

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 separated into three 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 is known to have been impacted as a result of mining activities within the Dry Fork area. 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 1960s and 2003, the geologic, hydrologic conditions within the Dry fork area were studied extensively and are summarized in more detail below. Through various monitoring and extraction wells (Figure 2) the impacted groundwater was determined to be confined to Bingham Canyon and its alluvial and 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. Kennecott placed waste rock in Bingham Canyon beginning in 1998 through the present, which covered most of the monitoring wells in Bingham Canyon. Monitoring is now performed from wells at the mouth of the canyon.

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. 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 the Salt Lake Valley aquifer.

Hydrologic Conditions

Vertical head gradient at the confluence of Bingham Canyon and Dry Fork Canyon is predominantly upward and averages 0.026 ft/ft (not density corrected). 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 (not density corrected). In these conditions, groundwater is reporting to alluvium where it can be captured in the alluvium pumping wells.

Waste rock was placed over approximately 100 feet of alluvial material in Bingham Canyon. Over this time period, the waste rock has drained meteoric water into the Bingham Canyon alluvial material and into bedrock. This change has affected the hydraulic gradient somewhat such that the upward gradient has decreased. Kennecott believes the alluvial material may be fully saturated and is partially influencing the water quality near the mouth of Bingham Canyon.

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 2. The purpose of the wells is to capture clean water upgradient of the Dry Fork waste rock area prior to coming into contact with waste rock contact water (WRCW) as well as minimize hydraulic head pressure created by upgradient groundwater sources in Dry Fork Canyon. Pumping on COP2701 began in the late 1990s, with an average monthly pumping rate of 192 gpm over the past 5 years when in use. Flow rates have ranged from approximately 100 to over 500 gpm. Pumping of COG1172 was re-established in 2007 and was implemented to supplement COP2701. The average flow rate (5 year rolling average) for COG1172 based upon a monthly average is 88 gpm and has ranged between 70 to 110 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	19	6
Surface elevation	6241	6341
Total Depth (ft)	345	962.8
Screen interval (ft)	20-275	80 - 952
Screened Lithology	Quartzitic alluvium/Quartzite	Quartzitic alluvium/Quartzite
Pump capacity (gpm)	500	375
Average Monthly pumping rate (gpm) ¹	192	88
Average annual water volume removed (acre- feet)	296 ²	136 ³
Static Water Level (ft)	~110	69.64

¹Average pumping rate based upon months when pump is in service

²Average volume based upon 5 year rolling average annual data

³Average volume based upon 5 year rolling average annual data

Section 2: Peripheral Monitoring Well Controls

Peripheral monitoring of the Dry Fork area is performed through compliance monitoring wells COG2806A&B. The wells are located north and east of the Dry Fork Canyon and Bingham Canyon intersect, as depicted in Figure 2, 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. Groundwater monitoring wells ECG1106A & B, located approximately 600 feet north of ECG2787 and drilled in bedrock, can also be used as monitoring the northern/eastern edge of the Dry Fork water quality.

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	4	Same
Casing elevation	6228.91	6228.67
Total Depth (ft)	800	1108
Screen interval (ft)	760-800	1068-1108
Screen Lithology	Limey Quartzite	Quartzite
Average DTW (ft)	691	695

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 groundwater contamination will be identified using these wells and operational control structures.

Section 3: Alluvial Controls
Down Gradient of Bingham Canyon Waste Rock Disposal Area

Groundwater impact to the alluvial material is 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 2. Table 3 summarizes well statistics. The wells were 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. There are no alluvial pumping or monitoring wells located in Bingham Canyon between the Dry Fork pumping wells and ECG2789A & B.

Table 3: Alluvial Pumping Wells Summary Information

Well ID	ECG2787 ¹	K83	ECG1185
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
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)	260	300	60
Average Monthly pumping rate	259	0 ²	32
Average annual volume removed (acre-feet)	359	0	36
Average DTW (ft)	75	49 ²	144

¹ Well performance and water quality statistics based upon 2013 annual reporting.

² This well operates when needed based on groundwater flow. This well has not operated since 2011

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 2.

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
DTW (ft)			
A Completion	108.2	90.2	14.8
B Completion	108.3	83.4	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 (mg/l)	Dissolved Cu (mg/l)	Dissolved Zn (mg/l)
ECG1100A	Bedrock	Semi-annual	6.5-8.50	3947	2404	0.002	0.650	2.85
ECG1100B	Bedrock	Semi-annual	6.50-8.50	390	79	0.001	0.130	1.25
ECG2789A	Bedrock	Semi-annual	6.50-8.50	3926	2220	0.050	1.2	0.20
ECG2789B	Bedrock	Semi-annual	6.50-8.50	5987	3509	0.050	3.0	0.60
K93	Bedrock	Semi-annual	6.50-8.50	480	39	0.050	0.100	0.06

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 average sulfate concentration in the Dry Fork plume has been known to be 20,000 mg/l. The following contingency measures will be used as a guide if the sulfate concentrations in bedrock as indicated by the above compliance monitoring wells reach historic levels and action levels:

- 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 DWQ 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 2. 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)
Average Monthly pumping rate	274 ¹
Average annual volume removed (acre-feet)	442
Average DTW in sump (ft)	85

¹ Average monthly pumping rate based upon 2014 monthly data.

The Bingham Creek Cut-off 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. Head measurements were not conducted 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 decreases in sulfate concentrations.

Reporting

Kennecott 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 (if available to sample) 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.