11 OPERATIONS: THICKENED TAILINGS MANAGEMENT

Tailings are what remain after desired recoverable minerals are removed from ore. Tailings at the Stibnite Gold Project will be comprised of the finely ground rock materials remaining after the minerals stibnite (hosting antimony and some silver) and pyrite (hosting the gold and some silver) and free gold, are extracted and concentrated in the ore processing facility (see Section 10). Since all sulfide minerals (primarily stibnite and pyrite) at the Project contain metal that has economic value, they will be recovered as much as practicable, thus reducing sulfide minerals to a very low level, thereby generating low sulfide content tailings. See Section 10.1.10 for a discussion of tailings chemistry.

Prior to hydraulically transporting tailings to the TSF, the tailings slurry will be thickened and neutralized (see Section 10.1.10) at the ore processing plant. Thickened tailings were selected as the preferred option, as detailed in the alternatives assessment contained in Appendix G. Thickening is a key step in the overall tailings management process as it will reduce the amount of water sent to the TSF, it produces a viscous material that inhibits segregation of the coarse and fine tailings particles as they are hydraulically deposited, which will result in a denser, stronger, faster-consolidating tailings.

Midas Gold will construct a tailings storage facility in incremental stages. Under this approach, Midas Gold will minimize the initial disturbance footprint and capital expenditures and be able to use spent heap leach ore, recycled legacy development rock and fresh development rock from ongoing mining for construction of the TSF. Since processing economics (ore cut-off grades, operational understanding of the mineralized zones, and process recovery) largely dictate the method of processing, Midas Gold designed the TSF to allow for operational flexibility and adaptive management.

11.1 THICKENED TAILINGS TRANSPORT & RECYCLE WATER PIPELINES

Neutralized, low-sulfide, thickened tailings slurry will be transported from the ore processing facility to the TSF through a slurry pipeline. The thickened tailings slurry will contain approximately 55% solids by weight and the remainder will be water. An estimated 100 million tons of tailings solids will be stored in the TSF, at full buildout.

After the tailings slurry is deposited in the TSF, the solids settle out and a supernatant water pond forms on the surface. Midas Gold will reclaim this supernatant water and recycle it back to the ore processing facility for reuse using pumps. The tailings delivery and water return pipelines will be routed adjacent to a haul road to enable pipeline monitoring and maintenance. See Figure 8-3 and Figure 10-2 for proposed routing.

To ensure long-term operational integrity, the tailings pipeline will be a 24-inch diameter carbon steel pipe (or equivalent), lined with high-density polyethylene (**HDPE**). A geosynthetic-lined trench will provide secondary containment of the pipeline and capture any potential release or spillage. The trench will have emergency containment catchment basins at low points along the alignment to collect any leakage, precipitation or runoff collected within the trench. The geosynthetic-lined trench will also house an 18-inch HDPE (or equivalent) reclaim water return pipeline to supply recycled water back to the ore processing facility.

To ensure protection of the EFSFSR, an extra precaution will be taken: a double-contained pipe within sleeves designed to contain the pipelines will be routed across the EFSFSR on a bridge. This construction will ensure that any leakage is contained within the redundant secondary pipe and delivered to the containment basins, and does not enter the EFSRSR. Similarly, at road crossings, the pipelines will be sleeved within a larger diameter pipe, and culverts (pipe-in-pipe) will be installed for continuous conveyance through the lined trench to allow containment of discharges in the event of a pipe break or leak.

11.2 TSF DESIGN & CONSTRUCTION DETAILS

Following an assessment of the alternative designs, as detailed in Appendix G, the preferred alternative is that the TSF consist of an engineered, stable rockfill embankment comprised primarily of development rock removed from the mine pits or from legacy development rock dumps, and legacy spent heap leach ore; a fully lined impoundment; and associated water management features. The rockfill embankment will be constructed using the downstream method (in which each successive lift of the structure is built on top of a previously constructed rock lift downstream of the prior lift), which substantially enhances stability of the embankment as compared to dams constructed of soil or tailings, or where the upstream or centerline construction methods are used (where successive lifts of the embankment are built on top of previously deposited tailings upstream of the prior lift). See Appendix G for further discussion of the relative advantages of various tailings dam construction methods. Midas Gold established tailings design and construction criteria based on the facility size, applicable regulations and industry best practices for a stand-alone TSF with appropriate factors of safety. Above and beyond these best practice criteria, the stability of the TSF will be further enhanced through the placement of development rock in the Hangar Flats DRSF buttressing the downstream slope of the TSF embankment; this material will substantially increase the geotechnical stability of the TSF. In addition, permanent stability is provided by the natural mountainous topography which forms approximately 90% of the TSF perimeter. These mountains have existed for millennia and will continue to provide stability long into the future.

11.2.1 TSF Embankment Design

The location of the TSF is shown on Figure 8-1. The general TSF design criteria are listed in Table 11-1; the TSF will comply with Idaho Administrative Procedures Act (**IDAPA**) regulations at §37.03.05, Mine Tailings Impoundment Structure Rules.

Table 11-1, TSF Design Criteria

Design Parameter	Design Criteria
Solution and Water Management	
Inflow Design Flood – Impoundment[(1)]	24-hour Probable Maximum Flood
Inflow Design Flood – Diversions[(2)]	1% probability (100-year, 24-hour event)
Impoundment Freeboard[(3)]	4 feet (wave height + 2 feet)
Surface Water Channel Freeboard	1 foot
Geotechnical Stability (Stand-alone TSF Embankment)	
Static Factor of Safety[(4)]	1.5[(5)]
Pseudo-Static (Earthquake) Factor of Safety[(4)]	1.0[(5)]
Design Earthquake	475-year (during operations); Maximum Credible Earthquake (post closure)

Notes:

(1) Facility will provide water storage capacity above the normal operating reclaim water pool to store the inflow design flood, assuming the surface water channels around the facility fail at the outset of the storm.

(2) Diversions will pass peak flow from the inflow design flood without damage.

(3) Dry freeboard above the stored inflow design flood, to prevent wave run-up from overtopping the embankment.

(4) The geotechnical factor of safety (FOS) is the ratio of the available strength of a material to the stress required to maintain equilibrium. Thus, a FOS of 1.5 means that the structure is 50% stronger than it must be to "just" resist movement or deformation. A FOS of 1.5 is generally considered conservative in the context of slope stability.
(5) Without considering benefit of having the DRSF buttressing the downstream slope.

As noted above, the TSF will be confined on approximately 90% of its perimeter by natural topography (mountains) that considerably exceed the final height of TSF; consequently, there is no risk of TSF instability on the substantial majority of the perimeter of the TSF. At the downstream end of the TSF, a compacted rockfill (development rock and legacy spent heap leach ore) embankment will be constructed to fully contain the thickened tailings (see Section 11.2.3); a composite liner system will be installed on the upstream face of the embankment (see Section 11.2.2). The compacted rockfill embankment will be constructed in stages, using the downstream construction method, as discussed in Section 11.4. The geotechnical stability of the compacted rockfill TSF embankment will be further enhanced by the Hanger Flats DRSF buttress (see Section 11.5).

11.2.2 TSF Liner Design Criteria

The entire TSF (including the upstream or internal embankment face) will be lined with a composite liner system to prevent seepage of process water and to enhance the geotechnical stability of the TSF embankment by reducing pore water pressures within the embankment (see Appendix G for additional discussion on the liner system). The general design criteria for the liner system are listed in Table 11-2.

Table 11-2, Tailings Storage Liner Design Criteria

Design Aspect	Description
Subgrade	Re-worked and compacted in situ materials or minimum 12 inches of buffer/liner bedding fill.
Secondary Liner	Geosynthetic clay liner (or equivalent).
Primary Liner	60-mil single-sided textured LLDPE geomembrane liner (or equivalent).
Leak Detection	Water quality monitoring of underdrain collection sumps and downgradient monitoring wells will allow detection of leaks. If testing reveals contamination, collected water will be treated before discharge.
Overdrain	Discontinuous geotextile-wrapped gravel trenches, wick drains, or geo-composite strip drains as needed on hillsides.
Underdrain	Geotextile-wrapped gravel, with perforated HDPE pipe as needed.

The proposed design for the composite TSF liner is a proven methodology for isolating mine tailings and process water from the environment. Similar systems are in successful use, many for multiple decades, throughout the western U.S. and internationally, often in more demanding environments with respect to factors most affecting degradation of geomembrane (temperature and UV light). While individual components of the system are expected to last hundreds of years, the composite system provides redundancy in the event one component fails; moreover, the embankment and buttress are designed to remain stable even if the liner system degrades. Construction and performance of the individual components are discussed in the following paragraphs.

11.2.3 TSF Embankment Construction

Prior to construction of the initial TSF embankment (and the subsequent engineered lifts of the rockfill embankment), vegetation within the footprint of the embankment, impoundment basin, and side slope areas will be removed. Vegetation and slash material removed will be stockpiled, chipped, and used for reclamation of disturbed areas; some material will be used immediately or concurrently with Project construction to reclaim certain previously impacted areas. Remaining topsoil and/or growth medium material collected during clearing efforts will be stockpiled for reuse during reclamation work during operations and on closure (see Section 14.2.3). Some of the growth medium will be placed within the footprint of the TSF, then re-handled during operations and closure, to minimize disturbance.

After vegetation has been removed, underdrains will be installed and the basin area will be prepared for the liner system; the underdrains have two primary functions: to reduce groundwater levels below the liner system and to detect leaks in the liner system. Multiple parallel underdrains will be installed, to be monitored individually at collection sumps, in order to facilitate identifying the source areas of leaks that are detected. Underdrains will be extended under the embankment and Hangar Flats DRSF in stages as the DRSF is constructed. Suitable native alluvial material (devoid of exposed angular coarse gravels and rock), and other supplementary materials will be scarified to a depth of approximately 12 inches, moisture conditioned, and then compacted with a vibratory roller compactor to produce a prepared liner subgrade.

On rocky areas, in particular side slopes (approximately a third of the TSF footprint), Midas Gold will grade the area and will use fill material to cover rocky sites and outcrops to prepare a suitable area for liner placement. Coarse rock will be covered with a minimum of 12 inches of liner bedding material, which would consist of alluvium, colluvium, legacy spent ore material, previously mined development rock, and/or screened rock material found at the site such as from within one of the existing or proposed open pits, borrow areas within the TSF footprint, or from an existing DRSF.

After the subgrade zone is completed, Midas Gold will install a geosynthetic clay liner (**GCL**) to provide a self-sealing, very low permeability barrier should the primary geomembrane liner be punctured, as well as serve as a sub-base for the primary liner. The GCL is shipped in rolls that will be laid over the prepared 12-inch thick bedding material. GCL has a permeability on the order of 5×10^{-9} centimeters per second (cm/s), representing a reduction in permeability of almost 3 orders of magnitude (1,000 times) less permeable than the requirement for compacted clay liners (10^{-6} cm/s).

Once the GCL is laid and secured, Midas Gold will install the primary liner, which will be a 60-mil linear low-density polyethylene (**LLDPE**) geomembrane (or equivalent). Similar to the GCL, the synthetic geomembrane will be shipped to the site in rolls, and the LLDPE liner will be deployed over the tailings facility area and welded together to form watertight seams. These welds will be inspected, tested and certified by the engineering firm that will be hired for quality control and assurance oversight. The liner will be anchored around the perimeter of the facility in trenches excavated in natural ground or at the top of the TSF embankment. Undamaged geomembrane liner material has a permeability of approximately 10^{-13} cm/s; accounting for potential leakage through defects in the liner due to manufacturing or installation, the equivalent permeability is still anticipated to be on the order of 10^{-11} cm/s, which is approximately 5 orders of magnitude (100,000 times) less permeable than the requirement for compacted clay liners (10^{-6} cm/s).

An over-liner seepage collection system will be installed atop the primary geomembrane liner, to facilitate a double-drained condition in the tailings, speeding tailings consolidation, reducing hydraulic head on the liner system, and making additional water available for process reclaim during operations instead of requiring management during pre-closure and requiring additional makeup water for operations. The overliner drain system will consist of geotextile-wrapped gravel drains, geocomposite drains or wick drains, laid in a parallel, grid or herringbone pattern and reporting to gravel-filled sumps. Collected water will be withdrawn from the sumps via submersible pumps installed in sloped pipes running up the sides of the facility, and either returned to the supernatant pool or introduced directly into the reclaim system. Geocomposite drains and/or wick drains are the preferred technologies for the overliner drain system, as they avoid the potential for liner damage associated with placing granular material directly on the liner with heavy equipment.

All foundation preparation, embankment construction and liner installation will be completed under a quality control and quality assurance program supervised by professional engineers with expertise in composite liner system design and installation.

All dams leak to some extent and this leakage must be observed, monitored and controlled. Leak detection will be accomplished via two independent and redundant systems:

- Water collected in the underdrain system will be tested at regular intervals. The installation of multiple, parallel underdrains will facilitate identification, allow isolation of leaks, and minimize the volume of water requiring treatment if a leak is detected; and,
- Monitoring wells installed downgradient of the TSF and Hangar Flats DRSF will be tested at regular intervals for constituents of concern.

Detection of liner system leaks, should they occur, would trigger adaptive management responses, whereby water from the underdrain with the leak would be collected and returned to the supernatant pond and recycled to the ore processing plant.

11.3 TSF OPERATION

The ultimate goal for the TSF is reclamation and rehabilitation as wildlife and fish habitat, including a meandering stream within a stream corridor dominated by wetlands and riparian habitat. In preparation for this goal, during the operational phase of the Project, the TSF will be designed and operated to speed consolidation of the tailings and maximize their in-place density, thereby minimizing closure water management requirements and differential settlement and enabling the earliest practical reclamation of the facility to its intended long-term status. To preserve and enhance existing in-stream water quality, the TSF will be designed and operated as a closed circuit, zero discharge facility meaning that no water will be discharged to the environment. Water collected or falling within the perimeter of the TSF will be recycled for use in the process facilities. Water balance modeling (see Section 8.11.3) demonstrates that there will be a net demand for makeup water to supplement precipitation on the TSF, hence the ability to operate the TSF as zero discharge.

In order to accelerate consolidation of the tailings, they will be discharged from spigots that surround the perimeter of the facility that will form “beach” areas using thin-layer, sub-aerial deposition techniques that promote drying and consolidation of the tailings. The sequencing of deposition around the perimeter of the facility will allow gradual development of tailings material that slopes from west to east within the facility. This deposition methodology will result in a final tailings surface that will allow successful reclamation of the TSF by creating a surface that allows a natural drainage system to be created. The development of tailings beaches is also a generally accepted industry practice to provide protection against floating ice that could damage the liner system.

Supernatant water will be recycled from the TSF back to the ore processing facility (see Section 10.3 and Section 11.7).

11.4 TSF CONSTRUCTION PHASES

An initial starter rock embankment and three subsequent stages of rock embankment and impoundment liner extensions are planned for the Project. TSF staging was determined based on planned development rock and tailings production rates coupled with the TSF water balance and tailings density estimates derived from consolidation testing/modeling. Each phase will allow sufficient space to contain the Probable Maximum Flood (**PMF**), in addition to the planned tailings and operational water pool volume, plus four feet of freeboard. Four feet of freeboard above the tailings surface provides a volume of approximately 27 to 57 million cubic feet (for the starter embankment and fourth stage, respectively), which is sufficient to contain an additional 1.2 to 2.5 times the runoff from the 500-year precipitation event thereby avoiding the risk of overtopping of the embankment even following multiple extreme precipitation events.

11.4.1 Initial TSF Construction

During initial site construction work, Midas Gold will construct the initial phase of the TSF rock embankment. The initial TSF rock embankment will have a capacity to hold approximately two to three years of materials generated by ore processing activity, depending on the mine production rates and sequencing of legacy tailings reprocessing. During the course of operations (at approximately 3-year intervals), Midas Gold plans for three TSF embankment raises. At the time of closure and reclamation, the TSF will be capable of holding approximately 100 million tons of tailings and the PMF while leaving a minimum 4-foot freeboard.

11.4.2 TSF Construction Materials

Development rock from the Midas Gold mine pits and from previous operations, or material from on-site borrow sources, will be used to construct the TSF rock embankment. In no circumstances will tailings or fine-grained soils be used as structural fill for the TSF embankment since coarse-grained, rock constructed embankments are inherently more stable. Further, the embankment will be raised using downstream construction techniques, which means the TSF embankment will always be raised on the down-drainage side of the TSF, not on top of tailings; this construction method is inherently more stable as compared to the upstream or centerline construction methods (where the embankment materials are placed on top of stacked tailings).

11.4.3 TSF Construction Method Comparisons

Recent notable failures of TSFs have generally involved the upstream or centerline construction methods, and frequently used tailings as embankment construction material. Both of these alternative construction approaches contribute to a higher risk of failure in the event of any weaknesses in foundation or construction, due to overtopping, high water levels within the dams leading to high pore pressures, or other such events that destabilize even a small portion of the embankment, but can rapidly lead to fluidization of the fine tailings materials and rapid failure of an embankment. Midas Gold's proposed rockfill and downstream construction techniques avoid these risks and provide an inherently more stable design (see Appendix G for additional discussion on TSF construction methods). As designed, the TSF embankment is estimated to have a static factor of safety of approximately 4 once the Hangar Flats DRSF is included in the stability calculations, which is substantially in excess of the Idaho requirements for a static factor of safety of 1.5 (see Section 11.5).

11.5 TSF BUTTRESS DESIGN & DEVELOPMENT ROCK PLACEMENT

In order to substantially enhance the geotechnical stability of the TSF embankment, even beyond that which will be provided by the use of compacted rockfill for construction and utilization of downstream construction techniques (see Section 11.4), Midas Gold has designed the Hangar Flats DRSF to serve as a buttress to the TSF rockfill embankment (see Appendix G for additional discussion of the buttress). Development rock from the Hangar Flats pit will be placed on the downstream face of the TSF embankment in successive layers, mirroring the staged raising of the TSF embankment, thereby buttressing the embankment. The Hangar Flats DRSF will extend from valley wall to valley wall, and extend more than 1,000 ft downstream of the TSF embankment, and ultimately contain approximately 65 million tons of development rock. The nature of the material (coarse rock) and its placement on the downstream face of the TSF embankment will substantially enhance the geotechnical stability of the facility, well beyond even its standalone design, increasing the static factor of safety from the 1.5 required for dams in Idaho to approximately 4.

11.6 TSF MANAGEMENT SUPPORT FACILITIES

As shown on Figure 8-1, Midas Gold will construct a haul road to allow access from the ore processing facility to the TSF, and this haul road will connect to the haul roads that access the three open pit mines and the onsite borrow sources defined in Section 8.15. Parallel to the haul road, from the ore processing facility to the TSF, will be the tailings delivery and reclaim water return pipelines (see Section 11.1). These haul roads will be used to haul material for TSF embankment construction, and they can be used should any pipeline maintenance be required.

An all-weather access service road will be constructed and maintained across the top of the TSF embankment and around the perimeter of the TSF. The tailings delivery and the water return pipelines will be located adjacent to this access service road. As the TSF expands upward, Midas Gold will establish new perimeter access service roads. These perimeter access roads will typically be 15 to 20 feet wide, including safety berms.

Electric power will be required to pump tailings to the TSF. These pumps will be located at the ore processing facility. Electric power will also be needed for the barge-mounted pump at the reclaim-water pond at the tailings impoundment. Midas Gold will install electric distribution lines to serve pumping facilities. Electric distribution line construction and use is discussed in Section 8.7.3.

The TSF will be surrounded by wildlife exclusionary fencing designed to keep large wildlife, such as deer and elk, from entering the impoundment area. In addition, tailings neutralization will reduce cyanide concentrations in the tailings slurry leaving the processing facility, and thus the TSF, to levels protective of wildlife, including waterfowl and birds of prey (see Section 10.1.10).

11.7 TSF WATER MANAGEMENT

Proper management of water within the TSF is critical for embankment safety, optimizing storage capacity, maintaining a zero-discharge facility and aligning Midas Gold’s core values, principles, and design criteria and design parameters. Water will be required to operate the ore processing facility and pump the tailings slurry to the TSF, but excess water in the TSF could slow tailings consolidation and reduces facility capacity and will be avoided. Process water will be recycled within the system rather than be discharged into the environment, only adding makeup water as required to balance the needs of the Project. In general, the tailings supernatant water pool will be managed to maintain an annual balanced condition, minimizing or eliminating any year-over-year increase in the dry season water pool volume. Pool levels will be subject to seasonal fluctuations in response to climate conditions – higher in the wet season, lower in the dry season. Whenever possible, recycle water will be used instead of freshwater as process makeup water.

Tailings will be pumped as slurry to the TSF, where the solids and water will separate as the tailings solids settle, forming a water pool atop the settled tailings. Decanted water from the pool will be returned to the ore processing facility for reuse. Some process water will naturally evaporate from the surface of the tailings impoundment, and some water will remain entrapped within the accumulated tailings solids. As the tailings consolidate, some of the water that was entrained with the tailings will rise to the pool or report to the overliner drain system, where it will be available for reuse, reducing makeup water requirements.

After the decant water clarifies (tailings solids settle), Midas Gold will recycle water from the reclaim water pond on the TSF to the process facility. However, due to the aforementioned evaporation and retention of residual water within the tailings, some makeup water will continue to be required at the ore processing facility throughout the life of the Project. Seasonal precipitation and temperature will also play a role in the amount of water recycled to the ore processing facility from the TSF (see Section 8.11). In the event of power outage from the main power line, backup generation capacity will be provided to ensure that process solutions can be pumped between the process facility and TSF.

As Midas Gold approaches the reclamation phase of the Project, as much water as practical will be drawn from the TSF reclaim pond, and less makeup water will be added to the system, reducing the size of the supernatant pond. Upon conclusion of ore processing facility operations, any remaining ponded water in the supernatant water pond will be removed. The water may evaporate naturally or enhanced through the use of mechanical evaporators (snowmakers but used in warm or dry conditions) as part of final closure activities. In the event that enhanced evaporation efforts do not adequately reduce the pond volume, water treatment to meet applicable discharge standards will be used as a means to eliminate the water pool to facilitate reclamation of the TSF.

11.8 TSF STORMWATER MANAGEMENT

In order for the Project to be aligned with Midas Gold's core values, principles, and design criteria and design parameter, it will be important to keep clean water clean. Therefore, Midas Gold will construct surface water channels to take clean water from the undisturbed watershed areas around the TSF area, thereby preventing impact by mining activities (see Figure 11-1 and Figure 11-2); these channels will remain intact throughout operations.

The main surface water channel will intercept water from the Meadow Creek watershed and route this water around the north side of the TSF and Hangar Flats DRSF and into Meadow Creek upgradient of the Hangar Flats pit. There will also be a smaller interceptor channel on the south side of the TSF that will serve to intercept upgradient runoff from the southern side of the facilities. These surface water channels will release water downgradient of the Hangar Flats DRSF (see Figure 11-1). Midas Gold will install and maintain sedimentation ponds and energy dissipation structures to control sediment loads and flow velocities, respectively, at the outfalls of the surface water channels. These will be part of a SWPPP to address onsite stormwater runoff, in accordance with EPA and Idaho regulations.

Following the closure of the TSF and the Hangar Flats DRSF, Meadow Creek will be re-established over the top of the covered and reclaimed TSF and Hanger Flats DRSF, and then routed down the north abutment of the Hangar Flats DRSF and into a reconstructed Meadow Creek channel on the valley bottom, providing a permanent, sustainable waterway for Meadow Creek (see Figure 14-3 and Figure 14-4).

The closure design will integrate wetlands and surface water features such as oxbows and side channels on top of the covered and reclaimed tailings to encourage wildlife, sustain bull trout habitat, and to provide for a self-sustaining environment similar in nature to those that formerly existed in the former wetlands in the upper EFMC valley. This outcome will align the closure with Midas Gold's objectives of developing wetlands while enhancing fish habitat and populations.

Figure 11-1, TSF and Hangar Flats DRSF Water Management

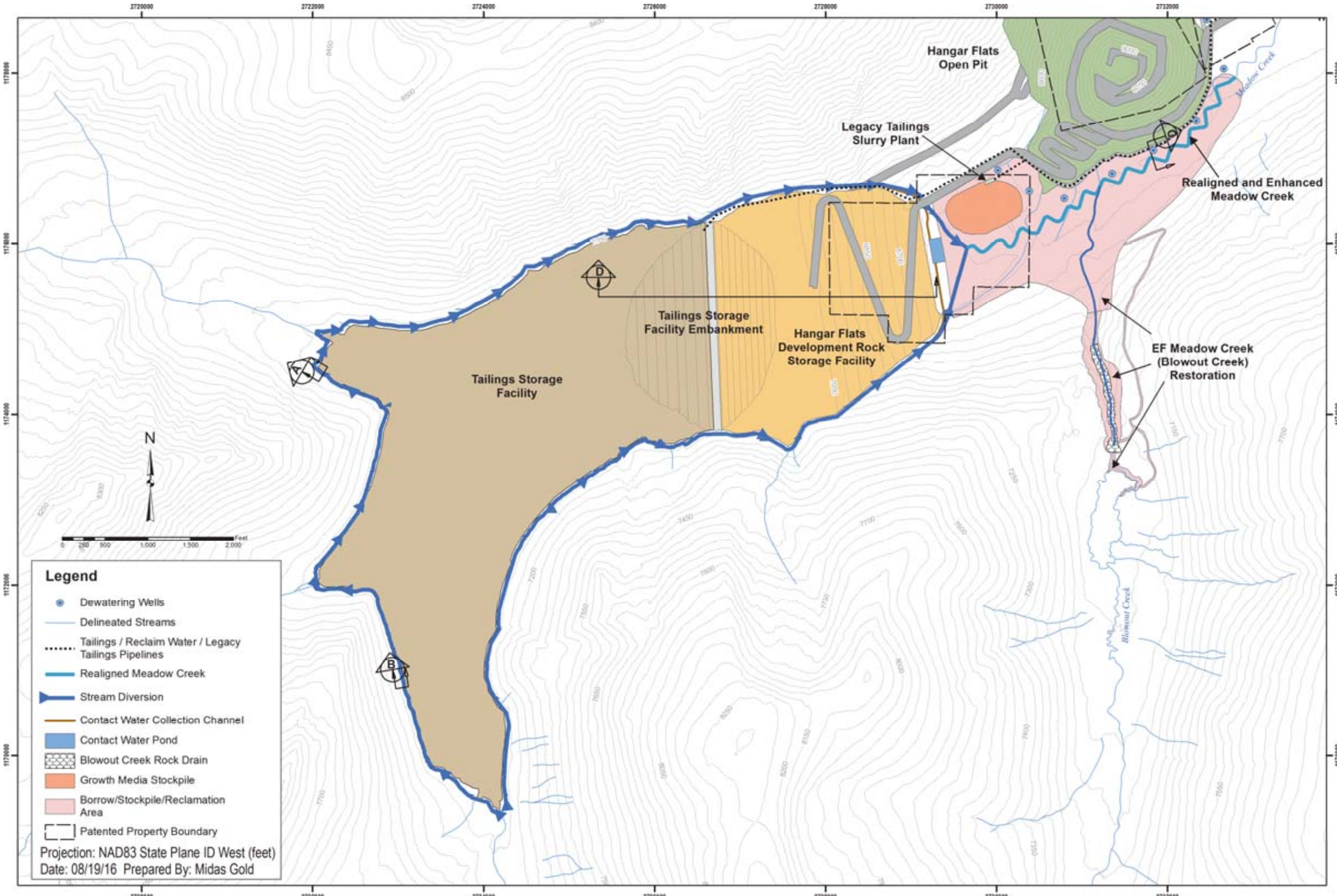

Figure 11-2, TSF and Hangar Flats DRSF Sections and Details