designed to manage all surface water and groundwater inflows during the 24-hour 100-year return period rainfall event.

The groundwater inflow rates presented in Section 5.2.1 (Table 5.1) were used to estimate the total groundwater inflow over a 24 hour period, this was then combined with the surface water inflows from the 24 hour 100 year return event (presented in Section 5.3.3, Table 5.5) in order to estimate the total combined volume of water draining to the in-pit sump within the 24 hour period. Table 5.6 presents the 24-hour groundwater inflows, the 24 hour 100 year return surface water inflows and the combined total inflow volume draining to the in-pit sump dewatering system for each of the six phases. Table 5.6 also presents the duration required to remove the combined water volume (both groundwater and surface water) from the pit following the design storm (24 hour 100 year return event) at a notional 50L/s pumping rate and the pumping rate which would be required in order to dewater each phase within a three day period.

Table 5.6: In-Pit Dewatering System – Inflows and Dewatering Options

Phase / Year [1]	Groundwater Inflows over 24 Hours (m^3)	Surface Water Inflows 24 Hours 100yr (m^3)	Total Inflow Volume over 24 Hours (m^3)	Days to Dewater at 50 L/s Pumping Rate	Pumping Rate to Dewater Pit in Three Days (L/s)
Phase 1 / Year 3	864	890	1,754	0.4	7
Phase 2 / Year 4	1,296	3,880	5,176	1.2	20
Phase 3 / Year 5	2,592	11,090	13,682	3.2	53
Phase 4/ Year 10	1,728	14,460	16,188	3.7	62
Phase 5 / Year 11	1,728	18,970	20,698	4.8	80
Final / Year 13	1,296	22,820	24,116	5.6	93

[1] Phase and Year dictates surface and groundwater inflows respectively.

Other important factors influencing the dewatering system design include the total head which would need to be overcome to pump water from the in-pit sump (at the base of the pit) to the pit crest and the length of water transmission pipeline which would be required.

An appropriate in-pit dewatering system has been developed based on the pit inflow estimations, pumping rate requirements to dewater in a maximum of three days (Table 5.6) and the pumping head requirements. Based on the pumping requirements, it is proposed that a combination of Sykes HH80 and HH130i (or similar performing pumps) are used for the in-pit sump dewatering system. Tables 5.7 and 5.8 provide details of the proposed in-pit dewatering system for the various phases of pit development, providing a summary of the dewatering infrastructure requirements (including all pumps and pipelines) and the minimum time required to dewater the total pit inflows for the 24 hour 100 year return period rainfall event at maximum pump capacity.

Table 5.7: In-Pit Dewatering System – Pumping Head and Pipeline Requirement

Phase	Elevation Head (Pit base to 440mRL) (m)	Total Pipe Length (m)	Water Transmission Pipe Specifications
1	40	150	160DN PN12.5
2	60	220	200DN PN12.5
3	110	370	200DN PN12.5
4	110	360	200DN PN12.5
5	140	420	200DN PN12.5 and 160DN PN12.5
Final	180	920	200DN PN12.5 and 160DN PN12.5

Table 5.8: In-Pit Dewatering System – Pumps, Pumping Capacity and Dewatering Duration

Phase	Selected Pump Arrangement	Installed Maximum Pumping Capacity (L/s)	Shortest Time to Dewater Pit days)
1	1 × Sykes HH80 at Pit Base	25	1
2	1 × Sykes HH130 at Pit Base	75	1
3	1 × Sykes HH130 at Pit Base 1 × Sykes HH130 at Transfer Station	75	3
4	1 × Sykes HH130 at Pit Base 1 × Sykes HH130 at Transfer Station	75	3
5	1 × Sykes HH80 and 1 × Sykes HH130 at Pit Base 1 × Sykes HH80 and 1 × Sykes HH130 at Transfer Station	100	3
Final	1 × Sykes HH80 and 1 × Sykes HH130 at Pit Base 1 × Sykes HH80 and 1 × Sykes HH130 at Transfer Station	100	3

In the initial phases of pit development, the in-pit dewatering system is planned to consist of pumping from a sump located in the base of the pit. As the pit development progresses and the pit deepens, it will reach a point where it is not practical to pump water from the pit floor to the pit crest in a single lift. When the pit base elevation drops below 350mRL, a transfer station will then be required at this level, pumping out of the pit, with pump(s) continuing to be utilised in the base of the pit. However, it will be necessary to pump to the transfer station first and to then pump from this transfer station to the pit crest.

The transfer station will require a balancing storage for differences inflow and outflow. Consideration should also be given to operations and maintenance requirements. A 500m^3 storage volume would provide 5.5 hours storage at 25L/s, allowing dewatering of the pit sump while maintenance or other works is undertaken on the Transfer Station Pump or infrastructure. It is recommended that the transfer station has a minimum of 10 minutes storage at the maximum proposed dewatering rate (100L/s in the final phase) as a minimum requirement, resulting in storage of approximately 60m^3.

An overview of the planned in-pit sump dewatering system for pit development Phase 1, Phase 3 and Final Phase is provided in Figures 7, 8 and 9, respectively.

5.5.3 Bench Dewatering System

Pit inflows (both groundwater and surface water) to all benches above the 440mRL elevation are planned to drain laterally with the water collected exiting the pit at the point where the pit intersects natural topography. This drainage is to be captured by pit perimeter drains, which will gravity drain to the sediment treatment system and thus this water will not need to be pumped from the pit.

The peak surface water inflow flows generated from the 2 hour 100 year return period event (Table 5.5) have been used to guide the design of a perimeter drainage channel to act as an appropriate bench dewatering system. Groundwater inflows are not been included in this assessment, as over a two-hour event these inflows are minor when compared to the rainfall runoff (surface water) component. The perimeter drain design flow has been taken to be half of the peak flow rate, based on the assumption that each perimeter drain would capture approximately half of the bench drainage rainfall runoff. The minimum slope of the channel has been based on the topography along the channel alignment, and it represents the largest required channel section size to convey the peak flow along the length of the channel. The water depth at steeper sections of channel will be lower. Table 5.9 presents the design flow, minimum channel slope and channel type for the perimeter drainage channel design for the bench dewatering system.

Table 5.9: Bench Dewatering System – Pit Perimeter Drainage Channel Design Criteria

Phase	Peak Flow Rate 2 Hour 100 Year (m^3/s)	Perimeter Channel Design Flow (m^3/s)	Minimum Channel Slope	Channel Type
Phase 1 Pit Area (above 440mRL)	1.89	0.95	0.18	Trapezoidal
Phase 3 Pit Area (above 440mRL)	3.07	1.54	0.11	Trapezoidal
Final Pit Area (above 440mRL)	4.76	2.38	0.05	Trapezoidal

The proposed trapezoidal channel dimensions for the perimeter drains of the bench dewatering system are provided in Table 5.10 (based on the below image). All channels will have side slopes of 1:2 ratio.

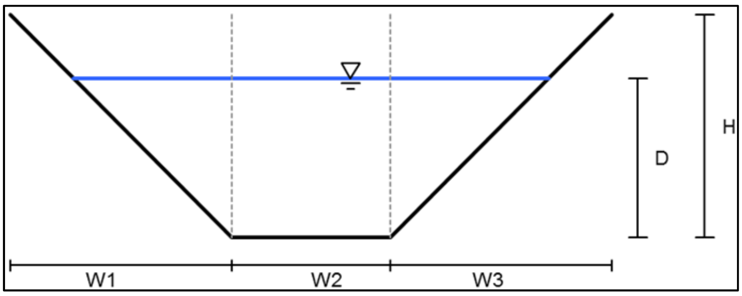

Table 5.10: Bench Dewatering System – Pit Perimeter Drainage Dimensions

	Channel Height H (m)	Width –W1 (m)	Width – W2 (m)	Width – W3 (m)
Phase 1 Pit Area (above 440mRL)	0.55	1.1	0.5	1.1
Phase 3 Pit Area (above 440mRL)	0.65	1.3	0.5	1.3
Final Pit Area (above 440mRL)	0.75	1.5	1	1.5

Table 5.11 presents the water depth at minimum channel slopes, the freeboard available and the flow capacity of the channel flow at the stated water depth for the minimum slopes listed in Table 5.9. These channel flow capacities illustrate that the proposed channels can convey the perimeter channel design flows listed in Table 5.9 (including the 0.3m freeboard) and thus that it is an appropriate bench dewatering design.

An overview of the proposed bench dewatering system for pit development Phase 1, Phase 3 and Final Phase is provided in Figures 7, 8 and 9, respectively.

Table 5.11: Bench Dewatering System – Pit Perimeter Drainage Channel Flow Capacity

Phase	Water Depth – D (m)	Freeboard (m)	Channel Flow Capacity (m^3/s)
Phase 1 Pit Area (above 440mRL)	0.25	0.3	1.1
Phase 3 Pit Area (above 440mRL)	0.35	0.3	1.7
Final Pit Area (above 440mRL)	0.45	0.3	3.0

5.5.4 Alluvial Dewatering System

An alluvial dewatering system is planned be installed to intercept groundwater inflows and standard rainfall event runoff from the alluvium sequence once intercepted by the pit wall. The proposed alluvial dewatering system comprises a collector bench drain and an associated in-pit sump(s) located on the bench below the base of this alluvium. This system will either comprise two small pumps and two sumps or one combined system (i.e. one sump and one pump).

During large rainfall events the alluvial dewatering system is not expected to be able to manage the rainfall runoff from the alluvium section of the pit wall area and the storm water runoff is expected to overflow and drain to the in-pit sump dewatering system. The storm event pit inflows presented in Tables 5.5 and 5.6 for the in-pit sump dewatering system include this rainfall runoff. Groundwater inflows from the alluvium have been estimated at up 15L/s in Section 5.2.1.

A Sykes HH80 pump (or similar performing pump) is proposed for the pumping of the alluvial pit inflows to the sediment treatment system. This pump has a maximum pumping rate of approximately 25L/s which is expected to be sufficient for all phases of pit development.

If significant groundwater inflow to the pit (greater than 10L/s) persist from the alluvium (possibly as a result of remaining hydraulic links between the pit area alluvium and either the Gökirmak River, upstream saturated alluvium or permeable structures) then a dewatering borehole(s) might be installed between the coffer dam and the pit crest in order to intercept these groundwater flows prior to them entering the pit. The ongoing hydrogeological field investigation is expected to provide a more in-depth understanding of the potential Gökirmak River, alluvium and bedrock hydraulic connection in the coffer dam area. In addition, the programme involves the installation of 200mm diameter cased boreholes that could act as dewatering boreholes, if required.

5.5.5 Borehole Dewatering System

Dewatering boreholes are not included in the current dewatering system as it is uncertain if they are a feasible option. An ongoing field investigation programme is currently evaluating if the fractured zones within the pit area may have sufficient permeability and storage to act as borehole dewatering targets. If borehole dewatering is a feasible option then the overall dewatering system should be modified to incorporate borehole dewatering, as a means of intercepting groundwater prior to it entering the pit and to act as a “clean” water supply option.

5.5.6 Mine Dewatering Treatment and Storage

We understand that AMI currently do not possess a discharge permit to allow for the discharge of mine dewatering to the Gökirmak River. It is proposed that water derived from the pit dewatering systems will be either pumped or drain via gravity to a sedimentation pond treatment system, which will subsequently overflow to a mine water storage pond, and which will then be subsequently pumped to the plant as a process water supply.

5.6 Pit Dewatering Water Quality

Groundwater quality is discussed in detail in Section 4.5 and suggests that the alluvium groundwater quality is generally good, although with localised elevated metals concentrations. The bedrock groundwater quality will also generally be good; however, groundwater in the vicinity of the orebody is likely to exhibit elevated metals concentrations, particularly zinc, iron, manganese and magnesium. Previous groundwater quality samples collected from boreholes within the pit area returned the following maximum concentrations: sulphates (2,672mg/L), zinc (13.82mg/L), iron (49.54mg/L), manganese (23.98mg/L) and magnesium concentrations (71.47mg/L). This is likely to be representative of worst case groundwater quality intercepted by the pit dewatering system and this high metals concentration water will be diluted naturally in the pit dewatering system by cleaner groundwater and rainfall runoff.

The pH values available from the pit area suggest mostly close to neutral groundwater suggesting a high buffer capacity within the bedrock (also supported by the elevated calcium and magnesium concentrations).

The groundwater quality of the pit dewatering should not be critical as it is not proposed to release this water to the environment. However, the water quality should be assessed with regards its use in the process plant and whether it contains any chemicals which will be detrimental to equipment or the mineral processing.

Additional groundwater quality monitoring from a more widespread area of the pit footprint is recommended in order to provide additional insight into the chemistry of the groundwater across the pit area and thus the likely quality of the water pumped from the in-pit sump and alluvial dewatering systems and the bench dewatering drainage system.

5.7 Pit Depressurisation

Hydrogeological investigations completed to date indicate that there will be areas within the pit where rocks with a low hydraulic conductivity will be exposed in the pit walls, although there will also be abundant heavily fractured rock across the pit walls. Rock mass exposed in the pit walls which exhibits a low hydraulic conductivity might be slow to drain, resulting in elevated phreatic surfaces (water tables) and high pore pressures behind the developing pit walls. This can have implications for pit design (safe pit slope angles) depending on the geotechnical properties of the pit wall rocks.

In hot climates the seepage face in low hydraulic conductivity rocks can often be hidden as seepages are small and evaporation can remove evidence of water. In-pit sump pumping alone might not achieve dry wall conditions in low permeable rocks, although the heavily fractured nature of the majority of the surrounding rock can assist drainage in this instance.

Standard methodologies for achieving pit wall depressurisation include the installation of Horizontal Drain Holes (HDH), targeting areas where the predicted water table and/or pore pressure distributions, under natural drainage conditions, would exceed pit slope design criteria. The length of these HDHs is often 20–100m and HDH spacings are often of the order 25–50m. Any flowing HDH can be plumbed into collection drains (draining either to the bench drainage dewatering system or the in-pit sump dewatering system) or directly to the in-pit collection points in order to reduce water related trafficability issues on the pit access ramp and pit floor. This can easily be done by connecting polyethylene tubing to drain hole collars. Alternatively, pit depressurisation can often be achieved by advanced dewatering using ex-pit dewatering bores.

The necessity for pit depressurisation for the Project is uncertain as yet. However, if required standard depressurisation techniques including HDH installation (and potential borehole dewatering) will be used to achieve the pit wall pore pressure design criteria.

5.8 Pit Dewatering System Costs

5.8.1 Capital Costs

Costs that we have acquired from previous projects have been used to develop a capital cost estimate for the proposed pit dewatering system for the Project. It should be noted that these costs have been pulled from various international projects and their applicability to Turkey needs to be confirmed. These costs only relate to the supply of the equipment, as we are uncertain whether AMI staff would complete the installation or if subcontractors would be used.

Unit costs for the various proposed dewatering system elements are provided in Table 5.12.

Table 5.12: Dewatering System Unit Costs (Supply Only)

Unit Cost	GBP (£)
Sykes HH80 Pump	£60,000
Sykes HH130 Pump	£80,000
160ND Pipe / m	£25
200ND Pipe / m	£35
Transfer Station Tank 500 m^3 tank providing 5.5 hours storage at 25 L/s	£60,000

The quantity of each element of the proposed dewatering system, presented as equipment required in addition to the preceding phase (for the proposed in-pit sump and alluvial dewatering system), is detailed in Table 5.13.

Table 5.13: Additional Dewatering Items Required per Phase (Not Including Dewatering Bores)

Item		Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Final Pit
Pit Dewatering Duty Pumps	Sykes HH80 Pump	1				1	
	Sykes HH130i Pump		1	1			
Alluvial Dewatering Duty Pumps	Sykes HH80 Pump		1				
Standby Pumps	Sykes HH80 Pump	1					
Pipeline (m)	160ND Pipe PN12.5	150				420	60
	200ND Pipe PN12.5		220	150		50	60
Transfer Station				1			

The cost of each element of the proposed dewatering system and the overall total cost, presented as additional cost per phase (for the proposed in-pit sump and alluvial dewatering system), is detailed in Table 5.14.

Table 5.14: Additional Dewatering System CAPEX per Phase (Not Including Dewatering Bores)

Item		Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Final Pit
Pit Dewatering Duty Pumps	Sykes HH80 Pump	£60,000				£60,000	
	Sykes HH130i Pump		£80,000	£80,000			
Alluvial Dewatering Duty Pumps	Sykes HH80 Pump		£60,000				
Standby Pumps	Sykes HH80 Pump	£60,000					
Pipeline (m)	160ND Pipe PN12.5	£3,750				£10,500	£1,500
	200ND Pipe PN12.5		£7,700	£5,250		£1,750	£2,100
Transfer Station	500 m^3 (5.5 hours at 25 L/s)			£60,000			
Total		£123,750	£147,700	£145,250	£0	£72,250	£3,600
Total (+20% contingency)		**£150,000**	**£180,000**	**£175,000**	**£0**	**£87,000**	**£5,000**

NB: HH80 Standby Pump assumed as standby for all Duty Pumps including HH130i

5.8.2 Operating Costs

It is assumed that the proposed in-pit sump and alluvial pit dewatering systems will use diesel engine pump sets. Based on the average annual rainfall and estimated groundwater inflows we have developed typical pump operating hours and diesel consumption values for each pump in each pit phase, which are presented in Table 5.15.

These values have been used to estimate average annual diesel consumption and diesel usage costs (using an indicative £0.85 per litre cost for diesel) per phase, broken down by whether it is associated with surface water, groundwater or alluvial pumping, presented in Table 5.16.

The diesel usage estimates have been derived based on the engines running at high revolutions per minute (rpm), the number of pumps operating and the operating hours of active pumping. Diesel rates (L/hr) have been taken from the corresponding Sykes Pumps brochures at high engine rpm.

Table 5.15: Dewatering System – Pump Operating Time and Diesel Consumption

	Pump Description	Pump Type	Pit Sump SW Dewatering (Hours)	Pit Sump GW Dewatering (Hours)	Alluvial Dewatering (Hours)	Diesel Consumption Rate (L/hr)	Annual Pump Operating Time per Pump (Hours/Year)	Annual Diesel Usage per Pump (Litres/Year)
Phase 1 Pit Area (below 440mRL)	Pit Base	Sykes HH80	43	3,504		5	3,547	17,733
Phase 2 Pit Area (below 440mRL)	Pit Base	Sykes HH130i	62	1,685		12	1,747	20,959
	Alluvial	Sykes HH80			5,256	8	5,256	42,048
Phase 3 Pit Area (below 440mRL)	Pit Base	Sykes HH130i	93	3,369		13	3,463	45,014
	Transfer Station	Sykes HH130i	93	3,369		33	3,463	114,267
	Alluvial	Sykes HH80			1,752	8	1,752	14,016
Phase 4 Pit Area (below 440mRL)	Pit Base	Sykes HH130i	129	2,246		13	2,375	30,871
	Transfer Station	Sykes HH130i	129	2,246		33	2,375	78,364
	Alluvial	Sykes HH80			1,752	8	1,752	14,016
Phase 5 Pit Area (below 440mRL)	Pit Base	Sykes HH130i	139			23	139	3,197
	Transfer Station	Sykes HH130i	139			33	139	4,587
	Pit Base	Sykes HH80	139	7,008		8	7,147	57,176
	Transfer Station	Sykes HH80	139	7,008		11	7,147	78,617
	Alluvial	Sykes HH80			1,752	8	1,752	14,016
Final Pit Area (below 440mRL)	Pit Base	Sykes HH130i	172			33	172	5,676
	Transfer Station	Sykes HH130i	172			33	172	5,676
	Pit Base	Sykes HH80	172	5,256		11	5,428	59,708
	Transfer Station	Sykes HH80	172	5,256		11	5,428	59,708
	Alluvial	Sykes HH80			1,752	8	1,752	14,016

Table 5.16: Dewatering System - Pump Operating Time and Diesel Consumption

Phase	No. of HH80 Pumps	No. of HH130i Pumps	Pit Sump SW Dewatering Diesel Consumption (L/Yr)	Pit Sump GW Dewatering Diesel Consumption (L/Yr)	Alluvial Dewatering Diesel Consumption (L/Yr)	Annual Total Diesel Consumption (L/Year)	Annual Diesel Cost at £0.84/L
1	1	-	213	17,520	-	17,733	£15,073
2	1	1	743	20,215	42,048	63,007	£53,556
3	1	2	4,296	154,985	14,016	173,297	£147,302
4	1	2	5,911	103,323	14,016	123,250	£104,763
5	3	2	10,425	133,152	14,016	157,593	£133,954
6	3	2	15,136	115,632	14,016	144,784	£123,066

6. SURFACE WATER MANAGEMENT

Surface water management designs have been developed, as part of this study, for the key Project developments, including:

- three representative phases of the pit development
- the coffer dam area
- the northern waste dump
- the western waste dump
- the process plant.

Surface water management designs for the two TDFs have been completed by Hidro Dizayn (Hidro Dizayn 2015).

Surface water management for the Project will focus on maximising the diversion of “clean” rainfall runoff from catchments not impacted by the Project development. Where rainfall runoff is originating from impacted catchment areas, this runoff is planned to be intercepted and managed in accordance with the quality of this water. As part of this study, we have defined the catchments impacted by the Project development and designed appropriate diversion drains to convey extreme rainfall runoff peak flows. In addition, where appropriate we have designed sedimentation ponds to manage the potential sediment load of runoff from impacted catchments.

In the pit area, mine water from the various components (upper benches, alluvium and pit sump) is planned to be intercepted and conveyed to a settlement pond system and ultimately a water storage pond, which will serve as a water supply for the process plant.

Monitoring of the mine water management activities is recommended to be completed on a regular basis in order to maintain and improve efficiency of the surface water management system. Corrective actions are recommended to be implemented, as required, internal AMI communications are recommended to seek to implement a continuous improvement process.

The key objectives for the Project site surface water management include the following:

- Maximise the diversion of “clean” surface runoff from catchments not impacted by the Project development. Thus minimising the inflow of “clean” water to the Project site and minimising the volume of water which needs to be managed (including treatment and disposal).
- Ensure that all surface water and groundwater flows from impacted catchments are captured and treated accordingly in order to ensure that there are no uncontrolled releases from the Project site and to ensure compliance with environmental discharge requirements.
- Maximise the reuse of water.
- Avoid the impact of flooding on Project infrastructure and operations.
- Avoid the disturbance of existing surface water drainage channels and features, where possible.

Currently it is not intended to capture “clean” surface water runoff in order for it to act as a water supply option. The only surface water runoff utilised as a water supply option is runoff from the pit area (which is pumped to the process plant as a water supply option, partly as AMI do not have a discharge permit for mine dewatering) and the sedimentation ponds around the northern waste dump, which can be used as a dust suppression supply.

6.1 Site Specific Surface Water Management

Three key phases of pit development have been examined, as representative stages in the life of the mine, in order to present a conceptual surface water management approach for the Project. The selected phases were Phase 1, Phase 3 and the Final Phase. In addition, surface water management approaches have also been developed for the western and northern waste dumps, the process plant site and two Tailings Disposal Facilities (TDFs). The following report sections provide an overview of the proposed site-specific surface water management designs for each of key pit phases and Project infrastructure.

In all cases, the “clean” surface water runoff from the un-impacted catchments is planned to be kept separate from the “dirty” surface water runoff from the impacted catchments.

6.1.1 Pit Development Phase 1

Figure 7 presents an overview of the water management design proposed for Phase 1 of the pit development. The Phase 1 catchments comprise the following:

- a large catchment not impacted by the development located to the south of the pit
- a small catchment not impacted by the development located to the north of the pit, draining to the area between the two coffer dams
- a small catchment not impacted by the development located immediately to the north-west of the pit
- the catchment area impacted by the pit development consists of both internally and externally draining catchments.

Channels intercepting runoff from the un-impacted catchments are proposed to divert this “clean” runoff to adjacent catchments upstream and downstream of the coffer dams and prevent interaction with runoff from impacted catchments. Details on these “clean” water interception channels are provided in Section 6.2.2.

Catchment areas below the channels intercepting runoff are planned to drain between the upstream and downstream coffer dams. This water is planned to drain to the downstream cofferdam, where it is planned to pond, facilitating some sediment settlement, prior to removal via a pumping system.

The pit impacted catchment and drainage consists of:

- The mining area uphill of the original river base elevation is planned to be captured and managed without the need of pumping. Runoff from this area is planned to gravity drain via lateral drains to a pit perimeter drain. This catchment area is approximately nine hectares.
- The western pit perimeter drain is planned to drain under gravity to sedimentation ponds and ultimately the mine water storage pond.
- The eastern pit perimeter drain is planned to drain under gravity to an eastern sedimentation pond, prior to it being pumped to the western sedimentation pond system and ultimately the mine water storage pond.
- The remainder of the pit area, below the original river base elevation, is planned to drain internally to a sump at the pit base. This area is approximately two hectares.
- The “dirty” (impacted) water captured in the pit sump is planned to be pumped out of the pit to the sedimentation ponds, ultimately draining to mine water storage pond.

6.1.2 Pit Development Phase 3

Figure 8 presents an overview of the water management design proposed for Phase 3 of the pit development. Similar to Phase 1, the Phase 3 catchments comprise the following:

- a large catchment not impacted by the development located to the south of the pit
- a small catchment not impacted by the development located to the north of the pit, draining to the area between the coffer dams

- a small catchment not impacted by the development located immediately to the north-west of the pit
- the catchment area impacted by pit development consists of both internally and externally draining catchments.

As with Pit Phase 1, channels intercepting runoff from the un-impacted catchments are proposed to divert the “clean” runoff to adjacent catchments upstream and downstream of the coffer dams, preventing interaction with runoff from impacted catchments.

The Phase 3 pit straddles the catchment divide to the west and there is no longer an un-impacted upstream catchment requiring diversion to the west.

Similar to Phase 1, the catchment areas below the channels intercepting runoff are planned to drain between the upstream and downstream coffer dams. These catchments are reduced in overall area compared to Phase 1 due to the expansion of the pit. The runoff from these areas is planned to drain to the downstream cofferdam, where it is planned to pond, facilitating sediment settlement prior to removal via a pumping system. Certain areas downstream of the channels are planned to drain to the internal pit catchment due to topography and they are planned to be managed by the in-pit dewatering system.

The pit impacted catchment and drainage consists of:

- The mining area uphill of the original river base elevation is planned to be captured and managed without the need of pumping. Runoff from this area is planned to gravity drain via lateral drains to a pit perimeter drain. In Phase 3 this area is approximately three times larger than that of Phase 1.
- The western pit perimeter drain is planned to drain under gravity to sedimentation ponds and ultimately the mine water storage pond.
- The eastern pit perimeter drain is planned to drain under gravity to an eastern sedimentation pond, prior to it being pumped to the western sedimentation pond system and ultimately the mine water storage pond. The eastern sedimentation pond is expected to require relocation from Phase 1 due to the pit development and the transfer pipeline relocated.
- The remainder of the pit area below the original river base elevation is planned to drain internally to a sump at the pit base. Small portions of the external catchment to the north which cannot be diverted due to topography are also planned to drain to the internal pit catchment. In Phase 3, this area has expanded to more than 10 times the area in Phase 1.
- The “dirty” (impacted) water captured in the pit sump is planned to be pumped out of the pit to the sedimentation ponds, ultimately draining to mine water storage pond.

6.1.3 Pit Development Final Phase

Figure 9 presents an overview of the water management design proposed for the Final Phase of the pit development. The Final Phase catchments comprise the following:

- a catchment not impacted by the development located to the south of the pit
- a small catchment not impacted by the development located to the north of the pit, draining to the area between the two coffer dams
- a small catchment not impacted by the development located immediately to the north-west of the pit
- the catchment area impacted by pit development consists of both internally draining and externally draining impacted catchments.

As with the previous pit phases, channels intercepting runoff from the un-impacted catchments are proposed to divert the “clean” runoff to adjacent catchments upstream and downstream of the coffer dams, preventing interaction with runoff from impacted catchments. The small catchment to the northwest of the pit is expected to no longer be able to be kept separate from the pit drainage system, due to the planned routing of the pit perimeter drainage to the west.

As with previous phases, the catchment areas below the channels intercepting runoff are planned to drain between the upstream and downstream coffer dams. These catchments are reduced in overall area compared to Phase 3 due to the expansion of the pit. The runoff from these areas is planned to drain to the downstream cofferdam where it is planned to pond, facilitating some sediment settlement prior to removal via a pumping system. Certain areas downstream of the channels are planned to drain to the internal pit catchment due to topography and they are planned to be managed by the in-pit drainage system.

The pit impacted catchment and drainage consists of:

- The mining area uphill of the original river base elevation is planned to be captured and managed without the need of pumping. Runoff from this area is planned to gravity drain via lateral drains to a pit perimeter drain. In the Final Phase this area is approximately 2.5 times larger than that of Phase 3.
- The western pit perimeter drain is planned to drain under gravity to sedimentation ponds and ultimately the mine water storage pond. It is also planned to capture the small un-impacted catchment to the north-west due to the topography and alignment of the perimeter drain.
- The eastern pit perimeter is planned to drain under gravity to a sedimentation pond prior to pumping to the western sedimentation pond system and ultimately the mine water storage pond. The eastern sedimentation pond is expected to require relocation from Phase 3 due to the pit development and the transfer pipeline relocated.
- The remainder of the pit area below the original river base elevation is planned to drain internally to a sump at the pit base. Small portions of the external catchment to the north which cannot be diverted due to topography are also planned to drain to the internal pit catchment. In the Final Phase this area is approximately twice as large as that of Phase 3.
- The “dirty” impacted water captured in the pit sump is planned to be pumped out of the pit to the sedimentation ponds, ultimately draining to mine water storage pond.

6.1.4 Coffer Dam Area

As described in Sections 6.1.1 to 6.1.3, there is an internally draining catchment located between the two coffer dams, runoff from within this area (below the interception drains) is planned to drain toward the downstream coffer dam. The runoff from this area is expected to consist of predominantly “clean” water. This water is planned to be captured in a storage pond or bunded area, in order to prevent it ponding directly against the cofferdam, and a pumping system is planned to discharge this water to east of the downstream coffer dam. A Sykes Contractors Low Head pump (or similar performing pump) capable of providing a minimum head of 20m would be required to manage this water and facilitate pumping it to the Gökirmak River downstream of the lower coffer dam.

6.1.5 Western Waste Dump

Figure 10 presents an overview of the surface water management design proposed for the western waste dump, located approximately 2km to the west and south of the pit. The western waste dump catchments comprise of the following:

- A large upstream catchment not impacted directly by the waste dump located to the south of the waste dump. This catchment covers an area of approximately 570 hectares.
- Two minor upstream catchments not impacted directly by the waste dump. The catchments are located to the northwest and northeast of the waste dump with catchment areas of 10 hectares and 18 hectares, respectively.
- The catchment directly impacted by the waste dump. The catchment area of the western waste dump is approximately 95 hectares.

Channels intercepting the runoff from the un-impacted upstream catchments are proposed to divert the “clean” runoff to adjacent catchments to the east and west or downstream of the waste dump into the natural drainage channel and prevent interaction with runoff from the impacted catchments of the waste dump.

Due to the topography of the area, it will not be possible to divert all of the un-impacted catchment to the adjacent catchments. Hence, a portion of this catchment area, approximately 33 hectares, is planned to drain to the waste dump and captured and managed as part of the western waste dump drainage system.

The western waste dump impacted catchment and drainage consists of:

- The waste dump development which can be divided into two sub-catchments one draining north and one draining south.
- The southern sub-catchment drains internally and in a southerly direction, into a channel which captures the runoff from this sub-catchment and the remaining upstream un-impacted catchment area which could not be diverted. A channel through the waste dump is recommended to transfer the runoff to the north, and ultimately a sedimentation pond prior to discharge to the environment.
- The northern sub-catchment drains internally and in a northerly direction into a drainage channel which collects runoff from the southern catchment, which ultimately drains to a sedimentation pond prior to discharge to the environment.
- Perimeter drainage are planned to be provided at the northern extremities of the waste dump, to ensure all runoff from impacted catchments and upstream catchment areas draining to the waste dump is captured by the drainage channel which drains north through the waste dump to the sedimentation pond.

6.1.6 Northern Waste Dump

Figure 11 presents an overview of the surface water management design proposed for the northern waste dump, located approximately 1km to the north of the pit. The northern waste dump catchment comprises of:

- the catchment directly impacted by the waste dump. The catchment area of the waste dump is approximately 190 hectares
- the site has very little un-impacted catchment as it is situated on a local topographic high, and runoff is shed externally in all directions. The one exception is along a ridgeline to the east, where the runoff from an un-impacted catchment area is intercepted by the waste dump.

Channels intercepting the runoff from the un-impacted upstream catchment are proposed to divert the “clean” runoff to prevent interaction with the unclean runoff from the impacted catchments.

Bunds are also proposed where the perimeter of the waste dump and sedimentation ponds are located adjacent to significant existing river channels, in order to prevent inundation and cross contamination during high flow conditions.

The northern waste dump impacted catchment and drainage consists of:

- 12 sub-catchments, draining outwards in all directions.
- perimeter drainage is planned to be provided to capture runoff from the sub-catchments and divert to appropriately located sedimentation basins prior to discharge to the environment
- the number of sedimentation ponds could be reduced with further optimisation, additional earthworks and capturing an increased un-impacted catchment area within the system.

6.1.7 Process Plant

Figure 12 presents an overview of the surface water management design proposed for the process plant site, located approximately 4km to the east of the pit development. The process plant catchment comprises of the following:

- a small upstream catchment not impacted by the development located to the south-west of the process plant site
- the site catchment directly impacted by the process plant site and excavated material dump. The catchment area of the process plant site is approximately 14 hectares.

Channels around the upstream side of the process plant site and excavated material dump are proposed to intercept the runoff from the un-impacted upstream catchment, to diverting the "clean" runoff and thus prevent interaction with the unclean runoff from the impacted catchment. The diverted runoff drains back into the natural stream channels downstream of the process plant site.

The material impacted catchment and drainage consists of:

- the process plant site with a perimeter drain intercepting "dirty" runoff from the impacted catchment area and diverting it to sedimentation ponds for treatment prior to discharge to the environment
- the excavated material site is planned to drain to a separate sedimentation pond for treatment prior to discharge to the environment, along with a portion of the process plant site and un-impacted catchment
- the number of sedimentation ponds could potentially be reduced from two to one with further optimisation, but this might require additional earthworks, capturing an increased un-impacted catchment area and grading the process plant site to drain solely in one direction.

6.1.8 Kepezkaya Tailings Dam Facility

A surface water management assessment for the Kepezkaya Tailings Dam Facility (TDF) was recently undertaken as part of a study completed by Hidro Dizayn Engineering Consultancy, Construction & Trade Inc. (Hidro Dizayn 2015).

The proposed design and surface water management approach adopts the same principal (as described above) of developing a separate water management systems for "dirty" runoff derived from impacted catchments and "clean" runoff derived from un-impacted catchments (see Figure 13).

The Kepezkaya TDF site is located in a valley. Interception channels are proposed to the right and left of the TDF in order to divert the "clean" runoff from the non-impacted upstream catchment around the TDF so that it discharges back into the natural streambed downstream of the TDF development. Stilling basins have been incorporated as part of the surface water management design prior to discharge. The proposed channel sizing for the right and left channels are as follows:

- Right Channel: Trapezoidal, concrete lined 0.65–1.3m depth, 1m base width, 1:1.5 (V:H) side slopes
- Left Channel: U section, reinforced concrete, 1.5m depth, 2m channel width.

The discharge capacity of the interception channels is Q100 (100-Year Peak Flow) with a freeboard, and Q500 (500-Year Peak Flow) without any freeboard.

The TDF area has two drainage systems:

- an upper drainage system collecting all precipitation and seepage from the tailings which drains to a sump at the reservoir base, which is then pumped to the process plant
- a lower drainage system collecting all shallow groundwater which drains to a collection pool, where the water quality is tested. If the water quality is compliant then the water is discharged to the environment and if the water quality is not compliant then the water is pumped back to the TDF.

6.1.9 Bağdere Tailings Dam Facility

A surface water management assessment for the Bağdere Tailings Dam Facility (TDF) is currently being undertaken, although the report is currently not available. A drawing of the Bağdere Tailings Dam Facility is available (Figure 14) which illustrates a water management approach similar to that of the Kepezkaya TDF.

The Bağdere TDF site is also located in a valley. Surrounding interception channels are proposed around the TDF in order to divert the not impacted upstream catchment "clean" runoff around the TDF to discharge back into the natural streambed downstream of the TDF. Stilling basins have been incorporated as part of the surface water management design prior to discharge. The channel design details are still being finalising. Similar to the Kepezkaya TDF, the TDF development area appears to have and upper and lower drainage systems, which are expected to operate the same as detailed above for the Kepezkaya TDF.

6.2 Sedimentation Ponds

The "dirty" water runoff from the impacted catchments described in Section 6.1 is planned to be drained to sedimentation basins in order to facilitate the settlement of suspended sediment prior to discharge to the environment. In order to design appropriate sedimentation ponds it is necessary to understand the nature of the soils and sediments in the area in order to evaluate the properties of the sediment, which will need to be settled.

The Project ESIA (ENVY 2014) indicates that the majority of the soil across the Project area is from the non-calcareous brown forest soil group, with the parent material defined as "gravely, sandy, clayey deposits and calcareous sandy clay and sandy claystones". Based on this information, for preliminary sedimentation basin sizing, the settlement design criteria adopted for sediment treatment system was a target particle size of 50 micron and above for runoff derived from the 6 hour 10 year return period rainfall event.

A minimum sedimentation basin depth of 1.2m is recommended, incorporating a minimum settling depth of 0.6m with an additional depth provided for the storage of settled sediment between maintenance.

6.2.1 Waste Dump Sedimentation Ponds

The northern and southern waste dumps have been divided into sub-catchments, within which the rainfall runoff drains locally to low points around the perimeter of the waste dump. The runoff from the waste dumps is expected to require sediment treatment at these points prior to discharge to the environment. Table 6.1 and Table 6.2 present the estimated sedimentation pond sizing for the northern waste dump and the western waste dump, respectively.

Table 6.1: Northern Waste Dump Sedimentation Ponds

Sedimentation Basin	Catchment Area (hectares)	Surface Area Required (m^2)	Width (m)	Length (m)	Component Catchments
SDN01	17.8	71	5	15	WDN01
SDN02	42.4	170	8	24	WDN02
SDN03	11.7	47	4	12	WDN03
SDN04	7.3	29	4	12	WDN04
SDN05	9.3	37	4	12	WDN05
SDN06	5.2	21	3	9	WDN06
SDN07	1.0	4	3	9	WDN07
SDN08	42.3	170	8	24	WDN08
SDN09	4.7	19	3	9	WDN09
SDN10	3.6	14	3	9	WDN10
SDN11	19.8	79	6	18	WDN11
SDN12	24.5	99	6	18	WDN12

Table 6.2: Western Waste Dump Sedimentation Ponds

Sedimentation Pond	Catchment Area (Hectares)	Surface Area Required (m^2)	Width (m)	Length (m)	Component Catchments
SDW01	126.8	509	14	42	WWD01 WWD02 WWD01-External Catchment

6.2.2 Pit Dewatering Sedimentation Ponds

Water derived from the pit dewatering system is expected to require sediment treatment prior to pumping to the process plant. The sedimentation pond surface area required for the sediment treatment has been based on the 6 hour 10 year rainfall event peak flow rate for the bench drainage catchment, in addition to discharge rates for the proposed maximum installed pumping capacity for the pit sump and alluvial dewatering systems. Table 6.3 presents the estimated sedimentation pond sizing for the pit dewatering system.

Table 6.3: Pit Dewatering Sedimentation Ponds

Sedimentation Basin	Catchment Area (hectares)	Surface Area Required (m^2)	Width (m)	Length (m)	Contributing Components
SPT01	N/A	751	16	48	Pit Sump Dewatering Alluvial Dewatering Pit Bench Drainage
SPT02	42	336	11	33	Pit Bench Drainage – Eastern Drainage Channel

The eastern pit sedimentation pond will require a pump and pipeline to transfer water to the western sedimentation treatment system, and ultimately the mine water storage pond. The pumping capacity required is ultimately a function of the storage available. The Final Phase has the largest volume reporting to the eastern sedimentation pond for the 24 hour 100 year return period rainfall event as shown in Table 6.4 below. Table 6.4 also presents the results for the remaining volumes following 24 hours pumping at the given rates.

Table 6.4: Eastern Sedimentation Pond Pumping Options & Storage Requirements

Phase/Year	Excess Volume (m^3) after 24 Hours – No Pumping	Excess Volume (m^3) after 24 Hours at 50L/s	Excess Volume (m^3) after 24 Hours at 100L/s	Excess Volume (m^3) after 24 Hours at 150L/s	Excess Volume (m^3) after 24 Hours at 200L/s	Excess Volume (m^3) after 24 Hours at 250L/s
Phase 1 Pit / Year 3	4,076	-	-	-	-	-
Phase 2 Pit / Year 4	7,688	3,368	-	-	-	-
Phase 3 Pit / Year 5	8,488	4,168	-	-	-	-
Phase 4 Pit / Year 10	12,158	7,838	3,518	-	-	-
Phase 5 Pit Year 11	15,098	10,778	6,458	2138	-	-
Final Pit / Year 13	22,093	17,773	13,453	9133	4813	493

Given the requirements for infrastructure in this relatively small area and for keeping “clean” runoff separate there is likely to be limited scope to provide a large storage pond at this location.

An alternative to a dedicated storage pond would be to provide a bund separating the area around the sedimentation pond and the “clean” runoff drainage channels, allowing excess volumes from the sedimentation pond to spill and be contained within this isolated area during high volume events, to be subsequently pumped out after the event.

A practical solution for the sedimentation pond and storage requirements associated with the eastern sedimentation pond in the pit area is as follows:

- Install 2 × Sykes CP150iC pumps, which would provide a 2 × 100L/s pump out capacity at Best Efficiency Point (BEP), with a maximum capacity of 115L/s per pump at 25m head.

The consequences of adopting this pumping set-up are illustrated in Table 6.5 for the final pit. The results show that this pumping setup will cope with the 24-hour 100-year event within the duration of the event for all but the final phase of pit development. During such a severe event, if the pumps are operated at maximum capacity, the excess volume is halved over the 24 hour period compared to pumping at the BEP, requiring much lower storage requirements, with a footprint less than half that at the BEP pumping rate.

Table 6.5: Eastern Sedimentation Pond Pumping & Storage Requirements

Phase/Year	Excess Volume (m^3) after 24 hrs at 200 L/s (BEP)	Storage Pond Area (m^2) at 2.5m deep	Storage Pond Length (m) × Width (m)	Excess Volume (m^3) after 24 hrs at 230L/s (MAX)	Storage Pond Area (m^2) at 2.5m deep	Storage Pond Length (m) × Width (m)
Final Pit / Year 13	4,813	1,925	25.5 × 76.5	2,221	890	17.5 × 52.5

6.3 Surface Water Drainage Channels

Rainfall runoff from non-impacted catchments upstream of the principal Project developments is planned to be diverted around these developments where practicable. The catchments areas from which rainfall runoff is to be captured in interception drains and diverted vary in size significantly, from small scale local low point catchments requiring only nominal sized channels, up to over 500 hectares upstream of the western waste dump development (requiring diversion to the east and downstream of the downstream coffer dam).

Table 6.6 presents the maximum catchment areas reporting to the diversion channels, the minimum channel slope along the length of the channel and the peak flows for the 2 hour 100 year rainfall event for each of the main Project developments.

Table 6.6: Diversion Channel – Minimum Channel Slope and Peak Flow

Site	Channel Direction	Catchment Area (Hectares)	Minimum Channel Slope	Peak Flow (m^3/s)
Coffer Dam Area	North east	5	0.06	0.3
Coffer Dam Area	North-west	7	0.05	0.3
Northern Waste Dump	South east	6	0.06	0.3
Northern Waste Dump	North east	2	0.06	0.1
Process Plant	South	9	0.07	0.4
Process Plant	West	1	0.10	0.0
Pit	East	109	0.04	5.4
Pit	North-west	3	0.10	0.1
Pit	West	12	0.03	0.6
Western Waste Dump	North-west	18	0.20	0.9
Western Waste Dump	North east	10	0.10	0.5
Western Waste Dump	West	35	0.02	1.7
Western Waste Dump	East	503	0.03	25.0

Table 6.7 presents the channel dimensions and the calculated flow rate at the given water depth while maintaining a freeboard of 300mm, with the depths and width based on the below image.

The channels have been grouped into five standard types based on flow capacities. The smallest channel (Type 2) has a W2 dimension of zero, indicating a V-shaped channel, while all others are trapezoidal.

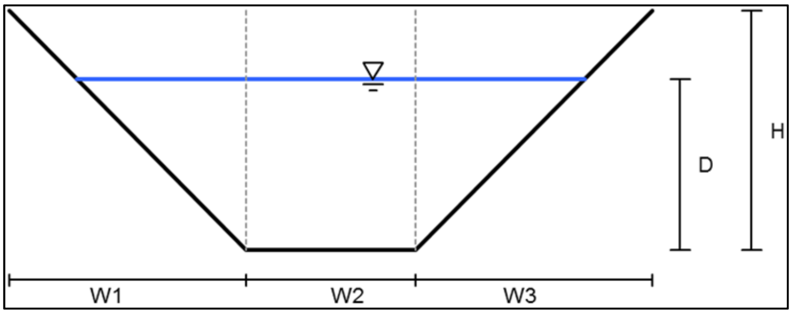

Table 6.7: Diversion Channel – Dimensions and Flow Rate

Site	Channel Direction	Channel Type	Channel Height (H) (m)	Water Depth (D) (m)	W1 (m)	W2 (m)	W3 (m)	Calculated Flow (m^3/s)	Freeboard (m)
Coffer Dam Area	North east	1	0.5	0.2	1	1	1	0.6	0.3
Coffer Dam Area	North-west	1	0.5	0.2	1	1	1	0.6	0.3
Northern Waste Dump	South-east	1	0.5	0.2	1	1	1	0.7	0.3
Northern Waste Dump	North-east	2	0.5	0.2	1	0	1	0.1	0.3
Process Plant	South	1	0.5	0.2	1	1	1	0.7	0.3
Process Plant	West	2	0.5	0.2	1	0	1	0.2	0.3
Pit	East	3	1	0.7	2	1	2	6.6	0.3
Pit	North-west	2	0.5	0.2	1	0	1	0.2	0.3
Pit	West	4	0.75	0.45	1.5	1	1.5	2.4	0.3
Western Waste Dump	North-west	1	0.5	0.2	1	1	1	1.2	0.3
Western Waste Dump	North-east	1	0.5	0.2	1	1	1	0.9	0.3
Western Waste Dump	West	4	0.75	0.45	1.5	1	1.5	1.9	0.3
Western Waste Dump	East	5	1.5	1.2	3	2.5	3	27.8	0.3

Note: A mannings N of 0.029 was applied to the channels, assuming gravel lined channels

Due to the topography of the site, many sections of the channel alignments are steep and velocity control measures will need to be implemented to prevent excessive channel erosion, including but not limited to catch pits, drop structures and in-channel check dams.

7. MINE WATER MANAGEMENT

7.1 Water Demand

7.1.1 Domestic Water Demand

The domestic water demand comprises both a potable and non-potable water component. The potable water demand for the mine site and processing plant site is planned to be fulfilled by the municipal water supply. The non-potable water demand for the administrative facilities at the mine site and processing plant site is also planned to be fulfilled by the municipal water supply, except the safety showers at the processing facility. The safety showers are planned to be supplied from the freshwater tank supplied from the caisson wells.

The safety showers will only be used on an "as needs" basis, thus the water demand can be seen as a stand-by water demand requiring a dedicated reserve of water. It is proposed to have 18 safety showers installed at the plant site. Research indicates that a water demand of 5.29m^3/hr is required for each safety shower, assuming eye, face and body wash unit are all being operated at the same time. Thus the total required reserve will be approximately 95m^3 assuming all 18 showers are required at one time for one hour.

The domestic water demand is estimated to be 2.5m^3/hr, (based on 200 L/day/person × 300 people). This domestic water demand is planned to supplied by the municipal water supply is not included in the site water balance.

7.1.2 Processing Plant – Freshwater Demand

The freshwater demand for the processing plant is planned to be fulfilled by water supplied from caisson wells adjacent to the Gökirmak River, located approximately 1km from the plant site. The freshwater is planned to be stored in a freshwater tank adjacent to the processing plant with a storage capacity of 1,800m^3 (35m × 15m × 4m).

The most recent mass balance for the process plant (Gökırmak Copper Project Mass Balance – Process Plant Rev B, Draft 08092015) indicates that the freshwater demand for the plant is estimated at 80.5m^3/hr.

7.1.3 Processing Plant – Process Water Demand

The process water demand is planned to be supplied by water recirculated from the TDF and pit dewatering. Any shortfall in the process water system is planned to be made up with freshwater from the adjacent freshwater tank. Process water is planned to be stored in a process water tank adjacent to the processing plant with a storage capacity of 1,800m^3 (35m × 15m × 4m).

The most recent mass balance for the process plant (Gökırmak Copper Project Mass Balance – Process Plant Rev B, Draft 08092015) indicates that process water demand for the plant is estimated at 907.7m^3/hr.

7.1.4 Dust Suppression

During the mine construction phase, the water demand for dust suppression is planned to be fulfilled by the caisson wells adjacent to the Gökirmak River. The total projected water demand for dust suppression during mine construction is estimated to be 8m^3/hr (200m^3/d). This total water demand comprises approximately 1.5m^3/hr (40m^3/d) for the diversion tunnel construction, 2.5m^3/hr (60m^3/d) for the facility construction and 4m^3/hr (100m^3/d) for the tailings dam construction.

During the mine operation phase the water demand for dust suppression is planned to be fulfilled initially by water remaining in the Gökirmak River valley between the two coffer dams. In the later years, surface water collecting in the sedimentation basins around the waste dumps can be used for dust suppression. If these water supply sources are insufficient at any stage, water from pit dewatering and the caisson well supply can be used.

Table 7.1 indicates the projected daily water demand estimates for dust suppression once the mine is operational. The dust suppression water demand estimate varies between 13m^3/hr and 40m^3/hr (assuming a 12-hour operational day) throughout the year.

Table 7.1: Projected Daily Water Demand for Dust Suppression – Operational Phase

	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Daily Water Consumption (m^3)	160	160	240	320	320	400	480	480	400	320	240	160

The sizing and capacities of the proposed waste dump sedimentation ponds are discussed in Section 6.2. The total capacity of the proposed waste dump sedimentation ponds is approximately 1,200m^3; however, this is based on the minimum size required. Based on a 12 hour day requirement for dust suppression, the waste dump sedimentation ponds would provide approximately 12 days' capacity during mine construction or two to seven days capacity during mine operation assuming that the sedimentation ponds are initially full and no evaporation or seepage. Additional water supply sources for dust suppression will need to be confirmed.

7.1.5 Fire Fighting Water Demand

The water demand for fire-fighting purposes is planned to be fulfilled by the caisson well water supply via the freshwater tank at the Process Plant. When required the fire water system is planned to be connected to the freshwater supply tank. A dedicated reserve of 300m^3 is planned to be maintained for fire fighting purposes. A nominal demand of 1m^3/hr is required for fire water supply (nominal monthly hydrant testing etc.).

7.1.6 Water Demand Summary

Table 7.2 summarises the different water demands associated with the Project.

Table 7.2: Projected Water Demand

Water Demand	Construction Phase (m^3/hr)	Operation Phase (m^3/hr)
Domestic Water	2.5	2.5
Plant Fresh Water	0	80.5
Plant Process Water	0	907.7
Dust Suppression	8	13-40
Fire Fighting	1	1

7.2 Water Supply Options

Water supply is an important element of site water management and an integral part of the water balance model.

The water supply options for the Project are as follows:

- TDF return water
- pit dewatering
- caisson well water supply
- sedimentation ponds
- alluvium boreholes, if utilised.

7.2.1 TDF Return Water

In accordance with the current water management practises and water circuit, the recirculation of water from the TDF is planned to be the primary source of water supply for the process plant. A notional TDF return of 70% of the water content of the tailings slurry (assuming 30% water entrainment with the settled tailings), plus incident rainfall runoff, minus evaporation has been assumed for the site water balance.

Based on the current mass balance for the plant (Gökirmak Copper Mass Balance – Process Plant Rev B, Draft 08092015), the thickened tailings slurry discharge into the TDF will contain approximately 194m^3/hr of water, assuming that 70% of this water is available (not entrained with the settled tailings) this would equate to a potentially available 135.8m^3/hr (without considering rainfall runoff or evaporation).

An assessment of the potential incident rainfall runoff gain and the potential evaporation loss that may occur on the TDF has been completed.

The assessment has been completed based on the following assumptions:

- Data from Hanönü Meteorological Station (1968-1994) has been used for storm event rainfall and average monthly rainfall values.
- Data from Kastamonü Meteorological Station (2011–2015) has been used for Wet and Dry Year rainfall.
- The TDF Sites (Keyezkaya and Bağdere) are independently and sequentially filled with no overlap in operation.
- The total internally draining area of the TDFs has been estimated as 254,800m^2 and 360,700m^2 for Keyezkaya and Bağdere respectively, derived from the following drawings:
    - Genel Yerlesim Plani
    - Bağdere Adt Genel Yerlesim Plani.
- The tailings pond surface area has been assumed as 50% of the total internally draining catchment area, for the purpose of deriving indicative values.
- Runoff coefficients (RoC) applied to the catchment areas were as follows:
    - pond area: Storm RoC = 1; Average RoC = 1
    - exposed embankments/remaining catchment: Storm RoC = 0.7; average RoC = 0.5.
- Total rainfall runoff volumes have been calculated using the following formula:
    - Rainfall Runoff Volume = Rainfall (m) × Catchment Area (m^2) × RoC.
- Mean open surface evaporation data from Devrekani Meteorological Station (1970–2011) has been used for the monthly evaporation values. The 24 hour storm events assumed no evaporation.
- There is always a tailings water pond on the TDFs on which evaporation can act.
- Evaporation volumes have been calculated by the follow formula:
    - Evaporation Volume = Evaporation (m) × Pond Catchment Area (m2).
- Net inflow volumes have been calculated by the follow formula:
    - Net Inflow Volumes = Rainfall Runoff Volume (m^3) - Evaporation Volume (m^3).
- As both the TDFs are planned to be lined it has been assumed that there was no loss through TDF seepage.

Tables 7.3 to 7.6 outline the net volumes derived from rainfall and evaporation for various storm events, monthly averages, annual average, a wet year and a dry year. These tables summarise the expected contribution of rainfall to the TDFs for use as a process water supply. These tables do not include the contribution to the TDF from water within the tailings slurry or losses via the return of water to the process plant.

The table of rainfall runoff inflow volumes for 24-hour storms (Table 7.3) indicates that storms can contribute a significant water volume in a short period ranging from 6,330 to 15,880m^3 for Kepezkaya TDF and 8,960 to 22,480m^3 for Bağdere TDF.

Table 7.3: TDF Rainfall Runoff Inflow Volume for 24 Hour Storms

Recurrence Interval (years)	Hanönü 24 Hour Rainfall (mm)	Kepezkaya Rainfall Inflow Volume (m^3)	Bağdere Rainfall Inflow Volume (m^3)
2	29	6,330	8,960
5	40	8,620	12,200
10	47	10,250	14,510
25	57	12,420	17,590
50	65	14,120	19,990
100	73	15,880	22,480

The net inflow volumes for average rainfall for the Kepezkaya and Bağdere TDFs are summarised in Tables 7.4 and Table 7.5, respectively. These tables indicate that evaporation exceeds rainfall runoff for several months of the average year (June to September). However, there is an overall positive net inflow volume for both TDFs for an average year. The average annual contribution to the tailings ponds from net rainfall inflow are approximately 7,000m^3 and 10,000m^3 for Kepezkaya and Bağdere, respectively.

Table 7.4: Average Year: Kepezkaya TDF Rainfall Runoff Monthly Net Inflow Volume

Month	Hanönü Average Rainfall (mm)	Rainfall Inflow Volume (m^3)	Evaporation Volume (m^3)	Net Inflow Volume (m^3)
January	39	7,424	0	7,424
February	29	5,622	0	5,622
March	34	6,518	0	6,518
April	55	10,467	459	10,008
May	67	12,760	12,689	71
June	52	9,956	15,161	-5,204
July	31	5,966	19,378	-13,411
August	29	5,626	19,327	-13,701
September	27	5,238	13,390	-8,152
October	38	7,260	6,638	622
November	40	7,560	153	7,407
December	50	9,633	0	9,633
Annual	492	94,031	87,193	6,838

Table 7.5: Average Year: Bağdere TDF Rainfall Runoff Monthly Net Inflow Volume

Month	Hanönü Average Rainfall (mm)	Rainfall Inflow Volume (m^3)	Evaporation Volume (m^3)	Net Inflow Volume (m^3)
January	39	10,510	0	10,510
February	29	7,959	0	7,959
March	34	9,228	0	9,228
April	55	14,817	649	14,167
May	67	18,063	17,963	100
June	52	14,094	21,462	-7,367
July	31	8,446	27,431	-18,985
August	29	7,964	27,359	-19,395
September	27	7,415	18,955	-11,540
October	38	10,277	9,396	881
November	40	10,702	216	10,486
December	50	13,637	0	13,637
Annual	492	133,112	123,432	9,680

An assessment of the net inflow volumes for an example wet year (Kastamonü 2014) and an example dry year (Kastamonü 2013) was completed for both TDFs, and is summarised in Table 7.6. The data derived for the example dry year indicates that there would be a negative net inflow volume i.e. evaporation would exceed rainfall runoff, and ultimately result in a loss to the system. The data derived for the wet year example, indicates that the net inflow volume may increase by an order of magnitude over the net inflow volume for the average year.

Table 7.6: Wet and Dry Years: TDF Rainfall Runoff Annual Net Inflow Volume

TDF	Month	Kastamonü Rainfall (mm)	Rainfall Inflow Volume (m^3)	Evaporation Volume (m^3)	Net Inflow Volume (m^3)
Kepezkaya	Wet Year (2014)	870	165,700	87,190	78,510
	Dry Year (2013)	450	85,900	87,190	-1,290
Bağdere	Wet Year (2014)	870	234,570	123,430	111,140
	Dry Year (2013)	450	121,600	123,430	-1,830

Based on the predicted values of rainfall runoff and evaporation within the TDF, there will typically be a net gain to the water supply system from rainfall, except during a dry year. In terms of the overall water supply from the TDF water return ($136m^3$/hr), the TDF rainfall net gain is estimated to be less than 1% (approx. $1m^3$/hr) for the average year, but could be as much as 10% (approx. $10m^3$/hr) for a wet year (e.g. Bağdere 2014).

The TDF return water is planned to be pumped to the process water tank for use as a process water supply.

7.2.2 Pit Dewatering

In-pit Dewatering

Water collected in the pit dewatering system (bench, in-pit sump and alluvial) is planned to either drain or be pumped to the sediment treatment system. The water subsequently discharges to a water storage pond, prior to being pumped to the process water tank adjacent to the process plant for use as process water supply. The average volume of water available from pit dewatering has been calculated in Section 5 as between $11m^3$/hr and $42m^3$/hr.

Ex-pit Dewatering

The ongoing hydrogeological investigation will provide additional information as to the feasibility of undertaking ex-pit dewatering.

7.2.3 Caisson Wells

There are currently three caisson wells constructed within the alluvium of the Gökırmak River in the vicinity of Hanönü. The location of the existing caisson wells are illustrated on Figure 2. The caisson wells are constructed from concrete rings and are 2m in diameter and 5m deep. It is proposed to construct an additional three caisson wells within the alluvium of the Gökırmak River. The caisson wells are planned to be used to provide a freshwater supply for the processing plant.

The available yields for the existing caisson wells have been assessed during August and September 2014. The wells were pumped at flow rates of 56.09m^3/hr (Well 1), 68.4m^3/hr (Well 2) and 46.0m^3/hr (Well 3). Based on the flow rates achieved, an average flow rate of 55m^3/hr per caisson well has been assumed. A total water supply of 275m^3/hr could be obtained from the caisson wells, assuming an average yield of 55m^3/hr for five wells (allowing for one standby well).

We understand that there are currently no legal restrictions on the abstraction of water from the caisson wells (pers. comm. AMI).

The Demirci Regulator and Hydroelectric Power Plant (HEPP) is currently under construction and, once operational, will result in a proportion of the Gökirmak River being diverted to the HEPP, via an open channel, upstream of the caisson wells. A minimum flow is planned to be maintained in the Gökırmak River in order to sustain the river ecosystem. AMI have been advised by their environmental consultant (Aecom) that this post-diversion minimum flow will be sufficient to allow the caisson wells to abstract 180m^3/hr (50L/s). AMI have commissioned a study to evaluate whether the remaining flow in the Gökırmak River, following the 180m^3/hr caisson well abstraction, will be sufficient to meet ecological requirements. While there are no legal requirements for AMI not to abstract the full 180m^3/hr from the caisson wells, if the study identifies that the abstraction results in an ecological requirement for additional water in the Gökırmak River, then AMI will evaluate options to supplement the Gökırmak River flows.

7.2.4 Sedimentation Ponds

The current mine water management approach is to separate the mine water as far as possible into "clean" water from non-impacted catchments and "dirty" water from catchments impacted by the Project developments.

"Clean" surface water derived from rainfall runoff from non-impacted catchments is not planned to be directed to sedimentation ponds prior to discharge to the environment. In the current surface water management design there is no collection point for this "clean" water, and as such there is no point where an abstraction could occur, thus "clean" water rainfall runoff is not considered in the water balance, at this stage.

"Dirty" surface water derived from rainfall runoff from impacted catchments (e.g. on the waste dumps) and adjacent to the plant site, is planned to be directed to sedimentation ponds. This water can be used directly for mining purposes (drilling, dust suppression, etc.). Any remaining water is planned to be discharged to the environment subject to any water quality restraints. The capacities of the waste dump sedimentation ponds are discussed in Section 6.2. The total capacity of the waste dump sedimentation ponds is approximately 1200m^3 under the current design.

7.2.5 Alluvium Dewatering Boreholes

If significant long-term groundwater inflows (greater than 10L/s) from the alluvium into the pit are encountered, dewatering boreholes are planned to be installed within the alluvium in the Gökırmak River valley between the pit crest and the upstream and downstream coffer dams. These dewatering boreholes are expected to dewater the alluvium reducing alluvial pit inflows and could act as a valuable clean water supply option, if required.

7.2.6 Water Supply Options Summary

Table 7.7 summarises the different water supply options associated with the Project.

Table 7.7: Summary of Potential Water Supply Options

Water Supply Source	Potential Water Supply Rate (m3/hr)
TDF Water Return	Approximately 136 (plus rainfall and minus evaporation)
Pit Dewatering	11 to 42
Caisson Wells (assuming 6 wells installed, 5 operational)	275
Sedimentation Ponds	100 (for a 12 hour period)
Alluvial Wells (if used)	36

7.3 Site Water Balance

The main components of the Project that have been evaluated from a water balance perspective are:

- process plant
- TDF
- pit
- sedimentation ponds
- mine site
- plant site.

A schematic plan of the main components of the water balance and their interconnection is provided in Figure 15.

7.3.1 Process Plant

The process plant water demand is planned to be supplied from the process water tank and the freshwater tank. Minor components of rainfall and evaporation are expected to act upon these two tanks. The net loss of water from each tank (rainfall minus evaporation) has been estimated as 0.01m^3/hr (approximately 100m^3/annum) based on the provided surface area for the tanks, an average annual rainfall of 492mm for Hanönü Meteorological Station, an average annual open water evaporation of 684.4mm for Devrekani Meteorological Station and assuming the water tanks are always full. The net loss is considered negligible and these components are not considered in the water balance.

Water is expected to input to the process plant from the following sources:

- return water from TDF
- make-up water from pit dewatering and contact rainfall runoff
- freshwater from caisson wells.

The following water outputs are expected to occur at the process plant:

- tailings slurry pumped from the processing operation.

7.3.2 TDF

The TDF receives the tailings from the process plant and then returns some of the water contained within the tailings slurry, which then becomes an input to the process plant via the process water tank. The TDF is planned to be lined; therefore, it is assumed that there will be no seepage losses from the TDF for the purposes of the water balance.

Water is expected to input to the TDF from the following sources:

- tailings slurry from the process plant
- rainfall runoff from the internally draining catchment of the TDF.

There is the potential for excess water from the site water management system to be stored in the TDF on a temporary basis.

The following water outputs are expected to occur at the TDF:

- evaporation losses
- water entrained in the tailings
- supply to the process plant via the process water tank.

7.3.3 Pit

Water is expected to input to the pit from the following sources:

- rainfall runoff from within the pit footprint
- groundwater inflows into the pit.

The following outputs from the pit are expected to occur:

- dewatering of the pit
- evaporation losses
- infiltration to the ground.

7.3.4 Sedimentation Ponds

Sedimentation ponds are proposed around the perimeter of the waste rock dump and around the plant site.

Water is expected to input to these sedimentation ponds from the following sources:

- rainfall runoff from the impacted catchments of the waste rock dump (waste dump sedimentation ponds)
- rainfall runoff from the plant site (plant site sedimentation ponds)

The following outputs to the sedimentation ponds are expected to occur:

- evaporation losses
- seepage losses
- water for dust suppression
- discharge to the environment.

7.3.5 Mine Site

The mine site administrative area will require a potable water supply and a non-potable water supply. The potable and non-potable water supply for the mine site is planned to be sourced from the local municipal supply and therefore is not considered in the water balance.

The output for the mine site administrative area is planned to be to the domestic water treatment plant.

7.3.6 Plant Site

The plant site administrative area will require a potable water supply and a non-potable water supply. The potable water supply for the plant site is planned to be sourced from the local municipal supply. The non-potable water supply is also planned be sourced from the local municipal supply, except the water supply for the safety showers. The water supply for the safety showers is planned to be sourced from the caisson wells and is included in the water balance. The water supplies sourced from the local municipal water supply are not considered in the water balance.

The output for the plant site administrative area is planned to be the domestic water treatment plant.

7.4 Water Balance Summary

A summary of the currently available data for the site water balance is presented in Table 7.8. This table summarises the various inputs and outputs for process plant water system.

The water supplies required for dust suppression and the water supplies sourced from the local municipal water supply are not considered in the water balance. The water supply for dust suppression is planned to be provided by the sedimentation ponds. The sedimentation ponds are considered to contain water, which after the settlement of suspended solids, is planned to passively discharge to the environment and as such have not included in the site water balance.

The water supplies required for the safety showers and fire-fighting purposes (apart from 1m^3/hr demand for nominal monthly hydrant testing etc.) are required on an "as needs" basis. Thus, the water demand for these purposes can be seen as a stand-by water demand requiring a dedicated reserve of water, and as such are not included in the water balance.

Table 7.8: Preliminary Site Water Balance

Category	Operation (m^3/hr)
Plant Input/Gains	
TDF Return (Assuming 30% entrainment of water in settled tailings i.e. 58m^3/hr)	136
Pit Dewatering (Bench drains, pit sump and alluvium)	11 to 42
Rainfall runoff (TDF)*	10 (Kepezkaya) 15 (Bağdere)
Fresh make up water (Caisson Wells)	165 (3 wells) 275 (5 wells operational)
Total Input/Gain	322 to 468
Plant Output/Losses	
Water content of tailings slurry to TDF	194
Evaporation (TDF)*	10 (Kepezkaya) 14 (Bağdere)
Fire Fighting Supply	1 (nominal value)
Total Output/Loss	205 to 209

* Average value of rainfall runoff and evaporation rate; refer to Section 7.2.1 for further discussion of the predicted range of rainfall and evaporation volumes.

Further assessment and refinement of the site water balance is required when more information is available regarding the proposed tailings dam construction and the specific tailings dam water balance.

7.5 Water Treatment Requirements

7.5.1 Domestic Water Treatment

Used domestic water is planned to be collected in a drainpipe network and treated with biological and chemical treatment units according to requirements. There is planned to be two domestic water treatment plants, one of about 20m^3/d capacity at the administration area and one of about 40 m^3/d capacity at the processing plant. This will allow sufficient flexibility in case the domestic wastewater should increase during the Project life.

Treated domestic water is planned to be finally discharged into an effluent and blending pond, controlled for compliance with effluent standards, and then released into natural watercourses that ultimately drain to the Gökırmak River.

The sludge generated in the domestic water treatment plants can be used to support vegetation in areas to be rehabilitated.

7.5.2 Tailings Disposal Facility Water Treatment

During the first year of operation, there is no planned requirement to pump water out of the TDF in order to manage storage volumes. However, in subsequent years it might be necessary to pump water out of the TDF to avoid water storage getting too high. Further work is required to confirm any potential TDF water removal or treatment requirements.

8. WATER MONITORING PROGRAMMES

Groundwater and surface water monitoring programmes are currently in place for the Project. The focus of the current monitoring programme is to develop a baseline dataset prior to the commencement of mining. As the Project moves into the construction and operational phases, it is recommended that the monitoring programme is updated to ensure the monitoring programme identifies any potential impacts and any variation to the local surface water and groundwater environment.

It is recommended that a detailed monitoring programme is developed upon the adoption of the final mine plan, following the principles and rationale set out below. It is recommended that the Environmental Consultant for the Project develops a comprehensive surface water and groundwater monitoring programme for the Project taking into consideration all the appropriate local regulatory and environmental requirements for the Project.

8.1 Surface Water Monitoring Programme

8.1.1 Surface Water Flow and Levels

Surface water flow and level monitoring has been conducted on a monthly basis on the Gökirmak River at the Project site since May 2013. Monitoring at the Project site gauging station (Ref: 37-100 GÖKIRMAK SEPETÇİ VILLAGE HANÖNÜ) has been suspended during the construction works on the river diversion tunnel.

It is recommended that, following the completion of construction works on the tunnel and the coffer dams, new surface water flow and level monitoring points are defined. One of the new surface water monitoring locations is recommended to be located up stream of the diversion tunnel and upstream coffer dam and one located downstream of the tunnel outlet and downstream coffer dam. The monitoring point location and monitoring approach should be selected in accordance with best international practice following ISO 18365 (Hydrometry -- Selection, establishment and operation of a gauging station).

It is recommended that surface water flow and level monitoring is completed on a monthly basis in accordance with the relevant best international practice based on the method adopted including but not limited to:

- ISO 4373: Hydrometry – Water level measuring devices
- ISO 748: Hydrometry – Measurement of liquid flow in open channels using current-meters or floats
- ISO 4375 Hydrometry – Cableway systems for stream gauging.

8.1.2 Surface Water Quality

Following the definition of the new surface water monitoring locations, it is recommended that surface water quality monitoring is completed on a monthly basis at the following locations:

- upstream Gökirmak River flow monitoring point
- downstream Gökirmak River flow monitoring point.

Once the mine site becomes operational, it is recommended that a surface water-monitoring scheme is developed to monitor the water quality of all managed water across the mine site. Additional monitoring points might include, but not limited to, the following locations:

- main sediment control ponds in the vicinity of the pit, waste dump, process plant and TDF areas
- downstream of any discharges from the waste dump, process plant and TDF areas.

It is recommended that surface water quality sampling is completed in accordance with best international practice (ISO-5667). Surface water quality analysis is recommended to include the following parameters:

- Temperature*
- pH*
- Conductivity*
- Dissolved Oxygen*
- Colour
- Copper
- Chemical Oxygen Demand
- Biological Oxygen Demand
- Suspended Solids
- Turbidity
- Sulphate
- Aluminium
- Iron
- Arsenic
- Mercury
- Cadmium
- Lead
- Nickel
- Zinc
- Chromium
- Cyanide

N.B. Parameters labelled with an asterix (*) will be monitored in the field.

8.2 Groundwater Monitoring Programme

8.2.1 Groundwater Levels

Groundwater level monitoring on site has, to date, been completed mainly on groundwater monitoring boreholes and various open exploration boreholes within the pit footprint and TDF area.

Most of the existing monitoring boreholes will be lost during the pit excavations and TDF construction. It is recommended that the existing monitoring network is maintained for as long as possible. However, as these monitoring locations will ultimately be lost it is expected to be necessary to install new dedicated groundwater monitoring points. It is recommended that these monitoring points are installed at the earliest opportunity to ensure a baseline dataset is collected prior to the initiation of mining.

The following groundwater monitoring points are recommended to be installed as part of the monitoring programme development:

- Pit Area – A minimum of four monitoring points, located to the north, west, south and west of the pit approximately 50m from the maximum pit extent. The depth of the boreholes are recommended to extend to at least 150m to ensure these do not dry out as the pit is dewatered.
- Northern and Western Waste Dump Areas – Four perimeter monitoring boreholes located around both the northern and western waste dumps. The existing boreholes (WD001 to WD003) around the northern waste dump can be reviewed in the context of the final waste dump designs in order to consider their suitability for long term monitoring.
- Kepezkaya TDF – A minimum of two down gradient monitoring locations and two up gradient monitoring locations, approximately 50m from the TDF boundary. The depth of the boreholes is recommended to be 20m below the average groundwater level.
- Bağdere TDF - A minimum of two down gradient monitoring locations and two up gradient monitoring locations, approximately 50m from the TDF boundary. The depth of the boreholes is recommended to be 20m below the average groundwater level.
- Process Plant Area - A minimum of one down gradient monitoring location and one up gradient monitoring location, approximately 50m from the plant site boundary. The depth of the boreholes is recommended to be 20m below the average groundwater level.

Groundwater level measurements are recommended to be completed manually on a monthly basis at all sites. In addition, groundwater level loggers are recommended to be installed in the four pit perimeter boreholes to record water levels on a six hourly basis, downloaded on a monthly basis and calibrated to the manual level measurements.

8.2.2 Groundwater Quality

It is recommended that groundwater quality monitoring is completed on a monthly basis at all groundwater monitoring locations, in accordance with best international standard (i.e. ISO-5667).

Groundwater quality analysis will include analysed of the following suite of parameters:

- Temperature*
- pH*
- Conductivity*
- Dissolved Oxygen*
- Redox*
- Sulphate
- Aluminium
- Iron
- Arsenic
- Mercury
- Cadmium
- Copper
- Lead
- Nickel
- Zinc
- Chromium
- Cyanide

(*) monitored in the field

9. SUMMARY & CONCLUSIONS

9.1 Hydrology

Rainfall data has been sourced primarily for the Project from the Hanönü Meteorological Station which has a data record ranging from 1968 to 1994. Rainfall data from the Hanönü Meteorological Station suggests:

- Average annual rainfall is 492mm.
- Rainfall totals are relatively consistent throughout the year, with average monthly rainfalls ranging from 27.41mm (September) to 66.77mm (May).
- Rainfall intensity data suggests that the 24 hour 100 year return frequency event is 73.31mm.

Daily rainfall data from the Kastamonü Meteorological Station, available from January 2011 to May 2015, has been used to define typical wet and dry years used in the TDF water balance assessment.

Two rain gauges were established on-site in May 2015 and daily site specific rainfall data has been recorded since this date. Anecdotal evidence from AMI staff suggests that winter snow fall and the subsequent spring snow melt are not expected to significantly impact water management on the site.

Evaporation data has been sourced from the Devrekani Meteorological Station, which has a data record ranging from 1970 to 201, and suggests that the mean annual open surface evaporation is 684.4mm.

The Project site is located within the catchment of the Gökırmak River, the main tributary of the Kizilirmak River which eventually flows into the Black Sea. The Gökırmak River flows all year round and is used for hydroelectric and irrigation purposes in the immediate vicinity of the Project area. The Gökirmak River is being diverted around the pit area by the installation of upstream and downstream coffer dams and a dual tunnel system. Average monthly automated Gökirmak River flows recorded between May 2014 to April 2015 vary between 0.75m^3/s (August 2014) and 44.4m^3/s (April 2015), maximum flows will be much higher with river flows of approximately 1,200m^3/s being predicted for the 1 in 100 year return period storm event. Assessment of the proposed Gökirmak River diversion infrastructure designs was not part of the scope of this study, but has been assessed in detail by Hidro Dizayn.

9.2 Hydrogeology

A significant amount of hydrogeological field investigations have previously been completed in the Project area and have focussed on defining the hydraulic properties of the rocks present within the pit and TDF areas. As part of this study a geotechnical and hydrogeological drilling programme was completed between May and August 2015, including the drilling and hydraulic testing of boreholes in pit and waste dump areas. In addition, there is an on-going hydrogeological field investigation programme focussed on fault zone hydraulic properties, river/alluvium/bedrock interactions and providing more advanced level hydrogeological insight for the Project.

The primary aquifers in the Project area are the fractured schists which are predominant in the pit area and the unconsolidated alluvial sediments associated with the Gökirmak River. The proposed open pit will interact with both of these two aquifer types. A low permeability cut-off wall is planned to be installed to the base of the alluvium, below both of the coffer dams, in order to reduce lateral groundwater flow through the alluvium towards the pit. The potential to dewater the principal fractured/fault zones using ex-pit dewatering boreholes is currently being evaluated.

Groundwater levels in the pit area are generally near surface in the vicinity of the Gökirmak River, and while maximum depths of up to 80m have been recorded (DG-111), they are generally within 20m of the surface elsewhere across the site. Groundwater levels in the Kepezkaya TDF area are generally 5 to 20m below ground level, although artesian conditions were evident at one location (KSK-05).

Groundwater recharge will occur predominantly through the infiltration of rainwater (and any localised snow melt). Recharge in the uphill areas of the Project area will drive groundwater flow through the rock mass towards the lower elevation river valleys, so groundwater flow will generally be from the high to low topographic elevations. Groundwater discharge will be primarily to the Gökırmak River (the main groundwater discharge feature), with this groundwater flow providing the baseflow component of the river. However, during the dry summer months, when there is little recharge and the groundwater table declines, the Gökirmak River appears to lose water through its riverbed and recharge the underlying rocks.

Based on Gokirmak River water elevations and the actual groundwater levels and groundwater level fluctuations recorded in boreholes within the river valley (e.g. OW-4 and OW-5) it appears that the surface water and groundwater are hydraulically linked in the lower elevations within the pit area. However, there is an on-going investigation to further assess surface water/groundwater interaction at the Project site.

Hydraulic testing completed as part of this study and from numerous previous investigations suggests that the hydraulic conductivities of the rocks in the Project area are as follows:

- Alluvium - highly variable, ranging from 10^{-8} to 10^{-4} m/s, with a median of 10^{-5} m/s.
- Bedrock (pit area) - highly variable, ranging from 10^{-8} to 10^{-6} m/s, with a median of 10^{-7} m/s.
- Bedrock (Kepezkaya TDF) - ranging from 10^{-7} to 10^{-4} m/s.
- Fractured zones – 10^{-6} to 10^{-5} m/s, but only limited testing.

Groundwater quality in the alluvium is generally good, although with localised elevated metals concentrations. The bedrock groundwater quality is also expected to generally be good. However, groundwater in the vicinity of the orebody is likely to exhibit elevated metals concentrations, particularly zinc, iron, manganese and magnesium. The recorded pH values available from the pit area are generally close to neutral suggesting a high buffer capacity within the bedrock (also supported by elevated calcium and magnesium concentrations).

9.3 Pit Dewatering and Depressurisation

Pit inflows will be derived from a combination of both groundwater and surface water (rainfall runoff induced) inflows. Inflows from both sources have been predicted using standard hydrological and hydrogeological models and using the pit areas and depths/volumes based on information provided by AMC in August–September 2015.

Conservative bulk average groundwater inflows to the pit have been predicted using an analytical groundwater flow model. Progressive average inflows have been predicted from the bulk rock mass, alluvium and fault/fracture zones with time as follows:

- Alluvium: initially 15L/s reducing to 5L/s (assuming effective hydraulic isolation of Gökirmak River and upstream alluvium); inflows increasing temporarily following heavy rainfall events
- Bedrock (above 440mRL): 0 to 15L/s
- Bedrock (below 440mRL): 10 to 30L/s
- Fracture zones: up to 20L/s.

Surface water (rainfall runoff induced) inflows to the pit have been calculated based on annual average rainfall (492mm) conditions and for large storm events, including the 24 hour 100 year return period event (73mm) and the 2 hour 100 year return period event (25.4mm). Surface water pit inflows have been derived for each of the six pit development phases (Phases 1-5 and Final). The pit area has been broken down into two sub-catchments for each Phase:

1. Pit sump catchment – area below 440mRL and some small external catchments where unavoidable, which drains to the in-pit sump.
2. Pit upper bench catchment – pit area above 440mRL and some small external catchments where unavoidable, with drainage captured on the pit benches and gravity drained laterally east and west to perimeter drains at the pit edge.

Surface water pit inflows have been predicted for each of the various phases as follows:

- Average annual – Bench drainage 24,000 to 185,000m^3 and In-Pit 3,850 to 98,450m^3.
- 2 hour 100 year storm – Bench drainage 1.89 to 4.76m/s.
- 24 hour 100 year storm – In-Pit 890m^3 to 22,820m^3.

A pit dewatering strategy and design has been developed to manage the predicted pit inflows; it comprises three different elements as follows:

- In-Pit Sump Dewatering System – Capturing groundwater and surface water pit inflows below 440mRL, gravity draining to an in-pit sump at the pit base of the pit.
- Bench Drainage Dewatering System – Capturing groundwater and surface water pit inflows above 440mRL, inflows captured on bench drains, gravity drain laterally east and west to perimeter drains at the pit edge.
- Alluvial Dewatering System – Capturing groundwater inflows from the alluvium intersected in the pit walls, collected in a bench drain on the bench below the base of the alluvium, draining laterally to an in-pit bench sump. Large storm events are planned to by-pass this system and drain to the in-pit sump dewatering system.

Dewatering boreholes are an additional pit dewatering option. However, at this stage there is insufficient data to confirm whether they would be a feasible option. The ongoing field investigation programme is evaluating whether the fractured zones present in the pit area have adequate permeability to warrant dewatering bore installation.

All water derived from the various pit dewatering systems is planned to be either pumped or drain through specifically designed channels to a sediment treatment system, prior to pumping to the plant as a process water supply.

The dewatering designs developed included the specification and timing of specific pumps, transfer pipelines, intermediary pumping transfer stations and drainage channel designs associated with each phase of pit development. The capital costs (CAPEX) and operational costs (OPEX) associated with pumping hours and associated diesel usage were developed for each pit phase development.

Pit depressurisation requirements for the Project area as yet uncertain, however, if required standard depressurisation techniques including the installation of horizontal drain holes (and possible ex-pit dewatering boreholes) will be used to achieve pit wall pore pressure design criteria.

9.4 Surface Water Management

Surface water management designs have been developed for all the key Project developments; including three representative phases of the pit development, the coffer dam area, the northern waste dump, the western waste dump and the process plant. The surface water management system for the two TDFs has been completed by Hidro Dizayn. The approach adopted, focused on maximising the diversion of “clean” rainfall runoff from catchments not impacted by the Project development, while “dirty” rainfall runoff originating from impacted catchment areas is planned to be intercepted and managed. Currently it is not intended to capture “clean” surface water runoff to act as a water supply option.

The topographic catchments impacted by the various Project developments have been defined and appropriate diversion channel designs have been developed to effectively capture and convey the predicted extreme rainfall runoff peak flows. In addition, the location and design of sedimentation ponds, where required to manage the potential sediment load of runoff from impacted catchments, has been presented for each of the key Project developments.

9.5 Water Demand, Water Supply and Water Balance

An assessment of the various Project water demands has been completed and based on our current understanding the various water demand components are estimated as follows:

- domestic – potable and non-potable (2.5m^3/hr)
- processing plant demand – freshwater (80.5m^3/hr)

- processing plant demand – process water (907.7m^3/hr)
- dust suppression (13–40m^3/hr)
- fire-fighting water (1m^3/hr).

The water supply options and potential supply rate for the Project have been identified as follows:

- TDF return water – approximately 136m^3/hr (assuming 30% lock-up in settled tailings); plus rainfall and less evaporation.
- pit dewatering – 11 to 42m^3/hr (excluding any dewatering boreholes).
- caisson well water supply – 275m^3/hr (assuming five operational wells).
- sedimentation ponds – 100m^3/hr (for a 12hr period, based on minimum sizing and full ponds).
- alluvium boreholes (if utilised) – 36m^3/hr.

An assessment of the potential incident rainfall runoff gain and the potential evaporation loss that may occur on the TDF has been completed. The assessment suggested the following:

- Individual 24 hour storms could contribute water volumes ranging from +6,330m^3 to +15,880m^3 for Kepezkaya TDF and +8,960m^3 to +22,480m^3 for Bağdere TDF.
- Evaporation exceeds rainfall for several months of the average year (June to September). However, there is an overall positive net inflow volume for both TDFs for an average year.
- Average annual contribution to the tailings ponds from net rainfall (i.e. rainfall minus evaporation) are estimated to be approximately +7,000m^3 and +10,000m^3 for the Kepezkaya and Bağdere TDFs, respectively.
- Based on the four years of daily rainfall data available from Kastamonü (for the Kepezkaya and Bağdere TDFs, respectively)
    - net rainfall contribution for a “dry” year (2013) was -1,290m^3 and -1,830m^3
    - net rainfall contribution for a “wet” year (2014) was +78,510m^3 to +111,140m^3.

A preliminary site water balance was developed (based on the assumptions described in Section 7) and is summarised in Table 9.1 below.

Table 9.1: Preliminary Site Water Balance

Category	**Operation (m^3/hr)**
Plant Input/Gains	
TDF Return (Assuming 30% entrainment of water in settled tailings i.e. 58m^3/hr)	136
Pit Dewatering (Bench drains, pit sump and alluvium)	11 to 42
Rainfall runoff (TDF) [a]	10 [b] 15 [c]
Fresh make up water (Caisson Wells)	165 [d] to 275 [e]
Total Input/Gain	322 to 468
Plant Output/Losses	
Water content of tailings slurry to TDF	194
Evaporation (TDF) [a]	10 [b] 14 [c]
Fire Fighting Supply	1 [f]
Total Output/Loss	205 to 209

[a] Average rainfall and evaporation
[b] Kepezkaya TDF
[c] Bağdere TDF
[d] three wells
[e] six wells
[f] Nominal value

Further assessment and refinement of the site water balance will be completed once more information is available regarding the TDF design and the specific TDF water balance.

9.6 Water Treatment Requirements

Domestic water is planned to be treated with biological and chemical treatment units according to requirements. There is planned to be two domestic water treatment plants, one of about 20m³/d capacity at the administration area and one of about 40m³/d capacity at the processing plant. Treated domestic water is planned to be discharged into an effluent and blending pond, controlled for compliance with effluent standards, and then released into natural watercourses that ultimately drain to the Gökırmak River. The sludge generated in the domestic water treatment plants can be used to support vegetation in areas to be rehabilitated.

During the first year of operation, there is planned to be no requirement to pump water out of the TDF in order to manage storage volumes. However, in subsequent years it might be necessary to pump water out of the TDF to avoid water storage getting too high. Further work is required to confirm any potential TDF water removal or treatment requirements.

9.7 Groundwater and Surface Water Management Programmes

Groundwater and surface water monitoring programmes are currently in place for the Project. The focus of the current monitoring programme is baseline dataset collection prior to the commencement of mining. As the Project is now moving into construction and soon operational phase, it is recommended that the monitoring programme is updated to switch focus to identifying any potential impacts from the Project. The principles and rationale for an appropriate surface water and groundwater monitoring programmes moving forward have been presented in this report, although full programmes are recommended to be developed by the Environmental Consultant for the Project.

10. RECOMMENDATIONS

Continuation of collection of site specific precipitation data, both rainfall and snowfall, in order to confirm the applicability of use of rainfall data from the Hanönü Meteorological Station for surface water management and pit dewatering assessment and to confirm the impact that snowfall will have on mine water management. A tipping bucket rain gauge should be installed on site, as part of a comprehensive site weather station, in order to provide site-specific data regarding rainfall intensities for large storm events.

Additional groundwater quality monitoring from a widespread area of the pit footprint should be undertaken, in order to provide additional insight into the chemistry of the groundwater across the pit area. This will be important for confirming the likely quality of the water derived from the pit dewatering system and to assist in the future assessment of long-term water quality aspects relevant for mine closure planning.

Further assessment of the baseflow component of the Gökirmak River downstream of the proposed HEPP diversion dam should be undertaken, in order to fully assess the long-term sustainable yield of the caisson wells.

Further assessment and refinement of the site water balance is required following receipt of more information regarding the proposed TDF construction and the specific TDF water balance.

11. REFERENCES

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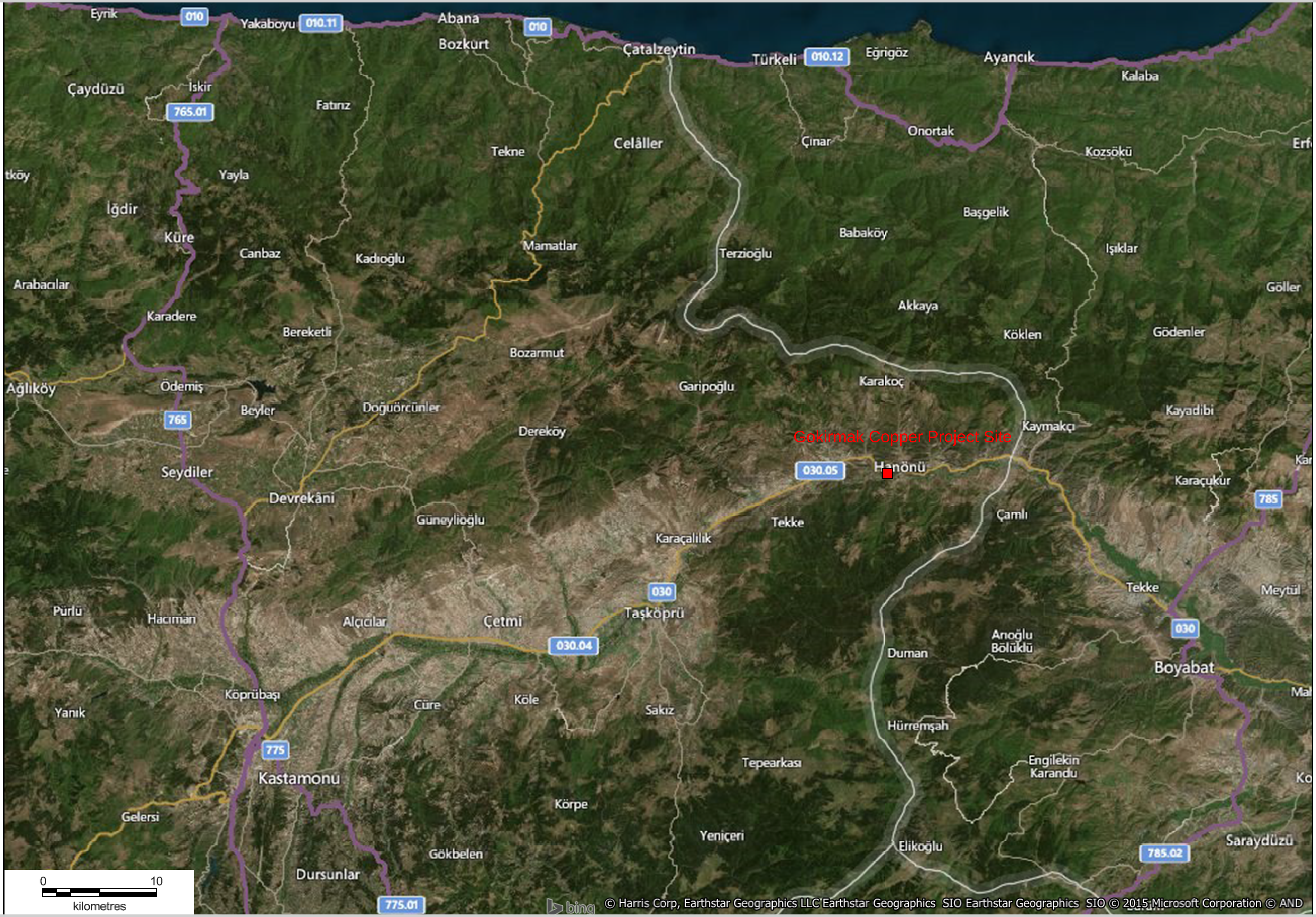
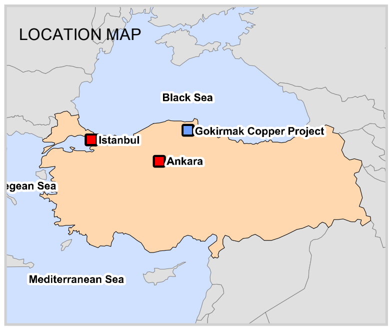
Nbaproje (2014b) Project Hanönü Derivation, Upstream and Downstream Cofferdams Geological and Geotechnical Study Report, 2014.

Nbaproje (2014c) Report on the Calculation of the Water to Fill the Excavation Pit at the AMI Kastanamonu Hanönü Copper Metal Open Pit Mine (Phase 2), September 2014.

FIGURES





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Kilometres

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Turkish Coordinate Systems
GK Central Meridian 36 (ED50)

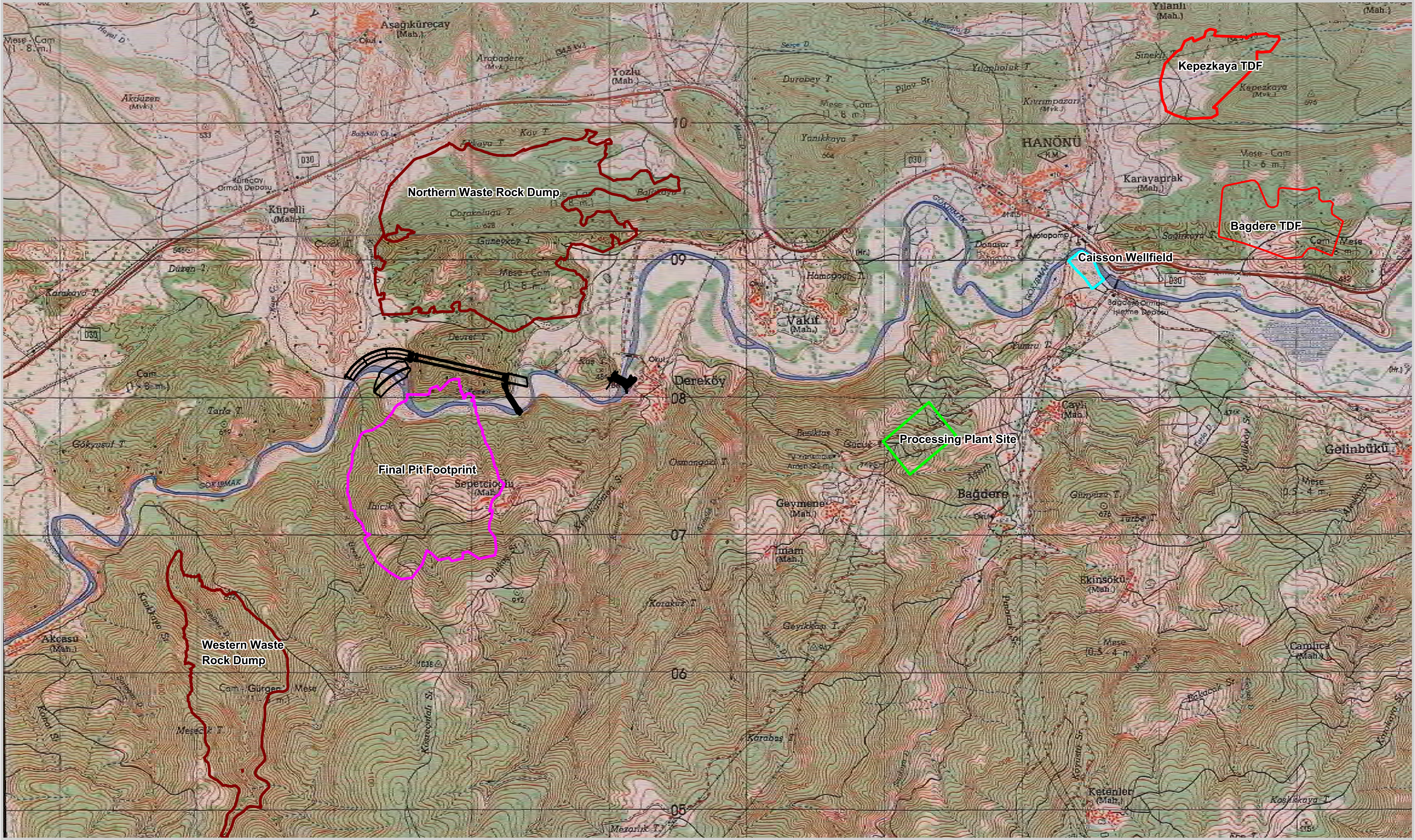
AUTHOR: GB	REPORT NO: 008
DRAWN: GB	REVISION: A
DATE: 16/09/2015	JOB NO: i200

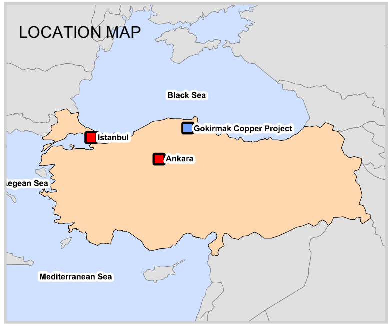
DATA SOURCES:
Input data source here

RPS Aquaterra

FIGURE 1

SITE LOCATION





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LEGEND

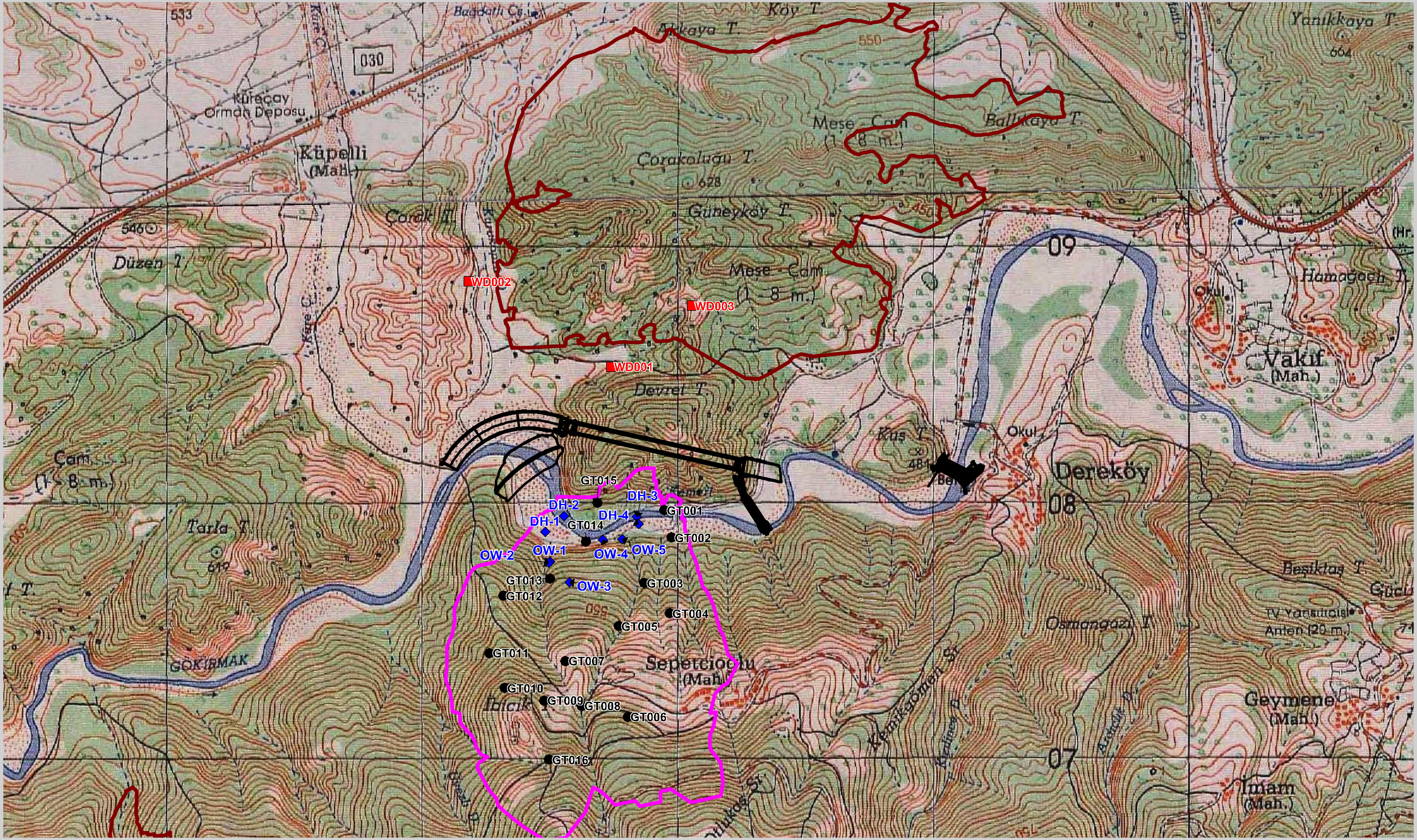
- Waste Rock Dump
- Final Pit Footprint
- Tailings Disposal Facility
- Processing Plant Site
- Caisson Wellfield
- Gok River Tunnel & Dams

DATA SOURCES:

RPS Aquaterra

FIGURE 2

SITE FEATURES



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Turkish Coordinate Systems
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DRAWN:	GB	REVISION:	A
DATE:	16/09/2015	JOB NO:	i200

Location: XXXX

LEGEND

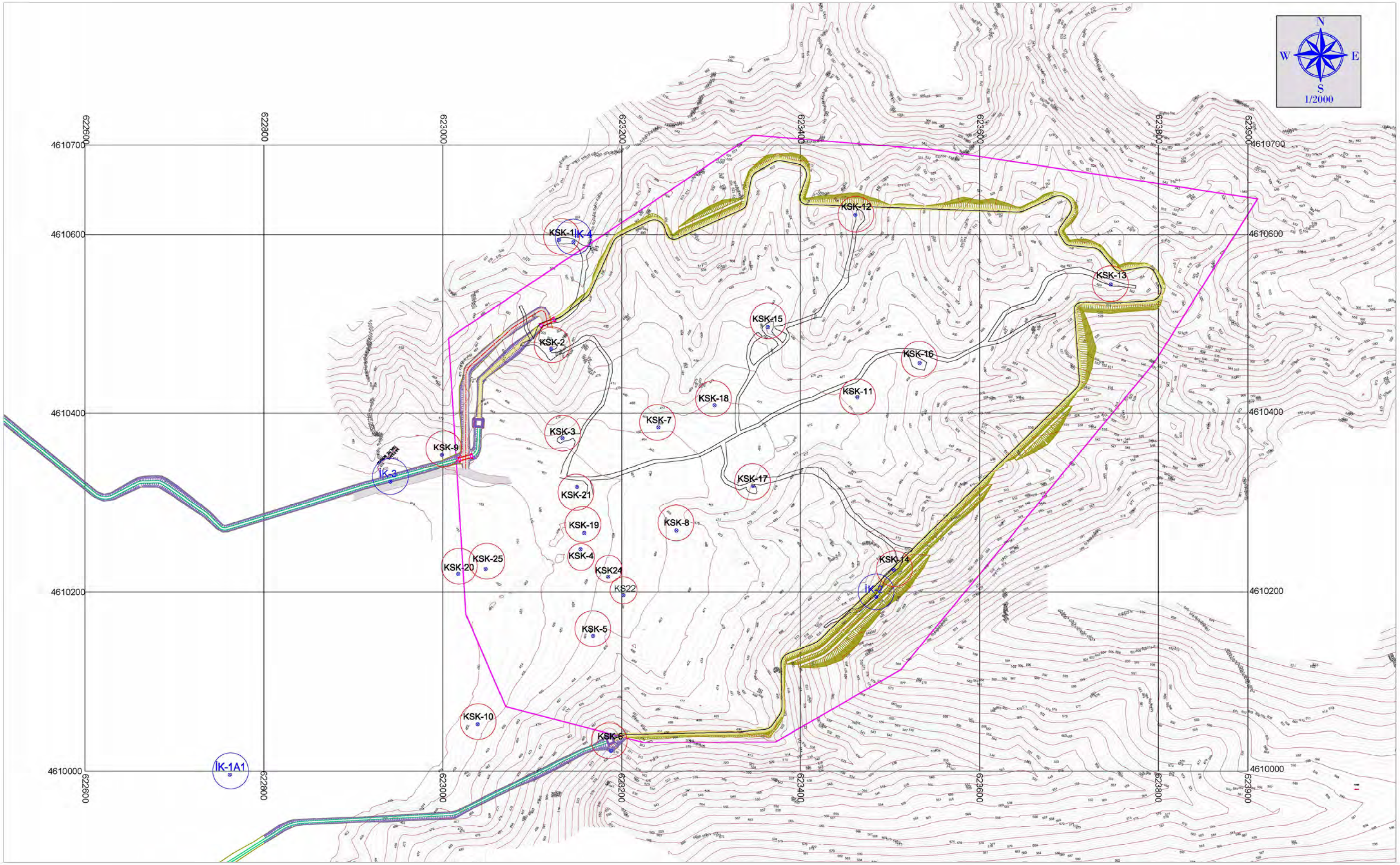
- Waste Rock Dump
- Final Pit Footprint
- Waste Rock Dump Boreholes
- Pit Geotechnical Boreholes
- Groundwater Monitoring Boreholes
- Gok River Tunnels and Dams

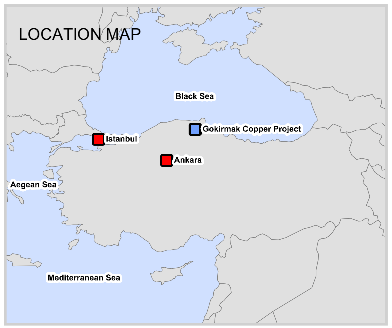
DATA SOURCES:

RPS Aquaterra

FIGURE 3

PIT AND NORTHERN WASTE ROCK DUMP BOREHOLE LOCATIONS





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Note: Drawing not to Scale

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DATE:	09/15	JOB NO:	I200

Location: O:\Jobs\i200 Gok Turkey\3000\Figures\Mapinfo\Workspaces\Figures 4 - Borehole Locations in TDF area.wor

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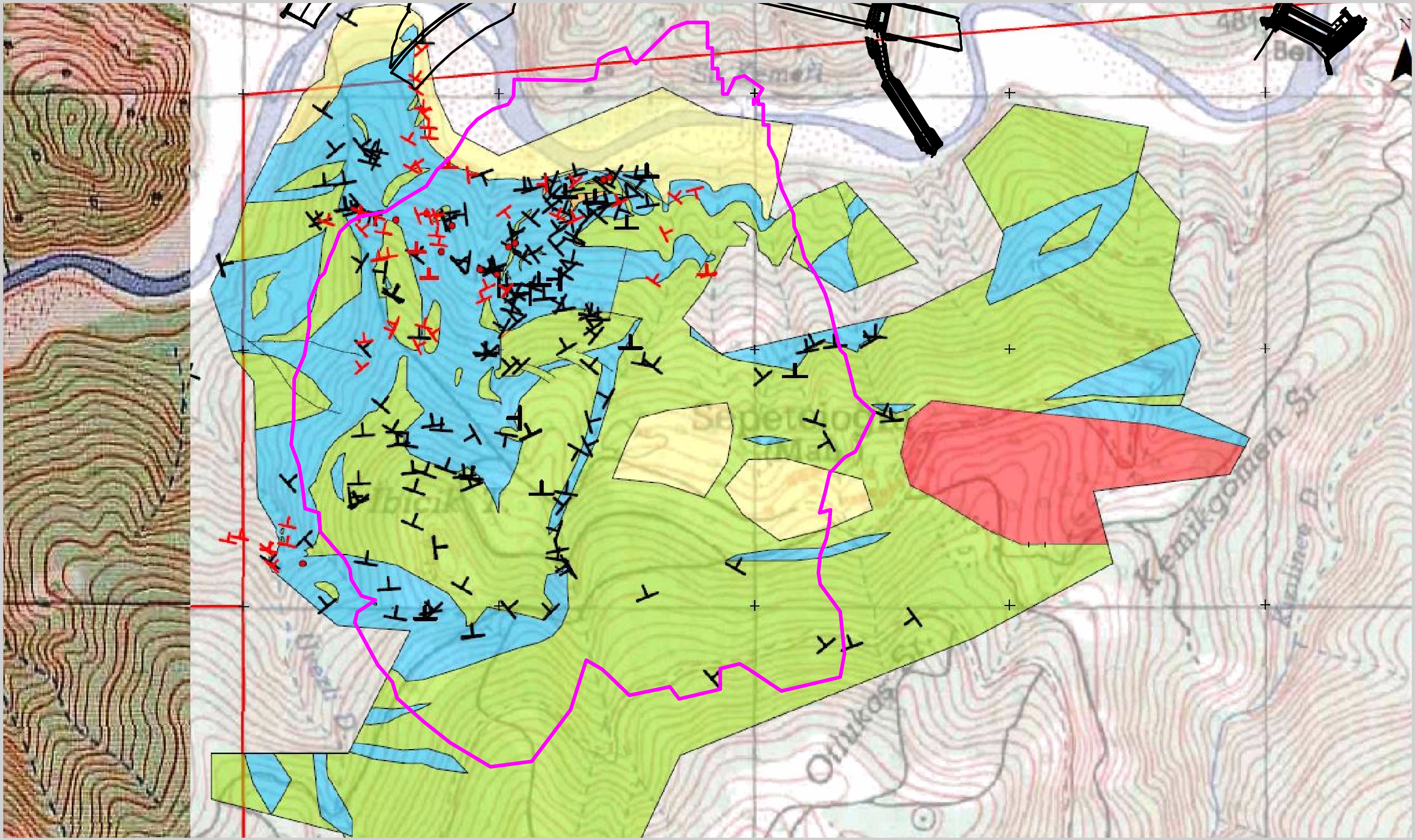
FIGURE 4

BOREHOLE LOCATIONS
KEPEZKAYA TDF AREA



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GK Central Meridian 36 (ED50)

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DRAWN: GB	REVISION: A
DATE: 16/09/2015	JOB NO: i200

Location: XXXX

LEGEND

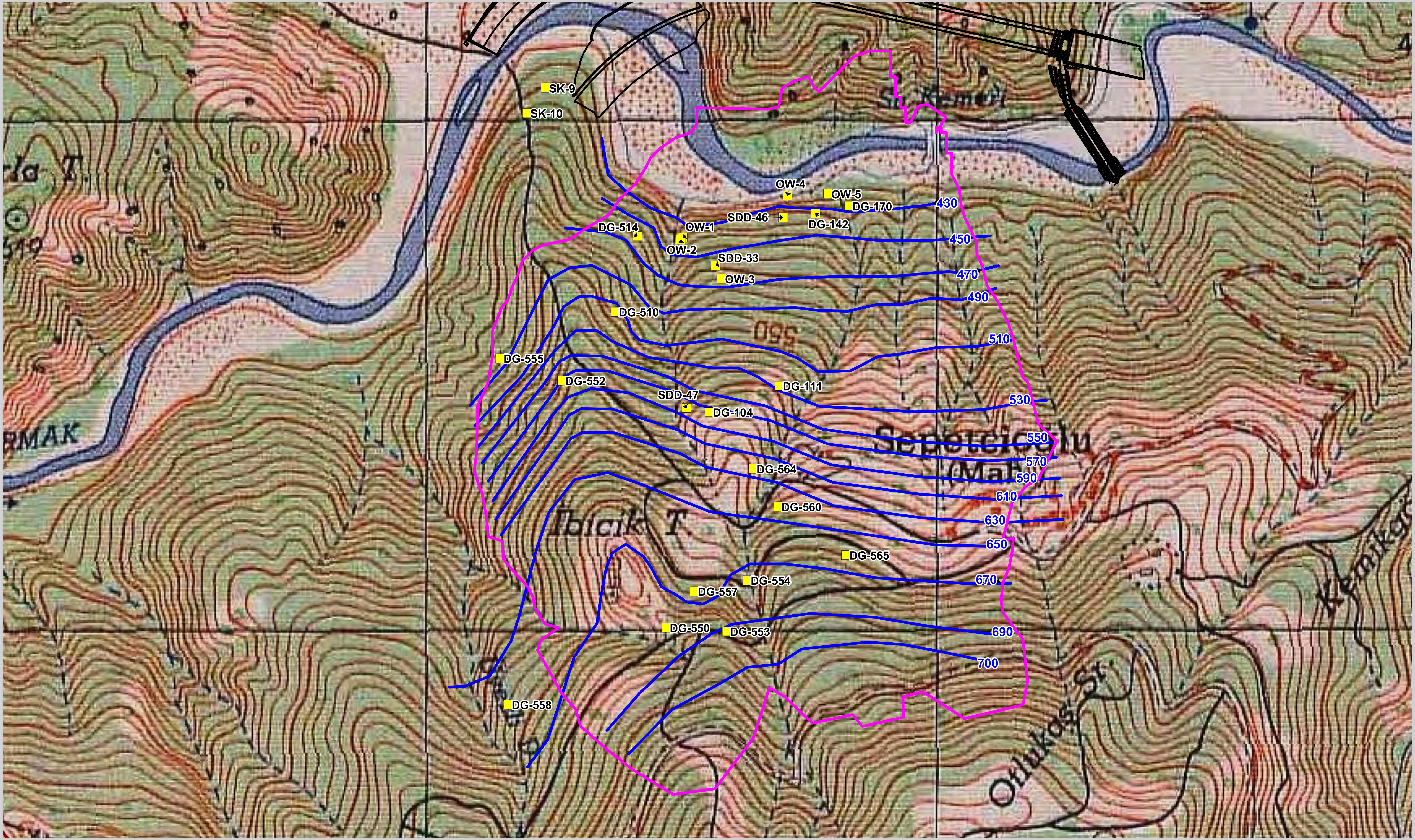
alluvium	mixed schist
alteration	limestone
greenschist	Tectonic Contacts (mapped)
siliciclastic sediments	License boundary

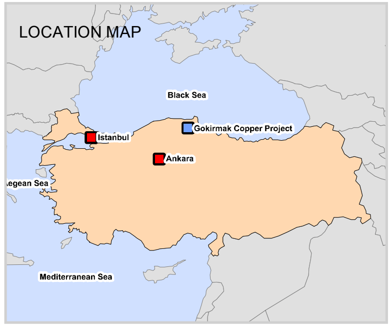
DATA SOURCES:

RPS Aquaterra

FIGURE 5

GEOLOGY





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Turkish Coordinate Systems
GK Central Meridian 36 (ED50)

AUTHOR:	GB	REPORT NO:	008
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DATE:	16/09/2015	JOB NO:	i200

LEGEND

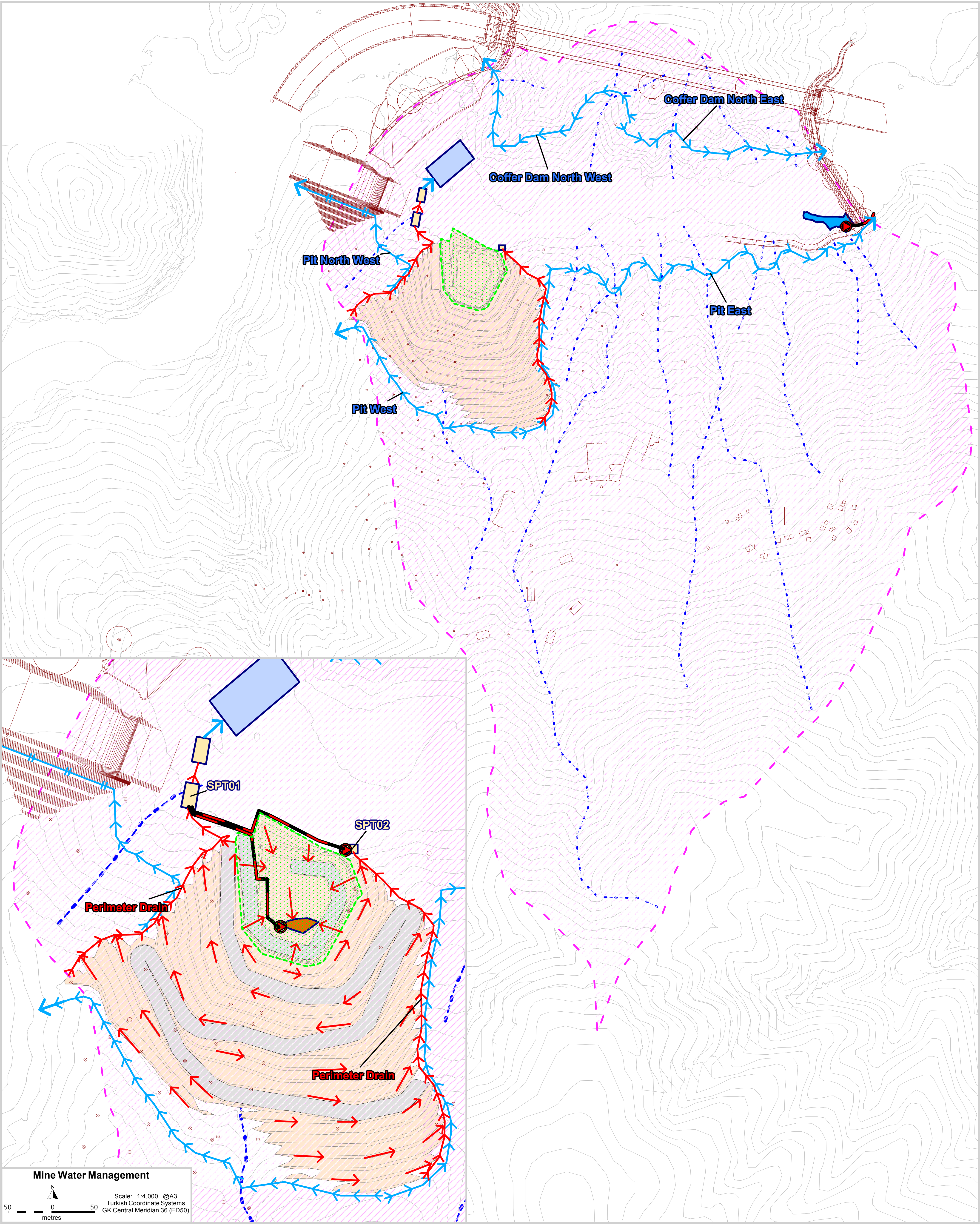
- Final Pit Footprint
- Groundwater Contours
- Groundwater Monitoring Boreholes

DATA SOURCES:

RPS Aquaterra

FIGURE 6

AVERAGE GROUNDWATER ELEVATION (AUG 2014 - MAY 2015)



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Turkish Coordinate Systems
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AUTHOR:	KS	REPORT NO:	008
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DATE:	09/15	JOB NO:	I200

Location: O:\Jobs\i200 Gok Turkey\3000\Figures\Mapinfo\Workspaces\Figure 7 - Pit Phase 1.wor

LEGEND

- Clean Runoff Open Channel
- Clean Runoff Culvert/Pipe
- Dirty Runoff Open Channel
- Indicative In-Pit Drainage
- Pre-development Streamflow
- Pre-development Catchment
- Pit Development
- Internally Draining Pit Catchment
- Infrastructure Outline
- Proposed Roads
- Sedimentation Pond
- Mine Water Pond
- Pit Sump
- Pump
- Pumped Pipeline
- Clean Runoff Drainage Pond

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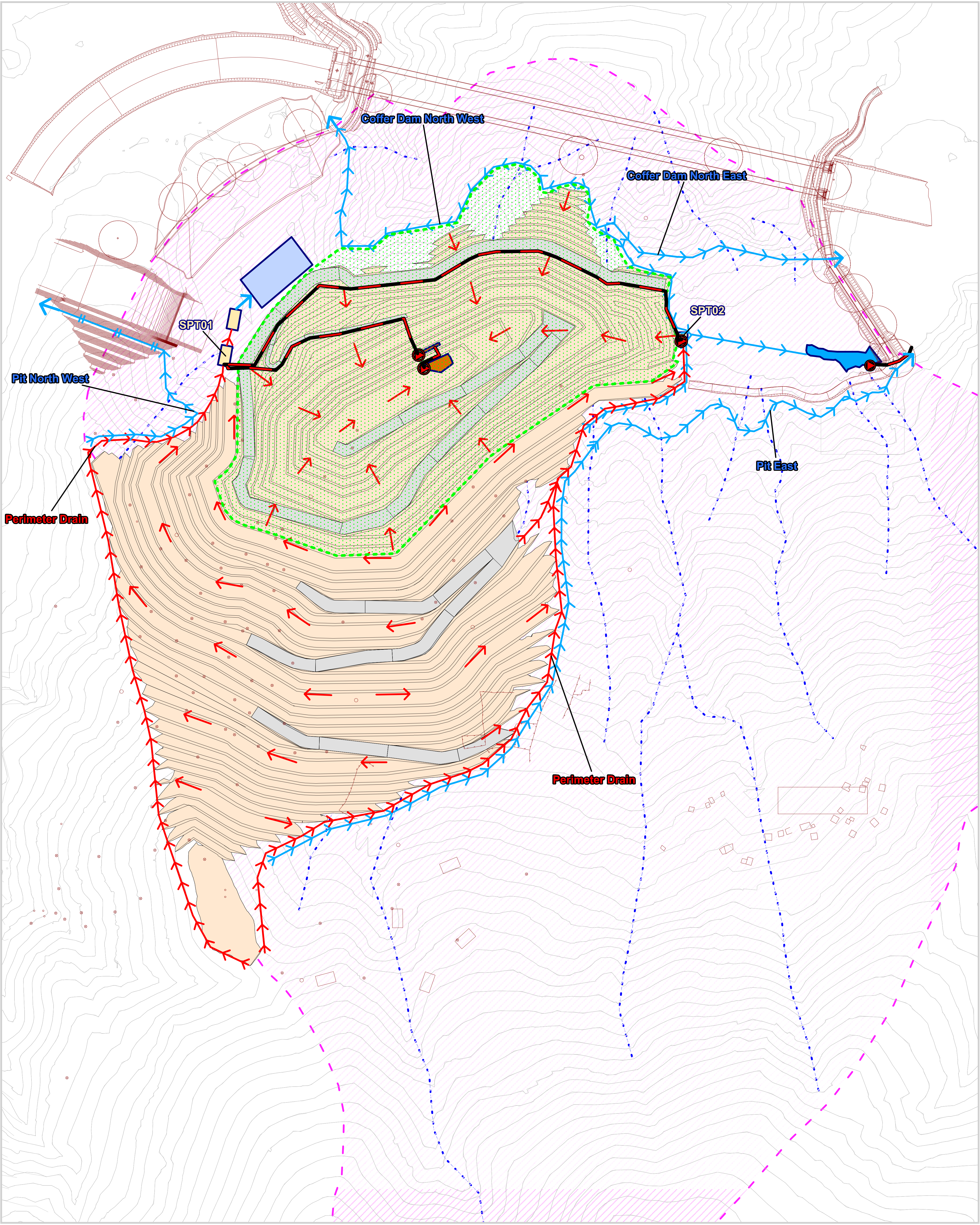
FIGURE 7

SURFACE WATER MANAGEMENT
PIT PHASE 1



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Turkish Coordinate Systems
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AUTHOR:	KS	REPORT NO:	008
DRAWN:	KS	REVISION:	A
DATE:	09/15	JOB NO:	I200

Location: O:\Jobs\i200 Gok Turkey\3000\Figures\Mapinfo\Workspaces\Figure 8 - Pit Phase 3.wor

LEGEND

- Clean Runoff Open Channel
- Clean Runoff Culvert/Pipe
- Dirty Runoff Open Channel
- Indicative In-Pit Drainage
- Pre-development Streamflow
- Pre-development Catchment
- Pit Development
- Internally Draining Pit Catchment
- Infrastructure Outline
- Proposed Roads
- Sedimentation Pond
- Mine Water Pond
- Pit Sump
- Pump
- Pumped Pipeline
- Clean Runoff Drainage Pond

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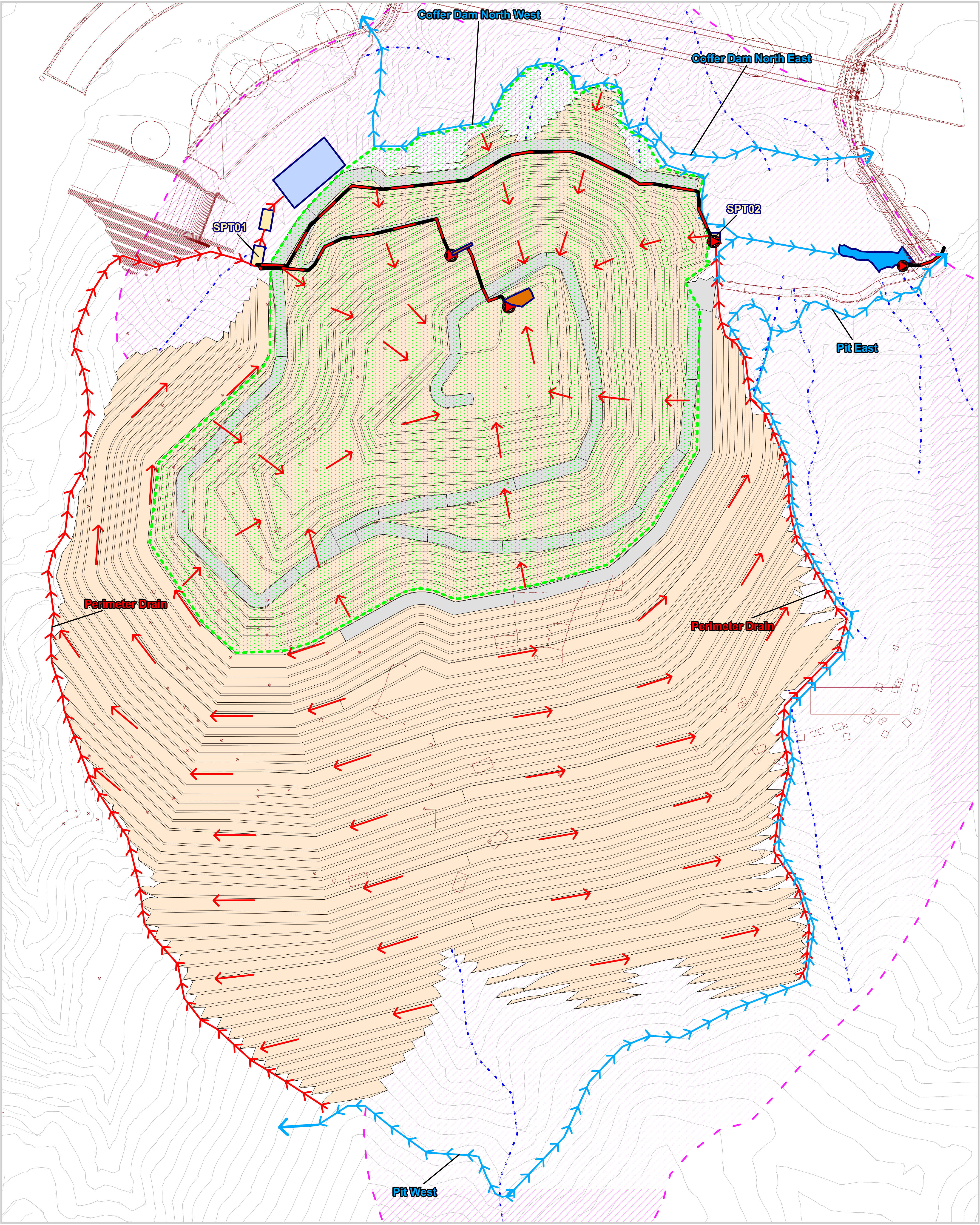
FIGURE 8

SURFACE WATER MANAGEMENT
PIT PHASE 3



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Turkish Coordinate Systems
GK Central Meridian 36 (ED50)

AUTHOR:	KS	REPORT NO:	008
DRAWN:	KS	REVISION:	A
DATE:	09/15	JOB NO:	I200

Location: O:\Jobs\i200 Gok Turkey\3000\Figures\Mapinfo\Workspaces\Figure 9 - Pit Final Phase.wor

LEGEND

- Clean Runoff Open Channel
- Clean Runoff Culvert/Pipe
- Dirty Runoff Open Channel
- Indicative In-Pit Drainage
- Pre-development Streamflow
- Pre-development Catchment
- Pit Development
- Internally Draining Pit Catchment
- Infrastructure Outline
- Proposed Roads
- Sedimentation Pond
- Mine Water Pond
- Pit Sump/Transfer Station
- Pump
- Pumped Pipeline
- Clean Runoff Drainage Pond

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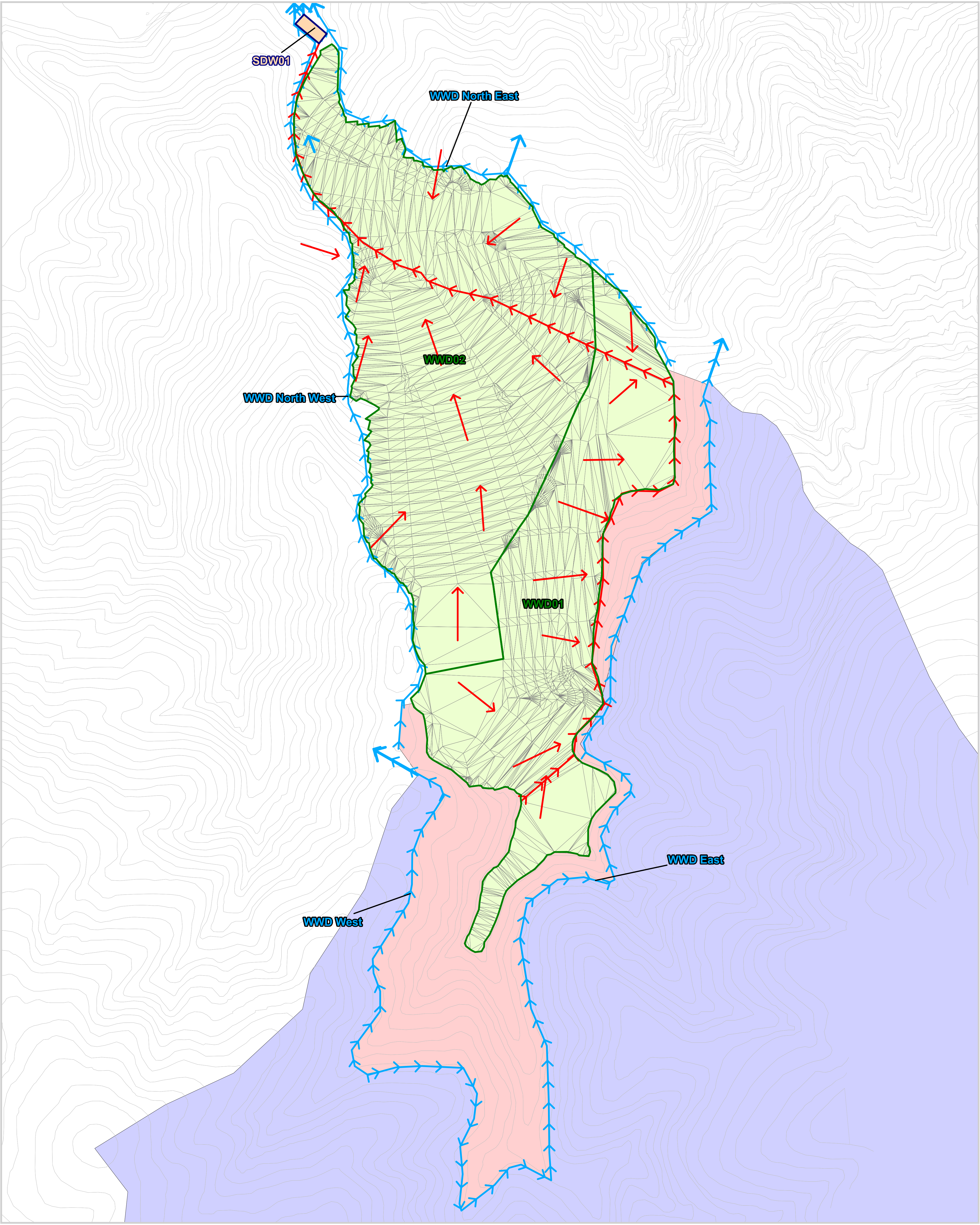
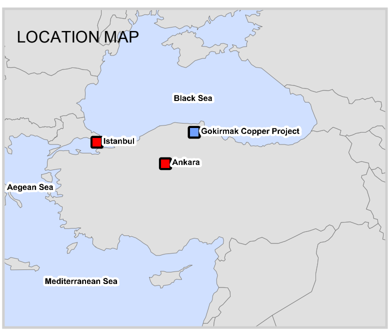
FIGURE 9

SURFACE WATER MANAGEMENT
PIT FINAL PHASE





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Turkish Coordinate Systems
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AUTHOR:	KS	REPORT NO:	008
DRAWN:	KS	REVISION:	A
DATE:	09/15	JOB NO:	I200

Location: O:\Jobs\i200 Gok Turkey\3000\Figures\Mapinfo\Workspaces\Figures 10&11 - Waste Dumps.wor

LEGEND

- Waste Dump
- Waste Dump Sub-catchment Divide
- External Catchment - Draining to Waste Dump
- External Catchment - Diverted
- Sedimentation Pond Locations
- Dirty Runoff Open Channel
- Clean Runoff Channel/Bund
- Waste Dump Runoff Direction

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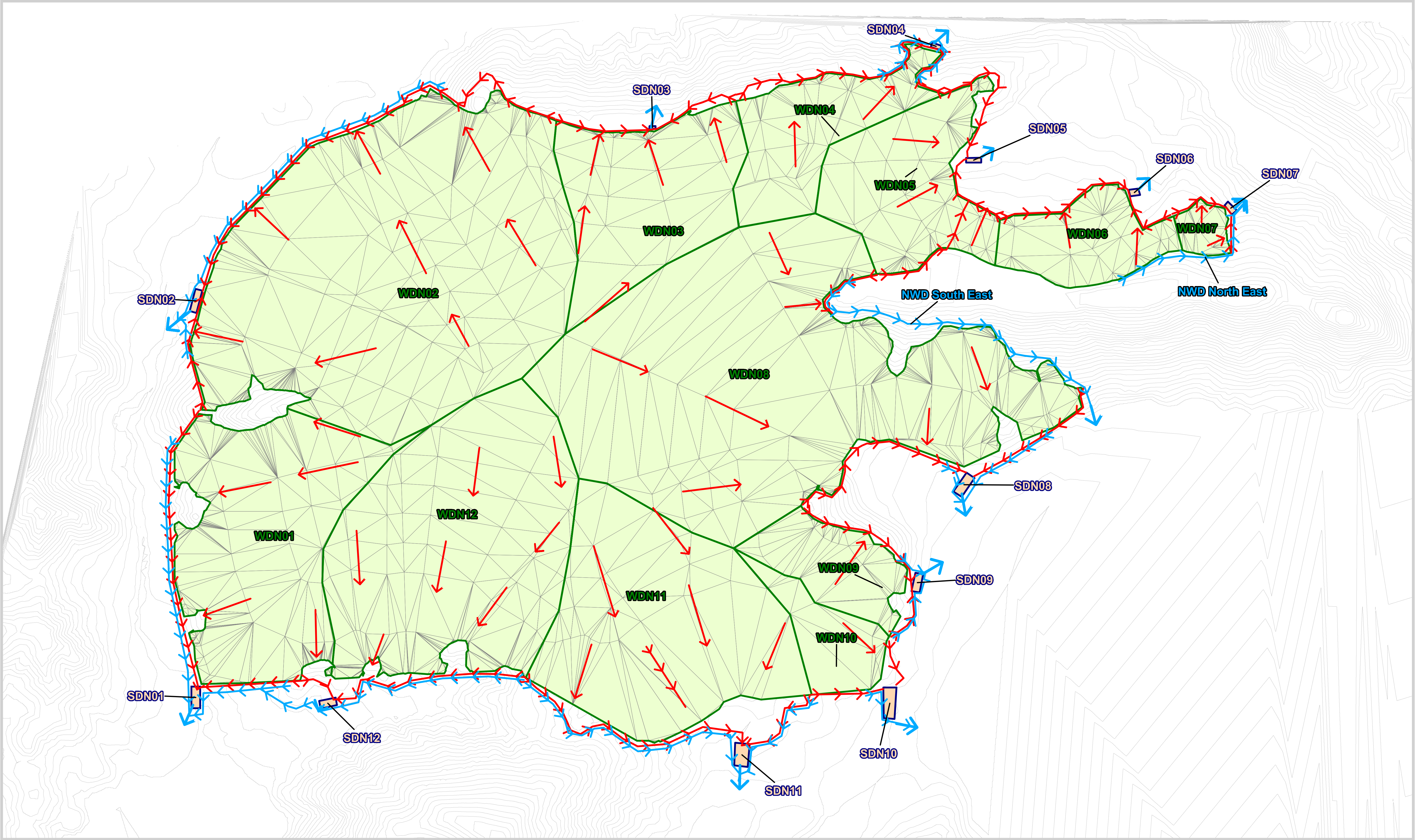
FIGURE 10

SURFACE WATER MANAGEMENT
WESTERN WASTE DUMP



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DRAWN:	KS	REVISION:	A
DATE:	09/15	JOB NO:	I200

Location: O:\Jobs\i200 Gok Turkey\3000\Figures\Mapinfo\Workspaces\Figures 10&11 - Waste Dumps.wor

LEGEND

- Waste Dump
- Waste Dump Sub-catchment Divide
- Sedimentation Pond Locations
- Dirty Runoff Open Channel
- Clean Runoff Channel/Bund
- Waste Dump Runoff Direction

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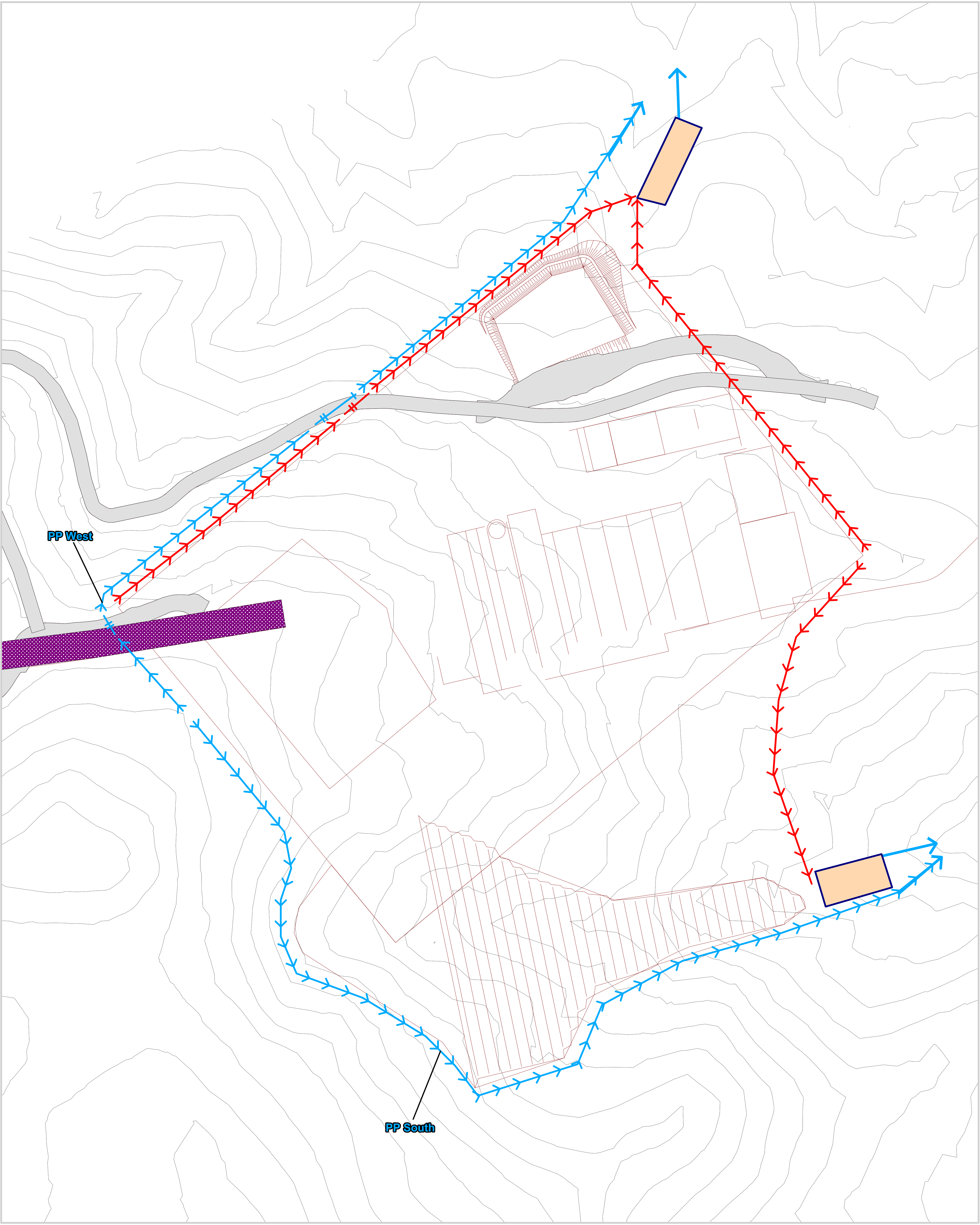
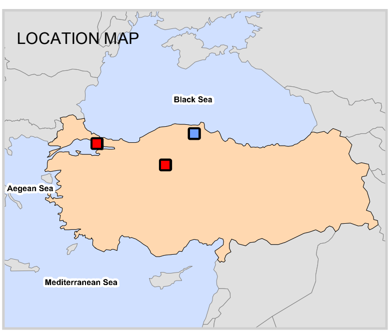
FIGURE 11

SURFACE WATER MANAGEMENT
NORTHERN WASTE DUMP





N

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metres

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Turkish Coordinate Systems
GK Central Meridian 36 (ED50)

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DATE:	09/15	JOB NO:	I200

Location: O:\Jobs\i200 Gok Turkey\3000\Figures\Mapinfo\Workspaces\Figure 12 - Process Plant.wor

LEGEND

- Clean Runoff Open Channel
- Clean Runoff Culvert/Pipe
- Dirty Runoff Channel/Bund
- Dirty Water Culvert/Pipe
- Proposed Roads
- Sedimentation Pond
- ROM Ore Transportation Belt
- Infrastructure Outline

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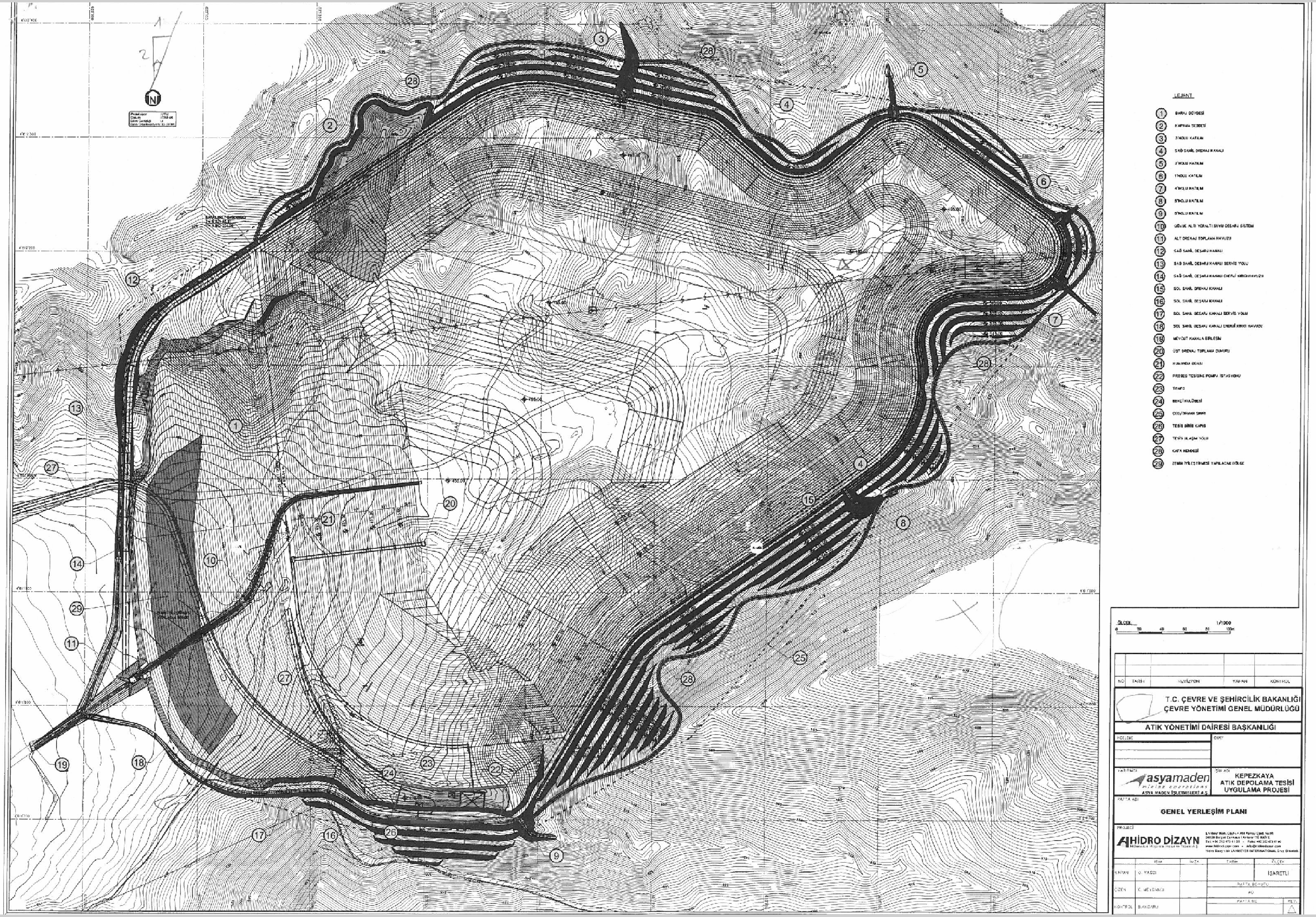
FIGURE 12

SURFACE WATER MANAGEMENT PROCESS PLANT



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Note: Drawing not to Scale

AUTHOR: KS	REPORT NO: 008
DRAWN: KS	REVISION: A
DATE: 09/15	JOB NO: I200

Location: O:\Jobs\I200 Gok Turkey\3000\Figures\Mapinfo\Workspaces\Figures 13 - Kepezkaya TDF.wor

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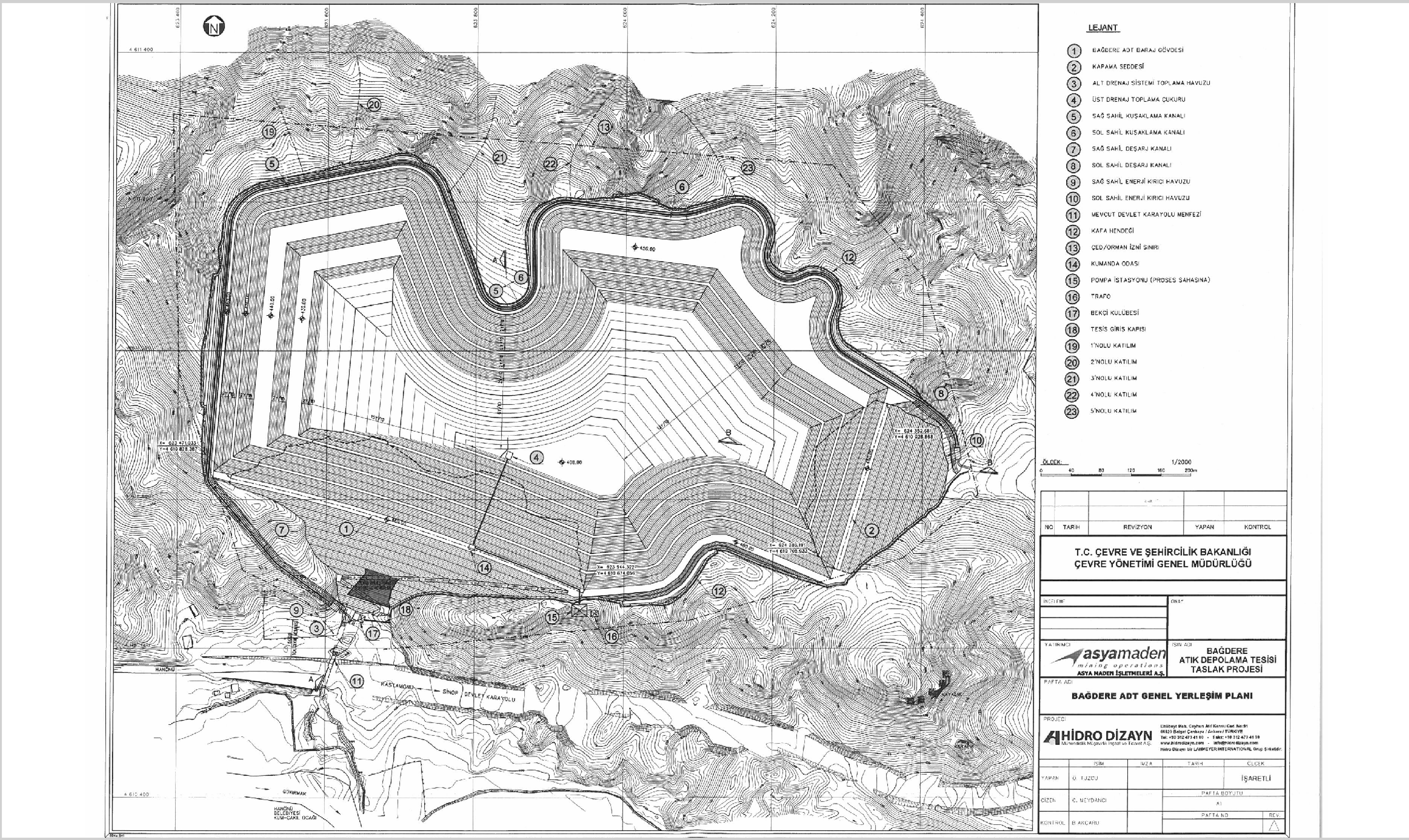
FIGURE 13

SURFACE WATER MANAGEMENT
KEPEZKAYA TDF



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Note: Drawing not to Scale

AUTHOR: KS	REPORT NO: 008
DRAWN: KS	REVISION: A
DATE: 09/15	JOB NO: I200

Location: O:\Jobs\I200 Gok Turkey\3000\Figures\Mapinfo\Workspaces\Figures 14 - Bagdere TDF.wor

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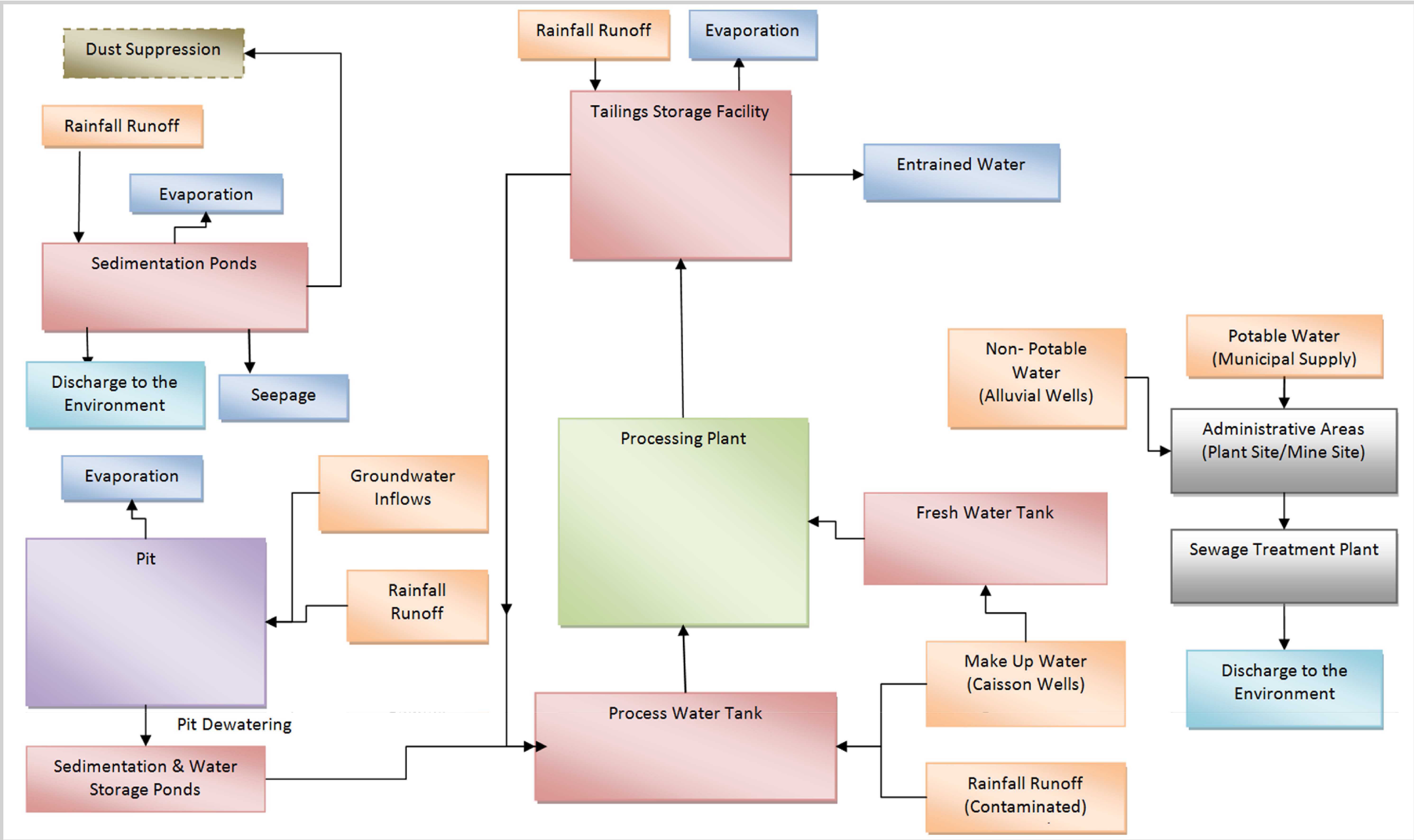
FIGURE 14

SURFACE WATER MANAGEMENT
BAGDERE TDF



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DATE: 09/15	JOB NO: I200

Location: O:\Jobs\I200 Gok Turkey\3000\Figures\Mapinfo\Workspaces\Figure 15 - Water Balance Schematic.wor

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FIGURE 15

GOKIRMAK COPPER MINE
SCHEMATIC WATER BALANCE

APPENDIX A

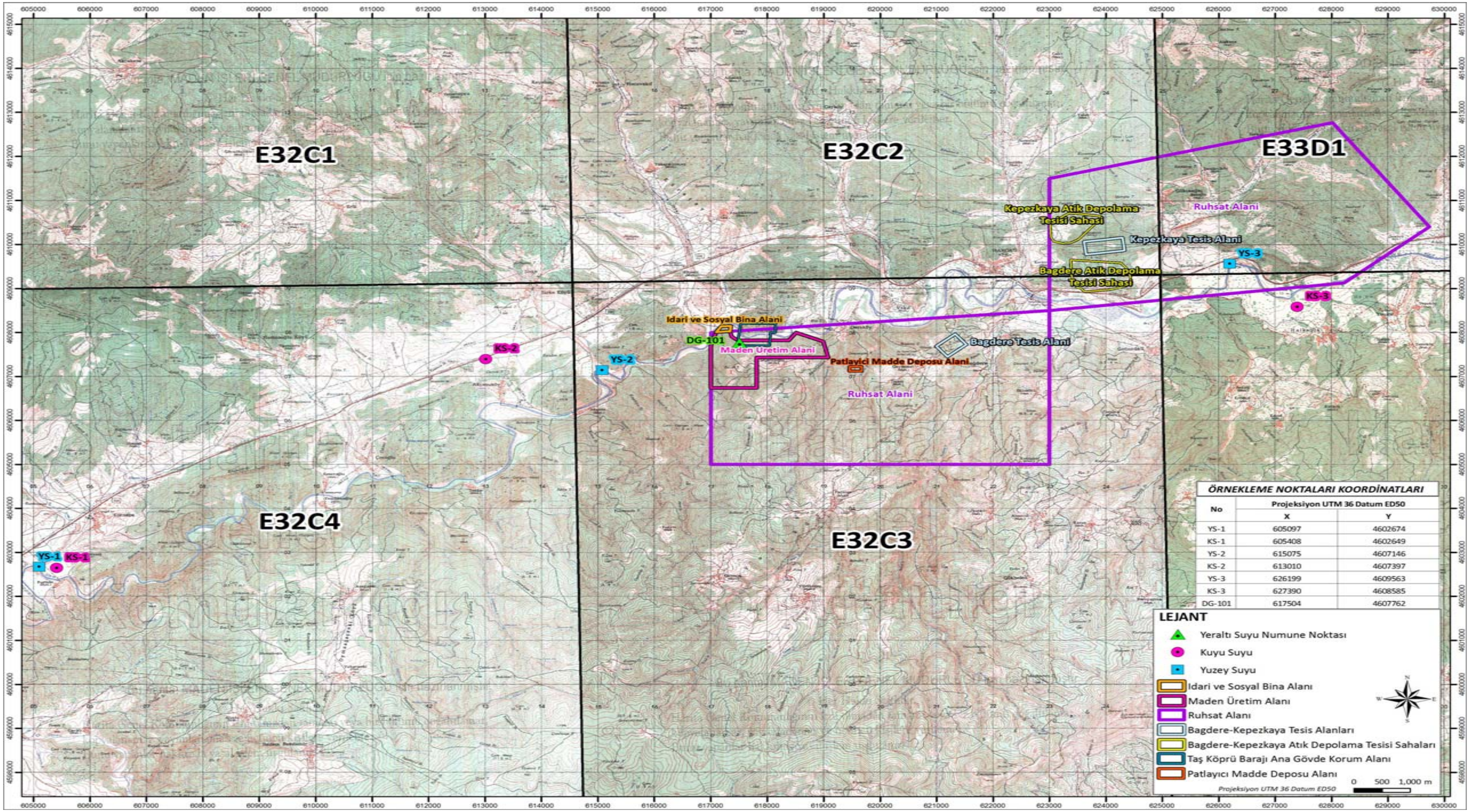
Project Site
Rainfall Data

Gokirmak Project Site - Daily Rainfall Data (22/05/15 - 27/08/15)

Date	*Rain Gauge-1 (Black)*	*Rain Gauge-2 (White)*	*Date*	*Rain Gauge-1 (Black)*	*Rain Gauge-2 (White)*
22/05/2015	0	0	10/07/2015	0	0
23/05/2015	0	0	11/07/2015	0	0
24/05/2015	0	0	12/07/2015	0	0
25/05/2015	0	0	13/07/2015	0	0
26/05/2015	0	0	14/07/2015	0	0
27/05/2015	0	0	15/07/2015	0	0
28/05/2015	**31**	**39**	16/07/2015	0	0
29/05/2015	1	2	17/07/2015	0	0
30/05/2015	**4**	**5**	18/07/2015	0	0
31/05/2015	**0**	**0**	19/07/2015	0	0
01/06/2015	13	14	20/07/2015	0	0
02/06/2015	0	0	21/07/2015	0	0
03/06/2015	0	0	22/07/2015	0	0
04/06/2015	0	0	23/07/2015	0	0
05/06/2015	**23**	**26**	24/07/2015	0	0
06/06/2015	**21**	**24**	25/07/2015	0	0
07/06/2015	0	0	26/07/2015	0	0
08/06/2015	**35**	**47**	27/07/2015	0	0
09/06/2015	0	0	28/07/2015	0	0
10/06/2015	0	0	29/07/2015	0	0
11/06/2015	11	13	30/07/2015	0	0
12/06/2015	1	1	31/07/2015	0	0
13/06/2015	3	3	01/08/2015	0	0
14/06/2015	0	0	02/08/2015	0	0
15/06/2015	0	0	03/08/2015	0	0
16/06/2015	14	15	04/08/2015	0	0
17/06/2015	0	0	05/08/2015	0	0
18/06/2015	7	8	06/08/2015	0	0
19/06/2015	0	0	07/08/2015	0	0
20/06/2015	7	8	08/08/2015	0	0
21/06/2015	10	10	09/08/2015	0	0
22/06/2015	0	0	10/08/2015	0	0
23/06/2015	0	0	11/08/2015	0	0
24/06/2015	1	2	12/08/2015	0	0
25/06/2015	6	7	13/08/2015	0	0
26/06/2015	1	2	14/08/2015	0	0
27/06/2015	**20**	**23**	15/08/2015	0	0
28/06/2015	3	4	16/08/2015	0	0
29/06/2015	2	3	17/08/2015	0	0
30/06/2015	0	0	18/08/2015	0	**2**
01/07/2015	0	0	19/08/2015	0	0
02/07/2015	0	0	20/08/2015	0	0
03/07/2015	0	0	21/08/2015	0	0
04/07/2015	0	0	22/08/2015	0	0
05/07/2015	0	0	23/08/2015	0	0
06/07/2015	0	0	24/08/2015	0	0
07/07/2015	**7**	**8**	25/08/2015	0	**3**
08/07/2015	0	0	26/08/2015	0	0
09/07/2015	0	0	27/08/2015	0	0

APPENDIX B

Surface Water & Groundwater Quality Results & Sampling Locations



ÖRNEKLEME NOKTALARI KOORDİNATLARI

No	Projeksiyon UTM 36 Datum ED50	
	X	Y
YS-1	605097	4602674
KS-1	605408	4602649
YS-2	615075	4607146
KS-2	613010	4607397
YS-3	626199	4609563
KS-3	627390	4608585
DG-101	617504	4607762

Surface Water Analysis Results – May 2012

Parameters	SW - 01 (x= 605097; y= 4602674)			SW - 02 (x= 615076 ; y= 4607144)			SW - 03 (x= 626208 ; y= 4609543)		
	Analysis of Results	Quality Class	Reference Value	Analysis of result	Quality Class	Referance Value	Analysis of Result	Quality Class	Reference Value
General Conditions									
Temperature (°C)	15,3	I	0-25	18,1	I	0-25	19,7	I	0-25
pH	7,60	I	6,5-8,5	7,55	I	6,5-8,5	7,52	I	6,5-8,5
Conductivity (µS/cm)	460	II	400-1.000	476	II	400-1.000	477	II	400-1.000
Colour(Pt-Co)	-	-	-	-	-	-	-	-	-
Oxygenation Parameters									
Dissolved Oxygen (mg/L)	8,12	I	>8	8,3	I	>8	8,0	I	>8
Oxygen Saturation (%)	96	I	>90	98	I	>90	94,2	I	>90
Chemical Oxygen Demand (COD) (mg/L)	<10	I	0-25	<10	I	0-25	<10	I	0-25
Biological Oxygen Demand (BOD) (mg/L)	<4	I	0-4	<4	I	0-4	<4	I	0-4
Nutrient Parameters									
Ammonium Nitrogen (mg NH_4^+ - N/L)	<0,1	I	0-0,2	<0,1	I	0-0,2	<0,1	I	0-0,2
Nitrite Nitrogen (mg NO_2^- - N/L)	0,078	IV	>0,05	0,101	IV	>0,05	0,081	IV	>0,05
Nitrate Nitrogen (mg NO_3^- - N/L)	1,46	I	0-5	1,53	I	0-5	1,55	I	0-5
Total Kjeldahl Nitrogen (mg/L)	1,01	II	0,5-1,5	1,12	II	0,5-1,5	0,9	II	0,5-1,5
Total Phosphorus (mg P/L)	0,094	II	0,03-0,16	0,076	II	0,03-0,16	0,052	II	0,03-0,16
Of trace elements (Metals)									
Mercury (µg Hg/L)	<1	III	0,5-0,2	<1	III	0,5-0,2	<1	III	0,5-0,2
Cadmium (µg Cd/L)	<3	II	2-5	<3	II	2-5	<3	II	2-5
Lead (µg Pb/L)	<50	III	20-50	<50	III	20-50	<50	III	20-50
Cupper (µg Cu/L)	<10	I	0-20	<10	I	0-20	<10	I	0-20
Nickel (µg Ni/L)	<20	I	0-20	<20	I	0-20	<20	I	0-20
Zink (µg/L)	34	I	0-200	<10	I	0-200	<10	I	0-200
Bacteriological Parameters									
Fecal Coliform (CFU/100 mL)	<1	I	0-10	<1	I	0-10	<1	I	0-10
Total Coliform (CFU/100 mL)	16	I	0-100	12	I	0-100	10	I	0-100

Surface Water Analysis Results – Agust 2012

Parameters	SW - 01 (x= 605097 ; y= 4602674)			SW - 02 (x= 615076 ; y= 4607144)			SW - 03 (x= 626208 ; y= 4609543)		
	Analysis of Results	Quality Class	Reference Value	Analysis of result	Quality Class	Referance Value	Analysis of Result	Quality Class	Reference Value
General Conditions									
Temperature (°C)	19,4	I	0-25	24,4	I	0-25	27,3	III	25-30
pH	8,19	I	6,5-8,5	8,09	I	6,5-8,5	8,09	I	6,5-8,5
Conductivity (µS/cm)	692	II	400-1.000	597	II	400-1.000	532	II	400-1.000
Colour(Pt-Co)	-	-	-	-	-	-	-	-	-
Oxygenation Parameters									
Dissolved Oxygen (mg/L)	18,8	I	>8	8,1	I	>8	7,8	II	8-6
Oxygen Saturation (%)	101	I	>90	93	I	>90	89	II	90-70
Chemical Oxygen Demand (COD) (mg/L)	<10	I	0-25	<10	I	0-25	<10	I	0-25
Biological Oxygen Demand (BOD) (mg/L)	<4	I	0-4	<4	I	0-4	<4	I	0-4
Nutrient Parameters									
Ammonium Nitrogen (mg NH_4^+ - N/L)	<0,1	I	0-0,2	<0,1	I	0-0,2	<0,1	I	0-0,2
Nitrite Nitrogen (mg NO_2^- - N/L)	0,24	IV	>0,05	0,09	IV	>0,05	0,035	III	0,01-0,05
Nitrate Nitrogen (mg NO_3^- - N/L)	1,49	I	0-5	1,52	I	0-5	1,35	I	0-5
Total Kjeldahl Nitrogen (mg/L)	1,01	II	0,5-1,5	0,67	II	0,5-1,5	0,67	II	0,5-1,5
Total Phosphorus (mg P/L)	0,07	II	0,03-0,16	0,016	I	0-0,03	<0,01	I	0-0,03
Of trace elements (Metals)									
Mercury (µg Hg/L)	<1	III	0,5-2	<1	III	0,5-2	<1	III	0,5-2
Cadmium (µg Cd/L)	<3	II	2-5	<3	II	2-5	<3	II	2-5
Lead (µg Pb/L)	71	IV	>50	69	IV	>50	55	IV	>50
Cupper (µg Cu/L)	<10	I	0-20	<10	I	0-20	<10	I	0-20
Nickel (µg Ni/L)	<20	I	0-20	<20	I	0-20	<20	I	0-20
Zink (µg/L)	<10	I	0-200	26	I	0-200	28	I	0-200
Bacteriological Parameters									
Fecal Coliform (CFU/100 mL)	100	II	10-200	200	II	10-200	600	III	200-2000
Total Coliform (CFU/100 mL)	600	II	100-20000	1000	II	100-20000	2000	II	100-20000

Groundwater Quality Results – May 2012

Parameter	KS – 01 (x= 605408; y= 4602649)			KS – 02 (x=613010; y=4607397)			KS – 03 (x=627390; y=4608585)		
	Results	Quality Class	Reference Value	Results	Quality Class	Reference Value	Results	Quality Class	Reference Value
General Conditions									
Temperature(°C)	14.9	I	0-25	17.2	I	0-25	15.7	I	0-25
pH	6.8	I	6.5-8.5	7.76	I	6.5-8.5	6.8	I	6.5-8.5
Conductivity (µS/cm)	958	II	400-1,000	10,080	IV	>3,000	648	II	400-1,000
Colour (Pt-Co)	-	-	-	-	-	-	-	-	-
Oxygenation Parameters									
Dissolved Oxygen (mg/L)	7.31	II	8-6	6.35	II	8-6	6.86	II	8-6
Oxygen Saturation (%)	86.3	II	90-70	75	II	90-70	81	II	90-70
Chemical Oxygen Demand (mg/L)	<10	I	0-25	<10	I	0-25	<10	I	0-25
Biological Oxygen Demand (mg/L)	<4	I	0-4	<4	I	0-4	<4	I	0-4
Nutrient Parameters									
Ammonium Nitrogen (mg NH4+ - N/L)	<0.1	I	0-0.2	<0.1	I	0-0.2	<0.1	I	0-0.2
Nitrite Nitrogen (mg NO2- - N/L)	<0.002	I	0-0.002	<0.002	I	0-0.002	<0.002	I	0-0.002
Nitrate Nitrogen (mg NO3- - N/L)	3.08	I	0-5	3.75	I	0-5	1.59	I	0-5
Total Kjeldahl Nitrogen (mg/L)	0.45	I	0-0.5	3.81	III	1.5-5	2.46	III	1.5-5
Total Phosphorus (mg P/L)	<0.01	I	0-0.03	<0.01	I	0-0.03	<0.01	I	0-0.03
Trace Metals									
Mercury (µg Hg/L)	<1	III	0.5-2	<1	III	0.5-2	<1	III	0.5-2
Cadmium (µg Cd/L)	<3	II	2-5	11	IV	>7	<3	II	2-5
Lead (µg Pb/L)	<50	III	20-50	309	IV	>50	<50	III	20-50
Copper (µg Cu/L)	<10	I	0-20	77	III	50-200	<10	I	0-20
Nickel (µg Ni/L)	<20	I	0-20	37	II	20-50	<20	I	0-20
Zinc (µg/L)	<10	I	0-200	1704	III	500-2000	51	I	0-200
Bacteriological Parameters									
Faecal Coliform (CFU/100 mL)	<1	I	0-10	5	I	0-10	<1	I	0-10
Total Coliform (CFU/100 mL)	8	I	0-100	10	I	0-100	10	I	0-100

Groundwater Quality Results – August 2012

Parameter	KS – 01 (x= 605408; y= 4602649)			KS – 02 (x=613010; y=4607397)			KS – 03 (x=627390; y=4608585)			DG – 101 (x=617504; y=4607762)		
	Results	Quality Class	Reference Value	Results	Quality Class	Reference Value	Results	Quality Class	Reference Value	Results	Quality Class	Reference Value
General Conditions												
Temperature (°C)	21	I	0-25	17.7	I	0-25	20.4	I	0-25	20.4	I	0-25
pH	7.55	I	6.5-8.5	7.86	I	6.5-8.5	7.84	I	6.5-8.5	6.15	IV	6.5-8.5
Conductivity (µS/cm)	625	II	400-1,000	10,890	IV	>3,000	641	II	400-1,000	10,710	IV	>3,000
Colour (Pt-Co)	-	-	-	-	-	-	-	-	-	-	-	-
Oxygenation Parameters												
Dissolved Oxygen (mg/L)	7.1	II	8-6	5.2	III	6-3	6.2	II	8-6	5.6	III	6-3
Oxygen Saturation (%)	83	II	90-70	63	III	70-40	74.4	II	90-70	68.3	III	70-40
Chemical Oxygen Demand (mg/L)	<10	I	0-25	17	I	0-25	<10	I	0-25	38	II	25-50
Biological Oxygen Demand (mg/L)	<4	I	0-4	<4	I	0-4	<4	I	0-4	12.6	III	8-20
Nutrient Parameters												
Ammonium Nitrogen (mg NH4+ - N/L)	<0.1	I	0-0.2	<0.1	I	0-0.2	<0.1	I	0-0.2	<0.1	I	0-0.2
Nitrite Nitrogen (mg NO2- - N/L)	0.012	III	0.01-0.05	0.027	II	0.01-0.05	0.0094	II	0.002-0.01	0.011	II	0.01-0.05
Nitrate Nitrogen (mg NO3- - N/L)	2.01	I	0-5	0.064	I	0-5	1.21	I	0-5	1.19	I	0-5
Total Kjeldahl Nitrogen (mg/L)	1.12	II	0.5-1.5	3.81	III	1.5-5	0.45	I	0-0.5	2.91	III	1.5-5
Total Phosphorus (mg P/L)	<0.01	I	0-0.03	<0.01	I	0-0.03	<0.01	I	0-0.03	0.011	II	0.03-0.16
Trace Metals												
Mercury (µg Hg/L)	<1	III	0.5-2	<1	III	0.5-2	<1	III	0.5-2	25	IV	>2
Cadmium (µg Cd/L)	<3	II	2-5	<3	II	2-5	<3	II	2-5	80	IV	>7
Lead (µg Pb/L)	55	IV	>50	249	IV	>50	72	IV	>50	690	IV	>50
Copper (µg Cu/L)	<10	I	0-20	<10	I	0-20	<10	I	0-20	15	I	0-20
Nickel (µg Ni/L)	23	II	20-50	70	III	50-200	30	II	20-50	1100	IV	>200
Zinc (µg/L)	<10	I	0-200	1690	III	500-2000	78	I	0-200	4650	IV	>2000
Bacteriological Parameters												
Faecal Coliform (CFU/100 mL)	0	I	0-10	0	I	0-10	0	I	0-10	0	I	0-10
Total Coliform (CFU/100 mL)	200	II	100-20000	80	I	0-100	30	I	0-100	0	I	0-100

Groundwater Quality Results – September 2013

DH1—DH4 Alluvial Boreholes (from IMC 2014)

Parameter/Well Number	DH-1	DH-2	DH-3	DH-4
pH	7,46	7,61	7,13	7,45
Temp (^{0}C)	14,90	20,70	19,60	15,50
Conductivity (µs/cm)	551,00	597,00	631,00	637,00
Ca (mg/L)	45,00	73,60	108,30	57,20
Mg (mg/L)	20,17	20,58	19,52	19,57
Na (mg/L)	35,00	39,50	36,40	37,10
K (mg/L)	3,30	3,53	3,30	3,27
Cl (mg/L)	9,50	17,50	17,00	12,00
Sulphates (mg/l)	164,00	163,20	166,00	151,00
Bicarbonate (mg/L)	146,00	192,00	250,00	201,00
Fe (mg/L)	0,240	0,046	0,016	0,000
Pb (mg/L	0	0,021	0,0055	0
Zn (mg/L)	0,012	0,034	1,150	0,012
Ni (mg/L)	0	0	0	0
Cd (mg/L)	0	0	0,012	0
Cu (mg/L)	0,0025	0,0050	0,0200	0,0026
As (mg/L)	0	0	0,006	0
Al (mg/L)	0,0500	0,1050	0,0550	0,0320
Mn (mg/L)	0,030	0,022	0,360	0,047

Groundwater Quality Results – September 2013

OW1—OW5 Bedrock Boreholes (from IMC 2014)

Parameter/Well Number	OW-1	OW-2	OW-3	OW-4	OW-5
pH	7,77	6,83	7,13	7,13	7,34
Temp (^{0}C)	14,20	14,30	13,60	15,20	13,90
Conductivity (µs/cm)	637,00	4670,00	996,00	686,00	996,00
Ca (mg/L)	54,90	425,70	120,10	61,40	125,00
Mg (mg/L)	22,28	426,10	28,86	21,52	29,39
Na (mg/L)	39,40	106,30	24,70	34,30	33,00
K (mg/L)	3,69	22,10	0,95	3,46	3,42
Cl (mg/L)	12,00	5,00	7,50	12,50	10,00
Sulphates (mg/l)	181,00	2676,00	185,00	163,00	340,00
Bicarbonate (mg/L)	176,00	317,00	334,00	198,00	220,00
Fe (mg/L)	0,164	49,540	0,123	0,000	0,036
Pb (mg/L	0	0	0	0	0
Zn (mg/L)	0,990	13,820	8,960	0,017	0,048
Ni (mg/L)	0	0	0	0	0
Cd (mg/L)	0	0,00320	0	0	0
Cu (mg/L)	0	0	0	0,0045	0,0045
As (mg/L)	0,006	0	0	0	0
Al (mg/L)	0,0690	0,1340	0,0370	0,0130	0,095
Mn (mg/L)	0,042	23,980	0,755	0,003	0,038

Müşteri Adı / Adresi: Customer Name / Address	ASYA MADEN İŞLETMELERİ A.Ş. Balmumcu Mah. Barbaros Bulv. Morbasan Sok. Koza İş Mrk. C Blok. No:14 Kat:12 Beşiktaş İSTANBUL
Numuneyi Alan Kurum / Kuruluş: Sampler Institution / Company	SEGAL Çevre Ölçüm ve Analiz Laboratuarı (Satılmış DOĞAN)
Numunenin Adı ve Örnekleme Tarihi: Name and Sampling Date of the Sample	Yeraltı suyu N-16678/15 - 24.07.2015
Numunenin Alınış Şekli: Receipt of the Sample Shape	Anlık
Numuneyi Teslim Eden: Deliverer of the Sample	Satılmış DOĞAN (SEGAL Çevre Ölçüm ve Analiz Laboratuarı personeli)
Proje Adı ve No: Name and Number of the Project	P-8179/15
Numunenin Teslim Tarihi: Date of Sample Acceptance	25.07.2015
Numunenin Teslim Koşulları: Delivery Conditions of the Sample	TS EN ISO 5667-3 standardına uygun olarak plastik kapta, soğuk ortamda, kimyasal korumalı, Mühürlü - Korumalı
Açıklamalar: Remarks	Kastamonu ili Hanönü ilçesi Gökırmak Dereköy Mevkii "OW-1"den alınan yeraltı suyu numunesinin analizi
Deneyin Yapıldığı Tarih: Date of the Test	25.07.2015 - 30.07.2015
Raporun Sayfa Sayısı: Number of the Pages of the Report	2 sayfa

Deney ve/veya ölçüm sonuçları, genişletilmiş ölçüm belirsizlikleri ve deney/ölçüm metotları takip eden sayfalarda verilmiştir. The test and/or measurements results, the uncertainties with confidence probability and test methods are given on the following pages which are part of this report.

Raporu Hazırlayan Prepared by	**Raporu Onaylayan** Confirm by
Kübra OLGUN Kimya Mühendisi	Fevzi KARAKAYA Laboratuar Müdürü

SEGAL

SEGAL ÇEVRE ÖLÇÜM ve ANALİZ LABORATUARI MÜH. MÜŞ. PROJE HİZM.SAN VE TİC.LTD.ŞTİ.
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TÜRKAK Test TS EN ISO/IEC 17025 AB-0425-T

Rapor No
R-15498/15

Rapor Tarihi
30.07.2015

NUMUNE ADI ve NO: Yeraltı suyu - N-16678/15
Sample Name and Number

Parametre - Birim Parameter - Unit	**Analiz Sonucu** Test Result	**Ölçüm Belirsizliği** Uncertainties	**Analiz Metodu** Test Method
Bakır (mg/L)	0,0042	% ± 9,96	EPA 200.7
Biyokimyasal Oksijen İhtiyacı (mg/L)	<4	% ± 3,12	SM 5210 B
Civa (mg/L)	<0,0005	% ± 11,14	SM 3112 B
Çinko (mg/L)	11,13	% ± 1,65	EPA 200.7
Çözünmüş Oksijen (mg/L)	4,64	% ± 0,56	TS EN 5814
Demir (mg/L)	0,466	% ± 3,30	EPA 200.7
İletkenlik (µS/cm)	1663	% ± 2,66	TS 9748 EN 27888
Kadmiyum (mg/L)	<0,001	% ± 2,40	EPA 200.7
Kalsiyum (mg/L)	253,3	% ± 2,18	EPA 200.7
Kimyasal Oksijen İhtiyacı (mg/L)	<10	% ± 4,72	SM 5220 B
Kurşun (mg/L)	<0,005	% ± 3,28	EPA 200.7
Magnezyum (mg/L)	71,47	% ± 1,96	EPA 200.7
Mangan (mg/L)	0,626	% ± 3,78	EPA 200.7
Nikel (mg/L)	<0,005	% ± 1,83	EPA 200.7
pH	7,56	% ± 1,10	TS EN ISO 10523
Potasyum (mg/L)	5,85	% ± 3,72	EPA 200.7
Sıcaklık (°C)	17	% ± 0,30	SM 2550 B
Sodyum (mg/L)	64,72	% ± 3,02	EPA 200.7
Sülfat (mg/L)	692,6	% ± 7,62	SM 4500 SO4-2 E

Numuneler TS EN ISO 5667-3 - Su Kalitesi - Numune Alma - Bölüm 3: Numunelerin Muhafaza ve Taşıma Kuralları çerçevesinde saklanır. Bu süre içerisinde kimyasal, mikrobiyolojik ve fiziksel açıdan bozulan veya tehlike arz eden numuneler, numune saklama süresinin bitimi beklemeden imha edilir.

Çevre Koşulları:

Hava Durumu	X	**Açık**	**Yağış**		**Var**	**Hava Sıcaklığı** 30 °C	**Koordinatlar**	**E**	617503
		Kapalı		X	**Yok**			**N**	4607774

Görüş ve Yorumlar:

Mühür

İmza

Müşterinin adı/ adresi: Customer Name / Address	ASYA MADEN İŞLETMELERİ A.Ş. Balmumcu Mah. Barbaros Bulv. Morbasan Sok. Koza İş Mrk. C Blok. No:14 Kat:12 Beşiktaş İSTANBUL
Numuneyi Alan Kurum / Kuruluş ***Sampler Institution / Company***	SEGAL Çevre Ölçüm ve Analiz Laboratuarı (Satılmış DOĞAN)
Numunenin Adı ve Örnekleme Tarihi: Name and Sampling Date of the Sample	Yeraltı suyu N-16678/15 - 24.07.2015
Numunenin Alınış Şekli: Receipt of the Sample Shape	Anlık
Numuneyi Teslim Eden: Deliverer of the Sample	Satılmış DOĞAN (SEGAL Çevre Ölçüm ve Analiz Laboratuarı personeli)
Proje Adı ve No: Name and Number of the Project	P-8179/15
Numunenin Kabul Tarihi: Date of Sample Acceptance	25.07.2015
Numunenin Teslim Koşulları: Delivery Conditions of the Sample	TS EN ISO 5667-3 standardına uygun olarak plastik kapta, soğuk ortamda, kimyasal korumalı, Mühürlü - Korumalı
Açıklamalar: Remarks	Kastamonu ili Hanönü ilçesi Gökırmak Dereköy Mevkii "OW-1"den alınan yeraltı suyu numunesinin analizi
Deneyin yapıldığı Tarih: Date of the Test	25.07.2015
Raporun Sayfa Sayısı: Number of the Pages of the Report	2 sayfa

Deney ve/veya ölçüm sonuçları, genişletilmiş ölçüm belirsizlikleri ve deney/ölçüm metotları takip eden sayfalarda verilmiştir. The test and /or measurements results, the uncertainties with confidence probability and test methods are given on the following pages which are part of this report.

Raporu Hazırlayan Prepared by	Raporu Onaylayan Confirm by
Kübra OLGUN Kimya Mühendisi	Fevzi KARAKAYA Laboratuar Müdürü

NUMUNE ADI ve NUMUNE NO: Yeraltı suyu – N-16678/15
SAMPLE NAME and NUMBER

Parametre-Birim Parameter-Unit	**Analiz Sonucu** Test Result	**Analiz Metodu** Test Method
EH (mV)	-50,3	TS EN ISO 10523

"Numuneler ***TS EN ISO 5667-3*** – Su Kalitesi – Numune Alma – Bölüm 3: Numunelerin Muhafaza ve Taşıma Kuralları çerçevesinde saklanır. Bu sure içerisinde kimyasal, mikrobiyolojik ve fiziksel açıdan bozulan veya tehlike arz eden numuneler, numune saklama süresinin bitimi beklemeden imha edilir."

Çevre Koşulları:

Hava Durumu		***Açık***	***Yağış***		***Var***	***Hava Sıcaklığı °C***	***Koordinatlar***	***E***	617503
		Kapalı			***Yok***			***N***	4607774

Görüş ve Yorumlar:

Mühür

İmza

T.C. ÇEVRE VE ŞEHİRCİLİK BAKANLIĞI Y-06/203/2012	SEGAL	TÜRKAK Test TS EN ISO/IEC 17025 AB-0425-T
İlk Basım : 03.05.2010 RP.01 / Rev.01 Rev.Tarihi : 20.01.2011 Sayfa 1 / 2	**SEGAL ÇEVRE ÖLÇÜM ve ANALİZ LABORATUARI MÜH. MÜŞ. PROJE HİZM.SAN VE TİC.LTD.ŞTİ.** Aşağı Öveçler Mah. 1322.Cad (eski 6.cad) No:12/11-12 Çankaya-ANKARA **Tel:** 0 312 481 83 00 **Fax:** 0 312 481 83 99 **mai l:** segal@segalanaliz.com **web :** www.segalanaliz.com www.segal.com.tr	**Rapor No** R-15499/15 **Rapor Tarihi** 30.07.2015

Müşteri Adı / Adresi: Customer Name / Address	ASYA MADEN İŞLETMELERİ A.Ş. Balmumcu Mah. Barbaros Bulv. Morbasan Sok. Koza İş Mrk. C Blok. No:14 Kat:12 Beşiktaş İSTANBUL
Numuneyi Alan Kurum / Kuruluş: Sampler Institution / Company	SEGAL Çevre Ölçüm ve Analiz Laboratuarı (Satılmış DOĞAN)
Numunenin Adı ve Örnekleme Tarihi: Name and Sampling Date of the Sample	Yeraltı suyu N-16679/15 - 24.07.2015
Numunenin Alınış Şekli: Receipt of the Sample Shape	Anlık
Numuneyi Teslim Eden: Deliverer of the Sample	Satılmış DOĞAN (SEGAL Çevre Ölçüm ve Analiz Laboratuarı personeli)
Proje Adı ve No: Name and Number of the Project	P-8179/15
Numunenin Teslim Tarihi: Date of Sample Acceptance	25.07.2015
Numunenin Teslim Koşulları: Delivery Conditions of the Sample	TS EN ISO 5667-3 standardına uygun olarak plastik kapta, soğuk ortamda, kimyasal korumalı, Mühürlü - Korumalı
Açıklamalar: Remarks	Kastamonu ili Hanönü ilçesi Gökırmak Dereköy Mevkii "OW-3"den alınan yeraltı suyu numunesinin analizi
Deneyin Yapıldığı Tarih: Date of the Test	25.07.2015 - 30.07.2015
Raporun Sayfa Sayısı: Number of the Pages of the Report	2 sayfa

Deney ve/veya ölçüm sonuçları, genişletilmiş ölçüm belirsizlikleri ve deney/ölçüm metotları takip eden sayfalarda verilmiştir. The test and/or measurements results, the uncertainties with confidence probability and test methods are given on the following pages which are part of this report.

Raporu Hazırlayan Prepared by	**Raporu Onaylayan** Confirm by
Kübra OLGUN Kimya Mühendisi	Fevzi KARAKAYA Laboratuar Müdürü

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Aşağı Öveçler Mah. 1322.Cad (eski 6.cad) No:12/11-12 Çankaya-ANKARA

Tel: 0 312 481 83 00 **Fax:** 0 312 481 83 99

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web : www.segalanaliz.com

www.segal.com.tr

TÜRKAK Test TS EN ISO/IEC 17025 AB-0425-T

Rapor No
R-15499/15

Rapor Tarihi
30.07.2015

NUMUNE ADI ve NO: Yeraltı suyu - N-16679/15
Sample Name and Number

Parametre - Birim Parameter - Unit	**Analiz Sonucu** Test Result	**Ölçüm Belirsizliği** Uncertainties	**Analiz Metodu** Test Method
Bakır (mg/L)	0,030	% ± 9,96	EPA 200.7
Biyokimyasal Oksijen İhtiyacı (mg/L)	<4	% ± 3,12	SM 5210 B
Civa (mg/L)	<0,0005	% ± 11,14	SM 3112 B
Çinko (mg/L)	10,38	% ± 1,65	EPA 200.7
Çözünmüş Oksijen (mg/L)	5,18	% ± 0,56	TS EN 5814
Demir (mg/L)	6,96	% ± 3,30	EPA 200.7
İletkenlik (µS/cm)	998	% ± 2,66	TS 9748 EN 27888
Kadmiyum (mg/L)	<0,001	% ± 2,40	EPA 200.7
Kalsiyum (mg/L)	177,2	% ± 3,6	EPA 200.7
Kimyasal Oksijen İhtiyacı (mg/L)	<10	% ± 4,72	SM 5220 B
Kurşun (mg/L)	<0,005	% ± 3,28	EPA 200.7
Magnezyum (mg/L)	40,34	% ± 1,96	EPA 200.7
Mangan (mg/L)	0,311	% ± 3,78	EPA 200.7
Nikel (mg/L)	<0,005	% ± 1,83	EPA 200.7
pH	7,30	% ± 1,10	TS EN ISO 10523
Potasyum (mg/L)	2,04	% ± 3,72	EPA 200.7
Sıcaklık (°C)	15	% ± 0,30	SM 2550 B
Sodyum (mg/L)	31,02	% ± 3,02	EPA 200.7
Sülfat (mg/L)	210,7	% ± 7,62	SM 4500 SO4-2 E

Numuneler TS EN ISO 5667-3 - Su Kalitesi - Numune Alma - Bölüm 3: Numunelerin Muhafaza ve Taşıma Kuralları çerçevesinde saklanır. Bu süre içerisinde kimyasal, mikrobiyolojik ve fiziksel açıdan bozulan veya tehlike arz eden numuneler, numune saklama süresinin bitimi beklemeden imha edilir.

Çevre Koşulları:

Hava Durumu	X	**Açık**	**Yağış**		**Var**	**Hava Sıcaklığı 30 °C**	**Koordinatlar**	**E**	617579
		Kapalı		X	**Yok**			**N**	4607693

Görüş ve Yorumlar:

Mühür

İmza

Müşterinin adı/ adresi: Customer Name / Address	ASYA MADEN İŞLETMELERİ A.Ş. Balmumcu Mah. Barbaros Bulv. Morbasan Sok. Koza İş Mrk. C Blok. No:14 Kat:12 Beşiktaş İSTANBUL
Numuneyi Alan Kurum / Kuruluş ***Sampler Institution / Company***	SEGAL Çevre Ölçüm ve Analiz Laboratuarı (Satılmış DOĞAN)
Numunenin Adı ve Örnekleme Tarihi: Name and Sampling Date of the Sample	Yeraltı suyu N-16679/15 - 24.07.2015
Numunenin Alınış Şekli: Receipt of the Sample Shape	Anlık
Numuneyi Teslim Eden: Deliverer of the Sample	Satılmış DOĞAN (SEGAL Çevre Ölçüm ve Analiz Laboratuarı personeli)
Proje Adı ve No: Name and Number of the Project	P-8179/15
Numunenin Kabul Tarihi: Date of Sample Acceptance	25.07.2015
Numunenin Teslim Koşulları: Delivery Conditions of the Sample	TS EN ISO 5667-3 standardına uygun olarak plastik kapta, soğuk ortamda, kimyasal korumalı, Mühürlü - Korumalı
Açıklamalar: Remarks	Kastamonu ili Hanönü ilçesi Gökırmak Dereköy Mevkii "OW-3"den alınan yeraltı suyu numunesinin analizi
Deneyin yapıldığı Tarih: Date of the Test	25.07.2015
Raporun Sayfa Sayısı: Number of the Pages of the Report	2 sayfa

Deney ve/veya ölçüm sonuçları, genişletilmiş ölçüm belirsizlikleri ve deney/ölçüm metotları takip eden sayfalarda verilmiştir. The test and /or measurements results, the uncertainties with confidence probability and test methods are given on the following pages which are part of this report.

Raporu Hazırlayan Prepared by Kübra OLGUN Kimya Mühendisi	Raporu Onaylayan Confirm by Fevzi KARAKAYA Laboratuar Müdürü

SEGAL ÇEVRE ÖLÇÜM ve ANALİZ LABORATUARI
Aşağı Öveçler Mah. 1322.Cad (eski 6.cad) ÇANKAYA-ANKARA
Tel: 0 312 481 83 00 **Fax:** 0 312 481 83 99
mail: segal@segalanaliz.com
web: www.segalanaliz.com
www.segal.com.tr

NUMUNE ADI ve NUMUNE NO: Yeraltı suyu – N-16679/15
SAMPLE NAME and NUMBER

Parametre-Birim Parameter-Unit	**Analiz Sonucu** Test Result	**Analiz Metodu** Test Method
EH (mV)	-39,3	TS EN ISO 10523

"Numuneler ***TS EN ISO 5667-3*** – Su Kalitesi – Numune Alma – Bölüm 3: Numunelerin Muhafaza ve Taşıma Kuralları çerçevesinde saklanır. Bu sure içerisinde kimyasal, mikrobiyolojik ve fiziksel açıdan bozulan veya tehlike arz eden numuneler, numune saklama süresinin bitimi beklemeden imha edilir."

Çevre Koşulları:

Hava Durumu		***Açık***	***Yağış***		***Var***	***Hava Sıcaklığı °C***		***Koordinatlar***	***E***	617579
		Kapalı			***Yok***				***N***	4607693

Görüş ve Yorumlar:

Mühür

İmza

Müşteri Adı / Adresi: Customer Name / Address	ASYA MADEN İŞLETMELERİ A.Ş. Balmumcu Mah. Barbaros Bulv. Morbasan Sok. Koza İş Mrk. C Blok. No:14 Kat:12 Beşiktaş İSTANBUL
Numuneyi Alan Kurum / Kuruluş: Sampler Institution / Company	SEGAL Çevre Ölçüm ve Analiz Laboratuarı (Satılmış DOĞAN)
Numunenin Adı ve Örnekleme Tarihi: Name and Sampling Date of the Sample	Yeraltı suyu N-16677/15 - 24.07.2015
Numunenin Alınış Şekli: Receipt of the Sample Shape	Anlık
Numuneyi Teslim Eden: Deliverer of the Sample	Satılmış DOĞAN (SEGAL Çevre Ölçüm ve Analiz Laboratuarı personeli)
Proje Adı ve No: Name and Number of the Project	P-8179/15
Numunenin Teslim Tarihi: Date of Sample Acceptance	25.07.2015
Numunenin Teslim Koşulları: Delivery Conditions of the Sample	TS EN ISO 5667-3 standardına uygun olarak plastik kapta, soğuk ortamda, kimyasal korumalı, Mühürlü - Korumalı
Açıklamalar: Remarks	Kastamonu ili Hanönü ilçesi Gökırmak Dereköy Mevkii "OW-5"den alınan yeraltı suyu numunesinin analizi
Deneyin Yapıldığı Tarih: Date of the Test	25.07.2015 - 30.07.2015
Raporun Sayfa Sayısı: Number of the Pages of the Report	2 sayfa

Deney ve/veya ölçüm sonuçları, genişletilmiş ölçüm belirsizlikleri ve deney/ölçüm metotları takip eden sayfalarda verilmiştir. The test and/or measurements results, the uncertainties with confidence probability and test methods are given on the following pages which are part of this report.

Raporu Hazırlayan	**Raporu Onaylayan**
Prepared by	Confirm by
Kübra OLGUN Kimya Mühendisi	Fevzi KARAKAYA Laboratuar Müdürü

NUMUNE ADI ve NO: Yeraltı suyu - N-16677/15
Sample Name and Number

Parametre - Birim Parameter - Unit	**Analiz Sonucu** Test Result	**Ölçüm Belirsizliği** Uncertainties	**Analiz Metodu** Test Method
Bakır (mg/L)	0,022	% ± 9,96	EPA 200.7
Biyokimyasal Oksijen İhtiyacı (mg/L)	<4	% ± 3,12	SM 5210 B
Civa (mg/L)	<0,0005	% ± 11,14	SM 3112 B
Çinko (mg/L)	0,041	% ± 1,65	EPA 200.7
Çözünmüş Oksijen (mg/L)	4,95	% ± 0,56	TS EN 5814
Demir (mg/L)	0,776	% ± 3,30	EPA 200.7
İletkenlik (µS/cm)	754	% ± 2,66	TS 9748 EN 27888
Kadmiyum (mg/L)	<0,001	% ± 2,40	EPA 200.7
Kalsiyum (mg/L)	136,7	% ± 2,18	EPA 200.7
Kimyasal Oksijen İhtiyacı (mg/L)	15	% ± 4,72	SM 5220 B
Kurşun (mg/L)	0,037	% ± 3,28	EPA 200.7
Magnezyum (mg/L)	28,39	% ± 1,96	EPA 200.7
Mangan (mg/L)	0,142	% ± 3,78	EPA 200.7
Nikel (mg/L)	<0,005	% ± 1,83	EPA 200.7
pH	7,09	% ± 1,10	TS EN ISO 10523
Potasyum (mg/L)	3,17	% ± 3,72	EPA 200.7
Sıcaklık (°C)	16,7	% ± 0,30	SM 2550 B
Sodyum (mg/L)	25,81	% ± 3,02	EPA 200.7
Sülfat (mg/L)	167,4	% ± 7,62	SM 4500 SO4-2 E

Numuneler TS EN ISO 5667-3 - Su Kalitesi - Numune Alma - Bölüm 3: Numunelerin Muhafaza ve Taşıma Kuralları çerçevesinde saklanır. Bu süre içerisinde kimyasal, mikrobiyolojik ve fiziksel açıdan bozulan veya tehlike arz eden numuneler, numune saklama süresinin bitimi beklemeden imha edilir.

Çevre Koşulları:

Hava Durumu	X	**Açık**	**Yağış**		**Var**	**Hava Sıcaklığı 30 °C**	**Koordinatlar**	**E**	617785
		Kapalı		X	**Yok**			**N**	4607861

Görüş ve Yorumlar:

Mühür

İmza

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<tr><td></td><td>SEGAL</td><td></td></tr>
<tr><td>İlk Basım: 03.05.2010
RP.01 / Rev.01
Rev. Tarihi: 20.01.2011
Sayfa 1 / 2</td><td>SEGAL ÇEVRE ÖLÇÜM ve ANALİZ LABORATUARI
Aşağı Öveçler Mah. 1322.Cad (eski 6.cad) ÇANKAYA-ANKARA
Tel: 0 312 481 83 00 Fax: 0 312 481 83 99
mail: segal@segalanaliz.com
web: www.segalanaliz.com
www.segal.com.tr</td><td>Rapor No
R-15513/15
Rapor Tarihi
30.07.2015</td></tr>
</table>

Müşterinin adı/ adresi: Customer Name / Address	ASYA MADEN İŞLETMELERİ A.Ş. Balmumcu Mah. Barbaros Bulv. Morbasan Sok. Koza İş Mrk. C Blok. No:14 Kat:12 Beşiktaş İSTANBUL
Numuneyi Alan Kurum / Kuruluş ***Sampler Institution / Company***	SEGAL Çevre Ölçüm ve Analiz Laboratuarı (Satılmış DOĞAN)
Numunenin Adı ve Örnekleme Tarihi: Name and Sampling Date of the Sample	Yeraltı suyu N-16677/15 - 24.07.2015
Numunenin Alınış Şekli: Receipt of the Sample Shape	Anlık
Numuneyi Teslim Eden: Deliverer of the Sample	Satılmış DOĞAN (SEGAL Çevre Ölçüm ve Analiz Laboratuarı personeli)
Proje Adı ve No: Name and Number of the Project	P-8179/15
Numunenin Kabul Tarihi: Date of Sample Acceptance	25.07.2015
Numunenin Teslim Koşulları: Delivery Conditions of the Sample	TS EN ISO 5667-3 standardına uygun olarak plastik kapta, soğuk ortamda, kimyasal korumalı, Mühürlü - Korumalı
Açıklamalar: Remarks	Kastamonu ili Hanönü ilçesi Gökırmak Dereköy Mevkii "OW-5"den alınan yeraltı suyu numunesinin analizi
Deneyin yapıldığı Tarih: Date of the Test	25.07.2015
Raporun Sayfa Sayısı: Number of the Pages of the Report	2 sayfa

Deney ve/veya ölçüm sonuçları, genişletilmiş ölçüm belirsizlikleri ve deney/ölçüm metotları takip eden sayfalarda verilmiştir. The test and /or measurements results, the uncertainties with confidence probability and test methods are given on the following pages which are part of this report.

Raporu Hazırlayan Prepared by	Raporu Onaylayan Confirm by
Kübra OLGUN Kimya Mühendisi	Fevzi KARAKAYA Laboratuar Müdürü

NUMUNE ADI ve NUMUNE NO: Yeraltı suyu – N-16677/15
SAMPLE NAME and NUMBER

Parametre-Birim Parameter-Unit	**Analiz Sonucu** Test Result	**Analiz Metodu** Test Method
EH (mV)	-23,7	TS EN ISO 10523

"Numuneler ***TS EN ISO 5667-3*** – Su Kalitesi – Numune Alma – Bölüm 3: Numunelerin Muhafaza ve Taşıma Kuralları çerçevesinde saklanır. Bu sure içerisinde kimyasal, mikrobiyolojik ve fiziksel açıdan bozulan veya tehlike arz eden numuneler, numune saklama süresinin bitimi beklemeden imha edilir."

Çevre Koşulları:

Hava Durumu		***Açık***	***Yağış***		***Var***	***Hava Sıcaklığı °C***	***Koordinatlar***	***E***	617785
		Kapalı			***Yok***			***N***	4607861

Görüş ve Yorumlar:

Mühür

İmza

Bu rapor, laboratuarın yazılı izni olmadan kısmen kopyalanıp çoğaltılamaz. İmzasız ve mühürsüz raporlar geçersizdir. ***Sonuçlar sadece deneyi yapılan numunelere aittir.*** (This report shall not be reproduced other than in full except with the permission of the laboratory. Testing reports without signature and seal are not valid. ***The results belong to the tested sample.***)
Bu rapor çevre mevzuatına ilişkin resmi işlemlerde kullanılamaz.

APPENDIX C

Project Site
Groundwater Level Data

Groundwater Level Measurements

Borehole	Pit Area Boreholes - Groundwater Level (mbgl)												
	25/08/2014	**01/09/2014**	**08/09/2014**	**15/09/2014**	**22/09/2014**	**01/10/2014**	**11/10/2014**	**03/05/2015**	**10/05/2015**	**17/05/2015**	**23/06/2015**	**23/07/2015**	**23/08/2015**
DG-104	15.35	15.45	15.35	15.37	15.43	15.49	15.38	15.35	15.30	15.28	15.10	13.56	12.57
DG-111	78.95	79.00	79.16	79.29	79.39	79.54	79.72	78.86	77.90	77.92	76.20	74.90	76.85
DG-142	17.65	17.75	17.74	17.75	17.82	17.83	17.89	18.18	18.10	18.10	17.40	17.97	18.28
DG-170	12.20	12.24	12.25	12.21	12.28	12.26	12.23	12.20	12.18	12.20	11.90	12.03	12.05
DG-510	19.05	19.10	18.97	18.95	18.94	18.96	18.92	18.90	17.90	18.88	18.80	18.78	18.48
DG-514	13.75	13.95	14.00	-	-	-	-	14.20	13.50	13.70	9.35	12.50	13.04
DG-550	49.93	49.95	43.25	49.85	49.85	-	-	-	-	-	-	-	-
DG-552	21.16	21.62	20.14	21.35	20.81	20.98	21.62	20.80	21.10	-	-	-	-
DG-553	51.58	51.59	48.40	51.55	51.55	36.49	43.85	50.60	48.53	50.80	31.03	30.98	31.50
DG-554	19.05	19.20	17.64	18.70	18.97	18.07	18.63	18.95	18.85	18.20	12.95	16.93	17.45
DG-555	42.13	42.39	42.68	42.90	43.09	43.47	43.12	43.92	44.50	44.15	37.78	36.45	37.10
DG-557	43.74	43.96	43.74	44.17	44.24	43.94	44.32	43.20	43.20	43.05	40.75	38.45	39.55
DG-558	32.37	32.45	32.40	32.42	32.41	32.51	32.55	32.30	32.40	32.43	31.95	30.75	31.85
DG-560	13.60	13.91	13.91	13.92	13.92	13.87	13.87	19.20	19.22	18.68	14.60	15.44	13.35
DG-564	16.90	16.97	17.06	17.09	17.15	17.23	17.22	17.28	17.22	17.25	16.45	16.30	-
DG-565	31.13	31.13	31.13	31.13	31.11	31.15	31.16	31.18	31.20	31.23	30.90	29.43	30.50
OW-1	37.38	37.57	37.74	37.82	37.88	37.93	37.94	35.05	35.22	35.12	31.53	30.63	32.38
OW-2	37.00	37.20	37.34	37.45	37.51	37.58	37.60	34.50	34.53	34.52	29.18	28.94	31.70
OW-3	49.76	49.78	49.83	49.83	49.86	49.86	49.90	45.80	45.75	45.82	45.10	44.65	44.43
OW-4	3.65	3.68	3.62	3.65	3.44	3.12	3.37	2.90	2.85	3.10	2.10	3.13	3.07
OW-5	10.81	10.85	10.79	10.82	10.60	10.23	10.48	9.93	9.88	10.10	9.12	10.12	10.10
SDD-33	30.31	30.35	30.36	30.38	30.40	30.42	30.46	27.50	27.50	27.48	25.67	17.88	15.60
SDD-46	18.65	18.75	18.71	18.70	18.66	18.51	18.72	18.10	18.10	18.05	17.40	17.30	17.45
SDD-47	58.79	58.01	58.70	57.93	58.09	58.34	58.04	60.50	59.70	60.15	-	-	-
SK-10	23.69	23.67	23.69	23.70	23.72	23.78	23.78	22.68	22.67	22.67	22.50	20.85	19.95
SK-9	15.47	15.48	15.52	15.58	15.64	15.73	15.82	11.62	11.68	11.80	11.50	11.35	-

Borehole	Tailings Dam Area Boreholes - Groundwater Level (mbgl)							Comment
	28/08/2014	**04/09/2014**	**11/09/2014**	**19/09/2014**	**03/10/2014**	**09/10/2014**	**17/10/2014**	
KSK-01	14.65	14.78	14.99	15.39	15.76	15.99	16.20	
KSK-02	-	-	-	-	-	-	-	Blocked
KSK-03	8.40	8.46	8.54	8.66	8.77	8.83	8.90	
KSK-04	14.89	14.95	15.03	15.07	15.09	15.12	15.13	
KSK-05	5.90	5.95	6.07	4.34	2.20	3.53	0.00	Artesian
KSK-06	34.90	37.33	35.63	35.69	36.08	36.26	36.45	
KSK-07	16.53	17.56	16.57	16.62	16.65	16.68	16.69	
KSK-08	9.23	9.27	9.32	9.38	9.45	9.49	9.51	
KSK-09	12.98	13.01	13.01	13.06	13.06	13.08	13.08	
KSK-10	-	-	-	-	-	-	-	Mud at 7.76m
KSK-11	-	-	-	-	-	-	-	Blocked
KSK-12	17.26	17.40	17.53	17.74	18.00	18.10	18.12	
KSK-13	-	-	-	-	-	-	-	Blocked
KSK-14	13.50	13.53	13.57	13.63	13.72	12.99	13.08	

Borehole	North Waste Dump (mbgl)	
	21/08/2015	**22/08/2015**
WD-01	5.7	-
WD-02	16.13	-
WD-03	-	24.58

APPENDIX D

DSK Borehole
Packer & Permeability Test Results

Well No.	Well Depth (m)	Lugeon Test		Permeability Test	
		Lugeon Permeability	K (m/s)	Q (L/m)	K (m/s)
DSK-1	2.00-3.80	-	-	0.1	3.23E-06
	4.00-6.00	-	-	0.1	3.07E-06
	5.80-8.00	15.7	1.18E-04	-	-
	8.00-10.00	14.21	9.60E-05	-	-
	10.00-12.00	16.92	1.09E-04	-	-
	12.00-14.00	14.64	9.60E-05	-	-
	14.00-16.00	9.98	6.50E-05	-	-
	16.00-18.30	7.96	5.00E-05	-	-
	18.30-20.30	7.83	5.10E-05	-	-
	20.30-22.00	8.55	5.60E-05	-	-
	22.00-23.00	13.78	8.90E-05	-	-
	23.00-25.00	6.35	4.40E-05	-	-
DSK-2	2.00-4.00	-	-	0.3	1.10E-05
	4.00-6.00	-	-	0.3	1.10E-05
	6.00-8.00	-	-	0.4	1.51E-05
	8.00-10.00	-	-	0.3	1.37E-05
	10.00-12.00	-	-	0.4	1.79E-05
	12.00-14.00	-	-	0.5	2.20E-05
	14.00-16.00	-	-	0.5	2.20E-05
	16.00-18.00	6.34	4.00E-05	-	-
	18.00-20.00	6.59	4.40E-05	-	-
	20.00-22.00	0.93	7.00E-06	-	-
	22.00-24.00	1.99	1.30E-05	-	-
	24.00-26.00	0.81	6.00E-06	-	-
	26.00-28.00	2.25	1.50E-05	-	-
	28.00-30.00	1.54	1.00E-05	-	-
	30.00-32.00	1.65	1.20E-05	-	-
	32.00-34.00	1.76	1.40E-05	-	-
	34.00-35.00	4.78	3.50E-05	-	-
DSK-3	2.00-4.00	-	-	0.3	6.87E-06
	4.00-6.00	-	-	0.2	3.64E-06
	6.00-8.00	-	-	0.3	6.46E-06
	8.00-10.00	-	-	0.3	8.08E-06
	10.00-12.00	-	-	0.3	6.87E-06
	12.00-14.00	-	-	0.3	6.46E-06
	14.00-16.00	-	-	0.3	7.27E-06
	16.00-18.00	-	-	0.4	9.70E-06
	18.00-20.00	-	-	0.4	8.89E-06
	20.00-22.00	-	-	0.4	8.89E-06
	22.00-24.00	-	-	0.4	9.70E-06
	26.00-28.00	-	-	0.4	9.70E-06
	28.00-30.00	-	-	0.4	9.70E-06
	30.00-32.00	-	-	0.4	9.70E-06
	32.00-34.00	-	-	0.3	6.46E-06
	50.00-52.00	4.76	3.30E-05	-	-
	52.00-54.00	4.86	3.70E-05	-	-
	54.00-56.00	4.6	3.20E-05	-	-
	56.00-58.00	4.76	3.10E-05	-	-

	58.00-60.00	4.3	2.90E-05	-	-
	60.00-62.00	0.54	5.00E-06	-	-
	62.00-64.00	0.76	6.00E-06	-	-
	64.00-66.00	0.73	4.00E-06	-	-
	66.00-68.00	0.51	5.00E-06	-	-
	68.00-70.00	0.66	5.00E-06	-	-
	70.00-72.00	1.89	1.50E-05	-	-
	72.00-74.00	1.81	1.50E-05	-	-
	74.00-76.00	2.71	1.80E-05	-	-
	76.00-78.00	2.85	1.90E-05	-	-
	78.00-80.00	2.36	1.60E-05	-	-
	80.00-82.00	0.85	7.00E-06	-	-
	82.00-84.00	0.95	6.00E-06	-	-
	84.00-85.00	0.78	7.00E-06	-	-
DSK-4	2.00-4.00	-	-	0.4	3.85E-06
	4.00-6.00	-	-	0.5	4.81E-06
	6.00-8.00	4.23	2.80E-05	-	-
	8.00-10.00	3.49	2.30E-05	-	-
	10.00-12.00	4.74	2.90E-05	-	-
	12.00-14.00	3.69	2.50E-05	-	-
	14.00-16.00	3.36	2.20E-05	-	-
	16.00-18.00	0.96	8.00E-06	-	-
	18.00-20.00	0.99	8.00E-06	-	-
	20.00-22.00	0.85	8.00E-06	-	-
	22.00-24.00	0.49	6.00E-06	-	-
	24.00-25.00	0.8	1.00E-05	-	-
DSK-5	2.00-4.00	-	-	0.7	2.78E-05
	4.00-6.00	-	-	2.8	1.06E-04
	6.00-8.00	-	-	2.6	9.85E-05
	8.00-10.00	-	-	3.7	1.41E-04
	10.00-12.00	-	-	4.4	1.67E-04
	12.00-14.00	4.38	3.50E-05	5.2	1.97E-04
	14.00-16.00	5.27	3.40E-05	-	-
	16.00-18.00	4.28	3.00E-05	-	-
	18.00-20.00	3.48	2.50E-05	-	-
	20.00-22.00	3.63	2.50E-05	-	-
	22.00-24.00	3.03	1.90E-05	-	-
	24.00-26.00	2.9	1.90E-05	-	-
	26.00-28.00	5.25	4.40E-05	-	-
	28.00-30.00	2.93	2.10E-05	-	-
	30.00-32.00	2.41	1.60E-05	-	-
	32.00-34.00	2.21	1.50E-05	-	-
	34.00-36.00	1.86	1.30E-05	-	-
	36.00-38.00	1.65	1.10E-05	-	-
	38.00-39.50	2.24	1.60E-05	-	-
	39.50-41.50	2.55	1.90E-05	-	-
	41.50-43.70	2.31	1.70E-05	-	-
DSK-6	2.00-4.00	-	-	0.3	1.76E-06
	4.00-6.00	-	-	0.3	1.41E-06
	6.00-8.00	-	-	0.3	1.76E-06

	8.00-10.00	-	-	0.9	4.57E-06
	10.00-12.00	-	-	0.3	1.41E-06
	12.00-14.00	-	-	0.2	8.78E-07
	14.00-16.00	-	-	0.2	1.23E-06
	16.00-18.00	-	-	0.2	1.23E-06
	18.00-20.00	-	-	0.3	1.41E-06
	20.00-22.00	-	-	0.5	2.81E-06
	22.00-24.00	-	-	0.5	2.46E-06
	24.00-26.00	7.89	5.50E-05	-	-
	26.00-28.00	9.39	6.20E-05	-	-
	28.00-30.00	7.06	4.30E-05	-	-
	30.00-32.00	6.64	4.40E-05	-	-
	32.00-34.00	7.13	4.90E-05	-	-
	34.00-36.00	3.03	2.10E-05	-	-
	36.00-38.00	3.08	2.00E-05	-	-
	38.00-40.00	3.23	2.20E-05	-	-
	40.00-42.00	1.06	9.00E-06	-	-
	42.00-44.00	1.74	1.30E-05	-	-
	44.00-46.00	2.29	1.40E-05	-	-
	46.00-48.50	2.05	1.30E-05	-	-
	48.50-50.00	1.64	1.10E-05	-	-
DSK-7	2.00-4.00	-	-	0.2	4.44E-06
	4.00-6.00	-	-	0.4	8.48E-06
	6.00-8.00	-	-	0.6	1.37E-05
	8.00-10.00	-	-	0.6	1.45E-05
	10.00-12.00	-	-	0.5	1.29E-05
	12.00-14.00	-	-	0.4	1.05E-05
	14.00-16.00	-	-	0.3	6.87E-06
	16.00-18.00	-	-	0.3	6.06E-06
	18.00-20.00	-	-	0.5	1.13E-05
	20.00-22.00	-	-	0.6	3.16E-06
	22.00-24.00	-	-	0.7	3.86E-06
	24.00-26.00	-	-	0.5	1.10E-05
	26.00-28.00	-	-	0.5	1.29E-05
	28.00-30.00	-	-	0.6	1.54E-05
	30.00-32.00	-	-	0.5	1.21E-05
	32.00-34.00	-	-	0.3	8.08E-06
	34.00-36.00	-	-	0.5	1.13E-05
	36.00-38.00	-	-	0.4	9.70E-06
	38.00-40.30	-	-	0.4	1.05E-05
	40.30-41.70	-	-	0.3	8.08E-06
	41.70-43.20	6.42	4.70E-05	-	-
	43.20-45.10	4.91	3.30E-05	-	-
	45.10-47.10	0.98	1.10E-05	-	-
	47.10-50	0.6	4.00E-06	-	-
DSK-8	2.00-4.00	-	-	0.2	8.08E-06
	4.00-6.00	-	-	0.2	8.08E-06
	4.00-7.00	3.96	2.70E-05	-	-
	7.00-9.50	4.75	3.20E-05	-	-
	9.50-12.00	4.75	3.20E-05	-	-

	12.00-14.00	5.94	4.00E-05	-	-
	14.00-16.00	5.94	4.00E-05	-	-
	16.00-18.00	5.3	3.70E-05	-	-
	18.00-20.00	5.34	3.60E-05	-	-
	20.00-22.00	6.12	3.90E-05	-	-
	22.00-24.00	6.27	4.20E-05	-	-
	24.00-26.00	5.6	3.60E-05	-	-
	26.00-28.00	3.76	2.80E-05	-	-
	28.00-30.00	1.05	8.00E-06	-	-
DSK-9	2.00-4.00	-	-	0.3	1.63E-06
	4.00-6.00	-	-	0.6	2.93E-06
	6.00-8.00	-	-	2.1	1.04E-05
	8.00-10.00	-	-	1.8	8.93E-06
	10.00-12.00	-	-	1.4	7.01E-06
	12.00-14.00	-	-	1.2	5.87E-06
	14.00-16.00	-	-	1.3	6.19E-06
	16.00-18.00	-	-	1	4.89E-06
	18.00-20.20	4.25	2.90E-05	0.7	3.26E-06
	20.20-22.20	4.73	3.10E-05	-	-
	22.20-24.10	5.2	3.50E-05	-	-
	24.10-26.00	4.97	3.50E-05	-	-
	26.00-28.00	4.38	3.00E-05	-	-
	28.00-30.00	4.58	3.00E-05	-	-
	30.00-32.20	3.32	2.40E-05	-	-
	32.20-34.00	4.29	3.00E-05	-	-
	34.00-36.00	3.45	2.40E-05	-	-
	36.00-37.90	3.25	2.10E-05	-	-
	37.90-40.00	2.82	1.80E-05	-	-
DSK-10	2.00-4.00	-	-	0.4	1.05E-05
	4.00-6.00	-	-	0.5	1.13E-05
	6.00-8.00	-	-	0.4	8.89E-06
	8.00-10.00	-	-	0.3	8.08E-06
	10.00-12.00	-	-	0.4	8.48E-06
	12.00-14.20	1.72	1.20E-05	0.4	1.05E-05
	14.20-16.10	5.08	3.40E-05	-	-
	16.10-18.10	5.05	3.40E-05	-	-
	18.10-20.00	5.21	3.70E-05	-	-
	20.00-21.90	5.16	3.30E-05	-	-
	21.90-22.90	7.1	5.10E-05	-	-
	22.90-25.00	4.1	2.70E-05	-	-
	25.00-26.90	3.79	2.50E-05	-	-
	26.90-28.50	3.69	2.50E-05	-	-
	28.50-31.00	1.81	1.20E-05	-	-
	31.00-33.50	0.7	5.00E-06	-	-
	33.50-36.00	0.85	7.00E-06	-	-

APPENDIX E

GT Borehole
Packer Test Results

GOK GT003

Depth (m)	min	Adopted Lv	k (m/s)	Lithology/Structure
170-172	1.5 dk	21	2.70E-06	MSCH
	2.5 dk	12	1.52E-06	
158-160	1.5 dk	132	1.71E-05	MSCH
	2.5 dk	50	6.50E-06	
148-150	1.5 dk	25	3.22E-06	MSCH
	2.5 dk	13	1.73E-06	
140-142	1.5 dk	52	6.76E-06	MSCH
	2.5 dk	33	4.28E-06	
130-132	1.5 dk	8	9.75E-07	Fault
	2.5 dk	4	5.20E-07	
119-121	1.5 dk	19	2.51E-06	MSCH
	2.5 dk	13	1.66E-06	
108-110	1.5 dk	16	2.06E-06	MSCH
	2.5 dk	9	1.19E-06	
98-100	1.5 dk	-	-	MSCH
	2.5 dk	-	-	
90-92	1.5 dk	38	4.88E-06	MSCH
	2.5 dk	23	2.93E-06	
78-80	1.5 dk	13	1.63E-06	GSCH
	2.5 dk	8	9.75E-07	
70-72	1.5 dk	17	2.17E-06	MSCH
	2.5 dk	17	2.19E-06	
58-60	1.5 dk	31	4.06E-06	MSCH
	2.5 dk	18	2.39E-06	
48-50	1.5 dk	18	2.37E-06	MSCH
	2.5 dk	9	1.11E-06	
39-41	1.5 dk	71	9.19E-06	MSCH/GSCH
	2.5 dk	66	8.55E-06	
28-30	1.5 dk	-	-	
	2.5 dk	-	-	
20-22	1.5 dk	-	-	
	2.5 dk	-	-	

GOK GT007

Depth (m)	Min.	Adopted Lv	k (m/s)	Lithology/Structure
190-192	1. 5 dk	67	8.75E-06	FB
	2. 5 dk	39	5.12E-06	
180-182	1. 5 dk	49	6.33E-06	FB
	2. 5 dk	25	3.3E-06	
170-172	1. 5 dk	57	7.37E-06	FB
	2. 5 dk	34	4.39E-06	
160-162	1. 5 dk	74	9.62E-06	FB
	2. 5 dk	22	2.86E-06	
150-152	1. 5 dk	44	5.72E-06	MSCH
	2. 5 dk	21	2.73E-06	
140-142	1. 5 dk	61	7.88E-06	FB
	2. 5 dk	28	3.64E-06	
130-132	1. 5 dk	20	2.6E-06	MSCH
	2. 5 dk.	8	1.04E-06	
118-120	1. 5 dk	58	7.54E-06	MSCH/FB
	2. 5 dk.	17	2.26E-06	
108-110	1. 5 dk.	45	5.85E-06	MSCH
	2. 5 dk.	33	4.24E-06	
98-100	1. 5 dk.	184	2.39E-05	GSCH
	2. 5 dk.	40	5.17E-06	
91-93	1. 5 dk.	47	6.11E-06	GSCH
	2. 5 dk.	32	4.11E-06	
78-80	1. 5 dk.	-	-	
	1. 5 dk.	-	-	
68-70	2. 5 dk.	-	-	
	1. 5 dk.	-	-	
60-62	2. 5 dk.	-	-	
	1. 5 dk.	-	-	
48-50	1. 5 dk.	-	-	
	2. 5 dk.	-	-	
38-40	1. 5 dk.	-	-	
	1. 5 dk.	-	-	
28-30	2. 5 dk.	-	-	
	1. 5 dk.	-	-	
18-20	2. 5 dk.	-	-	
	1. 5 dk.	-	-	
8_10	1. 5 dk.	-	-	
	2. 5 dk.	-	-	

GOK GT013

Depth	Min.	Adopted Lv	k	Lithology/Structure
(m)			(m/s)	
	1. 5 dk.	2	2.17E-07	
178-180	2. 5 dk.	1	1.3E-07	GSCH
	1. 5 dk.	136	1.77E-05	
168-170	2. 5 dk.	56	7.24E-06	MSCH
	1. 5 dk.	-	-	
158-160	2. 5 dk.	-	-	
	1. 5 dk.	-	-	
148-150	2. 5 dk.	-	-	
	1. 5 dk.	-	-	
138-140	2. 5 dk.	-	-	
	1. 5 dk.	-	-	
128-130	2. 5 dk.	-	-	
	1. 5 dk.	-	-	
118-120	1. 5 dk.	-	-	
	2. 5 dk.	-	-	
108-110	1. 5 dk.	-	-	
	2. 5 dk.	-	-	
98-100	1. 5 dk.	-	-	
	1. 5 dk.	-	-	
88-90	2. 5 dk.	-	-	
	1. 5 dk.	-	-	
78-80	2. 5 dk.	-	-	
	1. 5 dk.	22	2.82E-06	
68-70	1. 5 dk.	13	1.68E-06	SMCU/MCU
	2. 5 dk.	-	-	
58-60	1. 5 dk.	-	-	
	2. 5 dk.	-	-	
48-50	1. 5 dk.	-	-	
	1. 5 dk.	115	1.5E-05	
38-40	2. 5 dk.	70	9.08E-06	FB-MSCH

GOK GT014

Depth	Min.	Adopted Lv	k	Lithology/Structure
(m)			(m/s)	
	1. 5 dk.	-	-	
128-130	2. 5 dk.	-	-	
	1.5 dk.	-	-	
118-120	2.5 dk.	-	-	
	1. 5 dk.	5.9	7.66E-07	
108-110	2. 5 dk.	4.0	5.17E-07	FB
	1. 5 dk.	1.1	1.44E-07	
98-100	2. 5 dk.	0.5	6.5E-08	FB
	1. 5 dk.	-	-	
88-90	2. 5 dk.	-	-	
	1. 5 dk.	5.8	7.58E-07	
78-80	1. 5 dk.	18.0	2.34E-06	FB
	2. 5 dk.	44.1	5.73E-06	
68-70	1. 5 dk.	31.0	4.03E-06	GSCH
	2. 5 dk.	11.0	1.44E-06	
60-62	1. 5 dk.	11.0	1.43E-06	MCU
	1. 5 dk.	-	-	
48-50	2. 5 dk.	-	-	
	1. 5 dk.	3.3	4.33E-07	
38-40	1. 5 dk.	16.0	2.08E-06	MSCH
	2. 5 dk.	353.3	4.59E-05	
28-30	1. 5 dk.	197.0	2.56E-05	GSCH/MSCH
	2. 5 dk.	172.0	2.24E-05	
18-20	1. 5 dk.	133.3	1.73E-05	GSCH
	1. 5 dk.	2.8	3.61E-07	
8_10	2. 5 dk.	2.2	2.82E-07	GSCH

APPENDIX F

GT Borehole
Airlift Recovery Data

BH ID	OW1	Discharge Monitoring	1	2	3	4
Date:	28/05/2015	Pumping time (mins)	2	15	30	45
Time	14:44	EC (µS/cm)	1861	1831	1829	1825
Monitored By:	MB	pH	6.71	7.08	7.45	7.3
Test Number:	2	Temp (oC)	14	14.2	13.9	14
Time Air On	15:42	Flow (L/min)	156	169	152	150
Time Air Off	16:31					
Duration of airlift (mins):	49					
Height of Casing (magl):	1.32					
Dip:	90					
SWL at Start (mtoc):	34.53					

Time Since Pumping Stopped (min)	Water Level (mbtoc)	Comment
1		
2		
3		
4		
5	38.51	88.58
6.5	37.95	88.02
7	37.84	87.91
8	37.80	87.87
9	37.57	87.64
10	37.78	87.85
12	37.72	87.79
14	37.80	87.87
16	37.83	87.90
18	37.67	87.74
20	37.43	87.50
25	37.16	87.23
30	37.06	87.13
35	36.96	87.03
40	36.89	86.96
45	36.82	86.89

OW-2			
Eastings	Northings	Ground Elevation (mRL)	Casing Height (m)
617499.56	4607769.96	468.83	0.70
Lenght of Test Section (m)	6		
Screen Radius (m)	0.05		
Date of Injection	03/08/2013 14:27		
Static water level (mbgl)	36.09		
Maximum head (maswl)	15		
Maximum Displacement (m)	21.09		
Logger Data:			
Date	Time (mins)	Level (mbgl)	Residual Excess Head (maswl)
04/08/2013 12:00	1293	31.63	4.46
04/08/2013 13:00	1353	31.81	4.28
04/08/2013 14:00	1413	31.96	4.13
04/08/2013 15:00	1473	32.09	4
04/08/2013 16:00	1533	32.23	3.86
04/08/2013 17:00	1593	32.38	3.71
04/08/2013 18:00	1653	32.54	3.55
04/08/2013 19:00	1713	32.67	3.42
04/08/2013 20:00	1773	32.82	3.27
04/08/2013 21:00	1833	32.94	3.15
04/08/2013 22:00	1893	33.08	3.01
04/08/2013 23:00	1953	33.2	2.89
05/08/2013 00:00	2013	33.33	2.76
05/08/2013 01:00	2073	33.44	2.65
05/08/2013 02:00	2133	33.55	2.54
05/08/2013 03:00	2193	33.66	2.43
05/08/2013 04:00	2253	33.75	2.34
05/08/2013 05:00	2313	33.84	2.25
05/08/2013 06:00	2373	33.93	2.16
05/08/2013 07:00	2433	34.01	2.08
05/08/2013 08:00	2493	34.09	2
05/08/2013 09:00	2553	34.16	1.93
05/08/2013 10:00	2613	34.23	1.86
05/08/2013 11:00	2673	34.3	1.79
05/08/2013 12:00	2733	34.35	1.74
05/08/2013 13:00	2793	34.41	1.68
05/08/2013 14:00	2853	34.46	1.63
05/08/2013 15:00	2913	34.5	1.59
05/08/2013 16:00	2973	34.56	1.53
05/08/2013 17:00	3033	34.6	1.49
05/08/2013 18:00	3093	34.63	1.46
05/08/2013 19:00	3153	34.68	1.41
05/08/2013 20:00	3213	34.73	1.36
05/08/2013 21:00	3273	34.77	1.32
05/08/2013 22:00	3333	34.81	1.28
05/08/2013 23:00	3393	34.86	1.23
06/08/2013 00:00	3453	34.89	1.2
06/08/2013 01:00	3513	34.93	1.16
06/08/2013 02:00	3573	34.97	1.12
06/08/2013 03:00	3633	35.02	1.07
06/08/2013 04:00	3693	35.05	1.04
06/08/2013 05:00	3753	35.09	1
06/08/2013 06:00	3813	35.11	0.98
06/08/2013 07:00	3873	35.14	0.95
06/08/2013 08:00	3933	35.18	0.91
06/08/2013 09:00	3993	35.21	0.88
06/08/2013 10:00	4053	35.24	0.85
06/08/2013 11:00	4113	35.26	0.83
06/08/2013 12:00	4173	35.29	0.8
06/08/2013 13:00	4233	35.31	0.78
06/08/2013 14:00	4293	35.33	0.76
06/08/2013 15:00	4353	35.36	0.73
06/08/2013 16:00	4413	35.38	0.71
06/08/2013 17:00	4473	35.4	0.69
06/08/2013 18:00	4533	35.42	0.67
06/08/2013 19:00	4593	35.43	0.66
06/08/2013 20:00	4653	35.45	0.64
06/08/2013 21:00	4713	35.48	0.61
06/08/2013 22:00	4773	35.5	0.59
06/08/2013 23:00	4833	35.52	0.57
07/08/2013 00:00	4893	35.53	0.56
07/08/2013 01:00	4953	35.55	0.54
07/08/2013 02:00	5013	35.57	0.52
07/08/2013 03:00	5073	35.59	0.5
07/08/2013 04:00	5133	35.61	0.48
07/08/2013 05:00	5193	35.61	0.48
07/08/2013 06:00	5253	35.63	0.46
07/08/2013 07:00	5313	35.64	0.45
07/08/2013 08:00	5373	35.65	0.44
07/08/2013 09:00	5433	35.67	0.42

BH ID	**OW3**	Discharge Monitoring	1	2	3	4
Date:	27/05/2015	Pumping time (mins)	3	15		
Time	09:30	EC (µS/cm)				
Monitored By:	GB	pH				
Test Number:	1	Temp (oC)				
Time Air On	10:01	Flow (L/min)		5		
Time Air Off	10:17					
Duration of airlift (mins):	16					
Height of Casing (magl):	1.17					
Dip:	90					
SWL at Start (mtoc):	46.25					

Time Since Pumping Stopped (min)	**Water Level (mbtoc)**	**Comment**
1		
2		
3		
4.5	53.40	
5.5	53.35	
6		
7	52.87	
8	52.50	
9	52.37	
10	52.18	
12		Headworks Removed
20	49.00	
25	48.97	
35	48.60	
40	48.66	
45	48.43	
50	48.24	
60	47.85	
70	47.59	

BH ID	**OW4**	Discharge Monitoring	1	2	3	4
Date:	26/05/2015	Pumping time (mins)	2	10	20	25
Time	10:00	EC (µS/cm)				
Monitored By:	GB	pH				
Test Number:	1	Temp (oC)				
Time Air On	10:23	Flow (L/min)	40	30	30	30
Time Air Off	10:58					
Duration of airlift (mins):	35					
Height of Casing (magl):	0.69					
Dip:	90					
SWL at Start (mtoc):	3.33					

Time Since Pumping Stopped (min)	**Water Level (mbtoc)**	**Comment**
1	8.39	
2	7.98	
3	7.42	
4	7.01	
5	6.75	
6	6.36	
7	6.10	
8	6.05	
9	5.80	
10	5.75	
12	5.50	
14	5.25	
16	5.01	
18	4.84	
20	4.68	
25	4.36	
30	4.17	
35	3.98	
40	3.85	
45	3.73	

BH ID	OW5	**Discharge Monitoring**	1	2	3	4
Date:	26/05/2015	Pumping time (mins)	2	10	20	30
Time	14:14	EC (µS/cm)				
Monitored By:	GB	pH				
Test Number:	**1**	Temp (oC)				
Time Air On	15:04	Flow (L/min)	100	100	100	127
Time Air Off	15:38					
Duration of airlift (mins):	**34**					
Height of Casing (magl):	1.32					
Dip:	90					
SWL at Start (mtoc):	10.71					

Time Since Pumping Stopped (min)	**Water Level (mbtoc)**	**Comment**
1		
2	11.53	
3	11.23	
4	11.11	
5	11.03	
6	11.01	
7	10.98	
8	10.97	
9	10.95	
10	10.93	
12		
14	9.91	
16	9.78	
18	9.63	
20	9.75	
25	9.60	
30	9.59	
35		
40		
45		

BH ID	GT-002	Discharge Monitoring	1	2	3	4
Date:	10/07/2015	Pumping time	2	15	30	45
Time	17:48	EC (µS/cm)	1358	1082	1016	1030
Monitored By:	M.BAYRAM	pH	8.7	8.9	8.85	8.82
Test Number:	1	Temp (oC)	17.6	17.1	16.9	17.6
Time Air On	18:00	Flow (L/min)	160	48	30	10
Time Air Off	18:50	Flow (m3/d)	230	69	43	14
Duration of airlift (mins):	50					
Height of Casing with headworks (magl):18cm						
SWL at Start (mtoc):	5.4					
Total Borehole Depth (m)	150					
Lenght of Water Column (m)	144.6					
Vertical Lenght of Water Column (m)	135.89					
Lenght of slotted PVC (M)	100.00					
Vertical Lenght of PVC (m)	93.97					
Dip	70					

Time Since Pumping Stopped (min)	Water Level (mbtoc)	Comment
1		
2		
3		
4		
5		
6		
7		
8		
9		
10	5.27	
12	5.28	
14	5.48	
16	5.47	
18	5.46	
20	5.44	
25	5.41	
30	5.38	
35	5.38	
40		
45		
50		
60		
70		

BH ID	GT-003	Discharge Monitoring	1	2	3	4	5
Date:	13/07/2015	Pumping time	4	15	30	45	60
Time	14:08	EC (µS/cm)	2042	1643	1446	1378	1342
Monitored By:	M.BAYRAM	pH	9.1	9.04	8.89	8.51	8.51
Test Number:	1	Temp (oC)	21.4	17.7	17.4	17.2	17.2
Time Air On	14:16	Flow (L/min)	60	44.44	38.41	36.36	33.33
Time Air Off	15:24						
Duration of airlift (mins):	68						
Height of Casing with headworks (magl):40cm							
SWL at Start (mtoc):	20.67						
Total Borehole Depth (m)	200						
Lenght of Water Column (m)	179.33						
Vertical Lenght of Water Column	168.52						
Lenght of slotted PVC (M)	150.00						
Vertical Lenght of PVC (m)	140.96						
Dip	70						

Time Since Pumping Stopped (min)	Water Level (mbtoc)	Comment
1		
2		
3		
4	26.77	
5		
6	22.35	
7	22	
8	21.79	
9	21.6	
10	21.43	
12	21.3	
14	21.2	
16	21.03	
18	20.9	
20	20.83	
25	20.67	
30		
35		
40		
45		
50		
60		
70		

BH ID	GT-007	Discharge Monitoring	1	2	3	4
Date:	13/07/2015	Pumping time	2	15	30	45
Time	12:05	EC (µS/cm)	1714	1066	1016	951
Monitored By:	M.BAYRAM	pH	8.42	8.5	8.6	8.6
Test Number:	1	Temp (oC)	17	16	16.9	16
Time Air On	12:25	Flow (L/min)	198	198	150	109.1
Time Air Off	13:14	Flow (m3/d)	285	285	216	157
Duration of airlift (mins):	46					
Height of Casing with headworks (magl):	0.047					
SWL at Start (mtoc):	50.39					
Total Borehole Depth (m)	220					
Lenght of Water Column (m)	169.61					
Vertical Lenght of Water Column (m)	159.39					
Lenght of slotted PVC (m)	150.00					
Vertical Lenght of PVC (m)	140.96					
Dip	70					

Time Since Pumping Stopped (min)	Water Level (mbtoc)	Comment
1		
2		
3		
4		
5		
6	50.49	
7	50.46	
8	50.46	
9	50.46	
10		
12		
14		
16		
18		
20		
25		
30		
35		
40		
45		
50		
60		
70		

BH ID	**GT-007**	**Pumping time**	**EC (µS/cm)**	**pH**	**Temp (oC)**	**Flow (L/min)**
Date:	19/08/2015	2	1262	9.32	16.7	112
Time	14:45	20	1303	9.27	15.6	100
Monitored By:	M.BAYRAM	40	1252	9.25	15.6	112
Test Number:	2	60	1184	9.15	15.4	112
Time Air On	15:06	80	1145	8.81	15.3	112
Time Air Off	17:46	100	1160	8.79	15	112
Duration of airlift (mins):	160	120	1136	8.86	15.1	112
Height of Casing with headworks (magl):	0.47	140	1162	8.76	15.1	112
SWL at Start (mtoc):	**50.51**	160	1160	8.8	14.9	112
Total Borehole Depth (m)	200					
Lenght of Water Column (m)	149.49					
Vertical Lenght of Water Column (m)	140.48					
Lenght of slotted PVC (m)	147.00					
Vertical Lenght of PVC (m)	138.14					
Dip	70					

Time Since Pumping Stopped (min)	**Water Level (mbtoc)**	**Comment**
1		
2	51.9	
3	51.86	
4	51.8	
5	51.8	
6	51.8	
7		
8		
9		
10		
12		
14		
16		
18		
20		
25		
30		
35		
40		
45		
50		
60		
70		

BH ID	GT009	Discharge Monitoring	1	2	3	4
Date:	19/08/2015	Pumping time (mins)	3	15		
Time	11:00	EC (µS/cm)	780	920		
Monitored By:	MB	pH	9.44	9.62		
Test Number:	1	Temp (oC)	19.3	20		
Time Air On	11:14	Flow (L/min)	4.28	3.2		
Time Air Off	11:32					
Duration of airlift (mins):	18					
Height of Casing (magl):	0.17					
Dip:	70					
SWL at Start (mtoc):	73.6					

Time Since Pumping Stopped (min)	Water Level (mbtoc)	Comment
1		
2		
3		
4		
5		
6		
7	102.00	
8	101.71	
9	101.43	
10	101.28	
12	101.05	
14	100.80	
16	100.58	
18	100.37	
20	100.19	
25	99.88	
30	99.53	
35	99.26	
40	99.03	
45	98.81	
50	98.6	
60	98.55	

BH ID	GT011	**Discharge Monitoring**	1	2	3	4
Date:	18/008/15	Pumping time (mins)	4	15		
Time	13:40	EC (µS/cm)	1284	1271		
Monitored By:	MB	pH	7.35	7.96		
Test Number:	1	Temp (oC)	20.3	19.1		
Time Air On	13:55	Flow (L/min)	<10	<10		
Time Air Off	14:13					
Duration of airlift (mins):	18					
Height of Casing (magl):	0.2					
Dip:	70					
SWL at Start (mtoc):	19.61					

Time Since Pumping Stopped (min)	Water Level (mbtoc)	Comment
1		
2		
3		
4	39.81	
5	35.93	
6	33.90	
7	32.91	
8	31.26	
9	29.20	
10	27.50	
12	26.17	
14	25.50	
16	24.65	
18	24.10	
20	22.95	
25	21.93	
30	21.37	
35	20.90	
40	20.41	
45	19.97	
50	19.81	

BH ID	GT-013	Discharge Monitoring	1	2	3	4
Date:	10/07/2015	Pumping time	2	15	30	45
Time	15:09	EC (µS/cm)	2157	2271	2194	2200
Monitored By:	M.BAYRAM	pH	7.57	8.18	8.22	8.22
Test Number:	1	Temp (oC)	23.7	19.8	18.8	17.5
Time Air On	15:14	Flow (L/min)	12	12.5	12.7	11.21
Time Air Off	16:19					
Duration of airlift (mins):	60					
Height of Casing with headworks (magl):0	0					
SWL at Start (mtoc):	54.72					
Total Borehole Depth (m)	**180**					
Lenght of Water Column (m)	125.28					
Vertical Lenght of Water Column (m)	117.73					
Lenght of slotted PVC (m)	150.00					
Vertical Lenght of PVC (m)	140.96					
Borehole Dip	70					

Time Since Pumping Stopped (min)	Water Level (mbtoc)	Comment
1		
2		
3		
4		
5		
6		
7		
8		
9	61.68	
10	61.58	
12	61.42	
14	61.31	
16	61.28	
18	61.27	
20	61.24	
25	61.18	
30	61.14	
35	61.12	
40	61.09	
45	61.08	
50	61.07	
60	61.07	
70		

BH ID	GT015	**Discharge Monitoring**	1	2	3	4
Date:	21/08/2015	Pumping time (mins)	3			
Time	09:20	EC (µS/cm)	1672			
Monitored By:	MB	pH	13.1			
Test Number:	**2**	Temp (oC)	19.6			
Time Air On	09:27	Flow (L/min)	8			
Time Air Off	09:32					
Duration of airlift (mins):	**5**					
Height of Casing (magl):	0.13					
Dip:	70					
SWL at Start (mtoc):	7.5					

Time Since Pumping Stopped (min)	Water Level (mbtoc)	Comment
1		
2	28.57	
3	25.87	
4	23.97	
5	22.77	
6	21.47	
7	20.67	
8	20.27	
9	19.57	
10	19.17	
12	18.27	
14	17.24	
16	17.07	
18	16.97	
20	16.74	
25	16.27	
30	15.99	
35	15.72	
40	15.22	
45	14.62	
50	13.87	
60	13.47	

BH ID	**WD01**	**Discharge Monitoring**	1	2	3	4
Date:	21/08/2015	Pumping time (mins)	2			
Time	11:15	EC (µS/cm)	1710			
Monitored By:	MB	pH	10.1			
Test Number:	**1**	Temp (oC)	21			
Time Air On	11:32	Flow (L/min)	3.3			
Time Air Off	11:37					
Duration of airlift (mins):	**5**					
Height of Casing (magl):	0.2					
Dip:	80					
SWL at Start (mtoc):	5.9					

Time Since Pumping Stopped (min)	**Water Level (mbtoc)**	**Comment**
1	25.00	
2	24.80	
3	24.70	
4	24.49	
5	24.33	
6	24.25	
7	24.19	
8	24.11	
9	24.03	
10	23.88	
12	23.73	
14	23.59	
16	23.45	
18	23.32	
20	23.20	
25	22.82	
30	22.50	
35	22.13	
40	21.78	
45	21.50	
50	21.17	
60	20.92	

BH ID	**WD002**	Discharge Monitoring	1	2	3	4	5
Date:	21/08/2015	Pumping time	3	15	30	45	60
Time	16:09	EC (µS/cm)	2550	2500	2554	2560	2529
Monitored By:	M.BAYRAM	pH	9.75	8.72	8.55	8.12	8.05
Test Number:	1	Temp (oC)	20	18.9	18	17.4	16.9
Time Air On	16:24	Flow (L/min)	22.5	23.07	24.03	24.03	24
Time Air Off	17:26						
Duration of airlift (mins):	60						
Height of Casing with headworks (magl):0cm	20						
SWL at Start (mtoc):	16.33						
Total Borehole Depth (m)	**54**						
Lenght of Water Column (m)	37.67						
Vertical Lenght of Water Column (m)	37.10						
Lenght of slotted PVC (m)	20.00						
Vertical Lenght of PVC (m)	19.70						
Borehole Dip	80						

Time Since Pumping Stopped (min)	Water Level (mbtoc)	Comment
1	22.2	
2	20.2	
3	18	
4	16.85	
5	16.33	
6		
7		
8		
9		
10		
12		
14		
16		
18		
20		
25		
30		
35		
40		
45		
50		
60		
70		

BH ID	KSK-15	Discharge Monitoring	1	2	3	4	5	6	7
Date:	25/08/2015	Pumping time	2	15	30	45	60	75	90
Time	13:53	EC (µS/cm)	2017	1905	1817	1824	1871	1853	1848
Monitored By:	M.BAYRAM	pH	9.84	8.24	8.71	8.74	8.68	8.71	8.72
Test Number:	1	Temp (oC)	16.4	16.2	16.6	16.01	16.3	16.1	16.1
Time Air On	13:59	Flow (L/min)	260	157	255	255	255	254.9	254.8
Time Air Off	15:30	Flow (m3/d)	374	226	367	367	367	367	367
Duration of airlift (mins):	91								
Height of Casing with headworks (magl): 0.23									
SWL at Start (mtoc):	12.47								

Time Since Pumping Stopped (min)	Water Level (mbtoc)	Comment
1		
2	19.17	
3	19.17	
4	19.37	
5	19.32	
6	19.36	
7	19.34	
8	19.21	
9	19.15	
10	19.02	
12	18.93	
14	18.85	
16	18.78	
18	18.71	
20	18.5	
25	18.34	
30	18.21	
35	18.09	
40	17.98	
45	17.87	
50	17.67	
60		
70		

BH ID	**KSK-17**	Discharge Monitoring	1	2	3	4
Date:	24/08/2015	Pumping time	4			
Time	15:06	EC (µS/cm)	2213			
Monitored By:	M.BAYRAM	pH	8.87			
Test Number:	1	Temp (oC)	21			
Time Air On	16:09	Flow (L/min)	2	Hole blown dry		
Time Air Off	16:16					
Duration of airlift (mins):	7min					
Height of Casing with headworks (magl): 0.48						
SWL at Start (mtoc):	13.98					

Time Since Pumping Stopped (min)	Water Level (mbtoc)	Comment
1	25.64	
2		
3		
4	21.94	
5	20.82	
6	19.92	
7	18.98	
8	17.94	
9	16.95	
10	16.29	
12	15.24	
14	14.64	
16	14.4	
18	14.32	
20	14.31	
25	14.3	
30	14.29	
35	14.28	
40	14.27	
45	14.27	
50	14.27	
60		
70		

BH ID	**KSK-25**	Discharge Monitoring	1	2	3
Date:	26/08/2015	Pumping time	4		
Time	10:25	EC (µS/cm)	2155		
Monitored By:	M.BAYRAM	pH	8.86		
Test Number:	1	Temp (oC)	20.4		
Time Air On	10:29	Flow (L/min)	3	Hole blown dry	
Time Air Off	10:35				
Duration of airlift (mins):	6min				
Height of Casing with headworks (magl):0.09					
SWL at Start (mtoc):	20.7				

Time Since Pumping Stopped (min)	Water Level (mbtoc)	Comment
1		
2	34.8	
3	34.32	
4	33.99	
5	33.68	
6	33.45	
7	33.23	
8	33.01	
9	32.82	
10	32.6	
12	32.24	
14	31.93	
16	31.63	
18	31.35	
20	31.37	
25	30.44	
30	29.88	
35	29.35	
40	28.89	
45	28.49	
50	28.13	
60	27.5	
70	26.99	

APPENDIX G

KSK Borehole
Packer & Permeability Test Results

Borehole	Test Section Top (mbgl)	Test Section Bottom (mbgl)	LUGEON	Permeability (m/s)	Test Type
KSK-1	0	2	-	-	Falling Head Test
KSK-1	2	4	-	-	Falling Head Test
KSK-1	4	6	-	1.5E-06	Falling Head Test
KSK-1	6	8	-	4.1E-06	Falling Head Test
KSK-1	8	10	-	3.0E-06	Falling Head Test
KSK-1	10	12	1.86	1.8E-05	Lugeon
KSK-1	12	14	0	-	Lugeon
KSK-1	14	16	1.06	1.0E-05	Lugeon
KSK-1	16	18	3.88	2.6E-05	Lugeon
KSK-1	18	20	0	-	Lugeon
KSK-1	20	22	6.13	4.0E-05	Lugeon
KSK-1	22	24	7.11	4.8E-05	Lugeon
KSK-1	24	26	2.62	2.0E-05	Lugeon
KSK-1	26	28	0	-	Lugeon
KSK-1	28	30	0	-	Lugeon
KSK-1	30	32	0	-	Lugeon
KSK-1	32	34	1.71	1.3E-05	Lugeon
KSK-1	34	36	0	-	Lugeon
KSK-1	36	38	0	-	Lugeon
KSK-1	38	40	0	-	Lugeon
KSK-1	40	42	0	-	Lugeon
KSK-1	42	44	0	-	Lugeon
KSK-1	44	46	0	-	Lugeon
KSK-1	46	48	0	-	Lugeon
KSK-1	48	50	0	-	Lugeon
KSK-1	50	52	0	-	Lugeon
KSK-1	52	54	0	-	Lugeon
KSK-1	54	56	0	-	Lugeon
KSK-1	56	58	0	-	Lugeon
KSK-1	58	60	0	-	Lugeon
KSK-1	60	62	0	-	Lugeon
KSK-1	62	64	0	-	Lugeon
KSK-1	64	66	0	-	Lugeon
KSK-1	66	68	0	-	Lugeon
KSK-1	68	70	0	-	Lugeon
KSK-1	70	72	0	-	Lugeon
KSK-1	72	74	0	-	Lugeon
KSK-1	74	76	0	-	Lugeon
KSK-1	76	78	0	-	Lugeon
KSK-1	78	80	0	-	Lugeon
KSK-2	0	2	-	-	Falling Head Test
KSK-2	2	4	-	-	Falling Head Test
KSK-2	4	6	-	2.4E-06	Falling Head Test
KSK-2	6	8	-	3.6E-06	Falling Head Test
KSK-2	8	10	-	3.0E-06	Falling Head Test
KSK-2	10	12	0	-	Lugeon
KSK-2	12	14	1.5	1.2E-05	Lugeon
KSK-2	14	16	0	-	Lugeon
KSK-2	16	18	1.89	1.4E-05	Lugeon
KSK-2	18	20	0.94	9.0E-06	Lugeon
KSK-2	20	22	3.05	2.2E-05	Lugeon
KSK-3	0	2	-	3.4E-06	Falling Head Test
KSK-3	2	4	-	1.6E-05	Falling Head Test
KSK-3	4	6	-	1.7E-05	Falling Head Test
KSK-3	6	8	-	1.8E-05	Falling Head Test
KSK-3	8	10	-	1.9E-05	Falling Head Test
KSK-3	10	12	-	2.0E-05	Falling Head Test
KSK-3	12	14	-	4.3E-05	Falling Head Test
KSK-3	14	16	-	4.3E-05	Falling Head Test
KSK-3	16	18	-	2.3E-05	Falling Head Test
KSK-3	18	20	14.48	8.2E-05	Lugeon
KSK-3	20	22	6.89	5.6E-05	Lugeon
KSK-3	22	24	7.76	6.2E-05	Lugeon
KSK-3	24	26	5.71	3.8E-05	Lugeon
KSK-3	26	28	8.32	5.7E-05	Lugeon
KSK-3	28	30	6.68	5.4E-05	Lugeon
KSK-3	30	32	7.48	6.2E-05	Lugeon
KSK-3	32	34	4.18	3.7E-05	Lugeon
KSK-3	34	36	0	-	Lugeon
KSK-3	36	38	0	-	Lugeon
KSK-3	38	40	0	-	Lugeon
KSK-3	40	42	0	-	Lugeon
KSK-3	42	44	0	-	Lugeon

Borehole	Test Section Top (mbgl)	Test Section Bottom (mbgl)	LUGEON	Permeability (m/s)	Test Type
KSK-3	44	46	0	-	Lugeon
KSK-3	46	48	0	-	Lugeon
KSK-3	48	50	0	-	Lugeon
KSK-4	0	2	-	1.1E-06	Falling Head Test
KSK-4	2	4	-	1.1E-06	Falling Head Test
KSK-4	4	6	-	9.5E-07	Falling Head Test
KSK-4	6	8	-	1.6E-06	Falling Head Test
KSK-4	8	10	-	2.5E-06	Falling Head Test
KSK-4	10	12	-	1.8E-06	Falling Head Test
KSK-4	12	14	-	2.0E-06	Falling Head Test
KSK-4	14	16	-	2.0E-06	Falling Head Test
KSK-4	16	18	-	7.2E-06	Falling Head Test
KSK-4	18	20	-	1.0E-05	Falling Head Test
KSK-4	20	22	-	6.8E-06	Falling Head Test
KSK-4	22	24	3.86	4.9E-05	Lugeon
KSK-4	24	26	4.79	2.8E-05	Lugeon
KSK-4	26	28	9.16	6.4E-05	Lugeon
KSK-4	28	30	11.16	8.6E-05	Lugeon
KSK-4	30	32	11.28	6.9E-05	Lugeon
KSK-4	32	34	7.19	5.8E-05	Lugeon
KSK-4	34	36	5.65	5.1E-05	Lugeon
KSK-4	36	38	8.8	9.3E-05	Lugeon
KSK-4	38	40	0	-	Lugeon
KSK-4	40	42	0	-	Lugeon
KSK-4	42	44	0	-	Lugeon
KSK-4	44	46	0	-	Lugeon
KSK-4	46	48	0	-	Lugeon
KSK-4	48	50	0	-	Lugeon
KSK-5	0	2	-	1.9E-06	Falling Head Test
KSK-5	2	4	1.28	9.0E-06	Lugeon
KSK-5	4	6	5.68	4.2E-05	Lugeon
KSK-5	6	8	8.58	7.1E-05	Lugeon
KSK-5	8	10	3.64	2.8E-05	Lugeon
KSK-5	10	12	8.04	7.6E-05	Lugeon
KSK-5	12	14	12.78	1.0E-04	Lugeon
KSK-5	14	16	32.74	2.5E-04	Lugeon
KSK-5	16	18	0	-	Lugeon
KSK-5	18	20	0	-	Lugeon
KSK-5	20	22	0	-	Lugeon
KSK-5	22	24	0	-	Lugeon
KSK-5	24	26	0	-	Lugeon
KSK-5	26	28	0	-	Lugeon
KSK-5	28	30	0	-	Lugeon
KSK-5	30	32	0	-	Lugeon
KSK-5	32	34	0	-	Lugeon
KSK-5	34	36	0	-	Lugeon
KSK-5	36	38	0	-	Lugeon
KSK-5	38	40	0	-	Lugeon
KSK-5	40	42	0	-	Lugeon
KSK-5	42	44	0	-	Lugeon
KSK-5	44	46	0	-	Lugeon
KSK-5	46	48	0	-	Lugeon
KSK-5	48	50	0	-	Lugeon
KSK-5	50	52	0	-	Lugeon
KSK-5	52	54	0	-	Lugeon
KSK-5	54	56	0	-	Lugeon
KSK-5	56	58	0	-	Lugeon
KSK-5	58	60	0	-	Lugeon
KSK-6	0	2	-	-	Falling Head Test
KSK-6	2	4	-	-	Falling Head Test
KSK-6	4	6	-	-	Falling Head Test
KSK-6	6	8	-	-	Falling Head Test
KSK-6	8	10	-	-	Falling Head Test
KSK-6	10	12	-	-	Falling Head Test
KSK-6	12	14	-	5.4E-07	Falling Head Test
KSK-6	14	16	3.67	2.5E-05	Lugeon
KSK-6	16	18	3.38	2.9E-05	Lugeon
KSK-6	18	20	5.38	3.4E-05	Lugeon
KSK-6	20	22	1.54	1.5E-05	Lugeon
KSK-6	22	24	1.48	1.7E-05	Lugeon
KSK-6	24	26	0.91	9.0E-06	Lugeon
KSK-6	26	28	0	-	Lugeon
KSK-6	28	30	0	-	Lugeon

Borehole	Test Section Top (mbgl)	Test Section Bottom (mbgl)	LUGEON	Permeability (m/s)	Test Type
KSK-6	30	32	0	-	Lugeon
KSK-6	32	34	0	-	Lugeon
KSK-6	34	36	0	-	Lugeon
KSK-6	36	38	0	-	Lugeon
KSK-6	38	40	0	-	Lugeon
KSK-6	40	42	0	-	Lugeon
KSK-6	42	44	0	-	Lugeon
KSK-6	44	46	0	-	Lugeon
KSK-6	46	48	0	-	Lugeon
KSK-6	48	50	0	-	Lugeon
KSK-6	50	52	0	-	Lugeon
KSK-6	52	54	0	-	Lugeon
KSK-6	54	56	0	-	Lugeon
KSK-6	56	58	0	-	Lugeon
KSK-6	58	60	0	-	Lugeon
KSK-6	60	62	0	-	Lugeon
KSK-6	62	64	0	-	Lugeon
KSK-6	64	66	0	-	Lugeon
KSK-6	66	68	0	-	Lugeon
KSK-6	68	70	0	-	Lugeon
KSK-6	70	72	0	-	Lugeon
KSK-6	72	74	0	-	Lugeon
KSK-6	74	76	0	-	Lugeon
KSK-6	76	78	0	-	Lugeon
KSK-6	78	80	0	-	Lugeon
KSK-6	80	82	0	-	Lugeon
KSK-6	82	84	0	-	Lugeon
KSK-6	84	86	0	-	Lugeon
KSK-6	86	88	0	-	Lugeon
KSK-7	0	2	-	1.2E-06	Falling Head Test
KSK-7	2	4	-	1.5E-06	Falling Head Test
KSK-7	4	6	-	1.5E-06	Falling Head Test
KSK-7	6	8	-	9.8E-07	Falling Head Test
KSK-7	8	10	7.35	4.7E-05	Lugeon
KSK-7	10	12	52.85	3.3E-04	Lugeon
KSK-7	12	14	17.34	1.1E-04	Lugeon
KSK-7	14	16	11.21	8.0E-05	Lugeon
KSK-7	16	18	0	-	Lugeon
KSK-7	18	20	4.03	3.5E-05	Lugeon
KSK-7	20	22	0	-	Lugeon
KSK-7	22	24	0	-	Lugeon
KSK-7	24	26	0	-	Lugeon
KSK-7	26	28	0	-	Lugeon
KSK-7	28	30	0	-	Lugeon
KSK-8	0	2	-	1.4E-06	Falling Head Test
KSK-8	2	4	-	1.7E-06	Falling Head Test
KSK-8	4	6	-	1.7E-06	Falling Head Test
KSK-8	6	8	-	1.7E-06	Falling Head Test
KSK-8	8	10	-	1.3E-06	Falling Head Test
KSK-8	10	12	-	7.0E-07	Falling Head Test
KSK-8	12	14	3.08	2.8E-05	Lugeon
KSK-8	14	16	3.72	2.5E-05	Lugeon
KSK-8	16	18	2.5	2.0E-05	Lugeon
KSK-8	18	20	1.71	1.3E-05	Lugeon
KSK-8	20	22	1.07	1.4E-05	Lugeon
KSK-8	22	24	0	-	Lugeon
KSK-8	24	26	0	-	Lugeon
KSK-8	26	28	0	-	Lugeon
KSK-8	28	30	0	-	Lugeon
KSK-9	0	2	-	2.0E-06	Falling Head Test
KSK-9	2	4	-	4.4E-06	Falling Head Test
KSK-9	4	6	-	3.0E-06	Falling Head Test
KSK-9	6	8	-	3.3E-06	Falling Head Test
KSK-9	8	10	2.58	1.9E-05	Lugeon
KSK-9	10	12	2.03	1.7E-05	Lugeon
KSK-9	12	14	0.68	9.0E-06	Lugeon
KSK-9	14	16	0	-	Lugeon
KSK-9	16	18	0	-	Lugeon
KSK-9	18	20	0	-	Lugeon
KSK-10	0	2	-	2.3E-06	Falling Head Test
KSK-10	2	4	-	4.6E-06	Falling Head Test
KSK-10	4	6	-	4.2E-06	Falling Head Test
KSK-10	6	8	-	4.0E-06	Falling Head Test

Borehole	Test Section Top (mbgl)	Test Section Bottom (mbgl)	LUGEON	Permeability (m/s)	Test Type
KSK-10	8	10	3.37	3.0E-05	Lugeon
KSK-10	10	12	7.67	4.8E-05	Lugeon
KSK-10	12	14	2.73	2.3E-05	Lugeon
KSK-10	14	16	0	-	Lugeon
KSK-10	16	18	0	-	Lugeon
KSK-10	18	20	0	-	Lugeon
KSK-11	0	2	-	3.5E-06	Falling Head Test
KSK-11	2	4	-	5.4E-06	Falling Head Test
KSK-11	4	6	-	7.6E-06	Falling Head Test
KSK-11	6	8	-	2.6E-05	Falling Head Test
KSK-11	8	10	-	2.9E-05	Falling Head Test
KSK-11	10	12	-	3.5E-05	Falling Head Test
KSK-11	12	14	-	2.8E-05	Falling Head Test
KSK-11	14	16	16.32	1.1E-04	Lugeon
KSK-11	16	18	2.55	1.7E-05	Lugeon
KSK-11	18	20	0.99	8.0E-06	Lugeon
KSK-11	20	22	0	-	Lugeon
KSK-11	22	24	1.28	1.0E-05	Lugeon
KSK-11	24	26	0.76	6.0E-06	Lugeon
KSK-11	26	28	0	-	Lugeon
KSK-11	28	30	0	-	Lugeon
KSK-12	0	2	-	1.9E-06	Falling Head Test
KSK-12	2	4	-	3.5E-06	Falling Head Test
KSK-12	4	6	-	1.6E-05	Falling Head Test
KSK-12	6	8	30.68	3.6E-04	Lugeon
KSK-12	8	10	11.26	1.1E-04	Lugeon
KSK-12	10	12	5.04	3.5E-05	Lugeon
KSK-12	12	14	3.08	2.0E-05	Lugeon
KSK-12	14	16	1.78	1.6E-05	Lugeon
KSK-12	16	18	4.96	3.5E-05	Lugeon
KSK-12	18	20	1.7	1.2E-05	Lugeon
KSK-12	20	22	0	-	Lugeon
KSK-12	22	24	0	-	Lugeon
KSK-12	24	26	0	-	Lugeon
KSK-12	26	28	0	-	Lugeon
KSK-12	28	30	0	-	Lugeon
KSK-13	0	2	-	1.0E-06	Falling Head Test
KSK-13	2	4	-	1.8E-06	Falling Head Test
KSK-13	4	6	-	2.5E-06	Falling Head Test
KSK-13	6	7	138.34	6.9E-04	Lugeon
KSK-13	7	8.5	0	-	Lugeon
KSK-13	8.5	10	0	-	Lugeon
KSK-13	10	12	0	-	Lugeon
KSK-13	12	14	0	-	Lugeon
KSK-13	14	16	0	-	Lugeon
KSK-13	16	18	0	-	Lugeon
KSK-13	18	20	0	-	Lugeon
KSK-13	20	22	0	-	Lugeon
KSK-13	22	24	0	-	Lugeon
KSK-13	24	26	0	-	Lugeon
KSK-13	26	28	0	-	Lugeon
KSK-13	28	30	0	-	Lugeon
KSK-14	0	2	-	6.0E-07	Falling Head Test
KSK-14	2	4	-	4.5E-07	Falling Head Test
KSK-14	4	6	-	3.0E-07	Falling Head Test
KSK-14	6	8	5.21	4.3E-05	Lugeon
KSK-14	8	10	0	-	Lugeon
KSK-14	10	12	0	-	Lugeon
KSK-14	12	14	0	-	Lugeon
KSK-14	14	16	0	-	Lugeon
KSK-14	16	18	0	-	Lugeon
KSK-14	18	20	0	-	Lugeon
KSK-14	20	22	0	-	Lugeon
KSK-14	22	24	0	-	Lugeon
KSK-14	24	26	0	-	Lugeon
KSK-14	26	28	0	-	Lugeon
KSK-14	28	30	0	-	Lugeon