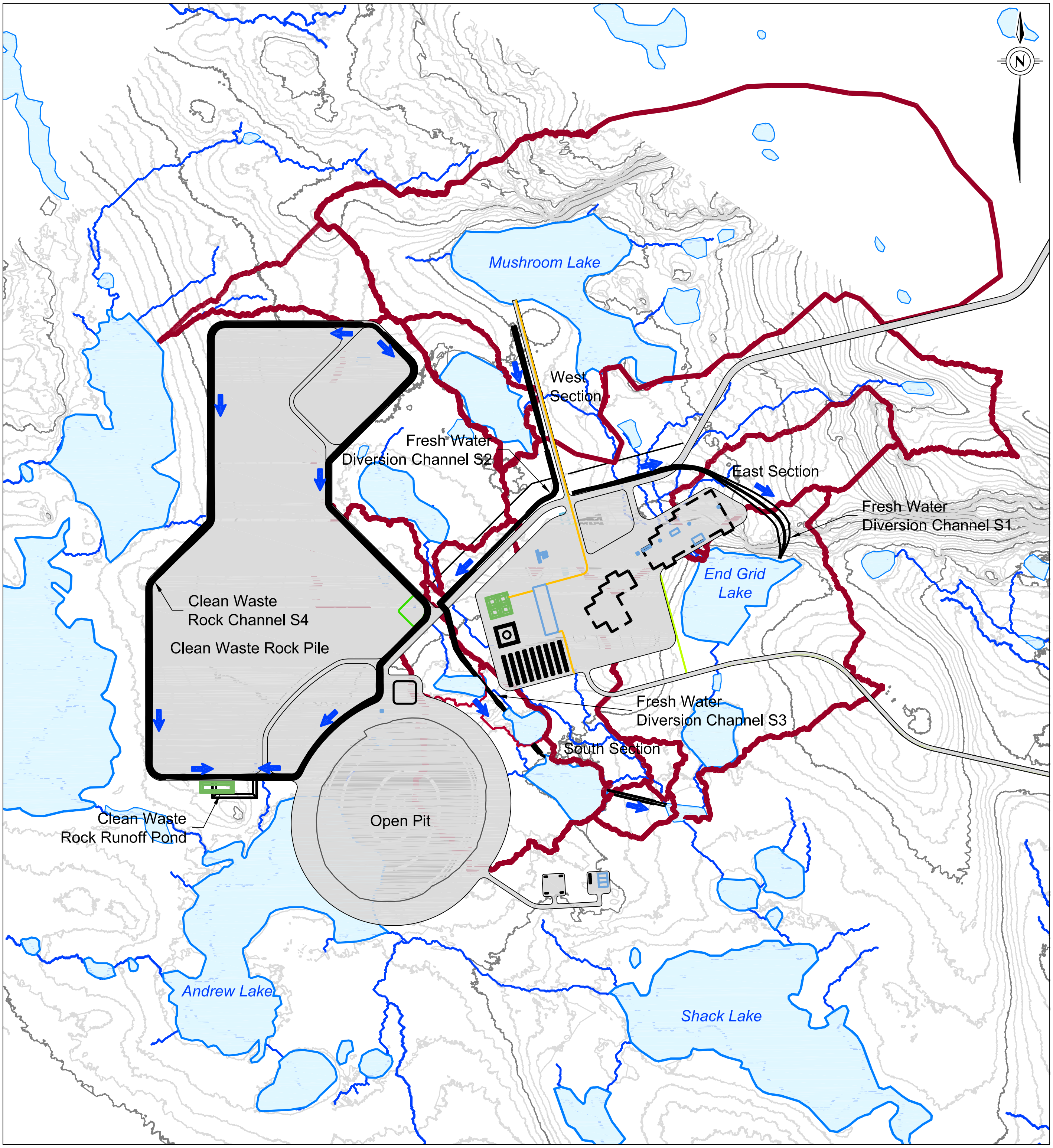

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SCALE 1:25,000 METRES

Legend

- Topographic Contour (1m Interval)
- Drainage Pathway
- Watershed Boundary
- Proposed Diversion Channel

Note:
Contours derived from LIDAR Survey, 2009

Reference:
Site Layout provided by AREVA, December 2010
NTS Mapsheet 66A05
NAD83 UTM Zone 14

PROJECT

AREVA

KIGGAVIK PROJECT

TITLE

SISSONS SITE - DRAINAGE AREAS, STREAM FLOW PATHS, AND DIVERSION CHANNEL ALIGNMENTS

DRAFT

Golder Associates
Saskatoon, Saskatchewan

PROJECT		09-1362-0610	FILE No.	
DESIGN			SCALE AS SHOWN	REV. 0
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G:\2009\1362\09-1362-0610 AREVA Kiggavik Baseline and EIA\KI08_Environment\D_Hydrology\CAD\ Drawing file: KI08D145 - Site Layout with Drainage Lines.dwg Sep 28, 2011 - 2:08pm

5.1 Fresh Water Diversion Channel and Contribution Areas

A detail of the topography, drainage areas and flow pathways reporting to the north border of the Sissons site are illustrated in Figure 2. Details for the channel alignment and stationing are provided in Appendix I, Figure 007.

5.1.1 East Section – S1

This section of the channel will collect runoff from the drainages north of the site, including the Mushroom Lake outflow channel. The length of this channel section is approximately 1,200 m. Stationing for this section begins at its discharge end at End Grid Lake (station 0+000) and ends at station 1+200. The channel intercepts Mushroom Lake outflow at approximately at station 0+900. The channel continues another 300 m (station 1+200) westward to collect runoff from a small area east of the proposed road to Mushroom Lake (Figure 2 for the general view, Appendix I Figure 007 for details). The site access road will cross the channel at station 0+750, likely using corrugated steel pipes (CSP) for cross-drainage.

A large rock ridge along the north side of End Grid Lake requires that large excavation will be required to construct the channel draining flows down to End Grid Lake. The existing natural channel gradient has been used as an analogue for the gradient design of the lower 500 m of this section down to End Grid Lake. The objective of matching this gradient is to reduce the likelihood that Mushroom Lake and End Grid Lake would become isolated from one another in terms of fish access. Arctic grayling and lake trout have been documented in the Mushroom Lake outlet channel. Although no fish have been observed in the main section of the channel connecting Mushroom and End Grid Lakes, field observation has not revealed any impediments to fish passage during the high flow spring runoff period. In order to mitigate the potential loss of fish passage between Mushroom and End Grid lakes, and maintain the productivity of this drainage system for use by existing and future commercial, recreational or Aboriginal fisheries, the diversion channel will be designed and constructed to facilitate fish passage. This proposed mitigation is anticipated to fully maintain the productivity of the affected fishery (Tier 3, Technical Appendix 5L). For design purposes, the length of this section of the channel is divided in six sub-sections to evaluate the gradual increase in the discharge downstream or to indicate channel gradient changes. A summary of the sub-sections and the local contributing areas for each is provided in Table 5.

Table 5: East Sections S1 and Contributing Drainage Areas

Channel Sub-section	From Station	To Station	Length (m)	Proposed Slope (m/m)	Local Contributing Area (km^2)
S1-1	1+210	0+890	320	0.002	0.056
S1-2	0+890	0+743	147	0.002	2.7
S1-3	0+743	0+587	156	0.002	0.22
S1-4	0+587	0+297	290	0.0071	0.48
S1-5	0+297	0+160	137	0.0071	0.23
S1-6	0+160	0+000	160	0.0278	-

Flow direction: from sub-section S1-1E to S1-6E.

5.1.2 West Section (S2)

This section of the channel collects runoff from the area immediately west of the proposed road to Mushroom Lake including the small lake that currently appears to drains in two directions, though the channels are not well defined. The headwater of this section of the diversion channel occurs south of Mushroom Lake. The channel extends south following the proposed road to Mushroom Lake, turning southwest until reaching the southeast corner of the clean waste rock pile for a total distance of about 1500 m. The stationing begins near Mushroom Lake at 0+000 and extends to 1+478 near the south east corner of the clean waste rock pile (Appendix I, Figure 007). A short natural channel connecting draining a peanut shaped waterbody also flows to the outlet of the west section. Cross-drainage at the road near the end of channel section S2 would likely be provided with CSP's.

For design purposes, the length of this section of the channel is divided in five sub-sections which mark the gradual increase in discharge from a combination of additional local runoff plus the discharge contributed from sections upstream. A summary of the local contributing areas for each of the sections is provided in Table 6. This table also include the proposed slope for the sections.

Fisheries investigations have determined that no fish species occur in the ponds and intermediate wetlands which occur along the proposed West Section (S2) nor South Section (S3) alignment.

Table 6: West Segment Channel Sections and Contributing Drainage Areas

Channel Sub-section	From Station	To Station	Length (m)	Proposed Slope (m/m)	Local Contributing Area (km^2)
S2-1	0+000	0+310	310	0.002	0.034
S2-2	0+310	0+515	205	0.002	0.192
S2-3	0+515	0+768	253	0.002	0.032
S2-4	0+768	1+080	312	0.002	0.032
S2-5	1+013	1+478	398	0.004	0.042

Flow direction: from sub-section S2-1W to S2-5W.

5.1.3 South Section (S3)

This section of the freshwater diversion channel follows a series of poorly defined channels and seepage pathways connecting three shallow waterbodies east and south of the clean waste rock pile. The outlet of the channel reports to a small unnamed waterbody south of the site, which also receives flow from End Grid Lake. Flow from the unnamed waterbody drains to Shack Lake, and ultimately to Judge Sissons Lake (Figure 2). The south channel section receives flow from the west section (S2), plus inflow from small adjacent drainage areas east of the clean waste rock pile and northeast of the open pit. The length of the section is approximately 1,100 m, including the shallow waterbody surface lengths.

For design purposes, four channel sub-sections are identified with the end of sub-section at the outlet of the waterbodies along the channel alignment. The design is simplified to estimate the flow cross-sectional area required to convey the peak flow reported to the beginning of the section assuming that the small shallow waterbodies do not offer much attenuation capacity. A summary of the sub-sections is provided in Table 7.

Table 7: South Segment S3 Channel Sections and Contributing Drainage Areas

Channel Sub-section	From Station (m)	To Station (m)	Length (m)	Proposed Slope (m/m)	Local Contributing Area (km²)
S3-1	0+000	0+446	413	0.006	0.48
S3-2	0+446	0+761	160	0.017	0.06
S3-3	0+761	1+176	140	0.006	0.08
S3-4	1+176	1+446	370	0.009	0.13

Flow direction: from sub-section S3-1 to S3-4.

5.2 Clean Waste Rock Channels (S4)

The clean waste rock pile has a perimeter length of approximately 6,000 m (Appendix I, Figure 007). Following the natural topography the highest channel invert elevation is at the northeast corner of the pile, while the proposed location for the sedimentation pond is at the low point along the south pile boundary. It is assumed that the pile height will increase to 50 m with a side slope of 4H:1V.

For design purposes, two main sections are considered for the channel; both starting with a gradual increase in runoff discharge from the flow divide location. The channels are divided in sub-sections that range from 200 m to 300 m in length. The subsections are based on the channel bottom gradient which is optimised to balance cut and fill requirements, depending on topography along the alignment. Runoff is generated to each subsection from an area based on the length of the channel to consider the gradual increase in flow along the channel.

The stationing begins east of the sedimentation pond near the southeast corner of pile (station 0+000) and ends at 5+600 near the sediment pond in a counter clockwise direction. The highest elevation point (flow divide point) is approximately at station 2+600. The ditch is divided in 25 sections as show in Table 8. The total drainage area associated to the pile is distributed into the sections proportional to the length of the section. The design flow for sections downstream corresponds to the runoff from the local area associate to the section, plus the discharge from sections upstream.

Table 8: Channel Sections and Contributing Drainage Areas for the Sissons Clean Waste Rock Pile

Channel Sub-section	From Station	To Station	Length (m)	Proposed Slope (m/m)	Local Contributing Area (km²)
S4-1	5+600	5+750	150	0.002	0.048
S4-2	5+750	6+000	250	0.002	0.080
S4-3	6+000	6+100	100	0.002	0.032
S4-4	0+000	0+250	250	0.0042	0.080
S4-5	0+250	0+500	250	0.0042	0.080
S4-6	0+500	0+750	250	0.0042	0.080
S4-7	0+750	1+000	250	0.0042	0.080
S4-8	1+000	1+250	250	0.0042	0.080
S4-9	1+250	1+412	162	0.0042	0.052
S4-10	1+412	1+750	338	0.002	0.076
S4-11	1+750	2+000	250	0.002	0.056
S4-12	2+000	2+136	136	0.002	0.030
S4-13	2+136	2+400	264	0.006	0.059
S4-14	2+400	2+582	182	0.006	0.041
S4-15	2+582	2+738	156	0.0025	0.035
S4-16	2+738	3+200	462	0.008	0.104
S4-17	3+200	3+500	300	0.006	0.067
S4-18	3+500	3+727	227	0.006	0.051
S4-19	3+727	4+000	273	0.002	0.061
S4-20	4+000	4+200	200	0.002	0.045
S4-21	4+200	4+500	300	0.002	0.096
S4-22	4+500	4+750	250	0.002	0.080
S4-23	4+750	5+000	250	0.002	0.080
S4-24	5+000	5+250	250	0.002	0.080
S4-25	5+250	5+600	350	0.002	0.112

Flow direction: from sub-section S4-14 to S4-1 and from sub-section S4-15 to S4-25.

6.0 SURFACE WATER MANAGEMENT GUIDELINES

Section 4.2.3 of the *Construction Guidelines for Pollution Control Facilities at Uranium Mining and Milling Operations* developed by Saskatchewan Environment and Resource Management (SERM 2000) outlines criteria for surface water runoff management from clean waste rock piles:

- Drainage should be diverted to site surface water runoff collection pond, where possible, otherwise drainage should be directed to a sedimentation pond to settle out solids prior to the water entering a surface water body.

6.1 Extreme Rainfall Events

Rainfall intensity duration-frequency curves (IDF) were developed for Baker Lake, approximately 80 km west of the mine site. These data were developed by Environment Canada (2010) and are based upon historical rainfall records. The rainfall event with a 1 in 100 year return period and 24-hour duration for the Baker Lake area is

74.7 mm. The PMP event is estimated following the method described by Hopkinson (1994 and 1999) and WMO (1986). The estimated value for the Kiggavik area is 184 mm over a 24 hour period. The detailed evaluation of the PMP is provided in Technical Appendix 4A. The PMP value is used for sizing freshwater diversion channels and for channels around clean waste rock piles to reduce the risk of clean water coming in contact with potential contaminants within the footprint area.

6.2 Storm flow Hydrologic Analysis

A hydrologic analysis is undertaken to estimate the storm flow event in the fresh water diversion channel and in the clean waste rock pile ditches resulting from a 24-hour extreme rainfall event on the contributing areas.

The 24-hour storm is distributed on time (the storm hyetograph) using the instantaneous intensity method, also known as the *Chicago* Storm distribution. The Chicago Storm hyetograph is estimated based in the IDF curves. The method assumes that IDF curve can be expressed by the following relationship:

$$i = \frac{a}{(t+b)^c}$$

Where “i” is intensity (mm/hr), a, b, and c are IDF parameters and “t” is the time distribution (minutes). The time to storm peak is determined from:

$$tp = r * td$$

Where “tp” is the time to peak and “r” is the ratio of time to peak versus storm duration (td), also known as the storm advance coefficient that normally ranges from 0.3 to 0.5. In this assessment “r” is assumed to be equal to 0.33. The parameter a, b and c are estimated using the IDF curves for Baker Lake. Specifically intensities associate 1-hr, 2-hr, 6-hr, 12-hr and 24-hr duration and a 100-year return period are used (Table 9). The following values were estimated:

$$a = 126.44; \quad b = 0; \quad c = 0.501$$

Results of the hourly rainfall distribution as a percentage for a 24 hour storm period (either a 1:100 year storm or a PMP) are provided in Figure 3. This hyetograph is applied to the 24-hr PMP storm estimated for the Kiggavik area.

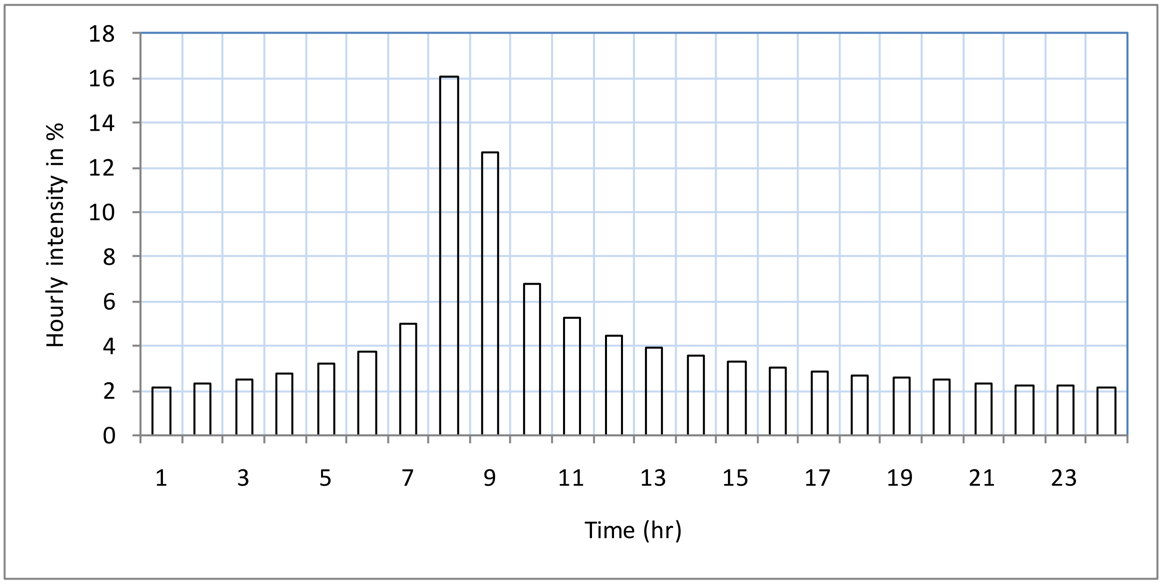

Figure 3: Hourly distribution of intensity in percentage for a 24-hr storm

6.3 Peak Flows and Total Runoff Volumes

The hydrological modeling system HEC-HMS, developed by the U.S. Army Corps of Engineers is used to simulate runoff from the 24-hour PMP event, to derive the peak flows and volumes as the design basis of the freshwater diversion channels and for the channels around the clean waste rock piles. Parameter and input information for the HEC-HMS were as follows:

- Estimates of drainage areas contributing runoff were based on available LiDAR for the site.
- The initial and constant loss methods were implemented in the model and were used to account for cumulative losses.
- The Soil Conservation Services (SCS) method in the HEC-HMS model was used to transform the precipitation excess into runoff. Overland flow length, surface slope and topographic characterization based on the LiDAR data were taken into account to estimate the approximate Lag-Time for peak flow, initial losses (depression storage and infiltration) and constant loss (infiltration) during the PMP event. Specifically the Lag-Time is estimated as 60% of the time of concentration as recommended by SCS.
- Time of concentrations for areas of interest is estimated using the Washington State Department of Transportation (WSDOT 2006) formula, i.e.,:

$$Tc = \frac{L}{k1\,S^{0.5}}$$

Where "Tc" is the time of concentration of a particular outlet in a basin in minutes (min), L is the length of the longest flow path in metres (m), k1 is a ground cover coefficient (m), and S is the surface slope (m/m). For this specific analysis the area of interest is basically bare ground. Consequently, a ground cover coefficient (k1) of 200 is used (WSDOT 2006).

- The Kinematic Wave routing model in HEC-HMS was used for flow routing through diversion channels and ditches. A standard trapezoidal flow cross-section was adopted to estimate the flow depth associated with peak flows.

7.0 HYDROLOGIC ANALYSIS RESULTS

The highest runoff scenarios for the site will occur under the presence of a rain PMP event or the rapid melting of large volumes of snow during the spring freshet. However, snowmelt is a much slower process when compared with a rainfall PMP event, i.e., the spring freshet would occur over several weeks, while the rain PMP event occurs over a period of 24 hrs. Consequently, it would be expected that the highest peak flow would occur under the PMP event of 24 hr duration (Figure 4). Based on snowcourse data from Baker Lake over the period 1965 to 2006, the maximum snow depth recorded was 188 mm (snow water equivalent) (SOCC 2008 internet site). This is similar to the PMP value but this snow volume would runoff over several weeks rather than 24 hours.

For the summer period, due to the permafrost and the gentle relief in the area, it would be expected soil moisture may be fairly high with surface drainage mainly confined within the active zone. For the spring freshet period the active zone has not been developed and a relative fast melting occurs over a frozen ground.

Due to the characteristics of a PMP event, i.e., high rainfall intensities in a relative short period, an initial loss of 10% of the PMP (i.e., 18 mm) and a constant loss rate of 0.5 mm/hr during the PMP are considered for the modeling process. These losses are comparatively small given the PMP magnitude of 184 mm. The initial loss may vary depending on when the event occurs i.e., early or late summer, because the active layer will be deeper and potentially more storage will be available.

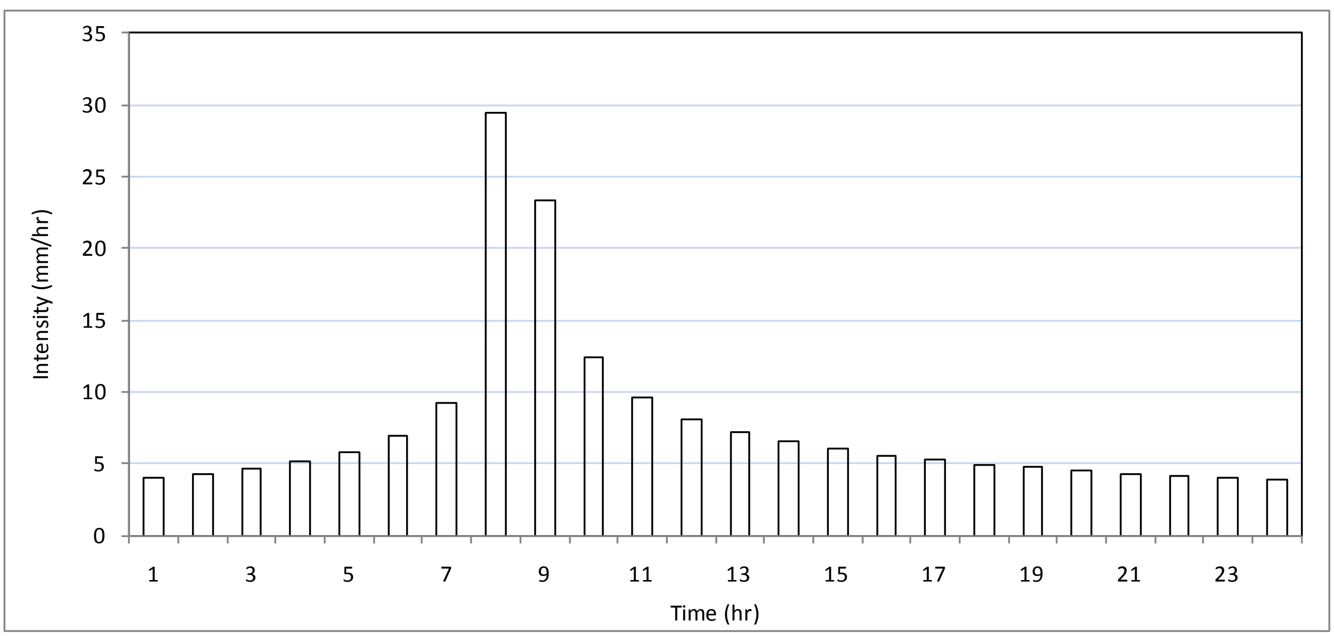

Figure 4: Distribution of Intensity versus Time for PMP 24-hour Storm at Kiggavik

7.1 Kiggavik Site

7.1.1 Freshwater Diversion Channel K1

Modeled peak flow and cross-sectional flow area results for each of the sub-sections considered for the diversion channel under the PMP distribution as shown in Figure 4 are provided in Table 9. In this table, sub-section identifiers contain “E” to indicate the east section of the channel, while the west sections contain “W”. Discharge hydrographs at the points where the diversion channels report to the natural drainage system are provided in Figure 5 for both sections.

Table 9: Freshwater Diversion Channel K1- Results for a PMP 24-hour Precipitation Event

Channel Sub-section	From Station	To Station	Total Contributing Area (km²)	Peak Flow (m³/s)	Cross-sectional Flow Area (m²)	Proposed Slope %
K1-1E	1+470	1+796	0.10	1.4	1.36	0.68
K1-2E	1+796	1+994	0.67	4	2.94	0.68
K1-3E	1+994	2+253	1.15	7.3	4.50	0.68
K1-4E	2+253	2+680	1.15	7.3	2.96	2.22
K1-5E	2+680	3+130	1.53	9.8	3.64	2.22
K1-6E	3+130	3+393	1.89	12.2	4.26	2.22
K1-7E	3+393	3+495	1.89	12.2	3.83	2.99
K1-8E	3+495	3+908	2.36	15.5	4.54	2.99
K1-9E	3+908	4+130	2.36	15.5	8.05	0.61
K1-10E	4+130	4+800	2.44	15.9	8.20	0.61
K1-11E	4+800	5+280	2.53[a]	20.1	9.73	0.61
K1-12E	5+280	6+390	2.69[a]	20.4	9.83	0.61
K1-1W	1+470	0+550	0.05	0.8	0.72	1.15
K1-2W	0+550	0+000	0.06	0.9	0.52	3.86

(a) Sub-section K1-11E receives runoff from the north clean waste rock pile.

Flow direction from subsection K1-1E to K1-12E and from sub-section K1-1W to K1-2W.

The discharge increases gradually in the east diversion channel from sub-sections K1-1E to K1-12E. Table 9 includes the expected peak flow in each of the sections together with the required cross-sectional flow area to convey the peak discharge. Sections at the west side of the core facilities area will have small peak flows to convey; therefore the cross-section geometry of this portion of the channel is much smaller and the design is more for constructability rather than for hydraulic requirements.

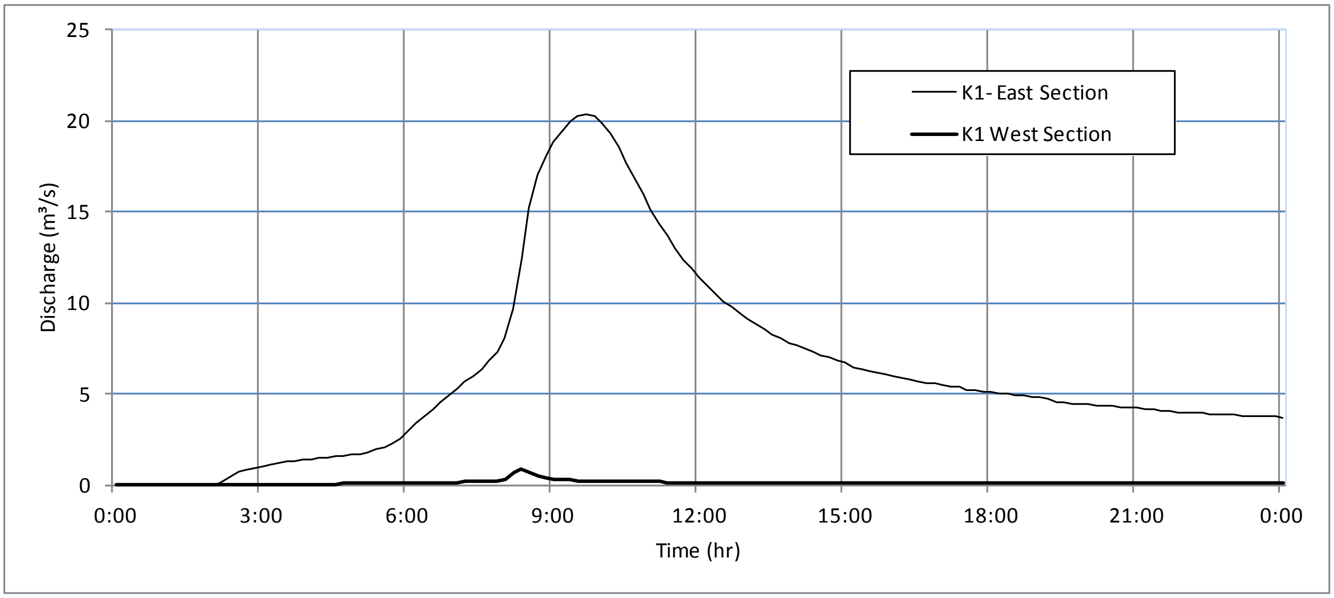

Figure 5: Hydrograph from the PMP 24-hour Storm for both East and West Sections of the Diversion at their Respective Outlet Locations

7.1.2 Channels for the Clean Waste Rock Piles

A similar procedure followed for the diversion channel is used for estimating the peak design flow for the ditches around the clean waste rock piles.

7.1.2.1 North Clean Waste Rock Pile K2

Peak flow and cross-sectional flow area for each of the 16 sub-sections defined for the north clean waste rock pile channel resulting from a PMP event are provided in Table 10. Both, sub-sections K2-1 and K2-16 discharge into the clean waste sedimentation pond located near station 0+000 and station 3+444 respectively, at the southeast end of the pile. Discharge hydrographs at the locations where the channels report to the sediment and the outflow from the sediment pond are provided in Figure 6. The peak flow under a PMP event from the sedimentation pond is 7.7 m^3/s.

Table 10: North Waste Rock Pile Channel K2 - Results for a PMP 24-hour Precipitation Event

Channel Sub-section	From Station	To Station	Total Contributing Area (km²)	Peak Flow (m³/s)	Cross-sectional Flow Area (m²)	Proposed Slope %
K2-1	0+000	0+250	0.345	5.1	2.2	2.0
K2-2	0+250	0+500	0.292	4.3	2.0	2.0
K2-3	0+500	0+750	0.238	3.6	1.7	2.0
K2-4	0+750	0+900	0.185	2.8	1.4	2.0
K2-5	0+900	1+150	0.152	2.4	1.9	0.7
K2-6	1+150	1+400	0.099	1.6	1.4	0.7
K2-7	1+400	1+610	0.045	0.7	0.8	0.7
K2-8	1+610	1+750	0.030	0.5	0.5	1.1
K2-9	1+750	1+950	0.073	1.2	1.0	1.1
K2-10	1+950	2+100	0.105	1.7	1.3	1.1
K2-11	2+100	2+350	0.159	2.6	1.0	4.4
K2-12	2+350	2+615	0.216	3.4	3.9	0.2
K2-13	2+615	2+800	0.256	3.8	4.2	0.2
K2-14	2+800	3+000	0.299	4.3	4.6	0.2
K2-15	3+000	3+250	0.352	4.8	5.0	0.2
K2-16	3+250	3+444	0.394	5.1	5.2	0.2
K2-17	-	-	0.739	7.7	2.7	2.6

Flow direction: from sub-section K2-7 to K2-1 and from sub-section K2-8 to K2-16.

Sub-section K2-17 is the release from the sediment pond to the north clean waste rock pile.

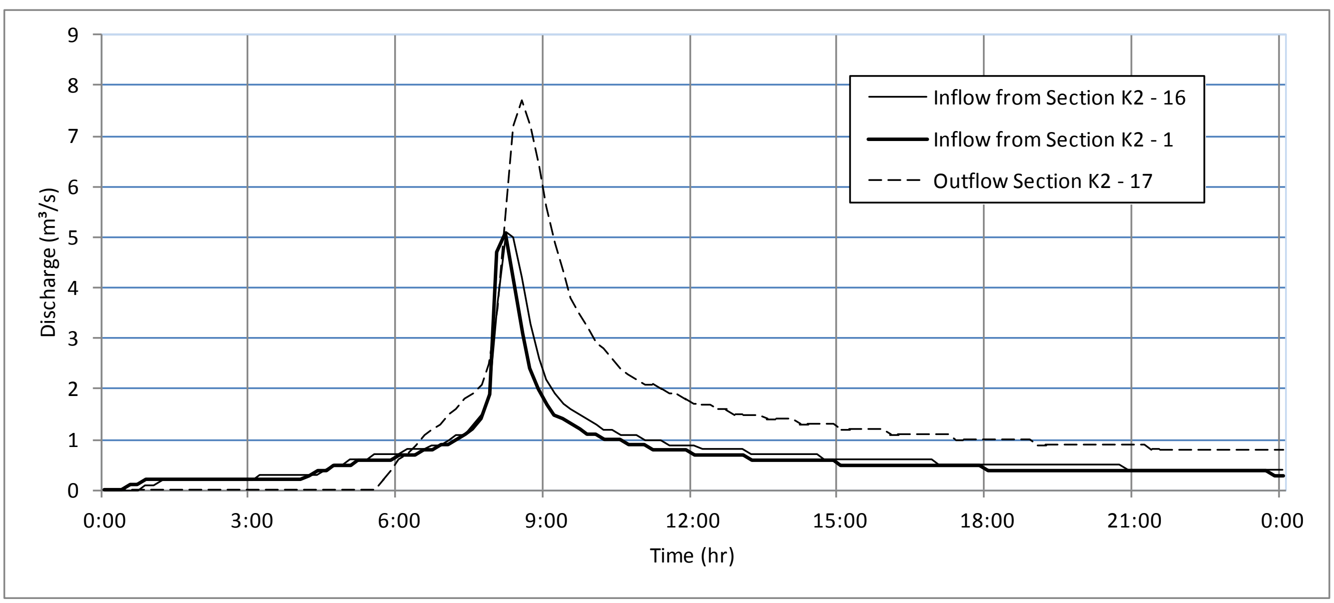

Figure 6: Hydrograph from the PMP 24-hour Storm for the Section K2- 1 and K2-15 at the Discharge Point to the Sediment Pond for the North Waste Rock Pile

7.1.3 South Clean Waste Rock Pile K3

Peak flow and cross-sectional flow area results for each of the 22 sub-sections defined for the collection channel around the south clean waste rock pile channel under the PMP event are provided in Table 11. In this table, sections labels increase numerically in counter clockwise direction. The direction of the flow is clockwise from Station 4+200 to Station 0+00, i.e., from section 17 to section 1, and counter clockwise from station 4+200.00 to station 6+602.00, i.e., from section 18 to section 22. Both, sections 1 and 22 discharge into the clean waste sediment pond located near station 0+00 along the south side. Discharge hydrographs at the points where the ditch channels report to the sediment pond are provided in Figure 7.

Table 11: South Waste Rock Pile Ditch - Results for a PMP 24-hour Precipitation Event (184 mm)

Channel Sub-section	From Station	To Station	Total Contributing Area (km^2)	Peak Flow (m^3/s)	Cross-sectional Flow Area (m^2)	Proposed Slope %
K3-1	0+000	0+250	0.646	6.0	4.6	0.7
K3-2	0+250	0+500	0.608	5.7	4.4	0.7
K3-3	0+500	0+750	0.571	5.4	4.2	0.7
K3-4	0+750	1+050	0.533	5.1	4.1	0.2
K3-5	1+050	1+250	0.488	4.8	4.1	0.2
K3-6	1+250	1+500	0.458	4.6	4.0	0.2
K3-7	1+500	1+800	0.421	4.3	3.8	1.0
K3-8	1+800	2+100	0.375	4.0	3.6	0.3
K3-9	2+100	2+250	0.330	3.7	5.1	0.3
K3-10	2+250	2+500	0.308	3.6	5.0	0.3
K3-11	2+500	2+750	0.270	3.4	4.8	0.2
K3-12	2+750	3+000	0.233	3.0	4.4	0.2
K3-13	3+000	3+250	0.195	2.6	3.9	0.2
K3-14	3+250	3+500	0.158	2.4	3.7	0.2
K3-15	3+500	3+750	0.120	1.8	1.5	0.2
K3-16	3+750	4+000	0.083	1.3	1.2	0.2
K3-17	4+000	4+300	0.045	0.7	0.8	0.2
K3-18	4+300	4+600	0.045	0.8	0.5	3.0
K3-19	4+600	4+750	0.068	1.1	1.2	0.4
K3-20	4+750	5+000	0.105	1.6	1.5	0.4
K3-21	5+000	5+300	0.150	2.3	2.0	0.4
K3-22	5+300	5+593	0.194	2.9	2.3	0.4

Flow direction: from sub-section K3-17 to K3-1 and from sub-section K3-18 to K3-22.

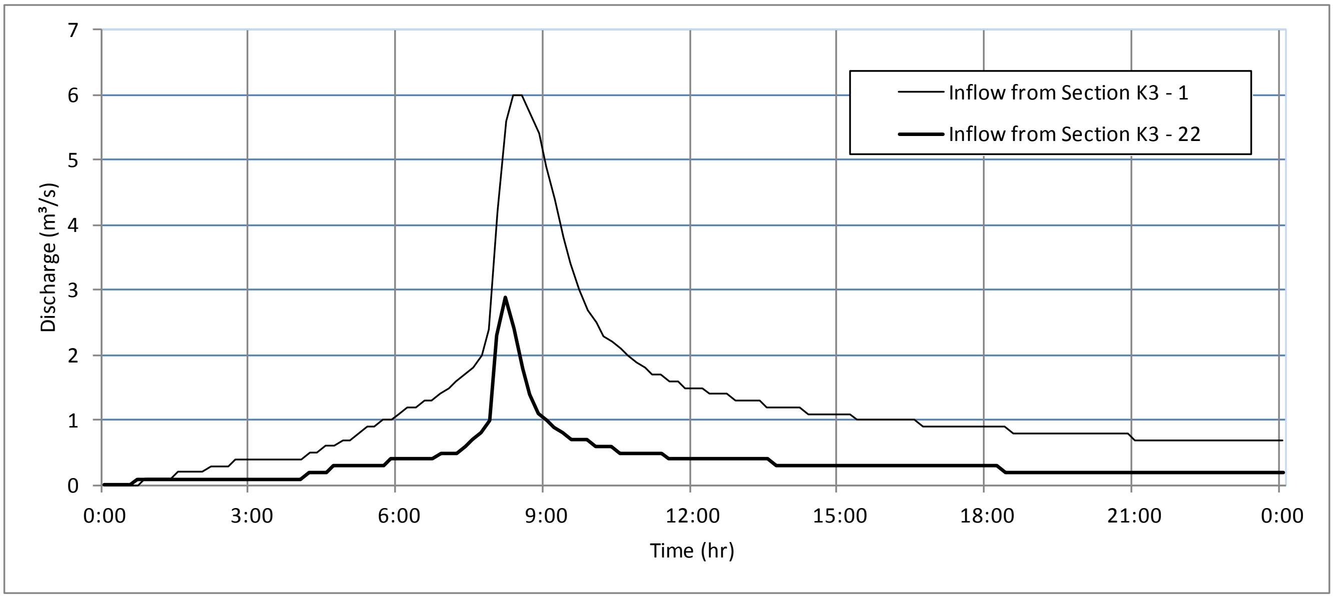

Figure 7: Hydrograph from the PMP 24-hour Storm for the Section 1 and 22 at the Discharge Point to the Sediment Pond for the South Waste Rock Pile

7.2 Sissons Site

7.2.1 Diversion Channel

Peak flow and cross-sectional flow area results are presented in Table 12 for each of the three main sections of the freshwater diversion channel. Peak flows are based on a PMP event. Diversion channel S1 is a separate channel, while channels S2 and S3 are connected (Figure 2, and Appendix I, Figure 007). Discharge hydrographs at the points where the diversion channels report to the natural drainage system are provided in Figure 8.

The discharge increases gradually into the east diversion channel from sections S1-1 to S1-6. Channel Section S1-2 receives the discharge for the large drainage area north of the site plus any amount form S1-1; therefore after S1-2 large discharges are observed downstream. Channel section S2 receives the discharges from three small lakes and their associated drainages (Figure 2) and transfers the flow to the S3 channel. Table 12 includes the expected peak flow in each of the sections together with the required cross-sectional flow area required to convey the peak. The peak flow at the outlet of channel S1 is 14m^3/s and 5.6 m^3/s at the outlet of channel S3.

Table 12: Freshwater Diversion Channels (S1 to S3) - Results for a PMP 24-hour Precipitation Event

Channel Sub-section	From Station	To Station	Total Contributing Area (km²)	Peak Flow (m³/s)	Cross-sectional Flow Area (m²)	Proposed Slope %
S1-1	1+210	0+890	0.056	0.7	1.3	0.2
S1-2	0+890	0+743	2.978	11.8	9.8	0.2
S1-3	0+743	0+587	3.462	13.4	10.8	0.2
S1-4	0+587	0+297	3.697	14.0	7.0	0.7
S1-5	0+297	0+160	3.697	14.0	7.4	0.7
S1-6	0+160	0+000	3.697	14.0	4.6	2.8
S2-1	0+000	0+310	0.034	0.3	0.7	0.2
S2-2	0+310	0+515	0.226	1.0	1.6	0.2
S2-3	0+515	0+768	0.258	1.1	1.8	0.2
S2-4	0+768	1+080	0.290	1.3	2.1	0.2
S2-5	1+013	1+478	0.332	1.7	2.0	0.4
S3-1	0+000	0+220	0.922	4.0	3.0	1.0
S3-2	0+275	0+325	0.981	4.3	2.3	1.7
S3-3	0+450	0+575	1.058	4.8	3.5	2.3
S3-4	0+770	0+825	1.189	5.6	3.4	1.5

Flow direction: from sub-section S1-1 to S1-6; S2-1 to S2-5 and for S3-1 to S3-4.

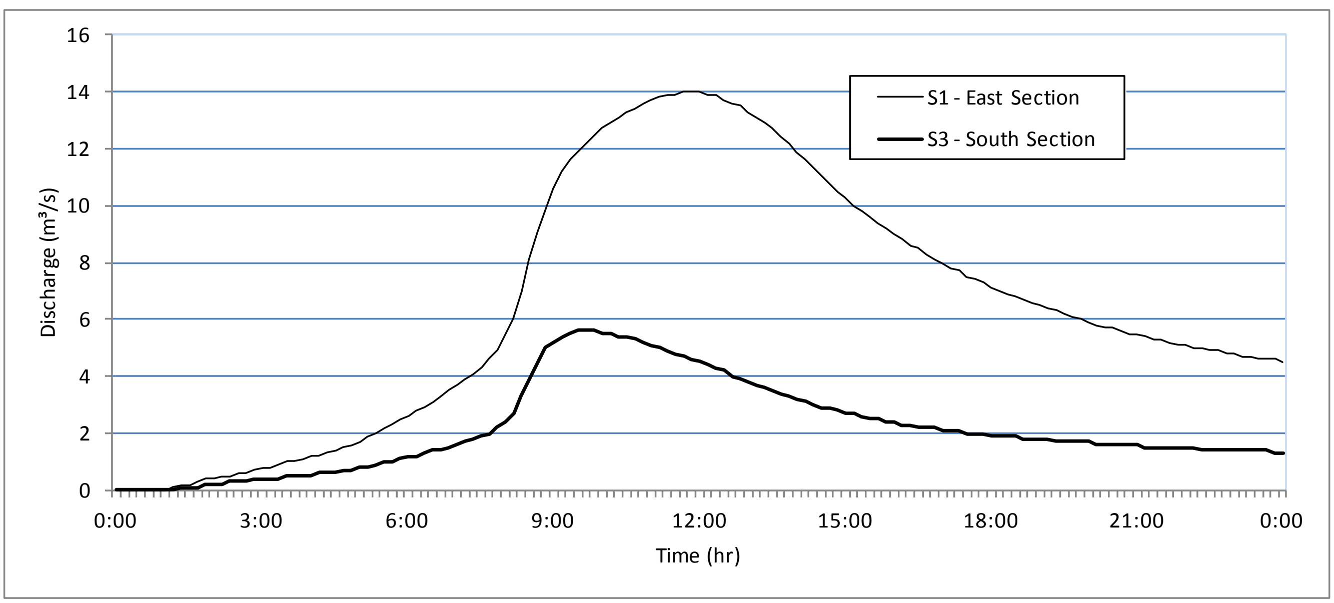

Figure 8: Hydrograph from the PMP 24-hour Storm for both Sections of the Diversion Channel Reporting to the Natural System – Sissons Site.

7.2.2 Channel for the Clean Waste Rock Pile S4

Peak flow and cross-sectional flow area results for each of the 25 sub-sections of the clean waste rock pile channel under a PMP event are provided in Table 13, and shown graphically in Figure 4. In this table, sub-sections labels increase numerically in counter clockwise direction. The direction of the flow would be clockwise from channel section S4-14 to channel section S4-1 and counter clockwise from station from channel sub-section S4-15 to sub-section 25. Both, channel sub-sections S4-1 and S4-25 discharge into the clean waste sediment pond located near station 5+600 at the south border of the pile. Discharge hydrographs at the points where the ditch channels report to the sediment pond are provided in Figure 9.

Table 13: Waste Rock Pile Channel S4 - Results for a PMP 24-hour Precipitation Event (184 mm)

Channel Sub-section	From Station	To Station	Total Contributing Area (km²)	Peak Flow (m³/s)	Cross-sectional Flow Area (m²)	Proposed Slope %
S4-1	5+600	5+750	0.88	10.4	8.85	0.2
S4-2	5+750	6+000	0.83	9.9	8.53	0.2
S4-3	6+000	6+100	0.75	9.2	8.08	0.2
S4-4	0+000	0+250	0.71	9	6.03	0.4
S4-5	0+250	0+500	0.63	8.1	5.58	0.4
S4-6	0+500	0+750	0.55	7.3	5.16	0.4
S4-7	0+750	1+000	0.47	6.3	4.63	0.4
S4-8	1+000	1+250	0.39	5.4	4.13	0.4
S4-9	1+250	1+412	0.31	4.4	3.55	0.4
S4-10	1+412	1+750	0.26	3.9	4.27	0.2
S4-11	1+750	2+000	0.19	2.9	3.43	0.2
S4-12	2+000	2+136	0.13	2	2.61	0.2
S4-13	2+136	2+400	0.10	1.6	1.49	0.6
S4-14	2+400	2+582	0.04	0.7	0.83	0.6
S4-15	2+582	2+738	0.03	0.6	1.01	0.3
S4-16	2+738	3+200	0.14	2.3	1.75	0.8
S4-17	3+200	3+500	0.21	3.2	2.47	0.6
S4-18	3+500	3+727	0.26	3.8	2.80	0.6
S4-19	3+727	4+000	0.32	4.6	4.83	0.2
S4-20	4+000	4+200	0.36	5	5.13	0.2
S4-21	4+200	4+500	0.46	6	5.88	0.2
S4-22	4+500	4+750	0.54	6.8	6.45	0.2
S4-23	4+750	5+000	0.62	7.6	7.01	0.2
S4-24	5+000	5+250	0.70	8.4	7.55	0.2
S4-25	5+250	5+600	0.81	9.5	8.27	0.2

Flow direction: from sub-section S4-14 toS4-1 and from sub-section S4-15 to S4-25.

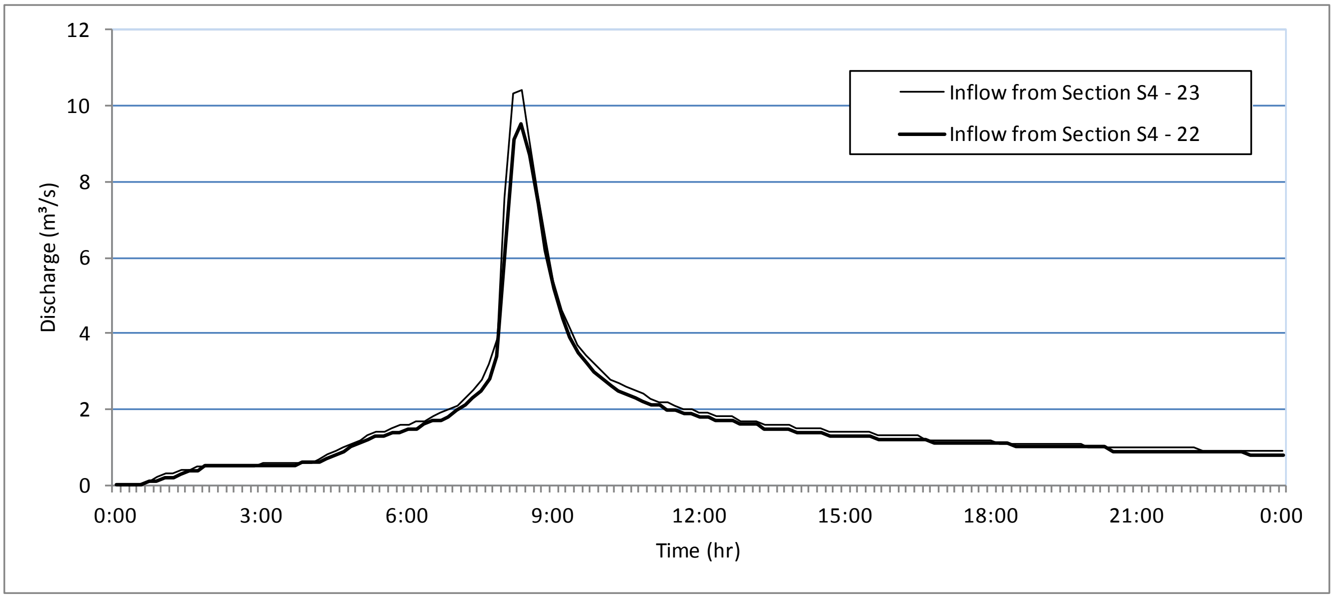

Figure 9: Hydrograph from the PMP 24-hour Storm for the Section 22 and 23 at the Discharge Point to the Sediment Pond. Waste Rock Pile - Sissons Site

7.3 General Consideration for Freshwater Diversion Channels

Details for the diversion channel, i.e. channel alignment, cross-sections and channel invert profiles are provided in Appendix I. A summary of the general considerations for the design of the diversion channels is as follows:

1) Channels are generally trapezoidal in shape with 3H:1V side slopes, though the natural ground may be used as one channel side when the channel is transverse across a slope and a berm is constructed on the opposite side to contain the flow.

2) The diversion channels will be constructed in one of three ways depending on topography and geotechnical conditions. These are channels with invert at existing grade with built-up berms to contain the flow, channels with excavation in overburden, and channels with excavation in bedrock.

3) There is potential for erosion and sediment transport in the constructed diversion channels and the degree to which this occurs depends on mainly soil type, channel gradient, channel geometry and flow magnitude. At present, geotechnical investigations along the proposed channel alignment has not been undertaken but it is expected that each of the three construction cases indicated above will occur at various locations along channel alignments. The potential for erosion and sediment transport is greatest in the first two cases and is much less where the excavation occurs in bedrock. Where the channel is built-up or excavated through overburden, the soil type will be identified and evaluated with respect erosion potential under peak flow conditions. Where peak flow velocities exceed soil material resistance (allowable to shear stress), riprap armouring overlying a geotextile will be placed on the channel bottom and sideslopes. Hydraulic models will be used to use to determine the appropriate median diameter of the riprap to resist the flow velocity and the lift thickness will be about 1.5 times the median diameter. Rip rap will consist of clean waste rock or pit run material. These measures will greatly reduce likelihood of erosion and sediment transport in the constructed diversion channels (Nishi-Khon/SNC-Lavalin 1999).

4) Technical Appendix 5O – Erosion and Sediment Control Plan, provides detailed information regarding best management practices (BMP's) to control erosion and sediment transport related to site construction activities. For diversion ditches, selected BMP's to limit erosion on exposed slopes may include topsoiling and seeding of indigenous species to stabilize slopes, riprap armouring and geotextiles on the channel bottom and sideslopes, along with checkdams and silt fences to trap sediment. Specific BMP attachments also provide details for inspection and maintenance.

5) The detailed design for the conveyance structures will provide specific BMP's to be used for each construction activity and will include drawings and site specific construction notes, along with monitoring, inspection, and record keeping protocols to confirm that BMP's are functioning as designed. Ongoing standardized inspection and maintenance reports will be carried out by qualified personnel at selected intervals during operations. Water quality monitoring for turbidity and total suspended solids will be carried to verify that erosion and sediment control measures remain effective.

6) As the channels are constructed in a permafrost environment there is potential for deformation in the constructed channel, and while detailed geotechnical investigations have not been conducted in the vicinity of the proposed channel it is assumed that the active layer thickness is 1.5 to 2 m, and channels will be constructed according to one or more of the three cases listed above. If the channel invert is cut to or into bedrock, then there is little concern with channel deformation. If the channel is constructed in till, to a depth of 1.5 to 2 m then there is potential for melting some permafrost below the adjacent active layer. If the permafrost below the pre-construction active layer is ice-rich (contains more frozen water than is required to fill the pore spaces) then likelihood and degree of deformation in the channel is greater and a modified design is required. General design approaches for the channel construction in ice-poor vs. ice-rich till is as follows:

   a. Ice-poor – the channel is cut with the geometry depending on local topography and required flow capacity. If riprap is required then the channel is over excavated an addition ~0.3 m to allow space for the riprap while maintaining the required cross sectional area

   b. Ice rich – The channel is over-excavated by 1 to 2 m deeper into the permafrost on the base and sides and compacted till placed in the oversized channel and built back up to the required channel geometry. Little deformation is expected in the in the ice-rich permafrost below the compacted fill.

   In addition to the design considerations implemented to reduce deformation in the channel due to permafrost melting, an ongoing monitoring and maintenance program will be in place (Nishi-Khon/SNC-Lavalin 1999).

   Detailed geotechnical and permafrost investigations will be completed prior to the detailed design and construction of the freshwater channels. Trenching or augering will be carried out at intervals along the channel alignment to evaluate subsurface conditions including the presence of rock subcrop. The detailed design will account for local variability in ground conditions so that the diversions will function as designed. While the results of the geotechnical investigations could influence the final design and construction methods, the results would not affect the function of the channels and thus, would not affect environmental effects predicted in the EIS.

7) Excavated soil material will be stockpile for reclamation purposes if possible, and bedrock/till will be used for construction materials where suitable or placed on the clean waste rock pile.

8.0 SUMMARY

The draft conceptual designs and channel alignments provided in this document are intended to redirect fresh water around the core facilities areas to limit the amount of water which must be managed on the Kiggavik and Sissons sites and to maintain natural flow pathways where possible. All structures are designed to convey the PMP 24 hour storm. This conservative design basis combined with the use of BMP's during construction and operations will protect against overflow and sediment transport to the receiving environment.

Further information regarding ground conditions and material types will be required to refine the design for these channels.

9.0 CLOSURE

We trust this submission meets your requirements. Should you have any questions or require further information please contact the undersigned. We appreciate the opportunity to conduct this work on your behalf.

Report Signature Page

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http://cms.stantec-ims.com/sites/areva/deis_april 2012 submission/volume 2 project description/tier 3 supporting technical appendices/tier 3 word documents/09-1362-0610 rpt 11 dec 8 ditches and diversions_final.docx

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APPENDIX I

Diversion Channel Details