APPENDIX 18

Water Management Plan

EAGLE GOLD PROJECT

Water Management Plan

FINAL REPORT

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LIST OF ACRONYMS

AET……………………………………………………………………actual evapotranspiration
AD .... active depressurization
ADR...Adsorption, Desorption and Recovery Facility
AG .... Ann Gulch
AG EDD ....Ann Gulch East Diversion Ditch
AG WDD ....Ann Gulch West Diversion Ditch
BP ....before present
CCME..Canadian Council of Ministers of the Environment
CGCM2 .... Canadian Global Climate Model
CSR.. contaminated sites regulation
DG..Dublin Gulch
DGDC... Dublin Gulch diversion channel
E.. evaporation
EC .... Eagle Creek
ECP.. Eagle Creek pond
EP ....Eagle Pup
ET...evapotranspiration
EVTP..Events Ponds
GWMR ....Groundwater Model Report
HDPE ....high density polyethylene
HLF ....Heap Leach Facility
HP .... Heap Pond
LDG..Lower Dublin Gulch
LCRS..Leachate Collection and Recovery System
LDRS..Leak Detection and Recovery System

LSGP....Lined Seepage Collection Pond
m^2....square metre
m^3....cubic metre
m^3/d....cubic metres per day
m^3/hr....cubic metres per hour
m^3/mo....cubic metres per month
m^3/s....cubic metres per second
m asl....metres above sea level
MBR....membrane breach reactor
Meq....milliequivalent
mg/L....milligrams per litre
MWTP....Mine Water reatment Plant
OP....Open Pit
P....precipitation
PE....potential evaporation
PET....potential evapotranspiration
PG....Platinum Gulch
SA....Study Area
SCP....Sediment Control Pond
SWBM....Surface Water Balance Model
SWBMR....Surface Water Balance Model Report
SWE....snow water equivalent
TDS....Total dissolved solids
TSS....Total suspended solids
USGS....United States Geological Survey
WMP....Water Management Plan
WRSA....Waste Rock Storage Area
WQ....water quality
WQM....water quality model

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1 INTRODUCTION

1.1 Objectives

This Water Management Plan (WMP) was prepared on behalf of Victoria Gold Corp. (VIT) for the Eagle Gold Project (the Project) in support of the requirements of environmental assessment and water licensing processes in the Yukon. A WMP establishes the protocol for the control and management of non-contact (i.e., from undisturbed basins or areas) and contact (i.e., from areas or facilities developed for the project) water during construction, operations, and reclamation activities.

The objective of the WMP is to provide specific strategies for addressing water requirements in all phases of the project in the lower Dublin Gulch valley of central Yukon (Figure 1.1-1). The WMP considers the environmental and engineering challenges and the effects of mining on water availability and conveyance for the project.

The WMP was developed with an understanding of the sequence of development and operation of mine-site facilities and integrated with the results of a detailed surface water balance model (SWBM) (Stantec 2010g), a water quality model (WQM) (Stantec 2010n), a groundwater model of the open pit (BGC 2010b), a groundwater model of the Dublin Gulch basin (Stantec 2010h). The SWBM provided detailed water-balance accounting for water conveyance and storage facilities associated with the project. The results of the SWBM provided the basis for decisions regarding the routing and storing of water, and with the results of the WQM for the assessment of potential effects from these facilities on water quality and aquatic habitat.

1.2 Site Location and Setting

The Project is located in the Mayo Mining District of central Yukon. The proposed facilities and mine site are located approximately 45 km north-northeast of Mayo. The Study Area (SA) for water management is in the Dublin Gulch and Eagle Creek watersheds, which are tributaries to Haggart Creek. The SA and water management domain includes all of the lower portions of the Dublin Gulch and Eagle Creek watersheds, plus portions of the adjacent Haggart Creek watershed. The Project, and its' proposed facilities (waste rock storage areas, open pit, heap leach facility and water storage structures) are located within the lower Dublin Gulch and Eagle Creek watersheds (Figure 1.2-1).

The access road to the project site requires minor alignment and water routing upgrades (e.g. culverts), and will be maintained by the proponent from the Construction phase to the end of the Post-closure monitoring phase. Roads at the project site include a lower and upper approach to the existing camp facilities near the mouth of Dublin Gulch. There are numerous access trails and roads within the project site property from past mineral exploration activities.

Existing infrastructure at the Project site consists of an advanced exploration camp. This camp is located between the lower drainages of Dublin Gulch and Eagle Creek on the east side of Haggart Creek and is the only semi-permanent infrastructure at the project site.

Portions of the Haggart Creek valley and the lower Dublin Gulch valley have been extensively reworked due to a long history of placer mining and exploration in the area. Currently, several of the drainages in the lower valley have been rerouted, including the Eagle Pup and Stuttle Gulch watercourses. Prior to placer mining activities, Eagle Pup and Stuttle Gulch flowed to Dublin Gulch. These watercourses are now tributaries to the existing Eagle Creek channel, which now discharges into Haggart Creek downstream of Gil Gulch (Figure 1.2-1).

1.3 Scope

The WMP describes and defines the spatial distribution and layout of natural and engineered water conveyance structures within both non-developed and developed areas including the proposed facilities that include:

- The Open Pit and dewatering/depressurization system
- The Heap Leach Facility and associated process and storage ponds
- The Waste Rock Storage Areas and associated sediment control ponds
- The water treatment system and ponds
- Major and minor stream diversions
- Other smaller water storage/conveyance structures around the mine site.

The WMP provides an accounting and decision-making process for managing various hydrologic conditions and mine scenarios through all phases of mine activity including the construction, operations, closure and reclamation, and post-closure monitoring phases. The plan incorporates predictions from surface water balance, water quality and groundwater modeling results of simulated conditions and scenarios for each of these phases. The modeling results are compared directly to predicted future conditions without development to facilitate the assessment of potential effects on water quality and aquatic habitat.

1.4 Project Timeline

Water management strategies are required for four general phases of the Project that include a 69 week Construction phase (including two summer construction periods), a 7.3 year Operations phase, a Closure and Reclamation phase which will vary in time for each facility, and an approximate five year post-closure environmental monitoring phase. Table 1.4-1 provides a summary of the key milestones that influence the water management plan.

Table 1.4-1: Key Phases of the Project

Phase	Period*	Details
Construction	Q1 2012 to Q3 2013** (Year 1 to Year 2)	Earthworks, construction and implementation of water supply wells, water treatment facilities, water diversion channels, water conveyance structures, bridges, culverts, sediment control ponds and other water storage facilities.
Operations	Q4 2013 to Q4 2020 (Year 3 to Year 9)	Operation, maintenance and monitoring of all structures associated with water management;
Closure and Reclamation	Varies from Q1 2021 up to Q4 2030 (Year 10 to Year 19)	Supplemental gold recovery, rinse-detoxify heap leach facility, heap draindown, site reclamation
Environmental Monitoring	As early as Q4 2025 to Q4 2035 (Year 15 to Year 25)	Stream, groundwater and seep water quality monitoring

NOTES:

* For module definition purposes only; environmental monitoring will begin as soon as each facility is reclaimed

** Assumes that major construction activities cannot be undertaken during the winter period from approximately Oct 29, 2012 through Mar 15, 2013

2 BASELINE CONDITIONS

2.1 Climate

2.1.1 Regional and Local Trends

The project site lies within the Mayo Lake-Ross River Eco-region in central Yukon. Regionally, the St. Elias mountain range to the west is the dominant physical feature in the region affecting climate. Moist Pacific maritime air masses are often blocked by the St. Elias range, which tends to reduce air temperatures and precipitation, particularly during the fall and winter. Local topographic enhancement of winter temperature inversions within the Yukon plateaus also tends to keep surface temperatures cool (Burn 1994). As such, the Dublin Gulch area is characterized by a “continental” type climate with moderate annual precipitation and a large temperature range. Summers are short and can be hot with periodic rainstorm events, the majority of snowmelt occurs in May contributing to high freshet flows, while winters are long and cold with moderate snowfall. Snowfall usually begins in October and the snowpack typically lasts until mid-June at higher elevations. Frost action may occur at any time during the summer or fall.

2.1.2 Temperature

Two weather stations are located at the project site. The Potato Hills station (1,420 m asl) is located in the alpine area of the site and the Camp location (823 m asl) is located in the lower valley near the existing camp (Figure 2.1-1). Historical temperature data exist for the Potato Hills station from 2007 – 2010 (data collection is on-going) and for the Camp station from 1993 – 1996 and 2009 – 2010 (data collection on-going) (Stantec 2010a). Temperatures at the project site have an annual expected range of approximately 70°C from +30°C to -40°C. However, temperature ranges have reached as great as 98°C at regional stations in the past (Stantec 2010a). Maximum annual temperatures occur in July or August, while minimum temperatures occur in December or January. Daily maximum temperatures exceed 0°C from late April to October, although daily mean temperatures may not rise above freezing until May. Based on baseline data collected from the Potato Hills and Camp stations, temperature inversions (i.e., where relatively warm air at higher elevations traps cooler air in the lower valley bottoms) have been observed during the late fall and winter at the project site (Stantec 2010a).

Regional historic data from Mayo (see Figure 3.1 in Stantec 2010g) indicate the mean annual temperature has fluctuated approximately 4°C over the past 85 years, but there has been no distinct warming or cooling trend (Stantec 2010a). Regional temperature trends and on-site data for both the Potato Hills (1993 – 1996 and 2007 – 2009 data) and Camp (2009 data) stations are summarized in the Climate Baseline Report (Stantec 2010a). Temperature estimates for specific proposed facilities at the site (e.g. Heap Leach Facility) were obtained by applying a lapse rate equation based on historical regional data from Mayo and Keno Hill (Table 2.1-1) and calibrated with on-site temperature data. This is described in more detail in the SWBM report (Stantec 2010g).

Table 2.1-1: Comparison of Mayo (1925 – 2009) and Keno Hill (1974 – 1982) Historical Temperatures

Month	Mean Temperature		Maximum Temperature		Minimum Temperature	
	Mayo	Keno Hill	Mayo	Keno Hill	Mayo	Keno Hill
Elevation (m asl)	**504**	**1,473**	**504**	**1,473**	**504**	**1,473**
October	-2.2	-5.2	2.0	-2.5	-6.4	-8
November	-15.4	-10.9	-10.8	-7.7	-19.9	-14.3
December	-22.3	-16.1	-17.2	-11.4	-27.5	-19.4
January	-25.5	-16.6	-20.3	-13.3	-30.9	-20.2
February	-19.6	-14.1	-13.3	-10.7	-25.9	-17.7
March	-10.7	-11.2	-3.5	-7.8	-18.0	-14.8
April	-0.1	-4.7	6.3	-1.3	-6.5	-8.2
May	8.0	2.1	14.6	5.6	1.4	-1.5
June	13.7	7.8	20.8	11.7	6.5	3.8
July	15.3	10.4	22.3	14.4	8.3	6.4
August	12.5	9.1	19.3	12.9	5.7	5
September	6.4	2.9	12.2	6	0.6	-0.3

2.1.3 Evaporation, Evapotranspiration and Sublimation

Several equations and regionalization techniques for estimating evaporation, evapotranspiration and sublimation were tested and compared to regional data from previous reports (e.g. Clearwater

Consultants, 1996, 2006). In this case, monthly variations of evaporation, evapotranspiration and sublimation are known to be dependent on temperature. The derivation for these three parameters is summarized below. A more detailed discussion is provided in the SWBM (Stantec 2010g).

2.1.3.1 Evaporation

Evaporation for the site was calculated with the Hamon model (from Hamon 1961) for data collected from Potato Hills (Table 2.1-2). The Hamon model provides an estimate of *PET*, but approximates actual lake evaporation particularly well (Peters 2003; Peters et al. 2006). The data indicate that evaporation generally begins in late April and ends in early October, while it peaks in June or July. The lower 2008 July estimate reflects cooler temperatures and wetter conditions compared to July 2009. These data were used to calibrate the evaporation and evapotranspiration coefficients in the SWBM.

Table 2.1-2: SA Evaporation Estimates 2007 – 2009

Station	Month												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2007													
Potato Hills	–	–	–	–	–	–	–	39.1	20.6	2.0	0.0	0.0	
2008													
Potato Hills	0.0	0.0	0.0	6.3	45.7	75.2	70.3	48.8	25.4	2.4	0.0	0.0	274.2
2009													
Potato Hills	0.0	0.0	0.0	7.0	– *	57.75*	94.8	56.5	29.8	0.0			
Camp	–	–	–	–	–	–	–	18.2[a]	36.2	7.9			

NOTES: Data derived using the Hamon evaporation model (annual data are partial totals from available data)
Data units are millimetres per month
[a] Data collection began Aug 21 2009
* Instrument error – missing data May 1 – June 6, 2009
– No available data

2.1.3.2 Evapotranspiration

Potential evapotranspiration (*PET*) was calculated by using a temperature based equation adapted to a monthly timescale (Hamon 1961 from Dingman (p.310) 2002).

$$PET = (29.8 * D_e * e_s) / (T_{mean} + 273.2),$$

where:

D_e = effective daylength
T_{mean} = mean monthly temperature
e_s = saturated vapour pressure for the reference elevation and of the basin or facility.

Table 2.1-3: Evapotranspiration Estimates

Station	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Monthly Total Evapotranspiration (mm)												
Calculated Monthly Average Based on On-site Climate Data*												
Potato Hills	0	0	0	0	47	76	69	50	30	0	0	0
Camp	0	0	0	0	47	76	67	49	27	0	0	0
Calculated Monthly Totals based on Baseline Model**												
2007								67	27	0	0	0
2008	0	0	0	0	47	73	69	50	29	0	0	0
2009	0	0	0	0	44	70	91	55	32			

NOTES:
* from Environmental Baseline Report: Climate (Stantec 2010a).
** using equation above from Hamon (1961)

To estimate actual evapotranspiration (*AET*), the potential evaporation estimate was input into an equation that used the relationship between precipitation (*P*) and *PET* (Dingman (p.312) 2002) where monthly precipitation is used as a proxy for the soil moisture.

$$AET = P / (1 + (P / PET)^2)^{0.5}$$

Although this equation actually underestimates evapotranspiration during summer-dry periods, such that if *P* = 0 during summer, the estimated *AET* would be zero. However, for the SWBM, there are no periods when *P* = 0.

2.1.3.3 Sublimation

Sublimation rates in the Yukon can vary considerably depending on latitude, physiographic location, temperature, time of year, aspect and cloud cover. Estimates from other reports (URS/Scott Wilson 2010; Golder 2008; Pomeroy, et al., 1997; Clearwater Consultants 1996) have ranged from negligible up to 50% of the snowpack (see Table 3.1-6 in Stantec 2010g). In this case, due to the high uncertainty in the estimate and the reported measureable levels, sublimation was assumed to be 20% of the estimated monthly snowpack.

2.1.4 Precipitation

Historical rainfall data exist for the site from the Potato Hills station from 2007 – 2009 (data collection is on-going) and for the Camp station from 1993 – 1996 and 2009 (data collection on-going). The data indicate that the higher elevations typically receive significantly more rainfall. The measured orographic gradients at the site vary seasonally and range up to 27 mm/100 m (Stantec 2010a).

On-site snow surveys were completed in 1996 (Knight Piésold 1996), 2009 (Stantec 2010a) and 2010. The survey data demonstrate substantial differences in snow accumulation between the high and low elevations at the project site. In all three years the Potato Hills station had considerably more snow and melted later than the Camp station. These data were compared to the historical regional data from the Calumet (1975 – 2009) (Calumet is located near Keno Hill, see Figure 3.1 in Stantec 2010g) and Mayo (1968 – 2009) snow survey stations to develop long-term estimates for the site (Stantec 2010a). In general, the on-site data are better represented by the Calumet station, which has a similar elevation. However, the Potato Hills station had higher snow depths, densities, and snow-water equivalents (SWE) than both Calumet and Mayo stations, while there was less SWE at the Camp location. Seasonally, the maximum snow depth typically occurs in April, based on long-term historic data from Calumet and Mayo. Snow surveys in 2009 and 2010 occurred in April and late March respectively suggesting that the maximum recorded depths and SWE were also recorded for the study area for those surveys.

Annual precipitation estimates for the project site were based on an evaluation of on-site rainfall and snow survey data and regional data and the development of a regional precipitation – elevation regression equation (see Stantec 2010a and Stantec 2010g), which reflects the well developed orographic effects associated with the relatively high topographic relief of the SA. Thus, total annual precipitation rates for specific facilities and sub-basins vary with elevation at the project site. Frequency analysis was completed on the regional precipitation data using a Log Pearson III distribution to assess the annual precipitation totals and their return periods. This information was used to estimate the project site annual precipitation estimates (Table 2.1-4). The methods for derivation of the precipitation estimates are described in the SWBM report (Stantec 2010g).

Table 2.1-4: Regional Annual Maximum Precipitation

Hydrologic Scenarios	Statistics		Regional Stations					Local Stations	
			Measured					Predicted	
	Exceedance Probability	Return Period	Dawson	Mayo	Elsa	Klondike	Keno Hill	Potato Hills	Camp
Elevation (m asl)			**370**	**504**	**814**	**973**	**1473**	**1420**	**823**
Units	**%**	**yrs**	**mm/a**	**mm/a**	**mm/a**	**mm/a**	**mm/a**	**mm/a**	**mm/a**
	0.2	500	520	481	514	749	749		
	0.5	200	494	463	466	724	738		
	1	100	473	447	431	701	727		
	2	50	451	430	396	674	711		
Wet Year (20 Year Return)	**5**	**20**	**420**	**404**	**350**	**629**	**681**	**660**	**496**
	10	10	393	381	315	586	647		
	20	5	363	352	279	531	597		
Average Year (2 Year Return Period)	**50**	**2**	**310**	**298**	**224**	**421**	**478**	**449**	**345**
	80	1.25	263	246	183	314	345		
	90	1.11	240	221	166	262	278		

Hydrologic Scenarios	Statistics		Regional Stations					Local Stations	
			Measured					Predicted	
	Exceedance Probability	Return Period	Dawson	Mayo	Elsa	Klondike	Keno Hill	Potato Hills	Camp
Dry Year * (1.055 Year Return Period)	**95**	**1.055**	**223**	**201**	**154**	**222**	**227**	**213**	**205**
	99	1.01	194	166	134	157	145		

NOTES:

Regional Annual Precipitation – Elevation Regression Equations

	y = precipitation x = elevation			
Hydrologic Scenarios	**Equation y = mx+b**	**m**	**b**	**r²**
Wet Year (20 Year Return Period - 5% Chance Exceedance)	y = 0.273x + 270.9	0.273	270.9	0.64
Average Year (2 Year Return Period - 50% Chance Exceedance)	y = 0.173x + 203.0	0.173	203.0	0.54
Dry Year* (1.055 Year Return Period - 95% Chance Exceedance)	y = 0.0135x + 194.1	0.0135	194.1	0.037

* Dry regression values indicate negligible correlation with elevation and are similar to mean dry values of the five regional climate stations

The annual distributions of total precipitation, rain fall and snowfall in the SA are based on an examination of local precipitation data with other regional stations. The Keno Hill station is located in an area most similar to the physiography, elevation, and latitude of the SA, and so the monthly proportions of precipitation, rain, and snow were based on the historical (1974 – 1982) Keno Hill annual distributions for total precipitation, rainfall, and snowfall (Table 2.1-5). Snowmelt typically begins in late April, with the majority of snowmelt (approximately 80%) occurring in May. While snowfall typically begins in September in the higher elevations, much of this snow will melt before mid-October. The derivations for the distribution of annual precipitation into monthly proportions of rain, snow and snowmelt are described in the SWBM report (Stantec 2010g).

Table 2.1-5: Distribution of Annual Precipitation, Rainfall, and Snowfall into Monthly Proportions at Keno Hill (1974 – 1982)

Month	Precipitation	Rainfall	Snowfall
October	0.109	0.013	0.195
November	0.080	0.000	0.152
December	0.079	0.000	0.151
January	0.057	0.000	0.108
February	0.045	0.000	0.085
March	0.058	0.000	0.111
April	0.051	0.001	0.097
May	0.050	0.069	0.032
June	0.123	0.250	0.009

Month	Precipitation	Rainfall	Snowfall
July	0.141	0.297	0.000
August	0.103	0.215	0.002
September	0.104	0.156	0.057
	1.000	**1.000**	**1.000**

2.1.5 Design Criteria

Peak flow and volume criteria were established for the design of various drainage ditches, diversions and control ponds. These criteria were also used to develop the scenarios to evaluate the effectiveness of various water routing systems within the project site. The design conditions included hydroclimatic scenarios, hydroclimatic events, and upset conditions.

Hydroclimatic scenarios include the average year conditions (50% chance of exceedance), wet year conditions (5% chance of exceedance); and dry year conditions (95% chance of exceedance). Upset conditions include facility malfunctions or shutdowns. Details on these scenarios are provided in the SWBM report (Stantec 2010g). A summary of the hydrologic scenarios in the SWBM is provided in Table 2.1-6.

Table 2.1-6: Water Balance Scenarios

Scenario	1	2	3	4	5	6	7
Hydro-climatic Condition	Average Year	Wet Year	Dry Year	Wet Year + Freshet Storm* (May)	Wet Year + Storm* (July)	Dry Year + Summer Drought	Average Year + Freshet (May) (Facility Condition)
				+	+	+	+
Hydro-climatic Event				1:100 Year 24 hour event	Storm Event 1:100 Year 24-hour event	1:50 year drought	
							+
Facility Conditions	HLF Cover Infiltration: 0/10/20/30/100%; WRSA Cover Infiltration: 0/5/10/20/30/100%	HLF Cover Infiltration: 0/10/20/30/100%; WRSA Cover Infiltration: 0/5/10/20/30/100%	HLF Cover Infiltration: 0/10/20/30/100%; WRSA Cover Infiltration: 0/5/10/20/30/100%	HLF Cover Infiltration: 20%; WRSA Cover Infiltration: 20%	HLF Cover Infiltration: 20%; WRSA Cover Infiltration: 20%	HLF Cover Infiltration: 20%; WRSA Cover Infiltration: 20%	HLF Cover Infiltration: 20%; WRSA Cover Infiltration: 20%; Process Plant and MWTP Shutdown (7 Day Draindown)

NOTES:
A = Average Year
W = Wet Year
D = Dry Year
*1 in 100 Year, 24 Hr Storm Event (95% confidence limit, defined in Table 3.4-4 of the Surface Water Balance Model Report, Stantec (2010g).)
Facility Condition simulation was a HLF liner malfunction and included a 7-day draindown condition

Hydroclimatic conditions are affected by the characteristics of a particular hydrologic event (e.g. snowmelt runoff, rainfall runoff, low base flow). Hydroclimatic events are specific instances of storm or drought conditions that affect the monthly management of water at the project site. The design storm event (1:100 year 24-hour event) is estimated as a rainfall event with an accumulation of 103.5 mm/24 hour. The design drought event is the 1:50 drought condition that is applied to the dry year scenario.

2.1.6 Permafrost

The project Operations phase will result in some permafrost loss within the footprints of the HLF, WRSAs, and Open Pit, and in various other locations planned for land clearing and re-contouring within the overall project footprint. Based on overlaying the project footprint on to permafrost areas (as identified in the Surficial Geology, Terrain, and Soils Baseline Report [Stantec 2010c]), the total potential permafrost area affected by facilities is approximately 12,150 m^2. Based on boring log and map data prepared from field investigations conducted in 1995, 1996 and 2009 (BGC 2009) and site observations, the thickness (and distribution) of permafrost varies considerably across the site, but likely averages between 10 m and 20 m where permafrost exists. If it is assumed conservatively that the permafrost has an ice content of 10% to 20%, then the melted permafrost would yield approximately 24,300 m^3 (12,150 m^3 to 48,600 m^3) of water over the approximately 9 year long Construction and Operations phases. Assuming the melt is constant during the ice-free months of the 9-yr life, and then this volume would amount to approximately 0.1% (0.05% to 0.2%) of the average annual flow of Dublin Gulch.

2.1.7 Climate Variability

Globally, there is evidence that the climate is warming. Climate modeling for the Canadian north suggests temperatures will increase from 2 to 5°C (above late-20th century temperatures) by 2050 (Walsh, et al. 2005). These temperature changes would also be accompanied by changes in precipitation volumes and distribution. Regional studies have shown larger temperature increases in the Yukon compared to British Columbia and annual precipitation has increased from 5 – 15% in Mayo over the past 50 years (Werner, et al. 2009). It is expected that the effects of increased temperatures will have a considerable affect on northern Canada because of the prevalence of permafrost and ground ice in the region (Natural Resources Canada 2010).

Permafrost loss coupled with predictions of increased precipitation in the region could lead to greater surface runoff in the Canadian north. These precipitation increases may be offset by increased evaporation associated with warmer temperatures and therefore the net result may be a relatively small effect on streamflow (Walsh, et al. 2005). However, the predicted increases in mean annual temperatures suggest permafrost loss will continue in the future.

A common method to assess the potential effects of climate variability is to model future climate conditions using emissions scenarios that reflect the future environmental conditions. These scenarios describe different emissions rates and are used as boundary conditions in climate models. Based on the second version of the coupled Canadian Global Climate Model (CGCM2), climate change studies for the Yukon predict precipitation increases of up to approximately 11% from the 1961-1990 baseline data for the period ending in 2030 (Lacroix 2010, pers. comm.).

In the context of the project, permafrost loss is expected at the site due to increased temperatures (e.g., climate variability) and to land disturbance (e.g. facility installation). Permafrost loss can affect slope stability and presents additional, though manageable, sediment control issues at the site. A detailed sediment control plan will be prepared as part of the water license application. Erosion and sedimentation issues are mitigated by use of sediment control ponds where entrained sediments may settle out, diversion ditches or silt fence to purposely direct sediment laden water to sediment control ponds, and the use hay or vegetation to cover newly-exposed soils to restrict soil erosion.

Thus, while the tertiary effects of permafrost loss will be managed through sediment and erosion control measures, the hydrological impact of permafrost loss at the site is of small magnitude (in terms of surface runoff) relative to the magnitude of a specific hydrologic event (i.e., an increased magnitude or intensity of a rainfall event associated with variable climatic conditions). Further, the total volume of water contained within the permafrost that would slowly melt on site is negligible (see Section 2.1.6 above) compared to the volumes of snowmelt, rainfall runoff and baseflow.

As part of the surface water model development, recent local and regional precipitation data were compared and used to develop precipitation-elevation regression equations. It is noteworthy that these equations are based on long-term data sets (i.e., Mayo: 85 years) that may underestimate the effect of increased magnitudes or intensities due to climate change. As discussed in Section 4.0, regional precipitation trends that are possibly linked with climate variability (i.e., Werner, et al. 2009) were accounted for in the calibration and sensitivity analysis of the SWBM by using a precipitation factor, which essentially increased the precipitation estimates predicted by the regression equations to match those observed on the site in the last three years. The precipitation factors were 1.55 for Wet year scenarios, 1.4 for Average year scenarios, and 1.0 for Dry year scenarios. These factors account for the estimated 11% precipitation increases derived from the CGCM2 models. Therefore, while the net effect of climate variability on the site water management plan is not clearly definable, the scenarios modeled in the water balance model are sufficiently robust to address the effects of predicted climate changes in the Yukon.

2.2 Physiography and Surface Water Drainage Network

2.2.1 Physiography

The project is located within the Mayo Lake-Ross River Ecoregion, which encompasses the Stewart, Macmillan, and Pelly plateaus, a subdivision of the Yukon Plateau physiographic subdivision. Terrain consists of rolling upland plateaus and small mountain groups with nearly level tablelands dissected by deep and broad U-shaped valleys (Stantec 2010c). During the Pleistocene, glacial ice extended up Dublin Gulch to Stewart Gulch and partially into Ann, Stuttle, and Platinum Gulches and Eagle Pup during the Reid glaciation (190,000 to 310,000 BP) (Bond 1998). The middle section of Dublin Gulch was not glaciated as late as the upper and lower sections of the valley. The depositional remnants of this glacial period primarily consist of till deposits in the lower Dublin Gulch valley and minor glaciofluvial or glaciolacustrine deposits. Most of the slopes in the project area are between 15 to 30%. Further details of the surficial geology and physiography of the SA are found in the Surficial Geology, Terrain, and Soils Baseline Report (Stantec 2010c) and the Hydrology Baseline Report (Stantec 2010d).

2.2.2 Surface Water Drainage

Drainage boundaries within the project area are shown on Figure 2.1-1. The Eagle Creek drainage was created as a result of historical placer mining activities in the Dublin Gulch valley. The Eagle Creek drainage now captures surface water runoff from Eagle Pup basin and Stuttle Gulch basin before entering the Haggart Creek valley south of Dublin Gulch. Eagle Creek flows parallel to Haggart Creek for several kilometers through placer deposits including several ponds that are also fed by groundwater seeps before draining to Haggart Creek downstream of the mouth of Gil Gulch.

The open-water season hydrograph is characterized by freshet-generated peak flows in May to early June, followed by a relatively rapid recession to moderate to low flows throughout July, August and September, depending on the volume of rainfall. Baseflow (groundwater discharge) minimum flows during the open-water season typically occur during August (Stantec 2010e). Intense rainfall events can cause short-term increases in streamflow and the storm-event recessions are generally rapid in the late summer and fall, reflective of low groundwater storage capacity of many of the basins.

Based on field observations, it is likely that certain reaches of lower Dublin Gulch and most of Haggart Creek (within the SA) are perennial streams with a very small sub-ice winter flow component. Winter flows are the lowest flows of the year, and reflect groundwater baseflow contributions. Some of the smaller streams are intermittent or ephemeral during the open-water season, and have been observed to either dry up or freeze to the bed in winter (e.g. Eagle Pup, Stewart Gulch, Ann Gulch, Stuttle Gulch and Platinum Gulch). It is assumed the other similarly-sized streams also either dry up or freeze to the bed in winter based on similar basin sizes and physiography (see the Hydrology Baseline Report [Stantec 2010d] for further details).

2.2.3 Surface Water Quality

A baseline water quality monitoring program was conducted in 2007 – 2009 and compared to historical data from 1993 – 1996. Twelve sites were sampled up to seven times during the recent program. The water quality monitoring sites are shown in Figure 2.1-1.

Data from recent studies (2007 – 2009) indicate water quality analytical results were within the range observed during the 1993 – 1996 period for general chemistry, nutrients and organics including pH, alkalinity, hardness, conductivity, sulphate, nitrate, dissolved ortho-phosphate, and total dissolved solids, although variability was higher in the historical data. The streams were circumneutral to basic in pH. Nutrient levels tended to be low and suggestive of oligotrophic levels, with ammonia below detection limits in most samples, measurable amounts of nitrate, and low phosphate levels. Dissolved organic carbon levels also tended to be low. All sites, except those located in Dublin Gulch, had high acid buffering capacity, as indicated by high alkalinity, calcium, and hardness.

Turbidity and total suspended solids tended to be low at most sites except for those streams in recently disturbed areas during spring freshet and following rain events.

Metals levels in surface water were consistent with a mineralized area. Some elevated levels may reflect previous disturbance of substrates during placer mining, or elevated levels in groundwater. Six parameters exceeded Canadian Council of Ministers of Environment (CCME) and BC guidelines for protection of aquatic life: aluminum, arsenic, cadmium, copper, iron and lead. The exceedances were observed occasionally for all these metals except arsenic. Total arsenic levels tended to be consistently higher than the guidelines for all sampling dates and all sites, except those in lower Lynx Creek and most of the Haggart Creek sites. More than 90% of samples analyzed for cyanide (total and weak acid dissociation) had levels below the analytical detection limit.

Seasonal trends indicate levels of pH, alkalinity, hardness, conductivity, TDS and nitrate tended to be lowest at most sites in May reflecting a lower influence of groundwater during high spring flows. Levels of TSS, aluminum, arsenic, cadmium, copper, iron, and lead tended to be highest at that time due to the re-suspension of metals from sediments disturbed by placer mining over many years. Further details on the water quality monitoring program are provided by the Water Quality and Aquatic Biota Baseline and Data Report (Stantec 2010e).

2.3 Groundwater

2.3.1 Hydrogeologic Units

Surficial material at the project site consists of a thin veneer of organic soils underlain by colluvium, glacialfluvial deposits, or till. Below these clastic units are either metasedimentary or granodiorite weathered bedrock. The surficial material thickness and physical properties varies significantly throughout the area. Recorded depths to bedrock in the project area range from 0 m to greater than 20 m (Stantec 2010b).

The Dublin Gulch valley contains large amounts of the fluvial materials that were considerably reworked by placer mining operations. Extensive stockpiles of placer deposits comprised of sub-rounded metasediment and granodiorite clasts, ranging in size from sands to boulders, and fine-grained material (i.e., settling ponds) are present adjacent to the Dublin Gulch and Eagle Creek watercourses.

Further details of the spatial distribution and characteristics of these materials are found in the Hydrogeology Baseline and Data Report (Stantec 2010b) and Surficial Geology, Terrain and Soils Baseline and Data Report (Stantec 2010c).

2.3.2 Groundwater Occurrence

Generally groundwater has been observed deeper (approximately >6 mbg) at higher elevations and shallow to artesian in lower elevations and in valley bottoms (Stantec 2010b). Springs and seeps have been observed in a few locations where valley bottoms have narrowed. These are typically associated with the re-emergence of a stream from channel deposits (i.e., a gaining reach). In these instances (e.g. Eagle Pup, Stewart Gulch), alluvium overlying shallow and low-permeability bedrock is the primary contributor to the emergence. Groundwater levels within the Lower Dublin Gulch valley have been observed to have seasonally delayed trends due to higher groundwater levels during spring freshet and/or associated with rainstorms and lower groundwater levels during dry summer periods.

2.3.3 Groundwater Properties

Hydraulic conductivity at the site ranged from 10^{-3} m/s to 10^{-7} m/s in the surficial deposits and from 10^{-5} m/s – 10^{-8} m/s for bedrock (Stantec 2010c). The variable hydraulic conductivity in the surficial geologic material is expected for the varying surficial geological facies and the variable hydraulic conductivity seen in the bedrock is typical of fractured crystalline rock. The test data did not demonstrate a measureable difference in the hydraulic conductivities of granodiorite and metasedimentary rock (Stantec 2010c).

2.3.4 Conceptual Groundwater Model

There are two principal aquifers in the SA: a deep relatively low permeability bedrock aquifer and a near-surface moderately permeable surficial geology aquifer. Generally the bedrock in the SA is dominated by an elongated granodiorite stock (ore bearing unit) which has intruded the surrounding host metasediment. The surficial geology aquifer in the SA is composed of relatively porous unconsolidated sediments. Discontinuous permafrost is also present, especially on the north-facing slopes and affects the connectivity between the deep and shallow aquifer in places.

Bedrock aquifer permeability is associated with fractures which have a higher density and an apparent greater connectivity closer to the ground surface. The bedrock has a thin to thick weathered horizon; the weathered zone appears to be greatest in the mid-valley area where glacial deposits are associated with much older Pleistocene glaciations. The bedrock is overlain in many places by glaciofluvial complexes that include deposits associated with ice contact environments, buried ice, till, and glaciolacustrine sediments. In areas where no glacially-influenced deposits occur, surficial material in the study generally consists of a thin cover of organic soils underlain by colluvium, followed by either metasedimentary or granodiorite weathered bedrock. The surficial material thickness and physical properties vary significantly throughout the study area.

The valley bottoms are filled with more recent alluvium and in some cases extensively reworked placer tailings (e.g. much of the lower Dublin Gulch valley). A large alluvial fan complex underlies the general vicinity of the confluence of Dublin Gulch and Haggart Creek.

Throughout most of the SA the groundwater divides of each sub-basin approximately coincide with the surface water divides (i.e., groundwater from the Eagle Pup and Stuttle Gulch drain to Eagle Creek, while groundwater from Ann and Stewart Gulch Basins drain to Dublin Gulch. However in the Lower Dublin Gulch valley the groundwater divide between the Eagle Creek and Dublin Gulch basins is not clearly defined. Field observations suggest that at times the divide migrates across the valley so that groundwater from the Dublin Gulch basin may flow into Eagle Creek. This shifting is seasonal and also due in part to the variability in the timing of the freshet and/or rainfall events across the entire watershed.

The hydrogeology of the Ann Gulch basin where the proposed HLF will be built is comprised of moderately sloping south-facing topography with fractured metasediments, with a thin to thick mantle of till and thin sandy gravel patches. Groundwater is relatively deep in the upper basin and shallows towards Dublin Gulch although Ann Gulch is generally a losing stream in its lower reaches (i.e. surface water is lost to groundwater over the watercourse).

The Eagle Pup basin where the proposed EP WRSA will be stored is comprised of north-facing steep sloping topography. There are numerous bedrock outcrops in the upper basin with extensive rockfall deposits below them. Alluvium is generally thin; the near-surface bedrock in the valley bottom forces groundwater to emerge as springs which feed Eagle Pup.

The Stuttle Gulch basin where much of the proposed Open Pit will be located has a steep upper basin and a moderately sloping lower basin. The lower slopes are covered by a thick sequence of glaciofluvial derived sediments. Much of the slopes contain permafrost, although much of the permafrost has been exposed by placer activity and is melting.

Many of the project facilities (storage, feed, polishing and events ponds) occur in the lower Dublin Gulch valley, which is underlain by a thick sequence of glaciofluvial deposits and more recent alluvium, although placer mining has reworked much of this area. A large aquifer that flows to the aquifer underlying Haggart Creek occurs within these deposits.

2.3.5 Surface Water – Groundwater Connectivity

Baseflow values represent the groundwater contributions to the surface water (streams). Groundwater contributes to stream flows where the groundwater table elevation intersects the ground surface, typically these intersections are located in stream channel inverts (e.g. Eagle Pup appears in mid-channel where the valley is well confined by bedrock); however, they also appear as seepage from slopes within the placer deposits of the Lower Dublin Gulch valley. The inflows to the Eagle Creek Pond (ECP) are an example of this type of source. The source of this sub-surface flow likely originates at times (alternates based on groundwater flow directions and gradients) from either upper Eagle Creek basins or the upper Dublin Gulch basin. Further, groundwater from the lower Dublin Gulch valley likely contributes a measureable portion of the baseflow to Haggart Creek. The baseflow contributions to the streams maintain flow during the drier months of the year (including winter flows) and were estimated by assuming baseflow was equal to the 7-day minimum low flow for each month.

2.3.6 Groundwater Quality

Groundwater quality data were collected in 1995, 1996, 2009 and 2010 for many areas of the site including in Eagle Pup, Dublin, Stuttle, Ann, Stewart, Olive, Bawn Boy and Platinum Gulches, The parameters analyzed included dissolved and total metals, nutrients, anions and other general parameters. All groundwater quality data were compared to CCME Canadian Water Quality Guidelines for the protection of Aquatic Life (December 2007), and to the British Columbia Contaminated Sites Regulation (CSR) Schedule 6 Generic Numerical Water Standards for the protection of Freshwater Aquatic Life (January 2009).

The following parameters exceeded the CCME and/or CSR guidance parameters in the project area: aluminum, arsenic, cadmium, copper, iron, lead, molybdenum, nickel, selenium, silver, and/or zinc (Stantec 2010c). The CSR guideline values apply to both surface and groundwater, whereas the CCME guidelines only apply to surface water. However, as groundwater ultimately discharges to surface water bodies, the CCME guideline values are included here for reference.

The exceedances do not imply that the groundwater at the site is currently contaminated; only that background concentrations of these parameters are higher than typically found in groundwater at other natural sites in Canada, and merely reflect the natural geologic and hydrogeologic conditions within these specific areas of the local study area.

Comparison of the multiple years of groundwater data indicated that groundwater quality parameters were generally in the same range and that seasonal trends were not apparent over the years sampled.

Groundwater is classified based on major ion chemical compositions, while taking into account major anions and cations exceeding 10 meq-%. The water type (hydrochemical facies) is determined by listing the ions with concentrations greater than 10 meq-% in decreasing order (cations are listed first). Charts 1 to 8 in Appendix D of the Hydrogeology Baseline Report (Stantec 2010c), show the major ion chemistry and hydrochemical facies summarized by watershed. The dominant cation in most of the samples was calcium. However magnesium concentrations exceeded calcium in six sampling locations (MW09-AG2, MW96-13, MW96-15, BH96-152, MW09-DG1, and MW09-DTU2). The dominant anion in all samples was carbonate. Further details on the groundwater quality monitoring program and the analytical results of all groundwater samples collected are provided in the Hydrogeology Baseline Report (Stantec 2010c).

3 WATER MANAGEMENT PROJECT COMPONENTS

This section describes the spatial and temporal context and proposed water-management-related design features for the project facilities (Figure 3-1). Design criteria for water storage facilities assumed for the SWBM and the effects assessment are provided in Table 3-1. For the purposes of this report contact water is defined as collected surface water that has been in contact with a project facility, excluding diversion channels or ditches that convey non-contact water through or around the project footprint. Non-contact water is defined as surface water runoff from undisturbed areas.

The following discussion describes and defines the spatial distribution and layout of natural and engineered water conveyance structures within each major facility in the developed areas, and is comprised of nine sub-sections that have been grouped by facility that include:

- Dublin Gulch diversion channel
- Lower Dublin Gulch Sediment Control Pond
- Open Pit

- Platinum Gulch Waste Rock Storage Area
- Eagle Pup Waste Rock Storage Area
- Heap Leach Facility
- Mine Water Treatment Plant
- Water Supply
- Other Water Diversion Structures and Sediment Control.

Section 3 describes the spatial layout and general geometries of the various facilities, while Sections 6 through 9 provide a detailed summary of critical aspects of the management of water quantities for each facility during the Construction, Operations, Reclamation and Post-closure phases.

3.1 Dublin Gulch Diversion Channel

A portion of Dublin Gulch will require re-alignment around the proposed heap leach facility (HLF) to convey non-contact streamflow past the HLF and divert the water to the Eagle Creek drainage downstream of the project (Figure 3.1-1). The Dublin Gulch diversion channel (DGDC) will be approximately 2.6 km long and constructed during Year 1 of the Construction phase (2012) and will remain in place indefinitely. There will be opportunities during the construction and Operations phase to enhance the channel and improve fish habitat along parts of the channel Dublin Gulch Velocity Reduction Ponds. Proposed habitat improvements are described in the Preliminary Fish Habitat Compensation Plan (Stantec 2010k).

The DGDC requires two velocity reduction ponds to reduce flow velocities at particularly steep sections of the channel. The upper Dublin Gulch velocity reduction pond will be located immediately above the intake of the DGDC (B in Figure 3.1-1). The pond will reduce the velocity of water from Dublin Gulch prior to entering the DGDC. The pond will be approximately 35,000 m^3 and designed to accommodate the 1:100 year 24-hour flood event. The excavation for the pond will be dug into the valley alluvium to bedrock and lined with coarse rockfill to act as an interceptor drain to capture subchannel groundwater (or hyporheic water).

The lower Dublin Gulch velocity reduction pond (F in Figure 3.1-1) will be built at the downstream end of a relatively steep channel reach in the existing Stuttle Gulch channel. The purpose of the pond will be to reduce stream velocity before entering the lower section of the DGDC (G in Figure 3.1-1).

3.2 Lower Dublin Gulch Sediment Control Pond

The Lower Dublin Gulch Sediment Control Pond (LDG SCP) will be located between the existing Eagle Creek channel and Dublin Gulch channel within 100 – 200 m of Haggart Creek, and will serve as the last (or most down-gradient) control pond of the Project water management system (Figure 2.1-1). Optional water routing to the LDG SCP includes flow from the polishing ponds associated with the treatment system and other runoff diversion ditches within the plant facilities. The source and conveyance system flowing to the LDG SCP is described in more detail in Sections 6, 7 and 8. The LDG SCP is designed as two storage areas connected by a weir overflow structure (H and I in

Figure 3.6-1). The maximum volume of the upstream storage area (H) is 15,000 m^3 and the maximum volume of the downstream storage area (I) is 17,600 m^3 for a combined volume of approximately 32,600 m^3 (Table 3.1-1), which will be designed to accommodate the 1:100 year 24-hour flood event. These capacities are discussed in more detail in Sections 6, 7 and 8 with reference to the average and wet year feed rates. The LDG SCP will be lined with HDPE and constructed from appropriate rockfill.

Table 3.1-1: Water Storage Facilities Summary

Location	Project Phase		Max. Water Surface Area	Maximum Depth	Max. Volume	Base Area	Allowable Volume	Total Volume	Water Quality	Operational Monitoring	From	To	Notes, Data Sources
	From	To	m^2	M	m^3	m^2	m^3	m^3					
Dublin Gulch Upstream Velocity Reduction Pond	Construction	Post-Closure Monitoring	10,428	3	35,000				Non-contact	Yes	Upper Dublin Gulch	Dublin Gulch diversion channel	[1], [2], [4]
Dublin Gulch Velocity Reduction Pond at Energy Dissipaters	Construction	Post-Closure Monitoring	n/a	n/a	n/a				Non-contact	No	Dublin Gulch diversion channel	Dublin Gulch diversion channel	[1], [2], [5]
Eagle Pup Sediment Control Pond	Construction	Closure/Reclamation	6,589	8	26,559				Non-Contact + Contact	Yes	Eagle Pup Waste Rock Storage Area	Depending on water quality result To MWTP Feed Pond or diversion channel	[1], [2], [5]
Platinum Gulch WRSA Sediment Control Pond	Construction	Closure/Reclamation	8,537	8	37,546				Non-Contact	No	Undisturbed Basin Area - Platinum Gulch	Platinum Gulch	[5]
Platinum Gulch WRSA Lined Seepage Collection Pond	Construction	Closure/Reclamation	8,338	n/a	n/a				Contact	Yes	Platinum Gulch Waste Rock Storage Area	Gravity drain to OP Sump Then to MWTP Feed Pond	[1], [2], [3]
Secondary HLF Storage 1 (Events Pond 1)	Construction	Closure/Reclamation	18,169	12		5,278	87,500	112,502	Contact	Yes	HLF drainage to Process Plant	Cycled back to HLF via irrigation unless extra storage is required	[1], [3], [5], [6]
Secondary HLF Storage 2 (Events Pond 2)	Construction	Closure/Reclamation	18,673	12		5,812	87,500	116,550	Contact	Yes	HLF drainage to Process Plant	Cycled back to HLF via irrigation unless extra storage is required	[1], [3], [5], [6]
Ann Gulch Sediment Control Pond East	Construction	Closure/Reclamation	13,566	2				27,132	Non-Contact	No	Ann Gulch (undisturbed)	Dublin Gulch Upstream Velocity Reduction Pond	[1], [2], [3]
MWTP – Feed Pond (Polishing Pond 1)	Construction	Closure/Reclamation	4,951	5		2,431	13,449		Contact	Yes	OP Sump, EP-WRSA SCP, PLAT-WRSA SCP	To MWTP	[1], [5], [6]
MWTP – Product Pond (Polishing Pond 2)	Construction	Closure/Reclamation	4,951	5		2,431	13,449		Treated	Yes	MWTP	Lower Dublin Gulch Sediment Control Pond 1 (Inlet)	[1], [5]
Lower Dublin Gulch Sediment Control Pond 1 (Inlet)	Construction	Closure/Reclamation	5,422	4		2,240		14,954	Treated/ Settled	Yes	MWTP Product Pond	Lower Dublin Gulch Sediment Control Pond 2 (Outlet)	[1], [5], [6]
Lower Dublin Gulch Sediment Control Pond 2 (Outlet)	Construction	Closure/Reclamation	5,510	5		1,820		17,605	Treated/ Settled	Yes	Lower Dublin Gulch Sediment Control Pond 2 (Outlet)	Eagle Creek/Lower diversion channel (optional to Haggart)	[1], [5], [6]
Open Pit Sump – Year 1 to 3	Operational	Operational	As required	As required				As required	Contact	Yes	OP Runoff and Dewatering	To MWTP Feed Pond	[1], [2], [3]
Open Pit Sump – Year 3 to 5	Operational	Operational	As required	As required				as required	Contact	Yes	OP Runoff and Dewatering	To MWTP Feed Pond	[1], [2], [3]
Open Pit Sump – Year 5 to 6	Operational	Operational	10,301	5				48,375	Contact	Yes	OP Runoff and Dewatering	To MWTP Feed Pond	[1], [2], [3]
Open Pit Sump – Year 6 to final	Operational	Operational	25,235	11				279,793	Contact	Yes	OP Runoff and Dewatering	To MWTP Feed Pond	[1], [2], [3]
Open Pit Sump – Backfilled	Final Year	Closure/Reclamation		10				249,793	Contact	Yes	OP Runoff	To MWTP Feed Pond	[3]

NOTES:

[1] - Stantec GIS calculations from pre-feasibility design drawings provided by URS/Scott Wilson (May, 2010)

[2] - Average depth

[3] - Volumes obtained from Project Description (Section 5 of the Project Proposal) * Allowable volume is the maximum filling capacity to maintain adequate freeboard and minimum volumes to protect the liners.

[4] - Estimated Volume based on Pre-Feasibility Information

[5] - Source: Dublin Gulch - pond storage capacities.xls - via email from Jason Cox: Mon 7/12/2010 6:20 AM

[6] - Surface area revisions from July 30, 2010 Stantec master drawing 1053550-179 - Water balance model will use data from [5]

tbd -To be determined

n/a- Detailed design data not available

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3.3 Open Pit

The Open Pit will be excavated on the relatively steep northwest-facing hillside located in an area that includes parts of Stuttle Gulch, Platinum Gulch, and Eagle Pup drainage basins (Figure 2.1-1). As a result of the steep topography, the excavation will have a high southeast wall and a short northwest wall, with a relatively small pit. The area of the Open Pit will grow from 166,000 m^2 to 640,000 m^2 during the Project (Figure 3.3-1). The median elevation of the Open Pit will decrease as the pit deepens from 1,230 m asl to 1,163 m asl during the project operations.

During the Operations phase, the Open Pit area will grow from 4% to 15% of the Stuttle Gulch basin, 8% to 24% of the Platinum Gulch basin, and 2% to 14% of the Eagle Pup basin. As a result of the growth of the open pit, there will be changes in the runoff from those basins over the life of the project. Table B-5 in the SWBM report (Stantec 2010g) provides a summary of the assumed conditions from the Construction phase through the Closure and Reclamation phase for the Open Pit.

Depressurization of the open pit walls is required to maintain the stability of the open pit walls. Open pit slope stability analyses (BGC 2010a) indicate that depressurization requirements will be driven by the bench scale of the open pit. Complete depressurization must be attained for an area extending approximately 50 m behind the excavated bench face to achieve sufficient stability. This will be accomplished using horizontal drains and perimeter wells beginning in the first year of construction. The total groundwater discharge rate is predicted to be low, ranging from approximately 38 m^3/d in the last year of operation to approximately 429 m^3/d in the fourth year of operation (Figure 21[1], BGC, 2010b; T. Crozier, BGC, personal communication, August 25, 2010 e-mail; and see Table 5.2-3 in Stantec 2010g). A detailed description and list of assumptions regarding estimated open pit inflows for construction and Operations phase is found in the SWBM, Section 5.1 (Stantec 2010g).

Water from the perimeter wells and depressurization will be conveyed into a open pit sump through a drainage pipe, which will be periodically re-located as the open pit geometry changes (E on Figure 3.2-2). Precipitation falling within the open pit drainage basin and subsequent runoff will also be collected in the open pit sump (B on Figure 3.2-2). The open pit sump water will be piped down through the Stuttle Gulch basin, across the DGDC, and into the MWTP Feed Pond (C on Figure 3.2-2). As an alternative, the well and drain water may be kept separate from the open pit runoff water, depending on water chemistry, to meet discharge criteria and/or allow these two different sources of water to be used for alternative purposes.

3.4 Platinum Gulch Waste Rock Storage Area

The Platinum Gulch Waste Rock Storage Area (PG WRSA) will be located in the Platinum Gulch drainage basin (A on Figure 3.3.1) and will hold approximately 2.9 million m^3 of waste rock deposited from the Open Pit during the first three years of Operations. A sediment control pond and

[1] Assumes the total groundwater discharge rate is equal to the added values for pit inflows and well intake beginning in first year of construction.

embankments, groundwater drainage system, and drainage ditches along the periphery of the facility footprint will be constructed prior to use of the PG WRSA.

The size of the PG WRSA will increase from approximately 4% (60,000 m^2) of the Platinum Gulch basin area at its confluence with Eagle Creek in Year 1 of operations to a maximum size of approximately 24% (330,000 m^2) of the basin in Year 3, while increasing in volume from 500,000 m^3 to 4,800,000 m^3. The PG WRSA will not be added to after Year 3. From a water management perspective, as the WRSA increases in area more of the surface is exposed to precipitation, so that the total volume of contact water also increases during the Operations phase. Figure 3.3-2 illustrates the anticipated annual growth in area and the annual incremental addition of waste rock of the WRSA during the Operations phase. The PG WRSA will grow the most during Year 3. Table B-7 in the SWBM report (Stantec 2010g) provides a summary of the assumed conditions from construction through operations and closure for the PG WRSA.

3.4.1 Platinum Gulch Ponds

Non-contact runoff from within the Platinum Gulch drainage basin will be diverted away from the WRSA and conveyed to the Platinum Gulch Sediment Control Pond (PG SCP) (E in Figure 3.3-1). Eventually this water will drain to Haggart Creek, while all contact water (seepage and runoff) from the WRSA will be captured in a lined seepage collection pond (PG LSGP) (B in Figure 3.3-1). The PG LSGP will be designed to store a 1:100 year 24-hour event with a peak flow of 1.5 m^3/s and will be fed by both the rock drain and runoff from the WRSA. The PG LSGP water will then be conveyed by a drainage ditch (C on Figure 3.3-1) to the Open Pit sump (D on Figure 3.3-1).

The embankment for the PG SCP will be located approximately 300 m downstream of the base of the PG WRSA. The maximum volume of the PG SCP will be designed to hold 37,540 m^3 or the 1:100 year flood event (Table 3.1). The PG LSGP will be smaller, as any overflow water will be captured by the PG SCP and all captured water will be continually conveyed to the Open Pit sump. Both ponds will be constructed to last until decommissioning in the Closure and Reclamation phase. The design of the PG SCP includes an embankment constructed from rockfill, an HDPE lined pond and variable height decant.

3.4.2 PG WRSA Groundwater Drainage System

A groundwater drainage system will be installed beneath the PG WRSA along the existing Platinum Gulch drainage between approximately 1,160 m asl to 1,000 m asl. The drainage system consists of Type 1 and Type 2 rock drains (Figure 3.3-1). The groundwater drainage system will drain to the PG LSGP at the base of the PG WRSA (B on Figure 3.3-1). The rock drains will collect water that has recharged and passed through the WRSA. The drainage system will drain to the PG LSGP and will be diverted to the Open Pit sump.

3.5 Eagle Pup Waste Rock Storage Area

The EP WRSA (A in Figure 3.4-1) will hold approximately 26,500,000 m^3 of waste rock by the end of the Operations phase. The EP WRSA will be used during all of the Operations phase. The EP

WRSA will be located in the Eagle Pup drainage basin (A in Figure 3.4-1). The size of the EP WRSA will increase from approximately 9% of the Eagle Pup basin area (120,000 m^2) in the first year of operations to a maximum size of approximately 63% (800,000 m^2) of the Eagle Pup basin in the last year, while increasing in volume from 1,000,000 m^3 to 26,500,000 m^3. The EP WRSA will grow substantially in the middle years (Figure 3.3-2). Table B-9 in the SWBM report (Stantec 2010g) provides a summary of the assumed conditions from construction through operations and closure for the EP WRSA.

3.5.1 Eagle Pup Sediment Control Pond

The Eagle Pup Sediment Control Pond (EP SCP) will be located at the base of the EP WRSA (C in Figure 3.4-1). The EP SCP will be designed to hold 25,000 m^3, or the 1:100 year 24-hour flood event (Table 3.3-1). The EP SCP will be constructed to last for the duration of the Operations phase and Closure and Reclamation phase. The design includes an embankment constructed from rockfill, an HDPE lined pond and variable height decant to control the rate of outflow.

Diversion channels around the EP WRSA are not considered to be practical due to steep topography. Therefore runoff from the catchment area above the WRSA is predicted to flow along the base or into the WRSA and exit at the toe prior to entering the EP SCP. As a result the EP SCP will receive both contact (runoff and seepage from the WRSA) and the non-contact water from the upstream catchment area. In most cases, this water will be routed to the Mine Water Treatment Plant (MWTP) Feed Pond, where it will be transferred into the Events Ponds for process make-up water. In other cases, and depending on water quality characteristics, this water may be routed to the LDG SCP for use in project activities (i.e., dust suppression) or eventual discharge.

3.5.2 EP WRSA Groundwater Drainage System

A groundwater drainage system will be installed beneath the EP WRSA along the existing Eagle Pup drainage between approximately 900 m to 1,050 m. The drainage system consists of Type 1 and Type 2 rock drains (Figure 3.4-1). Type 1 drains will be the up-gradient section excavated into rocky alluvium. Type 2 drains will be the down-gradient section feeding the EP SCP (B on Figure 3.4-1), excavated into bedrock and filled with drain rock. It is expected that the down-gradient Type 2 rock drain will collect groundwater, and both drains will collect water that has passed through the WRSA and near-surface meteoric water originating upslope of the WRSA. The groundwater drainage system will drain to the EP SCP and be distributed as described in section 3.5.1.

3.6 Heap Leach Facility

The majority of the Heap Leach Facility (HLF) will be located in the Ann Gulch drainage basin with the base of the HLF extending into a portion of the lower Dublin Gulch valley (Figure 3.5-1). The HLF footprint area will grow from 283,000 m^2 in the first year of operations to 785,530 m^2 at the end of operations (Figure 3.5-2). (The total footprint of the HLF facility including the embankment will be 904,820 m^2). The HLF embankment will extend across the Dublin Gulch valley and require that the existing Dublin Gulch channel be re-aligned into the DGDC. The HLF will be the major water demand for the project, requiring as much as 1,500,000 m^3/year of new water at maximum extent. Much of the water used for the HLF operations (leaching and recovery system) will be continually recycled and held within the HLF. Make-up water will come from precipitation on the HLF, the Open Pit sump and the EP SCP, or groundwater during exceptionally dry conditions. A smaller portion of the required make-up water will also come from moisture added during crushing. The water requirements for the project operations and details of the associated water management scheme for the HLF are discussed in Section 7.7 of this report. Table B-11 in the SWBM report (Stantec 2010g) provides a summary of the assumed conditions from the Construction phase through the Operations and the Closure and Reclamation phases for the HLF.

The HLF will receive crushed ore from the Open Pit for the purpose of extracting gold. Solution required for the HLF will be stored in two locations in addition to the storage tanks in the ADR facility. The Heap Pond (HP) will be the primary storage facility and located behind (or upstream) of the HLF embankment. Although the HP is labeled as a pond, it is actually the saturated portion of stacked ore behind the embankment (B in Figure 3.5-1) and there will be no exposed liquid solution. The maximum storage capacity of the HP is 435,000 m^3, although operationally it will be kept at approximately 60,000 m^3 at any one time during normal operations. The Events Ponds (or secondary storage facility) (A and B in Figure 3.6-1) will be located just down-gradient of the HLF. The combined maximum operating capacity of the Events Ponds will be approximately 175,000 m^3 (Table 3.1-1), while the combined maximum capacity with freeboard will be 229,000 m^3.

There are three water management systems beneath the HLF. These include a lined solution collection pad (the Leachate Collection and Recovery System – LCRS), a leakage solution recirculation system (the Leak Detection and Recovery System – LDRS), and a basal groundwater drainage system. The purpose of the LCRS and LDRS are to contain solution in the event a leak occurs in the liner. The purpose of the groundwater drainage system is to contain non-contact groundwater from the leak system and HLF. These systems are described in more detail in the Project Description. The solution systems will be a closed network, while the groundwater drainage system will drain to a sump at the downstream side of the embankment (G in Figure 3.5-1), where it may be used as process make-up water, conveyed to the MWTP Feed Pond or discharged into the DGDC or Haggart Creek.

3.6.1 Ann Gulch Diversion Ditches

Two surface water diversion ditches will be installed around the periphery of the HLF (Figure 3.5-1). The Ann Gulch East Diversion Ditch (AG EDD) will drain the east portion of the Ann Gulch basin and drain to a sediment control pond and then to Dublin Gulch at the upstream end of the DGDC (C in Figure 3.5-1), while the Ann Gulch West Diversion Ditch (AG WDD) will drain the west portion of the Ann Gulch basin (D in Figure 3.5-1) and drain to Haggart Creek. Erosion protection measures for the diversion ditches are to be consistent with the design hydraulic capacity of each structure and are to be based on the maximum flow velocities expected in the local channel based on estimated surface runoff volumes. As the HLF grows the diversion ditches will be periodically re-located farther up-basin, and will convey decreasing flow volumes as the runoff capture area decreases.

3.6.2 Ann Gulch Sediment Control Pond

The Ann Gulch Sediment Control Pond (AG SCP) will be located on the east side of the HLF adjacent to the DGDC upstream of the HLF (C in Figure 3.5-1), and will receive flows from the AG EDD. The pond capacity will be approximately 13,000 m^3, sufficient to accommodate a 1:100 year 24-hour flood event. The AG SCP will overflow into the DGDC (Table 3.1-1).

3.7 Water Treatment

3.7.1 Mine Water Treatment Plant and Ponds

The Mine Water Treatment Plant (MWTP, F in Figure 3.6-1) will be constructed to treat contact water and detoxified process solution to enable treated water to be released. The MWTP will be connected to two ponds, the MWTP Feed pond (E in Figure 3.6-1) and the MWTP Product Pond (G in Figure 3.6-1). Each pond's proposed surface area is 2,431 m^2 with an allowable capacity of 13,449 m^3 (Table 3.1-1). Depending on various hydroclimatic conditions (i.e., average, wet or dry), the Surface Water Balance Model (SWBM) was used to predict the number of days per month of storage that the Feed Pond can accommodate. Results from the SWBM are discussed in Sections 6, 7 and 8. The MWTP ponds will be constructed of rockfill and will be HDPE-lined. The MWTP will be located north of the MWTP Feed Pond and the Events Ponds, near the process plant and the adsorption, desorption and recovery facility (ADR).

The MWTP will be designed to treat an average flow rate of 1,500,000 m^3/yr (range between 500,000 m^3/yr and 2,500,000 m^3/yr). The treatment system design assumes approximately 150 days of operation per year, with an average flow rate of 10,000 m^3/d or 420 m^3/hr, and a maximum of 620 m^3/hr. Active treatment will be provided for the combined flows originating from the Open pit and WRSAs via sediment control ponds; and the net process water from the heap leach facility which will have undergone pre-treatment to detoxify cyanide (CN) by oxidation using hydrogen peroxide. These streams will be channeled through the Feed Pond and to the proposed MWTP system (Stantec 2010j).

The following parameters will be treated by the MWTP: aluminum, antimony, arsenic, cadmium, chromium, copper, fluorine, iron, lead, manganese, mercury, molybdenum, nickel, selenium, silver, uranium, zinc, ammonia (un-ionized and total), nitrate-n, and sulphate.

Conventional acid mine drainage treatment using lime addition, coagulation and settling, will not be sufficient to meet the projected discharge requirements. However, that treatment technology may be appropriate as an initial pretreatment step, to reduce particle loading on downstream treatment units. The low concentration targets for arsenic, cadmium, copper, selenium, and mercury will require advanced treatment technologies. Combinations of several treatment techniques are considered in order to meet the discharge requirements. These treatment options include:

- pH adjustment by addition of lime, sodium hydroxide, and or other reagents
- Addition of coagulants such as ferrous chloride
- Blending of granular floc seed material such as sand

- Flocculation in a slow-mix reactor
- Enhanced sedimentation in a rapid-settling configuration such as an inclined plate separator
- Withdrawal of the settled sludge and recovery of the floc seed sand by means of a cyclone separator (such as the Actiflo® process)
- Selective chelation ion exchange in closed vessels
- Ultra-filtration
- Reverse osmosis
- Final pH adjustment and possibly re-carbonation using carbon dioxide prior to discharge to the receiving stream.

Backwash and regeneration waste streams will be generated. Due to the expected flow and the level of treatment, it will be necessary to provide dewatering to feasibly allow secure long-term sludge disposal on the site in controlled covered disposal cells. During Operations, a relatively small pond (less than 400 m^2 in wet area – this facility is not shown on Figure 3.6-1 due to its small footprint) may be required for the dewatering and sludge thickening process. Alternatively the sludge could be thickened and dewatered by using physical, chemical and mechanical processes (Alexant 2010, pers. comm.). Consideration will be given to the feasibility of incorporating dewatered treatment system sludge into the WRSAs (and/or the HLF at closure), with an appropriate encapsulation design to minimize future exposure to moisture and air and minimize the potential for re-mobilizing pollutants that have been removed by the treatment system (Stantec 2010m).A hydraulic retention of approximately 20 minutes would be required for each stage of the chemical conditioning processes, including coagulation and pH adjustment. A maximum surface overflow rate of 4.17 $m^3/m^2/hr$ would be applied for the sedimentation tank at peak flow rates; this may be increased, depending on treatability testing. A maximum hydraulic loading rate of approximately 15 $m^3/m^2/hr$ would be applied for the ion exchange units.

3.7.2 Camp Wastewater Treatment

The camp wastewater collection system will be located northwest of the existing confluence of Dublin Gulch and Haggart Creek, and down-gradient from the accommodations complex, so that the wastewater treatment plant can be gravity fed. Insulated HDPE pipes will connect the camp site infrastructure with the wastewater treatment plant. The location of the camp wastewater treatment system is shown as “sewage” on Figure 3.6-1.

The camp wastewater treatment plant will be a membrane batch reactor (MBR) unit built to produce effluent in accordance with the Yukon Water Board requirements for treated sewage effluent. Treated effluent will be discharged from the plant through a rock drain and into Haggart Creek.

3.8 Water Supply

3.8.1 Potable Water for Camp

The project site will include a 400-person camp during the Construction phase followed by a 190-person camp during the Operations phase. The potable water for camp will be drawn from a groundwater well and pumped to fresh water storage tanks at the camp. The well will be installed and developed from February – March 2012.

Five step drawdown tests, a 24-hour aquifer test, and a 12-hour recovery test were completed in the lower Dublin Gulch valley at the Project Site to evaluate the potential groundwater yield of the alluvial aquifer for potential camp potable water supply (Stantec 2010f). Based on the assumed 400-person Construction phase and 190-person Operations phase, the camp requirements will be approximately 120[2] (m^3/d) during construction and approximately 57[3] m^3/d during the Operations phase. Based on the data obtained during the aquifer test and the results obtained from the analysis, the aquifer sustained a rate of over 200 m^3/day. This rate is adequate for the camp water supply during the Construction phase and the Operations phase.

Potable water and waste water treatment services will be constructed as required for a 400-person camp. The potable water treatment system will be a purchased system from a regional supplier and will treat the freshwater to Canadian Drinking Water Standards. The potable water will only be used to service the camp and will not be used for mine or process activities.

3.8.2 Process Make-up Water

During the Operations phase the Recovery Plant and HLF irrigation system has a peak monthly demand for makeup water of 37,000 m^3/mo (approximately 1,230 m^3/d). Process make-up water will be supplied by contact water (e.g. groundwater, seepage, and runoff) from the Open Pit and WRSAs. This water will be piped directly to the MWTP Feed Pond, where it will then be transferred into the Events Ponds, process plant or barren tank as necessary.

If the volume of contact water is not adequate for all process needs (i.e., during an exceptionally dry year), additional water could be provided from the DGDC, provided in-stream flow requirements for aquatic habitat in Eagle Creek are met. Groundwater wells located close to the process plant could also provide an additional source. The pumps at the intake station will be available to run year-round during the Operations phase if needed. The annual and monthly process water demands from EP WRSA, PG WRSA and Open Pit collection ponds/sumps, as well as potential maximum demands from non-contact water were examined in detail in the SWBM report (Stantec 2010g) and are summarized in Section 7.9.

[2] Assuming 400 people in camp during construction, using 300 L/day – 120 000 L/d at peak capacity

[3] Assuming 190 people in camp during the operations phase, using 300 L/day

3.8.3 Process Water for Crusher

Crushing of ore will require a constant feed of water for dust suppression. The maximum demand for this water will average approximately 91,000 m^3 per year. Water for the crusher will either be pumped from a groundwater well located adjacent to the Crusher facility (this may also be used as a perimeter depressurization well), or from water in the Platinum Gulch collection pond or Open Pit sump, if water quality meets the appropriate criteria.

3.8.4 Fire Suppression System

Water for fire suppression will flow by gravity through a pressurized pipe to the process facilities and stored in a fresh water storage tank. Water will be supplied from either a groundwater well or a surface stream (e.g. Haggart Creek, DGDC). The size of the fresh water tank or the approximate demand for fire suppression has not yet been determined but will be negligible compared to the overall project water demand.

3.8.5 Dust Control

Access roads and construction sites will require periodic wetting for dust suppression. The needs will be greatest during hot dry summer months and when access roads are not covered by snow. Dust suppression water will be drawn from sediment control ponds.

3.9 Other Water Diversion Structures and Sediment Control

Surface water diversions and interceptor ditches will be constructed around the perimeter of the HLF, all ponds, the Open Pit, plant site, and yards to convey non-contact water away from the structures and discharge into various sediment control ponds. Diversion ditches will be designed to convey peak flows from a 1:100 year event, with a storm duration consistent with the time of concentration of the local catchment area.

4 SURFACE WATER MODEL

4.1 Model Framework and Overview

A detailed surface water balance model was developed specifically for the Project. The model set-up, framework, assumptions and results are described in detail in Stantec (2010g). The Project Surface Water Balance Model (SWBM) is a custom-made, linked Excel® spreadsheet-based hydrologic model designed to simulate the effect of land use changes due to the project within the Dublin Gulch and Eagle Creek drainage basins.

The model integrates a rainfall-runoff watershed model with proposed facility designs and water management decisions to simulate the natural hydroclimatic processes and effects of water management on water resources. The SWBM was developed based on conceptual and empirical watershed-process equations that produce results at monthly time steps. Monthly model input and output data facilitate the assessment and management of seasonal watershed processes such as snowmelt, summer storm events and dry periods.

The SWBM includes information on the spatial distribution and layout of natural and engineered water conveyance structures within the existing (non-developed) landscape and the proposed Project facilities. The facilities include the:

- Dublin Gulch diversion channel (DGDC)
- Open Pit and depressurization system
- Heap Leach Facility (HLF) and associated process and storage ponds
- Waste Rock Storage Areas (WRSAs) and associated sediment control ponds
- Mine Water Treatment Plant (MWTP) system
- Various storage and control ponds and other smaller water storage/conveyance structures around the mine site.

The SWBM is designed to simulate various hydrologic conditions and mine scenarios through all phases of mine activity including the construction, operations, closure and reclamation, and post-closure monitoring phases to quantify the spatial and temporal changes to the site hydrology throughout the project. The results of modeling specific conditions and scenarios for each phase are then used to develop appropriate water management strategies for the mine site. The results are also compared directly to predicted future conditions to facilitate the assessment of potential effects on water quality and aquatic habitat.

Each of the proposed Project facilities has a suite of linked Excel® worksheets that describe the conditions for the specific month and phase of the project. The suite of worksheets include:

- Undisturbed Basin Model Inputs (e.g. unit area watershed variables for the reference elevation)
- Facility Constants (e.g. area, volume, tonnage, irrigation rate)
- Facility Model Inputs (e.g. unit area values for climate and hydrologic parameters, variables for the reference elevation)
- Facility Water Balance (e.g. simulation worksheets: contains the primary functioning of the water balance equations).

Additional worksheets that include climate (e.g. orographic effects on temperature and precipitation) and basin parameters (e.g. summary tables of basin areas, elevations, etc.), are linked to the model to support the various phases and conditions of the SWBM.

4.2 Model Timeframe

Water pathways (termed flow routing for project phases) were delineated and quantified for existing (baseline) conditions and for each phase of the project and then used to develop the following five temporal-based modules within the SWBM: Baseline, Construction, Operations, Closure and Reclamation and Post-closure Monitoring. Each module reflects the flow routing conditions of the natural watershed and/or mine-site facilities during that phase of the project. Each module is a contiguous simulation such that surface water flows at specific nodes (and along distinct flow pathways) is estimated for monthly time-steps though the duration of the project. The following is a description and rationale for each module:

- **Baseline**—the baseline module simulates existing watershed conditions and functions as a calibration tool that utilizes a locally and regionally-derived database to derive coefficients for model equations. The baseline module is used as an effect assessment tool where baseline module output can be directly compared to output from other project-phase modules to help assess the potential effects of the project. Flow pathways and flow nodes for the baseline module are depicted in Figure 4.2-1.
- **Construction**—the construction module simulates the beginning of the project when various sediment control, water storage and diversion structures are built (in addition to the general infrastructure required to operate the mine) to manage the flow of water and movement of sediment, and mitigate potential adverse effects from construction activities. The simulation period for the construction module is 1.7 yrs (Jan 2012 to Aug 2013). Construction module nodes and flow routing are depicted in Figure 4.2-2.
- **Operations**—the operations module simulates the period of time from the start of mining operations to the end of mining and ore processing, including the gradual development and growth of the WRSAs, the HLF and the Open Pit. The simulation period for the operational module is 7.3 years (88 months) from September 2013 to December 2020. Operations module nodes and flow routing are depicted in Figure 4.2-3.
- **Closure and Reclamation**—the Closure and Reclamation module simulates the period of time where mining and processing operations have ended and Closure and Reclamation activities are taking place. These include the initial first year of gold recovery followed by HLF rinsing and detoxification, HLF draindown and reclaiming of the HLF, the re-contouring and vegetating of the WRSAs, the partial back-filling of the Open Pit, and any aquatic habitat enhancements in diversion structures. Although the actual Closure and Reclamation phase varies for each facility, the simulation period for the Closure and Reclamation module is conservatively simulated for 10 years to accommodate the anticipated longer time period to complete all the reclamation activities for the HLF. Closure and reclamation module nodes and flow routing are depicted in Figure 4.2-4.
- **Post-closure Monitoring**—the post-closure monitoring module represents conditions in the project area after reclamation is complete. Although environmental monitoring will occur throughout all phases of the project, post-closure monitoring will be dependent on when reclamation activities are completed for each facility. At this time, we have assumed the post-closure monitoring module will begin in January 2031 for the project. Post-closure module nodes and flow routing is depicted in Figure 4.2.5.

4.3 Model Assumptions and Calibration

The watershed-runoff predictions in the SWBM were calibrated at specific nodes along flow pathways (Figures 4.2-1 to 4.2-5). Where possible, the model nodes were located at hydrometric stations. The predictions were based on equations representing physiographic and climate interactions, and adjusted by certain model forcing conditions to be compared to (or calibrated to) a continuous monthly precipitation- and streamflow-calibration databases.

Precipitation and streamflow data were obtained from the site between 2007 and 2010 (Stantec 2010d). This dataset was used in combination with data from other regional stations (e.g. Mayo, Calumet) and water-balance calculations to fill missing data points so that continuous synthetic monthly records of precipitation and streamflow were developed for specific stations at critical nodes in the SWBM.

4.3.1 Precipitation Calibration

Monthly precipitation estimates for the project site were derived for the Potato Hills climate station at elevation 1,420 m asl for the calibration period August 2007 to October 2009 (see Table A-1 in Stantec 2010g). The existing precipitation database at Potato Hills consists of rainfall and snow survey data. Snowfall estimates were derived by normalizing the existing database with the Calumet snow survey station (which has a similar elevation and physiography) and assuming a 20% sublimation rate throughout the winter. Snowfall was then distributed based on the monthly snowfall distribution observed at Keno Hill (1974 – 1982 snowfall record).

4.3.2 Streamflow Calibration

Monthly streamflows were estimated for nodes in the SWBM using the 2007 to 2009 data, supplemented with additional observations from 2010. Continuous streamflow records and additional instantaneous flows facilitated basin to basin comparisons and daily water-balance calculations. Additional observations and/or measurements at various times (including winter) helped to understand the spatial and temporal variability of streamflows. Details on the methods and development of the streamflow database are provided in (Stantec 2010g).

The synthetic streamflow and precipitation data were the primary databases used to calibrate the SWBM (see Table A-3 in Stantec 2010g). Sreamflow hydrographs for the Dublin Gulch Basin, Eagle Creek Basin and Haggart Creek Basin streams are shown in Figures 4.4-1, 4.4-2 and 4.4-3, respectively. From August 2007 to September 2009, Stewart and Ann Gulch provided only a small portion of the flows to Dublin Gulch, while Upper Dublin Gulch sometimes had greater flows than Lower Dublin Gulch during portions of the year indicating that the stream loses some of its water to the Lower Dublin Gulch Valley aquifer (Figure 4.4-1). This water is either discharged to Eagle Creek, Haggart Creek or into the Haggart Creek Valley aquifer. Figure 4.4-2 illustrates that the flow of Eagle Creek was greater than the combined flows of its tributaries, suggesting that groundwater discharge supplies the remaining flow. Much of this flow originates from the spring that feeds Eagle Creek pond located in the center of the Lower Dublin Gulch Valley. Figure 4.4-3 illustrates that Dublin Gulch and Eagle Creek represent only a minor component of flow in Haggart Creek.

Calibration using the streamflow database is described and summarized in detail in Stantec (2010g). Calibration involved adjusting monthly coefficients for runoff and base flow for each basin, and snowmelt and evaporative coefficients for snowmelt timing to yield a predicted streamflow record that matched the observed (and synthesized) streamflow database. The predictive equations for rainfall, snowfall and temperature were scaled by elevation; equations for evapotranspiration and evaporation were based on temperature and solar radiation equations scaled to the site location. All model equations are scaled by basin area (or facility footprint area). Model sensitivity was examined by the adjusting coefficients for evaporation, evapotranspiration, and/or recharge as appropriate. Further details of the SWBM calibration is described in the SWBM Report (Stantec 2010g).

5 GROUNDWATER MODELS

5.1 Open Pit Groundwater Model

BGC Engineering Inc. (BGC) conducted a Pre-Feasibility study (PFS) on the Open Pit slope depressurization analysis for the Project Zone deposit (BGC 2010b). The study used the numerical groundwater model (MODFLOW-SURFACT (Version 3.0) with Groundwater Vistas (Version 5.33, Build 28) acting as a pre- and post-processor. The model predicted that the total groundwater discharge rate would be low, ranging from approximately 38 m^3/d in the last year of operations to approximately 429 m^3/d in the fourth year of operations.

Results of simulations which incorporated pumping wells as the primary method of depressurization indicated that the hydraulic conductivity of the bedrock is likely too low to utilize vertical pumping wells. Thus, depressurization of the open pit slopes will have to be achieved through the use of horizontal drains. Based on the predicted groundwater flows from the proposed open pit area, BGC estimated that it would take approximately 100 to 120 horizontal drains over the mine life with an average drainhole length of about 120 m. BGC also recommended that VIT plan for 5 to 10 pumping wells throughout the life of mine to aid in local depressurization of the open pit slopes. Pumping wells could still prove to be effective for depressurizing the rock mass if areas of enhanced permeability due to fracturing were encountered, or where local highwall instabilities occurred.

Results of the sensitivity simulations indicated that the model predictions were sensitive to the hydraulic conductivity of the hydrogeologic units. Therefore, BGC recommended that additional packer tests be performed during the next stage of study, and that at least one longer term pumping test (i.e., 5 – 7 days) be conducted within the vicinity of the proposed open pit to provide an additional large scale estimate of the hydraulic conductivity of the bedrock.

5.2 Dublin Gulch Valley Groundwater Model

A three-dimensional groundwater flow model (Stantec 2010h) was developed and calibrated to simulate baseline, operational and post-closure groundwater flow conditions in the SA. This model evaluates groundwater conditions for the SA and simulates the effects from proposed project facilities. The objectives of the Dublin Gulch groundwater model were to:

- Simulate groundwater flow based on a conceptual understanding of the groundwater flow system in the Dublin Gulch Basin to predict the groundwater flow patterns prior to, during and after operation
- Estimate the effect of various project facilities (i.e., HLF, WRSAs) on recharge and discharge, groundwater occurrence, groundwater levels and flow
- Estimate the effects of pumping from groundwater wells.

The modeling software package Groundwater Vistas™ was used to facilitate model development in conjunction with the US Geological Survey (USGS) Modular Three-dimensional Finite Difference Groundwater Flow Model MODFLOW and MODDFLOW-SURFACT. These Groundwater Vistas™ simulations required the use of different MODFLOW packages (i.e., BAS (basic), DRN (drain), STR (stream), BCF4 (block-centered flow), RSF4 (recharge seepage-face), FWL4 (fracture-well) to assist in model development and performance.

The model extent included the entire Dublin Gulch basin to Haggart Creek and assumed five hydrostratigraphic layers based on the conceptual groundwater flow model described in Section 2.3.4. The hydrostratigraphic layers included: unconsolidated deposits in the surficial geology of the basin (Layer 1), a weathered bedrock zone (Layer 2), and bedrock units consisting of metasediment and granodiorite (Layers 3 through 5). The thickness of each layer varied depending on physiography and geology. Layers 1 and 2 were generally thin, ranging from approximately 5 to 20 m, while Layer 3 varied from 100 to 300 m. Groundwater flow conditions and aquifer properties were largely defined from existing well data, topographic features, and the hydrogeologic evaluation study, while stream and recharge input was derived from (and consistent with) data used for the SWBM (Stantec 2010g).

The groundwater model predicted that groundwater elevations would decline throughout the Operations phase, and in many cases there will be only marginal recovery during post-mining conditions. By the end of active mining, groundwater elevations within the lower Dublin Gulch valley are expected to decline and stabilize between 10 to 20 m below baseline conditions. This effect is translated up-gradient to areas within Upper Dublin Gulch, Stewart Gulch, and Olive Gulch. The groundwater elevation declines can be attributed to four principal causes:

- Active open pit dewatering, effectively eliminating groundwater recharge from the Stuttle Gulch groundwater basin and portions of the Eagle Pup groundwater basin
- Reduced recharge to both the Eagle Pup and Platinum Gulch groundwater basins due to the assumed effectiveness of the rock drains at the base of both WRSAs
- An assumed negligible recharge to the Ann Gulch groundwater basin under the HLF footprint in combination with the HLF groundwater drainage system
- The capturing of groundwater via the rock drain at the head of the DGDC.

Predicted groundwater contours and flow pathways indicate that the general direction of groundwater flow within Dublin Gulch valley will remain relatively consistent with the pre-mining condition. However, the aquifer will contribute less overall baseflow to Haggart Creek. This loss will have a minor effect on the Haggart Creek reach adjacent to the Dublin Gulch fan (currently, Dublin Gulch baseflow represents <10% of the baseflow to Haggart Creek). The effect will be partially mitigated downstream at the confluence of Eagle Creek, where much of this captured groundwater is returned via the 2.0 km long Eagle Creek Compensation Channel that will be constructed as part of the Fish Habitat Compensation Plan (Stantec 2010k). Details of the groundwater model are found in the Groundwater Model Report (Stantec 2010h).

6 CONSTRUCTION

This section describes the sequence of mine operations and water routing activities during the first two years of the project. Results of the SWBM for the Construction phase are included, where applicable.

The objective of the WMP for the Construction phase is to safely convey and/or store as necessary, all freshet and rainfall runoff through the project site, while maintaining water quality at background levels or meet CCME standards (if applicable) in receiving water bodies at the project site. This objective includes minimizing total suspended sediment levels and treating contact water to achieve water quality standards. The Construction phase of the Project will require approximately 1.7 yrs to complete, and includes approximately 69 weeks over two summer construction periods. Thus the WMP will address conditions during the two spring freshets, and summer-fall rainfall-runoff periods, including storm events, and low flow periods during the following summer and fall periods. Any construction activities planned for the winter period between Years 1 and 2, and any facilities constructed will need to withstand winter conditions at the site.

6.1 General Construction Sequence and Water Routing

The approximate 1.7 year schedule for major construction activities and water routing during the Construction phase include (this sequence is also provided by facility in Table A-1 in Appendix A). Figure 4.2-2 provides the flow pathways for the facilities described below. Specific reference maps and sequence details for each facility are described in Sections 6.3 to 6.8.

Year 1

March:

- Drill/install groundwater production well for camp
- Construct sediment control features associated with construction/installation of main camp (March – April).

April (prior to freshet):

- Construct the LDG SCP in the lower Dublin Gulch valley area

- Construct sewage treatment facility with temporary discharge to the LDG SCP and then to a rock drain and into lower Dublin Gulch/Haggart Creek when complete
- Construct a temporary sediment control pond (SCP) within the footprint of future Events Ponds
- Construct upper DGDC, including upper velocity reduction pond and energy dissipater
- Construct additional temporary (earthworks) sediment control ponds as required.

May – June:

- Route upper Dublin Gulch stream flow through upper DGDC and temporary SCP to LDG SCP (at freshet)
- Begin construction of lower DGDC and lower velocity reduction pond
- Construct Platinum Gulch WRSA (PG WRSA) sediment control pond – discharge to Platinum Gulch when complete (post freshet)
- Construct Ann Gulch east sediment control pond and diversion ditch (May – June; post-freshet); water routed to upper DGDC
- Construct Ann Gulch west diversion ditch and route to the LDG SCP
- Begin site preparation and earthworks for HLF (May – October)
- Construct additional temporary sediment control ponds as required for earthworks.

June:

- Begin drilling/installing and developing perimeter wells and horizontal drains for development of the Open Pit
- Begin construction of the Eagle Creek Compensation Channel
- Construct additional temporary (earthworks) sediment control ponds as required.

July – September:

- Drill/install additional groundwater production wells for process make-up and crushing requirements, and construct water distribution infrastructure
- Construct MWTP Feed and Product Ponds.

Late September – October:

- Upper DG diversion channel connected to lower DG diversion channel
- Reconfigure temporary SCP into the Events Ponds
- Open pit drains operational.

Year 2

May (post freshet):

- Entire DGDC operational including Eagle Creek connector (freshet); and discharge into Eagle Creek
- Construct Eagle Pup WRSA (EP WRSA) sediment control pond and route to MWTP feed pond
- Begin construction and installation of HLF groundwater drainage system and LDRS (April – September)
- Construct initial temporary sump pond at Open Pit
- Construct PG WRSA starter embankment and rock drain.

June:

- Construct EP WRSA rock drain and construct starter embankment
- Construct Platinum Gulch WRSA (PG WRSA) drainage ditch to Open Pit sump, and convey surface water from the PG WRSA to the Open Pit sump
- Drill/Install groundwater wells for fresh water make-up for crushing (June – July).

August:

- Complete all construction activities and water management infrastructure.

A detailed Sediment Control Plan for anticipated work on all proposed facilities will be prepared prior to any construction activities. Erosion and sediment control measures will be implemented during construction of all mine facilities, camp, soil salvage/storage sites, drainage ditches, and roads. Erosion and sediment control measures will include: minimizing land clearing in advance of construction, provision of silt fences, location of temporary diversions, stabilizing diversion channels, providing temporary piping to the sediment control ponds, and other best management practices as are necessary. These works will be detailed as part of feasibility design.

6.2 Undisturbed Basins

In drainage basins not affected by construction activities, maintaining conveyance and baseline water quality conditions are priorities of the WMP during Construction. Streamflow will not be disturbed in the upper Dublin Gulch sub-basins (e.g. Olive Gulch, Cascallen, Stewart Gulch). A water quality monitoring location will be situated above the upper Dublin Gulch velocity reduction pond for establishing upstream control and long-term monitoring of water quality.

6.3 Streamflow Routing

6.3.1 Dublin Gulch Diversion Channel

The DGDC will be completed in Year 1. The upper section and velocity reduction pond will be built in April prior to freshet. The lower section, energy dissipaters, and lower velocity reduction pond will be constructed post-freshet and will be completed by June. Full operations of the DGDC will begin at freshet of Year 2.

Water will enter the DGDC from upper Dublin Gulch (A on Figure 3.1-1) via a velocity reduction pond (B on Figure 3.1-1) near the existing hydrometric monitoring station W1. The diversion ditch along the eastern side of the HLF (Ann Gulch East Diversion or AG EDD) will also supply water to the DGDC (C on Figure 3.1-1). Flow will be routed from the upper DGDC (D on Figure A-1) to the temporary SCP located in the general location of the footprint of the Events Ponds (A on Figure 3.6-1) in Year 1 and from there through the LDG SCP (H and I on Figure 3.6-1) and into lower Dublin Gulch at freshet (May) of Year 1. As the lower sections of the DGDC are completed, flow will be routed to the LDG SCP, rather than the temporary SCP and through the lower section of Dublin Gulch until the spring of Year 2.

The lower sections of the DGDC will be routed down the Stuttle Gulch channel at an approximate 15% slope. Stream energy will be decreased through in-channel dissipation structures such as a cascade-pool sequences (E on Figure 3.1-1). Streamflow from the cascade-pool sequences will discharge to a velocity reduction pond (F on Figure 3.1-1) where the lower section of the DGDC begins. The lower section (G on Figure A-1) consists of an un-lined channel that will be 5 m wide, 3 m deep with an approximate gradient of 5% over a length of 1,160 m. The DGDC will be routed to the south of the Events Ponds and MWTP facilities in the lower Dublin Gulch valley and discharge into the lower Eagle Creek drainage beginning at freshet of Year 2 (H on Figure 3.1-1). The design of the Dublin Gulch diversion channel (DGDC) will include riffle- and cascade-pool sequences, habitat complexity features, riparian planting, and fish-passable gradients, while maintaining a stable geometry and planform. Habitat created within the DGDC will help offset the effects of the Project on fish productivity within the Dublin Gulch basin (Stantec 2010k).

6.3.2 Lower Dublin Gulch Sediment Control Pond

The LDG SCP will be built prior to freshet in the first year of construction. The pond will be lined by HDPE and constructed from appropriate rockfill. The conceptual pond design has two storage areas which have a combined capacity (~32,500 m^3 and see Table 3-1) to accommodate a 1:100 year storm event.

The upstream storage area (H on Figure 3.6-1) will receive surface runoff from the Ann Gulch West Diversion Ditch (K on Figure 3.6-1), Eagle Creek and any on-site runoff in the work zone during the Construction phase. The pond will discharge via an overflow pipe to Lower Dublin Gulch during Year 1 until the lower section of the DGDC is complete. After completion of the DGDC, the pond will discharge to the DGDC via an outlet channel (M on Figure 3.6-1). This will be the planned configuration and water routing plan for the operations phase of the project, although alternative routing to Haggart Creek could also be engineered and would not materially affect the operations of the project or the environment.

6.3.3 Lower Dublin Gulch

As described above, flow from upper Dublin Gulch will be diverted into the upper DGDC as soon as is practical (i.e., prior to, during or just after freshet of Year 1) and routed to the LDG SCP. The existing channel from the diversion point to the outlet of the LDG SCP will be filled, leaving an approximately 100 m reach upstream of the Haggart Creek confluence (i.e., downstream of the existing W-21 hydrometric monitoring station, see Figure 2.3-1). This short reach will receive all outflow from the LDG SCP during the first year of the Construction phase. This flow routing will amount to a maximum increase in flow of approximately 28% in July, and lesser increases in flow during other months. During the second year, this reach will receive no flow when all flow is redirected into Eagle Creek (i.e., beginning May 2013). Figures C6-2 and C6-3 in the Stantec (2010g) illustrate the expected changes in flow in the lower Dublin Gulch channel during construction based on results of the SWBM.

6.3.4 Haggart Creek Downstream of the Existing Dublin Gulch (W-4)

Minor increases in flow (e.g. up to 4%) are expected in Haggart Creek at hydrometric station W-4 during the first year of construction due to the re-routing of Eagle Creek through the LDG SCP and into the lower Dublin Gulch channel. In the second year of construction and all subsequent years, Haggart Creek flows will be slightly lower due to the re-routing of Dublin Gulch into Eagle Creek. The Haggart Creek stream length affected will extend from W-4 to the confluence with Eagle Creek (approximately 1.8 km). During the Year 2 of construction, flows during May through August are expected to be 75% to 92% of baseline flows, for all hydroclimatic conditions (average, wet, and dry conditions). Figures C8-3 and C8-5 in Stantec (2010g) illustrate the expected changes in flow in Haggart Creek at W-4 during construction based on results of the SWBM. The data for Figures C8-3 and C8-5 are summarized in Table C8-1, C8-2 and C8-3 (in Stantec 2010g).

6.3.5 Haggart Creek Downstream of Platinum Gulch (W-29)

In the first year of construction and during average, wet and dry years minor decreases in flow (up to 4%) are expected in Haggart Creek at hydrometric station W29. In the second year of construction, flows during May through August in average, wet and dry years are expected to differ by less than 1% of baseline (Figures C8-2, C8-4 and C8-6 in Stantec 2010g). The monthly percent changes to the streamflow in Haggart Creek at W29 are summarized in Table C8-1: Part 2 (in Stantec 2010g).

6.3.6 Eagle Creek

After freshet 2012 (first year of construction), all upper Eagle Creek flows (i.e., derived from Stuttle Gulch, Eagle Pup and groundwater seeps within the basin) will be routed to the LDG SCP and out to Haggart Creek via the lower channel of Dublin Gulch. This will accommodate the re-habilitation work for fish enhancement and stream stabilization on lower Eagle Creek. More detail on the timing of construction and the resultant gains and losses to fish habitat during construction are described in the Preliminary Fish Habitat Compensation Plan (Stantec 2010k). Additionally, diversions will be required to collect and route surface runoff and groundwater seeps away from various reaches (from the existing W-27 site to the confluence of Eagle and Haggart Creeks) under construction. Thus, there will be no flow in the existing Eagle Creek channel during almost all of the ice-free season in the first year of construction.

In the second year of construction and after the completion of the Eagle Creek connector and the Eagle Creek Compensation channel, the LDG SCP will discharge to Eagle Creek. This will result in a substantial increase in flows, including all flows routed via the DGDC. The SWBM predicts flows will increase in Eagle Creek by the greatest margins during May (over 6 to 7 times depending on average wet or dry scenarios), more than a threefold increase in June and variable increases in July and August, depending on scenario. These changes are due primarily to the re-routing of all of upper Dublin Gulch into Eagle Creek, while some of the rainfall and snowmelt runoff from the upper Eagle Creek basin will be largely being re-routed to the Events Ponds) for subsequent use in the HLF. Figures C7-3 and C7-4 in Stantec (2010g) illustrate the expected changes in flow in Eagle Creek at W-27 (or the approximate location of the LDG SCP outfall) during construction based on results of the SWBM. The data for Figures C7-3 and C7-4 are summarized in Table C7-1, C7-2 and C7-3 in Stantec (2010g).

6.4 Open Pit

Perimeter wells will be installed around the periphery of the Open Pit (E on Figure 3.2-2) to depressurize the open pit walls. The wells will be installed and developed beginning June of the first year of construction and are expected to be fully operational by the end of the first year. As the open pit increases in size during operations, some of these wells will be destroyed.

Horizontal drains will also be installed in the Open Pit area (A on Figure 3.2-2) to depressurize the open pit walls. The drains will be installed from June to October during the first year of construction. The wells and drains will supply water to a temporary sump pond which will be installed as the wells are developed during the first year (B on Figure 3.2-2). The operational sump pond will be constructed after freshet in the second year. A water quality monitoring site will be located at the sump for on-going monitoring. If additional depressurization wells are required in areas of enhanced permeability, these wells will be installed in June of the second year (F on Figure 3.2-2).

6.5 Platinum Gulch Waste Rock Storage Area

The construction of the PG WRSA will be preceded by removal of organic material for stockpiling for closure and removal of any unsuitable material in the foundations of the PG WRSA.

Construction will begin on the PG WRSA after the PG SCP, drainage ditches, starter embankment, and the lined seepage collection pond (LSGP) have been completed. The PG SCP (E on Figure 3.3-1) will be constructed after freshet in May of the first year of construction and will hold approximately 37,500 m^3. The PG SCP will discharge to Platinum Gulch via an overflow pipe (F on Figure 3.3-1). The embankment will be built after the completion of the SCP and be completed by June of Year 2. The LSGP will be constructed by June in the second year. The LSGP will be designed to less than half the capacity of the SCP. The primary use of the LSGP will be to collect runoff and seepage water to convey the water via a drainage channel (C on Figure 3.3-1) to the Open Pit sump (D on Figure 3.3-1).

6.6 Eagle Pup Waste Rock Storage Area

The construction of the EP WRSA will be preceded by removal of organic material for stockpiling for closure and removal of any unsuitable material in the foundations of the EP WRSA. Construction will begin after completion of the EP SCP, starter embankment, and groundwater drainage system.

The EP SCP (C on Figure 3.4-1) will be constructed to have a capacity of 26,600 m^3 in April of Year 2 before freshet. The EP SCP will discharge to the MWTP Feed Pond via an overflow pipe (D on Figure 3.4-1) during freshet of Year 2. The embankment will be constructed following the completion of the EP SCP and be complete by June the second year of construction.

6.7 Heap Leach Facility

The Ann Gulch West Diversion Ditch and the Ann Gulch East Diversion Ditch (AG WDD and AG EDD) will be installed around the HLF footprint to divert non-contact surface runoff from the HLF. The diversion ditches and a SCP will be built after freshet in the first year of construction. The ditches will be reconfigured and move up valley in phase with the development of the HLF during the operations phase of the project to divert non-contact water from the HLF.

The groundwater drainage system will be installed during May to August in the second year of the construction beneath the lowest liner of the HLF to drain groundwater from beneath the HLF and to prevent the buildup of a piezometric surface beneath the HLF. A build of piezometric pressure beneath the HLF may negatively affect the integrity of the liners.

The preliminary design of the HLF includes a double-layer liner system in the upslope area of the HLF and a triple liner under the primary storage area (or heap pond) of the HLF. The purpose of the liner system is to prevent loss of process solution and contamination of groundwater. The final extent of the lining system will cover approximately 785,000 m^2 and will expand in-phase with the development of the HLF. Details of the groundwater drains, the leak detection and recovery system (LDRS) and the leachate recovery and collection system (LRCS) are found in the Section 5 of the Project Description (Heap Leach Facility Construction). It is expected that the drains, LDRS and LRCS will be constructed from May to September during the second year of construction.

6.8 Water Supply

6.8.1 Process Water Storage Ponds

The Events Ponds will be constructed during the first year of construction. During the Construction phase, a temporary SCP will be constructed in April during the first year on the footprint of the Events Ponds and will receive water from the upper DGDC and Eagle Creek while the lower sections of the DGDC are constructed. The temporary SCP will drain to the LDG SCP. After completion of the DGDC, the flow routing from the DGDC will be changed to its final configuration and the temporary SCP will be converted to the two storage ponds for the Events Ponds. The Events Ponds will be constructed in September and October of the first year of construction.

The MWTP Feed and Product Ponds will be constructed from August to October in the first year. The ponds are not intended for water routing until the Operations phase of the project. The ponds will be used once the MWTP begins operations.

6.8.2 Potable Water for Camp

A groundwater potable supply well will be installed and developed at the camp location at the outset of construction Water quality will be monitored at the well. Sediment control features will be installed prior to construction of the main camp in March of the first year of construction. A camp wastewater treatment facility will be built at camp and will discharge through a sewage drainage field and eventually to Haggart Creek in March of the first year. Water quality will be monitored at the outlet of the drainage field.

6.9 Summary

Although none of the major project facilities (i.e., HLF, WRSAs and Open Pit) will be in service during the Construction phase, various water management structures, including sediment control ponds, feed and polishing ponds, the Events Ponds and diversion ditches and channels will be built prior to any upstream site development and utilized to control the routing of runoff and associated erosion and sediment movement from two freshets and two summer seasons. During this time, there are several key water management issues to be addressed, including:

- Construction and use of the DGDC and rehabilitation and enhancement of Eagle Creek will occur in the first year. During the first year all controlled flows will leave the developed area and drain to Lower Dublin Gulch via the LDG SCP, while during Year 2 all controlled flows will leave the developed area and feed Eagle Creek via the LDG SCP. In effect Eagle Creek will receive no flows in Year 1, while Lower Dublin Gulch will receive very little flow in the second year. The effect will be to slightly increase the flows in Haggart Creek (from W4 to the confluence with Eagle Creek) during the first year, while resulting in an approximate 14% decrease in total flows during May through August (or a drop from a 4-month mean flow of 0.90 m^3/s to 0.78 m^3/s).
- Open pit dewatering via horizontal drains and perimeter wells will begin in the first year. This will continue throughout the construction phase. During the second year after full build out of the drains and wells, an estimated 53,000 m^3 of water is expected to be dewatered prior to open pit development. It is expected that this water can be conveyed through the feed pond and into the Events Ponds, where water will be stored for use as HLF process later in the year.
- The EP SCP will be built early in the second year. Water collected in the EP SCP maybe conveyed through the Feed pond and into the Events Ponds. Any excess water from the combined sources of the dewatering and SCP would ultimately be discharged to Haggart Creek, provided water quality criteria are met.

7 OPERATIONS

The objective of the WMP during the Operations phase will be to safely convey and/or store as necessary, all freshet and rainfall runoff through the project site, while maintaining water quality at background levels or to meet CCME standards (if applicable) in receiving water bodies at the project site. This objective includes minimizing total suspended sediment levels and treating contact water to achieve water quality standards.

This section describes the sequence of mine operations and water routing activities during the Operations phase of the project. Results of the water balance modeling for the operational phase are described in detail in Stantec (2010g) and help quantify the routing of water at the project site.

The Operations phase of the project will occur over 7.3 years from September of the second year to December of the ninth year.

7.1 Operations Sequence and Water Routing

The major activities and water routing during Operations include:

Year 2

September:

- Full operations begin; all water management systems will be operational.

Years 3 to 5

- PG WRSA and EP WRSA in use, PG WRSA will be primary waste rock storage area.

Year 6

October:

- Decommission the PG WRSA and begin progressive reclamation including re-contouring and capping as appropriate
- Water routing from collection pond at PG WRSA to Open Pit sump will continue as long as water supply is needed and water chemistry requires some level of treatment
- Full operations of EP WRSA, water routing structures in place from Construction phase.

Years 6 to 9

- Full operations; water routing as described in sections below.

Year 9

December:

- End mining operations
- Begin Recovery/Reclamation phase (January, Year 10).

The above sequence is also provided by facility in Table A-2.

7.2 Undisturbed Basins

In drainage basins not affected by construction activities, maintaining conveyance and baseline water quality conditions are priorities of the WMP during Operations. Streamflow will not be disturbed in the upper Dublin Gulch sub-basins. A water quality monitoring location will be situated above the upper Dublin Gulch velocity reduction pond for upstream control and long-term water quality monitoring.

7.3 Streamflow Routing

7.3.1 Dublin Gulch Diversion Channel

During the Operations phase, water routing through the DGDC will be the same as water routing in the second year of construction (see Section 6.1.3 of the WMP). Water quality monitoring stations will be located on Dublin Gulch above the upper velocity reduction pond and at the outlet of the Eagle Creek connection (Figure 3.1-1). Optional water routing to the DGDC can occur from the EP SCP (E on Figure 3.4-1), provided water quality criteria are met, but this is generally not expected during average and dry years due to the process water requirements of the HLF. The DGDC will be in place for the duration of the mine life.

7.3.2 Lower Dublin Gulch Sediment Control Pond

During the Operations phase, the LDG SCP will receive surface runoff from the AG WDD (K on Figure 3.6-1) into its upstream storage area (H on Figure 3.6-1), as well as runoff from the up-gradient facility grounds. The LDG SCP will receive treated water from the MWTP Product pond (L on Figure A-6). Non-contact water from the Open Pit wells (N on Figure 3.6-1) could be routed to the LDG SCP if water criteria are met and process water requirements are met. LDG SCP will drain to Haggart Creek via an outlet channel (M on Figure 3.6-1) (H on Figure 3.1-1). A water quality monitoring site will be located at the outlet channel.

During an average precipitation year, the HLF will have a water demand that exceeds the amount of rainfall and snowmelt that it receives. In this case, make-up water will be supplied from water derived from the Open Pit and WRSAs. This water will be sent to the MWTP Feed Pond and then pumped into the Events Pond as required. Any excess will then eventually drain to the LDG SCP (via treatment if required). The predicted maximum monthly outflows from the LDG SCP to Haggart Creek for an average year range from approximately 31,000 m^3/mo in the first year of operations to 83,000 m^3/mo in the sixth year of operations, which is only 1.1 to 4.7% of the Haggart Creek flow, respectively. During a wet year the maximum monthly outflows are considerably higher, ranging up to 274,000 m^3/mo, or 8.2% of the Haggart Creek flow (Table C8-1 in Stantec 2010g). The maximums, which normally occur during June and July, will gradually increase during the life of the project as a result of the increasing catchment area of each facility footprint.

7.3.3 Haggart Creek Downstream of the Existing Dublin Gulch (W-4)

Throughout the Operations phase, minor decreases in flow (8 to 13%) are expected in Haggart Creek along the reach that extends from the hydrometric station W-4 to the confluence with Eagle Creek. These decreases would occur from September through June in average, wet and dry hydroclimatic conditions. The flow reductions result from the re-routing of Dublin Gulch into Eagle Creek via the DGDC. During July, the predicted decreases are somewhat greater and are 21%, 25% and 12% less than baseline for the average, wet and dry scenarios, respectively. During August the predicted decreases are 13%, 17% and 8% for the average, wet and dry scenarios, respectively. This proportional loss becomes less in the downstream direction as tributaries and groundwater discharge feed Haggart Creek. The rerouted Dublin Gulch water then returns to Haggart via Eagle Creek, where Eagle Creek joins Haggart downstream of Gil and Platinum Gulches. Figures C8-3 and C8-5 in Stantec (2010g) illustrate the expected changes in Haggart Creek (at W4) during the last year of operations based on results of the SWBM. The data for Figures C7-3 and C7-4 are summarized in Tables C8-3 and C8-5 in Stantec (2010g).

7.3.4 Haggart Creek Downstream of Platinum Gulch (W-29)

Throughout the Operation phase, flows at Haggart (W29) (located downstream of the project footprint), are expected to vary little (between 99% and 102%) from baseline during an average year. During a wet year, flows are expected to increase only slightly from May to September (102% to 106%), and be essentially the same (<1% change) for the remainder of the year (October to April). During a dry year, flows are expected to decrease only slightly (1.2% to 1.6%) from June through August, and be essentially the same for (<1% change) the remainder of the year (September – May) (Figures C8-2, C8-4 and C8-6 and Tables C8-1, C8-2 and C8-3 in Stantec 2010g)).

7.3.5 Eagle Creek Drainage

Beginning in Year 3 and continuing as a permanent feature there will be a substantial increase in flows in the Eagle Creek channel as a result of accommodating all of the flow from Dublin Gulch. The SWBM predicts flows will increase in Eagle Creek by the greatest margins during the winter, although the flows will not be significant. For the average hydroclimatic condition, wintertime (December through April) baseflows are expected to increase from 0.8 to 2.7 L/s (2,100 to 7,200 m^3/mo) to 13.1 to 33.1 L/s (35,000 to 89,000 m^3/mo). The wintertime increases are similar for the wet and dry scenarios.

From June to October, increases range from approximately 4 to 7 times for the average and wet hydroclimatic conditions, while the increases are less substantial during dry hydroclimatic conditions (approximately 1 to 4 times). Figures 4 in Stantec (2010g) illustrate the expected flows and changes in Eagle Creek (at W27) during Year 7 of operations based on results of the SWBM. The data for Figures C7-1 through C7-are summarized in Tables C7-1, C7-2 and C7-3 in Stantec (2010g).

7.4 Open Pit

Dewatering and depressurization of the open pit walls is expected to occur throughout the operations phase (E on Figure 3.2-2). A groundwater well will be needed to supply water for crushing activities (F on Figure 3.2-2). One of the open pit perimeter wells could be used for that purpose. It is assumed that crushing will require approximately 36,000 m^3/mo during full operations (i.e., Years 3 – 9).

Meteoric and surface runoff will be collected in drainage ditches around the Open Pit and diverted to small sediment controls ponds and eventually will be drained along with dewatered discharge to the MWTP Feed Pond (C on Figure 3.2-2) or to the crusher. This water may be routed to the LDG SCP if water requirements for the crusher are achieved and water quality criteria are met (D on Figure 3.2-2). A water quality monitoring site will be located at the Open Pit sump.

The predicted chemical characteristics of the Open Pit sump water are described in Section 6.5.2.2 and listed in Table 6.5-10 of the Project Proposal. Open pit sump water is predicted to have pH about 7.5, alkalinity 100 to 125 mg/L, chloride 3 to 4 mg/L, calcium 82 to 88 mg/L, magnesium 6 to 7 mg/L, potassium 12 to 15 mg/L, and sodium 2 to 3 mg/L. Open pit sump water quality is predicted to have relatively high concentrations of the following:

- Antimony, arsenic, cadmium, copper, selenium, and silver at more than ten times water quality guidelines
- Sulphate, fluoride, chromium, lead, manganese, mercury, thallium, uranium, and zinc at less than ten times water quality guidelines.

This water would need treatment if not used as process make-up water for the HLF. Total water supplied to the MWTP Feed Pond from the Open Pit sump is estimated to range from 26,000 m^3/mo to 125,000 m^3/mo r, with the higher rates later in the mine life and occurring during snowmelt periods and runoff periods (Figure C1-1 in Stantec 2010g).

7.5 Platinum Gulch Waste Rock Storage Area

During the Operations phase surface runoff from compacted access roads leading to the dump crests will be collected in drainage ditches next to the roads. This runoff will be conveyed to the ditch that is routed to the Open Pit sump.

Water quality of the PG SCP overflow will be monitored at the outlet of the PG SCP as well as downstream before entering Haggart Creek (Figure 3.3-1). The PG WRSA will be in operations from Year 2 to Year 5. The facility will be closed at the end of Year 5 and reclamation activities will begin in Year 6.

During operations, the SWBM assumed conservatively that the rock drains below the PG WRSA would capture all recharge through the pile and transmit the flow to the PG LSGP, thus there would be no direct recharge under the WRSA. Water quality will be monitored at the PG LSGP. Predicted water quality characteristics of the water in the PG SCP during operations are discussed in Section 6.5.2.2 of the Project Proposal.

Quality of contact water is assumed to be constant throughout a specific year, while concentrations of several parameters are expected to increase over the three years of operations. Predicted water quality for Year 5 is summarized in Table 6.5-9 of the Project Proposal. During the ice-free season, levels of almost all metals, sulphate, fluoride and nutrients are predicted to be above water quality guidelines. Nitrate and ammonia levels will be higher due to leaching of blast residues from the waste rock, although they are expected to leach out each year, and decrease to minimal levels in closure. For the PG LSGP water, pH is predicted to be about 7.1, alkalinity about 160 to 250 mg/L, chloride 10 to 14 mg/L, calcium 140 to 370 mg/L, magnesium 43 to 75 mg/L, potassium 27 to 43 mg/L, and sodium 7 to 12 mg/L. The following parameters are predicted to have elevated concentrations during operations, including:

- Antimony, arsenic, cadmium, copper, lead, manganese, selenium, silver, uranium, and zinc at ten times water quality guidelines
- Sulphate, fluoride, aluminum, chromium, iron, mercury, nickel, and thallium at less than ten times water quality guidelines.

Although monitoring will be in place to confirm predictions, the modeled results indicate that contact water from the EP WRSA will need to be treated prior to discharge.

The effect of potential recharge to groundwater from the rock drain was examined by the groundwater model (Stantec 2010h) and is discussed below in Section 7.6.

Rainfall and snowmelt from up-gradient areas will be diverted away from the WRSA. Any recharge that passes via shallow subsurface flow and under the diversion ditches will ultimately enter the rock drains, as this zone will be less resistant to flow. A minor component of the recharge will enter the bedrock aquifer and ultimately flow towards the lower Platinum Gulch valley and into the Haggart Creek valley. This water will not be in contact with the WRSA and would have concentrations equivalent to baseline water quality.

7.6 Eagle Pup Waste Rock Storage Area

The EP SCP will normally be drained by an overflow pipe (D on Figure 3.4-1) to the MWTP Feed Pond (E on Figure 3.6-1). However, during the Operations phase, if water criteria are met and water supply requirements (for process) are achieved during operations, water from the EP SCP may also be routed to the DGDC via an overflow pipe (E on Figure 3.4-1). Water quality will be monitored at the EP SCP. Predicted water quality characteristics of the water in the EP SCP during operations are discussed in Section 6.5.2.2 of the Project Proposal.

Quality of contact water is assumed to be constant throughout a specific year, while concentrations of many parameters are expected to increase over the years of operations. Predicted water quality for Year 9 is summarized in Table 6.5-11 of the Project Proposal. For the EP SCP water, pH is predicted to be about 7.0 to 7.2, alkalinity about 220 to 320 mg/L, chloride 8 to 13 mg/L, calcium 260 to 460 mg/L, magnesium 27 to 68 mg/L, potassium 27 to 41 mg/L, and sodium 4 to 11 mg/L. The following parameters are predicted to have elevated concentrations during operations, including:

- Antimony, arsenic, cadmium, copper, lead, manganese, selenium, silver, uranium, and zinc.at ten times water quality guidelines
- Sulphate, fluoride, aluminum, chromium, iron, mercury, nickel, and thallium at less than ten times water quality guidelines.

Although monitoring will be in place to confirm predictions, the modeled results indicate that contact water from the EP WRSA will need to be treated prior to discharge.

As with the PG WRSA rock drains, during the Operations phase it was conservatively assumed that the rock drains below the EP WRSA would capture all recharge through the pile and transmit the flow to the EP SCP, thus there will be no direct recharge under the WRSA. This assumption is reasonable based on the relatively low permeability of the underlying bedrock and the positive vertical gradients that have been observed in the area of the proposed drains. However, up-gradient areas will continue to receive recharge from rainfall and snowmelt. Most of this water will continue to flow towards the valley bottom, and because groundwater flow is directed towards the surface in the valley bottom, flow will enter the permeable areas at the rock drains. If a minor component of this water enters the bedrock it would ultimately flow towards the lower Dublin Gulch valley. This water would not be in contact with the WRSA.

The effect of potential recharge to groundwater from the rock drain was examined by the groundwater model (Stantec 2010h).

Although it was assumed for the SWBM that the rock drains would intercept all water and there would be no recharge, additional modeling was conducted to evaluate the effects on water quality and Haggart Creek should some of this water recharge into the subsurface. The evaluation included the following:

- To represent recharge, cells beneath sections of the WSRAs were assumed to have a constant recharge rate of 8.4 x 10-5 m^3/d (approximately 1% of the expected net precipitation in the areas of the WSRA) with a unit concentration value of 100.
- Transport was assumed to begin at the start of operations and continue for 10 years after mining activities ceased (to the end of closure and reclamation). During this time, recharge and concentration into Layer 2 was considered to be constant.
- To add into the conservancy of the simulation, no retardation or degradation rates were assumed.

Results of the model indicated that:

- Injected water would migrate towards Haggart Creek via either Platinum Gulch or lower Dublin Gulch.
- Groundwater with the injected solution would enter only the uppermost hydrostratigraphic unit of the model (Layer: surficial alluvium, placer deposits, and till) but would not migrate downward into deeper model layers.

- By the time groundwater beneath the WSRAs migrated to Dublin or Haggart Creek, attenuation effects (i.e., advection and dispersion transport) would have reduced concentrations to less than 1 in most areas and would not exceed 4. Thus, concentrations in groundwater that may occur due to seepage from the WSRA's would only be 1% to 4 % of the original concentration in the seepage.

7.7 Heap Leach Facility

During the Operations phase, the AG WDD will be routed to Haggart Creek via the lower Dublin Gulch channel and the AG EDD will be routed to the upper Dublin Gulch velocity reduction pond (C and D on Figure 3.5-1). These diversion ditches will operate as described in the Construction phase (see Section 6.7).

The HLF solution will continually irrigate a portion of the HLF surface (approximately 200,000 m^2 of HLF surface area could be under leach at any one time) and then drain to the Heap Pond (or primary storage) which will be designed to hold a maximum of 435,000 m^3 of storage volume (via pore space) (B on Figure 3.5-1). During the first year of operations, the HLF will be irrigated at a rate of 1,100 m^3/hr; as the HLF grows in Year 4 (Figure 3.5-2) the irrigation rate will be increased to 1,950 m^3/hr while the in-Heap Pond will be maintained at around 60,000 m^3. Based on the average HLF surface area under leach, an average HLF thickness of 100 m at maximum extent, and a 9.4% moisture content (derivation discussed in Section 5.4 of Stantec 2010g) the total volume of solution in saturation within the HLF is estimated to range from approximately 400,000 to 620,000 m^3. Under normal operating conditions, solution will be pumped from the Heap Pond to the ADR. As the size of the HLF increases, and/or during peak flow events, additional solution volume will be routed to the Events Ponds if required. Leached solution from the Heap Pond will be recycled to the ADR via a pump (E on Figure 3.5-1) and will return solution to the HLF irrigation system (F on Figure 3.5-1).

Throughout operations, process water demand is expected to vary due to the relative availability of water from rain or snowmelt. Figure C4-1 and Table 6.2-3 in Stantec (2010g) depicts the variations in water balance parameters, and demonstrates that the HLF will operate in a negative balance. Figure C4-2 depicts the varying water demand from the HLF through the Operations phase. Generally, precipitation on the HLF provides a sufficient supply from May to the end of summer. However, water will be required from other sources during dry hydroclimatic conditions and/or during low flow conditions of the year (i.e., August to April). The peak monthly demand each year is approximately 37,400 m^3/mo (Table C4-1 in Stantec 2010g).

The groundwater drainage system will intercept groundwater from the Ann Gulch, Dublin Gulch, and Eagle Pup drainage basins. Groundwater quality will be monitored at a temporary outflow storage facility at the toe of the HLF (G on Figure 3.5-1) and will be pumped to the LDG SCP via pipework if water quality criteria are met (J on Figure 3.6-1). If water quality standards are not achieved, the groundwater drainage system will be pumped to the EP to be used as process make-up water or the MWTP for treatment.

Baseline groundwater quality of the Ann Gulch basin and Dublin Gulch valley is discussed in Stantec (2010b), Section 6.5.2.2 of the Project Proposal and is summarized in Table 6.5-12 of the Project Proposal. No change from baseline is predicted, as there is no contact with HLF solution, and this groundwater currently discharges into Dublin Gulch. Groundwater chemistry is dominated by calcium, carbonate or bicarbonate, and sulphate, and also contains arsenic, cadmium, iron and manganese concentrations higher than water quality guidelines. This groundwater already discharges to the streams (Dublin Gulch or possibly Haggart Creek), contributing to elevated baseline levels of metals in the streams, so should be considered suitable for release to Haggart Creek during operation.

The LDRS will drain to a sump below the in-heap pond, and then pumped back to the ADR. More detail on the design and operation of the LDRS is found in the Project Proposal.

7.8 Process Water Storage Area

7.8.1 Events Ponds

The Events Ponds will be used for excess solution storage during peak flow events and for HLF draindown during plant shutdown and closure.

The Events Ponds will receive contact water from the HLF, processing plant, and MWTP Feed Pond as required. The Events Ponds will store water to be recycled back to the barren tank. Under normal operating conditions, water will be pumped from the MWTP Feed Pond to the Events Ponds. The Events Ponds will be empty during winter to ensure full storage capacity for an expected large volume of water generated during freshet.

In the event that the Events Ponds requires draining, contact water will be cycled through the cyanide detoxification plant (D on Figure 3.6-1), and then to the MWTP Feed Pond for treatment (E on Figure 3.6-1). When water quality standards are achieved, the treated water will be discharged to the MWTP Product Pond (G on Figure A-6), through a pipe connection (L on Figure 3.6-1) to the LDG SCP (H on Figure 3.6-1) before being discharged to Haggart Creek.

7.8.2 Mine Water Treatment Plant

At the mine operations plants and ponds area in the lower Dublin Gulch valley, the MTWP Feed Pond (E on Figure 3.6-1) will receive contact water from the Open Pit and EP WRSA. Initially (first couple of years) all of this will be routed to the Events Ponds A and B on Figure 3.6-1) and then used as required (for make-up water in the Process Plant. When the flow from the Open Pit sump and the EP SCP exceeds the process demand for water from the HLF, then the excess water will be sent to the MWTP (F on Figure 3.6-1) for treatment an eventual discharge to Haggart Creek via the Product Pond (G on Figure 3.6-1) and the LDG SCP (H on 3.6-1). Groundwater wells installed near the mine operations facilities could also provide make-up water to the process plant during dry seasons when runoff volumes have been depleted.

The HLF is predicted to have a negative water balance throughout operations, so the MWTP is not expected to receive any water from the Cyanide Detoxification facility (D on Figure 3.6-1) during operations (E on Figure 3.6-1). The MTWP Feed Pond will receive excess contact water from the Open Pit sump and EP SCP. The quality and quantity of the combined sources of contact water directed to the MWTP are summarized in Tables 6.5-10 and 6.5-11 of the Project Proposal. As noted for the individual sources of the influent water, levels of most metals and phosphate are elevated. During operations, the concentrations in the MWTP influent will be the highest of those identified for the Open Pit sump and WRSAs. Expected ranges of pH are 7.0 to 7.5, alkalinity about 106 to 320 mg/L, chloride 3 to 14 mg/L, calcium 82 to 460 mg/L, magnesium 6 to 73 mg/L, potassium 12 to 43 mg/L, and sodium 2 to 11 mg/L. Details of the treatment technologies and the parameters assessed are provided in Section 3.7.1.

Figure C5-2 in Stantec (2010g) provides an estimate of the average monthly flow rate (in m^3/hr) to the MWTP. Generally, during the first four years treatment will only be needed for a few months during late summer with average monthly flow rates not exceeding 100 m^3/hr. Assuming average hydroclimatic conditions, maximum average monthly treatment flow rates would be below 120 m^3/hr for a couple months during years 5, 6 and 7, while treatment would only be required from June to October. During this time the feed water would originate from the WRSA's and Open Pit sump. During the wet hydroclimatic conditions, average monthly flow rates to the MWTP could exceed 360 m^3/hr. during a single month and treatment would be required from May to October. These rates are all well below the maximum design flow capacity of 620 m^3/hr.

7.9 Water Supply

7.9.1 Process Water

During the Operations phase, process make-up water will be derived from several sources including groundwater, seepage and runoff from the Open Pit and WRSAs. This water will be piped directly to the MWTP Feed Pond, where it will then be transferred into the Events Ponds as necessary and when the Events Ponds volume is below the 175,000 m^3 maximum operating volume.

The SWBM results indicate that during average hydroclimatic conditions a supplemental groundwater supply will be required only during three Aprils (10,000 to 20,000 m^3/mo) when the Events Ponds have been fully depleted and there is no available runoff water. This supplemental groundwater supply could originate from the groundwater drains located below the HLF, or from supplemental wells located near the recovery plant. During dry years, a supplemental groundwater supply could be needed to supply a much larger proportion of the process demands during some the winter months and a small proportion of the demand during summer.

During the first year of the Operations phase, the demand on water for crushing will increase from 3,400 m^3/mo to 5,400 m^3/mo, and by the second year demand will reach approximately 7,600 m^3/mo, or 91,000 m^3 per year until closure. This water will be supplied from a nearby source, which could be either a groundwater well located adjacent to the crusher facility (this may a perimeter depressurization well), or from water in the Platinum Gulch LSGP or Open Pit sump, if water quality meets the appropriate criteria.

7.9.2 Potable Water for the Camp

Potable water for the camp will be provided by a groundwater well near camp. Water quality will be monitored at the well and treated prior to use. If required, additional water for gray water purposes may be taken from Haggart Creek. The camp wastewater treatment facility will drain to a drainage field and then to Haggart Creek. Water quality will be monitored at the outlet of the drainage field. Erosion and sediment control measures will remain in place from the Construction phase.

7.10 Summary

As the project facilities increase in footprint size over the course of the Operations phase, the amount of water to manage will increase proportionately. Figure 7.10-1 is a summary water balance flowsheet for Year 7 depicting the annual flow volumes passing through the major flow nodes. For simplification, the climate input (rain and snowmelt) and output parameters (evaporation, sublimation, and evapotranspiration) are left off the figure. The figure depicts several points of interest, including:

- Continued open pit dewatering, open pit runoff and contact water from the Platinum Gulch WRSA represent about 69% of the inflow to the feed pond, while contact and non-contact water from Eagle Pup WRSA make up the remaining 31%. Depending on water quality conditions, process make-up requirements and treatment requirements, some of this water could be conveyed directly to the LDG SCP to minimize treatment rates.
- During much of the year, water treatment will not be required (November through April), or may be required intermittently, expected average monthly feed rates will be less than 100 m^3/hr (compared to a design capacity of 620 m^3/hr) for all but June and July. The maximum treatment feed rate is expected to peak at 185 m^3/hr during June 2020, with an overall annual total treatment feed volume of 326,000 m^3 occurring during Year 7.
- Throughout all years in operation, all the water used by the HLF is recycled, and no water would need to go through cyanide detoxification prior to treatment.
- Dublin Gulch passes through the project via the DGDC and does not receive any inflows except from the LDG SCP.
- The DGDC represents 86% of the flow to the new Eagle Creek Compensation Channel, which will carry flows up to 5.6 times the existing flow regime.
- Eagle Creek (including flows from the DGDC) represents approximately 15% of the flow in Haggart Creek.

8 RECLAMATION

The objective of the WMP for the Reclamation phase will be to safely convey and/or store as necessary, all freshet and rainfall runoff through the project site, while maintaining water quality at background levels or to meet CCME standards (if applicable) in receiving water bodies at the project site. This objective includes minimizing total suspended sediment levels and treating contact water to achieve water quality standards. Furthermore, during the reclamation phase, most of the water-related mine facilities will be gradually decommissioned and reclaimed.

This section describes the sequence of mine operations and water routing activities during this phase of the project. Results of the water balance modeling for the reclamation phase are provided in Stantec (2010g) and which quantify the routing of water at the project site.

The reclamation phase of the project is conservatively assumed to occur over a 10-year period from January 2021 (Year 10) to December 2030 (Year 19). The 10-year length of time is a product of the required time to close the HLF, whereas most of the other facilities are less constrained and could be closed and reclaimed in a shorter time period. During this time, the closure of the HLF will have three successive periods:

1. Supplemental gold recovery period (first year after the Operations phase)
2. Rinse period (Years 2 and 3 following the Operations phase)
3. Draindown period (beginning after the rinse period), followed by post-closure monitoring.

The overall project design objective is a “walk-away” closure condition, with limited post-closure water quality monitoring until it is demonstrated that mitigation measures have achieved the required outcomes.

During the reclamation phase, all facilities will be decommissioned with the exception of some of the drainage ditches and portions of the DGDC, some of which will be enhanced for aquatic habitat and all of which will be stabilized for the long-term.

8.1 Reclamation Sequence and Water Routing

The major activities and water routing during the Reclamation phase include (this sequence is also provided by facility in Table A-3).

Year 10 (Gold Recovery):

- Final gold recovery from HLF; no more additional cyanide
- Recycle leach solution with no additives
- Stabilize all long-term diversion ditches and SCPs
- Reconfigure lower DGDC for stream habitat enhancement
- Cap EP WRSA
- Partial backfill of the Open Pit and formation of a pit lake
- Reclamation of Crusher area

- Groundwater wells sealed at Crusher
- WQ monitoring.

Year 11 – 12 (Rinsing):

- Rinsing of HLF
- Begin detoxification of HLF
- Maximum raw water additions to HLF (rinse cycle)
- Pit Lake drains to Platinum Gulch
- WQ monitoring.

Year 13 – 19 (Draindown):

- Cap HLF
- Solution drains from HLF
- Groundwater wells in the general area of the Process Plant sealed after HLF rinsing
- EP maintained until HLF capped
- Runoff routed to MWTP Feed Pond
- MWTP maintained until WQ criteria are met
- LDG SCP receives all runoff until WQ criteria are met and/or a passive wetland treatment system is constructed
- WQ monitoring until WQ requirements are met
- Final Closure of all activities except environmental monitoring.

Year 20 – 24:

- Post-closure monitoring (see Section 9).

8.2 Undisturbed Basins

In drainage basins not affected by construction activities, maintaining conveyance and baseline water quality conditions are priorities of the WMP during Closure and Reclamation. Streamflow will not be disturbed in the upper Dublin Gulch sub-basins. A water quality monitoring location will be situated above the upper Dublin Gulch velocity reduction pond for long-term water quality monitoring.

8.3 Streamflow Routing

8.3.1 Dublin Gulch Diversion Channel

In Year 10, the upper DGDC and velocity reduction ponds will be inspected for stability and vegetation requirements to meet the long-term reclamation objectives for downstream fish habitat.

The lower DGDC will be reclaimed beginning in Year 11. The riffle sequences, lower velocity reduction pond, lower DGDC, and Eagle Creek connector will be inspected and stabilized where necessary to improve the long-term stability of the channel and to enhance stream habitat. Water quality monitoring locations will remain in place.

8.3.2 Lower Dublin Gulch Sediment Control Pond

During reclamation, the LDG SCP will receive surface runoff from the AG WDD (K on Figure 3.6-1) into its upstream storage area (H on Figure 3.6-1), as well as runoff from the up-gradient facility grounds. The LDG SCP will receive treated water from the MWTP Product Pond (L on Figure 3.6-1). Non-contact water from the Open Pit wells (N on Figure 3.6-1) could be routed to the LDG SCP if water criteria are met and process water requirements are met. LDG SCP will drain to Haggart Creek via an outlet channel (M on Figure 3.6-1) (H on Figure 3.1-1). A water quality monitoring site will be located at the outlet channel.

8.3.3 Haggart Creek Downstream of the Existing Dublin Gulch (W-4)

The effects on flows in Haggart Creek at W-4 predicted for the Operations phase (Section 7.3.3) will continue for the remainder of the project through reclamation and post-closure monitoring.

While the MWTP is in place, treated effluent will enter Haggart Creek in the area of W4. Predicted water quality in Haggart Creek during draindown is summarized in Table 6.5-21 and Figure 6.5-5 of the Project Proposal. The following was evident:

- Metals are predicted to meet water quality guidelines or site-specific water quality guidelines during draindown, except for the periodic exceedances in aluminum and manganese noted for baseline.
- Nitrate and ammonia levels are predicted to be higher than baseline, when cyanide detoxification is on-going. Values for the June through September growing season are predicted to be 0.5 to 1.6 mg N/L nitrate and 0.5 to 1.9 mg N/L ammonia (total inorganic nitrogen of 1.0 to 3.6 mg/L). Combined, these inorganic nitrogen levels are 20 to 45 times higher than at baseline.
- Phosphate levels are predicted to be a little higher than during the Operations phase during the growing season, as phosphate contributions from the HLF will be slightly higher than water quality guidelines.

8.3.4 Haggart Creek Downstream of Platinum Gulch (W-29)

During the rinsing stage, the SWBM predicts that flows in Haggart Creek at W-29 are 99-102% of baseline, and slightly higher (104-107%) during freshet. During the first year of drain-down predicted flows are 103% to 115% higher; afterwards predicted flows are essentially the same during winter, 102% to 105% of baseline during summer and 108% to 111% of baseline during freshet for the remainder of the Reclamation phase (Tables C8-1, C8-2 and C8-3, and Figures C8-4 and C8-6 in Stantec 2010g).

8.3.5 Eagle Creek Drainage

The effects on Eagle Creek at W-27 predicted for the Operations phase (Section 7.3.4) will continue for the remainder of the project through reclamation and post-closure monitoring. Predicted water quality in the Eagle Creek drainage during closure is discussed in Section 6.5.2.2 of the Project Proposal. Findings include, pH is predicted to be 7.0 to 7.5, alkalinity about 106 to 320 mg/L, chloride 3 to 14 mg/L, calcium 82 to 460 mg/L, magnesium 6 to 73 mg/L, potassium 12 to 43 mg/L, and sodium 2 to 11 mg/L. Aquatic communities can adapt to these changes in water chemistry, as the changes are unlikely to result in toxic effects; there are either no water quality guidelines developed, or the concentrations are well below guidelines.

Phosphate levels in the DGDC are predicted to range from 0.03 to 0.09 mg/ PL during the June to September growing season, three to nine times higher than baseline (maximum of 0.01 mg/L), as a result of phosphorus release from the EP WRSA. Nitrate and ammonia levels are predicted to remain at baseline levels, given that blast residues will have leached out of the waste rock during operations. Elevated phosphate levels could lead to eutrophication in the DGDC, farther down in Eagle Creek or even further downstream in Haggart Creek, depending on the balance between nitrogen and phosphorus in the system. At baseline, the low nutrient levels indicate oligotrophic conditions and the relative levels of nitrate, ammonia, and phosphate suggests that nitrogen is the limiting nutrient for periphyton growth in Dublin Gulch and Eagle Creek. Although the CCME framework for managing phosphorus in freshwater environments (CCME 2004) would place the 0.03 to 0.09 mg P/L predicted for closure as a trigger for eutrophic conditions, it is likely that excessive periphyton growth would not occur in Dublin Gulch or Eagle Creek, given the limitation provided by nitrogen levels. However, the additional mitigation of a treatment wetland would also help reduce phosphorus levels in discharge from the EP WRSA.

8.4 Open Pit

During Year 10, the Open Pit will be back filled as water quality conditions permit. A small Pit Lake will form after backfilling is complete. The pit lake will take approximately one average summer to fill approximately 130,000 m^3 and then drain to Platinum Gulch, provided water quality criteria are met. The remaining perimeter wells at the end of operations will be sealed and the horizontal drains will remain in place. The crusher area will be reclaimed in Year 10 after mining stops. The make-up water supply groundwater wells will be sealed after crushing stops. The water quality monitoring station will be decommissioned after the groundwater wells have been sealed.

Pit Lake water quality will be influenced primarily by contact of rainwater with the open pit walls (given that 90% of the inflow will come from that runoff) and by groundwater discharged into the open pit. While geochemistry testing indicates the open pit walls will not be acid generating (SRK 2010), neutral metal leaching is predicted to result in antimony, arsenic, cadmium, selenium, and silver levels two to ten times higher than guidelines. Other metals will be less than two times higher than guidelines. Pit Lake chemistry is not expected to change through the year, over time, or with changing rainfall scenarios, although the volume discharged will vary through the year. The pit lake may provide some opportunities for settling of suspended sediment and for biogeochemical reactions (e.g. primary production facilitating sedimentation and precipitation of metals) to occur, which will reduce metals levels beyond those conservative worst case levels predicted.

Discharge water quality will be affected by the retention time of water in the Pit Lake. Many factors will affect retention time, including the ratio of annual flow inputs (during average, wet or dry years) to the pit lake volume, the relatively high influx of flow during spring freshet that could travel quickly through the pit lake (short-circuiting) and not mix vertically, and the volume of water lost through rock fractures. Temperature and possibly chemical stratification in the open pit (thermocline and chemocline) could also prevent water at depth from being flushed. Design of the pit lake outlet structure (to be done at the Feasibility stage) will control both the rate of outflow and maximum pit lake depth, and will also affect retention time. The expected discharge quality water and downstream conditions within Platinum Gulch are described in further detail in Section 6.5.2.2 of the Project Proposal.

8.5 Platinum Gulch Waste Rock Storage Area

Decommissioning the PG WRSA will begin September of Year 4 and be complete by September of Year 5. During this period, the PG WRSA will be re-contoured and covered with a soil reclamation cover (see the Project Proposal) to enhance re-vegetation, stabilization and help meet water quality criteria. The cover is assumed to have an infiltration rate of approximately 20% of net precipitation. The collection pond will be maintained to provide make-up water to the Open Pit sump during the remainder of the Operations phase.

At closure (Year 10 or later), Platinum Gulch flows will consist of non-contact water from the diversions and contact water from the PG WRSA. A channel will be built from the PG LSGP to PG SCP and then to Platinum Gulch, which will discharge to Haggart Creek upstream of W29. If needed, the seepage collection pond will be converted into a wetland for passive treatment of contact water, with outflow to Platinum Gulch, which is not considered fish habitat, given the intermittent and small flows at baseline.The alternative of sending seepage and open pit water to the mine water treatment plant during draindown of the HLF was considered but rejected, as preliminary modeling of phosphorus and nitrogen levels in effluent indicated the potential for elevated levels and eutrophication in Haggart Creek.

After Year 10 (i.e., post-operation) both the collection pond and the PG SCP will remain in place until water quality standards have been achieved and monitoring is no longer required (approximately five years, Year 15). If needed, the PG SCP could be converted into a small wetland for treatment. Water will flow to Platinum Gulch and then to Eagle Creek. At that stage, the monitoring station will be removed, the pond will be breached, and the natural drainage system reinstated and the pond areas will be re-vegetated.

8.6 Eagle Pup Waste Rock Storage Area

Decommissioning the EP WRSA will begin in January of Year 10 and be complete by September of Year 11. During this period, the EP WRSA will be re-contoured and covered with a soil reclamation cover (see the Project Proposal) to enhance re-vegetation, stabilization and help meet water quality criteria. The cover is assumed to have an infiltration rate of approximately 20% of net precipitation so that flows through the waste rock will be much lower than during operations. Quality of contact water collected in the EP SCP is expected be similar to or slightly better than that during operations. The EP SCP will remain in place until water quality standards have been achieved post-closure and monitoring is no longer required (approximately five years later in Year 16). At that stage, the pond will be breached and the natural drainage system reinstated and the pond area will be re-vegetated.

8.7 Heap Leach Facility

After mining has stopped at the end of Year 9, the HLF will continue to operate for supplemental gold recovery for approximately the first year of the Closure and Reclamation phase. In January of Year 10, cyanide will be added to the process solution and the remaining leach solution from the primary storage area will be recycled through the HLF to recover any gold resources remaining in the mined ore.

In January of Year 11, the detoxification and rinsing of the HLF will begin. The SWBM assumes this process will take 2.5 years. This process includes rinsing the HLF with a neutralized solution and raw water. After the cyanide concentrations have been reduced to sufficiently low levels, the process solution will be treated with hydrogen peroxide and copper sulfate to reduce the cyanide concentration below 0.2 mg/L CNWAD and 2.0 mg/L CNTOT.

During the recovery and rinsing periods, water will be recycled through the HLF to the primary storage and pumped to the ADR and will return to the HLF irrigation system. This cycle will continue until July of Year 13. The final process water will be cycled through the Events Ponds for aging, and then to the MWTP for final treatment. The treated water will be discharged to the MWTP Product pond and then to the LDG SCP.

Following rinsing, the HLF will be re-contoured and covered during Year 13 with a soil reclamation cover that has an infiltration rate of approximately 10% of net precipitation to enhance re-vegetation, stabilization and help meet water quality criteria. The HLF is assumed to start draining in July 2024. The SWBM assumes the draindown period will last approximately 6.5 years and be essentially complete by December 2030. About 40 to 50% of the total draindown is expected in the first month. Within the first year about 88% is expected to drain, while another 10 to 12% is assumed to take another five to six years to drain. There will likely be a residual amount that will continue to drain for a longer period of time, while infiltration will still occur through the cover.

After draindown is essentially complete, the MWTP will be decommissioned and based on the results of the geochemical characterization (SRK 2010), the WQM (Stantec 2010n) and the SWBM (Stantec 2010g), a passive engineered wetlands treatment system (approximately 1 km long) may need to be constructed between the HLF and Haggart Creek to mitigate the potential effects of metals in the HLF seepage that may still be elevated above site-specific water quality criteria. Descriptions of alternative types of engineered wetlands to mitigate the predicted effects are found in Stantec (2010o). The wetlands would be constructed in the location of the proposed ponds (Events Ponds, Feed Pond, Product Pond and LDG SCP). The groundwater drainage system and LDRS will remain in place post-closure and will be routed through the wetlands during the reclamation phase.

The diversion ditches in Ann Gulch will be stabilized in Year 10. The AG EDD will continue to be routed to Dublin Gulch and the AG WDD will be routed to Haggart Creek once water quality criteria are met. The Ann Gulch SCP will remain in place until water quality criteria are met, after which the pond will be decommissioned in approximately Year 15.

8.8 Process Water Storage Area

8.8.1 Events Ponds

The Events Ponds will remain in-place until the HLF is capped in Year 13. After the HLF is capped, drainage from the HLF will be routed to the MWTP Feed Pond or LDG SCP if water quality criteria are met. When the Events Ponds are no longer needed (i.e., HLF is capped, water quality standards are achieved), the Events Pond area will be reclaimed into the wetlands system.

8.8.2 Mine Water Treatment Plant

The MWTP will receive water from the HLF after the Events Ponds have been closed. The MWTP and ponds will remain intact until the HLF has been detoxified and seepage quality is suitable for release to the LDG SCP. It is expected the MWTP and ponds will be decommissioned by July of Year 18.

The quality of detoxified water from the HLF to the MWTP was predicted based on results of a standard humidity cell conducted on a composite ore sample provided by KCA (2010) and a modified humidity column of spent ore composite sample following cyanidation and detoxification in a metallurgical test column (SRK 2010). The short-term results of these tests were used to predict inputs to the MWTP. Water quality is expected to have the highest concentrations of parameters during peak draindown (July 2024) (Stantec 2010n and see Table 6.5-18 in the Project Proposal). Levels of sulphate, arsenic, antimony, aluminum, copper, lead, selenium and uranium are predicted to be between 20 and 250 times higher than water quality guidelines during this time. Treatment of this influent is discussed in Section 3.7.1.

Detoxified discharge from the HLF will eventually be suitable for direct release to Haggart Creek, given enough rinsing and draindown to release cyanide, nitrogen, and loosely bound metals in porewater. The cover is assumed to restrict the amount of rainfall infiltrating the HLF to about 20% of net precipitation, and this will reduce the amount of water draining from the HLF. Further discussions regarding predicted water quality during the Closure and Reclamation phase are provided in Section 6.5.2.2 of the Project Proposal. Details of the treatment technologies and the parameters assessed are provided in Section 3.7.1.

8.9 Water Supply

8.9.1 Process/Reclamation Water Requirements

During the first year of the reclamation phase, gold recovery will still occur so that the HLF process water requirements do not change. HLF rinsing will occur in the second and third year, which will require more water. During the rinse period, it is expected that additional rinse water can be supplied from either groundwater or the DGDC, if the collected water from WRSA and Open Pit sources are not sufficient.

8.9.2 Main Camp

Potable water needs will decrease over the reclamation phase from a maximum of 60,000 L/day to 6,000 L/day. Details of the water needs are summarized on Table 8.9-1. The camp facilities will be reclaimed at the end of post-closure monitoring. Details are provided in Section 9.

Table 8.9-1: Estimated Camp Water Supply Demands for the Project

Phase	Number of People	Volume (m^3/day)	Volume (l/day)
Construction	400	120	120,000
Operations	190	57	57,000
Reclamation/au recovery	200	60	60,000
Reclamation/rinse	200	60	60,000
Reclamation/rinse	100	30	30,000
Reclamation/draindown – Year 1	50	15	15,000
Reclamation/draindown – Years 2 to 6 (10)	20	6	6,000
Post closure monitoring – Year 1	10	3	3,000
Post closure monitoring – Years 2+	5	1.5	1,500

8.10 Summary

After mine closure and the beginning of reclamation activities, the routing of water among the various project facilities will change over several years, and the amount of water to manage will become progressively less. The exception will be the first year of the HLF draindown, where water stored in the HLF will need to be detoxified and then treated. Figure 8.10-1 is a summary water balance flowsheet for Year 4 of Closure and Reclamation phase (or the period following 2.5 years of rinsing and the beginning of draindown – assumed to occur in July 2024). Figure 8.10-1 depicts the annual flow volumes passing through the major flow nodes. As with Figure 7.10-1, climate inputs and outputs are left off the figure. The figure depicts several points of interest, including:

- The majority of the HLF is expected to draindown in Year 4 of Reclamation following one year of supplemental gold recovery and 2.5 years of HLF rinsing. Although the draindown process will likely take a number of years, a large portion (approximately 74%) of the draindown is expected to occur in the first two months, which is scheduled to begin in July in Year 4. The water would be cycled to the cyanide detoxification plant, and then to the MWTP. During peak draindown, the MWTP feed rate could exceed 500 m^3/hr (during an average year), which is less than the design feed rate of 620 m^3/hr. This includes the additional water piped from the Open Pit sump and the EP SCP. If a wet year occurred during draindown, however, the feed rates could be up to 1.3 times the design flow rate, several options are available to handle the extra short-term treatment requirement. These options include: delay the piping of open pit sump water (as there will be capacity in the sump), recycle some of the HLF drain water back to the HLF, or increase treatment capacity. In essence the draindown rate could be managed and draindown could be postponed if a wet month occurred. Treatment feed rates are expected to decrease quickly after the first several months of draindown and as the HLF cover is completed (Stantec 2010p). Eventually active treatment will not be required as various water sources meet discharge criteria, and/or the feed rates are small enough to begin using a passive wetland treatment system, as necessary.

- During the first several years of the reclamation phase the open pit sump will receive inflows from horizontal drains and open pit wall runoff, as well as contact water from the PG LSGP. The PG WRSA will have been capped (if deemed necessary) and closed during Years 4 and 5 of the Operations phase.
- At closure, the open pit volume will be approximately 280,000 m^3. Approximately 150,000 m^3 of waste rock will be used as open pit backfill, leaving approximately 130,000 m^3 to fill with water. When the pit lake water quality meets discharge criteria, and after the pit lake has filled (estimated to take approximately one summer), the pit lake will drain and form a tributary to Platinum Gulch.
- During the first several years of the reclamation phase, the EP WRSA will be capped as necessary. Seepage and runoff from the EP WRSA will continue to be collected by the EP SCP and conveyed to the Feed Pond until the water meets discharge criteria, after which the pond will be deactivated and the runoff allowed to drain to the DGDC.
- As reclamation progresses, Dublin Gulch will continue to pass through the Project via the DGDC. The DGDC will be enhanced in places depending on the feasibility and necessity for erosion protection and/or aquatic habitat. At some time flow from the Eagle Pup basin and the lower areas of Stuttle Gulch basin will be allowed to drain back into Eagle Creek.

9 POST-CLOSURE AND MONITORING

The objective of the WMP for the post-closure and monitoring phase is to monitor the reclaimed areas at the project site to ensure that water quality criteria are achieved and the stability of the long-term structures are maintained. The goals, objectives and criteria for measuring the achievement of these goals and objectives is described in Stantec (2010p). Thus, the ultimate goal is to complete the walk-away objective of the project design. Most of the facilities will be closed during the reclamation phase; therefore, facility management is minimal during the post-closure phase.

This section describes the water routing activities during the post-closure phase of the project for the remaining facilities. Results of the water balance modeling for the post-closure phase are provided which quantify the routing of water at the project site.

9.1 Dublin Gulch Diversion Channel

The lower DGDC will be reclaimed by Year 12. The area of the channel from the approximate location of the existing Stuttle Gulch channel down to the outlet of the Eagle Creek connector will be reclaimed habitat as part of the fish habitat compensation plan. Details of the fish habitat compensation plan are provided in the Project Proposal.

Flows in the upper and mid DGDC are expected to increase as the drainage from various facilities (i.e., EP WRSA SCP) is re-routed to the DGDC. However, since the LDG SCP routes all water into the Haggart Creek, flows downstream of W-27 will be same as before reclamation, with the exception that as the surface of the WRSAs and stockpile areas are covered and begin to vegetate, rates of ET would increase while runoff would decrease.

Water quality monitoring sites will be located at the existing locations above the upper DG velocity reduction pond and at the outlet of the Eagle Creek connector.

9.2 Open Pit

After backfilling and reclamation, it will take approximately one average precipitation year to fill the 250,000 m^3 open pit volume. The pit lake will then drain to Platinum Gulch. The effect will be to increase mean monthly flows in Platinum Gulch by approximately two to three times. A steadier pit lake outflow may cause the stream to flow longer during the summer and into fall. Currently, Platinum Gulch is intermittent to ephemeral during much of the summer. The effect of snowmelt and rainfall runoff events will not be as pronounced on the annual hydrograph of the channel. Increases in streamflows will be proportional to the increased area added by the Open Pit sub-basin. Predicted water quality of the Pit Lake discharge is discussed in Section 8.4.

9.3 Platinum Gulch and Eagle Creek Drainages

Natural drainage will be reinstated in Platinum Gulch during the reclamation phase in Year 15. Streamflow will report to the existing drainage. Rock drains will still operate. Predicted water quality of the discharge from the PG WRSA area and downstream Platinum Gulch during post-closure is discussed in Section 8.5.

Natural drainage will be reinstated in Eagle Pup during the reclamation phase (approximately Year 16). Streamflow will be routed to the upper DGDC. Rock drains will still operate. Predicted water quality of the discharge from the EP WRSA area and downstream drainages including the DGDC and Eagle Creek during post-closure is discussed in Section 8.5.

9.4 Heap Leach Facility

The Heap Pond will continue to collect seepage from the HLF during the closure and reclamation phase, when water will be pumped to either the Events Ponds or the MWTP Feed Pond. The post-closure monitoring pahse for the HLF will begin when flow rates and water quality conditions allow direct discharge to the environment or discharge to the environment through a wetland treatment system as described as part of the adaptive management strategy in the CCRP (Stantec 2010p). At that time, horizontal drains will be installed through the embankment and into the Heap Pond to allow gravity drainage. This drainage would be directed to the upstream portion of the wetlands. Water quality will be monitored at this location. The groundwater drainage system and LDRS will remain in place post-closure. Drainage will be directed to Haggart Creek via lower Dublin Gulch.

Long-term predictions of water quality in seepage water derived from the HLF is discussed in Section 6.5.2.2 of the Project Proposal. In essence, seepage concentrations will be dominated by chemical reactions of sulphide-bearing minerals within the HLF, rather than a pore water dominated seepage during draindown. While levels of many parameters are expected to decrease over the long term, levels of magnesium and phosphate are predicted to increase. Over the long-term in closure, the heap leach facility drainage is expected to be similar to that predicted for the Eagle Pup WRSA. Measures (such as wetlands and a cover designed to minimize infiltration) to control seepage and/or metal concentrations will be required to reduce the amount of metal loadings to the environment for a few 10’s of years or more following detoxification of the HLF (SRK 2010).

9.5 Haggart Creek

During the Post-closure Monitoring phase, the SWBM predicts that flows in Haggart Creek at W-29 are essentially the same during winter, 102% to 105% of baseline during summer and 108% to 111% of baseline during freshet. These slight increases are essentially due to the effects of greater runoff from the covers on the HLF and WRSAs (Tables C8-1, C8-2 and C8-3, Figures C8-4 and C8-6).

Predicted water quality in Haggart Creek at W4 during the long term is summarized in Table 6.5-23 and Figure 6.5-5 of the Project Proposal. The data suggest that some improvement can be expected over the long term, although the improvement for arsenic will be less, and is still 11 times higher than the CCME water quality guidelines. Nitrate, ammonia and phosphate levels are predicted to be close to baseline, and selenium will be close to guidelines (up to 0.004 mg/L during one month of the year). However, with an assumed 10% infiltration cover and the wetland treatment system in place, it is predicted that parameters will meet guidelines in Haggart Creek (Stantec 2010n).

The residual effect of post-closure discharges to Haggart Creek between W4 and W29, over the long term with employment of a treatment wetland, is considered low to moderate in magnitude, local in geographic extent, continuous and far future. The effect will be expressed in an area already disturbed by historic placer mining. This will be confirmed through monitoring of both surface water quality and groundwater.

9.6 Main Camp

The camp sewage treatment facility will operate until Year 24. At the end of the post-closure monitoring period, the facility and the camp buildings will be reclaimed. The groundwater well at camp will be sealed at the end of the post-closure monitoring period in Year 24.

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11 FIGURES

Please see the following pages.

Data Sources; Government of Canada, Victoria Gold Corp.

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Victoria GOLD CORP

GENERAL LOCATION MAP

EAGLE GOLD PROPERTY
YUKON TERRITORY

PROJECTION	DRAWN BY
UTM - ZONE 8	LS
DATUM	CHECKED BY
NAD 83	RS
DATE	FIGURE NO.
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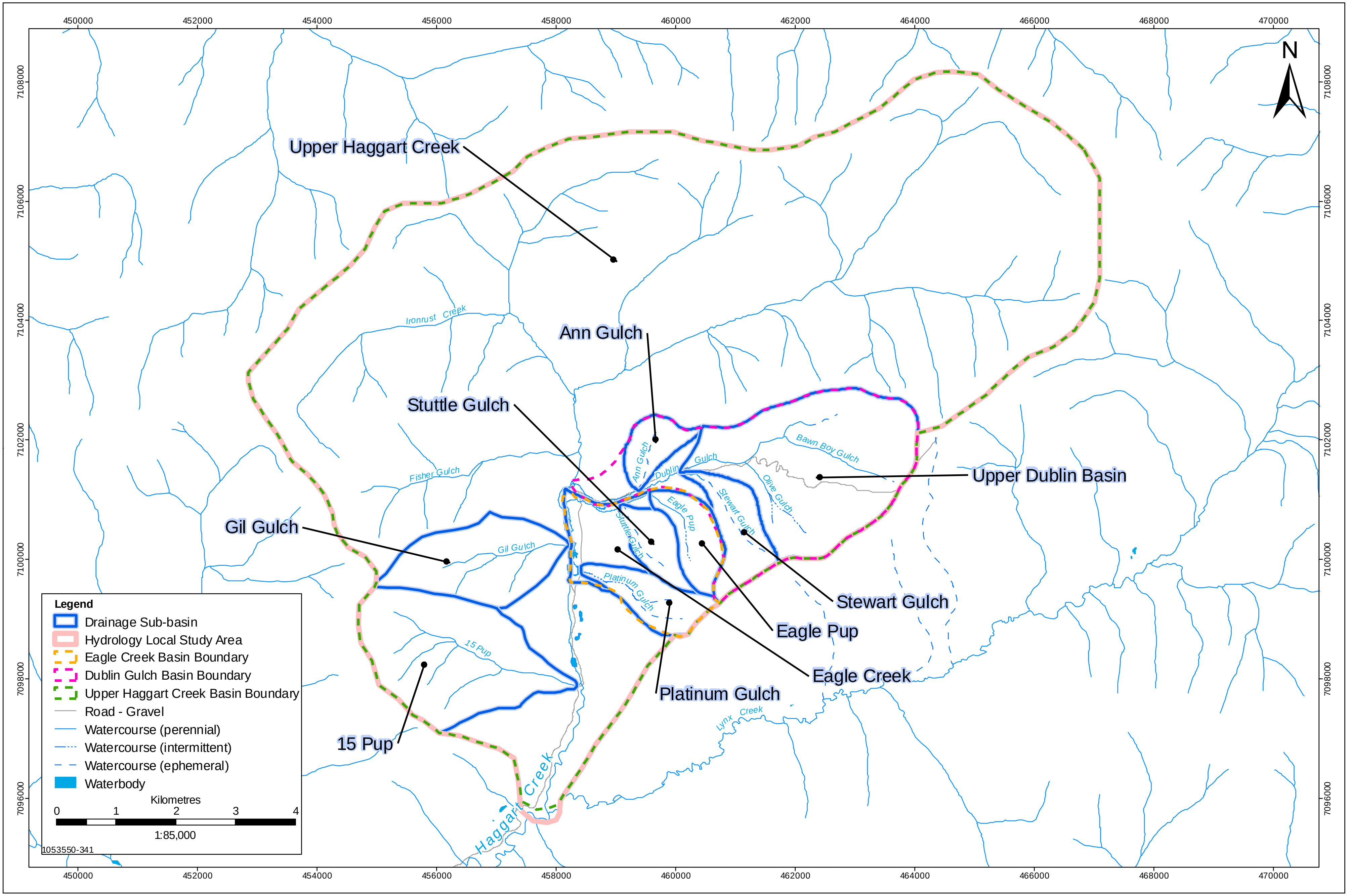

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Victoria GOLD CORP

HYDROLOGY STUDY AREA AND MAJOR SUB-BASINS

EAGLE GOLD PROPERTY
YUKON TERRITORY

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NAD 83	RS
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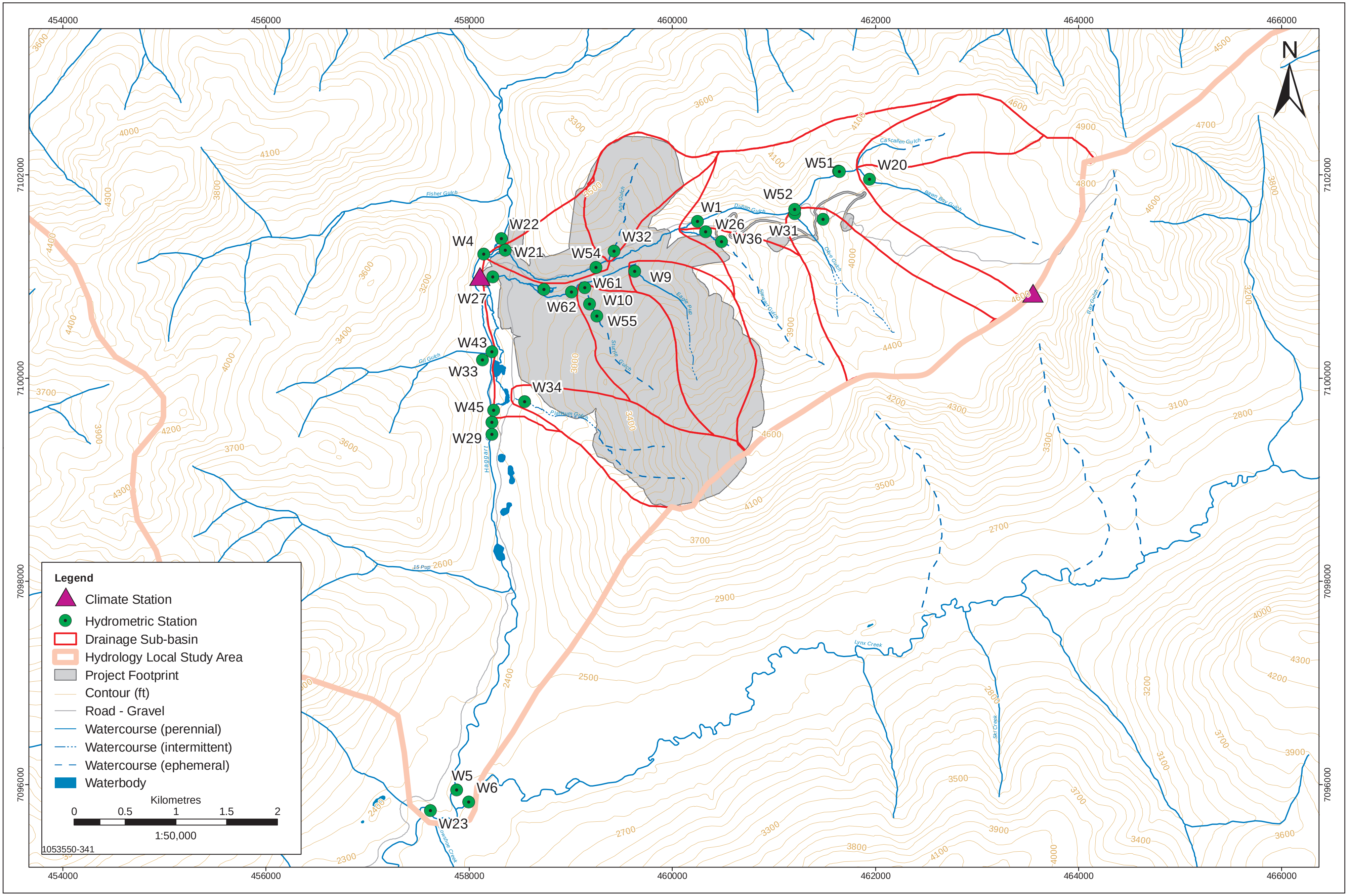

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DRAINAGE BOUNDARIES OF STREAMS IN PROJECT FOOTPRINT SHOWING HYDROMETRIC AND CLIMATE STATIONS

EAGLE GOLD PROPERTY
YUKON TERRITORY

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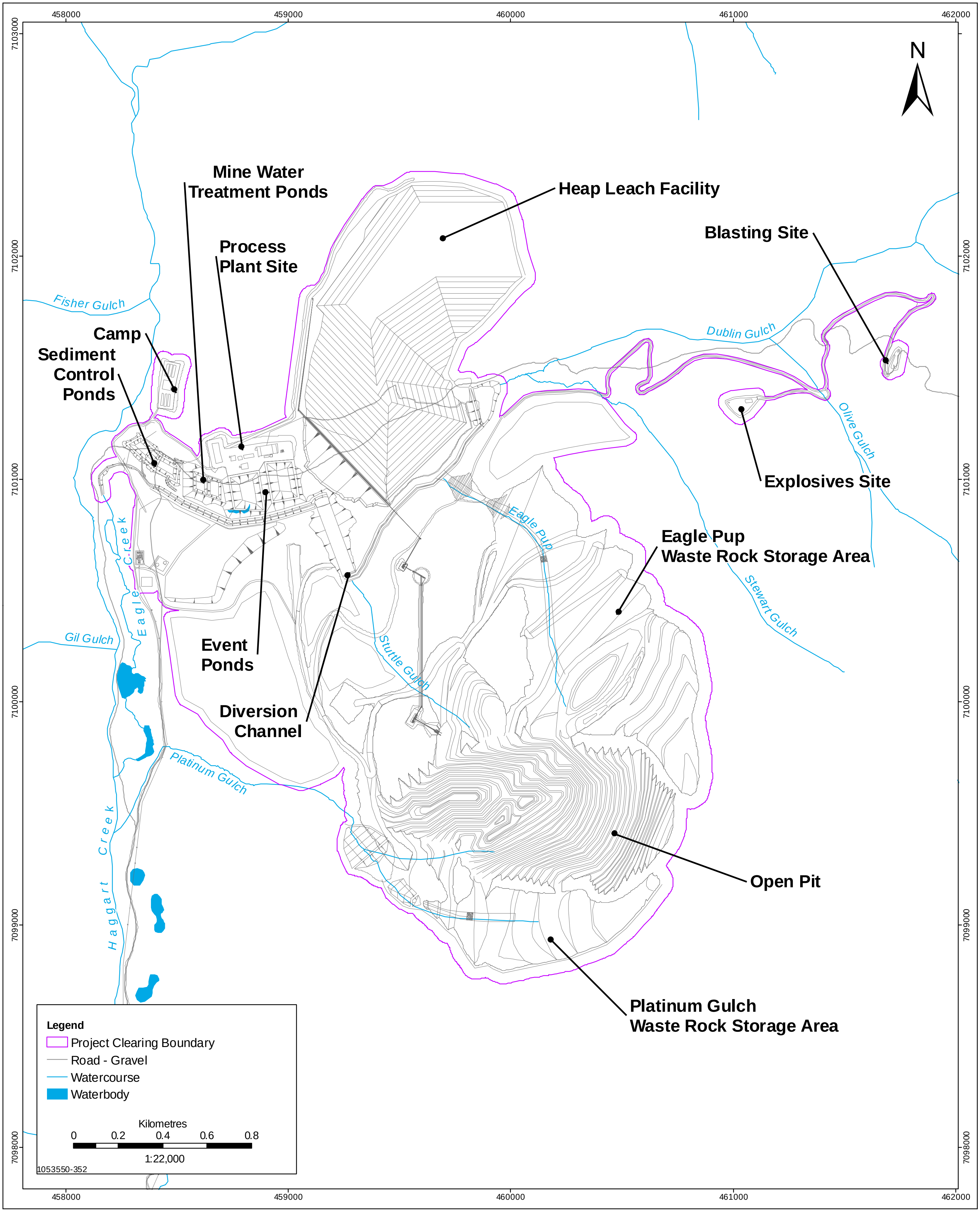
DATE: 11-November-2010	FIGURE NO.: 2.1-1



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PROJECT FACILITY LAYOUT

EAGLE GOLD PROPERTY
YUKON TERRITORY

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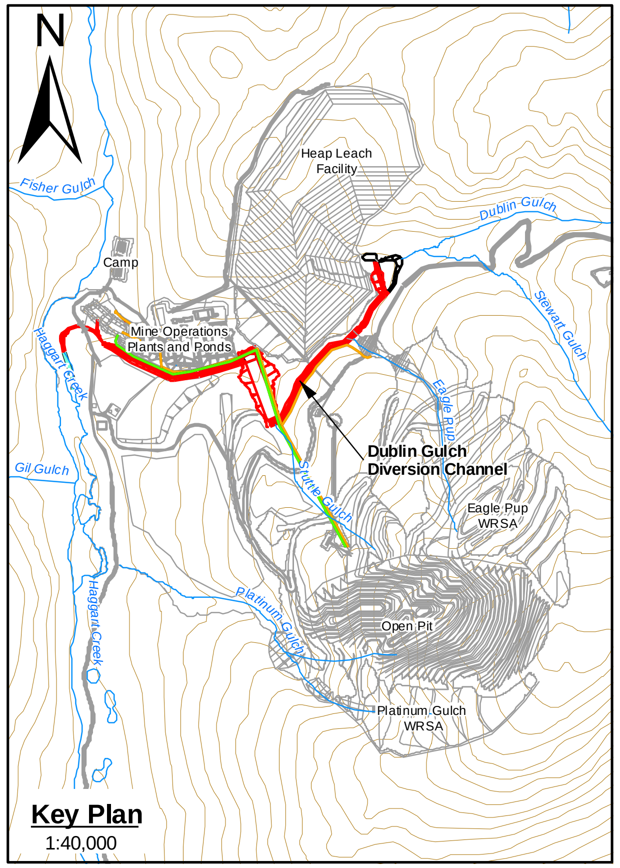
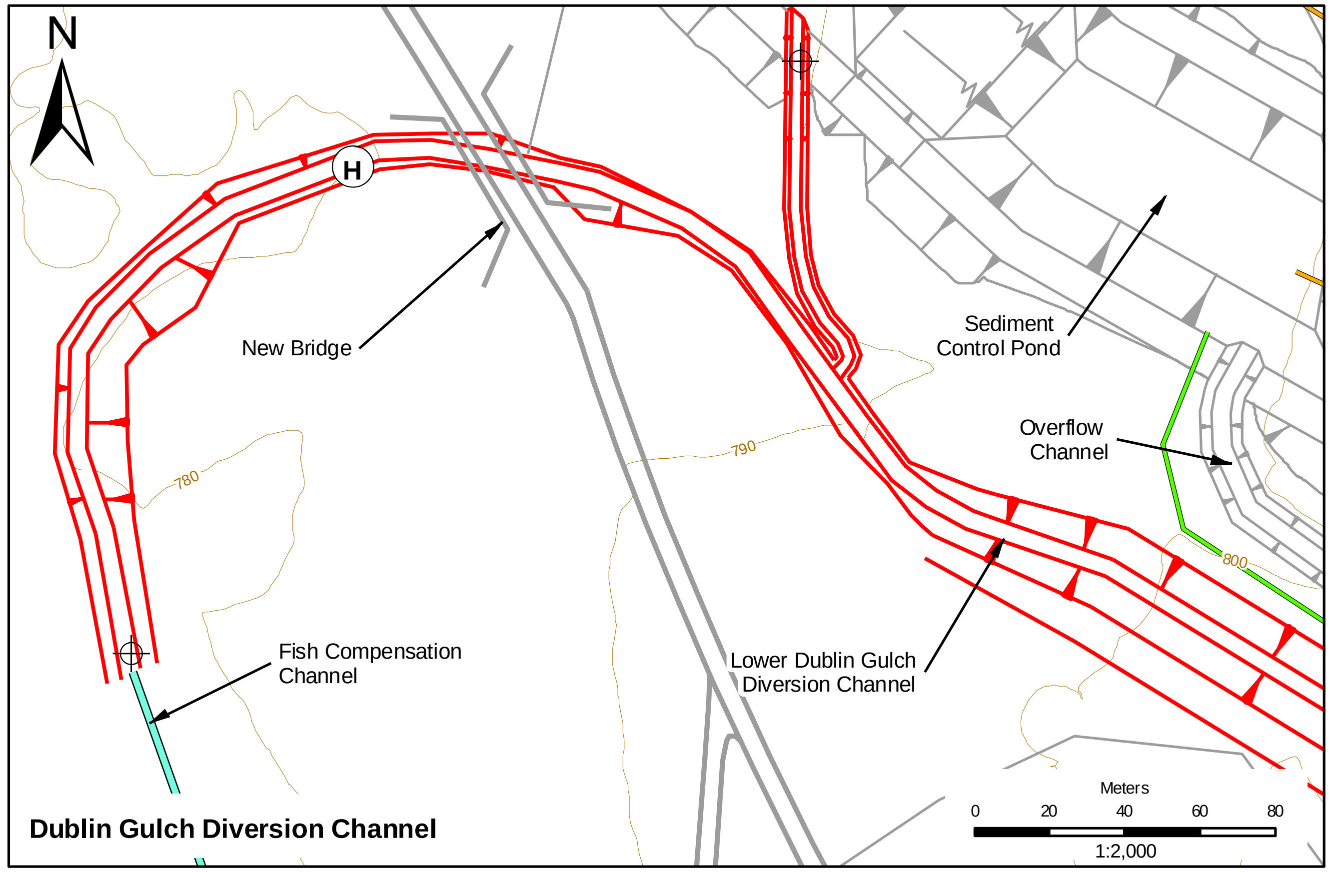
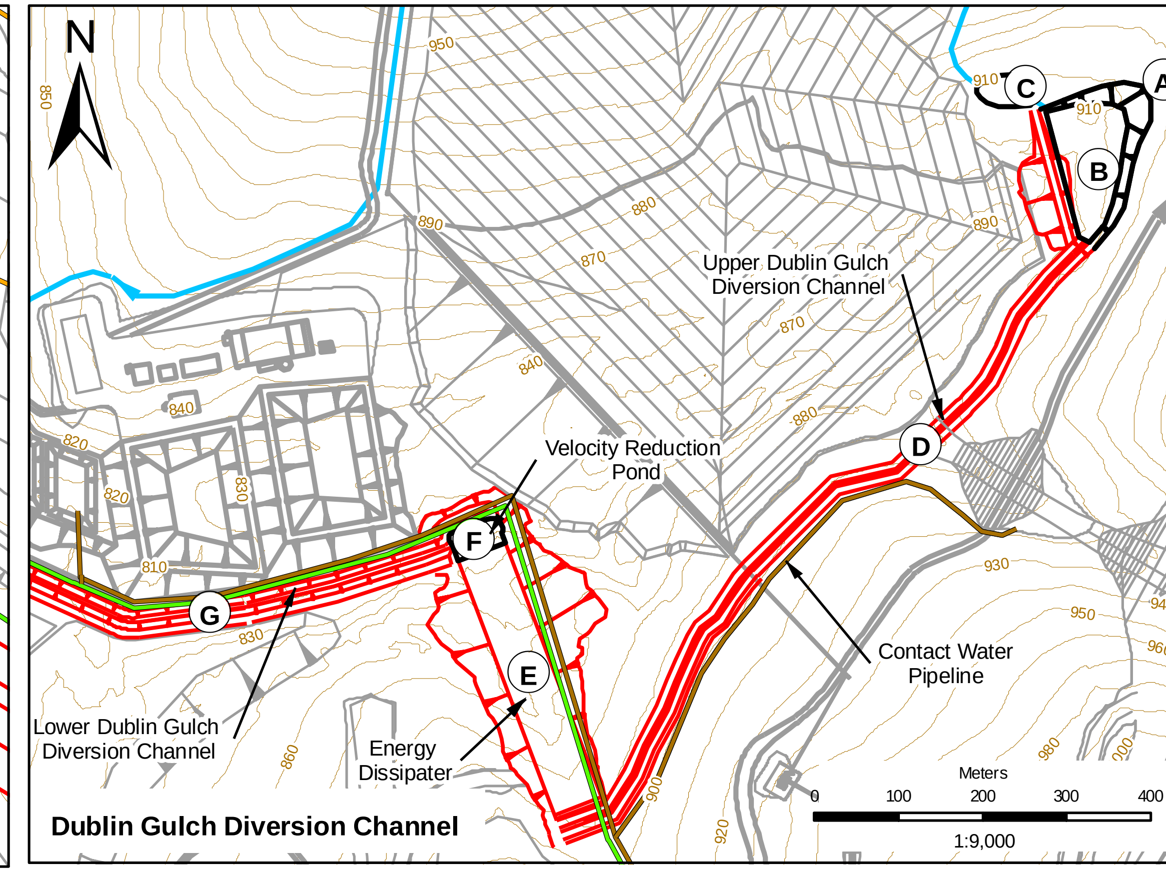
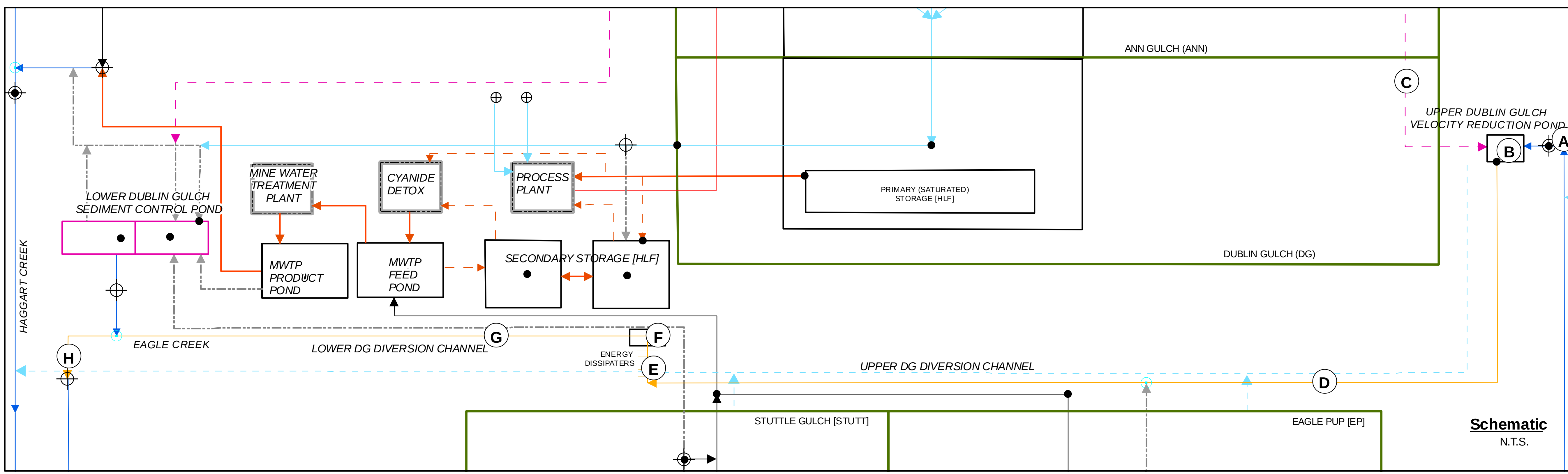
DATUM	CHECKED BY
NAD 83	RS
DATE	FIGURE NO.
25-November-2010	3-1









Legend

- Discharge to Channel
- Withdrawal from Channel
- Model Node
- Groundwater Well
- Environmental Monitoring Location
- Optional Routing
- Mine facility
- Diversion Channel (DC)
- Diverted Runoff (DRO)
- Non-Contact Surface Water (SW)
- Regional Groundwater

*Lettering system refers to this figure only

1053550-202

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WATER MANAGEMENT PLAN SCHEMATIC
DUBLIN GULCH DIVERSION CHANNEL - OPERATIONAL CONDITIONS

EAGLE GOLD PROPERTY
YUKON TERRITORY

PROJECTION	DRAWN BY
UTM 8	TG
DATUM	CHECKED BY
NAD 83	SW
DATE	FIGURE NO.
30-November-2010	3.1-1

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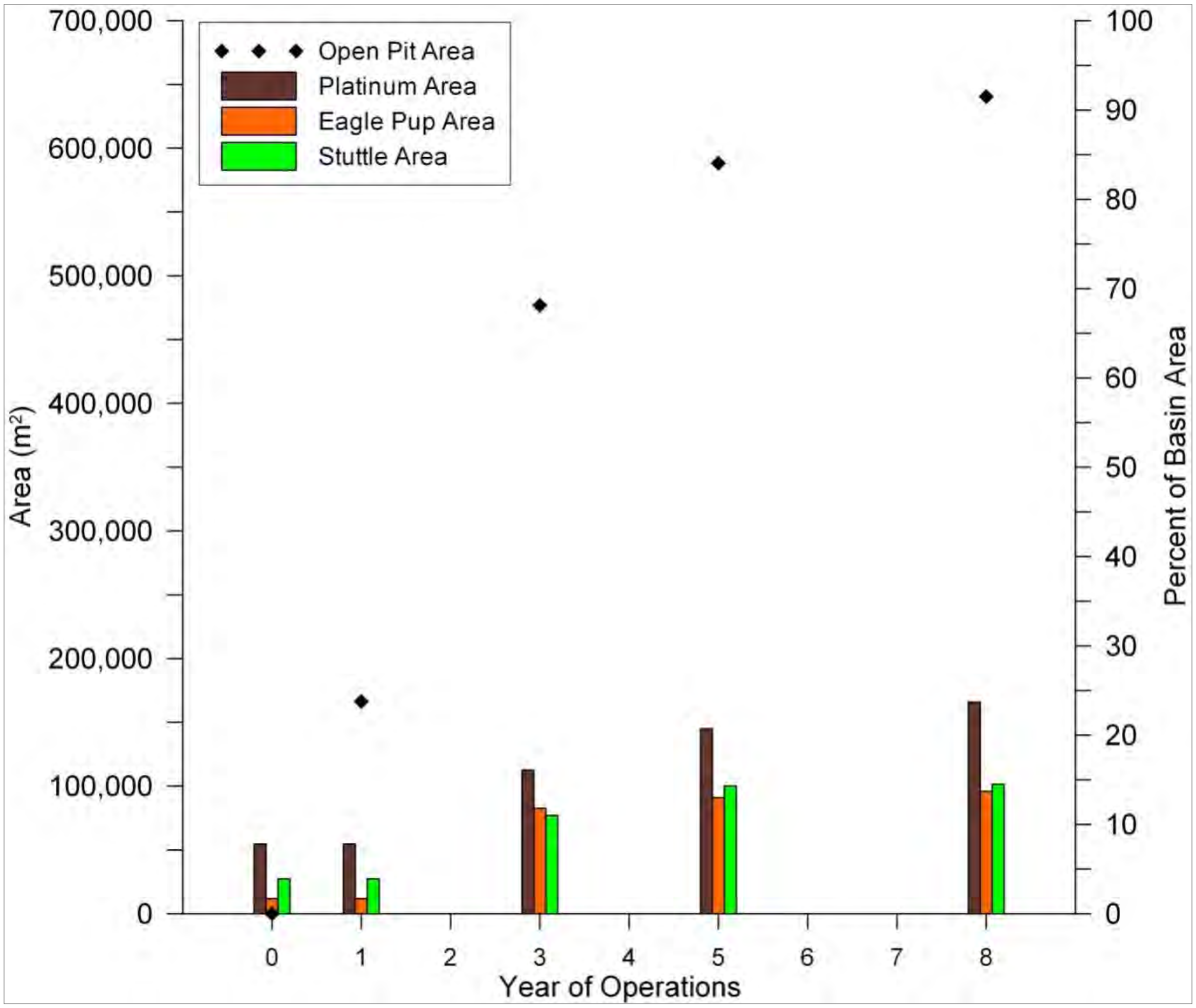
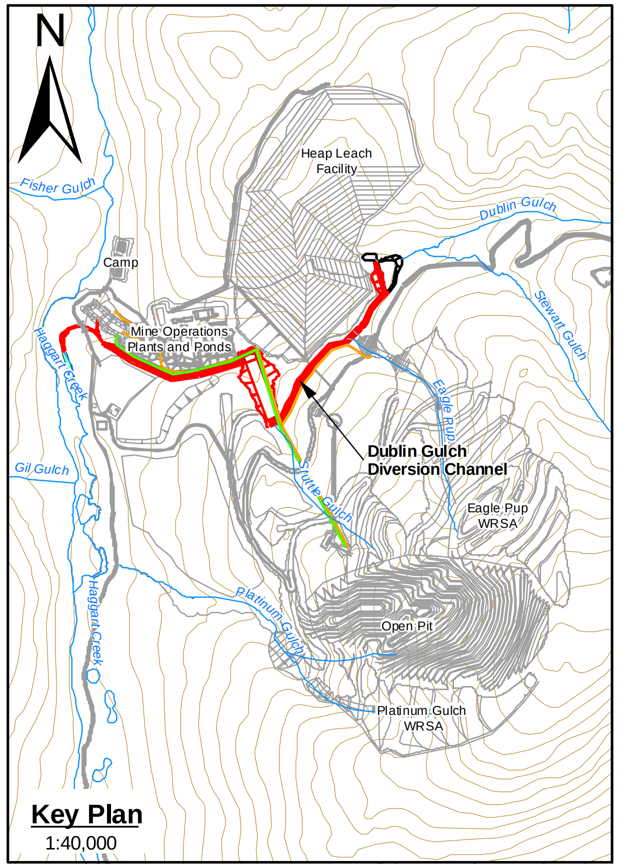
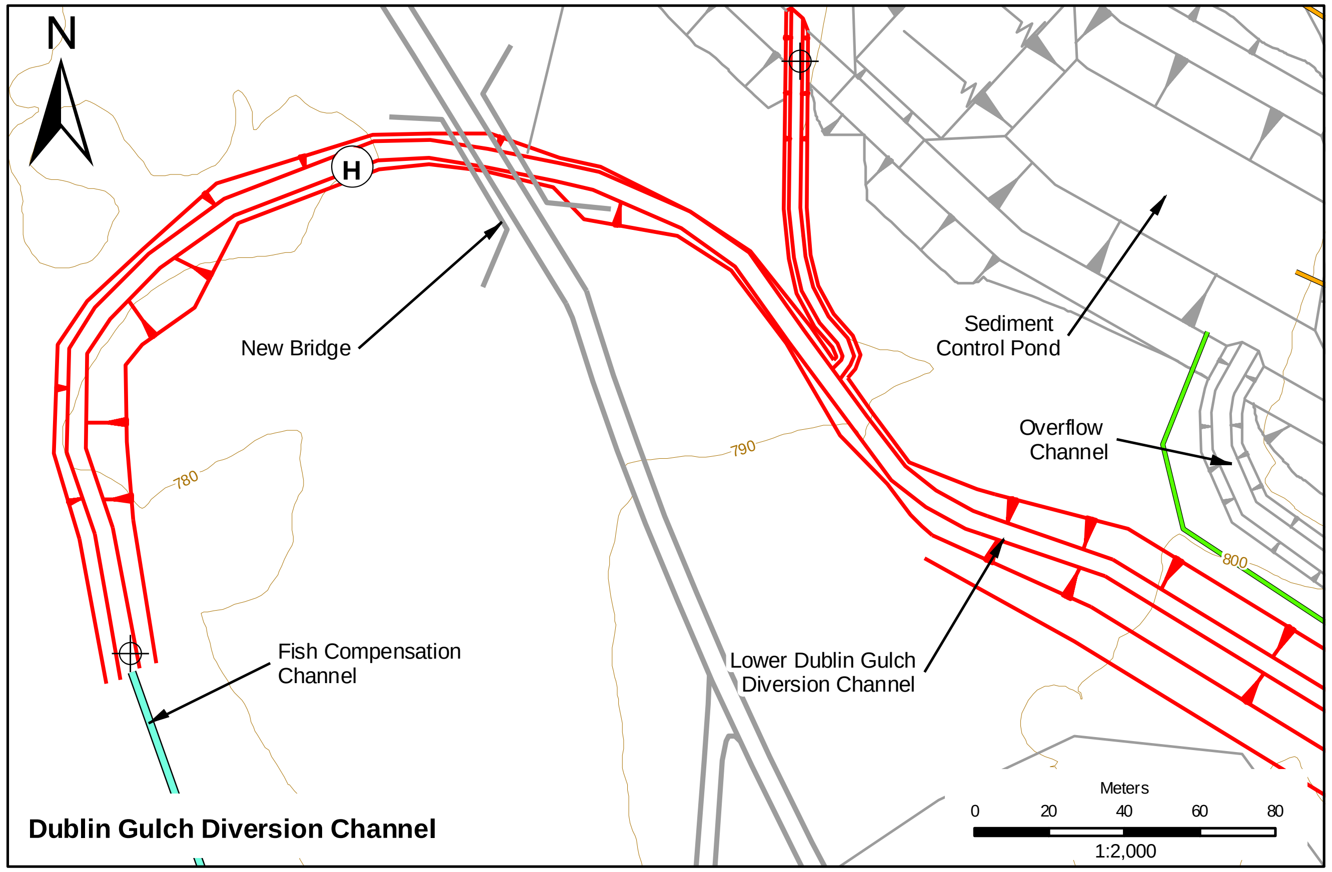
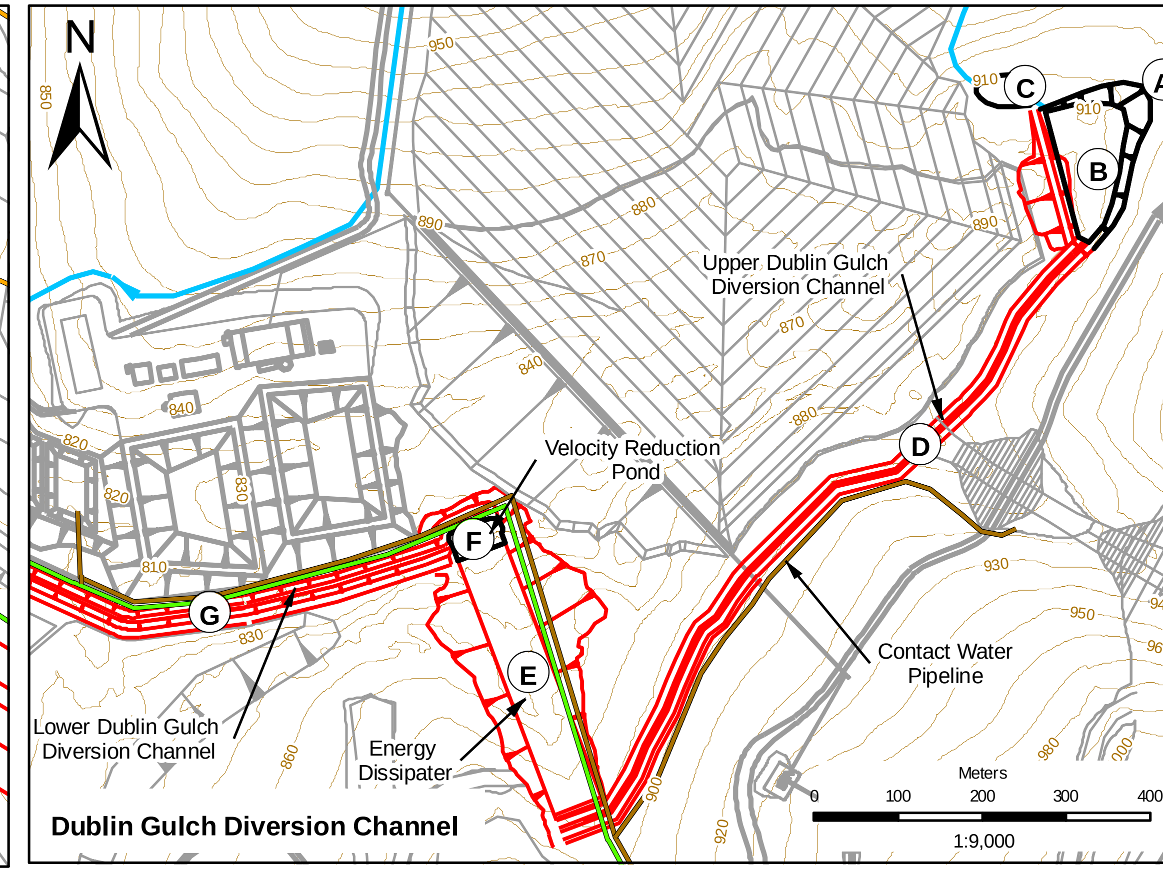
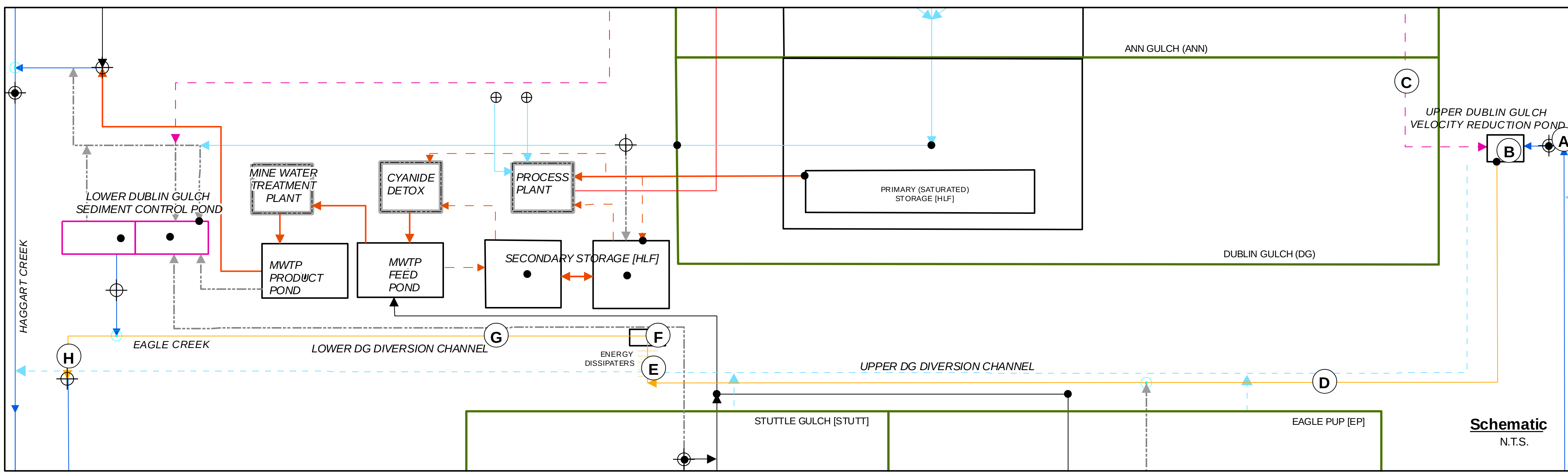
Figure 3.2-1: Anticipated Growth of the Open Pit during Operation











Legend

- Discharge to Channel
- Withdrawal from Channel
- Model Node
- Groundwater Well
- Environmental Monitoring Location
- Optional Routing
- Mine facility
- Diversion Channel (DC)
- Diverted Runoff (DRO)
- Non-Contact Surface Water (SW)
- Regional Groundwater

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WATER MANAGEMENT PLAN SCHEMATIC
DUBLIN GULCH DIVERSION CHANNEL - OPERATIONAL CONDITIONS

EAGLE GOLD PROPERTY
YUKON TERRITORY

PROJECTION	DRAWN BY
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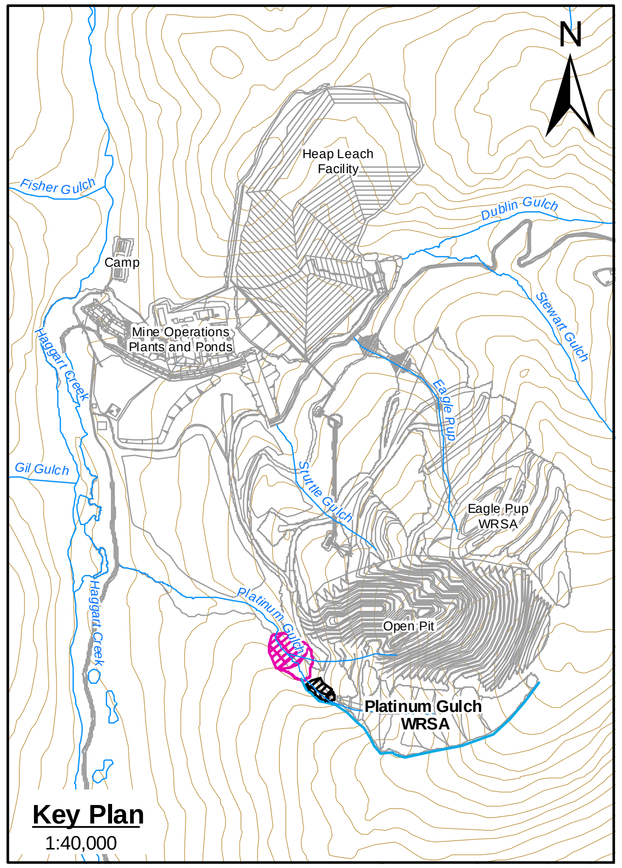
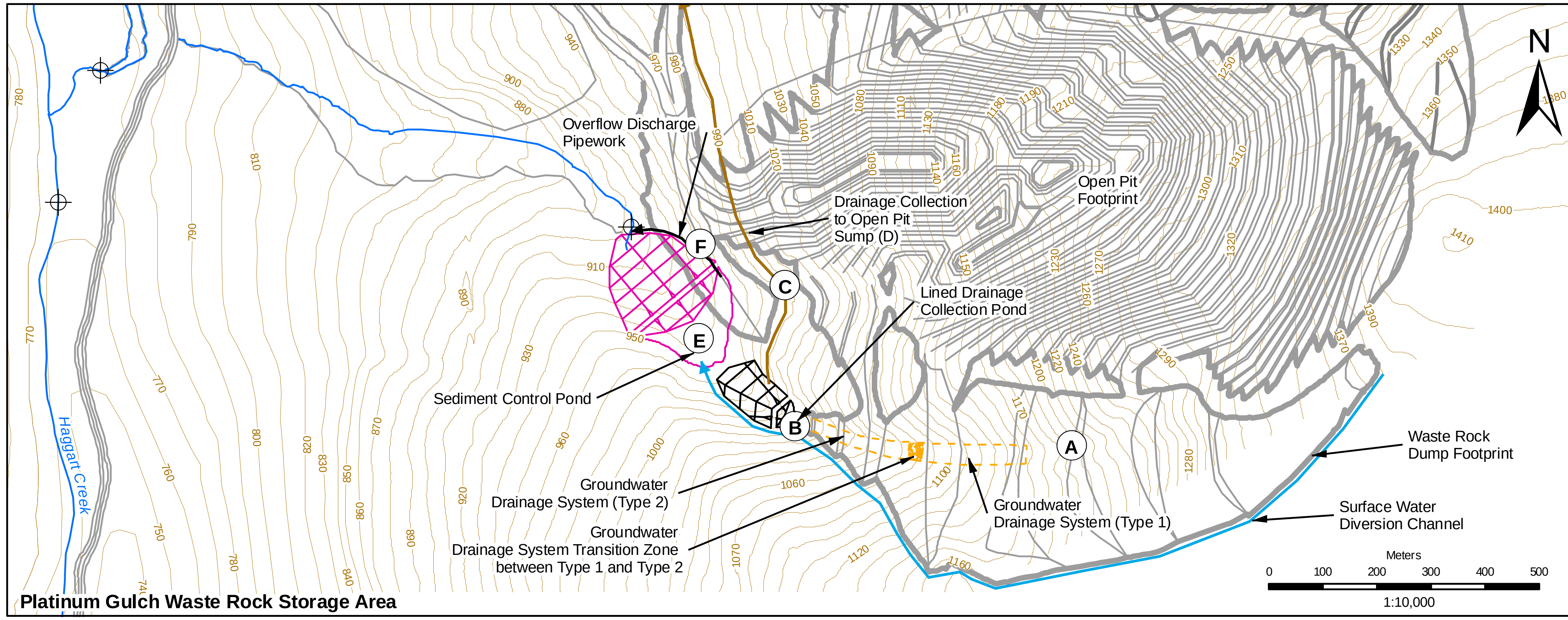
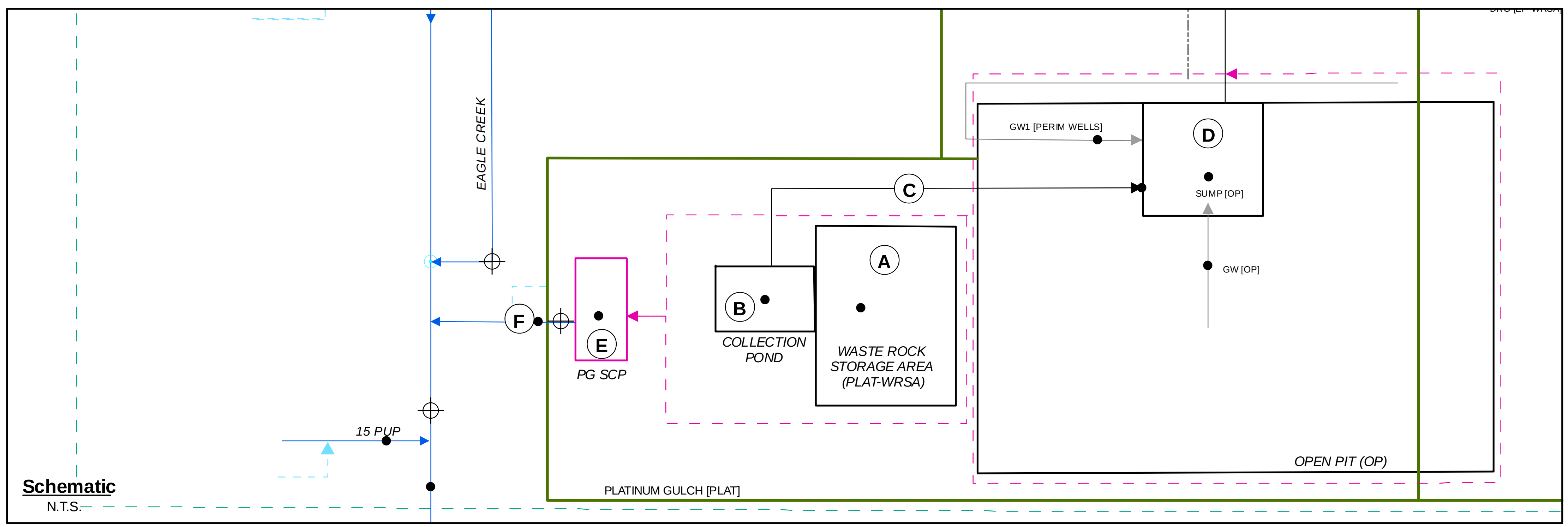
DATE	FIGURE NO.
30-November-2010	3.1-1







Legend

- Discharge to Channel
- Withdrawal from Channel
- Model Node
- Groundwater Well
- Environmental Monitoring Site
- Drainage Basin
- Mine Facility
- Sediment Control Pond
- Contact Surface Water
- Contact Groundwater
- Diverted Runoff (DRO)
- Non -Contact Surface Water (SW)
- Non-Contact Captured Groundwater (GW)
- Regional Groundwater

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WATER MANAGEMENT SCHEMATIC PLAN
PLATINUM GULCH WASTE ROCK STORAGE AREA - OPERATIONAL CONDITIONS

EAGLE GOLD PROJECT
YUKON TERRITORY

PROJECTION UTM 8	DRAWN BY TG
DATUM NAD 83	CHECKED BY SW
DATE 13-Sept-10	FIGURE NO. 3.3-1

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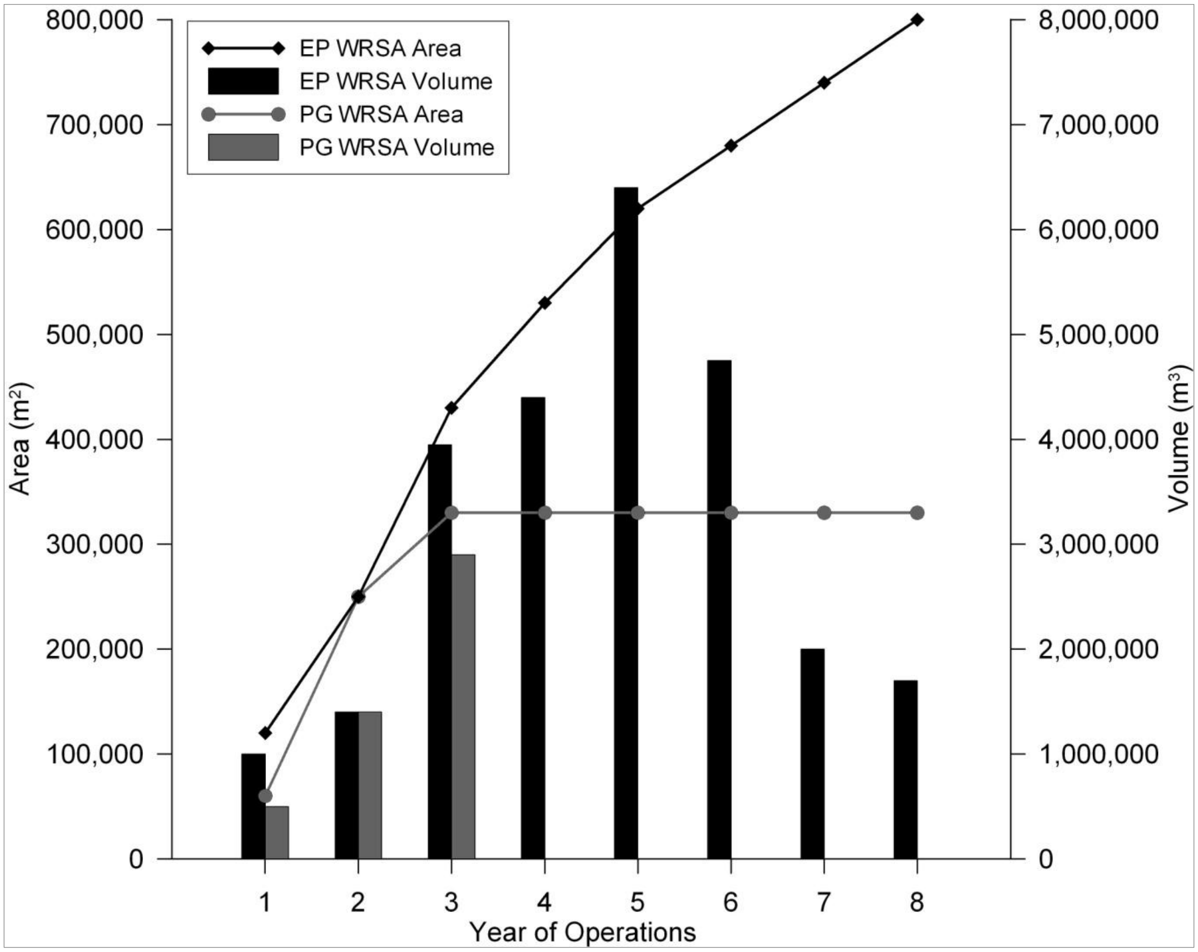
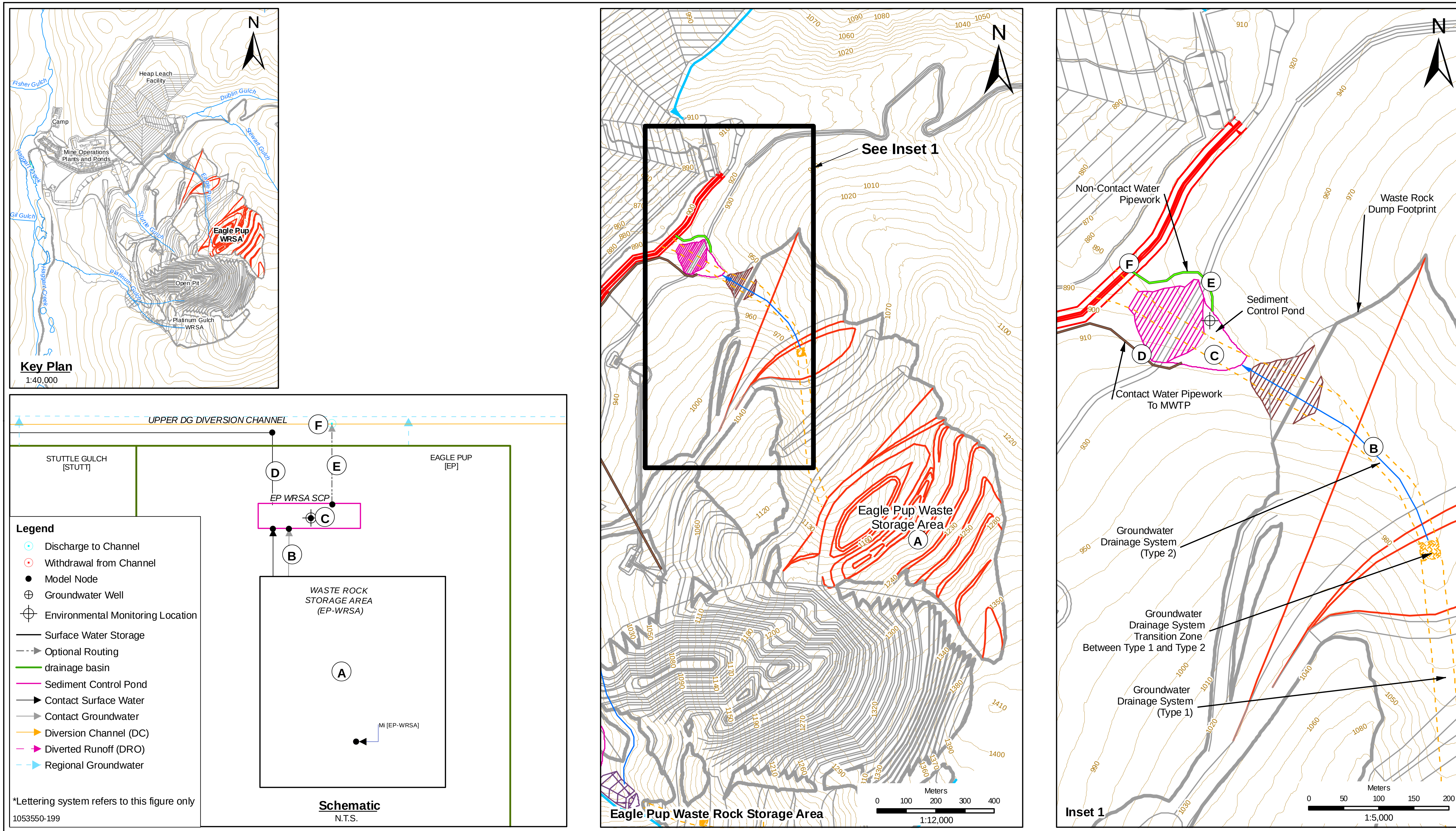
Figure 3.3-2: Anticipated Growth of the Waste Rock Storage Areas during Operation





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WATER MANAGEMENT PLAN SCHEMATIC
EAGLE PUP WASTE ROCK STORAGE AREA - OPERATIONAL CONDITIONS

EAGLE GOLD PROJECT
YUKON TERRITORY

PROJECTION	DRAWN BY
UTM 8	TG
DATUM	CHECKED BY
NAD 83	SW
DATE	FIGURE NO.
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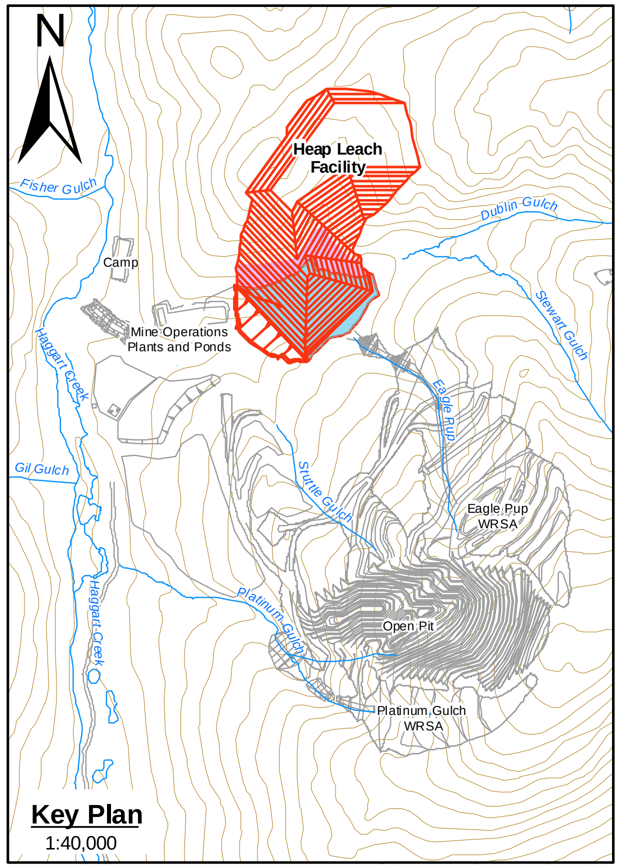

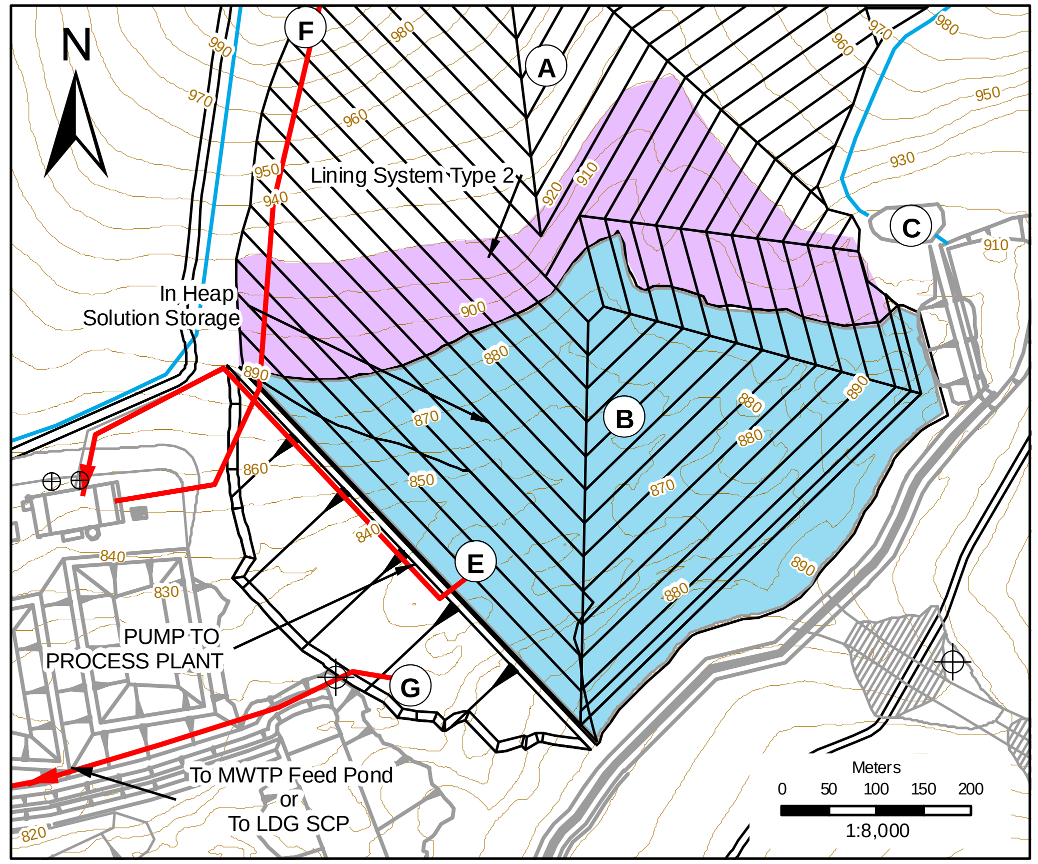

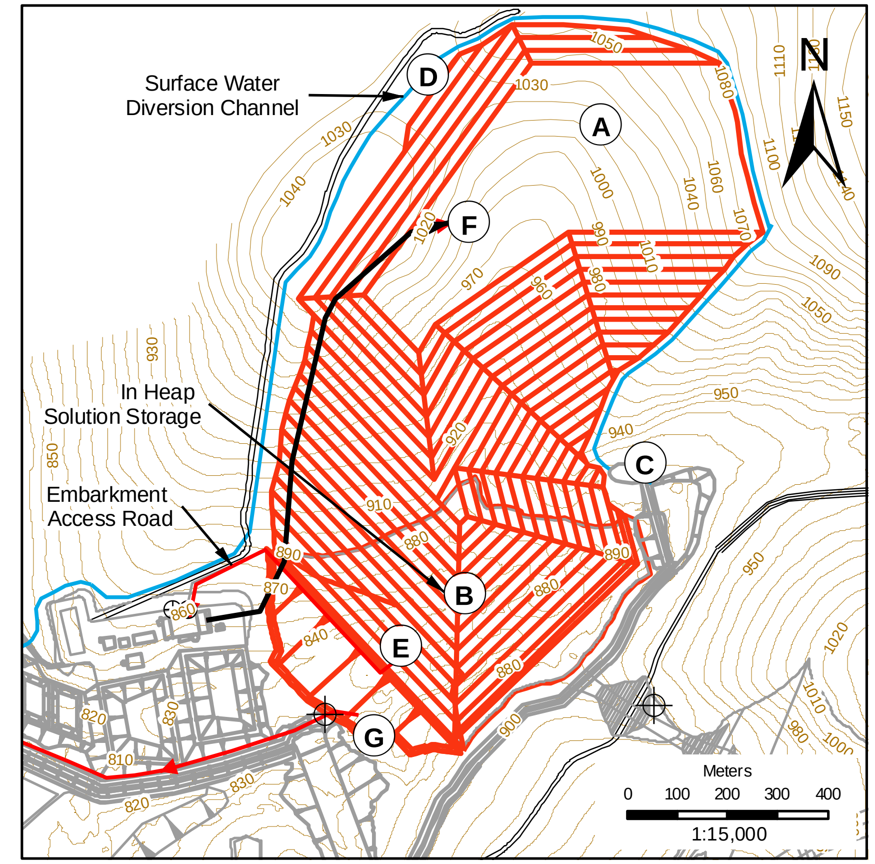

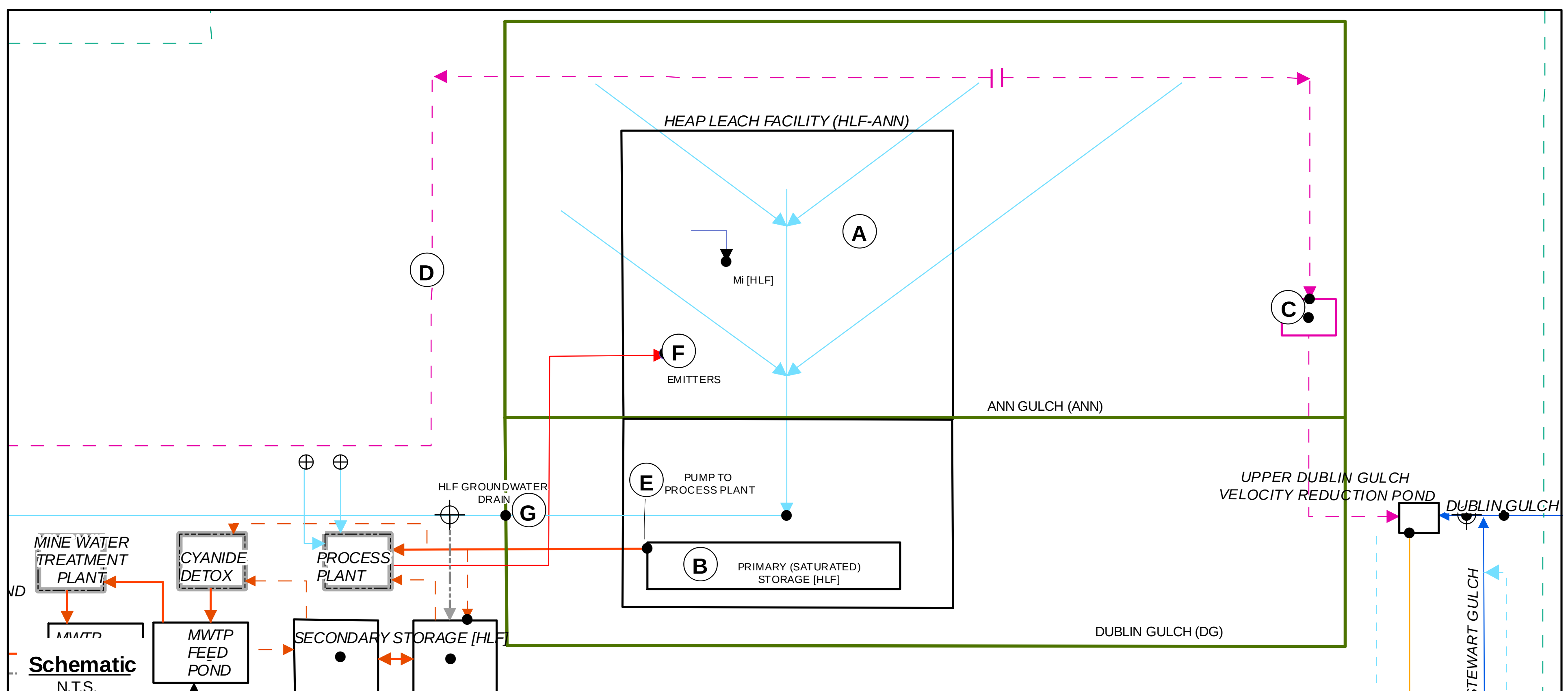

Legend

- Discharge to Channel
- Withdrawal from Channel
- Model Node
- Groundwater Well
- Environmental Monitoring Location
- Drainage Basin
- Surface Water Storage
- Plant
- Mine Facility
- Connection
- Optional Routing
- Diversion Channel (DC)
- Optimal Connection
- Diverted Runoff (DRO)
- Non -Contact Surface Water (SW)
- Non-Contact Captured Groundwater (GW)
- Regional Groundwater
- Initial Moisture Content (Mi)
- Irrigation Water

*Lettering system refers to this figure only

1053550-204

Data Sources: Government of Canada, Victoria Gold Corp.

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Victoria GOLD CORP

WATER MANAGEMENT PLAN SCHEMATIC
HEAP LEACH FACILITY - OPERATIONAL CONDITIONS
EAGLE GOLD PROPERTY
YUKON TERRITORY

PROJECTION	DRAWN BY
UTM 8	TG
DATUM	CHECKED BY
NAD 83	SW
DATE	FIGURE NO.
30-November-2010	3.5-1

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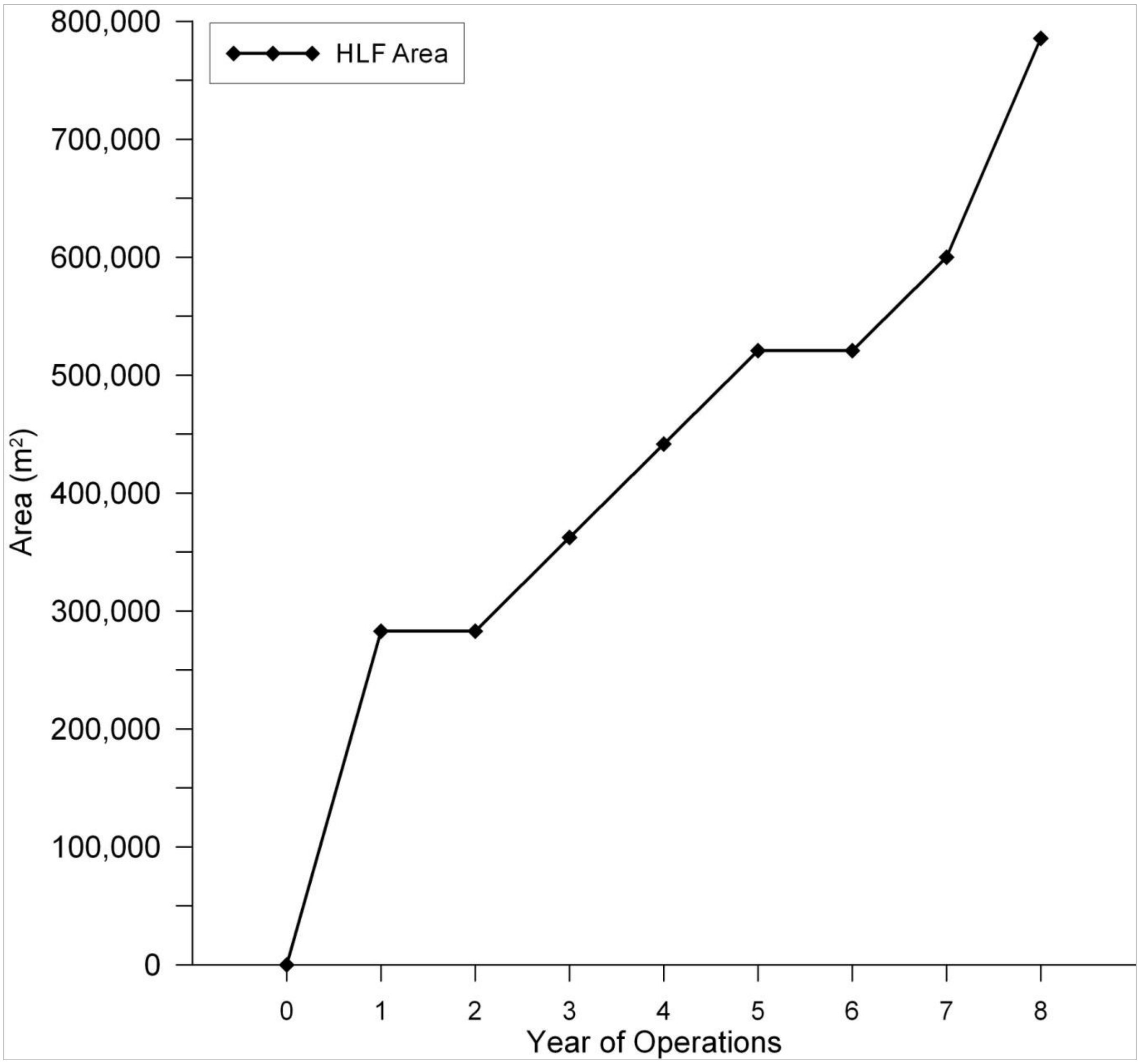
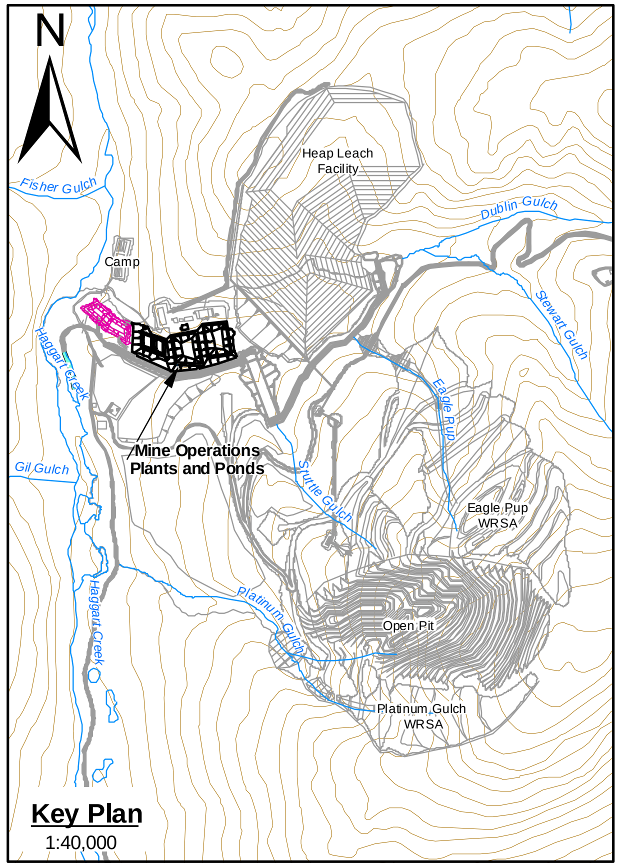
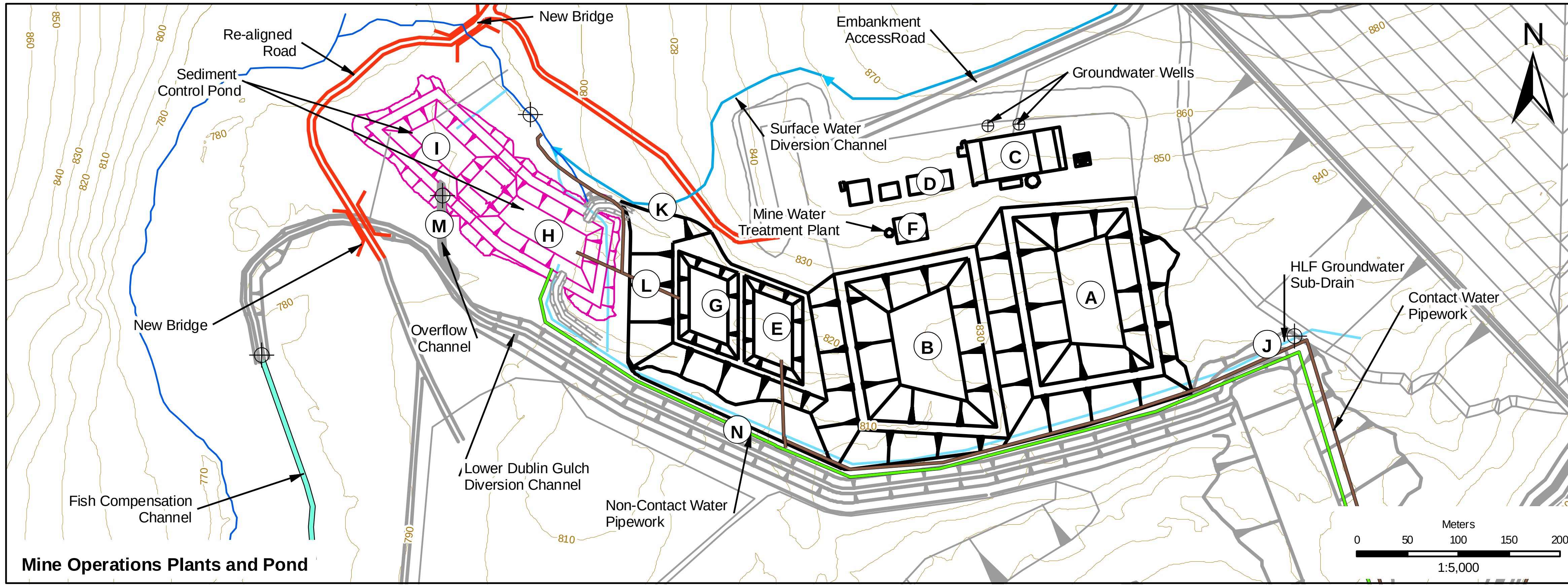
Figure 3.5-2: Anticipated Growth of Heap Leach Facility during Operation





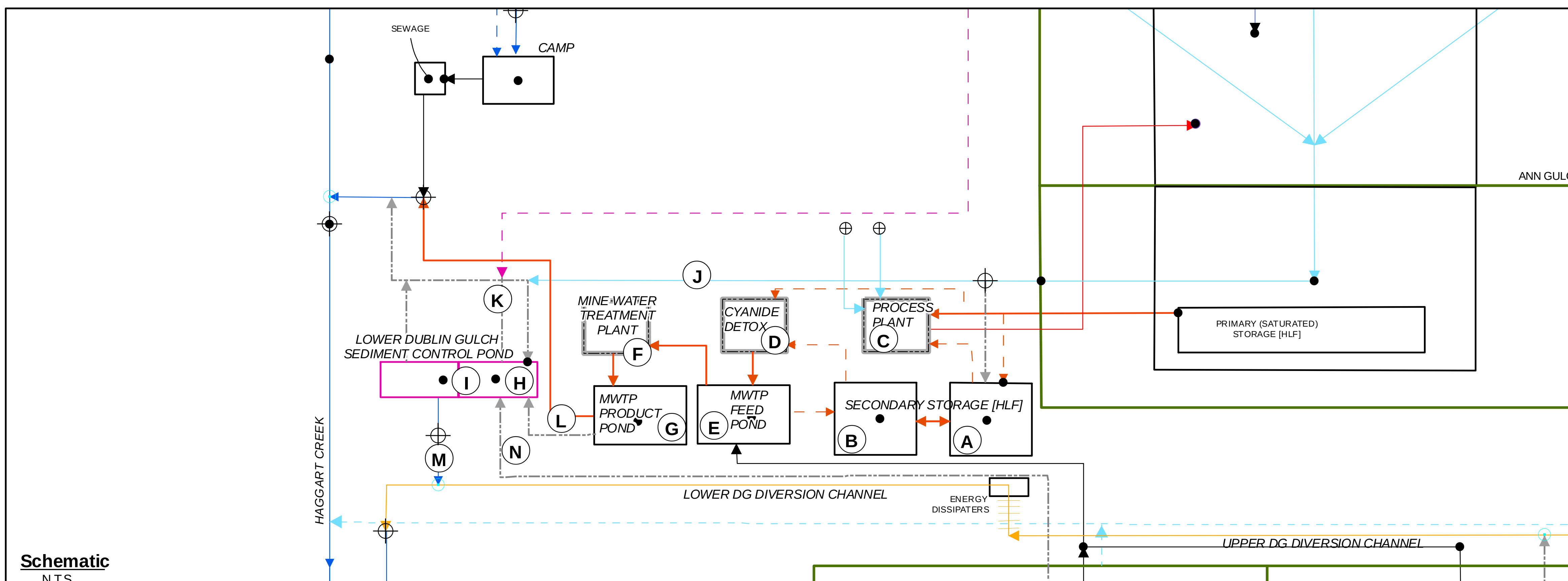


Legend

- Discharge to Channel
- Withdrawal from Channel
- Model Node
- Groundwater Well
- Environmental Monitoring Location
- Plant
- Mine Facility
- Sediment Control Pond
- Connection
- Optional Routing
- Optimal Connection
- Contact Surface Water
- Diverted Runoff (DRO)
- Non -Contact Surface Water (SW)
- Non-Contact Captured Groundwater (GW)
- Regional Groundwater
- Irrigation Water

*Lettering system refers to this figure only

1053550-201



Data Sources: Government of Canada, Victoria Gold Corp.

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Victoria GOLD CORP

WATER MANAGEMENT PLAN SCHEMATIC
MINE OPERATIONS PLANTS AND PONDS - OPERATIONAL CONDITIONS
EAGLE GOLD PROPERTY
YUKON TERRITORY

PROJECTION: UTM 8	DRAWN BY: TG
DATUM: NAD 83	CHECKED BY: SW
DATE: 30-November-2010	FIGURE NO. 3.6-1

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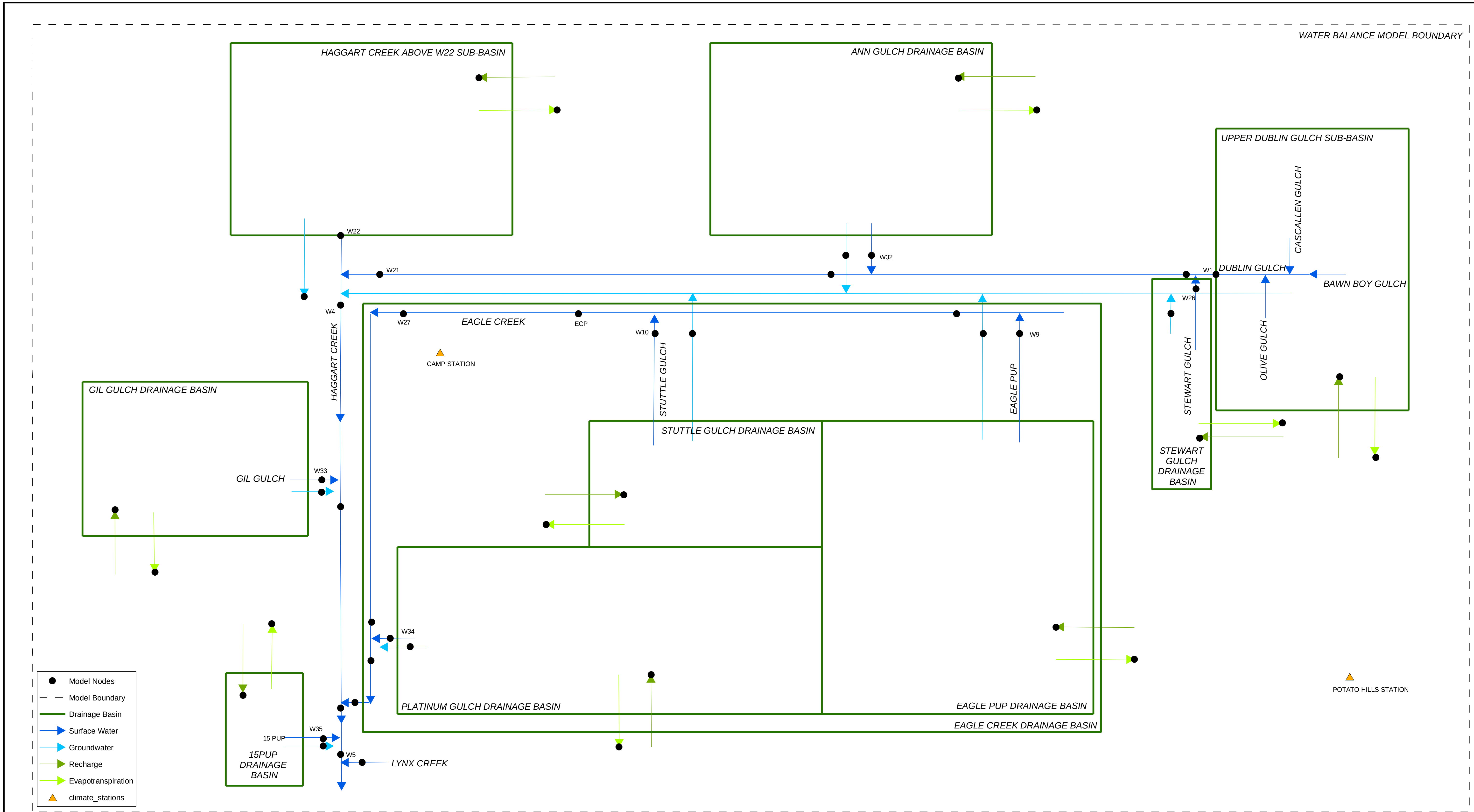

Source: 1053550-142

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Victoria GOLD CORP

WATER MANAGEMENT SCHEMATIC - SURFACE WATER MODEL BASELINE CONDITIONS

EAGLE GOLD PROJECT
YUKON TERRITORY

PROJECTION	DRAWN BY
N/A	TG
DATUM	CHECKED BY
N/A	SW
DATE	FIGURE NO.
13-Sept-10	4.2-1

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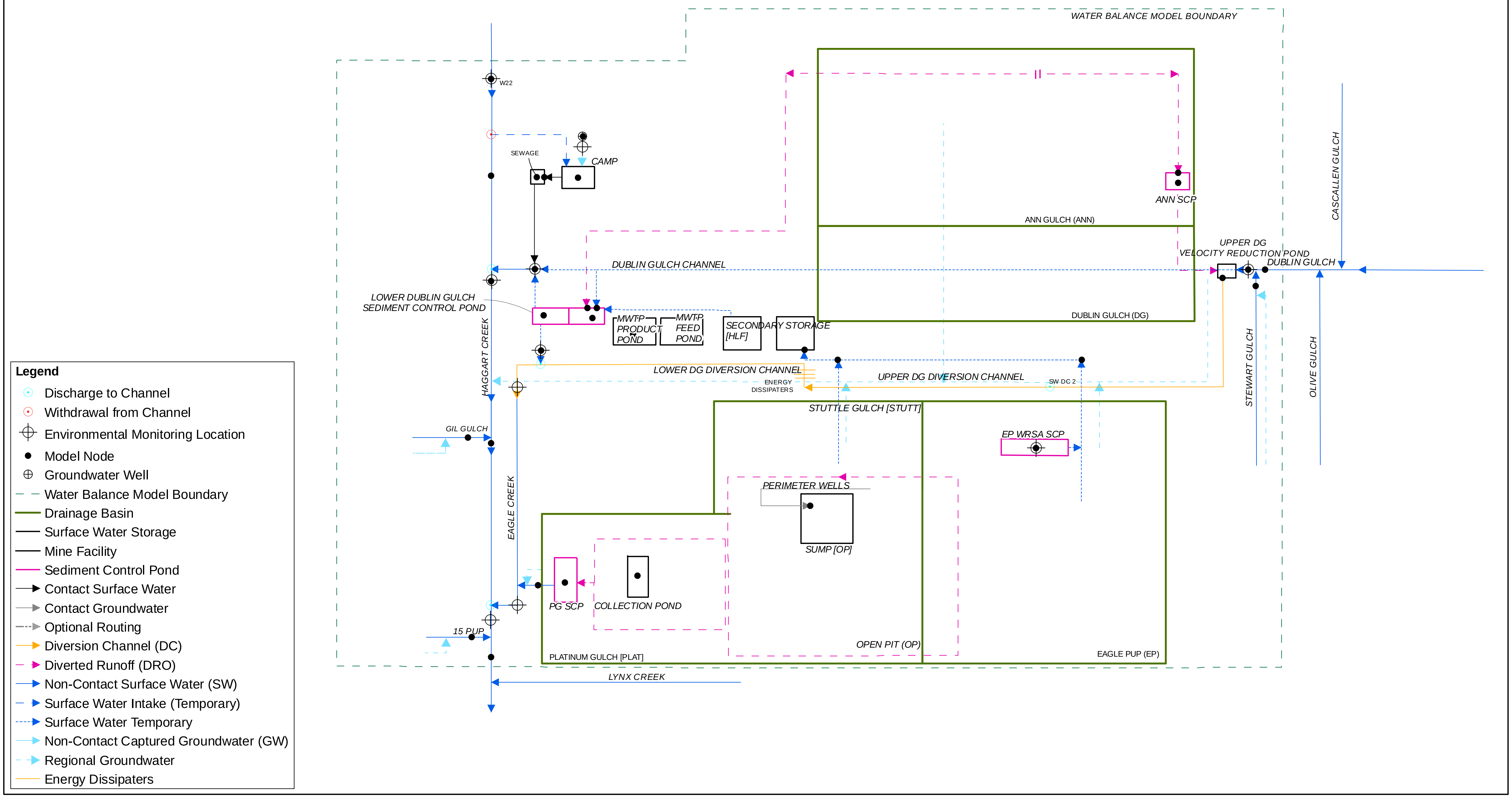

1053550-197

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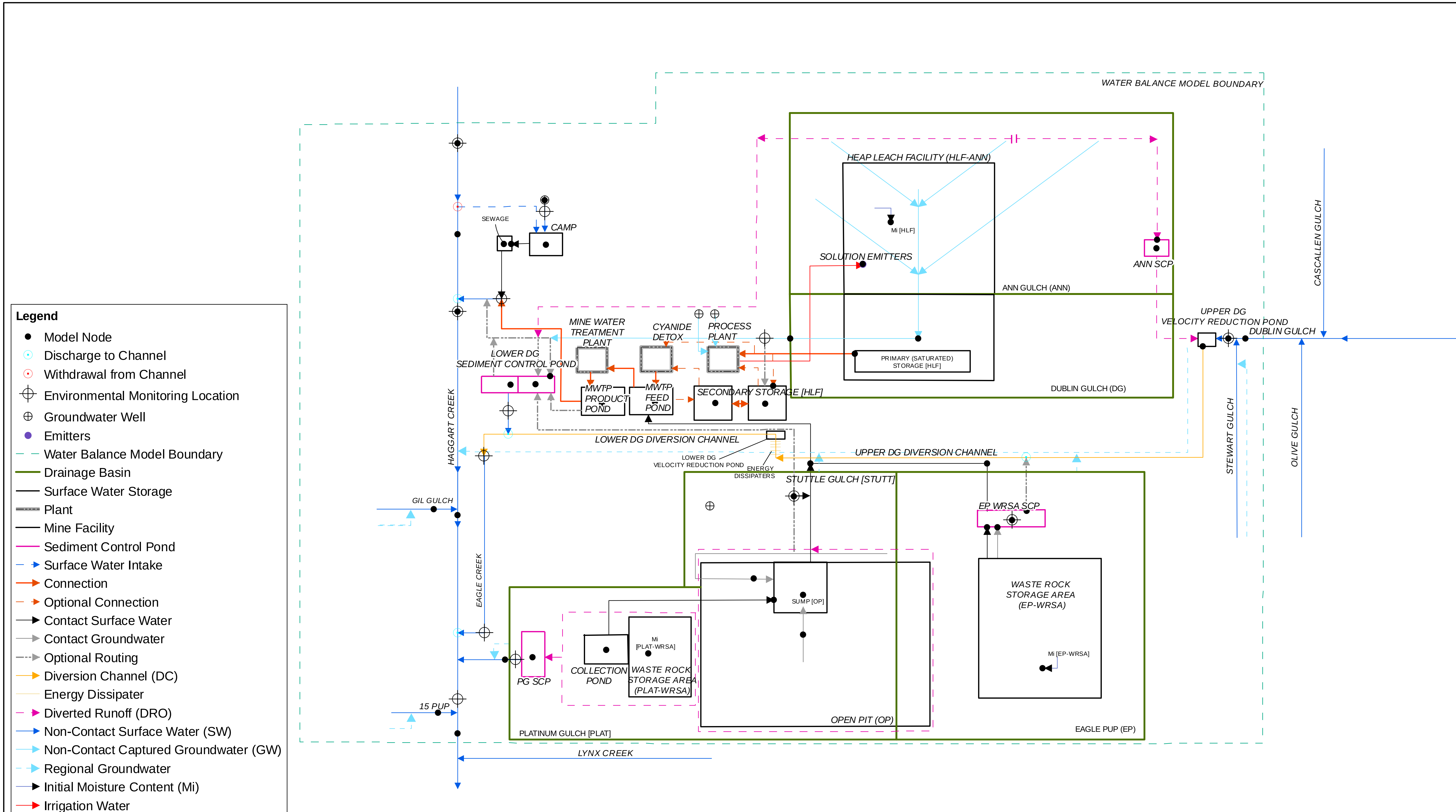
Victoria GOLD CORP

WATER MANAGEMENT SCHEMATIC - SURFACE WATER MODEL CONSTRUCTION

EAGLE GOLD PROPERTY
YUKON TERRITORY

PROJECTION	DRAWN BY
N/A	TG/JB
DATUM	CHECKED BY
N/A	LS
DATE	FIGURE NO.
29-October-2010	4.2-2



1053550-198c

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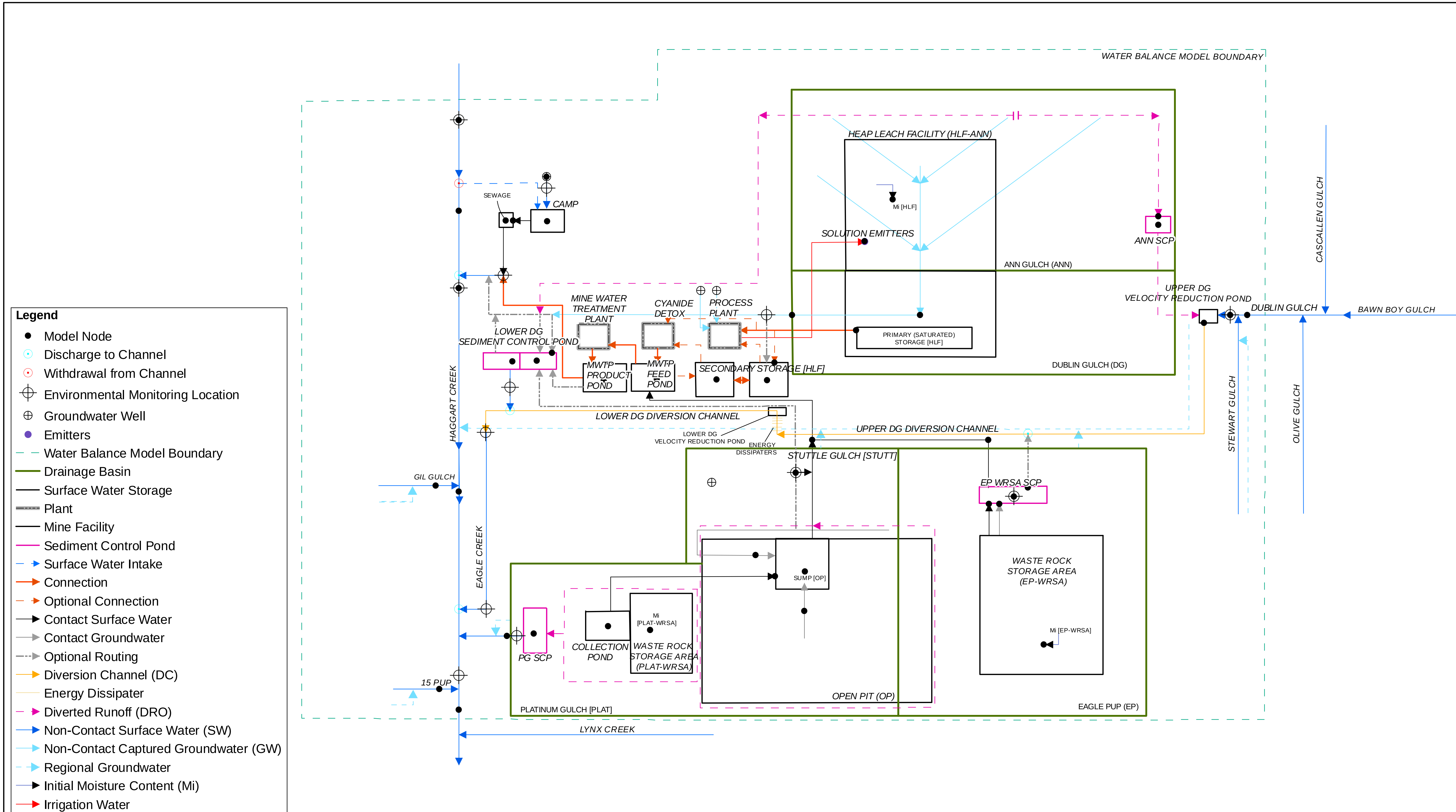
Victoria GOLD CORP

WATER MANAGEMENT SCHEMATIC - SURFACE WATER MODEL OPERATION

EAGLE GOLD PROPERTY
YUKON TERRITORY

PROJECTION N/A	DRAWN BY JB
DATUM N/A	CHECKED BY SW
DATE 30-November-2010	FIGURE NO. 4.2-3



Source:**1053550-207**

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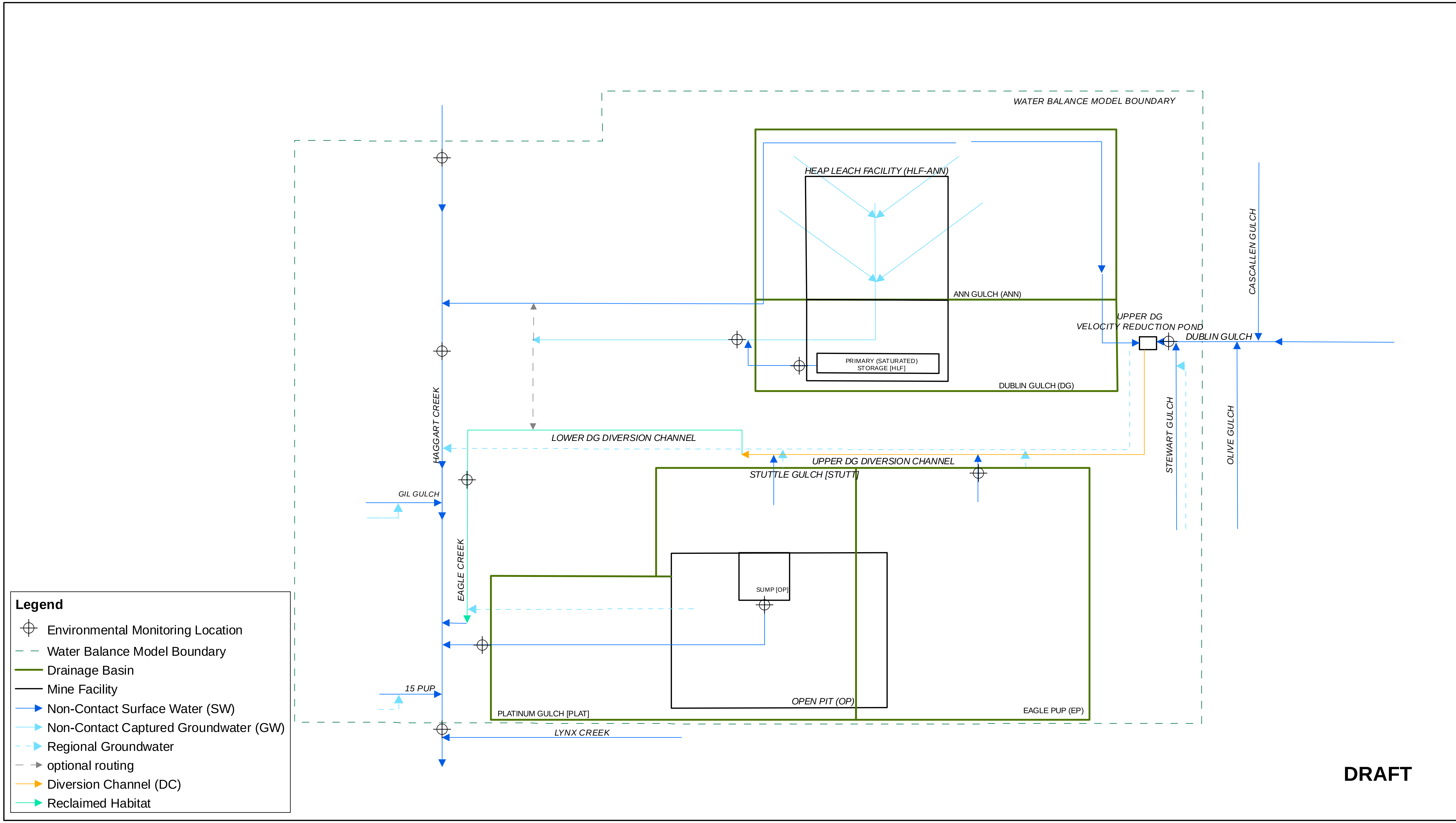
Victoria GOLD CORP

WATER MANAGEMENT SCHEMATIC - SURFACE WATER MODEL
CLOSURE AND RECLAMATION
EAGLE GOLD PROPERTY
YUKON TERRITORY

PROJECTION	DRAWN BY
N/A	TG
DATUM	CHECKED BY
N/A	SW
DATE	FIGURE NO.
30-November-2010	4.2-4



Source:1053550-206

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WATER MANAGEMENT SCHEMATIC - SURFACE WATER MODEL
POST-CLOSURE MONITORING

EAGLE GOLD PROPERTY
YUKON TERRITORY

PROJECTION	N/A	DRAWN BY	TG
DATUM	N/A	CHECKED BY	-
DATE	9-November-2010	FIGURE NO.	4.2-5

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Figure 4.4-1: Dublin Gulch Basin Streamflows August 2007 to October 2009

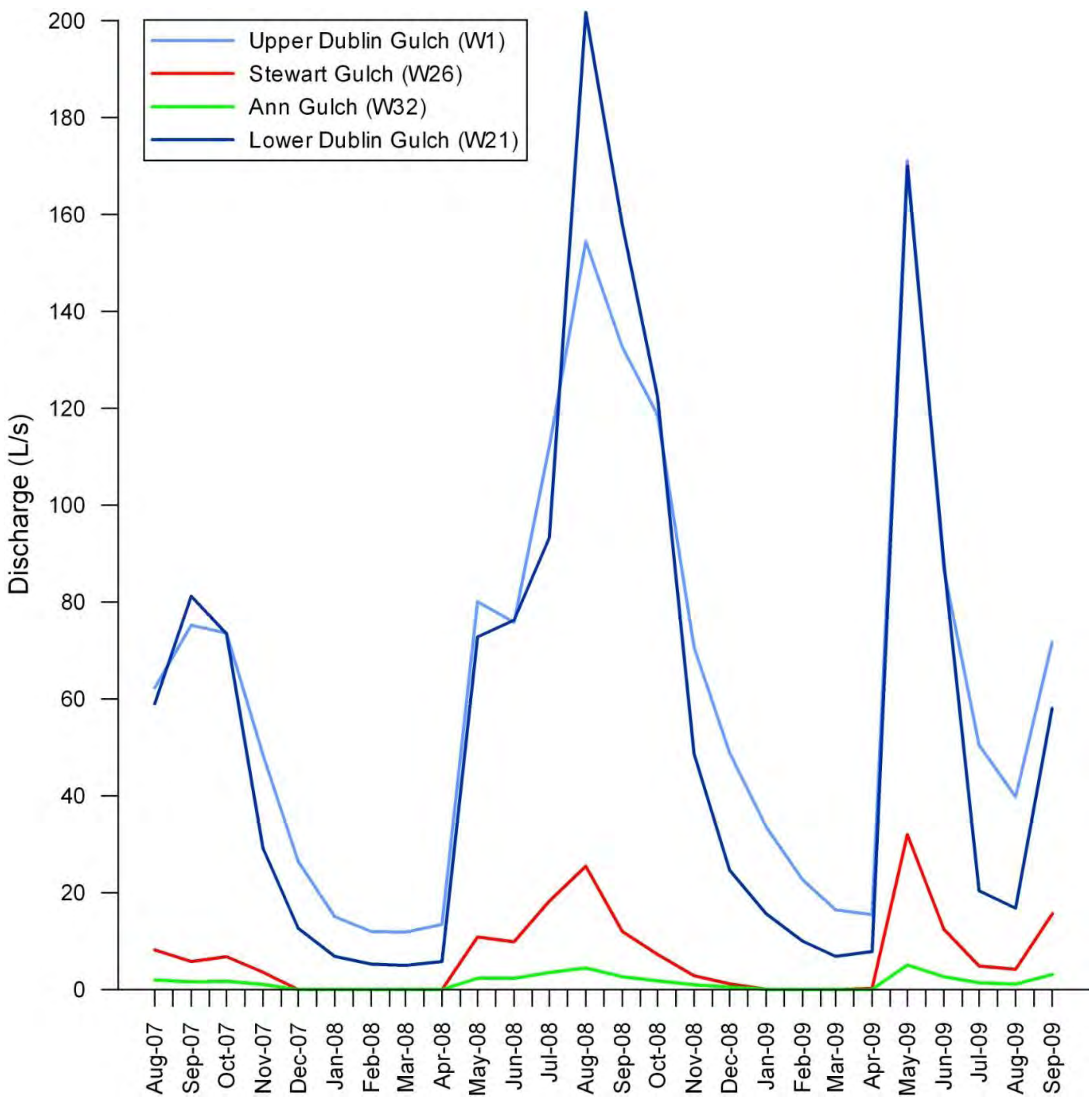


Figure 4.4-2: Eagle Creek Basin Streamflows August 2007 to October 2009

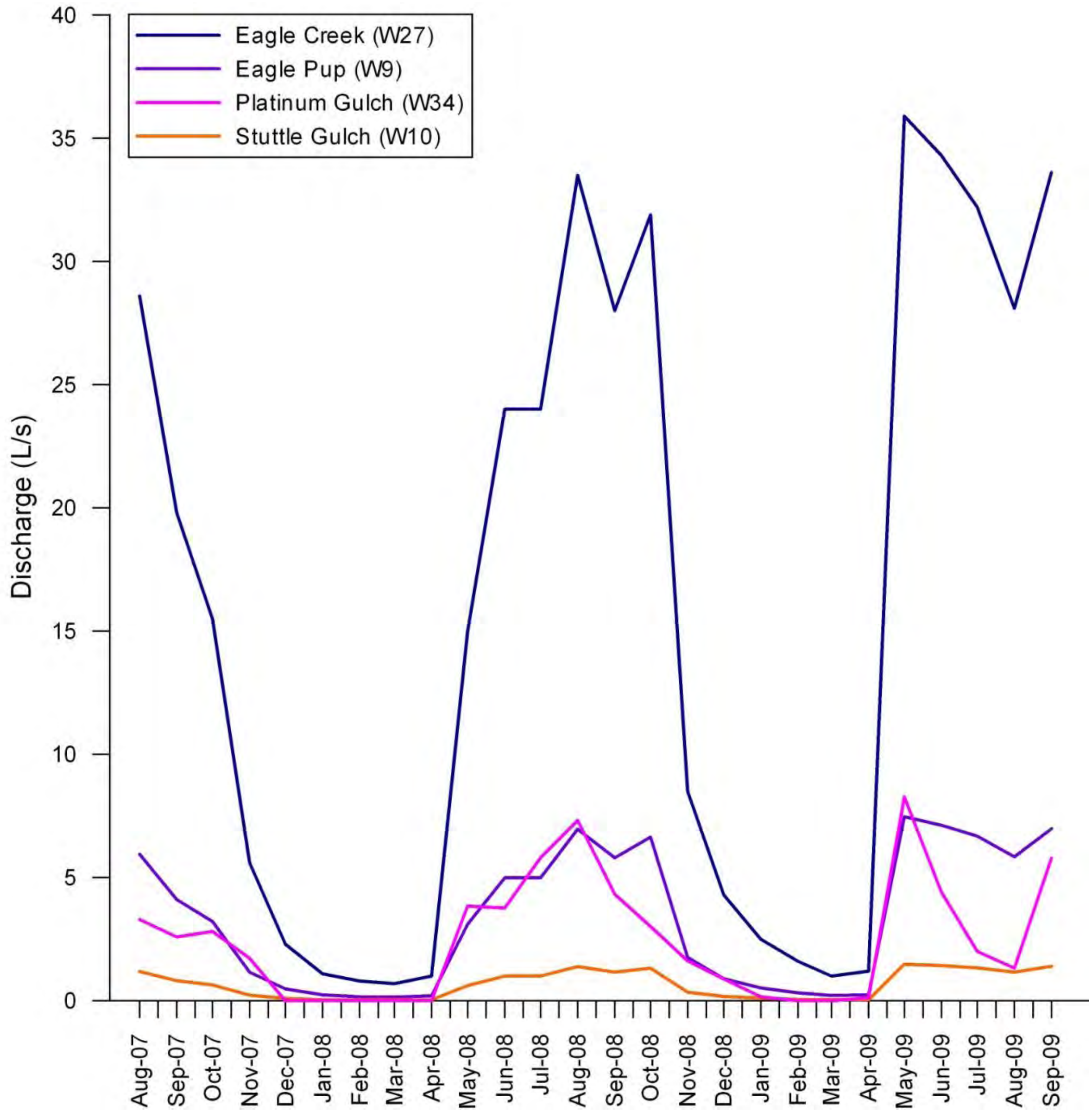


Figure 4.4-3: Haggart Creek Basin Streamflows August 2007 to October 2009

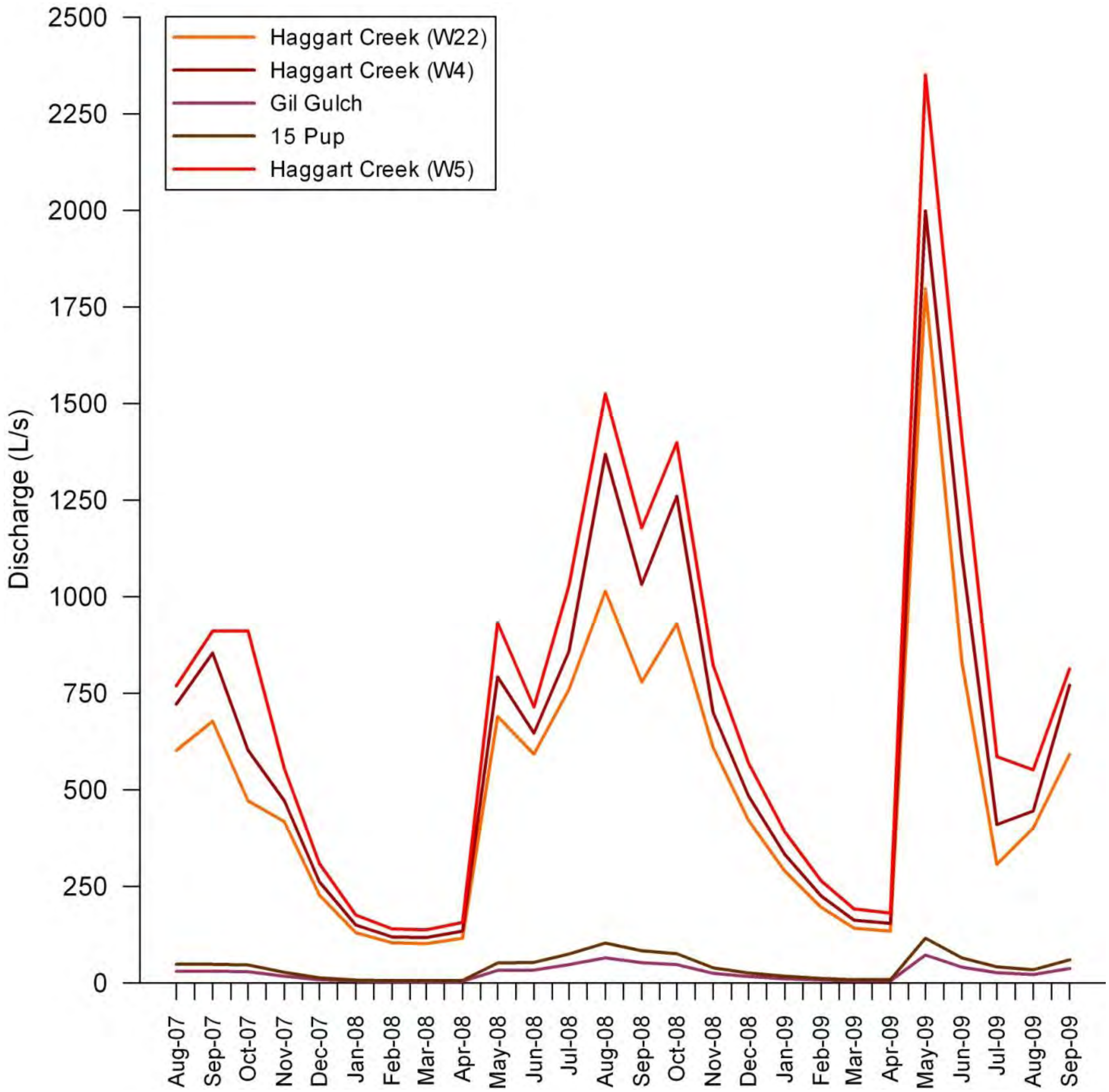


Figure 7.10-1 - WATER BALANCE FLOW SHEET FOR OPERATIONS
Operation: Final Year October - September (m^3/year)
Hydroclimatic Scenario: 1

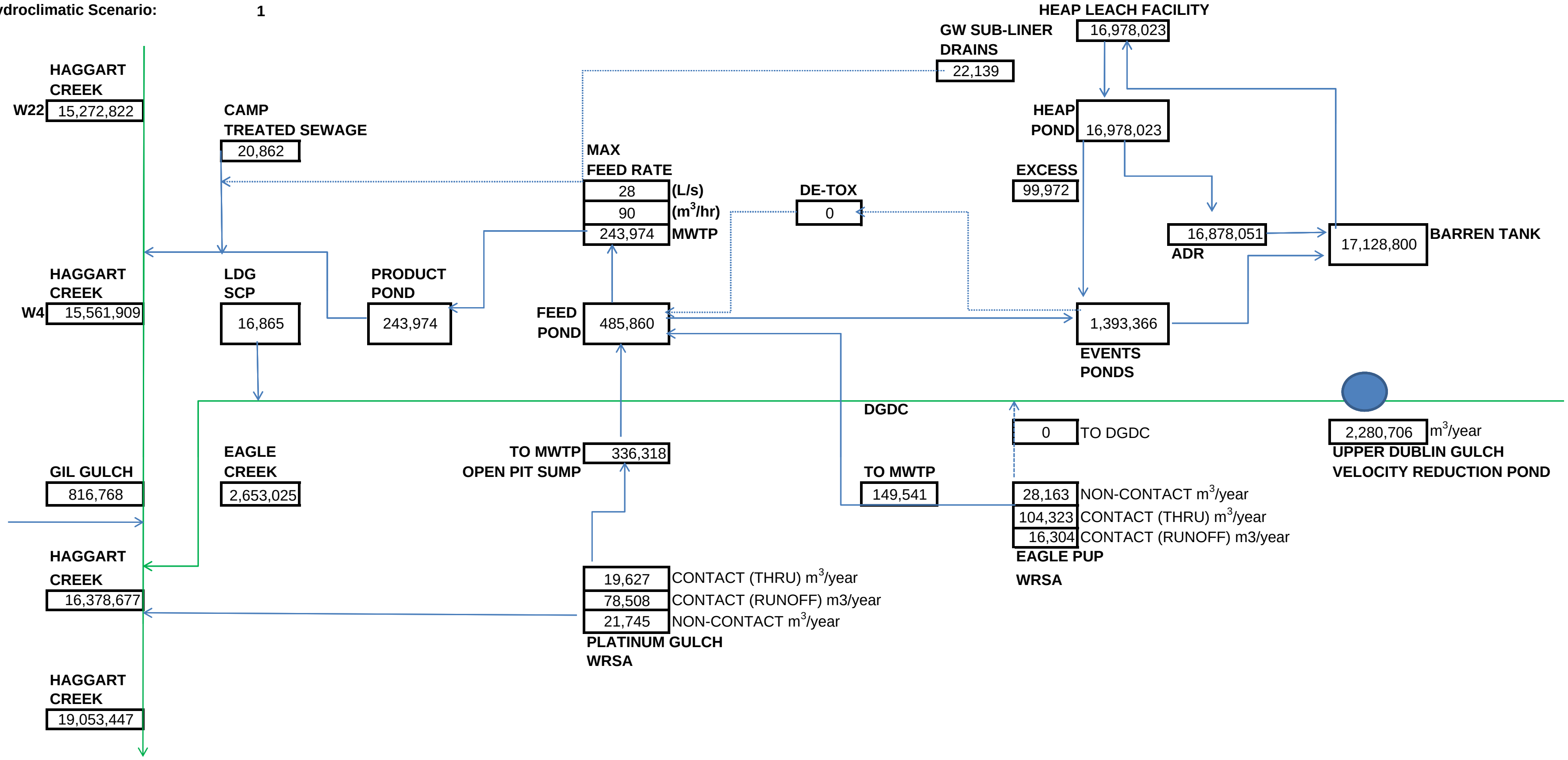
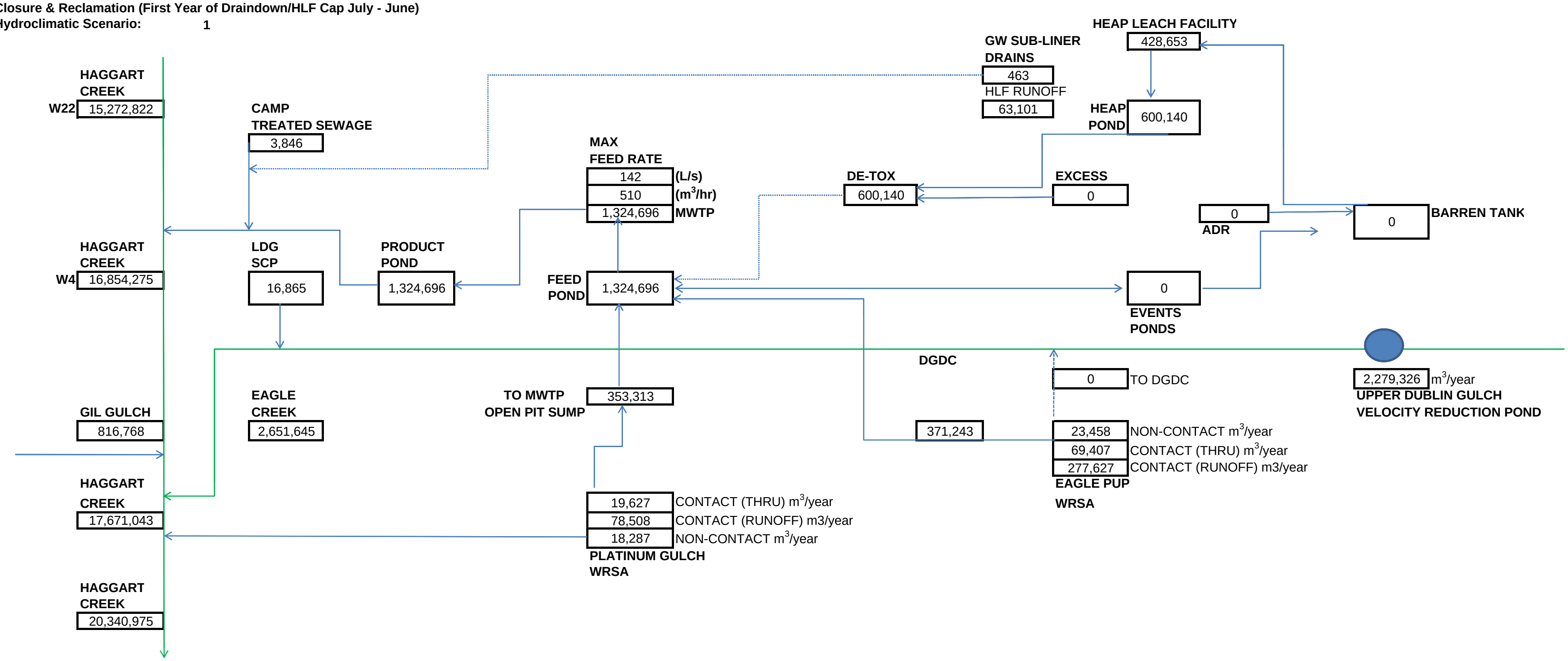


Figure 8.10-1 - WATER MANAGEMENT FLOW SHEET FOR CLOSURE AND RECLAMATION
Closure & Reclamation (First Year of Draindown/HLF Cap July - June)
Hydroclimatic Scenario: 1



APPENDIX A

Summary of Activities by Facility

Table A-1: Summary of Facility Construction Activities for Water Management Plan

Facility	Structure/Feature	Construction Conditions/Process	Begin Date	End Date	Comments
Eagle Pup Waste Rock Storage Area					
	Sediment Control Pond	Construct before freshet	Apr-13	Apr-13	Routed to MWTP feed pond at freshet
	Rock Drain and Starter Embankment	Construct once EP SCP is complete		Jun-13	
Platinum Gulch Waste Rock Storage Area					
	Sediment Control Pond	Construct and discharge to Platinum Gulch when completed	May-12	May-12	Post freshet
	Starter Embankment and Rock Drain	Construct once PG SCP is complete		May-13	Post freshet
	Drainage Ditch to Open Pit	Construct and then convey water to the Open Pit sump		Jun-13	
Open Pit					
	Perimeter Wells	Drill, install and develop	May-12	Jun-12	Wells operational by July 2012
	Horizontal Drains	Drill and install	Jun-12	Oct-12	Drains operational by October 2012
	Sump Pond	Develop Sump Pond		May-13	Post freshet
	Groundwater Wells	Drill and install as needed for use for fresh water make-up for crushing	Jun-13	Jul-13	May be able to use water from perimeter wells or drains depending on water quality
Heap Leach Facility					
	Ann Gulch East Diversion Ditch	Construct post freshet	May-12	Jun-12	
	Ann Gulch East Sediment Control Pond	Construct post freshet	May-12	Jun-12	
	Ann Gulch West Diversion Ditch	Construct post freshet and then connect to the LDG SCP	May-12	Jun-12	
	Ann Gulch East Diversion Ditch	Construct and then connect to the Upper DG velocity reduction pond	May-12	Jun-12	
	Groundwater Drainage System		Apr-13	Sep-13	
	LDRS		May-13	Oct-13	

Facility	Structure/Feature	Construction Conditions/Process	Begin Date	End Date	Comments
Lower Dublin Gulch Infrastructure					
	Sediment Control Ponds	Construct before freshet	Mar-12	Apr-12	
	MWTP Feed and Product Ponds	Construct	Aug-12	Oct-12	
	Secondary Heap Leach Storage Facility	Construct two-stage SCPs in the footprint of the EP, to be used initially while receiving flow from upper DG diversion channel (Year 1); reconfigure to EP once the diversion channel is complete	Apr-12	Sep-12	Begin late April
	Reconfigure Events Pond		Sep-12	Oct-12	
Dublin Gulch Diversion Channel					
	Upper Diversion Channel	Construct channel around HLF footprint – including upper velocity reduction pond and energy dissipater	Apr-12	May-12	Prior to freshet
	Upper Diversion Channel Routing	DG through upper diversion channel and into SHLLSF which will feed LDG SCP and to lower DG		May-12	At freshet
	Lower Dublin Gulch Diversion Channel	Construct channel – including lower velocity reduction ponds and Eagle Creek connector, while continuing to route through LDG SCP and into Lower DG	May-12	Jun-12	
	Eagle Gold Fish Enhancement Channel	Construct during first year	Jun-12	Oct-12	
	DG Diversion Channel Operation	Begin full DG diversion channel operation, using Eagle Creek connector and discharge into Eagle Creek (no more discharge to Dublin Gulch)	May-13		At freshet during second year; no more discharge to Dublin Gulch
Main Camp					
	Groundwater Production Well	Drill, install and develop	Feb-12	Mar-12	
	Sediment Control Features	Associated with construction/installation of main camp	Mar-12	Apr-12	As needed
	Sewage Treatment Facility	Discharge into Haggart Creek via Dublin Gulch channel when completed	Mar-12	Apr-12	

Table A-2: Summary of Facility Operation Activities for the Water Management Plan

Facility	Structure/Feature	Operational Conditions	Begin Date	End Date
Eagle Pup Waste Rock Storage Area				
	WRSA	Meteoric water input/outputs	Sep-13	
	EP Sediment Control Pond	Surface runoff from basin; routed to MTWP Feed Pond or DGDC if WQ crtiera are met	Sep-13	
Platinum Gulch Waste Rock Storage Area				
	WRSA	Meteoric water input/outputs	Sep-13	
	PG SCP	Water routed to Platinum Gulch if WQ criteria are met	Sep-13	
	PG to Open Pit Drainage Ditch	Water routed to Open Pit Sump from Collection Pond	Sep-13	
Open Pit				
	Pit Sump	Pit receives water from PG Collection Pond, and Perimeter wells	Sep-13	
	Crusher Pad	Make-up water supply from groundwater wells or Perimeter wells	Sep-13	Dec-20
	Perimeter Wells	Will be abandoned or destroyed as mine pit expands; Water to sump/Crusher	Sep-13	Dec-20
	Horizontal Drains	Will remain in place	Sep-13	
	Groundwater Wells	Will be abandoned when crushing has stopped		Dec-20
Heap Leach Facility				
	HLF Surface	Irrigated with solution from Process Plant	Sep-13	Dec-21
	HLF Primary Storage	In-heap solution storage; recycled to Process Plant; optional routing to Cyanide detox facility and EP	Sep-13	
	HLF Groundwater Drainage System	Groundwater drained and routed to LDG SCP if WQ criteria are met	Sep-13	
	Ann Gulch East Diversion Ditch	Divert water to SCP; configuration changes with HLF footprint	Sep-13	
	Ann Gulch East Sediment Control Pond	Receives water from AG EDD, water routed to DG velocity reduction pond	Sep-13	
	Ann Gulch West Diversion Ditch	Divert water to LDG SCP; configuration changes with HLF footprint	Sep-13	

Facility	Structure/Feature	Operational Conditions	Begin Date	End Date
Lower Dublin Gulch Infrastructure				
	EP	Receives solution routed from HLF and Feed Pond; Solution routed to Process Plant Cyanide Detox facility as required. Additional storage during wet scenarios available	Sep-13	
	MWTP Feed Pond	Receives water from Open Pit sump and Cyanide detox facility, water routed to MWTP and EP if required	Sep-13	
	MWTP Product Pond	Receives treated water from MWTP; water routed to LDG SCP	Sep-13	
	LDG Sediment Control Pond	Receives treated water from MWTP Product pond and diverted runoff from AG WDD; will also receive non-contact water from Open Pit and groundwater from HLF if WQ criteria are met. Will drain to DGDC via overflow channel. WQ monitored at overflow channel	Sep-13	
	Process Plant Groundwater Wells	Supply make up water to Process Plant	Sep-13	Dec-20
Dublin Gulch Diversion Channel				
	Upper Velocity Reduction Pond	Receives water from Dublin Gulch and AG WDD	Sep-13	
	Upper Channel	Receives water from upper velocity reduction pond; optional discharge from EP SCP if WQ criteria are met	Sep-13	
	Energy Dissipater		Sep-13	
	Lower Velocity Reduction Pond	Receives water from DGDC	Sep-13	
	Lower Channel	Receives water from lower velocity reduction pond; discharges to Eagle Creek connector	Sep-13	
	Eagle Creek Connector	Receives water from Eagle Creek connector	Sep-13	
Main Camp				
	Sewage Treatment Facility	Discharges to rockdrain and Haggart Creek	Sep-13	
	Groundwater Well	Supply water to camp	Sep-13	

Table A-3: Summary of Facility Closure Activities for Water Management Plan

Facility	Structure/Feature	Closure Conditions/Process	Begin Date	End Date	Comments
Eagle Pup Waste Rock Storage Area					
	WRSA cover	Recontour and cap as per WQ criteria	Jan-21	Sep-22	
	EP Sediment Control Pond	Maintain until WQ criteria are met and sustained for five years	Sep-22	Sep-27	
Platinum Gulch Waste Rock Storage Area					
	WRSA cover	Recontour and cap as per WQ criteria	Sep-16	Sep-17	
	PG SCP	Maintain until water is not required for make-up and meeting WQ criteria are met and sustained for five years	Jan-21	Jun-26	
	PG to Open Pit Drainage Ditch	Maintain until water is not required for make-up and WQ criteria are met and sustained for five years	Jan-21	Jun-26	
Open Pit					
	Pit Sump	Pit will be backfilled as geochemical conditions allow, small Pit Lake will form (2.5 ha) and drain to Platinum Gulch	Jan-21		Model will calculate time period for Pit filling and flow to Platinum Gulch
	Crusher Pad	Will be reclaimed when mining stops	Jan-21	Sep-21	
	Perimeter Wells	Will be abandoned or destroyed as mine pit expands		Sep-21	
	Horizontal Drains	Will remain in place		n/a	
	Groundwater Wells	Will be abandoned when crushing has stopped		Sep-21	

Facility	Structure/Feature	Closure Conditions/Process	Begin Date	End Date	Comments
Heap Leach Facility					
	HLF Surface	Stop cyanide addition; begin recycle leach solutions with no chemical additions	Jan-21	Dec-21	
		Start detoxification/recycle/continuous discharge/maximum raw water addition	Jan-22	Dec-23	
		Cap heap	Jan-24	Sep-24	
	HLF Primary Pond	Draindown heap to be treated on an as needed basis	Jan-24	Sep-27	Draindown period estimated at three years after maximum raw water additions (rinsing)
	Ann Gulch East Diversion Ditch	Stabilize for long-term – maintain drainage to Dublin Gulch	Jan-21	Sep-22	Likely to stabilize prior to end date
	Ann Gulch East Sediment Control Pond	Maintain SCP until AG EDD stabilized and WQ criteria met	Sep-21	Sep-26	
	Ann Gulch West Diversion Ditch	Stabilize for long-term, route drainage to Haggart Creek when stabilized and WQ criteria met	Sep-21	Sep-26	will likely stabilize before end date
Lower Dublin Gulch Infrastructure					
	Secondary Heap Leach Storage Facility	Will keep until HLF cover built; afterwards runoff conveyed to MWTP Feed Pond or directly to LDG SCP depending on WQ		Sep-24	
	MWTP Feed Pond	Will maintain until draindown water meets WQ criteria	Sep-28	Jul-29	
	MWTP Product Pond	Will maintain until draindown water meets WQ criteria	Sep-28	Jul-29	
	LDG Sediment Control Pond	Will receive all discharge water until WQ criteria are met		Sep-35	Will be primary discharge point during post-closure monitoring period
	Process Plant Groundwater Wells	Will abandon after HLF rinsing completed	Jan-23	Sep-23	

Facility	Structure/Feature	Closure Conditions/Process	Begin Date	End Date	Comments
Dublin Gulch Diversion Channel					
	Upper Velocity Reduction Pond	Will be stabilized for long-term	Jan-21	Sep-21	
	Upper Channel	Will be stabilized for long-term	Jan-21	Sep-21	
	Energy Dissipater		Jan-22	Sep-23	Consider re-aligning upper to lower channel for long-term stability and fish enhancement
	Lower Velocity Reduction Pond	Will either stabilize for long-term or be eliminated based on fish enhancement options	Jan-22	Sep-23	
	Lower Channel	Will be stabilized and enhanced for fish habitat	Jan-22	Sep-23	
	Eagle Creek Connector	will be stabilized and enhanced for fish habitat	Jan-22	Sep-23	
Main Camp					
	Sewage Treatment Facility	Reclaim at end of post-closure monitoring period		Sep-35	
	Groundwater Well	Abandon at end of post-closure monitoring period		Sep-35	