Reclamation Plan
Red Dog Mine, Alaska, USA

Teck Alaska Incorporated

September 2021

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List of Abbreviations

ADEC	Alaska Department of Environmental Conservation
ADNR	Alaska Department of Natural Resources
APDES	Alaska Pollution Discharge Elimination System
ARD	Acid Rock Drainage
BMP	Best Management Practices
BTU	British thermal unit
CFR	Code of Federal Regulations
ConPAC	construction personnel accommodations complex
CSB	concentrate storage building
COSB	Coarse Ore Stockpile Building
DD-1	Diversion Ditch-1
DD-2	Diversion Ditch-2
DD-3	Diversion Ditch-3
DD-4	Diversion Ditch-4
DMTS	DeLong Mountain Regional Transportation System
HDPE	high-density polyethylene
HDS	high-density sludge (water treatment process)
IWMP	Integrated Waste Management Plan
LLDPE	Linear low-density polyethylene
LMPT	Large Mine Permitting Team
LOM	Life of Mine
ML/ARD	metal leaching/acid rock drainage
MOU	Memorandum of Understanding
MPD	Main Pit Dump
MWD	Main Waste Dump
MPWR	Main Pit Water Reservoir
NANA	NANA Regional Corporation, Inc.
NPV	net present value
PAC	personnel accommodations complex
PMF	Probable Maximum Flood
QPD	Qanaiyaq Pit Dump
SAG	semi-autogenous grinding
TAK	Teck Alaska Incorporated
TDS	Total dissolved solids
TSF	Tailings Storage Facility
WMP	Waste Management Permit
WRD	Waste Rock Dump
WTP1	Water Treatment Plant 1
WTP2	Water Treatment Plant 2
WTP3	Water Treatment Plant 3
WVQM	Water Volume Quality Management

Units of Measure

bgal	billion gallons
C	Celsius
°	degree
ft	foot/feet
g	gram
gpd	gallons per day
gpm	gallons per minute
kg	kilograms
kW	kilowatt
lb	pound
m	meter
oz	ounce
pcf	pounds per cubic foot
ppm	parts per million
yd^2	square yard
yd^3	cubic yard

1 Introduction and Scope of Plan

1.1 Purpose

Teck Alaska Incorporated (TAK) and NANA Regional Corporation, Inc. (NANA), as associates in the operation of the Red Dog Mine (Mine), are committed to protecting the environment and neighbor communities. Part of that commitment includes developing plans for the orderly closure of the Mine and reclamation of disturbed areas.

This document presents a Reclamation Plan (Plan) for the Mine. Although current projections are that the Mine will remain in operation until 2032, closure and reclamation measures benefit from early planning that address concurrent reclamation, and details about the final orderly closure. In addition, State of Alaska regulations require a financial assurance to cover costs related to closure and reclamation, and the amount of financial assurance is best estimated using a well-conceived plan.

1.2 Applicant Information

1.2.1 Corporation Officer Completing Application

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1.2.3 Corporate Information

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Treasurer: Les Panther

Secretary/Vice President: Trevor Hall

1.2.4 Alaska Registered Agent

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Juneau, Alaska 99801

1.3 Scope of Closure and Reclamation Plan

This Plan describes the activities required to bring the Red Dog Mine from its current operating configuration to its final closure configuration and maintain the site for the long term, and also provides an estimate of the cost to do so.

Figure 1 shows the location of the Mine. Port and road facilities shown in Figure 1 are outside any of the mine permit boundaries and outside the scope of this Plan. Differences in ownership and use require that the port and road facilities be addressed through other planning and regulatory processes.

Figure 2 shows the boundary of the area considered in this Plan and corresponds to the boundaries of both the mine Waste Management Permit **(2021DB0001)** and the Air Quality Permit (**AQ0290TVP02**), although the areas disturbed by mine operations are small relative to the entire area.

This Plan begins with a brief description of the mine site, ongoing mine operations and the various facilities at the site in Section 2.

Section 3 describes the reclamation methods that will be implemented to transition the site to its final closure configuration. As discussed throughout the plan the current reserves at Red Dog are sufficient to support mining through 2032 and a "planned closure" is described to follow the end of mining. In addition, a hypothetical "premature closure" in 2023 is discussed in Section 5, because it reflects the maximum reclamation liability exposure during the next 5-year permit cycle which must be reflected in the mine's reclamation bond.

Section 4 describes the post-closure period when the site will be monitored and maintained in a stable state and water treatment and discharge will continue for the long term.

Section 5 of this Plan presents a schedule for the remaining mine operations (assuming a planned closure), reclamation, and post-closure activities discussed in this Plan. Section 5 also discusses the costs associated with a holding period, hypothetical premature mine closure, reclamation of the site, and long term post-closure activities. Estimated costs are presented as summary tables. The premature closure scenario costs are presented and discussed because they represent the highest reclamation liability for the project during the next reclamation plan approval cycle (2021 – 2026) and will be used by State agencies to calculate the financial assurance requirements for that cycle.

The detailed derivation of the estimated temporary closure, reclamation and post-closure costs was accomplished using the Standardized Reclamation Cost Estimator (SRCE) software. The Basis of Estimate Report that discusses the basis and assumptions for deriving these costs is included in Appendix B. In addition, several supporting documents that provide more detailed information are referenced throughout this Plan.

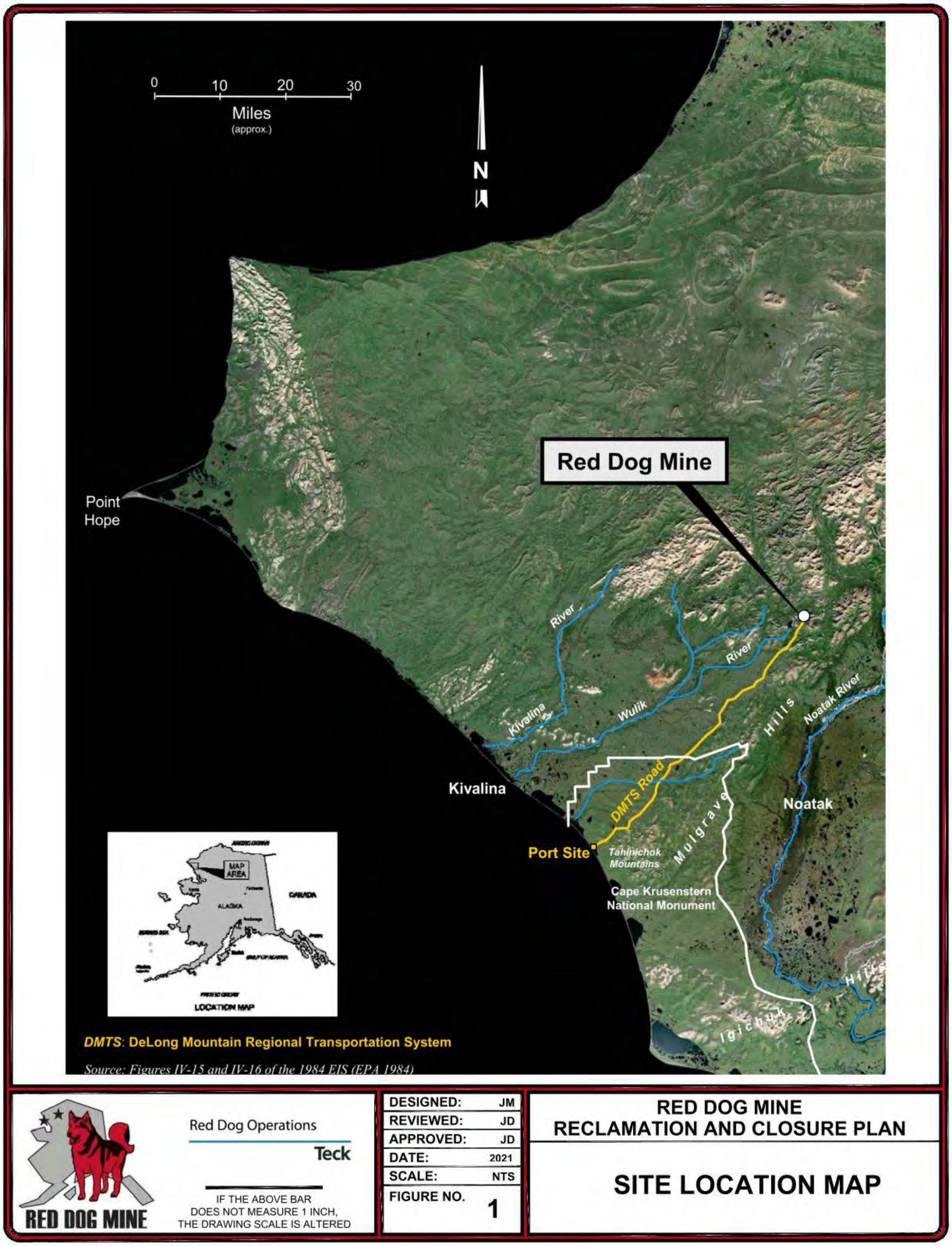


Figure 1: Site Location Map

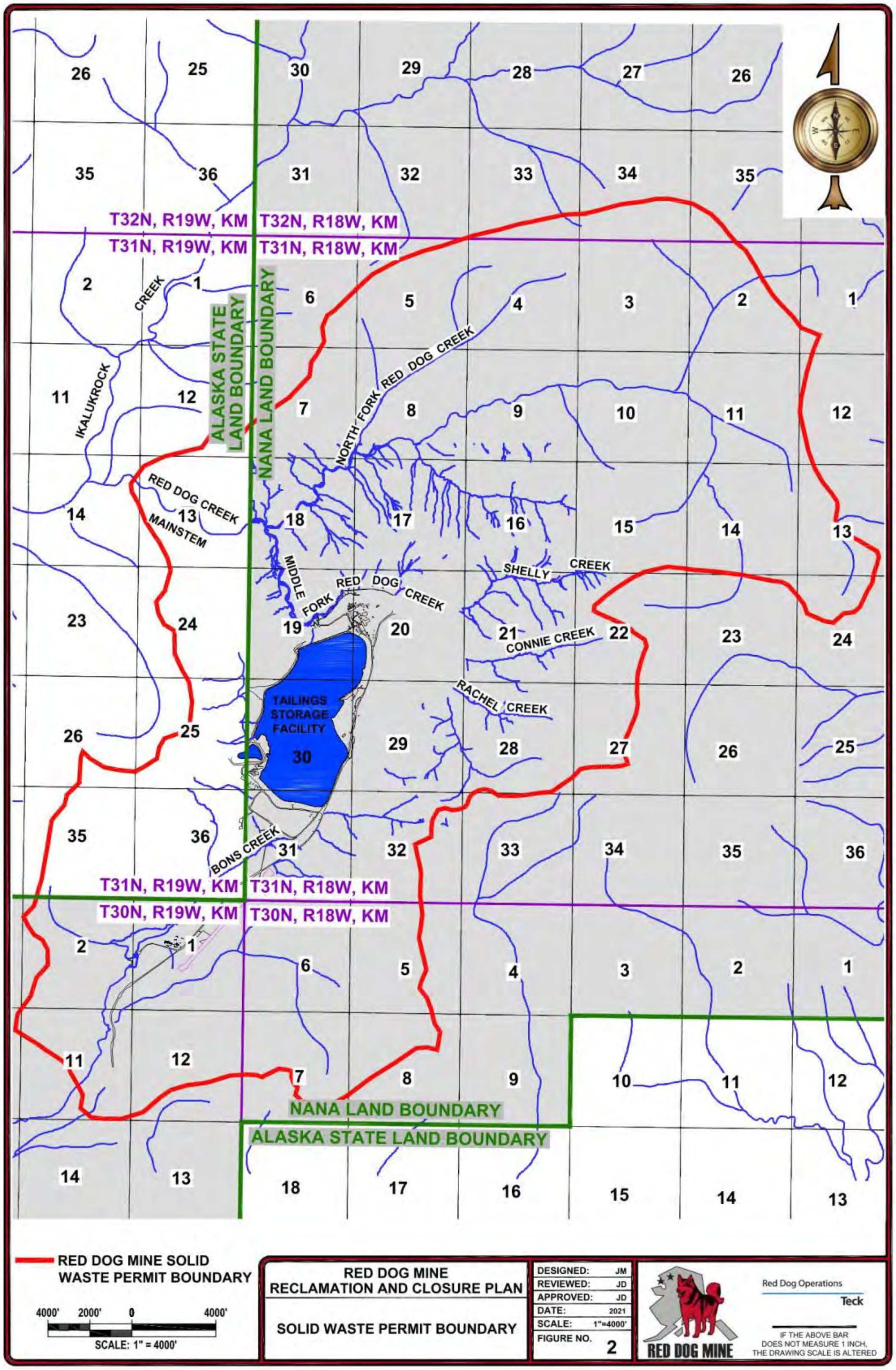


Figure 2: Solid Waste and Air Quality Permit Boundary

1.4 Reclamation and Closure Planning History

The Operating Agreement between NANA and TAK includes eight provisions that relate to environmental protection, including reclamation, as summarized in Table 1. The agreement called for a reclamation plan that was initially developed in 1983 and revised in 1986. Reclamation plans were required by the State mining regulations adopted in 1992 (11 AAC 97.300 – 97.400, Table 2.). A reclamation plan was filed to meet those regulations in 1994. That reclamation plan is approved by the State for a 5 year period and this plan was developed for the 2021 – 2026 cycle. Table 2 summarizes reclamation requirements of the State mining regulations.

In 1998, the State of Alaska Department of Environmental Conservation (ADEC) adopted solid waste regulations (18 AAC 60.265) that have additional requirements for closure and reclamation, including provision for financial responsibility for closure and post-closure monitoring. In addition, 2004 amendments to the ADNR State Dam Safety regulations (11 AAC 93) include requirements for financial assurance.

Table 1: Closure and Reclamation Provisions in the NANA – Teck Alaska Operating Agreement

(1)	The parties recognize that reclamation of disturbed lands is desirable.
(2)	The parties recognize that land disturbances related to surface mining and the deposition of tailings and waste rock are inevitable and complete return of all the disturbed land to its undisturbed condition is not possible.
(3)	Reclamation shall be generally designed to mitigate potential long-term danger to human life or the subsistence needs of the natives of the NANA Region, to mitigate any adverse visual or aesthetic conditions, and to the extent reasonably practicable, to restore the land to a condition compatible with surrounding land.
(4)	Disturbed land shall be restored to natural looking contours compatible with the surrounding terrain (it being recognized that the area of the mine excavation will not be refilled).
(5)	Where available in appropriate quantities, topsoil shall be separately removed and stockpiled for final application after reshaping of disturbed areas has been completed. However, the parties recognize that permafrost conditions could cause long-term stockpiling of topsoil to be impractical.
(6)	Appropriate measures shall be taken to control or reduce erosion, landslides and water runoff to the extent practicable.
(7)	Fisheries and wildlife habitats shall be rehabilitated to the extent practicable.
(8)	To the extent practicable, disturbed areas shall, through seeding, fertilizing, and other appropriate means be revegetated with a diverse vegetative cover of species native to the area and similar to that on adjoining areas.

This Plan is an update of the 2016 *Reclamation and Closure Plan* and incorporates nearly all sections of the earlier document with minor changes as required. This Plan has also been prepared in parallel to the 2021 renewal of the Red Dog Mine *Integrated Waste Management Plan* (IWMP).

TAK has long undertaken an ongoing process of consultation and inclusion with the communities of Noatak and Kivalina to ensure they are part of developing the concepts embraced by the mine closure and reclamation plans, including the current Plan. NANA also reviewed and provided input to the DRAFT Plan. The final version of this plan will also benefit from the review by the State LMPT.

Table 2: Select State of Alaska Mine Reclamation Requirements

"reclamation of the area so any surface that will not have a stream flowing over it is left in a stable condition to ensure:	11 AAC 97.200 (a)
• return of waterborne soil erosion to pre-mining levels within one year after the reclamation is completed, and that can reasonably be expected to achieve revegetation, where feasible, within five years after the reclamation is completed, without the need for fertilization or reseeding;	11 AAC 97.200 (a) (1)
• segregation of topsoil removed during the mining operation to protect it from erosion, protect it from contamination by acidic or toxic materials, and preserve it in a condition suitable for later use; and	11 AAC 97.200 (a) (2)
• promotion of natural revegetation wherever possible, including redistribution of topsoil where available"	11 AAC 97.200 (a) (3)
"reclamation of the area so that surface contours after reclamation are conducive to natural revegetation or are consistent with an alternate post-mining land use"	11 AAC 97.200 (b)
"reclamation of a pit wall is not required if the steepness of the wall makes it impracticable or impossible to accomplish; however, the wall must be left in a stable and safe condition"	11 AAC 97.200 (c)
"re-establishment of any stream channel, that was diverted and is no longer stable, to a stable location..."	11 AAC 97.200 (d)
"… reclaim a mined area that has potential to generate acid rock drainage (acid mine drainage) in a manner that prevents the generation of acid rock drainage or prevents the offsite discharge of acid rock drainage"	11 AAC 97.240
"…Post a performance bond with the commissioner to ensure complete compliance with AS 27.19, this chapter and the approved reclamation plan"	11 AAC 97.400

2 Site Components and Operations

Section 2 describes existing mine site facilities and the ongoing mine operations. This section is largely unchanged from the 2016 Reclamation Plan as the site facilities remain materially unchanged, except that the Plan has been updated with current numerical values for variables including acreage, elevations, years and tonnes etc.

2.1 Mine Area

2.1.1 Current Layout

Figure 3 shows the current layout of the mine area, and identifies key mine components including:

- Main Pit Dump, Main Waste Dump,
- Aqqaluk, Qanaiyaq and Main pits,
- Ore Stockpiles,
- Middle Fork of Red Dog Creek, Rachel Creek, Connie Creek, Shelly Creek, and Sulfur Creek,
- Components of Non-Contact Water Diversion System Red Dog Creek Diversion), and
- Components of Mine Water Diversion and Storage System, including the Tailings Storage Facility (TSF).

The *2021 Red Dog Mine Life of Mine Plan (TAK 2020)* has identified sufficient resources to support mining into 2032. Figure 4 summarizes the planned Life of Mine (LOM) ore and waste production. The LOM Plan is based on estimates of long-term metal prices and operating costs. Changes in these costs may affect future LOM plans. LOM plans are updated by TAK annually in mid-year.

Figure 5 shows the mine area layout at the end of operations in 2032. It also shows the Red Dog Creek Diversion which directs clean water around mine disturbance and reintroduces it into Middle Fork Red Dog Creek. The layout in Figure 5 assumes continuous mining and waste rock management as described in the 2020 LOM plan, and concurrent reclamation.

2.1.2 Pits

Main Pit

Mining in the Main Pit was completed in 2011. At that time, the Main Pit extended over a plan area of approximately 150 acres, with its deepest point at elevation 450 ft. The current LOM plan requires waste rock from Aqqaluk and Qanaiyaq Pits to be disposed into the Main Pit, creating the Main Pit Dump (MPD), and completely filling the pit and nearly covering the pit walls by 2032.

Aqqaluk Pit

Mining of the Aqqaluk Pit was initiated in 2010 and was in full production by 2012. TAK anticipates ore production through 2032 from the Aqqaluk Pit. Figure 6 illustrates the planned phases of development of the Aqqaluk Pit from 2019 to 2032. The pit will cover a plan area of approximately 153 acres, and the deepest point of the pit will be at elevation 450 ft.

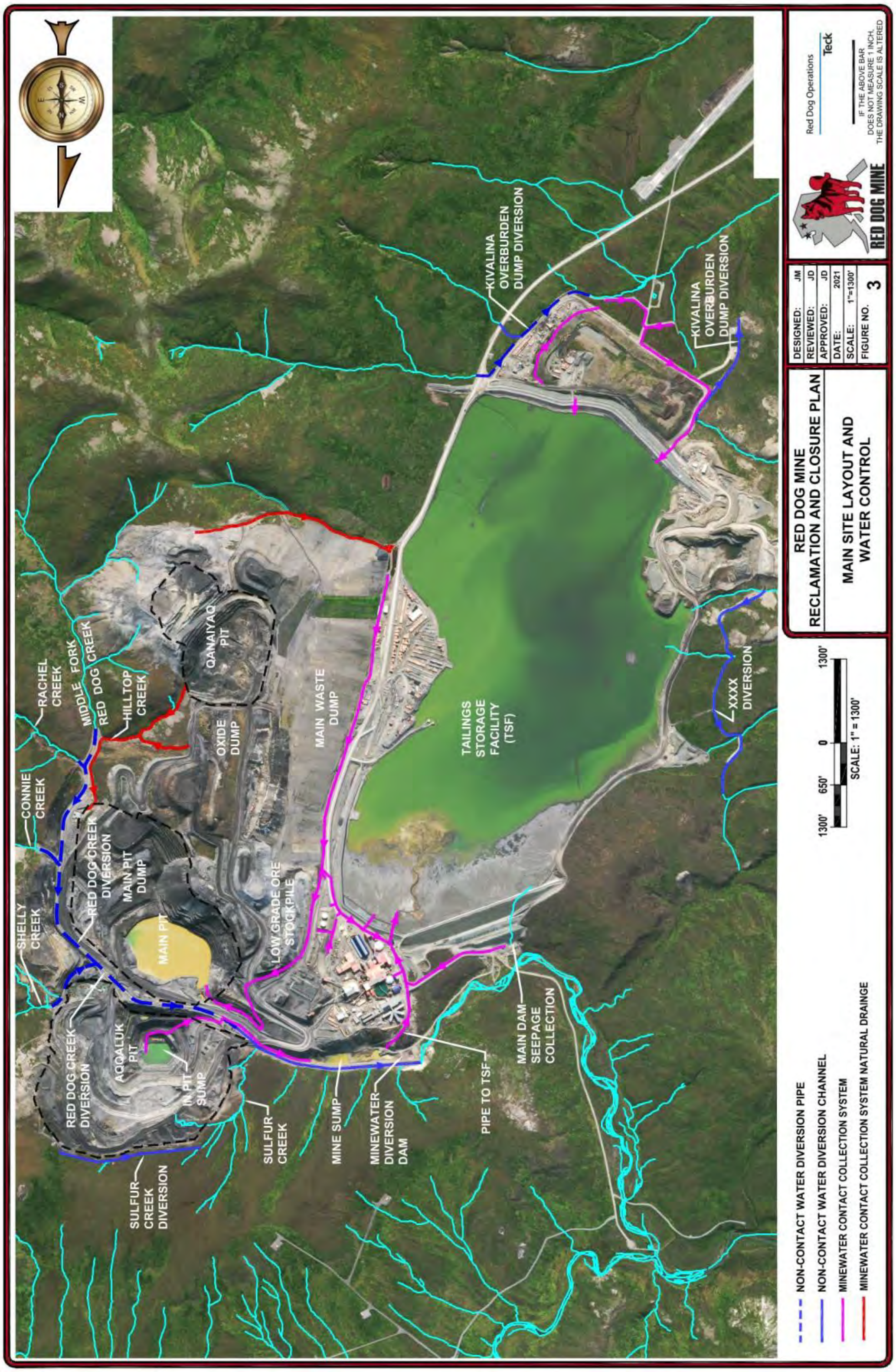
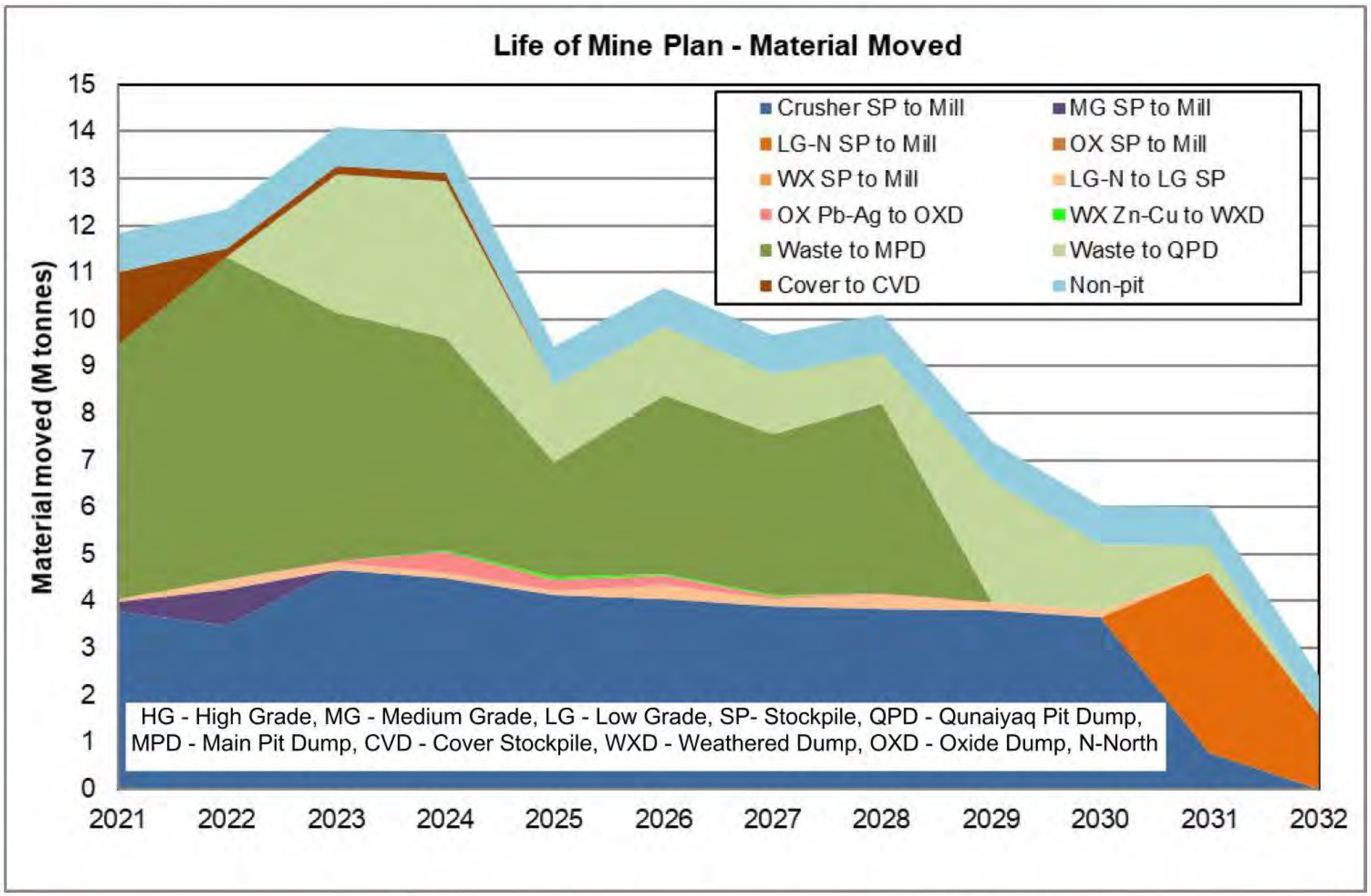


Figure 3: Current Mine Area Layout



RED DOG MINE

Red Dog Operations

Teck

IF THE ABOVE BAR
DOES NOT MEASURE 1 INCH,
THE DRAWING SCALE IS ALTERED

DESIGNED:	JM
REVIEWED:	JD
APPROVED:	JD
DATE:	2021
SCALE:	NTS
FIGURE NO.	4

RED DOG MINE
RECLAMATION AND CLOSURE PLAN

TOTAL MATERIAL MOVED BY
DESTINATION (RECOVERED BASIS)

Figure 4: LOM Ore and Waste Production

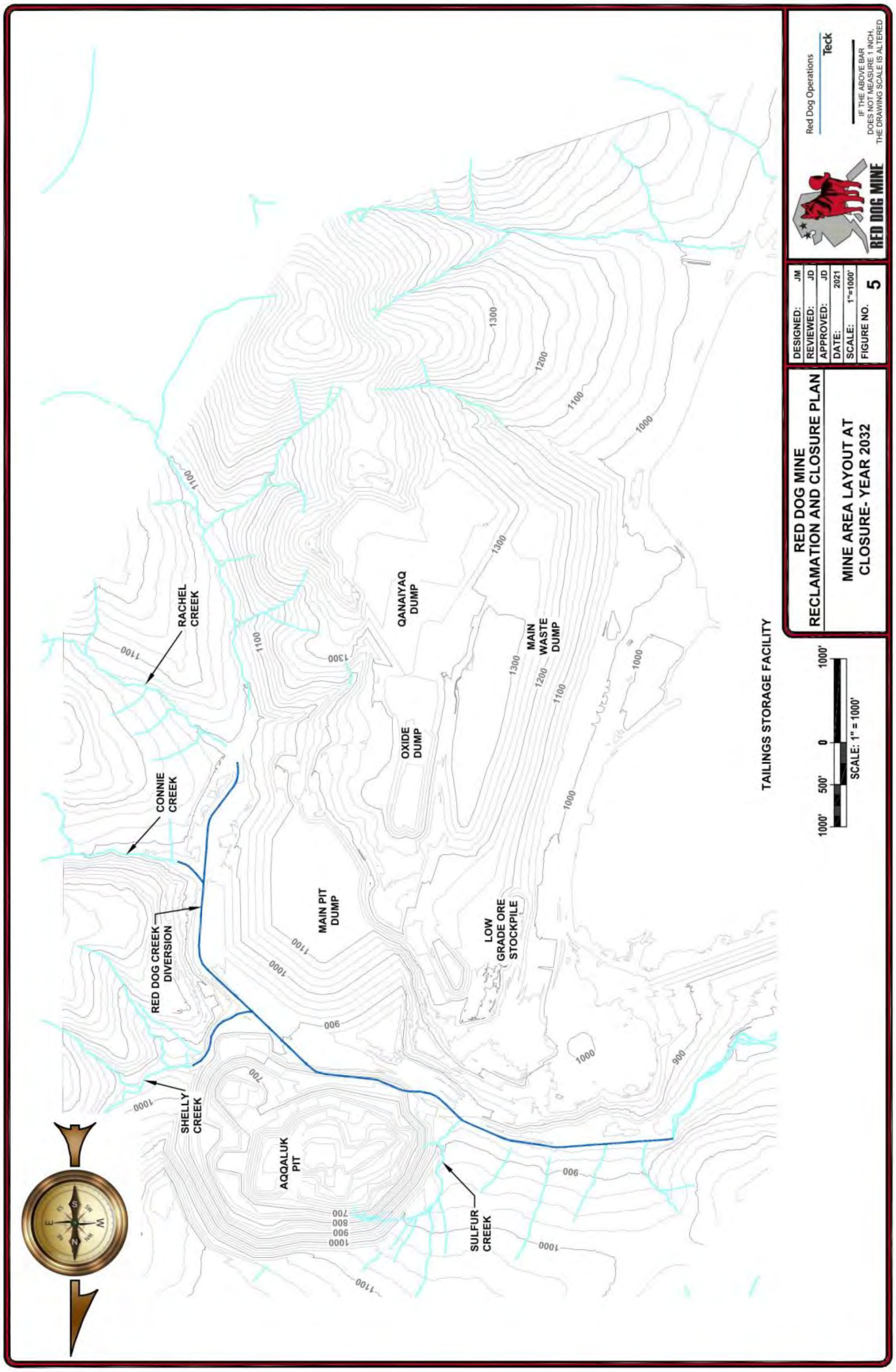


Figure 5: Mine Area Layout at Closure - Year 2032

Qanaiyaq Pit

Mining in the Qanaiyaq Pit began in 2016 and will be completed in 2028 according to the 2020 LOM plan. The Qanaiyaq Pit will be mined in two lobes. Waste rock from the south lobe is being placed in the Main Pit Dump (MPD), and waste rock from the north lobe will be placed in the south lobe beginning in 2022. Toward the end of mine life, waste rock from Aqqaluk Pit will be placed in the north lobe of Qanaiyaq Pit.

Figure 7 shows the planned phases of pit development and final Qanaiyaq Pit configuration and the schedule is provided in Figure 32. The area disturbed by the pit lobes will cover approximately 77 acres, with an ultimate pit floor elevation of 1,075 ft.

2.1.3 Waste Rock Dumps and Ore Stockpiles

Main Waste Dump

The Main Waste Dump (MWD) covers approximately 190 acres. The dump has been effectively inactive since 2012 and the dump face was re-sloped to 3H:1V and installation of a synthetic linear low-density polyethylene (LLDPE) cover over a 16-acre test plot is being used to evaluate the efficiency of the cover design. The geosynthetic cover design was approved by ADEC and ADNR in 2020 and the remainder of MWD will be covered during seasonal construction seasons starting in 2021. Figure 8 shows the MWD at the end of production in 2032. The highest bench of the MWD will have a maximum elevation of 1,300 ft. The upper bench will be lower in the southwest corner to avoid interference with the flight envelope for the airport, which is just over 1 mile to the south.

The stability of the MWD was assessed as part of the initial designs in 1987, and reassessed in 1997, 2002, and 2003 (Golder 2003). The geochemistry of the MWD is reviewed in *Consolidation of Studies on Geochemical Characterization of Waste Rock and Tailings* (SRK 2003) and in *Supporting Geochemical Review and Interpretation* (SRK 2006). Key conclusions from these studies are that most of the waste rock in the MWD weathers rapidly and either presently generates acid or has the potential to generate acid. However, the synthetic LLDPE covers on the MWD described in this plan are anticipated to reduce water and oxygen infiltration into the MWD thereby reducing the volume and constituent loading of seepage from the dump, reducing ML/ARD. Seepage from the MWD is collected in a series of sumps at the base of the dump and then pumped to water treatment.

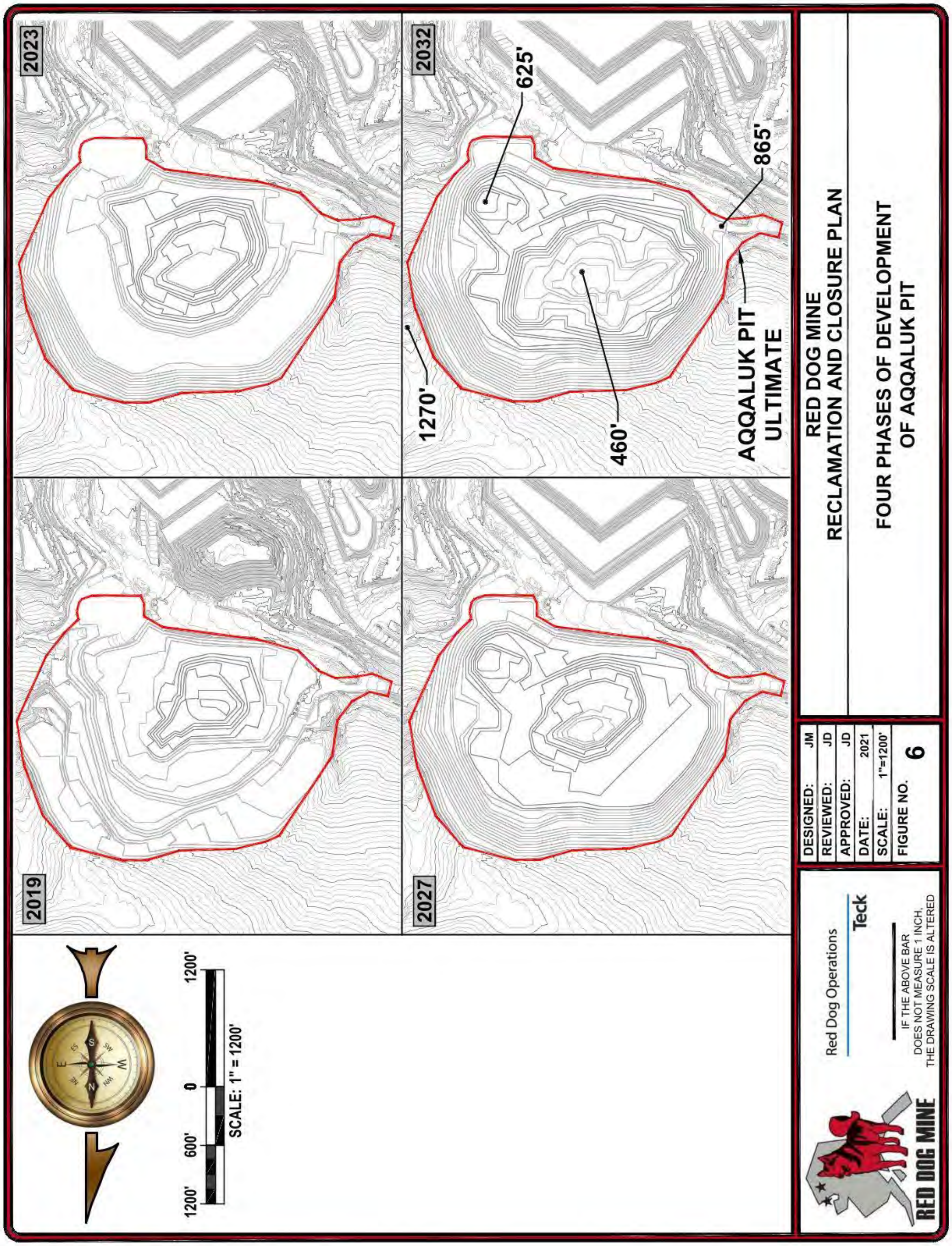


Figure 6: Phases of Development of Aqqaluk Pit

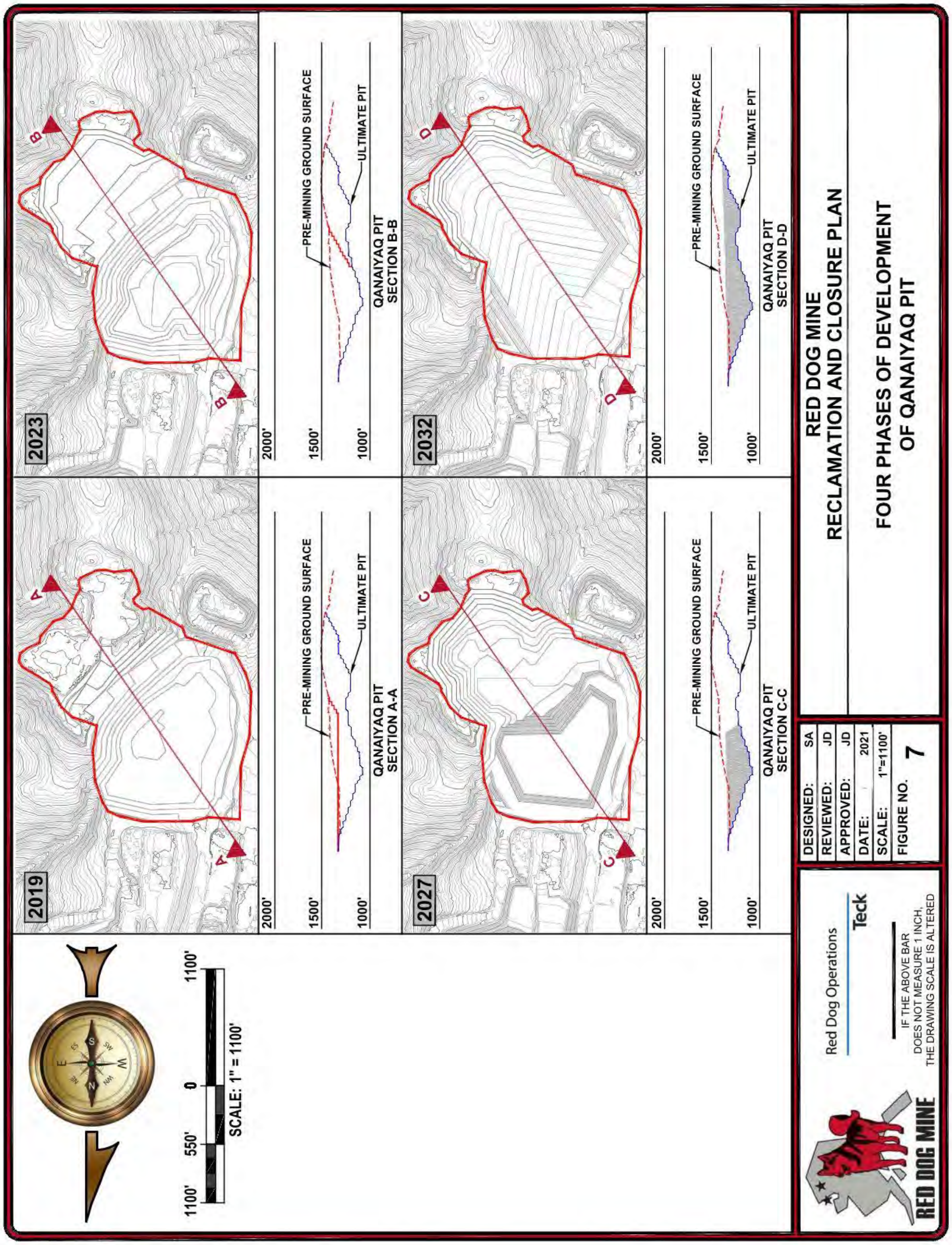


Figure 7: Four Phases of Development of Qanaiyaq Pit

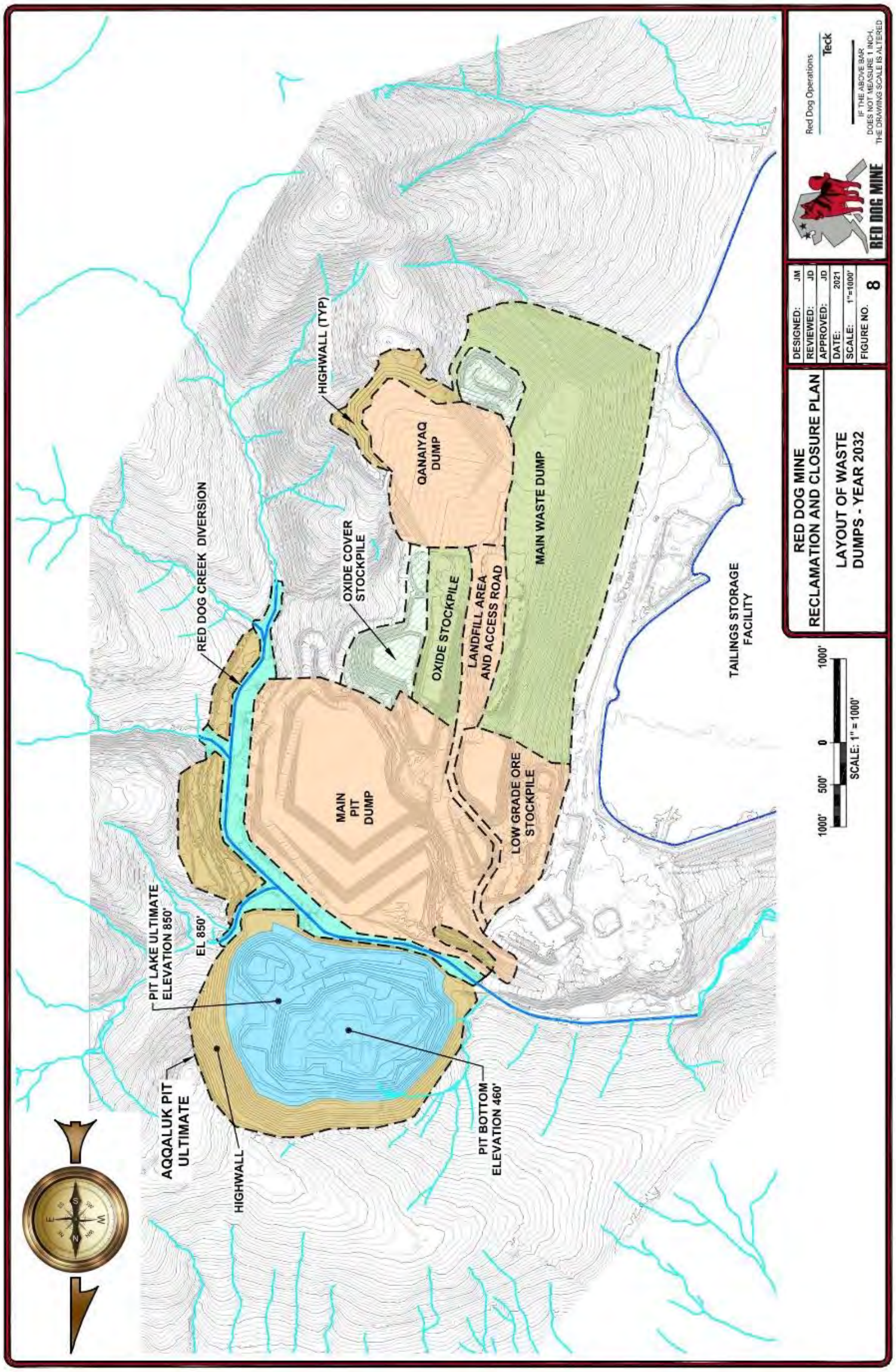


Figure 8: Layout of Waste Dumps - Year 2032

Main Pit Dump

The LOM plan calls for approximately 87,350,000 tonnes of waste rock to be backfilled into the Main Pit. The resulting MPD is expected to cover approximately 150 acres when completed in 2032. Water level in the main pit will be maintained at 840 ft during mine operations while the main pit is being filled with waste from the Aqqaluk Pit.

Most of the waste rock that will be placed in the MPD will come from the Aqqaluk Pit, while approximately 17,500,000 tonnes will come from the Qanaiyaq Pit. Waste rock from both pits is similar to waste rock from the Main deposit in that it is potentially acid generating and will be managed in a like mannner (SRK 2007a).

The LOM plan also calls for Qanaiyaq waste to be placed on top of the MPD, where it will cover about half of the upper dump surface.

Stability assessments and material characterization have been completed on Aqqaluk waste rock. It has geotechnical characteristics similar to waste rock in the MWD, and the MPD slopes have been designed accordingly.

At the end of mine operations in 2032, the MPD will be covered with a 40 mil LLDPE geosynthetic liner as described in Section 3. This will have the effect of reducing seepage and infiltration of surface water and oxygen and reduce constituent loading in the seepage water over time, and a reduction in ML/ARD is anticipated.

Qanaiyaq Pit Dump

Dumping in the Qanaiyaq Pit south lobe is expected to begin in 2022 at the end of Phase I mining in the south lobe and will continue through the end of Qanaiyaq Pit Phase II (north lobe) mining in 2028 and Aqqaluk Pit mining in 2032.

At the end of mine operations in the Qanaiyaq Pit, in approximately 2028, the Qanaiyaq Pit Dump will be covered with a LLDPE geosynthetic liner as described in section 4. This will have the effect of reducing seepage and infiltration of surface water and oxygen and reducing constituent loading in the seepage water and a reduction in ML/ARD is anticipated.

Oxide Ore Stockpile

The Oxide Ore Stockpile covers about 17 acres. Oxide material has high metal (Pb, Ag) content, but cannot be processed in the current sulfide flotation system. This material may be milled at the end of mine life.

Low Grade Ore Stockpile

Currently, the Low-Grade Ore Stockpile covers about 16 acres. The mine plan identifies additional quantities of low-grade ore that will be mined from the Aqqaluk and Qanaiyaq deposits. The future cost effectiveness of processing low grade ore at the end of mine life is unknown and may not occur. Therefore, for the purposes of this reclamation plan, it is assumed that the Low-Grade Ore Stockpile will need to be closed and reclaimed with a cover.

Ore Stockpile(s)

To provide a consistent supply of ore to the mill, ore stockpiles are created and consumed as needed. All ore stockpiles are expected to be completely processed prior to closure.

2.1.4 Red Dog Creek Diversion

The main water drainage, for non-contact water, through the mine area is the Middle Fork of Red Dog Creek. Tributaries that enter the Middle Fork through the mine area include Rachel Creek, Connie Creek, Shelly Creek, and Sulfur Creek.

The Middle Fork of Red Dog Creek is conveyed through the mine area, via the Red Dog Creek Diversion, the major components of which are shown in Figure 9. The first section of the diversion starts below Hilltop Creek and is contained within a 96-inch-diameter, heat-traced culvert that is approximately 5,500 ft long and conveys water past the Main and Aqqaluk Pits. Intake weirs and/or pipelines direct Middle Fork, Rachel, Connie, and Shelly Creeks into the first section of the diversion. The second section is a 3,200-foot-long, lined, open channel that runs from the culvert outlet to the Mine Water Diversion Dam area, where the flow re-enters the original stream channel of the Middle Fork of Red Dog Creek. With the expansion of the ultimate Aqqaluk Pit shell, a permanent contact water ditch was constructed to prevent pit contact water from entering Sulfur Creek.

2.1.5 Mine Drainage

The term “mine drainage” (aka contact water) is defined in 40 CFR Part 440.132(h) “as any water drained, pumped, or siphoned from a mine.” Examples include runoff and seepage from waste rock piles and ore stockpiles, water that accumulates in the pit, or otherwise contacts metal-leaching or acid-generating rock. Flow rates and constituent concentrations in all contact water flows are discussed in the 2020 *Red Dog Mine Water and Load Balance Update* (SRK 2020). Primary collection points for contact water are the Main Pit, Aqqaluk Pit and MWD sumps (Figure 9).

Other sources of water entering the mine water collection system are:

- Hilltop Creek, which drains the to the east down the ridge immediately east of the Oxide Dump and the Qanaiyaq deposit.
- Areas downstream of the clean water diversion intake points for Connie Creek and Shelly Creek that drain naturally into the mine pits.
- The Aqqaluk and Qanaiyaq Pit areas.
- Surface infiltration from the Red Dog Creek and tributary diversion system, and
- The main haul road and truck run-out, located above and to the south of the Mine Sump.

Contact water is recovered from the TSF, treated, and then discharged seasonally to Red Dog Creek at Outfall 001.

The clean water diversion system does not capture small areas above the confluences of Connie and Shelly creeks; French drains collect drainage from these areas and pass it under the clean water diversions and into the Main Pit.

Main Waste Dump Seepage

Seepage from the MWD is collected in a series of sumps located along the toe of the dump. This water is either pumped directly to treatment and then to the TSF, or directly to either the TSF or the Main Pit Water Reservoir. Seepage bypassing the sumps flows by gravity into the TSF impoundment. Section 2.4.1 discusses flow rates and constituent loadings. Following closure sump flows will be directed to the Aqqaluk Pit.

2.2 Tailings Storage Facility

2.2.1 General Layout and Basin Bathymetry

The TSF is in the valley below the MWD. Figure 10 shows the layout of the impoundment, along with topography and bathymetry from 2020.

2.2.2 Tailings

Tailings Physical Properties

The specific gravity of tailings solids ranges from 2.87 to 3.18, based on composite samples from Main, Aqqaluk, and Qanaiyaq Pit ore; target grind size is 80% passing 60 microns (230 mesh).

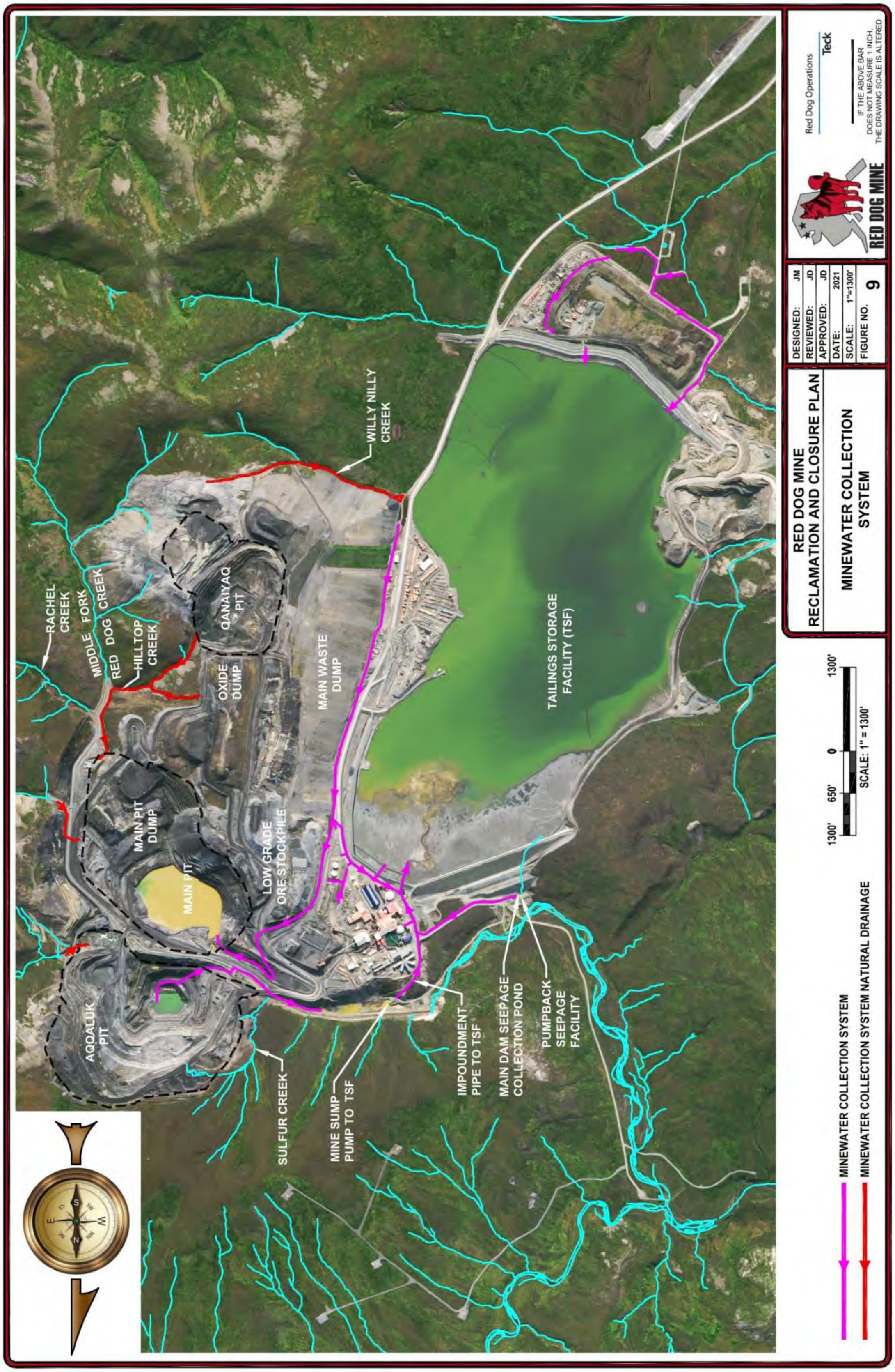


Figure 9: Mine Water Collection System

Tailings Geochemistry

Previous studies of the geochemistry of the tailings have been summarized in *Red Dog Mine Consolidation of Studies on Geochemical Characterization of Waste Rock and Tailings*, (SRK 2003) and *Red Dog Mine Closure and Reclamation Plan Supporting Geochemical Review, Interpretation* (SRK 2006). Key conclusions of the reports were:

- Zinc concentrations range from 2.4 to 6.2 weight percent, 1.2 to 2.8 weight percent for lead, and 4.6 to 11.4 weight percent for iron.
- Total sulfur content ranges from 9.65% to 16% (as S). Soluble sulfate, barite ($BaSO_4$) and galena (PbS) and anglesite (PbS-SO_4) account for one-quarter of the sulfur. Sphalerite (Zn, Fe) S accounts for another quarter and pyrite (FeS_2) accounts for the remainder.
- Comparison of acid generation and neutralization potentials indicate that the tailings are acid generating. The acid generation potential is between 155 and 240 kg $CaCO_3$/tonne. The neutralization potential ranges from 0.4 to 9.4 kg $CaCO_3$/tonne.
- Humidity cell tests show evidence of preferential sphalerite oxidation. On a molar basis, zinc release was initially higher than iron release. Zinc release remained steady for about a year, with iron release slowly increasing. Leachate pH was acidic during this period, dropping to less than 3 as iron release increased. After about a year, sphalerite becomes depleted accompanied by an increase in iron release. These observations are consistent with a galvanic interaction promoting the oxidation of sphalerite and delaying the oxidation of pyrite.
- The delay of pyrite oxidation creates a delay in the release of sulfate and acidity because sphalerite oxidation produces less sulfate and less acidity than pyrite oxidation. In humidity cell tests, sulfate and acidity release rates increased by a factor of about 2.7 after the sphalerite was depleted.
- Maintaining a water cover over the tailings during operations is an effective means to restrict oxidation and acid generation. At closure TAK plans to maintain that water cover over the tailings.

Ongoing monitoring and sampling results of tailings solids and decant solution are reported quarterly and there is no indication of any significant variations in the geochemical characterization of the tailings.

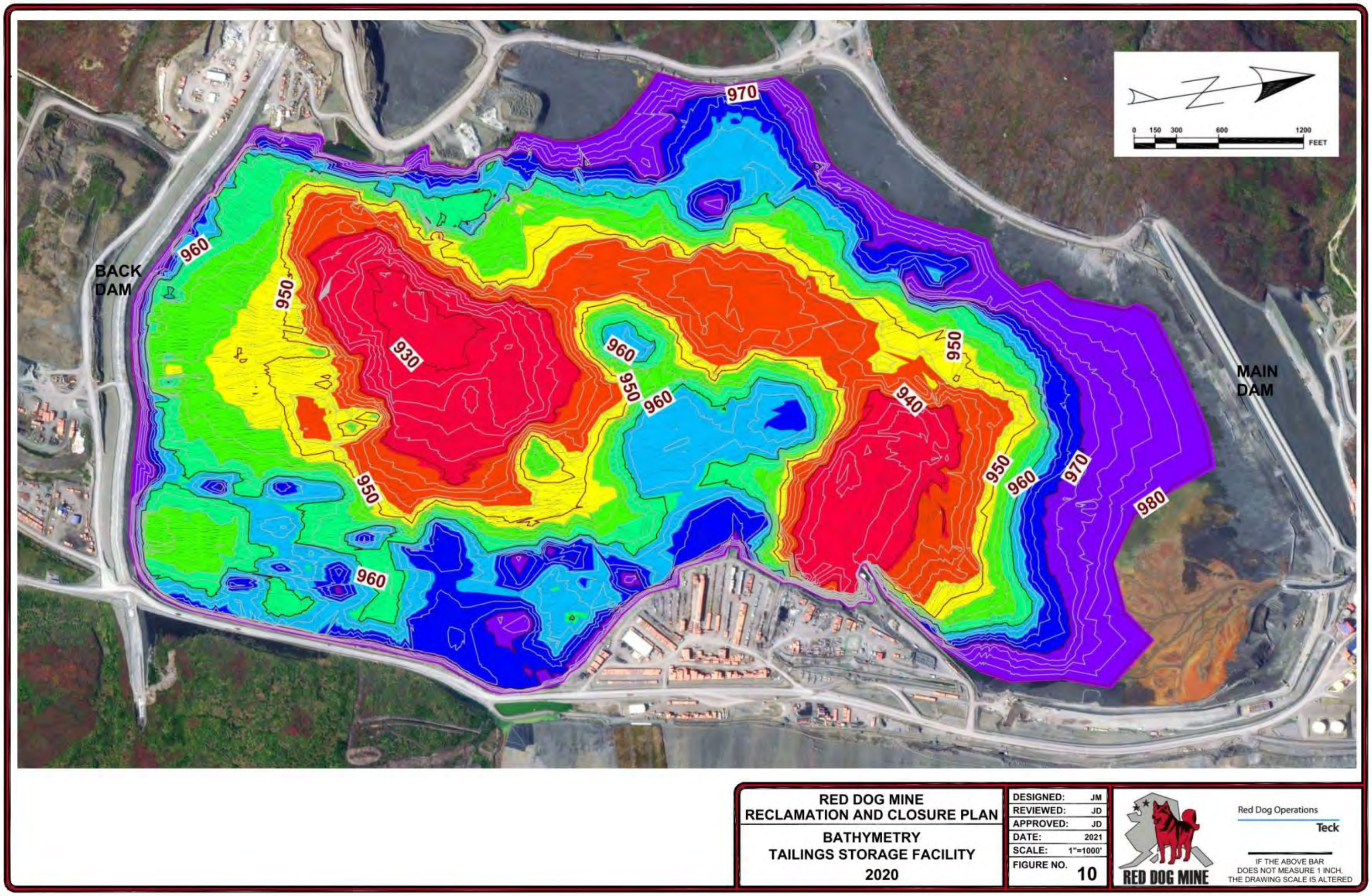


Figure 10: Bathymetry of Tailings Storage Facility

2.2.3 TSF Pond

The TSF Pond is a component of the Alaska Pollution Discharge Elimination System (APDES) permit as a treatment works, which allows for exceedances of water quality standards within the pond as defined in the permit. Inflow occurs throughout the year, but is dominated by spring freshet; direct precipitation, runoff from background areas, and inflows from the mine area add roughly 0.9 billion gallons to the TSF Pond each year. Discharge of approximately 1.39 billion gallons per year (1.40 billion gallons in 2018, 1.38 billion gallons in 2019) of treated water is the dominant outflow but occurs only during the open-water season. Only 870 million gallons of water was discharged at Outfall 001 in 2020 owing to the very high background TDS in Red Dog and Ikalukrok Creeks. In winter 2019/2020 water was also pumped back to the Aqqaluk Pit for temporary storage. Open-water season typically runs from May 1 to September 30. The ADNR Certificate to Operate the TSF main dam requires that TAK maintain a freeboard of five feet below the crest of the Main Dam. An emergency spillway will be constructed with the final raise of the dam (1006 ft) or during premature closure-reclamation.

Figure 11 shows the expected limits of the tailings and the overlying water at closure in 2032 for the proposed 1006’ dam elevation. Sources of water and constituent inputs to the TSF Pond, along with pond water chemistry, are discussed in *Red Dog Mine Water and Load Balance Update* (SRK 2020).

Ditches are currently in place in four locations to route non-contact water around the TSF Pond. The diversions are shown in Figure 10.

- Diversion Ditch 1 (DD-1) takes water from a draw on the slope above the west shore of the Pond and diverts it into the small catchment immediately west of the South Fork.
- Diversion Ditch 2 (DD-2) captures water from south of the DD-2 laydown area and routes it to the west end of the Overburden Dump.
- Diversion Ditch 3 (DD-3) extends DD-2 past the south end of the Overburden Dump.
- Diversion Ditch 4 (DD-4) captures additional water from the slope above the west shore of the Pond and routes it into DD-1.

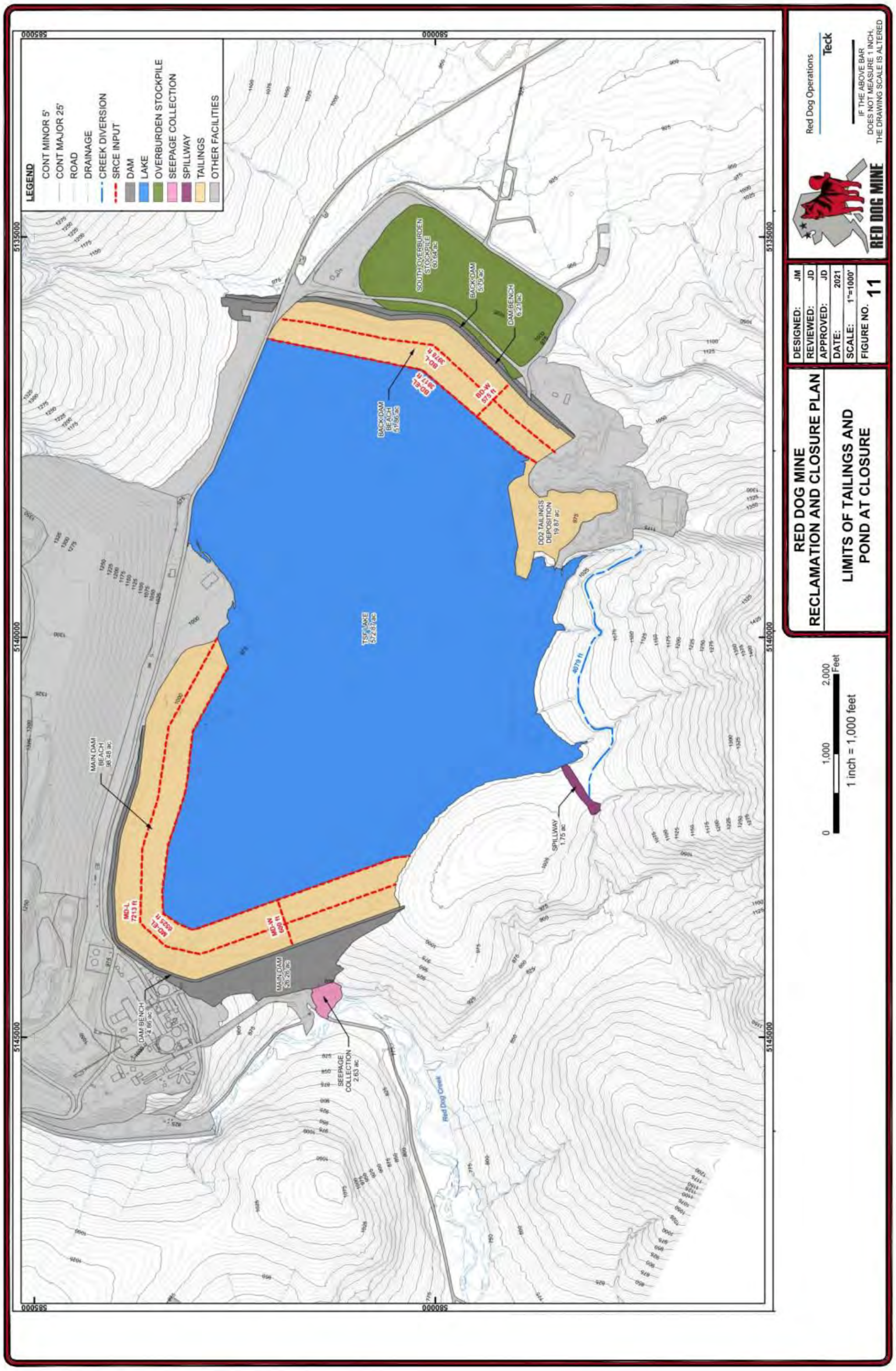


Figure 11: Limits of Tailings and Pond at end of Operations (1006 ft dam)

2.2.4 Main Dam

Construction History

The Main Dam, located at the northern end of the TSF, is currently being raised to an elevation of 991 ft as an interim step to raising the dam to 996 ft under a Certificate to Modify a Dam issued by ADNR on 5/19/20. That dam raise to 991 ft should be completed in 2020 but will require another Certificate to Modify the dam for the raise to 996 ft. The dam has been constructed in eleven stages, comprised of a starter dam and ten raises. Construction dates and crest elevations associated with each raise are provided in Table 3.

Table 3: Main Dam Construction Stages (from URS 2014)

Dam Stage	Year	Crest Elevation (ft)	Maximum Height (ft)
Stage I (Starter Dam)	1988	865	75
Stage II	1989	890	102
Stage III	1990	910	124
Stage IV	1991	925	141
Stage V	1993	940	158
Stage VI	1993	950	172
Stage VII-A	2003/2004	955	177
Stage VII-B	2005-2007	960	182
Stage VIII	2008-2011	970	192
Stage IX	2012-2013	976	198
Stage X	2017	986	208
Stage XI	2021	996	218
Stage XII	2028	1006	228

Future Raises

The design for Stage XI of the Main Dam calls for a crest elevation of 996 ft. This dam raise is in progress and is scheduled for completion in 2021. Another dam raise will likely be required to 1006 ft to accommodate water and tailings during the final few years of mining. The 1006 ft dam raise is tentatively scheduled for completion in 2028. Figure 12 and Figure 13 show a conceptual plan and cross-section, respectively, of the final dam raise to 1006 ft. Detailed analyses of stability and seepage through the raised dam are provided by URS (2014, 2007b, 2007c) and Golder (2019).

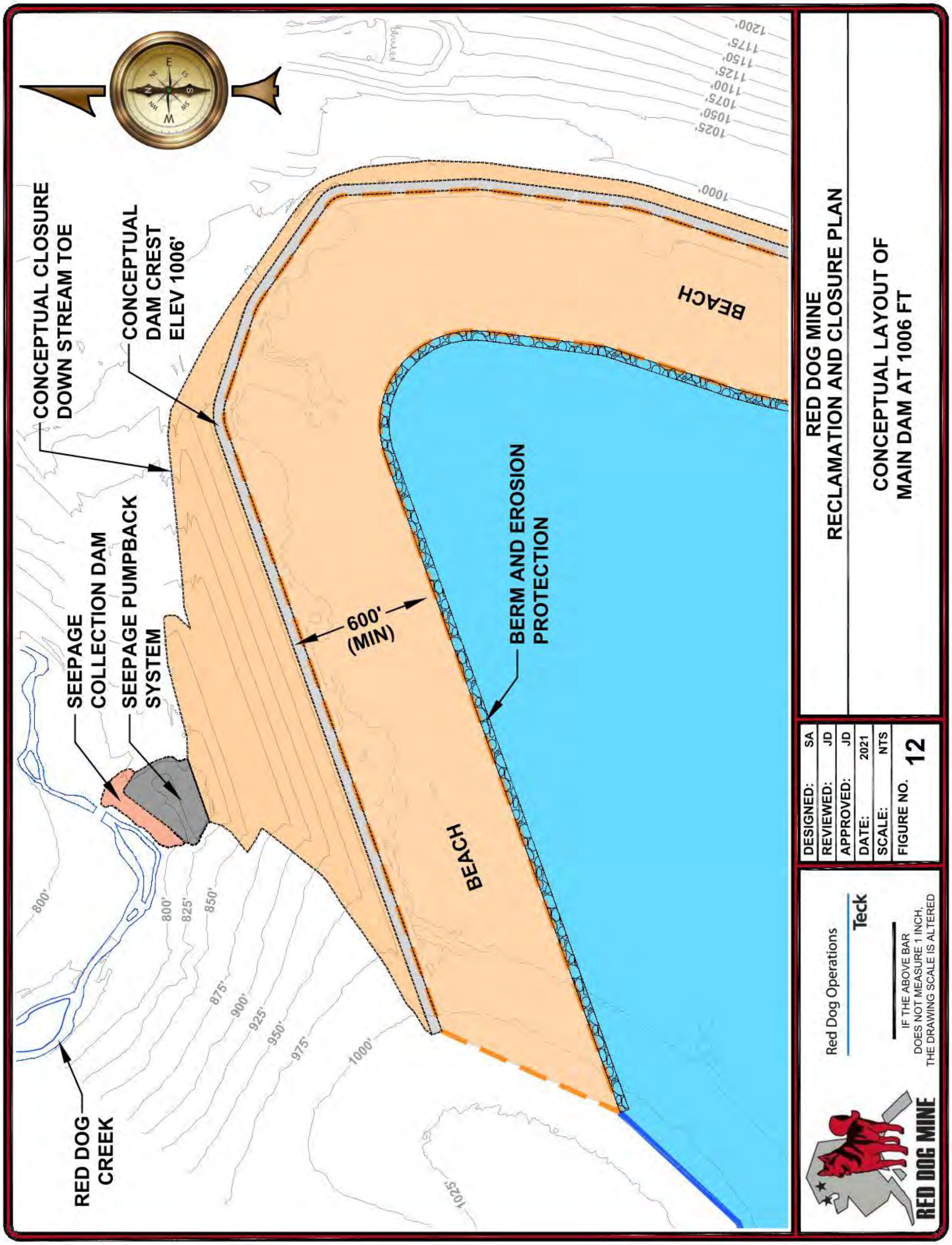


Figure 12: Design of Main Dam at 1006 ft elevation

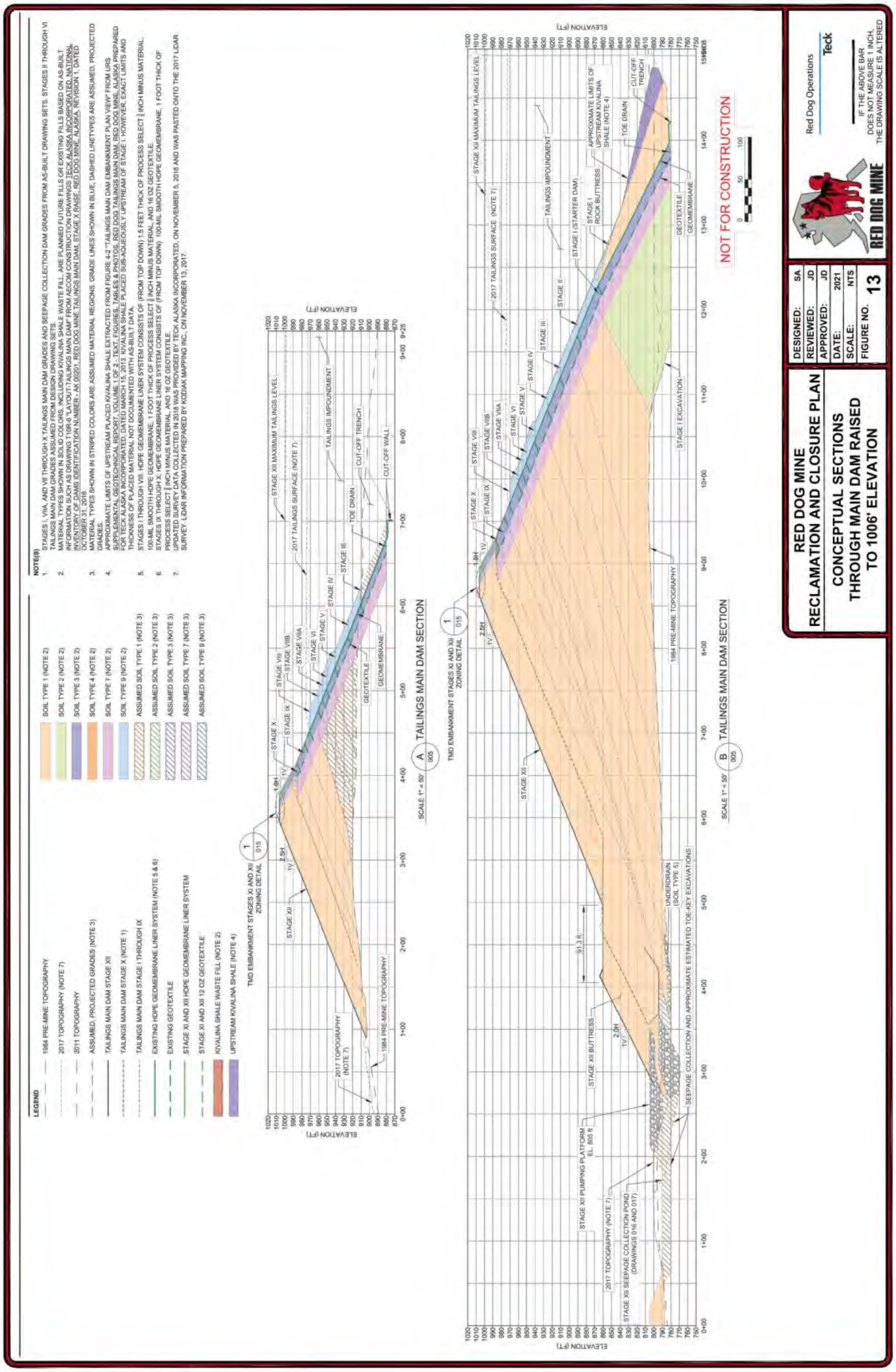


Figure 13: Section through Main Dam at 1006 ft elevation

Foundation Conditions and Dam Components

The following points summarize key foundation conditions and dam components:

- Foundation materials below the dam include alluvial deposits varying in thickness from 4 to 8ft, consisting of moderately graded silt, sand, and gravel with occasional cobbles, overlying moderate to highly weathered shale with discontinuous zones of clay gouge. An unfrozen talik was initially present along the creek alignment. The talik has grown wider and deeper and is predicted to reach a maximum width of about 800 ft if thawing continues. The thawed zone connects to sub-permafrost groundwater, but the sub-permafrost groundwater remains isolated by a combination of impermeable geologic structures and the permafrost.

- Similar foundation materials occur in the left (west) abutment, with competent shale bedrock under the Stage IV raise and moderately weathered shale bedrock under the Stage VII raise.

- In the east abutment, colluvium overlies the highly weathered shale. The colluvium is about 5 ft thick and consists of silty sandy gravel. Foundation materials are more variable further to the east, below the Stage VII-B extension, with zones of fill up to greater than 25 ft in thickness. The fill consists of well-graded gravel and sand with cobbles. Bedrock in the abutment includes zones of poorly durable black shale, with competent siltstone to the east.

- The body of the Main Dam is a zoned rockfill structure constructed with competent and durable material obtained from the mill site, the DD-2 borrow pit, and from mining in the Main Pit. The Stage IV raise also included zones of Kivalina shale, and blended Kivalina and Okpikurak shale. All raises have incorporated downstream construction methods.

- The upstream face of the dam is covered with 100-mil, high-density polyethylene (HDPE) geomembrane. The geomembrane is underlain by 1 foot of bedding consisting of 1-inch-minus crushed rock. Below the bedding is a 16-oz, non-woven geotextile underlain by 8 ft of filter drain consisting of rock crushed to less than 3 inches. Below the drain rock is a second 10-oz. non-woven geotextile underlain by 12 ft of <12-inch rockfill. The HDPE geomembrane is covered with two protective layers, consisting of 1.6 ft of minus 1-inch crushed rock and 6.4 ft of random rock fill. Prior to tailings placement, a thick blanket of Kivalina shale was placed through water on the upstream toe of the Starter Dam to reduce seepage observed prior to mill production.

- Along the upstream toe of the dam, the geomembrane continues into a cut-off system. During the Stage I construction, a cut-off trench was excavated. The depth of excavation was greater than originally planned, so the design was refined in subsequent raises. The design for Stages II through VI called for a cut-off trench to be excavated to a depth of 30 ft below the ground surface, and a much narrower cut-off wall to be excavated to a depth of either 4 ft or to competent bedrock, whichever was greater. The geomembrane was inserted through the trench and into the cut-off wall excavation. Review of the construction records demonstrated that the cut-off wall was built according to the design in Stages II through IV, but that no cut-off wall was built in Stages V and VI because it was intended that tailings would cover the upstream face of the dam. The cut-off system for Stages V and VI was therefore constructed as part of the Stage VII-A and VII-B raises.

- There is a perforated pipe installed in a toe drain along the downstream side of the base of the liner system to intercept any seepage leaking through the liner system. The toe-drain discharges to the rockfill (underdrain) under the starter dam. The pipes extent up to stage VIII within the toe drain. These pipes range from 10-12 inches in diameter. These pipes connect to the riser pipe which extend up the highest part of the Main Dam. P-06-74 is installed into this riser pipe. There are two riser pipes for redundancy. The purpose of these riser pipes was to drop submersible pumps down to lower the water level in the Main Dam if piezometers were showing high water levels. The east pipe was abandoned in 2006 due to rock fragment created a blockage. The piezometer in the west riser pipe still exists.

- Tailings were placed to seal the upstream face of the dam starting in 1997, and a complete tailings beach formed by 2000. Due to dust concerns, the beach was allowed to become inundated over the period 2002 to 2004. A series of eight low rock berms were constructed across the beach to act as windbreaks, and a surface sealant applied where necessary. Seepage pumpback records indicate that the seepage rate decreased from about 600 to less than 100 gpm over the twelve months prior to August 2002, when the beach was not submerged. The implication is that the tailings beach contributes to seepage control.
- In the winter of 2005-06, a coffer dam was constructed along the tailings beach to provide a beach as the Pond rises. Current tailings beach information is presented in the *Red Dog Mine Tailings and TSF Water Management Plan.*
- The water treatment sand filters were relocated from the east abutment to an area near WTP1 and WTP2, to facilitate future extensions of the dam and cutoff wall.

Seepage Collection System

A seepage collection and pumpback system for the main dam were redesigned and updated as part of the 996’ dam raise. This work was completed in 2019 and consisted of construction of a new seepage collection pumphouse and pump chambers. The pumps are connected via pipes and a manifold system to a 14-inch-diameter HDPE pipe through which the seepage is transferred back to the TSF Pond. The pond and ancillary facilities were being relocated slightly downstream in 2019 to accommodate the 996’ dam raise. During portions of 2019 and 2020 seepage water was pumped directly to the Aqqaluk Pit as part of ongoing water management.

Water volume pumped back to the TSF from the Main Dam Seepage Collection System for the last 4 years is:

- 2017 – 0.454 billion gallons
- 2018 – 0.274 billion gallons
- 2019 – 0.300 billion gallons
- 2020 – 0.305 billion gallons

Water seepage volumes and chemistry data for the TSF seepage collection system are presented in each Quarterly and Annual Monitoring Report provided by the TAK to ADEC.

2.2.5 Back Dam

The back dam prevents tailings and water from flowing into the Bons Creek drainage. The Back Dam is presently being raised to 996’ elevation with completion scheduled for 2021. It will also get raised to 1006 ft prior to 2028 in conjunction with the main dam raise. Figure 14 shows the design of the Back Dam raised to elevation 1006 ft.

Expansion of the beach prior to, or at, closure is expected to reduce seepage rates through the Back Dam. In 2018 the East and West Overburden Dump sumps collected 22.5 million gallons of seepage, or about 42 gpm. Widening the tailings beach is expected to decrease seepage to less than 20 gpm. In October 2019, the tailings beach was 150 ft wide. For the purposes of developing closure and reclamation costs, it has been assumed that a 600-ft-wide beach will be constructed by dredging tailings directly from the TSF. That beach and the beach at the Main Dam will receive a geosynthetic LLDPE cover at closure.

2.2.6 Overburden Dump

The southern end of the TSF area includes the Overburden Dump. The Overburden Dump has a plan area of 60 acres and a volume of approximately 6,600,000 cubic yards of overburden.

Material in the Overburden Dump consists of highly weathered, but relatively non-mineralized waste rock, stripped organic materials, and materials excavated from the tailings and mill site areas during initial construction. A survey of the dump surface in 2006 found it to be approximately 35% Kivalina shale, 25% Mélange, 20% Ikalukrok shale, 10% Okpikruak shale, and 10% Siksikpuk shale. Roughly 50% of the surface had zinc concentrations of less than 500 parts per million (ppm), and another 25% had zinc concentrations less than 1,000 ppm. Out of 21 samples, only one had a zinc concentration greater than 2,000 ppm.

The Overburden Dump is underlain by permafrost. TAI monitors that permafrost because degradation of the permafrost could lead to an increase of seepage through the dump. In accordance with Special Condition 10, Attachment A, Temporary Certificate of Approval to Operate a Dam (Certificate No FY2021-4-AK00303)) If monitoring indicates that the permafrost conditions of the overburden stockpile are thawing, TAI submit an application for a Certificate of Approval to Modify a Dam in accordance with the requirements of 11 AAC 93.171 for a seepage collection system adequate to collect all seepage from the Red Dog Tailings Back Dam and protect the Bons Creek drainage, or other mitigation measures.

The Overburden Dump straddles the divide between the TSF and Bons Creek, and reaches a maximum elevation of approximately 1,020 ft. Prior to the dump construction, the lowest point of the divide was at an elevation of approximately 937 ft. A system of ditches, sumps, and wells on the Bons Creek side of the Overburden Dump captures runoff from the Overburden Dump. The collection system pumps the water back to the TSF Pond. Water volume pumped back from the seepage collection system at the Overburden Dump for the last 4 years is:

- 2017 – 29.3M gallons
- 2018 – 22.5M gallons
- 2019 – 40.4M gallons
- 2020 – 18.1M gallons

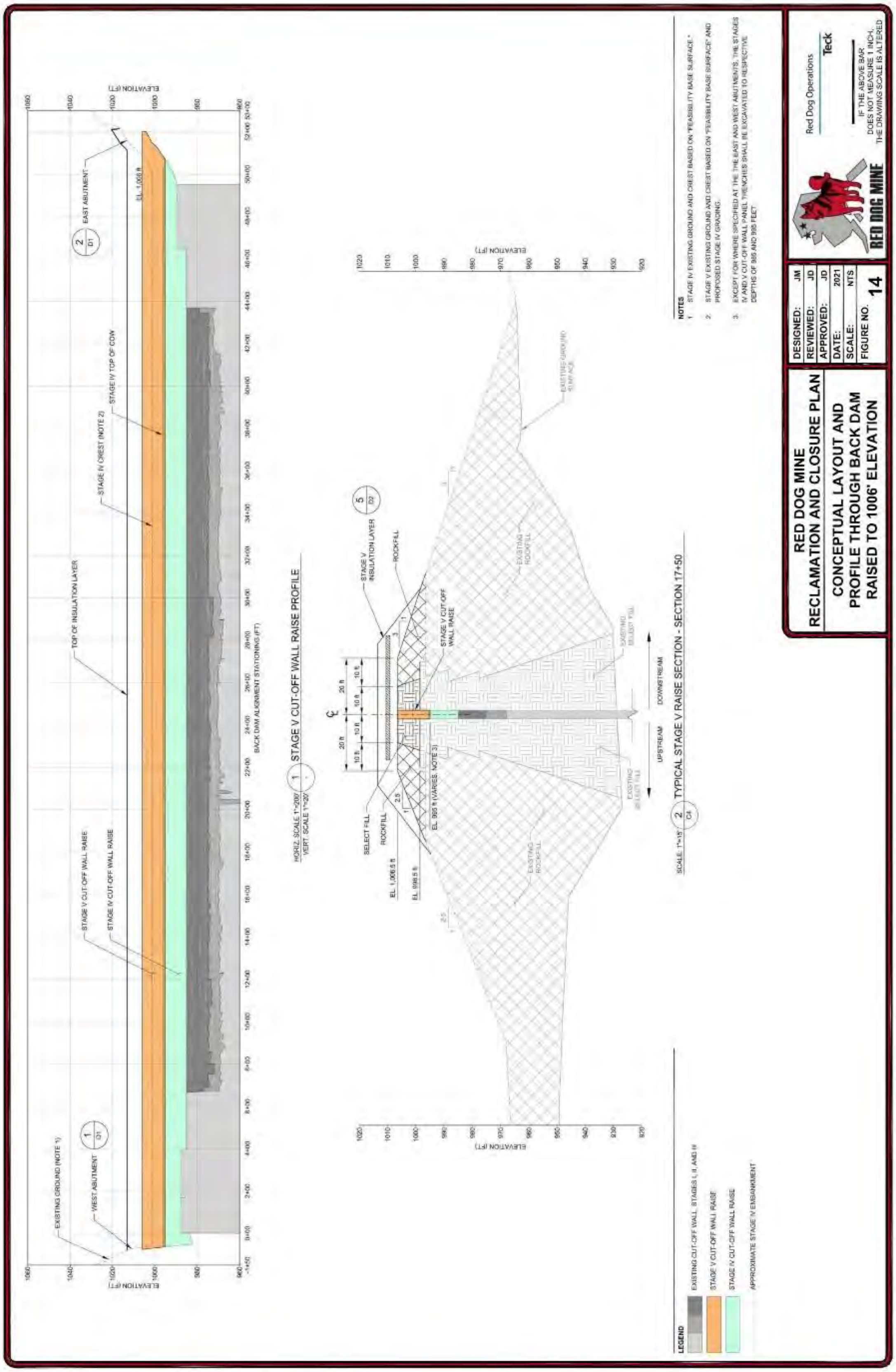


Figure 14: Layout and Profile through Back Dam Raised to Elevation 1006 ft

2.3 Water Treatment and Discharge

Mine-impacted water is collected and stored onsite in the TSF, the MPWR and the Aqqaluk Pit. Reducing water inventory reduces geotechnical risks. TAK's Water Volume Quality Management (WVQM) project is a holistic view of water volume and quality management on site. This project has identified Total Dissolved Solids (TDS) management and water treatment infrastructure upgrades as integral to a successful water balance control. As part of the upgrades, gypsum seeding was added to water treatment in 2017, lime capacity was upgraded in 2018 and other de-bottlenecking upgrades were completed in 2020 under WVQM efforts.

2.3.1 Water and Constituent Load Balance

Water and constituent load balances for the entire site have been developed and updated over the years. The water balance consists of a series of calculations that track water flows across the site, from precipitation through evaporation, treatment, and discharge. The constituent load balance is a similar series of calculations tracking constituent loadings from their respective sources to the "treatment works," which consist of the TSF pond and the water treatment plants.

Figure 15 shows a schematic of the catchment areas and flow paths considered in the water balance during operations generated from the *Red Dog Water and Load Balance Update (SRK 2020)*. Numbers on the schematic indicate average annual flows.

Major constituent concentrations from the mine area sources and TSF Pond are presented in detail in the *Red Dog Water and Load Balance Update (SRK 2020)*. Water and constituent load balances were used to simulate future requirements for water treatment volumes and treatment costs after closure.

Water Treatment

Contact water (mine water) is currently treated by three water treatment plants, located as shown in Figure 16. Potable water and sewage treatment are discussed under "Infrastructure" below. A microfiltration and reverse osmosis (MF/RO) water treatment plant has been commissioned at the mine. Effluent from this new plant is combined with treated water from the existing plants and its discharge to Outfall 001 was initiated in August 2020. In addition, treated water may be discharged, as snow, during winter months in the future. The 2020 water balance update did not incorporate treatment from the new microfiltration plant.

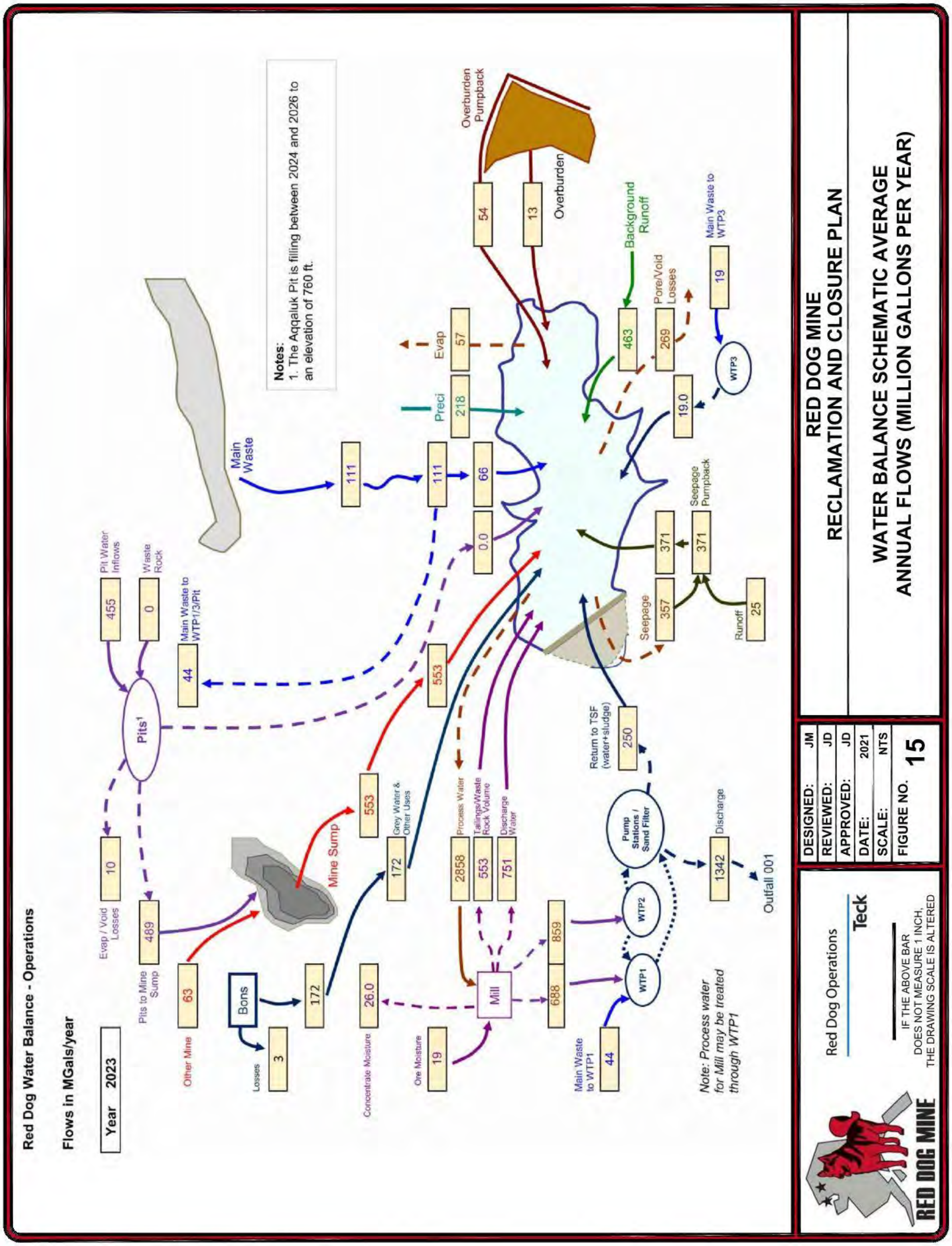


Figure 15: Water Balance Schematic Average Annual Flows - 2023 (million gallons per year)

Water Treatment Plant #1 (WTP1) operates year-round and is currently used to treat MWD seepage in the winter and TSF water during the discharge season to increase discharge capacity. It can treat water reclaimed from the TSF Pond for use in the Mill or treat MWD seepage. Approximately 3 billion gallons of reclaim water are used in the Mill and returned to the TSF annually.

Water Treatment Plant #2 (WTP2) treats water from the TSF Pond. About 60% of the water treated by WTP2 is released at Outfall 001. The remainder is returned to the TSF Pond along with the treatment sludge and filter backwash. WTP2 treats approximately 1.8 billion gallons per year and operates during the non-winter months.

Water Treatment Plant #3 (WTP3) seasonally treats water from MWD seepage and discharges it to the TSF Pond.

All three plants use a lime treatment process ("high density sludge" or "HDS" process) to raise the pH which results in metal hydroxide and gypsum (calcium sulfate) precipitation. WTP1 and WTP2 also include sulfide addition to precipitate cadmium and are configured to run through a sand filter system to remove suspended solids prior to discharge of water to Outfall 001. WTP sludge is discarded in the TSF.

Presently TAK is performing upgrades to all three water treatment plants to increase efficiency including throughput as part of their Water Quality-Volume Management (WVQM) project. Those upgrades will be completed in 2023.

2.3.2 Discharge of Treated Water

Red Dog discharges treated water from WTP2 to the Middle Fork of Red Dog Creek at Outfall 001, which is illustrated in Figure 16. The seasonal discharge is authorized under APDES Permit AK-0038652.

Since 1998, the total annual discharge at Outfall 001 has ranged from approximately 0.8 to 1.89 billion gallons; 1.89 billion gallons were discharged in 2017. The exception was in 2012 when elevated selenium levels precluded discharging after June 30. In 2012 and 2013, approximately 640 million gallons of water from the TSF were transferred into the Main Pit. During future operations it will be necessary to reduce the amount of excess water stored in the TSF Pond and eliminate the water in the Main Pit as it is filled with waste rock. The precise discharge requirements will depend on multiple factors, including the quality and volume of the receiving water in Red Dog Creek during freshet.

Figure 16: Plan View of Mill Area – Water and Discharge Locations

2.4 Ore Processing Area

2.4.1 Process Overview

A site plan of the ore processing area is shown in Figure 16. Ore throughput is approximately 11,495 tonnes per day (2018 average) to produce 1,077,000 tonnes of Pb and Zn concentrates. The process flowsheet is shown in Figure 17.

2.4.2 Crushers

Primary crushing operations involve both a gyratory crusher and a jaw crusher. The gyratory crusher is housed in a building with associated systems, including the apron feeder and drive assembly for the conveyor belt that transports crushed ore to the Coarse Ore Stockpile Building (COSB). The older jaw crusher is located near the gyratory crusher and is operated when the gyratory crusher is down for maintenance. The jaw crusher is in an enclosed building which also houses the feeder and related systems, and the drive system for the conveyor belt that transfers crushed ore to the coarse ore stockpile. Both crushers are equipped with baghouses to control dust.

2.4.3 Coarse Ore Stockpile Building

The COSB stores crushed ore prior to milling. It has a capacity of 16,500 tonnes and feeds conveyors that transport ore from the stockpile to the grinding circuit. The COSB and ore conveyors are completely enclosed. A baghouse is installed to further control dust by creating a negative pressure in the COSB.

2.4.4 Mill Complex

Inside the enclosed mill complex, crushed ore is subjected to primary and secondary wet grinding, lead and zinc rougher flotation and a regrinding operation, as well as lead and zinc cleaner flotation. In the primary grinding circuit, crushed ore is mixed with process water to form a slurry, which is wet-ground in semi-autogenous grinding (SAG) mills and ball mills that reduce the ore particle size further.

Several stages of flotation are necessary to achieve high grade concentrate products with maximum recovery of economic minerals and an efficient separation of the lead and zinc minerals into their respective concentrates. The gangue minerals, referred to as tailings, are discharged in slurry form from the mill to the TSF for permanent storage.

2.4.5 Reagent Building

The reagent building is located to the west of the mill and is connected to it by an enclosed utilidor. The building provides temporary storage and facilities to mix process reagents. Reagents are mixed with water in mix tanks and transferred to day tanks from where they flow to holding tanks in the mill.

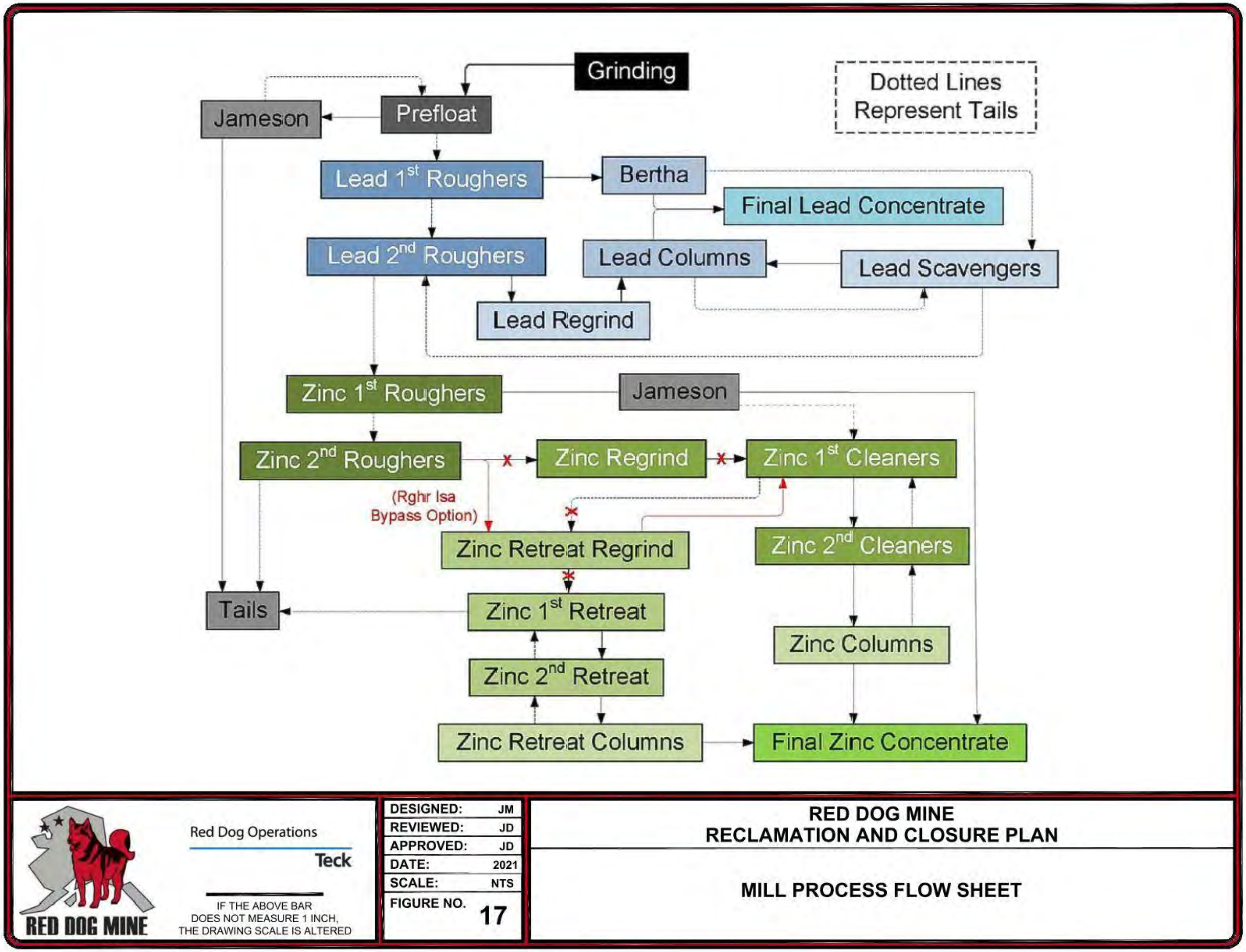


Figure 17: Mill Process Flow Sheet

2.4.6 Concentrate Storage Building

Slurried lead and zinc concentrates are thickened and filtered before being transported via an enclosed conveyor to a concentrate storage building (CSB) adjacent to the mill. Filtered lead and zinc concentrates are stockpiled inside the building while awaiting shipment by truck to the Port site. The CSB is completely enclosed and has a storage capacity of approximately 35,000 tonnes. Concentrate haul trucks enter the CSB drive-through and front-end loaders load the trailers with approximately 130 tonnes of concentrate. Haul trucks enter and exit the building drive-through doors that are closed during loading. Concentrate is trucked about 52 miles from the CSB to the Port site, where it is stored in two larger CSB’s while awaiting the summer shipping season.

2.4.7 Services Complex

The services complex is located on the mill site adjacent to the mill and CSB. The complex includes a warehouse, the analytical lab, the heavy equipment shop, and offices for administrative personnel.

2.4.8 Powerhouses

Powerhouses that provide electric power to the site are located on the mill site, adjacent to the mill and CSB. Eight diesel-fired generators, each rated at 5,000 kilowatts (kW) electrical output, are shared between the two powerhouses. The generators are fueled with ultra-low-sulfur diesel. Heat is supplied to mine site buildings by waste heat recovery units that utilize diesel engine cooling water and exhaust gas to heat a glycol/water mixture circulated by pumps. Three 650 kW diesel generators are installed to supply emergency power. In addition, there are three standby water/glycol heaters rated at 8,000,000 British Thermal Units (BTUs) each to provide emergency heat in the event of a power failure.

2.4.9 Maintenance Shops

Mine and mill maintenance shops are available to service equipment used throughout the operation and by contractors. The mill maintenance shop is part of the mill complex. The mine mobile equipment maintenance shop is part of the services complex.

2.5 Other Infrastructure

Due to the remote nature of the site, the mine includes extensive support infrastructure. Figure 18 shows the location of the facilities described below.

2.5.1 Airstrip

An asphalt airstrip capable of handling commercial jet aircraft is located approximately three miles south-southwest of the mill, in the Buddy Creek watershed. The airstrip is used year-round to transport personnel, equipment, supplies, and perishables to and from the mine site.

2.5.2 Internal Roads

A series of internal roads provide access to each of the major facilities on site.

2.5.3 Personnel Accommodations Complex

The personnel accommodations complex (PAC) is located adjacent to the mill/service complex and connected to it by an elevated, enclosed utilidor. The original PAC houses up to 365 people and includes kitchen, laundry, and recreation facilities. In 2019 additional housing was added to the PAC that added accommodation for 136 employees which brought the total current PAC capacity up to 500 people.

2.5.4 Construction Personnel Accommodations Complex

The construction personnel accommodations complex (ConPAC) is operated seasonally for contractors, as required, depending on construction and exploration activity. The camp is comprised of personnel living quarters, kitchen facilities, sewage and potable water treatment facilities, a backup generator, and an equipment staging yard. Temporary soft-sided accommodations were added to the ConPAC in 2018 to accommodate an additional 84 contract and exploration staff.

2.5.5 Bons Reservoir

This freshwater reservoir and pumping system are in the Bons Creek watershed near the airport. The reservoir was created by constructing a small dam across Bons Creek. The reservoir supplies water for drinking and other domestic uses as well as peripheral uses in the mill. The reservoir fills naturally during the summer by snow melt and precipitation. Fresh water is pumped from the reservoir to the ConPAC, PAC and mill site.

2.5.6 Potable Water Treatment Plant

The potable water treatment plant provides drinking water for on-site personnel. The plant treats raw water from Bons Reservoir near the contractors' personnel accommodations complex. Treatment includes polymer (flocculent) addition, two-stage sand filtering, and calcium hypochlorite (chlorine) disinfection. From the treatment plant holding tank, treated water is pumped to the PAC, mill complex, and services complex as well as to other small buildings within the mill site.

2.5.7 Sewage Treatment Plant

The sewage treatment plant is located between the PAC and the mill. Domestic wastewater is collected from the ConPAC, PAC, mill, and services complex. Average throughput is typically 40 gpm. Wastewater treatment consists of solid/liquid separation and disinfection. Solid sludge is incinerated. Liquids are discharged to the TSF.

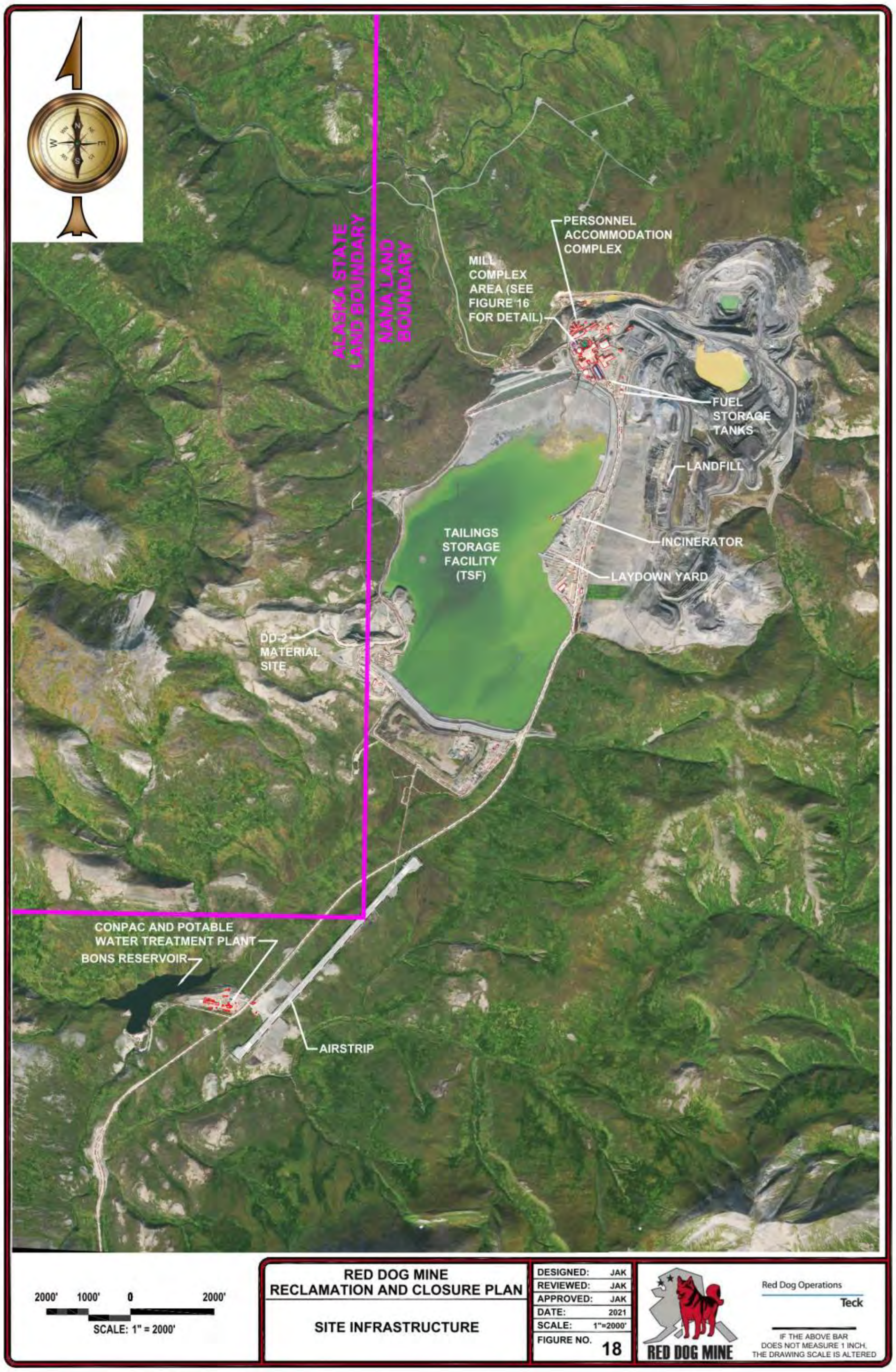


Figure 18: Site Infrastructure

2.5.8 Explosives Handling and Storage

Ammonium nitrate, emulsions, water gels, cast boosters, electric and non-electric caps, and dynamite are stored in specialized explosives storage units at the mine site.

2.5.9 Laydown Yard

The laydown yard, also known as cold storage, is located along the east side of the TSF about one mile from the mill and is the major bulk materials storage facility at the site. The yard is used as storage for reagents, other mill supplies, and large heavy equipment parts, drums packaged for off-site shipment, HDPE liners, and other miscellaneous supplies that can tolerate freezing conditions. All materials except oversize items are stored inside shipping Conex units, which are, by design, watertight.

2.5.10 Fuel Storage

The Mine consumes about 55,000 gallons of diesel fuel per day for power generation, equipment operation, and vehicle use. Fuel is shipped by barge to the Port site during the summer for storage and then transport to the mine site. The mine site has two 216,000-gallon fuel tanks (# 1 and #2), one 1,200,000-gallon tank (Tank #3), and one 1,125,000-gallon tank (Tank #4). The tanks are constructed on gravel pads that consist of several feet of structural fill material placed on a geotextile liner. The secondary containment structures in which the tanks are located are lined with a flexible membrane liner. The mine operates under a C Plan and an SPCC Plan. There are both buried and above-ground fuel pipelines at the mine. These pipelines transfer diesel fuel between bulk fuel tanks FST1, 2, 3 and 4, the power generating plant and the mill complex.

2.5.11 Solid and Hazardous Waste Management

Solid waste is managed in accordance with the requirements of the Resource Conservation and Recovery Act and the Alaska Solid Waste Management Regulations (18 AAC 60) and in accordance with the terms of the Mine Waste Management Permit No. 2021DB0001.

Two incinerators are located along the east side of the TSF and north of the laydown yard, and are used for burning all putrescible wastes, drained oil filters and oily absorbent pads, paper and other combustible, non-hazardous solid waste generated by the mine and its ancillary facilities. One active Class III Municipal Solid Waste Landfill is located at the mine site, in the MWD.

The landfill is used for the disposal of incinerator ash, construction waste, and domestic garbage. The landfill is operated under permits specifying covering, grading, working face size, etc., and according to documented procedures and in accordance with Permit No. 2021DB0001. At the end of mine life, the landfill will be closed.

Hazardous wastes are disposed of offsite at permitted Treatment, Storage, and Disposal Facilities regulated for handling hazardous wastes. Most liquids wastes are shipped offsite for disposal or recycling. Glycols are cleaned and/or recycled on site where possible. Used oil is shipped offsite. Wastes are stored in Conex units prior to shipping offsite. Solid waste items shipped offsite, such as batteries, are stored in containers and Conex units prior to shipping.

More details regarding waste management at the mine are included in the Red Dog Mine Integrated Waste Management Plan (TAK, 2020)

3 Reclamation Methods

This section describes the reclamation of the facilities described in Section 3. This section is largely unchanged from the 2016 Reclamation Plan except for the change in the design of the dump covers which have been changed from engineered soil covers in the 2016 plan to geosynthetic covers in this plan.

3.1 Mine Area

3.1.1 Overview

Primary closure objectives in the Mine Area include the following as summarized in Figure 19.

- Developing a stable landscape over the reclaimed mine lands.
- Limiting safety hazards.
- Reducing acid generation from all sources.
- Maintaining a wet cover over the TSF.
- Maintaining diversions for non-contact water (Red Dog Creek Diversion, DD-1, 2, 3 and 4).
- Capturing and treating contact water.
- Reducing the ARD potential and volume of contact water that requires treatment in the future.
- Maintaining the stability of the tailings facility for the long term.

3.1.2 Pits

The Main Pit will be backfilled during operations with waste from Aqqaluk and Qanaiyaq Pits. Portions of the southwestern and northeastern highwalls will remain exposed after reclamation as depicted in Figure 19. The wide and accessible benches in that area would be covered with soil and revegetated. The crest of the highwall along the eastern limit of the pit would be blasted back to a 4H:1V slope to allow snow machine operators to see the pit wall in sufficient time to stop safely.

Aqqaluk Pit will be used as a sump for contact water storage in the post-closure period. The contact water within the pit will be maintained at a level of no more than 840 ft. To accommodate a 1-100 yr. wet winter season the water level in the pit will managed so it is at or below 760 ft level going into each winter season. Boulders and berms will be placed near the rim of the pit to demark the high wall as a measure of safety for snow machine operators.

Qanaiyaq Pit will be backfilled during operations with waste rock from Aqqaluk Pit and from earlier phases of Qanaiyaq mining by the end of mining in 2032. The Qanaiyaq Pit is located at the top of a drainage divide, resulting in a small catchment area.

3.1.3 Waste Rock Dumps and Ore Stockpiles

All stockpiles and dumps that remain in-place and uncovered at the end of mining will be flattened to an approximate overall slope angle of 3H:1V and covered at closure. As discussed in Section 2.1.3, the MWD will be covered during operations. The remainder of the MWD, the MPD, Qanaiyaq

Pit Dump (QPD) and any unprocessed material in the Ore Stockpiles will be covered with a 40 mil geosynthetic LLDPE cover after the end of mining planned for 2032. Figure 20 shows the extent of site disturbance in 2023, the year used for the bonding cost estimate. In 2023 the LLDPE covers will still have to be installed on all the dump and stockpile areas after those areas are recontoured. The LLDPE geosynthetic liners will reduce seepage and infiltration of water into the subsurface and reduce available oxygen with the cumulative effect of reducing acid generation and the constituent loading of that water. The liners will be covered with crushed cover material from the key plate unit which will support revegetation. Monitoring of test plots of the geosynthetic covers placed on the MWD indicate essentially 100% effectiveness at preventing seepage through the liner system and into the underlying waste rock. (Geosyntec 2018). However, for the purposes of this reclamation plan Teck is assuming the covers will be 90% effective. Figure 21 is an artistic representation of what the re-shaped dumps should look like following reclamation and revegetation and Figure 22 is a cross-section of the cover design. A network of perforated seepage collection pipes will be constructed on top of the liner as an overliner seepage collection network, integrating surface swales and overlain fabric to encourage seepage into these pipes. Finally, the seepage collection pipe system and the synthetic liner system will be buried with approximately 2 feet of cover material. The overliner seepage collection network will deliver seepage water to a surface trench where it will be conveyed to the main Mine Sump or Aqqaluk Pit. At some point in the future, it could be released to the environment as storm water, provided it meets water quality standards at the discharge point. Overliner seepage/runoff is not anticipated to meet water quality standards initially so it is assumed it will report to mine water collection system for the closure cost estimate and water and load balance.

The surface of the geosynthetic cover will covered with soil, seeded and fertilized (if necessary) to promote vegetation. The proposed seed mixes are shown in Table 4. Seeds will be purchased commercially, augmented with some local forbs. Internal discussions and with the National Forest Service are in progress on developing seed farms but nothing definitive has been initiated.

The LOM plan includes segregation of Key Plate material to be stockpiled for use as cover material. With the use of LLDPE geosynthetic covers on the waste dumps, approximately the same volume of cover material will be required as for the previous plans to construct engineered soil covers. Currently there are approximately 2.24 million tonnes (5.6 million yd^3) of stockpiled cover material. Between 2020 and 2023 approximately 6.7 million tonnes of cover material will be mined and stockpiled from Key Plate waste coming from the Aqqaluk Pit. Therefore, alternative borrow sources outside of the current mine area are not anticipated to be required to generate enough material for cover construction.

The main mine haul road and truck run-out, will also be covered at that time.

Covered and reclaimed areas will be monitored and, where necessary, maintained for several years after construction. Post-closure monitoring and maintenance requirements are described further in Section 5 below.

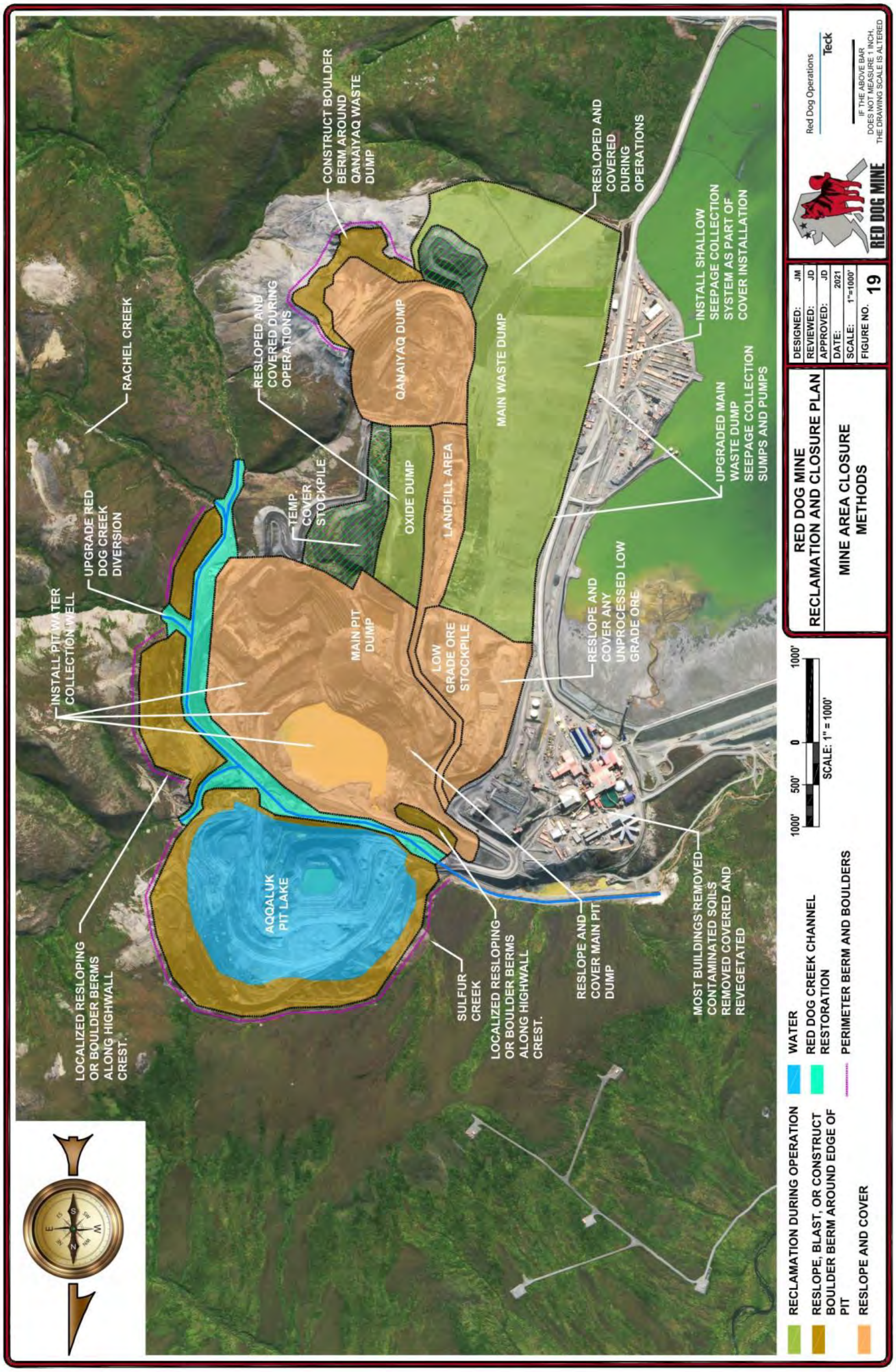


Figure 19: Mine Area Reclamation Methods

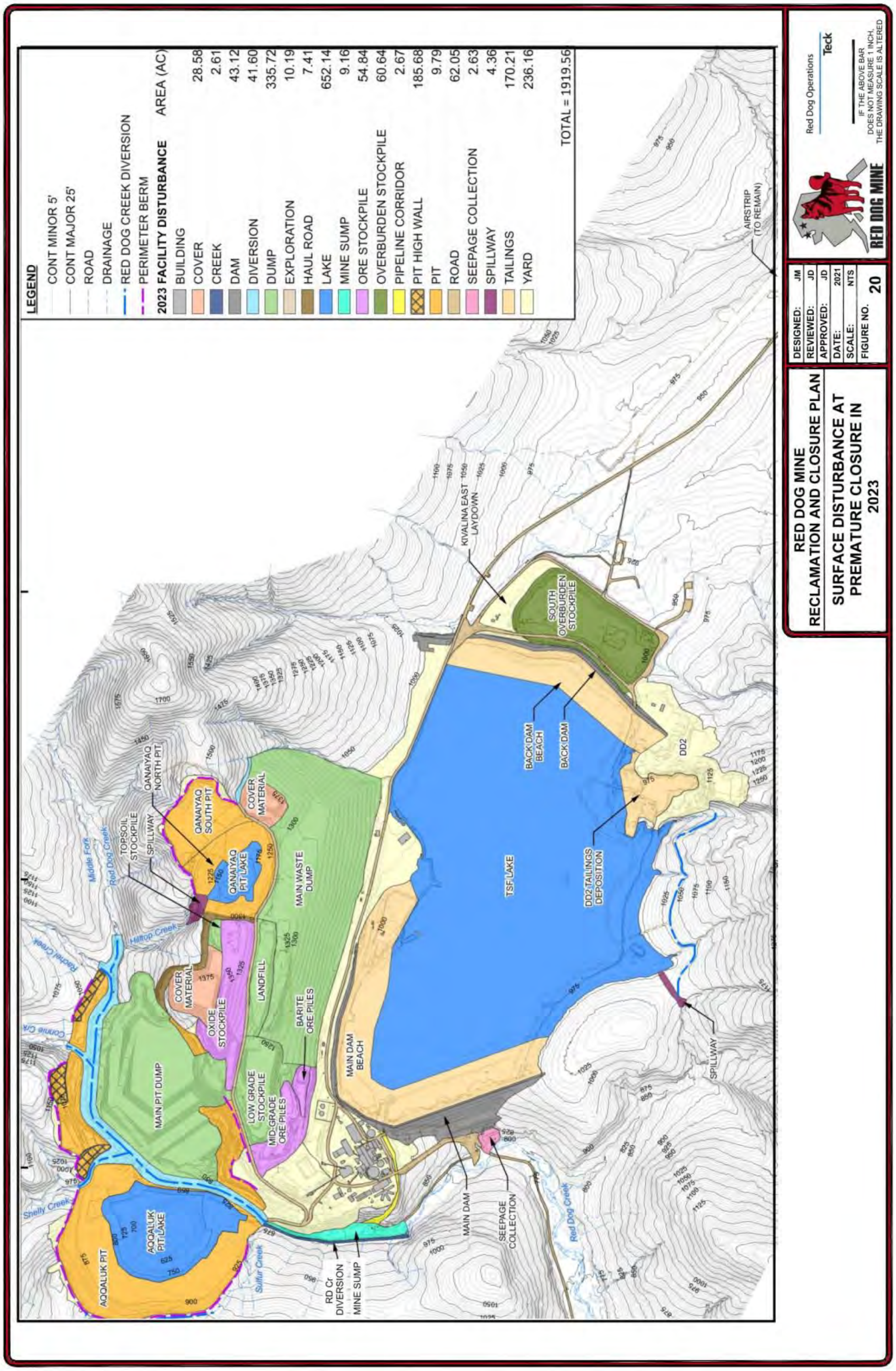


Figure 20: Snapshot of Site at Premature Closure in 2023

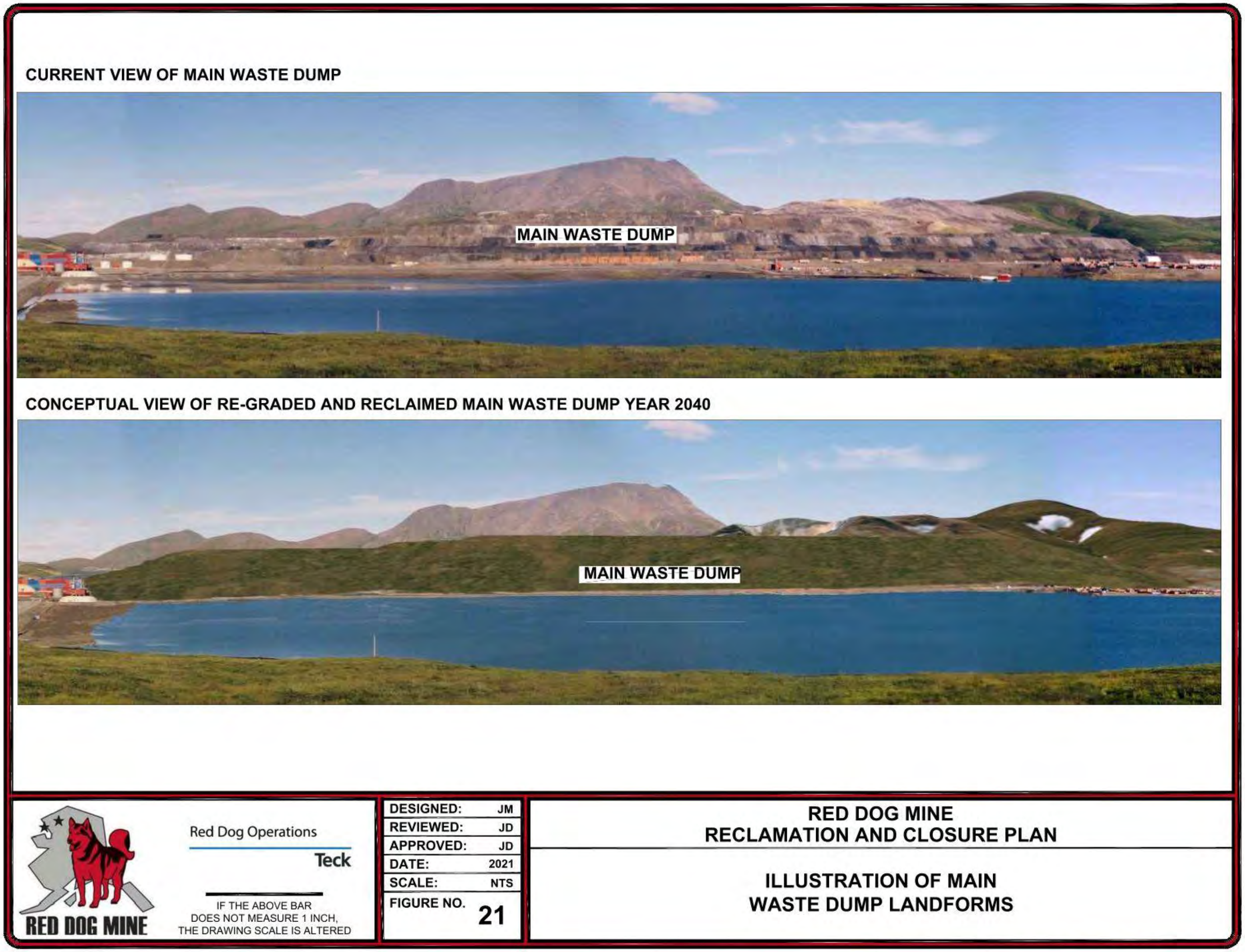


Figure 21: Waste Dump Landforms after Reclamation

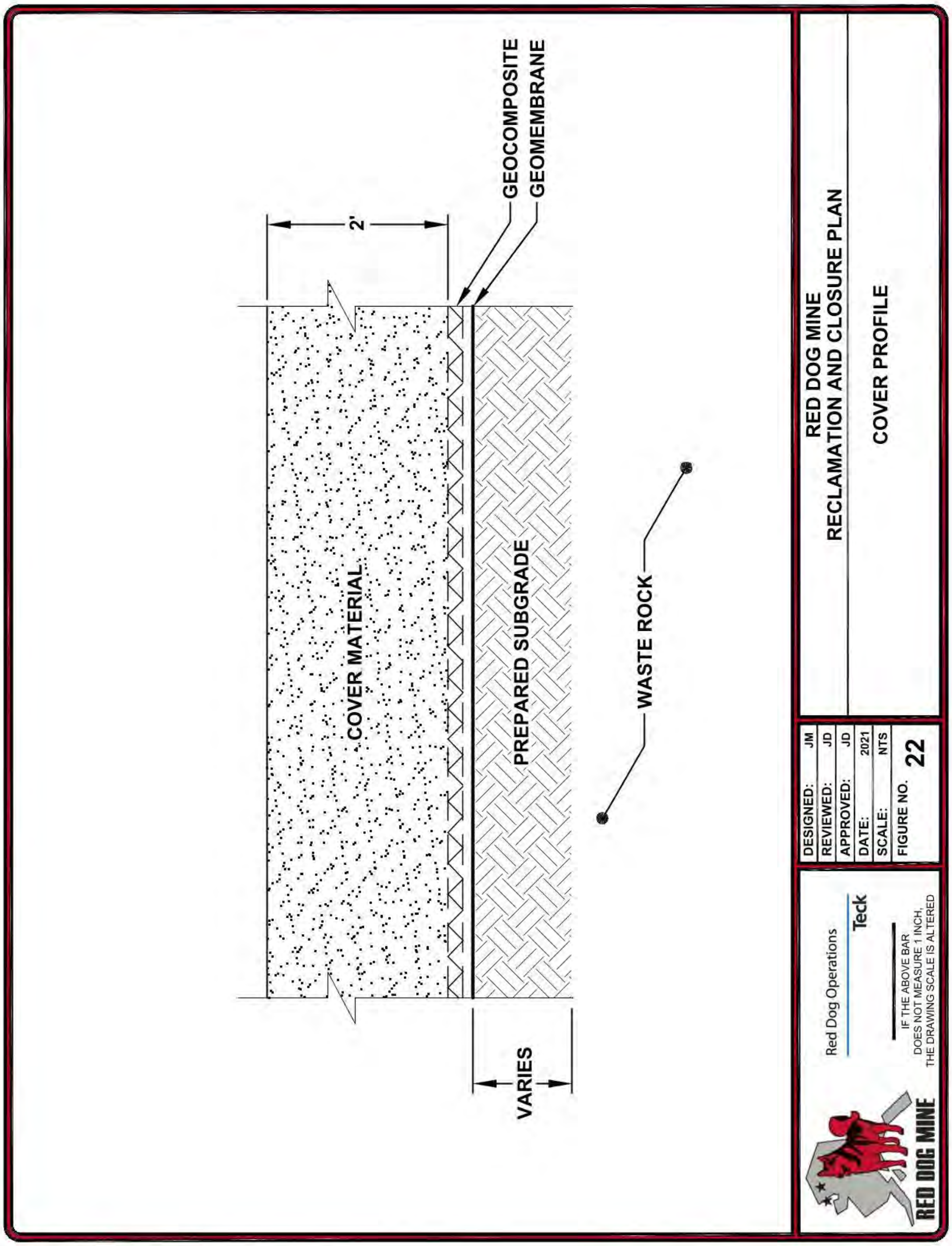


Figure 22: Geosynthetic Cover Profile

Table 4: Proposed Revegetation Species for Waste Rock Facilities and Stockpile Covers

Plant Species		Planting specifications
Native-grass cultivars		
Boreal red fescue	*Festuca rubra*	Apply seed at 20 lb/acre (final mixture). Ratio of species will depend on availability but may include predominantly P. alpina for drier areas and D. caespitosa, E. trachycaulus, and C. canadensius for mesic sites.
Glaucous tundra bluegrass	*Poa glauca*	
Gruening alpine bluegrass	*Poa alpina*	
Nortran tufted hairgrass	*Deschampsia caespitosa*	
Reed bluejoint	*Calamagrostis canadensis*	
Wainwright (“slender”) wheatgrass	*Elymus trachycaulus*	
Native forbs		
Alpine sweetvetch (masu)	*Hedysarum alpinum*	Apply forb seed at 5% of total seed rate in equal parts per species or as available. E.g., if grass seed rate is 20 lb/acre, apply grass at 19 lb/acre and forbs at 1 lb/acre. Mix may include A. alpinus, A. arcticus, E. sibirica, L. arctica, and O. campestris in drier/alpine areas, and A. millefolium, Chamerion spp, and H. alpinum in mesic areas.
Dwarf fireweed	*Chamerion latifolium*	
Indian milkvetch	*Astragalus aboriginum*	
Low-lying stinkweed	*Artemisia arctica*	
Other potential forb species		
Alpine milkvetch	*Astragalus alpinus*	
Arctic bladderpod	*Lesquerella arctica*	
Boreal yarrow	*Achillea millefolium borealis*	
Field oxytrope	*Oxytropis campestris*	
Siberian aster	*Eurybia sibirica*	
Tall fireweed	*Chamerion angustifolium*	

3.1.4 Red Dog Creek Diversion

No changes have been made to the current reclamation plans for the Red Dog Creek Diversion from the 2016 reclamation plan. The Red Dog Creek Diversion will be rebuilt as an open channel designed to handle non-contact water from a 1,000-year flood event. The alignment will be around the toe of the re-graded MPD, at a distance sufficient to allow a sediment collection ditch between the toe and the diversion ditch. Figure 23 shows a conceptual alignment and sections. By the time a final design is needed, the site will have almost forty years of experience with the Red Dog Creek Diversion. Any details needed to minimize ice formation or sediment deposition, and to minimize long-term maintenance requirements, will be incorporated into the design at that time.

If Hilltop Creek meets water quality standards (is non-contact water) after closure it would be redirected to Red Dog Creek (natural channel). Otherwise, Hilltop Creek would be directed to an infiltration basin along the toe of the backfilled Main Pit.

3.1.5 Mine Water and Waste Rock Facility Seepage

Water diversion and collection structures will be constructed adjacent to the covered dumps to collect and remove surface runoff. The water would be monitored and pumped to Aqqaluk Pit or allowed to flow into Red Dog Creek or Bons Creek if/when it is of sufficiently good quality for direct discharge.

Cover studies to date suggest that a synthetic cover would reduce the infiltration of water to the underlying waste. Seepage studies performed by Geosyntec on the test covers at Red Dog suggest that the synthetic covers may keep very nearly all the surface water from infiltrating the cover and seeping into the waste rock. The conservative assumption herein and in the 2020 water balance model update (SRK 2020) is that approximately 10% of precipitation would infiltrate through the cover.

Water that infiltrates through the covers on the MWD will continue to be collected in the series of sumps along the toe of the MWD. From there seepage would flow or be pumped either directly to a water treatment plant or to the Aqqaluk Pit for storage and future treatment. Figure 24 shows the layout for the seepage collection system. The sumps and piping along the toe of the MWD have already been upgraded.

Water infiltrating the MPD will drain downward. The groundwater level in the filled MPD will be maintained no higher than 840 ft keeping the water level below the hydraulic level of the Red Dog Creek Diversion. This will likely require the installation of pit dewatering wells in the MPD. Contact water collecting in the MPD wells will be routed to treatment or to the Aqqaluk Pit. Excess water will be pumped from the Aqqaluk Pit each year and treated for discharge. The water level in the Aqqaluk Pit will be 840 ft or less. To accommodate a heavy snow season, the pit water level will be drawn down annually to 760 ft or less by the end of the frost-free season. Accumulated water in the Qanaiyaq Pit Dump, if any, will be pumped to either the Aqqaluk Pit or directly to treatment.

3.2 Tailings Storage Facility Area

3.2.1 Overview

The reclamation plan for the TSF area remains unchanged from the 2016 Plan, except that the current plan for planned closure in 2032 contemplates a final dam elevation of 1006 feet instead of 996 ft. Figure 25 depicts the proposed closure and reclamation configuration for the TSF area. Primary closure objectives for closure of the TSF area are:

- Maintaining a water cover over the tailings to restrict oxidation and acid generation
- Managing covers and vegetation over the tailings beaches
- Managing contaminated water
- Maintaining long-term stability of the dams, while minimizing seepage
- Reclaiming surface disturbances in areas that will no longer be used

3.2.2 Tailings

The 2019 conceptual design for the dam incorporates a final struck tailings elevation of 993 ft (Golder 2019) by the end of production in 2032. The struck tailings elevation assumption for this Reclamation Plan is 993 ft, corresponding to a dam crest of 1006 ft. The 2020 LOM plan indicates that the 996’ dam raise needs to be completed by Q3-2021 and the 1006’ dam raise needs to be completed by 2028. Further details and discussion of TSF storage capacity are presented in the *Red Dog Mine Tailings and TSF Water Management Plan (TAK 2020)*.

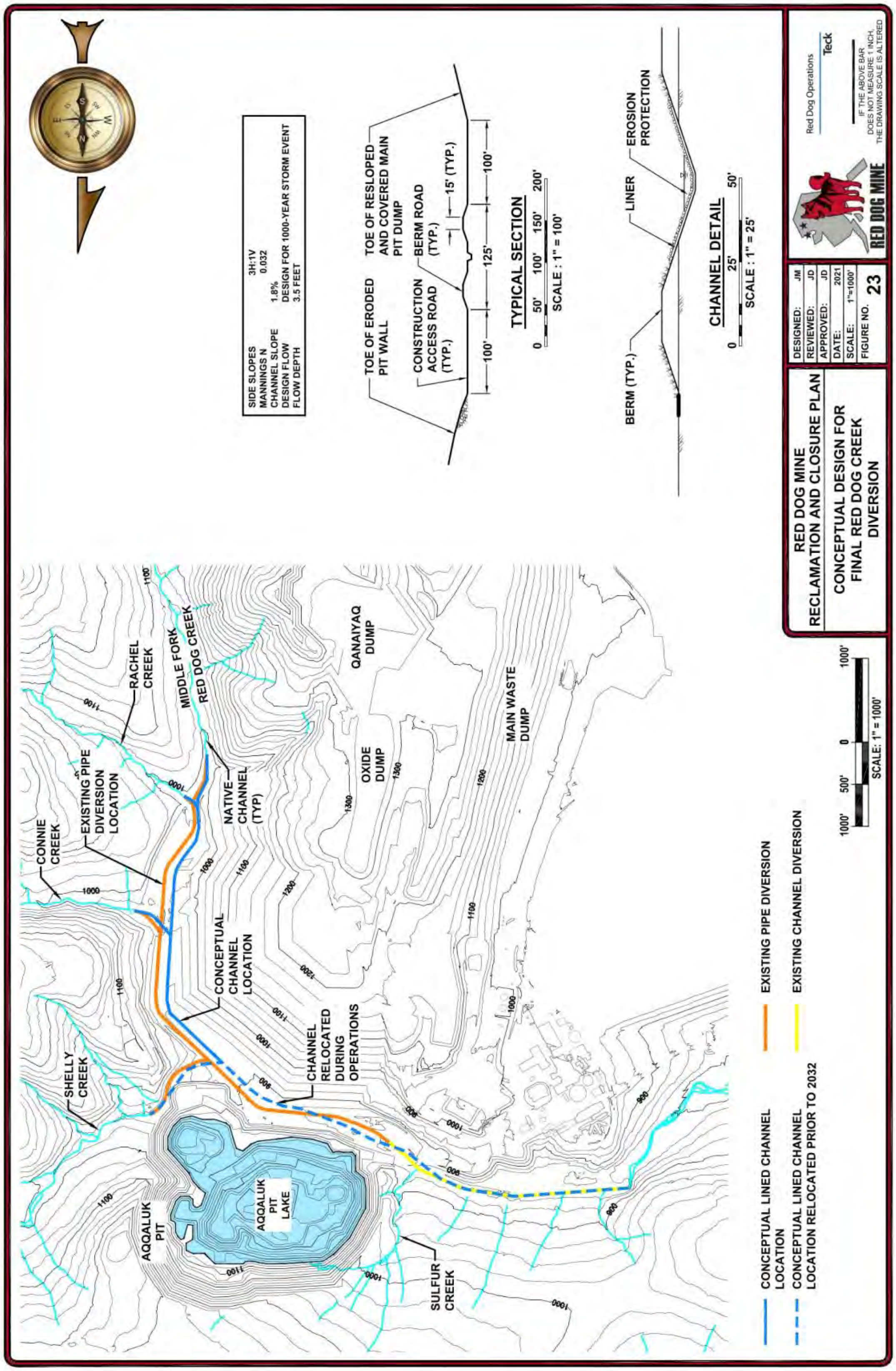


Figure 23: Conceptual Design for Final Red Dog Creek Diversion

Tailings deposition will be managed to make the final surface as level and as close to the target elevation as possible. The tailings surface will be re-graded as necessary to provide generally level deposition of tailings. Examples of tailings regrading methods include using barge-mounted dredges or boat-mounted harrows.

Water treatment capacity and efficiency are being upgraded over the next 2 years as part of the mine's Water Volume Quality Management (WVQM) Plan to allow pre-treatment of all inflows to the TSF Pond.

3.2.3 Water Cover

A water cover will be maintained over the tailings for the post-closure period. The beach areas will have a geosynthetic LLDPE liner installed and be covered with clean fill material as described in Section 3.2.4.

Through many years of experience at other sites, it has been demonstrated that an effective way to prevent oxidation and acid generation from sulfidic tailings is to keep the tailings underwater. Depth of water cover in the TSF Pond will be maintained at a minimum of two feet over the tailings.

The criteria for the 1006-foot dam crest are specified in the *Tailings Main Dam Stage XII Conceptual Design Report, Red Dog Mine, Alaska* (Golder 2019). The 1006-foot dam crest is based on a final tailings elevation of 993 ft (struck-level elevation). The conceptual Golder design includes a minimum water level of 995 ft, which is based on a 2-foot water cover above the tailings. This would be the target level to achieve at the end of each discharge season. A total of 4.9 ft of capacity is included between the minimum water level of 995 ft and the spillway invert elevation of 1002.1 ft. This includes the estimated average inflow of 1.7 ft during freshet in May (assuming no discharge during that month) above the minimum water cover. An additional 3.2 ft of surcharge storage is incorporated between this 996.7 ft elevation and the spillway invert elevation of 1002.1, which conservatively includes the estimated probable maximum flood rain plus snowmelt. On top of that there is still 1.9 ft of freeboard below the spillway invert to accommodate 1.3 ft of setup plus 0.6 ft of runup. Above the spillway invert there is 2.3 ft of flood routing capacity with another 1.6 ft of freeboard to the top of the dam at 1006 ft elevation as illustrated in Figure 26.

3.2.4 Main Dam

Final Configuration

The Main Dam is currently planned to be raised to a final elevation of 1006 ft by 2028. Further details can be found in Section 2.3.4 and in the Tailings Main Dam Stage XII Conceptual Design Report (Golder, 2019).

Spillway

To protect against overtopping of the Main Dam, a spillway will be constructed on the west side of the TSF (Golder 2019). A conceptual design for the spillway is shown in Figure 26. The conceptual design has the spillway located in bedrock. The invert elevation is 1002.1 ft, and the width of the channel is sufficient to pass an inflow design flood with a flow depth of 2.6 ft. The flow would therefore remain 1.6 ft below the dam crest.

Surcharge Capacity

The volume between the assumed tailings surface elevation of 993 ft and the spillway invert elevation of 1002.1 ft determines how much water can be stored prior to discharge via the spillway. Calculations show that even the combination of the minimum water cover of two feet, a spring freshet, a probable maximum flood (PMF) series, and snowmelt event could be contained between the tailings surface elevation and the level of the spillway invert (Golder 2019), as shown in Figure 26.

Beach

Seepage rates at the Main Dam have been assessed and a model to predict future seepage rates has been developed (URS 2007d). To reduce seepage rates after closure, a permanent beach is being constructed in front of the Main and Back dams. Presently the beach is constructed of tailings and is approximately 600 ft wide at the Main dam and 150 ft wide at the Back dam. The beaches will restrict seepage rates to about 550 gpm (main dam seepage collection rates were 521 gpm average in 2018 and east/west overburden sumps averaged 43 gpm in 2018). The final cover for the beaches will be constructed of suitable unmineralized cover material, and a geosynthetic LLDPE liner to reduce the amount of oxygen reaching the underlying tailings. Figure 27 shows a typical section through the Main Dam beach. The current assumption is that this beach may be extended along the eastern shore of the TSF Pond, parallel to the wing wall. Observations of seepage during operations may lead to the conclusion that a narrower beach is adequate, particularly at the Back Dam.

Seepage Collection

Seepage collection at the toe of the Main Dam will continue after closure, but the pumpback system will be re-configured to send the seepage to the Aqqaluk Pit. The seepage management system, including the seepage collection pond below the Main Dam has a conceptual design capacity of approximately 11.7 acre-feet or 3,812,500 gallons, a volume sufficient to contain approximately 4.8 days at a seepage rate of 550 gpm. The tailings and pond limits projected at closure are illustrated in Figure 25.

3.2.5 Back Dam

As discussed in Section 2.3.5 above, the Back Dam is currently planned to be raised to an elevation of 1006 ft during operations. Any seepage from the Back Dam would be collected and pumped to the Aqqaluk Pit at the end of operations. The design report for the Back Dam (Golder 2017) includes results of seepage analyses. Seepage rates through the final dam are predicted to range from about 22 for the base case and up to 44 gpm for the case without a beach (Golder 2017). Seepage pumps at the back dam will be upgraded prior to closure as well.

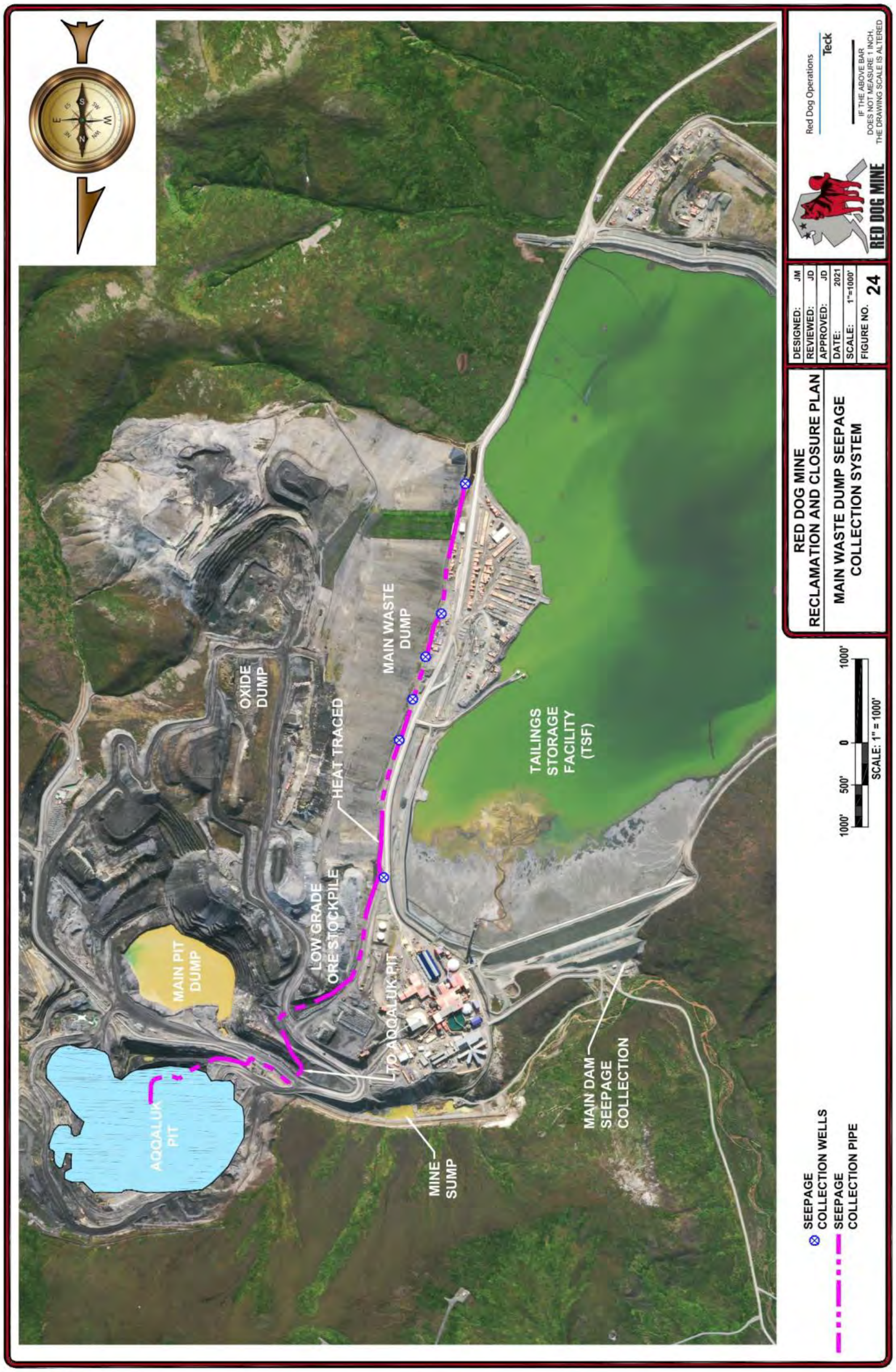


Figure 24: Layout of Main Waste Dump Seepage Collection System

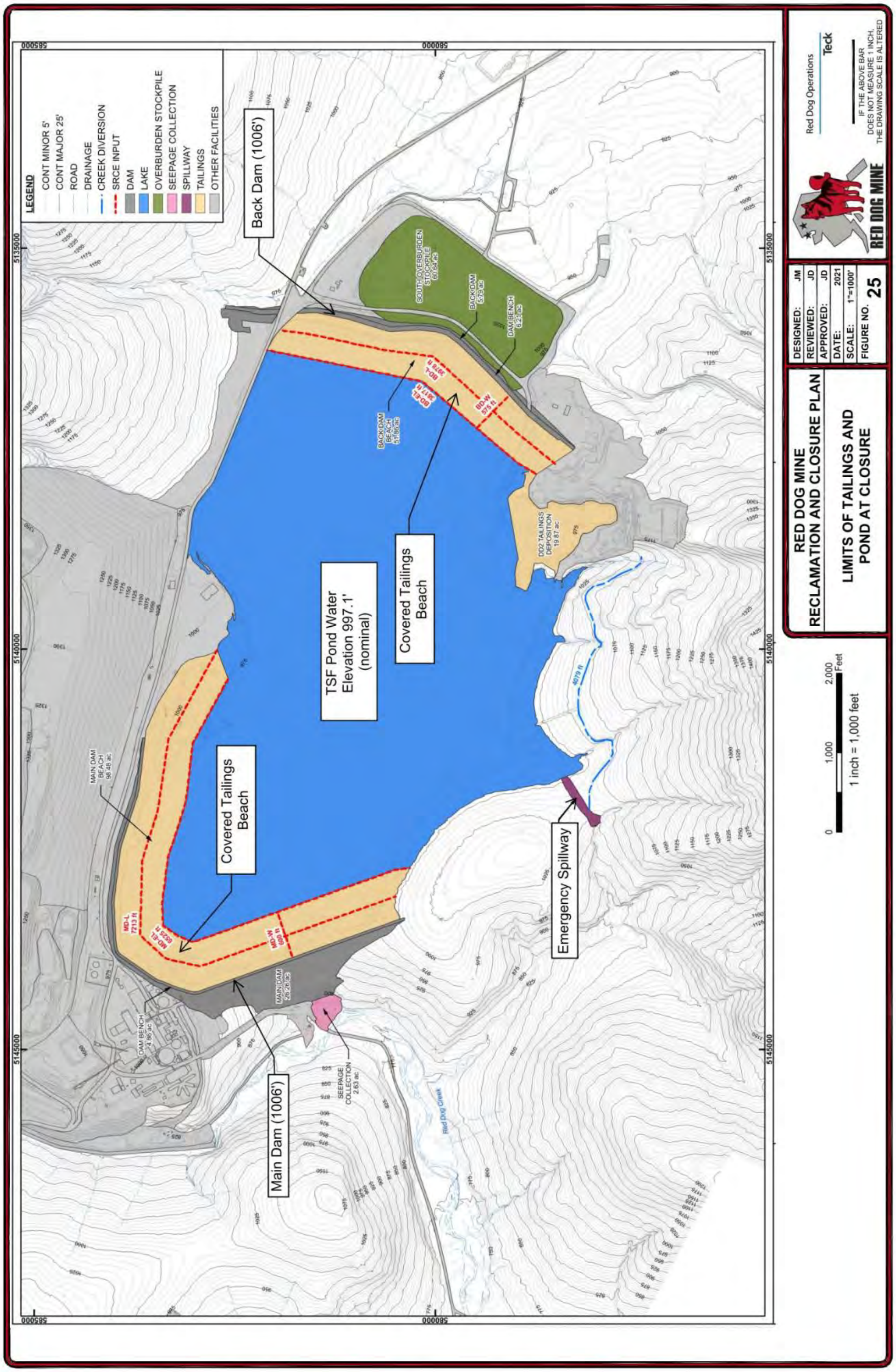


Figure 25: Limits of the Tailings Storage Facility at Closure

3.2.6 Overburden Dump

The Overburden Dump and any of its exposed footprint will be re-graded and revegetated. Revegetation trials on the Overburden Dump were completed in 2007 (ABR 2007).

3.3 Water Treatment and Discharge

3.3.1 Water and Constituent Load Balance

The collection and treatment of contact water will continue during the temporary closure, reclamation, and post-reclamation periods. Flows and constituent loads from each source area will transition from the operational levels discussed in Section 2.4.1 to post-reclamation levels. This will take approximately 20 years. The precise timing of the transition from operational to post-reclamation conditions will depend on the schedule of closure activities and rate of seepage under the covered waste rock dumps.

3.3.2 Water Treatment

During Reclamation the mine will continue to treat mine water much as it does presently which incorporates a series of progressive improvements in treatment technology and operational efficiencies integrated over the years. The assumption is also that the mine will continue to treat mine water using the technology in use today - mainly high-density-sludge lime treatment into the post-reclamation period. As the mine approaches planned closure it will continue to refine predictions of post-reclamation load and water balance and weigh these data against the performance of water treatment plants at site. The closure cost estimate includes funds to continue to treat water using the existing water treatment plants during reclamation and post-reclamation periods and also includes funds to construct a new plant following reclamation assuming that approximately 50% of any new plant will consist of re-purposed parts from the existing mine water treatment plants. Therefore, the mines intention is continue treating water into the post-reclamation period the same way as it does presently and will continue to improve predictions of post-reclamation conditions and implement any meaningful changes to water treatment technology or capacity in response to new information. The reclamation cost estimate preserves those options in any default situation as well.

3.3.3 Discharge of Treated Water

Discharge of HDS treated water at Outfall 001 will continue during the reclamation and post-reclamation periods. The quantities discharged will transition from operational levels to approximately 1.134 billion gallons per year in the steady-state conditions as discussed in Section 4.2.2.

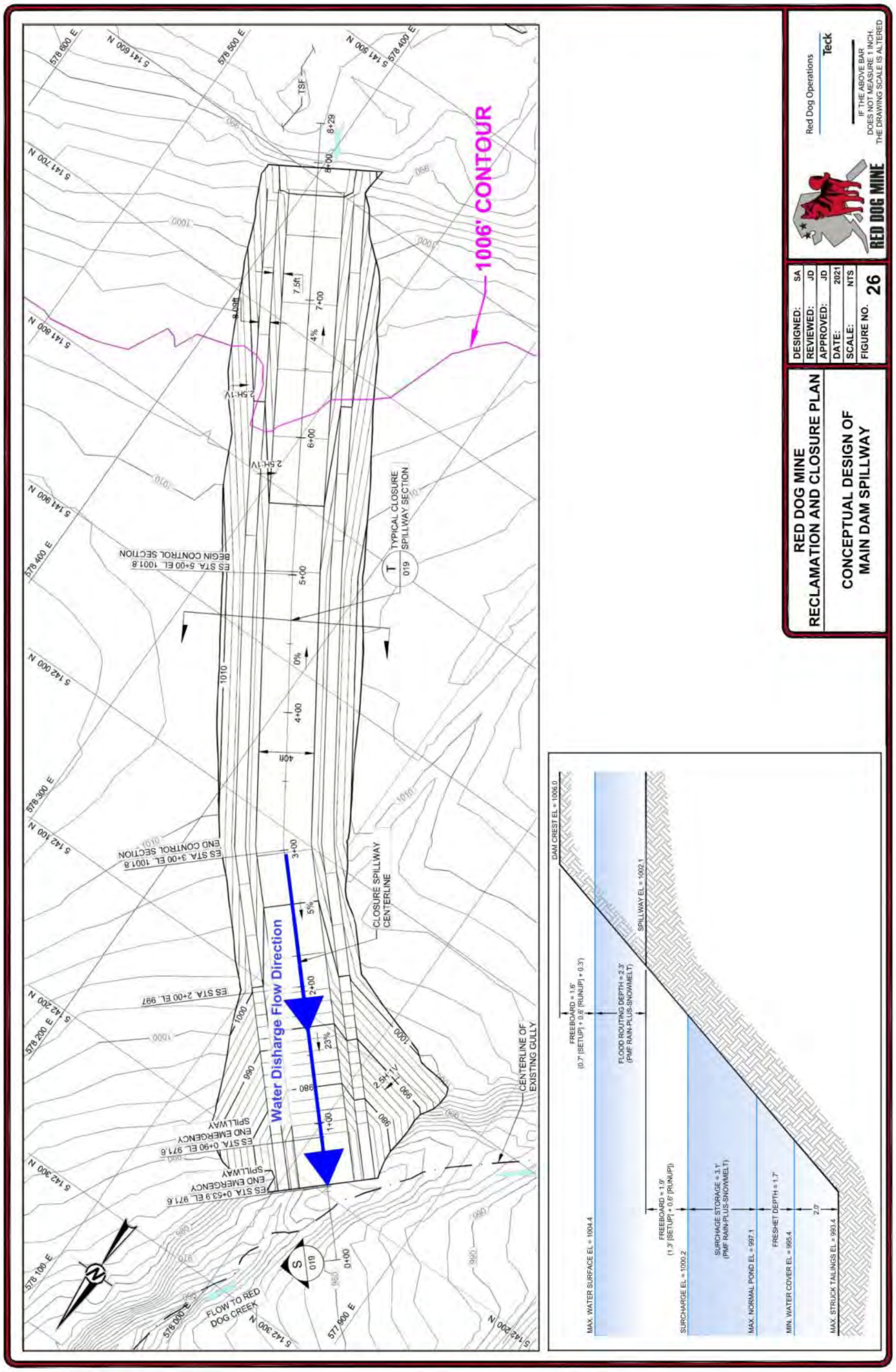
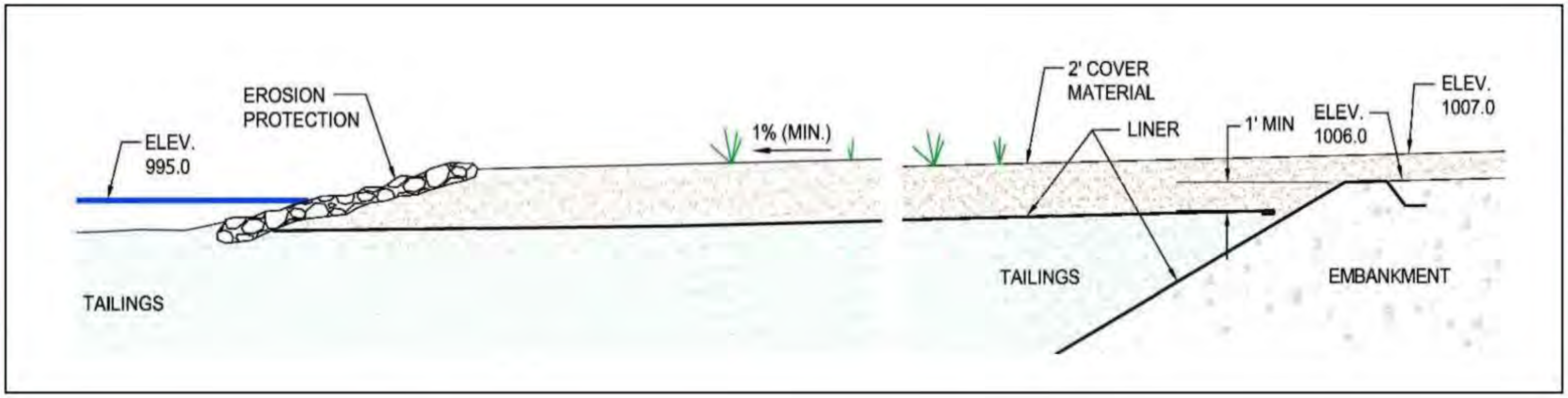


Figure 26: Conceptual Design of TSF Spillway



COMPONENT OF STORAGE	DEPTH (FEET)	RESULTING ELEVATION (FEET AMSL)
TAILINGS SURFACE	N/A	993.4
MINIMUM WATER COVER	2.0	995.4
SPRING FRESHET	1.7	997.1
PROBABLE MAXIMUM FLOOD SERIES	3.1	1001.2
100-YEAR FLOOD	N/A	1001.2
SPILLWAY CREST	N/A	1002.1
INFLOW DESIGN FLOOD	2.3	1004.4
FREEBOARD FOR WIND/WAVE	1.6	1006
DAM CREST	N/A	1006

RED DOG MINE

Red Dog Operations

Teck

IF THE ABOVE BAR DOES NOT MEASURE 1 INCH, THE DRAWING SCALE IS ALTERED

DESIGNED:	SA
REVIEWED:	JD
APPROVED:	JD
DATE:	2021
SCALE:	NTS
FIGURE NO.	27

RED DOG MINE
RECLAMATION AND CLOSURE PLAN

MAIN DAM BEACH
TYPICAL SECTION

Figure 27: Main Dam Beach Typical Section

3.4 Ore Processing Area

Reclamation plans for the ore processing area remain unchanged from the approved 2016 Reclamation Plan. Ore processing facilities will be decommissioned after operations end in 2032. Waste materials will be removed and handled according to regulations specific to each material. High value components will be removed for salvage and scrap, and the remainder of the structures will be demolished (Denison Environmental Services 2004). Bulk demolition wastes will be disposed of in a landfill to be developed, possibly below the Low-Grade Ore Stockpile. Salvage values were not included in the reclamation cost estimate per state agency guidelines.

It is assumed that metal-contaminated soils will be identified below portions of the ore processing area, once the structures are removed. These soils will be removed and hauled to the Low Grade Ore Stockpile. Further reclamation of the ore processing area is discussed in the following section.

3.5 Infrastructure

Reclamation plans for the mine Infrastructure remain unchanged from the approved 2016 Reclamation Plan. By the time operations cease in 2032, NANA will decide what additional site infrastructure, beyond what is required for post-reclamation activities, they want to remain in place.

Infrastructure that is not needed for the post-reclamation requirements or is not on NANA's list of infrastructure to remain intact, will be decommissioned. Hazardous materials and high value components will be removed. The facilities will be demolished and placed in the demolition landfill. Concrete foundations will be removed as well.

Figure 28 shows the infrastructure locations that are expected to require reclamation. The total surface area is about 225 acres. Any contaminated soil present in these areas will be removed to the stockpiles, and areas regraded. Material that is not highly mineralized will be brought in as fill where necessary and the areas revegetated following the recommendations in Table 5.

Table 5: Revegetation Recommendations for Infrastructure Areas

Area	Plant Species	Planting Specifications
Reclaim roads, laydown areas, pads and quarries	Native grass cultivars Native forbs	(see Table 4) (see Table 4)
Banks of Red Dog Creek Diversion and other wet areas	Shrub cuttings and seedlings Diamond leaf willow Felt leaf willow Richardson willows Shrub/dwarf birch	 Cuttings on one-foot centers Cuttings on one-foot centers Cuttings on one-foot centers 80 seeds/yd^2

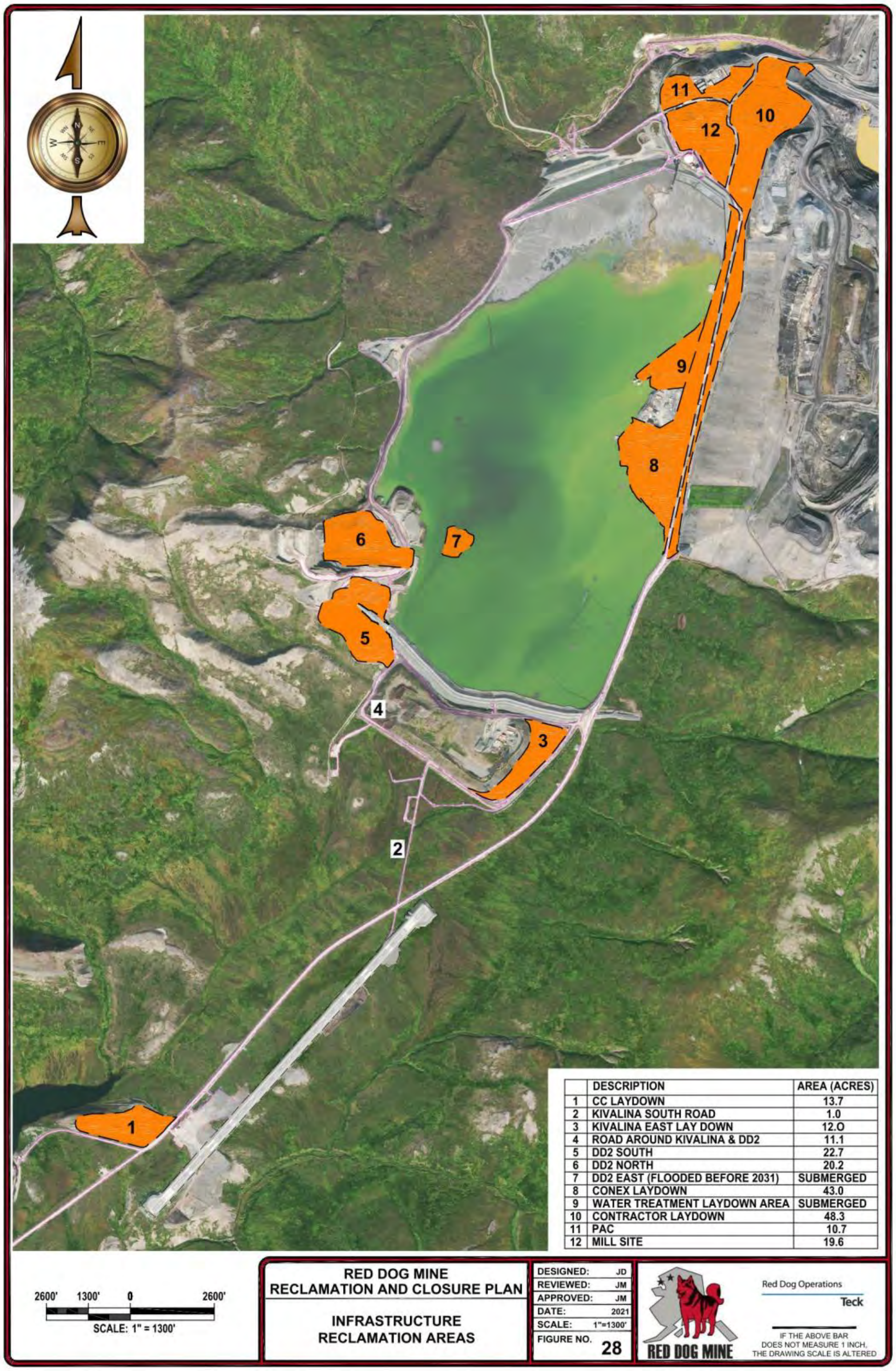


Figure 28: Infrastructure Reclamation Areas

4 Post-Reclamation Requirements

4.1 Overview

Post-reclamation requirements remain largely unchanged from the approved 2016 Reclamation Plan. Perhaps the largest change is an anticipated decrease in constituent loading in seepage water recovered from the various mine dumps after those dumps are covered with the LLDPE geosynthetic covers. After reclamation activities are completed, the site will transition to post-reclamation status. Figure 29 provides an overview of the reclaimed site and Figure 30 shows typical sections.

The principal post-reclamation requirement will be the collection, treatment, and discharge of contact water. Geosynthetic covers constructed on dumps and stockpiles will reduce the volume of seepage water that has to be collected as well as the rate at which constituents are released from the mine waste materials, but seepage water will still need to be treated.

A second post-reclamation requirement will be the monitoring and maintenance of the Main and Back Dams, ditches, dump covers and other earthworks constructed prior to or during the closure period. Maintenance activities are expected to gradually diminish as stable conditions develop.

Additional long-term requirements will include the maintenance and replacement of infrastructure and equipment, including power generators and water treatment plant(s), and ongoing maintenance, inspection, and monitoring.

4.2 Water Treatment and Discharge

4.2.1 Water and Constituent Load Balance

Water treatment on site is expected to continue over the long term. The operations-period water and constituent load balances introduced in Section 2.3.2 were extended to develop estimates of post-reclamation flows and water quality (SRK 2020).

Figure 31 shows the estimated site water balance during the post-reclamation period for an average year. The Aqqaluk Pit will be the primary storage area for impacted water, and will receive seepage from the MWD, MPD, Main Dam, Back Dam, Overburden collection system, and direct runoff. Each summer, an average of about 1.134 billion gallons of water is estimated to be extracted from the Aqqaluk Pit and treated by the time the site reaches steady-state conditions in about 20 years. Before that, discharge rates will be closer to 1.3 billion gallons. During the approximate 20-year period that the site reaches steady state conditions loading will decrease as will sludge production. As a result, there will be a gradual decrease in water treatment costs over those 20 years. However, in the initial year of closure, when the Aqqaluk Pit is filling and the TSF will supply all the water for treatment, the loading and lime demand will be relatively low as will the water treatment cost. Two years after the end of operations, when water treatment starts to include water from the Aqqaluk Pit, loading, lime consumption and treatment costs go very high for about two years before starting a 20 year trend of decreasing lime consumption and treatment cost. Annual water treatment costs were estimated for each of the first 25 years following reclamation after which they were estimated to remain the same.

Runoff from the covered MWD, and from the northern portion of the Overburden Dump, could be released into the environment if it meets water quality standards, otherwise it would be redirected to the Aqqaluk Pit. However, the water balance and cost estimate assume this runoff will be captured and redirected to the Aqqaluk Pit and treated prior to discharge. Precipitation, runoff from the west side of the TSF (below the diversion ditches), treated domestic wastewater and backwash water from the treatment plant(s) will be directed to the Aqqaluk Pit or TSF. The outflows will be evaporation and excess water in the Aqqaluk Pit which will have to be treated and discharged seasonally at Outfall 001.

The current GoldSim load balance estimates that post-reclamation steady-state constituent concentrations in the TSF Pond water will be about 3,500 mg/L TDS, 2,600 mg/L sulfate, and 51 mg/L zinc. Steady state in the TSF pond is anticipate in about 2030 under a 2023 premature closure scenario and in about 2042 under a 2032 planned closure. The post-reclamation water balance and load balance results are presented in more detail in the *Red Dog Mine Water and Load Balance Update* (SRK 2020).

4.2.2 Water Treatment

Seasonal water treatment operations will continue in the post-reclamation period. Impacted water stored in the Aqqaluk Pit will be withdrawn each summer for treatment and discharge. The maximum water level in the Aqqaluk will be 840 ft, but by the end of each discharge season the water level will be at or below 760 ft to accommodate spring freshet following a 1-100 year winter season.

The water and load balance estimates required average annual discharges of about 1.134 billion gallons from the Aqqaluk Pit, and a loss of 80 million gallons to evaporation. Slightly larger volumes will need to be treated, because some of the treated water is used for backwashing the sand filters and removing the treatment sludge. Total volumes entering the treatment system each year are estimated at 775 million gallons from the Aqqaluk Pit. The backwash and sludge removal water would be routed to the TSF and/or Aqqaluk Pit. Review of water treatment methods concluded that lime addition will remain the preferred method of water treatment after closure. All three of the current treatment plants will be available for use, and various configurations are possible. It may prove more cost-effective to modify one of the three plants or construct entirely new components. Entering the winter season with a water level of 760 ft in the Aqqaluk Pit will accommodate a 100-year rain-on-snow event as a contingency.

The water treatment reagent requirements were estimated from the water and load balance for the post closure period. Table 6 shows estimates of lime consumption under steady-state conditions (2049). They were derived by converting the estimated constituent concentrations in each source stream to a theoretical lime demand, and then increasing the theoretical values by 12.5% for Aqqaluk Pit water and 11.25% for TSF water to account for inert and incompletely reacted lime. Under steady state conditions the site will treat 1.373 million gallons annually from the TSF and Aqqaluk Pit, return 120 million gallons to the TSF and discharge 1.134 million gallons at Outfall 001.

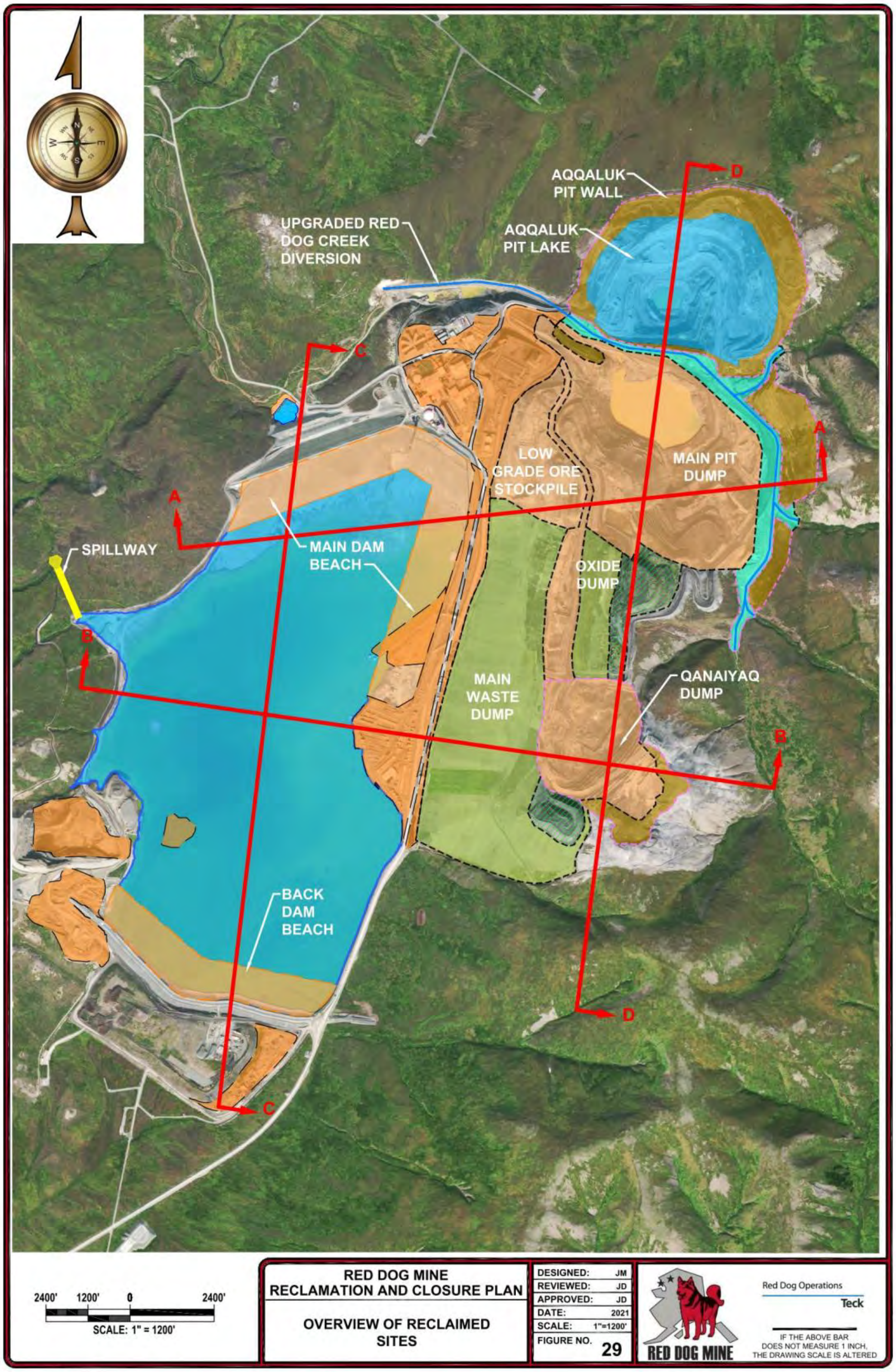


Figure 29: Overview of Reclaimed Sites

Table 6: Estimated Lime Requirements for Water Treatment

Source	Annual Volume (million gallons)	Theoretical Lime Demand (tonnes per year)	Estimated Actual Lime Demand (tonnes per year)
TSF Pond	478	818	920
Aqqaluk Pit	895	9,100	10,235
Total	**1,373**	**9,918**	**11,155**

The lime treatment process creates a sludge consisting of gypsum and neutralized metal hydroxides. Estimates of sludge production in Table 7 are also based on the current water and load balance.

4.2.3 Sludge Management

TAK will continue researching options for very long-term post-reclamation sludge management. Current sludge generated from treating TSF water comprises 5% solids while Aqqaluk water treatment sludge comprises 10% solids. With future water treatment plant upgrades, scheduled for 15 years after closure in the cost estimate, Aqqaluk solids are expected to increase from 10% to 20%. The current concept is water treatment sludge will initially be directed to the TSF and then the Aqqaluk Pit until available space in the pit is exhausted. Under the 2023 premature closure scenario there is sufficient room to store more than 100 years of sludge in the TSF and Aqqaluk Pit. This cost estimate reflects that as discussed in Section 5.5.

Table 7: Estimated Sludge Production

Source	Estimated Production - Operations (million gallons)	Initial Solids Content	Estimated Production Post-Reclamation Steady State (million gallons)	Final Solids Content
TSF Pond	2.3	5%	2.3	5%
Aqqaluk Pit	21	10%	9.7	20%
Total	23.3		12.0	

4.2.4 Discharge of Treated Water

Treated water will continue to be discharged at Outfall 001 at an average annual volume of about 1.134 billion gallons under steady-state conditions about 20 years after closure. Prior to that discharge rates will gradually decrease from about 1.3 billion gallons to 1.134. The total storage capacity at site during the long-term closure period is about 4.5 billion gallons in the Aqqaluk Pit and 1.2 billion gallons in the TSF.

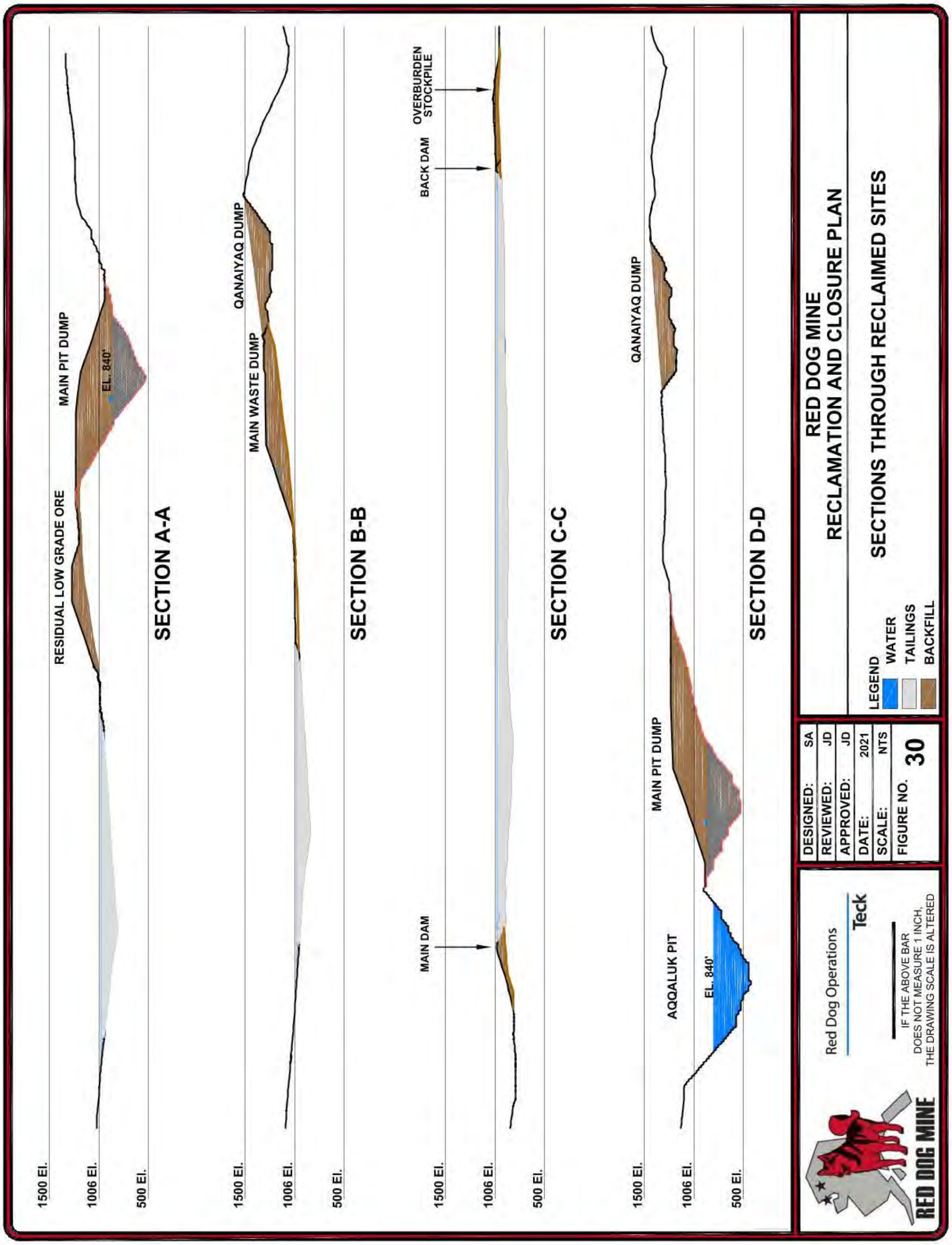


Figure 30: Sections through Reclaimed Sites

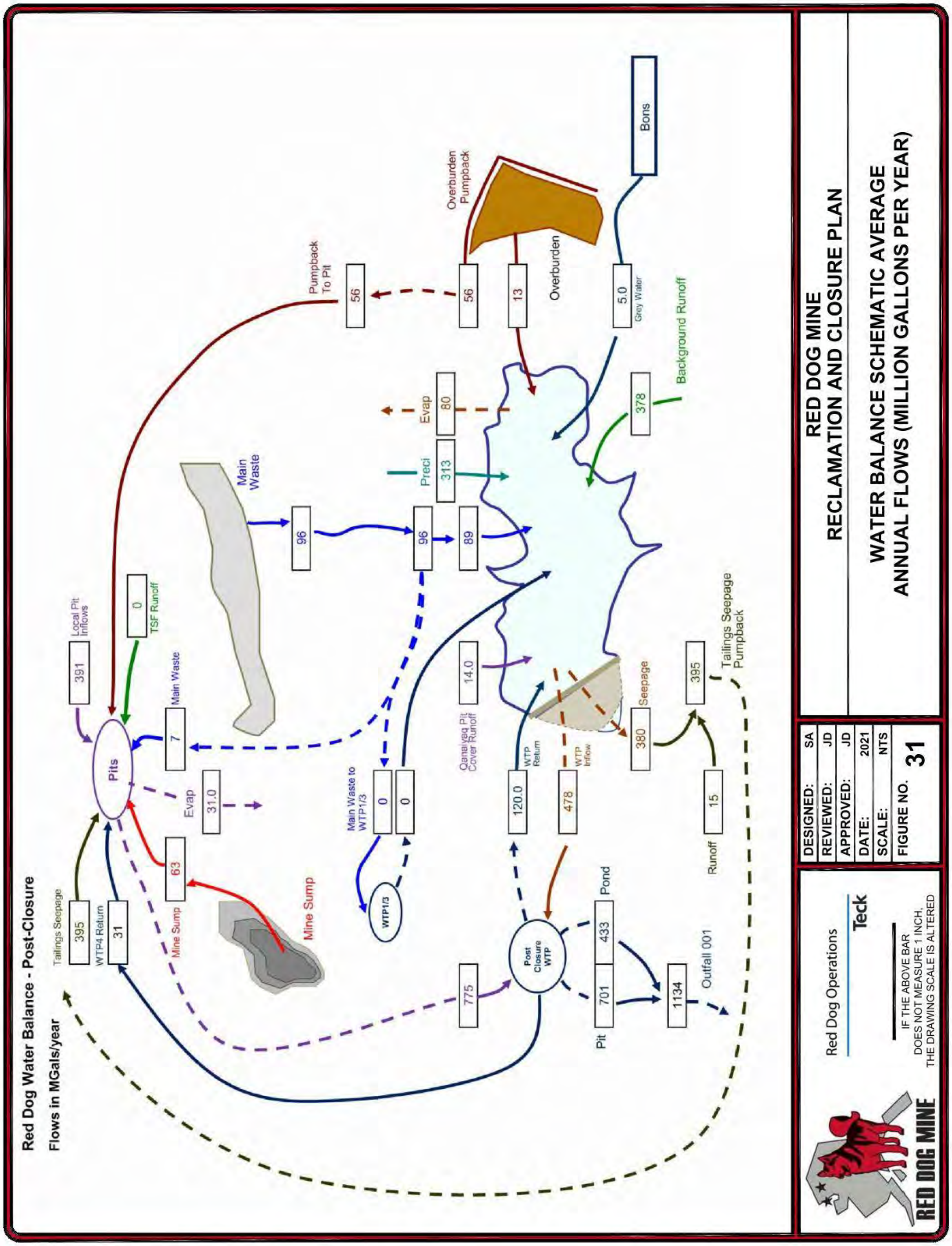


Figure 31 Site Water Balance after Closure

4.3 Maintenance Requirements

Earthworks and facilities constructed during closure will all need some level of maintenance in the post-reclamation period. Table 8 summarizes the expected requirements.

Requirements for maintenance of covers and ditches are expected to diminish over time. The reason is that the most significant instabilities will be noted and repaired in the first few years after closure. The development of vegetation also helps to reduce erosion problems and associated maintenance requirements.

Maintenance of active facilities, such as the water treatment systems, camp, airport and access roads will continue as long as they remain in use.

Table 8: Post-Reclamation Maintenance Requirements

Area	Feature	Requirement
Mine Area	Pits	Repair of berms and cutback slopes, where necessary
	Waste Rock Dumps	Repair of erosion or settlement damage to covers; Maintenance and repair of surface water ditches; Supplemental planting, seeding or fertilization
	Red Dog Creek Diversion	Maintenance and repair as needed
TSF Area	Main Dam	Maintenance and repair as needed
	Back Dam	Maintenance and repair as needed.
	Covers	Repair of beach covers, Supplemental planting, seeding or fertilization
	Overburden dump	Supplemental planting, seeding or fertilization
	Seepage Collection System	Maintenance and repair as needed
	DD-1 thru DD-4 Diversions	Maintenance and repair as needed
Infrastructure	Decommissioned areas	Supplemental planting, seeding or fertilization
	Access roads	Snow removal; Grading and re-surfacing
	Water treatment system	Mechanical & electrical maintenance
	Camp & support facilities	Snow removal; Structural maintenance; Mechanical & electrical maintenance
	Bons Creek reservoir and dam	Monitoring, maintenance and repair as needed
	Airstrip	Surface maintenance, snow removal

4.4 Infrastructure Requirements

Infrastructure requirements are unchanged from those that were described in the approved 2016 Reclamation Plan. The continuing water treatment and maintenance activities will create a requirement for support infrastructure, including access roads, airport, accommodations, communication, the water treatment plant and associated equipment, power supply, fuel storage, materials storage and equipment maintenance. Table 9 lists specific site infrastructure requirements under each category, if only the required activities continue. It is assumed that barge access to the Port and access over the Port road will remain. As noted above, NANA may develop other plans for the site and those could include retention of other infrastructure.

4.5 Monitoring and Inspection Requirements

Monitoring and inspection requirements are unchanged from those described in the approved 2016 Reclamation Plan. Monitoring and inspections will be required in the post-reclamation period. Water quality monitoring will continue for the long term, i.e., if water collection and treatment are required. Other programs that are expected to be required in the long term include dam inspections, ditch and other earthworks inspection and maintenance.

Table 9: Infrastructure Requirements after 2032

Requirement	Infrastructure to be Retained
Communications	Voice and data connectivity with offsite
Site access	Airstrip and airport building Internal road system to any areas needing maintenance
Accommodations	Personnel Accommodations Complex (may be modified) Bons Creek freshwater pumphouse and supply line Potable water Sewage treatment
Water treatment	Water Treatment Plant #2 (may be modified or re-built) Reclaim barge and reclaim line Lime slaking system Sodium Sulfide mixing system Flocculant preparation system Compressed air system
Power supply	Powerhouse Emergency power supply
Fuel storage	One 1,000,000-gallon bulk fuel tank Fueling island and day tanks
Materials storage and equipment maintenance	Select storage area / Conex Trailer facilities Shop for mobile equipment and some mobile equipment

Several other programs will be intensive in the immediate post-reclamation years but are expected to be reduced once it can be demonstrated that stable conditions have been established. These include, but may not necessarily be limited to, monitoring of cover performance and revegetation success, fugitive dust monitoring, groundwater and ground temperature monitoring and site-specific ecological risk monitoring.

Teck will develop a post-reclamation monitoring plan in the future.

4.6 Site Use Restrictions

Site use restrictions remain from the approved 2016 Reclamation Plan. The mine area is currently off-limits to subsistence harvesting, and that restriction will remain in effect at least throughout operations. Potential for constituent intake by animals around the closed mine was evaluated using methods developed in more extensive DeLong Mountain Regional Transportation System (DMTS) study (Exponent 2007). The study evaluated potential risks to animals living in or passing through the mine area and to the vegetation community in the mine area.

The study concluded that the closed mine is unlikely to present any significant risk of adverse effects on caribou, fox, teal or muskrat, but that individual ptarmigan, tundra vole and tundra shrew could take in enough lead or cadmium to be adversely affected. The difference is partly attributable to the small home range of the ptarmigan, shrew, and vole, which were assumed to spend their entire lives in areas with the highest metal concentrations. Study conclusions also note that several cautious (conservative) assumptions were made in the evaluation and that more realistic assumptions would reduce uncertainties and refine (i.e., lower) the estimated potential risk.

As the landowner, NANA will determine post-reclamation uses of the site, beyond those uses required to perform the post-reclamation operations of the mine. Results of the DMTS human health risk assessment indicated that potential risks to human health would not be elevated even if harvesting were to occur in currently restricted areas of the DMTS (Exponent 2007). Because metal concentrations within the mine area are like those at the Port, human health risks would not be expected if subsistence harvesting were to occur within the mine area. However, the existing restrictions on subsistence harvesting will remain in effect until they are lifted.

5 Reclamation Schedule, Cost Estimate and Financial Assurance

5.1 Concurrent Reclamation Schedule

The discussion of LOM operations in Section 2 above includes several commitments to concurrent reclamation, i.e., reclamation that will be done concurrent with active mine operations in advance of mine closure and the formal reclamation period.

Figure 32 presents a summary schedule from the 2020 LOM Plan that includes reclamation and water management activities during the operational period. Other milestones are included to provide context. In many cases, the precise scheduling of activities will depend on factors that are not fully predictable. The schedule therefore shows ranges for many activities and is subject to modification.

5.2 Closure and Reclamation Schedule

Reclamation activities related to the planned mine closure described in Section 3 will begin in 2032, when mill production ceases. It is expected that reclamation measures will require at least two construction seasons to complete. Figure 32 shows most of the reclamation activities taking place in 2032, 2033 or 2034.

5.3 Post-Reclamation Schedule

Post-reclamation activities described in Section 4 would begin after the reclamation activities are complete. Practical experience suggests this may take some years to transition as the site stabilizes to routine, post-reclamation conditions, including to steady state water quality conditions. The 2020 water and load balance model suggest the site would reach steady state conditions regarding loading in about 2045.

Post-reclamation activities are expected to be required indefinitely. However, as noted in Section 4, requirements for maintenance and monitoring are expected to be more intensive during the first few post-reclamation years and to diminish thereafter. The post-reclamation cost estimate is included in Appendix D.

5.4 Temporary Closure

Temporary closure status as described here would apply when mine and mill cease operations for a temporary period of not more than five years. TAK has no plans to close temporarily but the concept is included in the cost estimate in Section 5.6, to serve as equivalent to “holding costs” that are required by state agencies for inclusion in the bond calculation.

While no temporary closures are anticipated at Red Dog, they have occurred at some mines and for a range of reasons that might include:

1) Economic reasons.

2) Unforeseen weather events.

3) A failure in a major system component or a process failure.

4) The cessation of operations because of litigation.

TAK will notify the agencies within 10 calendar days following the first day of any unanticipated temporary closure that is expected to last more than 90 calendar days or more. The notice will state the nature and reason for the temporary closure, the anticipated duration of the temporary closure and any event that would reasonably be anticipated to result in either the resumption or abandonment of operations. Project operations must resume for not less than 90 consecutive days to terminate the temporary closure status. TAK will maintain the project area in a safe and stable condition during a temporary closure. TAK will continue, in full force, all water management activities including collection and treatment, monitoring and reporting and all other compliance-required activities during temporary closure. Teck would also keep the existing facilities in a condition ready for resuming operations while water treatment and monitoring are continued.

The estimated annual cost for temporary closure (aka holding cost) is included in Section 5.6.

5.5 Premature Closure Schedule

The premature closure scenario describes site conditions in the event the mine closes unexpectedly before 2032. In selecting a point in the mine life for estimating costs for a premature closure, TAK selected the year during the next 5-yr. permit cycle (2021 – 2026) with the maximum reclamation liability, based on the 2020 LOM Plan. TAK determined that the maximum reclamation liability occurs in year 2023 for the following reasons:

- The Aqqaluk Pit would be near full disturbance and the Main Pit will only be partially backfilled.
- Construction of the Main and Back Dam tailings beaches would need to be completed and geosynthetic liners would have to be installed on the new beaches.
- The Main Pit Dump would need to be recontoured and the geosynthetic cover will have to be installed.
- Qanaiyaq Pits will not be backfilled. A spillway will have to be designed and constructed to redirect Qanaiyaq pit water to Hilltop Creek.
- The main dam raise to 1006’ will be underway. The lift will not have to be completed but some reshaping of the partially widened 996’ ft dam will have to be done essentially leaving a buttress at the base of the 996’ dam.
- The emergency spillway will have to be constructed at the Tailings Storage Facility

The cost estimates for a premature closure scenario are included in Appendix B.

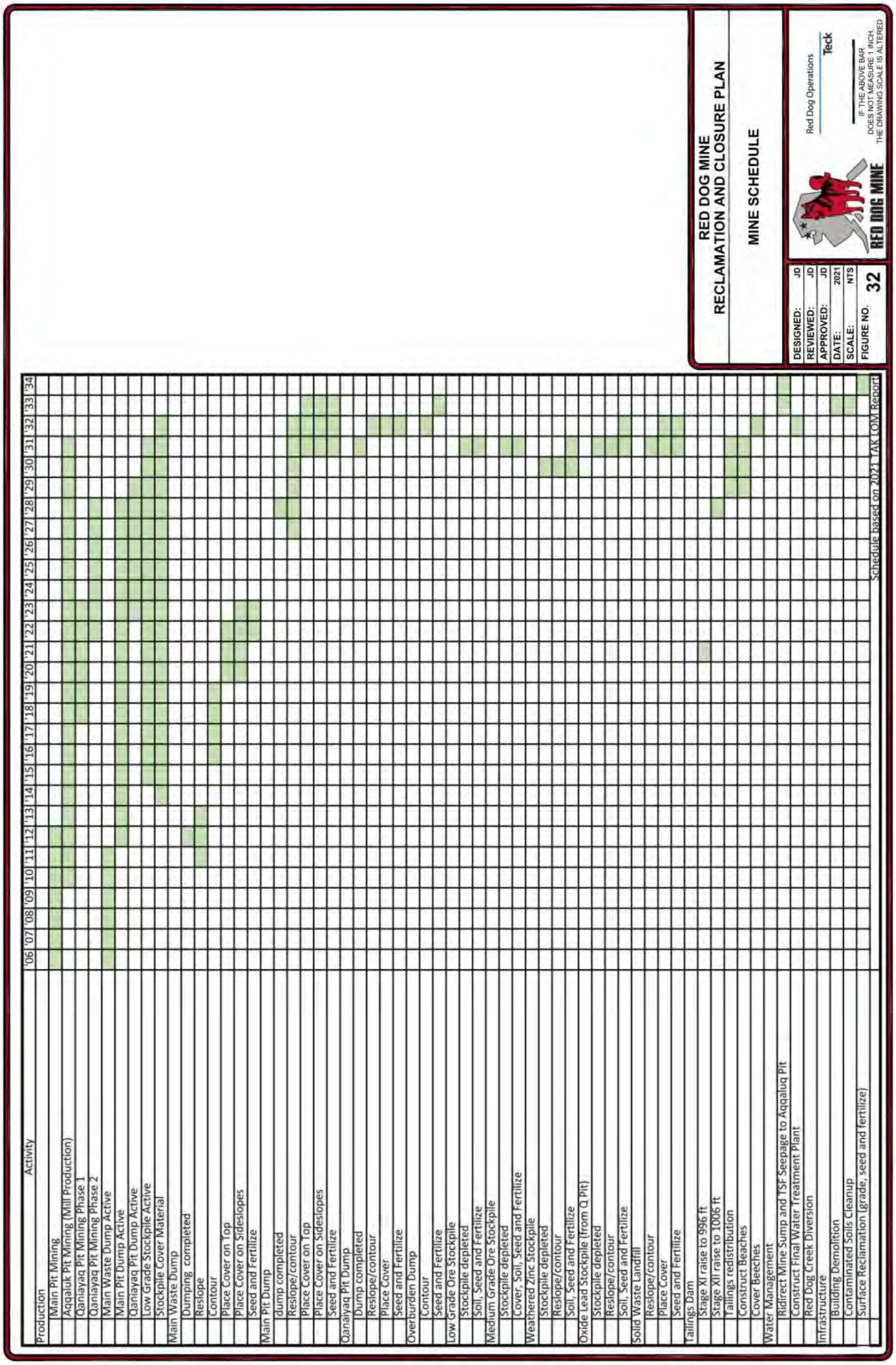


Figure 31: Production Milestones and Reclamation Schedule

5.6 Holding, Reclamation, and Post-Reclamation Cost Estimates

State agencies require reclamation cost estimates for the maximum reclamation and post reclamation liability during the 5-yr permit cycle covered by this Reclamation Plan. Other Alaska large mines submit a single reclamation cost estimate for the maximum reclamation liability in that 5-yr period. However, in the past TAK provided estimates of temporary closure, premature closure and final planned closure costs. Since the premature closure estimate represented the maximum reclamation liability, financial assurance amounts for Red Dog have been calculated historically based on that premature closure estimate.

For this current Plan TAK is providing cost estimates for reclamation for a premature closure in 2023, holding costs (temporary closure), and post-reclamation costs. It is not including a reclamation cost estimate for the planned closure in 2032. This modified approach is like the approach used by other large Alaska mines and is in alignment with regulatory agency expectations. Because the premature closure cost estimate represents the maximum reclamation liability during the next 5-year permit cycle it is enough to meet all the potential planned or premature closure costs and meets the regulatory requirements for use in calculating a financial assurance amount required by the state regulatory agencies.

TAK calculated the holding, reclamation and post-reclamation costs using the Standardized Reclamation Cost Estimator software (SRCE). The SRCE model incorporates changes in site activities, modeled changes in water and load balance, and need for periodic replacement of capital items to estimate the annual costs for 100 years into the future (through 2119) and then uses those scheduled costs and a discount rate of 4.3% to generate a net present value (NPV) for the post closure costs, as a component of the financial assurance amount. The NPV does not include the costs for the initial two years of temporary closure, the two years of reclamation costs, or the two years of water treatment and site monitoring during the reclamation years, because the state agencies require that these funds be available immediately and not subject to any investment risk in the short-term.

Additional details about the estimated holding, reclamation and post-reclamation costs are presented in the Basis of Estimate Report in Appendix B.

Table 10 summarizes estimated reclamation costs for the premature closure scenario.

Table 11 summarizes estimated average annual costs for post-reclamation activities. The reader is advised that the estimated annual post-reclamation costs vary widely from year to year owing to changing water treatment costs and periodic replacement of equipment and facilities. As a result, the average annual cost is only provided here for discussion purposes and reference. Refer to the SRCE model for estimated annual costs for each of the first 100 years of mine closure.

Table 12 summarizes the estimated average annual “holding” or temporary closure costs.

5.7 Financial Assurance

ADEC and ADNR each have requirements for financial assurance to provide for reclamation and long-term maintenance of the Red Dog Mine site in the event of a default scenario in which the

State had to assume management of the site. TAK will ensure that the financial assurance will be in place to implement the reclamation, and post-reclamation monitoring and water treatment obligations when and if it is needed, in accordance with State financial assurance requirements. The financial assurance must reflect reasonable and probable cost estimates. Since the agencies require that the financial assurance be sufficient to pay the costs of maximum reclamation exposure during the next 5-yr permit cycle, TAK selected the most conservative scenario as the basis for determining the level of financial security, as follows:

- A premature closure in 2023
- Long-term water management and site maintenance requirements
- A holding period lasting two years
- Ongoing water treatment during 2 years of site reclamation
- Post-reclamation monitoring and maintenance requirements

The final financial assurance amount will be calculated after an agency review of the draft cost estimate.

Table 10: Summary of Estimated Reclamation Costs for Premature Closure

SRCE Cost Category	2025 Cost	2026 Cost
Direct Costs		
Pit	$ 63,756	$ -
Waste Rock Dump	$ 23,866,649	$ 23,866,649
Tailings Facility	$ 5,651,087	$ 5,219,474
Access Road	$ -	$ 57,504
Exploration Roads	$ 11,371	$ 11,371
Foundation and Buildings	$ 1,908,290	$ 1,908,290
Yards	$ 685,162	$ 685,162
Drainage and Sediment Control	$ 2,629,728	$ 2,629,728
Water Treatment	$ 7,025,645	$ 7,025,645
Riprap and Rock Linings	$ 349,851	$ 349,851
Drill and Blast	$ 1,391,878	$ 1,391,878
Waste Management	$ 478,133	$ 478,133
Office Supplies	$ 600	$ 600
Utilities	$ 7,740	$ 7,740
Supplies – General supplies.	$ 3,600	$ 3,600
Light Vehicles & Equipment	$ 127,800	$ 127,800
QA/QC Service	$ 50,400	$ 50,400
Material/Goods Transport	$ 41,400	$ 41,400
Closure HR	$ 2,799,264	$ 2,799,264
Mobilization	$ 2,448,500	$ 2,448,500
Road maintenance - Con	$ 575,730	$ 575,730
	$ 388,468	$ 388,468
G&A	$ 1,974,510	$ 1,974,510
Total Direct Costs	**$ 52,479,560**	**$ 52,041,696**
Indirect Costs		
Contractor Profit	$ 3,935,967	$ 3,903,127
Contractor Overhead	$ 2,886,376	$ 2,862,293
Performance/Payment Bonds	$ 1,469,428	$ 1,457,167
Liability Insurance	$ 262,398	$ 260,208
Contract Administration	$ 3,411,171	$ 3,382,710
Engineering Redesign	$ 2,623,978	$ 2,602,085
Scope Contingency	$ 4,460,763	$ 4,423,544
Bid Contingency	$ 3,568,610	$ 3,538,835
Total Indirect Costs	**$ 22,618,691**	**$ 22,429,971**
Total Reclamation Costs	**$ 75,098,251**	**$ 74,471,667**

Table 11: Summary of Estimated Average Annual Post-Reclamation Costs

SRCE Cost Category	*Average Annual Costs
Direct Costs	
Revegetation and cover maintenance	$ 61,092
Road maintenance	$ 84,093
Monitoring	$ 348,033
WTP Consumeables	$ 4,778,150
WTP and Camp - manpower	$ 3,814,596
Mobile Equipment	$ 339,078
Maintenance and Material Expenses	$ 436,963
Capital Replacement (periodic)	$ 1,792,150
Power Cost	$ 2,035,820
Camp and Administrative Costs	$ 205,776
Dam Inspection and Maintenance	$ 375,217
Sludge Management	$ 88,550
Total Direct Costs	**$14,359,521**
Indirect Costs	
Contractor Profit	$ 717,976
Contractor Overhead	$ 430,786
Performance/Payment Bonds	$ 358,988
Liability Insurance	$ 71,798
Contract Administration	$ 574,381
Engineering Redesign	$ 430,786
Scope Contingency	$ 430,786
Bid Contingency	$ 287,190
Total Indirect Costs	**$3,302,690**
Total Undisounted Average Costs	**$17,662,211**

*Estimated annual costs range from $56.2M to $15.2M dollars, variability is attributed to periodic capital replacement costs and decreasing water treatment costs over first 20 years of closure. Refer to SRCE model for estimated annual costs by year for first 100 years of closure.

Table 12: Summary of Estimated Annual Operating Costs during Holding Period and Reclamation Years for Premature Closure

SRCE Cost Categeory	2023 Holding Period	2024 Holding Period	2025 Reclamation Period	2026 Reclamation Period
Direct Costs				
Road maintenance	$ 159,778	$ 159,778	$ -	$ -
Monitoring	$ 388,468	$ 388,468	$ 388,468	$ 388,468
WTP Consumeables	$ 5,427,285	$ 1,912,528	$ 6,175,880	$ 9,708,322
WTP and Camp - manpower	$ 3,814,596	$ 3,814,596	$ 3,814,596	$ 3,814,596
Mobile Equipment	$ 339,078	$ 339,078	$ 339,078	$ 339,078
Maintenance and Material Expenses	$ 436,963	$ 436,963	$ 436,963	$ 436,963
Power Cost	$ 2,035,820	$ 2,035,820	$ 2,035,820	$ 2,035,820
Camp and Administrative Costs	$ 205,776	$ 205,776	$ 205,776	$ 205,776
Dam Inspection and Maint	$ 310,000	$ 310,000	$ 310,000	$ 310,000
Sludge Management	$ 87,585	$ 87,585	$ 87,585	$ 87,585
Total Direct Costs	**$ 13,205,350**	**$ 9,690,593**	**$ 13,794,167**	**$ 17,326,610**
Indirect Costs				
Contractor Profit	$ 792,321	$ 581,436	$ 827,650	$ 1,039,597
Contractor Overhead	$ 528,214	$ 387,624	$ 551,767	$ 693,064
Performance/Payment Bonds	$ 330,134	$ 242,265	$ 344,854	$ 433,165
Liability Insurance	$ 66,027	$ 48,453	$ 68,971	$ 86,633
Contract Administration	$ 660,268	$ 484,530	$ 689,708	$ 866,330
Engineering Redesign	$ 396,161	$ 290,718	$ 413,825	$ 519,798
Scope Contingency	$ 792,321	$ 581,436	$ 827,650	$ 1,039,597
Bid Contingency	$ 905,887	$ 664,775	$ 946,280	$ 1,188,605
Total Indirect Costs	**$ 4,471,332**	**$ 3,281,235**	**$ 4,670,705**	**$ 5,866,790**
Total Average Annual Cost	**$ 17,676,682**	**$ 12,971,828**	**$ 18,464,872**	**$ 23,193,400**

* Years 2023 and 2024 are Temporary Closure Period, 2025 and 2026 costs are concommittant with site reclamation and in addition to the Reclamation Costs in Table 10. Variation in annual cost is mainly due to variable water treatment cost resulting from loading differences in TSF and Aqqaluk Pit. Aqqaluk pit is filling in 2024 and mainly TSF water is treated and discharged. WTP costs increase signiifcantly in 2026 as Aqqaluk pit water is treated and discharged.

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Appendix A – Legal Description of Property

Appendix B – Basis of Estimate Report for the Holding Costs, Reclamation and Post-Reclamation Costs

Red Dog Mine Reclamation Plan

Appendix A: Legal Description of Property

1. INTRODUCTION

The boundary for the Solid Waste Permit for the Red Dog Mine, as previously approved, is identical to the 1999 Air Shed Ambient Air Quality Boundary. This boundary encompasses all the applicable facilities. In addition, it avoids duplicating the effort of determining the legal description and maintaining multiple permit boundaries.

2. LEGAL DESCRIPTION

Teck Alaska Incorporated submits this legal description of lands encompassed by the 1999 Air Shed Ambient Air Quality Boundary as the geographical boundary for the Solid Waste Permit for Red Dog Mine. It is referred to as the Solid Waste Permit Boundary and applies to the geographic area within the outline depicted on the drawing attached hereto as Figure 1 and located approximately within the following described lands:

Township 30 North, Range 18 West, Kateel River Meridian

Section 5: NW¼NE¼, SW¼NE¼, W½, NW¼SE¼, SW¼SE¼

Section 6: All

Section 7: NE¼, N½NW¼, N½S½NW¼, SW¼SW¼NW¼, NE¼SE¼, NE¼NW¼SE¼

Section 8: W½NE¼NE¼, NW¼NE¼, N½SW¼NE¼, SW¼SW¼NE¼, N½SE¼NE¼, NW¼, N½NW¼SW¼

Township 31 North, Range 18 West, Kateel River Meridian

Section 1: SW¼SW¼

Section 2: NW¼NW¼NE¼, S½NW¼NE¼, SW¼NE¼, SW¼SE¼NE¼, W½, SE¼

Section 3: All

Section 4: All

Section 5: NE¼NE¼, NE¼NW¼NE¼, S½NW¼NE¼, S½NE¼, S½NE¼NW¼, SW¼NW¼, SE¼NW¼, S½

Section 6: S½SE¼NE¼, E½SE¼, E½W½SE¼

Section 7: NE¼NE¼, E½NW¼NE¼, S½NE¼, SE¼SE¼NW¼, NE¼SW¼, S½NW¼SW¼, S½SW¼, SE¼

Section 8: All

Section 9: All

Section 10: All

Section 11: All

Section 12: W½NW¼NW¼, NW¼SW¼NW¼, W½SW¼SW¼

Section 13: W½NW¼, N½SE¼NW¼, SW¼SE¼NW¼, SW¼NE¼NW¼, SW¼NW¼SE¼, SW¼SE¼, SW¼

Section 14: All

Section 15: All

Section 16: All

Section 17: All

Section 18: All

Section 19: All

Section 20: All

Section 21: All
Section 22: N½NE¼NW¼, SW¼NE¼NW¼, W½NW¼, S½SE¼NW¼, SW¼, NW¼SE¼, W½SW¼SE¼
Section 23: N½NW¼NE¼, NE¼NE¼
Section 24: N½NW¼NE¼, SW¼NW¼NE¼, N½NW¼, N½SW¼NW¼, SE¼NW¼
Section 27: W½NW¼NE¼, W¼SW¼NE¼, NW¼, N½SW¼, N½S½SW¼
Section 28: N½, SW¼, N½SE¼, SW¼SE¼, N½SE¼SE¼, SW¼SE¼SE¼
Section 29: All
Section 30: All
Section 31: All
Section 32: N½NE, SW¼NE¼, W½, W½NW¼SE¼, SW¼SE¼
Section 33: N½N½NW¼, NW¼NW¼NE¼

Township 32 North, Range 18 West, Kateel River Meridian

Section 32: SE¼SE¼SE¼
Section 33: S½SW¼SW¼, NE¼SE¼SW¼, S½SE¼SW¼, S½SE¼ Section 34: NE¼NE¼SW¼, S½N½SW¼, S½SW¼, SE¼
Section 35: S½NW¼SW¼, SW¼SW¼, W½SE¼SW¼,

SE¼SE¼SW¼ Township 30 North, Range 19 West, Kateel River Meridian

Section 1: All
Section 2: NE¼, NE¼NW¼, E½NW¼NW¼, SE¼NW¼, NE¼SW¼, SE¼NW¼SW¼, E½SW¼SW¼, SE¼SW¼, SE¼
Section 11: NE¼, NE¼NW¼, NE¼NW¼NW¼, E½NW¼NW¼, E½SE¼NW¼, NE¼NE¼SW¼, N½SE¼, NE¼SW¼SE¼, N½SE¼SE¼
Section 12: N½, N½NE¼SW¼, SW¼NE¼SW¼, NW¼SW¼, N½SW¼SW¼, NW¼NW¼SE¼

Township 31 North, Range 19 West, Kateel River Meridian

Section 12: S½SW¼SE¼, SE¼SE¼
Section 13: E½, NE¼NW¼, NE¼NW¼NW¼, S½NW¼NW¼, S½NW¼, NE¼SW¼, N½NW¼SW¼, SE¼NW¼SW¼, SE¼SW¼
Section 24: E½, E½NW¼, E½NE¼SW¼, NE¼SE¼SW¼
Section 25: E½, E½SE¼NW¼, NE¼SW¼, S½NW¼SW¼, S½SW¼
Section 26: SE¼NE¼SW¼, E½SE¼SW¼, S½NE¼SE¼, NW¼SE¼, S½SE¼
Section 35: E½, E½NW¼, NE¼SW¼, E½SW¼SW¼, SE¼SW¼
Section 36: All

3. BOUNDARY DRAWING

The boundary for the Solid Waste Permit for the Red Dog Mine is shown on the attached drawing “Red Dog Mine Solid Waste Permit Boundary”.


Meridian Kateel River
T32N R19W
Meridian Kateel River
T32N R18W
Meridian Kateel River
T31N R19W
Meridian Kateel River
T31N R18W
Alaska State Land Boundary
NANA Land Boundary
Meridian Kateel River
T30N R19W
Meridian Kateel River
T30N R18W
Red Dod Mine Solid Waste Permit Boundary
N
W
E
S
0 2,900 5,800
Feet

Appendix B
Red Dog Mine Reclamation Plan

Basis of Cost Estimate for Holding, Reclamation, and Post-Reclamation Activities

Red Dog Mine, Alaska, USA

Prepared by

Teck Alaska Incorporated

September 2021

Table of Contents

LIST OF TABLES

List of Abbreviations

ADNR	Alaska Department of Natural Resources
ADEC	Alaska Department of Environmental Conservation
MPD	Main Pit Dump
MWD	Main Waste Dump
NANA	NANA Regional Corporation, Inc.
NPV	Net Present Value
TAK	Teck Alaska Incorporated
TSF	Tailings Storage Facility

Units of Measure

m	meter
m^2	square meter
m^3	cubic meter

1 Introduction

Teck Alaska Incorporated (TAK) and NANA are working closely with State agencies, through the Large Mine Permitting Team process, to update the Reclamation and Closure Plan and Integrated Waste Management Plan for the Red Dog Mine. One objective of the process is to estimate the cost of temporary closure, reclamation, and long-term post-reclamation activities for the purpose of calculating the amount required to meet financial assurance obligations to the state.

This document provides details about the basis for estimating the costs for:

1) temporary closure, alternatively referred to as the holding period by agencies,
2) reclamation of the site to the final closure configuration, and
3) post-reclamation activities to maintain the site and manage water for the long-term.

The cost estimates were generated using the Standardized Reclamation Cost Estimation software supplemented by vendor quotes, Alaska-specific and actual Red Dog mine costs. TAK presents three separate cost estimates (temporary closure, reclamation and post-reclamation) for the purpose of calculating the financial assurance requirement but these costs were all derived in a single SRCE model. The three different cost estimates were extracted from the single SRCE model using SRCE filters. Throughout this document we reference the specific tabs in the SRCE model spreadsheet where subject costs were calculated or where unit costs are provided.

The temporary closure portion of the cost estimate is intended to reflect the estimated costs that would be incurred to maintain the site, a) during a hypothetical temporary closure, b) for a holding period say if the state took over management of the site under a default situation, and c) for the two years that mine site reclamation was being performed under a default situation.

The reclamation cost estimate is intended to reflect the estimated costs to perform the reclamation work necessary to reconfigure the site to its closed configuration. The costs include building demolition, removal of all non-permanent structures, recountouring and covering dumps, reclaiming certain roads, reconfiguring electrical and piping infrastructure, upgrading the Red Dog Creek diversion, remediating contaminated soils, and revegetating reclaimed areas and more. TAK estimates it will take two construction seasons to complete the reclamation work. The cost estimate assumes the work will be carried out by third-party contractors under State supervision, and without realizing any salvage value for buildings or equipment. During those two years, water treatment and site monitoring and maintenance would also continue, and those costs are accounted for in the temporary closure costs. These costs would be additive to the reclamation costs for the two years that reclamation is performed. The reclamation cost estimate is sufficient to pay the cost for reclamation when these liabilities are highest during the next permitting cycle (2021 – 2026). During development of this reclamation plan, TAK determined that the maximum reclamation liability for the 2021 – 2026 permit cycle occurs in year 2023 for the following reasons:

- The Aqqaluk Pit would be near full disturbance and the Main Pit will only be partially backfilled.
- Construction of the Main and Back Dam tailings beaches would need to be completed through dredging and geosynthetic liners would have to be installed on the new beaches.
- The Main Pit Dump would need to be recontoured and the geosynthetic cover will have to be installed.

- Qanaiyaq Pits will not be backfilled and will collect water, over time. A spillway will have to be designed and constructed to redirect Qanaiyaq pit water to Hilltop Creek (part of mine water collection).
- The main dam raise to 1006' will be underway. The raise will not have to be completed but some reshaping of the partially widened 996' ft dam will have to be done essentially leaving a buttress at the base of the 996' dam.
- The emergency spillway will have to be constructed at the Tailings Storage Facility

Finally, the post-reclamation cost estimate is intended to reflect the estimated long-term annual costs required every year for site monitoring and maintenance and water treatment, following site reclamation. As a basis for estimating the post-reclamation costs, TAK assumed that monitoring and water treatment will be required far into the post-reclamation period (at least 100 years) and that the site will remain active with enough infrastructure to support these activities for the long-term. As a result, TAK included the costs to maintain the site in a stable state, treat and discharge water, periodically upgrade or replace equipment and facilities (capital costs), sustain environmental monitoring, and more. The estimated year-to-year capital costs associated with periodic replacement of facilities and equipment vary during the long-term post-reclamation period. While these are incorporated into the cash flow model, we also provide a single annual average undiscounted cost estimate for discussion purposes.

Indirect costs are discussed under each of the three separate cost estimate categories (premature closure, reclamation, post-reclamation). TAK elected to apply indirect costs differently to the three cost estimates because the state guidance is not as applicable to the temporary closure and post-reclamation cost estimates as it is to the reclamation cost estimate. TAK has concluded that the fundamental risk and level of uncertainty associated with the temporary and post-reclamation cost estimates are lower than during the reclamation activities. Principally because post-reclamation activities are largely a continuation of long-practiced operating procedures for which there are adequately trained personnel and well-defined costs. This is discussed in more detail in the respective cost estimate category sections.

The following is an estimate of the temporary closure, reclamation, and post-reclamation costs for the Red Dog Mine assuming a premature mine closure in 2023.

Table 1. Summary of Estimated Holding, Reclamation, and Post-Reclamation Costs

Cost Category	Cost	Period
Holding	$18,076,695*	Per Year, for 4 years
Reclamation	$74,784,959**	Per Year, for 2 yrs.
Post-Reclamation	$17,662,211***	Per Year, long-term
*Average, estimated annual costs vary from $12.9M to $23.2M **Average, estimated annual costs vary from $74.5M to $75.1M ***Average, undiscounted estimated annual costs vary from $15.2M to $56.2M		

2 Holding Cost Estimate

The holding (aka temporary closure) cost estimate was prepared using several fundamental assumptions described below. It is an estimate to staff, operate and maintain the site in a stable manner, continue environmental monitoring, and treat and discharge water seasonally to maintain the site water balance. These costs also serve as holding costs, a term that the state agencies use for those costs they would incur in a default situation while they take over management of the site which could take a year or two and secure contractors to perform the reclamation. These costs would also be incurred during the two years required for site reclamation. So, the total annual costs for those two reclamation years would be the sum of reclamation costs plus holding (temporary closure) costs.

The estimated average holding (temporary closure) cost is $18,076,695. The estimated temporary closure cost estimate was derived for a 4-year period including two years of temporary closure and two years when reclamation is being performed. During the 4-yr period the annual temporary closure/holding costs range from $12.9M to $23.2M. While reclamation is being performed the assumption is that a skeletal staff will still be required to maintain the basic monitoring and water treatment functions of the site. During those four years the principal reason that annual costs vary is because water treatment costs change as the site transitions from normal operations, to closure. Initially water treatment costs are low because the Aqqaluk pit is being filled and only TSF water is being treated. TSF loading is less than the predicted loading for the Aqqaluk pit. Once the Aqqaluk pit is full (about 17 months to fill), water from both the pit and the TSF will be treated, loading will go up for a number of years, before going back down during the post-reclamation period.

2.1 Personnel and Camp

During holding (temporary closure), the site staff would be reduced to those necessary for basic operations including environmental monitoring, routine maintenance, camp support, and seasonal water treatment and discharge. For the cost estimate we assume that at least 8 people will be on site working a 4-week rotation. During the water discharge season there would be approximately 17 people on site.

Labor rates were estimated using the Alaska Department of Labor’s rates as listed in Issue 40 of the *Laborers’ & Mechanics’ Minimum Rates of Pay* (Pamphlet 600). Labor rates not available in Pamphlet 600 were sourced from wages available on the Alaska Department of Labor’s website (Research and Analysis, April 2020 Wages in Alaska). Base hourly rates include standard overtime, benefits, and payroll burden. Labor rates do not include the costs of camp accommodation or flights, which are included elsewhere. Manpower is detailed in SRCE tab “Human Resources” and camp costs are derived in SRCE tab “USER 18 camp, admin.”

2.2 Consumables

Water treatment plant consumables are a significant component of annual operating costs under a holding scenario. During holding (temporary closure), certain waste rock dumps would remain uncovered, and water treatment reagent costs would be like current operating costs which are higher than what is estimated for the post-reclamation steady-state scenario. Water treatment plant consumables are derived in SRCE tab “USER 13 WT consumables.”

During holding (temporary closure), the average annual lime requirement would be approximately 20,077 tonnes. Estimates of the annual requirements for the other treatment consumables (flocculant, sodium sulfide, and antiscalant) were estimated in proportion to the lime demand. Unit costs were assumed to be the same as in the post-reclamation cost estimate. Lime consumption would decrease over the long term until steady-state conditions develop. The water balance model suggests that this would be in about 2045 when annual lime consumption would be approximately 11, 400 tonnes as discussed under the post-reclamation cost estimate.

These assumptions may be conservative for the two years during site reclamation. During these two years it may be advantageous and possible to reduce the volume of water treatment while the site buildings are being demolished, power and other infrastructure is being reconfigured. This would allow the reclamation, particularly building demolition and power infrastructure reconfiguring to proceed without also managing a full season of water treatment and discharge treatment. However, the cost estimate assumes full season discharges every year, including during the two years of reclamation.

2.3 Power

During the holding (temporary closure) period and two years of reclamation, the site would continue to use the existing diesel-powered generators. Estimates of fuel consumption for power generation were therefore based on current Red Dog rates of 12.9kW-hours per gallon. Like water treatment plant consumables, power generating costs could be lower during the two years of reclamation compared to the two years of holding (temporary closure) if a smaller volume of water were treated and discharged. However, water would be pumped from the TSF to the Aqqaluk Pit, and the additional power for pumping would partially offset the savings in water treatment power. As a simple but conservative assumption, the overall power cost was assumed to be the same for both the holding period years as well as the reclamation years. Power costs are derived in SRCE tab “USER 17 power costs.”

2.4 Indirect Costs

TAK applied indirect costs to the holding (temporary closure) cost estimate following the guidance provided by ADNR and ADEC in the DOWL report (2015). However, TAK also notes that the discussion by DOWL is more relevant to indirect costs related more to reclamation activities rather than the continuation of site operations as discussed in more detail below.

As discussed by DOWL (2015), the estimation of a mine’s direct reclamation costs is a relatively straight-forward exercise; however, estimating indirect costs presents a greater challenge because each category of indirect costs exhibits a degree of variability that results from several factors including access, climate, mine maturity, scale of operations, and whether a mine is a surface mine or underground mine. As a result, DOWL recommends a range of possible indirect costs for the seven of the eight categories of indirect costs. Liability insurance is generally applied as 1.5% of labor costs. This is difficult in SRCE which does not allow an easy summation of labor costs. As a surrogate we applied 0.5% of direct costs in place of 1.5% of labor costs.

To calculate the indirect costs for the holding (temporary closure) cost estimate, TAK elected to apply the lowest percentage value in all seven categories of indirect costs for the following reasons:

- Holding (temporary closure) activities are an extension of a subset of current activities at the site that include routine maintenance, materials handling, water treatment and monitoring. As a result, the procedures and their related costs are well understood.
- Even under a default scenario, where the state assumes site management, it is reasonable to assume that enough task-trained mine employees will be available to continue this subset of site activities during holding (temporary closure). This is partly due to the limited alternative employment options in the region.
- Combined, these factors lower the risk and uncertainties associated with the holding (temporary closure) period, say compared to the activities directly associated with the civil construction process of reclaiming the mine site. With the lower risk and well-established procedures and costs, low indirect costs are a reasonable assumption for the holding (temporary closure) cost estimate.

Table 2. Indirect Costs Applied to the Holding (Temporary Closure) Cost Estimate

Indirect Cost Matrix - Holding Period		
Indirect Category	Temporary Closure	
Contractor Profit	6.00	
Contractor Overhead	4.00	
Performance/Payment Bonds	2.50	
Liability Insurance	1.50	
Contract Administration	5.00	
Engineering Redesign	3.00	
Scope Contingency	6.00	
Bid Contingency	6.86	
Total Indirect Recommendation	**33.36**	**% of Direct**
	1.5*	**% of Labor**

*Used 0.5% of Direct Costs for Liability Insurance in SRCE

3 Reclamation Cost Estimate

This section describes the basis for the cost estimate associated with performing the reclamation work during a 2-year period required to transition the site to its final closure configuration and assuming the reclamation started in a pre-mature closure scenario, in this case starting in 2023. While TAK has not provided a “planned” closure cost estimate for reclamation, several previous iterations have shown that reclamation costs for a premature closure costs are higher than for a planned closure.

The reclamation cost estimate was prepared using several assumptions described below. During the two years that this reclamation work is being performed the site will also continue to be otherwise maintained and monitored and mine water will be treated and discharged seasonally. These operating costs are not included in this estimate of reclamation costs. Instead, they were separately estimated as temporary closure costs and are discussed in the section for Temporary Closure. During the two years of reclamation, the total annual cost to operate the site would be the sum of temporary closure costs (which are essentially operating costs) and reclamation costs.

Premature closure would require reclaiming the mine by bringing it to a final closure configuration like the one described for the Planned Closure (2032) in the Red Dog Mine Reclamation Plan. However, under the premature closure scenario in 2023, several site components are in earlier stages of development than they would be at the end of mine life in 2032. As a result, more work is required to bring these site components to their final closure configuration and the costs would also be higher compared to a planned closure.

At premature closure in 2023:

- The Aqqaluk Pit would be near full disturbance and the Main Pit will only be partially backfilled. The Main Pit Dump would need to be recontoured and the geosynthetic cover will have to be installed.
- Construction of the Main and Back Dam tailings beaches would need to be completed by dredging tailings from the TSF, and the beaches will need to be covered with geosynthetic covers like the ones being installed on the waste rock dumps.
- The Qanaiyaq Pits will not be backfilled. A spillway will have to be designed and constructed to redirect Qanaiyaq pit water to Hilltop Creek. Hilltop Creek is part of the mine water collection system and gets treated prior to discharge. These pits could provide a repository for a portion of the water treatment sludge in the long-term, although there is sufficient capacity to store sludge for the next 100 years in the TSF and Aqqaluk pits.
- The main and back dam raises to 1006’ will be underway, but not complete. The raises will not have to be completed but some reshaping of the partially widened 996’ ft main dam will have to be performed, essentially leaving a buttress at the base of the 996’ dam.
- The emergency spillway will have to be constructed at the Tailings Storage Facility

The estimated reclamation cost is $150,235,332 spread equally over two construction seasons with slight annual differences owing to the scheduling of certain pit and access road work.

3.1 Reclamation Activities by Area

3.1.1 Tailings Area Activities

Closure activities in the Tailings areas are described in Section 3.2 of the *Red Dog Mine Reclamation and Closure Plan*. Major activities are described below.

Spillway

A spillway will be constructed between the TSF and Kulas Creek to convey excess water in the TSF and avoid overtopping the dam under extreme circumstances. Refer to Figure 26 of the *Reclamation and Closure Plan*. For additional details, also refer to the Tailings Dam Stage XII Conceptual Design Report (Golder 2019). Spillway construction costs are derived in SRCE tab “USER 06 Seepage and Drill Blast” tab.

Main Dam and Back Dam Beaches

A 600-foot (180m) wide beach will be constructed of tailings upstream of both dams to reduce seepage through the dams. The beaches will be covered with a geosynthetic HDPE liner and unmineralized cover material, like covers on the main waste rock dump. Unmineralized cover material is assumed to be obtained from Aqqaluk Pit in the 2023 scenario. A berm will be constructed to act as a coffer dam during deposition of the beach material and faced with riprap for erosion protection. Dam regrading, tailings beach construction and cover costs are addressed in SRCE tabs “Tailings” and “USER 03 Beaches” and “USER 24 Beach Tailings Dredging”.

Borrow Areas

The DD-2 and MS-14 borrow pits will be resloped, where practical, and revegetated. These costs are addressed in SRCE tab “Quarries & Borrow Pits”.

3.1.2 Water Treatment Activities

Closure activities related to water treatment and discharge are described in Section 4.2 of the *Reclamation and Closure Plan*. Major water treatment costs including operating and capital replacement costs are part of the Temporary Closure and/or Post-Reclamation costs sections of this report.

3.1.3 Ore Processing Area and Infrastructure Activities

Closure activities related to the ore processing area and infrastructure are described in Sections 3.4 and 3.5 of the *Reclamation Plan*. Major activities include:

Demolition

Infrastructure not required for long-term use will be decommissioned and demolished. Hazardous materials will be removed, high value components may be salvaged, and the remainder demolished and placed in the landfill at the top of the Main Waste Dump. No salvage values have been applied to offset the reclamation cost estimate. Demolition costs are derived in SRCE tabs “Foundation & Buildings” and “Other Demo & Equip Removal.”

Sufficient infrastructure will be left in place at site to support limited year-round operations. The new PAC wings will remain in place as will the existing PAC kitchen/dining facilities and the gymnasium complex. The existing warehouse/office complex will also remain in place to accommodate maintenance and office needs. The newer powerhouse and the water treatment plants will remain, although the final treatment plant configuration for the post-reclamation period is yet to be determined. Funds were included in the cost estimate to upgrade and/or combine plants into a plant(s) sufficient to meet long-term needs with allowances for periodic capital cost replacement, though these capital costs are part of the post-reclamation costs rather than the reclamation costs. Roads as required for site operations and monitoring will remain in-place.

Contaminated Soil Removal

Contaminated soil will be removed, and the areas backfilled with unmineralized material. Known or likely areas of soil contamination include the areas now covered with mining infrastructure (mill, crusher, stockpiles, conveyor, concentrate building, etc.). It is assumed that the depth of soil removal and backfilling will average two feet. Reclamation costs (regrading, cover placement, ripping costs are addressed in the SRCE tab “Yards, etc.”

Road Decommissioning

Site roads no longer required will be reshaped and reseeded to integrate with the surrounding topography and drainage.

Limestone Quarry Reclamation

The limestone quarry will be reclaimed by re-grading the steep slopes, seeded and fertilized.

Revegetation

All reclaimed areas will be seeded and fertilized. Seed mixes are described in the Reclamation Plan.

3.2 Assumptions

3.2.1 Quantities

Quantity estimates used for inputs to reclamation cost estimate were derived using standard engineering calculations and included area measurements derived from current air photos of the site. Calculations are straightforward with additional information provided below. Quantities are also addressed in SRCE tab “Reclamation Quantities.”

Pit Walls

Pit berms were estimated to be constructed around the perimeter of the pits where highwalls are present. Pit berms were assumed to be 3.3 feet high with a 1-foot-wide crest width and 1H:1V side slopes. Pit perimeters were obtained from topographic plans showing conditions at closure.

Pit rims were estimated to be re-sloped around the eastern side of the remaining portion of the Main Pit. The rims will be blasted back 150 feet to a slope of 4H:1V to improve visibility for snow machine or ATV drivers.

Stockpile Re-Sloping

In SRCE, stockpile re-sloping costs are calculated using the length of the dump mid-slope contour line combined with cost and productivity assumptions for the mobile equipment.

Cover Volumes

Cover volumes for waste dumps were estimated by using areas calculated in AutoCAD by comparing available topographic surveys and aerial photography. An average depth of cover was assumed for all waste rock covers and beaches. A depth of 3 feet (1m) was assumed for all quantity volumes. Covers on dumps will consist of geosynthetic material and assumes 1 ft of cover material under the geosynthetic covers and 2 ft on top. Cover volume requirements were compared to existing cover stockpile volumes and volumes of cover material that will be mined from the Aqqaluk pit (Key Plate shales) through 2023 based on the 2020 LOM plan. There will be a surplus of cover material available for the 2023 premature closure scenario. Cover volumes are addressed in SRCE tab “Reclamation Quantities.”

Seepage Collection

Seepage water from the Main Waste Rock Dump sumps and the main dam seepage collection systems will be directed to the Aqqaluk pit. This system is already in place and functioning though some monies were included in the estimate to harden this infrastructure. Seepage collection costs are addressed in SRCE tab “USER 06 Seepage and Drill Blast”.

Tailings Beaches

Material quantities for tailings beaches were determined from topographic plans and an assumed beach width of 600 feet. Estimates of liner area, cover material volume, and revegetation area were derived for both a beach at the Main Dam and the Back Dam. Tailings will be dredged and placed to form the beaches. As of 2020, a conservative estimate of five feet (1.5m) of tailings must be placed to form the proposed final beach surfaces. The estimate assumes a volume of dredged tailings to form the beaches is equal to the length of the beaches by 600 feet by 5 feet in depth.

Demolition

Demolition quantities were estimated directly in SRCE using building dimensions and accounted for concrete slab removal where they exist at site. Demolition costs in SRCE were derived with data in tab “USER 10 Buildings” and “Foundations & Buildings”

Waste Disposal

Solid waste, hazardous waste and contaminated soil disposal costs are included in the reclamation cost estimate. These costs are addressed SRCE tab “Waste Disposal”.

Revegetation

Revegetation areas were estimated in AutoCAD using current topography and aerial photography. Revegetation unit costs for the SRCE Cost Data File are derived in SRCE tab “USER 04 Revegetation.”

3.2.2 Unit Costs

Equipment Rates

Equipment rates were based on monthly rental rates provided in 2020 by NC Machinery. The construction schedule assumes two construction seasons, with a complete mobilization and demobilization for each construction season. Rental rates were provided in terms of 4-week increments. Each construction season is assumed to span five 4-week terms.

Overhead costs for equipment, such as ground-engaging tools (GET), tires, and major maintenance, are included in the average wear and tear clause of the rental terms.

This method of calculating equipment costs is consistent with the standard reclamation cost estimator (SRCE) method for calculating hourly rates, and Caterpillar Handbook for calculating ownership costs. Equipment rates are addressed in SRCE tab “Equipment Costs.”

Fuel

A fuel unit cost of $2.04 per gallon was used throughout the cost estimate. The estimate is based on the 5-year average (2015-2019) price of fuel delivered to Red Dog Port.

Labor Rates

Labor rates for an independent contractor were built up from base hourly rates presented in Issue 40 (effective April 3, 2020) of the *Laborers’ & Mechanics’ Minimum Rates of Pay* (Pamphlet 600), published by the Alaska Department of Labor and Workforce Development https://labor.alaska.gov/lss/pamp600.htm. Base hourly rates include standard overtime, benefits, and payroll burden. Labor rates are addressed in SRCE tab “Labor Rates.”

Material Properties

SRCE has its own rock types and can utilize generic rock types from the CAT handbook.

Haul Routes

Distances and grades used in haul time calculations were obtained from topographic plans. Reasonable assumptions were made as to where roads would be located at the time of closure. These variables are utilized in SRCE tab “Haul Material.”

3.3 Indirect Costs

TAK applied indirect costs to the reclamation cost estimate following the guidance provided by ADNR and ADEC in the DOWL report (2015). As discussed by DOWL (2015), the estimation of a mine’s direct reclamation costs is a relatively straight-forward exercise; however, estimating indirect costs presents a greater challenge because each category of indirect cost exhibits a degree of variability that results from several factors including access, climate, mine maturity, scale of operations, and whether a mine is a surface mine or underground mine. As a result, DOWL recommended a range of possible indirect costs for the seven of the eight categories of indirect costs. Liability insurance is applied as 1.5% of labor costs. ADNR and ADEC have adopted DOWL's recommendation for the range of indirect costs in these seven indirect cost categories.

To calculate the indirect costs for the reclamation cost estimate, TAK developed a matrix that considered seven variables identified by DOWL that affect indirect costs in each indirect cost category shown in Table 3. The variables include mine scale/complexity, applicable mining laws, presence of ARD/ML, remoteness, climate, and mine maturity. The matrix combines the seven variables and the seven indirect cost categories to derive a recommended indirect cost for the reclamation cost estimate. You will see that most indirect costs are applied to the direct cost estimate, but liability insurance indirect costs are only applied to labor. Table 3 shows that TAK calculated 49.2 percent of direct costs. Liability insurance is generally applied as 1.5% of labor costs. This is difficult in SRCE which does not allow an easy summation of labor costs. As a surrogate we applied 0.5% of direct costs in place of 1.5% of labor costs.

SRCE incorporates indirect costs different than TAK's approach or the State of Alaska's approach. As a result, and for ease of review, we have produced "USER 10 Summary Tables" tab in SRCE that lists the indirect cost percentages and amounts for the 7 state-recommended indirect cost categories separately for the reclamation, temporary closure, and long-term cost estimates.

Table 3. Indirect Costs Applied to the Reclamation Cost Estimate

Indirect Cost Matrix - Reclamation			
Indirect Cost Category	DOWL Range, Variables	Notes	Recommended Percent
Contractor Profit	6 - 10%, Direct		
	Scale/Complexity	not overly complex, conventional closure/reclamation techniques favor low range, mod to large size project favors mid-low range	7
	Applicable Mining Law and Oversight	well established so favors lower end	6
	Presence of ARD/ML?	presence of ARD/Ml suggests higher end	10
	Surface v. U/G	surface favors lower end	6
	Remoteness	favors high end	10
	Climate	cold but not arctic	8
	Mine Maturity	mature mine favors low end	6
	Average		**7.5**
Contractor Overhead	4 - 8%, Direct		
	Scale/Complexity	large scale favors lower end while, complexity is not extreme - conventional closure techniques favoring mid range	5
	Applicable Mining Law and Oversight	well established so favors lower end	4
	Presence of ARD/ML?	presence of ARD/Ml suggests higher end	8
	Surface v. U/G	surface favors lower end	4
	Remoteness	favors high end	8
	Climate	cold but not arctic	6
	Mine Maturity	mature mine favors low end	4
	Average		**5.5**
Performance/Pmnt Bonds	2.5 - 3.5%, Direct		
	Scale/Complexity	unaffected	2.5
	Applicable Mining Law and Oversight	unaffected	2.5
	Presence of ARD/ML?	favors higher end	3.5
	Surface v. U/G	unaffected	2.5
	Remoteness	favors high end	3.5
	Climate	cold but not arctic	3
	Mine Maturity	mature mine favors low end	2.5
	Average		**2.8**
Liability Insurance	1.5%, Labor*		
	Scale/Complexity		1.5
	Applicable Mining Law and Oversight		1.5
	Presence of ARD/ML?		1.5
	Surface v. U/G		1.5
	Remoteness		1.5
	Climate		1.5
	Mine Maturity		1.5
	Average		**1.5**
Contract Administration	5 - 9%, Direct		
	Scale/Complexity	scale favors lower end, complexity is moderate favoring mid number	6
	Applicable Mining Law and Oversight	stable favors lower end	5
	Presence of ARD/ML?	favors mid-range	7
	Surface v. U/G	mid range same for surface/u/g	7
	Remoteness	favors higher end	9
	Climate	cold but not arctic, favors mid-range	7
	Mine Maturity	favors lower end	5
	Average		**6.6**
Engineering Redesign	3 - 7%, Direct		
	Scale/Complexity	scale favors lower end, complexity is moderate favoring mid number	5
	Applicable Mining Law and Oversight	stable favors lower range	3
	Presence of ARD/ML?	favors higher end	7
	Surface v. U/G	Unaffected, should be mid-range	5
	Remoteness	favors higher end	7
	Climate	cold but not arctic, favors mid-range	5
	Mine Maturity	favors lower end	3
	Average		**5.0**
Scope Contingency	6 - 11%, Direct		
	Scale/Complexity	lower end favored by scale, moderate complexity favors mid-range	8.5
	Applicable Mining Law and Oversight	mid range per DOWL	8.5
	Presence of ARD/ML?	favors higher end	11
	Surface v. U/G	mid range per DOWL	8.5
	Remoteness	favors high end	8.5
	Climate	cold but not arctic, favors mid-range	8.5
	Mine Maturity	favors lower end	6
	Average		**8.5**
Bid Contingency	4 - 9%, Direct		
	Scale/Complexity	lower end favored by scale, moderate complexity favors mid-range	6.5
	Applicable Mining Law and Oversight	mid range per DOWL	6.5
	Presence of ARD/ML?	favors higher end	9
	Surface v. U/G	mid range per DOWL	6.5
	Remoteness	favors higher end	9
	Climate	cold but not arctic, favors mid-range	6.5
	Mine Maturity	favors lower end	4
	Average		**6.9**
Recommendation	**As a percentage of Direct Costs**		**42.6**
	As a percentage of Labor Costs*		**1.5**
*Used 0.5% of Direct Costs in SRCE			

4 Post-Reclamation Cost Estimate

4.1 Scope of Estimate

This section describes the basis for the cost estimate associated with long-term post-reclamation operations at the Red Dog mine site, following reclamation of the site to its final closure configuration. Long-term operations at the site will focus on maintaining the site in a stable state, managing water, including treating and seasonal discharge, continuing environmental monitoring and performing periodic upgrades and replacement to facilities and equipment as they age, over the long-term. To perform these operations, there will be a year-round presence at site with the need for housing, offices, warehouse, maintenance shop, power generation, water treatment, airport and roads, and voice and data capabilities.

The post-reclamation costs were estimated as an annual cost. The annual cost will be used in a collaborative effort with ADNR and ADEC in an economic model to derive the financial assurance amount that will incorporate these long-term annual post-reclamation costs with the reclamation costs and the annual temporary closure (aka holding costs). The financial assurance amount is the sum of the short-term costs (reclamation and temporary closure costs) and the NPV of the long-term Post-Reclamation costs.

Annual cost during the pos-closure period will vary depending on the capital cost requirements for different years. The annual undiscounted costs are estimated to vary between $56.2M and $15.2M and the average annual undiscounted cost is estimated to be $18,761,408.

4.2 General Assumptions

Requirements for the post-reclamation period are described in Section 4 of the *Reclamation and Closure Plan*. The primary activities include:

- Water management including collection and storage of contact water in the Aqqaluk Pit, Main Pit or TSF, with seasonal treatment and discharge of excess water at Outfall 001,
- Sludge management (product of water treatment) disposal in the TSF, Aqqaluk or Qanaiyaq pits,
- Maintenance of earthworks (covers, ditches, etc.) constructed during the reclamation period,
- Operation and maintenance of remaining site infrastructure (roads, airport, power, communications),
- Operation and maintenance of remaining site facilities (housing, water treatment plants, other buildings),
- Environmental monitoring and inspections, including periodic dam safety inspections, and
- Logistics and materials handling between port and mine site.

4.3 Assumptions by Cost Item

4.3.1 Manpower

Year-round staffing will consist of the following staff:

- One site manager,
- One environmental coordinator,
- One environmental technician,
- One mechanic,
- One electrician,
- One equipment operator, and
- Two camp support staff.

There will be approximately 8 people on site during the winter, with some variability due to rotation schedules.

In the summer, additional staff will be on site to operate the water treatment plants, haul consumables and fuel from the port to the mine and carry out the earthworks and maintenance. Additional summer staffing will consist of the following staff:

- One water treatment plant operator,
- One water treatment plant operator assistant,
- One technician,
- One Powerhouse Operator (cost included as part of power costs)
- One additional mechanic,
- One additional electrician,
- Two truck drivers, and
- Two additional equipment operators.

There will be approximately 17 people on site during the summer with some variability due to rotation schedules.

Labor rates were estimated using the Alaska Department of Labor’s rates as listed in Issue 40 of the *Laborers’ & Mechanics’ Minimum Rates of Pay* (Pamphlet 600). Labor rates not available in Pamphlet 600 were sourced from wages available on the Alaska Department of Labor’s website (Research and Analysis, April 2020 Wages in Alaska). Base hourly rates include standard overtime, benefits, and payroll burden. Labor rates do not include the costs of camp accommodation or flights, which are included elsewhere. Manpower is detailed in SRCE tab “Human Resources”.

4.3.2 Water Treatment Consumables

The major consumables will be those used in the water treatment system, specifically lime, flocculant, sodium sulfide, and antiscalant. Water treatment consumable costs are derived in SRCE tab "USER 13 WT consumables."

A post-reclamation water and load balance is described in the *Red Dog* Mine *Reclamation and Closure Plan*, Section 4, and the *Red Dog Water and Load Balance Report (SRK, 2020)*. The water and load balance provides estimates of the annual treatment flows and the lime demand from the Aqqaluk Pit and from the TSF, also referred to as the Tailings Pond. Estimates of post-reclamation water quality were derived using the 2020 water and load balance. The flows and lime demands vary slightly over the first few years after closure. The long-term steady state values, which are generally reached about 20 (2045) years after closure, were used for the estimate.

It was assumed that actual lime demand would be 23% greater than the theoretical lime demand provided by the water and load balance (SRK, 2020). The difference accounts for grit content and unreactive lime.

The amounts of flocculant, sodium sulfide, and antiscalant were assumed to be proportional to the lime demand (1 tonne lime:10 kg flocculant:26 kg Na S2:4 kg antiscalant). The ratios of the amount of each consumable to the lime tonnage were calculated from site records. The resulting estimates of treated flows, lime demand, and consumable requirements were as follows for steady state conditions.

The unit cost for lime is $220.58 per tonne, which is the current (2020) price as delivered to the Red Dog Port. Annual lime demand in the post-reclamation period will decrease over about 20 years between 2023 and 2045. The costs estimate reflects this gradual decrease in lime demand. Once steady state conditions are established, lime demand will be approximately 11,400 tonnes.

Unit costs for the other water treatment consumables (flocculant, sodium sulfide, gypsum and antiscalant) were based on the 2019 price for each consumable as delivered to the Red Dog Port.

4.3.3 Mobile Equipment

Equipment sizes were assumed to be similar to the equipment presently on site or used to transport consumables to site:

- One 16M Grader
- One 966 Loader
- Two Articulated Haul Trucks (35 ton)
- One Excavator (2.3 cy)
- One 988 Loader
- Two Forklifts
- One Portable Generator (20 kW)
- One D6 Dozer
- One Field Service Truck

- Two Semi Tractors
- Two Flatbed Trailers
- One Heavy Equipment Trailer
- Two Fuel Tankers
- One Van-mounted Steam Generator
- One Snowblower
- Four Pick-up Trucks

Hourly equipment rates were based on the 2020 NC Machinery rates. The equipment rates include fuel, maintenance and overhaul parts, lube and oil, tires, and GET costs. Equipment operator rates are included separately in the estimate. Costs for the mobile fleet are derived in SRCE tab “USER 14 PC mobile equip.”

4.3.4 Maintenance Materials

Maintenance material costs were estimated based on historical site maintenance department records. Generally, maintenance costs are relatively low, with the pumpback systems requiring a majority of the maintenance costs. Specific maintenance items vary between maintenance areas, which prevent updating costs from vendor quotations with any accuracy. Maintenance material costs are derived in SRCE tab “USER 15 PC maint mat’ls”

4.3.5 Capital Replacement

Capital replacement costs were included in the post-reclamation cost estimate to account for replacement of major capital items over the long-term. The estimated and actual capital replacement cost will vary from year to year depending on the replacement cycle for the various pieces of equipment or the facility that is being upgraded or replaced. Capital replacement costs are addressed in SRCE tabs “USER 09 Water Treatment” and “USER 16 Capital Replacement”.

The replacement capital cost used in the post-reclamation cost estimate is sufficient to provide for:

- Replacement of 25% of the water treatment system in years 15, 45, 75, etc., and replacement of the other 75% in years 30, 60, 90 etc.
- Replacement of pick-up trucks, field service truck, and steam generator every 10 years,
- Replacement of semi tractors and trailers every 15 years,
- Replacement of heavy equipment fleet every 25 years,
- Replacement of generators and switch gear every 20 years,
- Replacement of monitoring equipment (thermistors) every 15 years.

Actual capital expenditures will not likely correspond directly to the above. But comparison of the annual allowance to the above shows that it is conservative. For example, there are many examples of water treatment plants that have been in operation for more than thirty years without complete replacement. Considering the plants will only be in operation about 5 months per year may also increase the life of the plants.

4.3.6 Sludge Management

This post-reclamation cost estimate provides cost estimates for long-term, post-reclamation sludge management. A period of 100 years was used for the duration of sludge management while acknowledging that requirements and technologies for water treatment and sludge management will change with time. Sludge management costs are primarily hauling costs to transport the sludge to one of the pits.

This cost estimate assumes the post-reclamation water treatment plants will generate approximately 23 million gallons of sludge annually at 10% solids from Aqqaluk Pit water and 5% solids from the TSF water. At steady state conditions about 20 years into post-reclamation, and with planned water treatment plant upgrades, sludge density from the Aqqaluk put will increase to 20% solids, reducing the annual sludge production to 12 million gallons going forward. Sludge will be stored in available space in the TSF, and Aqqaluk and Qanaiyaq pits. In the premature closure scenario, the Qanaiyaq pits will be at their maximum stage of development (i.e. largest open volume) and provide storage additional capacity for sludge. Sludge management costs are derived in SRCE tab “USER 22 Sludge”.

4.3.7 Power

Power requirements were estimated based on a listing of the equipment needed to operate in the both the winter and summer months. Power costs are derived in SRCE tab “USER 17 power costs.”

During the winter, power will be required primarily to operate the pumps and heat tracing systems on the seepage systems, office, warehouse and living area. Winter power consumption was estimated to be 500 kW.

During the summer, water treatment will increase the power requirements. In addition to the plant, the operation of water treatment requires operation of the reclaim pumps, Bons Creek pumps, process water distribution pumps, lime, flocculant, and sulfide mixing and distribution systems, and a compressor. Summer power consumption was estimated to be 2,000 kW.

The power costs were based on:

- Three generators optimally sized for the winter and summer seasons, producing power at an efficiency of 14.2 kW-hours per gallon,
- A fuel cost of $2.04 per gallon. The estimated fuel cost is based on the 5-year average price of fuel delivered to Red Dog Port from 2014 - 2019.

4.3.8 Camp and Administration

The estimate of camp and administration costs included:

- Camp operation at $79 per person per day;
- Turnaround costs of $906 per person per trip; and
- An annual port maintenance fee of $100,000.

The camp cost of $79 per person day is the actual average 2020 cost for the mine. The turnaround transportation cost was calculated using current Alaska Air flight costs from Anchorage to Kotzebue, plus current mine costs for a charter flight from Kotzebue to Red Dog. Camp and admin costs are derived in SRCE tab “USER 18 camp, admin.”

4.3.9 Environmental Monitoring

Environmental monitoring costs include all external sample analysis requirements, sampling and preparation supplies, and external consulting and contracted services. Post-reclamation environmental monitoring costs are derived in SRCE tab “USER PC Monitoring.”

The sampling and analytical requirements were based on sampling the following locations: Outfall 001, Station 2, Station 9, Station 10, Station 12, Station 20, Station 73, Station 140, Station 150, Station 160, and Red Dog Creek above Qanaiyaq, Shelly Creek, Connie Creek, Rachel Creek, and Sulfur Creek. All analyses were assumed to be completed by external laboratories. Monthly WET (toxicity) testing was assumed to continue during the summer. Costs of sample shipping and data manipulation were included. The ADFG bioassessment program was assumed to continue as well. Helicopter time for accessing the remote sampling sites was also included.

Monitoring requirements over time may be reduced in the future. This estimate assumes all monitoring needed at closure will be needed throughout the life of the project.

Monitoring costs reflect actual site cost data.

4.3.10 Dam Inspections and Maintenance

Dam inspections are currently required on a periodic basis as well as an annual basis. In SRCE dam inspection and maintenance costs are derived in tab “USER 21 Dam inspection, maint.” The estimate includes the following assumptions:

- Annual dam inspections for each dam by a licensed and qualified engineer, as per Alaska Statute 46.17, to inspect all dams for obvious deficiencies. However, this frequency may be required less often by the ADNR-Dam Safety Unit in the post-reclamation period,
- Provides $50,000 per year for dam instrumentation replacement,
- Provides $700,000 for Periodic Dam Safety Inspections allocated over 3 years at $233,000 per year,
- Provides $32,000 for repair of potential surface erosion on the Main Dam, as well as the Main Dam and Back Dam beach armoring, allocated over 20 years at $1,600 per year, and
- Provides $1,500,000 for Main Dam rock drain reconstruction and repair, allocated over 20 years at $75,000 per year,

Post-reclamation maintenance of dam spillways is assumed to be provided by on-site staff and equipment, and the cost is included with the scheduled manpower and equipment hours.

4.4 Indirect Costs

TAK used a modified approach to calculate the indirect costs for the post-reclamation cost estimate. As discussed by DOWL (2015), the estimation of a mine's indirect costs presents a greater challenge (than direct costs) because each category of indirect cost exhibits a degree of variability that results from several factors including access, climate, mine maturity, scale of operations, and whether a mine is a surface mine or underground mine. However, the post-reclamation costs are different than say the mine reclamation costs that would involve several contractors completing a significant amount of work, away from their home base, over a relatively short couple of construction seasons. Likely, the long-term nature of the post-reclamation activities will encourage a firm, possibly NANA, to enter a long-term contract for the work with the state to perform the Post-Reclamation activities.

In fact, the post-reclamation activities and their related costs are more analogous to operating any other long-term project. They are an extension of a small subset of activities that the mine has a long history of performing and paying for, extended out for an exceptionally long time. The procedures and associated costs are well known. As a result, the level of risk, uncertainties and need for engineering and oversight are not nearly as great as they might be for the reclamation portion of the mine closure. As a result, TAK does not believe that that the guidance in the DOWL report is applicable to these long-term post-reclamation activities and is not a very useful guide for estimating the indirect costs that should be applied to these activities. As a result, TAK applied lower percentages than recommended in the DOWL report for certain categories of indirect costs as discussed in more detail below and illustrated in Table 4.

Contractor Profit – Whomever takes on the role of contractor-operator during the post-reclamation period will need to make a profit. The typical variables that DOWL (2015) applies to rationalizing this category of indirect costs do not apply to the activities planned for the post-reclamation period at Red Dog. TAK believes that the contractor profit should be low, commensurate with the low risk and long duration of the post-reclamation activities. The DOWL report notes "Smaller profit margins on simple and small projects may be justified while a contractor may expect greater profit margins when undertaking large, complex projects with a substantial amount of risk." TAK characterizes the post-reclamation activities as relatively simple and relatively small, with relatively low risk. Accordingly, TAK recommends using 5% of direct costs for the contractor profit category of indirect costs.

Contractor Overhead - Contractor overhead refers to all ongoing business expenses not including or related to direct labor, direct materials, or third-party expenses that are billed directly to a project. A number of cost elements that make up a contractor's non-direct, overhead cost total include: general management, insurance, marketing and proposal costs, internal quality control or quality assurance, home office rent, utilities, computers, phones, general accounting, and legal or other business costs that are not directly charged to each project. TAK included some of these cost elements (supervision, utilities, office, phones) into the post-reclamation cost estimate and recommends using 3% of direct costs for the contractor overhead category of indirect costs for the post-reclamation cost estimate.

Performance and Payment Bonds - TAK recommends using 2.5% of direct costs for the performance and payment bonds category of indirect costs for the post-reclamation cost estimate.

Liability Insurance - Liability insurance is generally applied as 1.5% of labor costs. This is difficult in SRCE which does not allow an easy summation of labor costs. As a surrogate we applied 0.5% of direct costs in place of 1.5% of labor costs.

Contract Administration – Contract administration costs during the long-term post-reclamation period are expected to be lower than for the reclamation period. The post-reclamation activities will consist more or less of standard operations that will require fewer inspections and less regulatory oversight compared to the site reclamation period. TAK recommends using 4% of direct costs for the contract administration category of indirect costs for the post-reclamation cost estimate.

Engineering Redesign – According to DOWL (2015) Engineering redesign is one of the more complex, specialized, and variable indirect cost categories. This involves altering or updating the mine's Plan of Operations (POO) or R&C Plan to:

- Add enough detail and description for a contractor to comfortably bid on the full scope of the R&C work package.
- Confirm that the tasks and activities described in the R&C Plan are in fact appropriate, viable, and sufficient to achieve the R&C goals; and
- Prepare engineering plans and technical specifications necessary to depict what work is needed to complete the R&C project properly and fully. The engineering design work would typically be conducted by an independent engineer prior to engaging an R&C contractor.

However, none of these tasks are relevant to a post-reclamation period per-se. TAK does acknowledge there may be a limited need to redesign some components of the closed site including aspects of water treatment and some civil designs, over the very long-term. As a result, TAK recommends using 3% of direct costs for the engineering redesign category of indirect costs for the post-reclamation cost estimate.

Scope Contingency – DOWL (2015) characterizes scope contingency as being a direct reflection of uncertainty in contract bid items or the completeness of detail in the R&C plan upon which the contractor has based their bid. TAK believes that the uncertainty addressed in scope contingency will be very low for the contractors that may bid on executing the activities required during the post-reclamation period. The uncertainty is low because the activities required during this period are activities that are well understood, having been performed for many years of mine operations, and their costs have also been established over those years. As a result, TAK recommends using 3% of direct costs for the scope contingency category of indirect costs for the post-reclamation cost estimate.

Bid Contingency - DOWL (2015) characterizes bid contingency as being related to the cost uncertainty inherent in proposing, designing, and executing the construction work needed to implement a R&C plan. To the extent that bid contingency applies to the post-reclamation period activities at all, the inherent risk in proposing and executing the activities of the post-reclamation period are low for the same reasons they are low for scope contingency category. Years of operations at Red Dog provide a solid record of costs and standard operating procedures for the activities of the post-reclamation period. As a result, TAK recommends using 2% of direct costs for the bid contingency category of indirect costs for the post-reclamation cost estimate.

Table 4. Indirect Costs Applied to the Post-Reclamation Cost Estimate

Indirect Cost Matrix - Post-Closure		
Indirect Cost Category	DOWL Range, Variables	Recommended Percent
Contractor Profit	6 - 10%, Direct Scale/Complexity Applicable Mining Law and Regulatory Oversight Presence of ARD/ML? Surface v. U/G Remoteness Climate Mine Maturity Recommendation	**5.00**
Contractor Overhead	4 - 8%, Direct Scale/Complexity Applicable Mining Law and Regulatory Oversight Presence of ARD/ML? Surface v. U/G Remoteness Climate Mine Maturity Recommendation	**3.00**
Performance/Pmnt Bonds	2.5 - 3.5%, Direct Scale/Complexity Applicable Mining Law and Regulatory Oversight Presence of ARD/ML? Surface v. U/G Remoteness Climate Mine Maturity Recommendation	**2.50**
Liability Insurance	1.5%, Labor Scale/Complexity Applicable Mining Law and Regulatory Oversight Presence of ARD/ML? Surface v. U/G Remoteness Climate Mine Maturity Recommendation	**1.50**
Contract Administration	5 - 9%, Direct Scale/Complexity Applicable Mining Law and Regulatory Oversight Presence of ARD/ML? Surface v. U/G Remoteness Climate Mine Maturity Recommendation	**4.00**
Engineering Redesign	3 - 7%, Direct Scale/Complexity Applicable Mining Law and Regulatory Oversight Presence of ARD/ML? Surface v. U/G Remoteness Climate Mine Maturity Recommendation	**3.00**
Scope Contingency	6 - 11%, Direct Scale/Complexity Applicable Mining Law and Regulatory Oversight Presence of ARD/ML? Surface v. U/G Remoteness Climate Mine Maturity Recommendation	**3.00**
Bid Contingency	4 - 9%, Direct Scale/Complexity Applicable Mining Law and Regulatory Oversight Presence of ARD/ML? Surface v. U/G Remoteness Climate Mine Maturity Recommendation	**2.00**
Recommendation	**As a percentage of Direct Costs**	**22.50**
	As a percentage of Labor Costs*	**1.50**

*Used 0.5% of Direct Costs in SRCE