Coffee Gold Mine
YESAB Project Proposal
Appendix 31-E Water Management Plan

VOLUME V

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TABLE OF CONTENTS

List of Tables

List of Figures

ACRONYMS AND ABBREVIATIONS

Acronym	Definition
CSP	Corrugated Steel Pipes
ECCC	Environment and Climate Change Canada
EOM	End of Mine
FS	Feasibility Study
HLF	Heap Leach Facility
hp	Horse Power
km	Kilometres
km^2	Square Kilometres
L	Litre
m	Metres
m^3	Cubic Metres
m^3/s	Cubic Metres per Second
m/hr	Metres per Hour
μm	Micrometres
masl	Metres above Sea Level
Mg	Milligram
mm	Millimetre
MMER	Metal Mine Effluent Regulations
Mt/a	Million Tonnes per Annum
SCS	Soil Conservation Service
TSS	total Suspended Solids
WRSF	Waste Rock Storage Facility

1.0 INTRODUCTION

1.1 PROJECT SUMMARY

The proposed Coffee Gold Mine (Project), is an advanced exploration gold project owned by Kaminak Gold Corporation, a wholly owned subsidiary of Goldcorp Inc. (Goldcorp or Proponent), and located in the White Gold District of west-central Yukon, approximately 130 kilometres (km) south of the City of Dawson. The Project contains several gold occurrences within an exploration concession covering an area of more than 600 km^2.

Precipitation that comes into contact with the Mine Site will be collected, retained and discharged at a controlled rate, so as to minimize erosion and sedimentation of watercourses, and to minimize the concentration of total suspended solids (TSS) in contact water before it is discharged to the receiving environment. In addition, some water will be collected and used as process water in the heap leach facility (HLF). Excess water that accumulates in the HLF that cannot be used for rinsing of the heap will be treated and discharged to the environment.

1.2 SCOPE AND OBJECTIVES

The purpose of the Water Management Plan is to describe how water will be managed at the Mine Site through life of mine. The Mine Site is situated along a ridge top, from which water flows into the headwaters of three separate catchments **Figure 1.2-1**):

- Latte Creek
- YT-24
- Halfway Creek.

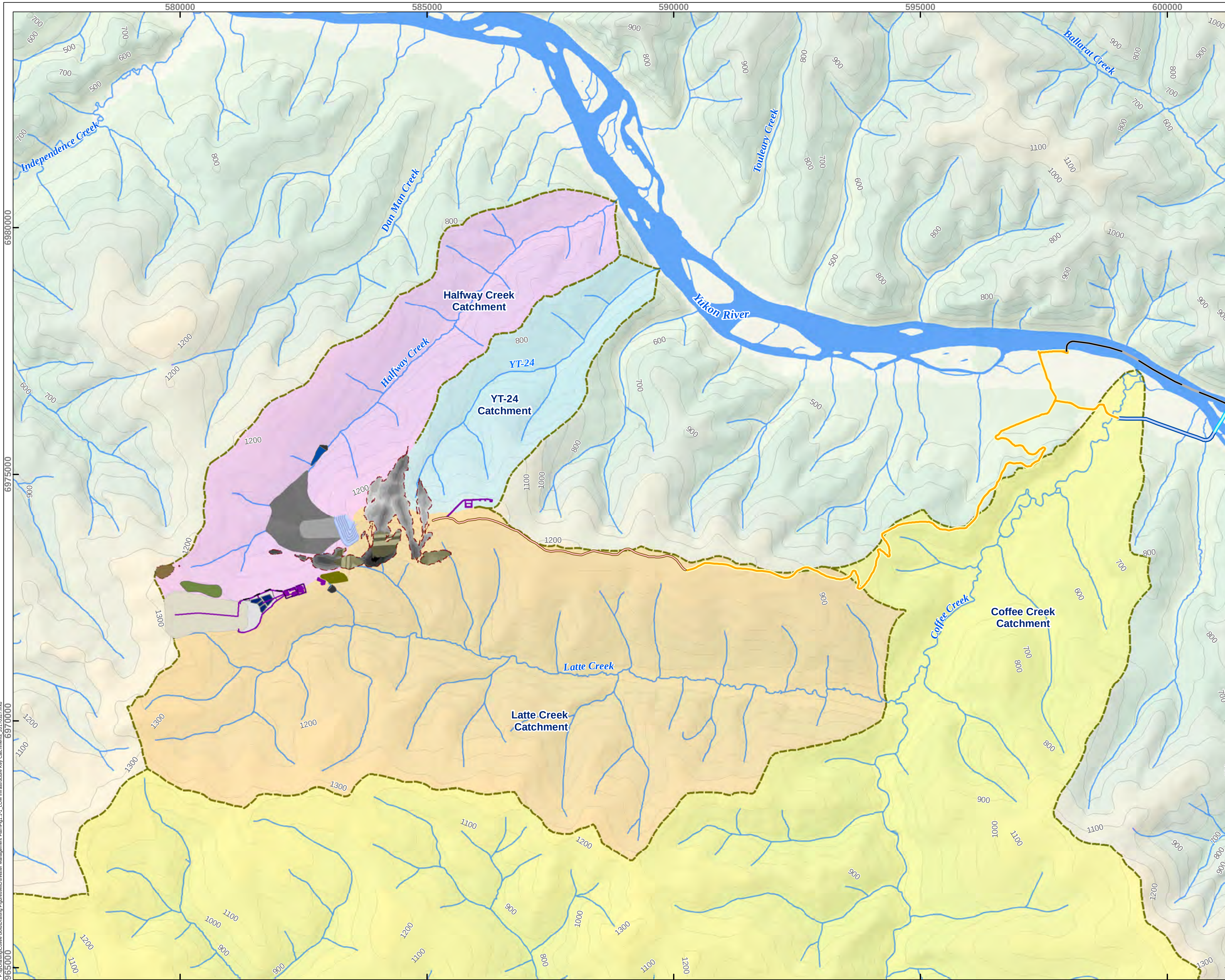
The objectives of this plan are to provide guidance, and to summarize information, relevant for water management for the Mine Site. The Plan is intended to be used as a guide and reference document to facilitate achievement of specific performance objectives. It is anticipated that this Plan will be updated from time to time, as project-specific regulatory requirements are confirmed, and water management at the site is refined.

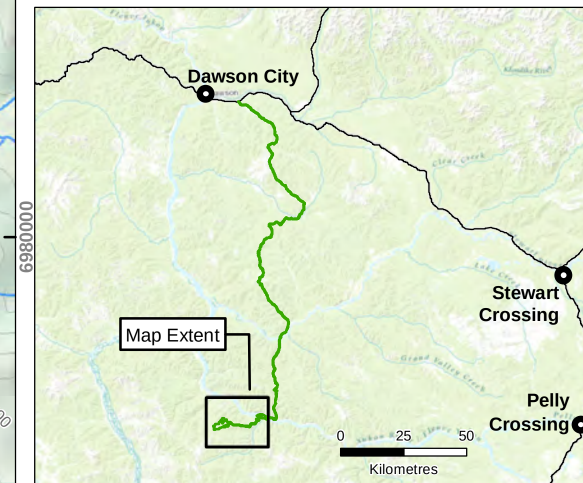
1. The performance objectives for water management at the Mine Site are to:
2. Maintain the physical integrity and stability of the Mine Site through controlled water management;
3. Manage water that could potentially be affected by the mine (e.g., contact water) in accordance with industry best management practices;
4. Ensure that the quantity and quality of contact water discharged from the mine complies with applicable regulatory requirements;

5. Minimize alteration to the pre-development drainage network, and the volume of contact water to be managed;
6. Maintain the physical integrity and stability of slopes and watercourses downstream of the Mine Site, and
7. Minimize any potential effects to surface water and groundwater quantity and quality in the receiving environment.

COFFEE GOLD MINE

Life-of-Mine Infrastructure in Relation to Key Catchments





Legend

- City/Community
- Project Footprint
- Catchment Boundary
- Waterbody
- Watercourse
- Elevation Contours (100m)
- Yukon River Barge Route
- Yukon River Ice Road
- Winter Road
- Mine Site Access Route
- Northern Access Route

Pre-Mine Catchment Area

- Halfway Creek
- Latte Creek
- YT-24 Creek
- Coffee Creek

Proposed Infrastructure

- WRSF
- Backfill
- Total Pit Outline
- ROM Stockpile
- Organics Stockpile
- Frozen Soil Storage Area
- Event Pond
- Heap Leach Access Disturbance Footprint
- Heap Leach Pad Base
- Support Infrastructure

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Kilometers

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Figure 1.1-1	Date: Mar 30, 2017	Drawn by: GM	Reviewed: AS

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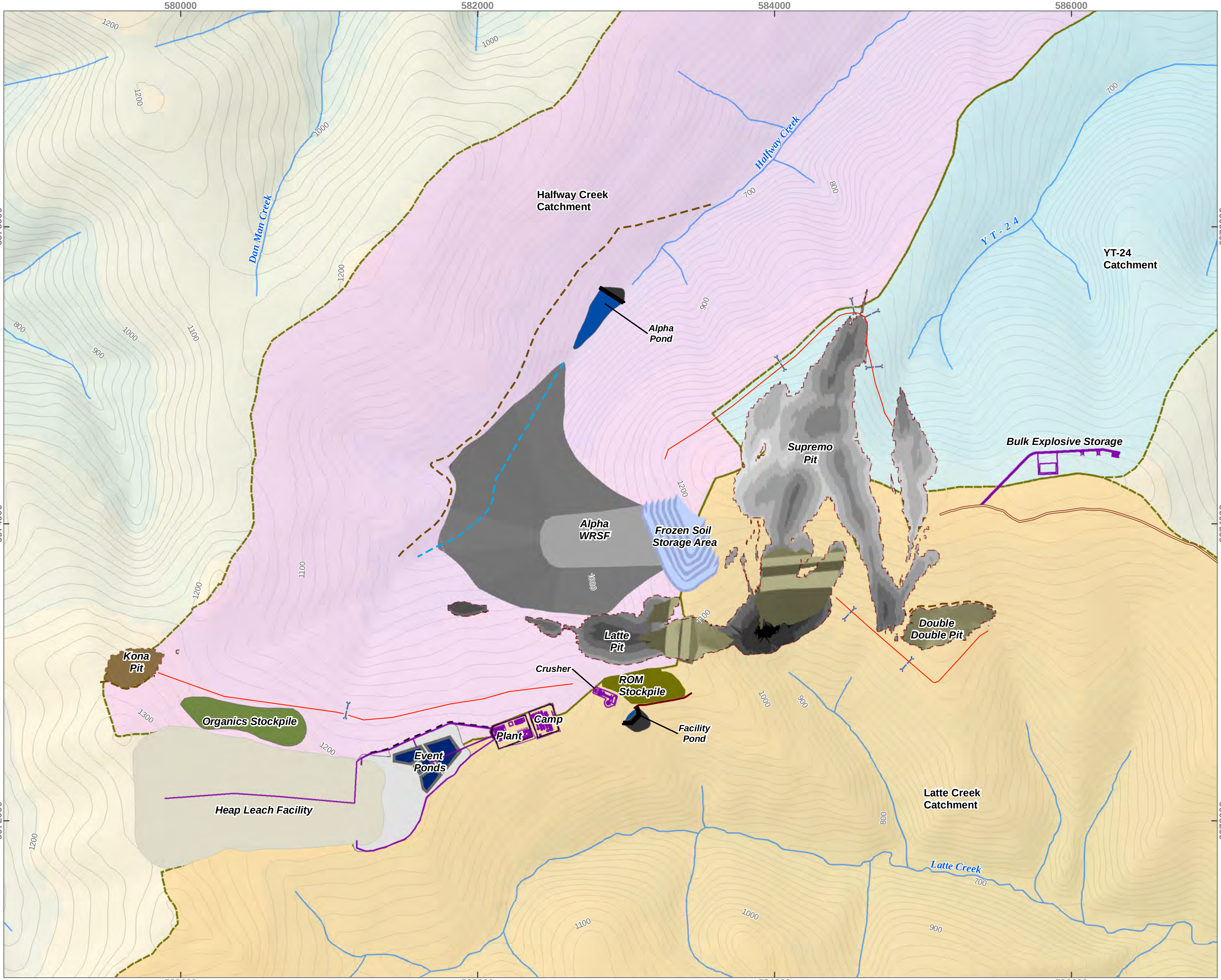
1.3 SUMMARY OF WATER MANAGEMENT

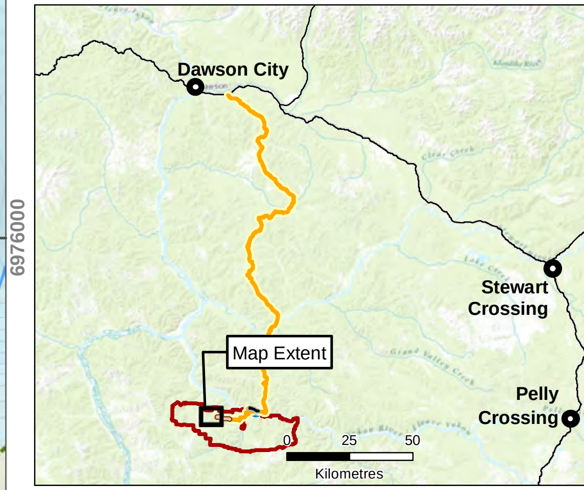
For the purposes of water management, the Mine Site is divided into seven distinct areas. These are:

1. *Alpha Waste Rock Storage Facility (WRSF) and Alpha Pond*. The Alpha WRSF will be the primary storage facility for waste rock generated from the Project (**Figure 1.3-1**). The Alpha WRSF will be situated in the upper Halfway Creek catchment and will include a rock drain to safely convey flow beneath the facility into the Alpha Pond. Precipitation and snowmelt that infiltrate the Alpha WRSF will report to the rock drain and be collected in the Alpha Pond. Contact water collected in the Alpha Pond will be discharged to Halfway Creek starting when the pond is complete in Y-2 (**Figure 1.3-2** and **Figure 1.3-3**.). A diversion channel will be developed on the west slope of the Halfway catchment which will divert clean runoff away from the Alpha WRSF and into Halfway Creek, downstream of the Alpha Pond. Ultimately, the Alpha Pond will be decommissioned during Post-Closure (**Figure 1.3-4**) and water conveyed through the rock drain will discharge directly into Halfway Creek.
2. *Kona Pit and Beta WRSF*. Water that collects in the Kona Pit during mining will be pumped to the HLF process plant as make-up water. Runoff and seepage infiltration from the Beta WRSF will discharge passively to the Alpha WRSF rock drain and be collected in the Alpha Pond (**Figure 1.3-2**). At the beginning of closure, the Kona Pit will be backfilled with rock from the Beta WRSF. Backfill will occur during winter to facilitate re-establishment of permafrost in the Kona Pit by using frozen waste rock. Upon completion of backfill, surface runoff from the Kona backfill will be passively discharged to the Alpha WRSF rock drain and collected in the Alpha Pond (**Figure 1.3-3**).

COFFEE GOLD MINE

End of Mine (EOM) Configuration and Water Management Components





Legend

- City/Community
- Mine Site Access Route
- Catchment Boundary
- Elevation Contour (20m)

End of Year 9 Catchment Areas

- Halfway
- Latte Creek
- YT-24 Creek

Proposed Infrastructure

- WRSF
- Backfill
- Total Pit Outline
- ROM Stockpile
- Organics Stockpile
- Frozen Soil Storage Area
- Event Pond
- Heap Leach Access Disturbance Footprint
- Heap Leach Pad Base
- Support Infrastructure

Water Management

- Culverts
- Pond Berm
- Diversion Channel
- Road Drainage Ditch
- Rock Drain
- Collection Channel
- Settling Pond Dam
- Settling Pond

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Meters

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Figure 1.3-1	Date: Mar 29, 2017	Drawn by: GM	Reviewed: AS

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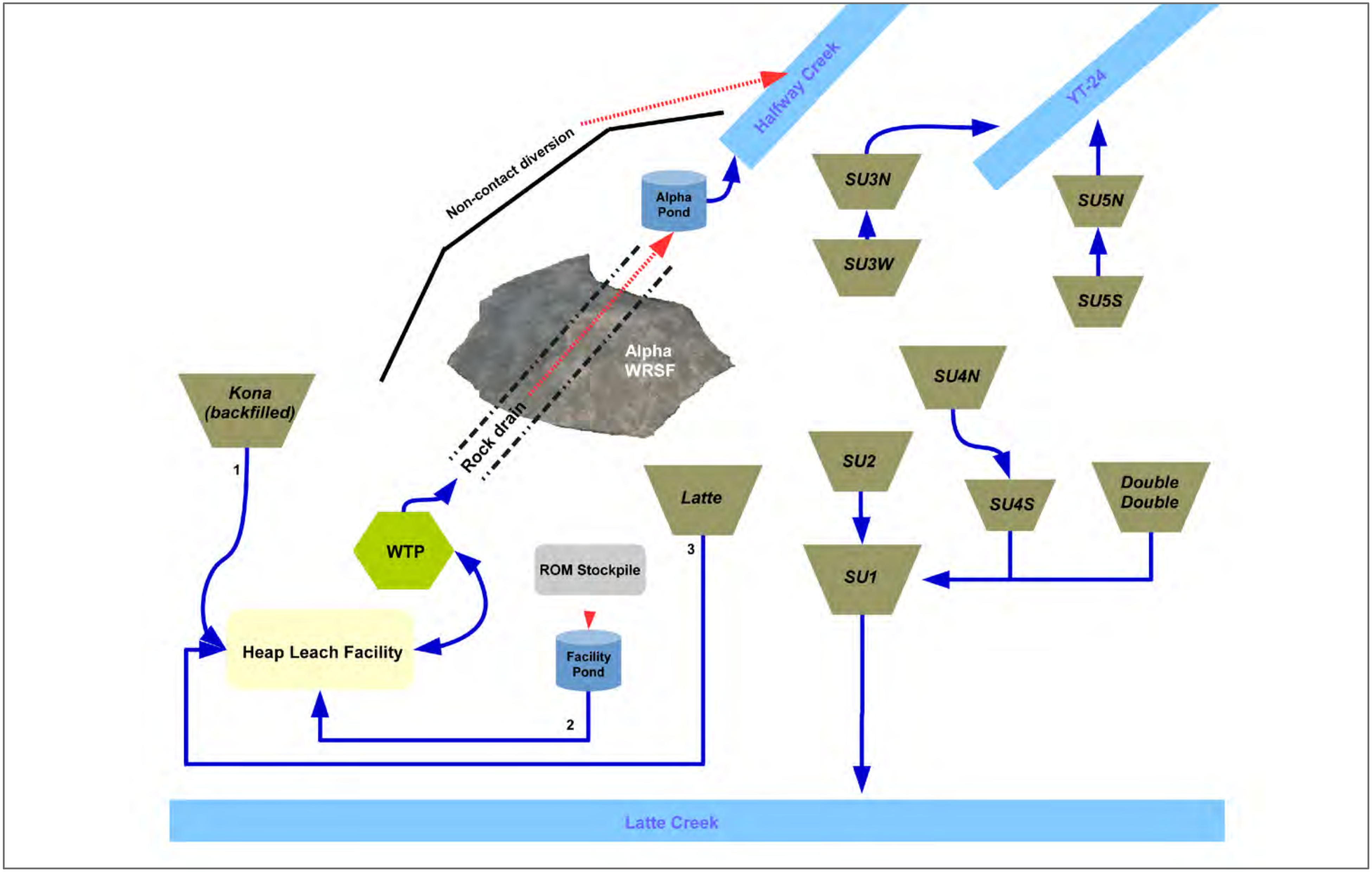

LEGEND

Pumped

Passive

1 HLF Makeup Water Priority

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LORAX ENVIRONMENTAL

PROJECT: **Coffee Gold Project**

TITLE: Schematic of Water Management Components at EOM

PROJECT #: A362-2

FIGURE: 1.3-2

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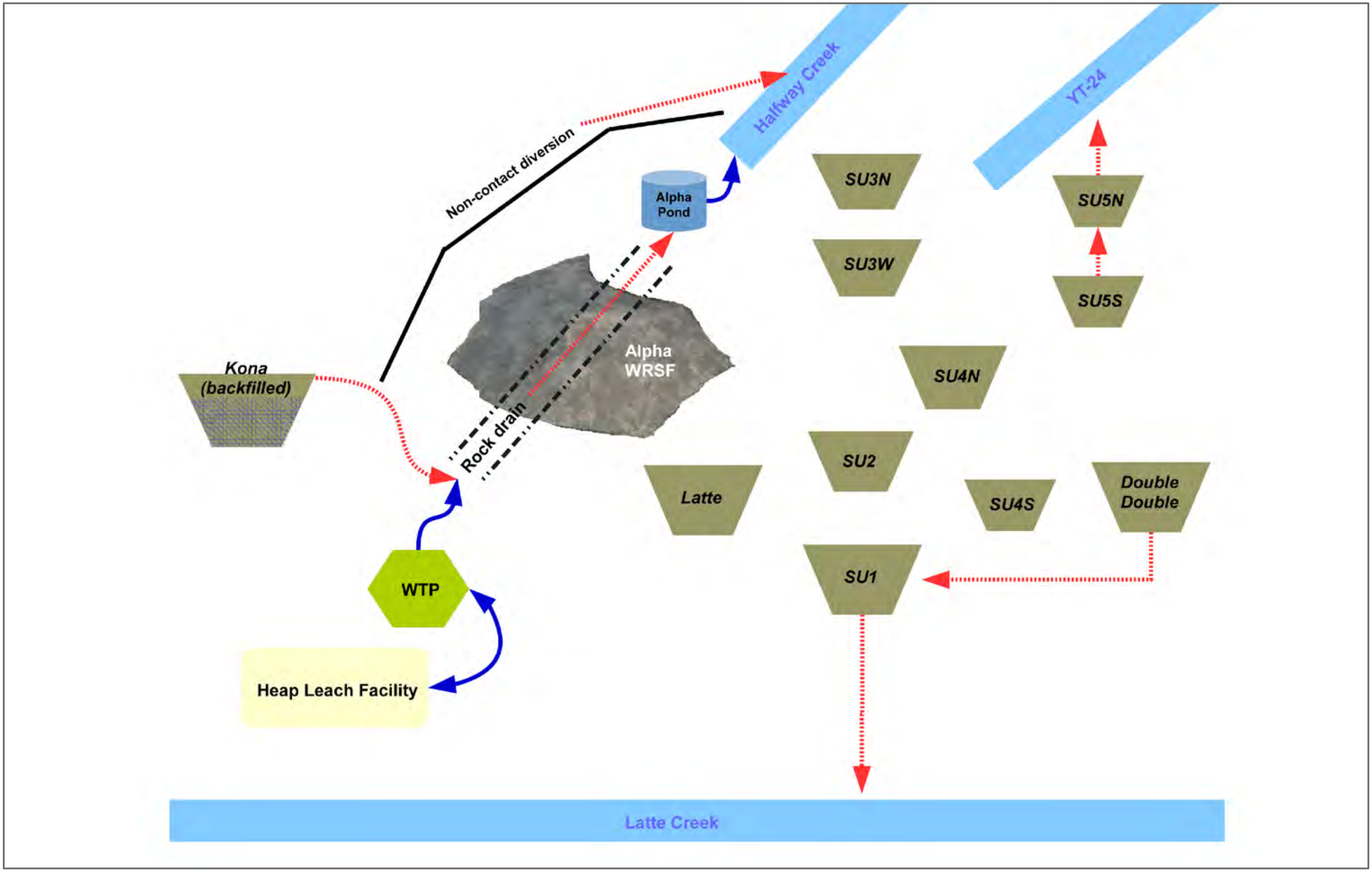

LEGEND
- Pumped
- Passive
- Permafrost

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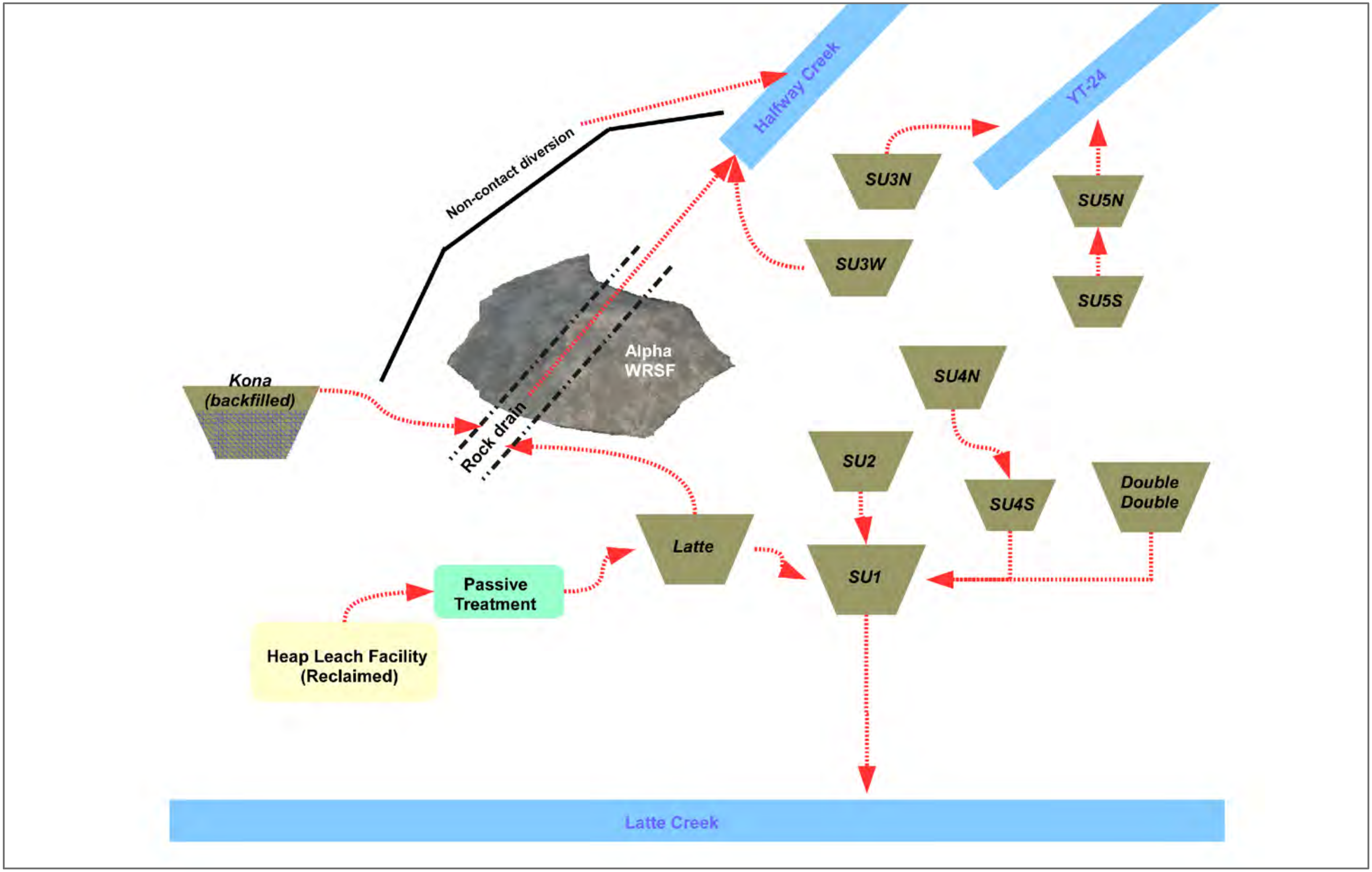
LORAX ENVIRONMENTAL

PROJECT: **Coffee Gold Project**

TITLE: Schematic of Water Management Components at Closure

PROJECT #: A362-2

FIGURE: 1.3-3



LEGEND

Passive

Permafrost

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VERSION:	1

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CLIENT: GOLDCORP

LORAX ENVIRONMENTAL

PROJECT: **Coffee Gold Project**

TITLE: Schematic of Water Management Components at Post-Closure

PROJECT #: A362-2 FIGURE: 1.3-4

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3. *Heap Leach Facility (HLF).* The HLF will be operated predominantly as a closed system from a water management perspective for most of the operation phase. Outside makeup water demand will only appear in Year 1 and Year 2, after the initial water recruited for startup in Year -1 and early Year 1 is used up in charging the system with water and wetting the ore after stacking begins in mid-Year -1. The heap will be free draining with no in-heap storage of solution other than retained moisture. The leach pad will be divided into 5 stages and each stage will be further divided into cells. During the Operation Phase and the early stages of closure, geomembrane covers (raincoats) will be used over the heap to reduce the amount meteoritic water infiltrating into the heap and entering the process solution. The raincoats will remain in use over portions of the heap until closure is complete. The heap will be rinsed and capped in stages (progressive closure) and as each stage is capped the raincoats for that area will be removed and used in other areas or incorporated as part of the closure capping. Heap solution management will be addressed through rinsing of the heap and collection and treatment of rinse solutions. Under the current HLF water balance, treatment of excess rinse water will be required in Year 9. Excess water will be treated to remove residual cyanide with hydrogen peroxide followed by a bioreactor treatment system to reduce nitrogen, metalloids and metal concentrations to acceptable concentrations. Treated water of acceptable quality will be released to the Halfway Creek drainage during the Operation Phase and early Reclamation and Closure **(Figure 1.3-2** and **Figure 1.3-3**). During the Active Closure stage, and upon cessation of active water treatment (~ Year 20) the water treatment plant will be decommissioned and HLF seepage water will be directed through events ponds that have been converted to passive treatment cells and ultimately into Latte Pit **(Figure 1.3-4**).
4. *Plant Site.* The Plant Site collectively includes the process plant, camp, associated facilities and Run-of-Mine (ROM) ore stockpile. Contact water from the Plant Site will be collected and discharged to the Facility Pond. Water collected in the Facility Pond will be used for the HLF. Excess water will be discharged into the Latte Creek catchment (**Figure 1.3-2**).
5. *Latte Pit.* Latte Pit will be one of the first pits to be developed. Meteoric water that collects in the Latte Pit during mining will be used as make-up water in the HLF (**Figure 1.3-2**). Once mining is complete, meteoric water accumulating in the Latte Pit will be allowed to passively fill in the pit. The Latte Pit will also receive overflow from the passive treatment system during post closure. Once it is completely filled, Latte Pit water will overflow into the Alpha rock drain and report to Halfway Creek (**Figure 1.3-4**).
6. *Supremo South and Double Double Pit Complex.* The Supremo South and Double Double Pit complex comprises pits SU4N, SU2, SU4S, Double Double and SU1 (**Figure 1.3-2**). During mining, meteoric water that accumulates in pits SU4N, SU2, SU4S and Double Double will be pumped to SU1. Water in SU1 will be settled in an in-pit sump designed to ensure settling of suspended solids to a maximum of 15 milligrams(mg) per litre (L). Water that meets this criterion will be discharged

to the small ephemeral drainage that discharges to Latte Creek (**Figure 1.3-2**). During the Reclamation and Closure and Post-closure phases, SU1 will fill to the pit spill point and water will be allowed to passively discharge to the Latte drainage. Contact water from the backfilled Double Double Pit at closure and post-closure will discharge passively to the Latte drainage (**Figure 1.3-3** and **Figure 1.3-4**).

7. *Supremo North Pit Complex.* The Supremo North pit complex comprises pits SU3W, SU3N, SU5S, and SU5N (**Figure 1.3-2**). During mining, meteoric water that accumulates in pits SU3W and SU3N will be settled in in-pit sumps designed to ensure settling of suspended solids to a maximum of 15 mg/L. Water that meets this criterion will be discharged from SU3N to the YT-24 drainage. Similarly, meteoric water that accumulates in SU5S and SU5N will be settled in in-pit sumps to meet suspended solids discharge criteria and discharged via SU5N to the YT-24 drainage (**Figure 1.3-2**). At closure, SU5S and SU5N will fill to their respective spill points and passively discharge to YT-24. SU3W and SU3N are larger pit voids and do not fill to their respective fill points until the Post-closure Phase. The SU3W pit will ultimately spill passively to Halfway Creek and SU3N will spill passively to YT-24. (**Figure 1.3-3** and **Figure 1.3-4**).

1.4 REGULATORY CONSIDERATIONS

The discharge of contact water from the Mine Site is anticipated to be subject to both the Metal Mine Effluent Regulations (MMER), a regulation issued pursuant to the Federal *Fisheries Act*, RSC 1985, c.F-14, as well as the conditions established in the Quartz Mining License and Water Use Licence that will be required for the Project under the provisions of the *Quartz Mining Act,* SY 2003, c. 14, and *Waters Act* SY 2003, c. 19. The requirements associated with these regulations and licenses that are relevant to water management are outlined below.

1.4.1 FEDERAL REGULATIONS

The MMER prescribes authorized limits for monthly mean concentrations, maximum concentration in a composite sample, and maximum concentration in a grab sample, for a total of eight water quality parameters. These limits apply at designated final discharge points. These maximum authorized concentrations are shown in **Table 1.4-1**.

Table 1.4-1 Maximum Concentration Limits of Deleterious Substances as Specified in Schedule 4 of the Metal Mining Effluent Regulations

Deleterious Substance	Maximum Authorized Monthly Mean Concentration (mg/L except Bq/L for Radium 226)	Maximum Authorized Concentration in a Composite Sample (mg/L except Bq/L for Radium 226))	Maximum Authorized Concentration in a Grab Sample (mg/L except Bq/L for Radium 226))
Arsenic	0.50	0.75	1.00
Copper	0.30	0.45	0.60
Cyanide	1.00	1.50	2.00
Lead	0.20	0.30	0.40
Nickel	0.50	0.75	1.00
Zinc	0.50	0.75	1.00
TSS	15.0	22.5	30.0
Radium 226	0.37	0.74	1.11

The MMER also stipulates requirements related to effluent monitoring, including toxicity tests, calculation of monthly mean concentrations and loading, and effluent monitoring, as well as biological monitoring. The timing as to when MMER will apply to the Project will be determined in consultation with Environment and Climate Change Canada (ECCC), which administers the MMER. However, it is anticipated that it will be triggered once waste rock is placed in the Alpha WRSF or mine effluent discharged. Final discharge points will be specified during the licensing phase of the Project. In addition, and prior to the Operation phase, detailed monitoring requirements in support of Environmental Effects Monitoring (EEM) will be confirmed, also in consultation with ECCC.

1.4.2 Territorial Regulations

Quartz Mining and Water Use Licenses will be required for the Project. This Plan is intended to meet the application guidance for a water management plan that outlines the objectives, strategies, activities and methods to manage water produced or affected by the Project.

The Water Use License will specify mine effluent discharge standards that must be met for the Project, and may also include water quality objectives for the receiving environment. These will be determined as part of Project licensing, and will be informed by consultation with First Nations, the Yukon Government and Yukon Water Board, and will be developed with reference to the water quality predictions that have been derived for the Project. This plan will be updated to include water quality objectives once they have been established.

1.5 SYNERGIES WITH OTHER PROJECT DOCUMENTS

The Water Management Plan is an integral part of the overall environmental management that will be undertaken for the Project. This plan should be viewed in concert with the following management plans:

- Waste Rock and Overburden Management Plan (**Appendix 31-D**); and
- Conceptual Reclamation and Closure Plan (**Appendix 31-C**).

2.0 PROJECT SETTING

The Project is situated in the Dawson Range, just south of the Yukon River, approximately 130 km south of the City of Dawson. Surface water quality has been identified as a Valued Component (VC) for the purpose of the environmental effects assessment that has been undertaken for the Coffee Gold Project in accordance with the requirements of the *Yukon Environmental and Socio-economic Assessment Act,* SC 2003, c. 7 (YESAA). A brief overview of the Project setting follows. More detailed information is available in the relevant sections of the Project Proposal and associated appendices.

2.1 TOPOGRAPHY

Topography in the area is characterized by gently rounded hills that rise above treeline to more than 1,500 metres above sea level (masl), with tightly incised valleys descending to the Yukon River, which lies at an elevation of approximately 400 m in the vicinity of the Project. The Project is situated along a high, undulating ridge that ascends to more than 1,300 masl. The incised valleys in the area were not affected by Quaternary glaciation.

2.2 SOILS AND VEGETATION

Soils at the Mine Site consist of a thin layer of colluvium, silts, and clays with intermittent rock outcrops. Discontinuous permafrost of varying depth is present on site. Frozen soils are predominately on the north and west-facing slopes, and valley floors; however, isolated areas of frozen soils may be present in other areas. Vegetation at higher elevations is dominated by sparse, deciduous shrubs. Mature pine forests dominate the steeply-incised valleys and the Yukon River valley.

2.3 WATERCOURSES AND HYDROLOGY

A number of small watercourses originate on the ridge and flow into the Yukon River. Latte Creek drains the south face of this ridge and has a catchment area of approximately 70 km^2. Latte Creek flows eastward to its confluence with Coffee Creek. Coffee Creek has a total catchment area of approximately 487 km^2 and drains an area to the south and east of the Mine Site, generally flowing from south to north to the Yukon River. The north face of the ridge is drained by Yukon Tributary 24 (YT-24), on the eastern side of the Mine Site. YT-24 has a total catchment area of approximately 12 km^2. Halfway Creek drains the western side, and has a total catchment area of approximately 27 km^2. Both YT-24 and Halfway Creek flow northeast to their confluences with the Yukon River.

These creeks experience peak flows in May due to melting snowpack and following rainfall events in summer and early fall. The creeks are frozen in winter, with the exception of Coffee Creek. Baseflow and groundwater discharge freeze in winter, resulting in accumulation of aufeis in stream channels. Surface water at the Mine Site is expected to be frozen, and a snowpack to accumulate, from October to April each year.

2.4 AQUATIC HABITAT

Slimy Sculpin (*Cottus cognatus*), Arctic Grayling (*Thymallus arcticus*) and juvenile Chinook Salmon (*Oncorhynchus tshawytscha*) are present in Coffee Creek and the Yukon River year-round. The reaches of the Yukon River into which these streams discharge (reaches upstream of the White River confluence) provide habitat for 14 species of fish, including Chum Salmon (*Oncorhynchus keta*). This part of the Yukon River supports both commercial and recreational fisheries.

All of the local watercourses provide feeding and rearing habitat for fish in summer. Slimy Sculpin occur in all of these watercourses in summer, although only the lower and middle reaches of Latte Creek, mouth of YT-24, and lower reaches of Halfway Creek are fish-accessible. Arctic Grayling also occur in lower Latte Creek and the mouth of Halfway Creek in summer. Fish access to upper reaches of all of these watercourses is limited by steep gradients, fish barriers, and seasonal low flows. The mouth of YT-24 is accessible to fish (Slimy Sculpin), only when backwatered by the Yukon River.

2.5 TRADITIONAL USE

All watercourses in the area are valued by First Nations and other stakeholders, and support aquatic habitat. First Nations consulted as part of the environmental assessment process emphasized the importance of the Coffee Creek corridor, including the salmon runs, wildlife and vegetation it supports, as well as its traditional usage for travel. Traditional use of the area is well-documented, and fish camps were set up annually near the mouth of Coffee Creek by several First Nations groups.

3.0 LOCAL CLIMATE

The Mine Site is situated along a ridge with an average elevation of roughly 1,300 masl. Consequently, precipitation is the only significant source of water at the Mine Site. Surface water is limited to small seeps and springs.

A synthetic 28-year record of both temperature and precipitation has been developed for the site. It is based on measurements obtained at a climate station at the Mine Site since July 2012, supplemented by measured values from a nearby station with a longer record, to better characterize long-term variability. The measured and synthetic records are briefly summarized below, and are described in detail in **Appendix 8-A Coffee Gold Project: Hydro-meteorology Baseline Report** of the Project Proposal.

3.1 PRECIPITATION

Mean annual precipitation is estimated to be 485 millimetres (mm) at the Mine Site (based on the synthetic record). Mean annual precipitation measured at the Mine Site was 419 mm from 2012-15, with approximately a third of this total occurring as snow.

The synthetic 28-year record was derived from statistical relationships between the data from site and the elevation-adjusted record from the McQuesten climate station (from 1986-2014), which was selected as the best regional proxy for the Project site. The McQuesten station record was adjusted to reflect the fact that precipitation increases with elevation, due to orographic effects. The methodology for the development of this synthetic record is described in detail in section 2.3.2 of **Appendix 8-A: Hydro-meteorology Baseline Report**.

Precipitation occurs as snowfall in winter months. The mean air temperature is below 0°C from October through April, and most of the precipitation that occurs during this period falls as snow, and accumulates, until the snowpack melts in spring (typically May and June). Precipitation occurs as rainfall in summer months, from May through September. The largest daily precipitation events have been attributed to over-land convective events that occur frequently in summer. On average, there are 20-30 days of appreciable precipitation (>5mm/day) in summer **(Table 3.1-1**, **Table 3.1-2**, **Figure 3.1-1**, and **Figure 3.1-2**).

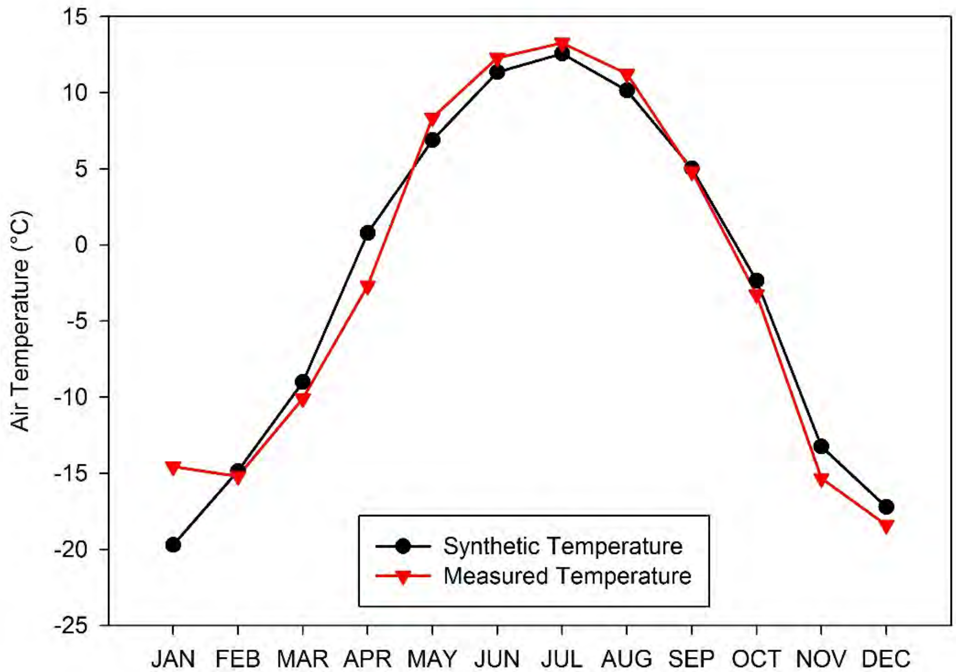


Figure 3.1-1 Average monthly mean air temperatures as measured by the Project climate station, and from the synthetic 28-year record

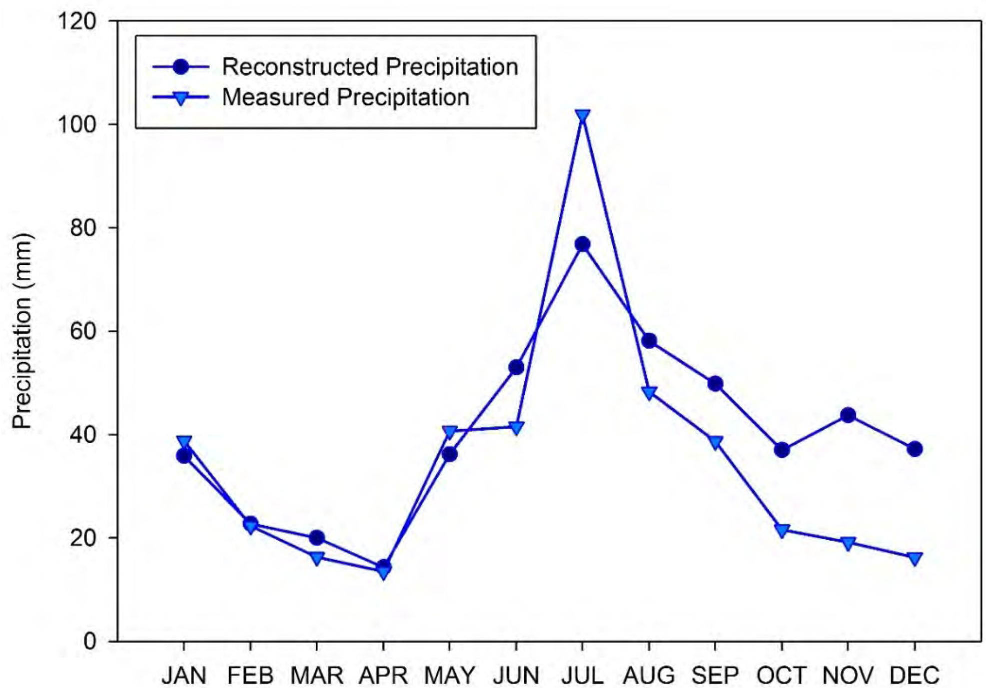


Figure 3.1-2 Average monthly precipitation as measured by the Project climate station and from the synthetic 28-year record. Both data series are scaled to elevation 1,300 masl

Table 3.1-1 Monthly measured and synthetic climate records for the Coffee Gold Project at 1,300 masl

	Precipitation (mm)		Air Temperature (°C)	
	Synthetic (1986-2014)	Measured (2012-2015)	Synthetic (1986-2014)	Measured (2012-2015)
Jan	35.9	38.8	-19.7	-14.6
Feb	22.7	22.3	-14.9	-15.2
Mar	20.0	16.3	-09.0	-10.1
Apr	14.3	13.5	0.8	-2.7
May	36.2	40.7	6.9	8.3
Jun	53.0	41.5	11.3	12.3
Jul	76.8	101.9	12.6	13.3
Aug	58.1	48.3	10.1	11.2
Sep	49.8	38.7	5.0	4.8
Oct	37.0	21.6	-2.4	-3.2
Nov	43.7	19.2	-13.2	-15.3
Dec	37.2	16.2	-17.2	-18.4
Annual	**484.6**	**419.0**	**-2.5**	**-2.5**
May-Sep	273.8	271.1	9.2	10.0
Oct-Apr	210.8	147.9	-10.8	-11.4

Table 3.1-2 Monthly measured and synthetic climate records for the Coffee Gold Project at 1,300 masl

Interval	Precipitation (mm) for Various Return Periods						
	1:2	1:5	1:10	1:25	1:50	1:100	1:200
24-hour	32	46	55	65	73	79	90
2 day	38	52	62	73	81	89	97
3 day	44	60	69	82	91	104	122
10 day	67	88	100	118	132	148	165
30 day	122	155	173	191	202	214	226

1. The higher of the values derived from elevation scaling and the upper bound approach are reported.

3.2 Extreme Events

Extreme precipitation events occur in summer. Estimated summer rainfall events for five time intervals (24-hour, 2-day, 3-day, 10-day and 30-day) and seven return periods (1:2 year, 1:5 year, 1:10 year, 1:25 year, 1:50 year, 1:100 year and 1:200 year) are noted in **Table 3.2-1** below. These estimates were calculated based on regression of measured values from regional climate stations against station latitude, longitude and elevation, as described in Appendix B (Extreme Precipitation Depths and Snowmelt, Coffee Gold) of **Appendix 8-A: Hydro-Meteorology Baseline Report**. The information is provided as the basis for engineering studies and engineering design for the Project.

Table 3.2-1 Estimated Summer Rainfall at 1,300 m elevation1 for Various Intervals and Return Periods

Interval	Precipitation (mm) for Various Return Periods						
	1:2	1:5	1:10	1:25	1:50	1:100	1:200
24-hour	32	46	55	65	73	79	90
2 day	38	52	62	73	81	89	97
3 day	44	60	69	82	91	104	122
10 day	67	88	100	118	132	148	165
30 day	122	155	173	191	202	214	226

1. The higher of the values derived from elevation scaling and the upper bound approach are reported.

3.3 Snow Pack and Melt

The maximum snow pack that is estimated to occur at the Mine Site in a typical year is approximately 151 mm (snow water equivalent), and it is expected to reach its maximum depth by approximately April 1. The snow pack is predicted to range from 77 mm to 317 mm in the 1:200 year dry and wet years, respectively. The estimated maximum accumulated snow water equivalents for various return periods are shown in **Table 3.3-1**.

Table 3.3-1 Estimated Maximum Snow Pack (Snow Water Equivalent) at 1,300 m Elevation for Various Return Periods

	Dry Year						Mean	Wet Year					
Return Period	1:200	1:100	1:50	1:25	1:10	1:5	1:2	1:5	1:10	1:25	1:50	1:100	1:200
Snow Water Equipment (mm)	77	82	88	95	108	121	151	191	217	249	272	295	317

Data from regional climate stations indicate that ablation of snow pack begins to occur by April 15, and the snow pack is typically completely melted at some point between May 15 and June 1 of any given year. Normal maximum melt rate is estimated to be approximately 26 mm per day, however maximum rates as high 40 mm to 50 mm per day may occur. This suggests that in a very dry year, the snow pack may melt within a week or so in mid- to late-April, while in a very wet year, the snow pack may melt over a period of 25 days or more, ending in early June.

3.4 CLIMATE CHANGE

The information noted above does not reflect the influence of potential climate change. The predicted temperature and precipitation noted above are not expected to be significantly altered from current conditions within the mine life.

Climate change has been estimated and accounted for in the water balance that has been developed for the Project. This was done by extending the synthetic 28-year record through three cycles to the year 2101, and incorporating projected changes in temperature and precipitation that are predicted using published climate models for that time frame. Scenarios that were evaluated for the Mine Site indicate that by the year 2100, average temperatures are expected to rise by 3°C to 5°C, and this change is expected to be most pronounced in summer. Average annual precipitation is not expected to change significantly. Summer and winter are expected to be slightly wetter, while little net change in precipitation is expected in spring or autumn. The net result of climate change will be earlier spring thaw, and delayed freeze-up in autumn, relative to current conditions. The warming trend is also expected to lead to minor degradation of permafrost. The methods and predicted climate variability for the Mine Site are described in Appendix D1 (Climate Change Projections for Coffee Creek Region, Yukon) of **Appendix 8-A: Hydro-meteorology Baseline Report**.

3.5 PERMAFROST

There is extensive, discontinuous permafrost at the Mine Site. It extends to depth on the ridge, and is thickest on higher elevation, north-facing slopes. It is estimated to be 165 m deep on the north side of the ridge at the top of the YT-24 catchment, for example. It is generally thinner on south-facing slopes, and appears to become thinner at lower elevations, based on the hydrogeological assessment completed to date. The hydrogeologic assessment is described in detail in **Appendix 7-A Coffee Gold Baseline Hydrogeological Assessment** of the Project Proposal.

Permafrost reduces hydraulic conductivity, as groundwater freezes, and pores and cracks in bedrock fill with ice. Consequently, it generally behaves as an aquiclude or aquitard, confining groundwater to the thin seasonal active layer above it, or the bedrock beneath it. The effects of permafrost have been taken into account in the water balance that has been developed for the Mine Site, as described in **Appendix 12-C Water Balance-Water Quality Model Report** of the Project Proposal.

The implications for water management at the site are that no infiltration is assumed from ditches or ponds and low rates of infiltration to ground are assumed for Open Pits, as the maximum depth of all pits is expected to remain within the permafrost layer. Overtime, in pits filled with water, degradation of permafrost and the formation of taliks are assumed in the hydrogeology and water balance models.

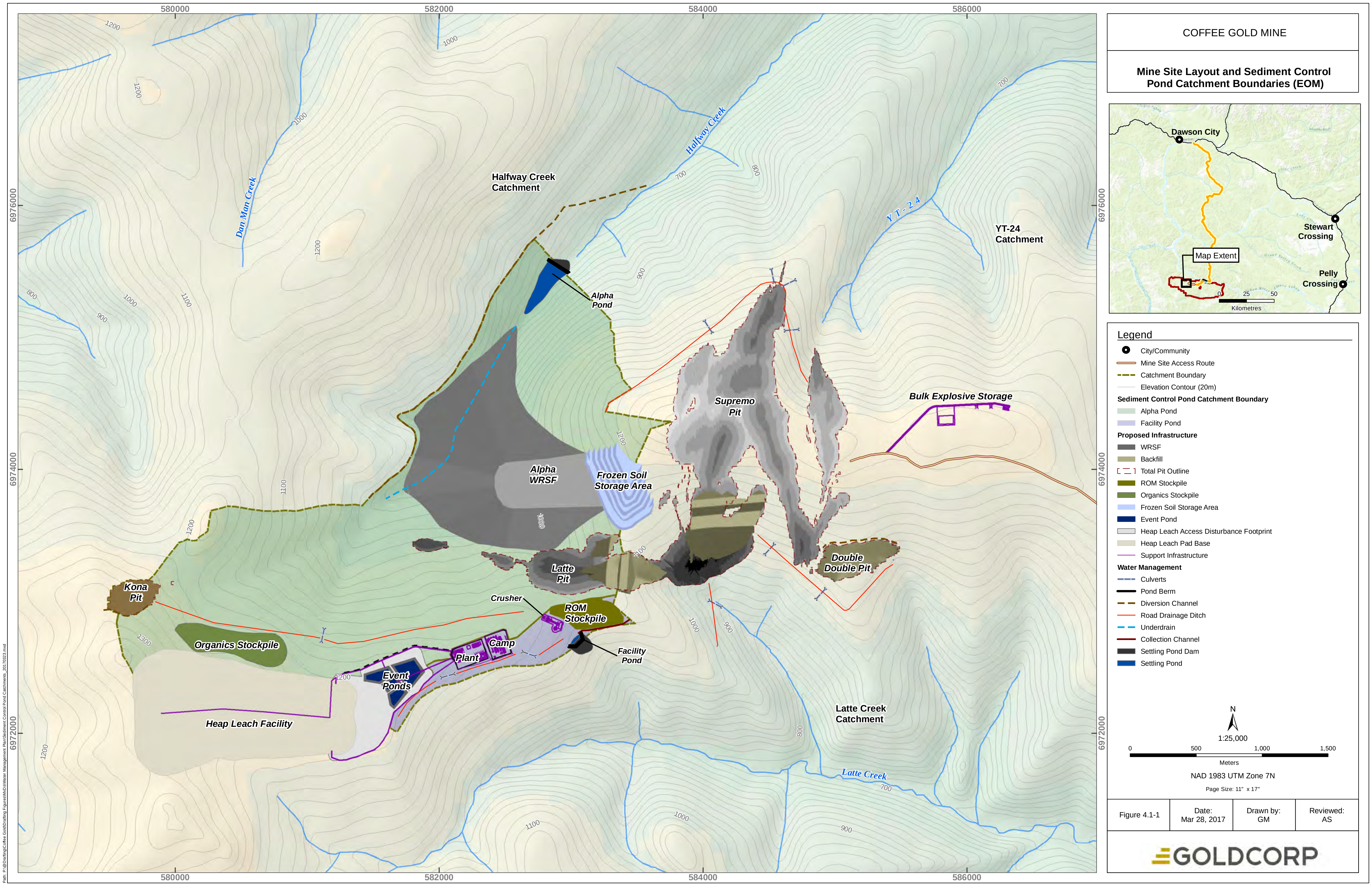
4.0 MINE AFFECTED WATER

4.1 OVERVIEW

Mine-affected (contact) surface water will be collected in two sedimentation ponds: one that will be constructed down-gradient of the Alpha WRSF (Alpha Pond), and one that will serve the Camp Site, Plant Site and ROM Stockpile (Facility Pond). **Figure 4.1-** shows the extent of the catchment areas and location of mine facilities that are situated up-gradient of the ponds The HLF facility is described in **Section 4.4** below.

The sedimentation ponds will generally receive contact water from April through October, during the months of snow ablation and rainfall. Peak contact water flows and sedimentation pond discharge are expected to occur in the month of May, with a decline in discharge rates in the following months. With minimal surface water runoff in winter, little or no contact water flow or discharge to the receiving environment is expected from November to March.

During the Construction and Operations phases, the Open Pits that are being actively mined will be dewatered. These discharges will be intermittent, in response to accumulated water volumes in pit sumps following freshet and rainfall events. These discharges will be managed both by adjusting pumping rates, and an upper limit on discharge volumes will be determined by pumping capacity. TSS will be managed by providing sufficient retention time of accumulated water in the pit sumps to allow solids to settle prior to pumping. When pits are allowed to fill, the flow rates experienced at the down-gradient monitoring locations will be reduced. Once development of an Open Pit is completed, the pit will be allowed to flood, and contact water will be stored in it, while it is flooding. Once flooded, the pits will begin to spill, and flows at the monitoring point downstream will approach the original rates (the rate experienced when pits were being dewatered), except that a small volume of water is presumed to infiltrate into the ground. Some pits will be backfilled, and reclaimed, such that no contact water will be stored within. The Open Pits are expected to be completed, and dewatering ceased, in accordance with the schedule shown in **Table 4.1-1**. The table also shows in which year pits are predicted to spill. A summary of scheduled pit dewatering and predicted years of pit lake filling and spillover is shown in **Figure 4.1-.**



COFFEE GOLD MINE
Mine Site Layout and Sediment Control Pond Catchment Boundaries (EOM)
Dawson City
Stewart Crossing
Pelly Crossing
Map Extent
0 25 50
Kilometres
Legend
City/Community
Mine Site Access Route
Catchment Boundary
Elevation Contour (20m)
Sediment Control Pond Catchment Boundary
Alpha Pond
Facility Pond
Proposed Infrastructure
WRSF
Backfill
Total Pit Outline
ROM Stockpile
Organics Stockpile
Frozen Soil Storage Area
Event Pond
Heap Leach Access Disturbance Footprint
Heap Leach Pad Base
Support Infrastructure
Water Management
Culverts
Pond Berm
Diversion Channel
Road Drainage Ditch
Underdrain
Collection Channel
Settling Pond Dam
Settling Pond
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0 500 1,000 1,500
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Figure 4.1-1
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GOLDCORP
580000
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584000
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6972000
Halfway Creek Catchment
YT-24 Catchment
Latte Creek Catchment
Dan Man Creek
Halfway Creek
YT-24
Latte Creek
Alpha Pond
Alpha WRSF
Frozen Soil Storage Area
Supremo Pit
Bulk Explosive Storage
Double Double Pit
Latte Pit
Kona Pit
Crusher
ROM Stockpile
Facility Pond
Organics Stockpile
Camp
Plant
Event Ponds
Heap Leach Facility

Table 4.1-1 Estimated Reduction of Flows in Receiving Streams Post Pit Dewatering

Catchment	Open Pit	Year Dewatering Completed	Year Pit Filling Complete	Total Years of Estimated Flow Reduction
Latte	SU1	7	10	3
	SU2	8	23	15
	SU4S	11	23	12
	SU4N	11	23	12
YT-24	SU3N	10	34	24
	SU5S	12	13	0.5
	SU5N	12	13	0.5
	SU3W	8	34	28
Halfway	Latte	2	32	30

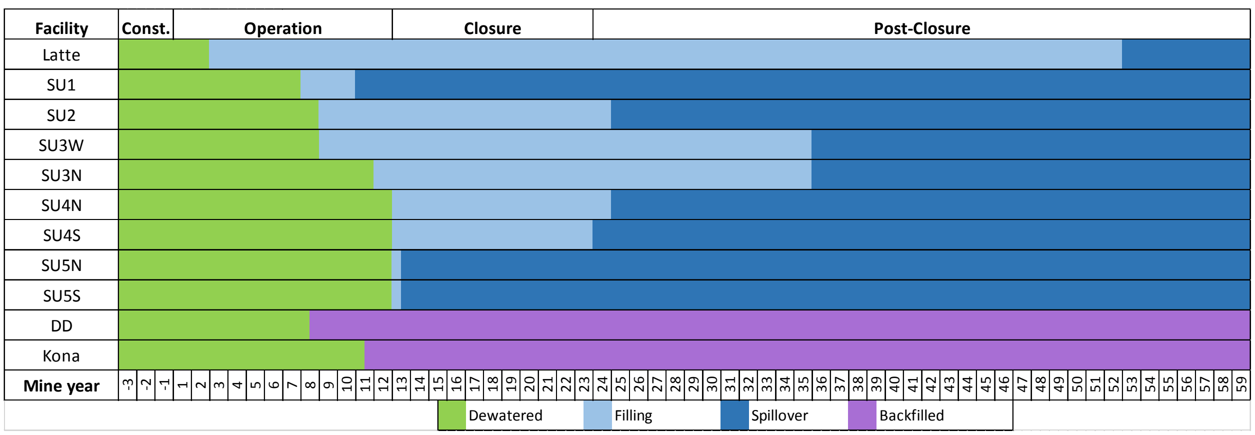


Figure 4.1-2 Open Pit Dewatering Schedule and Predicted Years of Filling and Spillover

4.2 SURFACE WATER

Further information on the expected discharge rates from the two sedimentation ponds is provided by catchment below.

4.2.1 LATTE CREEK CATCHMENT

The Facility Pond is within the Latte Creek catchment. This sedimentation pond and the associated water management infrastructure will be constructed in Year -1. Catchment boundaries of the Facility Pond in Year 12 are shown in **Figure 4.1-1**.

4.2.1.1 Facility Pond

The Facility Pond will collect contact water runoff from the ROM Stockpile, Plant Site and the Camp Site. The water management network for the Facility Pond is constructed in Year -2, and will not be modified subsequently. The Facility Pond contact water catchment area is 0.48 km^2, and remains constant. The predicted mean monthly discharge from the Facility Pond is shown in **Figure 4.1.2**, with peak mean monthly discharge rates of approximately 3.5 L/s during May. The actual discharge rate from the pond will be controlled during operations to ensure discharge quality objectives for TSS are met. The Facility Pond does not discharge to the environment, but rather this water is used in the HLF. The Facility Pond will be decommissioned at the end of Operations, following decommission of the Plant and Camp sites.

4.2.1.2 Upper Latte Creek

Contact water from the Double-Double Pit / backfill and the Supremo Pit / backfill (SU1, SU2, SU4S and SU4N) will be conveyed to Upper Latte Creek from the commencement of mining in Year -1. More specifically:

- Water accumulated in Latte Pit during Operations is routed to the HLF as process makeup water, and does not report to Latte Creek. Any excess water that accumulates in a large storm event will report to the Alpha Pond. Once this pit is mined out in Year 2, it will begin to fill, and is expected to reach the spill elevation during the Post-closure Phase.
- Dewatering of Double-Double Pit will occur from Year -1 to Year 8. A small volume of contact water is expected to flow to the SU1 pit and on to Upper Latte Creek from that time.
- The SU1 and SU2 portions of the Supremo Pit will be dewatered until Year 8. Upon completion of mining in SU1 and SU2, dewatering will cease, and the contact water volume reporting to Upper Latte Creek will be reduced as the pits are allowed to fill. The SU1 pit is expected to fill more rapidly than the SU2 pit, with the predicted time to spill being 3 years and 15 years, respectively.
- Dewatering of the SU4S and SU4N pits will cease in Year 12, and these pits are expected to spill 12 years after the cessation of operational dewatering.

4.2.1.3 Summary

With the above considerations in mind, the predicted mean monthly discharge from the Facility Pond is shown in **Table 4.2-1**.

Table 4.2-1 Predicted Mean Monthly Discharge Rates for the Facility Sedimentation Pond

Sedimentation Pond	Catchment Area (km^2)	Predicted Mean Monthly Discharge (L/s)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Facility Pond	0.32	0.0	0.0	0.1	2.6	2.6	1.4	2.1	1.6	1.4	0.6	0.0	0.0

The mean monthly discharge rates from the Facility Pond is shown graphically in **Figure 4.2-1**, to illustrate the variability through the year and through life of mine. The Facility Pond will be decommissioned in approximately Year 15, thus the effective discharge rate will drop to zero at this time.

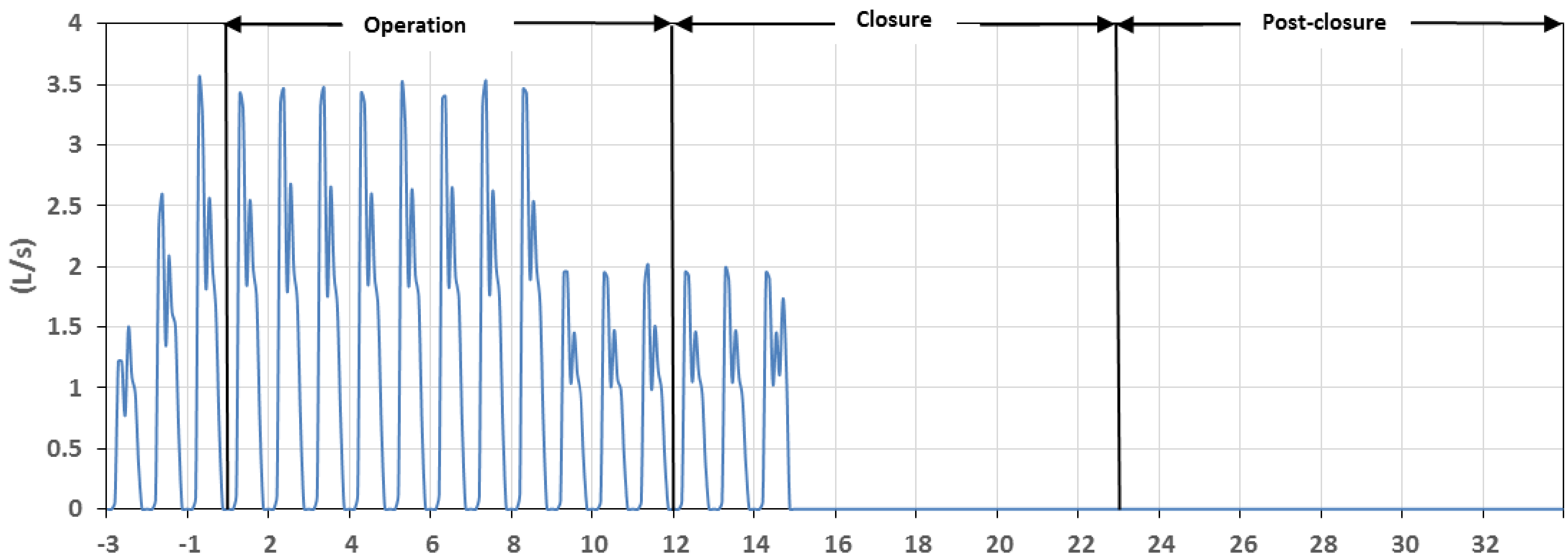


Figure 4.2-1 Mean Monthly Discharge Rates from the Facility Pond

4.2.2 HALFWAY CREEK CATCHMENT

The Alpha Pond will be situated within the Halfway Creek catchment. This pond, along with the associated water management structures, will be constructed and begin discharging water in Year -1. The catchment area for the Alpha Pond is 429.1 ha (**Figure 4.1-1**). These areas remain static through the Construction and Operation phases of the mine.

4.2.2.1 Alpha Pond

Contact water from the Alpha WRSF, frozen soil storage area, non-contact water from the HLF raincoat ponds and treated water discharged from the HLF water treatment plant will all route to the Alpha Pond via the Alpha WRSF rock drain. While mining of the Latte Pit is undertaken from Year -1 to Year 3, contact water collected in the Latte Pit will be routed to the HLF for use as process makeup water. Latte Pit is not predicted to spill over during the Operation and Reclamation and Closure phases. Any excess water that does accumulate in a major storm event will collect in Alpha Pond, as noted above. Contact water that accumulates in the Kona Pit sump from Year 1 to Year 11, while the Kona Pit is being dewatered, is expected to typically amount to less than 1 L/s, and is expected to be consumed in the Process Plant. In Q1 of Year 12, waste rock from the Beta WRSF will be used to backfill the Kona Pit. Water that contacts the backfilled pit will continue to be directed to the Alpha WRSF rock drain, and then to the Alpha Pond.

The predicted mean monthly inflow rates to the Alpha Pond are shown in **Table 4.2-2**. Because the capacity of Alpha Pond is so large, the instantaneous inflow rate to the pond does not need to equal the outflow rate. Water will accumulate in the pond when the discharge rate is less than the inflow rate, and the pond volume will increase. The discharge rate will generally be constant over storm events. Over longer timescales (months), the average monthly inflow and outflow rates will be equal.

Table 4.2-2 Predicted Mean Monthly and Rainfall Event Discharge Rates for the Alpha Pond

Sedimentation Pond	Catchment Area (km^2)	Predicted Mean Monthly Discharge (L/s)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Alpha Pond	4.29	0.0	0.0	0.0	1	172	92	95	80	70	32	1.8	0.0

The predicted mean monthly discharge from the Alpha Pond is shown graphically in **Figure 4.2-2**. The average monthly Alpha Pond discharge is predicted to reach maximums of 190 L/s during the Reclamation and Closure Phase, while the treated HLF draindown water is being directed to the Alpha WRSF rock drain. During the Post-closure Phase, this pond is predicted to discharge at an average monthly maximum rate of 100 L/s to 160 L/s.

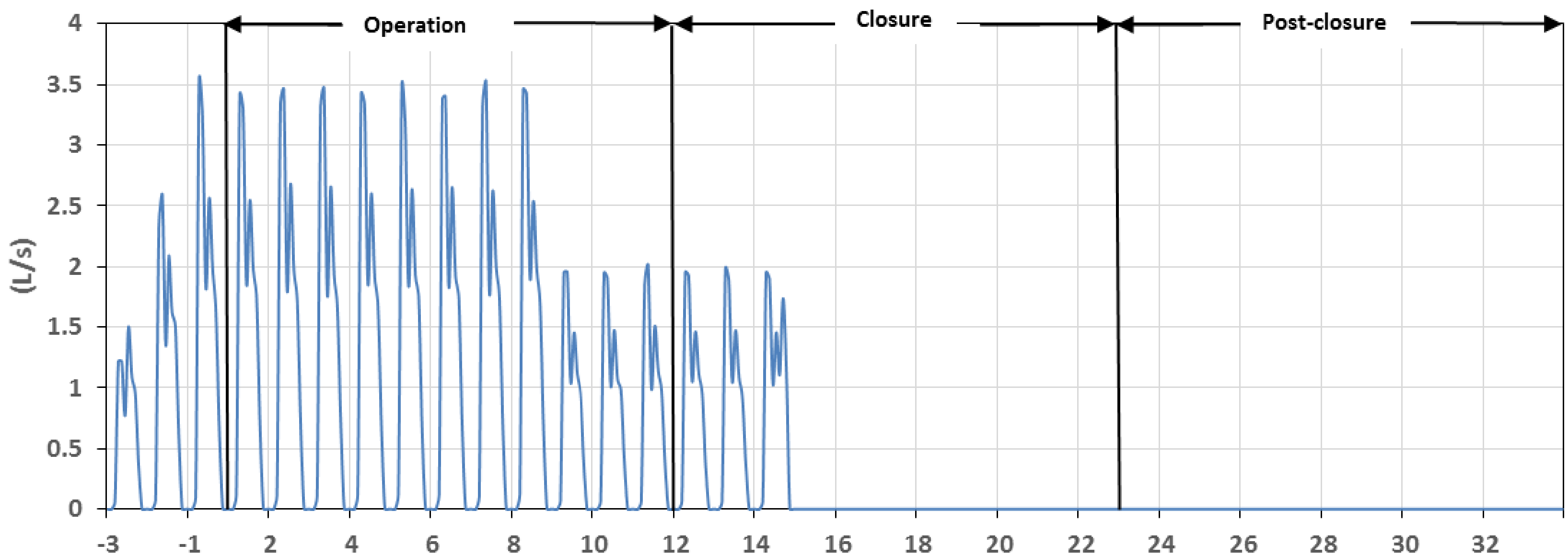


Figure 4.2-2 Mean Monthly Discharge Rates from the Alpha Pond

4.3 GROUNDWATER

Some water is expected to infiltrate into bedrock from the Open Pits. This is expected to be minimal given that the bottom of all pits are expected to be within permafrost at end of mine (EOM). Water that does infiltrate is expected to constitute a small contribution to surface water flows downstream of mine infrastructure. Consequently, it is not considered necessary to manage groundwater.

4.4 HEAP LEACH FACILITY

The HLF will be developed in stages and has been designed so that it functions as a closed system. Precipitation that falls on the exposed heap pad will be collected, and used internally, in the heap leach and gold extraction process. Consequently, site-wide water management need consider the HLF only to the extent that makeup water is withdrawn from the Mine Site, and when treated water that meets effluent discharge criteria is discharged from the HLF to the Alpha Pond during Operation and early Reclamation and Closure phases. Once the water treatment plant is decommissioned, HLF seepage will report to the Latte Pit.

Precipitation is expected to supply most of the required rinse and process water. Some additional water will be required to initiate the heap leach. Some make-up water may also be required from time to time in dry periods. This will be supplied from the Facility Pond, Kona Pit sump, and Latte Pit sump.

- Three event ponds will be constructed as part of the HLF (EP-1S, EP-1N and EP2) to contain water in upset conditions, which may include:
- Heap draining during an extended power or pumping outage
- Extreme precipitation and freshet events, and
- Cumulative water storage during wet years or temporary shut downs.

Raincoats (geomembrane covers) will be used to cover portions of the heap as it is developed, to reduce the amount of precipitation infiltrating into the heap and entering the process solution, and to increase heat retention in winter. The raincoats will remain in use over portions of the heap until individual sections are progressively reclaimed (rinsed and capped).

Rainwater that is shed by the raincoats will be collected in a rainwater pond and used as makeup water during drier periods, and as a supply of freshwater for rinsing parts of the heap during progressive reclamation. **Table 4.4-1** provides a summary of the storage capacity of the event and rainwater ponds.

Table 4.4-1 Event Ponds and Rainwater Pond

Pond	Construction Year	Design Criteria Capacity[a] (m^3)	Storage Capacity[b] (m^3)
EP-1N	Year -1	191,360[c]	112,349 (122,184)
EP-1S	Year -1		89,777 (97,810)
EP-2	Year +6	210,000	222,874 (240,468)
Rainwater	Year +3	47,000	47,000 (51,925)

Notes:

a. The event pond design capacities include seasonal water accumulation, full heap drainage, the 24-hour Probable Maximum Precipitation (PMP) storm event, and seasonal solution accumulation.

b. Storage capacity to free board elevation (to crest elevation)

c. Combined containment capacity required through Year 6.

5.0 PRELIMINARY ENGINEERING DESIGN

The following sections summarize the preliminary design.

5.1 SUPPORTING INFORMATION

5.1.1 HYDROLOGY

Hydrologic data used in the design of water management infrastructure was developed by Lorax (**Appendix 8-A Coffee Gold Project: Hydro-meteorology Baseline Report**) and AECOM (2012) to estimate runoff volumes, peak flow rates and catchments. Reference material includes:

- Rainfall depths for each return period and duration
- Hydrologic parameters for approximate Soil Conservation Service (SCS) hydrologic soils groups are based on AECOM (2012)
- Snowpack and snowmelt data from nearby snow pillow stations in Alaska, and
- Long-term synthetic monthly flow hydrograph for Halfway Creek (HC-2.5).

5.1.2 TOPOGRAPHY AND SITE LAYOUT DRAWINGS

All topographic and photogrammetric survey data were provided by the Proponent and AECOM. The proposed design documents for development of the Mine Site were provided by the Proponent and JDS Energy & Mining Inc.

5.1.3 SOIL CHARACTERIZATION

Geomorphological terrain mapping (AECOM 2012) shows soil texture, geomorphologic process, surficial materials, and drainage characteristics. The soils were divided into seven characteristic draining categories in terms of expected infiltration or runoff performance. Drainage performance was estimated using the identified soil properties, with expected performance ranging from very well-drained to very poorly-drained. These categories are slightly more complex than the SCS method; however, the categories have been redefined from Drainage Classification to Soil Classification (**Table 5.1-1**) for simplicity and compatibility with the HEC-HMS model. See AECOM (2012) for geomorphology mapping of the site.

Table 5.1-1 Drainage Classification and SCS Soil Classification Conversion

AECOM –Drainage Classification	Very Rapidly Drained	Rapidly Drained	Well Drained	Moderately Well Drained	Imperfectly Drained	Poorly Drained	Very Poorly Drained
Symbol	x	r	w	m	I	p	v
SCS Soil Classification	A		B		C		D
Woods/grass (CN)	32		58		72		79

AECOM 2012

The soils within the drainage basins consist of thin soils overlying permafrost at depths zero to more than 5 m. Soil depth increased from the ridge lines to the valley floors. For the design presented, the developed areas are assumed to be overlain with 2 m of soil.

5.2 Design Criteria

5.2.1 Water Classification

Water on site is classified into three types (Error! Reference source not found.).

Table 5.2-1 Water Classification

AECOM –Drainage Classification	Very Rapidly Drained	Rapidly Drained	Well Drained	Moderately Well Drained	Imperfectly Drained	Poorly Drained	Very Poorly Drained
Symbol	x	r	w	m	I	p	v
SCS Soil Classification	A		B		C		D
Woods/grass (CN)	32		58		72		79

AECOM 2012

Each water type is managed separately. Non-contact water is diverted away from mine infrastructure to the extent possible to reduce infiltration into WRSFs and pit inflows. Contact water is intercepted and conveyed by a system of berms and channels to sedimentation ponds and pit lakes. The purpose of the water management system is to collect and treat impacted water to meet discharge objectives for TSS.

5.2.2 Component Definition

Water management at the Project area will consist of multiple conveyances and sedimentation ponds. The sedimentation ponds have a finite operational life, and will be operated until water quality from site runoff meets site-specific post-closure water quality objectives, after which they will be decommissioned.

Diversion berms and channels intercept and route surface runoff to pit lake reservoirs and sedimentation ponds, and will be decommissioned after post-closure water quality objectives are met.

Pit lakes may develop in the completed pits that have not been backfilled.

5.2.3 Hydrotechnical Design Criteria

The hydrotechnical design criteria for the Project are based on best engineering practices, professional engineering judgement and/or constructability considerations. Design criteria for water management infrastructure are presented in **Table 5.2-2**, **Table 5.2-3**, **Table 5.2-4**, **Table 5.2-5**, and **Table 5.2-6**.

Table 5.2-2 Hydrologic Design Criteria for Estimating Peak Flows

Item	Value	Unit	Source
Maximum Snowmelt Rate	26	mm/day	SRK
Rainfall Distribution	SCS Type I	-	NRCS
Minimum Time of Concentration	10	minutes	Engineering Judgement
Rainfall Depth			
1: 10 Year Return Period	55	**mm**	Lorax 2015a
1: 100 Year Return Period	79	mm	Lorax 2015a
1: 200 Year Return Period	90	mm	Lorax 2015a

Table 5.2-3 Sedimentation Pond Design Criteria

Item	Value	Unit	Source / Comments
Rainfall Return Period	10	Years	(BC MOE, December 2015)
Minimum Retention Time	48	hours	Operational Consideration
Storage Requirement – Facility Pond	10-year 24-hour storm	m³	(BC MOE, December 2015)
Storage Requirement – Alpha Pond	100-year freshet with discharge to allow time for settling	m³	Engineering Judgement
Minimum Freeboard	1.0	m	Engineering Judgement
Outlet Structure Return Period	100	Years	Operational Consideration
Emergency Spillway Return Period	200	Years	(BC MOE, December 2015)
Minimum Particle Size Settling Requirement	5	µm	(BC MOE, December 2015)

Table 5.2-4 Diversions and Berm Design Criteria

	Item	Value	Unit	Source / Comments
Diversion Channel Design	Rainfall Return Period	100	Years	BMP
	Base Width Range	1 - 5	m	Engineering Judgement
	Minimum Channel Depth	1	m	Engineering Judgement
	Conveyance Capacity	24-hour total rainfall volume + Snowmelt	m³	BMP
	Minimum Freeboard	0.3	m	BMP
	Side Slopes	2:1	(H:V)	Constructability Consideration
	Manning's Roughness	0.035	-	For minor natural steam with stones and weeds (Chow, 1994)
	Minimum Slope	0.005	m/m	BMP
Diversion Berm Design	Minimum Top Width	1	m	Engineering Judgement
	Minimum Berm Height	1	m	Engineering Judgement

	Item	Value	Unit	Source / Comments
	Side Slopes	2:1	H:V	Constructability Consideration
Pond Embankment Design	Freeboard	1.0	m	Engineering Judgement
	Crest Width	14	m	Engineering Judgement
	Liner Tie-Back Length	3	m	Engineering Judgement
	Upstream Side Slope	3:1	(H:V)	Constructability Consideration
	Downstream Side Slope	2:1	(H:V)	Constructability Consideration
	Riprap Layer Thickness	0.5	m	Engineering Judgement

Table 5.2-5 Rock Drain Design Criteria

Item	Value	Unit	Source / Comments
Event Return Period	100	Years	
Conveyance Capacity	2 x 24-hour total rainfall volume + snowmelt	m^3	

Table 5.2-6 Culvert Design Criteria

Item	Value	Unit	Source / Comments
Event Return Period	100	Years	BMP
Conveyance Capacity	24-hour total rainfall volume + Snowmelt	m^3	BMP
Maximum Headwater Depth above Culvert	0.3	m	BMP
Manning's Roughness for culverts without cobble stone base	0.024	-	(Chow, 1994)

5.3 PRELIMINARY DESIGN

The preliminary design of the water management system is described in the following sections.

5.3.1 CATCHMENT DELINEATION

Catchments for containing mine infrastructure were delineated for the mine based on available topography, and the latest mine plan, using AutoCAD (AutoDesk) software. The areas for each catchment were used to determine preliminary sizing of sedimentation ponds, and will be used to size conveyance structures at the next stage of the Project.

5.3.2 HYDROLOGIC MODEL

The hydrologic modeling program HEC-HMS version 4.1, U.S. Army Corps of Engineers (USACE 2013), was used to perform the hydrologic calculations. Methods and assumptions for the HEC-HMS model parameter inputs are discussed below.

5.3.2.1 Snowmelt

Snowpack and snowmelt data were analyzed. Historic data for the immediate Project area are limited. To determine approximate snowmelt depths, nearby snow pillow stations in Alaska were analyzed. These stations are located from 150 km to more than 300 km from the Mine Site. SRK reviewed the estimates, and assumed an average snowmelt depth of 26 mm/day for the site. The daily snowmelt depth was transformed into flow rates by multiplying the catchment area. Snowmelt was included in the HEC HMS model as a constant flow when running the peak flow simulations.

The average daily snowmelt runoff rate was used. A snowmelt hydrograph for the site was not developed to account for variation in snowmelt over a 24-hour period.

Transformation of Precipitation to Flow

The SCS Unit Hydrograph method was used to transform precipitation into an outflow hydrograph for each sub-area. HEC-HMS uses a single input parameter, the lag time (T_{lag}), defined as the time between the centroid of precipitation mass to the peak of the resulting hydrograph. The basin lag time can be determined from lag time directly or time of concentration using the National Resource Conservation Service (NRCS) method. The NRCS transformation is T_{lag} = 0.6*Tc. Time of Concentration and resulting lag times are relatively short (<15 minutes). This results in peak discharges near the time of the storm peak. The time of concentration was estimated with the methods cited in Li et al (2008). A minimum time of concentration of 10 minutes was applied to all catchments.

The SCS Type I rainfall distribution was selected for use in the HEC-HMS model. This distribution approximates an intense, short-duration storm event typical of storms in Yukon and nearby interior Alaska. SRK (2015) compared climate and hydrological information to publicly available information. SRK's analysis concluded that the information adequately characterized the regional dataset for the purposes of the preliminary design of the water management system.

5.3.2.2 Channel Routing

The Muskingum-Cunge routing method transforms a hydrograph within a catchment along a channel reach. Input parameters for routing reaches were based on designed channel geometries.

The SCS Curve Number method accounts for losses of total precipitation (NRCS 1986). This method was used to estimate runoff as the difference between precipitation and losses of precipitation. Precipitation losses include absorption, evaporation, transpiration, and surface storage. An Antecedent Moisture Condition of 2 (AMC II) was assumed for the site. AMC-II is average conditions existing before a maximum annual flood. AMC-I is dry soils after a period without rain. AMC-III is saturated soil due to heavy rainfall during five days prior to a storm. The Curve Number is also dependent on the SCS hydrologic soil group (A through D), land use type, and vegetative cover condition.

Vegetated areas within the Project limits are considered undisturbed and consist of a mixed shrub, tundra grasses, deciduous and coniferous forest. The soils are generally classified as moderately-well-drained to poorly-drained (AECOM 2012). The SCS soil classifications expected for the soil types assume grouping of similar drainage classifications and comparing to soil types present. Conservatively, an average Hydrologic Soil Group of B, C or an average of the two was used in the HEC-HMS model. The forest cover is considered to be in good condition for all areas within the disturbance footprint. The corresponding curve numbers (**Table 5.3-1**) are for undisturbed and disturbed areas.

Table 5.3-1 Project Area SCS Curve Numbers (CN)

Generalized Areas	CN	Drainage Classification (Average)	Notes
Undisturbed Areas[1]			
Alpha WRSF	72	Imperfect – Poorly	Average of Drainage Classification for the soils found within the drainage area.
Mill Site and Kona Pit	72	Imperfect – Poorly	
Disturbed Areas			
Waste Rock Storage Facilities	75	N/A	No cover, assumes compacted benches.
Covered WRSFs	80	N/A	Assume GCL liner and a vegetated cover of minimal depth.
Pits	80	N/A	Rock walls and fractured bedrock.

[1]Undisturbed areas

5.3.2.3 Interpretation of Results

Watershed areas, precipitation, precipitation loss, transformation and channel routing were added as inputs into HEC-HMS to estimate runoff potential for the study area

Model results were used to evaluate peak instantaneous flows and required storage volumes for channels and ponds, respectively.

5.3.3 CONVEYANCE DESIGN

The channels will be designed to convey the 100-year, 24-hour peak flows and will have a minimum of 0.3 m of dry freeboard for the peak flow event to allow for possible ice buildup, sedimentation, and climatic and natural uncertainties.

Prior to construction, seeps and perennial streams will be identified and mapped. These water sources could present locations where ice and glaciation could occur and impede channel flow, especially during spring freshet. As the design progresses, the channel configuration may be adjusted to accommodate potential glaciation and ice buildup in these locations. Channels will have freeboard to account for variation in storm intensities and will also provide storage for ice buildup.

Conveyance structures are classified into five categories based on the location of the structure and its purpose:

1. Waste Rock Toe Collection Channels
2. Waste Rock Surface Diversion Channels
3. Drainage Ditches
4. Diversion Berms
5. Waste Rock Bench Diversion Ditches

5.3.3.1 Waste Rock Perimeter Collection Channels

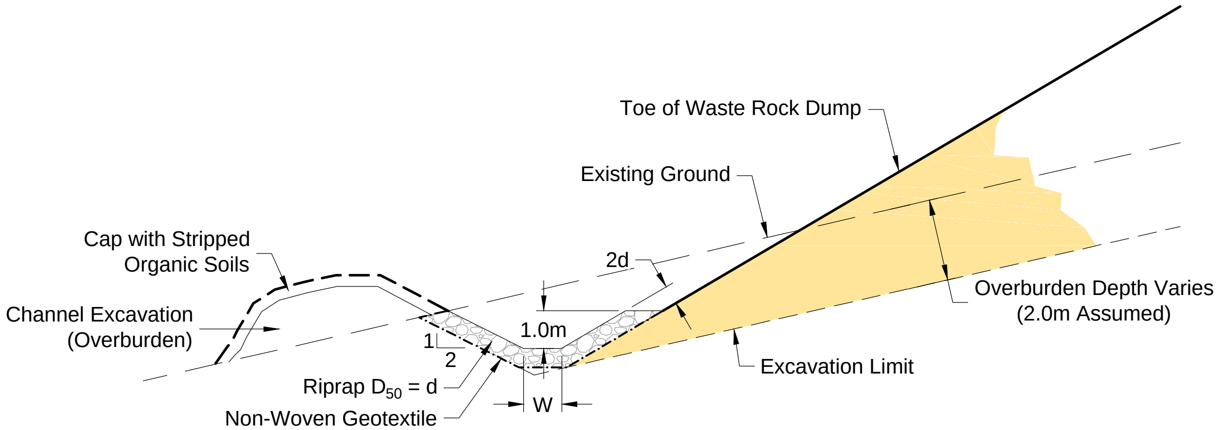
The waste rock collection channels will be situated around the perimeter of the WRSFs, and will be excavated into existing ground. These collection channels will collect waste rock runoff and captured flows to the downstream sedimentation pond.

Each channel will be constructed prior to waste rock placement as needed. Overburden material will be stripped from the existing ground as part of the WRSF preparation. The channel will be excavated into the underlying material and the stripped overburden material will be placed to form a small berm downgradient of the excavation limits. This berm will be capped with stripped organic soils.

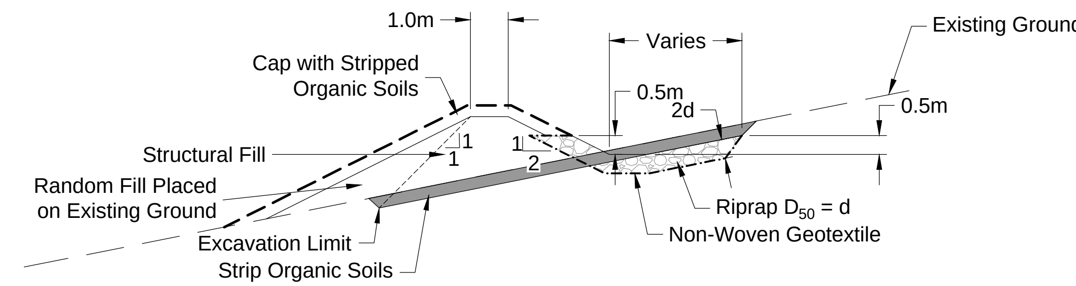
The channel excavation footprint will be lined with a nonwoven geotextile, followed by a layer of riprap. The riprap thickness will be 2 times the D50 rock size diameter. A typical cross-section for the waste rock toe collection channels is presented in **Figure 5.3-1**. The channels will be designed in detail as the Project progresses.

COFFEE GOLD MINE

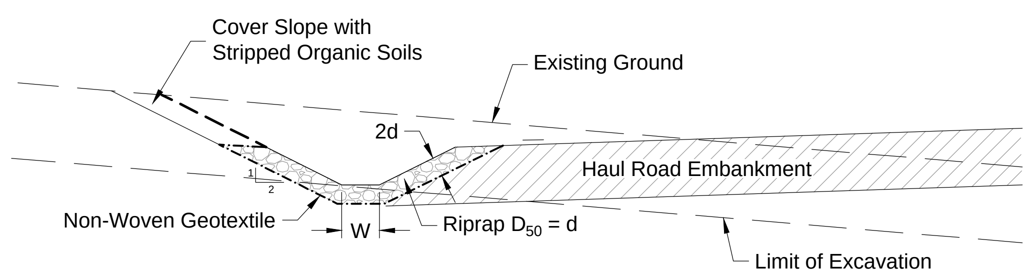
Typical Cross-sections for Water Management Infrastructure



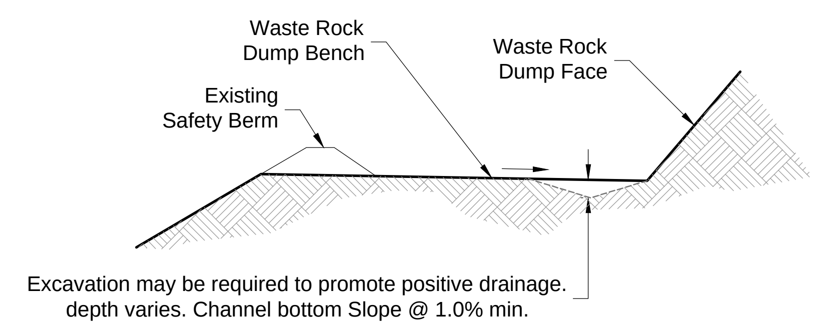
Detail 1 - Typical Section
Waste Rock Perimeter Collection Channel



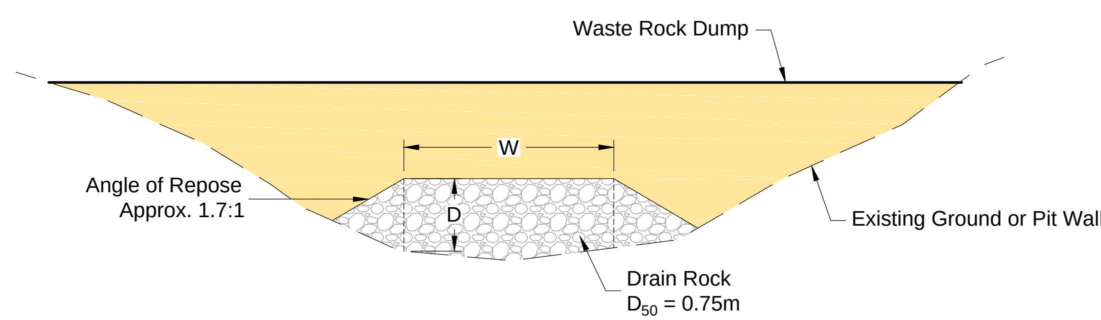
Detail 2
Typical Section - Diversion Berm



Detail 3 - Typical Section
Haul Road Drainage Ditch



Detail 4 - Typical Section
Waste Rock Bench Diversion Ditch



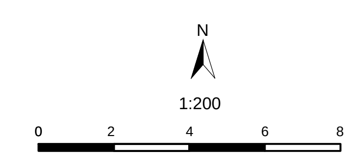
Detail 5 - Typical Section
Waste Rock Dump Rock Drain

Legend

- Waste Rock Dump
- Rip Rap
- Haul Road Embankment
- Existing Ground
- Impervious Liner
- Non-Woven Geotextile

Notes

1. This figure is not intended to be a "stand-alone" document, but a visual aid to the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.



NAD 1983 UTM Zone 7N

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Figure 5.3-1	Date: Mar 30, 2017	Drawn by: TAH	Reviewed: DP/TS

GOLDCORP

5.3.3.2 Diversion Berms

Non-contact water is will be diverted around the Double Double Pit, Kona Pit and upgradient of the Alpha rock drain by a diversion berm, and discharged towards the valley bottom. The diversions will be designed at detail design but will consist of either building a berm on the natural slope or creating a v-notch channel on natural ground. The Alpha WRSF diversion berm along the west toe of the facility will be formed by an access road to the Alpha Pond. The berms will be built after stripping the organic top soils and a layer of riprap will be placed along the berm face and channel bottom to reduce erosion of natural soils.

A typical cross-section of the berms is shown in **Figure 5.1-1**.

5.3.4 DRAINAGE DITCHES

Haul and access roads will be sloped inwards. Runoff from the haul and access roads will drain across the roads to the upgradient side slope, where the drainage ditch runs parallel to haul or access road. These ditches direct runoff to a downgradient conveyance structure such as culverts or in some cases, an Open Pit. Best management practices will be applied along haul and access roads to reduced erosion.

Theses ditches will be excavated into the original ground at the toe of the haul road embankments, in a similar fashion to the waste rock toe collection channels being located at the toe of the WRSFs. The ditches were will be designed with a minimum channel depth and width of 1.0 m. A non-woven geotextile will be placed along the top of the exposed soils, followed by a layer of riprap. **Figure 5.1-1** shows a typical cross-section for the drainage ditches.

5.3.4.1 Waste Rock Bench Diversion Ditches

The benches on the WRSFs will be designed to slope inwards away from the WRSF crest. Runoff will be concentrated along the inside of each bench and prevented from running over the WRSF face by a series of diversion berms, creating the waste rock bench diversion ditches. Runoff is diverted to the perimeter of the WRSFs and collected in the waste rock toe collection channels at the WRSF perimeter. Maintaining this drainage pattern during operations may be challenging, and a variation of channels and berm cuts directing runoff down the WRSF face may be considered for minor runoff volumes.

The channels will have a v-shaped cross section, and will have a minimum slope of 1% towards the perimeter waste rock toe collection channels. A typical cross-section is presented in **Figure 5.1-1**.

5.3.4.2 Erosion Control

To protect channels and diversion berms from erosion, rock armor (riprap) size will be determined using NRCS Practice Standard 486 as developed for the United States Federal Highway Administration (Robinson 1998). The Practice Standard uses the Manning's equation and an iterative calculation to determine the depth and velocity of flow. Manning's n is based on depth of flow over a rough surface and varies depending on riprap size and slope based on the expressions of Strickler, Anderson and Abt et al (1988). The practice calculates a stable median riprap size (D50) to resist the tractive force of design peak flow in the channel. As a check for riprap size, two other methods will be applied (Isbash 1935, Khan and Ahmad 2011). The NRCS method tended to return slightly larger D50 sizes, so the results were used in the design to be conservative.

Riprap thickness for the design is assumed to be 2 times D50. The Surface Mining Water Diversion Design Manual (OSM, 1982) suggests riprap lining for steep channels (i.e., slopes greater than 10%) be 1.5 to 2 times the D50; for mild slope channels (i.e., slopes less than 10%) recommended riprap lining thickness is 1.5 times the D50.

The riprap will be placed over a non-woven geotextile drainage fabric. The geotextile fabric is intended to form a stable, non-erodible surface to minimize migration of underlying soils downstream, and reduce the likelihood of embankment failure and erosion. Alternatively, a drainage layer of sorted crushed stone could be placed under the riprap in lieu of geotextile fabric. Geotextile fabric is the preferred alternative for cost and ease of installation; however, the gravel filter layer may have a longer life expectancy.

Additional details of erosion and sediment control practices that will be used for the Project will be described in the **Erosion and Sediment Control Plan (Section 31.0 Environmental and Socio-economic Management Programs)**.

5.3.4.3 Permafrost Protection

Construction in permafrost and ice-rich soils present on site will be carefully analyzed prior to final design. Geotechnical investigations in the summer of 2016 collected information on ice-rich soils near the sedimentation pond dams. Soils on site are presumed to be shallow with depths ranging from 1 to 5 m for most of the site (AECOM 2012). The design presented assumes surficial soils are 2 m in depth. Channels will be constructed as part of the foundation preparation for the WRSFs, or incorporated into the haul or access roads and other infrastructure. Placing spoil material on the downslope side of the berms and channels may promote permafrost aggradation in the embankment, further increasing the stability of the conveyance. The final design presented for all surface water structures will be optimized as more geotechnical and permafrost information becomes available.

5.3.5 ALPHA ROCK DRAIN

The Alpha rock drain is a flow-through drain that will convey water through the base of Alpha WRSF during the Construction Phase, Operation Phase and Reclamation and Closure Phase. **Figure 4.1-1** shows the location of the rock drain.

The rock drain is designed to accommodate up to two times the 100-year, 24-hour storm event with average snowmelt runoff (**Table 5.3-2**).

Table 5.3-2 Preliminary Rock Drain Summary

Name	Storm "Q" (m^3/s)	Minimum Bottom Width (m)	Minimum Height (m)	Drain Rock D_{50} (m)	Approximate Volume (m^3)
Alpha Rock Drain	17.9	30	8	0.3	985,000

The Alpha WRSF rock drain will be constructed in areas where permafrost may be present; however, the majority of the area has been mapped as unfrozen based on the TT EBA (2016) permafrost mapping. Perennial freezing within the drain is not expected. Localized areas of the drain may freeze during the winter as groundwater seeps into the channel, but this ice will melt during freshet flows.

Based on industry standards, the material used to construct the rock drain will have a D_{50} of 0.3 m. This rock will either be selected and segregated by screening or end dumping of the waste rock. It has also been assumed that the rock drain will have a porosity of 30%. Based on these assumptions, and applying a factor of safety of 2, the cross-sectional area of the Alpha WRSF rock drain will be 615 m^2. The safety factor of 2 is conservative and has been applied to the cross-sectional areas of the rock drain to account for:

- potential migration of fine grained materials into the voids in the drain
- potential freezing of the drain
- decrease in void ratio over time due to compression
- potential degradation of the rock drain material over time.

The safety factor and these assumptions will be re-evaluated once the drain rock material has been selected during detailed design and once the site-specific conditions of the rock drains are further evaluated. **Table 5.3-2** summarizes capacity and design specifications for rock drains.

5.3.6 Sedimentation Ponds

Runoff from the Mine Site will be routed to two sedimentation ponds located downstream of proposed mining areas (**Figure 4.1-1**):

- Alpha Pond, and
- Facility Pond.

The ponds will serve two purposes. Firstly, they will settle the total suspended solids (TSS) load prior to discharge, and secondly, they will reduce the peak discharge rate of a storm by attenuating (storing and releasing) runoff and discharging it at a lower peak rate. The Alpha Pond will also have the capacity to hold the 100-year freshet flow while discharging water at a maximum rate of 5,000 GPM (gallons per minute). This will give flexibility to manage runoff and seepage from Alpha WRSF.

Pond locations are based on the latest WRSF footprints and current geotechnical information for proposed dam footprints. A detailed geotechnical investigation is required in order to advance the dam design and location selection. The results of this investigation may shift the dam locations slightly. This may affect catchment areas contributing to each pond and increase or decrease the design inflow volumes. For this reason, the detailed design of outflow structure will be finalized when the dam design is finalized.

5.3.6.1 Pond Sizing

Facility Pond

Rainfall on the site occurs during spring freshet, throughout the summer, with an occasional major storm event. Sizing the sedimentation pond volume requires an assessment of the average expected runoff during a given year. The maximum one-day precipitation event is equal to approximately 17 mm (**Appendix 8-A Hydro-meteorology Baseline Report**). The 1-year depth represents a volume much less than the volume generated during the 10-year, 24-hour rainfall event (55 mm) for which the Facility Pond was sized.

The maximum average daily snow melt during spring freshet will generate a runoff volume approximately 1.5 times that of the 10 year, 24-hour storm event. The TSS loading from snowmelt is usually less than the erosion from runoff generated by intense summer storms. Additionally, flocculant can be added to pond inflows to enhance settling. **Section 5.3.6.1** presents pond sizing and preliminary dam configurations.

Runoff volumes greater than the 10-year event, but less than or equal to the 200-year event, will be discharged through an outlet structure. Storms up to the 200-year event will be routed through the emergency spillway. Peak discharge (m^3/s) from the ponds will be at a rate less than or equal to the pre-development rates for storms less than or equal to the 10-year, 24-hour event.

Alpha Pond

The Alpha Pond will be sized to manage the 100-year freshet volume while discharging water from the pond at 0.32 m^3/s. This will provide sufficient time for TSS settling (~12 days).

The long-term synthetic time series for HC-2.5 (Lorax 2016) was used to generate monthly flows for the developed catchment areas upstream of Alpha Pond. The catchment delineation was based on the maximum footprint of the mine layout, including backfilled Kona Pit, Beta WRSF and the final Alpha WRSF footprint.

Table 5.3-3 provides a summary of maximum peak average monthly freshet volumes for a range of return period and required volume of impounded water at a maximum discharge rate of 0.32 m^3/s.

Table 5.3-3 Alpha Pond Monthly Inflow Rates and Volumes for Different Freshet Return Periods

Return Period	Maximum Monthly Flow [m^3/s]	Inflow Volume [$m^3/month$]	Pond Volume [m^3]
100	0.44	1,135,040	357,400
50	0.40	1,038,850	261,250
20	0.35	904,170	126,570
10	0.31	794,170	16,572

The Alpha Pond was sized to have the operational ability to manage the 100-year freshet volume with discharge from the pond. Additionally, the pond is sized to manage TSS in the 100-year freshet volume by providing enough volume (residence time) for settling (~12 days). The Alpha Pond volume is approximately two times the volume of the 100-year 24-hr storm event (i.e., 163,000 m^3).

Runoff volumes greater than the 100-year freshet will be routed downstream and storms up to the 200-year event will discharge from the emergency spillway.

5.3.6.2 Pond Dams

The sedimentation ponds will be constructed by building a dam at the downstream end of the pond to satisfy the storage requirements shown in **Table 5.3-4**. Conceptual locations of the dams are shown on **Figure 4.1-1**. Pond locations may shift within the mine footprint as information on the detailed geotechnical investigation of the dam foundation areas become available. Additionally, it may be possible to excavate the ponds instead of building a dam.

Table 5.3-4 Drainage Areas and Storage Volumes for Alpha Pond and Facility Pond

Description	Drainage Area [km2]	Required Storage Volume [m3]
Alpha	6.27	357,400
Facility	0.32	9,400

Dam design criteria are summarized in **Table 5.2-4**. The dams will be constructed of ROM rock or locally sourced material and overlain by a protective layer, an impervious liner, confined by a fine-grained material, and covered by layer of riprap on the upstream face. Liner key-trench details will be designed in greater detail after geotechnical investigations characterize subsurface conditions, namely depth to bedrock and distribution of frozen soils (if present).

5.3.6.3 Pond Discharge Infrastructure

The sedimentation ponds will retain runoff volumes by controlling outflows. Outflow infrastructure will be sized to maximize the retention time of smaller storms but also allow a minimum of 48-hours retention time for the 10-year, 24-hour storm event. Several options will be investigated which will include spillways, pumps and siphons.

Outflow structures will be designed in detail once the pond configurations have been finalized after a detailed geotechnical investigation of the subsurface in the proposed dam locations. Storms greater than the 200-year event will discharge over the emergency spillway.

5.3.6.4 Pond Settling Capacity

The sedimentation ponds will reduce TSS by allowing settling of the sediment to occur and thereby improve water quality at the discharge point. Reduction of TSS will be accomplished by gravity settling during extended retention and/or by the addition of flocculent. Stokes law was used to calculate particle-settling velocity. The potential range in TSS concentrations of mine contact water is unknown. The depth a particle ranging in size from 5 μm to 100 μm (clay to fine sand sized particles) would settle in 12 and 48 hours, respectively, was estimated using Stokes Law **(Table 5.3-5**). During spring freshet, snowmelt runoff will be retained in the pond for approximately 12 hours or less. During storms up to the 10-year 24-hour event, the retention time is up to 48 hours.

Table 5.3-5 Particle Settling Rates Calculated with Stokes Law

Particle Size (μm)	Settling Rate (m/hr)	Settling Depth in 12 hours (m)	Settling Depth in 48 hours (m)
100	29.4	352	1,411
75	16.5	198	792
45	5.96	72	286
30	2.65	32	127
20	1.18	14	57
15	0.662	7.9	32
10	0.294	3.5	14
5	0.074	0.9	3.5
1	0.003	0.04	0.14

5.3.6.5 Flocculation Stations

Flocculant may be used to enhance settling when needed. If determined to be necessary or desired, flocculent dosing stations may be installed at the sedimentation pond inlets, or closer to sediment sources and will contain a flocculent metering system to add flocculent proportionally to flow. Flocculent dosing rates will be determined by on-site bench scale testing. A non-toxic anionic or non-ionic flocculent may be used.

5.3.7 SEDIMENT REMOVAL

Sediment accumulated within the sedimentation ponds will be removed as needed. The volume of sediment that has accumulated in the ponds will be monitored annually. If warranted, sediment will be removed from the ponds during low flow periods of the year, most likely in the late fall. The water level will be lowered, sediment will be removed and haul to a storage site. Potential storage sites include dedicated cells within the WRSFs or completed pits.

5.3.8 CULVERTS

Culvert crossings will be required to facilitate runoff conveyance across the haul roads. All culverts will be circular corrugated steel pipes (CSP) with a corresponding Manning's roughness of 0.024. The culverts will be placed in a compacted fine grained engineering fill according the appropriate manufacturers specifications. Sizing of culverts and locations will be designed as the Project progresses.

5.3.9 WATER TREATMENT OF EXCESS HEAP LEACH RINSE SOLUTION

Progressive reclamation of the HLF will entail rinsing of individual sections of the heap leach ore that has completed the gold recovery cycle. As such, potential parameters of concern have been identified as those elements in heap leach rinse solutions that are predicted to be at concentrations unacceptable for direct discharge to the receiving environment and will therefore require treatment prior to release.

The processing of heap leach ore at the Project will entail the use of dilute cyanide solutions under pH conditions ranging between pH 10.5 and 11.0. While the dissolution of gold is the primary chemical process occurring during cyanide leaching, other metals are liberated during the leaching process, both as a result of complexation reactions with cyanide (e.g. Cu-CN, Cd-CN, Zn-CN) and increased solubility under elevated pH conditions (e.g. arsenic (As) and uranium (U)). In addition, natural degradation of cyanide in situ within the HLF results in elevated concentrations of nitrogen species in heap leach solutions. Collectively, leaching of heap leach ores is predicted to produce leaching solutions with chemical characteristics as summarized in **Table 5.3-6** below as determined through metallurgical column leach testing. This process solution will only report to the ADR plant and will not be directed to water treatment.

Table 5.3-6 Summary of Expected Heap Rinse Solution Water Quality following Final Rinsing

Parameter	Concentration Range	MMER Limits[1]
pH	8.0 - 9.0	6.5 - 9.0
Total Suspended Solids	1.0 - 10.0	15.0
CN_{Total}	1.0 - 5.0	1.0
CN_{WAD}	0.2 - 1.0	
Sulphate	100 - 500	
Ammonia-N	5 - 20	
Nitrite-N	1.0 - 10.0	
Nitrate-N	100 - 300	
As	1.0 - 2.0	0.5
Sb	0.1 - 1.0	
Cd	0.0005 - 0.001	
Cu	0.01 - 1.0	0.3
Fe	0.5 - 5.0	
Hg	0.0005 - 0.001	
Pb	0.001 - 0.02	0.2
Ni	0.05 - 0.13	0.5
U	0.1 - 0.5	
Zn	0.1 - 1.0	0.5

Notes: all units as mg/L except pH
[1] maximum authorized monthly mean concentra

Phase I - Preliminary rinsing of the leached ore using pH adjusted (e.g., pH 7.5 to 8.0) barren solution, which will continue until the chemistry of the heap effluent reaches approximate equilibrium with the rinse solution.

Phase II - Final rinsing of the heap will be performed using fresh water, stored in the rainwater pond, and/or treated rinse solution. The heap effluent from final rinsing will then be used as either rinse water for preliminary rinsing, or as makeup water for the process circuit until active leaching for gold recovery is completed.

Heap rinse solutions following Phase I rinsing are anticipated to have water quality characteristics in the range as summarized in **Table 5.3-7**.

Table 5.3-7 Summary of Expected Heap Rinse Solution Water Quality following Initial Rinsing

Parameters of Concern	Expected Range of Concentrations (mg/L)	MMER Limits[1] (mg/L)
pH	8.0 – 9.0	6.5 – 9.0
Total Suspended Solids	1 - 10	15
CN_{Total}	1 - 5	1
CN_{WAD}	0.2 - 1	
Sulphate	100 - 500	
Ammonia-N	5 - 20	
Nitrite-N	1 - 10	
Nitrate-N	100 - 300	
As	1 - 2	0.5
Sb	0.05 – 1	
Cd	0.0005 – 0.001	
Cu	0.01 - 1	0.3
Fe	0.5 – 5	
Hg	0.0005 – 0.001	
Pb	0.001 – 0.02	0.2
Ni	0.05 – 0.13	0.5
U	0.1 – 0.5	
Zn	0.1 - 1	0.5

All units in mg/L except pH

1: Metal Mining Effluent Regulation Limits for authorized monthly mean concentration

As illustrated, a number of parameters are predicted to remain elevated in rinse solutions and therefore require further treatment prior to release to the environment. The most notable of these parameters include total cyanide (CN_{Total}), WAD cyanide (CN_{WAD}), nitrate, nitrite, As, antimony (Sb), cadmium (Cd), copper (Cu), mercury (Hg), nickel (Ni), U and zinc (Zn). While some of the above parameters are readily removed using chemical treatment processes, nitrate and U are more amenable to biological treatment using microbial reduction techniques.

Discharge of water to the receiving environment from the water treatment plant will likely commence in Year 9. The treatment plant will be constructed prior to this time and used in treatment of rinse solutions. Currently, the water treatment plant is expected to operate through closure to Year 20 and will operate for approximately six to eight months of the year, depending when flowing water is present. As described above, treated water from the water treatment plant will either be discharged to the environment or used in additional rinsing of the heap. Water discharged to the environment will be directed to the Alpha WRSF rock drain, which will report to the Alpha Pond and eventually, Halfway Creek.

5.3.10 PROPOSED WATER TREATMENT PROCESS

The proposed water treatment system is a two-stage process. The first stage of the treatment process will oxidize residual cyanide using hydrogen peroxide. The products of this process will be cyanate and/or ammonia and carbon dioxide. The second stage of the process will utilize a biological reactor system termed Electrochemical Biological Reactor or EBR. The overall water treatment system is designed to treat 34 m^3/hr (10 L/s). The EBR treatment system has been designed by Inotec of Salt Lake City, Utah. A description of the EBR process and fundamentals is provided below.

5.3.10.1 EBR Treatment Process

Microbes mediate the removal of metal and inorganic contaminants through electron transfer (redox processes). For example, nitrate reduction can be described by the following redox reaction:

$$NO_3^- + 5e^- + 6H^+ \rightarrow 0.5N_2 + 3H_2O \qquad (1)$$

The biotransformation shown in reaction 1 occurs under anaerobic, reductive conditions, and thus requires low dissolved oxygen levels and a negative oxidation-reduction potential environment. Five electrons are needed to reduce one molecule of nitrate to nitrogen gas. Other co-contaminants, such as arsenic and uranium, etc., would add to the electron demand. One molecule of glucose, often used as a cost-effective nutrient in the form of molasses, can provide up to 24 electrons under optimal conditions and complete glucose metabolism (usually measured in hours). In environmental applications, this efficiency or the amount of electrons actually realized is usually considerably less; only a few of these electrons are available within 4 to 6 hours.

In conventional biological treatment systems, electrons are supplied from excess nutrients added to the system. Excess nutrients/chemicals are typically required to compensate for inefficient and variable electron availability needed to adjust the reactor chemistry, microbial growth, contaminant removal, and to compensate for system sensitivity. However, these excess nutrients lead to additional CAPEX and OPEX, due to higher nutrient consumption and excessive biomass production. The EBR technology overcomes these shortcomings by directly supplying needed electrons to the reactor and microbes, using a low applied potential across the reactor cell (1-3 V). For a comparison with a conventional nutrient electron donor, the current of 1 mA provides 6.2 x 10^{15} electrons per second. These electrons replace and supplement the electrons normally supplied to the reactor/microbial system by excess nutrients, at a considerable monetary savings and reactor, microbial, and environmental benefits. The directly supplied electrons are readily available to the microbes in a consistent controllable manner without metabolic energy expenditure. The excess electron provision in the EBR systems allows for a better control of the ORP conditions, without the need to add chemicals, such as bisulfide to adjust the ORP. Moreover, those “free electrons”, from the microbes’ metabolic standpoint, make the EBR bioreactors more robust and less sensitive to wide fluctuations in water chemistries than the past generations of biotreatment systems.

5.3.10.2 Bench-Scale Performance Testing of Treatment Process – Proof of Concept

Bench-scale testing of the proposed EBR treatment system was performed on Coffee Gold metallurgical leach solutions. Microbial isolation and screening tests were conducted on solutions received and initial column materials at 5ºC and 20ºC. Microbes isolated from the heap solution waters and spent ore materials were tested for their ability to remove arsenic, uranium, and nitrate from solution. These isolates were tested in direct comparative screening tests alongside Inotec's repository microbes in order to select a site-specific inoculum for removal of contaminants of interest. These tests provided the microbes for the EBR treatability assessment. A microbial population screened to be effective at removing arsenic, uranium, and nitrate were grown into an inoculum for the EBR testing.

The bench-scale setup consisted of a two-stage, up-flow, fixed bed EBR system. The tests were conducted under continuous flow conditions, i.e., the water was treated 24 hours per day. The system was operated using a total hydraulic retention time of 44 hours. The EBR column tests were conducted continuously for two months for process assessment and validation testing.

Prior to the EBR treatment, the cyanide in the leachate solutions was oxidized using hydrogen peroxide treatment. To confirm that the treatment process could remove anticipated concentrations of nitrate, leach solutions were spiked with nitrate to provide treatment feed solutions of at least 150 mg/L NO_3-N.

Results of the bench-scale testing indicated that the proposed two stage treatment process for heap leach rinse solutions is highly effective at removal of contaminants of concern. **Table 5.3-8** below provides a summary of the water treatment results using the EBR. As illustrated, water quality exiting the EBR water treatment system is of high quality with removal efficiencies for most parameters over 99%. Nitrate and Nitrite-N removal via denitrification was highly effective. Uranium removal in the EBR system was also highly effective and achieved treated water concentrations of less than 0.002 mg/L and well below receiving water quality objectives.

Table 5.3-8 Summary of Bench-Scale Water Treatment Performance for EBR System

Parameters of Concern	Feed to Water Treatment Plant (mg/L)	Treated Effluent (mg/L)	MMER Limits[1] (mg/L)
pH	8.0 – 9.0	7.0 – 8.0	6.5 – 9.0
Total Suspended Solids	1 – 10	< 5	15
CNTotal	1 – 5	0.08 – 0.3	1
CNWAD	0.2 – 1	0.007- 0.01	
Sulphate	100 - 500	50 - 100	
Ammonia-N	5 – 20	0.1 – 0.25	
Nitrite-N	1 – 10	0.02 – 0.05	
Nitrate-N	100 - 300	0.1 – 0.25	
As	1 – 5	0.01 – 0.015	0.5
Sb	0.05 – 1	<0.005	
Cd	0.0005 – 0.001	<0.00001	
Cu	0.01 – 1	<0.003	0.3
Fe	0.5 – 5	<0.5	
Hg	0.0005 – 0.001	<0.00005	
Pb	0.001 – 0.02	<0.0005	0.2
Ni	0.05 – 0.13	<0.002	0.5
U	0.1 – 0.5	<0.0015	
Zn	0.1 – 1	0.03 – 0.05	0.5

All units in mg/L except pH

1: Metal Mining Effluent Regulation Limits for authorized monthly mean concentration

Based on the above, treated water from the water treatment plant will either be discharged to the environment or used in additional rinsing of the heap. Water discharged to the environment will occur directly to Halfway Creek.

As introduced previously, progressive reclamation of the HLF will also evaluate the efficacy of accelerating the detoxification of the heap through in situ stabilization as successfully employed at Brewery Creek. For the Project, the closure concept is to use treated water from the EBR in the rinsing process. Treated effluent will provide an “inoculum” from the EBR containing microbes that denitrify and remove soluble metals (e.g., As and U) to the heap. Nutrients will also be added to the treated effluent and discharged onto the heap during the rinsing. The addition of nutrients and inoculum is designed to promote in situ detoxification of the heap and will further improve rinsing efficiencies and geochemical stabilization of the spent heap ore for closure.

At the current early design stage of the Project, it is difficult to determine if in situ stabilization of the heap pad will be sufficiently successful to allow direct discharge of heap seepage solutions to the environment. As such, additional contingency reclamation efforts will be afforded to providing for passive treatment polishing of heap seepage solutions prior to release to the environment. A permeable reactive barrier (PRB) system may be employed, if needed. PRBs have been used as a successful passive treatment technology for treating mine waste solutions containing elevated nitrogen species, metalloids such as arsenic and metals including uranium. The potential application of a PRB system is discussed in the **Conceptual Reclamation and Closure Plan** (**Appendix 31-C**).

5.4 LIFE-OF-MINE WATER MANAGEMENT

This section describes water management throughout the following phases of the mine life:

- Phase 1: Construction (Year -3 to -1)
- Phase 2: Operation (Year 1 to Year 12)
- Phase 3: Post-mining Closure Stage (Year 13 to 17)
- Phase 4: Active Closure Stage (Year 17 to 23)
- Phase 5: Post-Closure (Year 23+).

Figure 5.4-1 through **Figure 5.4-13** below highlight the development of the water management from the Construction Phase to the Post-closure Phase.

5.4.1 PHASE 1: CONSTRUCTION (YEAR -3 TO -1)

Figure 5.4-1 illustrates the water management during the construction phase at Year -1. The majority of the water management infrastructure will be built in Phase 1. Initial earthworks and site preparation will begin in Year -3. In this first year, the camp, haul roads, and the pad for the HLF will be constructed. As each haul road is constructed, haul road drainage ditches will be built along the up-gradient toe of the haul road and culverts will be placed to maintain drainage. The Alpha Pond and Facility Pond will both be constructed in Year -2. Open Pit mining will begin in Year -1 at Latte Pit and Double Double Pit and waste rock will be placed in Alpha WRSF in Year -1. Processing at the heap leach pad begins in Year -1 and runoff from the Alpha WRSF and Ore Stockpiles will flow to the Alpha Pond and Facility Pond, respectively. The access road to Alpha Pond will be built in Year -2 along with the clean water diversion of the Halfway Creek catchment. Diversions will also be constructed upstream of the Kona Pit and Double Double Pit.

The Alpha WRSF rock drain will be built in stages as appropriate, prior to placement of the Alpha WRSF in the corresponding footprint. The first stage of the Alpha rock drain will be built in Year -1 before waste rock is placed in the Alpha WRSF. Waste rock toe collection channels and waste rock bench diversions will be built and modified to fit as the Alpha WRSF grows.

Pit inflows, including pit wall runoff and direct precipitation, will be collected in sumps at the low point of each pit. Water is then pumped back for process or into to the ponds for sediment removal before discharge to the downstream catchments. Pumping rates and durations will be set to mining objectives in the pits.

5.4.2 PHASE 2: OPERATION (YEAR 1 TO 12)

The water management activities during this phase are illustrated in **Figure 5.4-2** to **Figure 5.4-13**, for each year of operation

Active mining at the Project continues in Latte Pit Main, Double Double Pit, and expands to Kona Pit, Latte West Pit, and Supremo Pit. Additional haul roads will be built to access the pits. As each haul road is constructed, haul road drainage ditches are built along the up-gradient and culverts will be placed to maintain drainage.

Mining of Kona Pit will begin in Year 1 and waste rock will be placed in the temporary Beta WRSF prior to being backfilled back into Kona Pit in Year 11. A waste rock toe collection channel will be constructed in Year 2, and mine affected water flows downstream to the Alpha rock drain and ultimately Alpha Pond.

Latte Pit will be backfilled in Year 3 to create a haul road crossing. Supremo Pit will begin to be backfilled in Year 6 and waste rock will be placed in Double Double Pit in Year 10.

5.4.3 PHASE 3 TO 5: RECLAMATION AND CLOSURE (YEARS 13+)

The following sections provide a summary of the closure phases. There are two stages within the Reclamation and Closure Phase: Post-mining Closure and Active Closure. The Post-closure Phase will follow the Reclamation and Closure Phase. Additional information on the activities that will be undertaken during these phases is included in **Appendix 31-C Conceptual Reclamation and Closure Plan**.

5.4.3.1 Post Mining Closure Stage

The Post-mining Closure stage will be the first stage of the Reclamation and Closure Phase. During the Post-mining Closure stage, the HLF will continue to operate to recover residual gold from the leach solution. No new ore will be added to the pad. Water treatment may be required until Year 15 to 20, after which the mine will enter the Active Closure stage. Water treatment will operate eight months per year, during the summer months. Sludge from the operation of the water treatment plant will be disposed of on-site in an appropriate facility. Closure of the heap leach pad is described in the **Conceptual Reclamation and Closure Plan** (**Appendix 31-C**).

Pit sumps and associated pit dewatering systems (pumps and pipes) will be removed from Supremo Pit. The pumps will be recycled or placed in the designated landfill. Associated pipelines, if not being reused, will be cleaned if necessary and placed in the landfill.

5.4.3.2 Active Closure Stage

The Active Closure stag will be the second stage of the Reclamation and Closure Phase. During the Active Closure stage, roads, pads, processing equipment and other mine infrastructure will be decommissioned and areas will be reclaimed. Sedimentation ponds and conveyance structures will continue to operate as designed until the water quality in the ponds meets the discharge requirements, at which point each pond can be decommissioned. The sedimentation ponds will be drained. Sediment that has accumulated in the pond will be removed and disposed of in the pits, dedicated disposal areas in the WRSFs or other appropriate locations. The sediment pond dams will be decommissioned. Material from the dams will be used to backfill pond excavations, if present, or used to cover the inundation footprint of the ponds. Liners on the dams or in the ponds and in conveyance structures will be removed and disposed of in the landfill or other appropriate on site disposal areas. The reclaimed ponds and conveyance structures will be graded as required to ensure proper drainage. Disturbed areas will be covered as needed with soil or organic layer material stockpiled during mine development to the extent available.

This decommissioning process of water management infrastructure will be the final step in the Active Closure stage, at which point the Post-closure Phase will begin.

5.4.3.3 Post-closure Phase

The Post-closure Phase will start when post-closure water quality objectives are met, water management infrastructure that is no longer required is decommissioned, and all non-permanent infrastructure has been dismantled and reclaimed. This phase will consist of active monitoring of water quality in the long-term.

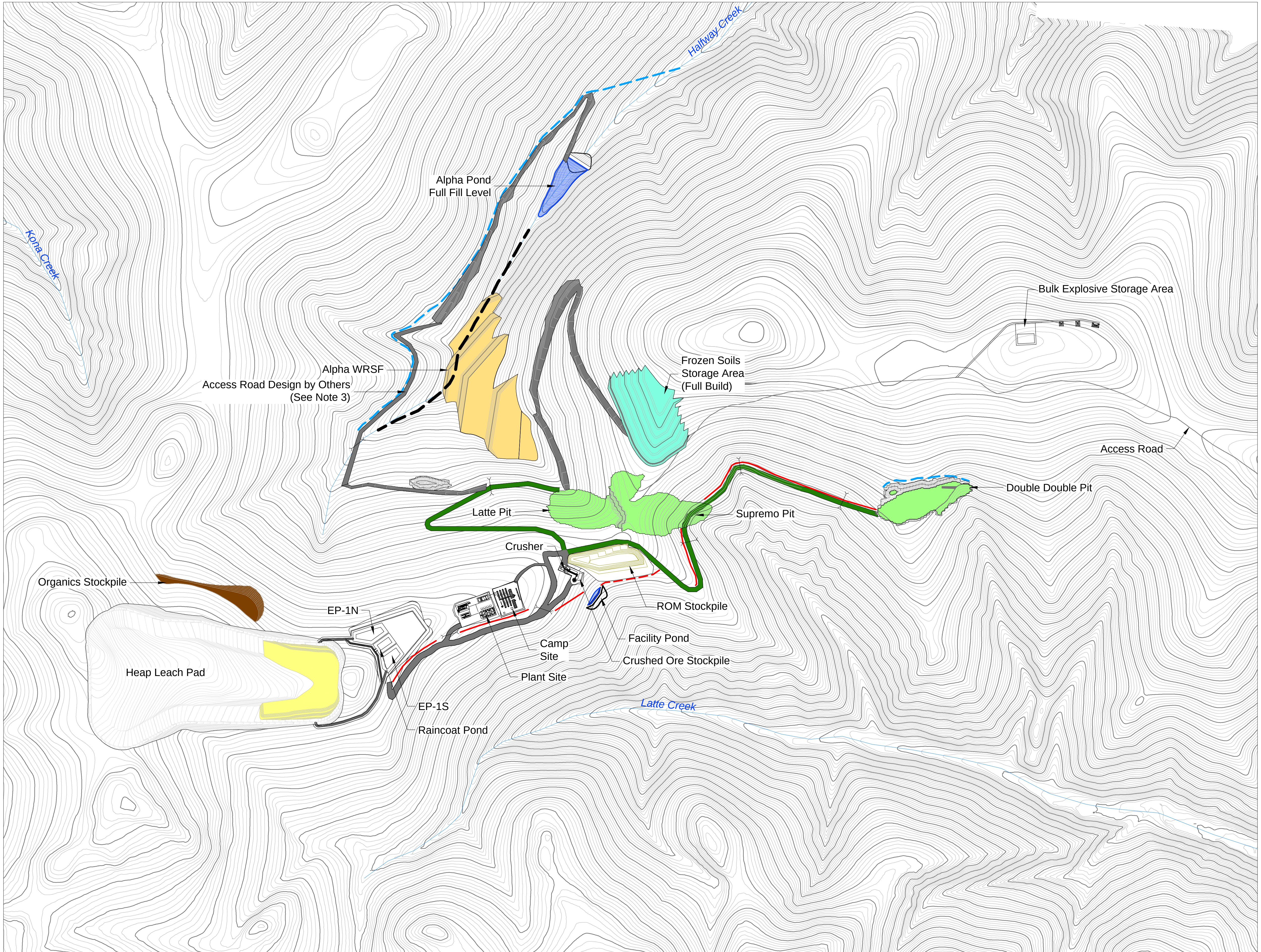
5.4.3.4 Concurrent Reclamation or Progressive Closure

The Open Pits and WRSFs will be reclaimed as they are completed. Pit sumps and associated pit dewatering systems (pumps and pipes) will be removed as Open Pits are completed. Pumps which are not reused will be recycled or placed in the designated landfill. Associated pipelines, if not being reused, will be cleaned if necessary and placed in the landfill.

The clean water diversion up gradient of the Halfway Creek may be adapted to establish an appropriate post-closure drainage pathway. Double Double and Kona Pits will be backfilled with waste rock and the non-contact water diversion berm up gradient of these two pits will be decommissioned. The Beta Temporary WRSF footprint will be reclaimed and revegetated after the waste rock is placed in the Kona Pit.

COFFEE GOLD MINE

Site Layout of Water Management Structures Year -1 Pre-Mining



Legend

- Diversion Berm
- Rock Drain
- Road Drainage Ditch
- Waste Rock Collection Channel
- Active Pit
- Frozen Soils Storage Area
- Pit Backfill
- Pit Footprint
- Sedimentation Pond
- Waste Rock Storage Facility
- Heap Stack
- Access Road
- Haul Road
- Culvert

Notes

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2. Contours shown at a 5 meter contour interval.
3. Access road design to be finalized in next phase.

N

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0 2500 5000 7500 10000

Metres

NAD 1983 UTM Zone 7N

Page Size: 11" x 17"

Figure 5.4-1	Date: Mar 30, 2017	Drawn by: TAH	Reviewed: DP/TS

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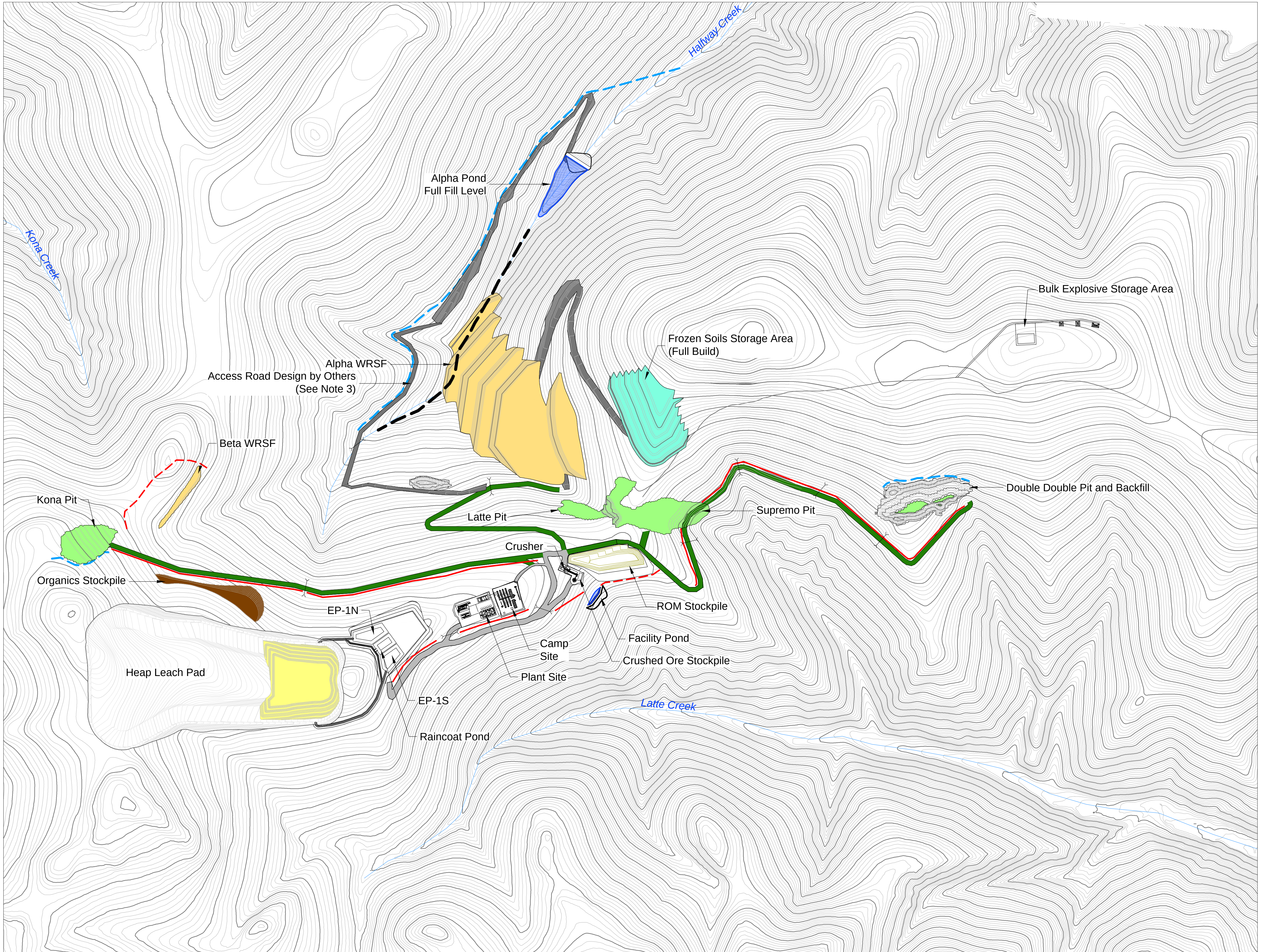

COFFEE GOLD MINE

Site Layout of Water Management Structures Year 1

Legend

- Diversion Berm
- Rock Drain
- Road Drainage Ditch
- Waste Rock Collection Channel
- Active Pit
- Frozen Soils Storage Area
- Pit Backfill
- Pit Footprint
- Sedimentation Pond
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Metres

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Page Size: 11" x 17"

Figure 5.4-2	Date: Mar 30, 2017	Drawn by: TAH	Reviewed: DP/TS

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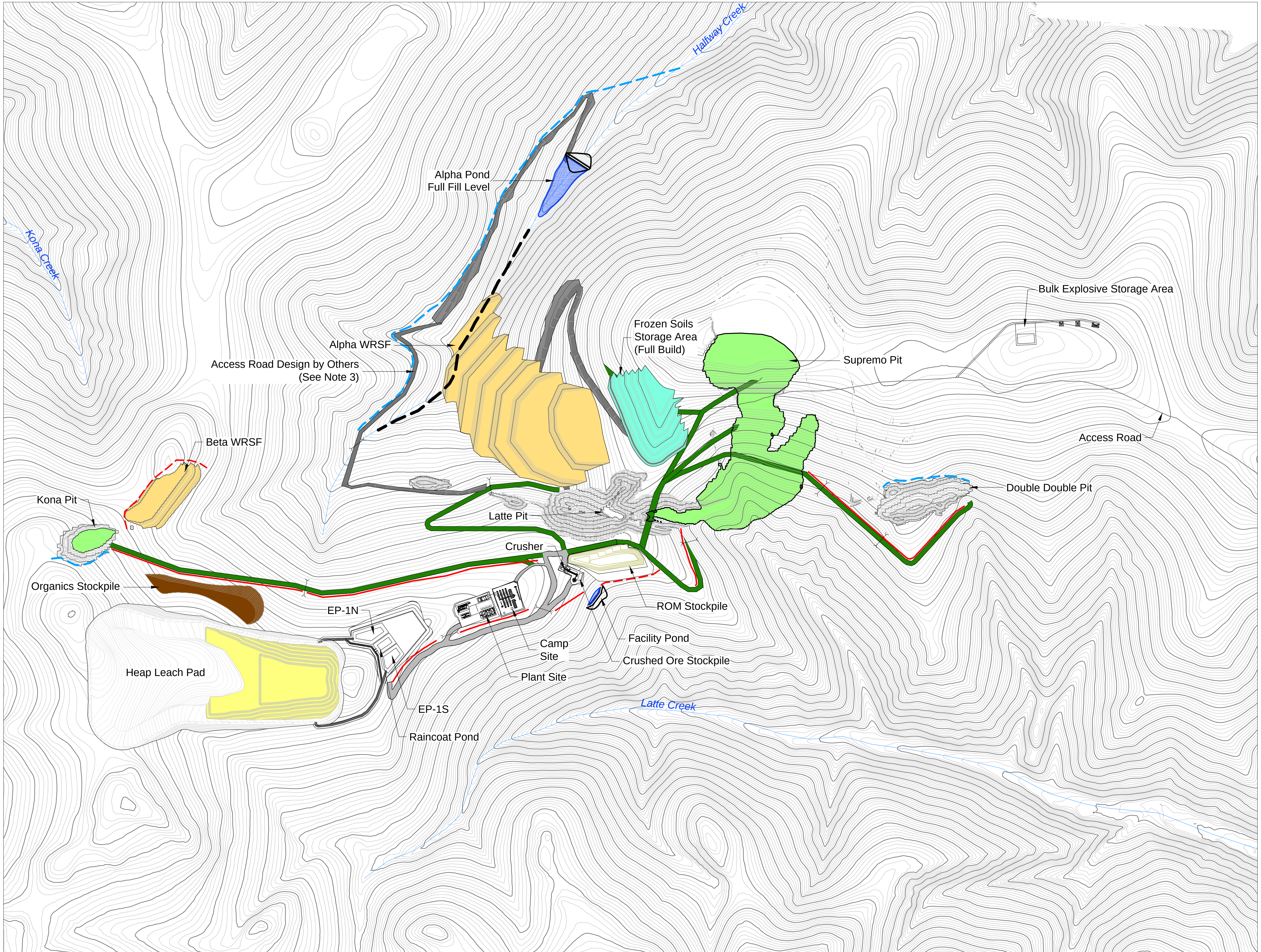

COFFEE GOLD MINE

Site Layout of Water Management Structures
Year 2

Legend

- Diversion Berm
- Rock Drain
- Road Drainage Ditch
- Waste Rock Collection Channel
- Active Pit
- Frozen Soils Storage Area
- Pit Backfill
- Pit Footprint
- Sedimentation Pond
- Waste Rock Storage Facility
- Heap Stack
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- Culvert

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Metres

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Page Size: 11" x 17"

Figure 5.4-3	Date: Mar 30, 2017	Drawn by: TAH	Reviewed: DP/TS

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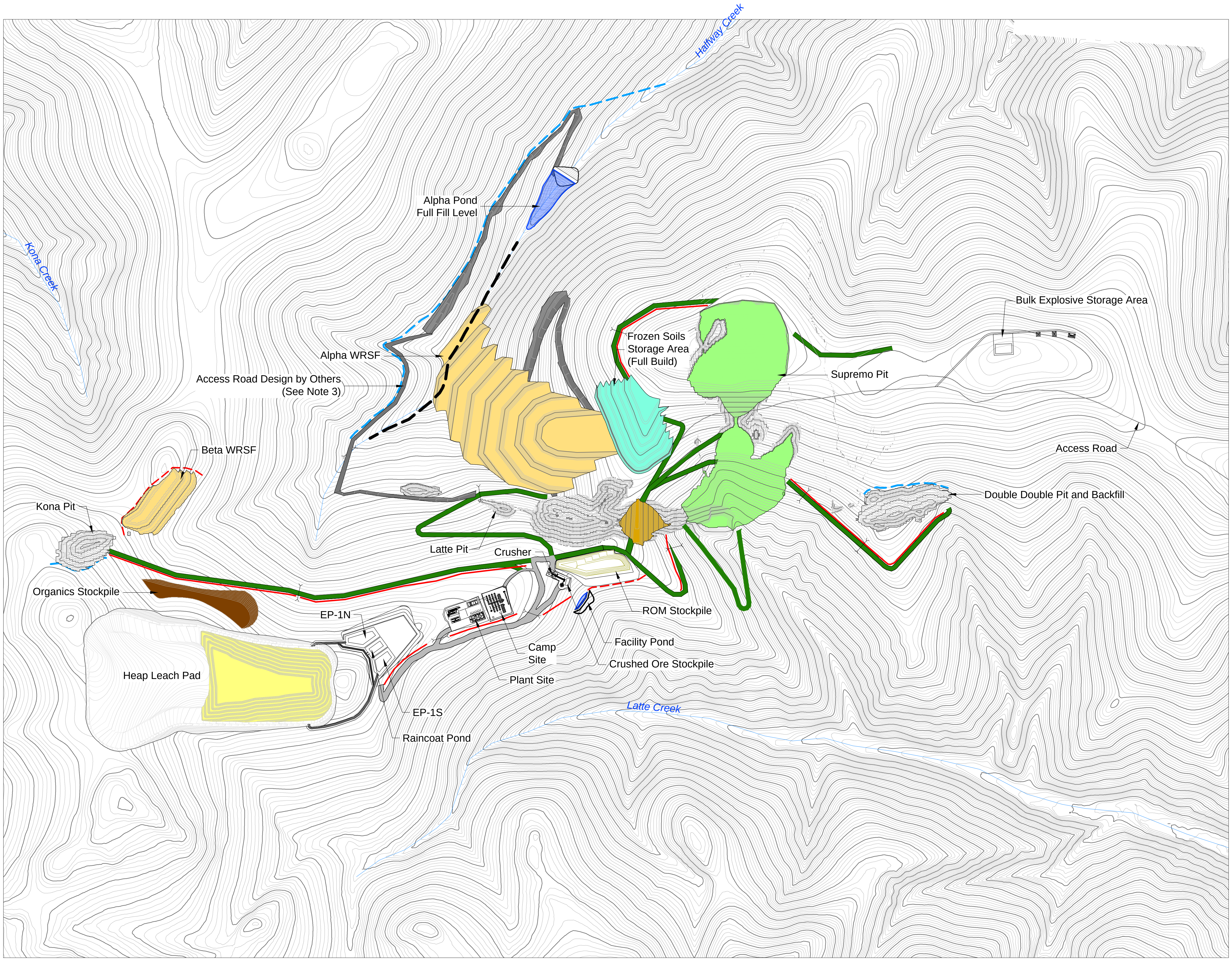

COFFEE GOLD MINE

Site Layout of Water Management Structures
Year 3

Legend

- Diversion Berm
- Rock Drain
- Road Drainage Ditch
- Waste Rock Collection Channel
- Active Pit
- Frozen Soils Storage Area
- Pit Backfill
- Pit Footprint
- Sedimentation Pond
- Waste Rock Storage Facility
- Heap Stack
- Access Road
- Haul Road
- Culvert

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Figure 5.4-4	Date: Mar 30, 2017	Drawn by: TAH	Reviewed: DP/TS

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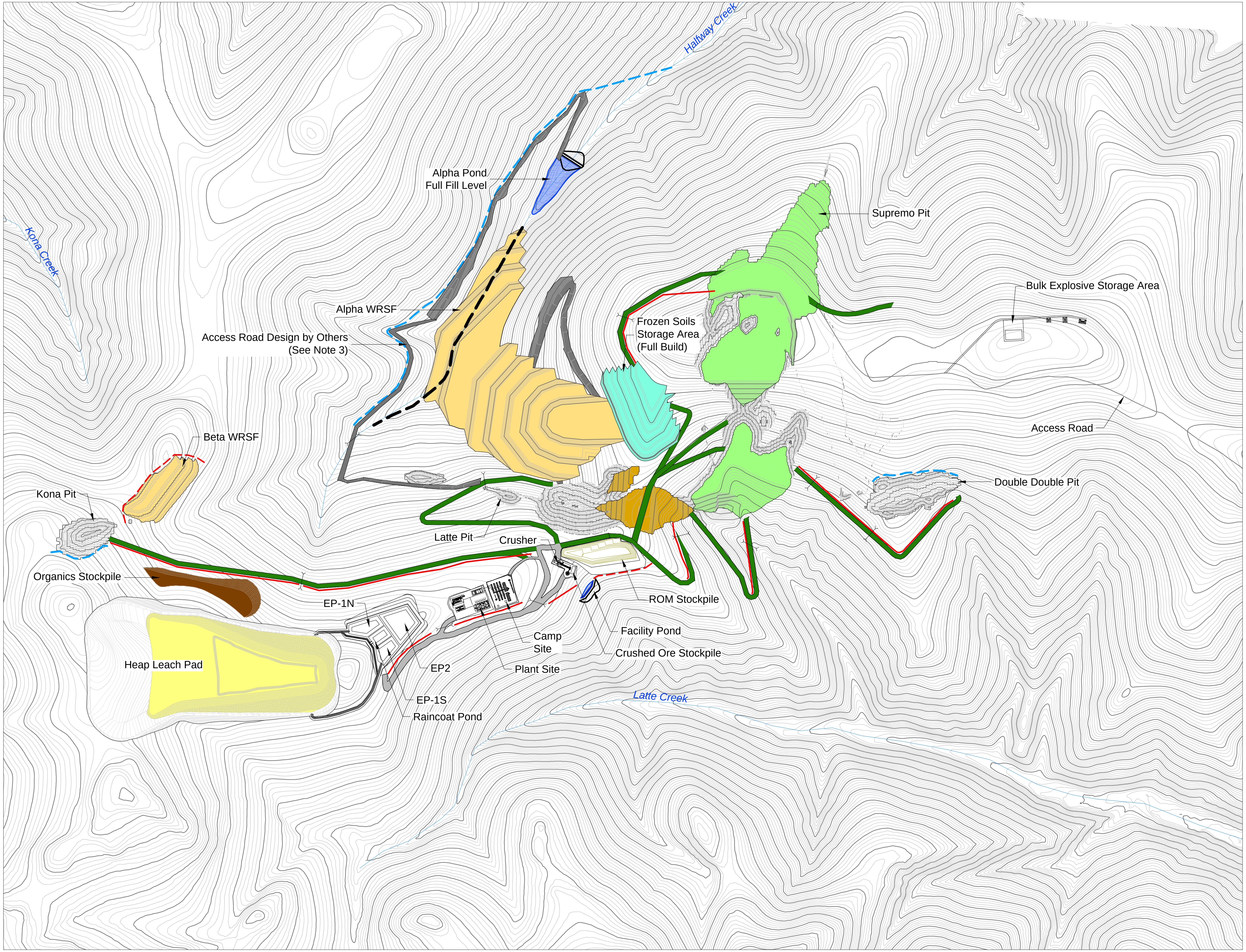

COFFEE GOLD MINE

Site Layout of Water Management Structures
Year 4

Legend

- Diversion Berm
- Rock Drain
- Road Drainage Ditch
- Waste Rock Collection Channel
- Active Pit
- Frozen Soils Storage Area
- Pit Backfill
- Pit Footprint
- Sedimentation Pond
- Waste Rock Storage Facility
- Heap Stack
- Access Road
- Haul Road
- Culvert

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Metres

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Page Size: 11" x 17"

Figure 5.4-5	Date: Mar 30, 2017	Drawn by: TAH	Reviewed: DP/TS

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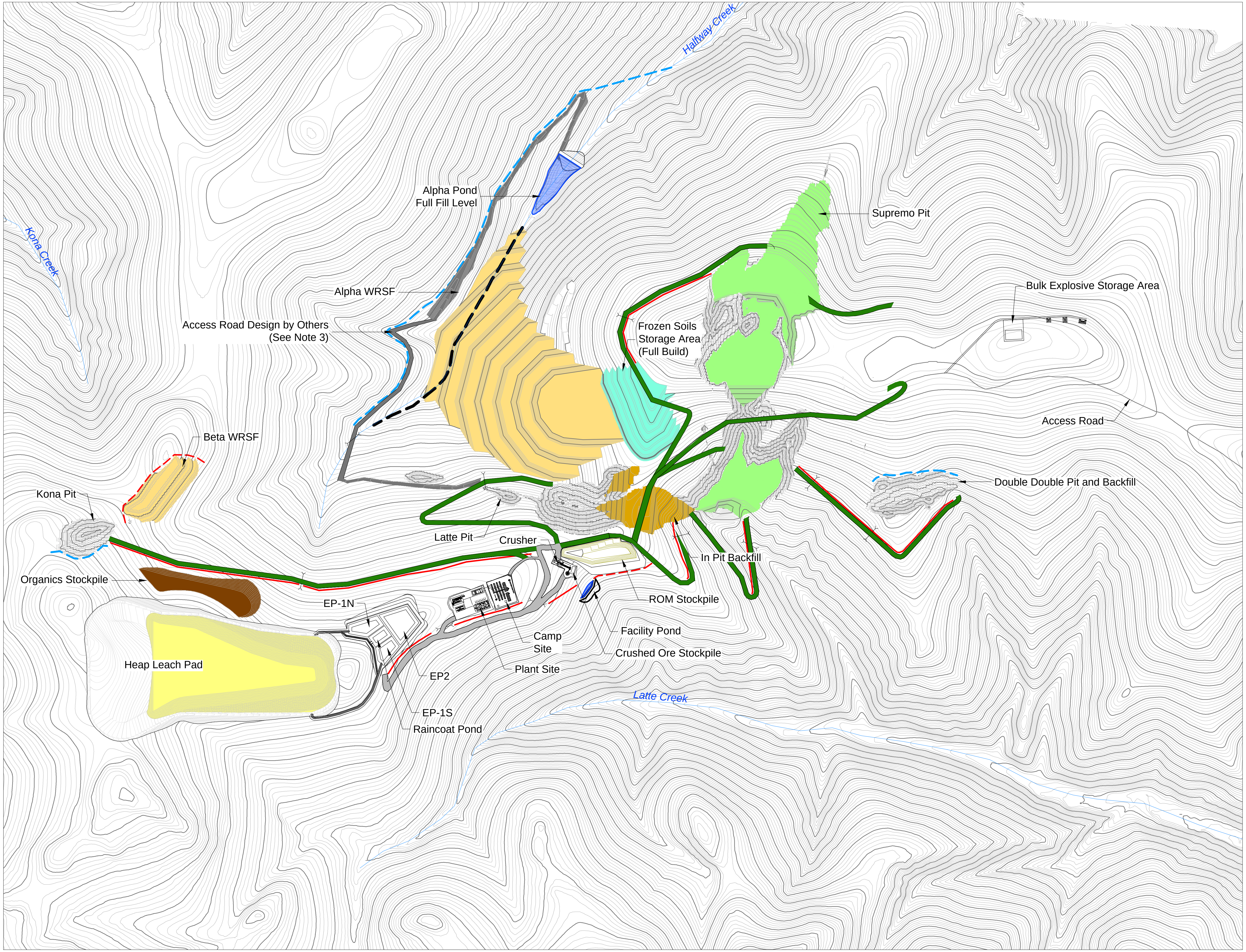

COFFEE GOLD MINE

Site Layout of Water Management Structures
Year 5

Legend

- Diversion Berm
- Rock Drain
- Road Drainage Ditch
- Waste Rock Collection Channel
- Active Pit
- Frozen Soils Storage Area
- Pit Backfill
- Pit Footprint
- Sedimentation Pond
- Waste Rock Storage Facility
- Heap Stack
- Access Road
- Haul Road
- Culvert

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Metres

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Page Size: 11" x 17"

Figure 5.4-6	Date: Mar 30, 2017	Drawn by: TAH	Reviewed: DP/TS

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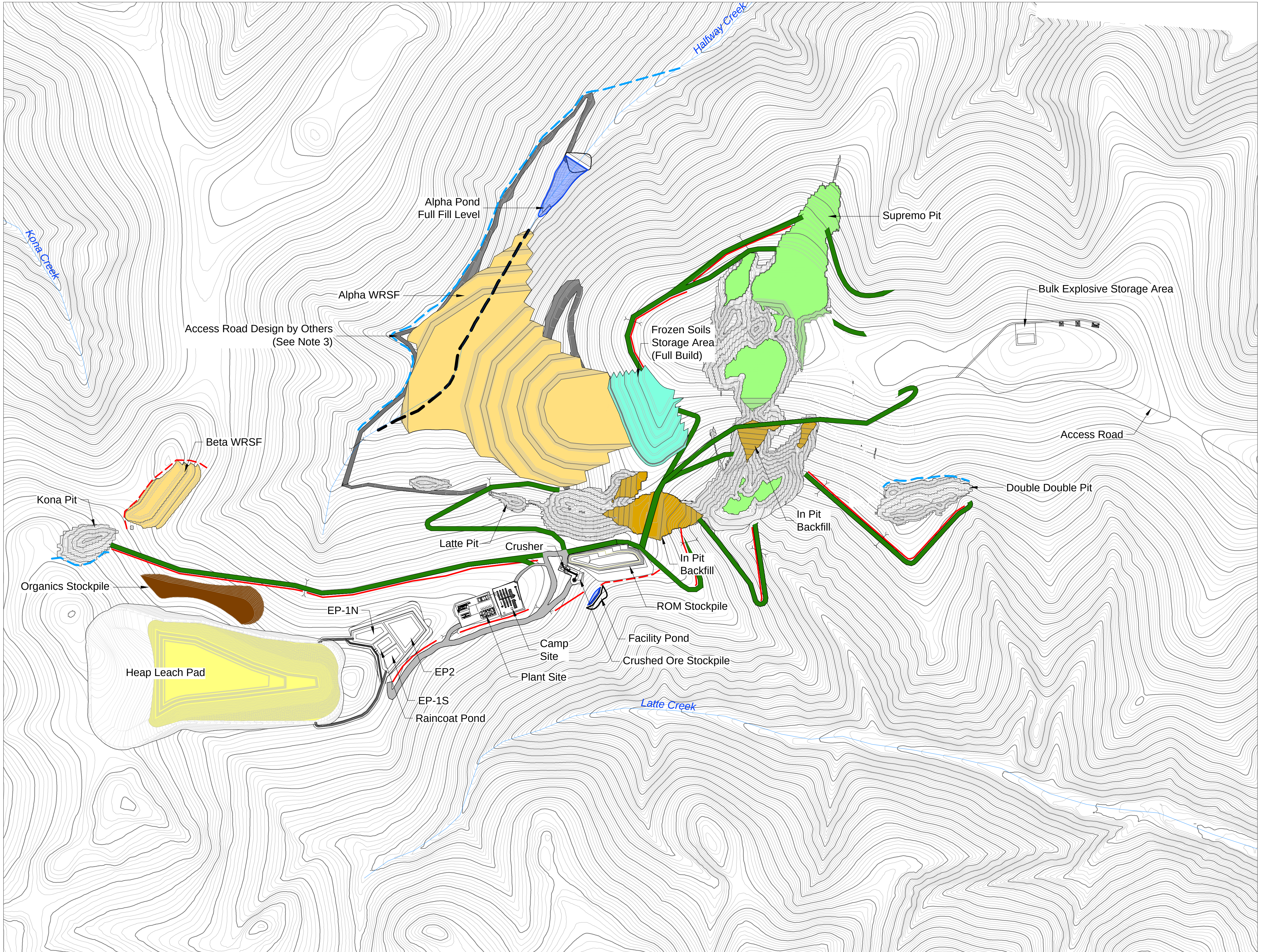

COFFEE GOLD MINE

Site Layout of Water Management Structures Year 6

Legend

- Diversion Berm
- Rock Drain
- Road Drainage Ditch
- Waste Rock Collection Channel
- Active Pit
- Frozen Soils Storage Area
- Pit Backfill
- Pit Footprint
- Sedimentation Pond
- Waste Rock Storage Facility
- Heap Stack
- Access Road
- Haul Road
- Culvert

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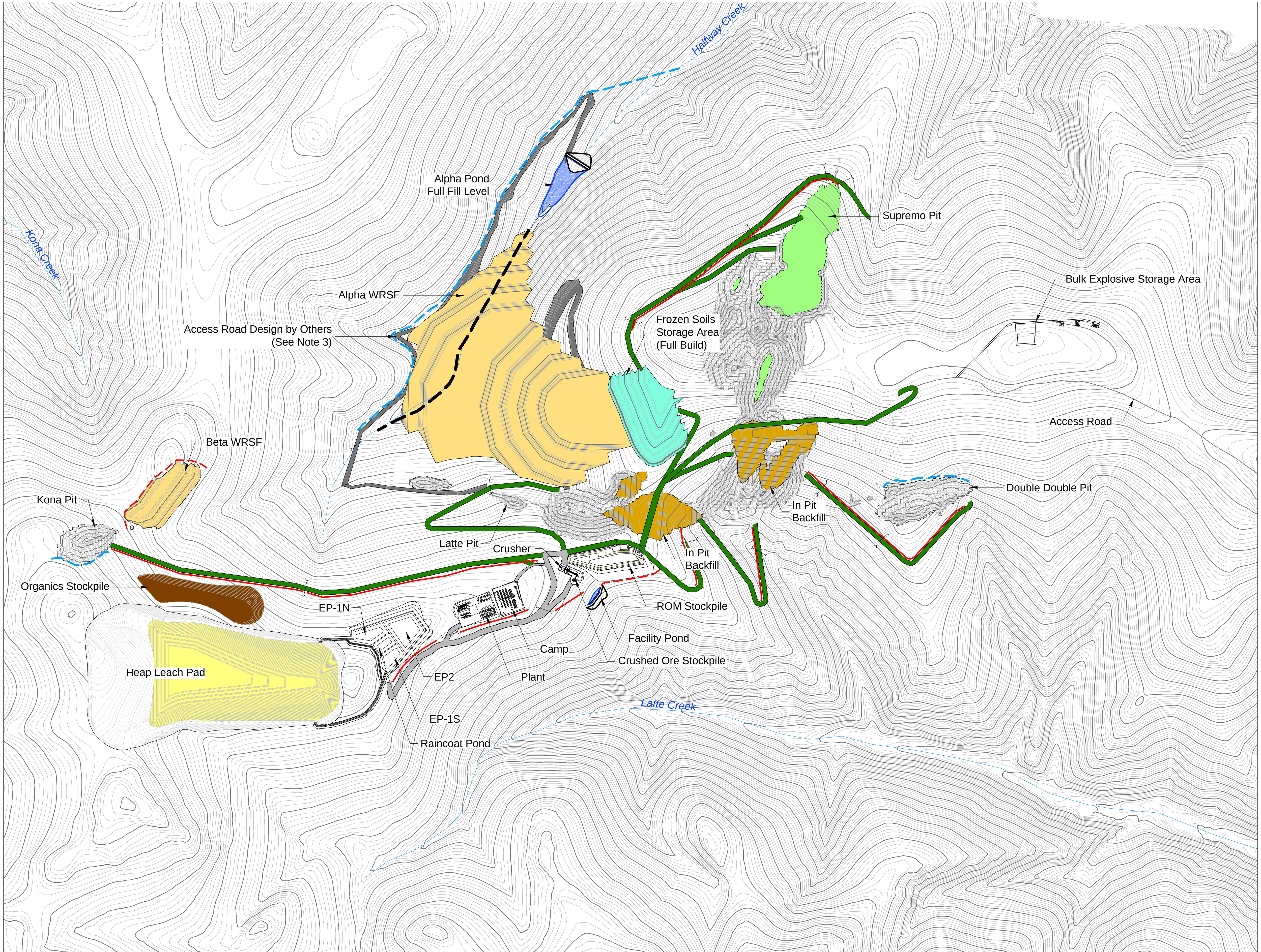
Metres

NAD 1983 UTM Zone 7N

Page Size: 11" x 17"

Figure 5.4-7	Date: Mar 30, 2017	Drawn by: TAH	Reviewed: DP/TS



COFFEE GOLD MINE

Site Layout of Water Management Structures
Year 7

Legend

- Diversion Berm
- Rock Drain
- Road Drainage Ditch
- Waste Rock Collection Channel
- Active Pit
- Frozen Soils Storage Area
- Pit Backfill
- Pit Footprint
- Sedimentation Pond
- Waste Rock Storage Facility
- Heap Stack
- Access Road
- Haul Road
- Culvert

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N

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Metres

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Page Size: 11" x 17"

Figure 5.4-8	Date: Mar 30, 2017	Drawn by: TAH	Reviewed: DP/TS

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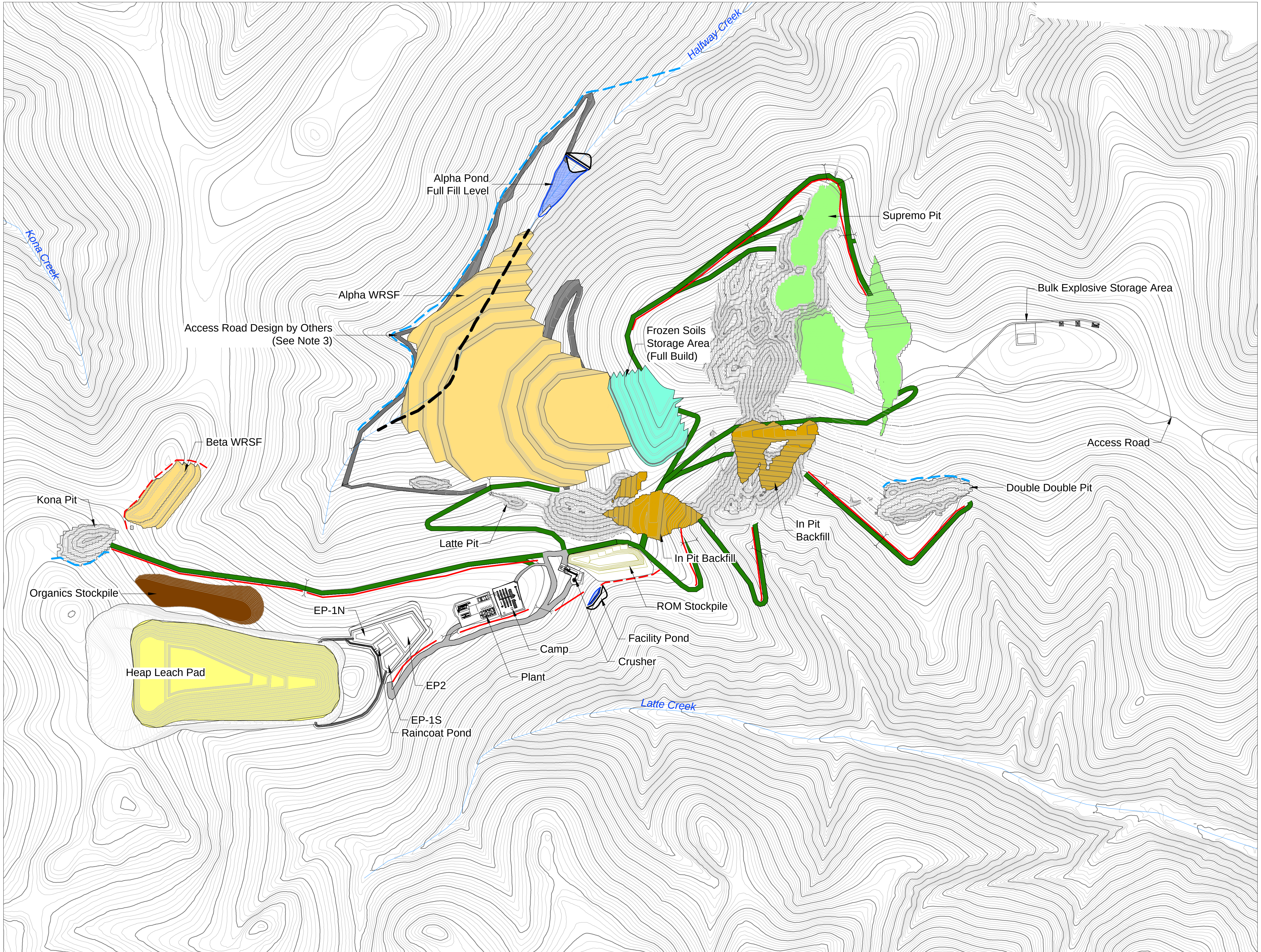
COFFEE GOLD MINE

Site Layout of Water Management Structures Year 8



Legend

- Diversion Berm
- Rock Drain
- Road Drainage Ditch
- Waste Rock Collection Channel
- Active Pit
- Frozen Soils Storage Area
- Pit Backfill
- Pit Footprint
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3. Access Road design to be finalized in next phase.

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Metres

NAD 1983 UTM Zone 7N

Page Size: 11" x 17"

Figure 5.4-9	Date: Mar 30, 2017	Drawn by: T. Haye	Reviewed: DP/TS

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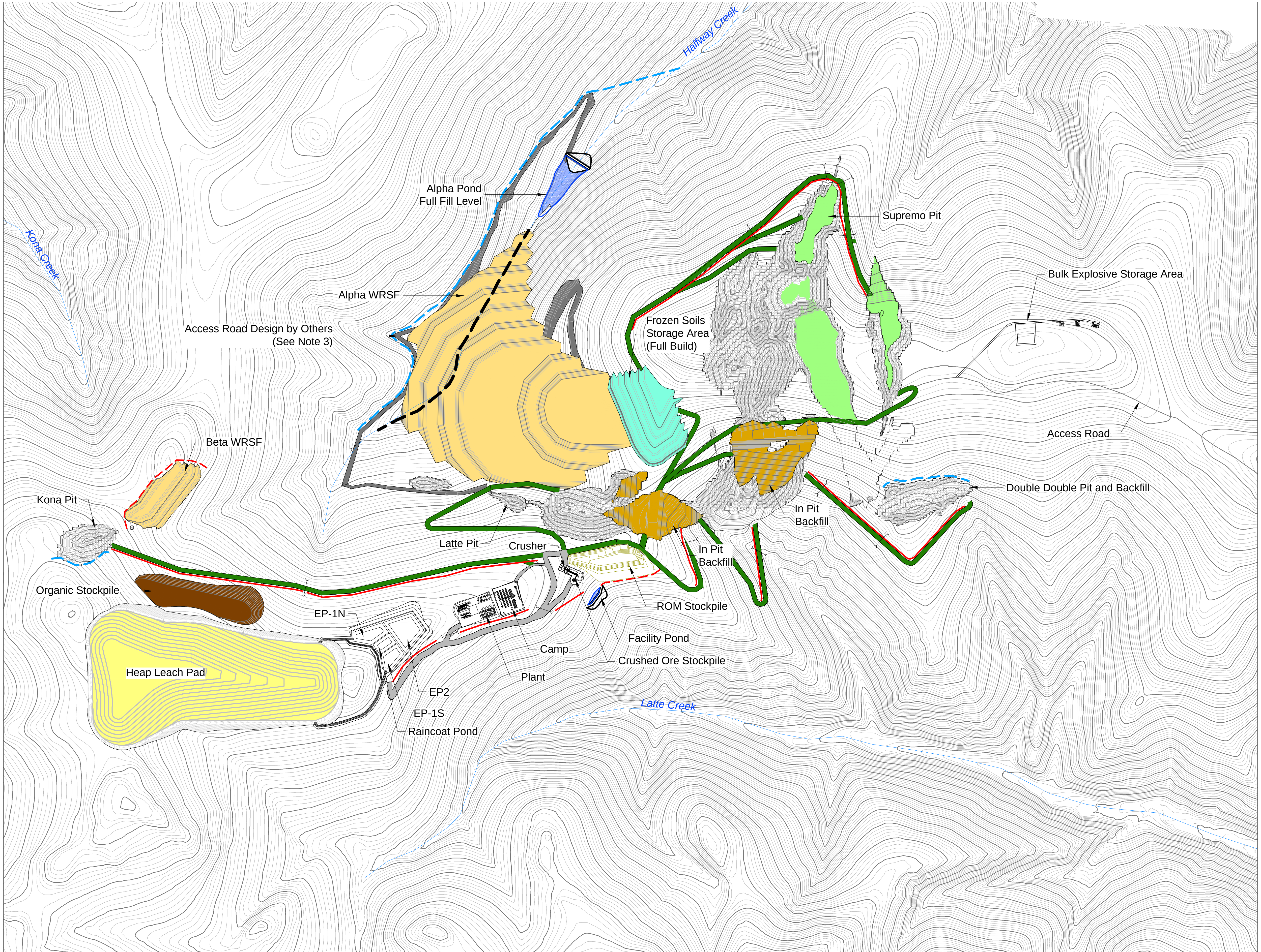
COFFEE GOLD MINE

Site Layout of Water Management Structures Year 9



Legend

- Diversion Berm
- Rock Drain
- Road Drainage Ditch
- Waste Rock Collection Channel
- Active Pit
- Frozen Soils Storage Area
- Pit Backfill
- Pit Footprint
- Sedimentation Pond
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- Heap Stack
- Access Road
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- Culvert

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Metres

Page Size: 11" x 17"

Figure 5.4-10	Date: Mar 30, 2017	Drawn by: TAH	Reviewed: DP/TS

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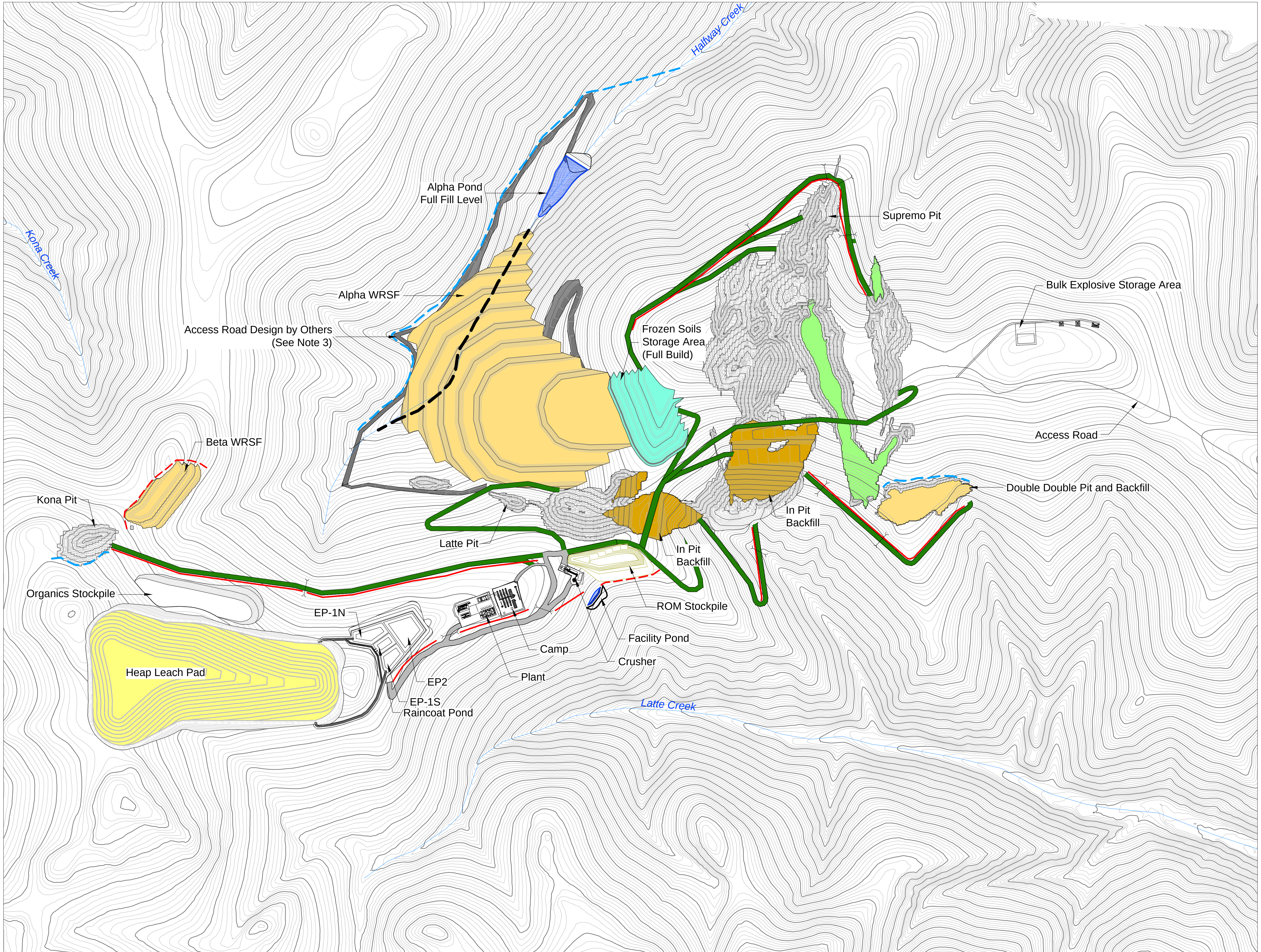
COFFEE GOLD MINE

Site Layout of Water Management Structures Year 10



Legend

- Diversion Berm
- Rock Drain
- Road Drainage Ditch
- Waste Rock Collection Channel
- Active Pit
- Frozen Soils Storage Area
- Pit Backfill
- Pit Footprint
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Metres

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Page Size: 11" x 17"

Figure 5.4-11	Date: Mar 30, 2017	Drawn by: T. Haye	Reviewed: DP/TS

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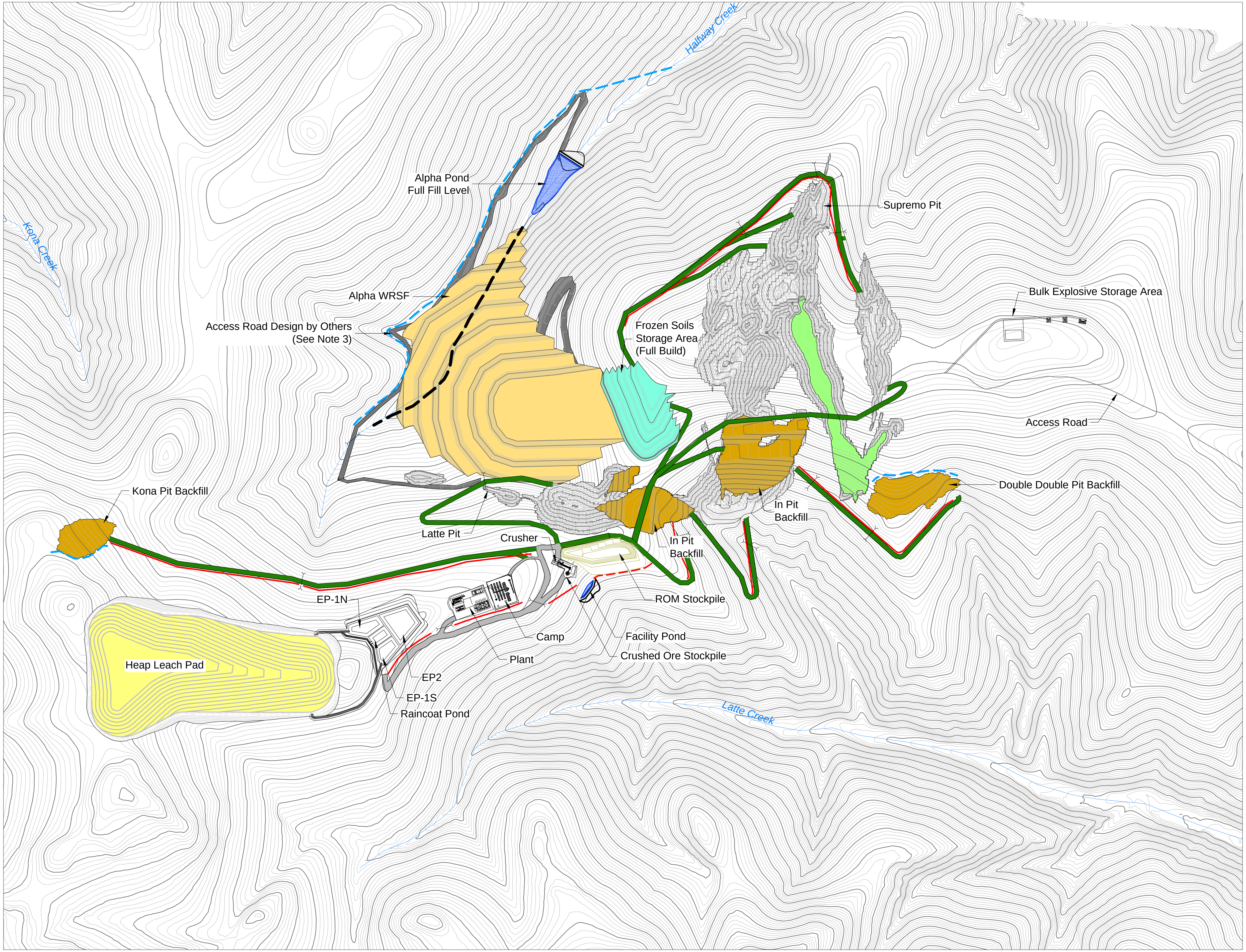

COFFEE GOLD MINE

Site Layout of Water Management Structures Year 11

Legend

- Diversion Berm
- Rock Drain
- Road Drainage Ditch
- Waste Rock Collection Channel
- Active Pit
- Frozen Soils Storage Area
- Pit Backfill
- Pit Footprint
- Sedimentation Pond
- Waste Rock Storage Facility
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Metres

NAD 1983 UTM Zone 7N

Page Size: 11" x 17"

Figure 5.4-12	Date: Mar 30, 2017	Drawn by: T. Haye	Reviewed: DP/TS

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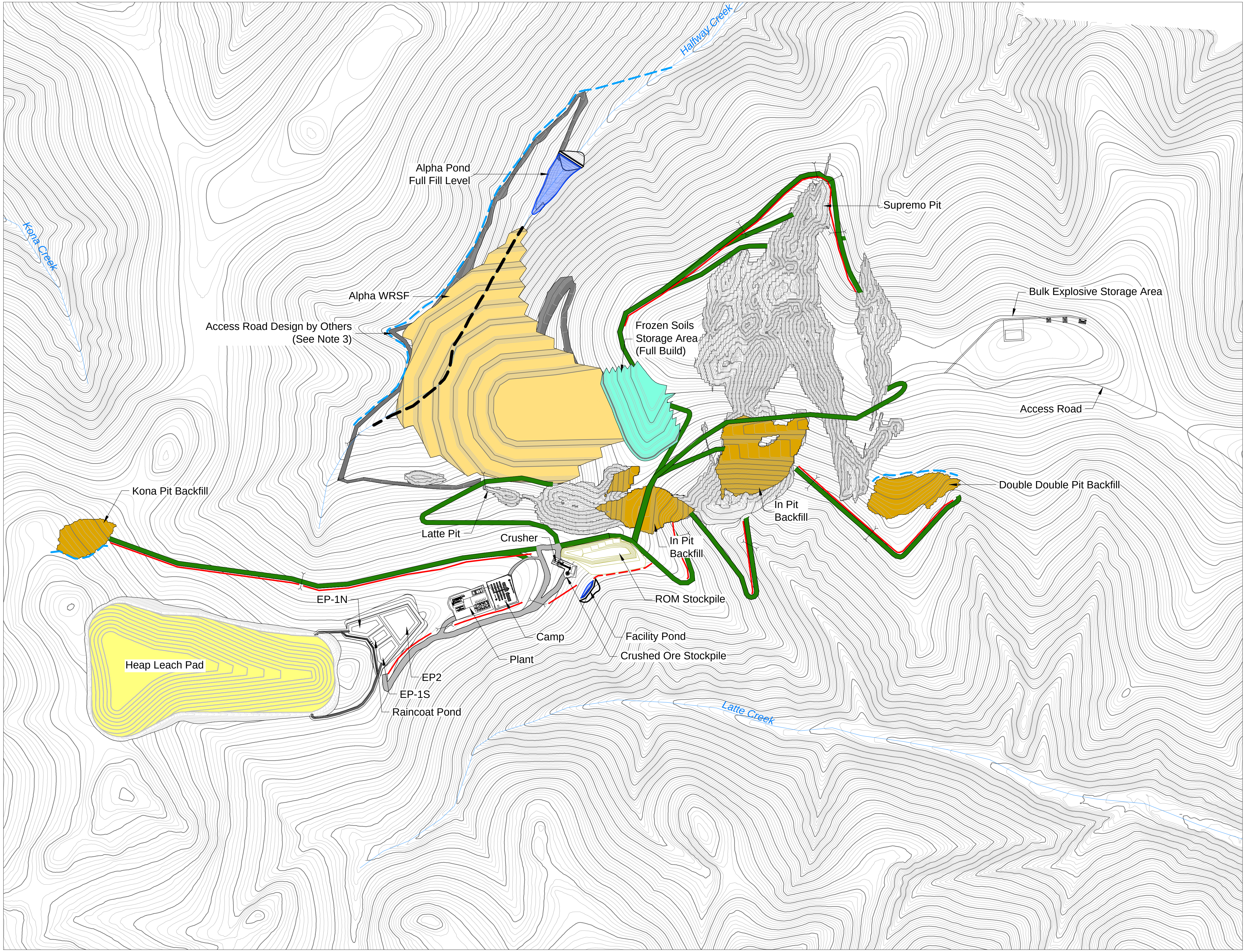
COFFEE GOLD MINE

Site Layout of Water Management Structures Year 12



Legend

- Diversion Berm
- Rock Drain
- Road Drainage Ditch
- Waste Rock Collection Channel
- Active Pit
- Frozen Soils Storage Area
- Pit Backfill
- Pit Footprint
- Sedimentation Pond
- Waste Rock Storage Facility
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3. Access Road design to be finalized in next phase.

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Metres

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Figure 5.4-13	Date: Mar 30, 2017	Drawn by: TAH	Reviewed: DP/TS

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6.0 MONITORING

Monitoring will be undertaken to 1) verify and monitor the site water balance, 2) assess water quality to verify that performance objectives are being met, and 3) verify the integrity and stability of conveyance structures. Each of these aspects of the monitoring program are summarized below. More detailed monitoring programs will be developed as the Project progresses through licensing.

6.1 METEOROLOGICAL MONITORING

The purpose of meteorological monitoring is to verify that temperature, precipitation, and snowpack accumulation fall within expected ranges, and use the data acquired to update and refine the water balance, as appropriate. Meteorological monitoring will include:

- Operation of the existing weather station, which is at an elevation of 975 m, between mine infrastructure and the airstrip.
- Installation and operation of a new, research-grade, automated weather station at the elevation of the HLF (1,300 asl). This station will be designed to collect the same information as is currently obtained at the existing weather station.
- Continued monitoring of baseline snow courses to quantify snow water equivalent accumulation.

6.2 PHYSICAL / GEOTECHNICAL MONITORING

All conveyance structures (drainage ditches, collection channels) and both sedimentation ponds and their dams will be inspected for stability (slumping or failure), signs of seepage, blockage due to ice or foreign debris and significant erosion or damage to any geosynthetic components. SRK's preliminary assessment of these dams classified them as significant dams under the Canadian Dam Association Dam Safety Guidelines (CDA 2007, Revised 2013). Monitoring by a qualified professional in accordance with the requirements of the CDA guidelines will be required.

6.2.1 PHASE 1: CONSTRUCTION (YEAR -2 TO -1)

The following structures will require monitoring at the frequency shown in **Table 6.2-1**. This monitoring will be the responsibility of the Engineering and Environmental departments.

Table 6.2-1 Phase 1 Monitoring Requirements

Phase	Description	Year	Facility	Frequency
1	Construction	-1	**Sedimentation Ponds:** Alpha Pond and Facility Pond	Daily- during open water seasons
1	Construction	-1	**Conveyance Structures:** Halfway Creek Diversion, Alpha WRSF Perimeter Ditches, Double Double Pit Diversion, Haul Road Ditches, Access Road Ditches	Daily- during open water seasons

6.2.2 PHASE 2: OPERATIONS (YEAR 1 TO 12)

The following structures will require monitoring at the frequency shown in **Table 6.2-2**. This monitoring will be the responsibility of the surface superintendent and environmental monitoring staff. Inspection is only required during open-water season.

Table 6.2-2 Phase 2 Physical Monitoring Requirements

Phase	Description	Year	Facility	Frequency
2	Operations	1-11	**Sedimentation Ponds:** Alpha Pond and Facility Pond	Weekly- during open water seasons
2	Operations	1-11	**Conveyance Structures:** Halfway Creek Diversion, Alpha WRSF Perimeter Ditches, Double Double Pit Diversion, Kona Pit Diversion, Kona WRSF Collection Ditch, Haul Road Ditches, Access Road Ditches	Weekly - during open water seasons
2	Operations	12	**Sedimentation Ponds:** Alpha Pond and Facility Pond	Weekly - during open water seasons
2	Operations	12	**Conveyance Structures:** Halfway Creek Diversion, Alpha WRSF Perimeter Ditches, Double Double Pit Diversion, Kona Pit Diversion, Haul Road Ditches, Access Road Ditches	Weekly - during open water seasons

6.2.3 PHASE 3: POST-MINING CLOSURE STAGE (YEAR 13– 18)

The following structures will require monitoring at the frequency shown in **Table 6.2-3**. This monitoring will be the responsibility of the Engineering and Environmental departments.

Table 6.2-3 Phase 3 Physical Monitoring Requirements

Phase	Description	Year	Facility	Frequency
3 and 4	Post-mining Closure Stage	13- 18	**Sedimentation Ponds:** Alpha Pond and Facility Pond	Weekly- during open water seasons for 2 years than monthly for remaining 4 years
3 and 4	Post-mining Closure Stage	13 -18	**Conveyance Structures:** Halfway Creek Diversion, Alpha WRSF Perimeter Ditches, Double Double Pit Diversion, Kona Pit Diversion, Haul Road Ditches, Access Road Ditches	Weekly- during open water seasons for 2 years than monthly for remaining 4 years

6.2.4 PHASE 4: ACTIVE MINING CLOSURE STAGE (YEAR 19– 23):

The following structures will require monitoring at the frequency shown in **Table 6.2-4**. This monitoring will be the responsibility of the Engineering and Environmental departments.

Table 6.2-4 Phase 4 Physical Monitoring Requirements

Phase	Description	Year	Facility	Frequency
4	Active Closure	19- 23	**Sedimentation Ponds:** Alpha Pond and Facility Pond	Monthly- during open water seasons
3 and 4	Active Closure	19 -23	**Conveyance Structures:** Halfway Creek Diversion, Alpha WRSF Perimeter Ditches, Double Double Pit Diversion, Kona Pit Diversion, Haul Road Ditches, Access Road Ditches	Monthly- during open water seasons

6.2.5 Phase 5 Post-closure (Year 15 – 20)

This decommissioning of all water management infrastructure (conveyance structures and sedimentation ponds) will be the final step in the Active Closure stage (Phase 4). Therefore, there will be no physical monitoring requirements during Phase 5, the Post-closure Phase.

6.3 Surface Water Quantity and Quality Monitoring

Monitoring of surface water during the Operation Phase, Reclamation and Closure and Post-closure Phases, in support of water management, will include both hydrologic (flow) monitoring and water quality sampling.

6.3.1 Hydrologic Monitoring

The current hydrologic regime and flow path distribution at the Project site is well understood, and there is a high-degree of confidence in the planned alterations to existing flow paths from the placement of engineered water management structures. However, it will be necessary to implement a strategic and flexible water monitoring program at the Mine Site for the following reasons:

- Enhance baseline understanding of local hydro-meteorological processes;
- Verify the accuracy of the residual change and residual cumulative change predictions;
- Assess the efficacy of mitigation measures and the need for modifications to those measures;
- Identify analysis discrepancies that may arise related to the Surface Hydrology IC, and;
- Implement additional mitigation measures as per adaptive management plans as required.

A generic hydrologic monitoring program is discussed below for the Project, with focus below on monitoring concepts as they relate to: Mine Site Monitoring; Effluent Monitoring; and Receiving Environment Monitoring. During the Construction Phase, water monitoring is anticipated to evolve and expand as mine design concepts, construction schedules and permitting details become certain, whereas during the Operation and Reclamation and Closure Phases, additional water-specific monitoring initiatives may be required to inform mitigative actions. Following successful reclamation and closure of the Mine Site, water monitoring directives for the Post-closure Phase are envisioned, albeit with reduced scope compared to preceding mine phases. Design and delivery of future monitoring activities will require the involvement of the regulatory agencies that have jurisdiction over water-related issues, affected First Nations and coordinated efforts by Goldcorp staff.

6.3.1.1 Mine Site Monitoring

Mine Site monitoring is intended to record the quantity of both surface and groundwater that is affected by the various mine facilities. It is required primarily to confirm that site-wide water management systems are effective and functioning as intended. As such, Mine Site Monitoring will include: measurement of flow and associated seepage from WRSFs, runoff from pit walls that reports to in-pit sumps, stored water in event ponds, Open Pits, the Alpha Pond and mine sumps used during the Construction and Operation Phases.

In addition, the HLF will have a comprehensive water monitoring program associated with operation of the heap to allow for routine updates to the HLF water balance model. The HLF water balance model will be reconciled quarterly to actual solution levels and flow rates for the prior year.

6.3.1.2 Effluent Monitoring

Effluent monitoring is intended to record the quantity of surface water that collects in sedimentation ponds and sumps, located downgradient of mine infrastructure, and discharged to the receiving environment. For the Construction and Operation phases, two ponds (Facility and Alpha ponds) are proposed and surface water quantity will be monitored at each of them. Additionally, contact water that reports southward to Latte Creek (i.e., south Supremo pits and associated backfill) and northward to YT-24 (north Supremo pits, no backfill features) will be managed to dedicated sumps which will require flow measurement capability.

Effluent water flow monitoring will also occur on the water treatment plant effluent. Surplus rinse water from the HLF will require discharge and therefore treatment starting in Year 9 and is anticipated to continue into the Active Closure stage. Monitoring to verify compliance with appropriate discharge rate limits for treated effluent pond discharges are important components of the plan and are expected to be subject to certain regulatory requirements. Following reclamation and drain-down of the HLF, seepage from the closed facility will be directed to Latte Pit. Measuring discharges from this future pit lake will be a requirement following spillover.

6.3.1.3 Receiving Environment Monitoring

Monitoring in the receiving environment will include monitoring intended to record the quantity of water in the receiving environment downstream of mine inputs. Surface water monitoring will include monitoring at selected stations on Latte Creek, Coffee Creek, YT-24, Halfway Creek, and on the Yukon River, as well as Independence Creek, the latter of which serves as the undisturbed control drainage (**Figure 6.3-1**). Flows in the receiving environment, downstream of the Mine Site, will reflect the ultimate effects of the mine on the relevant intermediate and valued components (ICs and VCs, respectively). Receiving environment water quantity is also expected to be subject to specific regulatory requirements.

Hydrology methods observe the standards and procedures outlined in the *Manual of British Columbia Hydrometric Standards – Version 1.0* (RISC, 2009). This document defines standards and detailed procedures for the acquisition of water quantity data, and provides specific direction on monitoring site selection, station construction and benchmarking, recording discharge measurements, developing stage-discharge relationships, and reporting and presenting hydrometric data.

These standard methods have been employed since 2010 as part of the baseline monitoring program, and will continue to be used through the Construction and Operation phases of the Project.

6.3.2 SURFACE WATER QUALITY MONITORING

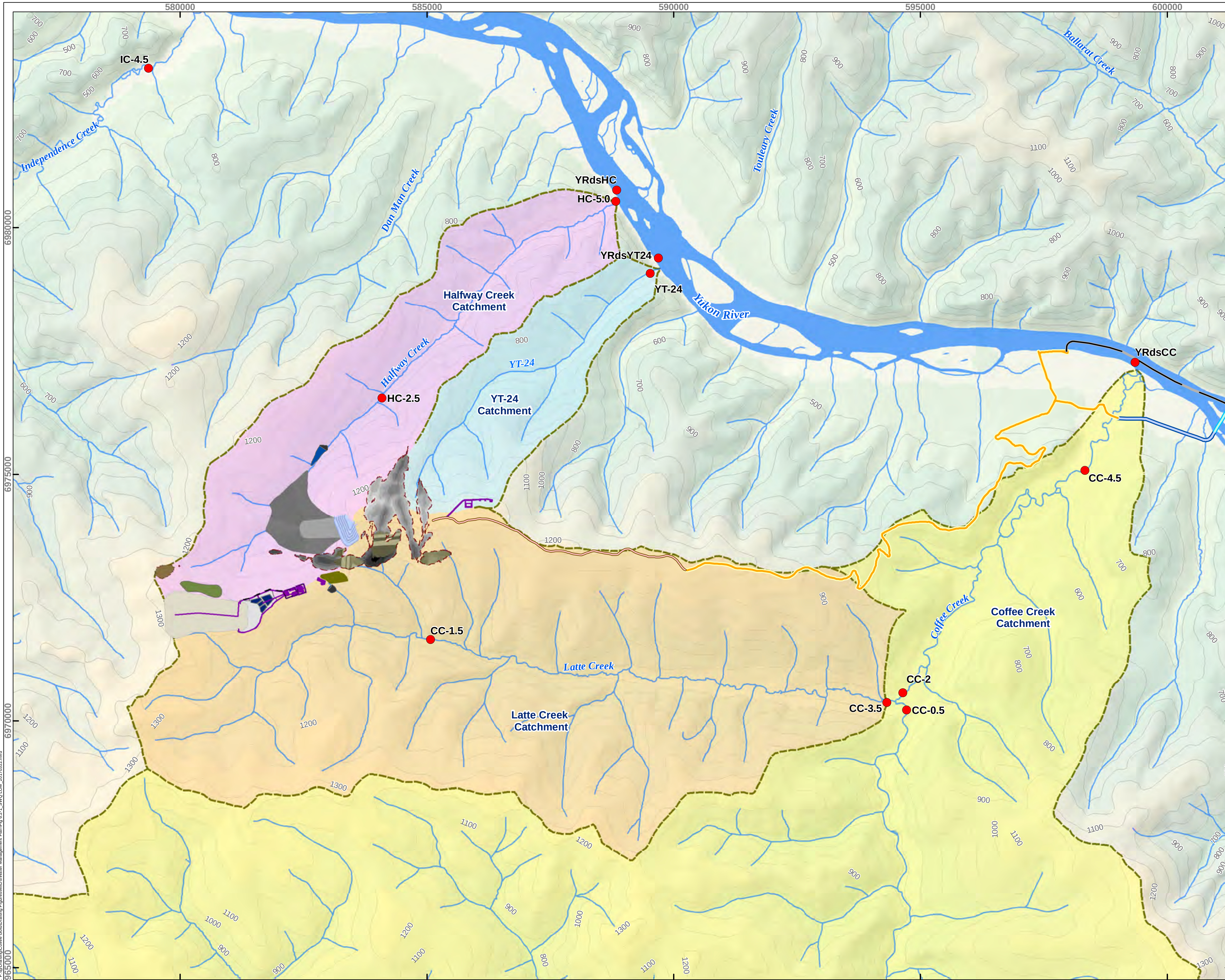
Surface water quality monitoring will be required to verify water quality predictions, and to identify any unanticipated effects on surface water quality that may occur through life of mine and, in particular, closure. Monitoring will include surface water quality within the Mine Site, at effluent discharge points, and in the receiving environment. The surface water quality monitoring program is intended to:

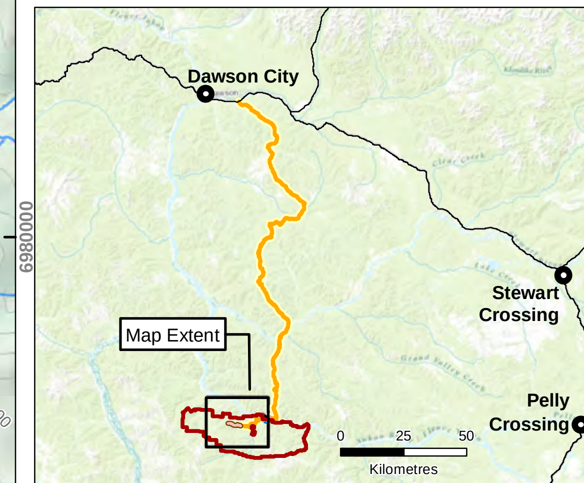
- Verify and update water quality predictions for all phases of the Project, based on monitoring results, as necessary;
- Assess compliance with applicable water quality discharge limits for Mine Site effluent; and
- Assess whether any mitigation or adaptive management is required.

A preliminary surface water quality monitoring program is discussed below for the Project, with a focus on monitoring concepts as they relate to Mine Site monitoring, Effluent Monitoring and Receiving Environment Monitoring during the Reclamation and Closure Phase. It is anticipated that surface water quality monitoring requirements will be reduced in the Post-closure Phase, following successful reclamation and closure of the Mine Site. Design and delivery of future monitoring activities will require the involvement of First Nations partners, regulatory agencies that have jurisdiction over water-related issues, and coordinated efforts by mine staff.

COFFEE GOLD MINE

Hydrology and Surface Water Monitoring Locations





Legend

- Surface Water Quality Monitoring Location
- City/Community
- Catchment Boundary
- Coffee Property Claims Boundary
- Waterbody
- Watercourse
- Elevation Contours (100m)
- Yukon River Barge Route
- Yukon River Ice Road
- Winter Road
- Mine Site Access Route
- Northern Access Route

Pre-Mine Catchment Area

- Halfway Creek
- Latte Creek
- YT-24 Creek
- Coffee Creek

Proposed Infrastructure

- WRSF
- Backfill
- Total Pit Outline
- ROM Stockpile
- Organics Stockpile
- Frozen Soil Storage Area
- Event Pond
- Heap Leach Access Disturbance Footprint
- Heap Leach Pad Base
- Support Infrastructure

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Kilometers

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6.3.2.1 Mine Site Monitoring

Mine Site water quality monitoring will be intended to record the quality of surface water affected by the various mine facilities. It will be required to confirm and/or verify geochemical 'source terms', (quantitative assumptions and predictions made to anticipate the effects of bedrock disturbance that will occur in the course of mine development and attendant water quality predictions in the receiving environment). Mine Site Monitoring will include measurement of water quality associated with seepage from WRSFs, runoff from pit walls that reports to in-pit sumps, and stored water in the event ponds.

6.3.2.2 Effluent Monitoring

Effluent monitoring will record the quality of water discharging from:

- Alpha Pond
- Pit sump discharges to YT-24 and Latte Creek catchments;
- Water treatment plant,
- Passive treatment systems for the HLF (if utilized); and
- Pit lakes, upon complete filling.

6.3.2.3 Receiving Environment Monitoring

Receiving environment water quality monitoring will be undertaken to assess the quality of surface water that is affected by the various mine facilities. Surface water quality monitoring will include monitoring at selected stations on Latte Creek, Coffee Creek, YT-24, Halfway Creek, and on the Yukon River, as well as Independence Creek, the latter of which currently serves as the undisturbed control drainage. Key monitoring locations are provided in **Figure 6.3-1.** Water quality in the receiving environment downstream of the Mine Site will reflect the ultimate effects of the mine on the relevant intermediate and valued components (ICs and VCs, respectively). The number of water quality sample locations may increase or decrease, depending upon final mine configuration and closure conditions.

Water quality sampling will continue to be undertaken in accordance with the *British Columbia Field Sampling Manual* (BC Ministry of Environment, 2013). Samples will be collected and shipped to an accredited laboratory and are analyzed for physical parameters, major ions, nutrients, total and dissolved organic carbon, WAD cyanide, and total and dissolved metals. The full list of parameters that are analyzed, and detection limits, are provided in **Table 6.3-1**.

Table 6.3-1 Analytical Parameter List and Reportable Detection Limits

Analysis		Reportable Detection Limit
Physical Parameters	**Unit**	
Conductivity	µS/cm	1.0
Hardness (as $CaCO_3$)	mg/L	0.5
pH	pH	0.01 unit
Total Suspended Solids (TSS)	mg/L	1.0
Total Dissolved Solids (TDS)	mg/L	10.0
Turbidity	NTU	0.1
Major Ions and Nutrients		
$Alkalinity_{Total}$ (as $CaCO_3$)	mg/L	0.5
$Alkalinity_{PP}$ (as $CaCO_3$)	mg/L	0.5
Bicarbonate (HCO_3)	mg/L	0.5
Cabonate (CO_3)	mg/L	0.5
Chloride (Cl)	mg/L	0. 5
Sulphate (SO_4)	mg/L	0.5
Fluoride (F)	mg/L	0.01
Nitrate (as N)	mg/L	0.002
Nitrite (as N)	mg/L	0.002
Total Ammonia (as N)	mg/L	0.005
Nitrate plus Nitrite (as N)	mg/L	0.002
Total Phosphorus as P	µg/L	0.002
Cyanide		
Weak acid dissociable cyanide (CN_{WAD})	mg/L	0.0005
Organic Carbon		
Total Organic Carbon (TOC)	mg/L	0.5
Dissolved Organic Carbon (DOC)	mg/L	0.5
Total and Dissolved Metals		
Aluminum (Al)	µg/L	0.5
Antimony (Sb)	µg/L	0.02
Arsenic (As)	µg/L	0.02
Barium (Ba)	µg/L	0.02
Beryllium (Be)	µg/L	0.02
Bismuth (Bi)	µg/L	0.01
Boron (B)	µg/L	10
Cadmium (Cd)	µg/L	0.005
Calcium (Ca)	mg/L	0.05

Analysis		Reportable Detection Limit
Physical Parameters	**Unit**	
Chromium (Cr)	µg/L	0.1
Cobalt (Co)	µg/L	0.005
Copper (Cu)	µg/L	0.05
Iron (Fe)	µg/L	1.0
Lead (Pb)	µg/L	0.005
Lithium (Li)	µg/L	0.5
Magnesium (Mg)	mg/L	0.05
Manganese (Mn)	µg/L	0.05
Mercury (Hg)	µg/L	0.002
Molybdenum (Mo)	µg/L	0.5
Nickel (Ni)	µg/L	0.02
Potassium (K)	mg/L	0.05
Selenium (Se)	µg/L	0.04
Silicon (Si)	mg/L	50
Silver (Ag)	µg/L	0.005
Sodium (Na)	mg/L	0.05
Strontium (Sr)	µg/L	0.05
Thallium (Tl)	µg/L	0.002
Tin (Sn)	µg/L	0.2
Titanium (Ti)	µg/L	0.5
Uranium (U)	µg/L	0.002
Vanadium (V)	µg/L	0.2
Zinc (Zn)	µg/L	0.1

shipped to an accredited labor

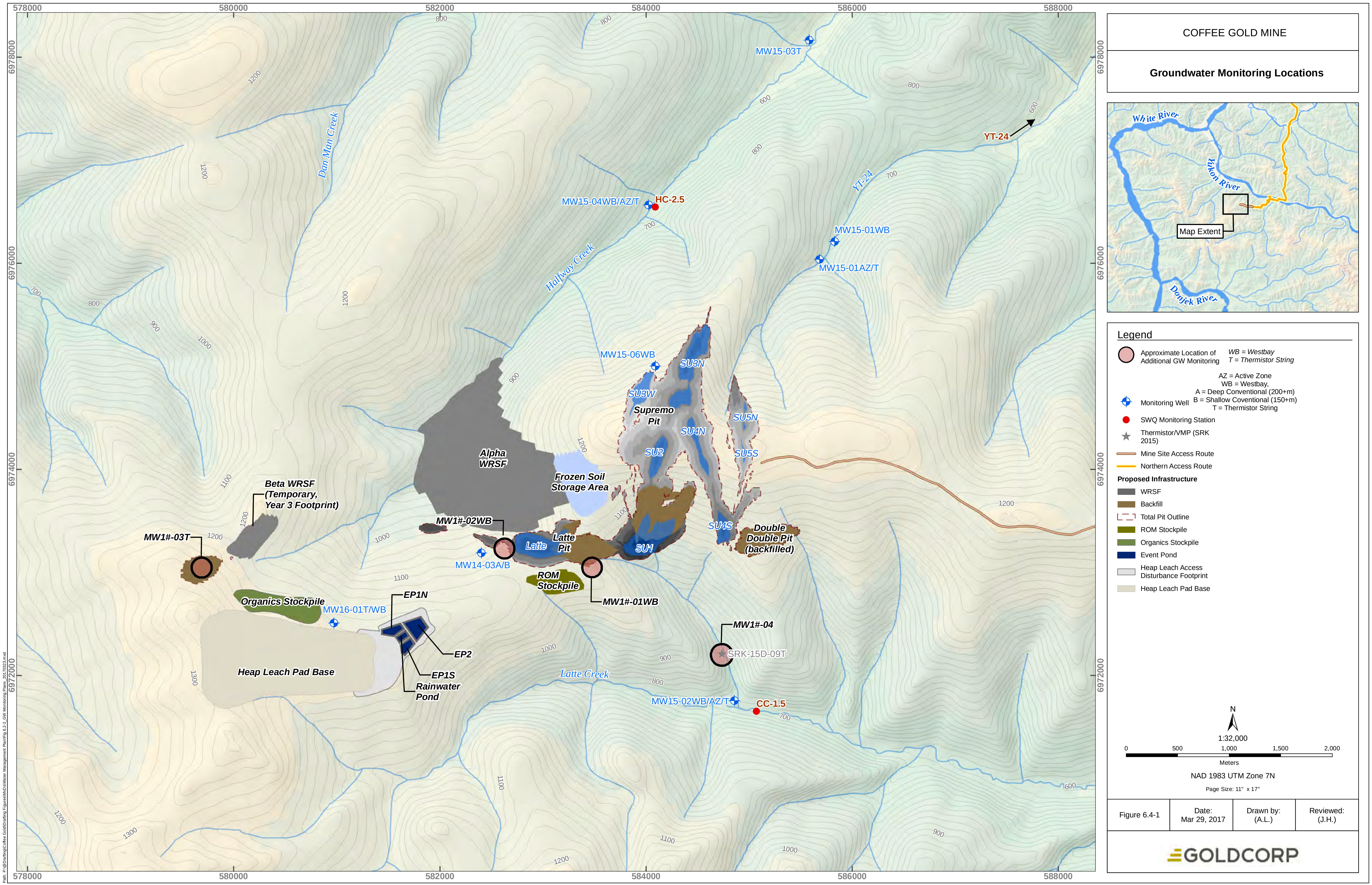
6.4 GROUNDWATER MONITORING

Groundwater flows (which recharge local streams) and groundwater quality will be monitored during Construction, Operation and the Post-mining Closure Stage to detect any changes in groundwater pressure (i.e., water table elevations), or groundwater quality, that may be caused by mine operation and closure activities. Groundwater monitoring is not proposed for the Post-closure Phase.

The groundwater monitoring system includes thermistor strings to measure ground temperature, vibrating wire piezometers to measure depth to groundwater, and a series of shallow and deep groundwater monitoring wells. Hydrogeological monitoring locations and monitoring frequency specific to the Reclamation and Closure Phase (Post-mining Closure and Active Closure stages) are described below and illustrated in **Figure 6.4-1**.

For the Post-mining and Active Closure stages, ground temperature and groundwater levels will be monitored continuously (except quarterly at Westbay wells), while groundwater quality adjacent to, and immediately down-gradient from mine facilities will be sampled quarterly, with receiving environment locations to be sampled quarterly or semi-annually, depending on proximity to mine facilities. A thermistor string will be installed in the backfilled Kona Pit to verify that the waste rock remains frozen (permafrost aggrades into the backfilled pit).

During the Active Closure stage, surface water quality will be used as the key indicator of changes in groundwater, as no groundwater discharge from the HLF is likely, noting that this is the only facility (in conjunction with the water treatment plant) that requires active management in the Active Closure stage.



COFFEE GOLD MINE
Groundwater Monitoring Locations
White River
Yukon River
Donjek River
Map Extent
Legend
Approximate Location of Additional GW Monitoring
WB = Westbay
T = Thermistor String
Monitoring Well
AZ = Active Zone
WB = Westbay,
A = Deep Conventional (200+m)
B = Shallow Conventional (150+m)
T = Thermistor String
SWQ Monitoring Station
Thermistor/VMP (SRK 2015)
Mine Site Access Route
Northern Access Route
Proposed Infrastructure
WRSF
Backfill
Total Pit Outline
ROM Stockpile
Organics Stockpile
Event Pond
Heap Leach Access Disturbance Footprint
Heap Leach Pad Base
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Figure 6.4-1
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Reviewed: (J.H.)
GOLDCORP
MW15-03T
YT-24
Dan Man Creek
MW15-04WB/AZ/T
HC-2.5
MW15-01WB
MW15-01AZ/T
Halfway Creek
MW15-06WB
SU3N
SU3W
Supremo Pit
SU4N
SU5N
SU5S
SU2
Alpha WRSF
Frozen Soil Storage Area
Beta WRSF (Temporary, Year 3 Footprint)
MW1#-02WB
MW1#-03T
Latte
Latte Pit
SU1
SU4S
Double Double Pit (backfilled)
MW14-03A/B
ROM Stockpile
MW1#-01WB
Organics Stockpile
EP1N
MW16-01T/WB
EP2
MW1#-04
SRK-15D-09T
EP1S
Rainwater Pond
Heap Leach Pad Base
Latte Creek
MW15-02WB/AZ/T
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7.0 REPORTING

The Water Management Plan is anticipated to be subject to authorization under the Quartz Mine License and Water Use License that are required for the Project. As such, reporting to the appropriate regulatory bodies is expected to be required as conditions of these licences.

Reporting the results of ongoing monitoring activities will likely be required monthly and/or annually, and will include, but not necessarily be limited to, details of:

- Meteorological monitoring;
- Description and volumes of the water use and waste deposition;
- Results of any water quality monitoring, including groundwater, and stream-flow measurements;
- Any updates to water balance for Mine Site or HLF;
- Detailed data on the volume of water collected, transferred, contained, or released to the environment; and
- Summary of physical inspections and any corrective actions taken as a result of the inspections.

Copies of reports will be provided to First Nations and will be made available for public viewing on platforms provided by the regulatory bodies, as required.

8.0 REFERENCES

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