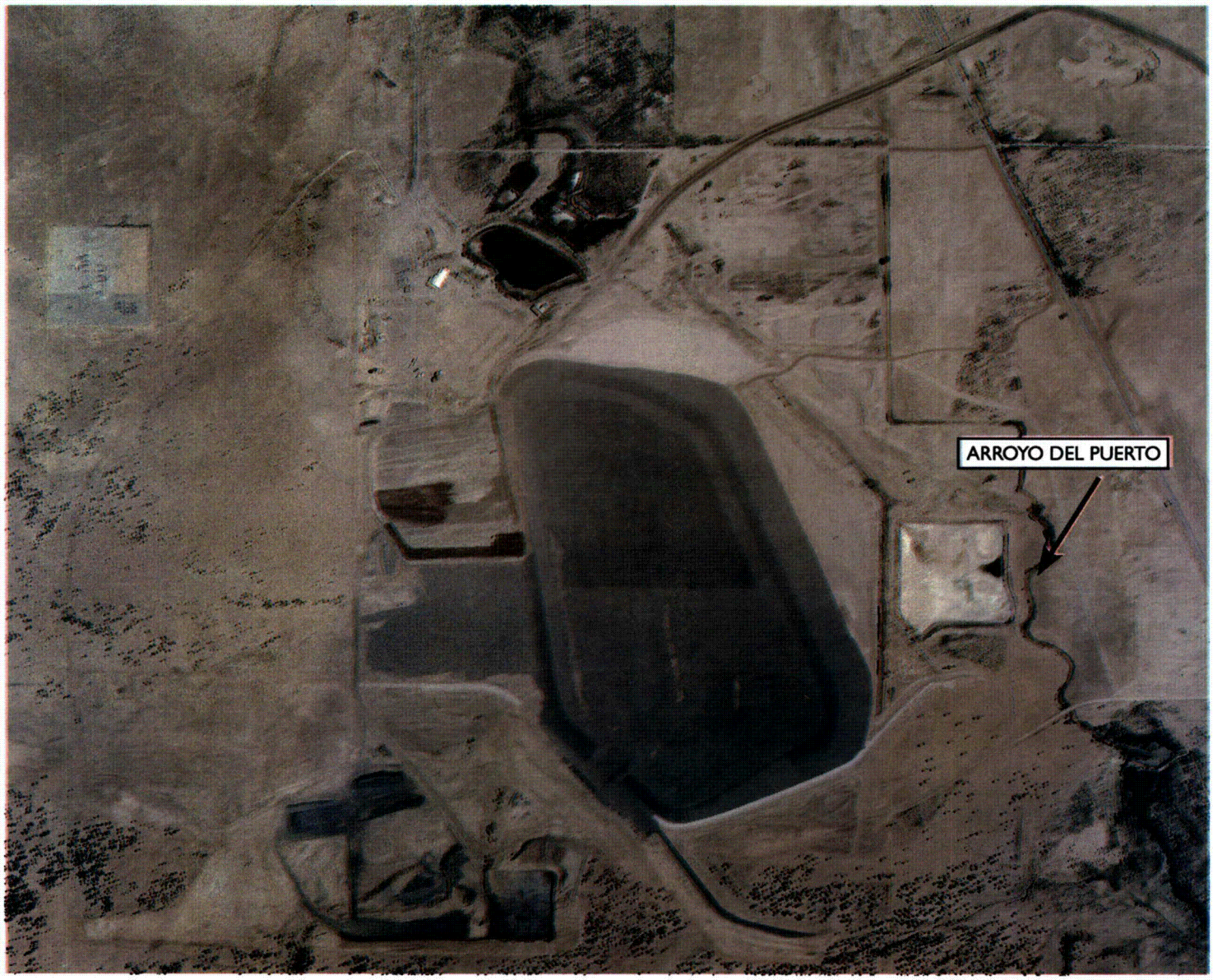
SITE EROSION PROTECTION MEASURES FROM SURFACE WATER FLOW IN THE ARROYO DEL PUERTO AMBROSIA LAKE MILL AMBROSIA LAKE, NEW MEXICO



Prepared for:
Rio Algom Mining LLC
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October 2007

Prepared By:

TETRA TECH, INC.

GLOBAL BCG, LLC

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1.0 INTRODUCTION

The following design report was prepared by Tetra Tech Inc. for Rio Algom Mining LLC (Rio Algom) to evaluate erosion protection measures to protect the site from the effects of surface water flow during storm events in the Arroyo del Puerto. Initially, an option was considered to return the Arroyo del Arroyo channel to its historic general natural course and prevent future lateral migration of the re-established channel towards Tailings Pond 3. However, this historic location placed it between Tailings Pond 3 on one side and Tailing Ponds 4, 5, & 6 on the opposite side. The resulting evaluation was required to consider the impact from a probable maximum flood (PMF) down the Arroyo del Puerto and the erosion protection necessary to protect the pond areas containing tailings or residual contaminants. Three options were evaluated with the preferred option primarily involving diversion of the Arroyo del Puerto to the east of Tailing Ponds 4, 5, & 6 utilizing an embankment and a new excavated channel that would rejoin the original arroyo near the northeast corner of Tailings Pond 9. Additionally, the historic location of the arroyo west of Tailing Ponds 4, 5, & 6 would be designed to provide drainage of onsite runoff. This report provides the basis for the design and construction of the new embankment and channel as well as the historic channel draining onsite drainage, together with drawings and specifications for construction. In addition, an evaluation of the geomorphic processes affecting the Arroyo del Puerto was performed to determine the long-term stability of the design with respect to aggradation or degradation processes.

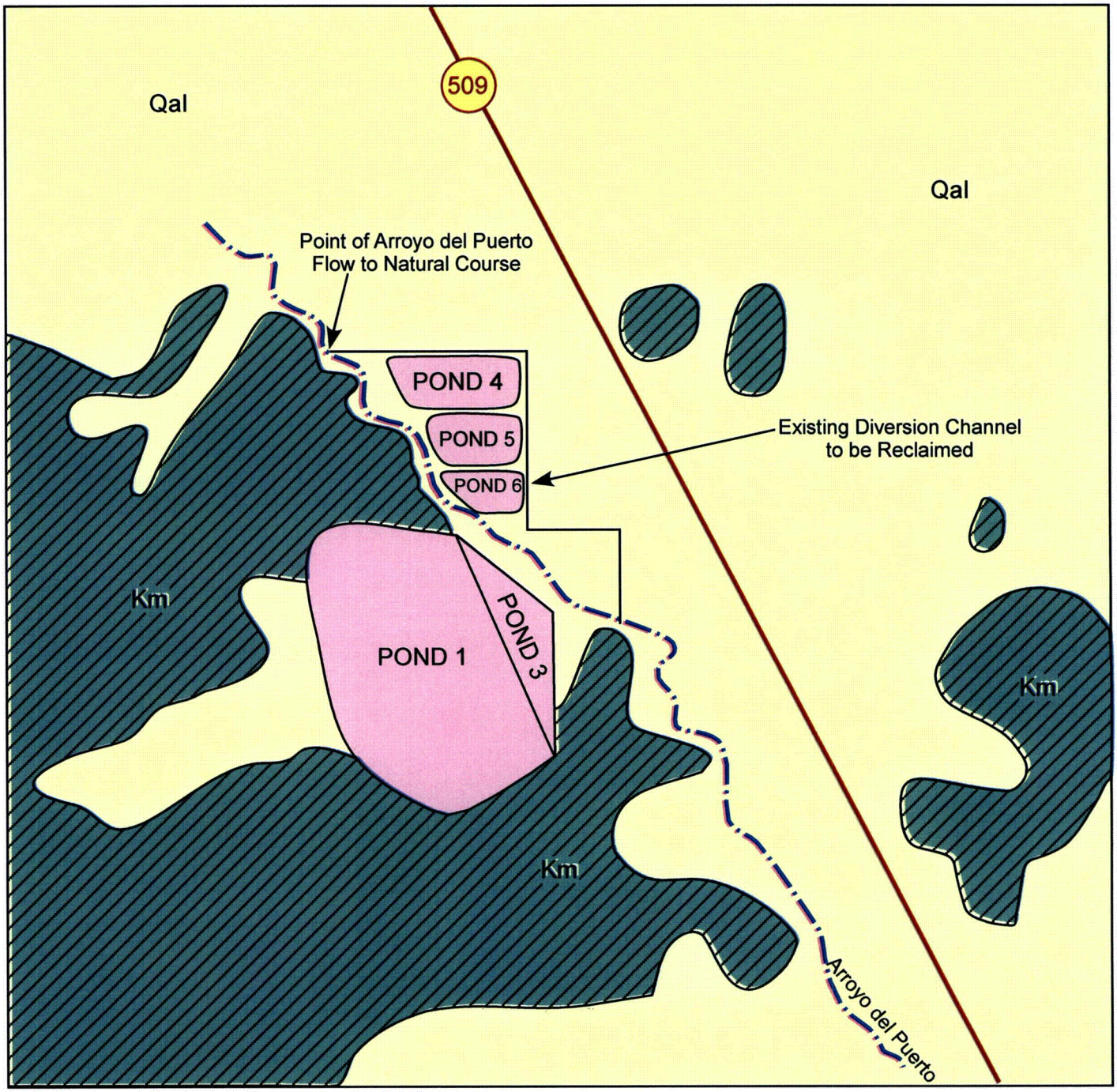
1.1 Historical Perspective

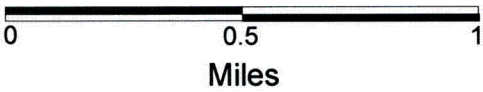
The Arroyo del Puerto historically has been a relatively narrow channel, in a broad alluvial flood plain. Historically, it was a dry wash and flowed only in response to significant rainfall events and periods of prolonged snow melt. In the late fifties, several mining companies began sinking mining shafts, with subsequent pumping from the Westwater Formation into the Arroyo del Puerto. The flows in the Arroyo del Puerto reached San Mateo Creek about 4 miles to the south. These flows eventually decreased with cessation of mining in the valley. The Creek then became dry until it

reached the United Nuclear-Homestake IX plant in Section 25, northwest of the mill where the Homestake IX discharges were added to the arroyo.

In late 1976, the arroyo was realigned by Kerr McGee as part of their operations to flow north and east of Tailings Pond Nos. 4, 5 and 6 away from Ponds 1 and 3 (Figure 1.1). This new diversion channel rejoined the original arroyo Tailing Ponds 4, 5, & 6 near the northeast corner of Tailings Pond 9. Drainage from the channel reach of the abandoned creek was captured behind a small dam and pumped back into Tailings Pond 3.

The initial Rio Algom reclamation plans considered restoration of the Arroyo del Puerto to its original channel as nearly as achievable to the pre-1976 grade and alignment. It was thought that the stream restoration would re-establish the general structure, function and self sustaining behavior of the arroyo to that which existed prior to the diversion channel construction.





Qal Alluvium

Km Mancos Shale (undifferentiated)

Arroyo del Puerto

FIGURE 1.1

Simplified Geologic Map of the Site
Showing Outcrop of Bedrock Surface

TETRA TECH, INC.

Scope

Rio Algom, formally Quivira Mining Company is conducting reclamation of its Uranium facility located in the Ambrosia Lake Valley northeast of Grants, New Mexico. This work is being performed under Rio Algom's NRC license No SUA-1473.

As part of the reclamation program, Rio Algom has reclaimed Tailings Pond 1 and is in the process of reclaiming Tailings Pond 3. The tailings pile reclamation was designed and constructed to provide assurance of control of radiological hazards for 1,000 years to the extent reasonably achievable. Specifically, the plan meets Appendix A of 10 CFR Part 40 for decommissioning of the tailing ponds. Erosion protection designs for Tailings Pond Nos. 1 and 3 were an integral part of the reclamation plan. These designs were submitted to the NRC on May 16, 2005 and September 26, 2002. The NRC conducted a detailed technical evaluation report (TER), on the design, which was transmitted to Rio Algom on November 27, 2002 (See Appendix A). The NRC staff concluded that the designs submitted appropriately addressed the long-term erosion protection of Tailings Pond Nos. 1 and 3, for a Probable Maximum Precipitation (PMP) event, and issued Amendment 51 to update License condition 37 of Source Materials License, SUA-1473.

However, the TER summary stated that the toe of Tailings Pond 3 (at Section 3) should be revisited (i.e. re-evaluated) to determine if the erosion protection adequately protects against lateral migration of the Arroyo del Puerto, thus potentially undercutting the toe of Tailings Pond 3. In response to this TER, Rio Algom submitted a report assessing the potential for migration of the Arroyo del Puerto (Appendix B). The NRC issued another TER addressing this report on October 5, 2004 (Appendix A). This second TER by the NRC concluded that since the maximum differential distance between the toe of Tailings Pond 3 and the re-established channel bed would be approximately 10 feet, that Rio Algom should again address the potential for undercutting of the impoundment toe due to the potential migration of the arroyo. The TER suggested that methods of toe protection could include stabilizing the stream at its reconstructed location or providing additional protection against migration into the toe of Tailings Pond 3.

Subsequent to the second TER, NRC also expressed concern for remaining subsurface contaminants beneath the previous locations of Tailings Ponds 4, 5, & 6. NRC indicated that in addition to Tailings Pond 3, these materials needed to be protected from dispersal by the impact of a PMF down the Arroyo del Puerto.

Rio Algom has evaluated three options for cost impacts based on these design considerations. These options are described as follows:

- Option 1: Re-align the Arroyo del Puerto to the historic alignment and design for PMF streamflows. Protect Tailings Ponds 4, 5, & 6 and the channel for the resulting PMF flow velocities and scour depths, as well as the toe and sideslope of Tailings Pond 3.
- Option 2: Re-align the Arroyo del Puerto to the historic alignment to provide interior site drainage and protect Tailings Ponds 3, 4, 5, & 6 and the channel for the runoff from a Probable Maximum Precipitation (PMP). Divert upstream PMF drainage in the Arroyo del Puerto to the east of Tailing Ponds 4, 5, & 6 utilizing an embankment and a new excavated channel that would rejoin the original arroyo near the northeast corner of Tailings Pond 9.
- Option 3: Re-align the Arroyo del Puerto to the historic alignment and design for PMF stream flows. Build a weir embankment at the downstream end of Tailings Pond 6 to back up flood flows and reduce flow velocities over Tailings Ponds 4, 5, & 6. Protect Tailings Ponds 3, 4, 5, & 6 and the channel for the resulting PMF flow velocities and scour depths.

The evaluation determined that Option 2 would be more cost effective and would provide better protection of the area of Tailings Ponds 4, 5, & 6 as well as mitigate the concern for lateral migration into Tailings Pond 3. The following design summary and associated drawings addresses the NRC's concerns and presents erosion protection measures for the interior site drainage as well as the PMF design for the diversion embankment/channel as shown on Sheet 1.

The interior site drainage and erosion protection is discussed in Section 2 and the applicable calculations are contained in Appendix C. The Diversion

Embankment/Channel PMF analysis and erosion protection is discussed in Section 3 and the applicable calculations are contained in Appendix D. Section 4 discusses erosion protection specifications to include requirements for rock gradations, rock filters, rock quality, rock placement, and a summary of estimated volumes required. Section 5 contains a geomorphic evaluation summary that is supported by calculations and a geomorphic report contained in Appendix E. Section 6 contains a design summary, Section 7 contains references, and Section 8 contains the design drawings (Sheets 1 thru 23). In order to better show some of the erosion protection details on Sheet 4, a map size version of this drawing has been placed into a map inset at the back of the report.

2.0 INTERIOR SITE DRAINAGE AND EROSION PROTECTION

2.1 Design Basis

The top and side slopes of Tailings Pond 3 and the overland areas of Tailings Ponds 4, 5, & 6 require protective rock to prevent erosion and gullying into the cover materials and tailings. The general approach for this erosional analyses consists of several tasks as follows with the more stringent design requirements controlling the final design configurations.

1) Determination of the probable maximum precipitation (PMP) rainfall depth calculated for the 1-hour local storm.
2) Determination of the hydrological parameters for each catchment area, to provide basis for erosion protection requirements in accordance with NUREG-1623, Appendix D.
3) Determination of the rock size requirements for the surface slopes of the tailings pond areas to provide adequate erosion protection in accordance with NUREG-1623, Appendix D, Section 2.
4) Determination of the rock size requirements for aprons based on runoff analysis for embankment slopes in accordance with NUREG-1623, Appendix D, Section 6.
5) Determination of the channel parameters to control runoff and longitudinal flow in accordance with NUREG guidance.
6) Determination of the rock size requirements for the open channel to control the runoff and longitudinal flow in accordance with NUREG-1623, Appendix D, Section 3.
7) Determination of the rock size requirements for the channel outflows to control upstream head-cutting due to scour in accordance with NUREG-1623, Appendix D, Section 4.

Each of these analyses is described separately in this section of the report; and calculations can be found in Appendix C (Interior Site Drainage Calculations).

2.2 PMP Calculations

The analysis conducted for this design is consistent with Nuclear Regulatory Commission (NRC) guidance, specifically, Design of Erosion Protection for Long-Term Stabilization (NRC 2002). This guidance, referred to as NUREG-1623 in this report, requires, in most cases, that erosion protection be designed for a 1,000-year life to minimize long term care of the cell. Because flood events with a 1,000-year recurrence interval are difficult to quantify, the guidance recommends use of the PMP event for design purposes.

PMPs can be derived for various parts of the United States using appropriate hydrometeorological reports. The report that addresses New Mexico east of the continental divide is Hydrometeorological Report No. 55A (HMR 55A), Probable Maximum Precipitation Estimates – United States between the Continental Divide and the 103rd Meridian (Hansen, et al. 1988). Appropriate PMP's are used to develop runoff hydrographs and determine the PMF for an area of concern. The final step in the design process is to apply the PMF to the appropriate erosion control design method. Guidance for design of riprap erosion protection is found in Appendix D of NUREG-1623 (NRC 2002).

The PMP rainfall depth calculated for the 1-hour local storm is 9.6 inches with no areal reduction. This calculation is contained in Appendix C.1, PMP Calculation, Local Storm.

2.3 Hydrological Parameters

The interior site drainage will occur as a result of direct precipitation over the site. The applicable drainage areas are shown on Sheet 2 and the calculations are contained in Appendix C.2, Design Flowrates and Erosion Protection. To compute the peak runoff, the Rational Formula was used in the calculations, whereby this formula takes the form of Equation 2.1.

$$Q = CIA \qquad \text{(Equation 2.1)}$$

Where: Q = Design peak runoff (cfs)

C = Runoff coefficient (assumed = 1 for PMF applications)
I = Rainfall intensity (inches per hour)
A = Area (acres)

Calculations for the rainfall intensity were estimated from the local PMP value and adjusted for the rainfall depth similar to Table 2.1, NUREG 4620 (HMR 49) but adapted for HMR 55A. The time of concentration was estimated by Equation 2.2.

$$T_c = 0.0078 \frac{(L^{0.77})}{S^{0.385}} \qquad \text{(Equation 2.2)}$$

Where: T_c = Time of concentration (minutes)
L = Longest flow path of catchment (ft)
S = Slope of catchment (ft/ft)

The surface intensity was determined by Equation 2.3.

$$I = \text{rainfall depth } [60 / T_c \text{ (minutes)}] \qquad \text{(Equation 2.3)}$$

This method of computing rainfall intensity is generally considered a conservative value and represents the peak rainfall intensity of the design storm. The results of the hydrology analyses are shown in Table 2.1.

Table 2.1
Interior Site Drainage - Surface Hydrology
Rio Algom Mining LLC

Catchment Drainage Area No.	A = Area[1] (acres)	Time of Concentration (min)	q_d = Design Unit Discharge (cfs/ft)	Q = Peak Discharge (cfs)
1	180.2	24.1		570.11
2	15.7	12.2		875.78
3	16.3	13.2		838.48
4	29.8	13.3		833.95
5	34.4	19.7		650.41
5 Overland[2]	0.0458	17.0	1.10	
6	87.6	29.7		495.52
6 Overland[2]	0.0550	19.7	1.20	
7	107.4	10.1		959.47
Inlet Channel at Sta 8+00 – 0.5% Slope	180.2			570.11
Channel at Sta 8+00 - 4% Slope	180.2			570.11
Channel at Sta 10+25 - 4% Slope	180.2			570.11
Channel at Sta 10+25 - 0.5% Slope	180.2			570.11
Channel at Sta 24+00 - 0.5% Slope	237.6			1924.39
Channel at Sta 27+50 - 0.5% Slope	276.5			3768.73
Channel at Sta 43+00 - 0.5% Slope	374.0			4496.23
Outlet Channel at Sta 43+00 - 0.5% Slope	374.0			4496.23
Channel at Sta 56+00 - 0.84% Slope	471.5			5223.73
Outlet Channel at Sta 56+00 - 0.84% Slope	471.5			5223.73

[1] Sheet 2, Section 8
[2] Unit width

2.4 Erosion protection for Tailings Pond 3

The previous submittal "Design Report, Pond 3 Erosion Protection and Erosion Protection for the Area North of Pond 1, Ambrosia Lake Mill, New Mexico" (Maxim 2003) evaluated the erosion protection for the sideslope of Tailings Pond 3 with two different precipitation events. The first was the local PMP storm that would fall on the slope of Tailings Pond 1 and run-off to the surface of Tailings Pond 3 combined with the run-off accumulated from rain that falls onto Tailings Pond 3, which will run-off the pond surface, and onto the embankment slope. The second event was a PMF that could occur in the Arroyo del Puerto drainage basin. The evaluation at the time determined that the PMF occurring in the Arroyo del Puerto would produce the larger erosional forces. The previous report concluded that the over-bank velocities in the Arroyo del Puerto would be 11 fps at a depth of 10 ft, and predicted a D_{50} of 12 inches for erosion protection on the sideslope using the U.S. Army Corps of Engineers method (USACE 1995). However, under the present option that diverts the Arroyo del Puerto such that PMF in the arroyo do not impact upon Tailings Pond 3, then the original calculations for run-off from the PMP local storm event should be valid again. These calculations resulted in using a D_{50} of 3.2 inches for the sideslope and a D_{50} of 9.2 inches for the apron at the base of the slope. The original calculations for the PMP local storm event that would fall onto the surfaces noted above and run-off down the embankment slope are included in Appendix C.3.

2.5 Erosion Protection for Tailings Ponds 4, 5, & 6

Surface protection rock for Tailings Ponds 4, 5, & 6 was selected based on the longest possible flow distance from the new diversion embankment to the north to the southern end of Tailings Pond 6 before entering the interior drainage channel. This was used to determine worst case conditions, and to determine a consistent rock size. Equation 2.4 (NUREG-1623) was used to calculate the median rock size (D_{50}).

$$D_{50} = 5.23\,(S^{0.43})(q_d^{0.56}) \qquad \text{(Equation 2.4)}$$

Where: D_{50} = Median rock size (inches)
S = Slope of catchment (ft/ft)
q_d = Design unit discharge (cfs/ft)

The parameters for Tailings Ponds 4, 5, & 6 erosion protection are shown in Table 2.2.

2.6 Erosion Protection for Channel Flow

The erosion protection for the interior channel was calculated based on the runoff for each catchment area that flows into the channel, the station location along the channel alignment, and the specific channel configuration. Manning's equation was used to determine the cross-sectional area of the channel, and using the specific shape of the channel at each applicable station location, the normal depth of flow in the channel was found using Equation 2.5.

$$Q = [1.49\ (A)(R^{2/3})(S^{1/2})]/n \qquad \text{(Equation 2.5)}$$

Where: Q = Design peak discharge (cfs)
A = Cross-sectional area of channel (ft^2)
R = Hydraulic radius (ft)
S = Slope of channel (ft/ft)
n = Manning's coefficient

Once the normal depth of flow has been calculated, the rock sizing can be calculated primarily by one of the following two methods as follows:

- Safety Factors Method using Peak Shear Stress (NUREG-1623)
- Abt and Johnson Method (NUREG-1623)

The following summarizes each of the methods.

1) <u>Safety Factors Method Using Peak Shear Stress (NUREG-623)</u>

Rock sizing with this method determines the actual shear stress on the bottom of the channel by Equation 2.6.

$$t = W_w\ (y)(S) \qquad \text{(Equation 2.6)}$$

Where: t = Actual shear stress (lb/ft^2)
W_w = Unit weight of water = 62.4 lb/ft^3
y = Normal depth of flow (ft)
S = Slope of bottom of channel (ft/ft)

The median rock size is determined by Equation 2.7.

$t = (D_{50})\ a\ (W_s - W_w)$ (Equation 2.7)

Where: t = Actual shear stress (lb/ft^2)
D_{50} = Median rock size (inches)
a = Coefficient = 0.04
W_w = Unit weight of water = 62.4 lb/ft^3
W_s = Unit weight of rock = 165 lb/ft^3

Equation 2.7 can be simplified to Equation 2.8 to determine the median rock size.

$(D_{50}) = t/4.1$ (Equation 2.8)

Where: D_{50} = Median rock size (inches)
t = Actual shear stress (lb/ft^2)

2) <u>Abt and Johnson Method (NUREG-1623)</u>

This method of rock sizing utilizes Equation2.4 previously presented in Section 2.5.

$D_{50} = 5.23\ (S^{0.43})(q_d^{0.56})$ (Equation 2.4)

Where: D_{50} = Median rock size (inches)
S = Slope of catchment (ft/ft)
q_d = Design unit discharge (cfs/ft)

The parameters for channel erosion protection are shown in Table 2.2.

Table 2.2
Interior Site Drainage - Erosion Protection Parameters
Rio Algom Mining LLC

Rock Placement Area[1]	Q = Max Design Flow Rate (cfs)	q_d = Max Design Unit Width Flow Rate (cfs/ft)	Overland or Channel Slope (%)	Channel Bottom Width (ft)	Min D_{50} (in) Shear Stress Method	Min D_{50} (in) Abt and Johnson Method	Average of Methods Min D_{50} (in)	Oversize Min D_{50} 4% (in)	D_{50} Available to Use (in)	Min Rock Thickness Ratio	Min Rock Thickness to Use (in)
Tailings Pond 3-Top Slope		0.84	0.3%			0.40	0.4	.42	1.0	2	3
Tailings Pond 3 Sideslope		0.88	20.0%			2.43	2.43	2.53	3.2	2	6
Tailings Pond 3 Base Apron		0.88	20.0%			8.50	8.50	8.84	9.2	3	27
Area 5 (Ponds 4 & 5)		1.10	0.85%			0.71	0.71	0.74	1.0	2	3
Area 6 (Ponds 4, 5, & 6)		1.20	0.83%			0.74	0.74	0.77	1.0	2	3
Inlet Channel at Sta 8+00 -	570.11		0.50%	100.0		1.42	1.42	1.48	3.2	2	6
Channel at Sta 8+00	570.11		4.00%	100.0	5.40	3.47	4.44	4.61	7.8	2	16
Channel at Sta 10+25	570.11		4.00%	60.0	7.23	4.62	5.92	6.16	7.8	2	16
Channel at Sta 10+25	570.11		0.50%	60.0	1.66	1.89	1.78	1.85	3.2	2	6

Table 2.2
Interior Site Drainage - Erosion Protection Parameters
Rio Algom Mining LLC

Rock Placement Area[1]	Q = Max Design Flow Rate (cfs)	q_d = Max Design Unit Width Flow Rate (cfs/ft)	Overland or Channel Slope (%)	Channel Bottom Width (ft)	Min D_{50} (in) Shear Stress Method	Min D_{50} (in) Abt and Johnson Method	Average of Methods Min D_{50} (in)	Oversize Min D_{50} 4% (in)	D_{50} Available to Use (in)	Min Rock Thickness Ratio	Min Rock Thickness to Use (in)
Channel at Sta 24+00	1924.39		0.50%	105.0	2.48	2.73	2.61	2.71	3.2	2	6
Channel at Sta 27+50	3768.73		0.50%	125.0	3.62	3.61	3.62	3.76	7.8	2	16
Channel at Sta 43+00	4496.23		0.50%	150.0	3.64	3.60	3.62	3.76	7.8	2	16
Outlet Channel at Sta 43+00	4496.23		0.50%	150.0		3.60	3.60	3.74	7.8	2	16
Channel at Sta 57+00	5223.73		0.84%	190.0	5.01	4.28	4.65	4.83	7.8	2	16
Outlet Channel at Sta 57+00	5223.73		0.84%	190.0		4.28	4.28	4.46	12.0	2	24

2.7 Erosion Protection for Channel Inlet/Outlet Flow

Channel inlets or outlets are designed for scour depths to prevent upstream or downstream channel cutting and ultimate dispersal of contaminated materials within or adjacent to the channel. The method of rock sizing the inlet or outlet channel and the buried or thickened apron utilizes Equation 2.4 previously presented in Section 2.5.

$$D_{50} = 5.23\,(S^{0.43})(q_d^{\,0.56}) \qquad \text{(Equation 2.4)}$$

Where: D_{50} = Median rock size (inches)
S = Slope of catchment (ft/ft)
q_d = Design unit discharge (cfs/ft)

Additionally, the scour depth for the channel outlet apron toe can be determined with Equation 2.9 (USDOT HEC No. 14, 2006).

$$d_S = RC_S(\alpha/(\sigma^{1/3}))(Q / ((g^{1/2})(R^{5/2})))^{\beta}(t/316)^{\theta} \qquad \text{(Equation 2.9)}$$

Where: d_s = Depth of scour (ft)
R = Hydraulic radius (ft)
C_S = Slope correction coefficient
α, β, θ are coefficients
σ = Material standard deviation = $(D_{84}/D_{16})^{0.5}$
D_{84} = Riprap size of which 84% is finer by weight (inches)
D_{16} = Riprap size of which 16% is finer by weight (inches)
Q = Design peak discharge (cfs)
g = Gravitational constant = 32.2 ft/sec^2
t = Time flow (minutes)

The parameters for channel outlet erosion protection and scour depth are shown in 2.3.

Table 2.3
Interior Site Drainage – Inlet/Outlet Aprons
Rio Algom Mining LLC

Rock Placement Area[1]	D_{50} Available to Use (in)	Min Apron Thickness = 3x D_{50} (in)	Apron Thickness to Use (in)	Min Apron Width = 15 x D_{50} (ft)	Apron Width to Use (ft)	Max Scour Depth (ft)
Inlet Channel at Sta 8+00 - 0.5% Slope	3.2	9.6	24	4.0	10.0	1.34
Outlet Channel at Sta 43+00 - 0.5% Slope	7.8	23.4	36	9.8	15.0	2.65
Channel at Sta 57+00 - 0.84% Slope	7.8	23.4	36	9.8	15.0	2.65
Outlet Channel at Sta 57+00 - 0.84% Slope	12.0	36	36	15.0	30.0	2.55

2.8 Channel Design

2.8.1 Alignment

The reconstruction of the Arroyo del Puerto will begin just upstream of the existing haul road at Interior Site Drainage Channel Station 8+00. The site plan (Sheet 1) shows the general configuration and alignment of the re-established channel for interior site drainage. Sheets 12 through 15 show the general plan and profile for the new construction. As shown by the drawings, the re-established channel generally follows the alignment of the historic channel but with more gentle curves in the alignment. The Interior Site Drainage Channel ends at Station 58+00 as it intersects and ties into the Diversion Channel northeast of Tailings Pond 9.

2.8.2 Channel Configuration and Grade

The channel will have a minimum bottom width that varies according to the details shown on Sheet 5 and it will be constructed with side slopes of 5 (horizontal) to 1 (vertical) with a minimum depth of 4 feet to Station 24+00 and a minimum depth of 5 feet thereafter thus allowing for 1 foot of free-board. This channel design will accommodate a PMP design storm event with increasing flood flows of 570 cfs at Station 8+00 to 5224 cfs at Station 57+00 (Appendix C.2, Design Flowrates and Erosion Protection).

The re-established arroyo channel is designed to have a gradient typical of the Arroyo del Puerto original slope and surrounding topography. The channel from stations 8+00 to 52+00 will have a 0.5% grade, while the remainder of the channel to Station 58+00 will have a 0.84% gradient. These slopes nearly match the existing grades of the existing cut channel between Station 27+50 and 58+00. The fill depths required to provide positive drainage of surrounding areas into the constructed arroyo channel will range from 0 to 2 ft with some isolated areas requiring 4 ft of fill for positive drainage. Fill for the channel will be compacted to a minimum of 90% Standard Proctor density (ASTM D-698) to help reduce erosion of surrounding areas and inner channel slopes.

2.8.3 Channel Bottom Configuration

Sheet 5 shows the typical channel section details. As shown by the drawing, the channel bottom will be provided with a cross slope of 1.5% to "the outside" of the channel away from Tailings Pond 3. Low flows will be directed along the toe of the far side of the channel approximately 400 feet from the nearest point of Tailings Pond 3.

2.8.4 Channel Erosion Protection

Erosion protection rock will be provided between Stations 8+00 and 58+00. The channel will be fully lined with erosion protection rock from approximately station 8+00 to station 43+00. From approximately station 43+00 to station 58+00 the channel will be lined on only the Tailings Pond 3 side. The size and thickness of the erosion protection rock along the channel stationing are listed in Table 2.2 and also identified on Sheet 5. The rock and filter materials will have the gradation requirements shown in Table 4.1.

3.0 EXTERIOR SITE DRAINAGE AND EROSION PROTECTION

3.1 PMF Magnitude Evaluation

Calculation of a PMF from a probable maximum precipitation (PMP) event requires information on the type of storm, the geometry of the basin, the infiltration properties of the basin as well as assumptions about the behavior of the flood peak as it travels through the basin. The number and uncertainty of variables in the calculation can lead to greatly varying results in the magnitude of the PMF. Previous consultants to Rio Algom on the project developed a PMF value of 78,000 cfs which was approved by the NRC in previous design documents. It has later been suggested by the NRC that a much larger PMF value (200,000 cfs) should be used. For purposes of the present design the PMF value of 78,000 PMF will be used without adjustment. In a previous Maxim (Tetra Tech) design report, "Pond 3 Erosion Protection and Erosion Protection for the Area North of Pond 1, Ambrosia Lake Mill, New Mexico (Maxim, 2002)", a PMF value of 75,200 cfs was calculated using the HEC-1 model (U.S. Army Corps of Engineers, 1990). The flood analysis was modeled with the following:

a) A 6-hr PMP, local storm with areal reduction of 9.2 inches was used.
b) A basin area of 57.6 square miles was used.
c) The entire drainage area (57.6 sq. mi.) was input as one basin without subdividing into subbasins.
d) A curve number of 73.4 was used as a composite for the entire drainage basin.

The following items are noted that would suggest that the Maxim calculation of 75,200 cfs was performed on a conservative basis.

a) A drainage basin of 57.6 sq. mi. would have an areal reduction factor of ~40% when modeling with only one basin and at least ~80% when subbasins are modeled.
b) A PMP value of 9.2 inches would indicate that a reduction factor of 96% was used which would be very conservative.

c) Modeling with only one basin instead of several subbasins would also produce a conservative result. A more appropriate depiction of the drainage area with delineated subbasins in shown on calculation Sheet 3 of 37, Appendix D.1.

d) It is also noted in the delineated subbasin map that Subbasin 4D (comprising 11% of the drainage area) enters the site at Tailings Pond 9 which is below the present area of design and therefore would not impact it.

e) Also, the Geomorphic Report by Jerry Lindsay, Appendix E, would tend to suggest that due to high infiltration rates that a curve number of 73.4 might be somewhat conservative.

3.2 Diversion Embankment / Channel Design Layout

An initial configuration assumed a 15 ft high embankment berm with 3:1 side slopes, and a channel width of 250 ft with the bottom sloping 1 1/2% down and away from the berm. This is illustrated in the cross-section on Sheet 6 and the alignment is shown on Sheet 4. The layout of the diversion embankment/channel is driven primarily by balancing the cut and fill, and approximately matching the upstream and downstream existing elevations. Another consideration is matching the converging elevations of the interior and exterior channels as they come together at the northeast corner on Pond #9. The slope of the diversion channel was adjusted along its course so as to best balance the cut and fill. The geometric data and estimated volume of cut and fill for the Diversion Embankment/Channel is shown on calculation Sheets 6 thru 9 of 37, Appendix D, Calculation D.1. The cut and fill estimate specific to the Diversion Embankment and adjacent Channel (Station 83+50 to Station 1+50) is approximately 275,000 cy of fill required and approximately 225,000 cy of cut available. The remaining volume of fill required will be obtained from a clean borrow location to be identified by Rio Algom Mining LLC. The geometric data along with additional topography data was utilized as input into the HEC-RAS Model (USACE 2003) for the hydraulic analysis of the Diversion Embankment/Channel. 27 cross-sections were used in the analysis as

shown on Sheet 3 of Section 8. A summary of this input data is contained on calculation Sheets 10 thru 15 of 37, Appendix D.1.

3.3 HEC-RAS Results

The complete calculations involving the exterior site drainage calculations and the Diversion Embankment/Channel are contained in Appendix D.1, Design Flowrates and Erosion Protection. The detailed results of the HEC-RAS analysis are summarized on the table contained on calculation Sheets 16 thru 19 of 37, Appendix D.1. The extent of the PMF is illustrated on Sheet 3 and is also illustrated by the graphic cross-sections of the flood flow taken from the HEC-RAS Model and contained calculation Sheets 22 thru 30 of 37, Appendix D.1.

3.4 Erosion Protection for Toe of Embankment

Erosion protection sizes have been estimated by the Shear Stress Method; & the Abt and Johnson Method (previously discussed in Section 2.6). An average of these 2 methods and then oversizing by 4% (see basis of 4% oversizing in Section 4.3) has been used to determine the D_{50} size rock protection to use. The scour depths along the diversion channel have also been estimated and are shown on the detailed table contained on calculation Sheets 16 thru 19 of 37, Appendix D.1. The extent of the erosion protection is illustrated on Sheet 4. A summary of the estimated rock sizes to use on the Diversion Embankment/Channel is shown on Table 3.1.

In addition to the erosion protection placed on the stream side of the embankment, the top and back side of the embankment will be protected by a layer of D_{50} = 1 inch size rock.

Table 3.1
Exterior Site Drainage – Erosion Protection
Rio Algom Mining LLC

River Station	Station	Embankment Slope / Apron D_{50} (inches)				
		D_{50} - Shear Stress Method (inches)	D_{50} - Abt and Johnson Method (inches)	Average Size (inches)	Add 4% Oversize (inches	D50 to Use
21	96+75	N/A	N/A	N/A	N/A	N/A
20	91+75	N/A	N/A	N/A	N/A	N/A
19	86+75	N/A	N/A	N/A	N/A	N/A
18	83+50	2.11	3.27	2.69	2.80	3.2
17	80+00	1.48	2.57	2.03	2.11	3.2
16	75+00	2.19	3.41	2.80	2.91	3.2
15	70+00	2.76	4.01	3.38	3.52	7.8
14	65+00	4.00	5.17	4.58	4.77	7.8
13	60+00	3.19	4.39	3.79	3.94	7.8
12	55+00	6.41	7.03	6.72	6.99	7.8
11	50+00	3.60	4.65	4.12	4.29	7.8
10	45+00	3.28	4.33	3.81	3.96	7.8
9	40+00	7.98	8.11	8.04	8.37	9.2
8	35+00	8.04	8.09	8.07	8.39	9.2
7	30+00	8.23	8.27	8.25	8.58	9.2
6	25+00	8.51	8.53	8.52	8.86	9.2
5	20+00	7.64	8.18	7.91	8.22	9.2
4	15+00	8.57	8.66	8.62	8.96	9.2
3	10+00	8.71	8.95	8.83	9.18	9.2
2	5+00	8.06	8.68	8.37	8.71	9.2
1.3	1+50	8.06	8.68	8.37	8.71	9.2
1	0+00	11.19	10.62	N/A	N/A	N/A
0	-1+00	9.58	9.65	9.62	10.00	12
-1	-5+00	7.61	8.27	N/A	N/A	N/A
-2	-10+00	7.92	8.47	N/A	N/A	N/A
-3	-15+00	7.44	8.25	N/A	N/A	N/A
-4	-20+00	13.69	12.54	N/A	N/A	N/A
-5	-22+00	9.71	9.98	N/A	N/A	N/A

3.5 Diversion Embankment/Channel Design

3.5.1 Alignment

The diversion of the Arroyo del Puerto will begin upstream of the tailings ponds at Station 83+50 adjacent to the existing site entrance road. The site plan (Sheet 1) shows the general configuration and alignment of the diverted channel. Sheets 16 through 23 show the general plan and profile for the new construction. As shown by the drawings, the Diversion Embankment extends from Station 1+50 to Station 83+50. At Station 83+50 the embankment also extends another 1335 feet south along the site entrance road and ties into elevation 6970. The excavated Diversion Channel extends from Station 83+50 to Station -5+00 downstream past the intersection with the Interior Site Drainage Channel and Tailings Pond 9.

It is noted that the locale of the Arroyo del Puerto that is adjacent and southeast of Tailings Pond 9 is presently being used as a fill material borrow source. The final configuration of the channel within this area may result in it being much wider than the proposed alignment indicated on Sheet 4 and Sheet 16. The HEC-RAS analysis of the proposed alignment as shown reflected a tendency to have a choked flow condition south of Tailings Pond 9 in the vicinity of Diversion Channel Station -20+00. The resulting effect is higher water surface elevations in this area but the effect diminishes upstream between Diversion Channel Stations -1+00 and -5+00. Likewise, a HEC-RAS analysis was performed with revised geometric data (widened channel) for the Diversion Channel Stations between -5+00 to -20+00. The resulting effect removed the choked condition and the water surface elevation decreased. It was again noted that the changed conditions did not extend upstream beyond the area between Diversion Channel Stations -1+00 and -5+00. Therefore, the changing geometric conditions southeast of Tailings Pond 9 do not have an effect on the upstream flow conditions where the Diversion Embankment is located.

3.5.2 Channel Configuration and Grade

The channel will have a minimum bottom width of 250 feet and will be constructed with side slopes of 3 (horizontal) to 1 (vertical). This channel design will accommodate a PMF design storm event of 78,000 cfs.

The diverted arroyo channel from Sstations 83+50 to 77+50 will have a 0.25% grade, Stations 77+50 to 45+00 will have a 0.10% grade, Stations 45+00 to 30+00 will have a 0.50% grade, Stations 30+00 to -1+00 will have a 1.00% grade, and Stations -1+00 to -22+00 will have a 0.90% grade. Areas requiring fill within the Diversion Channel will be compacted to a minimum of 90% Standard Proctor density (ASTM D-698). The fill required for the Diversion Embankment will also be compacted to a minimum of 90% Standard Proctor density (ASTM D-698). As shown on calculation Sheets 8 & 9 of 37, Appendix D.1, the relative height of the Diversion Embankment is gradually reduced from 15.0 feet to 12.5 feet and back to 15.0 feet between River Stations 65+00 to 15+00. This was done to reduce the embankment fill requirement and still maintain a minimum 3-foot freeboard.

3.5.3 Channel Bottom Configuration

Design sheet No. 6 shows the typical channel section details. As shown by the drawing, the channel bottom will be provided with a cross slope of 1.5% to "the outside" of the channel away from the Diversion Embankment. Low flows will be directed along the toe of the far side of the channel and provide a silt buildup location away from the Diversion Embankment.

4.0 EROSION PROTECTION SPECIFICATIONS

4.1 Rock Gradation Summary

Table 4.1 Interior & Exterior Site Drainage Riprap Gradation Requirements Rio Algom Mining LLC		
Filter/Bedding Rock and Erosion Protection Gravel (D_{50}=1.0" Nominal, 0.9" Actual)		
Seive Size Designation (inches)	**Percent Passing Range Specification**	
	Low	**High**
3	100	
2	70	100
1	25	55
3/4	15	40
1/2	0	25
Erosion Protection Rock (D_{50}=3.2")		
Seive Size Designation (inches)	**Percent Passing Range Specification**	
	Low	**High**
6.0	100	
5.0	75	100
4.0	35	100
3.0	10	40
2.0	0	20
Erosion Protection Rock (D_{50}=7.8")		
Seive Size Designation (inches)	**Percent Passing Range Specification**	
	Low	**High**
12.0	100	
9.0	45	70
6.0	5	20
4.0	0	5

Table 4.1 Interior & Exterior Site Drainage Riprap Gradation Requirements Rio Algom Mining LLC		
Erosion Protection Rock (D_{50}=9.2")		
Seive Size Designation (inches)	Percent Passing Range Specification	
	Low	High
15.0	100	
12.0	70	90
9.0	20	45
6.0	0	10
Erosion Protection Rock (D_{50}=12.0")		
Seive Size Designation (inches)	Percent Passing Range Specification	
	Low	High
18	100	
14	60	90
12	25	50
10	10	30
6	0	10

4.2 Filter Requirements

A six-inch thick rock filter layer having a mean stone diameter (D_{50}) of one inch will be placed in all areas protected by riprap having a D_{50} size of 3.2 inches or greater, as shown on the various design drawings.

This filter layer will be placed between the rock protection and natural soils or compacted fill materials. The interstitial flow velocities are sufficiently low (less than 0.5 feet/sec for a maximum 20 percent slope) such that a secondary filter below the one inch filter is not required (see calculations, Appendix C-1).

4.3 Rock Quality Specifications

The material that will be used to provide erosion protection for this project is a calcitic dolomite from a rock quarry (Tinaja Pit) south of Milan, New Mexico. Rio Algom, along with other uranium mill sites in the area, previously acquired all erosion protection materials from a quarry that produced basalt rock. Subsequent closure of this basalt pit precluded its use and alternative rock sources were investigated. The Tinaja Pit was selected as the best source.

In 2001 Rio Algom had American Petrographic Services, Inc. evaluate the dolomite from Tinaja Pit. The petrographic analyses results are presented in Appendix B-1 (Rock Quality Testing). In addition, Western Technologies performed physical and mechanical tests to evaluate the quality of the rock in accordance with NUREG-1623. These results are also shown in Appendix B-1 (Rock Quality Testing).

The dolomite was found to have a rock quality rating of 76.7 percent. Based on these evaluations, Rio Algom incorporated a four percent over design factor on rock diameter sizing calculations to meet the NRC rock quality rating of 80.

4.4 Rock Placement Procedures for Erosion Protection

4.4.1 General Guidelines for Rock Placement

In general, proper placement is created by providing a relatively uniform thickness of rock at a specified gradation. The following are general guidelines that should be used in conjunction with specific placement criteria to achieve adequate placement of rock riprap layers:

A. The various riprap sizes should be placed in layer thicknesses according to that specified on the associated design drawings. In general, these specified thicknesses are based on a minimum layer thickness being at least 1.5 to 2 times the D_{50} rock size.

B. Where the D_{50} size is eight inches or more, the placement procedures should include a certain amount of individual rock placement (using specialized equipment or hand labor) to ensure that proper thicknesses and areal coverage are achieved. Where the D_{50} size is less than 8 inches and the layer thickness exceeds two times the average rock size, dumping and spreading by heavy equipment will generally be the only procedures necessary to achieve adequate rock placement.

C. After the start of construction of the various erosion protection layers, test sections of the proper thickness and gradation will be constructed for layers with 3.2", 7.8", and 9.2" D_{50} size rock. This test section should be visually examined, and contractor personnel should become familiar with the visual properties of this section; that is, the acceptable section should be used as visual guidance of proper placement and should be used to evaluate future riprap placement. The test section should be tested to determine its gradation and rock weight-unit volume that will be achieved in future rock placement activities.

D. Riprap materials shall be reasonably well-graded within the limits presented in Table 4.1. The sizes are specified in terms of square openings of-U.S.

Standard Sieves or by the Nominal Sizes of the Materials. The Contractor reserves the right of inspection while the samples are being taken.

4.4.2 Placement and Compaction

A. Erosion protection materials shall be handled, loaded, transported, stockpiled, and placed in a manner that avoids nonconformance with specifications due to segregation and degradation, including materials moved to and from stockpiles.

B. Subgrade preparation shall be as specified in Specifications. In addition, the subgrade (frost protection layer) shall be prepared so that it will adequately support the rock placement equipment. Care will be exercised to eliminate the potential damage due to rutting of the subgrade during rock placement activities. Any rutting or deviations to the subgrade surface shall be repaired prior to the resumption of rock placing activities. Also, in order to prevent rock migration into the subgrade layer, rock shall not be placed on frozen or saturated subgrade.

C. Where the required bedding material thickness is six inches or less, the bedding material shall be spread and compacted in one layer.

D. Placing of material by methods that will tend to segregate particle sizes within the layer will not be permitted.

E. Dumped riprap shall be placed to its full course thickness in one operation and in such a manner as to avoid displacing the bedding material. The larger stones shall be well- distributed throughout the mass. The finished riprap shall be free from pockets of small stones and clusters of larger stones. Placing stone by dumping into chutes or by similar methods likely to cause segregation of the various sizes will not be permitted. The desired distribution of the various sizes of stones throughout the mass shall be obtained by selective loading of the material at the quarry or other source, by controlled dumping of successive loads during final placing, or by other methods of placement that

will produce the specified results. Rearranging of individual stones by mechanical equipment or by hand may be required to the extent necessary to obtain a well-keyed and reasonably well-graded distribution of stone sizes as specified above. Larger riprap may require individual placement by equipment. Hand arrangement will be required only to the extent necessary to secure acceptable results. Stones shall be selected and positioned so as to produce an essentially solid, densely placed face of rock with all stones firmly wedged in place. Any stones that are not firmly wedged shall be adjusted and additional selected stones inserted or existing stones replaced, so as to achieve a solid interlock

F. For riprap placed by clam-shell or similar equipment, hand arrangement will be required only to the extent necessary to secure the results specified herein. Stones shall be selected individually and positioned manually under experienced supervision so as to produce an essentially solid layer with all stones firmly wedged in place. Any stones that are not firmly wedged, in the opinion of the Contractor, shall be adjusted by crow-bars or similar tools and additional selected stones inserted, or existing stones replaced, so as to achieve solid interlock.

G. Each layer of riprap shall be track-walked by two passes of a Caterpillar D6 bulldozer or equal unless otherwise approved by the Contractor. Riprap shall be spread in a manner that will achieve full coverage and a uniformly distributed well-keyed, densely- placed layer.

H. Construction equipment other than spreading and compaction equipment shall not be allowed to move over the placed riprap material and bedding material layers except at equipment crossovers as designated by the Contractor. Fill materials shall be placed temporarily at equipment crossovers to prevent degradation of placed riprap materials. Each crossover shall be cleaned of all contaminating materials and approved by the Contractor before additional materials are placed in these areas. Other construction equipment may move

over placed riprap and bedding layers. The Contractor may restrict such traffic to minimize damage to completed layers. Areas of riprap and bedding layers damaged by construction equipment shall be restored to meet the requirements of the Specifications.

4.4.3 Acceptability of Rock Placement

A. The material placed meets the gradation requirements specified.

B. The in-place thickness of riprap material shall be between 90 percent and 125 percent of the thickness shown. Local irregularities not exceeding the thickness limits above will be permitted provided that such irregularities do not form noticeable mounds, ridges, swales or depressions that in the opinion of the Contractor could cause concentrations of surface runoff or form ponds or gullies. Riprap layer thickness will be directly measured on a specified grid to determine that minimum thickness requirements are met. A specified area is determined on top of the riprap layer. The rock within the grid is removed to the top of the bedding layer (when appropriate).

C. Materials segregated or not placed according to the above requirements shall be regraded or adjusted, or removed and replaced using appropriate equipment, to conform within the limits given above.

D. Materials not meeting the requirements of this Section shall be removed and placed with specified materials. Rejected materials shall be disposed of at designated disposal Sites. Materials not meeting the grading requirements shall be reprocessed or discarded. The Contractor may require modification of the processing and grading operations to ensure that the specified grading requirements are met.

4.4.4 Erosion Protection Materials Testing

A. The bedding material and each type of riprap shall be tested by a commercial testing laboratory during production in accordance with several tests utilized in the scoring process. These tests include the following:

Specific Gravity (SSD)	ASTM C-127
Absorption	ASTM C-127
Soundness (5 cycles)	ASTM C-88
Abrasion (100 revolutions)	ASTM C-131
Schmidt Rebound Hardness	ISRM Method

B. Each type of riprap and bedding material shall be tested for gradation in accordance with ASTM C-l17 and ASTM C-136, as applicable. Test results shall be in accordance with the Design Specifications.

C. Bedding material and each type of riprap material shall be tested at a minimum frequency of one test for each 10,000 cubic yards or fraction thereof produced or placed.

D. At least one petrographic examination shall be made for each rock type used for erosion protection materials. Testing shall be performed in accordance with ASTM C-295-90.

4.4.5 Inspections

Daily visual inspections shall be performed to verify that quality-related activities are performed in accordance with requirements. Daily visual inspections performed by qualified and certified inspection personnel shall be accomplished during execution of the various work activities to verity compliance to the above-listed criteria.

4.5 Volume Summary

Table 4.2 shows the total volumes needed for the different layers of erosion protection rock. These volumes are broken down both by individual rock placement areas, and by rock size.

Table 4.2
Erosion Protection Layers: Volume Requirements
Rio Algom Mining LLC

Site Drainage Area	D_{50} Rock Size (inches)	Rock Placement Area	Surface Area (ft^2)	Cross-Sectional Area (ft^2)	Length (ft)	Specified Thickness (inches)	Rock Volume(cubic yards)	Filter Thickness (inches)	Filter Volume (inches)
Interior Site Drainage Rock Volumes	D_{50}= 1.0"	Left Overbank	4,677,500	N/A	N/A	3	43,310	0	0
	D_{50}= 7.8"	MC 8+00 - 10+25	N/A	80.5	225	16	671	6	252
	D_{50}= 3.2"	MC 10+25 - 24+00	N/A	46.4	1,375	6	2,365	6	2,365
	D_{50}= 3.2"	MC 24+00 - 27+50	N/A	70.2	350	6	911	6	911
	D_{50}= 7.8"	MC 27+50 - 43+00	N/A	217.3	1,550	16	12,476	6	4,679
	D_{50}= 7.8"	MC 43+00 - 43+42 (Sideslopes)	N/A	68.0	42	16	106	6	40
	D_{50}= 7.8"	MC 43+00 - 43+42 (Outlet Apron)	N/A	450.0	42	36	600	6	121
	D_{50}= 7.8"	MC 43+42 - 57+00 (Sideslope)	N/A	34.0	1,358	16	1,710	6	641
	D_{50}= 7.8"	MC 43+42 - 57+00 (Apron)	N/A	45.0	1,358	36	2,263	6	931
	D_{50}= 12.0"	MC 57+00 - 58+00 (Sideslope)	N/A	51.0	100	24	189	6	47
	D_{50}= 12.0"	MC 57+00 - 58+00 (Apron)	N/A	90.0	100	36	333	6	96
	D_{50}= 12.0"	Wet Sideslope – Ext. Sta. -1+00 to -2+00	N/A	N/A	100	24	94	6	24
	D_{50}= 12.0"	Wet Sideslope Apron – Ext. Sta. -1+00 to -2+00	N/A	N/A	100	36	333	6	86
Exterior Site Drainage Rock Volumes	D_{50}= 1.0"	Dry Slope Rock Cover	N/A	N/A	9,535	6	7239	0	0
	D_{50}= 1.0"	Top Berm Rock Cover	N/A	3.75	9,535	3	1324	0	0
	D_{50}= 3.2"	Wet Sideslope - Station 83+50 to 70+00	N/A	N/A	2,185	6	1,396	6	1,396

Table 4.2
Erosion Protection Layers: Volume Requirements
Rio Algom Mining LLC

Site Drainage Area	D_{50} Rock Size (inches)	Rock Placement Area	Surface Area (ft^2)	Cross-Sectional Area (ft^2)	Length (ft)	Specified Thickness (inches)	Rock Volume(cubic yards)	Filter Thickness (inches)	Filter Volume (inches)
Exterior Site Drainage Rock Volumes	D_{50}= 3.2"	Wet Sideslope Apron – Station 83+50 to 70+00	N/A	N/A	2,185	24	1,619	6	841
	D_{50}= 7.8"	Wet Sideslope - Station 70+00 to 40+00	N/A	N/A	3,500	16	7,612	6	2,855
	D_{50}= 7.8"	Wet Sideslope Apron – Station 70+00 to 40+00	N/A	N/A	3,500	36	7,778	6	2,346
	D_{50}= 9.2"	Wet Sideslope - Station 40+00 to 1+50	N/A	N/A	3,850	18	9,261	6	3,087
	D_{50}= 9.2"	Wet Sideslope Apron - Station 40+00 to 1+50	N/A	N/A	3,850	36	10,694	6	2,937
Summary of Interior & Exterior Rock Volumes	Filter D_{50}=1.0"	Combined Quantity	N/A	N/A	N/A	N/A		N/A	23,652
	D_{50}= 1.0"	Combined Quantity	N/A	N/A	N/A	N/A	51,873	N/A	N/A
	D_{50}= 3.2"	Combined Quantity	N/A	N/A	N/A	N/A	6,290	N/A	N/A
	D_{50}= 7.8"	Combined Quantity	N/A	N/A	N/A	N/A	33,216	N/A	N/A
	D_{50}= 9.2"	Combined Quantity	N/A	N/A	N/A	N/A	19,955	N/A	N/A
	D_{50}= 12.0"	Combined Quantity	N/A	N/A	N/A	N/A	949	N/A	N/A

5.0 GEOMORPHIC EVALUATION

5.1 Geomorphic Evaluation of the Arroyo del Puerto

A geomorphic evaluation of the Arroyo del Puerto Drainage, Ambrosia Lake Area, was prepared by: Jerry Lindsey of AMEC, July 2007 and is contained in Appendix E.1. The geomorphic processes that most affect the Option 2 plan appear to be mitigating factors for supporting the stability of the proposed diversion channel. The lack of gullying in the most prominent drainages is a result of a high infiltration rate because of low slope gradients and deep permeable soils. The potential for infiltration is matched by a high capacity of storage evident by the granular fill in the underlying broad paleochannel. It is expected that infiltration could result in a substantial loss of runoff for a PMF.

The fine grained, low plasticity soils in which the channel is founded may result in local minor sedimentation that could mostly fill the interstices of the rock erosion protection but as a consequence of its fine grain and lack of cohesion/cementation should be of negligible consequence to any significant run-off event. It is unlikely that sedimentation of native coarse sand or gravel that might form deposits resistant to runoff will occur since there are no sources for such material.

Sedimentation of Arroyo Del Puerto valley has been in progress for at least 2500 years. Long term geomorphic stability of the valley is dependent on the stability of San Mateo Creek down stream from the site, is in near playa conditions. The stability of that valley has an added protection with the clean-up conditions of the Homestake mill and tailings site.

5.2 Geomorphic Calculations

The following discussion is a summary of the detailed evaluation contained in Appendix E.2. This evaluation utilizes NUREG-1623 Appendix E and compares sediment yield, trap efficiency, and sediment transport capacity of the exterior Diversion Embankment/Channel utilizing the gradation of the native floodplain materials. In addition, the HEC-RAS model for the exterior Diversion Channel was evaluated with a

silt buildup of 3.75 feet and with a silt buildup of 8.0 feet. The effects in terms of erosion protection requirements as well as potential overtopping of the embankment berm were evaluated.

5.2.1 Sediment Yield, Trap Efficiency, and Sediment Transport Capacity

The procedures contained in Appendix E of NUREG-1623 that evaluate sediment yield are listed as follows:

- Sheet and Rill Erosion
- Gully Erosion
- Estimated Sediment Yield
- Measured Sediment Yield
- Trap Efficiency
- Sediment Transport Capacity of a channel

Sheet and rill erosion was estimated using the Modified Universal Soil-Loss Equation (USLE) which determines the soil loss as a product of four major factors as described in the Erosional Soil Loss Technical Evaluation Report contained in Appendix E.3. This report was performed previously looking specifically at erosion on the interior site tailings ponds. This procedure is less adapted to large drainage areas like the Arroyo del Puerto and the variability of the results is greater depending on the availability of sufficient field information of the upland drainage area. The variability of results is recognized and the procedure is used here only in terms of a general estimate for comparative purposes.

Gully erosion is usually estimated from aerial photographs taken at different times and/or from field surveys. A cursory survey of the drainage area indicated only one area of gullying. As stated in the Geomorphic Evaluation of Arroyo del Puerto Drainage in Appendix E.1, high infiltration rate of the thick surficial alluvial deposits significantly reduces the potential for gullying. Therefore gully erosion was neglected for this evaluation

Estimated sediment yield was calculated by applying a sediment-delivery ratio (SDR) to the amount of sheet and rill erosion estimate previously calculated. This procedure was

used in lieu of the measured sediment yield procedure since field data measurements were available for this evaluation to accurately develop flow-duration and sediment-rating curves.

Trap efficiency was then calculated to determine the percentage of incoming sediment for given size fractions that will settle within a given reach. The size fractions that were used came from measured samples of native materials within the area. The PMF of 78,000 cfs was used as a maximum flow and then divided evenly into ten flood values to evaluate lower flood levels and determine flood depths and flow velocities across the spectrum. The original design prior to the Diversion Embankment/Channel option estimated a 100-year flood event of approximately 3000 cfs. Therefore, the range of flood values used in this evaluation are larger than twice the 100-year flood (7,800 cfs) and increase uniformly to the maximum value of the PMF (78,000 cfs).

The sediment transport capacity of the channel was calculated from the same flow data used in the previous step. This procedure calculates a sediment calculation that is then substituted into the flow-duration sediment-rating curve method shown as Table E-1 (NUREG-1623) developed during the measured sediment yield procedure. Since a similar curve is not available for this evaluation of the Arroyo del Puerto, the curve from Table E-1 (NUREG-1623) was applied to the PMF 78,000 cfs in ratio form to at least perform a rough estimate of sediment transport for different flood events.

The results of this evaluation are contained in Calculation E.1 of Appendix E.2. The summary of results indicates dramatically that the fine sandy silty nature of the native soil materials do not settle easily compared to the sediment yield from the drainage area. Additionally, even small flood events have a much greater ability to transport the fine sediments out of the channel system. The system is also protected from extensive scour and head-cutting because the natural existing Arroyo del Puerto channel sits upon bedrock at the vicinity of Tailings Pond 9 (just downstream of the intersection of the exterior Diversion Channel and the Interior Site Drainage Channel. Therefore, the system is considered to be safe from sedimentation problems that could increase the

risk of overtopping the Diversion Embankment by building up sediment in the Diversion Channel and choking the flood flows.

5.2.2 Sediment Effects on PMF Channel Flow

In addition to the sedimentation yield evaluation, the HEC-RAS model for the exterior Diversion Channel was also evaluated with a silt buildup of 3.75 feet and with a silt buildup of 8.0 feet. The effects in terms of erosion protection requirements as well as potential overtopping of the Diversion Embankment were calculated. These detailed results are contained in Appendix E.2, Calculation E.2 and E.3.

It is noted that even the added 8.00 feet of sediment t the channel bottom did not seriously impact the rock sizing performed in Calculation D.1 of Appendix D. In effect, as the bottom is filled with silt, the channel flow begins to spread out into the left overbank area thus minimizing the impact to flow velocities and water surface elevations.

6.0 DESIGN SUMMARY

In conclusion, the revised design for the diversion of the Arroyo del Puerto fully addresses the concerns brought forth by the NRC in the technical evaluation reviews with respect to potential long-term lateral migration and undercutting of Tailings Pond 3 by the arroyo as well as the adverse effects upon Tailings Ponds 4, 5, & 6. The interior site drainage channel and Tailings Ponds 4, 5, & 6 are adequately protected in the long-term from the effects of a PMP. The Diversion Embankment is protected adequately from the effects of a PMF and has adequate freeboard to prevent overtopping. The Diversion Channel and overbank area is adequate in size to contain the PMF flood flows without creating velocities too large for the available erosion protection rock sizes. Additionally, the system is not subject to sedimentation problems that would increase the risk of overtopping the Diversion Embankment.

7.0 REFERENCES

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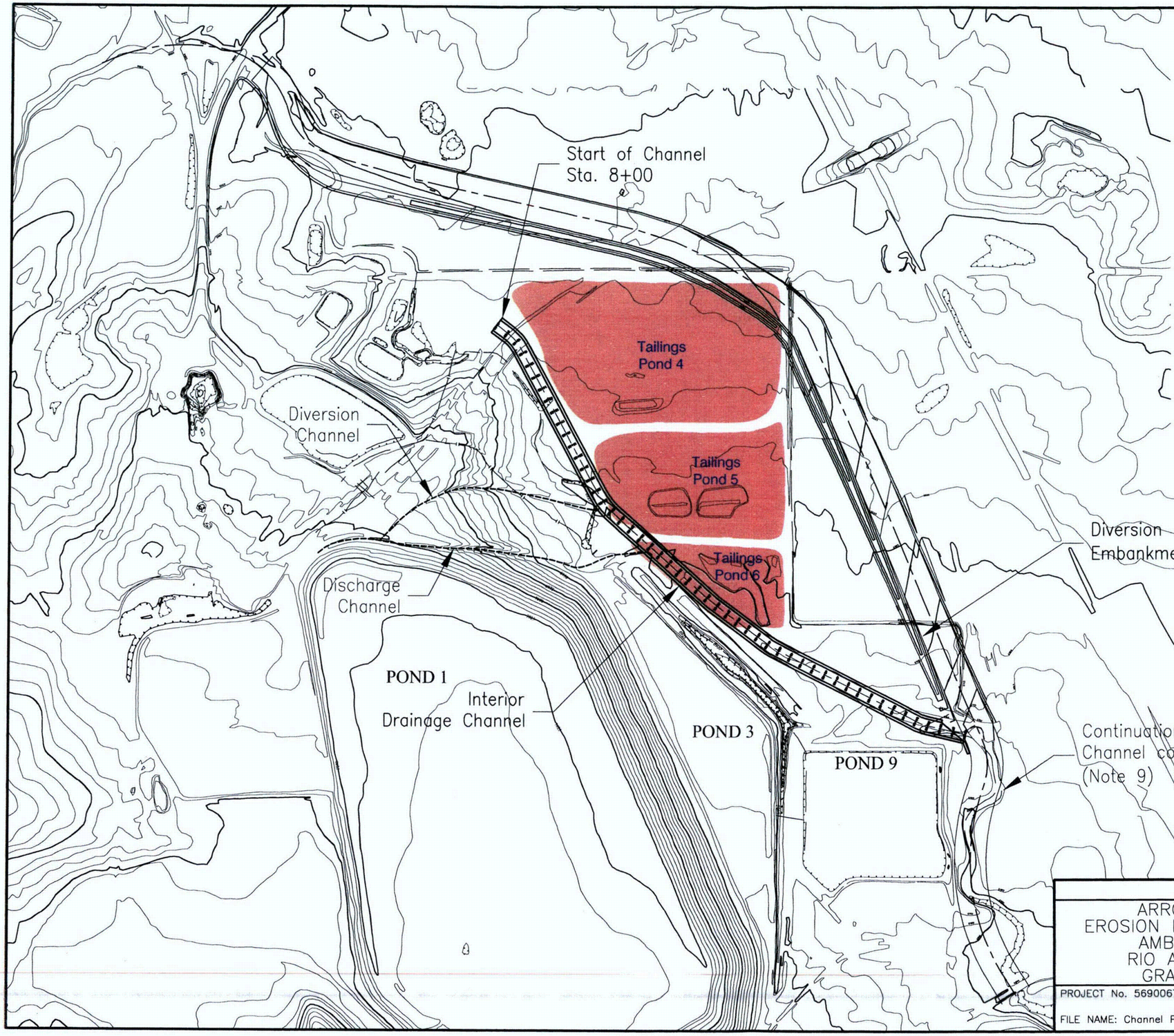
8.0 DESIGN DRAWINGS

The following Table 8.1 is a list of the design drawings contained in this section by sheet #, title, and applicable scale on the drawing>

Table 8.1
Interior & Exterior Site Drainage – Design Drawings
Rio Algom Mining LLC

Sheet #	Title	Scale
1	SITE PLAN	1' = 800'
2	INTERIOR SITE DRAINAGE PLAN	1' = 800'
3	EXTENT OF PROBABLE MAXIMUM FLOOD	1' = 800'
4	EROSON PROTECTION MEASURES	1' = 800'
5	INTERIOR SITE DRAINAGE CHANNEL SECTION DETAILS	Varies
6	DIVERSION EMBANKMENT/CHANNEL SECTION DETAILS	Varies
7	PLAN DETAILS (1 OF 5)	Varies
8	PLAN DETAILS (2 OF 5)	Varies
9	PLAN DETAILS (3 OF 5)	Varies
10	PLAN DETAILS (4 OF 5)	Varies
11	PLAN DETAILS (5 OF 5)	Varies
12	INTERIOR CHANNEL PLAN AND PROFILE (1 OF 4)	1" = 100' Hor, 1" = 10 Ver
13	INTERIOR CHANNEL PLAN AND PROFILE (2 OF 4)	1" = 100' Hor, 1" = 10 Ver
14	INTERIOR CHANNEL PLAN AND PROFILE (3 OF 4)	1" = 100' Hor, 1" = 10 Ver
15	INTERIOR CHANNEL PLAN AND PROFILE (4 OF 4)	1" = 100' Hor, 1" = 10 Ver
16	DIVERSION EMBANKMENT/CHANNEL PLAN AND PROFILE (1 OF 8)	1" = 150' Hor, 1" = 15 Ver
17	DIVERSION EMBANKMENT/CHANNEL PLAN AND PROFILE (2 OF 8)	1" = 150' Hor, 1" = 15 Ver
18	DIVERSION EMBANKMENT/CHANNEL PLAN AND PROFILE (3 OF 8)	1" = 150' Hor, 1" = 15 Ver
19	DIVERSION EMBANKMENT/CHANNEL PLAN AND PROFILE (4 OF 8)	1" = 150' Hor, 1" = 15 Ver
20	DIVERSION EMBANKMENT/CHANNEL PLAN AND PROFILE (5 OF 8)	1" = 150' Hor, 1" = 15 Ver
21	DIVERSION EMBANKMENT/CHANNEL PLAN AND PROFILE (6 OF 8)	1" = 150' Hor, 1" = 15 Ver
22	DIVERSION EMBANKMENT/CHANNEL PLAN AND PROFILE (7 OF 8)	1" = 150' Hor, 1" = 15 Ver
23	DIVERSION EMBANKMENT/CHANNEL PLAN AND PROFILE (8 OF 8)	1" = 150' Hor, 1" = 15 Ver



CONSTRUCTION NOTES:

1) Location of Interior Drainage Channel and Diversion Embankment/Channel alignment and grade based on 2006 Aerial Survey provided by Rio Algom Mining LLC.

2) Adjustments to the Interior Drainage Channel and Diversion Embankment/Channel alignment and grade will be necessary to fit actual topography.

3) All fill areas adjacent to the Interior Drainage Channel and Diversion Embankment/Channel shall be graded to have positive drainage.

4) Drainage gradients upstream of Station 8+00 shall be graded to allow unobstructed sheet flow directly into the channel.

5) Beginning at Station 8+00 on the Interior Drainage Channel, slopes shall be graded to allow unobstructed sheet flow directly into the adjacent channel.

6) Disturbances to the area shall be kept to a minimum during construction. Temporary erosion control measures shall be taken where necessary.

7) Topsoil that is to be removed within existing vegetated areas shall be stockpiled for later use where needed as directed by owner. Topsoil removal shall be limited to construction limits. Care shall be taken to prevent damage to vegetated areas outside construction limits.

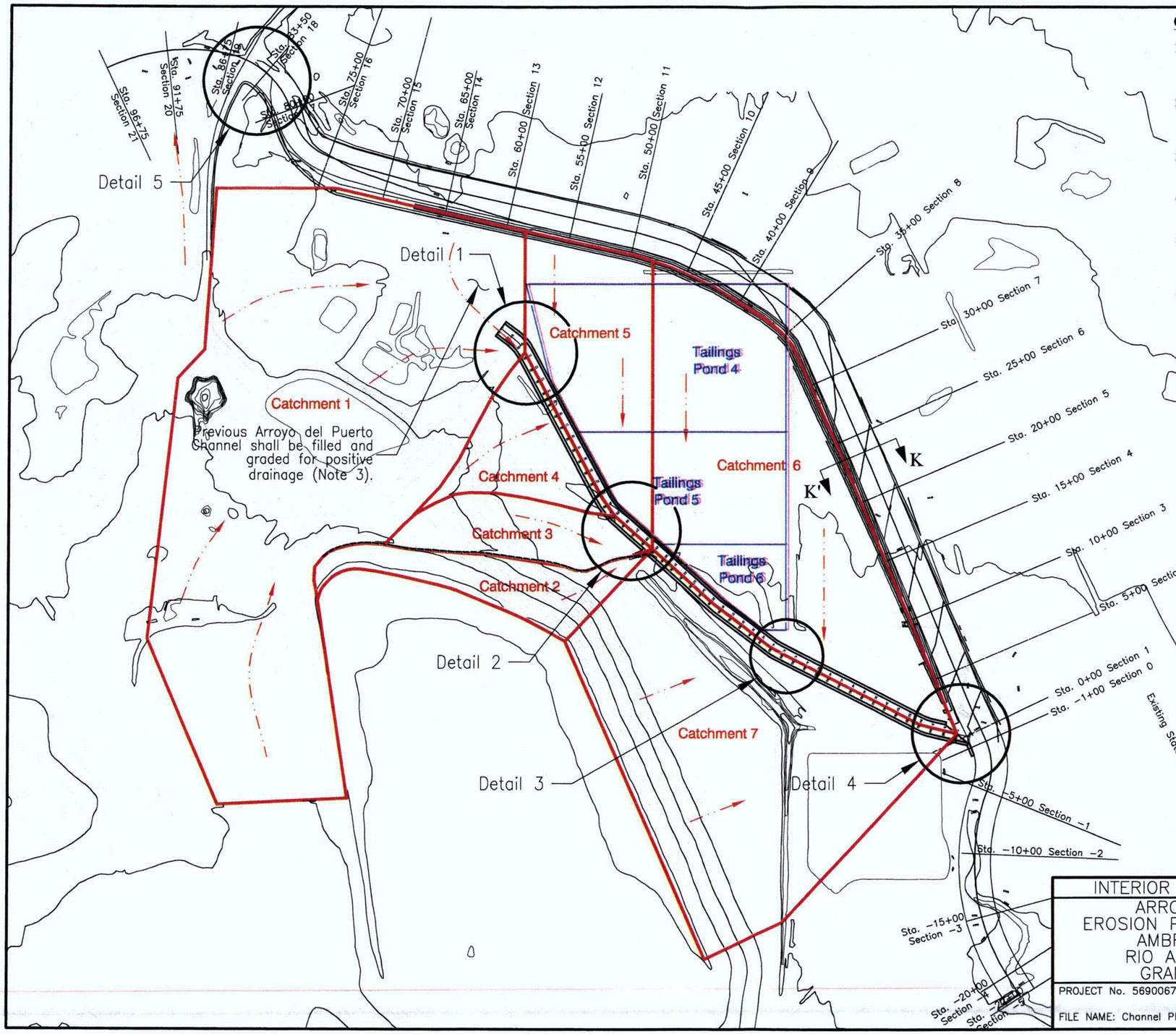
8) All existing drainages along and near the Interior Drainage Channel and Diversion Embankment/Channel shall remain in place and undisturbed.

9) The locale of the Arroyo del Puerto that is adjacent and southeast of Tailings Pond 9 is presently being used as a fill material borrow source. The final configuration of the channel within this area may result in being much wider than the proposed alignment indicated on this drawing.

SITE PLAN
ARROYO DEL PUERTO
EROSION PROTECTION MEASURES
AMBROSIA LAKE MILL
RIO ALGOM MINING LLC
GRANTS, NEW MEXICO

TETRA TECH

PROJECT No. 5690067	DRAWING BY: EJS 10/12/07	SHEET 1
FILE NAME: Channel Plan_04.DWG	REVIEWED BY: MEB	



CONSTRUCTION NOTES:

1) Location of Interior Drainage Channel and Diversion Embankment/Channel alignment and grade based on 2006 Aerial Survey provided by Rio Algom Mining LLC.

2) Adjustments to the Interior Drainage Channel and Diversion Embankment/Channel alignment and grade will be necessary to fit actual topography.

3) All fill areas adjacent to the Interior Drainage Channel and Diversion Embankment/Channel shall be graded to have positive drainage.

4) Drainage gradients upstream of Station 8+00 shall be graded to allow unobstructed sheet flow directly into the channel.

5) Beginning at Station 8+00 on the Interior Drainage Channel, slopes shall be graded to allow unobstructed sheet flow directly into the adjacent channel.

6) Area to the West of Catchment 1 drains North and intersects the Arroyo del Puerto Channel upstream of the Diversion Embankment/Channel.

INTERIOR SITE DRAINAGE PLAN
ARROYO DEL PUERTO
EROSION PROTECTION MEASURES
AMBROSIA LAKE MILL
RIO ALGOM MINING LLC
GRANTS, NEW MEXICO

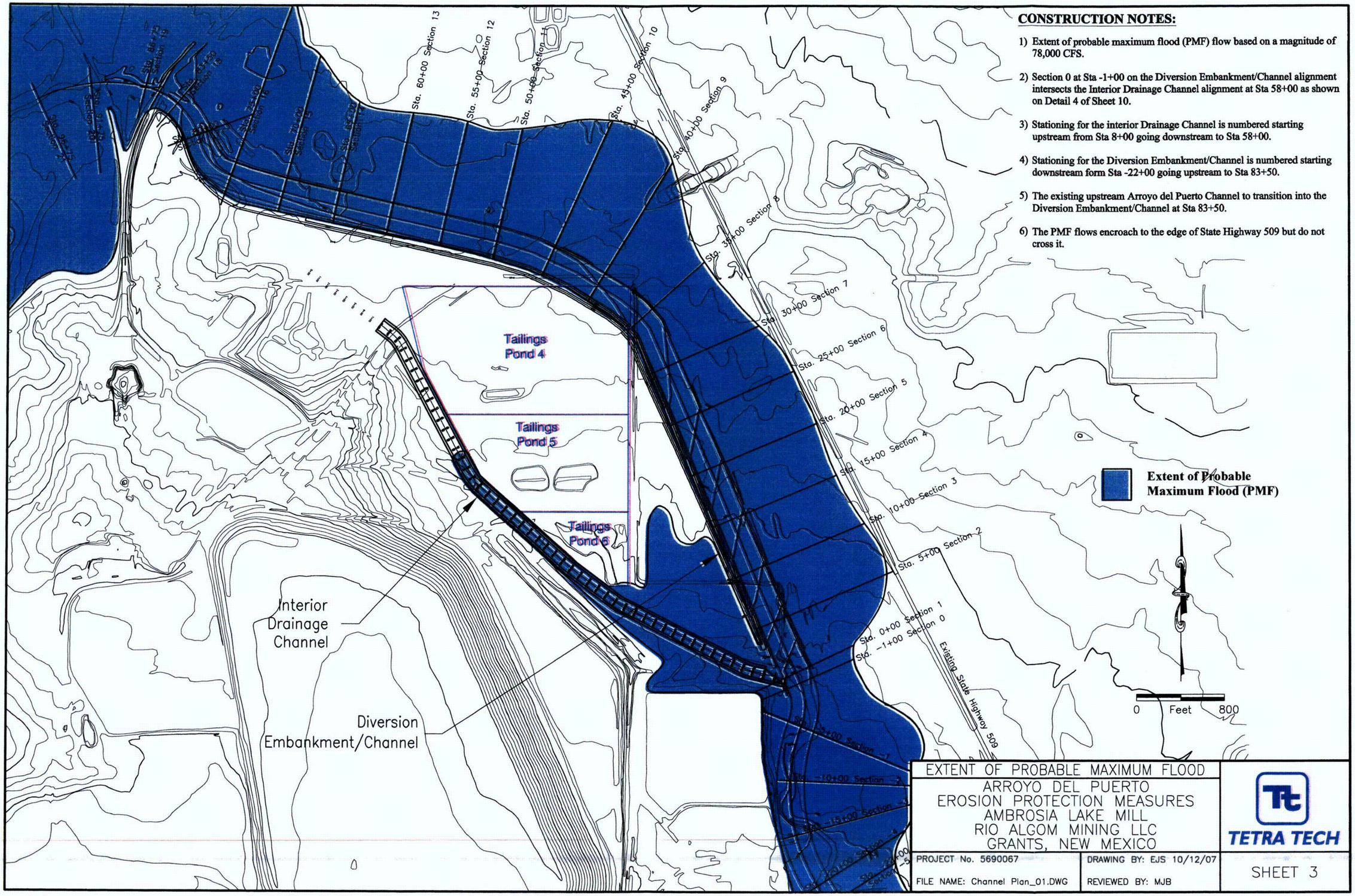
TETRA TECH

PROJECT No. 5690067	DRAWING BY: EJS 10/12/07
FILE NAME: Channel Plan_03.DWG	REVIEWED BY: MJB

SHEET 2

CONSTRUCTION NOTES:

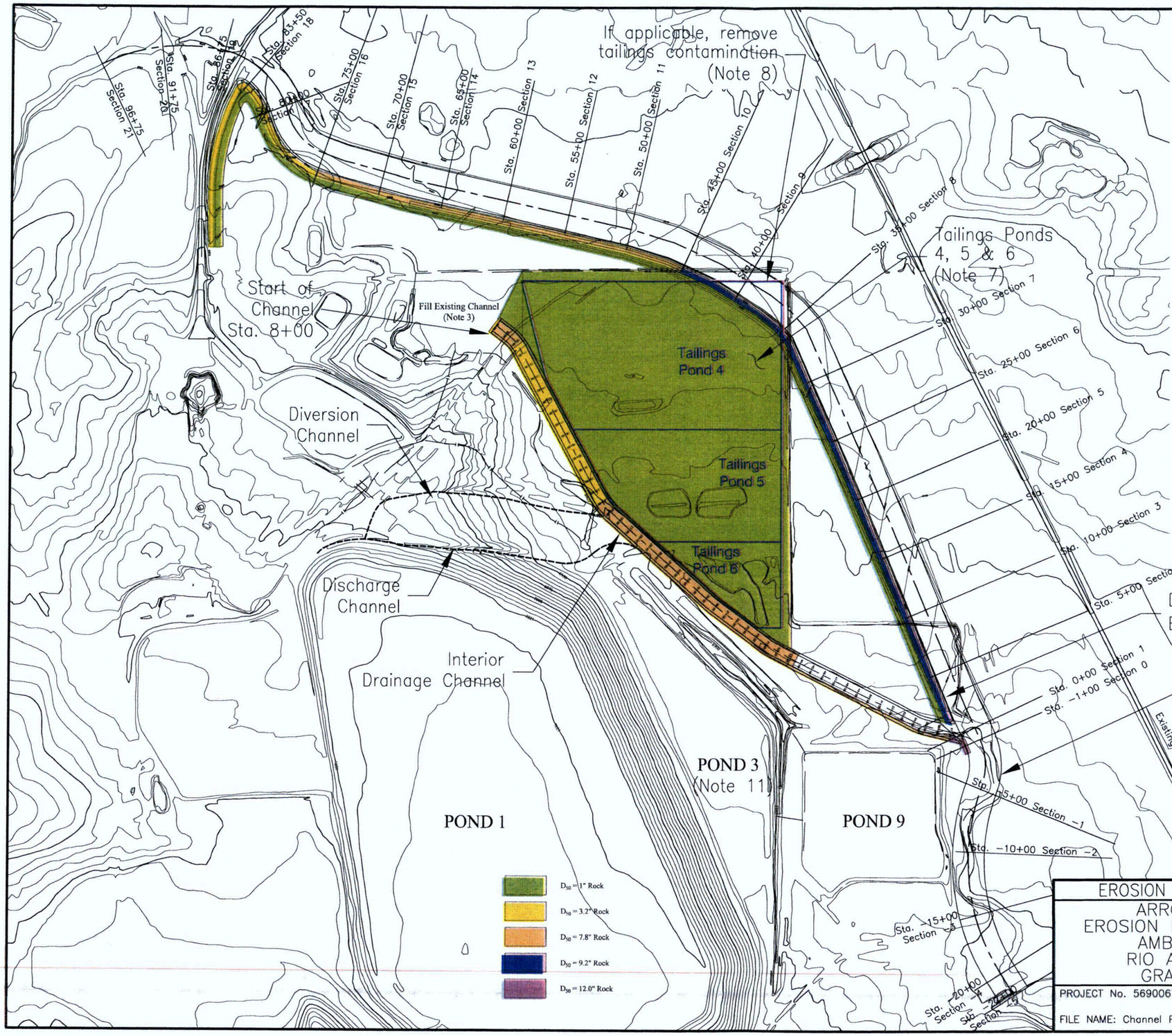
1) Extent of probable maximum flood (PMF) flow based on a magnitude of 78,000 CFS.
2) Section 0 at Sta -1+00 on the Diversion Embankment/Channel alignment intersects the Interior Drainage Channel alignment at Sta 58+00 as shown on Detail 4 of Sheet 10.
3) Stationing for the interior Drainage Channel is numbered starting upstream from Sta 8+00 going downstream to Sta 58+00.
4) Stationing for the Diversion Embankment/Channel is numbered starting downstream form Sta -22+00 going upstream to Sta 83+50.
5) The existing upstream Arroyo del Puerto Channel to transition into the Diversion Embankment/Channel at Sta 83+50.
6) The PMF flows encroach to the edge of State Highway 509 but do not cross it.



EXTENT OF PROBABLE MAXIMUM FLOOD
ARROYO DEL PUERTO
EROSION PROTECTION MEASURES
AMBROSIA LAKE MILL
RIO ALGOM MINING LLC
GRANTS, NEW MEXICO

TETRA TECH

PROJECT No. 5690067	DRAWING BY: EJS 10/12/07	SHEET 3
FILE NAME: Channel Plan_01.DWG	REVIEWED BY: MJB	



CONSTRUCTION NOTES:

1) Location of Interior Drainage Channel and Diversion Embankment/Channel alignment and grade based on 2006 Aerial Survey provided by Rio Algom Mining LLC.

2) Adjustments to the Interior Drainage Channel and Diversion Embankment/Channel alignment and grade will be necessary to fit actual topography.

3) All fill areas adjacent to the Interior Drainage Channel and Diversion Embankment/Channel shall be graded to have positive drainage.

4) Drainage gradients upstream of Station 8+00 shall be graded to allow unobstructed sheet flow directly into the channel.

5) Beginning at Station 8+00 on the Interior Drainage Channel, slopes shall be graded to allow unobstructed sheet flow directly into the adjacent channel.

6) Disturbances to the area shall be kept to a minimum during construction. Temporary erosion control measures shall be taken where necessary.

7) Topsoil that is to be removed within existing vegetated areas shall be stockpiled for later use where needed as directed by owner. Topsoil removal shall be limited to construction limits. Care shall be taken to prevent damage to vegetated areas outside construction limits.

8) All existing drainages along and near the Interior Drainage Channel and Diversion Embankment/Channel shall remain in place and undisturbed.

9) The areas of Tailings Ponds 4, 5 & 6 to be protected by 12 inches of clean fill covered by a 3-inch thick layer of erosion protection with a rock diameter of D_{50}=0.9" conforming to the gradation as presented on Table 4.1 of the report.

10) The Northern corner of Tailings Pond 4 to be checked for remaining tailings contamination. If exists, contamination on the Northeast side of the embankment shall be removed to a depth of 10 feet below final grade and replaced with clean fill.

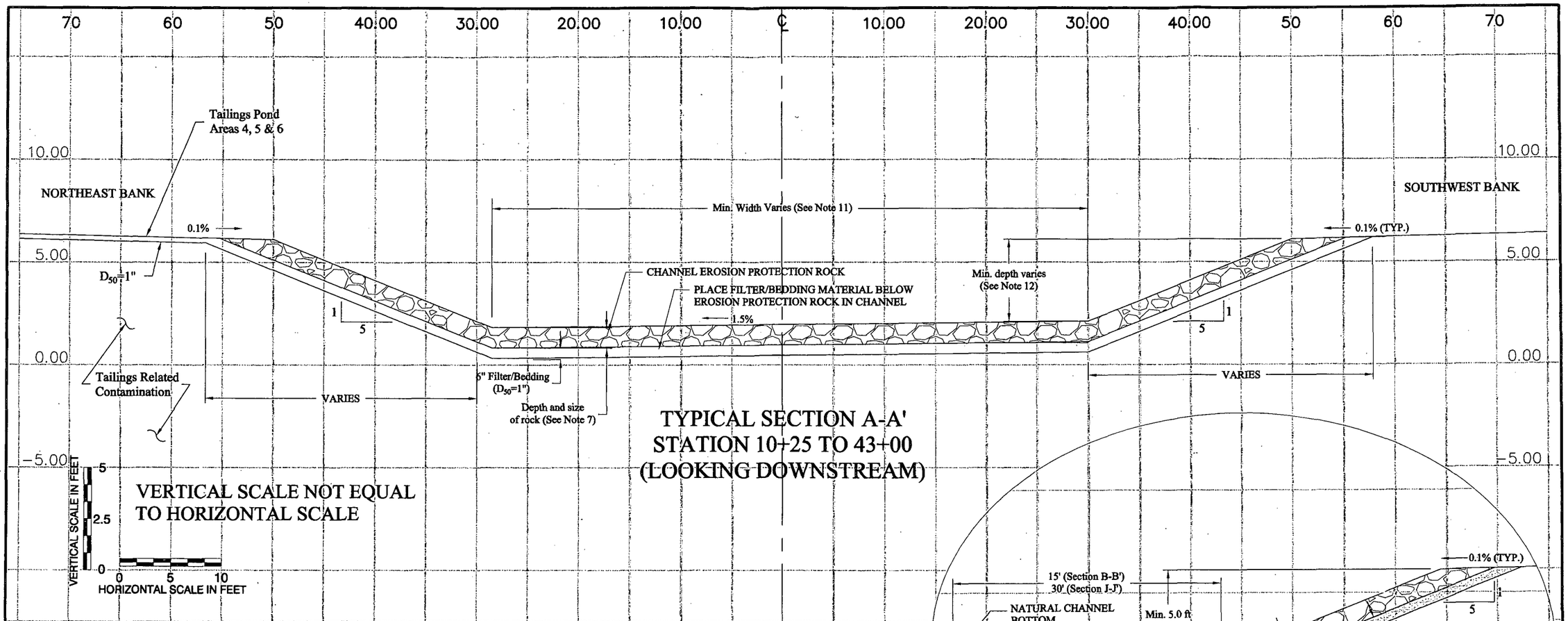
11) The erosion protection on Tailings Pond 3 is revised on this design to D_{50} of 3.2" for the sideslope and D_{50} of 9.2" for the apron at the base of the slope.

12) The locale of the Arroyo del Puerto that is adjacent and southeast of Tailings Pond 9 is presently being used as a fill material borrow source. The final configuration of the channel within this area may result in being much wider than the proposed alignment indicated on this drawing.

EROSION PROTECTION MEASURES
ARROYO DEL PUERTO
EROSION PROTECTION MEASURES
AMBROSIA LAKE MILL
RIO ALGOM MINING LLC
GRANTS, NEW MEXICO

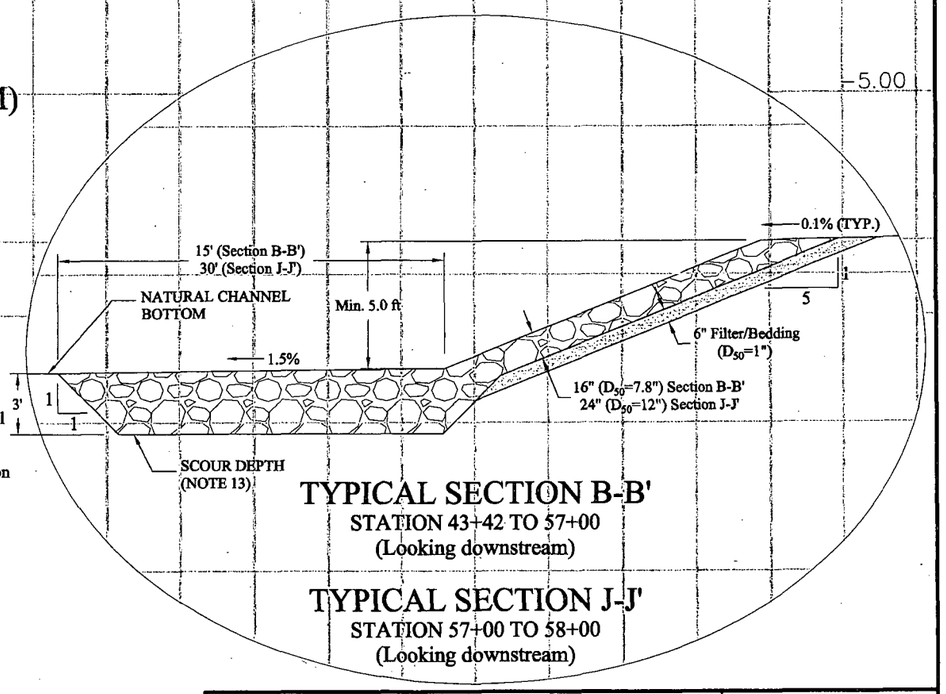
TETRA TECH

PROJECT No. 5690067	DRAWING BY: EJS 10/12/07	SHEET 4
FILE NAME: Channel Plan_02.DWG	REVIEWED BY: MEB	



TYPICAL SECTION A-A'
STATION 10+25 TO 43+00
(LOOKING DOWNSTREAM)

VERTICAL SCALE NOT EQUAL
TO HORIZONTAL SCALE



TYPICAL SECTION B-B'
STATION 43+42 TO 57+00
(Looking downstream)

TYPICAL SECTION J-J'
STATION 57+00 TO 58+00
(Looking downstream)

CONSTRUCTION NOTES:

1) Rock Riprap for erosion protection shall be placed in conformance with Appendix F of *Design of Erosion Protection for Long-Term Stabilization,* U.S. Nuclear Regulatory Commission's NUREG - 1623 Final Report.

2) Constructed channel slopes shall not exceed 5H:1V.

3) The arroyo channel bottom shall be constructed with a slope of 1.5%, sloping down to the northeast bank.

4) The channel excavation shall be constructed with bottoms free of loose debris, vegetation and muddy surfaces.

5) The erosion protection filter/bedding layer shall be placed at a minimum thickness of 6" along the length of the channel. The filter/bedding material shall extend up the 5H:1V side slopes to the existing grade or berm crest, which ever is greater. Filter/bedding materials shall be spread and compacted in one layer, and be constructed of a rock diameter of D_{50}=1.0" conforming to the gradation as presented on Table 4.1 of the Design Report.

6) The Steep Slope Inlet Apron into the interior site drainage channel shall be constructed fully lined with riprap with a minimum thickness of 16" of D_{50}=7.8" from Station 8+00 to Station 10+25.

7) The channel shall be constructed fully lined with riprap with a minimum thickness as follows:

Station	D_{50} Rock Diameter	Thickness
10+25 to 24+00	3.2"	6"
24+00 to 43+00	7.8"	16"
43+00 to 43+42	7.8"	3.0'

The rock shall be extended up the side slopes to the existing grade on the exterior.

8) The channel from Station 43+42 to 57+00 shall be constructed with riprap on the South side of the channel as shown in the detail . The riprap shall have a minimum thickness of 16" of D_{50}=7.8" on the side slope. The rock shall be extended up the side slope to the existing grade on the exterior. The rock at the toe of the slope shall be constructed to the dimensions as shown on the detail.

9) The channel from Station 57+00 to Station 58+00 shall be constructed with riprap on the South side of the channel as shown in the detail. The riprap shall have a minimum thickness of 24" of D_{50}=12.0" on the side slope. The rock shall be extended up the side slope to the existing grade on the exterior. The rock at the toe of the slope shall be constructed to the dimensions as shown on the detail.

10) The channel erosion protection rock shall be constructed of the rock diameters as specified and conform to the gradation as presented on Table 4.1 of the Design Report.

11) Minimum width of Channel Bottom varies as follows:

Station	Channel Bottom Width
10+25 to 24+00	60 ft to 105 ft
24+00 to 27+50	105 ft to 125 ft
27+50 to 43+00	125 ft to 150 ft
43+00 to 56+00	150 ft to 190 ft

12) Minimum depth of channel varies as follows:

Station	Channel Depth
10+25 to 24+00	4 ft
24+00 to 58+00	5 ft

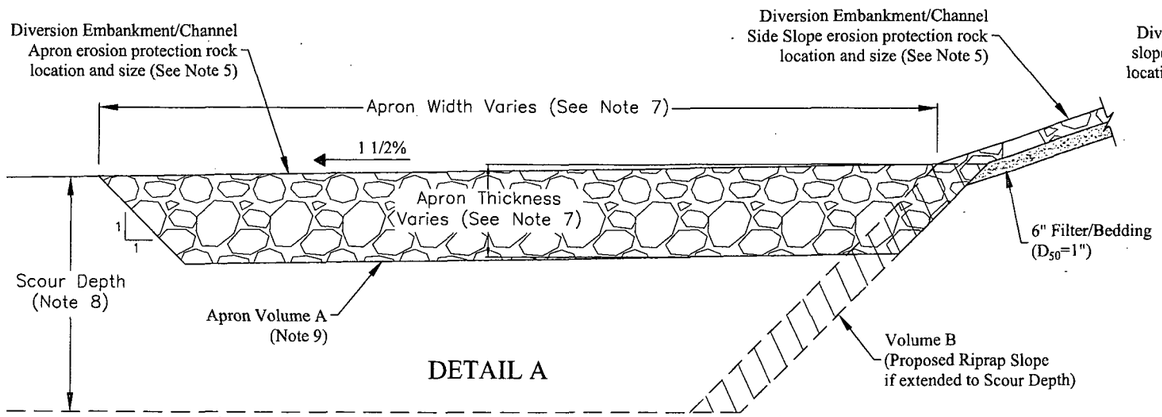
13) Maximum scour depth for Interior Site Drainage Channel is <3.0 feet.

INTERIOR SITE DRAINAGE
CHANNEL SECTION DETAILS
ARROYO DEL PUERTO
EROSION PROTECTION MEASURES
AMBROSIA LAKE MILL
RIO ALGOM MINING LLC
GRANTS, NEW MEXICO

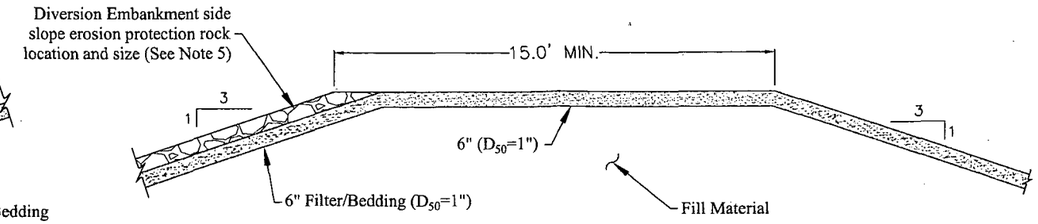
TETRA TECH

PROJECT No. 5690067 | DRAWING BY: EJS 10/12/07
FILE NAME: Chanel Section_02.DWG | REVIEWED BY: MJB

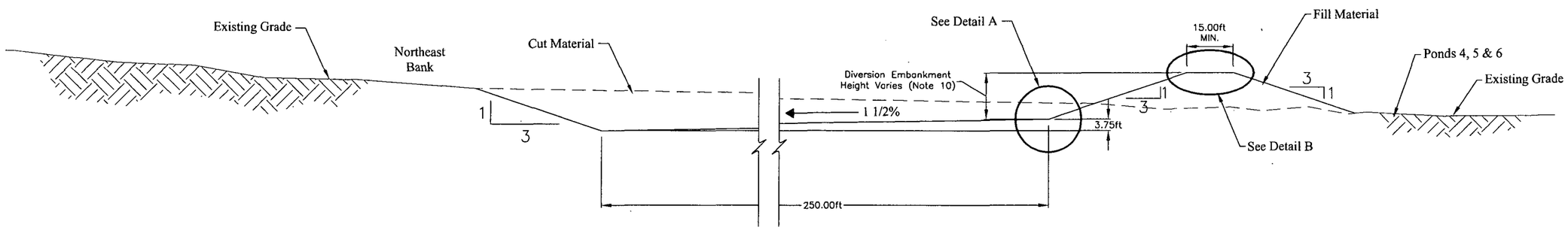
SHEET 5



DETAIL A



DETAIL B



TYPICAL SECTION K-K'
(Sta. 83+00 to 1+50)

CONSTRUCTION NOTES:

1. Rock Riprap for erosion protection shall be placed in conformance with Appendix F of *Design of Erosion Protection for Long-Term Stabilization,* U.S. Nuclear Regulatory Commission's NUREG - 1623 Final Report.

2. Constructed channel slopes shall not exceed 3H:1V.

3. The arroyo channel bottom shall be constructed with a slope of 1.5%, sloping down to the northeast bank.

4. The channel excavation shall be constructed with bottoms free of loose debris, vegetation and muddy surfaces.

5. The Diversion Channel/Apron and Embankment side slope erosion protection rock shall be constructed on the Right Channel (looking downstream) Diversion Embankment with rock diameters as follows:

Station	D_{50} Rock Diameter	Thickness
Sta. 83+50 to 75+00	3.2"	6"
Sta. 75+00 to 45+00	7.8"	16"
Sta. 45+00 to 1+50	9.2"	18"
Sta. -1+00 to -2+00	12.0"	24"

6. The rock diameters specified shall be constructed comforming to the gradations as presented on Table 4.1 of the Design Report.

7. The Apron width and thickness varies as follows:

Station	Width	Thickness
83+50 to 75+00	10'	24"
75+00 to 45+00	20'	36"
45+00 to 1+50	25'	36"
-1+00 to -2+00	30'	36"

8. Scour depth for the Diversion Channel varies between 6.5 to 9.3 feet between Stations 83+50 to 1+50.

9. Apron Volume A equals a minimum of 1.5 x Volume B with a minimum width of 15 D_{50} and a minimum thickness of 3 D_{50}.

10. The relative height of the Diversion Embankment from the base of the right channel bottom varies as follows:

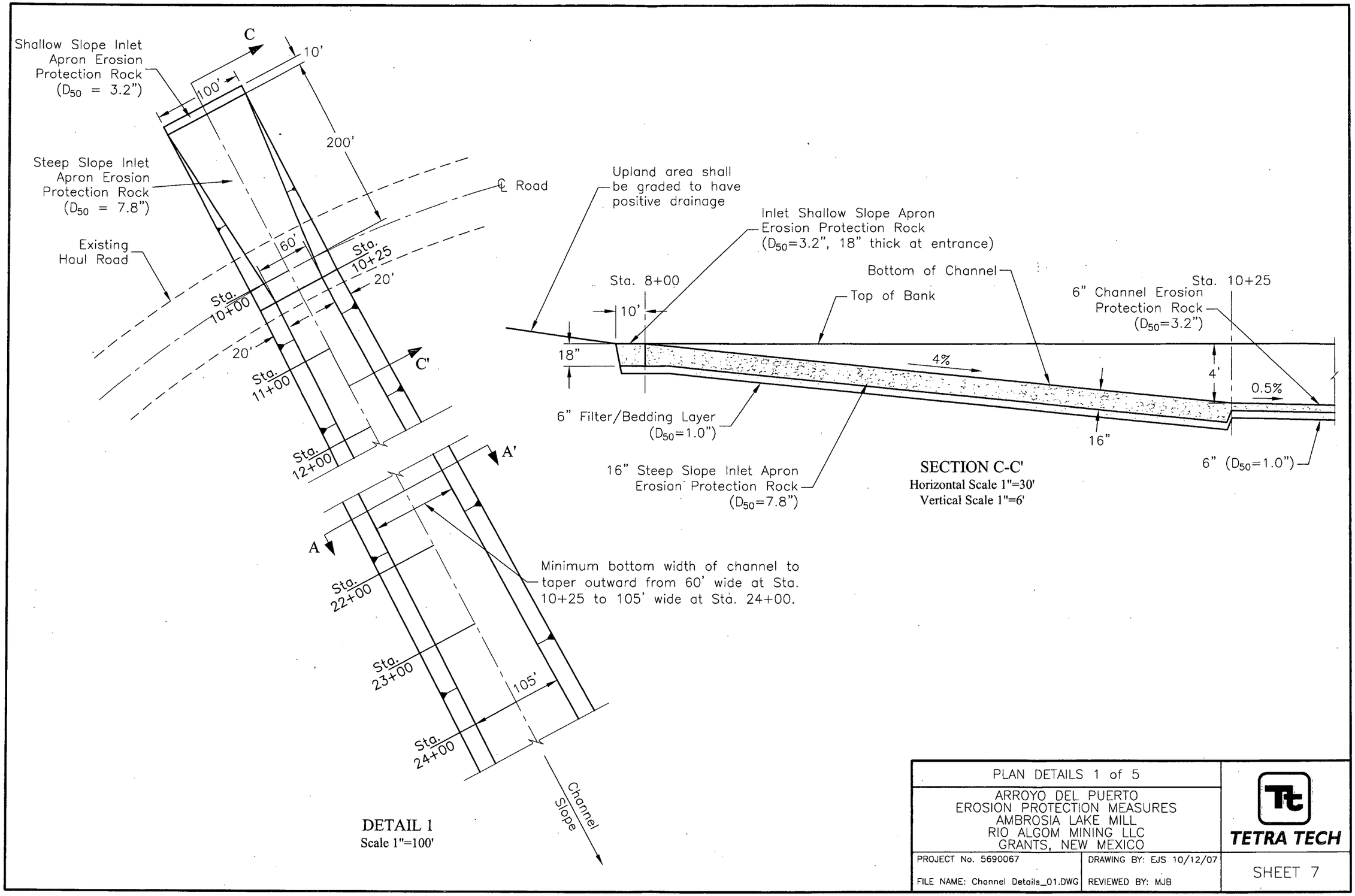
Station	Relative Height	Proposed Top of Berm Elevation
83+50 to 80+00	16.27' to 15.00'	6969.00 to 6962.86
80+00 to 65+00	15.00' to 15.00'	6962.86 to 6961.00
65+00 to 45+00	15.00' to 12.50'	6961.00 to 6956.50
45+00 to 35+00	12.50' to 12.50'	6956.50 to 6951.50
35+00 to 15+00	12.50' to 15.00'	6951.50 to 6936.50
15+00 to 1+50	15.00' to 15.00'	6936.50 to 6923.00

DIVERSION EMBANKEMENT/
CHANNEL SECTION DETAILS
ARROYO DEL PUERTO
EROSION PROTECTION MEASURES
AMBROSIA LAKE MILL
RIO ALGOM MINING LLC
GRANTS, NEW MEXICO

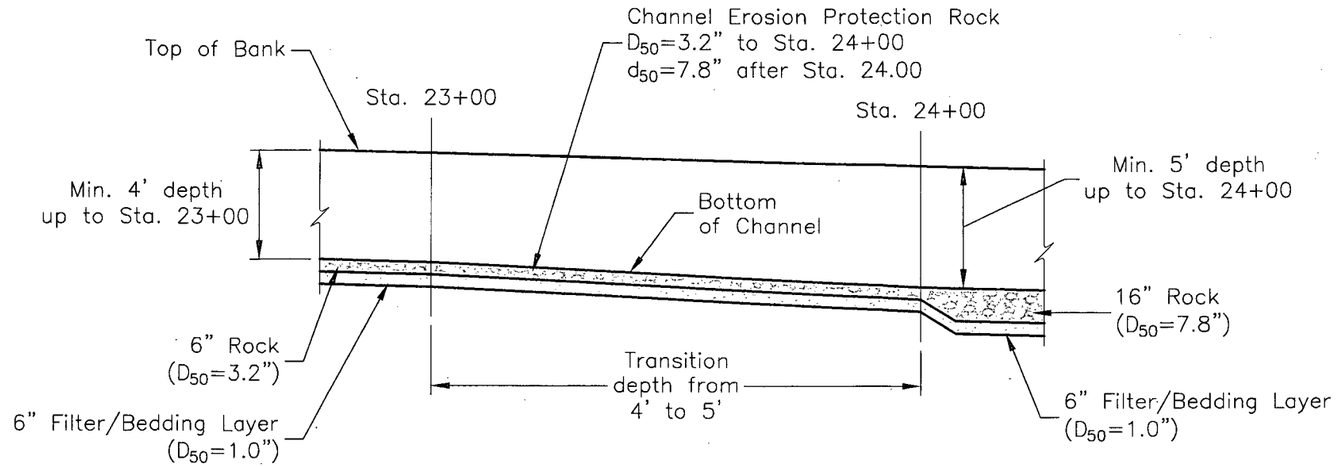
TETRA TECH

PROJECT No. 5690067 | DRAWING BY: EJS 10/12/07
FILE NAME: Channel Section_01.DWG | REVIEWED BY: MJB

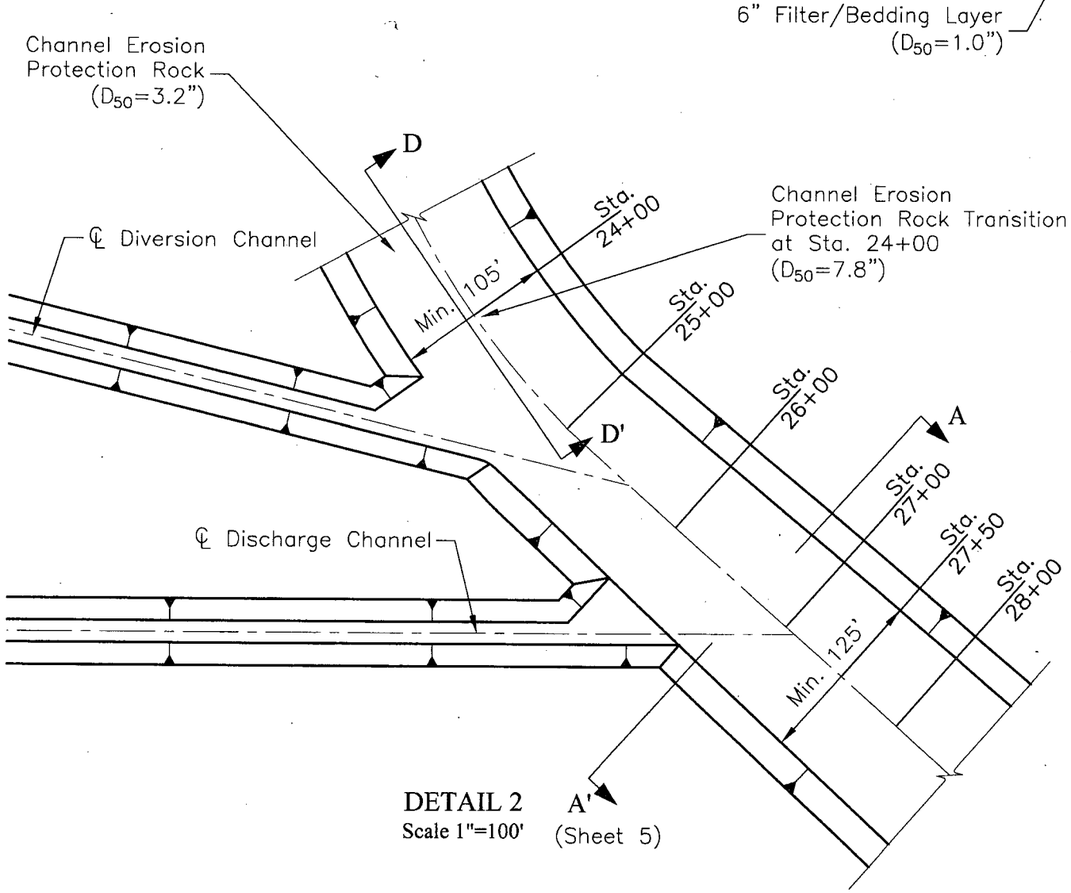
SHEET 6



PLAN DETAILS 1 of 5	TETRA TECH
ARROYO DEL PUERTO EROSION PROTECTION MEASURES AMBROSIA LAKE MILL RIO ALGOM MINING LLC GRANTS, NEW MEXICO	
PROJECT No. 5690067 / DRAWING BY: EJS 10/12/07	SHEET 7
FILE NAME: Channel Details_01.DWG / REVIEWED BY: MJB	



SECTION D-D'
Horizontal Scale 1"=30'
Vertical Scale 1"=6'

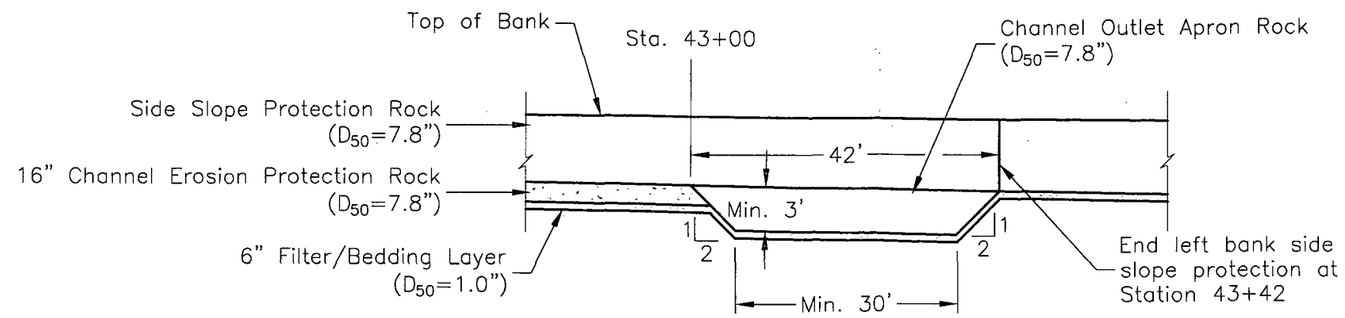


DETAIL 2
Scale 1"=100'

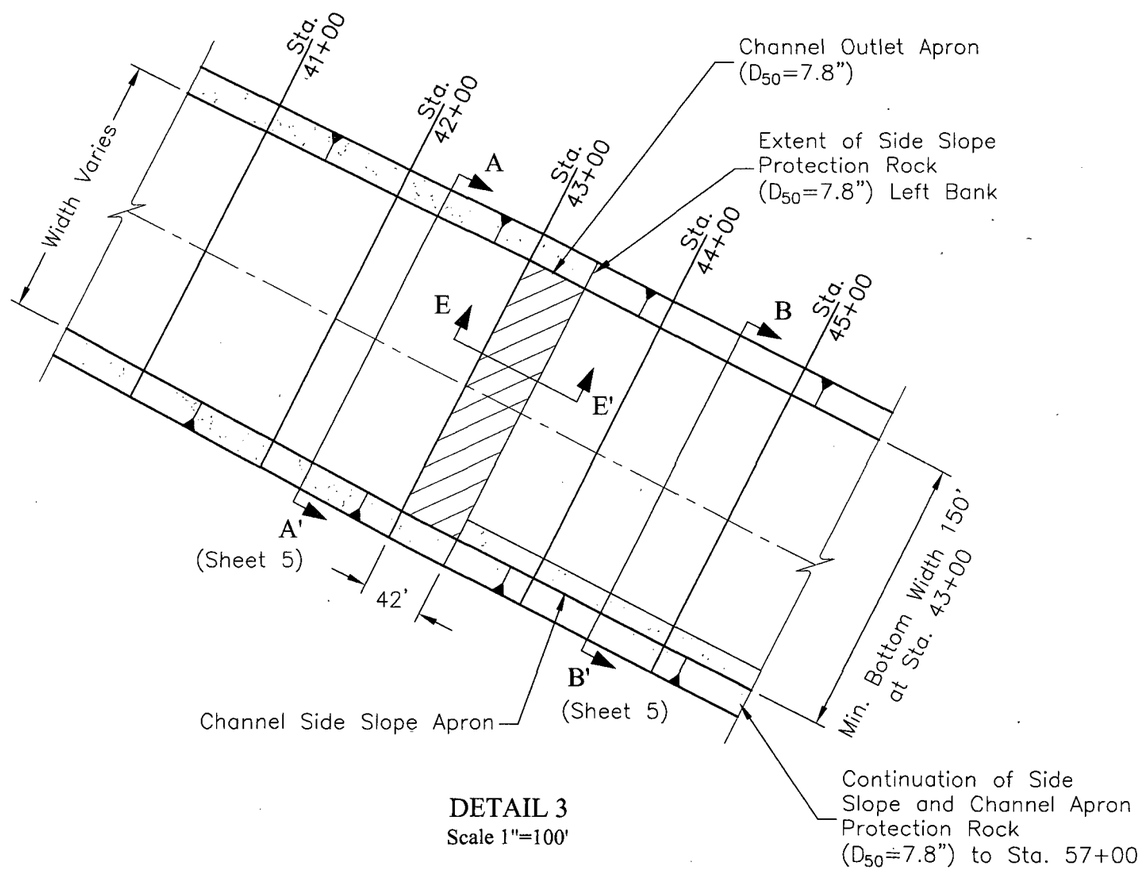
CONSTRUCTION NOTES:

1) Modify exit walls of Discharge Channel and Diversion Channel to blend with transition into Interior Drainage Channel to prevent narrow walls as slopes come together.

PLAN DETAILS 2 of 5		TETRA TECH
ARROYO DEL PUERTO EROSION PROTECTION MEASURES AMBROSIA LAKE MILL RIO ALGOM MINING LLC GRANTS, NEW MEXICO		
PROJECT No. 5690067	DRAWING BY: EJS 10/05/07	SHEET 8
FILE NAME: Channel Details_01.DWG	REVIEWED BY: MJB	

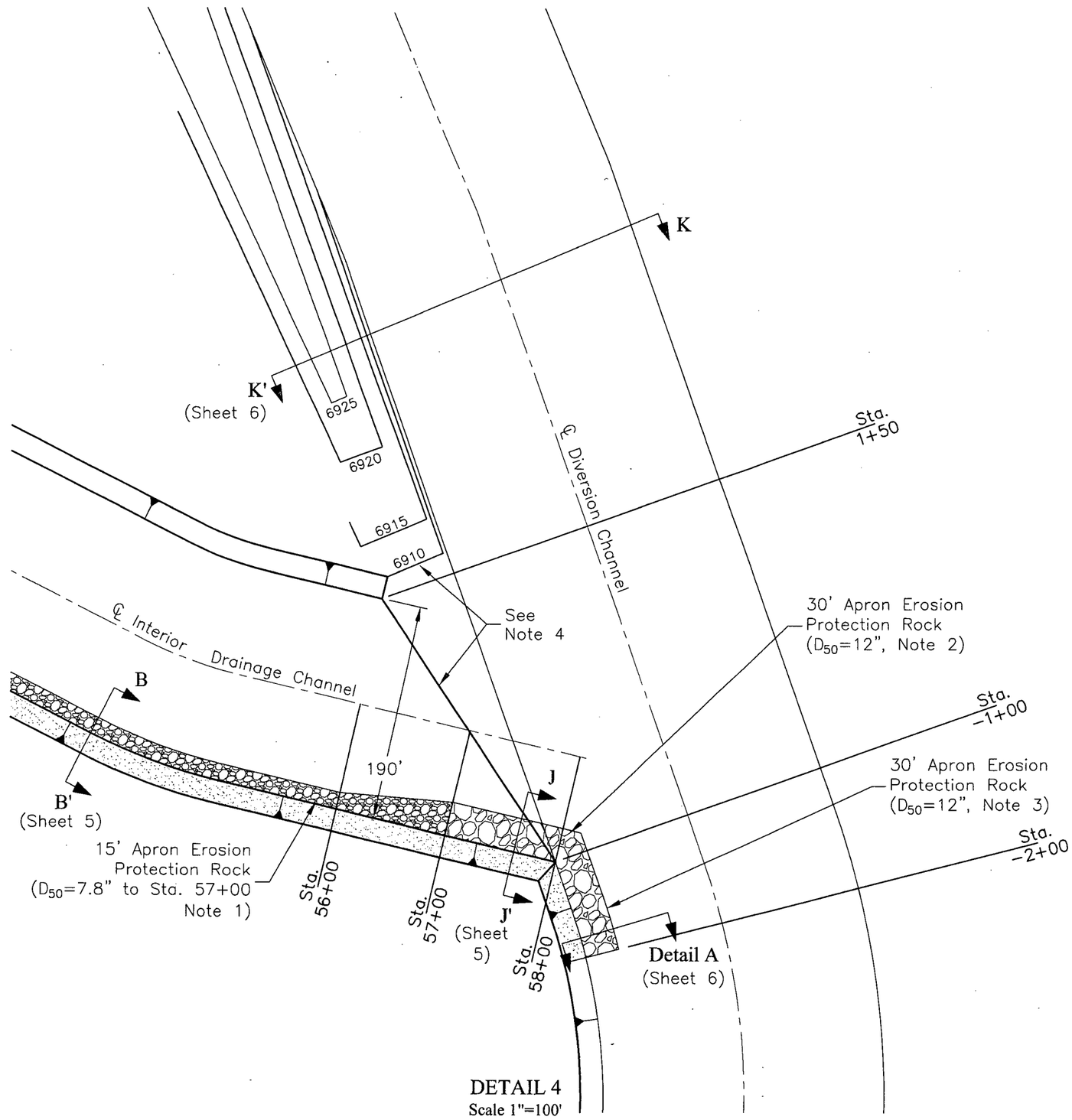


SECTION E-E'
Horizontal Scale 1"=20'
Vertical Scale 1"=10'



DETAIL 3
Scale 1"=100'

PLAN DETAILS 3 of 5		TETRA TECH
ARROYO DEL PUERTO EROSION PROTECTION MEASURES AMBROSIA LAKE MILL RIO ALGOM MINING LLC GRANTS, NEW MEXICO		
PROJECT No. 5690067	DRAWING BY: EJS 10/12/07	SHEET 9
FILE NAME: Channel Details_01.DWG	REVIEWED BY: MJB	



DETAIL 4
Scale 1"=100'

CONSTRUCTION NOTES:

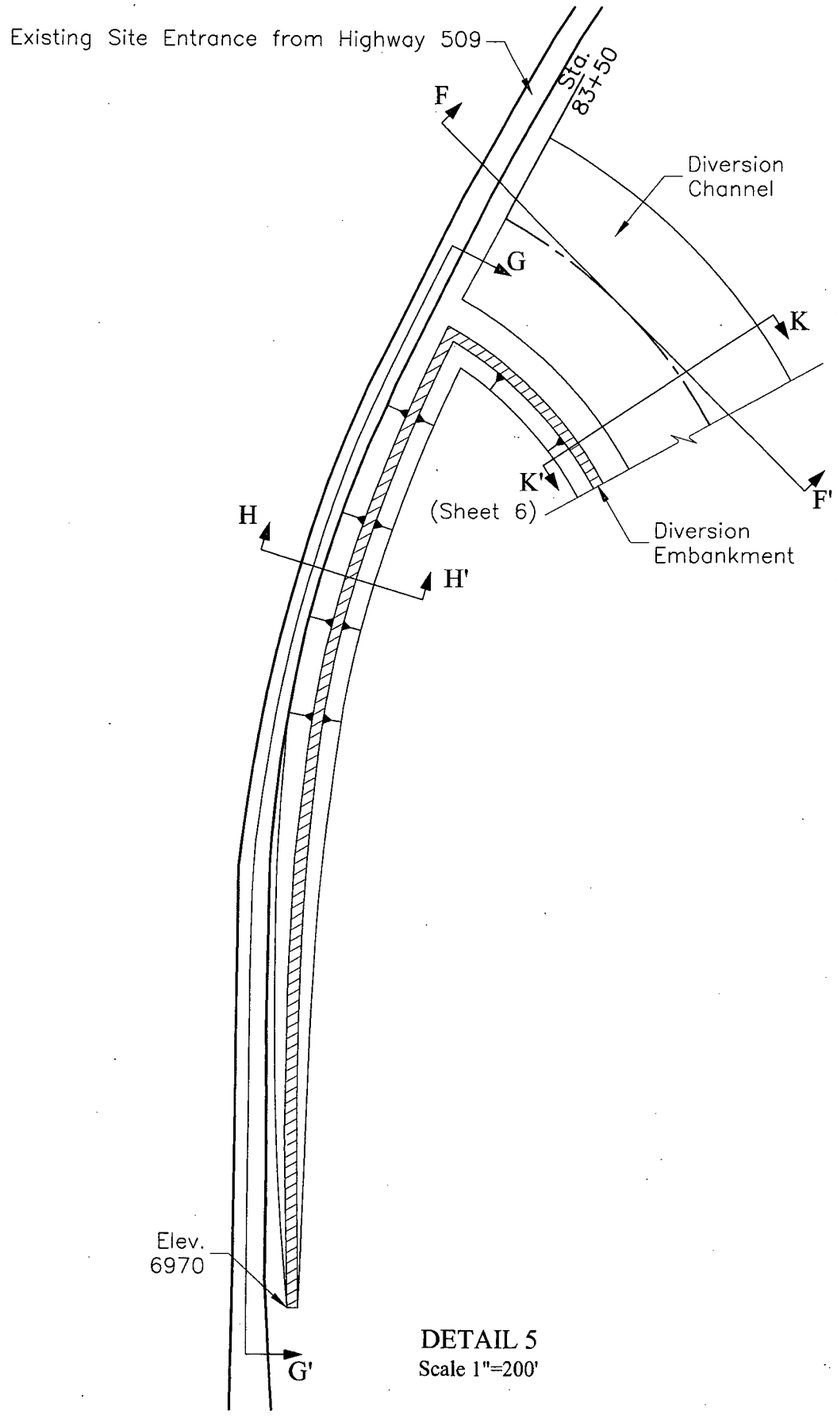
1) The Interior Drainage Channel Side Slope Apron from Station 43+42 to Station 57+00 shall be constructed with riprap on the South side of the Channel. The rock at the toe of the slope shall be constructed of D_{50}=7.8" to the dimensions shown on Section B-B' on Sheet 5.

2) The Interior Drainage Channel Side Slope Apron from Station 57+00 to Station 58+00 shall be constructed with riprap on the South side of the Channel. The rock at the toe of the slope shall be constructed of D_{50}=12" to the dimensions shown on Section B-B' on Sheet 5.

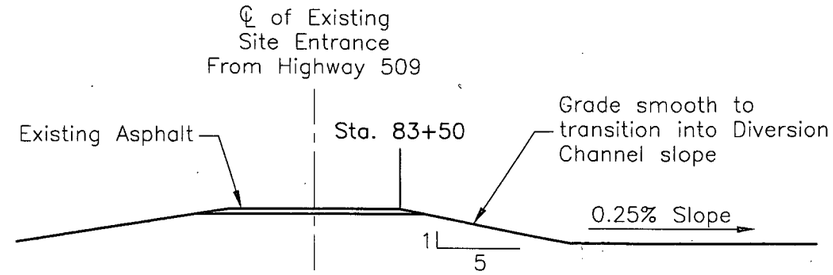
3) The Exterior Diversion Channel Side Slope Apron from Station -1+00 to Station -2+00 shall be constructed with riprap on the right channel base of slope (looking downstream). The rock at the toe of the slope shall be constructed of D_{50}=12" to the dimensions shown on Detail A on Sheet 6.

4) Channel bed elevations at the intersection of the Interior Drainage Channel and the Exterior Diversion Embankment Channel shall be field adjusted to provide a smooth transition.

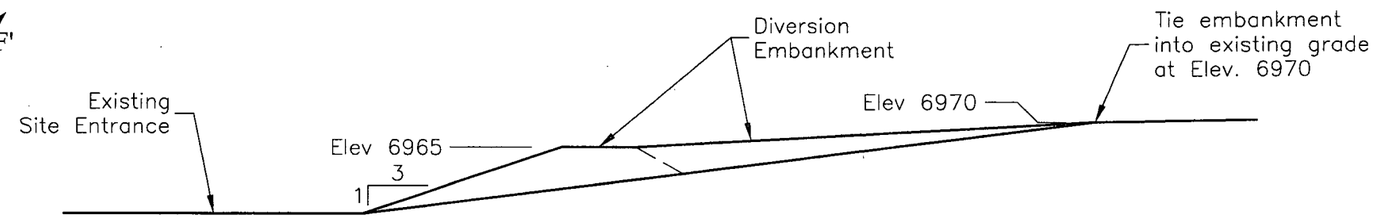
PLAN DETAILS 4 of 5	TETRA TECH
ARROYO DEL PUERTO EROSION PROTECTION MEASURES AMBROSIA LAKE MILL RIO ALGOM MINING LLC GRANTS, NEW MEXICO	
PROJECT No. 5690067 / DRAWING BY: EJS 10/12/07	SHEET 10
FILE NAME: Channel Details_01.DWG / REVIEWED BY: MJB	



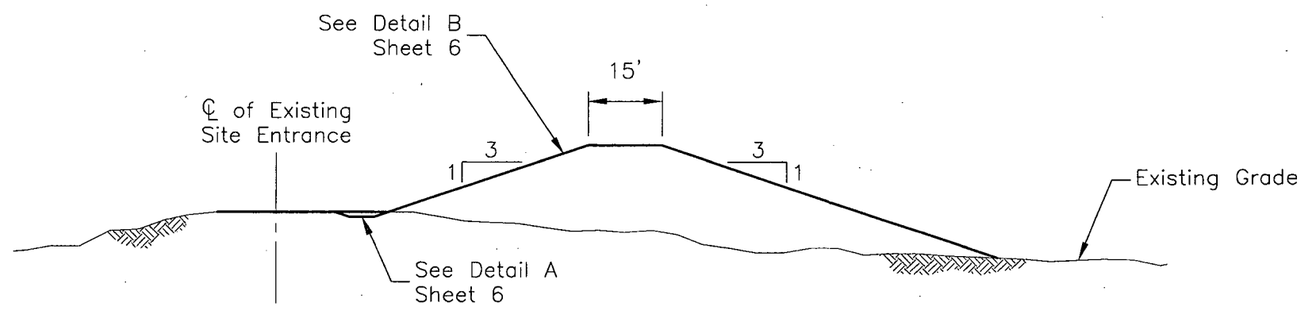
DETAIL 5
Scale 1"=200'



SECTION F-F'
Scale 1"=30'

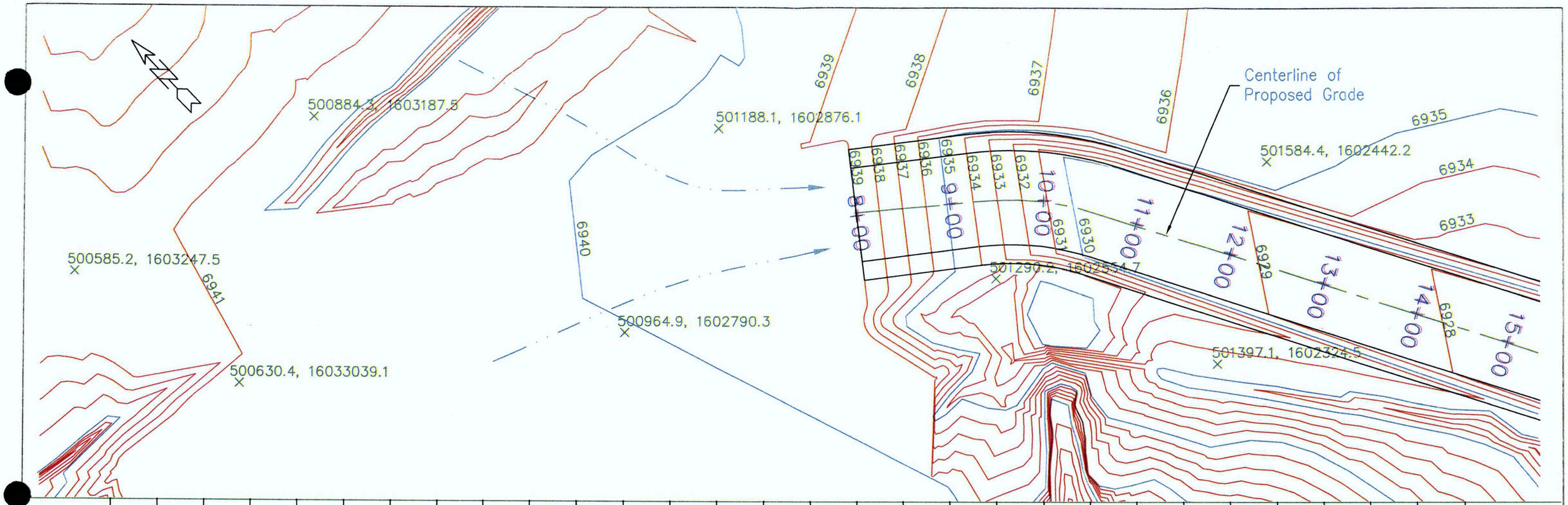


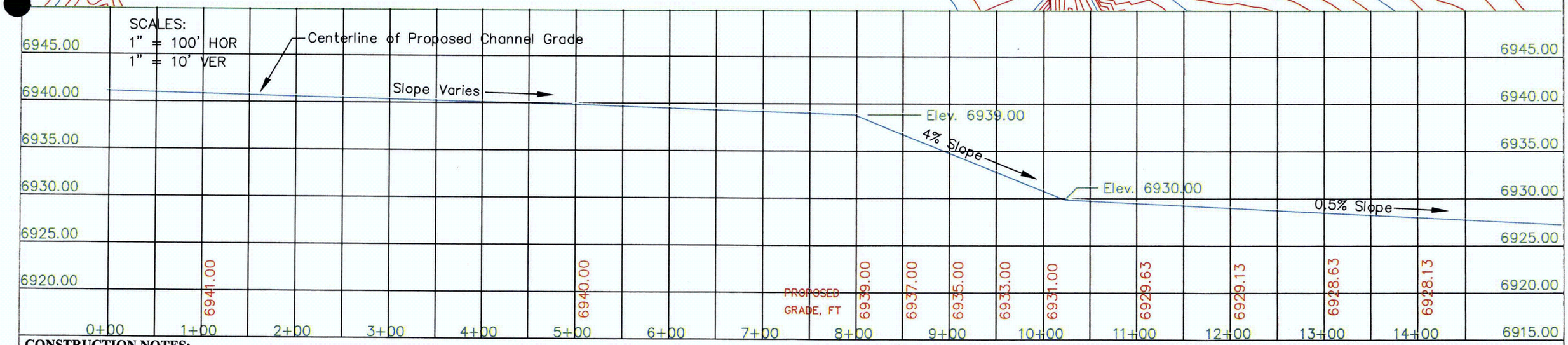
SECTION G-G'
Scale 1"=30'



SECTION H-H'
Scale 1"=30'

PLAN DETAILS 5 of 5		TETRA TECH
ARROYO DEL PUERTO EROSION PROTECTION MEASURES AMBROSIA LAKE MILL RIO ALGOM MINING LLC GRANTS, NEW MEXICO		
PROJECT No. 5690067	DRAWING BY: EJS 10/12/07	SHEET 11
FILE NAME: Channel Details_01.DWG	REVIEWED BY: MJB	





CONSTRUCTION NOTES:

1) Location of channel alignment and grade based on June 2006 Aerial Survey provided by Rio Algom Mining, LLC, and performed by New Mexico Aerial Surveys, Inc. of Albuquerque, NM.

2) Adjustments to the channel alignment and grade will be necessary to fit actual topography.

3) Erosion protection rock shall be placed in the entire channel cross section from Approximate Station 8+00 to Approximate Station 43+42, according to Section A-A' on Sheet 5.

4) Erosion protection rock shall be placed on the southwest side of the channel cross section from Approximate Station 43+42 to Approximate Station 58+00, according to Section B-B' and Section J-J' on Sheet 5.

5) The channel shall have a minimum depth of 4 feet from Station 10+25 to Station 24+00 and a minimum depth of 5 feet from Station 24+00 to 58+00, with a bottom slope of 1.5% to the northeast side of the channel, and a minimum bottom width as identified on Sheet 5 Details.

6) Actual channel widths will vary according to Note 11 on Sheet 5.

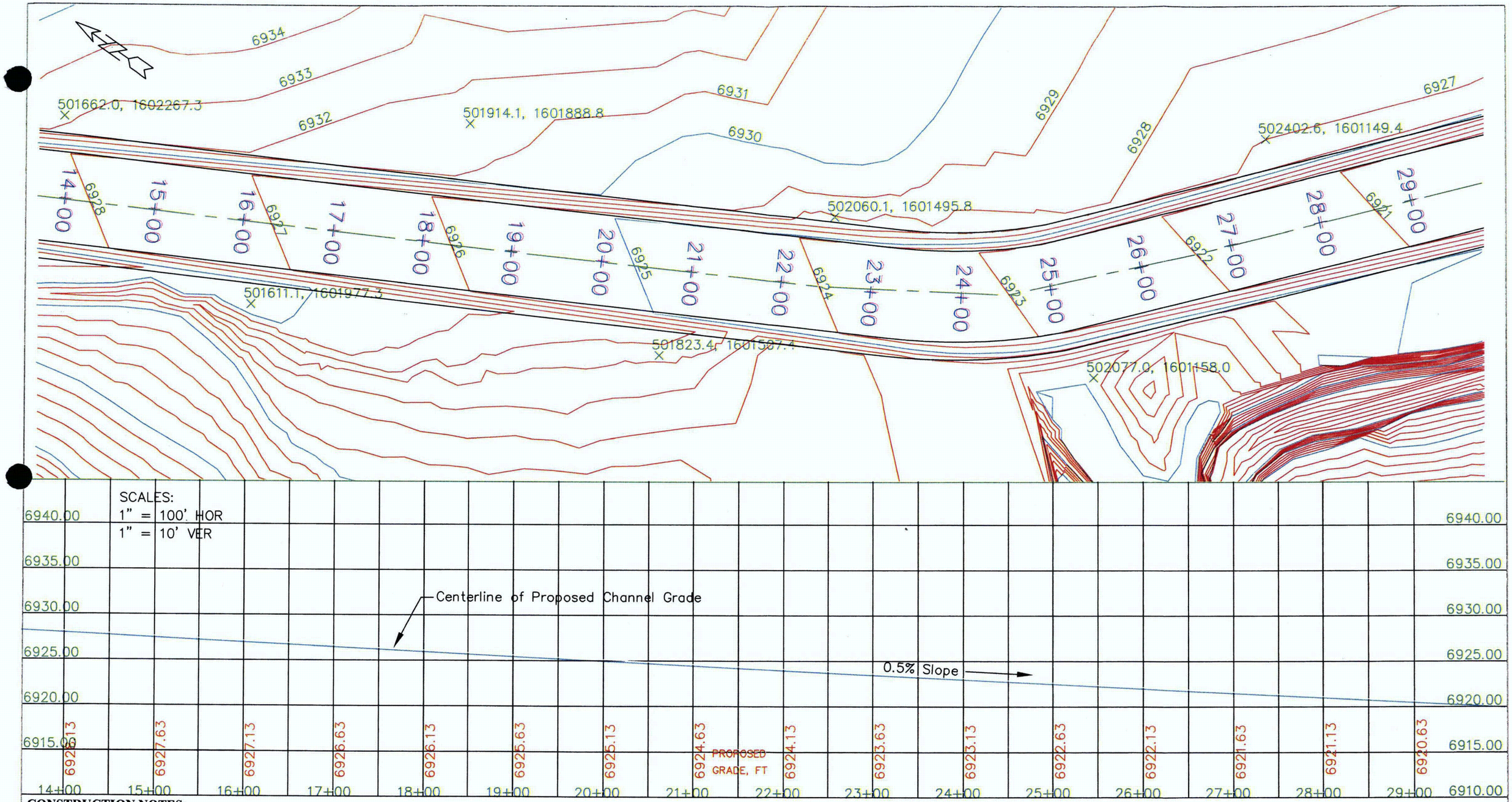
INTERIOR CHANNEL PROFILE 1 of 4

ARROYO DEL PUERTO
EROSION PROTECTION MEASURES
AMBROSIA LAKE MILL
RIO ALGOM MINING LLC
GRANTS, NEW MEXICO

TETRA TECH

PROJECT No. 5690067	DRAWING BY: EJS 10/12/07
FILE NAME:Channel Profile Sheet_2.dwg	REVIEWED BY: MEB

SHEET 12



CONSTRUCTION NOTES:

1) Location of channel alignment and grade based on June 2006 Aerial Survey provided by Rio Algom Mining, LLC, and performed by New Mexico Aerial Surveys, Inc. of Albuquerque, NM.

2) Adjustments to the channel alignment and grade will be necessary to fit actual topography.

3) Erosion protection rock shall be placed in the entire channel cross section from Approximate Station 8+00 to Approximate Station 43+42, according to Section A-A' on Sheet 5.

4) Erosion protection rock shall be placed on the southwest side of the channel cross section from Approximate Station 43+42 to Approximate Station 58+00, according to Section B-B' and Section J-J' on Sheet 5.

5) The channel shall have a minimum depth of 4 feet from Station 10+25 to Station 24+00 and a minimum depth of 5 feet from Station 24+00 to 58+00, with a bottom slope of 1.5% to the northeast side of the channel, and a minimum bottom width as identified on Sheet 5 Details.

6) Actual channel widths will vary according to Note 11 on Sheet 5.

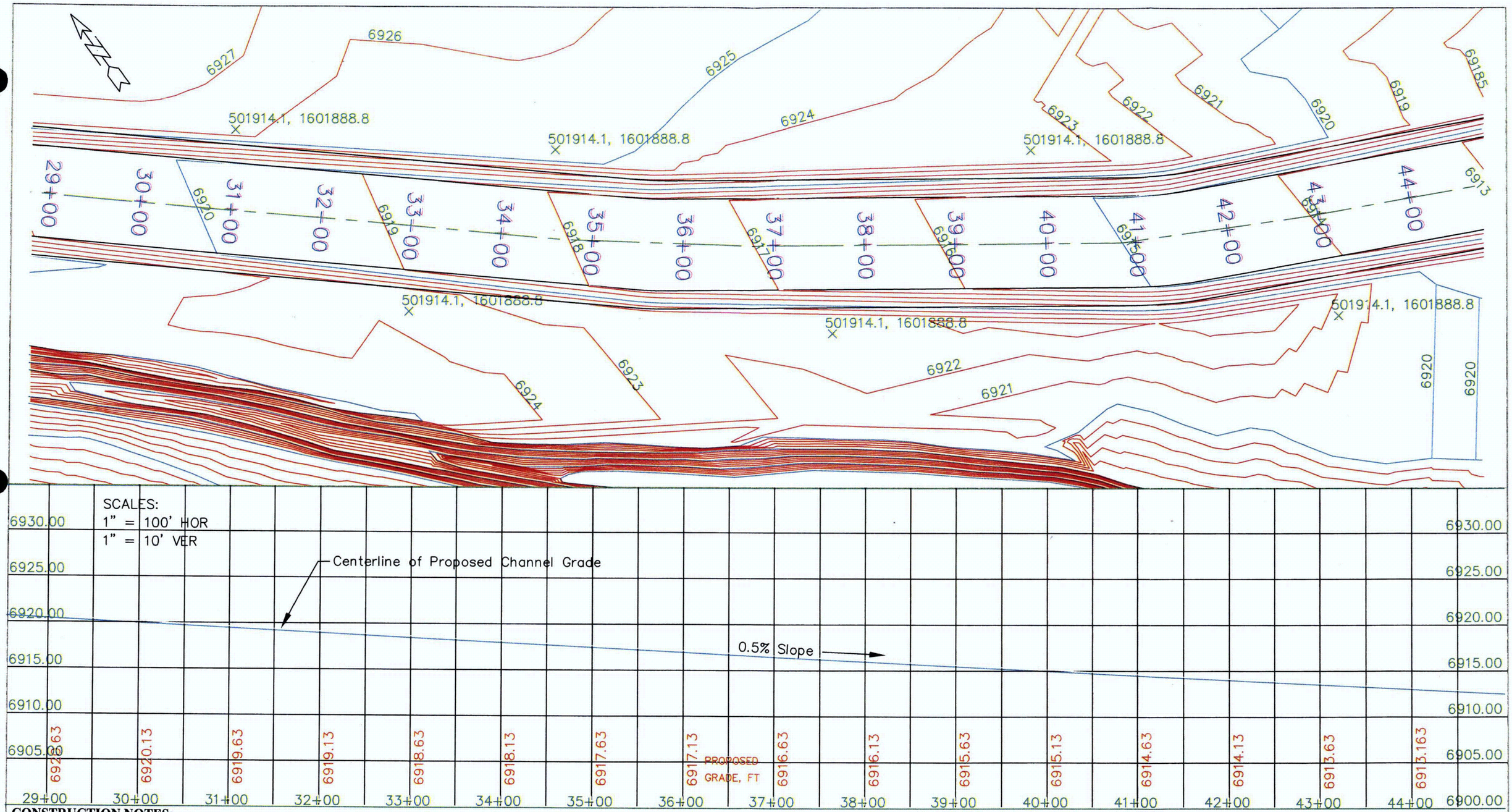
INTERIOR CHANNEL PROFILE 2 of 4

ARROYO DEL PUERTO
EROSION PROTECTION MEASURES
AMBROSIA LAKE MILL
RIO ALGOM MINING LLC
GRANTS, NEW MEXICO

TETRA TECH

PROJECT No. 5690067	DRAWING BY: EJS 10/12/07
FILE NAME:Channel Profile Sheet_3.dwg	REVIEWED BY: MEB

SHEET 13



CONSTRUCTION NOTES:

1) Location of channel alignment and grade based on June 2006 Aerial Survey provided by Rio Algom Mining, LLC, and performed by New Mexico Aerial Surveys, Inc. of Albuquerque, NM.

2) Adjustments to the channel alignment and grade will be necessary to fit actual topography.

3) Erosion protection rock shall be placed in the entire channel cross section from Approximate Station 8+00 to Approximate Station 43+42, according to Section A-A' on Sheet 5.

4) Erosion protection rock shall be placed on the southwest side of the channel cross section from Approximate Station 43+42 to Approximate Station 58+00, according to Section B-B' and Section J-J' on Sheet 5.

5) The channel shall have a minimum depth of 4 feet from Station 10+25 to Station 24+00 and a minimum depth of 5 feet from Station 24+00 to 58+00, with a bottom slope of 1.5% to the northeast side of the channel, and a minimum bottom width as identified on Sheet 5 Details.

6) Actual channel widths will vary according to Note 11 on Sheet 5.

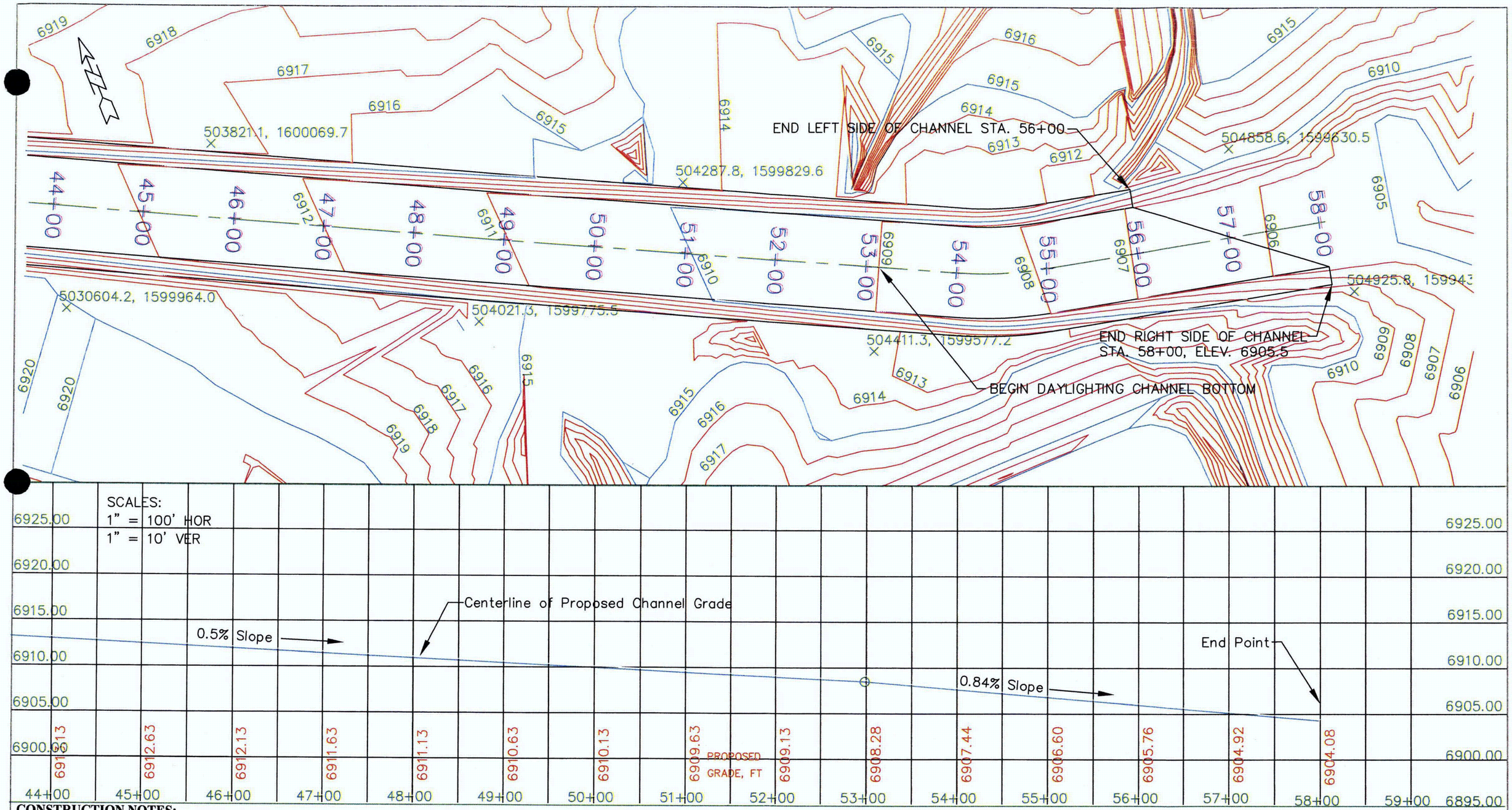
INTERIOR CHANNEL PROFILE 3 of 4

ARROYO DEL PUERTO
EROSION PROTECTION MEASURES
AMBROSIA LAKE MILL
RIO ALGOM MINING LLC
GRANTS, NEW MEXICO

TETRA TECH

PROJECT No. 5690067	DRAWING BY: EJS 10/12/07
FILE NAME:Channel Profile Sheet_4.dwg	REVIEWED BY: MEB

SHEET 14



CONSTRUCTION NOTES:

1) Location of channel alignment and grade based on June 2006 Aerial Survey provided by Rio Algom Mining, LLC, and performed by New Mexico Aerial Surveys, Inc. of Albuquerque, NM.

Adjustments to the channel alignment and grade will be necessary to fit actual topography.

3) Erosion protection rock shall be placed in the entire channel cross section from Approximate Station 8+00 to Approximate Station 43+42, according to Section A-A' on Sheet 5.

4) Erosion protection rock shall be placed on the southwest side of the channel cross section from Approximate Station 43+42 to Approximate Station 58+00, according to Section B-B' and Section J-J' on Sheet 5.

5) The channel shall have a minimum depth of 4 feet from Station 10+25 to Station 24+00 and a minimum depth of 5 feet from Station 24+00 to 58+00, with a bottom slope of 1.5% to the northeast side of the channel, and a minimum bottom width as identified on Sheet 5 Details.

6) Actual channel widths will vary according to Note 11 on Sheet 5.

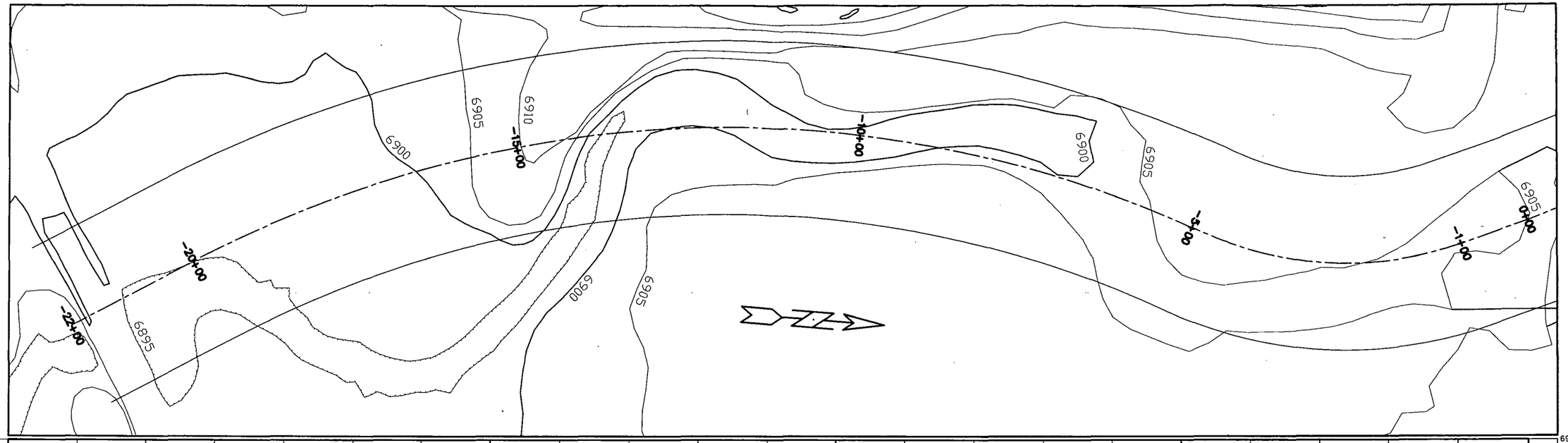
INTERIOR CHANNEL PROFILE 4 of 4

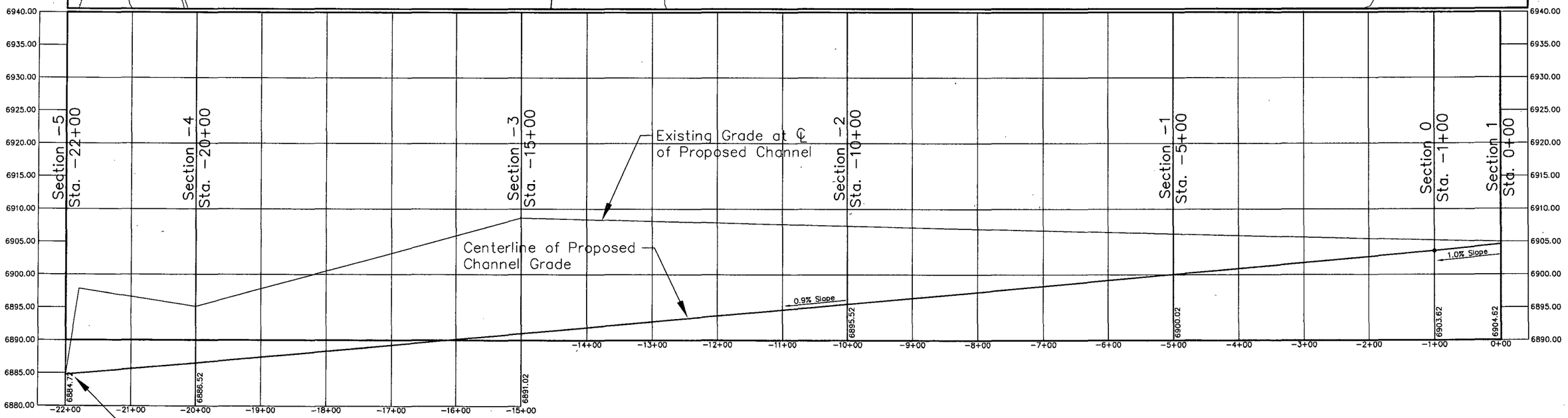
ARROYO DEL PUERTO
EROSION PROTECTION MEASURES
AMBROSIA LAKE MILL
RIO ALGOM MINING LLC
GRANTS, NEW MEXICO

TETRA TECH

PROJECT No. 5690067	DRAWING BY: EJS 10/12/07
FILE NAME:Channel Profile Sheet_5.dwg	REVIEWED BY: MEB

SHEET 15





End Proposed Channel Grade at Station −22+00. Blend into Existing Grade

CONSTRUCTION NOTES:

1) Location of channel alignment and grade based on June 2006 Aerial Survey provided by Rio Algom Mining, LLC, and performed by New Mexico Aerial Surveys, Inc. of Albuquerque, NM.

2) Adjustments to the channel alignment and grade will be necessary to fit actual topography.

HORIZONTAL SCALE 0 25' 50' 100' 200'
1" = 50'-0"

VERTICAL SCALE 0 2.5' 5' 10' 20'
1" = 5'-0"

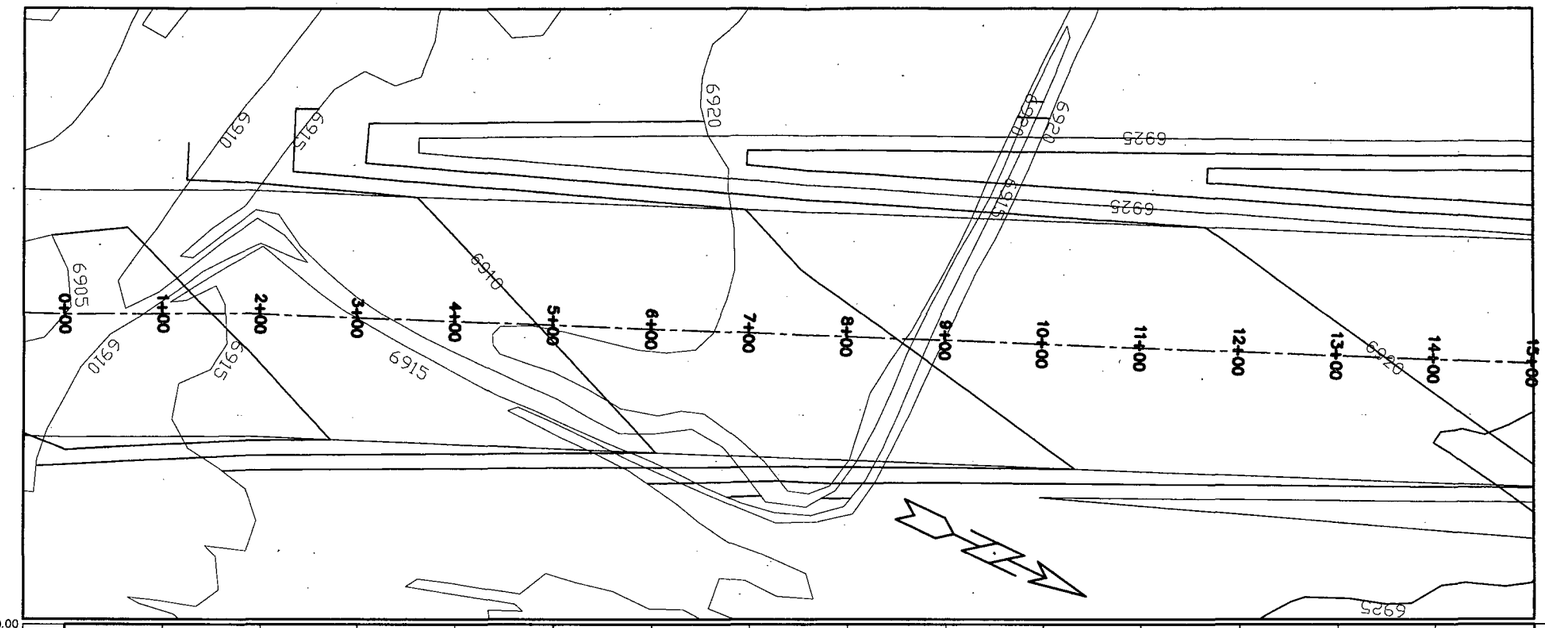
DIVERSION CHANNEL PROFILE 1 of 8

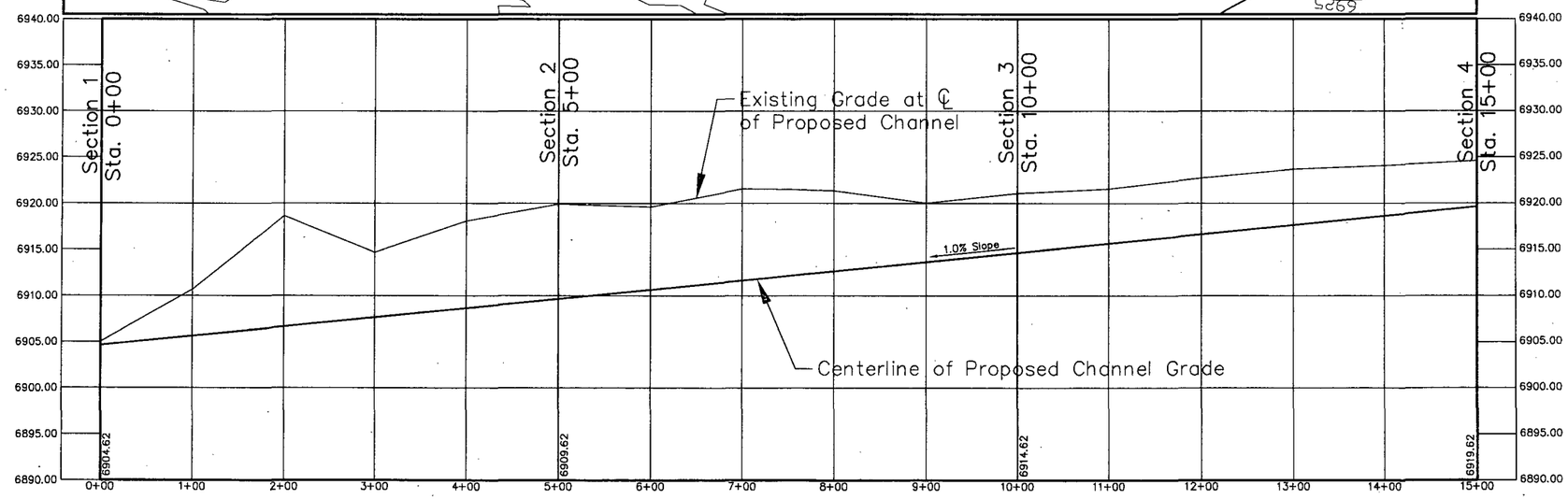
ARROYO DEL PUERTO
EROSION PROTECTION MEASURES
AMBROSIA LAKE MILL
RIO ALGOM MINING LLC
GRANTS, NEW MEXICO

TETRA TECH

PROJECT No. 5690067	DRAWING BY: EJS 10/03/07
FILE NAME:Diversion Channel Profile Sheet_0	REVIEWED BY: MEB

SHEET 16





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2) Adjustments to the channel alignment and grade will be necessary to fit actual topography.

HORIZONTAL SCALE 0 25' 50' 100' 200'
1" = 50'-0"

VERTICAL SCALE 0 2.5' 5' 10' 20'
1" = 5'-0"

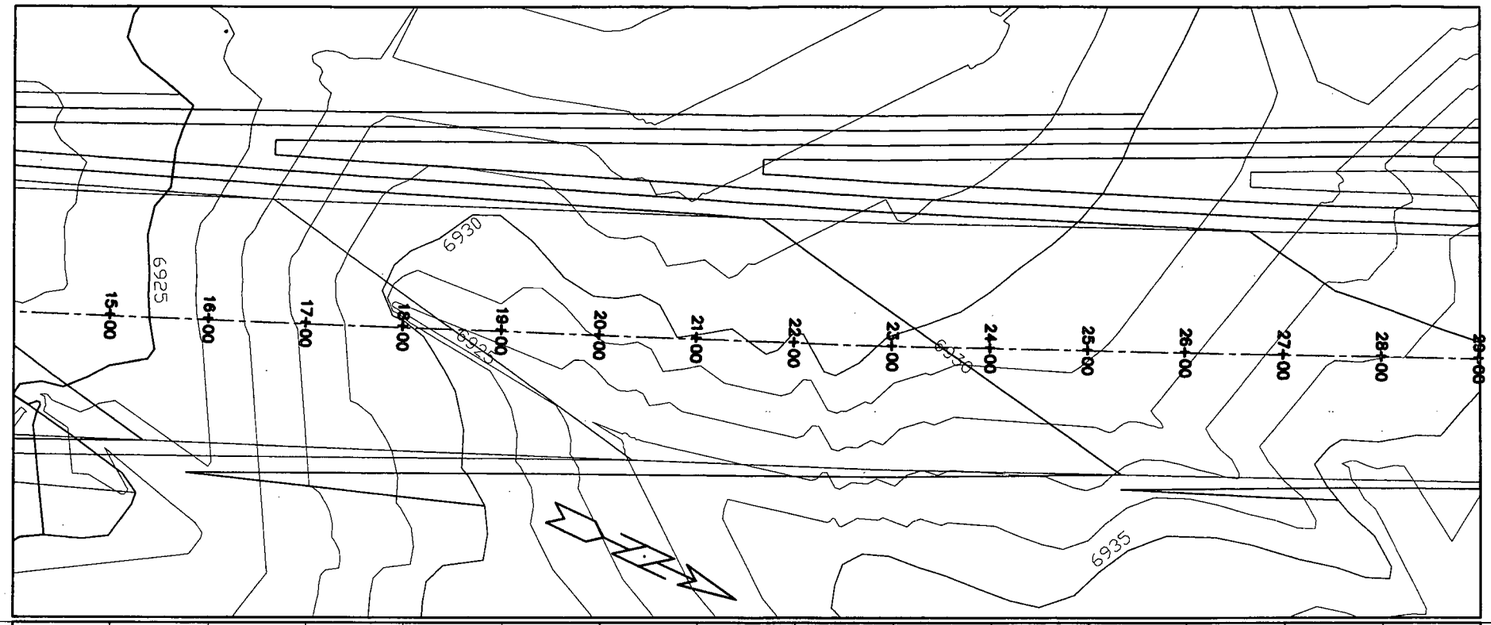
DIVERSION CHANNEL PROFILE 2 of 8

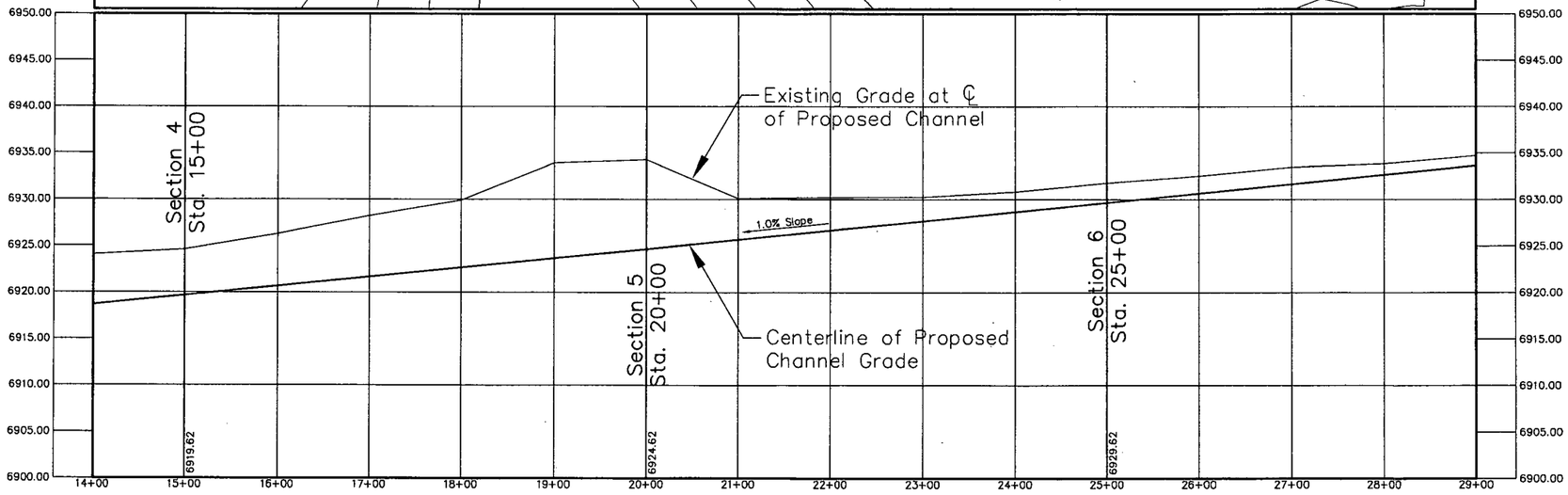
ARROYO DEL PUERTO
EROSION PROTECTION MEASURES
AMBROSIA LAKE MILL
RIO ALGOM MINING LLC
GRANTS, NEW MEXICO

TETRA TECH

PROJECT No. 5690067	DRAWING BY: EJS 10/03/07
FILE NAME:Diversion Channel Profile Sheet_1	REVIEWED BY: MEB

SHEET 17





CONSTRUCTION NOTES:

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2) Adjustments to the channel alignment and grade will be necessary to fit actual topography.

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VERTICAL SCALE 0 2.5' 5' 10' 20'
1" = 5'-0"

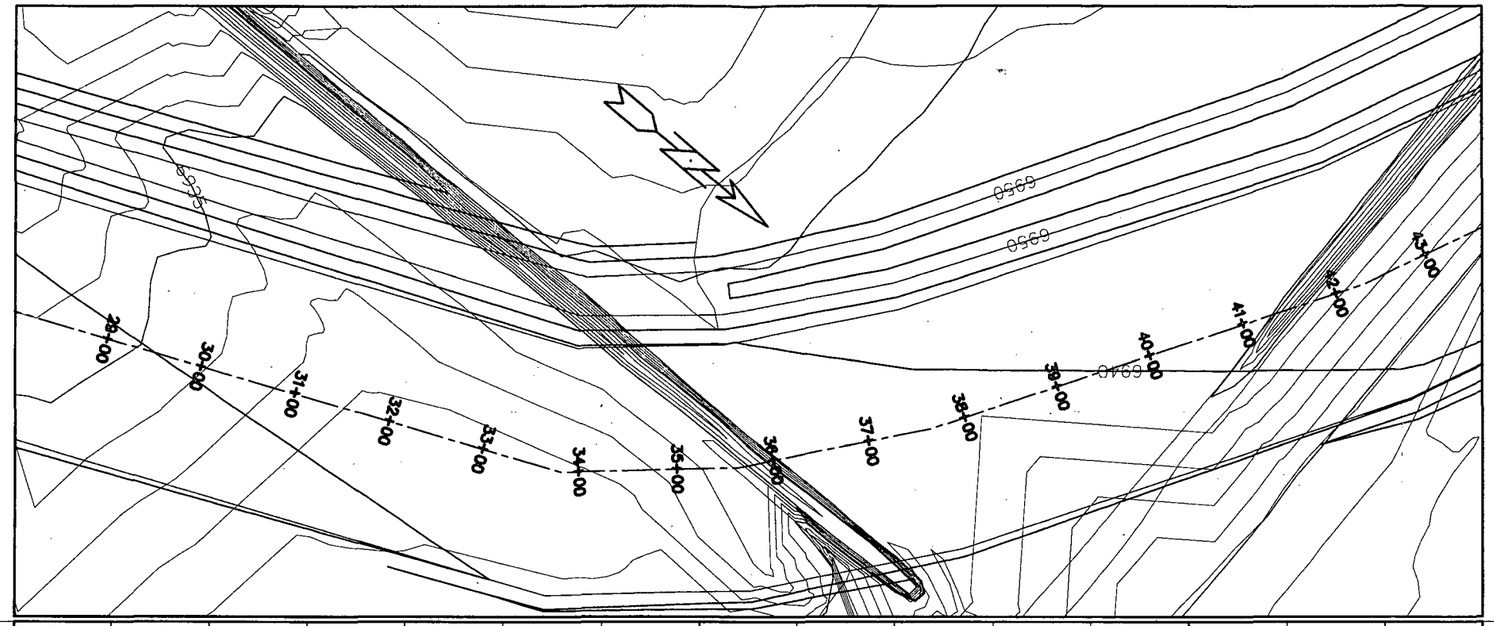
DIVERSION CHANNEL PROFILE 3 of 8

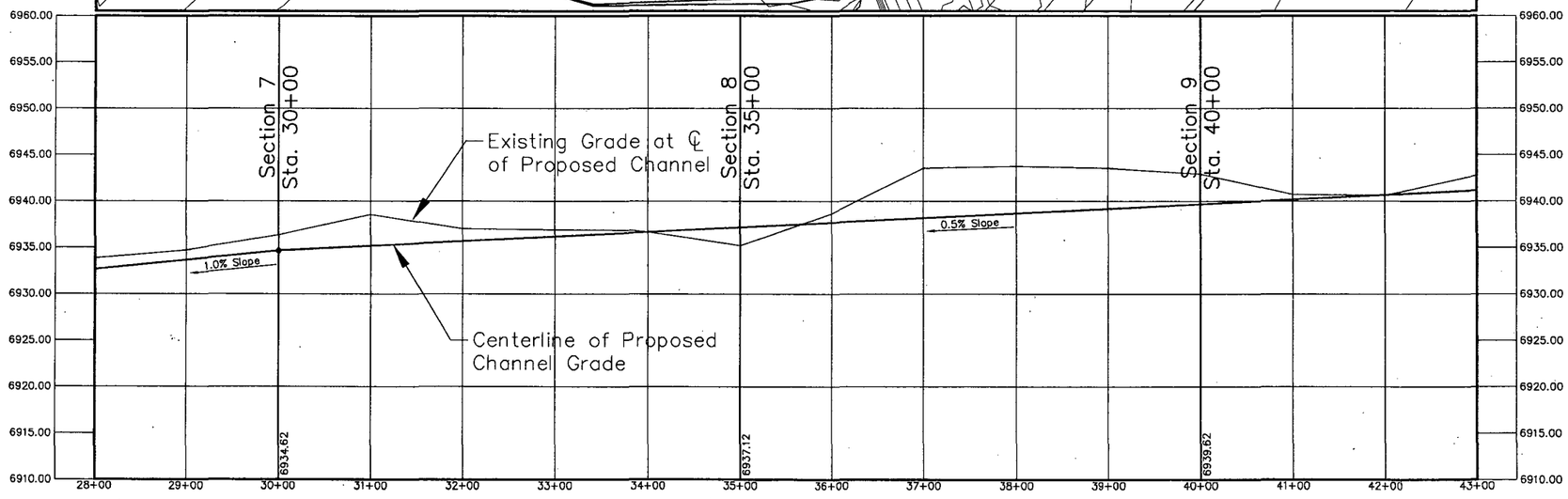
ARROYO DEL PUERTO
EROSION PROTECTION MEASURES
AMBROSIA LAKE MILL
RIO ALGOM MINING LLC
GRANTS, NEW MEXICO

TETRA TECH

PROJECT No. 5690067	DRAWING BY: EJS 10/03/07
FILE NAME:Diversion Channel Profile Sheet_2	REVIEWED BY: MEB

SHEET 18





CONSTRUCTION NOTES:

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2) Adjustments to the channel alignment and grade will be necessary to fit actual topography.

HORIZONTAL SCALE 0 25' 50' 100' 200'
1" = 50'-0"

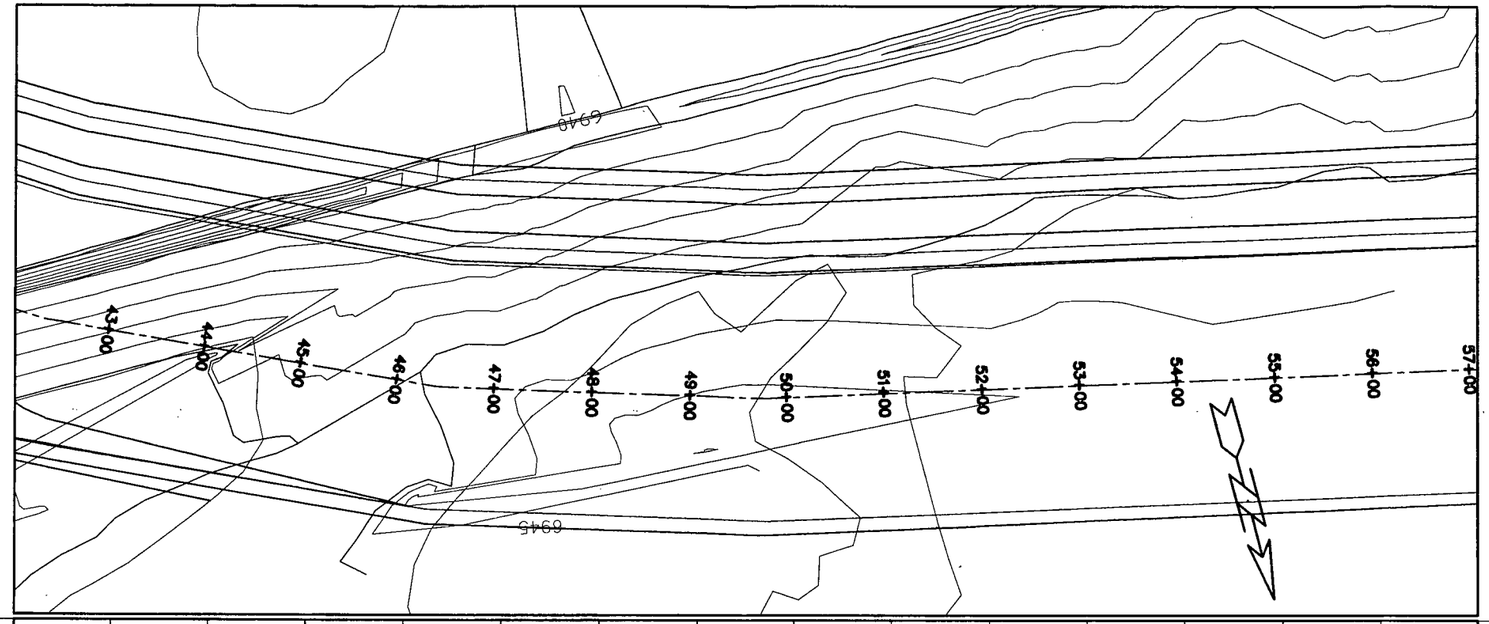
VERTICAL SCALE 0 2.5' 5' 10' 20'
1" = 5'-0"

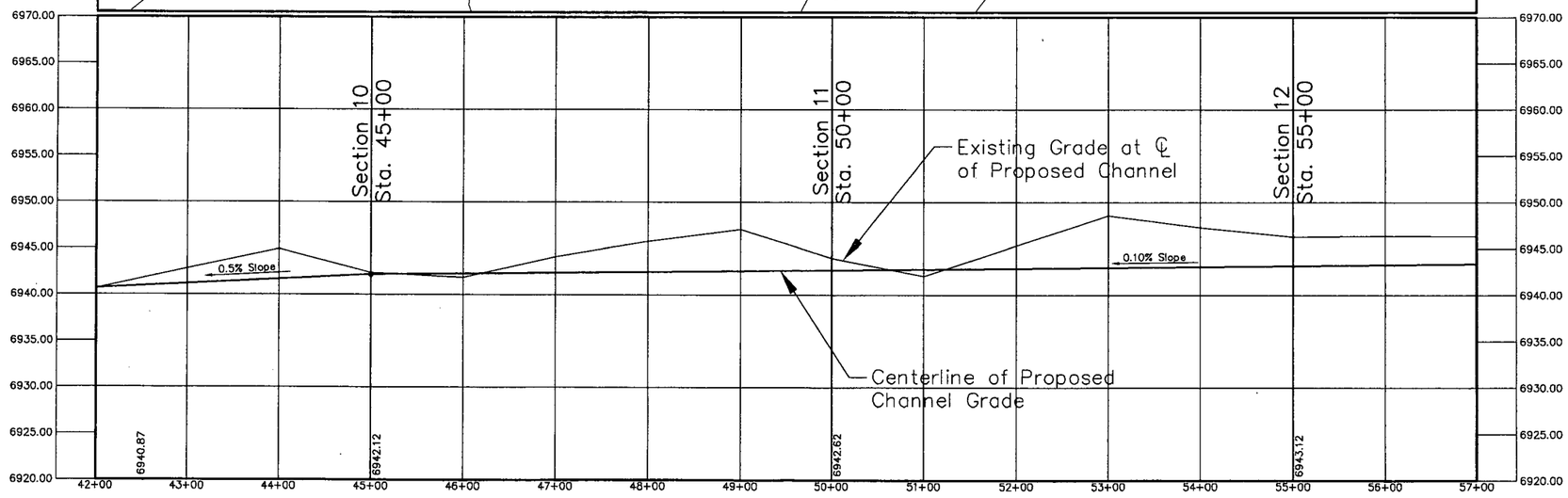
DIVERSION CHANNEL PROFILE 4 of 8
ARROYO DEL PUERTO
EROSION PROTECTION MEASURES
AMBROSIA LAKE MILL
RIO ALGOM MINING LLC
GRANTS, NEW MEXICO

TETRA TECH

PROJECT No. 5690067
DRAWING BY: EJS 10/03/07
FILE NAME:Diversion Channel Profile Sheet_3
REVIEWED BY: MEB

SHEET 19





CONSTRUCTION NOTES:

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2) Adjustments to the channel alignment and grade will be necessary to fit actual topography.

HORIZONTAL SCALE 0 25' 50' 100' 200'
1" = 50'-0"

VERTICAL SCALE 0 2.5' 5' 10' 20'
1" = 5'-0"

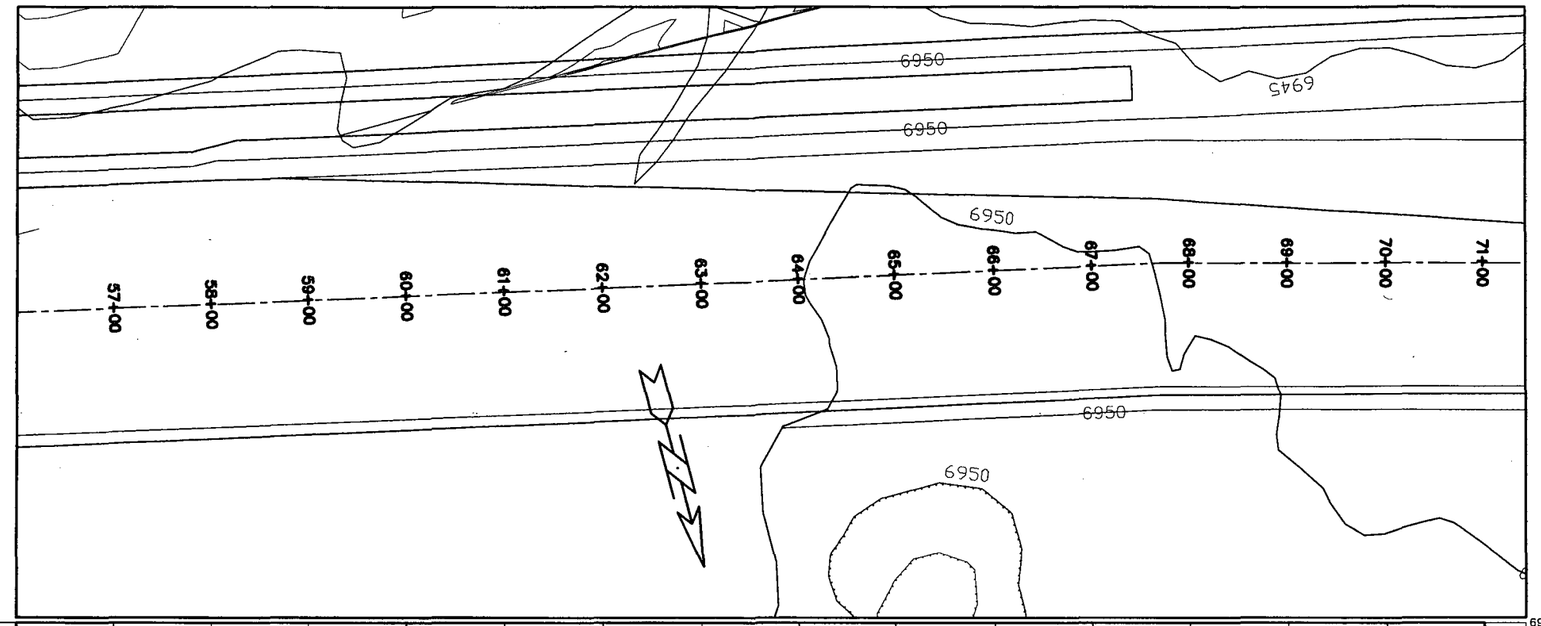
DIVERSION CHANNEL PROFILE 5 of 8

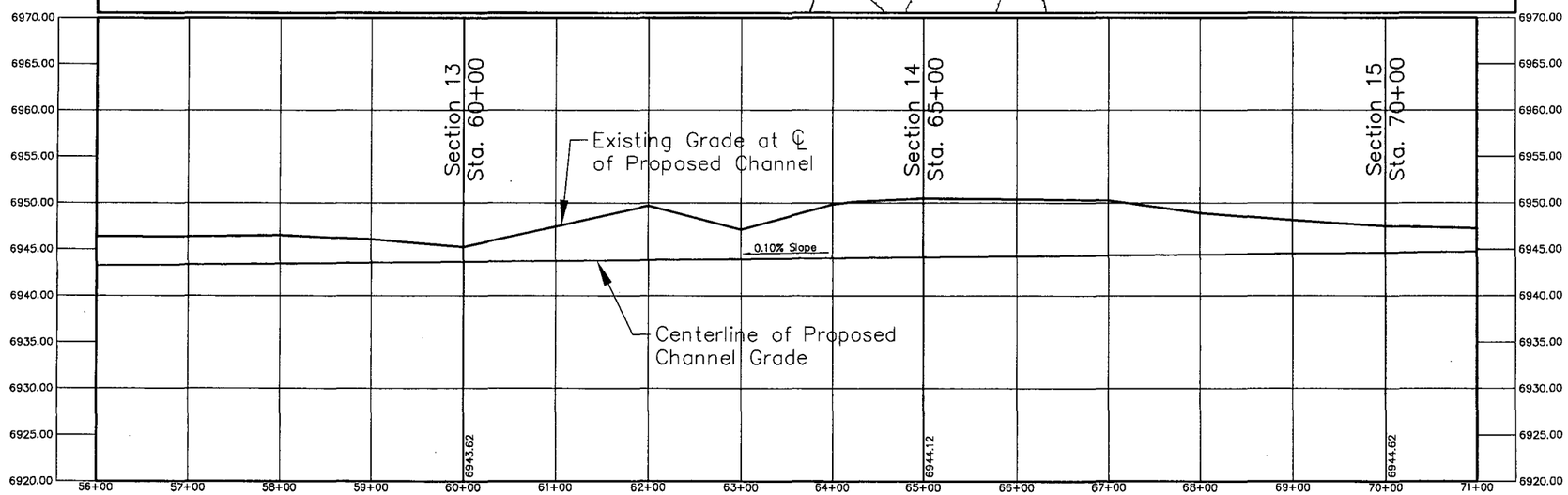
ARROYO DEL PUERTO
EROSION PROTECTION MEASURES
AMBROSIA LAKE MILL
RIO ALGOM MINING LLC
GRANTS, NEW MEXICO

TETRA TECH

PROJECT No. 5690067	DRAWING BY: EJS 10/03/07
FILE NAME:Diversion Channel Profile Sheet_4	REVIEWED BY: MEB

SHEET 20





CONSTRUCTION NOTES:

1) Location of channel alignment and grade based on June 2006 Aerial Survey provided by Rio Algom Mining, LLC, and performed by New Mexico Aerial Surveys, Inc. of Albuquerque, NM.

2) Adjustments to the channel alignment and grade will be necessary to fit actual topography.

HORIZONTAL SCALE 0 25' 50' 100' 200'
1" = 50'-0"

VERTICAL SCALE 0 2.5' 5' 10' 20'
1" = 5'-0"

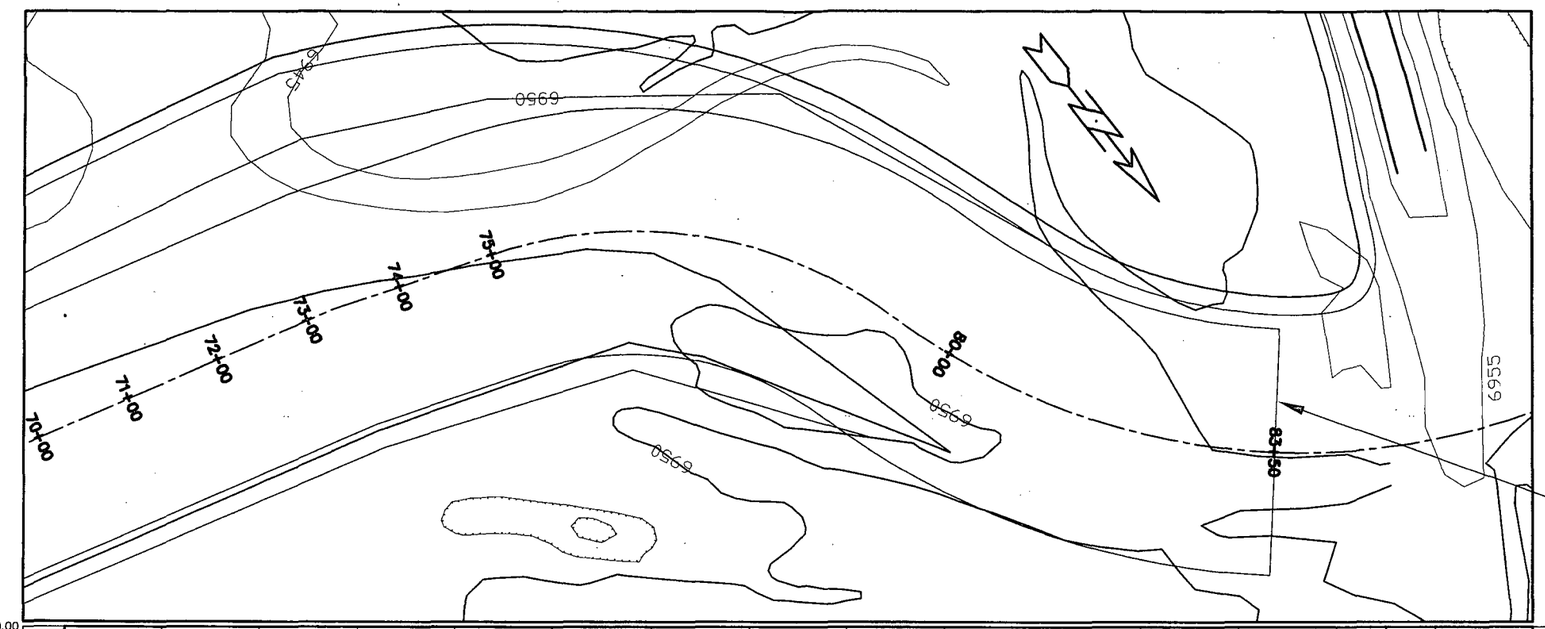
DIVERSION CHANNEL PROFILE 6 of 8

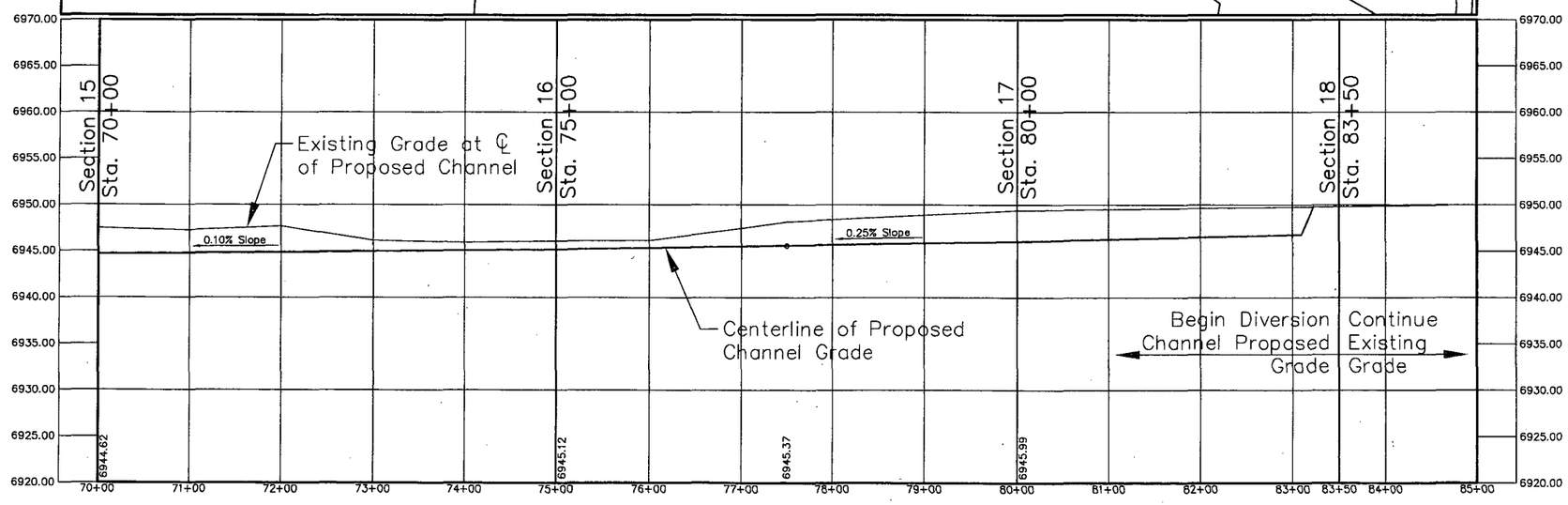
ARROYO DEL PUERTO
EROSION PROTECTION MEASURES
AMBROSIA LAKE MILL
RIO ALGOM MINING LLC
GRANTS, NEW MEXICO

TETRA TECH

PROJECT No. 5690067	DRAWING BY: EJS 10/03/07
FILE NAME:Diversion Chonnel Profile Sheet_5	REVIEWED BY: MEB

SHEET 21





CONSTRUCTION NOTES:

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2) Adjustments to the channel alignment and grade will be necessary to fit actual topography.

HORIZONTAL SCALE 0 25' 50' 100' 200'
1" = 50'-0"

VERTICAL SCALE 0 2.5' 5' 10' 20'
1" = 5'-0"

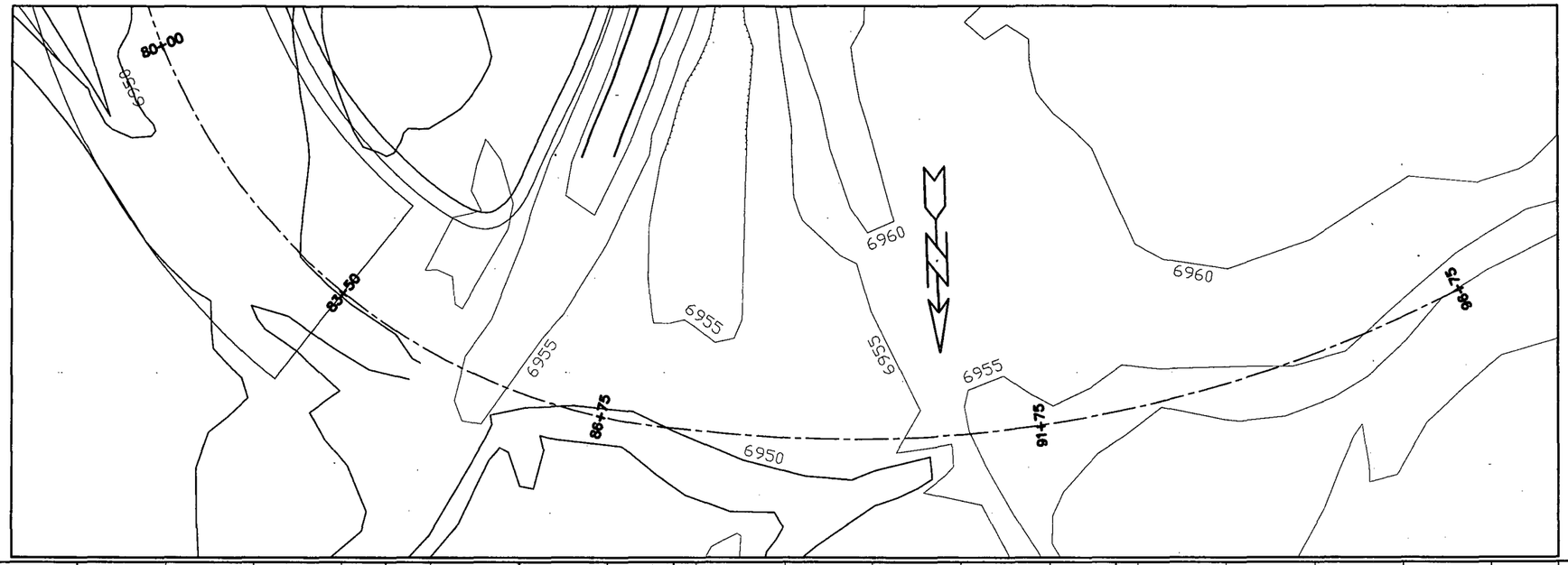
DIVERSION CHANNEL PROFILE 7 of 8

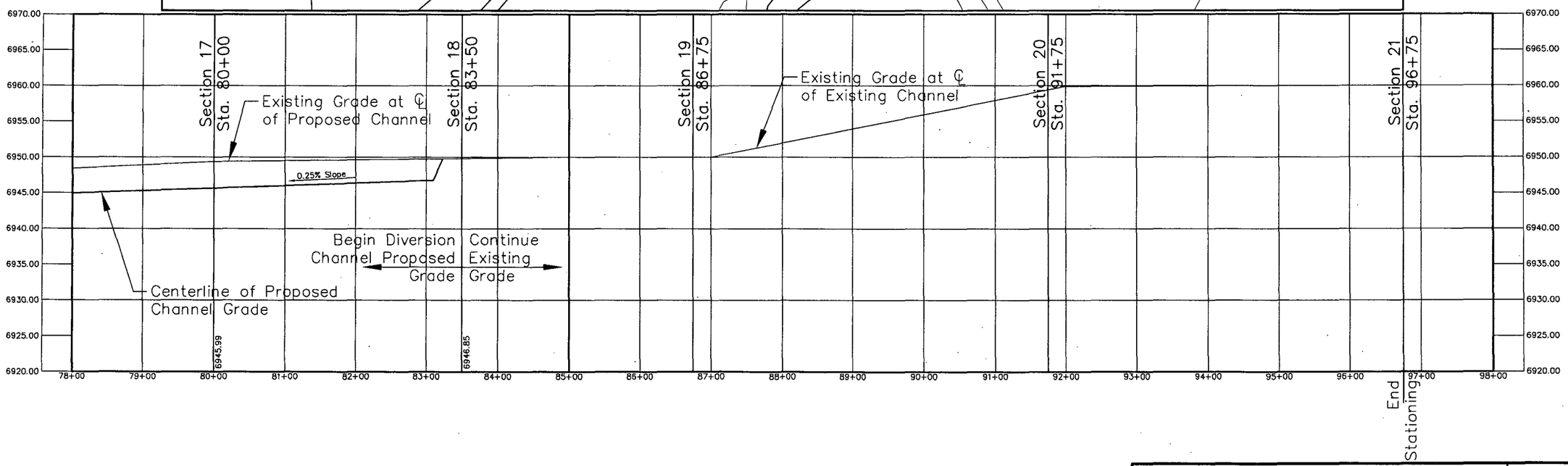
ARROYO DEL PUERTO
EROSION PROTECTION MEASURES
AMBROSIA LAKE MILL
RIO ALGOM MINING LLC
GRANTS, NEW MEXICO

TETRA TECH

PROJECT No. 5690067	DRAWING BY: EJS 10/03/07
FILE NAME:Diversion Channel Profile Sheet_6	REVIEWED BY: MEB

SHEET 22





CONSTRUCTION NOTES:

1) Location of channel alignment and grade based on June 2006 Aerial Survey provided by Rio Algom Mining, LLC, and performed by New Mexico Aerial Surveys, Inc. of Albuquerque, NM.

2) Adjustments to the channel alignment and grade will be necessary to fit actual topography.

HORIZONTAL SCALE 0 25' 50' 100' 200'
1" = 50'-0"

VERTICAL SCALE 0 2.5' 5' 10' 20'
1" = 5'-0"

DIVERSION CHANNEL PROFILE 8 of 8

ARROYO DEL PUERTO
EROSION PROTECTION MEASURES
AMBROSIA LAKE MILL
RIO ALGOM MINING LLC
GRANTS, NEW MEXICO

TETRA TECH

PROJECT No. 5690067

DRAWING BY: EJS 10/03/07

FILE NAME:Diversion Channel Profile Sheet_7

REVIEWED BY: MEB

SHEET 23