DRAINAGE REPORT
FOR
PANDORA MINE
SAN JUAN COUNTY, UTAH

Prepared for:

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Acronyms

ac	acres
ARC	antecedent runoff condition
BLM	U.S. Bureau of Land Management
cfs	cubic feet per minute
CMP	corrugated metal pipe
CN	curve number
cy	cubic yards
D	depth
DRA	development rock area
ft	feet
ft/s	feet per second
FHWA	Federal Highway Administration
HSG	hydrologic soil group
in	inches
in/hr	inches per hour
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
SCS	Soil Conservation Service
sq-mi	square miles
T_c	time of concentration
USDA	U.S. Department of Agriculture
USDT	U.S. Department of Transportation
USGS	U.S. Geological Survey

Section 1 Introduction

This report presents the design analysis for the storm water drainage facilities at the Pandora Mine owned by Denison Mines (USA) Corp. (Denison). The scope of this drainage report covers aspects of storm water collection, conveyance, and retention design necessary to comply with U.S. Department of Interior, Bureau of Land Management (BLM) requirements for the mine site including Title 43 Code of Federal Regulations Section 3809 (43 CFR §3809.401(2)(iii)). Detailed hydrologic and hydraulic calculations are provided in the appendices of the report.

On March 12, 2010, field reconnaissance was conducted to evaluate the existing storm water drainage at each mine site and identify drainage control design alternatives. This drainage report was revised to address the reconnaissance findings. As discussed in this report, the following storm water control features were revised:

- Diversion Channel 1, Diversion Channel 2, Diversion Channel 3, Diversion Channel 4, Berm 1 and Berm 2

Two different drainage plans were developed for Pandora Mine due to drastically different development rock areas (DRA) when the facility is in operation and when the facility is reclaimed; i.e., Operational Drainage Plan and Reclamation Drainage Plan. The surface water control structures designed for the Operational Drainage Plan will be implemented during mining operation and were designed based on the maximum available channel size and capacity. The Reclamation Drainage Plan surface control structures were designed based on the BLM requirements (100-year design storm) for reclamation.

1.1 Site Location

The Pandora Mine is part of the La Sal Mine Complex located in the vicinity of La Sal, Utah, on the south flank of the La Sal Mountains in San Juan County. The Pandora Mine is located on the southeastern side of the La Sal Mine Complex (see Figure 1). The mine permit area is approximately 9.5-acres and mine surface features include a small office building, mine portal, and development rock area (DRA) (see Figure 2).

1.2 Report Organization

This report is organized as follows:

- Section 1: Introduction
- Section 2: Pandora Mine Operational Drainage Control Design
- Section 3: Pandora Mine Reclamation Drainage Control Design
- Section 4: Conclusions and Recommendations
- Section 5: References

Section 2
Pandora Mine Operational Drainage Control Design

This section discusses the operational drainage control approach and procedures used to design the drainage facilities components during the functional life of Pandora Mine. From the field reconnaissance, CDM found that it is difficult to construct a couple of designed operational drainage control structures (i.e., Diversion Channel 2 and Berm 1) to meet the BLM requirements for reclamation (i.e., 100-year design storm) to minimize surface disturbance during mining operation. Therefore, these operational drainage control structures are designed for 25-year design storm and operation and maintenance (O&M) are recommended after large storm events during mining operation. All flows overtopping these control structures will be contained on site by Berm 2. Specifically, this section describes the overall drainage control approach, existing drainage conditions, drainage plan, peak discharge estimates, and design of the surface water control structures used for the Pandora Mine area during mining operations.

2.1 Drainage Control Approach

The following approach was used to design the drainage facilities components:

1. The peak discharges were estimated for selected storm return intervals using drainage basin characteristics from available topographic data and aerial photographs.

2. A diversion channel, located to the north of the DRA, consisting of a half-circular pipe was designed to convey the peak offsite discharge.

3. A drainage channel, located to the west of the DRA, was designed to convey the peak discharge.

4. The type of channel lining was designed for the estimated flow condition.

5. Catchment berms were designed to retain water within the mine surface facility and DRA for the peak discharge.

The design of storm water collection, conveyance, and retention facilities components for the Pandora Mine is provided below.

2.2 Existing Drainage Conditions

The Pandora Mine is located within a drainage area of approximately 251 acres which encompasses the 9.5-acre surface mine permit area. Run-on drainage is partially diverted via an existing berm at the crest of the DRA where runoff drains down the DRA access road and into another existing earthen berm. Runoff from the DRA flows east to west into an existing earthen berm located west of the facility offices, this berm acts as a retention basin for the mine surface facility. An existing drainage channel west of the facility drains the runoff outside of the surface mine permit area and runoff from the surface facility area that is not retained by the existing earthen berms. The site area topography and features are shown in Exhibit A. Existing topography, overland drainage flow patterns, and site features were observed during a March 12, 2010 site reconnaissance.

2.3 Drainage Plan

Seven drainage basins were delineated based on the topography and existing mine surface as illustrated in Exhibit A:

Basin 1 – Surface water runoff from offsite southeast of the surface mine facilities (17.2 acres).

Basin 2 – Surface water runoff from offsite east of the surface mine facilities (6.3 acres).

Basin 3 – Surface water runoff from offsite northeast of the surface mine facilities (63 acres).

Basin 4 – Surface water runoff from offsite north of the surface mine facilities (0.5 acres).

Basin 5 – Surface water runoff from offsite north of the surface mine facilities (0.6 acres).

Basin 6 – Surface water runoff from offsite northwest of the surface mine facilities (148 acres).

Basin 7 – Surface mine facility area and DRA embankment slope (7.34 acres).

2.4 Peak Discharge Estimate

Consistent with BLM regulations (BLM, 1999), the 100-year, 24-hour storm event was selected as the design storm return interval for surface water control structure design, except for control structures intended to divert the surface water from Basin 1 and 2. To minimize surface disturbance, an operational drainage plan designed for the 25-year peak discharge was developed for these two basins, and overtopping flow for storm events greater than the 25-year storm event will be captured and retained onsite by Berm 2 (refer to Section 2.5.4).

Two different methods were used to determine the peak discharge for surface control designs (e.g., diversion channels and culverts). To estimate peak discharge for larger basins (Basins 1, 3 and 6), the HEC-HMS hydrologic analysis modeling previously completed by others was utilized (JDE 2009; see Appendix J). In smaller surface control designs (Basins 2, 4, and 5,), peak discharge was established using the graphical peak discharge method from the U.S. Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS), Urban Hydrology for Small Watersheds TR-55 (USDA, 1986). Peak discharge calculations were not completed for Basins 7 and 8 because catchment berms will be utilized to control storm water within these areas. The peak discharge estimated using the NRCS TR-55 is based on hydrologic characteristics of the mine area including estimated precipitation and runoff, soil type, basin slope, time of concentration and travel time. These hydrologic characteristics are described in detail below.

The point precipitation frequency estimate for the 100-year, 24-hour storm, obtained from National Oceanic and Atmospheric Association (NOAA) Atlas 14, Volume 1 for Utah (NOAA, 2004) is 3.09 inches. The 25-year, 24-hour storm is 2.42 inches (NOAA, 2004). CDM used the Soil Conservation Service (SCS) runoff equation to estimate runoff from the 3.09 inches of rainfall. The SCS runoff equation is:

$$Q = \frac{(P - 0.2S)^2}{(P + 0.8S)}$$

Where:

Q = runoff (in)
P = rainfall (in)
S = potential maximum retention after runoff begins (in)

S is related to the soil and cover conditions of the watershed through the Curve Number (CN). CN has a range of 0 to 100, and S is related to CN by:

$$S = \frac{1000}{CN} - 10$$

According to the NRCS TR 55 (USDA, 1986), the major factors that determine the CN include the hydrologic soil group (HSG), cover type, treatment, hydrologic condition, and antecedent runoff condition (ARC). HSG of the Pandora Mine was determined based on USDA, NRCS soil map (see Appendix A). The soil type of the mine area is classified as “Ustic Torriorthents-Ustollic Haplargids complex”, which has a very low to moderately high rate of water transmission (0.00–0.20 inches per hour [in/hr]). Therefore, based on the soil type and soil drainage class, the mine area was classified as HSG “C”.

The CN for newly graded areas, average ARC, and HSG of “C” is 91. For P equal to 3.09 inches (100year, 24-hour storm), and CN equal to 91, S equals 0.989 and Q equals 2.16 inches (refer to Appendix B). Therefore, CDM used 2.16 inches as the 100-year, 24-hour design runoff for the peak discharge calculation. Similarly, the design runoff for the peak discharge associated to the 25-year, 24-hour storm is 1.54 inches.

For drainage Basin 2, 4 and 5, the time of concentration and travel times for each basin was estimated. The travel time is the time it takes water to travel from one location to another within the basin. Different flow segments were used to accurately predict the time of concentration; sheet flow, shallow concentration flow, and channel flow. The addition of the travel times for each flow segment determines the time of concentration, which is the time it takes runoff to reach the central drainage destination from the hydraulically most distant point of the basin. The time of concentration (T_c) equation is (USDA, 1986):

$T_c = T_{t1} + T_{t2} + T_{t3}$

T_{t1} is the travel time of sheet flow which is flow over plane surface. Typically, sheet flow occurs in the headwaters of the basin runoff. Based on the NRCS TR-55 (USDA, 1986), sheet flow is less than or equal to 300 feet. The sheet flow travel time equation is:

$$T_{t1} = \frac{0.007(nL)^{0.8}}{(P_2)^{0.5}S^{0.4}}$$

Where:

n = Manning's roughness coefficient (0.40 for woods with light underbrush)

L = flow length in feet (considering the maximum sheet flow length of 300 feet)

P_2 = 2-year, 24-hour rainfall in inches (1.4 inches from NOAA Precipitation-Frequency Atlas 14 Maps for Utah)

S = land slope in ft/ft (Measured from the USGS topographic map)

T_{t2} is the travel time of shallow concentrated flow which is runoff over plan surface and flow just below the surface. Typically, shallow concentration flow occurs after sheet flow. The shallow concentration flow travel time equation is:

$$T_{t2} = \frac{L}{3600V}$$

Where:

V = average velocity in feet per second (ft/sec) (based on Figure 3-1 (USDA, 1986))

L = estimated from the existing topographic map

T_{t3} is the travel time of channel flow which is runoff confined in a channel. Typically, channel flow occurs after shallow concentration flow. The channel flow travel time equation is:

$$T_{t3} = \frac{L}{3600V}$$

Where:

V = average velocity in ft/sec (based on Figure 3-1 (USDA, 1986))

L = estimated from the existing topographic map

Based on the previous calculations, the graphical peak discharge method is calculated using the following equations:

$q_p = q_u A_m Q$

Where,

q_p = peak discharge in cfs (based on Exhibit 4-II (USDA, 1986))

A_m = drainage area in square miles

Q = runoff in inches

These equations were used to determine the peak discharge for Basins 2; detailed calculations are provided in Appendix B. The peak discharges for each basin are summarized in Table 2-1.

Table 2-1 100-year Peak Discharges for the Pandora Mine Basins

Basin	Area		100-year Peak Discharge (25-year Peak Discharge)
	(ac)	(sq-mi)	(cfs)
1	Not Applicable – Catchment Berm Utilized (see Section 2.5.4)		
2	6.32	0.0099	14.37 (10.25)
3	62.95	0.0984	34.47
4	Not Applicable – Catchment Berm Utilized (see Section 2.5.4)		
5	Not Applicable – Catchment Berm Utilized (see Section 2.5.4)		
6	147.85	0.2310	66.5
7	Not Applicable – Catchment Berm Utilized (see Section 2.5.4)		

2.5 Surface Water Control Structure Design

Diversion Channel 1 was designed using the 100-year peak discharge to route offsite surface water runoff from Basins 2 through 6 to the existing drainage channel (refer to Exhibit A). Diversion Channel 2 was designed using the 25-year peak discharge to route offsite surface water runoff from Basin 2 to the existing drainage channel (refer to Exhibit A). A culvert was designed to convey the 100-year peak discharge from Basins 2 and 3 to the existing drainage channel west of the facility. The 25-year storm water runoff from Basin 1 will be captured and retained by an earthen berm along the crest of the DRA. The 100-year storm water runoff from Basins 1, 2, 4, 5 and 7 will also be captured and retained by an earthen berm along the facility area and toe of the DRA.

2.5.1 Diversion Channel Design

Diversion Channel 1 was sized to convey the 100-year peak discharge and the channel layout was selected to minimize the cut/fill required. Diversion Channel 2 made of a 30-inch half-circular corrugated metal pipe (CMP) was sized to convey the 25-year peak discharge due to limited space between Basin 2 and DRA. In designing

Diversion Channel 2 for 25-year design storm, O&M are recommended after large storm events. Also, overtopping discharge from Diversion Channel 2 will be captured by Berm 2, which was designed with 1 ft freeboard.

To accomplish this optimization, the diversion channels were divided into multiple longitudinal slopes as follows:

Diversion Channel 1 – Two longitudinal slopes of 1A and 1B (conveys flow from Basins 2 through 6).

Diversion Channel 2 – one constant longitudinal slope (conveys flow from Basin 2).

The Diversion Channel 1 drains Basins 2 through 6; therefore the sum of these 100-year, 24-hour basin discharges (117.8 cfs) was selected as the design discharge for the Diversion Channel 1 (see Table 2-1). The following equations (Chow, 1973) were used to calculate the flow velocity and depth in the diversion channel. Input values (listed in Table 2-2) into the equations include peak discharge, cross section geometry, slope, and Manning's n value.

$$Q = VA$$

$$A = (b + zh)h$$

$$V = \frac{1.49}{n}\left[\frac{(b+zh)h}{b+2h\sqrt{1+z^2}}\right]^{2/3} S^{1/2}$$

Where:

Q = discharge in cfs

V = velocity in ft/sec
z : 1 = side slope
A = flow area in ft^2
b = bottom width of the cross section in ft
h = flow depth in ft
S = channel slope in ft/ft
n = Manning's roughness coefficient

Table 2-2 Input values for Diversion Channel

Basin	S (ft/ft)	n	Z (ft/ft)	B (ft)	Peak Discharge (cfs)
Diversion Channel 1A	0.009	0.035	3	4	117.8 (100-yr)
Diversion Channel 1B	0.100	0.041	3	4	117.8 (100-yr)
Diversion Channel 2	0.074	0.024	Half-Circle*		10.25 (25-yr)

*Bentley's normal depth calculation program, CulvertMaster was used to calculate the flow velocity and depth.

CDM used the Urban Drainage and Flood Control Department (UDFCD) Drainage Criteria (UDFCD, 2005) to calculate flow velocity to determine the appropriate lining for the drainage channels. UDFCD (2005) recommends flow velocity be less than 5 ft/sec for grass-lined channels and less than 12 ft/sec for riprap channels. Based on these recommendations, a Manning's n values of 0.035 and 0.041 were selected for design calculations to check the capacity of grass-lined and riprap-lined channels, respectively.

To connect the drainage channel to the existing drainage, steeper channel slope was required at Diversion Channel 1B. As shown in Table 2-3, the calculated maximum flow velocity of this channel is greater than 5 ft/sec. Therefore, CDM recommends riprap-lined channel for Diversion Channel 1B. However, in the case of Diversion Channel 2, although the calculated flow velocity is greater than 5 ft/sec, riprap lining is not required, because it is made of half-circular CMP.

After adding 2 feet of freeboard to the calculated flow depth (refer to Table 2-3) to account for potential channel overtopping, CDM recommends using the 4.5 ft as the design depth for Diversion Channel 1.

Table 2-3 Calculated Summary of Diversion Channel

Channel	Design Depth			Design Velocity (ft/s)
	Calculated (ft)	Freeboard (ft)	Design (ft)	
Diversion Channel 1	A – 2.25	2	4.5	A - 4.84
	B –1.36			B – 10.47
Diversion Channel 2	0.7	1	1.5	9.19

Please note that Drainage Channel 1 also has a culvert to route flow beneath the facility access road; design of the culvert is described in Section 2.5.3.

2.5.2 Riprap Channel Protection Design

Based on the estimated flow velocity (see Table 2-3), riprap protection is recommended to prevent scour along Diversion Channel 1B. The following riprap gradations/sizing were calculated using the USACE riprap sizing program, CHANLPRO version 2.0 (see Appendix C):

Table 2-4. Riprap Gradation for Diversion Channel Protection

Channel	D_{100} (max)	D_{100} (min)	D_{50} (max)	D_{50} (min)	D_{15}(max)	D_{15}(min)
Diversion Channel 1B	27 in	19.9 in	18.0 in	15.8 in	14.3 in	10.7 in

Riprap channel protection layout is shown in Exhibits A and B. Riprap protection (D_{50}(max) = 18 inches) is also required at the culvert outlet of the Diversion Channel 1 (refer to schematic Figure 3), to minimize scour damage caused by high exit velocities and turbulence occurring at conduit outlets (see Exhibit D).

Figure 3 Example Photograph of Scour Protection

2.5.3 Culvert Design

This section discusses the design of the following culverts: (1) surface facility culvert, and (2) Drainage Channel 1 culvert.

Surface Facility Culvert (Culvert 1): A long underground culvert will be used to convey surface water runoff from Basins 2, 3, and 4 beneath the surface mine facility to the proposed Diversion Channel 1. The size of the culverts was estimated using the Bentley's culvert design program, CulvertMaster version 3.1 (see Appendix D). The pipe size was designed to convey the 100-year peak discharge (50 cfs) without overtopping from Basins 2, 3, and 4, This calculation is conservative, considering that only a portion of runoff from basin 4 is conveyed through the culvert. A 36-inch circular CMP culvert with 3-foot berm should be utilized for water conveyance (see Exhibit A). However, if the distance between the culvert and the top of the access road is greater than or equal to 3 feet at the culvert berm location (see Exhibit A), a berm is not required. Riprap protection (D_{50}(max) = 18 inches) is required at the outlet of this long culvert (see Exhibit D).

Drainage Channel 1 Culvert (Culvert 2): A culvert will be used to convey water within Diversion Channel 1 under the existing access road located on the west side of the basin. The size of the culvert was estimated using the Bentley's culvert design program, CulvertMaster version 3.1. Based on the program, two 36-inch CMP culverts should be used to convey flow with a 3-foot high headwall to prevent overtopping (see Appendix E).

2.5.4 Catchment Berm Design

Earthen berms will be utilized to capture and retain surface water runoff from Basins 1, 2, 4, 5, and 7. Runoff in Basin 1 will be captured by a berm along the crest of the DRA. Runoff in Basin 1, 2, 4, 5, and 7 will be captured by a berm along the facility area and toe of the DRA (see Exhibit A). The catchment berm for Basins 1, 2, 4, 5, and 7 were designed to contain runoff from the 100-year, 24-hour storm event, while the catchment berm for Basin 1 was designed for the 25-year, 24-hour storm event (NOAA, 2004). The total runoff volume from Basin 1 was calculated by multiplying the basin area by the design runoff (1.54 inches). Then the calculated total runoff volume was divided by available retention area within the surface facilities area to calculate the minimum required catchment berm elevation of Basin 1. The calculated minimum catchment berm elevation is 3 feet, which includes 0.5-foot of freeboard. Details for these calculations are shown in Table 2-5. It should be noted that this calculation was based on the assumption that the retention area is flat. However, according to surveyed data, the retention area marked on Exhibit A is sloped to the north. Therefore, to retain the calculated runoff volume using the 3-foot high berm, it is required to flatten out the retention surface marked on Exhibit A.

The total runoff volume from Basin 1, 2, 4, 5, and 7 was also calculated by multiplying the sum of the basin areas by the design runoff (2.16 inches). Then the calculated total runoff volume was divided by available flat retention area along the facility area and toe of the DRA to calculate the minimum required catchment berm elevation of Basin 1, 2, 4, 5, and 7. The calculated minimum catchment berm elevation is 3.0 feet, which includes 1-foot of freeboard. Details for these calculations are shown in Table 2-5.

Table 2-5 Calculation Summary for Catchment Berms

Basin	Basin Area (ac)	25-yr, 24-hr Storm (in)	Runoff (in)	Runoff Volume (ft^3)	Retention Area (sq-ft)	Berm Height		
						Calculated (ft)	Freeboard (ft)	Design (ft)
1	17.1	2.42	1.54	79,381	32,799	2.42	0.5	3.0
1,2,4,5,7	33.7	3.09	2.16	264,549	160,000	1.65	1	3.0

Section 3
Pandora Mine Reclamation Drainage Control Design

This section discusses the drainage control approach and procedures used for reclamation at the Pandora Mine area. This design complies with BML requirements (43 CFR §3809.401(2)(iii)) and should be implemented during reclamation. Specifically, this section describes the overall drainage control approach, existing drainage conditions, drainage plan, peak discharge estimates, and design of the surface water control structures used for reclamation at the Pandora Mine area.

3.1 Drainage Control Approach

The following approach was used to design the drainage facilities components:

1. The peak discharge was estimated for a selected storm return interval using drainage basin characteristics from available topographic data and aerial photographs.

2. Diversion channels were designed to convey the peak discharge.

4. The type of channel lining was designed for the estimated flow condition.

5. Catchment berms were designed to retain water within the mine surface facility and DRA for the peak discharge.

The design of storm water collection, conveyance, and retention facilities components for the Pandora Mine is provided below.

3.2 Drainage Plan

Eight drainage basins were delineated based on the topography and existing mine surface as illustrated in Exhibit E:

Basin 1 – Surface water runoff from offsite southeast of the surface mine facilities (18.3 acres).

Basin 2 – Surface water runoff from offsite east of the surface mine facilities (6.3 acres).

Basin 3 – Surface water runoff from offsite northeast of the surface mine facilities (63 acres).

Basin 4 – Surface water runoff from offsite north of the surface mine facilities (0.5 acres).

Basin 5 – Surface water runoff from offsite north of the surface mine facilities (0.6 acres).

Basin 6 – Surface water runoff from offsite northwest of the surface mine facilities (148 acres).

Basin 7 – Surface mine facilities area (2.97 acres).

Basin 8 – DRA embankment slope (6.51 acres).

3.3 Peak Discharge Estimate

Consistent with BLM regulations (BLM, 1999), the 100-year, 24-hour storm event was selected as the design storm return interval for surface water control structure design. Two different methods were used to determine the peak discharge for surface control designs (e.g., diversion channels and culverts). To estimate peak discharge for larger basins (Basins 1, 3 and 6), the HEC-HMS hydrologic analysis modeling previously completed by others was utilized (JDE 2009; see Appendix J). In smaller surface control designs (Basins 2, 4, and 5), peak discharge was calculated as described in Section 2.4. Table 3-1 summarizes the 100-year peak discharge for each basin.

Table 3-1 100-year Peak Discharges for the Pandora Mine Basins

Basin	Area		100-year Peak Discharge
	(ac)	(sq-mi)	(cfs)
1	18.3	0.0286	14.2*
2	6.32	0.0099	14.37
3	62.95	0.0984	34.47*
4	0.53	0.0008	1.16
5	0.6	0.0009	1.3
6	147.85	0.2310	66.5*
7	Not Applicable – Catchment Berm Utilized (see Section 2.5.4)		
8	Not Applicable – Catchment Berm Utilized (see Section 2.5.4)		

*Peak discharge based on HEC-HMS Hydrology model (JDE 2009)

3.4 Surface Water Control Structure Design

Four diversion channels (Channels 1 through 4) were designed to route offsite surface water run-on from Basins 1, 2, 3 and 6 to the existing drainage channel (refer to Exhibit E). Diversion Channel 3 is designed to replace the surface facility culvert 1 in the operational drainage plan to reduce maintenance associated to culverts and to restore natural drainage channels. Diversion Channel 4, which was Diversion Channel 1 of the operational drainage plan, will remain the same for the reclamation drainage control design. Storm water runoff from Basin 7 will be captured and retained by an earthen berm along the crest of the DRA. Storm water runoff from Basin 4, 5 and 8 will also be captured and retained by an earthen berm along the toe of the DRA.

3.4.1 Diversion Channel Design

Each diversion channel was sized to convey the 100-year peak discharge and the channel layout was selected to minimize the cut/fill required. To accomplish this optimization, the diversion channels were divided into multiple longitudinal slopes as follows:

Diversion Channel 1 – Three longitudinal slopes of 1A, 1B and 1C (conveys flow from Basin 1).

Diversion Channel 2 – Two longitudinal slopes of 2A and 2B (conveys flow from Basin 2).

Diversion Channel 3 – One longitudinal slope (conveys flow from Basin 2, 3, 4).

Diversion Channel 4 – Two longitudinal slopes of 5A and 5B (conveys flow from Basins 2 through 6).

For the 100-year 24-hour storm events, the design discharge used for each diversion channel is the peak discharge described in Section 2.4 that corresponds to the conveyed runoff for each channel, except for Diversion Channel 3 and 4. The Diversion Channel 3 was designed to drain Basins 2 through 4 to be conservative (only part of basin 4 will drain into channel); therefore the sum of these basin discharges (46.8 cfs) was selected as the design discharge for the Diversion Channel 3 (see Table 3-1). Diversion Channel 4 was designed to drain Basins 2 through 6 to be conservative (only part of Basin 4 and 5 will drain into channel); therefore the sum of these basin discharges (117.8 cfs) was selected as the design discharge for the Diversion Channel 4 (see Table 3-1). The following equations (Chow, 1973) were used to calculate the flow velocity and depth in the diversion channels. Input values (listed in Table 3-2) into the equations include 100-year peak discharge, cross section geometry, slope, and Manning's n value.

$$Q = VA$$

$$A = (b + zh)h$$

$$V = \frac{1.49}{n}\left[\frac{(b + zh)h}{b + 2h\sqrt{1 + z^2}}\right]^{2/3} S^{1/2}$$

Where:

Q = discharge in cfs
V = velocity in ft/sec
z : 1 = side slope
A = flow area in ft^2
b = bottom width of the cross section in ft
h = flow depth in ft
S = channel slope in ft/ft
n = Manning's roughness coefficient

Table 3-2 Input values for Diversion Channel

Basin	S (ft/ft)	n	Z (ft/ft)	B (ft)	100-year Peak Discharge (cfs)
Diversion Channel 1A	0.0035	0.035	3	4	14.2
Diversion Channel 1B	0.2835	0.041	3	4	14.2
Diversion Channel 1C	0.0069	0.035	3	4	14.2
Diversion Channel 2A	0.0431	0.035	3	4	14.37
Diversion Channel 2B	0.0734	0.041	3	4	14.37
Diversion Channel 3	0.0558	0.041	2	0	46.8
Diversion Channel 4A	0.009	0.035	3	4	117.8
Diversion Channel 4B	0.100	0.041	3	4	117.8

The Urban Drainage and Flood Control Department (UDFCD) Drainage Criteria (UDFCD, 2005) was used to calculate flow velocity to determine the appropriate lining for the drainage channels. UDFCD (2005) recommends flow velocity be less than 5 ft/sec for grass-lined channels and less than 12 ft/sec for riprap channels. Based on these recommendations, a Manning's n values of 0.035 and 0.041 were selected for design calculations to check the capacity of grass-lined and riprap-lined channels, respectively.

To connect the drainage channel to the existing drainage, steeper channel slope was required at Diversion Channel 1B, Diversion Channel 2B, Diversion Channel 3 and Diversion Channel 4B. As shown in Table 2-3, the calculated maximum flow velocity of these is greater than 5 ft/sec. Therefore, riprap-lined channels for Diversion Channel 1B, Diversion Channel 2B, Diversion Channel 3 and Diversion Channel 4B are recommended.

After adding 2 feet of freeboard to the calculated flow depth (refer to Table 3-3) to account for potential channel overtopping, the following design depths for each of the five diversion channels are recommended; 3.0 ft, 2.5 ft, 2.5 ft, 2.5 ft and 4.5 ft for Diversion Channels 1, 2, 3 and 4, respectively.

Table 3-3 Calculated Summary of Diversion Channel

Channel	Design Depth			Design Velocity (ft/s)
	Calculated (ft)	Freeboard (ft)	Design (ft)	
Diversion Channel 1	A - 1.0	2	3.0	A - 1.97
	B – 0.34			B – 8.26
	C – 0.86			C – 2.51
Diversion Channel 2	A – 0.53	2	2.5	A - 4.83
	B – 0.5			B – 5.21
Diversion Channel 3	1.8	2	2.5	7.38
Diversion Channel 4	A – 2.25	2	4.5	A - 4.87
	B –1.37			B – 10.55

3.4.2 Riprap Channel Protection Design

Based on the estimated flow velocity (see Table 3-3), riprap protection is recommended to prevent scour along the following diversion channel segments: 1B, 2B, 3 and 4B. The following riprap gradations/sizing were calculated using the USACE riprap sizing program, CHANLPRO version 2.0 (see Appendices F, G, H and I):

Table 3-4. Riprap Gradation for Diversion Channel Protection

Channel	D_{100} (max)	D_{100} (min)	D_{50} (max)	D_{50} (min)	D_{15}(max)	D_{15}(min)
Diversion Channel 1B	24 in	17.7 in	16.0 in	14.0 in	12.7 in	9.5 in
Diversion Channel 2B	9 in	6.6 in	6.0 in	5.3 in	4.8 in	3.6 in
Diversion Channel 3	12 in	8.8 in	8 in	7 in	6.3 in	4.8 in
Diversion Channel 4B	27 in	19.9 in	18.0 in	15.8 in	14.3 in	10.7 in

Riprap channel protection layout is shown in Exhibits F, G, H and I.

3.4.3 Culvert Design

Drainage channel 4 culvert described in Section 2.5.3 will not change between Operational and Reclamation drainage plans.

3.4.4 Catchment Berm Design

Earthen berms will be utilized to capture and retain surface water runoff from Basins 7 and 8. Runoff in Basin 7 will be captured by a berm along the crest of the DRA. Runoff in Basin 8 will be captured by a berm along the toe of the DRA (see Exhibit E), which is equivalent to the Operational Berm 2 described in Section 2.5.4.

The catchment berms were designed to contain runoff from the 100-year, 24-hour storm event (NOAA, 2004). The total runoff volume from Basin 7 was calculated by multiplying the basin area by the design runoff (2.16 inches). Then the calculated total runoff volume was divided by available retention area within the surface facilities area to calculate the minimum required catchment berm elevation of Basin 7. The calculated minimum catchment berm elevation is 1.5 feet, which includes 1-foot of freeboard. Details for these calculations are shown in Table 3-5. The total runoff volume from Basin 8 was also calculated by multiplying the basin area by the design runoff (2.16 inches). Then the calculated total runoff volume was divided by available flat retention area along the toe of the DRA to calculate the minimum required catchment berm elevation of Basin 8. The calculated minimum catchment berm elevation is 1.5 feet, which includes 1-foot of freeboard. Details for these calculations are shown in Table 3-5.

Table 3-5 Calculation Summary for Catchment Berms

Basin	Basin Area (ac)	100-yr, 24-hr Storm (in)	Runoff (in)	Runoff Volume (ft^3)	Retention Area (sq-ft)	Berm Height		
						Calculated (ft)	Freeboard (ft)	Design (ft)
7	2.97	3.09	2.16	22,532	64,687	0.36	1	1.5
8	6.30	3.09	2.16	49,397	83,905	0.6	1	1.5

Section 4 Conclusions and Recommendations

This section provides a summary of the conclusions and recommendations for additional drainage control structures to route offsite surface flow around the surface mine area and retain the specified storm event within the onsite berms for the Pandora Mine facilities.

4.1 Operational Drainage Control Structure Design

The following storm water drainage features will be utilized:

1. Diversion Channel 1 with configuration and design criteria illustrated in Exhibits A and B. Riprap channel protection will be used to reduce scour (see Table 2-4).

2. Diversion Channel 2 made of a 30-inch half-circular CMP to convey surface runoff from Basin 2 to the inlet of surface facility culvert (Culvert 1) as illustrated in Exhibit A. O&M are recommended after large storm events.

3. Drainage Berm 1 to retain runoff flow from Basin 1 with configuration and design criteria as illustrated in Exhibit A.

3. Drainage Berm 2 to retain runoff flow from Basin 1, 2, 4, 5, and 7 with configuration and design criteria as illustrated in Exhibit A.

4. Two 36-inch CMP culverts (Culvert 2) to convey water within Diversion Channel 1 under the existing access road located on the west side of the basin.

5. Based on the configuration for Diversion Channel 1, a balanced cut/fill approach was not achieved; channel construction will require a cut of approximately 1,431 cy and fill of approximately 5,822 cy. The net earth fill is approximately 4,391 cy.

4.2 Reclamation Drainage Control Structure Design

The following storm water drainage features will be utilized:

1. Diversion Channels 1, 2, 3 and 4 with configuration and design criteria illustrated in Exhibits E, F, G, H and I. The channel slope should be designed less than or equal to the slope in Table 3.2. Riprap channel protection will be used to reduce scour (see Table 3-4). Diversion Channel 3 is replacing Culvert 1 in the Operational Drainage Plan. Diversion Channel 4 is as designed in Operational Drainage Plan (Channel 1).

2. Drainage Berm 1 to retain runoff flow from Basin 7 with configuration and design criteria as illustrated in Exhibit E.

3. As designed in the Operational Drainage Plan (Berm 2), drainage Berm 2 to retain runoff flow from Basin 4, 5 and 8 with configuration and design criteria as

illustrated in Exhibit E. Berm 2 will be extended along the banks of Diversion Channel 3 to prevent uncontaminated runoff mixing with contaminated runoff as shown in Exhibit E.

4. As designed in the Operational Drainage Plan (Culvert 2), two 36-inch CMP culverts to convey water within Diversion Channel 4 under the existing access road located on the west side of the basin. These culverts will remain in place for site reclamation.

Section 5
References

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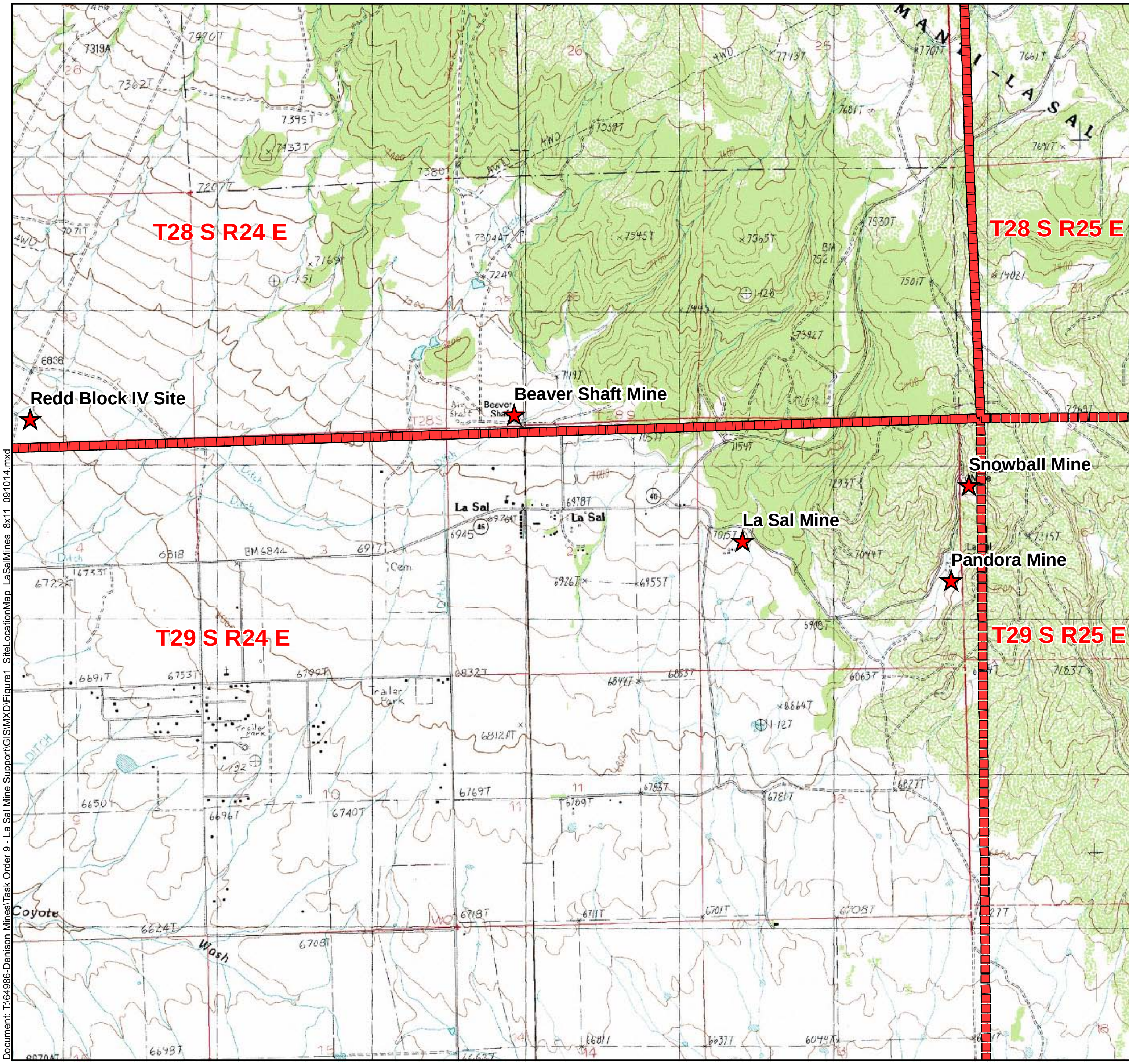
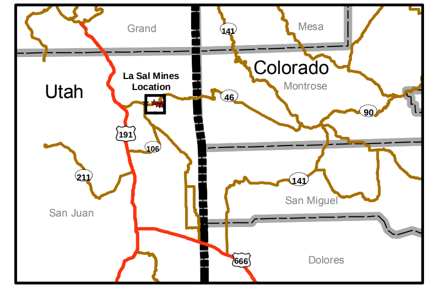
Figures





Legend

★ Mine Location

N
W E
S

Scale of Feet

0 3,000 6,000

1 inch = 3,000 feet

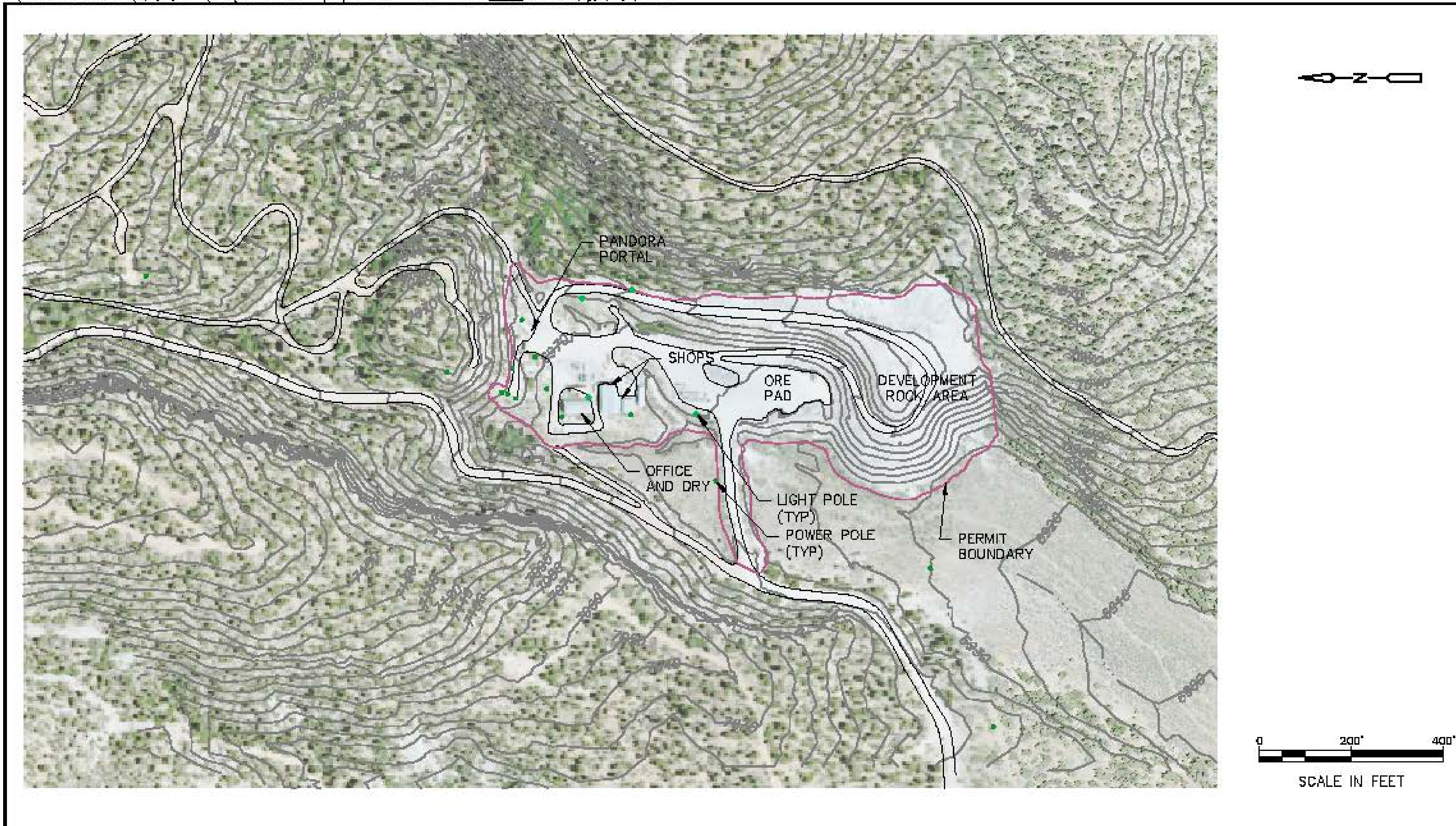
Figure 1
Site Location Map
La Sal Mines
Denison Mines (USA) Corp.

San Juan County, Utah

Source: USGS La Sal West
and La Sal East Quadrangle Maps

CDM

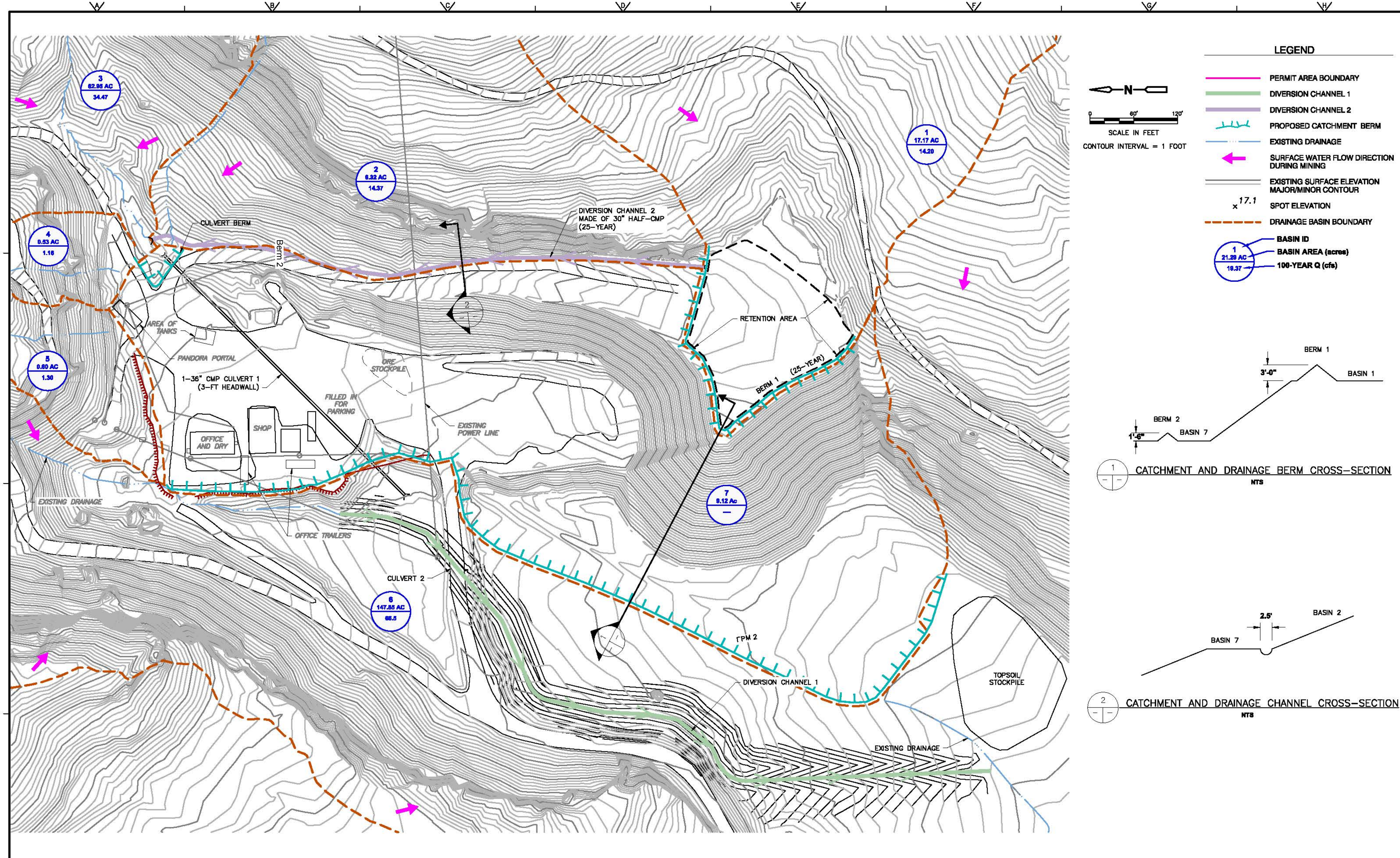
Document: T:\64986-Denison Mines\Task Order 9 - La Sal Mine Support\GIS\MXD\Figure1_SiteLocationMap_LaSalMines_8x11_091014.mxd



CDM

Figure 2
Pandora Mine Area
Site Map

Exhibits



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REV. NO.	DATE	DRWN	CHKD	REMARKS

DESIGNED BY: C. BREWER
DRAWN BY: J. HUMPHREY
SHEET CHK'D BY: M. EOM
CROSS CHK'D BY: T. BRAGDON
APPROVED BY:
DATE: NOVEMBER 2009

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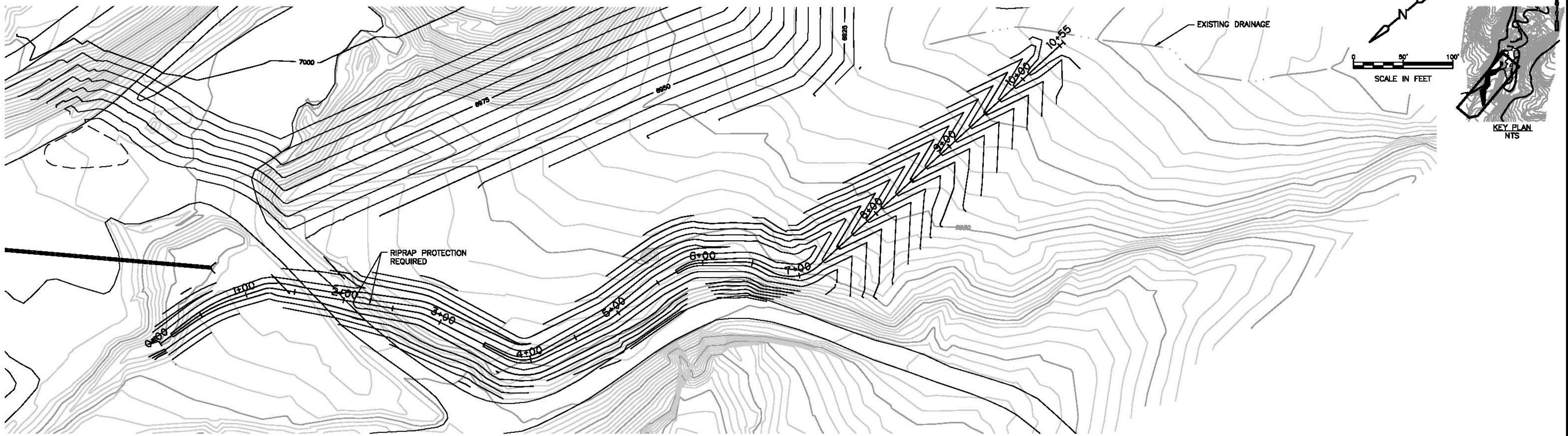
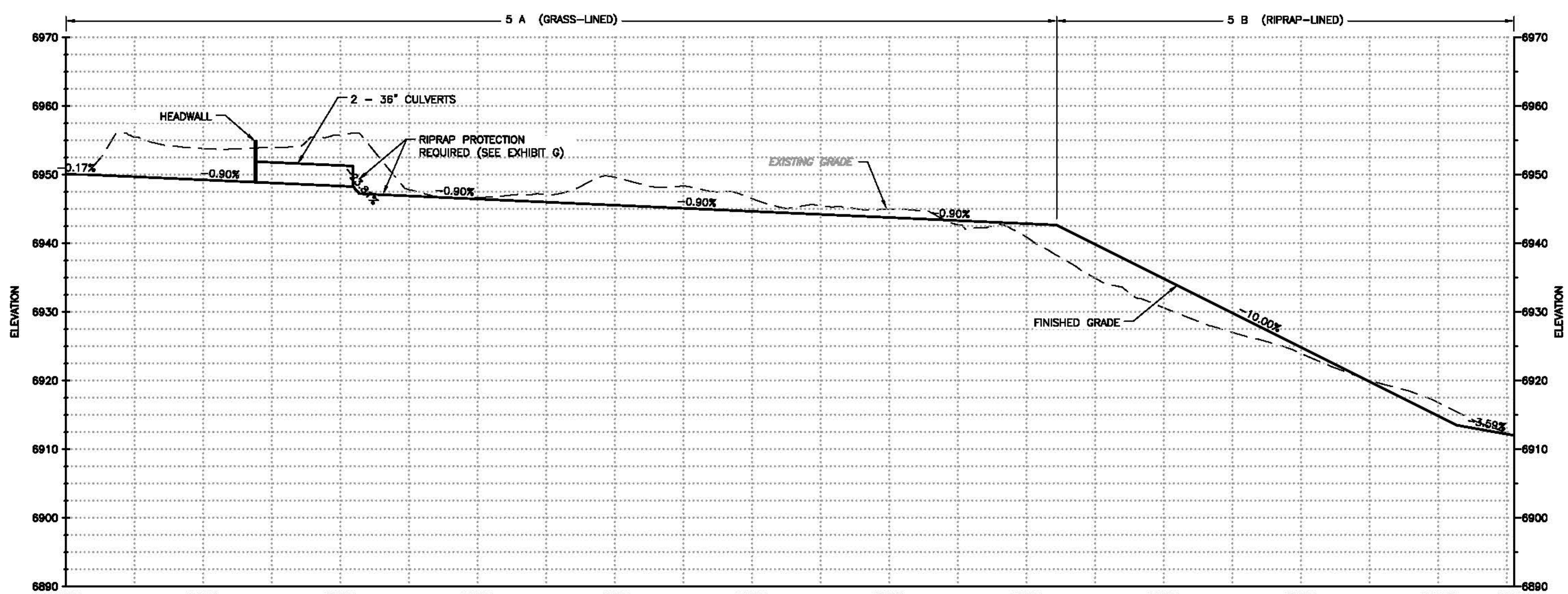
DENISON MINES
SAN JUAN COUNTY, UTAH
PANDORA MINE SITE

SURFACE FACILITY AREA
DRAINAGE PLAN AND DETAILS

PROJECT NO. 64986
FILE NAME:
SHEET NO.
EXHIBIT A

PRELIMINARY DESIGN - NOT FOR CONSTRUCTION





PROFILE

SCALE:
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1" = 10' VERTICAL

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CROSS CHK'D BY: T. BRAGDON
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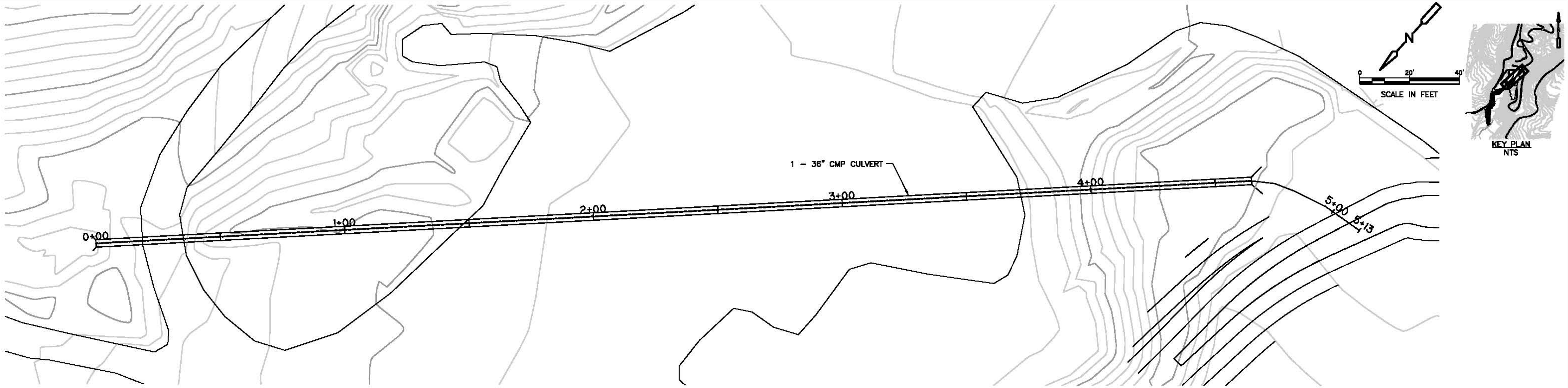
PANDORA MINE SITE

PLAN AND PROFILE
DIVERSION CHANNEL 1

PROJECT NO. 64986
FILE NAME:
SHEET NO.
EXHIBIT B

PRELIMINARY DESIGN - NOT FOR CONSTRUCTION



PROFILE
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1" = 5' VERTICAL

REV. NO.	DATE	DRWN	CHKD	REMARKS

DESIGNED BY: C. BREWER
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PLAN AND PROFILE
CULVERT DRAINAGE CHANNEL

PROJECT NO. 64986
FILE NAME:
SHEET NO.
EXHIBIT C

PRELIMINARY DESIGN - NOT FOR CONSTRUCTION

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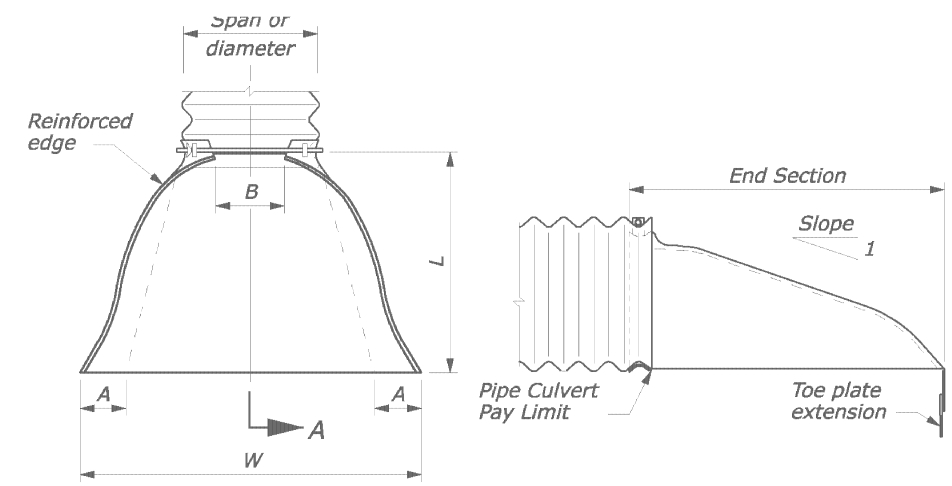
END SECTIONS FOR ROUND PIPE CULVERT

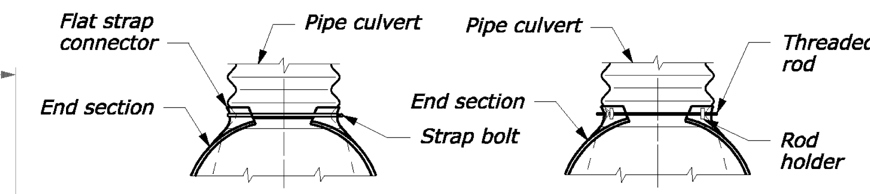
PIPE SIZE DIAMETER INCHES	METAL THICKNESS STEEL INCHES	STEEL GAGE	ALUMINUM INCHES	ALUMINUM GAGE	DIMENSIONS INCHES A	B	H	F	L	W	SLOPE Approx.
12	0.064	16	0.060	16	5	7	6	22	21	44	2¼
15	0.064	16	0.060	16	6	8	6	28	26	52	2¼
18	0.064	16	0.060	16	7	10	6	34	31	58	2⅛
24	0.064	16	0.060	16	9	13	6	46	40	72	2⅛
30	0.079	14	0.075	14	11	16	8	55	51	88	2⅛
36	0.079	14	0.075	14	13	19	9	70	60	104	2
42	0.109	12	0.105	12	15	25	10	82	69	122	2⅛
48	0.109	12	0.105	12	17	29	12	88	78	130	2
54	0.109	12	0.105	12	17	33	12	100	84	141	2
60	0.109	12	0.105	12	17	36	12	112	87	155	1⅞
66	0.109	12	0.105	12	17	39	12	118	87	160	1⅝
72	0.109	12	0.105	12	17	44	12	120	87	169	1½
78	0.109	12	0.105	12	17	48	12	130	87	178	1⅜
84	0.109	12	0.105	12	17	52	12	136	87	184	1¼
90	0.109	12	0.105	12	17	58	12	142	87	188	1¼
96	0.109	12	0.105	12	17	58	12	144	87	197	1⅛



PLAN

SECTION A-A

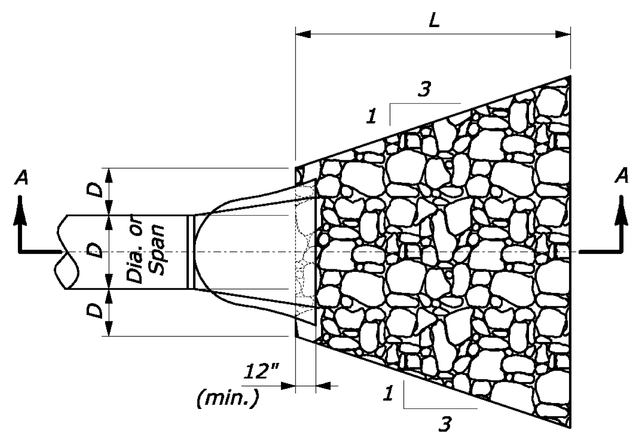
ROUND OR PIPE ARCH CULVERT



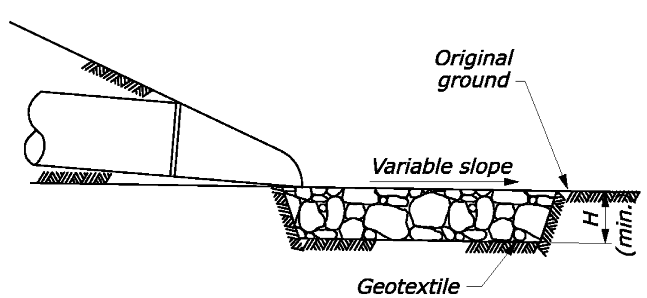
For 12" thru 24" round pipe and 17" x 13" thru 28" x 20" pipe arch

For 30" thru 60" round pipe and 35" x 24" thru 66" x 51" pipe arch

DESIGN A
CONNECTION TO ANNULAR CORRUGATED METAL PIPE



PLAN VIEW



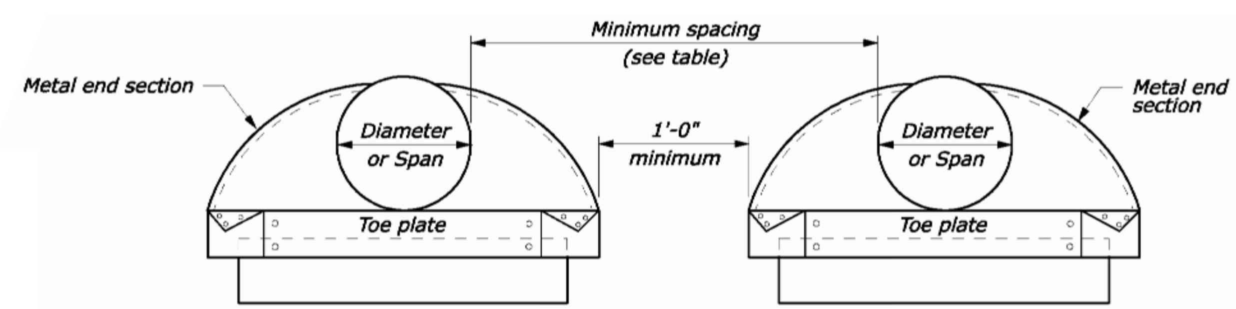
SECTION A-A

CULVERT WITH STANDARD END SECTION

Notes:
L = 6 x D
H = 2.5 feet

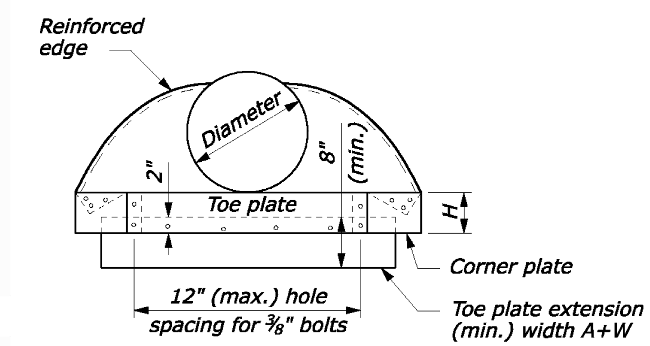
PROTECTIVE APRON AT CULVERT OUTLET

MINIMUM SPACING	
DIAMETER or SPAN	SPACING
UP to 48"	24"
48" and UP	Half diameter or span OR 36" whichever is less



ELEVATION

MULTIPLE PIPE INSTALLATION



ELEVATION

ROUND PIPE CULVERT

METAL END SECTIONS

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CROSS CHK'D BY:
APPROVED BY:
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DETAILS

PROJECT NO. 64986
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EXHIBIT D

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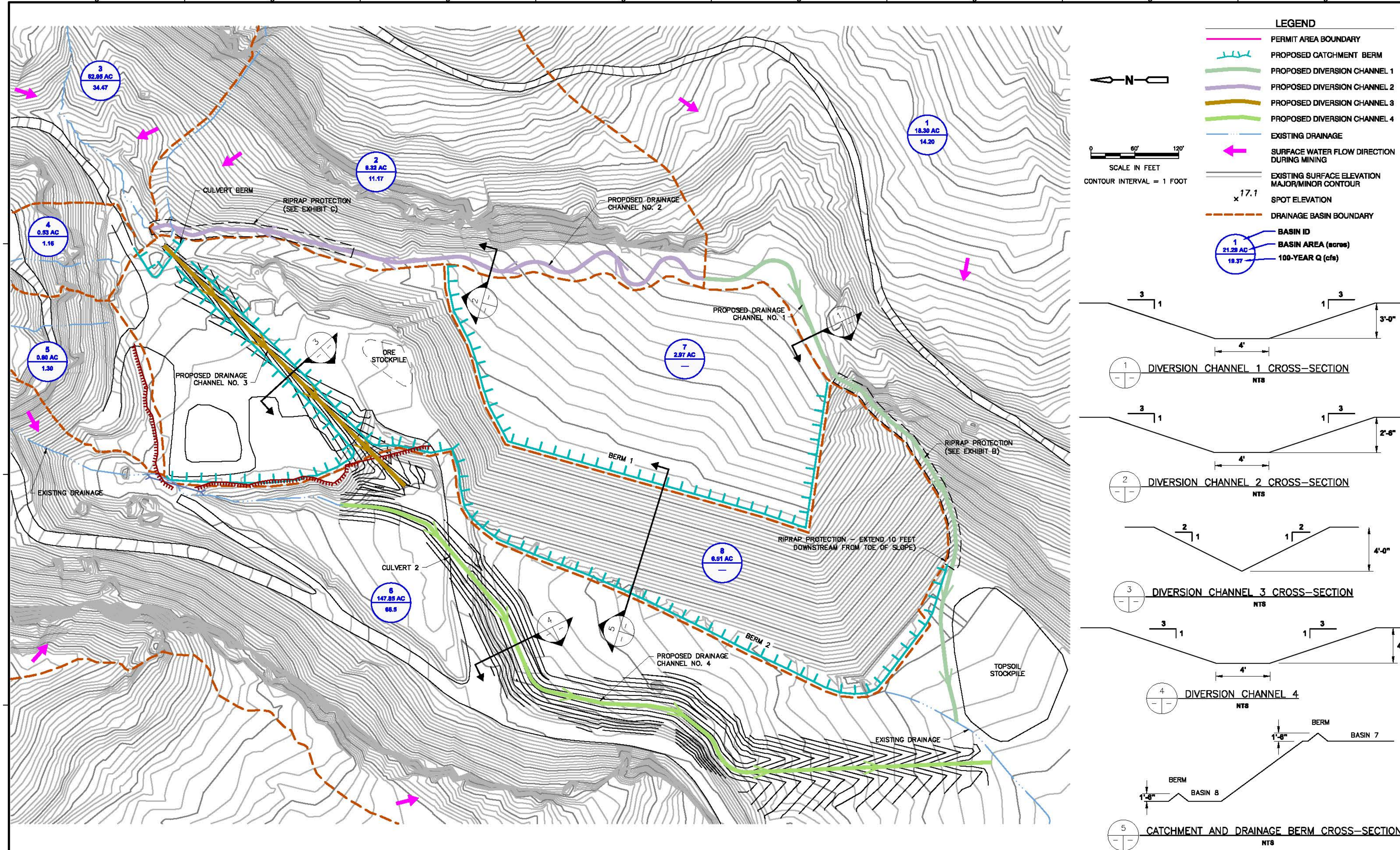

REV. NO.	DATE	DRWN	CHKD	REMARKS

DESIGNED BY: C. BREWER
DRAWN BY: J. HUMPHREY
SHEET CHK'D BY: M. EOM
CROSS CHK'D BY: T. BRAGDON
APPROVED BY:
DATE: NOVEMBER 2009

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SURFACE FACILITY AREA
DRAINAGE PLAN AND DETAILS

PROJECT NO. 64986
FILE NAME:
SHEET NO.
EXHIBIT E

PRELIMINARY DESIGN - NOT FOR CONSTRUCTION

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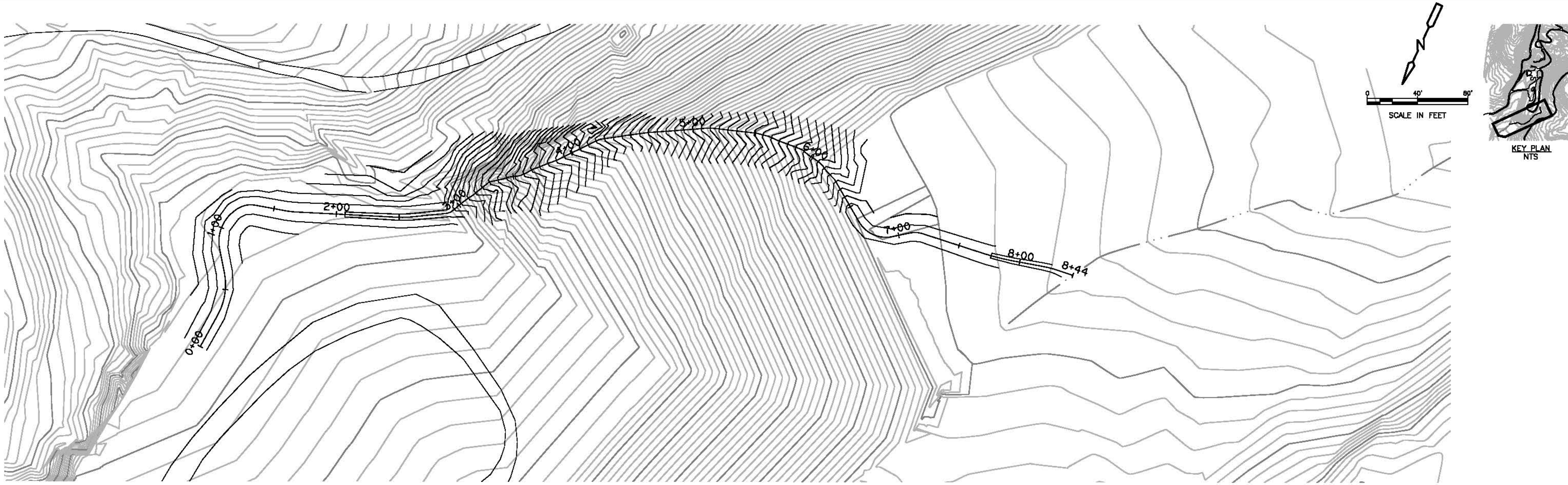

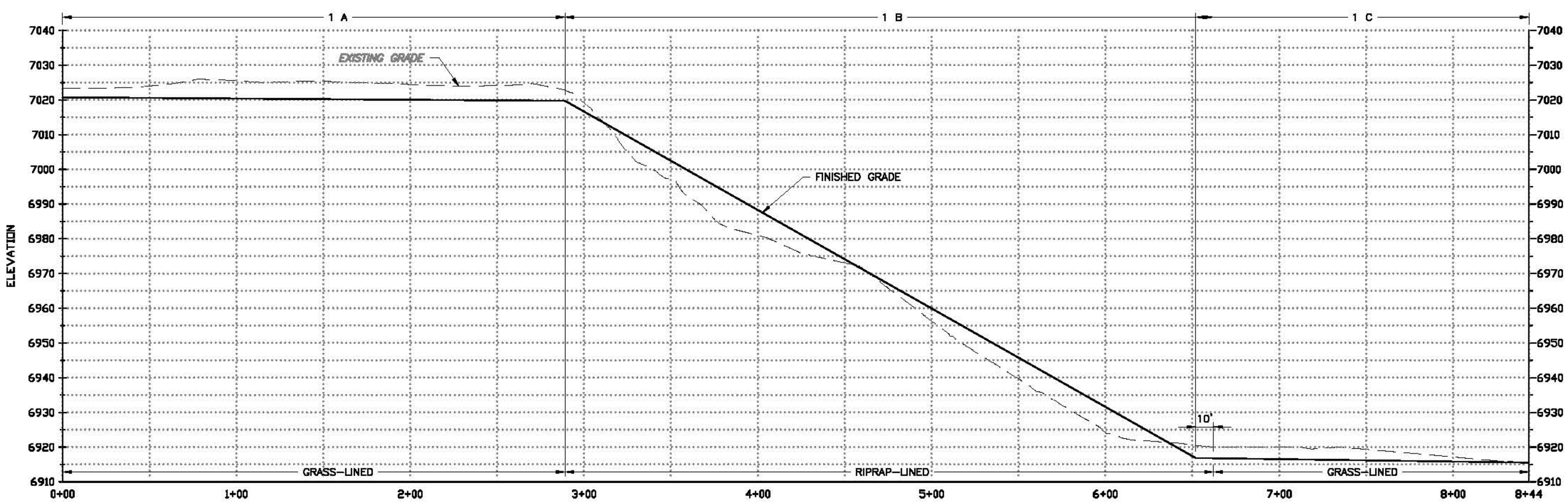

PROFILE

SCALE:
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1" = 20' VERTICAL

REV. NO.	DATE	DRWN	CHKD	REMARKS

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PANDORA MINE SITE

PLAN AND PROFILE
DIVERSION CHANNEL 1

PROJECT NO. 64986
FILE NAME:
SHEET NO.
EXHIBIT B

PRELIMINARY DESIGN - NOT FOR CONSTRUCTION

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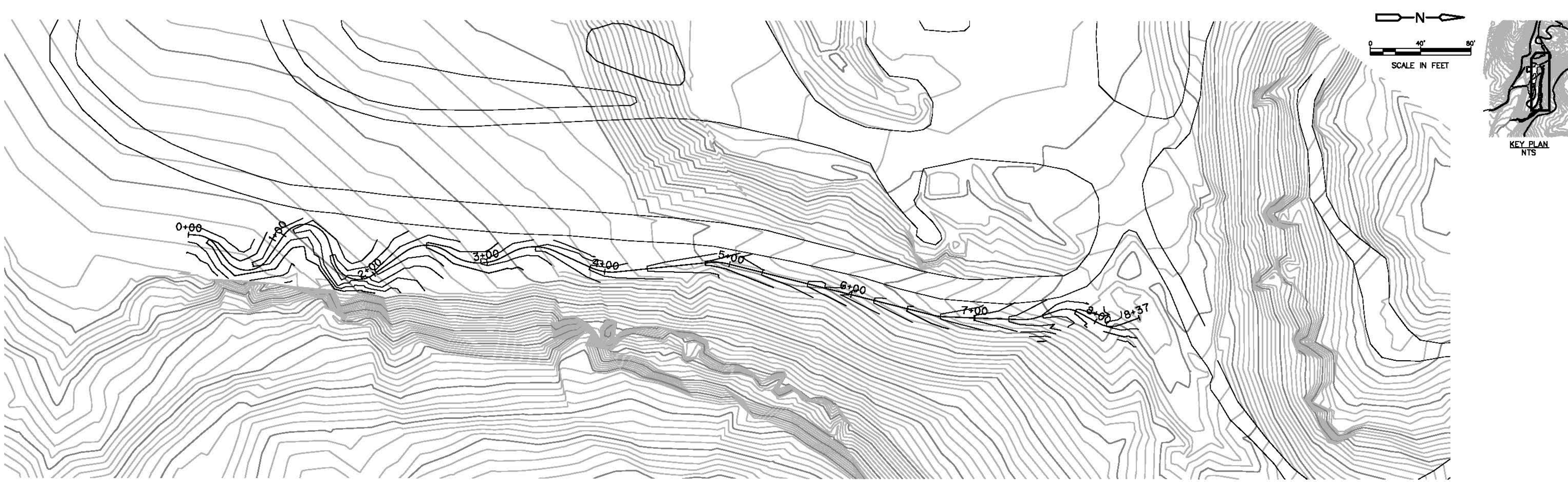

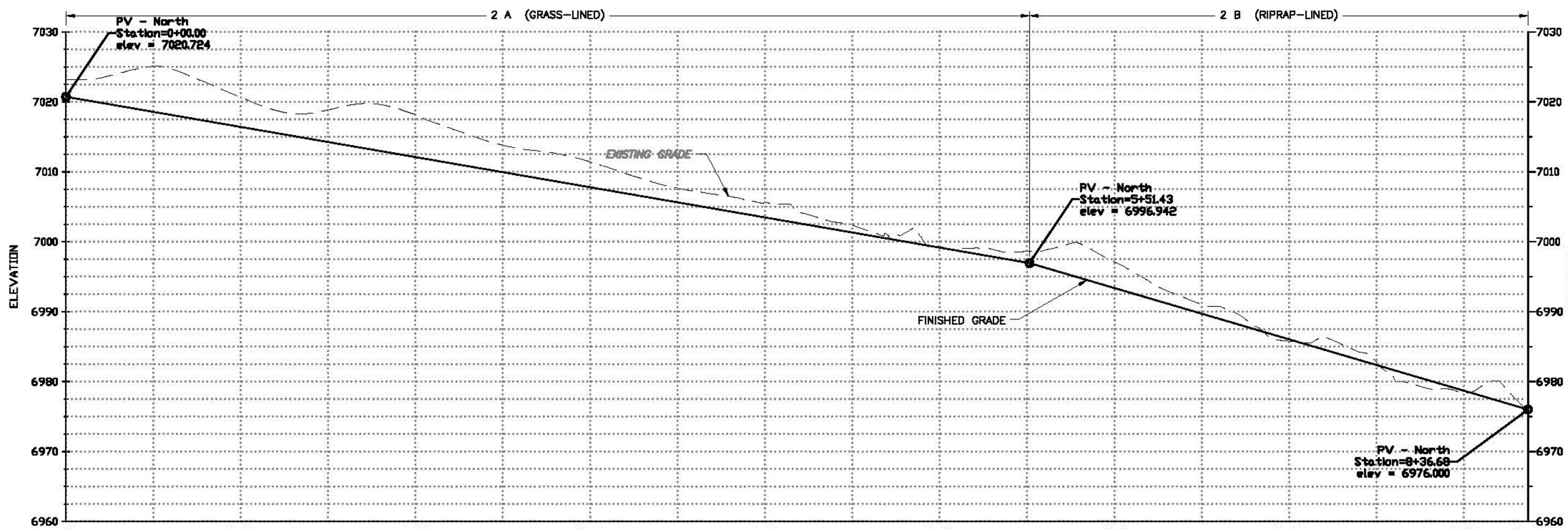

PROFILE

SCALE:
1" = 40' HORIZONTAL
1" = 10' VERTICAL

REV. NO.	DATE	DRWN	CHKD	REMARKS

DESIGNED BY: C. BREWER
DRAWN BY: J. HUMPHREY
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CROSS CHK'D BY: T. BRAGDON
APPROVED BY:
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PANDORA MINE SITE

PLAN AND PROFILE
DIVERSION CHANNEL 2

PROJECT NO. 64986
FILE NAME:
SHEET NO.
EXHIBIT C

PRELIMINARY DESIGN - NOT FOR CONSTRUCTION

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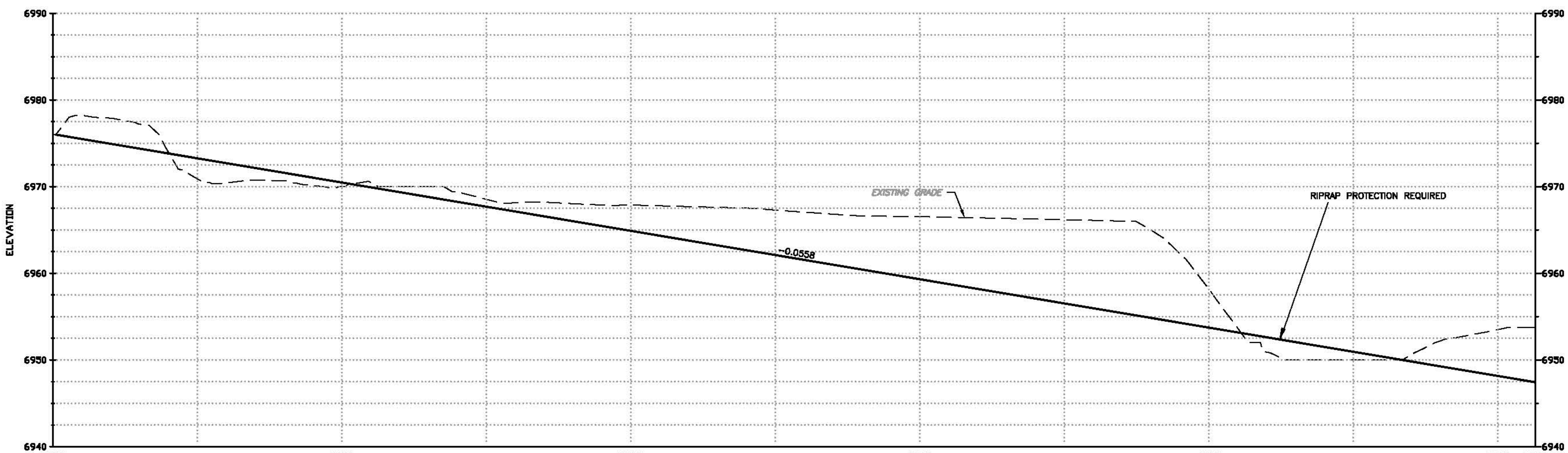

PROFILE

SCALE:
1" = 20' HORIZONTAL
1" = 5' VERTICAL

REV. NO.	DATE	DRWN	CHKD	REMARKS

DESIGNED BY: C. BREWER
DRAWN BY: J. HUMPHREY
SHEET CHK'D BY: M. EOM
CROSS CHK'D BY: T. BRAGDON
APPROVED BY:
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PANDORA MINE SITE

PLAN AND PROFILE
CULVERT DRAINAGE CHANNEL

PROJECT NO. 64986
FILE NAME:
SHEET NO.
EXHIBIT C

PRELIMINARY DESIGN - NOT FOR CONSTRUCTION

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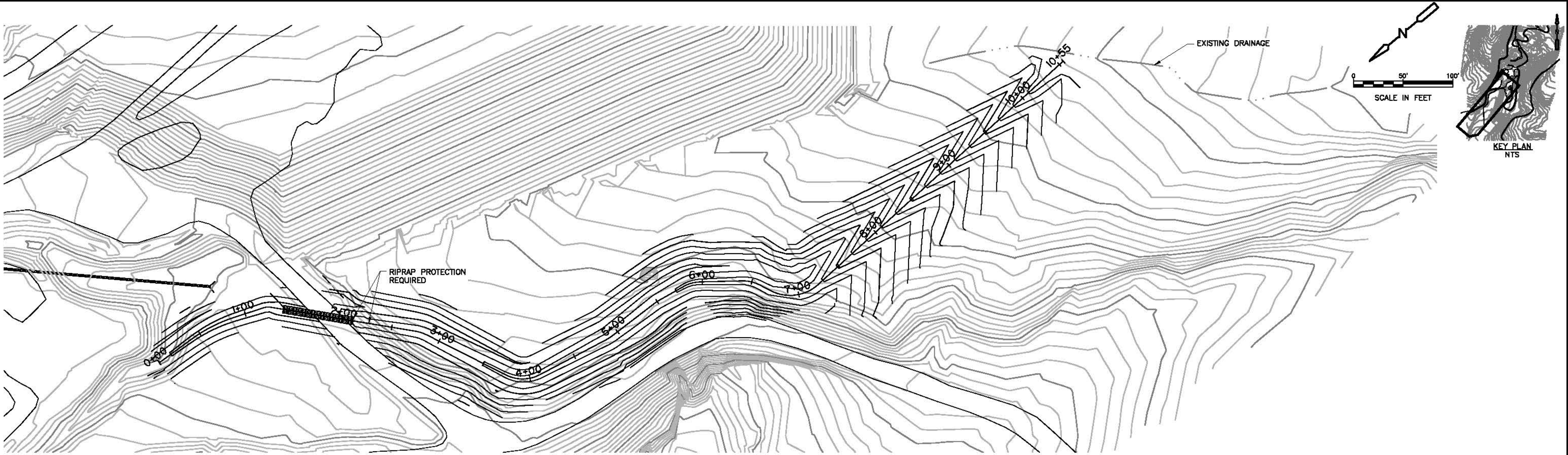

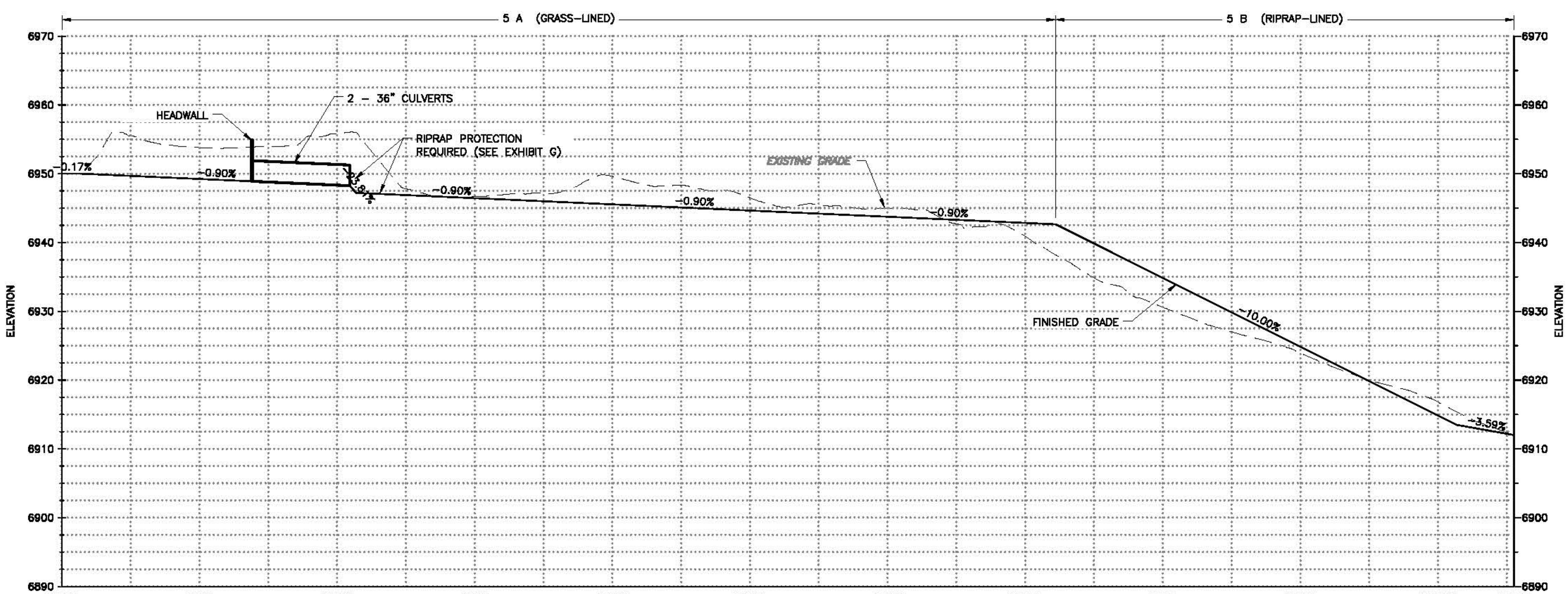

PROFILE

SCALE:
1" = 50' HORIZONTAL
1" = 10' VERTICAL

REV. NO.	DATE	DRWN	CHKD	REMARKS

DESIGNED BY: M. EOM
DRAWN BY: J. HUMPHREY
SHEET CHK'D BY: M. EOM
CROSS CHK'D BY: T. BRAGDON
APPROVED BY:
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PANDORA MINE SITE

PLAN AND PROFILE
DIVERSION CHANNEL 5

PROJECT NO. 64986
FILE NAME:
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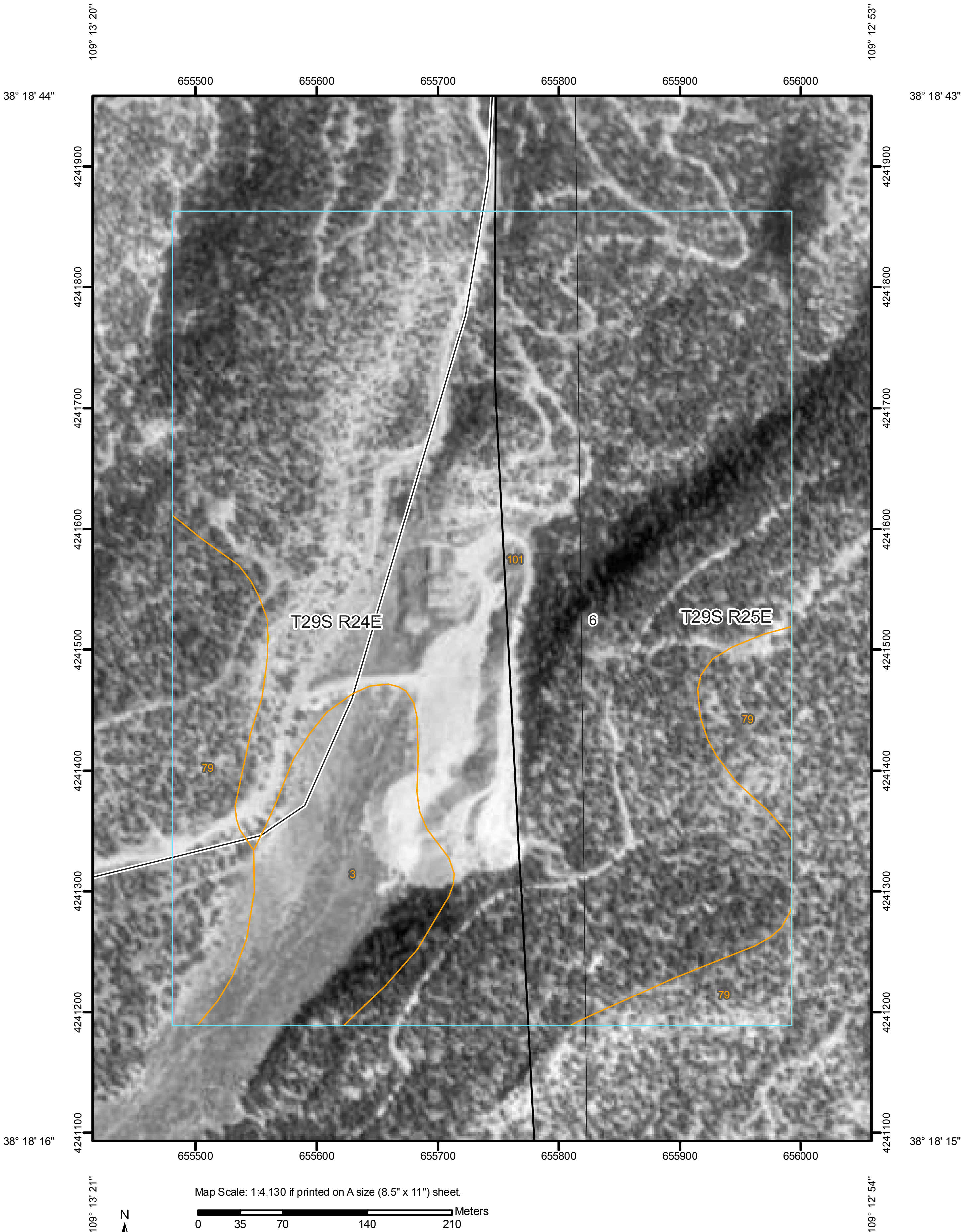
EXHIBIT E

PRELIMINARY DESIGN - NOT FOR CONSTRUCTION

X:\64986-Denison Mines\Pandora Mine\CIVIL\ CSTPR-002 11/05/09 15:30 HUMPHREYJL XREFS: CSTPL100, 64986-TB

Appendix A
NRCS Soil Map and Soil Type Description for the Pandora Mine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109° 12' 53''
38° 18' 44"
38° 18' 43"
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655600
655700
655800
655900
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4241800
4241700
4241600
4241500
4241400
4241300
4241200
4241100
101
T29S R24E
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T29S R25E
79
79
3
79
38° 18' 16"
38° 18' 15"
109° 13' 21''
109° 12' 54''
Map Scale: 1:4,130 if printed on A size (8.5" x 11") sheet.
N
Meters
0 35 70 140 210
Feet
0 150 300 600 900

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

- Soil Map Units

Special Point Features

- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other

Special Line Features

- Gully
- Short Steep Slope
- Other

Political Features

- Cities
- PLSS Township and Range
- PLSS Section

Water Features

- Oceans
- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

MAP INFORMATION

Map Scale: 1:4,130 if printed on A size (8.5" × 11") sheet.

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for accurate map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 12N NAD83

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Canyonlands Area, Utah - Parts of Grand and San Juan Counties
Survey Area Data: Version 7, Sep 28, 2009

Date(s) aerial images were photographed: 9/3/1998

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Canyonlands Area, Utah - Parts of Grand and San Juan Counties

101—Ustic Torriorthents-Ustollic Haplargids complex, 10 to 60 percent slopes

Map Unit Setting

Elevation: 5,800 to 7,500 feet
Mean annual precipitation: 10 to 14 inches
Mean annual air temperature: 48 to 52 degrees F
Frost-free period: 120 to 140 days

Map Unit Composition

Ustic torriorthents and similar soils: 45 percent
Ustollic haplargids and similar soils: 30 percent
Minor components: 25 percent

Description of Ustic Torriorthents

Setting

Landform: Landslides on escarpments
Down-slope shape: Linear
Across-slope shape: Convex, linear
Parent material: Colluvium derived from sandstone and shale

Properties and qualities

Slope: 10 to 60 percent
Depth to restrictive feature: 20 to 79 inches to paralithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately high (0.00 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 4.0 mmhos/cm)
Available water capacity: Low (about 5.2 inches)

Interpretive groups

Land capability (nonirrigated): 7e
Ecological site: Talus Slope (Blackbrush-Shadscale) (R035XY018UT)

Typical profile

0 to 3 inches: Very cobbly sandy loam
3 to 11 inches: Very cobbly loam
11 to 30 inches: Very gravelly sandy clay loam
30 to 45 inches: Cobbly sandy clay loam
45 to 49 inches: Weathered bedrock

Description of Ustollic Haplargids

Setting

Landform: Landslides on escarpments
Down-slope shape: Linear
Across-slope shape: Convex, linear
Parent material: Colluvium derived from sandstone

Properties and qualities

Slope: 10 to 40 percent
Depth to restrictive feature: 20 to 79 inches to paralithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to high (0.06 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 40 percent
Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)
Available water capacity: High (about 10.6 inches)

Interpretive groups

Land capability (nonirrigated): 7e
Ecological site: Upland Stony Loam (Pinyon-Utah Juniper) (R035XY321UT)
Other vegetative classification: Upland Shallow Loam (Pinyon-Utah Juniper) (035XY315UT_3)

Typical profile

0 to 8 inches: Stony sandy loam
8 to 24 inches: Stony sandy clay loam, stony clay loam
24 to 60 inches: Stony silty clay loam

Minor Components

Strych

Percent of map unit: 8 percent

Ignacio

Percent of map unit: 5 percent

Rock outcrop

Percent of map unit: 5 percent

Rizno

Percent of map unit: 5 percent

Badland

Percent of map unit: 2 percent

Data Source Information

Soil Survey Area: Canyonlands Area, Utah - Parts of Grand and San Juan Counties
Survey Area Data: Version 7, Sep 28, 2009

Map Unit Legend

Canyonlands Area, Utah - Parts of Grand and San Juan Counties (UT633)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
3	Barnum loam, 0 to 3 percent slopes	8.7	10.2%
79	Shalako-Anasazi-Rock outcrop complex, 3 to 15 percent slopes	10.2	12.0%
101	Ustic Torriorthents-Ustollic Haplargids complex, 10 to 60 percent slopes	66.3	77.8%
Totals for Area of Interest		**85.2**	**100.0%**

Appendix B
Peak Discharge Estimate Calculation Brief

CDM

PROJECT:	Pandora	COMPUTED BY :	Brewer C.	CHECKED BY:	Eom M.
JOB NO.:		DATE :	7/26/2010	DATE CHECKED:	7/26/2010
CLIENT:	Denison Mine			PAGE NO. :	1 of 1

Description: These sheets show the calculation of time of concentration for the subwatersheds listed, as described in USDA Natural Resources Conservation Service - Construction and Engineering Division Technical Release 55

Basin 2

Assumptions:
-100yr 24hr storm in La Sal 2 SE, Utah, 3.09 in
-Soil type: 101 - very low to moderatley high, Group C

P 100 yr 24 hr (in)	3.09
P 2yr 24hr (in)	1.4
Ia (eq2-2)	0.198
Ia/P100	0.1
CN	91
S	0.989
Q (inches) eq 2-3	2.16

TR-55 Time of Concentration

Sheet Flow		Shallow Conc Flow	
n	0.4	s (ft/ft)	0.312242091
L (ft)	300	L (ft)	727
100yr 24hr	3.09	V (ft/s)	8.9
s (ft/ft)	0.23333		
Tt (hr)	0.328	Tt (hr)	0.023

Total Tt (hr)	0.35
Total Tt (min)	21
Lag Time (min)	12.6
Am (drainage area, mi2)	0.00988
Q (runoff, in)	2.16
qu (csm/in) (Exhibit 4-II)	675
Peak discharge (cfs), eq 4-1	14.37

Basin 2

Assumptions:
-2yr 24hr storm in La Sal 2 SE, Utah, 1.4 in
-Soil type: 101 - very low to moderatley high, Group C

P 2yr 24hr (in)	1.4
Ia (eq2-2)	0.198
Ia/P100	0.1
CN	91
S	0.989
Q (inches) eq 2-3	0.66

TR-55 Time of Concentration

Sheet Flow		Shallow Conc Flow	
n	0.4	s (ft/ft)	0.312242091
L (ft)	300	L (ft)	727
2yr 24hr	1.4	V (ft/s)	8.9
s (ft/ft)	0.23333		
Tt (hr)	0.488	Tt (hr)	0.023

Total Tt (hr)	0.51
Total Tt (min)	31
Lag Time (min)	18.4
Am (drainage area, mi2)	0.00988
Q (runoff, in)	0.66
qu (csm/in) (Exhibit 4-II)	525
Peak discharge (cfs), eq 4-1	3.42

CDM

PROJECT:	Pandora	COMPUTED BY :	Brewer C.	CHECKED BY:	Eom M.
JOB NO.:		DATE :	7/26/2010	DATE CHECKED:	7/26/2010
CLIENT:	Denison Mine			PAGE NO. :	2 of 3

Description: These sheets show the calculation of time of concentration for the subwatersheds listed, as described in USDA Natural Resources Conservation Service - Construction and Engineering Division Technical Release 55

Basin 4

Assumptions:
-100 yr 24hr storm in La Sal 2 SE, Utah, 3.09 in
-Soil type: 101 - very low to moderatley high, Group C

P 100 yr 24 hr (in)	3.09
P 2yr 24hr (in)	1.4
Ia (eq2-2)	0.198
Ia/P100	0.1
CN	91
S	0.989
Q (inches) eq 2-3	2.16
TR-55 Time of Concentration	
Sheet Flow	
n	0.4
L (ft)	254
100yr 24hr	1.4
s (ft/ft)	0.37
Tt (hr)	0.353
Total Tt (hr)	0.35
Total Tt (min)	21
Lag Time (min)	12.7
Am (drainage area, mi2)	0.001
Q (runoff, in)	2.16
qu (csm/in) (Exhibit 4-II)	640
Peak discharge (cfs), eq 4-1	1.16

Basin 5

Assumptions:
-100 yr 24hr storm in La Sal 2 SE, Utah, 3.09 in
-Soil type: 101 - very low to moderatley high, Group C

P 100 yr 24 hr (in)	3.09
P 2yr 24hr (in)	1.4
Ia (eq2-2)	0.198
Ia/P100	0.1
CN	91
S	0.989
Q (inches) eq 2-3	2.16
TR-55 Time of Concentration	
Sheet Flow	
n	0.4
L (ft)	241
100yr 24hr	1.4
s (ft/ft)	0.36
Tt (hr)	0.344
Total Tt (hr)	0.34
Total Tt (min)	21
Lag Time (min)	12.4
Am (drainage area, mi2)	0.00094
Q (runoff, in)	2.16
qu (csm/in) (Exhibit 4-II)	645
Peak discharge (cfs), eq 4-1	1.30

Source: USDA NRCS TR-55

Appendix C
Detailed Analysis for Diversion channel 1B
Riprap Protection

Appendix C
Diversion Channel 1B Riprap Sizing using CHANLPRO

```
    PROGRAM OUTPUT FOR A TRAPEZOIDAL CHANNEL INVERT, STRAIGHT REACH
 STRAIGHT REACH IS > 5 WS WIDTHS DS OF ANYTHING CAUSING A FLOW IMBALANCE
                  INPUT PARAMETERS
    SPECIFIC WEIGHT OF STONE,PCF              165.0
    LOCAL FLOW DEPTH,FT                         1.4
    CHANNEL SIDE SLOPE,1 VER: 3.00 HORZ
    AVERAGE CHANNEL VELOCITY,FPS              10.47
    COMPUTED LOCAL DEPTH AVG VEL,FPS          12.04
    (LOCAL VELOCITY)/(AVG CHANNEL VEL)         1.15
    BOTTOM WIDTH,FT TRAP SECT                  4.00
    MAXIMUM FLOW DEPTH,FT TRAP SECT            1.36
    SIDE SLOPE CORRECTION FACTOR K1            1.00
    CORRECTION FOR VELOCITY PROFILE IN BEND    1.00
    RIPRAP DESIGN SAFETY FACTOR                1.10


                          SELECTED STABLE GRADATIONS
                                ETL GRADATION

    NAME    COMPUTED D30(MIN)  D100(MAX)  D85/D15  N=THICKNESS/   CT  THICKNESS
             D30 FT     FT        IN                  D100(MAX)           IN
     5                 .85      21.00       1.70    NOT STABLE
     6         .97     .97      24.00       1.70       1.46       .90    35.0
     7        1.08    1.10      27.00       1.70       1.00      1.00    27.0

  D100(MAX)        LIMITS OF STONE WEIGHT,LB          D30(MIN)  D90(MIN)
     IN          FOR PERCENT LIGHTER BY WEIGHT           FT        FT
                   100           50            15
   24.00      691    276    205    138    102     43     .97      1.40
   27.00      984    394    291    197    146     62    1.10      1.59

          EQUIVALENT SPHERICAL DIAMETERS IN INCHES
  D100(MAX)  D100(MIN)  D50(MAX)  D50(MIN)  D15(MAX)  D15(MIN)
   24.0       17.7       16.0      14.0      12.7       9.5
   27.0       19.9       18.0      15.8      14.3      10.7
```

Appendix D
Detailed Analysis for Culvert 1 Design

Culvert Calculator Report
Culvet#2

Solve For: Headwater Elevation

Culvert Summary

Allowable HW Elevation	6,978.00	ft	Headwater Depth/Height	1.34	
Computed Headwater Eleva	6,972.42	ft	Discharge	50.00	cfs
Inlet Control HW Elev.	6,972.29	ft	Tailwater Elevation	6,950.00	ft
Outlet Control HW Elev.	6,972.42	ft	Control Type	Entrance Control	

Grades

Upstream Invert	6,968.40	ft	Downstream Invert	6,949.19	ft
Length	388.00	ft	Constructed Slope	0.049510	ft/ft

Hydraulic Profile

Profile	S2		Depth, Downstream	1.71	ft
Slope Type	Steep		Normal Depth	1.71	ft
Flow Regime	Supercritical		Critical Depth	2.30	ft
Velocity Downstream	11.99	ft/s	Critical Slope	0.021882	ft/ft

Section

Section Shape	Circular		Mannings Coefficient	0.024	
Section Material	CMP		Span	3.00	ft
Section Size	36 inch		Rise	3.00	ft
Number Sections	1				

Outlet Control Properties

Outlet Control HW Elev.	6,972.42	ft	Upstream Velocity Head	1.15	ft
Ke	0.50		Entrance Loss	0.57	ft

Inlet Control Properties

Inlet Control HW Elev.	6,972.29	ft	Flow Control	Submerged	
Inlet Type	Headwall		Area Full	7.1	ft²
K	0.00780		HDS 5 Chart	2	
M	2.00000		HDS 5 Scale	1	
C	0.03790		Equation Form	1	
Y	0.69000				

Appendix E
Detailed Analysis for Culvert 2 Design

Culvert Calculator Report
diversion1_culvert

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	106.70	ft	Headwater Depth/Height	1.95	
Computed Headwater Eleva	106.63	ft	Discharge	117.80	cfs
Inlet Control HW Elev.	105.53	ft	Tailwater Elevation	102.20	ft
Outlet Control HW Elev.	106.63	ft	Control Type	Outlet Control	

Grades					
Upstream Invert	100.77	ft	Downstream Invert	100.00	ft
Length	85.50	ft	Constructed Slope	0.009006	ft/ft

Hydraulic Profile					
Profile	CompositeM2PressureProfile		Depth, Downstream	2.48	ft
Slope Type	Mild		Normal Depth	N/A	ft
Flow Regime	Subcritical		Critical Depth	2.48	ft
Velocity Downstream	9.42	ft/s	Critical Slope	0.026148	ft/ft

Section					
Section Shape	Circular		Mannings Coefficient	0.024	
Section Material	Concrete		Span	3.00	ft
Section Size	36 inch		Rise	3.00	ft
Number Sections	2				

Outlet Control Properties					
Outlet Control HW Elev.	106.63	ft	Upstream Velocity Head	1.08	ft
Ke	0.50		Entrance Loss	0.54	ft

Inlet Control Properties					
Inlet Control HW Elev.	105.53	ft	Flow Control	Submerged	
Inlet Type	Square edge w/headwall		Area Full	14.1	ft²
K	0.00980		HDS 5 Chart	1	
M	2.00000		HDS 5 Scale	1	
C	0.03980		Equation Form	1	
Y	0.67000				

Appendix F
Detailed Analysis for Diversion channel 1B Riprap Protection

Appendix F
Diversion channel 1B Riprap Sizing using CHANLPRO

PROGRAM OUTPUT FOR A TRAPEZOIDAL CHANNEL INVERT, STRAIGHT REACH

STRAIGHT REACH IS > 5 WS WIDTHS DS OF ANYTHING CAUSING A FLOW IMBALANCE

INPUT PARAMETERS

SPECIFIC WEIGHT OF STONE,PCF	165.0
LOCAL FLOW DEPTH,FT	0.3
CHANNEL SIDE SLOPE,1 VER: 3.00 HORZ	
AVERAGE CHANNEL VELOCITY,FPS	8.26
COMPUTED LOCAL DEPTH AVG VEL,FPS	9.50
(LOCAL VELOCITY)/(AVG CHANNEL VEL)	1.15
BOTTOM WIDTH,FT TRAP SECT	4.00
MAXIMUM FLOW DEPTH,FT TRAP SECT	0.34
SIDE SLOPE CORRECTION FACTOR K1	1.00
CORRECTION FOR VELOCITY PROFILE IN BEND	1.00
RIPRAP DESIGN SAFETY FACTOR	1.20

SELECTED STABLE GRADATIONS

ETL GRADATION

NAME	COMPUTED D30 FT	D30(MIN) FT	D100(MAX) IN	D85/D15	N=THICKNESS/ D100(MAX)	CT	THICKNESS IN
4		.73	18.00	1.70	NOT STABLE		
5	.85	.85	21.00	1.70	1.33	.92	27.9
6	.92	.97	24.00	1.70	1.00	1.00	24.0

D100(MAX) IN	LIMITS OF STONE WEIGHT,LB FOR PERCENT LIGHTER BY WEIGHT 100		50		15		D30(MIN) FT	D90(MIN) FT
21.00	463	185	137	93	69	29	.85	1.23
24.00	691	276	205	138	102	43	.97	1.40

EQUIVALENT SPHERICAL DIAMETERS IN INCHES

D100(MAX)	D100(MIN)	D50(MAX)	D50(MIN)	D15(MAX)	D15(MIN)
21.0	15.5	14.0	12.3	11.1	8.3
24.0	17.7	16.0	14.0	12.7	9.5

Appendix G
Detailed Analysis for Diversion channel 2B Riprap Protection

Appendix G
Diversion channel 2B Riprap Sizing using CHANLPRO

PROGRAM OUTPUT FOR A TRAPEZOIDAL CHANNEL INVERT, STRAIGHT REACH
STRAIGHT REACH IS > 5 WS WIDTHS DS OF ANYTHING CAUSING A FLOW IMBALANCE

INPUT PARAMETERS

SPECIFIC WEIGHT OF STONE,PCF	165.0
LOCAL FLOW DEPTH,FT	0.5
CHANNEL SIDE SLOPE,1 VER: 3.00 HORZ	
AVERAGE CHANNEL VELOCITY,FPS	5.00
COMPUTED LOCAL DEPTH AVG VEL,FPS	5.75
(LOCAL VELOCITY)/(AVG CHANNEL VEL)	1.15
BOTTOM WIDTH,FT TRAP SECT	4.00
MAXIMUM FLOW DEPTH,FT TRAP SECT	0.46
SIDE SLOPE CORRECTION FACTOR K1	1.00
CORRECTION FOR VELOCITY PROFILE IN BEND	1.00
RIPRAP DESIGN SAFETY FACTOR	1.20

SELECTED STABLE GRADATIONS
ETL GRADATION

NAME	COMPUTED D30 FT	D30(MIN) FT	D100(MAX) IN	D85/D15	N=THICKNESS/ D100(MAX)	CT	THICKNESS IN
1	.24	.37	9.00	1.70	1.00	1.00	9.0

D100(MAX) IN	LIMITS OF STONE WEIGHT,LB FOR PERCENT LIGHTER BY WEIGHT						D30(MIN) FT	D90(MIN) FT
	100		50		15			
9.00	36	15	11	7	5	2	.37	.53

EQUIVALENT SPHERICAL DIAMETERS IN INCHES

D100(MAX)	D100(MIN)	D50(MAX)	D50(MIN)	D15(MAX)	D15(MIN)
9.0	6.6	6.0	5.3	4.8	3.6

Appendix H
Detailed Analysis for Diversion channel 3 Riprap Protection

Appendix H
Diversion Channel Riprap Sizing using CHANLPRO

PROGRAM OUTPUT FOR A TRAPEZOIDAL CHANNEL SIDE SLOPE, STRAIGHT REACH

STRAIGHT REACH IS > 5 WS WIDTHS DS OF ANYTHING CAUSING A FLOW IMBALANCE

INPUT PARAMETERS

SPECIFIC WEIGHT OF STONE,PCF	165.0
LOCAL FLOW DEPTH,FT	1.8
CHANNEL SIDE SLOPE,1 VER: 2.00 HORZ	
AVERAGE CHANNEL VELOCITY,FPS	7.43
COMPUTED LOCAL DEPTH AVG VEL,FPS	7.92
(LOCAL VELOCITY)/(AVG CHANNEL VEL)	1.07
BOTTOM WIDTH,FT TRAP SECT	.00
MAXIMUM FLOW DEPTH,FT TRAP SECT	1.80
SIDE SLOPE CORRECTION FACTOR K1	.88
CORRECTION FOR VELOCITY PROFILE IN BEND	1.00
RIPRAP DESIGN SAFETY FACTOR	1.20

SELECTED STABLE GRADATIONS

ETL GRADATION

NAME	COMPUTED D30 FT	D30(MIN) FT	D100(MAX) IN	D85/D15	N=THICKNESS/ D100(MAX)	CT	THICKNESS IN
1		.37	9.00	1.70	NOT STABLE		
2	.45	.48	12.00	1.70	1.00	1.00	12.0

D100(MAX) IN	LIMITS OF STONE WEIGHT,LB FOR PERCENT LIGHTER BY WEIGHT 100		50		15		D30(MIN) FT	D90(MIN) FT
12.00	86	35	26	17	13	5	.48	.70

EQUIVALENT SPHERICAL DIAMETERS IN INCHES

D100(MAX)	D100(MIN)	D50(MAX)	D50(MIN)	D15(MAX)	D15(MIN)
12.0	8.8	8.0	7.0	6.3	4.8

Appendix I
Detailed Analysis for Diversion channel 4B Riprap Protection

Appendix I
Diversion Channel 4B Riprap Sizing using CHANLPRO

```
   PROGRAM OUTPUT FOR A TRAPEZOIDAL CHANNEL INVERT, STRAIGHT REACH
STRAIGHT REACH IS > 5 WS WIDTHS DS OF ANYTHING CAUSING A FLOW IMBALANCE
                  INPUT PARAMETERS
   SPECIFIC WEIGHT OF STONE,PCF                 165.0
   LOCAL FLOW DEPTH,FT                            1.4
   CHANNEL SIDE SLOPE,1 VER: 3.00 HORZ
   AVERAGE CHANNEL VELOCITY,FPS                 10.47
   COMPUTED LOCAL DEPTH AVG VEL,FPS             12.04
   (LOCAL VELOCITY)/(AVG CHANNEL VEL)            1.15
   BOTTOM WIDTH,FT TRAP SECT                     4.00
   MAXIMUM FLOW DEPTH,FT TRAP SECT               1.36
   SIDE SLOPE CORRECTION FACTOR K1               1.00
   CORRECTION FOR VELOCITY PROFILE IN BEND       1.00
   RIPRAP DESIGN SAFETY FACTOR                   1.10


                          SELECTED STABLE GRADATIONS
                                 ETL GRADATION

   NAME    COMPUTED D30(MIN)  D100(MAX)  D85/D15  N=THICKNESS/   CT  THICKNESS
            D30 FT     FT         IN               D100(MAX)           IN
    5                 .85       21.00       1.70    NOT STABLE
    6         .97     .97       24.00       1.70       1.46       .90    35.0
    7        1.08    1.10       27.00       1.70       1.00      1.00    27.0

 D100(MAX)        LIMITS OF STONE WEIGHT,LB          D30(MIN)  D90(MIN)
    IN          FOR PERCENT LIGHTER BY WEIGHT           FT        FT
                 100           50            15
  24.00       691    276    205    138    102     43     .97      1.40
  27.00       984    394    291    197    146     62    1.10      1.59

          EQUIVALENT SPHERICAL DIAMETERS IN INCHES
 D100(MAX)  D100(MIN)  D50(MAX)  D50(MIN)  D15(MAX)  D15(MIN)
  24.0       17.7       16.0      14.0      12.7       9.5
  27.0       19.9       18.0      15.8      14.3      10.7
```

Appendix J
Jones & DeMille Engineering Pandora Mine Drainage Summary

PANDORA MINE
DRAINAGE SUMMARY

Prepared for:

DENISON MINES (USA) CORP

January 2009

Jones & DeMille Engineering

1535 South 100 West
Richfield, UT 84701
PH: 435-896-8266
FAX: 435-896-8268
[0801-126]

Basin Boundary Assumptions

The basin boundaries have been defined utilizing the surveyed existing ground contours as well as contour information from the USGS Quad Map "Lost Spring Quadrangle". Four basins have been created to define the drainage within the Pandora area. The basins were laid out assuming that all off site water is channelized to bypass the surface disturbance area. It is recommended that any work necessary to divert off site runoff be completed to minimize the size of onsite drainage facilities.

Basins 1: This basin is the disturbed mining and wasterock area at the Pandora Mine and encompasses 10.3 acres.

Basin 2: This basin is located directly east of the wasterock pile and encompasses approximately 18.3 acres.

Basin 3: This is the area northeast of the Pandora Portal and encompasses approximately 70.4 acres.

Basin 4: This is the basin located directly north of the Pandora mining area and encompasses approximately 148 acres.

Method of Analysis

The hydrology for the site has been determined using the program HEC-HMS, created by the Army Corp of Engineers. The hydrology was analyzed using the SCS Method. The SCS Method is based on the area of the basin (in square miles), the rainfall hydrograph, SCS Type II distribution, and a coefficient that represents the relative runoff potential for the soils located in the basin, called a Curve Number (CN). The lag time for each basin is determined by estimating the amount of time it takes the runoff to make it from the furthest extent of the basin to the discharge point. The CN value, is determined by the type of land use (i.e. residential, agriculture, commercial, undeveloped or natural land covers). The Curve numbers for this project were obtained from the USDA Soil Conservation Service Technical Release – 55. All appropriate reference material and calculations are included in Appendix B.

Each basin was analyzed individually. Where multiple basins may contribute to a single wash or culvert, the peak flows will be summed to be conservative in sizing.

Rainfall Data

Rainfall depth data has been referenced from the *Precipitation-Frequency Atlas of the United States*, NOAA Atlas 14 Volume 1, Version 4 for a location near LaSal, Utah. A copy of the rainfall data may be found in Appendix B.

This study has analyzed the drainage runoff potential for the 25 and 100 year/24 hour and 6 hour storm event.

Lag Time

The lag time for each basin is based on two estimated flow times. The first is considered the overland flow, or sheet flow, time. This overland flow time represents the amount of time it takes the runoff to be collected by a channelized drainage system. The second time is the time required for the flow within the channelized system to make it to the discharge location. The total lag time is the sum of these two estimated values multiplied by a factor of 0.6 and represents the time required of the entire basin to generate runoff at the outlet of the basin.

CN Value Determination

Typical CN values have been published and a copy of a referenced table is included in the Appendix. The CN value for each basin was determined using the known land usage for the area. All of the pertinent reference material may be found in Appendix B.

Summary of Hydrologic Analysis

A single analysis for each storm event has been analyzed. The analysis represents the mine site after drainage improvements have been completed.

The following tables show the results of each storm event analyzed. Please refer to Exhibit A for the drainage basin layout and to Exhibit B to see the proposed drainage improvements.

Table 1: 25 Year 6 Hour Storm Event

Drainage Basin	Area (acres)	Peak Discharge (cfs)	Volume (acre–feet)
Basin 1	10.3	1.7	0.1
Basin 2	18.3	3.0	0.2
Basin 3	70.4	11.1	0.9
Basin 4	148.0	18.5	2.0

Table 2: 100 Year 6 Hour Storm Event

Drainage Basin	Area (acres)	Peak Discharge (cfs)	Volume (acre–feet)
Basin 1	10.3	6.1	0.3
Basin 2	18.3	11.0	0.6
Basin 3	70.4	37.3	2.2
Basin 4	148.0	53.0	4.7

Table 1: 100 Year 24 Hour Storm Event

Drainage Basin	Area (acres)	Peak Discharge (cfs)	Volume (acre–feet)
Basin 1	10.3	7.9	0.8
Basin 2	18.3	14.2	1.4
Basin 3	70.4	48.1	5.2
Basin 4	148.0	66.5	10.8

Drainage Structure Design

All culverts and washes throughout the project have been designed to pass the 25 year 6 hour storm event. The culverts were sized using the Nomograph put out by Federal Highways Administration and the US Department of Transportation. A copy of the Nomograph is included in Appendix B. The sediment basin was sized to hold the volume from the 100 year 24 hour storm event with 12" of freeboard.

Summary

This hydrologic analysis for the Pandora Mine Site was conducted to help understand the site's potential for runoff. The runoff values determined by this study were used in the conceptual design of anticipated storm drainage facilities, i.e. culverts and channels.

Figure A, *Drainage Exhibit*, shows the anticipated flow pattern and runoff amounts anticipated from this site.

Appendix A

Figures

NO.	DATE	DESIGN REV. BY	MAPS CORR. BY	PARCELS AFFECTED	REQUEST BY	REMARKS
		ORIGINAL SUBMISSION FOR AUTHORIZATION				

REVISIONS

SCALE: 1" = 600'

DWG NAME:
SHT SET:
DWG CREATED: 01/09
PEN TBL:
LAST UPDATE:

Jones & DeMille Engineering, Inc.
1535 South 100 West - Richfield, Utah 84701
Phone (435) 896-8266 Fax (435) 896-8268
www.jonesanddemille.com

DESIGN:	CHECK:	REVIEW	
DRAWN: RJ 01/09	CHECK:	DATE:	
QUANT:	CHECK:	BY:	

APPROVAL RECOMM: DATE
PROJECT DESIGN ENGINEER
APPROVED: DATE

DENISON MINES, USA CORP

PANDORA MINE DRAINAGE

DRAINAGE BASIN EXHIBIT

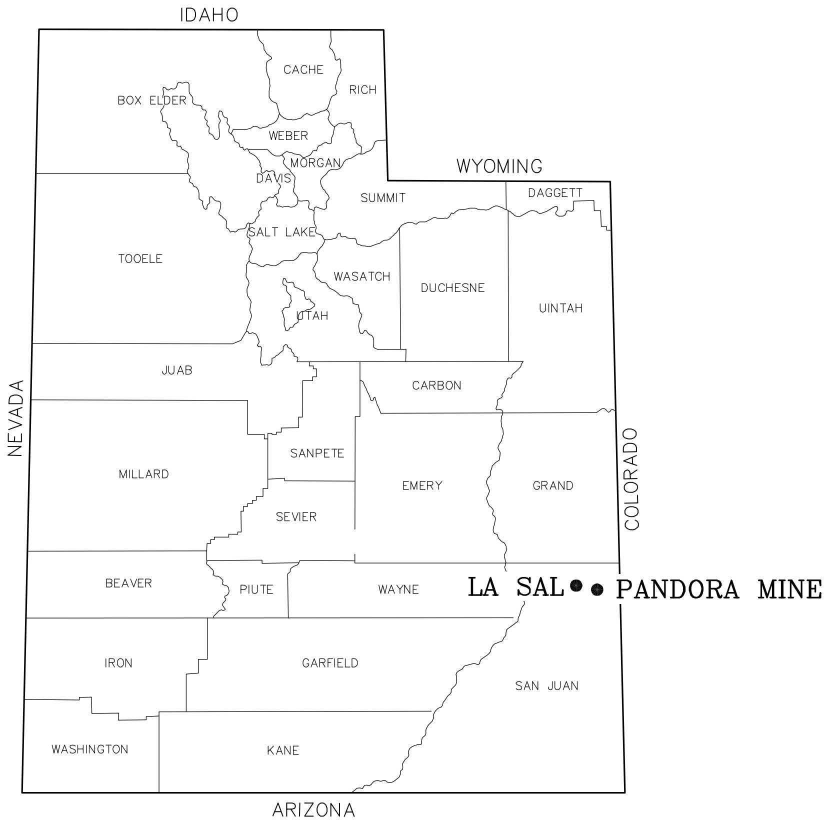
PROJECT NUMBER: 0806-045

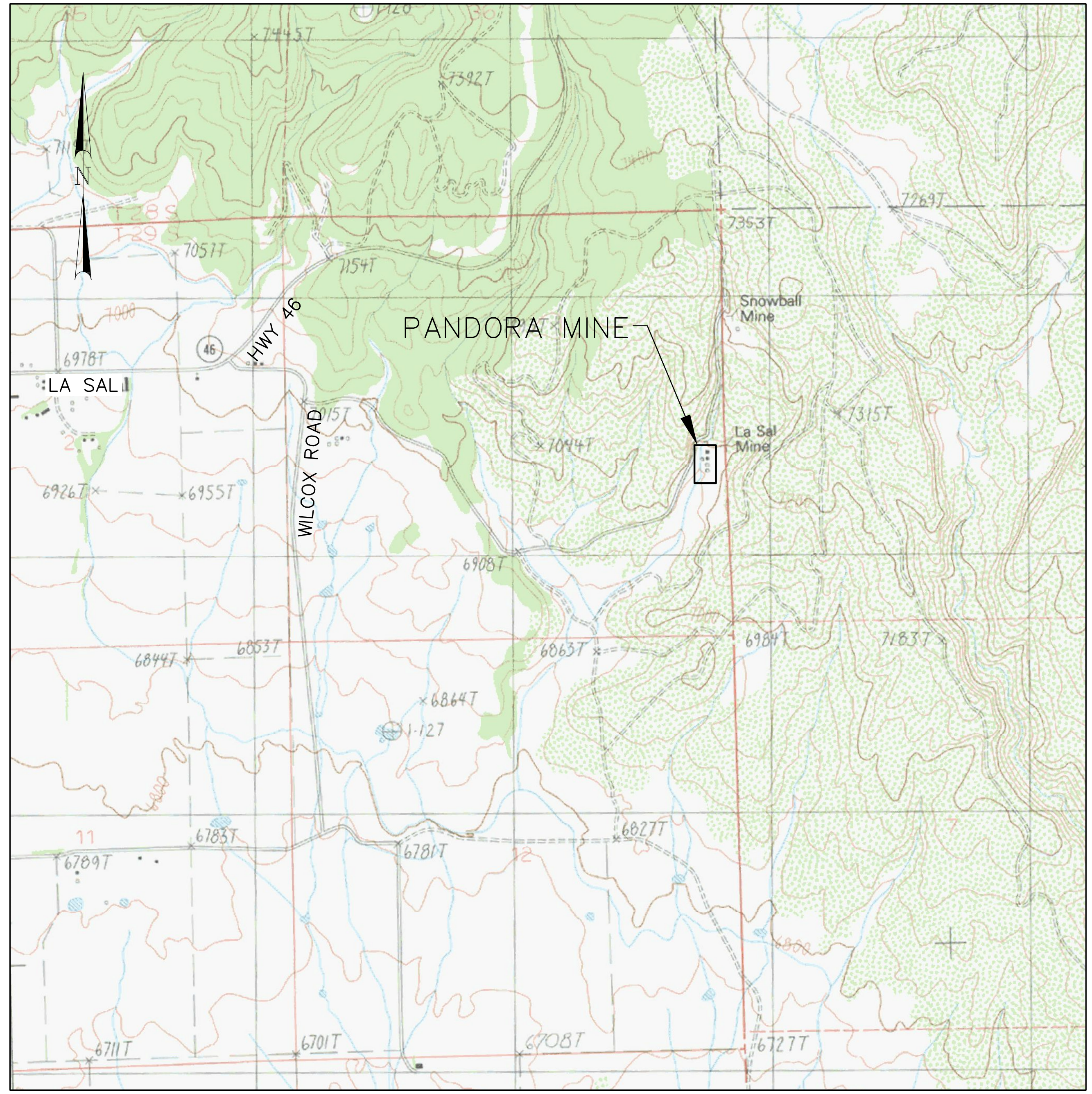
SAN JUAN
COUNTY

SHEET NO. A

DENISON MINES, USA
PANDORA MINE
2009

PROJECT NO.	SHEET NO.
0806-045	1





VICINITY MAP

INDEX TO SHEETS	
1	COVER SHEET
2	ON-SITE & OFF-SITE DRAINAGE PLAN
3	CROSS SECTIONS SHEET
4	DETAIL SHEET

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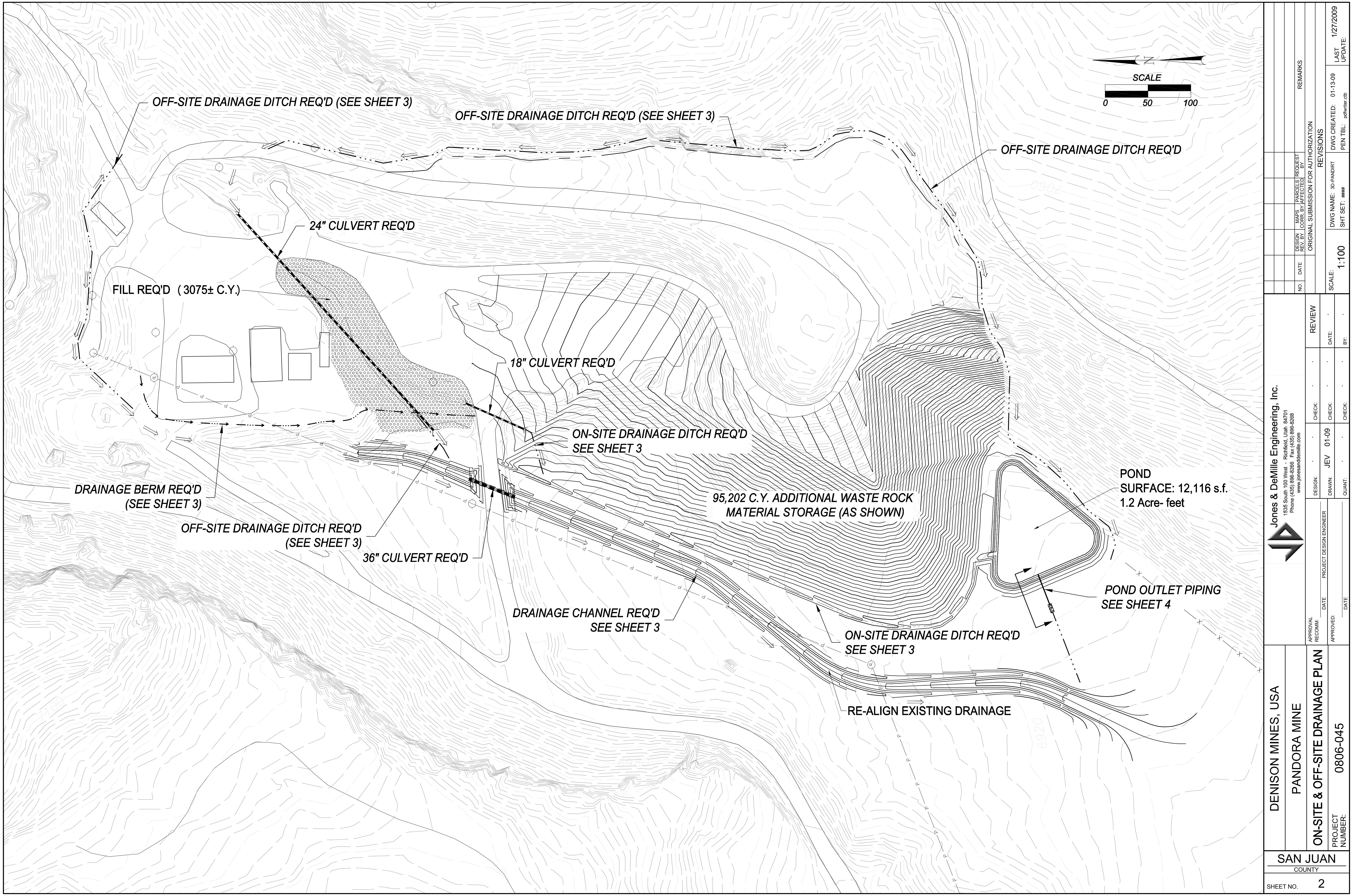
SCALE
0
50
100
OFF-SITE DRAINAGE DITCH REQ'D (SEE SHEET 3)
OFF-SITE DRAINAGE DITCH REQ'D (SEE SHEET 3)
OFF-SITE DRAINAGE DITCH REQ'D
24" CULVERT REQ'D
FILL REQ'D (3075± C.Y.)
18" CULVERT REQ'D
ON-SITE DRAINAGE DITCH REQ'D
SEE SHEET 3
DRAINAGE BERM REQ'D
(SEE SHEET 3)
OFF-SITE DRAINAGE DITCH REQ'D
(SEE SHEET 3)
36" CULVERT REQ'D
95,202 C.Y. ADDITIONAL WASTE ROCK
MATERIAL STORAGE (AS SHOWN)
POND
SURFACE: 12,116 s.f.
1.2 Acre- feet
POND OUTLET PIPING
SEE SHEET 4
DRAINAGE CHANNEL REQ'D
SEE SHEET 3
ON-SITE DRAINAGE DITCH REQ'D
SEE SHEET 3
RE-ALIGN EXISTING DRAINAGE
NO.
DATE
DESIGN REV. BY
MAPS CORR. BY
PARCELS AFFECTED
REQUEST BY
REMARKS
ORIGINAL SUBMISSION FOR AUTHORIZATION
REVISIONS
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SHT SET: ####
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PEN TBL: pdfwriter.ctb
LAST UPDATE: 1/27/2009
REVIEW
DATE:
BY:
Jones & DeMille Engineering, Inc.
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DESIGN:
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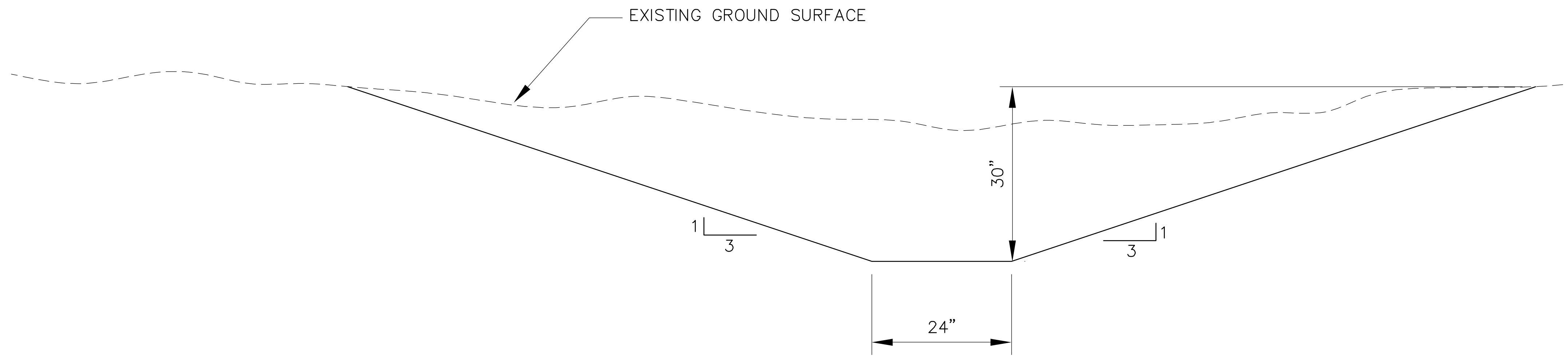
QUANT:
APPROVAL RECOMM:
DATE
PROJECT DESIGN ENGINEER
APPROVED:
DENISON MINES, USA
PANDORA MINE
ON-SITE & OFF-SITE DRAINAGE PLAN
PROJECT NUMBER: 0806-045
SAN JUAN
COUNTY
SHEET NO. 2



DRAINAGE CHANNEL X-SECTION
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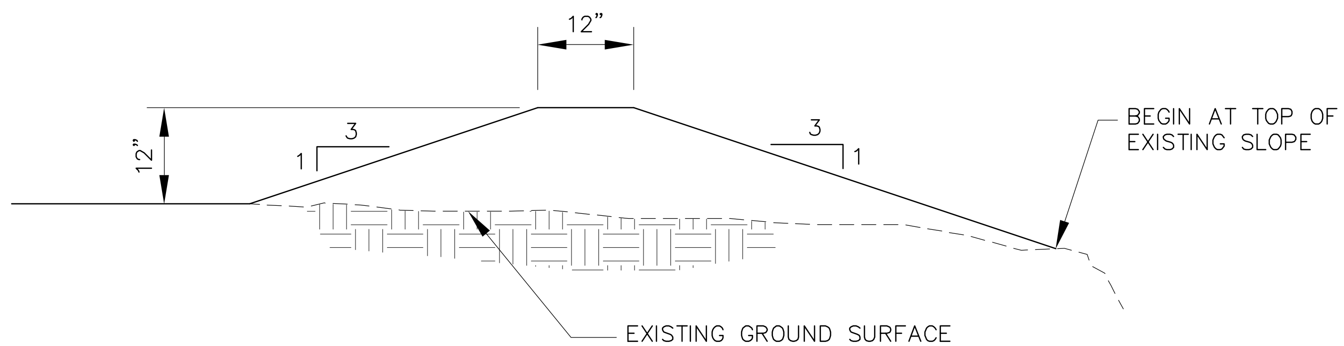
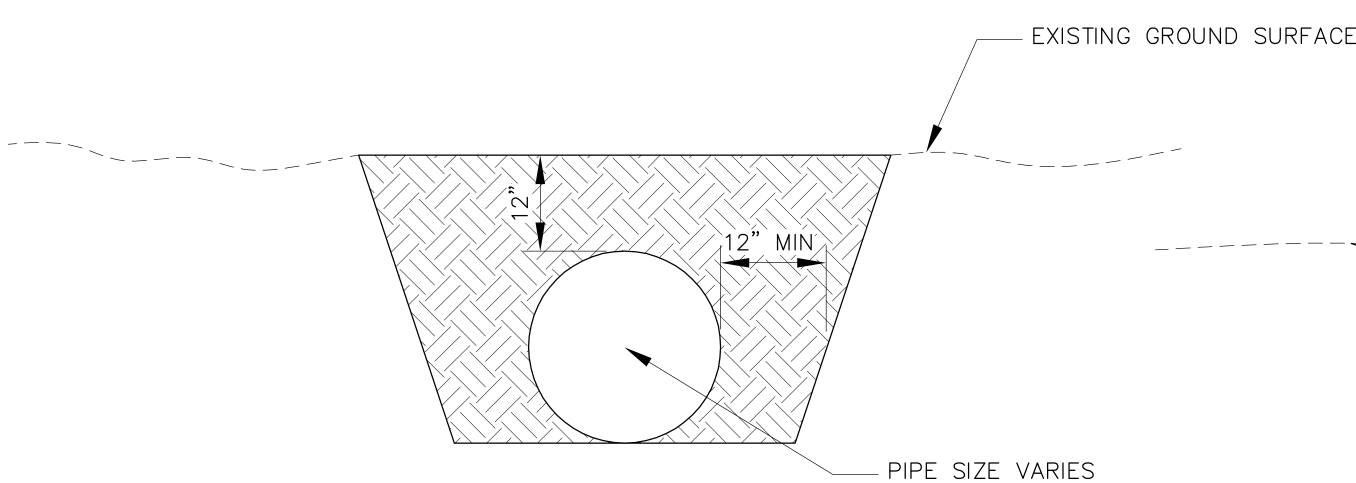
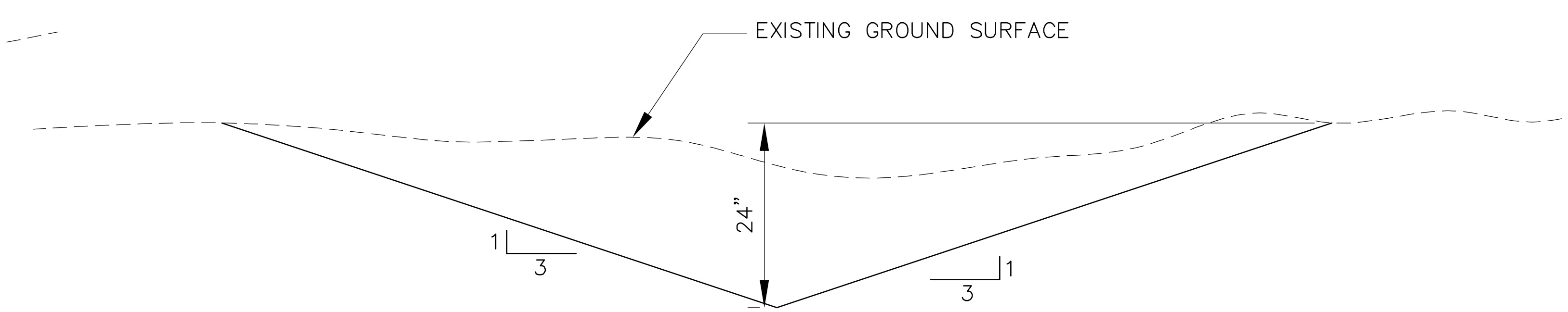


DRAINAGE BERM X-SECTION
SLOPE TO OUTFLOW



CULVERT INSTALLATION DETAIL

NOTES: (1) 1% MIN SLOPE FOR CULVERT
(2) 12" MIN COVER
(3) TRENCH WIDTH = PIPE DIAMETER PLUS 2' TO ALLOW FOR COMPACTION AROUND PIPE
(4) COMPACT BACKFILL TO 90% MAX DENSITY



OFFSITE/ONSITE DRAINAGE DITCH X-SECTION
MIN SLOPE = 1%

NO.	DATE	DESIGN REL'Y BY	MAPS CORR. BY	PARCELS AFFECTED	REQUEST BY	REMARKS
						ORIGINAL SUBMISSION FOR AUTHORIZATION

REVISIONS

SCALE: NONE

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SHT SET: ####; PEN TBL: pdfwriter.ctb
LAST UPDATE: 1/27/2009

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REVIEW		DATE: .	BY: .
DESIGN: .	CHECK: .	.	.
DRAWN: JEV 01/09	CHECK: .	.	.
QUANT: .	CHECK: .	.	.

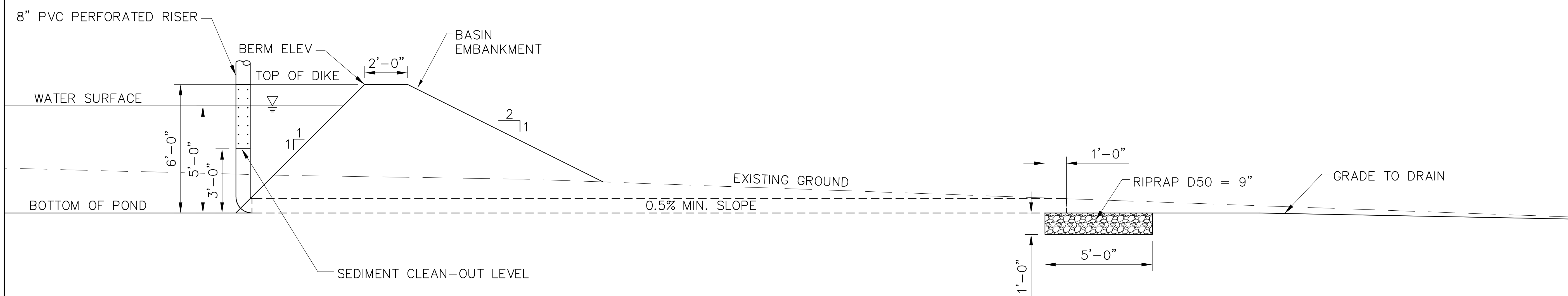
APPROVAL RECOMM: ____ DATE ____ PROJECT DESIGN ENGINEER
APPROVED: ____ DATE ____

DENISON MINES, USA
PANDORA MINE
CROSS SECTIONS

PROJECT NUMBER: 0806-045

SAN JUAN
COUNTY

SHEET NO. 3



TEMPORARY SEDIMENT BASIN OUTLET DETAIL
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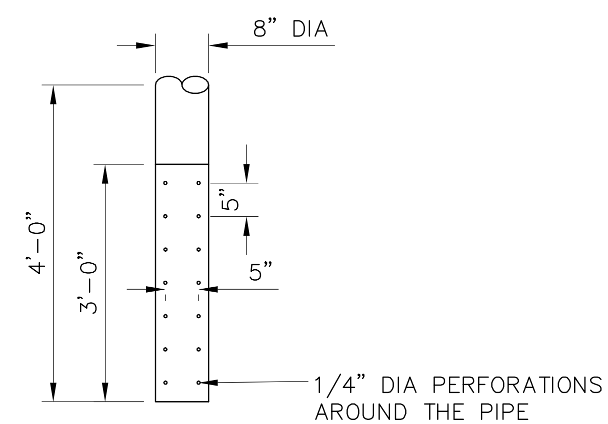

PERFORATION DETAIL FOR STAND PIPE
NTS

NO.	DATE	DESIGN REV. BY	MAPS CORR. BY	PARCELS AFFECTED	REQUEST BY	REMARKS
						ORIGINAL SUBMISSION FOR AUTHORIZATION

REVISIONS

SCALE: VARIES

DWG NAME: 3d_pandit cross sections
DWG CREATED: 01/09
LAST UPDATE: 1/27/2009
SHT SET: ####
PEN TBL: pdfwriter.ctb

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DESIGN: . . CHECK: . . REVIEW
DRAWN: JEV 01/09 CHECK: . . DATE: .
QUANT: . . CHECK: . . BY: .

APPROVAL RECOMM: ____ DATE ____ PROJECT DESIGN ENGINEER
APPROVED: ____ DATE ____

DENISON MINES, USA
PANDORA MINE
DETAIL SHEET
PROJECT NUMBER: 0806-045

SAN JUAN
COUNTY

SHEET NO. 4

Appendix B

SCS METHOD

Reference Material

&

Calculations

POINT PRECIPITATION FREQUENCY ESTIMATES FROM NOAA ATLAS 14

LA SAL, UTAH (42-4946) 38.3167 N 109.25 W 7011 feet

from "Precipitation-Frequency Atlas of the United States" NOAA Atlas 14, Volume 1, Version 4
G.M. Bonnin, D. Martin, B. Lin, T. Parzybok, M.Yekta, and D. Riley
NOAA, National Weather Service, Silver Spring, Maryland, 2006
Extracted: Thu Jan 8 2009

Precipitation Frequency Estimates (inches)

ARI* (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	0.14	0.20	0.25	0.34	0.42	0.52	0.58	0.73	0.91	1.12	1.29	1.51	1.77	2.00	2.60	3.17	3.93	4.75
2	0.17	0.26	0.33	0.44	0.54	0.65	0.72	0.90	1.13	1.40	1.60	1.89	2.21	2.49	3.24	3.94	4.88	5.88
5	0.23	0.35	0.44	0.59	0.73	0.87	0.94	1.13	1.40	1.73	1.98	2.35	2.76	3.10	3.98	4.80	5.93	7.08
10	0.29	0.44	0.54	0.73	0.90	1.06	1.12	1.33	1.62	2.02	2.29	2.75	3.22	3.61	4.56	5.47	6.75	7.98
25	0.37	0.56	0.69	0.93	1.15	1.36	1.42	1.63	1.94	2.42	2.73	3.29	3.84	4.31	5.32	6.35	7.81	9.15
50	0.43	0.66	0.82	1.10	1.37	1.64	1.69	1.88	2.20	2.74	3.08	3.73	4.33	4.87	5.90	7.02	8.60	9.99
100	0.52	0.78	0.97	1.31	1.62	1.96	2.02	2.18	2.48	3.09	3.45	4.19	4.85	5.45	6.49	7.70	9.38	10.82
200	0.60	0.92	1.14	1.54	1.90	2.33	2.39	2.56	2.81	3.45	3.83	4.68	5.38	6.06	7.06	8.35	10.15	11.62
500	0.74	1.13	1.41	1.89	2.34	2.93	2.99	3.17	3.41	3.96	4.36	5.36	6.11	6.91	7.82	9.23	11.15	12.63
1000	0.87	1.33	1.64	2.21	2.74	3.48	3.55	3.72	3.96	4.36	4.79	5.91	6.70	7.59	8.39	9.88	11.89	13.37

* These precipitation frequency estimates are based on a partial duration series. **ARI** is the Average Recurrence Interval.
Please refer to NOAA Atlas 14 Document for more information. NOTE: Formatting forces estimates near zero to appear as zero.

*** Upper bound of the 90% confidence interval**
Precipitation Frequency Estimates (inches)

ARI** (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	0.16	0.24	0.29	0.40	0.49	0.59	0.65	0.80	1.00	1.23	1.40	1.65	1.94	2.19	2.85	3.47	4.30	5.17
2	0.20	0.31	0.38	0.51	0.63	0.75	0.82	1.00	1.25	1.53	1.74	2.06	2.42	2.73	3.56	4.31	5.35	6.41
5	0.27	0.41	0.51	0.69	0.85	0.99	1.05	1.24	1.53	1.90	2.15	2.56	3.03	3.40	4.39	5.25	6.49	7.73
10	0.34	0.51	0.63	0.85	1.06	1.20	1.26	1.46	1.78	2.21	2.50	2.99	3.52	3.96	5.03	6.00	7.39	8.72
25	0.43	0.66	0.82	1.10	1.37	1.55	1.59	1.80	2.15	2.65	2.97	3.59	4.21	4.74	5.89	6.98	8.57	10.01
50	0.52	0.80	0.99	1.33	1.65	1.87	1.91	2.09	2.44	3.02	3.36	4.08	4.76	5.37	6.55	7.73	9.47	10.96
100	0.63	0.96	1.19	1.61	1.99	2.26	2.28	2.45	2.76	3.41	3.79	4.62	5.35	6.05	7.22	8.52	10.36	11.91
200	0.77	1.17	1.44	1.95	2.41	2.72	2.74	2.90	3.14	3.83	4.24	5.19	5.98	6.76	7.91	9.29	11.25	12.87
500	0.98	1.50	1.85	2.50	3.09	3.49	3.53	3.64	3.86	4.45	4.89	6.03	6.90	7.81	8.84	10.35	12.46	14.09
1000	1.20	1.82	2.26	3.04	3.77	4.23	4.27	4.34	4.54	4.96	5.44	6.73	7.63	8.66	9.55	11.14	13.39	15.01

* The **upper** bound of the confidence interval at 90% confidence level is the value which 5% of the simulated quantile values for a given frequency are **greater** than.
** These precipitation frequency estimates are based on a partial duration series. **ARI** is the Average Recurrence Interval.

Please refer to NOAA Atlas 14 Document for more information. NOTE: Formatting prevents estimates near zero to appear as zero.

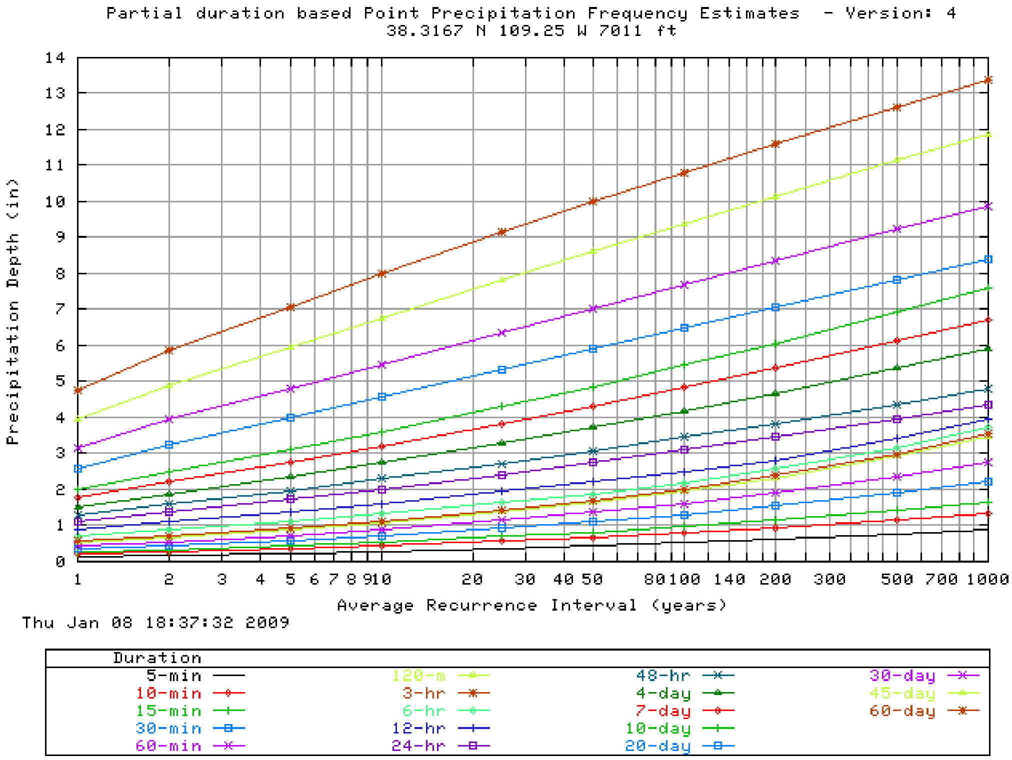
*** Lower bound of the 90% confidence interval**
Precipitation Frequency Estimates (inches)

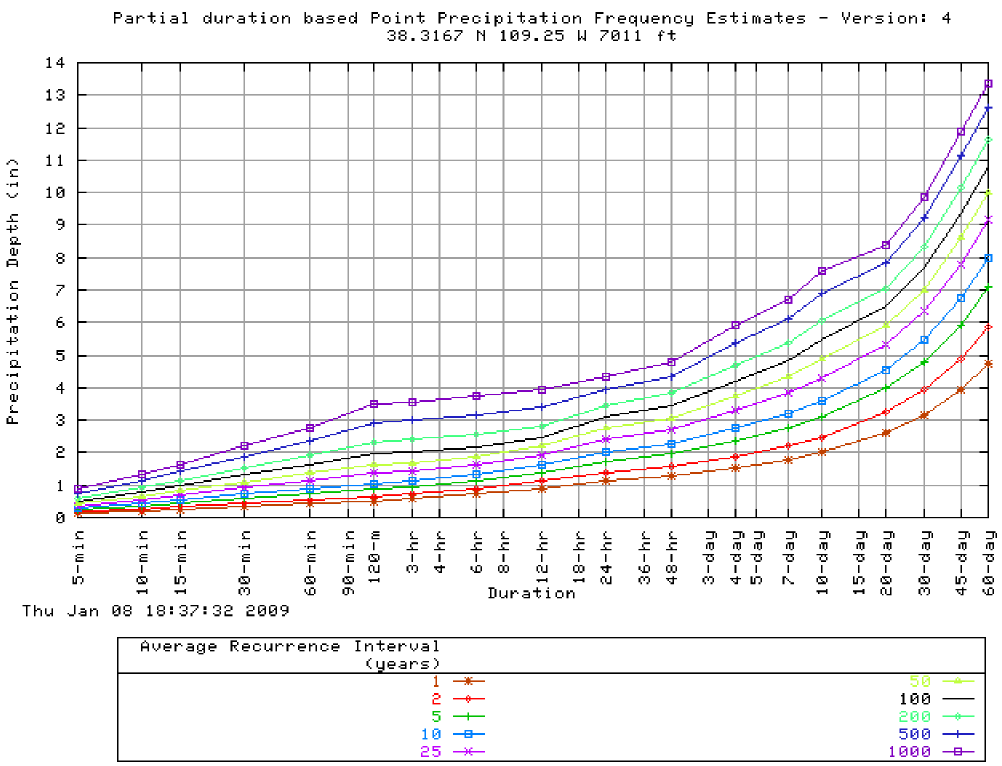
ARI** (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	0.12	0.18	0.22	0.30	0.37	0.46	0.52	0.66	0.83	1.04	1.18	1.39	1.61	1.82	2.37	2.89	3.60	4.35
2	0.15	0.24	0.29	0.39	0.49	0.58	0.65	0.82	1.03	1.28	1.47	1.74	2.02	2.27	2.95	3.58	4.46	5.38
5	0.21	0.32	0.39	0.53	0.65	0.77	0.84	1.02	1.27	1.60	1.81	2.16	2.51	2.81	3.62	4.36	5.42	6.47
10	0.25	0.39	0.48	0.65	0.80	0.93	1.00	1.20	1.47	1.85	2.09	2.51	2.92	3.27	4.13	4.97	6.16	7.29
25	0.32	0.49	0.61	0.82	1.02	1.18	1.25	1.45	1.75	2.21	2.48	2.99	3.47	3.89	4.80	5.77	7.10	8.32
50	0.38	0.58	0.72	0.97	1.20	1.39	1.46	1.67	1.97	2.48	2.78	3.36	3.90	4.36	5.29	6.35	7.79	9.05
100	0.45	0.68	0.84	1.13	1.40	1.62	1.71	1.90	2.20	2.77	3.10	3.75	4.32	4.84	5.78	6.93	8.44	9.76
200	0.52	0.79	0.98	1.32	1.63	1.88	1.98	2.19	2.45	3.07	3.41	4.14	4.75	5.32	6.25	7.46	9.08	10.42
500	0.62	0.95	1.18	1.58	1.96	2.27	2.40	2.64	2.92	3.46	3.83	4.68	5.32	5.97	6.84	8.15	9.88	11.23
1000	0.72	1.09	1.35	1.82	2.25	2.61	2.76	3.04	3.35	3.77	4.15	5.08	5.75	6.46	7.30	8.65	10.47	11.81

* The **lower** bound of the confidence interval at 90% confidence level is the value which 5% of the simulated quantile values for a given frequency are **less** than.

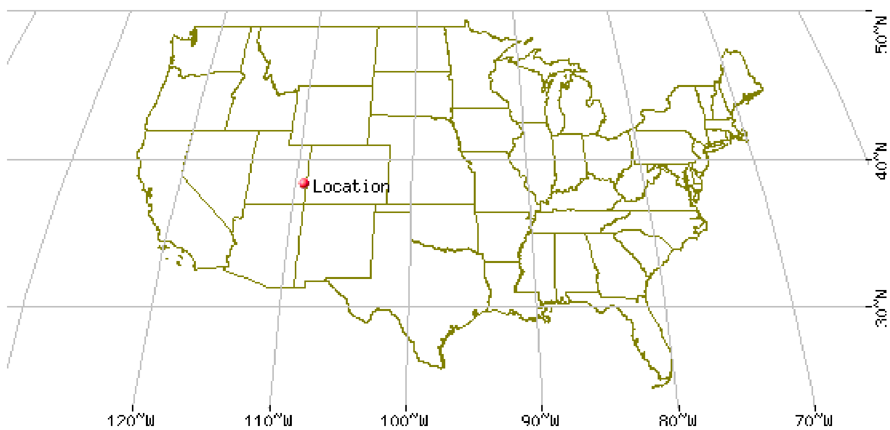
** These precipitation frequency estimates are based on a partial duration maxima series. **ARI** is the Average Recurrence Interval.
Please refer to NOAA Atlas 14 Document for more information. NOTE: Formatting prevents estimates near zero to appear as zero.

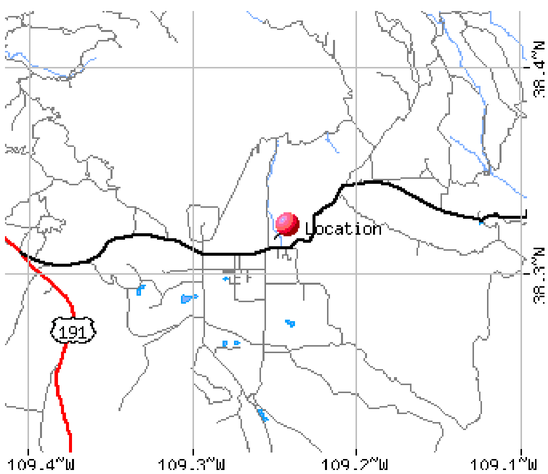
Text version of tables





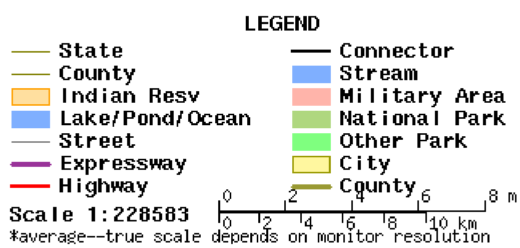
Maps -





These maps were produced using a direct map request from the U.S. Census Bureau Mapping and Cartographic Resources **Tiger Map Server**.

Please read disclaimer for more information.



Other Maps/Photographs -

View USGS digital orthophoto quadrangle (DOQ) covering this location from TerraServer; **USGS Aerial Photograph** may also be available from this site. A DOQ is a computer-generated image of an aerial photograph in which image displacement caused by terrain relief and camera tilts has been removed. It combines the image characteristics of a photograph with the geometric qualities of a map. Visit the USGS for more information.

Watershed/Stream Flow Information -

Find the Watershed for this location using the U.S. Environmental Protection Agency's site.

Climate Data Sources -

Precipitation frequency results are based on data from a variety of sources, but largely NCDC. The following links provide general information about observing sites in the area, regardless of if their data was used in this study. For detailed information about the stations used in this study, please refer to NOAA Atlas 14 Document.

Using the **National Climatic Data Center's (NCDC)** station search engine, locate other climate stations within:

+/-30 minutes ...OR... +/-1 degree of this location (38.3167/-109.25). Digital ASCII data can be obtained directly from **NCDC**.

Find Natural Resources Conservation Service (NRCS) SNOTEL (SNOwpack TELemetry) stations by visiting the **Western Regional Climate Center's state-specific SNOTEL station maps**.

Hydrometeorological Design Studies Center
DOC/NOAA/National Weather Service
1325 East-West Highway
Silver Spring, MD 20910

(301) 713-1669
Questions?: HDSC.Questions@noaa.gov

Disclaimer

BASIN PARAMETERS

DEVELOPMENT: Pandora Mine

JOB # 0806-04 **CALCULATED BY:** RJ

V1 applies to the first 500 feet of travel distance V2 applies to the remaining travel distance	
Existing:	**Developed**
$V1 = 148 * S^{1/2}$ $V2 = 294 * S^{1/2}$	$V1 = 202 * S^{1/2}$ $V2 = 306 * S^{1/2}$

$$Ti = \frac{1.8(1.1-k)L^{1/2}}{S^{1/3}} \qquad T_t = \frac{L}{60V}$$

$$k = 0.0132C_n - 0.39 \qquad T_c = T_i + T_t$$

SUB-BASIN DATA					INITIAL/OVERLAND TIME (Ti)					TRAVEL TIME (Tt)					FINAL Tc	LAG TIME	REMARKS
DESIG. (1)	Cn	K (2)	AREA Ac. (3)	AREA Mi^2	LENGTH Ft (4)	High Elev Ft (4a)	Low Elev Ft (4b)	SLOPE % (5)	Ti Min. (6)	LENGTH Ft. (7)	SLOPE % (8)	V1 fps (9a)	V2 fps (9b)	Tt Min. (10)	Min.	TLAG Min.	
1	73	0.574	10.3	0.0161	560	6975	6950	4.5	13.62	450	4.4	3.1	6.2	2.40	16.02	9.613	
2	73	0.574	18.3	0.0286	1078	7275	7120	14.4	12.79	1173	11.9	5.1	10.2	2.73	15.53	9.317	
3	73	0.574	70.4	0.1100	1476	7395	7250	9.8	17.00	1706	18.8	6.4	12.7	2.88	19.88	11.925	
4	73	0.574	147.9	0.2310	3115	7600	7410	6.1	28.94	5770	8.3	4.3	8.5	12.31	41.25	24.752	

TRAVEL TIME CALCULATIONS

DEVELOPMENT: **Pandora Mine**
W.O. # **0806-045** **CALCULATED BY:** **RJ**

$$Velocity = CS^{1/2}$$

C1 applies to the first 500 feet of travel distance C2 applies to the remaining travel distance			
Existing:		**Developed**	
C1=14.8	C2=29.4	C1=20.2	C2=30.6

					First 500 feet		Remaining Travel Distance	
Basin	**Length** (ft)	**High Elev** (ft)	**Low Elev** (ft)	**Slope** (ft/ft)	**C1**	**V1** (fps)	**C2**	**V2** (fps)
1	450	6950	6930	0.044	14.8	3.1	29.4	6.2
2	1173	7120	6980	0.119	14.8	5.1	29.4	10.2
3	1706	7250	6930	0.188	14.8	6.4	29.4	12.7
4	5770	7410	6930	0.083	14.8	4.3	29.4	8.5

References

- ***Precipitation-Frequency Atlas of the United States, NOAA Atlas 14, Volume1, Version 4*****,** NOAA, National Weather Service, 2006 (downloaded from: http://hdsc.nws.noaa.gov/hdsc/pfds/sa/ut_pfds.html)