

# APPENDIX G

## Kennecott Bingham Canyon Mine and Water Collection System: Dry Fork Management Plan

### Operational Plan Summary

This plan targets groundwater monitoring and controls of historic mine impacted waters in the Dry Fork area. The management of these waters is broken out into two areas:

1. Clean water capture upgradient of Dry Fork area;
2. Bedrock groundwater monitoring; and
3. Alluvial extraction of Dry Fork/Bingham Creek area mine groundwater.

The plan is formatted into five sections and summarizes well “as-built” specifications, pumping rates, historic concentrations of key analytes and geologic and hydrogeologic conditions where applicable. The five sections specifically addressed are:

1. Upgradient clean water capture;
2. Peripheral or lateral monitoring wells;
3. Alluvial pumping wells below the toe of Bingham Canyon waste rock disposal area;
4. Bedrock monitoring wells between Bingham Canyon waste rock disposal area and the Bingham Canyon cut-off wall; and
5. Bingham Canyon cut-off wall.

### Historic Overview Including Geologic/Hydrologic Factors

#### Overview

Bedrock groundwater was known to have been impacted as a result of mining activities within the Dry Fork area since the 1990’s. Efforts were made to monitor the extent of the contamination as well as extract contaminated water with sulfate concentrations in excess of 20,000 mg/L. During the extraction period which lasted between 1998 and 2003, the geologic, hydrologic conditions within the Dry fork area were studied exhaustively and are summarized in more detail below. Through various monitoring and extraction wells (Dwg. No. 454-T-0415) the impacted groundwater was determined to be confined to Bingham Canyon and its bedrock flow path impeded by local structures resulting in mine contact waters reporting to down canyon alluvium. Mining operations were modified in 2004 resulting in a change in Dry Fork plume management strategies. This plan details those strategies.

#### Geologic Conditions

The geology of the Dry Fork area consists of Paleozoic sedimentary bedrock which is heavily folded and faulted. Two large fold structures are known to exist within Dry Fork Canyon: the Copperton Anticline and the Copperton Overturn. The anticline is steeply dipping to the west and overturned on the east side. The Conger and Champion thrust faults cut across Bingham Canyon and the zones are insignificant. These structures generally impose down gradient bedrock barriers which minimize the migration of ground water deeper into bedrock to the east where it could impact Salt Lake Valley aquifer.

# APPENDIX G

## **Hydrologic Conditions**

Vertical head gradient at the confluence of Bingham Canyon and Dry Fork Canyon is predominantly upward and averages 0.026 ft/ft. The upward gradient is reflective of a compilation of piezometer data collected from locations within the canyon both historic and current. The lower and most eastern part of Bingham Canyon has an upwards gradient as large as 0.051 ft/ft. In these conditions, groundwater is reporting to alluvium where it can be captured in the alluvium pumping wells.

## **Monitoring Controls & Contingency Plan**

### **Section 1: Upgradient Clean Water Capture**

Two pumping wells are located upgradient of the Dry Fork dump area. The wells are COP2701 (Mid Valley Well) and COG1172 (Upper Dry Fork Well or Picnic Flats Well) as depicted in Figure 1 of Dwg. No. 454-T-0415. The purpose of the wells is to capture clean water upgradient of the Dry Fork area prior to becoming contaminated as well as minimize hydraulic head pressure created by upgradient groundwater sources in Dry Fork Canyon. Pumping on COP2701 began in 2003 and has had an average monthly pumping rate of 163 gpm when in use. Flow rates have ranged from ~120 to over 400 gpm. Pumping on COG1172 was re-established in 2007 and was implemented to supplement COP2701 and, as such, is only operated seasonally. The average flow rate for COG1172 based upon a monthly average is 150 gpm and has ranged between 75 to 200 gpm.

**Table 1: Dry Fork Area Clean Water Capture Wells Summary Information**

Well ID	COP2701	COG1172
Alias	Mid Valley Well	Picnic Flats Well
General Location	300 ft upgradient of Dry Fork dump toe	1500 ft upgradient of COP2701
Coordinate (state plane 83)	N 7378029.3 E 1459357.4	N 7378749.7 E 1458019.9
Years in Service	2003	2007
Surface elevation	6241	6341
Total Depth (ft)	345	962.8
Screen interval (ft)	20-275	80 - 952
Screened Lithology	Quartzitic alluvium	Quartzitic alluvium/Quartzite
Pump capacity (gpm)	500	375
Mean Monthly pumping rate (gpm) <sup>1</sup>	163	150
Mean annual water volume removed (acre- feet)	275.3 <sup>2</sup>	50 <sup>3</sup>
Static Water Level (ft)	70	98

<sup>1</sup>Mean pumping rate based upon months when pump is in service

<sup>2</sup>Mean volume based upon 2005-2008 annual data

<sup>3</sup>Mean volume based upon 2007-2008 annual data

# APPENDIX G

## **Section 2: Peripheral Monitoring Well Controls**

Peripheral monitoring of the Dry Fork area is done through compliance monitoring wells COG1204A & B. The wells are located north and east of the Dry Fork Canyon and Bingham Canyon intersect, as depicted in Figure 2 of Dwg. No. 454-T-0415, and both intervals are screened in quartzite. The wells are intended to monitor the potential lateral movement of mine impacted ground water originating from Dry Fork Canyon. Due to the low yield of COG1204A & B as well as the proximate location to active mining and waste rock placement over the next several years, KUC may replace bedrock monitoring well COG1204A & B with a bedrock monitoring wells COG2806A & B as agreed upon by the Executive Secretary. KUC submitted a formal letter to UDWQ detailing well location and anticipated well construction prior to execution for review and approval by the Executive Secretary.

**Table 2: Peripheral Bedrock Monitoring Wells Summary Information**

Well ID	COG2806A	COG2806B
General Location	NE corner of Dry Fork-Bingham Canyon Intersect	Same
Coordinate (state plane 83)	N 7375371.5 E 1468620.3	Same
Years in Service	2010 to present	Same
Casing elevation	6228.91	6228.67
Total Depth (ft)	800	1108
Screen interval (ft)	760-800	1068-1108
Screen Lithology	Limey Quartzite	Quartzite
Mean DTW (ft)	689	691
pH	8.26	7.85
TDS (mg/L)	492	430
Sulfate (mg/L)	54	36
Copper (mg/L)	Non Detect	Non Detect
Cadmium (mg/L)	Non Detect	Non Detect
Zinc (mg/L)	0.046	Non Detect

**Notes**

Permit limits for these wells will be established based upon an accelerated sampling schedule of 12 consecutive quarterly samples over three years which will start during the calendar quarter of completion. Once the permit limits have been established, the wells will be sampled on a semiannual frequency.

Monitoring of contaminated waters to the immediate south is precluded by active waste rock placement and historic waste rock disposal areas. The east side collection system is located further south and east, which is comprised of a robust monitoring network of cut-off walls and monitoring wells. Bedrock ground water contamination will be identified using these wells and operational control structures.

# APPENDIX G

## **Section 3: Alluvial Controls**

### **Down Gradient of Bingham Canyon Waste Rock Disposal Area**

Contamination to the alluvium will be controlled with three pumping wells situated between the toe of Bingham Canyon waste rock disposal area and the Bingham Canyon Cut-off Wall (COW) as depicted in Figure 3 of Dwg. No. 454-T-0415. Table 3 summarizes well statistics. The wells are placed to capture mine impacted water moving through alluvium and minimize water reporting to the Bingham Canyon COW. The goal of the wells is to maximize alluvial extraction before mine impacted waters can enter the bedrock, however pumping rates for individual wells may vary or cease all together based upon alluvial saturation conditions.

**Table 3: Alluvial Pumping Wells Summary Information**

Well ID	ECG2787 <sup>1</sup>	K83 <sup>2</sup>	ECG1185 <sup>2</sup>
Alias	NA	Curtis Springs	Copperton Channel
General Location	900 feet east of dump toe	3200 feet east of dump toe	3500 feet east of dump toe
Coordinate (state plane 83)	N 7373909 E 1469365	N 7373754.9 E 1471616.3	N 7374630.6 E 1471905.2
Years in Service	2009 to present	2006 to present	1999 to present
Surface elevation	5496	5426	5509
Total Depth (ft)	130	109.8	200.7
Screen interval (ft)	75 – 129	46.5 – 96.5	130 – 200
Pump capacity (gpm)	225	150	60
Mean Monthly pumping rate	190	72	26
Mean annual volume removed (acre-feet)	300	100	40
Mean DTW (ft)	70	72	149
pH	3.38	3.60	3.87
TDS (mg/L)	22400	15373	3481
Sulfate (mg/L)	16200	14079	2241
Copper (mg/L)	418	378	43
Cadmium (mg/L)	0.370	0.231	0.084
Zinc (mg/L)	89	577	11

<sup>1</sup> Well performance and water quality statistics based upon 2009 monthly sampling between June and September.

<sup>2</sup> Well performance and water quality data based upon 2008 annual reporting statistics.

# APPENDIX G

## **Section 4: Bedrock Controls**

### **Down Gradient of Bingham Canyon Waste Rock Disposal Area**

Three monitoring wells screened in bedrock act as early warning detection for impacts from Mine impacted water potentially impacting groundwater. The well locations are depicted in Figure 3 of Dwg. No. 454-T-0415 as well as cross-sections located in Dwg. No. 454-T-0416.

**Table 4a: Bedrock Monitoring Wells Summary Information**

Well ID	ECG2789 A & B	ECG1100 A & B	K93
Comment	Paleozoic dual completion bedrock well ECG1202 replacement	Paleozoic dual completion bedrock well	Paleozoic-Volcanic Bedrock contact MDG1101 Replacement
General Location	Toe of Bingham Canyon dump	900 feet east of dump toe	2100 feet east of dump toe
Coordinate (state plane 83)	N 7373789 E 1468530	N 7373797 E 1469391.8	N 7373736.3 E 1470610.3
Year built	2009	1994 (mod. 1997)	1968
Surface elevation	5558	5511	5451
Total Depth (ft)	730	861	765
Screen interval (ft)			
A Completion	297 – 337	406 - 426	685 - 765
B Completion	675.7 – 715.7	828 - 857	NA
Mean DTW (ft)			
A Completion	102.6	67	36.3
B Completion	102.0	60	NA

**Table 4b: Permit Limits for Bedrock Compliance Monitoring Wells**

Well ID	Screen Lithology	Sampling Frequency	pH	TDS mg/L	SO4 mg/L	Dissolved Cd (µg/L)	Dissolved Cu (µg/L)	Dissolved Zn (µg/L)
ECG1100A	Bedrock	Semi-annual	6.50-8.50	3947	2404	2	650	2848
ECG1100B	Bedrock	Semi-annual	6.50-8.50	390	79	2	130	1250
ECG2789A	Bedrock	Semi-annual						
ECG2789B	Bedrock	Semi-annual						
K93	Bedrock	Semi-annual						

**Notes**

Compliance limits have not yet been assigned for three Dry Fork wells (ECG2789A&B, K93). Permit limits for these wells will be established based upon an accelerated sampling schedule of 12 consecutive quarterly samples for three years which will begin upon permit renewal. Once the permit limits have been established, the wells will be sampled on a semiannual frequency.

### **Bedrock Contamination Contingency Plan**

The purpose of the bedrock monitoring wells is to monitor groundwater conditions relative to historic Dry Fork plume concentrations prior to 2003. The mean sulfate concentration in the Dry Fork plume has been known to be 20,000 mg/L. The following contingency measures will be followed should the sulfate concentrations in bedrock as indicated by the above compliance monitoring wells reach historic levels and action levels set through accelerated ground water sampling:

# APPENDIX G

- Evaluate potential risks to human health and the environment.
- Evaluate potential contamination to waters of the state.
- Assess the feasibility and effectiveness of extracting and treating ground water using wells or drains.
- Petitioning of the Water Quality Board for an alternative Corrective Action Concentration Limits consistent with the risks identified.

Corrective Action Plans will be written in accordance with UCA R317-6-6.15 D and submitted for approval to the UDWQ upon completion of the Contamination Investigation.

## **Section 5: Bingham Creek Cut-off Wall**

The Bingham Creek COW is a concrete structure which spans Bingham Canyon and is built into volcanic bedrock which has very low permeability. The wall is located approximately 5600 feet down canyon from the toe of the waste rock disposal area as depicted in Figure 3 of Dwg. No. 454-T-0415. The wall is designed to capture alluvial water migrating down Bingham Canyon not captured by the alluvial pumping wells up canyon. Water collected at the wall's sump is removed through pumping. Pumping rates fluctuate seasonally and can be dependant upon the effectiveness of the alluvial pumping wells in Bingham Canyon upgradient of the cutoff wall listed in Table 3.

**Table 5:** Bingham Creek Cut-off Wall Specifications

Site ID	ECP2562
Alias	Bingham Creek COW
General Location	5600 ft down gradient of dump toe
Coordinate (state plane)	N 7373492.5 E 1473938.0
Years in Service	1995 to present
Surface elevation	5353
Total Depth (ft)	140
Pump capacity (gpm)	900 total (2 pumps)
Mean Monthly pumping rate	343 <sup>1</sup>
Mean annual volume removed (acre-feet)	553
Mean DTW in sump (ft)	80
pH	3.62
TDS (mg/L)	17100
Sulfate (mg/L)	12500
Copper (mg/L)	309
Cadmium (mg/L)	0.34
Zinc (mg/L)	77.7

<sup>1</sup> Mean monthly pumping rate based upon 2008 monthly averages.

# APPENDIX G

The Bingham Creek Cutoff wall spans approximately 375 feet across Bingham Creek channel and is approximately 100 feet deep and built into volcanic bedrock. During excavation and construction of the wall, the majority of the alluvial flow came from the bottom 20 feet of coarse quartzitic gravel immediately above bedrock. Several previous borings/wells into the underlying volcanic bedrock were exposed during the excavation and water flowed upward from the bedrock into the excavation area. No head measurements were made on the upgradient flow. Water quality from the upward flow had conductivities measuring less than 2,000 umhos/cm. After the cutoff wall was completed, down gradient monitoring wells completed in alluvium and volcanic bedrock exhibited dramatic decreases in sulfate concentrations. These wells include P248A completed in alluvium, P248B completed in the upper 30 ft of bedrock and P248C completed 70 feet into bedrock. Sulfate concentrations decreased in P248A from the 7500 mg/l range to 750 to 1250 mg/l; P248B decreased from the 3500 mg/l range to 1600 to 2000 mg/l and P248C decreased from the 500 mg/l range to around 400 mg/l.

## **Reporting**

KUC will follow guidelines set forth by permit UGW350010 regarding compliance well monitoring and reporting and will be reported on a quarterly basis. Operational sites upgradient of the Dry Fork area will be sampled on an annual basis for water quality. Operational sites below the Dry Fork area will be sampled on a semiannual basis for water quality. Water flow data, specifically average monthly pumping rates and corresponding annual totals will be tracked throughout the year for operational locations and reported in the annual report as well as associated water quality data.