

# MONTANA RESOURCES, LLP YANKEE DOODLE TAILINGS IMPOUNDMENT



## ALTERNATIVES ASSESSMENT

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**MONTANA RESOURCES, LLP  
YANKEE DOODLE TAILINGS IMPOUNDMENT**

**ALTERNATIVES ASSESSMENT  
VA101-126/12-4**

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## EXECUTIVE SUMMARY

Montana Resources, LLP (MR) operates an open pit copper and molybdenum mine located within the northeastern part of Butte, Montana. The operation includes a mill throughput of approximately 50,000 short tons per day and a small-scale leaching operation. The Yankee Doodle Tailings Impoundment (YDTI) is the tailings storage facility for the mine. The YDTI was originally constructed in 1963 using rockfill obtained from Berkeley Pit stripping operations and has been continuously expanded to EL. 6,400 ft using rockfill from the Berkeley Pit and the Continental Pit. The existing permitted disturbance boundaries of the YDTI will allow continued impoundment filling through 2020. Additional tailings storage is required for continued operations.

The purpose of the study is to identify the best tailings storage alternative that will allow MR to continue operation of the mine while limiting the potential of new environmental impacts or operational interruptions. The assessment includes consideration of safety, implications for the environment, technical and financial aspects, and closure. The assessment is structured to telescope down from broadly available additional tailings storage alternatives to more detailed tailings management alternatives, and finally to embankment design alternatives.

The results of this assessment indicate that the only practicable solution for additional tailings storage is to increase capacity at the YDTI. There are many site selection limitations for options further afield that are imposed by the location of the project including extensive limitations due to public and private land ownership. This option leverages the existing knowledge of the project area and the extensive experience of the operator. The mine facilities will remain clustered within the mine site area and will not cause substantial increase in disturbance of previously undisturbed areas.

The best technique to increase storage capacity at the YDTI is to use multiple discharge points to develop tailings beaches along the full embankment length. Extensive tailings beaches separating the supernatant pond from the embankment enhances the safety characteristics of the facility and reduces the potential for seepage impacts at the West Embankment compared to the existing single discharge point arrangement. Alternative tailings technologies were considered and do not provide any favorable attributes for this site.

The best design alternative for development of the West Embankment incorporates an upstream drain and other seepage control features to maintain hydraulic confinement of YDTI contact water within the valley. Controlling hydraulic gradients is a technique that is consistent with regional practices for environmental protection. Controlling the hydraulic gradient is the only preventative measure to manage hydrogeological risks along the West Ridge, making it the best available technology. All other measures are actions to reduce seepage, but cannot eliminate the potential for off-site water quality impacts. The proposed alternative is consistent with past successful operations, and uses construction techniques that are reasonable and appropriate for the YDTI. Some additional incremental costs will be incurred during construction of proposed mitigation measures in order to improve performance of the facility and to protect the environment.

The upstream drain will be most protective if constructed at the lowest elevation possible given the limits imposed by the YDTI. This potential constraint was recognized several years ago prior to the last permit amendment, and the upstream drain is currently being constructed at a level that supports on-going filling of the YDTI.

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**ABBREVIATIONS**

ACC .....	Anaconda Copper Company
BMFOU .....	Butte Mine Flooding Operable Unit
DEQ .....	Montana Department of Environmental Quality
EL .....	Elevation
EOR .....	Engineer of Record
EPA .....	Environmental Protection Agency
GPS .....	Global Positioning System
HsB .....	Horseshoe Bend
IRP .....	Independent Review Panel
KP .....	Knight Piésold Ltd.
MCA .....	Montana Code Annotated
MR .....	Montana Resources, LLP
OMS .....	Operations Maintenance and Surveillance
ROD .....	Record of Decision
TAC .....	The Anaconda Company
US .....	United States
WTP .....	Water Treatment Plant
YDTI .....	Yankee Doodle Tailings Impoundment

## 1 – INTRODUCTION

### 1.1 GENERAL

Montana Resources, LLP (MR) operates an open pit copper and molybdenum mine located within the northeastern part of Butte, Montana. The operation includes a mill throughput of roughly 50,000 short tons per day and a small-scale leaching operation.

The Yankee Doodle Tailings Impoundment (YDTI) is the tailings storage facility for the mine. The YDTI was originally constructed in 1963 using rockfill obtained from Berkeley Pit stripping operations and has been continuously expanded to EL. 6,400 ft using rockfill from the Berkeley Pit (until 1982) and from the Continental Pit (beginning in 1986). The YDTI comprises a valley-fill style impoundment created by a continuous rockfill embankment as shown on Figure 1.1. The embankment is divided into three rockfill embankments according to the general geometry of each limb of the continuous embankment for descriptive purposes. These embankments are the:

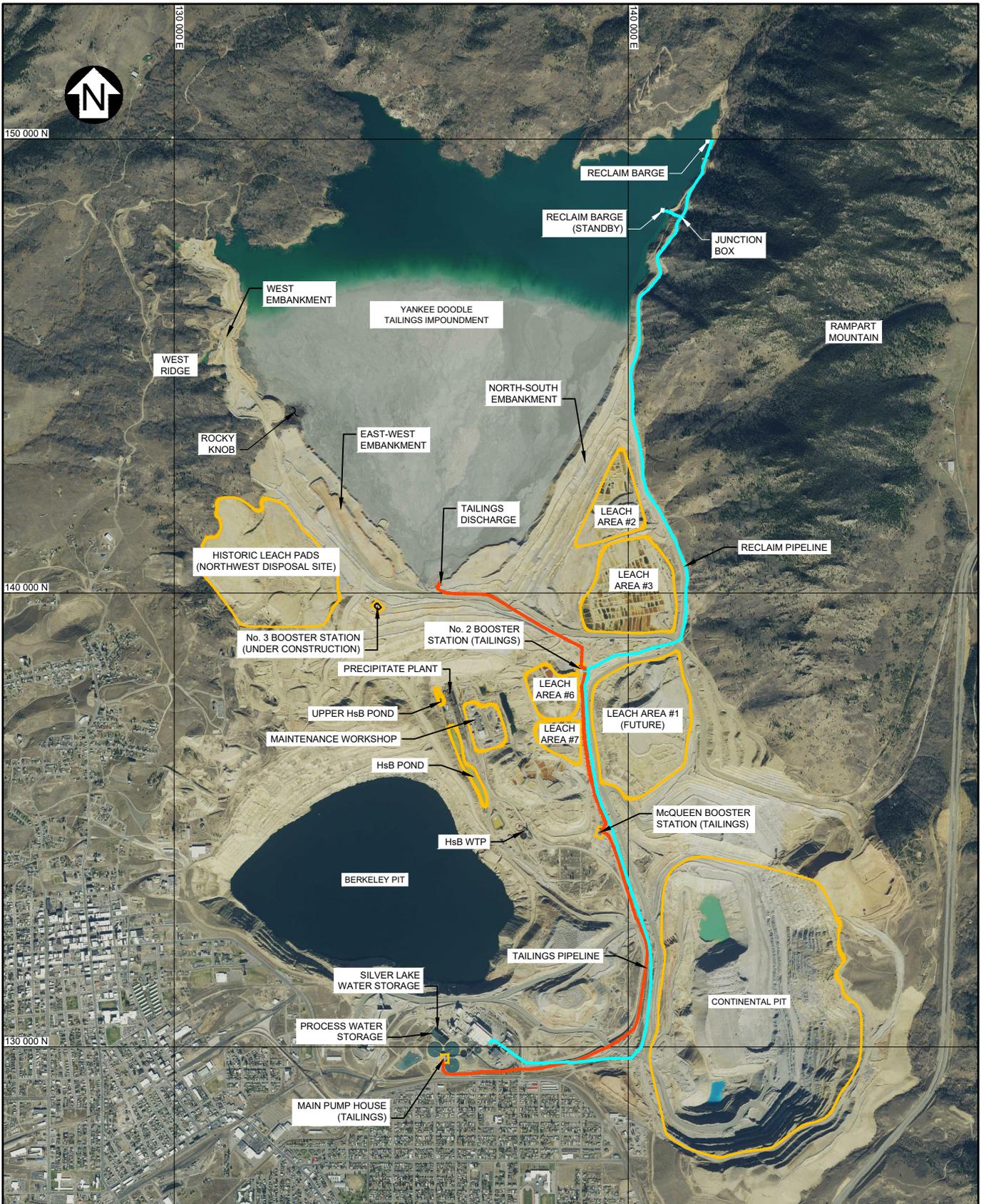
- North-South Embankment - The North-South Embankment forms the eastern to southeastern limb of the YDTI and runs approximately north to south in orientation. The North-South Embankment abuts onto the base of Rampart Mountain, forming the eastern limit of the MR mine site.
- East-West Embankment - The East-West Embankment forms the southwestern limb of the YDTI and runs approximately east to west in orientation. The East-West Embankment is constructed upstream of Horseshoe Bend and the Berkeley Pit.
- West Embankment - The West Embankment forms the western limb of the YDTI and runs approximately north to south in orientation. The West Embankment is constructed along the side of the West Ridge and forms the western battery limit of the facility.

Historically the YDTI has been constructed by progressively placing rockfill to form free-draining rockfill embankments. The rockfill comprises pit-run material end-dumped in 30 to 100 ft lifts with the mine haul fleet. Ripping of the completed lift surfaces has been commonly completed to enhance vertical infiltration. The embankment design incorporates a zone of fine-grained material (alluvium) placed on the upstream face of the embankment to limit tailings migration into the rockfill.

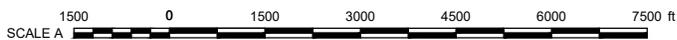
Tailings have been continuously discharged into the YDTI at a single point near the maximum section of the East-West Embankment since the initiation of MR mining operations in 1986. Supernatant water is reclaimed for re-use in the mill process from the northeast end of the YDTI using two floating barges. The tailings beaches and supernatant pond rise at an approximate rate of 6 ft per year due to filling of the impoundment. The supernatant pond is separated from the YDTI embankments by extensive tailings beaches. Property boundaries, topography along the west side of the YDTI, and the rise of the supernatant pond necessitated construction of the West Embankment beginning in 2016.

Seepage water flows through the free-draining rockfill embankments and discharges as a number of small seeps along the downstream toe of the East-West Embankment. Smaller flows of perched seepage (Seep 10) discharge at EL. 5,925 ft. The seepage flows are collected and conveyed to the leachate Precipitation Plant to recover copper. The seepage is then collected in the HsB Ponds, located immediately downstream of the East-West Embankment, treated in a water treatment plant before it is incorporated into the process water system.

▲ R2



- NOTES:**
- COORDINATE SYSTEM AND ELEVATIONS ARE BASED ON ANACONDA MINE GRID.



MONTANA RESOURCES, LLP	
YANKEE DOODLE TAILINGS IMPOUNDMENT	
PROJECT GENERAL ARRANGEMENT	
<b><i>Knight Piésold</i></b> CONSULTING	
PIA NO. VA101-126/12	REF NO. 4
<b>FIGURE 1.1</b>	
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## 1.2 PURPOSE AND SCOPE

The Continental Pit is currently being mined, and MR has sufficient reserves and the relevant operating permits for continued mining. The existing permitted disturbance boundaries of the YDTI will allow continued impoundment filling through 2020. Additional tailings storage is required for continued operations. A proposed permit amendment seeks sufficient storage for continued mining of the Continental Pit beyond 2020. This report, prepared by Knight Piésold Ltd. (KP), presents an examination of the available alternatives for tailings storage. ▲ R2

The purpose of the study is to identify the best tailings storage alternative that will allow MR to continue operation of the mine while limiting the potential of new environmental impacts or operational interruptions. The assessment includes consideration of safety, implications for the environment, technical and financial aspects, and closure.

## 1.3 LEGISLATED REQUIREMENTS

Montana Code Annotated (MCA) 82-4-376 describes the design document requirements for an operator proposing to expand an existing tailings storage facility and is the governing legislation for preparation of the expansion design (MCA, 2015). The requirements include:

*“an evaluation indicating that the proposed tailings storage facility will be designed, operated, monitored and closed using the most applicable, appropriate, and current technologies and techniques practicable given site specific conditions and concerns.”*

The legislation further defines the word “practicable” to mean the following:

*“Available and capable of being implemented after taking into consideration cost, existing technology, and logistics in light of the overall project purposes.”*

This assessment fulfills the above requirements of the legislation by comparing alternatives for the continued tailings storage in order to provide a transparent rationale for the selection of certain alternatives.

## 1.4 INDEPENDENT REVIEW PANEL

An Independent Review Panel (IRP) for the YDTI has been selected consistent with the requirements of MCA 82-4-376. The members of the MR IRP are as follows:

- Dr. Dirk Van Zyl
- Dr. Leslie Smith, and
- Mr. Jim Swaisgood.

## 1.5 ENGINEER OF RECORD

MCA 82-4-375 describes the requirement for an Engineer of Record (EOR). The EOR is required to be a Professional Engineer licensed in the State of Montana. The EOR for the YDTI is Mr. Ken Brouwer, P.E., of Knight Piésold Ltd.

The EOR is responsible for the following:

- Review the design and other documents pertaining to the tailings storage facility.
- Certify and seal designs or other documents pertaining to the tailings storage facility submitted to the Department of Environmental Quality (DEQ).

- Complete an annual inspection of the tailings storage facility.
- Notify the operator when credible evidence indicates the tailings storage facility is not performing as intended.
- Immediately notify the operator and the DEQ when credible evidence indicates that the tailings storage facility presents an imminent threat or a high potential for imminent threat to human health or the environment.

#### 1.6 COORDINATE SYSTEM

The existing YDTI and the design for increasing storage capacity of the YDTI reference the site coordinate system known as the 'Anaconda Mine Grid' established by The Anaconda Company (TAC) in 1957. The Anaconda Mine Grid is based on the Anaconda Copper Company (ACC) Datum established in 1915. All elevations are stated in Anaconda Mine Grid coordinates with respect to the ACC Vertical Datum unless specifically indicated otherwise. The Montana Resources GPS Site Coordinate System is based on the 'Anaconda Mine Grid' and utilizes International Feet.

## **2 – COMPARISON CATEGORIES AND RATING CRITERIA**

The alternatives assessment considers five categories to compare the relative merits and risks of development for each alternative. The purpose of the rating system is to examine the relative differences of the alternatives in each level of assessment. The categories are safety, technical execution, environmental, economic, and closure as shown in Table 2.1. Each alternative will be scored using the semi-quantitative rating criteria provided in the table. A discussion of the merits and risks of each alternative will be included with the selected rating criteria in the sections that follow.

The safety category is intended to differentiate alternatives that enhance safety characteristics of tailings storage. Preference is given to alternatives that would improve safety or maintain current safe characteristics, and are consistent with long-term operational experience of MR staff. Significant changes in performance requirements and increases to worker hazards are less preferable.

The technical execution category is intended to identify alternatives which have the most achievable implementation of the design and can be permitted without interrupting operations. Alternatives that would be easier to permit are more preferable than those that may require a longer permitting timeline. Novel or unconventional technology, or significant changes in the operating plan for the mine are less preferable because they have the potential to lead to extended permitting timelines and an interruption of operations.

The environmental category is intended to differentiate alternatives that are the least likely to have a new impact on environmental attributes in previously unaffected areas. Alternatives that would have minor increases to disturbance area and less potential for environmental effects are preferable. Large scale disturbances of previously undisturbed areas are less preferable, as is long-term impact to off-site water quality or other environmental attributes.

The economic category is intended to differentiate alternatives that maintain or improve current project economics. Increased costs may be considered acceptable if costs are reasonable and the expenditure improves performance in other categories. Alternatives that have the potential to affect profitability or viability of the operation are less preferable.

The closure category is intended to differentiate alternatives that require less incremental increase to reclamation requirements or can enhance closure characteristics of the facility. Alternatives that decrease achievability of reclamation objectives or substantially increase the area requiring reclamation are less preferable.

**Table 2.1 Rating Criteria**

Rating		Safety	Technical Execution	Environmental	Economic	Closure
Most Preferred  Least Preferred	1	Enhances safety characteristics of tailings storage. Operation, maintenance and surveillance (OMS) of facility unchanged and consistent with operator experience.	No permitting required to implement alternative or minor amendment with little supporting documentation.	Limited or no change to risk of impact to off-site water quality or other environmental attributes. Mitigation applied is the best available and limits potential risk off-site.	No cost to implement alternative.	Marginal or no change in reclamation requirements, progressive improvement to surface reclamation potential. Enhances passive management in closure.
	2	Minor to moderate modification to OMS using technologies and methodologies consistent with long-term experience.	Alternative is consistent with past successful operations and requires a permit amendment.	Expected moderate increase to risk of impact to off-site water quality or other environmental attributes without additional mitigation.	Cost to implement is favourable, and provides improvement in other categories.	Alternative requires minor to moderate alteration to closure and reclamation plan. Active management in closure required.
	3	Alternative alters performance requirements of facility such that long-term experience is no longer applicable and increases worker hazards.	Alternative introduces an unconventional technology or methodology which may lead to permitting complications (including potential for a brief shutdown of operations).	Substantial risk of long-term impact to off-site water quality or environmental attributes requiring permanent monitoring and possibly long-term water treatment.	Cost to implement feasible only with increased commodity value.	Reclamation objectives are significantly complicated by choice of alternative, and may not be achievable.
	4	Alternative increases risk of failure.	Permitting process will be complicated and may exceed 3 years, and could lead to long-term interruption of operations.	Irreparable damage, very serious long-term impact to off-site water quality, or large scale disturbance of previously undisturbed site.	Cost to implement exceeds threshold to continue operating.	Implementation of alternative substantially increases area requiring reclamation.

### 3 – LOCATION

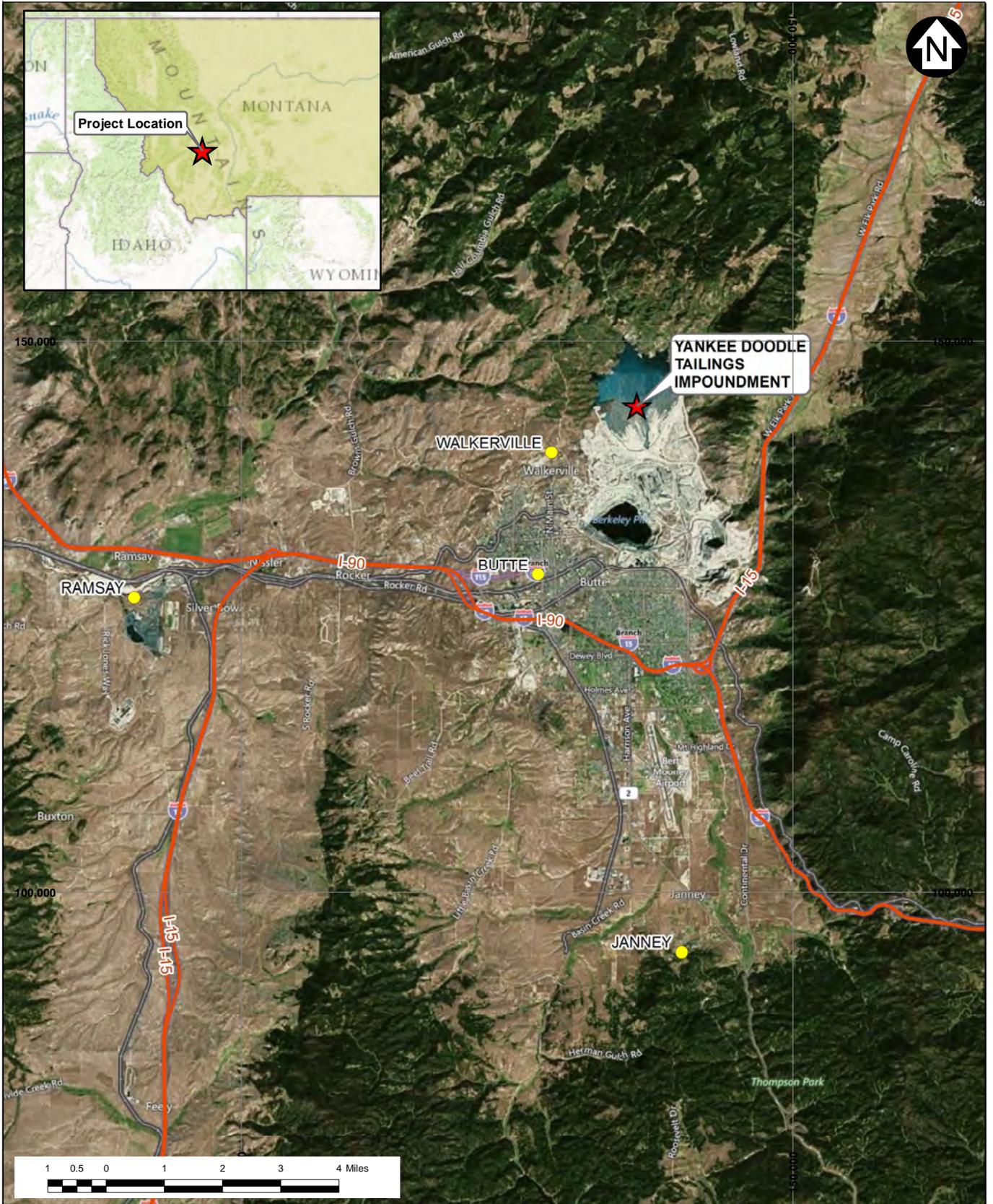
#### 3.1 GENERAL

The initial assessment was determination of the location for future tailings storage. There are fundamentally two options that exist for future tailings storage for MR. The capacity of the YDTI can be increased or an alternative location can be identified and constructed. An overview of the project location is shown on Figure 3.1.

There are many site selection limitations for options further afield that are imposed by the location of the project. The existing mine site is clustered in the northern part of Butte, and is bounded by Interstate 15 and the Continental Divide on the east, Moulton Reservoir Road on the west, and Farrell Street, Continental Drive and Shields Avenue to the south. The city of Butte and town of Walkerville border the mine property to the south and west limiting expansion of the mine site in these directions. Interstate 90 runs west towards Anaconda and subsequently north. Land ownership in this direction is largely privately held land with some State Trust Lands intermixed.

US Forest Service land wraps broadly around the municipal area of Butte to the south, east, and north. Development of a tailings facility towards the south beyond Butte would require traversing municipal and privately held lands with a tailings pipeline, and identifying a suitable location for a tailings facility in US Forest Service land beyond. The pipeline route would be long and land ownership issues would be restrictive. A pipeline corridor could potentially impact many local stakeholders, which substantially increases the risk of development in this direction. Potential development options are limited on the east by a steep ridge, known locally as the East Ridge, which in several places exceeds 8,000 ft in altitude and is dissected by numerous small streams. Interstate 15 runs to the north through this area towards Elk Park immediately east of the YDTI beyond Rampart Mountain. The majority of the land surrounding Interstate 15 is privately owned.

Moulton Reservoir Road runs north from Walkerville connecting to privately owned land parcels along the road upstream of the YDTI. The majority of the land north (upslope) of the YDTI is US Forest Service land. There appears to be limited land development outside of the land parcels along Moulton Reservoir Road; however, there are rural roads and trails interconnecting the area. The most logical direction to develop an alternative tailings storage location would be towards the north within the existing catchment areas upslope of the YDTI. Any potential development in this direction would be impacted by private land ownership and recreational outdoor land use. However, this location minimizes the potential impact on private and municipal lands relative to other off site options, and would position a potential new facility upslope of the environmental controls at the mine site below.



**LEGEND**

-  PROJECT LOCATION
-  CITY
-  ROAD

**NOTES:**

1. BASE MAP: (C) MICROSOFT BING MAPS.
2. COORDINATE GRID IS IN FEET. COORDINATE SYSTEM: MONTANA MINE GRID.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:150,000 FOR 8.5x11 (LETTER) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.

MONTANA RESOURCES, LLP

YANKEE DOODLE TAILINGS IMPOUNDMENT

**PROJECT LOCATION OVERVIEW**

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**FIGURE 3.1**

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## 3.2 ALTERNATIVES

### 3.2.1 Alternative A (On Site Storage)

Alternative A represents tailings storage in any location on the currently permitted mine site. The alternative primarily considers increased capacity and continued operation of the YDTI, and could also include alternative tailings storage concepts in another location largely within the MR property boundary. Alternative A has been rated using the criteria in Table 2.1 assuming that the YDTI would be the best alternative for increased tailings storage capacity on site.

The existing site has an extensive history of operation spanning over five decades and multiple operators. The features of the YDTI that are important to the stability and safety of the impoundment are well understood. The embankments have been constructed almost continuously since early in the 1960s using rockfill borrowed during mining of the open pits. Continued use of the YDTI would be largely consistent with long-term operator experience, although there could be minor modifications to operating procedures to enhance safety of the impoundment.

Increasing the capacity of the YDTI is consistent with the existing operating plan for the mine. Additional disturbance area will require a permit amendment and possibly minor adjustments to property boundaries. The additional disturbance is limited for this option compared to an off-site option, and requires no large scale disturbance of previously undisturbed areas. There may be incremental increases to visual and noise related environmental effects. Without engineering mitigation, construction above the lowest point on the West Ridge has the potential for additional incremental risks for impacts to off-site water quality.

The economics of continued development and use of the YDTI are favorable in current market conditions and the profitability and viability of the operation can be maintained.

Continued use of the YDTI would remain consistent with previous closure plans for the site. There will be incremental increases to total embankment and tailings beach areas requiring reclamation, and also opportunities for progressive improvements to surface reclamation potential through development of additional rockfill disposal sites in the vicinity of historic leach pads downstream of the North-South Embankment. The increased rockfill in this area will make possible the inclusion of a closure spillway in the future, which will enhance safety of the facility in the long-term. However, the long-term management of water quality in the West Ridge area would complicate reclamation objectives without further mitigation.

### 3.2.2 Alternative B (Off Site Storage)

Alternative B represents a new tailings storage in any location outside of the currently permitted mine site. Conceptually, a newly developed tailings disposal facility located to the north upslope of the existing YDTI could be identified, designed, permitted and constructed. However, any of the off-site options described in Section 3.1 have limitations imposed by the project location and surrounding development.

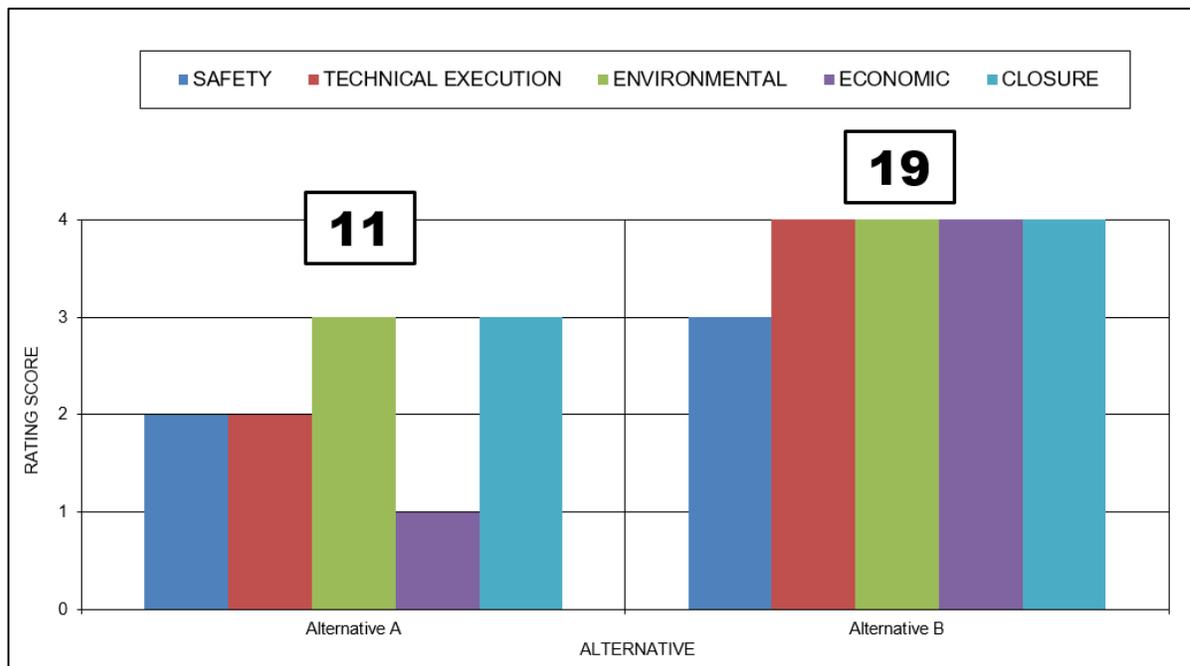
A new tailings facility located anywhere would fundamentally change the risk of tailings management. Any new site would add to the project risk portfolio and negate the long-term experience of operating the current facility. Land ownership and topographic constraints limit the possibility of development in most directions. The timeline to locate, investigate, design, permit and construct a new facility could

easily exceed 3 years, which would likely lead to at least a temporary interruption of operations. It is possible that a new site would be difficult or even impossible to permit, or that the local site conditions would not be conducive for development of a suitable tailings facility.

Any new development would likely result in large scale disturbance of a previously undisturbed site coupled with land ownership issues, and would require substantial increases to areas requiring reclamation after mine closure. The capital costs to develop a new location, including investigation, engineering and construction could be enormous. Operating costs would also increase in order to distribute tailings to a new location, and for continued construction of the new tailings facility. Construction materials would have to be sourced locally (with associated disturbance areas) or hauled long distances from the Continental Pit. There would also be continued land disturbance associated with the disposal of non-ore rock from the Continental Pit. The cost to develop a new tailings facility would likely substantially impact the profitability and viability of continued operations.

### 3.3 RESULTS

The two alternatives were ranked based on the rating criteria outlined in Table 2.1 and the results are shown on Figure 3.2.



**Figure 3.2 Future Tailings Storage Location Alternatives Rating Summary**

The best location for continued tailings storage is on site. This option leverages the existing knowledge of the project area and the extensive experience of the operator. The mine facilities will remain clustered within the mine site area and does not require substantial additional disturbance of previously undisturbed areas. The cost to implement the alternative is more favorable and the permitting and social issues should be less than other options.

**4 – TAILINGS MANAGEMENT**

**4.1 GENERAL**

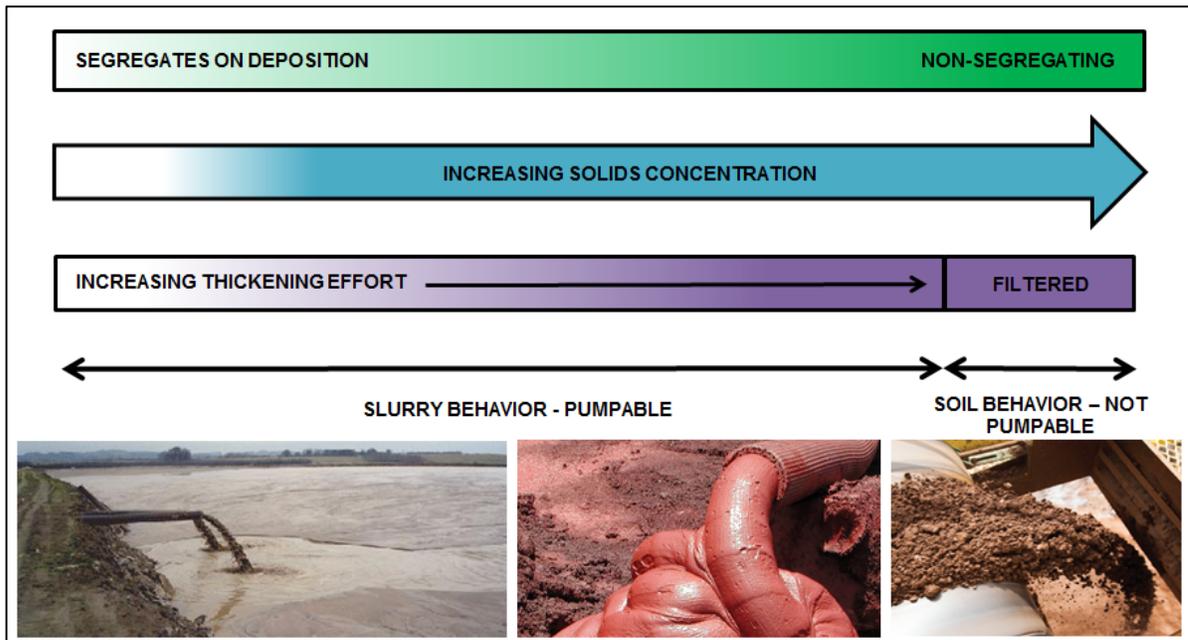
The second level of assessment accepts that the best location for continued tailings storage is on the existing mine site. Tailings are currently deposited into the YDTI as a slurry from a single location at the southern point of the impoundment. This assessment evaluates options for tailings processing and distribution to determine the most appropriate and applicable technique to move forward with considering alternative tailings technologies, site history, logistics and cost.

The description of alternatives for tailings management considers the hydrogeological conditions on the West Ridge only in generalities. Alternatives for the design of the West Embankment to manage hydrogeological risks will be evaluated further in Section 5.

Mine tailings can be produced according to a range known as the tailings continuum, which qualitatively describes tailings solids content, thickening effort (and/or dewatering) required, behavior/method of conveyance, and segregation during placement. The tailings continuum is shown on Figure 4.1. Certain points within the tailings continuum were selected to develop alternatives for this study. The following sections provide a general description of each of the tailings processing and distribution alternatives referenced in this assessment.

The alternatives evaluated in this report are based on capacity for storage of 300 million short tons of tailings produced at 50,000 tons/day. The storage requirements for alternatives considering slurry tailings were evaluated based on an average initial settled density of 1.15 tons/yd<sup>3</sup>. The storage requirements for alternatives considering filtered tailings were based on an in place average density of 1.25 tons/yd<sup>3</sup>. The volumetric storage requirements based on these densities are 260 and 240 million cubic yards (Myd<sup>3</sup>) for slurry tailings and filtered tailings, respectively.

▲ R2



**Figure 4.1 Tailings Continuum**

## 4.2 TAILINGS TECHNOLOGIES

▲ R2

### 4.2.1 Slurry Tailings

Slurry tailings are a mixture of water and the ground tailings after ore processing, and are typically transported by pipeline to a final storage location using pumps or gravity flow. MR currently produces tailings with a gravimetric solids content of approximately 35%. The tailings distribution system is comprised of tailings pumps, booster stations, and pipelines. The system conveys tailings from the Concentrator to the YDTI. Tailings are currently discharged from a single point at the southern end of the YDTI and settle at a shallow beach slope that grades away from the discharge point. The tailings material segregates upon deposition with the coarsest sand particles settling near the discharge point and finer sands settling farther down slope. Finer silt and clay sized tailings particles are carried out into the supernatant pond in suspension and settle over a longer period of time.

### 4.2.2 Thickened Slurry Tailings

Slurry tailings can be thickened by removing water from the slurry. Thickened slurry tailings typically have a gravimetric solids content in excess of 45%. Tailings can be thickened to a paste with certain additives. The paste point of tailings depends on tailings grain size, mineralogy, specific gravity, and other characteristics. Generally, the term paste only applies if certain yield stress criteria are met and these criteria can be difficult to achieve in practice. Thickened tailings require less water to be cycled through the tailings distribution and reclaim water systems, more pumping effort with different pumps, and the tailings tend to segregate less after discharge. The initial settled density and final consolidated density of tailings are largely unaffected by the solids content of a tailings slurry at discharge. The main benefit to thickening tailings is a reduction in reclaim water that is recycled from the tailings facility.

### 4.2.3 Filtered Tailings

The term “filtered tailings” describes tailings that are mechanically dewatered to a point at which they will no longer be considered slurry and will behave as a soil. Mechanical dewatering can be achieved through a variety of technologies including both vacuum and pressure filtration processes. Filtered tailings were assumed to be dewatered to a moisture content of approximately 15% for the MR site. Characteristics of a flowing slurry do not apply to a soil; however, if these characteristics were applied to the filtered tailings it will equate to a gravimetric solids content of approximately 80 to 85%.

The tailings filtration process will encounter conditions where the plant is unable to provide material dewatered to the design moisture content at times, whether for maintenance or due to changes in tailings grind. These conditions are referred to as ‘upset conditions’. An alternative using filtered tailings storage requires a location designated for storage of slurry tailings during upset conditions, which for this study is assumed to be an area within the YDTI.

## 4.3 TAILINGS MANAGEMENT ALTERNATIVES

The second assessment was to determine the type of most practicable alternative for future tailings management. The alternatives selected for comparison were:

- Alternative A1: Continue to operate using the current tailings slurry arrangement by piping and pumping tailings to a single discharge point in the YDTI.

- Alternative A2: Continue to operate using the current tailings slurry arrangement and configure the tailings distribution system to include multiple discharge points.
- Alternative A3: Modify tailings processing and distribution to pump a thickened tailings slurry to the YDTI.
- Alternative A4: Mechanically filter and stack dewatered tailings on or around the existing YDTI.

#### 4.3.1 Alternative A1

Alternative A1 is to increase storage capacity at the YDTI and continue deposition of tailings slurry from a single discharge point at the center of the embankment. This option is consistent with the operational practices of the past few decades. Construction of the YDTI embankments would remain consistent with historic practices. The embankments would be constructed of pit-run rockfill placed in 50 ft-thick lift(s) using downstream and centreline construction methods.

▲ R2

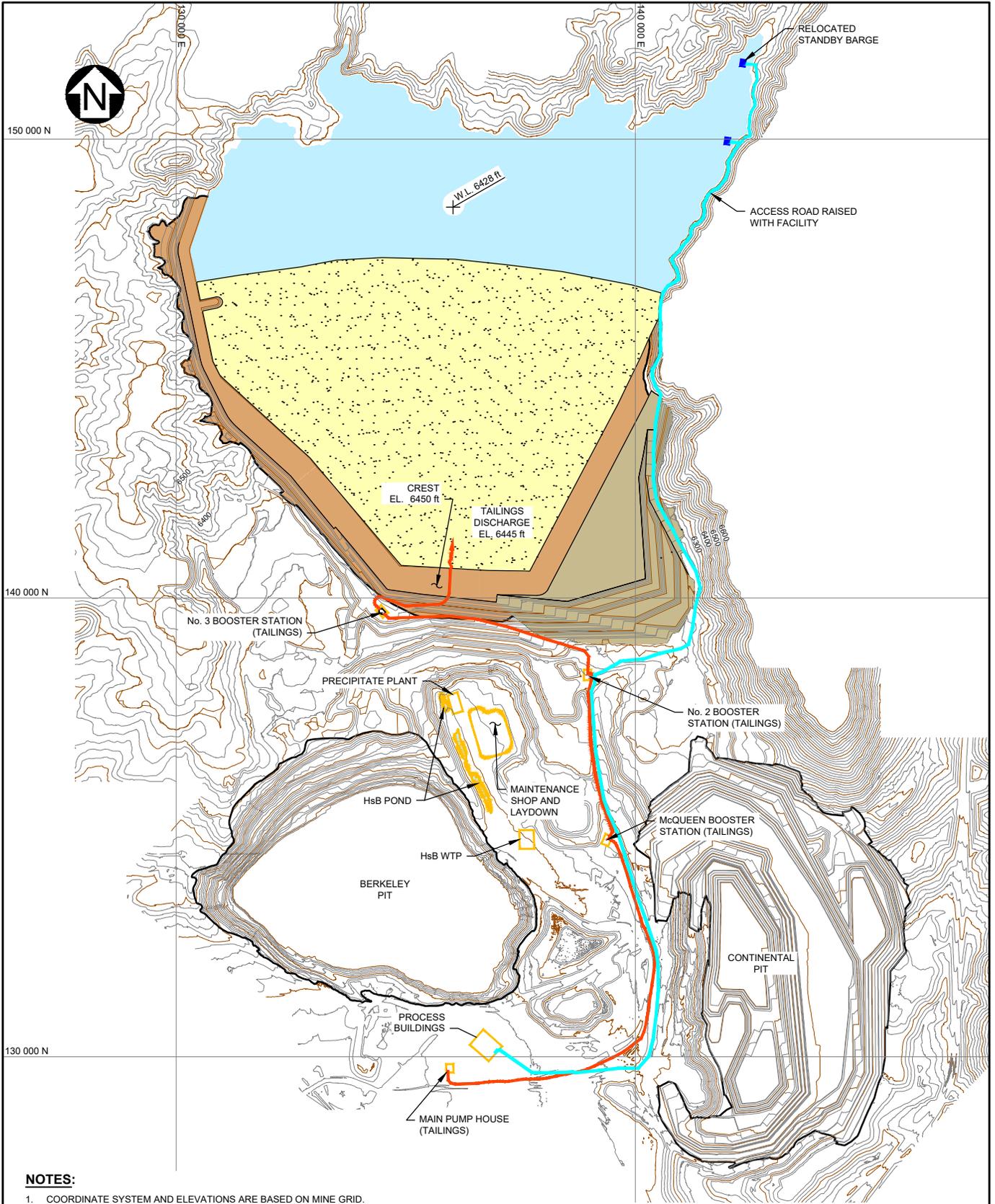
Tailings distribution would continue to follow existing practices using a single discharge point. The tailings beach would continue to develop as a cone-shaped alluvial fan with a well drained tailings beach adjacent to the highest sections of the embankment as shown on Figure 4.2. The incremental cost to implement this alternative would be the lowest of all alternatives.

The supernatant pond would be managed in the northern end of the facility, but would be expected to be in contact with a portion of the West Embankment. The closure and reclamation objectives would be complicated by the final position of the supernatant pond. The pond water level would rise to a level that could lead to greater seepage loss along the West Embankment. Long-term risk for impact to off-site water quality could be expected without additional engineering mitigation. There would be marginal increases in area requiring reclamation, but the long-term management of water quality in the West Ridge area would complicate reclamation objectives. The rating of Alternative A1 is consistent with Alternative A, and represents essentially no change from the current operating plan.

#### 4.3.2 Alternative A2

Alternative A2 is a variation of Alternative A1 with one fundamental change. The tailings distribution system would be modified such that tailings would be deposited from multiple locations during future operation of the facility to develop extensive tailings beaches adjacent to all of the embankments. The development of the tailings beaches in this manner would remain consistent with long-term operator experience and would enhance the safety characteristics of the YDTI. There would be some increased costs to expand the tailings distribution system, although the costs would not be prohibitive. A conceptual arrangement of Alternative A2 is shown on Figure 4.3.

Development of the tailings beaches in this manner would reduce the potential for seepage towards the west as compared to Alternative A1. The modified closure and reclamation plan would be generally consistent with the current plan.

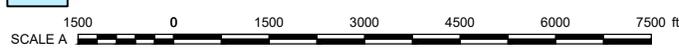


**NOTES:**

- 1. COORDINATE SYSTEM AND ELEVATIONS ARE BASED ON MINE GRID.

**LEGEND:**

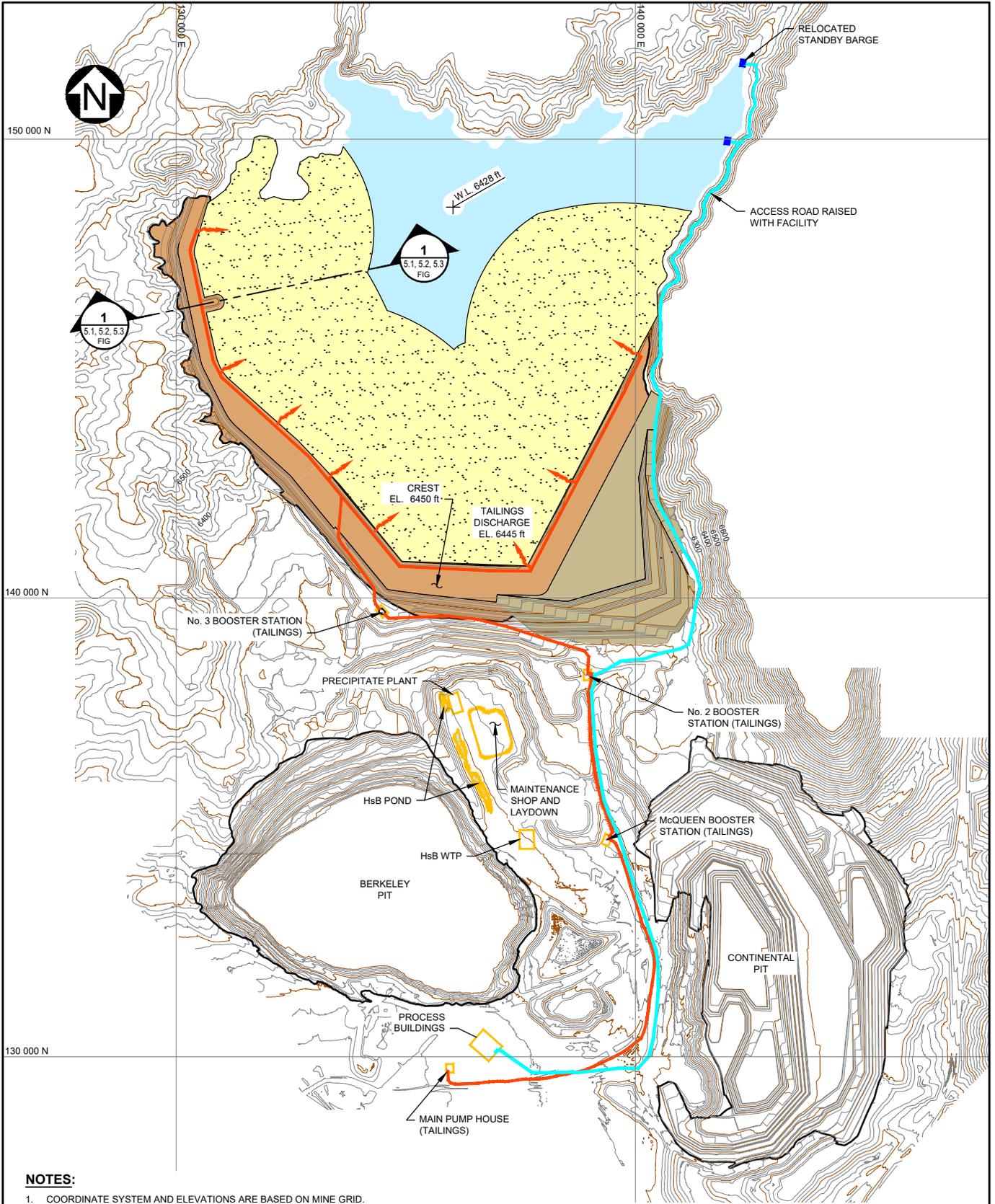
	TAILINGS BEACH		TAILINGS DEPOSITION
	EMBANKMENT FILL		TAILINGS PIPELINE
	ROCK DISPOSAL SITE		RECLAIM PIPELINE
	MINE WATER		RECLAIM BARGE



MONTANA RESOURCES, LLP	
YANKEE DOODLE TAILINGS IMPOUNDMENT	
<b>ALTERNATIVE A1 SLURRY TAILINGS SINGLE DISCHARGE POINT</b>	
<i><b>Knight Piésold</b></i> CONSULTING	PIA NO. VA101-126/12 REF NO. 4
FIGURE 4.2	REV 1

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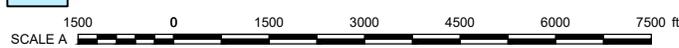


**NOTES:**

1. COORDINATE SYSTEM AND ELEVATIONS ARE BASED ON MINE GRID.

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|--|--------------------|--|---------------------|
|  | TAILINGS BEACH     |  | TAILINGS DEPOSITION |
|  | EMBANKMENT FILL    |  | RECLAIM PIPELINE    |
|  | ROCK DISPOSAL SITE |  | RECLAIM BARGE       |
|  | MINE WATER         |  |                     |



MONTANA RESOURCES, LLP	
YANKEE DOODLE TAILINGS IMPOUNDMENT	
ALTERNATIVES A2 AND A3 SLURRY TAILINGS MULTIPLE DISCHARGE POINTS	
<b><i>Knight Piésold</i></b> CONSULTING	P/A NO. VA101-126/12
REF NO. 4	REV 1
<b>FIGURE 4.3</b>	

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 1 06JUN17 ISSUED WITH REPORT DBR RMM/JC DDF  
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#### 4.3.3 Alternative A3

Alternative A3 is to modify tailings processing and distribution to pump a thickened tailings slurry to the YDTI. A tailings thickener would need to be added at the back end of the process. The tailings thickener would conceptually be located in the vicinity of the concentrator buildings. The tailings distribution system would be modified in a similar manner as Alternative A2 and tailings would be deposited from multiple locations during the continued construction and use of the facility. This alternative would conceptually look the same as Alternative A2, as shown on Figure 4.3, because the ultimate consolidated density of the tailings is largely unaffected by the solids content of a tailings slurry at discharge.

The existing tailings distribution system pumps and pipelines would need to be replaced to distribute thickened tailings. The cost would be considerable without an offsetting benefit to balance the incremental capital and operating costs of the change. The reclaim water system is already in place, and therefore no offsetting benefit can be realized by reducing the size of that system. Tailings would segregate less during deposition; however, tailings beaches could still be developed. There would be no expected detriment or benefit to environmental attributes or closure objectives compared to Alternative A2 as a result of thickening the tailings. The change would essentially be an expenditure of capital to retrofit the tailings distribution system with no substantial offsetting benefit to the project.

#### 4.3.4 Alternative A4

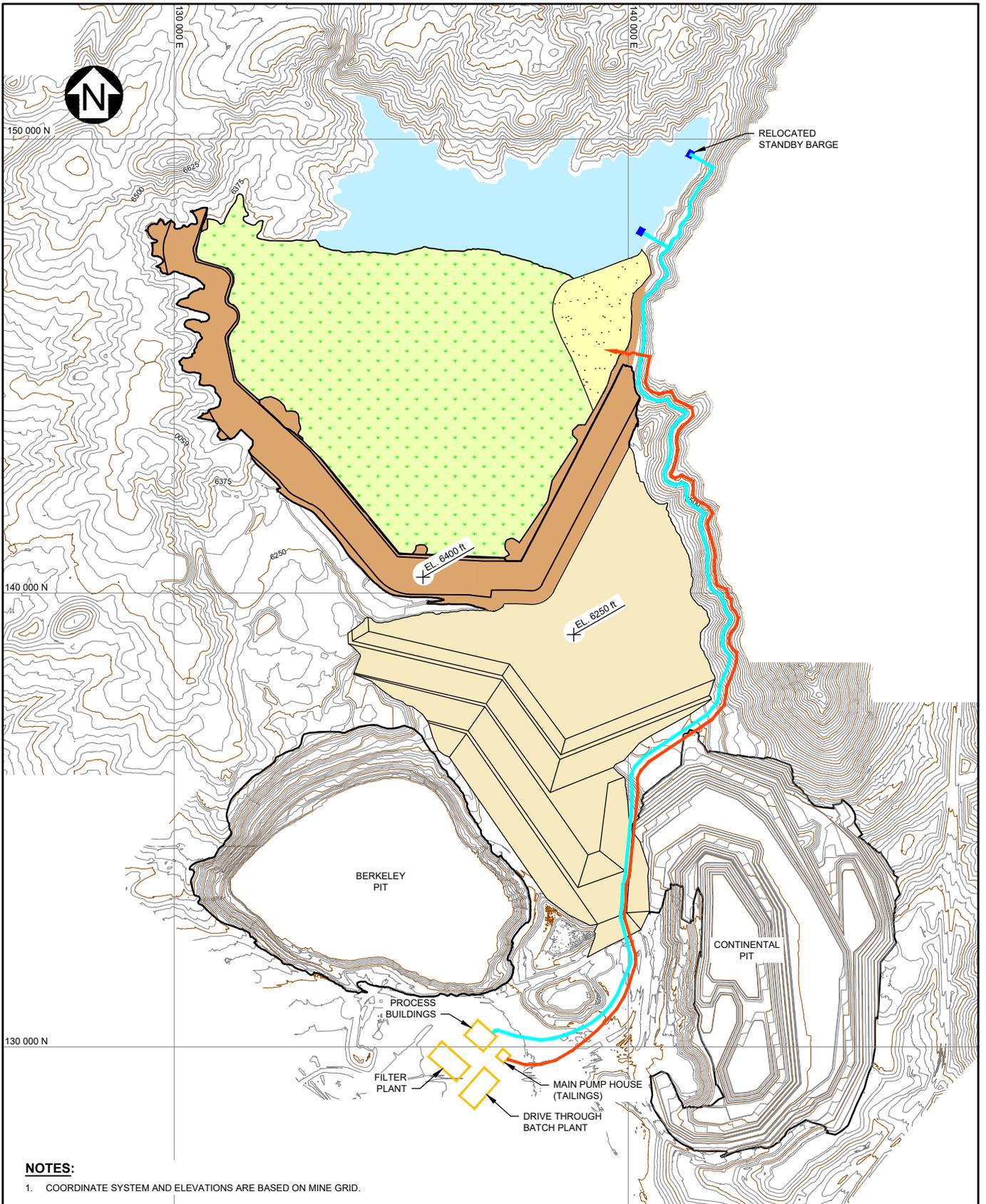
Alternative A4 considered in this comparison is to modify the tailings processing and distribution infrastructure to produce and stack filtered tailings within the currently disturbed mine site area. A tailings thickener and filtration plant would need to be added at the back end of the process to produce filtered tailings. Tailings would then be distributed by conveyor or truck to the disposal area. A filter plant capable of dewatering tailings at the rate required for the project exceeds the current industry precedent; however, the increase in scale of filtration alone is probably not insurmountable.

The outer edge of the tailings pile would be compacted and armored with rockfill to reduce erosion, improve stability, and to facilitate reclamation. An area within the tailings stack would be designated for tailings that do not meet the required moisture content for optimum compaction in the structural areas, to allow ongoing placement during precipitation events and freezing conditions. The existing pond at the northern end of the YDTI would be maintained for additional reclaim water, storage of storm water and storage of slurry tailings during upset conditions at the filtration plant. Water removed during filtration will be sent back the mill for reuse in processing. Water from the storage pond will be reclaimed for use in processing as a supplement to water recovered during filtration.

A conceptual arrangement demonstrating the storage requirements necessary to dispose of filtered tailings in the mine site area is shown on Figure 4.4. Approximately 240 million cubic yards of storage would be required to store tailings produced through Year 2031. Filtered tailings could fill the entire area between the existing YDTI and extend into the McQueen area of the mine site between the Berkeley and Continental Pits. The filtered tailings stack would conceptually cover the Precipitation Plant, Maintenance Shop and Laydown Area, and the Horseshoe Bend (HsB) Water Treatment Plant (WTP). The stack would reach in excess of 550 ft high. Non-ore rock mined from the Continental Pit would be disposed with the tailings or on the surface of the existing YDTI.

▲ R2

▲ R2

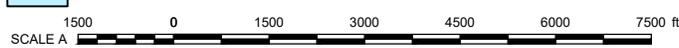


**NOTES:**

- 1. COORDINATE SYSTEM AND ELEVATIONS ARE BASED ON MINE GRID.

**LEGEND:**

	TAILINGS BEACH		TAILINGS DEPOSITION
	FILTERED TAILINGS		TAILINGS PIPELINE
	RECLAIMED TAILINGS BEACH		RECLAIM PIPELINE
	MINE WATER		RECLAIM BARGE



<b>MONTANA RESOURCES, LLP</b>							
<b>YANKEE DOODLE TAILINGS IMPOUNDMENT</b>							
<b>ALTERNATIVE A4 FILTERED TAILINGS</b>							
<b><i>Knight Piésold</i></b> CONSULTING	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="font-size: small;">PIA NO. VA101-126/12</td> <td style="font-size: small;">REF NO. 4</td> </tr> <tr> <td colspan="2" style="text-align: center;"><b>FIGURE 4.4</b></td> </tr> <tr> <td style="font-size: x-small;">REV</td> <td style="text-align: center;">1</td> </tr> </table>	PIA NO. VA101-126/12	REF NO. 4	<b>FIGURE 4.4</b>		REV	1
PIA NO. VA101-126/12	REF NO. 4						
<b>FIGURE 4.4</b>							
REV	1						

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A variation of the arrangement of this alternative includes filtered tailings placement on a portion of the existing YDTI surface in addition to placement downstream of the embankment. Placement over the existing tailings surface would require equipment and workers to be present regularly on the surface of the YDTI, which would increase worker hazards. Initial transition to this concept would require careful equipment trafficking, tailings placement, and monitoring the response of the existing in-place tailings. Filtered tailings placement would not be possible near the existing supernatant pond where the slimes have accumulated, substantially limiting the storage capacity on the existing facility.

There are many issues associated with the development of this alternative. Distribution using a truck fleet would at least double the existing truck fleet and the fuel needs, increasing greenhouse gas emissions. The capital cost to construct a filter plant of this capacity and purchase equipment to move the tailings would be expected to be in excess of a hundred of million dollars. Operating costs would also increase substantially due to the energy required to dewater the tailings and the fuel and maintenance costs for the new truck fleet. The risk of blowing dust would increase for this alternative compared to other alternatives. The closure objectives for the entire site would be fundamentally altered by pursuing this alternative. Stability of the disposal site and the potential impact to other facilities would need to be considered carefully. The ultimate size of the filtered tailings pile would substantially exceed any existing precedent by nearly an order of magnitude. The rate of rise in the maximum section would be on the order of 30 ft per year and would have the potential for development of saturated conditions and excess pore pressures due to the rapid rate of construction and due to water entrainment due to snow or rainfall events. The entrainment of snow and/or excess pore pressure development could impact the stability of the pile in the short and long-term. The pile position adjacent to both open pits would add loading to the surface in these areas and could potentially impact pit wall stability. The seismicity of the area and the presence of the Continental Fault is also a consideration.

#### 4.3.5 Tailings Storage in Berkeley Pit

Tailings storage in the Berkeley pit was not considered directly in the assessment due to existing regulatory requirements and judicial commitments, and the potential for loss of resources. ▲ R2

Although the Berkeley Pit is located within MR's mine permitted area, it is also located within the Butte Mine Flooding Operable Unit ("BMFOU") to the Silver Bow Creek/Butte Area National Priorities List (NPL) Site and subject to Environmental Protection Agency (EPA) jurisdiction and requirements. According to EPA, the Berkeley Pit is the major feature in the BMFOU. In 1994, the EPA, with the concurrence of the State of Montana, selected a remedy to address the contaminated water reporting to the Berkeley Pit from hydraulically connected underground mine workings, and alluvial and bedrock aquifers. To prevent a reversal of the hydraulic gradient (allowing water to leave the pit), EPA and the State determined that the water level in the Berkeley Pit must be maintained below the critical water level of 5,410 ft (United States Geological Survey Datum). That determination was made in compliance with the Comprehensive Environmental Response Compensation and Liability Act and is documented, along with other remedy requirements, in the 1994 Record of Decision ("BMFOU ROD"). The remedy and remedy requirements were predicated upon an analysis of rising water levels and the control of surface inflows to the Berkeley Pit. At the time it was anticipated that the Berkeley Pit would be used for the containment of water and not for future tailings storage purposes.

In 2002 MR and others ("Settling Defendants") agreed to implement the remedy set out in the BMFOU ROD. That agreement (including the BMFOU ROD) was lodged in the federal District Court for the

District of Montana on March 25, 2002. The Consent Decree was approved by the Court on August 14, 2002. The Settling Defendants are bound to follow the Consent Decree which provides for stipulated and other penalties in the event of non-compliance. The use of the Berkeley Pit for tailings storage would require a change to both the BMFOU ROD and Consent Decree.

The use of the Berkeley Pit for tailings storage would also obstruct access and the potential for future exploration of a significant mineral resource. ▲ R2

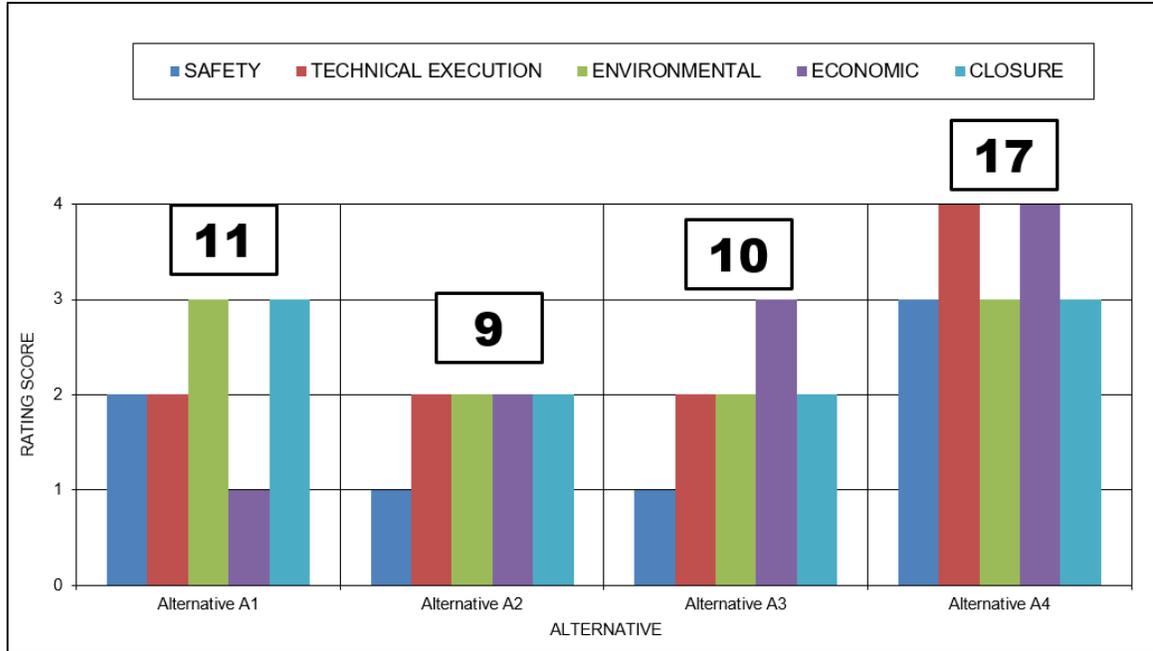
#### 4.3.6 Selection of the Design Embankment Elevation for Permit Amendment ▲ R2

Two potential design crest elevations were considered for the permit amendment application. One option was to construct the embankments to a crest elevation of 6,450 ft, which is consistent with the elevation currently permitted for the North-South and East-West Embankments, and to amend the permit to commence operation of the West Embankment Drain (WED). The other option considered was to propose a permit amendment to increase the permitted embankment crest elevation and associated disturbance boundaries to EL. 6,500 ft. The option to amend the permit for continued use of the YDTI up to EL. 6,450 ft and to operate the WED was selected for the following reasons:

- Site investigation programs and installation of new monitoring instrumentation may inform future design considerations for the YDTI.
- There is the potential for future land acquisition that may impact the design of the embankments for the YDTI.
- The option of Berkeley Pit tailings storage, despite the complex jurisdictional and logistical issues, may influence future needs for tailings storage in the YDTI and should be evaluated further in conjunction with multiple stakeholders.
- The total remaining ore reserves should be considered in the assessment of future tailings storage alternatives including use of the Berkeley Pit and YDTI, both together and separately, and the proposed permit amendment allows time to fully execute the land acquisition as well as conduct the alternatives assessment.

4.4 RESULTS

The four alternatives were ranked based on the rating criteria outlined in Table 2.1 and the results are shown on Figure 4.5.



**Figure 4.5 Tailings Management Alternatives Rating Summary**

Presently, the only practicable solution for additional storage capacity on site is to increase storage capacity at the YDTI. The best alternative for increasing storage capacity at the YDTI is Alternative A2, which includes modifying the tailings distribution system to develop multiple discharge points along the entire embankment. This modification will allow development of tailings beaches separating the supernatant pond from the embankment in all areas, which enhances the safety characteristics of the facility and reduces the potential for seepage impacts at the West Embankment compared to the single discharge point option. There is an increased cost to implement this alternative. The cost is acceptable because it improves performance of the facility, decreases potential impacts to the environment in the short term, and reduces the potential for complications in the long-term following closure.

## 5 – WEST EMBANKMENT DESIGN

### 5.1 GENERAL

The third level of assessment accepts that the only practicable solution for increasing tailings storage capacity is the YDTI. The best way to increase storage capacity at the YDTI is to use multiple discharge points to develop tailings beaches along the full embankment length. Development of the tailings beaches in this manner reduces the potential for seepage towards the west; however, seepage would still be expected.

The West Embankment forms the western limb of the YDTI and runs approximately north to south in orientation. The West Embankment is constructed into the side of the West Ridge and forms the western battery limit of the facility. The presence of a mounded water table in the groundwater system along the West Ridge has been evaluated in several site investigation programs and is a focus of ongoing groundwater monitoring by MR. These investigation programs and the resulting interpretation of the hydrogeological conditions in the West Ridge are described in the Site Characterization Report (KP, 2017a). The groundwater elevations are shown to be depressed within a saddle in the central portion of the West Ridge as indicated by the groundwater level measurements. The pond elevation within the future YDTI will rise above the lowest groundwater level measurements on the West Ridge. If the tailings and/or supernatant pond are allowed to accumulate against the natural topography higher up, the hydraulic gradient could reverse in this area and seepage from the impoundment could migrate to the west of the MR property boundary. This would potentially impact water quality and other environmental attributes outside of the mine site area.

### 5.2 WEST EMBANKMENT DESIGN ALTERNATIVES

This assessment considers the potential design alternatives for the West Embankment in order to determine the most applicable and appropriate design to manage hydrogeological risks in the West Ridge area while increasing the capacity of the YDTI. The alternatives selected for comparison were:

- Alternative A2-1: Free draining rockfill embankment with no zonation
- Alternative A2-2: Reduction of seepage using an embankment with core zone and/or foundation cut-off, and
- Alternative A2-3: Prevention of seepage using an embankment with an upstream drain to maintain an easterly hydraulic gradient towards the YDTI.

#### 5.2.1 Alternative A2-1 (Free Draining Embankment)

This option is consistent with the operational practices of the past few decades. Construction of the YDTI embankments would remain consistent with historic practices. The embankments would be constructed of pit-run rockfill in a 50 ft-thick lift using downstream and centreline construction methods. The tailings distribution system would be modified such that tailings would be deposited from multiple locations during the use of the facility to develop extensive tailings beaches adjacent to all of the embankments. The development of the tailings beaches in this manner would remain consistent with long-term operator experience and would enhance the safety characteristics of the YDTI. There will be an increased cost to re-configure the tailings distribution system; however, the cost would be the lowest compared to the other options.

▲ R2

Rocky Knob is a topographic feature that separates the East-West and West Embankments at the current crest elevation as indicated previously on Figure 1.1. This topographic feature extends eastward into the tailings facility underlying the tailings and restricts southward groundwater flow. The historic drainages prior to the development of the YDTI were likely infilled with recent stream deposits, which have the capacity to carry some flow eastward to the historic confluence with Silver Bow Creek under the present day tailings facility and hence towards Horseshoe Bend. The future crest elevation will rise above Rocky Knob and the crest of the embankment will be continuous along its length as shown previously on Figure 4.3.

The free-draining rockfill embankments and coarse tailings beach will allow drainage to reach the underlying alluvium, thereby promoting some downward gradient within the tailings. However, a phreatic surface would be expected to develop and reverse the easterly hydraulic gradient within a portion of the West Ridge. Seepage from the impoundment would be expected to develop as shown on Figure 5.1 with some eventually reaching the downstream receiving environment beyond the West Ridge. A long-term impact to off-site water quality could be expected under these conditions without additional mitigation. Modifications to the closure and reclamation plan would likely require some long-term active management due to the potential for new water quality impacts. The permitting process would require evaluating the significance of these potential water quality effects, which would extend the permitting process compared to other alternatives. The permitting process would require impacts to off-site water quality to be mitigated. A permit could not be issued that had the potential to result in the exceedance of water quality standards. Collection of seepage within the ridge would likely be more expensive than preventing seepage into the ridge. The concept is not unconventional for the project given the long history of development, but it may be difficult to permit if a more conventional concept is practicable and more protective of the environment. There is a risk that permitting could be more difficult and extended timelines could potentially lead to a interruption of operations if the predicted environmental effects were deemed to be potentially significant.

#### 5.2.2 Alternative A2-2 (Core Zone and Foundation Cut-off)

This alternative introduces seepage control measures meant to reduce the quantity of seepage potentially leaving the YDTI and migrating westward off-site. A low permeability core zone and foundation cut-off (if appropriate) could be integrated into the design of the embankment as shown on Figure 5.2. These seepage reduction measures would lower the potential for seepage compared to Alternative A2-1, but would still allow the development of a hydraulic gradient to the west and the potential for seepage out of the facility. The seepage control measures contemplated are conventional and protective of the environment; however, there is uncertainty with the effectiveness of decreasing the hydraulic conductivity of bedrock below the values measured in the site investigation programs. The potential for environmental effects off-site would be reduced compared to the previous alternative. Some potential for seepage would still be possible and could influence the permitting timeline. A brief interruption of operations would be possible if the permitting timeline was extended for unforeseen reasons. The closure and reclamation plan would require minor to moderate alterations to support long-term water quality monitoring and may require the development of mitigation options for groundwater interception and/or treatment.

The embankment would be constructed using similar procedures to historic practices, but would have to be altered in the central portion to allow slower construction of the core zone. The constructability of the embankment would be affected and support from outside contractors to assist with the core

zone and foundation cut-off would likely be required. Earthfill materials to construct a core zone and appropriately graded filters are not readily available on site and would need to be produced at the mine or imported from other sources. The costs to construct this alternative would increase substantially.

### 5.2.3 Alternative A2-3 (Upstream Drain)

The third alternative is to construct an embankment that incorporates seepage control features to locally depress the water table on the western boundary of the impoundment, thereby maintaining the easterly hydraulic gradient within the West Ridge towards the YDTI. This can be achieved by incorporating an upstream drain and other independent systems to maintain hydraulic confinement of YDTI contact water within the valley. This concept is shown on Figure 5.3. Controlling the hydraulic gradient is the only preventative measure to manage hydrogeological risks on the West Ridge and provides the greatest protection to groundwater of the alternatives considered.

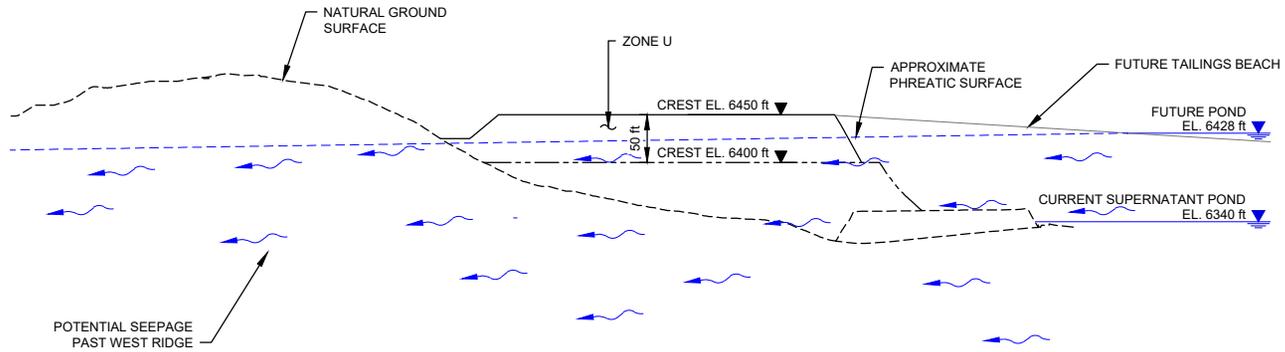
The embankment would be constructed using similar historic practices but with a free draining upstream zone (Zone U) and less permeable downstream zone (Zone D1). Zone U will be constructed in a manner that promotes infiltration of seepage into the upstream drain. Zone D1 will be constructed to act as an impediment to drainage and horizontal migration of perched seepage flow towards the downstream face of the embankment and to encourage free draining behavior in Zone U such that seepage flows are ultimately collected in the upstream drain. The majority of fill material for the embankment would be sourced from the Continental Pit.

The upstream drain will consist of a subsurface aggregate drain and appropriately graded filters, which will be located along the upstream toe of the West Embankment. Aggregates for drain construction will need to be imported from off the mine site. The drain will be graded at a decline from north to south, which will allow it to passively drain from the northern extent of the West Embankment (from the area known as 'Bum Town') southward along the West Embankment and through a rock cut beyond the topographic boundary known as Rocky Knob.

The costs to construct this alternative are favorable compared to Alternative A2-2, but will exceed the cost of the no mitigation option proposed in Alternative A2-1. Mining equipment can be used for the majority of construction. A contractor will be needed to perform the detailed excavation in the existing drainages and to construct the upstream drain. The mining equipment can perform the ongoing raises of the embankment once the drain is complete. Constructing the West Embankment so that seepage is contained within the facility will be cost effective and limits any requirements for off-site mitigation.

The alternative is consistent with past successful operations and will require a permit amendment. The permitting process should be simplified by demonstrating that the site conditions will be capable of supporting hydraulic confinement.

Constructing the West Embankment will require minor alteration to the closure plan to maintain drained conditions in the embankment over the long-term. There will be no significant change in the impacted area for the closure requirements with seepage constrained within the facility.



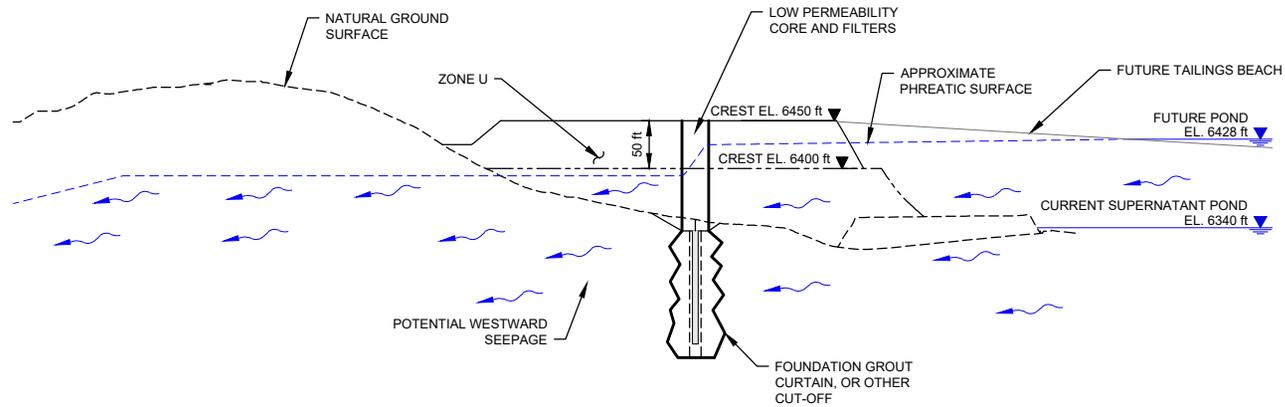
**1**  
4.3  
FIG SECTION  
NTS

**LEGEND:**

- WATER LEVEL (W.L.)
- GROUNDWATER FLOW DIRECTION
- CONCEPTUAL PHREATIC SURFACE

MONTANA RESOURCES, LLP			
YANKEE DOODLE TAILINGS IMPOUNDMENT			
<b>WEST EMBANKMENT DESIGN ALTERNATIVE A2-1 FREE DRAINING EMBANKMENT</b>			
<b><i>Knight Piésold</i></b> CONSULTING		P/A NO. VA101-126/12	REF NO. 4
		<b>FIGURE 5.1</b>	
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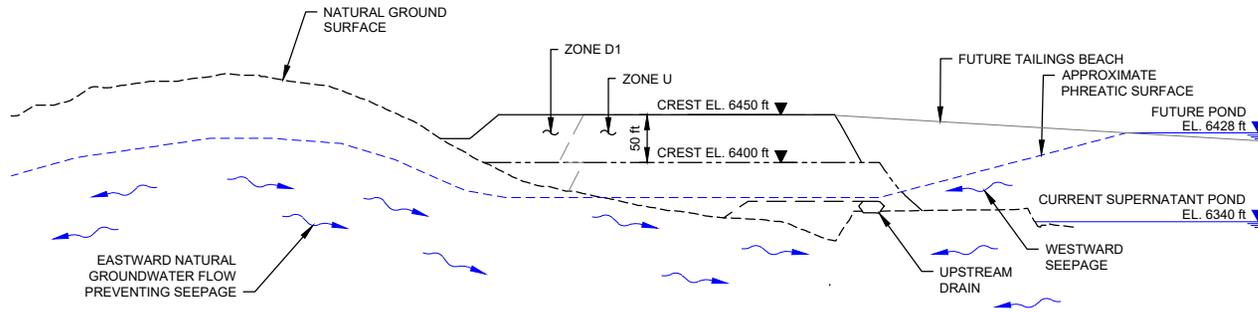
1 SECTION  
4.3 NTS  
FIG

**LEGEND:**

-  WATER LEVEL (W.L.)
-  GROUNDWATER FLOW DIRECTION
-  CONCEPTUAL PHREATIC SURFACE

MONTANA RESOURCES, LLP		
YANKEE DOODLE TAILINGS IMPOUNDMENT		
<b>WEST EMBANKMENT DESIGN ALTERNATIVE A2-2 CORE ZONE AND FOUNDATION CUT-OFF</b>		
<b><i>Knight Piésold</i></b> CONSULTING	P/A NO. VA101-126/12	REF NO. 4
	<b>FIGURE 5.2</b>	
		REV 1

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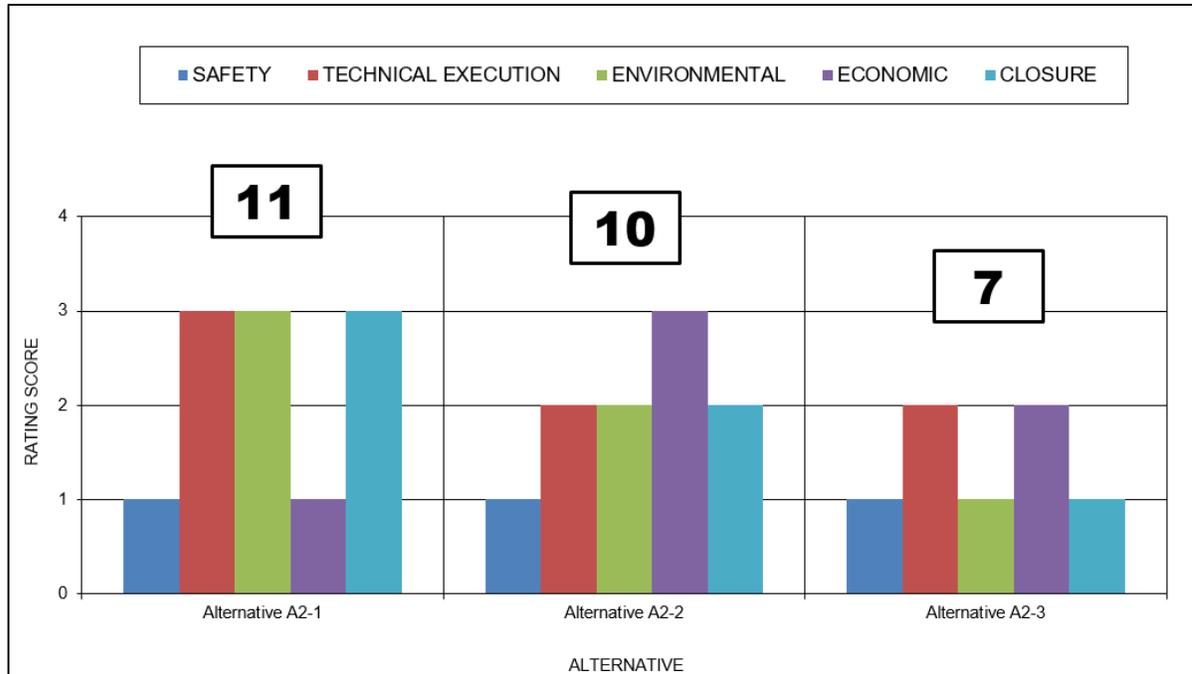
-  WATER LEVEL (W.L.)
-  GROUNDWATER FLOW DIRECTION
-  CONCEPTUAL PHREATIC SURFACE

MONTANA RESOURCES, LLP	
YANKEE DOODLE TAILINGS IMPOUNDMENT	
<b>WEST EMBANKMENT DESIGN ALTERNATIVE A2-3 UPSTREAM DRAIN</b>	
<b><i>Knight Piésold</i></b> CONSULTING	P/A NO. VA101-126/12
REF NO. 4	REV 1
<b>FIGURE 5.3</b>	

1	06JUN'17	ISSUED WITH REPORT	DBR	RM/MJC	DDF
REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED

### 5.3 RESULTS

The three alternatives were ranked based on the rating criteria outline in Table 2.1 and the results are shown on Figure 5.4.



**Figure 5.4 West Embankment Design Alternatives Rating Summary**

The development of the West Embankment with an upstream drain to control the hydraulic gradient in the West Ridge is the best available alternative. The alternative would require minor to moderate modification to operation of YDTI while using technologies and methodologies consistent with long-term experience. The alternative is consistent with past successful operations and requires a permit amendment. There is an increased relative cost to implement the alternative. The cost is acceptable because it improves performance of the facility, limits potential impacts to the environment in the short term and long-term following closure.

Controlling the hydraulic gradient is the only preventative measure to manage hydrogeological risks along the West Ridge, making it the best available technology. All other measures are actions to reduce seepage, but cannot eliminate the potential for off-site water quality impacts.

Additional measures to reduce seepage through foundation treatment or downstream seepage interception remain viable contingencies with the selected alternative. The upstream drain will be most protective if constructed at as low an elevation as possible given the limits imposed by the expanding YDTI. This potential constraint was recognized several years ago prior to the last permit amendment, and the upstream drain is currently being constructed to support future use of the YDTI.

## 6 – CONCLUSIONS

The results of this assessment indicate that the only practicable solution for additional tailings storage capacity is to increase the capacity of the YDTI. The best technique to increase the capacity of the YDTI is to use multiple discharge points to develop tailings beaches along the full embankment length. Extensive tailings beaches separating the supernatant pond from the embankment enhances the safety characteristics of the facility.

The best design alternative for construction of the West Embankment incorporates an upstream drain and other seepage control features to maintain hydraulic confinement of YDTI contact water within the valley. Controlling hydraulic gradients is a technique that is consistent with regional practices for environmental protection. The design of the West Embankment Drain is described in detail in the West Embankment Drain Design Report (KP, 2017c). Controlling the hydraulic gradient is the only preventative measure to manage hydrogeological risks on the West Ridge and provides the greatest protection to groundwater of the alternatives considered. The alternative is consistent with past successful operations, and uses construction techniques that are reasonable and appropriate for the YDTI. Some additional incremental costs will be incurred during construction of proposed mitigation measures in order to improve performance of the facility and to protect the environment.

▲ R2

Geotechnical and hydrogeological site investigation programs commensurate with the complexity encountered in the site geology have been performed. These investigation programs and the resulting interpretation of the hydrogeological conditions in the West Ridge are described in the Site Characterization Report (KP, 2017a).

The design of for increasing capacity of the YDTI is described in detail in other reports. The Design Basis Report (KP, 2017b) outlines the basic criteria for the ongoing design, construction and operation of the YDTI and incorporates the findings of this alternatives assessment.

## 7 – REFERENCES

- Knights Piésold Ltd. (KP, 2017a). Yankee Doodle Tailings Impoundment, Site Characterization Report ▲ R2  
(KP Reference No. VA101-126/14-2), Vancouver, BC.
- Knights Piésold Ltd. (KP, 2017b). Yankee Doodle Tailings Impoundment, Design Basis Report (KP  
Reference No. VA101-126/12-1), Vancouver, BC. ▲ R2
- Knights Piésold Ltd. (KP, 2017c). Yankee Doodle Tailings Impoundment, West Embankment Drain  
Design Report (KP Reference No. VA101-126/13-3), Vancouver, BC. ▲ R2
- Montana Code Annotated (MCA, 2015). Title 82: Minerals, Oil, and Gas, Chapter 4: Reclamation,  
Part 3: Metal Mine Reclamation, Sections 75 and 76. Accessed: November 2015.  
Available at: <http://leg.mt.gov/bills/mca/82/4/82-4-376.htm>

**8 – CERTIFICATION**

This report was prepared and reviewed by the undersigned.



Prepared:

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Daniel Fontaine, P.Eng.  
Senior Civil Engineer | Associate



Reviewed:

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Ken Brouwer, P.E.  
President

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