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May 16, 2002

CERTIFIED MAIL 7000 1670 0013 4034 8097
Return Receipt Requested

ATTN: Document Control Desk
Dan Gillen, Chief
Fuel Cycles Facilities Branch, NMSS
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Subject: Design Report for Pond 1 North Embankment Erosion Protection, Pond 3 Erosion Protection, and Erosion Protection for the Area North of Pond 1
Ambrosia Lake Facility
License No.: SUA-1473 Docket No.: 40-8905

Dear Mr. Gillen:

On May 9, 2001, Ted Johnson, NRC and Art Kleinrath, DOE visited the Ambrosia Lake Facility as a follow-up to an earlier inspection where the inspector observed rilling of the soil along the southern toe trench of Pond #1. During the follow-up visit, several issues were discussed including excessive rilling along the northern Pond #1 toe trench and the potential for head-cutting from the run-off along the drainage north of Pond #1. As a result of these discussions, Rio Algom retained a consultant, Maxim Technologies, to review these items and to prepare a design for the erosion protection facility for Pond #3 as required by License Condition 53E.

The attached report provides the design of the head-cutting control and toe protection facilities to be constructed along the northern edge of Pond #1. Rio Algom believes that these designs are not part of the requirements of License Condition 53, but are a proactive approach to address potential long-term maintenance issues resulting from erosional characteristics that were not anticipated in the original, approved designs. The report also includes the design of the erosion protection facilities for Pond #3 as required by License Condition 53E.

If you have any questions, pleas call me at (405) 858-4807.

Sincerely,

William Paul Goranson, P.E.
Manager, Radiation Safety, Regulatory Compliance and Licensing

Enclosures
CC: Jill Caverly, NRC

NMSS01 Public

DESIGN REPORT
POND 1 NORTH EMBANKMENT EROSION PROTECTION
POND 3 EROSION PROTECTION
AND
EROSION PROTECTION FOR THE AREA NORTH OF POND 1
AMBROSIA LAKE MILL, NEW MEXICO

DESIGN REPORT
POND 1 NORTH EMBANKMENT TOE EROSION PROTECTION
AMBROSIA LAKE MILL, NEW MEXICO

Prepared for:

Rio Algom Mining Company, LLC
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Grants, New Mexico 87020

Prepared by:

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10601 Lomas NE, Suite 106
Albuquerque, New Mexico 87112

WILLIAM H. BUCHER
NEW MEXICO
15469
REGISTERED PROFESSIONAL ENGINEER

April 23, 2002

March 11, 2002

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INTRODUCTION

This design report was prepared by Maxim Technologies, Inc. (Maxim) for Rio Algom Mining Company, LLC. (Rio Algom) as part of their agreement for engineering services dated July 2001. Maxim has been retained to evaluate flood and long-term erosion conditions at the Ambrosia Lake Facility near Grants, New Mexico and to prepare designs for the long-term stability of tailings and evaporation ponds at this uranium mill tailings disposal site. This report provides the basis for the design required by the second of four tasks included in the agreement. Task Two addresses erosion concerns at the toe of the north embankment of Pond 1, a reclaimed tailings pond, and consists of designing a channel/run-off apron for the north embankment of Pond 1. Figure 1 is a schematic representation of the area of concern in the current study.

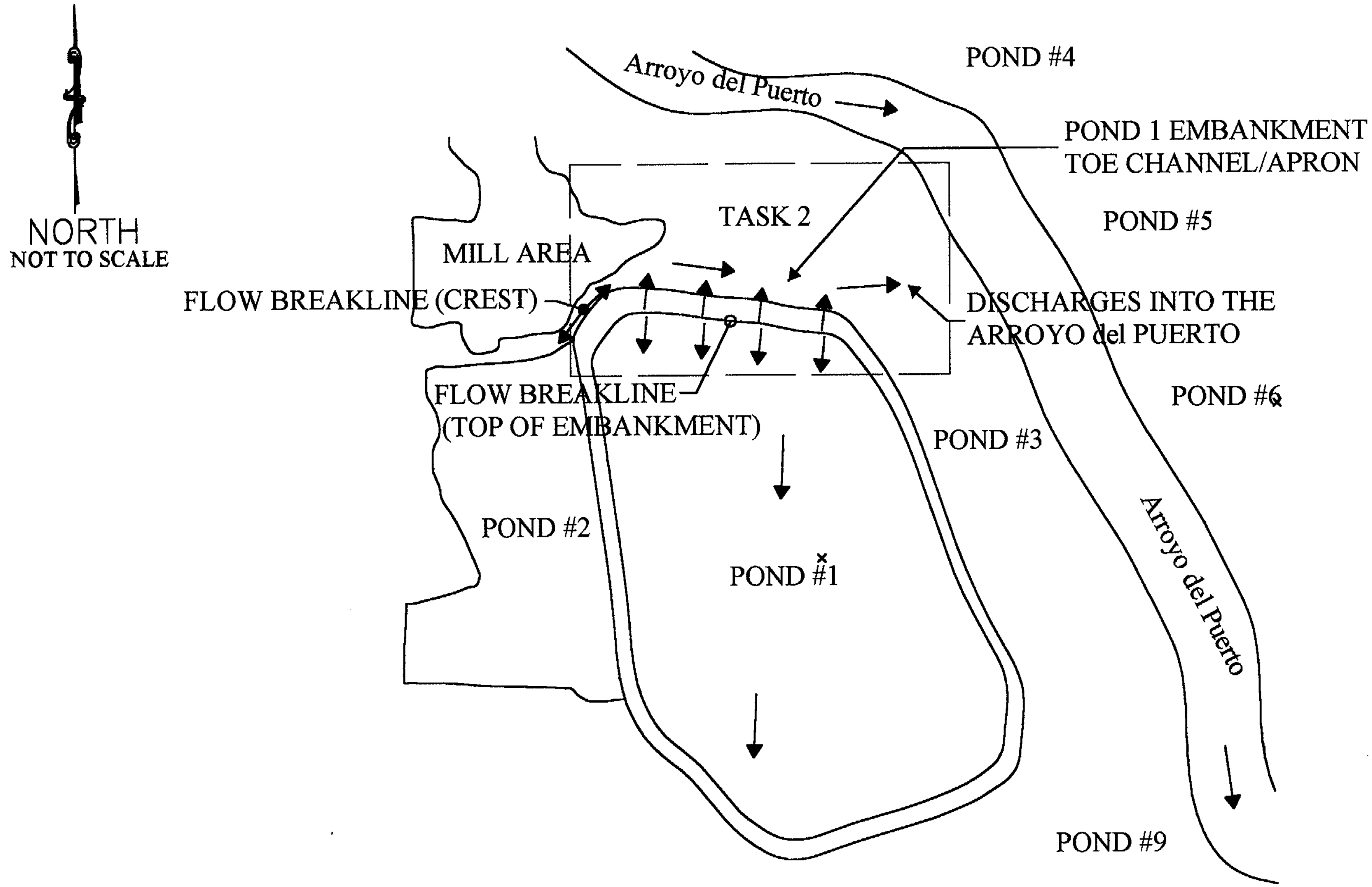
Pond 1 is a reclaimed tailings disposal site and was used for burial of byproducts produced at the mill. The embankment of Pond 1 is constructed with a radon barrier and overlying rock cover serving as erosion protection. The following report provides a design to prevent erosion of the embankment toe from run-off from the north embankment slope. For purposes of this design effort, it has been assumed that the erosion protection channel/apron shall only handle precipitation that falls on the north embankment slope or within the channel/apron limits. Local topographic information supplied by Rio Algom indicates precipitation that falls on the Pond top surface will run-off to the south and drain into the south diversion channel and then into the Arroyo del Puerto, which is down stream of the north embankment of Pond 1 and our proposed erosion protection system. The area north of the proposed erosion protection system drains to the north and away from the site on moderate to steep slopes. Therefore, no other flows are anticipated to enter the channel/apron. The proposed erosion protection system for the north embankment toe of Pond 1 is a combination of an apron designed to withstand the hydraulic jump of the flow running of the steeper embankment slope and onto the flat toe surface and a channel design that will withstand that longitudinal flow that is anticipated to run adjacent to the embankment toe. The greatest design requirements for developing apron protection and channel protection were used to develop the design configurations that follow.

The analysis conducted for this design is consistent with Nuclear Regulatory Commission (NRC) guidance, particularly, *Design of Erosion Protection for Long-Term Stabilization* (Johnson 1999). 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 future maintenance issues. Because flood events with a 1,000 year recurrence interval are difficult to quantify, the guidance recommends use of the probable maximum precipitation event (PMP) 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, Probable Maximum Precipitation Estimates – United States between the Continental Divide and the 103rd Meridian* (Hansen *et al.* 1988). Appropriate PMPs are used to develop runoff hydrographs and determine the probable maximum flood (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.

This design report is limited to those items affecting design of the north embankment of Pond 1 erosion protection, namely, the run-off issues mentioned previously. Methods of analysis are described for design issues including derivation of the PMP and calculation of the appropriate PMFs. The calculation of the riprap sizing is then described, and the report concludes with a discussion of other issues that affect the design.

1.0 PMP CALCULATION

Maxim verified the PMP calculation performed by others following the methods outlined in *Hydrometeorological Report No. 55A* (Hansen *et al.* 1988). The PMP rainfall depth calculated previously for the 1-hour local storm was 9.6 inches with no areal reduction. Maxim's calculation of the PMP depth



Legend:
→ Local Flow Direction

AMBROSIA LAKE MILL RIO ALGOM MINING COMPANY, LLC. GRANTS, NEW MEXICO		MAXIM TECHNOLOGIES INC
Location of Channel Catchment	DRAWING BY: RLH 3/5/02	
PROJECT No. 1690030-200 FILE NAME: 1690030T2F1.DWG	REVIEWED BY: WHB	FIGURE 1

arrived at a 9.5 inch value for the 1-hour, 1-square mile local storm, slightly less than the previously calculated value of 9.6 inches. Because the values are so similar, we used the slightly higher, previously determined values in our calculations. Calculation sheets are attached in Appendix A.

2.0 DESIGN BASIS

A run-off erosion protection channel/apron is needed along the north toe of the Pond 1 embankment to prevent scour from undercutting the tailings rock cover during extreme run-off events. Another erosion concern at the toe of the embankment is the potential for longitudinal flow along the toe due to moderate slopes adjacent to the toe. Therefore, the general approach for this analysis consisted of two tasks with the greater design requirements controlling the final design configurations.

1) Determining the apron requirements based on run-off analysis for the north embankment of Pond 1 in accordance with NUREG-1623, Appendix D, Section 6; and

2) Determining open channel requirements to control the run-off and longitudinal flow from the north embankment by an open channel in accordance with NUREG-1623, Appendix D, Section 2 and 3.

Each of these analyses is described separately in this section of the report.

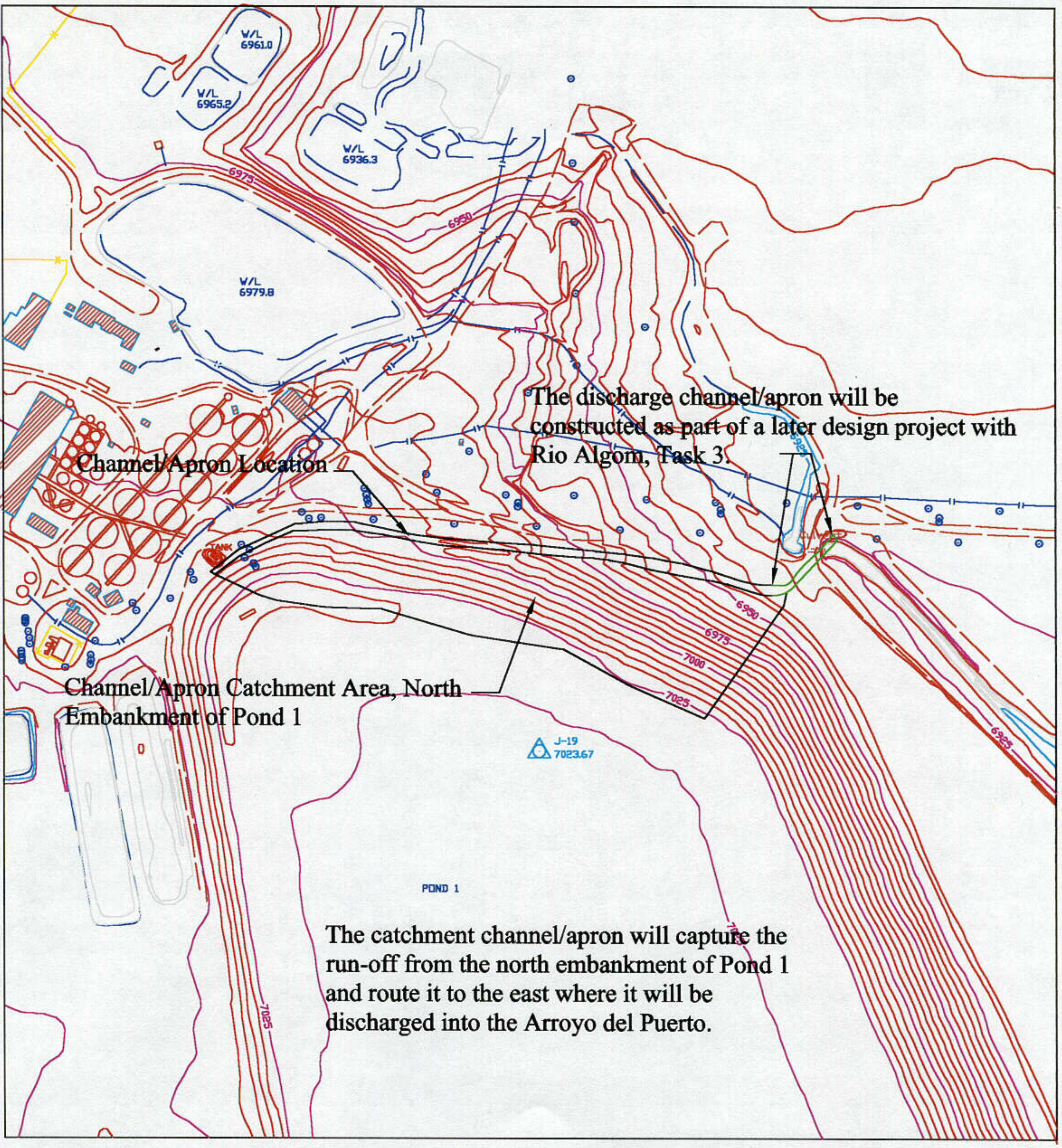
The development of this design is based on the 1 hr. local PMP depth for Pond 1 of 9.6 inches. The 13.4-acre catchment area includes essentially impervious covered tailings. In these calculations it is assumed that the entire catchment area is capped with a rock cover and is impervious. This catchment drains to the north, down the 5H:1V embankment slopes and exits in an existing internal apron that is constructed along the entire Pond 1 embankment toe. Visual observations during site visits have indicated that minor erosion has occurred outside the internal apron on the adjacent unprotected natural soils; therefore, redesign and replacement of the existing apron is necessary. Replacement of the existing apron will be required in order to install the new channel/apron. The proposed design is an external channel/apron that will replace the current internal apron. The catchment area is shown on Figure 2.

2.1 EROSION PROTECTION APRON FLOW

For the 13.4-acre catchment, a time of concentration was calculated for two slope lengths; a mid length slope and a long slope, to evaluate using two rock sizes in the erosion protection apron design. The two slope lengths are 350 ft in length and 575 ft in length, producing time of concentrations of 1.5 minutes and 2.6 minutes, respectively. Both time of concentrations are at or near the smallest incremental rain duration provided by Nelson et all (1986) for developing a PMF depth. Therefore the shortest increment rainfall duration of 2.5 minutes was used for both slope lengths in developing the 2.5 minute PMP depth. The 2.5 minute PMP depth for a local storm of 9.6 inches is 2.64 inches. Using a runoff coefficient of 1.0, the Rational Method gives a unit peak flow of 0.5 cfs/ft and 0.819 cfs/ft. for this catchment with respect to the two slope lengths of 350 and 575 ft. Using a maximum embankment slope of 20 percent and a flow concentration factor of 2.5, the method of Abt *et al.* (1998) predicts a rock d_{50} of 6.0 inches for the slopes shorter than 350 ft and 7.8 inches for slopes between 350 ft and 575 ft. Calculations are found in Appendix B.

2.2 EROSION PROTECTION CHANNEL FLOW

Due to the moderate longitudinal slopes at the toe of the north embankment of Pond 2, a second design approach was evaluated for providing erosion protection at the toe of the north embankment of Pond 1. The moderate slopes may possibly induce longitudinal flows along the embankment toe, which may cause instability of the embankment by erosion. This approach places an open channel/apron at the base of the slope that will catch the precipitation that falls on the embankment slope and runs off. The



NORTH
1 in. = 500 ft

AMBROSIA LAKE MILL
RIO ALGOM MINING COMPANY, LLC.
GRANTS, NEW MEXICO
RUNOFF CHANNEL/APRON, POND 1

Location of Catchment Areas

DRAWING BY: RLH 3/5/02

PROJECT No. 1690030-200
FILE NAME: 1690030T2F2.DWG

REVIEWED BY: WHB

C01

MAXIM TECHNOLOGIES INC

FIGURE 2

open channel/apron approach takes into consideration NUREG-1623 erosion control apron parameters as well as NUREG-1623 channel parameters and the Army Corp of Engineers, *Hydraulic Design of Flood Control Channels,* design methods (ACE 1995). Per a phone discussion with Mr. Ted Johnson of the Nuclear Regulatory Commission (NRC), the parameters provided within the NUREG-1623 shall be adequate for design of open channels, using Sections 2 and 3 of Appendix D, the Abt and Johnson Method.

For development of the erosion protection channel/apron, the 13.4-acre north embankment was subdivided into two sections, the first being a 5.1-acre section comprising the upper (upstream) half of the north embankment length. The 5.1-acre section was segregated from the 13.4-acre section because of its upstream location and the flatter longitudinal slopes existing at the base of the embankment slope. By dividing the erosion protection channel/apron into two sections a smaller, more cost effective design was provided for the upper section.

The second subdivision is the remaining 8.3-acres which is the lower (downstream) half of the embankment length. Greater longitudinal slopes exist in this section; slopes as steep as 7.7% are indicated by the topographical information provided by Rio Algom. Design flow included the total flow exiting the upper section as well as that which is added to the erosion protection channel/apron by precipitation that falls on the lower embankment section and runs into the channel/apron.

For design of the upper section, the time of concentration was developed using the maximum flow length for this area, 1,195 ft., starting at elevation 7,026 ft. and ending just above the increasing slope grades at the embankment toe midpoint, at elevation 6,990 ft. For this flow length, the time of concentration was calculated to be 7.0 minutes. From Nelson et all (1986), a 7.0 minute PMP depth for a local storm of 9.6 inches is 5.09 inches. The Rational Method gives a peak flow of 221 cfs for the upper section. Calculations are found in Appendix C.

For the design of the lower section, the time of concentration was developed using the maximum flow length for this area, 2,100 ft., starting at 7,026 ft. elevation (same start location used in upper section calculations) and ending at the intersection of the toe north toe of Pond 1 and the north corner of Pond 3, elevation 6,935 ft. The time of concentration takes into consideration the flow length of the upper section as well as the lower section. Calculations with these parameters indicated a time of concentration for design of the lower section of 9.5 minutes. Using the Nelson et. all (1986) and a 10 minute time of concentration value, the 10 minute PMP depth for a local storm of 9.6 inches is 5.95 inches. The Rational Method give a peak flow of 480 cfs for the entire system, which was used in determining the lower section erosion protection channel/apron configuration.

2.3 CHANNEL CONFIGURATION

The channel/apron configurations were developed using the results of the flow calculations noted above in conjunction with NUREG-1623 Sections 2 and 3 and Flow Pro 2.0, a hydraulic design software for steady-state open channel flow. The software was used to develop a flow depth in the proposed channel/apron sections. All other channel/apron dimensions were developed using recommendations from the NUREG-1623 and relations established by Abt et al. (1998). The more protective of the requirements for developing a channel configuration between channel design and apron design was chosen for each part of the channel/apron development. Manning's roughness value was developed using equation D-8 of Section 3 in the NUREG-1623. The roughness value was then entered into the Flow Pro 2.0 modeling software with an estimated channel width greater than or equal to the D_{50} of the calculated apron rock size times 15 (the requirement for apron width from Section 6 of the NUREG), and the calculated flows noted above for the appropriate channel/apron section. For the upper section a D_{50} = 6.0 inches was used and for the lower section a D_{50}=7.8 inches was used for calculating the minimum channel/apron width. The Flow Pro modeling software outputs the depth of flow in the channel with the above noted input parameters.

Using the outputs of the Flow Pro modeling software and the requirements for apron and channel construction outlined in the NUREG 1623 report; two erosion control channel/apron sections were developed.

In an effort to reduce the number of rock gradations used to complete several design tasks for erosion control at the mill site, the channel configurations were adjusted appropriately to fit a common rock size of other design tasks. A rock of D_{50}=9.2 inches was previously selected for use in an erosion control design at the mill site, the same rock size has been selected for use in this erosion control project. Calculations for developing the channel/apron are shown in Appendix D. Typical channel/apron configurations and location are shown on drawing Sheets 3 and 4 with the transition between the two sections detailed on Sheet 5 of Appendix E.

3.0 OTHER DESIGN/CONSTRUCTION CONSIDERATIONS

As part of this erosion protection design, the existing erosion control apron must be removed and the subgrade properly re-graded such that run-off from the embankment flows into the proposed channel/apron. It is recommended that the entire existing apron be removed as part of the proposed construction and replaced with this proposed channel/apron.

The outflow section for this proposed channel/apron is to be designed as part of a later design task at the mill site. The design is not provide within this report due to the continued construction at the Pond 3 disposal pond at the mill site. Existing elevations are anticipated to change and alterations of the discharge slopes and elevations would be expected if a discharge apron was developed at this time.

4.0 REFERENCES

Abt, S. R., T. L. Johnson, C. I. Thornton, and S. C. Trabant, 1998. *Riprap Sizing at Toe of Embankment Slopes.* Journal of Hydraulic Engineering, v. 124, No. 7.

American Society of Civil Engineers (ASCE), 1995. *Hydraulic Design of Flood Control Channels.* U. S. Army Corps of Engineers engineer manual EM 1110-2-1601.

Hansen, E. M., D. D. Fenn, L. C. Schreiner, R. W. Stodt, and J. F. Miller, 1988. *Hydrometeorological Report No. 55A, Probable Maximum Precipitation Estimates – United States between the Continental Divide and the 103rd Meridian.* U. S. Department of Commerce, Silver Spring, Maryland.

Johnson, T. L., 1998. *Design of Erosion Protection for Long-Term Stabilization.* Draft Report for Comment, NUREG-1623. U. S. Nuclear Regulatory Commission, Washington, D.C.

Nelson, J. D., S. R. Abt, R. L. Volpe, D. van Zyl, N. E. Hinkle, W. R. Staub, 1986. *Methodologies for Evaluating Long-Term Stabilization Designs for Uranium Mill Tailings Impoundments.* NUREG/CR-4620, U. S. Nuclear Regulatory Commission, Washington, D.C.

APPENDIX A

PMP/Local Storm Calculation

MAXIM
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JOB NO. 1690030-200 **JOB TITLE** Quivira **DATE** 10/10/01 **BY** BD/RH (revised)

SUBJECT PMP Calculation - Local Storm **CHECKED** ______ **SHEET** 1 **OF** 1

Reference: Hydrometeorological Report No. 55A
US. Department of Commerce
NOAA, June 1988, Section 14.3

Stepwise Procedure, Local Storm PMP.

Index 1-hr 1-mi² PMP estimate at 5,000 ft elev

∴ From Plate IIIC, 1-hr 1-mi² @ 5,000 ft

1.) 1-hr - 1mi² PMP @ 5,000 ft el. = 10.5 ins.

2.) Adjustment For Mean Elevation of Site

Mean El. Use 7,000 ft Site Elev.

Maximum 12-hr Persisting 1000 MB DP @ 76.6 °F From Figure 4.11

From 14.3 Elevation Adjustment = 0.90

3.) Index 1hr - 1mi² PMP Estimate @ Mean El.

0.90 x 10.5 in = **9.5 in** 1hr-1mi²

4.) From Table 12.4, 6 hr storm is:

1.35 x 1hr. = **12.83 in**

5.) Areal Reduction Factors: Depend On Basin Location

— Summary: 1hr - 1mi² PMP = 9.5" ≈ **9.6"**

Previous Work at The Site Indicated The PMP = 9.6". Because Values we obtained compare to previously calculated values during past design work at Quivira by others, we will use the slighty higher value of 9.6" In our design calcs.

APPENDIX B

CALCULATIONS FOR POND 1 PROTECTION APRON

MAXIM
TECHNOLOGIES INC

JOB NO. 1690030-200 **JOB TITLE** Quivira **DATE** 9/21/01 **BY** RLH

SUBECT Run off Pond 1-Task 2 **CHECKED** ________ **SHEET** 1 **OF** 1

Apron Calculation Method

Use Method in NUREG/CR-1623 Appendix D. Section 6.

1 Slope Length 350' (From Fly Over Topo Graphic Map)

→ Length of section Mid Point of Apron.

2 Maximum Slope 0.20 (20%) (From Fly Over - Quivira)

3 Elevation Difference = 6972' to 7026' = $Del_{350} = 54.0'$

$Del_{575} = 91.0'$

$$t_c = \left(11.9\ L^3/H\right)^{0.385}$$

H = Feet
t_c = hours
L = miles

$$= \left(11.9\left(\frac{350}{5280}\right)^3 / 54.0\right)^{0.385}$$

$$t_c = \left(11.9\,(5.16 \times 10^{-6})\right)^{0.385} = 0.024\ \text{hrs} = 1.5\ \text{min}\ (350'\ \text{Sl}$$

$= 0.043$ hrs $= 2.6$ min (575' S

4 * Use 2.5 min rainfall From Nelson et al (1986) - Shortest Increment Available

2.5 min PMP = 0.275 × 9.6" = 2.64"

* Use 9.6" PMP For Embankment Slope Local Storm

5 Use Rational Method Equation for Unit Width

Slope L = 575 A_{575} = 1 × 575' = 575 ft² or 0.013 acres

Slope L = 350 A_{350} = 1 × 350' = 350 ft² or 0.008 acres

i = 60 × 2.64/2.5 = 63 in/hr (For Both)

Q = Cia = 1.0 × 63 × 0.008 = 0.504 cfs/ft_{350}

= 0.819 cfs/ft_{575}

C = 1.0 (Rocked Slope)

6 Using Equation D-18 From NUREG/CR1623 App D Rock Size Calcs.

Concentration Factor 2.5

$$D_{50} = 10.46 \cdot S^{0.43}\,(C_f \times q_u)^{0.56}$$

$D_{50_{350}} = 6.0"$ $D_{50_{575}} = 7.8"$

APPENDIX C

CHANNEL FLOW CALCULATIONS

→ Flow Section

Method: Calculate Flow Rate For Toe Channel For North Embankment Toe Pond 1 Using NUREG CR1623

Location: Pond 1 - North Embankment

Entire Length Toe Channel Length Along Toe => 1,900 ft

Toe Channel length Total => 2,100 ft

A

1) PMP = 9.6" (1hr - 1mi²)

Calculate PMF From Rational Method Equation.

Area Draining Into Channel => 13.4 acres.

T_c => 2100 length slope (length of Channel)

$T_c = (11.9 \; L^3/H)^{0.385}$

L = 2100/5280 = 0.398

H = 7026 - 6935 = 91 ft

$T_c = \left(11.9 \dfrac{(0.398 \text{ mi.})^3}{91}\right)^{0.385}$

T_c = 0.158 hrs => 9.5 min ≈ 10 min

Use Available Increment
(Increment From Nelson et al (1986))

10.0 min PMP = 0.62 × 9.6" = 5.95"

Intensity = 60 × 5.95/10 = 35.7 in/hr

2.) Discharge Q = CIA

Area 'A' = 13.4 acres
Intensity 'I' = 35.7 in/hr
C = 1 Complete Run-Off (No Infiltration)

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JOB NO. 1690030-200 **JOB TITLE** Quivira **DATE** 10/9/01 **BY** RLH

SUBJECT Task 2 Channel/Apron **CHECKED** ______ **SHEET** 2 **OF** 2

→ Flow Section Continued

2.) continued

$Q = CiA$

$Q = 1 \times 35.7 \text{ in/hr} \times 13.4 \text{ Acres}$

$Q = 478.4 \text{ cfs}$

3.) Flow For Entire System Is 480 cfs

→ Flow Section - Upper

Method: Calculate Flow Rate For Toe Channel/Apron Using NUREG - CR1623

Location: Pond 1 - North Embankment

Upper Length (Above Steeper Slope, 7.7%)

1.) PMP = 9.6" 1hr - 1mi²

Rational Method

Area Draining Into Upper Channel = 5.1 acres

$T_c \Rightarrow$ 1,195 Ft = 0.226 miles

$T_c = (11.9 \cdot L^3/H)^{0.385}$ $L = 1195/5280$

T_c = 0.11738 hrs = 7.04 min.   H = 7026 - 6990 = 36'

Available Increments From Nelson et al (1986)

- 7 min PMP = 0.53 × 9.6" = 5.09"

i = 60 × 5.09"/7.04 min = 43 in/hr

2.) Discharge (Flow At End of Upper Section)

Q = CiA

Q = 1.0 × 43 in/hr × 5.1 acres = 221 cfs

C = 1.0 "Rock" Surface No Infiltration

3.) Flow For Upstream (Upper) Section Is 221 cfs

APPENDIX D

CALCULATIONS FOR POND 1 CHANNEL PROTECTION
CHANNEL DESIGN CONFIGURATION CALCULATIONS

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JOB NO. 1690030-200 **JOB TITLE** Quivira **DATE** 10/8/01 **BY** RLH

SUBJECT Rock Sizing - Channel **CHECKED** ______ **SHEET** 1 **OF** 1

Task 2 Toe Channel — UPPER 1/2

Method: Johnson and Abt, et al - NUREG CR 1623 Section 3, Appendix D

1.) Channel Parameters - Upper 1/2

- 8' wide Open Channel - Trapezoidal
- 1V: 2H Side Slopes
- 2.2% - Steepest slope: From Quivira Survey
- Length = 1,195 ft For t_c Calculation
- Area = 5.1 Acres
- PMP = 9.6" For 1 hr 1 mi²
  Calculated Using HMRC Report 55A
  US. Dept of Commerce, June 1988
- Flow For 5.1 Acre Area
  (See Flow Section, Part D for calcs)

$Q = 221$ cfs

2.) Using Johnson & Abt et al (1998) Method For Sizing

$D_{50} = 5.23\, q_f^{0.56} * S^{0.43}$

$q_f = Q/\text{width}$ = Unit Flow

$q = 221 \text{ cfs} / 8' \text{ft} = 27.6 \text{ cfs/ft}$

$D_{50} = 5.23\,(27.6 \text{ cfs/ft})^{0.56} * (0.022)^{0.43}$

$D_{50} = 6.5'' >$ Apron Rock Selection (6.0")

∴ Channel Rock Size Controls

$D_{50} = 6.5''$ For Upper 1/2

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JOB NO. 1690030-200 **JOB TITLE** Quivira **DATE** 10/10/01 **BY** RLH

SUBJECT Open Channel - Design **CHECKED** ________ **SHEET** 1 **OF** 2

Redesign To Use 9.2" Rock

Task 2 Toe Channel - Lower 1/2

Method: Johnson and Abet et al NUREG 1623 Section 3 Appendix D

1 Channel Parameters - Lower 1/2

- 20' wide Open Channel - Trapezoidal
- 1V:2H Side Slopes
- Average Slope 6.2% Quivira Survey
- Length = 2,100 ft (All of System)
- Area = 13.4 Acres (All of System
- PMP = 9.6" For 1hr 1mi²

Calculated Using HMRC Report 55A U.S. Dept. of Commerce, June 1988

- Flow For 13.4 Acres Area (see Flow section, Part A)

$Q = 480$ cfs

2 Using Johnson & Abet Method (1998) For Sizing

$D_{50} = 5.23\, q^{0.56} * S^{0.43}$

$q = \frac{Q}{\text{width}} = 480/20 = 24.0$ cfs/ft

$D_{50} = 5.23\,(24.0)^{0.56} * (0.062)^{0.43}$

$D_{50} = 9.3" \rightarrow 9.2"$

$D_{50} = 9.2$ Used In Previous Design Task 1

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TECHNOLOGIES INC

JOB NO. 1690030-200 **JOB TITLE** Quivira **DATE** 10-9-01 **BY** RLH

SUBJECT Channel Rock Thickness **CHECKED** ______ **SHEET** 1 **OF** 1

Layer Thickness

Task 2 - Open Channel

Upper/Lower Section Rock Layer Thickness

- A $D_{50} = 6.5''$ is required for the parameters outlined for the upper section. At the request of Quivira Mining A $D_{50} = 9.2''$ will be substituted for design/construction of this section. The $D_{50} = 9.2''$ rock was chosen by Quivira to reduce the quantity of different rock gradations required to complete construction of erosion control systems at the Quivira Mill Site.

- $D_{50} = 9.2''$

1.) Method & Layer Thickness Per Hydraulic Design of Flood Control Channels, US Army Corp of Engineers No. 10 chapter 3, Section 3.2 of Part E.

Per ACE Thickness $= D_{50} \times 1.5$ For Channel Rock Size

$\therefore 9.2 \times 1.5 = 13.8''$

Per NUREG-CR1623 Thickness $= D_{50} \times 3$ For Apron Rock Sizing

$\therefore 9.2 \times 3 = 28''$

$\therefore$ Apron Rock Layer Thickness Requirement Control as well as improves placement of large rock sizes.

Rock Layer Thickness = 28"

Task 2 Channel Design - Channel Lower 1/2 - Inputs to get channel Depth

1. MANNING OUTPUT

OPEN CHANNEL DESIGN - NUREG CR-1623

ASSUMPTIONS & EQUATIONS

Mannings Value, n ~ 0.0456(D_{50} * S)^0.156

S = Slope

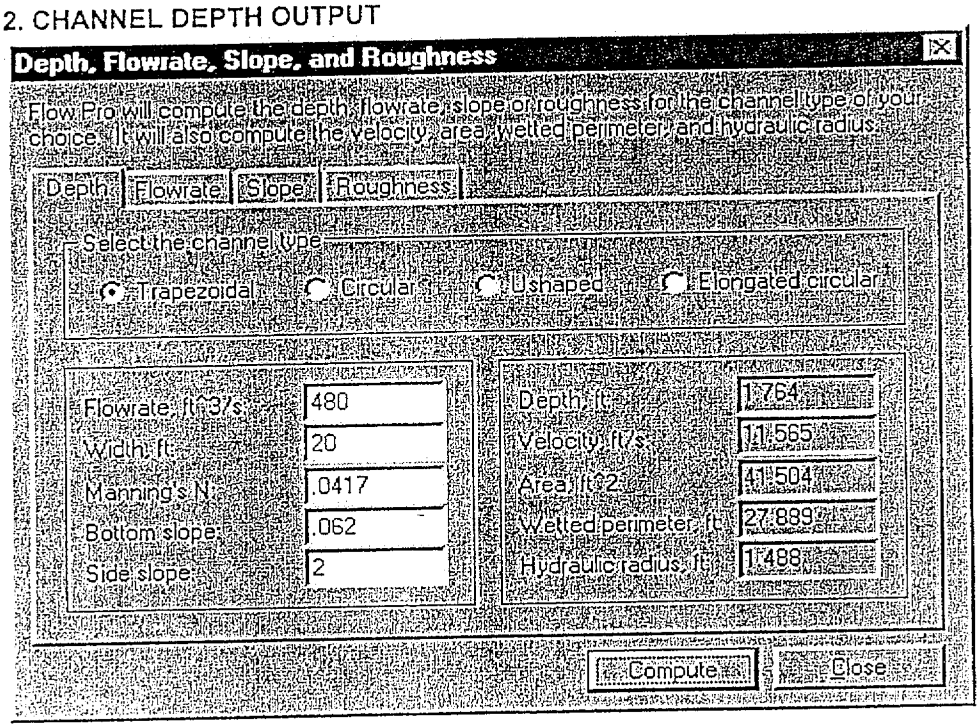
Note: NUREG CR-1623, Section 3, Appendix D

CALCULATION: Using Army Corp. Of Engineers (ACE) Method (ACE, 1991)

Inputs	Value	Units
S	0.062	
D_{50}'	9.2	inches

Output	Value	Units
n	0.0417	

2. CHANNEL DEPTH OUTPUT



Task 2 Channel Design - Channel Upper 1/2 - Inputs to get Channel Depth

1. MANNING OUTPUT

OPEN CHANNEL DESIGN - NUREG CR-1623

ASSUMPTIONS & EQUATIONS

Mannings Value, n ~ 0.0456(D_{50} * S)^0.156

S = Slope

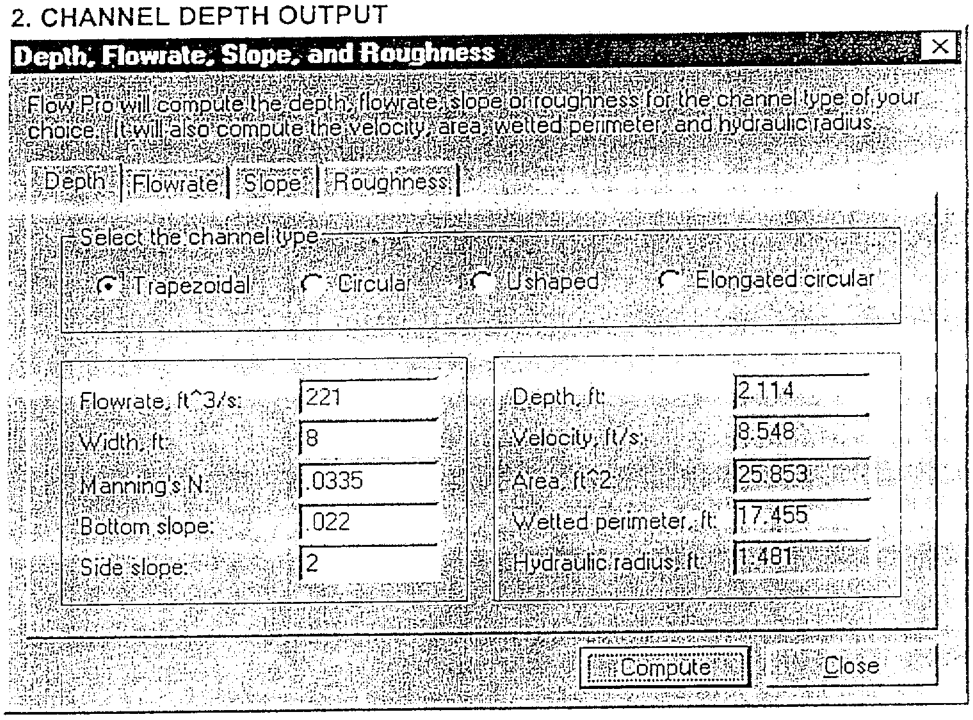
Note: NUREG CR-1623, Section 3, Appendix D

CALCULATION: Using Army Corp. Of Engineers (ACE) Method (ACE, 1991)

Inputs	Value	Units
S	0.022	
D_{50}'	6.5	lbs/cu. ft

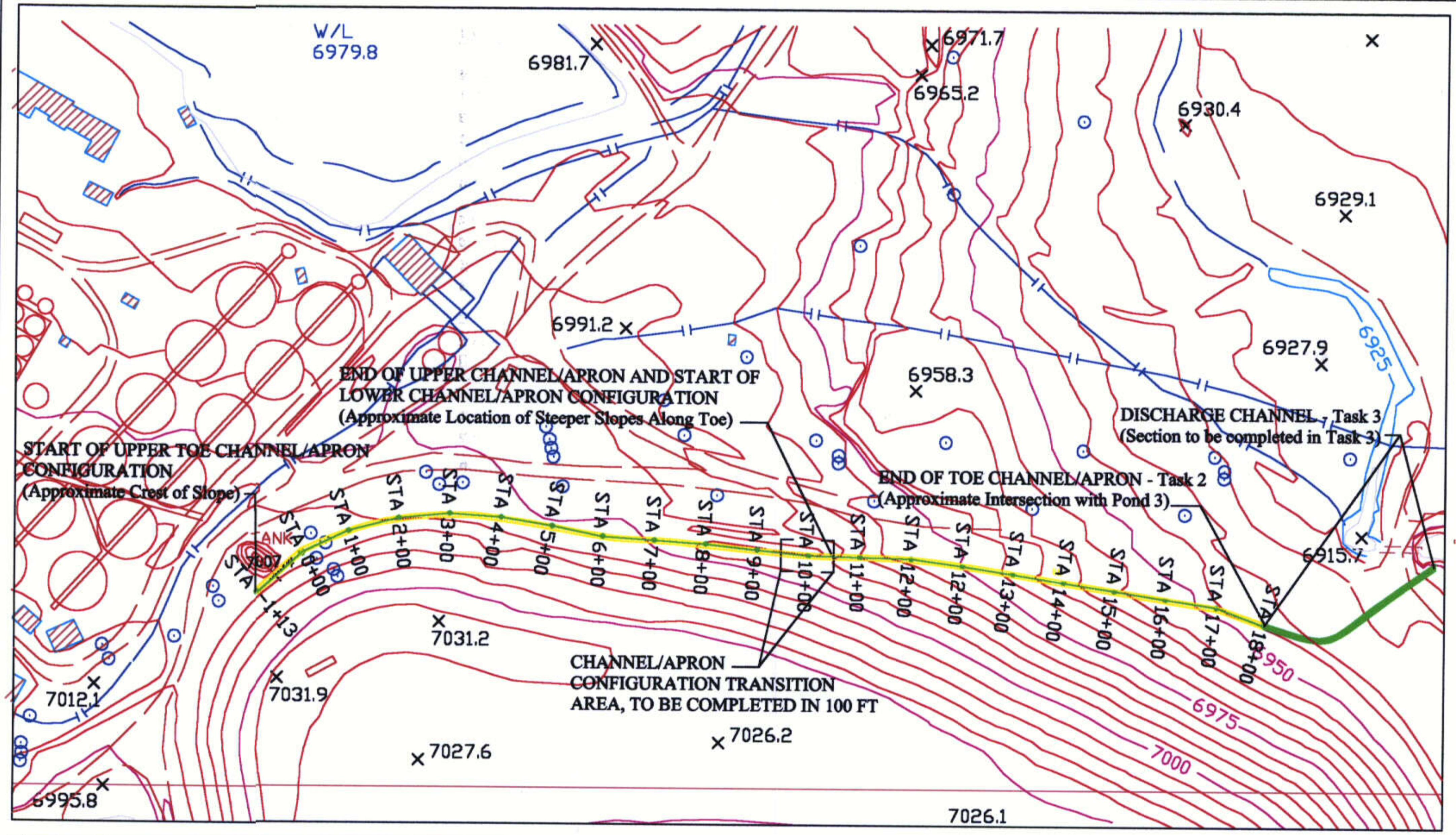
Output	Value	Units
n	0.0335	

2. CHANNEL DEPTH OUTPUT



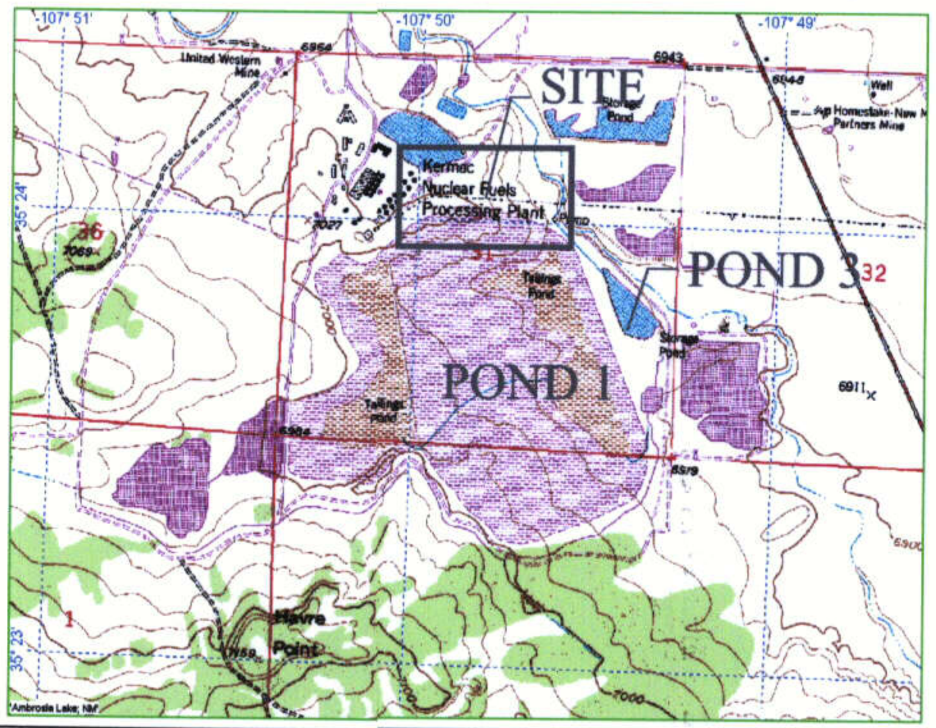
APPENDIX E

DESIGN DRAWINGS



CONSTRUCTION NOTES:

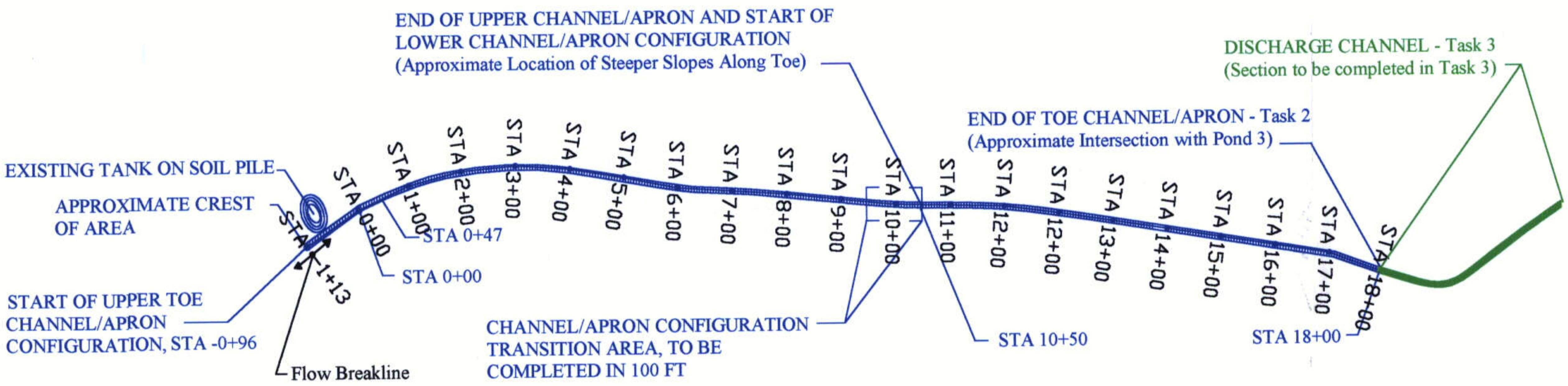
1. The erosion protection channel/apron shall be constructed adjacent to the existing internal apron constructed within the Pond 1 north embankment slope. As part of the new erosion protection channel/apron construction, the existing internal apron will be removed and reconstructed as shown on design Sheets 2 and 3. Horizontal location of stationing for channel/apron is approximate.
2. The lines and grades of the proposed channel/apron route shall match that of the existing ground surface along the Pond 1 embankment toe. The existing grades provide the necessary slope grades, flow rates and flow patterns for proper channel/apron stability.
3. Two erosion protection channel/apron configurations are provided for the north embankment of Pond 1. The two configurations shall be transitioned on the flatter upper slopes (approximately between Station 9+50 and 10+50) and completed in 100.0 ft. See Sheet 4 of 5 for details.
4. The channel/apron beyond STA 18+00 shall be completed as part of later design work at the Ambrosia Lake Mill.
5. Horizontal Location and Stationing Of Channel/Apron is Approximate.



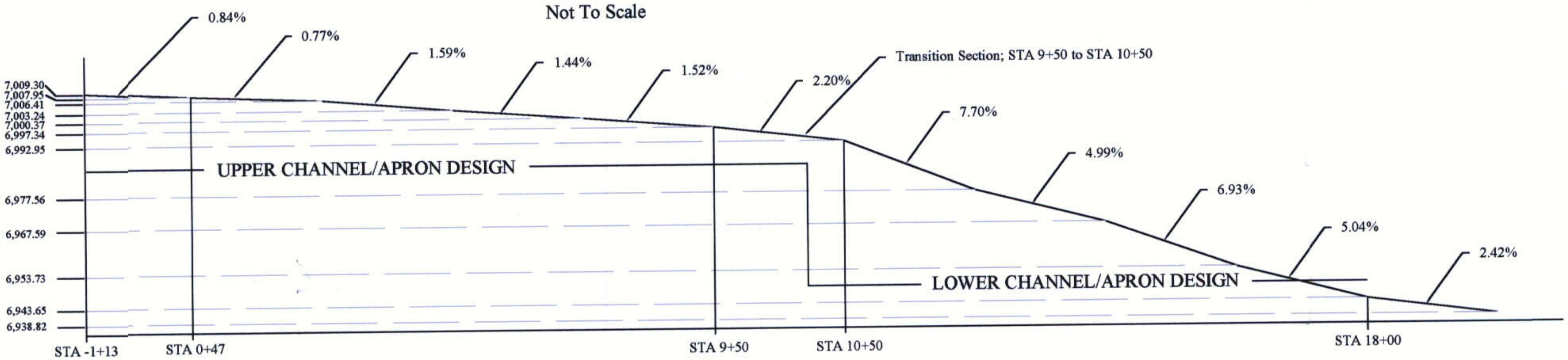
CO2

AMBROSIA LAKE MILL RIO ALGOM MINING COMPANY, LLC. GRANTS, NEW MEXICO POND 1 TOE EROSION PROTECTION		MAXIM TECHNOLOGIES INC
PROJECT No. 1690030-200	DRAWING BY: RLH 3/5/02	SHEET 1 of 5
FILE NAME: 1690030T2S1.DWG	REVIEWED BY: WHB	

PLAN VIEW
Not To Scale



PROFILE VIEW
Not To Scale



C03

NOTE:

Profile Developed From Aerial Survey Supplied by Rio Algom Mining Company, LLC. (5.0 ft Contour)

Horizontal Location and Distances Are Approximate and Used Only For References Due to The 5 ft Contour Provided By Rio Algom Mining Company, LLC. As A Base Map. The Proposed Channel/Apron Shall Start At The Crest of The Pond 1 Toe and Run Adjacent to the Toe. The Crest of the Toe is Located West of the Existing Tank Placed on the Soil Pile Shown Above.

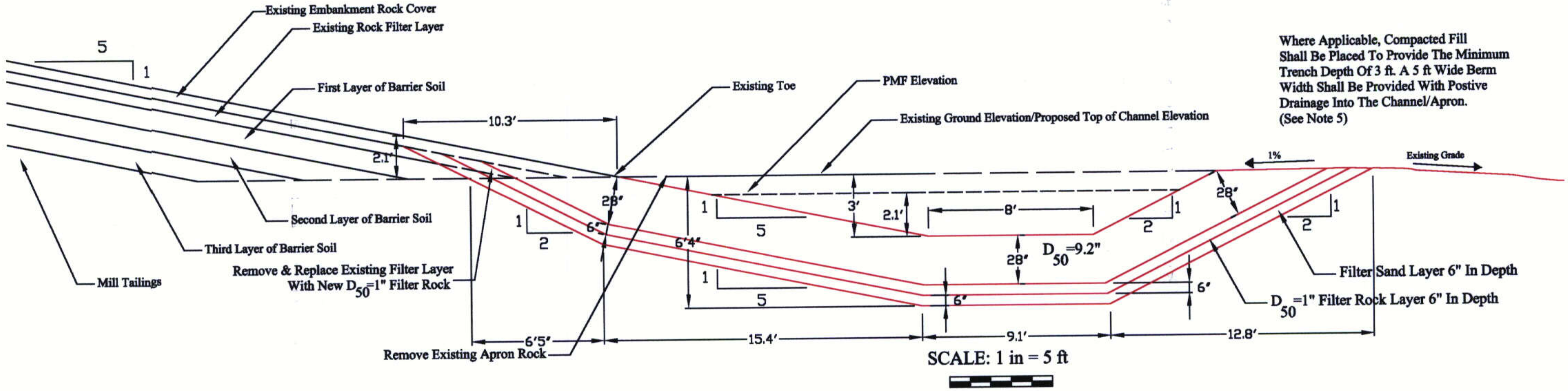
AMBROSIA LAKE MILL
RIO ALGOM MINING COMPANY, LLC.
GRANTS, NEW MEXICO
NORTH EMBANKMENT TOE CHANNEL/APRON

PROJECT No. 1690030-200	DRAWING BY: RLH 3/5/02
FILE NAME: 1690030T2S2.DWG	REVIEWED BY: WHB

MAXIM TECHNOLOGIES INC

SHEET 2 of 5

CHANNEL/APRON STATION -1+13 to STATION 9+50



CONSTRUCTION NOTES:

1. The upper portion of the Pond 1 erosion protection channel/apron shall be constructed adjacent to the existing Pond 1 internal apron. Estimated length of channel/apron is 1,100 ft. The channel/apron shall extend from the existing water tank at the north end of Pond 1 to where the longitudinal slope along the Pond 1 embankment toe exceeds 2.5%.
2. The existing internal apron of the Pond 1 embankment shall be removed and replaced as shown above such that the apron shall provide positive drainage into the newly constructed channel/apron.
3. The bottom of the channel/apron shall be constructed flat from side slope to side slope to prevent concentrated flows.
4. 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 -CR1623 Draft Report unless otherwise specified in the Pond 1 Embankment Toe Erosion Protection Report or the included Design Drawings.
5. Where applicable, compacted fill may be placed on the exterior to construct an embankment that will provide the minimum 3.0 ft of depth for the channel/apron. The fill required to construct the embankment shall consist of material excavated from within the channel/apron trench. The fill shall be compacted to a minimum of 95% of maximum density as determined by ASTM D-698 and within +/- 2% of optimum moisture content. Each lift of fill shall not exceed a loose thickness of 10 inches. The embankment shall maintain the 2H:1V slope on its interior and a 5H:1V or flatter slope on the exterior. The embankment shall have a crest width of not less than 5 ft.
6. The exterior slope of the channel/apron shall be constructed with 2H:1V slopes. The interior slope shall match the existing embankment slope, approximately 5H:1V.
7. The channel/apron excavation shall be constructed with bottoms free of loose debris, vegetation and muddy surfaces.
8. The erosion protection bedding/filter material shall be placed at a minimum thickness of 6" along the length of the channel/apron. The bedding/filter material shall extend up the 2H:1V side slopes and end flush with the existing ground elevation. Bedding/filter materials shall be spread and compacted in one layer.
9. Existing erosion protection rock disturbed during construction of the channel/apron shall be replaced such as to maintain existing slopes and riprap conditions as approved previously by the U.S. Nuclear Regulatory Commission. Care shall be taken in removing and stockpiling the riprap such that the material is not degraded or otherwise damaged. Rock degraded or otherwise not in conformance with the NUREG 1623 due to removal and replacement methods shall be replaced with similar approved materials. Care shall be taken such that existing tailings are not disturbed during erosion protection channel/apron construction.
10. The channel/apron shall be covered with a minimum of 28" of d_{50} =9.2" rock. The rock shall be extended up the side slopes to the existing grade on the exterior and interlock with the existing interior rock placed on the Pond 1 embankment slope as shown above.
11. The channel/apron erosion protection rock shall be constructed of a rock diameter d_{50}=9.2" conforming to the following gradation:

Sieve Designation	Percent Passing
15"	100
12"	70 - 90
9"	30 - 55
6"	0 - 10

12. The channel/apron erosion protection rock shall be constructed on 6" of bedding/filter rock of diameter d_{50}=1" conforming to the following gradation:

Sieve Designation	Percent Passing
3"	100
2"	80 - 90
3/4"	20 - 70
3/8"	10 - 30
No.4	0 - 10

13. The channel/apron erosion protection filter rock shall be constructed on 6" of bedding/filter sand conforming to the following gradation:

Sieve Designation	Percent Passing
No.4	100
No.10	80 - 100
No.20	36 - 76
No.40	10 - 20
No.100	0 - 10

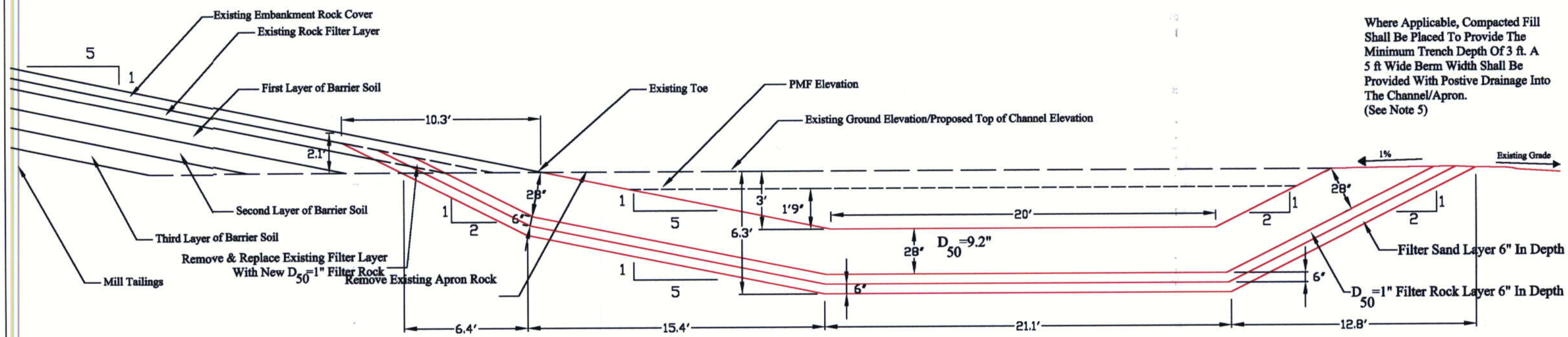
C04

AMBROSIA LAKE MILL
RIO ALGOM MINING COMPANY, LLC.
GRANTS, NEW MEXICO
POND 1 TOE EROSION PROTECTION
CHANNEL/APRON, STA -1+13 to 9+50

MAXIM TECHNOLOGIES INC

PROJECT No. 1690030-200	DRAWING BY: RLH 3/5/02	SHEET 3 of 5
FILE NAME: 1690030T2S3.DWG	REVIEWED BY: WHB	

CHANNEL/APRON STATION 10+50 TO STATION 18+00



SCALE: 1 in = 5 ft

CONSTRUCTION NOTES:

1. The lower portion of the Pond 1 erosion protection channel/apron shall be constructed adjacent to the existing Pond 1 internal apron. Estimated length of channel/apron is 800 ft. The channel/apron shall extend from the end of the proposed upper channel/apron to the north corner of Pond 3 where it ends along the toe of Pond 1. The remaining portion of the channel that extends from the toe of Pond 1 to the Arroyo del Puerto will be designed as part of a later design for the Ambrosia Lake Mill.
2. The existing internal apron of the Pond 1 embankment shall be removed and replaced as shown above such that the apron shall provide positive drainage into the newly constructed channel/apron.
3. The bottom of the channel/apron shall be constructed flat from side slope to side slope to prevent concentrated flows.
4. 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 -CR1623 Draft Report unless otherwise specified in the Pond 1 Embankment Toe Erosion Protection Report or the included Design Drawings.
5. Where applicable, compacted fill may be placed on the exterior to construct an embankment that will provide the minimum 3.0 ft of depth for the channel/apron. The fill required to construct the embankment shall consist of material excavated from within the channel/apron trench. The fill shall be compacted to a minimum of 95% of maximum density as determined by ASTM D-698 and within +/- 2% of optimum moisture content. Each lift of fill shall not exceed a loose thickness of 10 inches. The embankment shall maintain the 2H:1V slope on its interior and a 5H:1V slope on the exterior. The embankment shall have a crest width of not less than 5 ft.
6. The exterior slope of the channel/apron shall be constructed with 2H:1V slopes. The interior slope shall match the existing embankment slope, approximately 5H:1V.
7. The channel/apron excavation shall be constructed with bottoms free of loose debris, vegetation and muddy surfaces.
8. The erosion protection bedding/filter material shall be placed at a minimum thickness of 6" along the length of the channel/apron. The bedding/filter material shall extend up the 2H:1V side slopes and end flush with the existing ground elevation. Bedding/filter materials shall be spread and compacted in one layer.
9. Existing erosion protection rock disturbed during construction of the channel/apron shall be replaced such as to maintain existing slopes and riprap conditions as approved previously by the U.S. Nuclear Regulatory Commission. Care shall be taken in removing and stockpiling the riprap such that the material is not degraded or otherwise damaged. Rock degraded or otherwise not in conformance with the NUREG 1623 due to removal and replacement methods shall be replaced with similar approved materials. Care shall be taken such that existing tailings are not disturbed during erosion protection channel/apron construction.
10. The channel/apron shall be covered with a minimum of 28" of d_{50} =9.2" rock. The rock shall be extended up the side slopes to the existing grade on the exterior and interlock with the existing interior rock placed on the Pond 1 embankment slope as shown above.
11. The channel/apron erosion protection rock shall be constructed of a rock diameter d_{50}=9.2" conforming to the following gradation:

Sieve Designation	Percent Passing
15"	100
12"	70 - 90
9"	30 - 55
6"	0 - 10

12. The channel/apron erosion protection rock shall be constructed on 6" of bedding/filter rock of diameter d_{50}=1" conforming to the following gradation:

Sieve Designation	Percent Passing
3"	100
2"	80 - 90
3/4"	20 - 70
3/8"	10 - 30
No.4	0 - 10

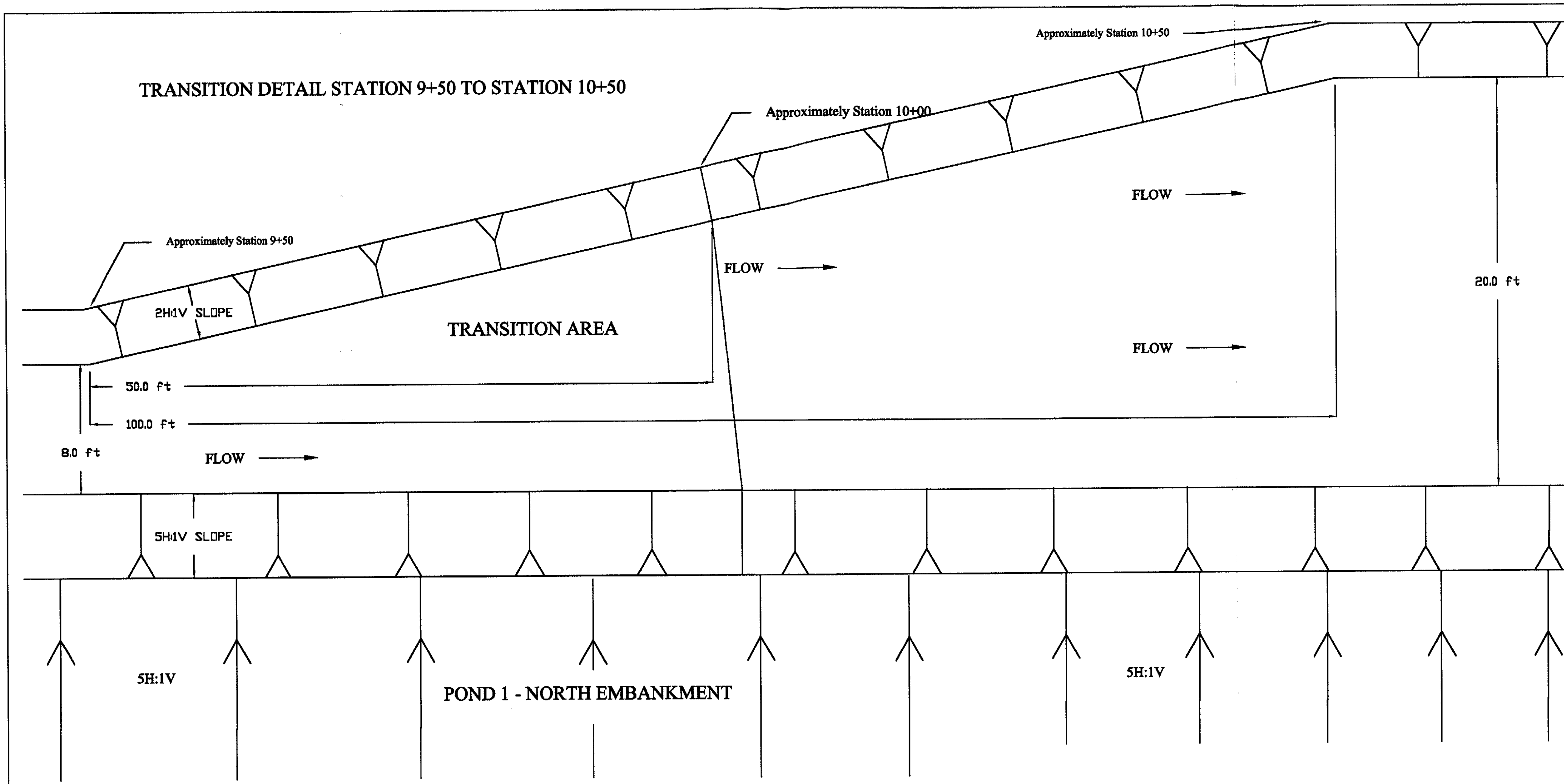
13. The channel/apron erosion protection filter rock shall be constructed on 6" of bedding/filter sand conforming to the following gradation:

Sieve Designation	Percent Passing
No.4	100
No.10	80 - 100
No.20	36 - 76
No.40	10 - 20
No.100	0 - 10

C05

AMBROSIA LAKE MILL RIO ALGOM MINING COMPANY, LLC. GRANTS, NEW MEXICO POND 1 TOE EROSION PROTECTION CHANNEL/APRON, STA 10+50 TO STA 18+00		MAXIM TECHNOLOGIES INC
PROJECT No. 1690030-200	DRAWING BY: RLH 3/5/02	SHEET 4 of 5
FILE NAME: 1690030T2S4.DWG	REVIEWED BY: WHB	

TRANSITION DETAIL STATION 9+50 TO STATION 10+50



Not To Scale

CONSTRUCTION NOTES:

1. The upper channel/apron configuration shall transition to the lower channel/apron configuration in 100.0 ft. The channel/apron design shall conform to the lower channel apron configuration at the midpoint of the transition section.
2. The channel/apron bottom shall be constructed flat such that flow is evenly distributed across the channel bottom.

AMBROSIA LAKE MILL RIO ALGOM MINGING COMPANY, LLC. GRANTS, NEW MEXICO POND 1 TOE EROSION PROTECTION TRANSITION DETAIL, STA 9+50 TO STA 10+50		MAXIM TECHNOLOGIES INC
PROJECT No. 1690030-200	DRAWING BY: RLH 3/5/02	SHEET 5 of 5
FILE NAME: 1690030S2.DWG	REVIEWED BY: WHB	

DESIGN REPORT
POND 3 EROSION PROTECTION
AND
EROSION PROTECTION FOR THE AREA NORTH OF POND 1
AMBROSIA LAKE MILL, NEW MEXICO

Prepared for:

Rio Algom Mining Company, LLC.
P.O. Box 218
Grants, New Mexico 87020

Prepared by:

Maxim Technologies, Inc.
10601 Lomas NE, Suite 106
Albuquerque, New Mexico 87112

WILLIAM H. BUCHER
NEW MEXICO
15469
REGISTERED PROFESSIONAL ENGINEER

April 23, 2002

April 22, 2002

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LIST OF APPENDICES

INTRODUCTION

This design report has been prepared by Maxim Technologies, Inc. (Maxim) for Rio Algom Mining Company, LLC. (Rio Algom) as part of an agreement for engineering services dated July 2001. Maxim has been retained to evaluate flood and long-term erosion conditions at the Ambrosia Lake Facility near Grants, New Mexico and to prepare designs for the long-term stability of tailings and evaporation ponds at this uranium mill tailings disposal site. This report provides the basis for the design required by the third of four tasks included in the agreement. Task three addresses potential erosion of the surface and embankment slope of Pond 3. As part of an addendum to Task 3, this report addresses potential erosion on approximately 20 acres north of the north embankment of Pond 1. Also included in this design report is the completion of the Pond 1 North Embankment Erosion Protection Channel/Apron, herein referred to as the Discharge Channel. Figure 1 is a schematic representation of the three (3) areas of concern in the current study.

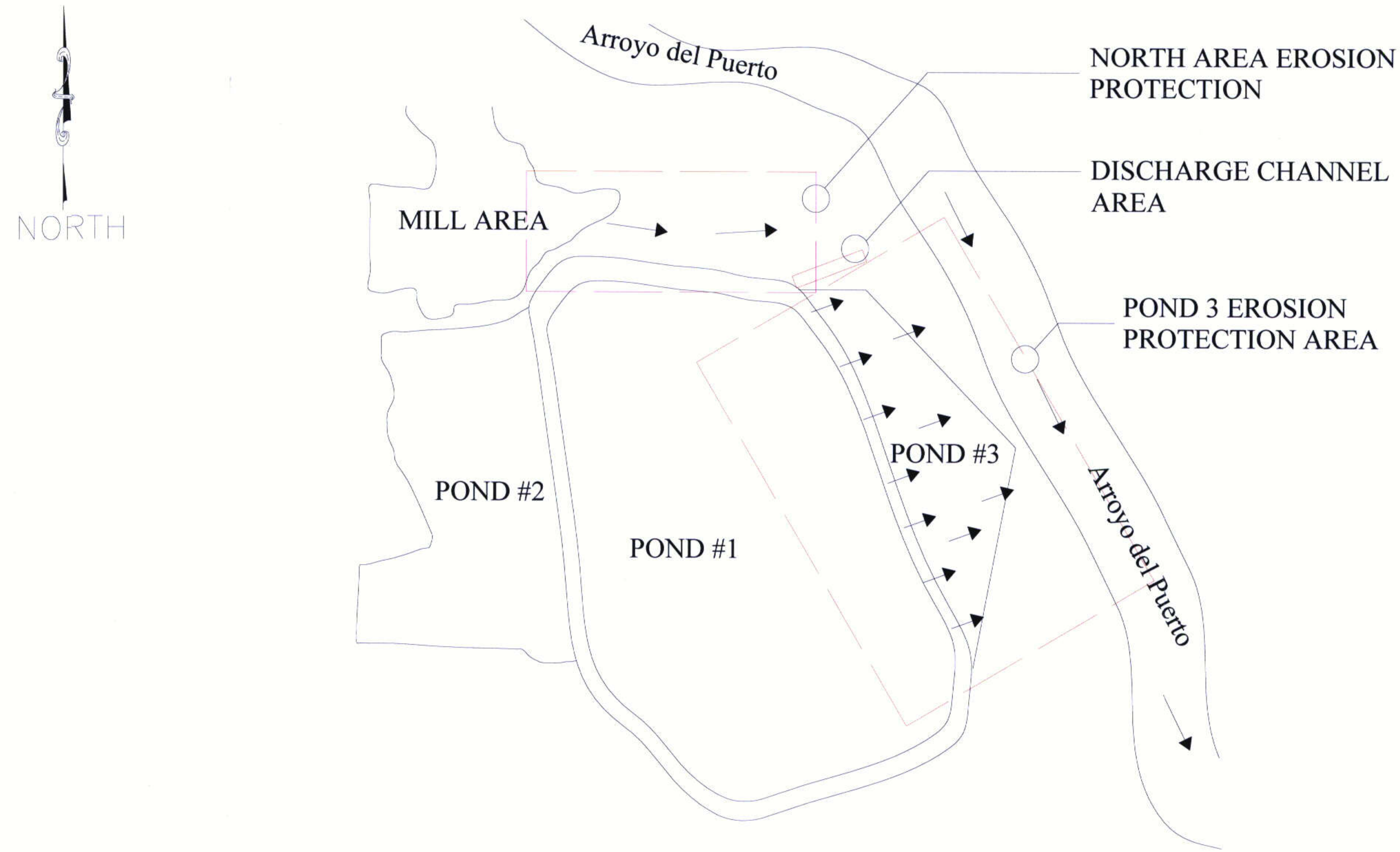
Pond 3 is a contaminated soils disposal site currently under reclamation by Rio Algom. The tailings disposal site was used in the past for burial of byproducts produced at the Ambrosia Lake Mill. The current reclamation activities for Pond 3 include but are not limited to placement of general site waste soils, re-grading of the pond surface contours, and contouring of the east embankment. The re-contouring activities at Pond 3 were not completed at the time of this design report submittal. This report provides a design to limit erosion after completion of the re-contouring activities of the following areas: the surface, the east embankment and the east embankment toe of Pond 3, and the interface between the Pond 1 embankment toe and the Pond 3 surface. Local topographic information supplied by Rio Algom indicates precipitation that falls on the Pond 1 embankment slope that interfaces with Pond 3 will run-off to the east and onto the surface of Pond 3. As part of this design, the surface of Pond 3 will be re-graded such that the precipitation from the Pond 1 embankment slope that flows onto the surface of Pond 3 and the precipitation that falls onto the Pond 3 surface will run across the surface of Pond 3 as sheet flow toward the east embankment of Pond 3, where it will then flow down the embankment and into the Arroyo del Puerto basin. Through the design process for erosion protection of this area, the east embankment of Pond 3 was determined to be within the Probable Maximum Flood (PMF) extent of the Arroyo del Puerto; therefore, the design for erosion protection of the east embankment was based on longitudinal flows created by the PMF in the Arroyo del Puerto.

Included in this report is a design for erosion protection of approximately 20 acres of generally undeveloped land adjacent to the north embankment of Pond 1. This area slopes away from the embankment to the northeast at an average grade of 7.5%. The Nuclear Regulatory Commission (NRC) has described the area as an area of concern for erosion caused by local storm events. The area is bound to the south by the Pond 1 embankment toe and a proposed erosion protection toe channel/apron for Pond 1, to the immediate west by a ridge that will act as a dividing line between this area and the mill facilities for runoff, to the east by the Arroyo del Puerto, and to the north by a proposed diversion channel placed appropriately through analysis of head-cutting directions depicted by the local topographic information provided by Rio Algom. Within this area are slopes in excess of 10%; however, these areas are limited in extent. Part of the erosion protection design for this area is the re-grading of the area and of slopes greater than 7.5%. The erosion protection design for this area is to re-contour the steeper slopes, to place erosion protection rock to limit local erosional head-cutting that could eventually impact the toe of Pond 1, and to capture flows from this area and discharge them to the Arroyo del Puerto via an engineered diversion channel.

The last erosion design included in this report is a discharge channel for the north embankment erosion protection channel/apron of Pond 1. The discharge channel will be used to direct flow captured in the channel/apron from the toe of the north embankment of Pond 1 around the north limits of Pond 3 where it will discharge through an energy dissipation outlet apron into native soils of the Arroyo del Puerto.

Erosion protection for the areas discussed above consists of seven items:

1. Toe erosion protection apron placed at the interface of Pond 1 and Pond 3,



Legend:
→ Local Flow Direction

C06

AMBROSIA LAKE MILL
RIO ALGOM MINING COMPANY, LLC.
GRANTS, NEW MEXICO

MAXIM TECHNOLOGIES INC

GENERAL OVERVIEW OF TASK	DRAWING BY: RLH 2/21/02	
PROJECT No. 1690030-300 FILE NAME: 1690030Fig1.DWG	REVIEWED BY: WHB	FIGURE 1

2. Surface erosion protection for Pond 3,
3. Erosion protection for the east embankment of Pond 3,
4. Toe erosion protection apron placed at the toe of the east embankment of Pond 3
5. Surface run-off protection of the area north of Pond 1,
6. Diversion channel construction along the northern limit of the area north of Pond 1,
7. Discharge channel construction from the end of Pond 1 north embankment channel/apron to the Arroyo del Puerto basin.

This design report is limited to those items affecting design of the erosion protection areas outlined above. In the next section of this report, general methods of analysis are described including derivation of the PMP and calculation of the appropriate PMFs. In the following section, the design basis for each design item is presented. The report concludes with a discussion of other issues that affect the design.

1.0 METHODS

The analysis conducted for these designs are consistent with Nuclear Regulatory Commission (NRC) guidance, particularly, *Design of Erosion Protection for Long-Term Stabilization* (Johnson 1999). 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 future maintenance issues. Because flood events with a 1,000 year recurrence interval are difficult to quantify, the guidance recommends use of the probable maximum precipitation event (PMP) 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, Probable Maximum Precipitation Estimates – United States between the Continental Divide and the 103rd Meridian* (Hansen *et al.* 1988). Appropriate PMPs are used to develop runoff hydrographs and determine the probable maximum flood (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.

Maxim verified the PMP calculation performed by others following the methods outlined in *Hydrometeorological Report No. 55A* (Hansen *et al.* 1988). The PMP rainfall depth calculated previously for the 1-hour local storm was 9.6 inches with no areal reduction. Maxim's calculation of the PMP depth arrived at a 9.5 inch value for the 1-hour, 1-square mile local storm, slightly less than the previously calculated value of 9.6 inches. Because the values are so similar, we used the slightly higher, previously determined values, in our calculations. Calculation sheets are attached in Appendix A.

For areas which are exposed to the PMF from the Arroyo del Puerto, the approach consisted of two tasks with the greater design requirements controlling the final design configurations.

1) Determining the erosion protection requirements based on run-off analysis for sheet flows down slopes as well as across pond surfaces in accordance with NUREG-1623, Appendix D, Section 2; and

2) Determining open channel and/or toe apron requirements to control the run-off and/or longitudinal flow from a PMF event by an open channel or apron in accordance with NUREG-1623, Appendix D, Sections 3, 4, and 6.

The study of longitudinal forces of the PMF for the Arroyo del Puerto drainage was conducted using HEC-1 (USACE 1990) and the PMF water-surface profile in the vicinity of Pond 3 was determined using HEC-RAS (USACE 1998). Previous correspondence from Quivira Mining Company to the Nuclear Regulatory Commission (QMC, 1990) indicated that the accepted PMF for Arroyo del Puerto at the Ambrosia Lake Millsite is 78,000 cfs. There are no indications how this PMF was calculated and we do not know the duration of the storm event used or if it was a local or general storm. Therefore, we reviewed several potential storm durations and types for the Arroyo del Puerto.

The Arroyo del Puerto basin contains 57.6 square miles upstream of the Ambrosia Lake Mill. Because no information was developed on the run-off characteristics of this basin, we used the same Soil Conservation Service curve number that was used on the Montanosa Mesa drainage, 73.4. The lag time was chosen to be 0.6 of the time of concentration or 1.83 hours. Areal reduction factors for the 57.6 square mile basin were used. We investigated the 1-hour and 6-hour local storms and the 6-hour, 24-hour, and 72 hour general storms with these basin characteristics and found that the highest value for the PMF was obtained with the 6-hour local storm which produced a peak flow of 75,200 cfs. This seemed to confirm the value of 78,000 cfs found in the QMC letter of 1990. We chose to use the higher value originally reported in all our subsequent calculations. Our calculations for the 6-hour local storm are included in Appendix A.

We constructed a hydraulic model of the Arroyo del Puerto in the vicinity of the Ambrosia Lake Mill and routed the 78,000 cfs peak flow through this area to determine the elevation of the flood water in the vicinity of Pond 3. We used existing topography from the Quivira Mining Company map with the following exceptions:

1. Arroyo del Puerto was rerouted to a new alignment east of its existing position in the vicinity of the mill. The new channel rejoins the original channel near the north-east corner of Pond 9.
2. The Pond 3 embankment was assumed to be constructed to a final elevation of 6936 feet at its eastern edge and to have a slope of 6 percent.
3. The existing groundwater dewatering trench was assumed to be backfilled.
4. Pond 9 was assumed to be removed and have a final elevation of 6917 feet.

With these assumptions, the elevation of the water surface at the northern edge of Pond 3 is about 6935 feet or one foot lower than the top of the embankment. The flood profile declines rapidly as it moves south along Pond 3 and attains an elevation of about 6917 feet at its southern extent. Note that these water surface elevations are very sensitive to assumptions about final topography in this area. Results of the HEC-RAS model for Arroyo del Puerto are found in Appendix A.

2.0 DESIGN BASIS

This section of the design report describes in detail the basis for the seven design items listed previously. The individual catchment areas and a description of the catchment surface type are briefly described for each design area. Visual observations during site visits were used to aid in fitting an appropriate design to limit erosional effects. The areas of erosion protection designs at the mill site are depicted on Sheet 1 of the design drawings.

As part of this erosion protection design, rock sizing was developed. The sizes were based on previous erosion protection design tasks at the Ambrosia Lake Mill to reduce the number of rock size gradations. Rock grading of D_{50} = 1.0, 3.2, and 9.2 inches have been previously selected for use in erosion protection systems at the mill site. These rock sizes have been used as the basis for rock sizing for this design task.

2.1 EROSION PROTECTION APRON – POND 1 AND POND 3 INTERFACE

This 31-acre catchment area consists of an embankment slope that is covered with a radon barrier and erosion protection rock. The embankment slopes downward to the east from a crest elevation of approximately 7,025 ft. Because of continuing re-contouring work being performed by Rio Algom at Pond 3, the embankment toe elevation is not yet determined; therefore, an elevation of 6,938 ft has been assumed for design purposes. The design grade of the embankment is 20%, according to Rio Algom. This value was verified to be between 17% and 20% by the topographic information supplied by Rio Algom. For the 31-acre catchment, a time of concentration was calculated for the longest slope length measured at the east embankment of Pond 1, 520 ft. With the noted slope length and the elevation change of the embankment, a time of concentration of 1.92 minutes was determined. This time of concentration is near the smallest incremental rain duration provided by Nelson *et. al* (1986) for developing a PMP depth. Therefore the shortest incremental rainfall duration of 2.5 minutes was used for developing the PMP depth. The 2.5 minute PMP depth for a local storm of 9.6 inches is 2.64 inches. Using a runoff coefficient of 1.0 (rock covered surfaces with no infiltration), the Rational Method gives a unit peak flow of 0.76 cfs/ft for this catchment. Using a maximum embankment slope of 20% and a flow concentration factor of 2.5, the method of Abt *et al.* (1998) predicts a rock d_{50} of 7.5 inches for the erosion protection apron at the Pond 1 and Pond 3 interface. Calculations are included in Appendix B. The detailed erosion protection apron design and minimum apron configurations are shown on the design sheets included in Appendix E.

From the available rock sizes noted above, a rock d_{50} of 9.2 inches was selected for construction of the apron. The apron configuration was based on 15 times the d_{50} for the apron width and three times the d_{50} for the apron depth (NUREG 1623). For the Pond 1 embankment toe apron width, the predicted rock size of d_{50} = 7.5 inches was used for this calculation, making the channel width 9.4 ft. At the wishes of Rio Algom, the apron depth was based on a rock d_{50} of 9.2 inches for ease of placement of the larger rock into the apron, which exceeds the thickness requirement of NUREG 1623.

2.2 SURFACE EROSION PROTECTION – POND 3 SURFACE

The surface of Pond 3 at the time of this design study had not yet been regraded to its final configuration. Current reclamation activities at the mill site include the placement of waste site soils in Pond 3 where they will be covered and an erosion protection system placed. As part of the erosion protection system for the surface of Pond 3, Rio Algom has committed to placing a rock erosion protection layer. Whether the rock layer was required by run-off or not, Rio Algom has indicated that a rock layer will be placed to limit erosion caused by run-off as well as wind erosion of the soil barrier layer.

Although the finished pond surface elevation and slope conditions of the pond surface were not yet determined at the time of this study, it is anticipated that a 33 acre area will be covered. Based on conversations with Rio Algom, the pond surface was near a completion elevation; therefore, an assumed elevation near the current elevation was used to complete erosion protect designs. Included in this estimated elevation is the 12-inch thick cover layer, which results in an estimated elevation of 6,938 ft for the western limits of Pond 3 where the toe of Pond 1 intersects the Pond 3 surface. For design purposes, a pond surface grade of 0.3% for Pond 3 was established to prevent ponding or concentrated flows across the pond. With the start elevation of 6,938 ft at the toe of Pond 1 and a maximum horizontal surface length of 700 ft across Pond 3, the minimum ending elevation of the pond surface at a 0.3% grade will be 6,936 ft. The minimum elevation of the Pond 3 surface is approximately 1 ft above the highest elevation estimated for a PMF of the Arroyo del Puerto basin. This maximum PMF elevation will occur at the northeast end of Pond 3 and quickly lower in elevation as the PMF progresses south along the Pond 3 embankment. At the southeast limits of the Pond 3, the embankment will not be affected by a PMF event according to the calculations. Therefore, the PMF in the Arroyo del Puerto was not considered when designing protection for the surface of Pond 3.

For this 33-acre catchment area, a time of concentration was calculated for the longest surface slope length measured starting at the west limits of Pond 3 and ending at the furthest east point of the Pond 3 surface, assuming that the pond surface will be finish graded to drain perpendicular to the Pond 1 toe. With these limits, a measured slope length of 700 ft was established for design purposes. With the noted slope length of 700 ft and the 0.3% grade of the surface, a time of concentration of 11.6 minutes was determined. Because the Pond 1 embankment flows will be discharged onto the Pond 3 surface, the time of concentration for the precipitation that falls onto the embankment was added to the time of concentration calculated for the Pond 3 surface, making the total time of concentration equal to 13.52 minutes for the system. This time of concentration was then used to obtain the PMF depth using the incremental rain duration provided by Nelson *et. al* (1986). The incremental rainfall duration of 13.52 minutes was used for developing the PMP depth of 6.72 inches for a local storm of 9.6 inches. Using a runoff coefficient of 1.0 (used for rock covered surfaces and no infiltration) and the Rational Method, a unit peak flow of 0.84 cfs/ft for this catchment was calculated. With a maximum surface slope of 0.3%, the method of Abt *et al.* (1998) predicts a rock d_{50} of 0.4 inches for the erosion protection layer of Pond 3 surface. Calculations are included in Appendix B. The detailed erosion protection design is shown on the design sheets included in Appendix E.

With an available rock size of d_{50} of 1.0 inch adequately meeting the required rock size, the surface erosion protection for Pond 3 will consist of d_{50} = 1.0 inch rock. The surface erosion protection rock will be placed three inches thick which meets the one times the d_{100} of the selected rock size for proper placement of the erosion protection layer (NUREG 1623).

2.3 SIDE SLOPE EROSION PROTECTION – POND 3 EAST EMBANKMENT SLOPE

For the side slope erosion protection design of the east embankment of Pond 3, we used the same assumptions of finish elevations for the Pond 3 surface. For design purposes we assumed an embankment crest elevation of 6,936 ft and a toe elevation of 6,923 ft. Because the Pond 3 embankment toe terminates in the Arroyo del Puerto basin, the toe elevations will vary, and the crest elevation will also vary due to the slope projection of 0.3% along varying horizontal surface lengths of Pond 3. For design purposes, we measured a slope length of 60 to 70 ft at the mid-point of the east embankment of Pond 3, which also corresponds with the longest horizontal flow surface length of Pond 3. This combination yields the greatest potential flow volume that the embankment slope should experience during a PMF event. Rio Algom indicated for design purposes that the embankment slope would be constructed at a 20% grade. For design calculations a slope length of 65 ft was used. The actual length may vary slightly; however, a slight length change should not affect design results.

For the design of the erosion protection system of the embankment slope, two different precipitation events were evaluated. The first was the local PMP that would fall on the slope of Pond 1 and run-off to the surface of Pond 3 combined with the run-off accumulated from rain that falls onto the 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 basin. After evaluation of the two separate storm events, it was found that the PMF that could occur in the Arroyo del Puerto would produce the larger erosional forces. The calculations for the rain event that would fall onto the surfaces noted above and run-off and down the embankment slope are included in Appendix B; however, because the controlling design criteria are developed by a PMF in the Arroyo del Puerto, only that flow is used for design purposes. The velocity and depth of flow determined from the hydraulic analysis were used to determine the riprap sizes on the embankment slope of Pond 3. Calculations for this analysis are found in Appendix B.

For rock sizing to prevent erosion caused by the longitudinal flows, the Army Corp of Engineers method for riprap sizing (ACE 1995) was used. With over-bank flow velocities in the Arroyo del Puerto of 11 fps at a depth of 10 ft, the ACE method predicts a d_{50} of 12 inches. The slope erosion protection rock layer will be placed at a thickness of one times the d_{100} of the selected rock size or 12 inches (NUREG 1623).

2.4 EROSION PROTECTION APRON – POND 3 EAST EMBANKMENT TOE

Again, assumptions were made as to the location of the east embankment toe of Pond 3 due to the on-going reclamation work at Pond 3. For design purposes the embankment toe elevation of 6,923 ft was assumed. The toe apron will dissipate energy from run-off from a 60 to 70 ft long slope constructed at a 20% grade that crests at an elevation of 6,936 ft. The measurement of the slope length is taken from the mid-point of the east embankment of Pond 3 which corresponds with the longest horizontal surface flow length of Pond 3. The largest flows from a PMP would be experienced at this point. For design calculations a slope length of 65 ft was used. The actual length may vary slightly; however, a slight length change should not affect the design results.

For the design of the erosion protection system of the embankment slope, two different precipitation events were evaluated. The first was a local PMP that would fall onto the slope of Pond 1, Pond 3 and run-off onto the Pond 3 east embankment slope where it will flow across the toe apron and into the Arroyo del Puerto basin. The second event was a PMF that could occur in the Arroyo del Puerto basin. After evaluation of the two separate storm events, the PMF that could occur in the Arroyo del Puerto would produce the larger erosional forces. The calculations for the rain event that would fall onto the surfaces noted above and run-off to the embankment slope and across the apron are included in Appendix B; however, because the controlling design forces that the embankment could experience are developed by a PMF in the Arroyo del Puerto, only that flow is used for design purposes. The velocity and depth of flow determined from the hydraulic analysis were used to determine the need for riprap in the embankment toe apron of Pond 3. Calculations for this analysis are found in Appendix B.

For rock sizing to prevent erosion caused by the longitudinal flows at the toe of the embankment, the Army Corp of Engineers method for riprap sizing (ACE 1995) was used. With over-bank flow velocities in the Arroyo del Puerto of 11 fps at a depth of 10 ft, the ACE method predicts a d_{50} of 12 inches. However, for apron design, dimensions are based on slope runoff rock size, which is 8.5 inches. The apron width was based on 15 times this d_{50} (NUREG 1623) resulting in a channel width of 10.7 ft. For the apron depth, the d_{50} of 12 inch rock size was used. For ease of placement of the larger rock into the apron Algom, a thickness of three times d_{50} results in an apron depth of 36 inches which exceeds present guidance by NUREG 1623.

2.5 NORTH EROSION PROTECTION AREA – SURFACE PROTECTION

The 20 acres of undeveloped land adjacent to the north embankment of Pond 1 were investigated for the need of an erosion protection surface rock layer. The investigation was concentrated on the rainfall that would fall directly on this area and run-off potentially producing head-cutting that might undermine the north embankment channel/apron and embankment slope of Pond 1. Through analysis of the PMP on the area, it was determined that an erosion protection rock layer to be necessary to prevent potential head-cutting. The area is generally bound by topography that limits the area of flows into the system; therefore, only analysis of direct rainfall on this area was studied.

Minor head-cutting due to local rain events was visually observed in this area during site visits. The location of the head-cutting was used as the north boundary of the area to be rock covered for erosion protection. The head-cut area will be re-contoured and an engineered diversion channel constructed in its place to prevent future head-cutting. The diversion channel design is presented in the next subsection of this report, *North Erosion Protection Area – Diversion Channel.* The area south of the diversion channel, designated as the North Erosion Protection Area, will require a rock cover to prevent erosion during rainfall. To provide an effective rock cover, the slopes greater than 7.5% will need to be regraded to slopes equal to or less than 7.5%.

This catchment basin has a maximum elevation of 7,005 ft and a discharge elevation of 6,926. For the time of concentration analysis, a slope length of 1,700 ft was used over a drop in elevation of 79 ft. With the noted slope length and the elevation change of the area, a time of concentration of 7.82 minutes was determined. This time of concentration was then used to obtain the PMP depth using the incremental rain duration provided by Nelson *et. al* (1986). The incremental rainfall duration of 7.82 minutes was used to develop the PMP depth of 5.2 inches for a local storm of 9.6 inches. Using a runoff coefficient of 1.0 (rock covered surfaces with no infiltration) and the Rational Method, a unit peak flow of 1.6 cfs/ft for this catchment was calculated. With a maximum surface slope of 7.5%, the method of Abt *et al.* (1998) predicts a rock d_{50} of 2.2 inches for the erosion protection layer for the North Erosion Protection Area surface. Calculations are included in Appendix B. The detailed erosion protection design is shown on the design sheets included in Appendix E.

2.6 NORTH EROSION PROTECTION AREA – DIVERSION CHANNEL

In the north erosion protection area just described, minor head-cutting caused by past rainfall was visually observed during site visits. Rainfall that falls in the area flows toward the Arroyo del Puerto producing head-cut erosion that is directed west toward the mill site. An investigation into an appropriate erosion control method determined that head-cutting could be prevented by placing an engineered diversion channel at this location. This approach places an open channel at the base of the slope that will catch the precipitation that falls on the north erosion protection area. The open channel design is based on NUREG-1623 channel design (Appendix D, Section 3) and the Army Corp of Engineers, *Hydraulic Design of Flood Control Channels,* design methods (ACE 1995). According to a phone discussion with Mr. Ted Johnson of the Nuclear Regulatory Commission (NRC), the parameters provided within the NUREG 1623 shall be adequate for design of open channels, using Sections 2 and 3 of Appendix D, the Abt and Johnson Method. The diversion channel terminates at an apron in the Arroyo del Puerto basin.

For development of the erosion protection channel, the 20-acre north erosion protection area was divided into three segments because of the varying slopes and catchment areas along the diversion channel. The first segment extends from Station 0+00 to 9+00 where the channel is relatively gentle and the flows are relatively small. For design of the first segment, the time of concentration was developed using the maximum flow length for this area of 900 ft starting at elevation 7,007 ft and ending just above the increasing slope grades at elevation 6,989 ft. For this flow length, the time of concentration was calculated to be 6.6 minutes. From Nelson et al (1986), a 6.6 minute PMP depth for a local storm of 9.6 inches is 4.8 inches. The estimated catchment basin size is 2.2 acres. The Rational Method gives a peak flow of 97 cfs for the first channel segment. The channel was sized based on this flow and a two percent slope. The rock was sized using the method of Abt *et al* (1998) with a correction for side slope according to ASCE (1995). A rock size of D_{50} = 9.2 inches adequately protected a channel with a bottom width of three feet. Calculations are found in Appendix C.

The second segment runs from station 9+00 to 17+00 which is the steepest terrain traversed by the channel. Because the channel slope varies in this segment, the minimum slope of five percent was used to size the channel and the maximum slope of eight percent was used to size the riprap protection. The time of concentration was calculated based on a top elevation of 7,007 feet, a base elevation of 6,939 feet, and a channel length of 1,700 feet. The resulting time of concentration is 8.3 minutes; the corresponding incremental rainfall is 5.4 inches, and the rainfall intensity is 39 in/hr. Using a catchment basin size of 7.4 acres, the peak flow for the PMP is 288 cfs. A channel bottom width of 20 feet was used to contain this flow and a rock size of D_{50} = 9.2 inches adequately protected this channel on the steepest grades. Calculations are again found in Appendix C.

For the final segment of the channel, the slope is much flatter and the diversion channel will cross a low area that will need to be filled. A slope of 0.9 percent was selected for this segment beginning at station 17+00 and ending at 27+01.The time of concentration calculation was based on a start elevation of 7,007 feet, a base elevation of 6,926 feet and a channel length of 2,701 feet. The resulting time of concentration is 13.2 minutes; the incremental storm depth is 6.7 inches; and the rainfall intensity is 30.5 inches. Using the Rational Method with a catchment area of 16.3 acres, a peak flow of 497 cfs results. A channel with a bottom width of 28 feet will keep the water surface below three feet deep and allow protection of the channel with a rock size of D_{50} = 9.2 inches. Calculations are included in Appendix C.

A hydraulic jump develops between the steeper second segment of the diversion channel and the flatter third segment. In this reach, a hydraulic model was developed using HEC-RAS (USACE, 1998) to determine hydraulic conditions near the hydraulic jump. It was concluded that the channel needed additional height to contain the jump for a distance of about 25 feet. In addition, the transition area has been designed according to the apron design criteria found in NUREG-1623, Appendix D, Section 6 in order to dissipate the energy in this area. This requires placing rock with a D_{50} = 17 inches for a depth of 4.3 feet for the area of the expected hydraulic jump. Calculations are found in Appendix C.

2.7 POND 1 CHANNEL/APRON - DISCHARGE SECTION

Runoff from the north embankment of Pond 1 collects in a apron/channel designed in Task 2 that runs eastward towards the Arroyo del Puerto. Under this task, a discharge channel is designed to connect the apron/channel to the Arroyo del Puerto, circumventing Pond 3 on the north. The discharge channel begins with a transition section 25 feet long to convert the apron/channel to a normal channel with 2:1 side slopes. In the next 25 feet, the channel rock size is increased and thickened to accommodate the expected hydraulic jump as the grade flattens. The channel then returns to the typical rock size and follows two large radius curves to join with the north erosion area diversion channel at the discharge apron. Curve radii were set about eight times the channel width to prevent increased erosion potential (ASCE, 1995).

The time of concentration calculation for the channel is based on a drop from 7,026 feet at the top of Pond 1 to 6,926 feet at the discharge apron. The length of the slope is 2,706 feet and the resulting time of concentration is 12.2 minutes. The incremental PMP depth for this period is 6.5 inches, and the rainfall intensity is 31.7 in/hr. Using a catchment basin of 15.7 acres, the expected discharge according to the Rational Method is 498 cfs. A channel with a 25-foot bottom width was designed to accommodate this flow on a 1.75 percent grade. The rock was sized according to Abt *et al* (1998) and a factor of 1.2 to was used to allow for the increased tractive force on the side slopes (ASCE, 1995). A D_{50} = 9.2 inch rock provides adequate protection of the channel under these conditions. Calculations are found in Appendix D and Appendix E contains drawing sheets for the discharge channel.

The discharge channel shares a common discharge apron with the north erosion protection area diversion channel. The intent of the discharge apron is to slow water velocities to 4 ft/sec. to prevent scour of the native silty clays found in the Arroyo del Puerto basin. The apron is built on a slope of 0.5 percent, and an apron width of 80 feet reduces the velocity of the combined flows of the two channels (995 cfs) to less than 4 ft/sec. A toe is constructed at the edge of the discharge apron to prevent scour beneath the apron. The toe depth is determined from by the equation presented in Abt *et al* (1996), which is recommended in Section 4 of Appendix D of NUREG-1623. For a one-hour PMP of 9.6 inches falling on the combined area of 32 acres, 1,115,000 cubic feet of water will runoff an impermeable surface. Assuming all water runs off in one hour (a worst-case assumption), the average flow rate is 310 cfs. Using these values in the scour equation, a scour depth of just under six feet results. The toe is designed to extend to a six-foot depth with a 2H:1V slope.

Wingwalls also extend for an additional 25 feet beyond the apron to protect the corners of the apron. The wing walls are constructed with a rock toe extending to a six-foot depth with 2H:1V side slopes. Before covering the rock toes with compacted native materials, the contractor should work filter rock into the upper portion of the rock to prevent the loss of native material in voids.

3.0 OTHER DESIGN/CONSTRUCTION CONSIDERATIONS

The erosion protection methods outlined in this design report are based on current engineering practices for erosion control at uranium mill sites. For these erosion protection methods to perform as intended, a "durable rock" should be used. The erosion protection methods outlined above have been developed around the use of "durable rock" as characterized in Section 7.2.1 *Procedures for Assessing Rock Quality*, (NUREG 1623 & 4620). If suitable rock meeting the criteria set forth by NUREG 1623 and 4620 is not available, oversizing of the rock is permissible per Section 7.2.2 *Oversizing Criteria* (NUREG 1623). If oversizing of the selected rock sizes in this design report is required due to the lack of "durable rock", the erosion protection methods provided in this report should be reviewed. Depending on the magnitude of the change, the change in rock size could affect channel capacity and apron capacity as well as the rock thickness.

4.0 REFERENCES

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APPENDIX A

PMP AND PMF CALCULATIONS

MAXIM
TECHNOLOGIES INC

JOB NO. 1690030-300 **JOB TITLE** Quivira **DATE** 12/10/01 **BY** RLH

SUBJECT PMP Calculation - Local Storm **CHECKED** ______ **SHEET** 1 **OF** 1

Reference: Hydrometeorological Report No. 55A U.S. Department of Commerce NOAA, June 1988, Section 14.3

Stepwise Procedure, Local Storm PMP

Index 1-hr 1-mi² PMP Estimate @ 5,000 ft

∴ From Plate VIc 1-hr 1-mi² @ 5,000 ft

1.) 1-hr - 1mi² PMP @ 5,000 ft elev. = 10.5 inches

2.) Adjustment For Mean Site Elevation

Mean Elev. = 7,000 ft @ Site

Maximum 12-hr Persisting 1000 MB DP at 76.6°F From Figure 4.11

From Figure 14.3 Elev. Adjustment = 0.90

3.) Index 1-hr 1-mi² PMP Estimate @ Mean Elev

0.90 x 10.5 in = <u>9.5 in</u> 1hr - 1mi²

4.) From Table 12.4, 6-hr Storm is:

1.35 x 1hr = <u>12.83</u> in

5.) <u>Summary</u>: 1 hr - 1mi² PMP = 9.5" ≈ <u>9.6"</u>

Previous Work at the site by others indicated the PMP to be 9.6". Because the values we obtained compare to previously calculated values during past design work at the site, we will use the slightly higher value of 9.6" for design calculations.

6 hr Storm — 9.½"

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HEC1 S/N: 1343001338        HMVersion: 6.33    Data File: n:\quivira\adpin1.txt

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*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*
*              MAY   1991               *
*
*           VERSION 4.0.1E              *
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*                                       *
*
*  RUN DATE  09/07/2001  TIME  15:45:10 *
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*                                       *
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*
*    U.S. ARMY CORPS OF ENGINEE
*    HYDROLOGIC ENGINEERING CEN
*          609 SECOND STREET
*       DAVIS, CALIFORNIA 95616
*           (916) 756-1104
*
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X     X  XXXXXXX   XXXXX          X
X     X  X        X     X        XX
X     X  X        X               X
XXXXXXX  XXXX     X        XXXXX  X
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37 Brookside Road * Waterbury, Connecticut 06708 * (203) 755-1666

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THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTUR
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL   LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM
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                                   HEC-1 INPUT                                   PAGE  1

LINE        ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  1         ID   QUIVIRA - ARROYO DEL PUERTO FLOOD HYDROLOGY  FILE:ADPIN3.TXT
  2         ID   6-HR. PMF, LOCAL STORM WITH AREAL REDUCTION,  - 9.2 IN.
  3         ID   SEPTEMBER 7, 2001
  4         ID   B. BUCHER, MAXIM TECHNOLOGIES, HELENA, MT
*** FREE ***
            *
            * *** TIME SPECIFICATION
  5         IT      15 01JUL01    0000      50
            *
            * Rainfall time increment
  6         IN      60
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                 *
                 * *** GLOBAL OUTPUT OPTIONS
      7          IO       2       0
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      8          KK     IN1
      9          KM   HYDROGRAPH FOR ARROYO DEL PUERTO DRAINAGE
                 *
                 * Basin area
     10          BA    57.6
                 *
                 * Rainfall data
     11          PB     9.2
     12          PI     .02     .04     .12     .74     .05     .03
                 *
                 * Basin Losses
     13          LS       0    73.4       0
                 *
                 * Unit hydrograph
     14          UD    1.83
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     15          ZZ
HEC1 S/N: 1343001338      HMVersion: 6.33    Data File: n:\quivira\adpin1.txt

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*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)  *                                        *   U.S. ARMY CORPS OF ENGINEE
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*           VERSION 4.0.1E            *                                       *        609 SECOND STREET
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*                                     *                                       *     DAVIS, CALIFORNIA 95616
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                         QUIVIRA - ARROYO DEL PUERTO FLOOD HYDROLOGY  FILE:ADPIN3.TXT
                         6-HR. PMF, LOCAL STORM WITH AREAL REDUCTION,  - 9.2 IN.
                         SEPTEMBER 7, 2001
                         B. BUCHER, MAXIM TECHNOLOGIES, HELENA, MT

  7 IO          OUTPUT CONTROL VARIABLES
                      IPRNT          2  PRINT CONTROL
                      IPLOT          0  PLOT CONTROL
                      QSCAL         0.  HYDROGRAPH PLOT SCALE

    IT          HYDROGRAPH TIME DATA
                       NMIN         15  MINUTES IN COMPUTATION INTERVAL
                      IDATE     1JUL 1  STARTING DATE
                      ITIME       0000  STARTING TIME
                         NQ         50  NUMBER OF HYDROGRAPH ORDINATES
                     NDDATE     1JUL 1  ENDING DATE
                     NDTIME       1215  ENDING TIME
                      ICENT         19  CENTURY MARK

                  COMPUTATION INTERVAL    0.25 HOURS
                       TOTAL TIME BASE   12.25 HOURS

        ENGLISH UNITS
             DRAINAGE AREA         SQUARE MILES
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          PRECIPITATION DEPTH   INCHES
          LENGTH, ELEVATION     FEET
          FLOW                  CUBIC FEET PER SECOND
          STORAGE VOLUME        ACRE-FEET
          SURFACE AREA          ACRES
          TEMPERATURE           DEGREES FAHRENHEIT

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  8 KK  *      IN1   *
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               HYDROGRAPH FOR ARROYO DEL PUERTO DRAINAGE

  6 IN       TIME DATA FOR INPUT TIME SERIES
                JXMIN          60  TIME INTERVAL IN MINUTES
               JXDATE      1JUL 1  STARTING DATE
               JXTIME           0  STARTING TIME

          SUBBASIN RUNOFF DATA

 10 BA       SUBBASIN CHARACTERISTICS
                TAREA       57.60  SUBBASIN AREA

             PRECIPITATION DATA

 11 PB          STORM        9.20  BASIN TOTAL PRECIPITATION

 12 PI        INCREMENTAL PRECIPITATION PATTERN
                0.01     0.01     0.00     0.00     0.01     0.01     0.01     0.01     0.03     0.03
                0.03     0.03     0.19     0.19     0.19     0.19     0.01     0.01     0.01     0.01
                0.01     0.01     0.01     0.01
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13 LS          SCS LOSS RATE
                     STRTL          0.72   INITIAL ABSTRACTION
                    CRVNBR         73.40   CURVE NUMBER
                     RTIMP          0.00   PERCENT IMPERVIOUS AREA

14 UD          SCS DIMENSIONLESS UNITGRAPH
                      TLAG          1.83   LAG

                                                     ***

                                                 UNIT HYDROGRAPH
                                            39 END-OF-PERIOD ORDINATES
        705.      2138.      4134.      7003.     10294.     12728.     14053.     14204.     13660.     12456.
      11010.      9091.      7084.      5649.      4569.      3747.      3083.      2512.      2008.      1644.
       1341.      1075.       875.       709.       573.       472.       383.       310.       253.       203.
        167.       141.       119.        97.        75.        56.        38.        20.         2.

*******************************************************************************************************************************
*****

                                         HYDROGRAPH AT STATION      IN1

*******************************************************************************************************************************
*****
                                                     *
 DA MON HRMN  ORD     RAIN    LOSS  EXCESS     COMP Q    *    DA MON HRMN  ORD     RAIN    LOSS  EXCESS      COMP
                                                     *
  1 JUL 0000    1     0.00    0.00    0.00         0.    *     1 JUL 0615   26     0.00    0.00    0.00     60179
  1 JUL 0015    2     0.05    0.05    0.00         0.    *     1 JUL 0630   27     0.00    0.00    0.00     51935
  1 JUL 0030    3     0.05    0.05    0.00         0.    *     1 JUL 0645   28     0.00    0.00    0.00     43607
  1 JUL 0045    4     0.05    0.05    0.00         0.    *     1 JUL 0700   29     0.00    0.00    0.00     36274
  1 JUL 0100    5     0.05    0.05    0.00         0.    *     1 JUL 0715   30     0.00    0.00    0.00     30392
  1 JUL 0115    6     0.09    0.09    0.00         0.    *     1 JUL 0730   31     0.00    0.00    0.00     25454
  1 JUL 0130    7     0.09    0.09    0.00         0.    *     1 JUL 0745   32     0.00    0.00    0.00     21187
  1 JUL 0145    8     0.09    0.09    0.00         0.    *     1 JUL 0800   33     0.00    0.00    0.00     17494
  1 JUL 0200    9     0.09    0.09    0.00         0.    *     1 JUL 0815   34     0.00    0.00    0.00     14323
  1 JUL 0215   10     0.28    0.27    0.00         2.    *     1 JUL 0830   35     0.00    0.00    0.00     11645
  1 JUL 0230   11     0.28    0.24    0.03        29.    *     1 JUL 0845   36     0.00    0.00    0.00      9458
  1 JUL 0245   12     0.28    0.21    0.06       128.    *     1 JUL 0900   37     0.00    0.00    0.00      7650
```

1	JUL	0300	13	0.28	0.19	0.09	358.	*	1	JUL	0915	38	0.00	0.00	0.00	6187
1	JUL	0315	14	1.70	0.78	0.92	1367.	*	1	JUL	0930	39	0.00	0.00	0.00	5029
1	JUL	0330	15	1.70	0.45	1.25	4046.	*	1	JUL	0945	40	0.00	0.00	0.00	4089
1	JUL	0345	16	1.70	0.29	1.41	9223.	*	1	JUL	1000	41	0.00	0.00	0.00	3325
1	JUL	0400	17	1.70	0.20	1.50	17933.	*	1	JUL	1015	42	0.00	0.00	0.00	2708
1	JUL	0415	18	0.11	0.01	0.10	29894.	*	1	JUL	1030	43	0.00	0.00	0.00	2196
1	JUL	0430	19	0.12	0.01	0.10	43620.	*	1	JUL	1045	44	0.00	0.00	0.00	1784
1	JUL	0445	20	0.11	0.01	0.10	57193.	*	1	JUL	1100	45	0.00	0.00	0.00	1455
1	JUL	0500	21	0.11	0.01	0.10	67905.	*	1	JUL	1115	46	0.00	0.00	0.00	1191
1	JUL	0515	22	0.07	0.01	0.06	73880.	*	1	JUL	1130	47	0.00	0.00	0.00	983
1	JUL	0530	23	0.07	0.01	0.06	75200.	*	1	JUL	1145	48	0.00	0.00	0.00	809
1	JUL	0545	24	0.07	0.01	0.06	72759.	*	1	JUL	1200	49	0.00	0.00	0.00	655
1	JUL	0600	25	0.07	0.01	0.06	67547.	*	1	JUL	1215	50	0.00	0.00	0.00	514
								*								

****
*****

TOTAL RAINFALL = 9.20, TOTAL LOSS = 3.26, TOTAL EXCESS = 5.94

PEAK FLOW	TIME		MAXIMUM AVERAGE FLOW					
			6-HR	24-HR	72-HR	12.25-HR	(CFS)	(HR)
		(CFS)	75200.	5.50		35645.	17987.	17987.	17987.
		(INCHES)	5.754	5.928	5.928	5.928		
		(AC-FT)	17675.	18210.	18210.	18210.		

CUMULATIVE AREA = 57.60 SQ MI

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD			BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAG
				6-HOUR	24-HOUR	72-HOUR			
HYDROGRAPH AT	IN1	75200.	5.50	35645.	17987.	17987.	57.60		

HEC-RAS Plan: ADP PMF River: Arroyo del Puert Reach: Ambrosia Mill Profile: PF 1

Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Ambrosia Mill	7460	78000.00	6938.00	6950.23	6950.23	6952.03	0.008301	19.47	7828.17	1996.25	1.00
Ambrosia Mill	7080	78000.00	6933.06	6947.21	6946.20	6948.42	0.005969	12.40	9063.01	2156.39	0.61
Ambrosia Mill	6810	78000.00	6930.47	6945.79		6946.66	0.002788	8.98	10649.12	1819.70	0.42
Ambrosia Mill	6310	78000.00	6928.82	6943.34		6945.36	0.007495	14.16	6895.15	1257.27	0.69
Ambrosia Mill	5500	78000.00	6924.36	6939.21		6940.49	0.004540	11.20	8856.19	1674.95	0.54
Ambrosia Mill	4580	78000.00	6919.30	6934.77		6936.09	0.005033	12.15	8746.61	1747.90	0.57
Ambrosia Mill	3080	78000.00	6911.05	6926.21		6927.77	0.006100	13.18	8072.49	1660.94	0.62
Ambrosia Mill	1980	78000.00	6905.00	6920.54	6919.80	6921.62	0.005331	12.55	9668.55	2324.85	0.59
Ambrosia Mill	1450	78000.00	6904.00	6916.59	6916.59	6919.12	0.005642	17.14	7020.86	1247.15	0.86
Ambrosia Mill	0	78000.00	6893.00	6907.57	6907.33	6909.55	0.006007	19.05	7643.78	1482.35	0.90

APPENDIX B

POND 1 AND 3 APRON, SURFACE AND EMBANKMENT CALCULATIONS

MAXIM
TECHNOLOGIES INC

JOB NO. 1690030-300 **JOB TITLE** Quivira **DATE** 12/10/01 **BY** RLH

SUBJECT Pond 1 Run-off to Pond 3 **CHECKED** ______ **SHEET** 1 **OF** 2

Apron Calculations / Method

Using Method of NUREG CR-1623 Appendix D
Section 6 - Riprap Sizing at Toe

1.) Slope Length = 520ft (From Quivira Fly Over Survey)

Note: Two Slopes Measured For Length
Both Similar In Length. Longest
Length of 460ft chosen for calcs.

2.) Maximum Slope:

Length = 520ft
Δelev. = 7025' - 6938' = 87 ft

Slope = 17% (From Fly Over Survey)

Embank. Slope Designed At 20% (From Quivira)

Max. Slope = 20% for calculations.

3.) Time of Concentration:

$$t_c = (11.9\ L^3/H)^{0.385}$$

$$= \left(11.9\left(\frac{520}{5280}\right)^3 / 87\right)^{0.385}$$

t_c = 0.032 hrs = 1.92 minutes

4.) * Use 2.5 min. rainfall From Nelson et al (1986)
- Shortest Increment Available

2.5 min PMP = 0.275 x 9.6" = 2.64"

* - Using 9.6" PMP For Local Storm

(continued)

5.) Use Rational Method For Unit Flow Width

$L = 460$ $\quad Area_{unit\,h} = 520 \times 1ft = 520\ ft^2$
$= \underline{0.012\ acres}$

$i = 60 \times \dfrac{2.64''}{2.5} = 63\ in/hr$

Flow, q_u @ Unit Width:

$q_u = Cia = 1.0 \times 63 \times 0.012 = 0.76\ \frac{cfs}{ft}$

$C = 1.0$ (Rock Covered Slope)

6.) Using Equation D-18 From NUREG 1623
Appendix D - Rock Sizing

Concentration Factor $C_f = 2.5$

$D_{50} = 10.46 \cdot S^{0.43} (C_f \times q_u)^{0.56}$

$D_{50} = 10.46 \cdot (.2)^{0.43} (2.5 \times 0.76)^{0.56}$

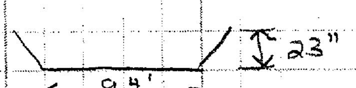
$D_{50} = \underline{7.5''}$

__Notes:__ Assuming Pond 3 Is Level North to South.

7.) Minimum Apron Configurations:
Per NUREG 1623

1.) Minimum __Depth__ of Rock Apron @ 7.5" = $3 \times D_{50}$
Placement Depth = __23"__

2.) Minimum __Width__ of Rock Apron @ 7.5"
$= D_{50} \times 15 = 7.5'' \times 15 = 112.5''$



Placement Width = __9.4 ft__

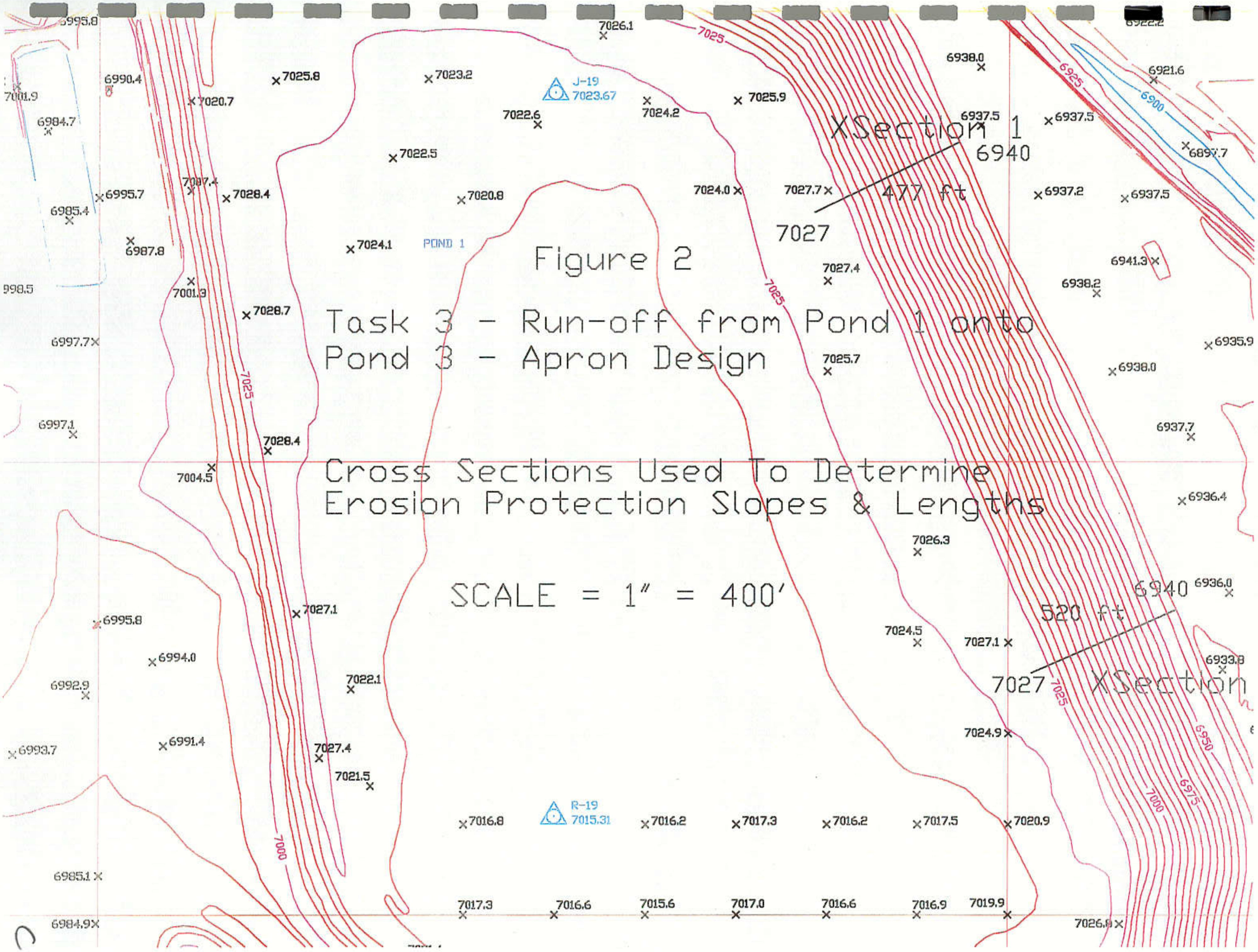


Figure 2
Task 3 - Run-off from Pond 1 onto
Pond 3 - Apron Design
Cross Sections Used To Determine
Erosion Protection Slopes & Lengths
SCALE = 1″ = 400′
XSection 1
6940
477 ft
7027
XSection
6940
520 ft
7027
POND 1
J-19
7023.67
R-19
7015.31
7025
7000
6975
6950
6925
6900

C07

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JOB NO. 1690030-300 **JOB TITLE** Quivira **DATE** 12/10/01 **BY** RLH
SUBJECT Pond 3 Top Rocked Slope **CHECKED** ______ **SHEET** 1 **OF** 2

Top Slope of Pond 3 Erosion Control Calculations:

Using Method of NUREG CR-1623 Appendix D
Section 2 - Rip Rap Sizing on Slopes.

1) Slope Length = 700 ft (From Quivira Fly Over Survey)
(Pond 3 Surface)
Note: Used longest length obtainable on Surface of Pond 3.

2) Maximum Slope:

Length = 700 ft

(*) Set Top of Pond 3 Slope to 0.3 %

Assumptions:
Pond 3 Surface will be graded such that concentrated flows are not present; that the Pond 3 Surface will all be constructed at 0.5% with positive drainage into the Arroyo del Puerto.

3.) Time of Concentrations: (For Pond 3 Surface)

$t_c = (11.9 \times L^3/H)^{0.385}$

$= (11.9 \times (\frac{700}{5280})^3/2)^{0.385}$

$t_c = 0.193$ hours $= 11.6$ minutes

4.) From Nelson et al (1986) - Percent of Probable Maximum Precipitation For Rainfall Durations. (1 hr - 1 mi.^{2}) 9.6" PMP

Total Time of Concent. $= t_c + t_c$ of Pond 1 Slope

$T_c = 11.6\text{ min} + 1.92\text{ min} = 13.52\text{ min}$

Rainfall Increment from From Nelson et al.
For 13.52 min = % of 1 hour PMP = 70%
∴ 13.52 min PMP = 0.70 × 9.6" = 6.72"

(continued)

5.) Using Rational Method For Unit Flow Width

$L_{P_3 side} = 520$ ft

$L_{P_3 Surface} = 700$ ft Unit Area = 700 ft × 1 ft = 700 ft²

→ $L_{System} = L_{P_1 side} + L_{P_3 surface} = 520 + 700 = 1220$ ft = 1220 ft²

= <u>0.028 acres</u>

$i_{intenisty} = 60 \times \frac{6.72}{13.52} = 29.8$ in/hr

$q_{Unit Flow} = Cia = 1.0 \times 29.8 \times 0.028$

$q_u =$ <u>0.84</u> cfs/ft

C = 1.0 (Rock Covered Slope)

6.) Using Equation in Section 2.4.1, the Abt and Johnson Method for Top Slopes.

$D_{50} = 5.23 (Slope)^{0.43} (q_u)^{0.56}$

q_u: Unit Flow Across Pond 3 includes Flow (Run OFF) From The Pond 1 Embankment. The Unit Flow was previously calculated For the Run-off Apron at The Pond 1 and Pond 3 Interface. Unit Flow used For The Calculating the D_{50} For the Pond 3 Surface was developed using the sum of the ~~t~~ t_c and unit area of both Pond 1 Side Slope and Pond 3 Surface.

$D_{50} = 5.23 (S_{slope})^{0.43} (q_{u sum})$

$D_{50} = 5.23 (0.003)^{0.43} (0.84)^{0.56}$

$D_{50} =$ <u>0.4 inches</u>

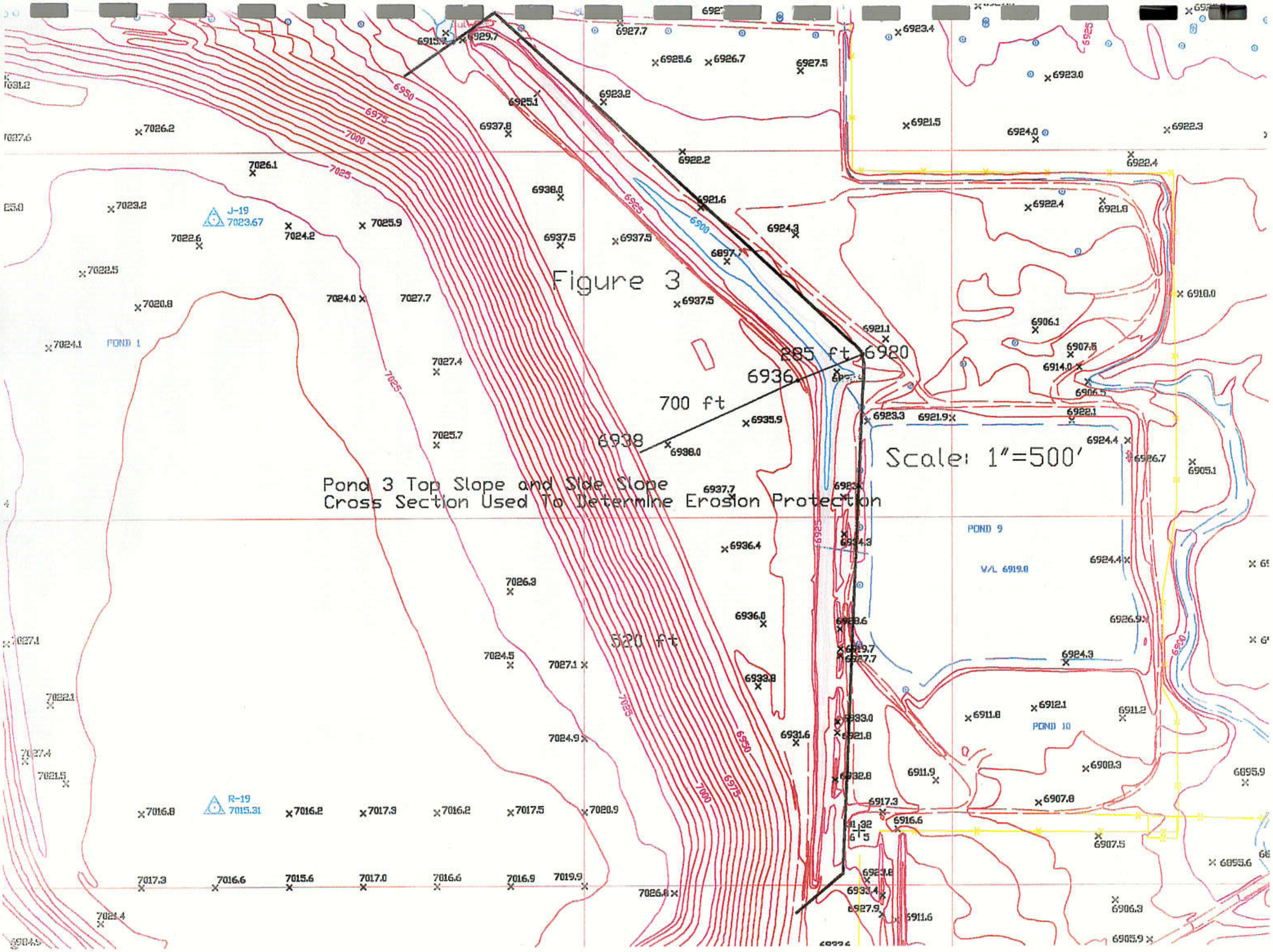

Figure 3
Scale: 1"=500'
Pond 3 Top Slope and Side Slope
Cross Section Used To Determine Erosion Protection
285 ft
6920
6936
700 ft
6938
520 ft
POND 1
POND 9
W/L 6919.8
POND 10
J-19
7023.67
R-19
7015.31

C08

Side Slope of Pond 3 Erosion Control Calculations

Using Method of NUREG CR-1623 Appendix D
Section 2 - Rip Rap Sizing on Slopes

1.) Slope Length = 65' ft (From Quivira Fly Over Survey)

Notes: Used Average to Long Slope Lengths From Projected Slope on an Estimated Pond 3 Crest Elevation of 6936 ft. And Approximate Toe Elevation of 6923 ft was used in Thes Calculations. Del = 13'

2.) Maximum Slopes

Length = 65 ft
Δ elev = 6936 - 6923 = 13 ft > 20% Slope 5H:1V

* Assumptions: Crest Elevation of Pond 3 Assumed to be 6936 ft and Toe Elevation to be 6923 ft for Design Calculations. With these Parameters, the Average slope Length is approximately 65 ft.

3.) Time of Concentrations: (For Pond 3 Embankment Surface)

$$t_c = (11.9 \times L^3/H)^{0.385}$$

$$= \left(11.9 \times \left(\frac{65}{5280}\right)^3 / 13'\right)^{0.385}$$

t_c = 0.006 hrs = 0.36 minutes

4.) Total Time of Concentration, t_c equal to Σt_c.

$\therefore \Sigma t_c = t_c$ Pond 1 Emb + t_c Pond 3 surface + t_c Pond 3 Emb.

Total Time of Cocentration = $t_c + t_{c\text{ of Pond 1 Side}} + t_{c\text{ of Pond 3 Surface}}$

T_c = 0.36 + 1.92 + 11.6 min = 13.88 min

Rainfall Increment From Nelson et al For 13.98 min = % 1 hour PMP

$\therefore$ 13.98 min PMP = 0.71 x 9.6" = 6.8"

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JOB NO. 1690030-300 **JOB TITLE** Quivira **DATE** 12/10/01 **BY** RLH

SUBJECT Pond 3 Side Rocked Slope And Apron Calcs. **CHECKED** ______ **SHEET** 2 **OF** 3

5.) Using Rational Method For Unit Flow Width:

L_{sum} = Pond 1 Side + Pond 3 Surface = 1220 ft

L = 65 ft Area = 65 ft x 1 ft = 65 ft^2

L = 1220 + 65 = 1285 ft = 1285 ft^2 Area = 0.030 acres

$i_{intensity} = 60 \times \frac{6.8}{13.88 min} = 29.4 in/hr$

$q_{unit flow} = Cia = 1.0 \times 29.4 \times 0.030 = \underline{0.88} \frac{cfs}{ft}$

C = 1.0 (Rock Covered Slopes)

6.) Using Equation in Section 2.4.1 the Abt and Johnson Method For Side Slopes.

$D_{50} = 5.23 (Slope)^{0.43} (q_u)^{0.56}$

q_u = Unit Flow Across Pond 3 Side Slope includes Flow from Pond 1 side slope plus Pond 3 top slope and Pond 3 Side Slope. Unit Flow used to For calculating the D_{50} For Pond 3 Side Slope was developed using the sum of the tc and unit width area of Pond 1 side Slope, Pond 3 Surface and Pond 3 Side Slope

q_u = 0.88 cfs/ft

$D_{50} = 5.23 \times (20\%)^{0.43} \times (0.882)^{0.56}$
0.932

D_{50} = $\underline{2.43 inches}$

7.) Pond 3 Side Slope Rock Apron Calculations:
Using Some Parameters and Results Above To calculate Apron Rock Sizing with The use of equation D-18 of Appendix D.

$D_{50} = 10.46 \times S^{0.43} \times (q \times C_f)^{0.56}$

(Continued)

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JOB NO. 1690030-300 **JOB TITLE** Quivira **DATE** 12/10/01 **BY** RLH

SUBJECT Pond 3 Side Slope / Apron Rock Calculations. **CHECKED** ______ **SHEET** 3 **OF** 3

7.) Continued. (Apron Calc. For Rock Size)

$$D_{50} = 10.46 \times (0.20)^{0.43} \times (0.882 \times 3.0)^{0.56}$$

Note: Flow Concentration Factor = 3.0

D_{50} = <u>8.5 inches</u>

8.) Minimum Apron Configurations:
Per NUREG 1623

1.) Minimum <u>Depth</u> of Rock @ 8.5 inches (Apron)

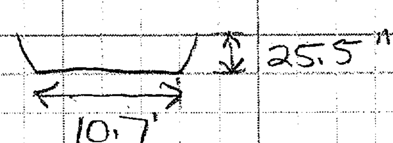
Depth = $3 \times D_{50}$

Depth = <u>25.5 inches</u>

2.) Minimum <u>Width</u> of Rock Apron @ 5.7 inches

Width = $15 \times D_{50}$

Width = 128. inches = <u>10.7 ft</u>



ALBUQUERQUE, NEW MEXICO 505-237-8440 MIDLAND, TEXAS 915-686-8081

- Erosion Protection For Slopes North of Pond 1, Near Pond 1 North Embankment and South of The Arroyo De Puerto:

Using Method of NUREG 1623 Appendix D Section 2 - RipRap Sizing on Slopes.

1.) Slope Length:

Longest Possible Slope Length, 1,700 ft.

Starting at Elevation 7005
Ending at Elevation 6926

- * Route Chosen From Maximum Possible Length and Along Steeper Sloped Areas.

2.) Average Slope:

Slopes for Calculation of Erosion Protection were obtained from Topographic information provided by Quivira.

- Station 0+00 to Station 6+50

Average Slope is approximately 3.0

- Station 6+50 to Station 13+00

Average Slope is approximately 7.5

- Station 13+00 to Station 17+00

Average Slope is approximately 2.5

3.) Time of Concentration:

Time of Concentration was calculated Below Using The Entire Drainage Path Length of 1,700 ft.

(continued)

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JOB NO. 16900 30-300 **JOB TITLE** Quivira **DATE** 12/10/01 **BY** RLH

SUBJECT Task 3- North Area Rock **CHECKED** ______ **SHEET** 2 **OF** 3

3.) Continued.

$$t_c = (11.9 \times L^3 / H)^{0.385}$$

$$t_c = \left(11.9 \times \left(\frac{1700}{5280}\right)^3 / 79\right)^{0.385}$$

t_c = 0.13 hrs = 7.82 minutes

4.) From Nelson et al (1986) - Percent of Probable Maximum Precipitation for Rainfall Duration (1 hr - 1 mi^2)

@ t_c = minutes ; % of 1 hr - PMP = 54%

Using PMP for Local Storm of 9.6"

∴ 7.82 min PMP => 0.54 × 9.6" = 5.2"

5.) Using Rational Method For Unit Flow Width

L = 1,700 ft Area = 1,700 ft^2 = 0.04 acres,

$$i_{intensity} = 60 \times \frac{5.2}{7.82} = 39.9 \text{ in/hr}$$

$q_{unit\ flow}$ = Cia = 1.0 × 39.9 × 0.04

q_u = 1.6 cfs/ft

C = 1.0 (Rock Surfaced Slope)

6.) Using Equation in Section 2.4.1, the Abt and Johnson Method for Slopes,

$$D_{50} = 5.23 (\text{Slope})^{0.43} (q_u)^{0.56}$$

$$D_{50} = 5.23 (7.5\%)^{0.43} \left(\frac{1.6}{1.3}\right)^{0.56}$$

D_{50} = 2.2 inches For Entire Slope.

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SUBJECT ______ **CHECKED** ______ **SHEET** 3 **OF** 3

Alternative

6. a.) Rock Sizing by breaking North Area into two(2) Sections: The flatter top slope Area and the steeper longer sections of the lower slopes.

1.) Upper Section: STA 0+00 to STA 6+50

- Slope Length L = 650 ft
- Average Slope = 3.0 %
- Change In Elev. = 7005 to 6985 = 20 ft
- t_c = 0.073 hrs. = 4.4 min.
- @ t_c = 4.4 min the 4.4 min PMP For a 1hr storm is:

From Nelson et al (1986)

4.4 min PMP = 9.6" x 0.44 = 4.2 in

- Unit Area - Rational Method Area = 650 ft^2 = 0.015 acres.
- Intensity $i = 60 \times \frac{4.2}{4.4 \text{ min}} = 57.6$ in/hr
- q_u = cia = 1.0 x 57.6 x 0.015 = 0.865
- $D_{50} = 5.23(0.03)^{0.43}(0.865)^{0.56}$ (.221)

D_{50} = 1.1 inch. (Upper 650 ft)

2.) Lower Section: STA 6+50 to STA 17+00

Rock Size same As Calculated In Step 6.

D_{50} = 2.2 inches.

APPENDIX C

DIVERSION CHANNEL CALCULATIONS

I Station 0+00 To Station 9+00 (Diversion Channel)

Method: Calculate Flow Rate For Channel Used To Control Flows From South of This Channel And North Of Pond 1 & To Prevent Headcutting Using NUREG CR-1623

Location: Area North of Pond 1 Where Possible Head Cutting May occur. STA 0+00 to 9+00.

- Channel Length = 900 ft
- Start Elev. = 7,007 ft
  End Elev. = 6,989 ft   ΔEl = 18 ft
- Average Slope $= 100 \frac{\Delta El}{Length} = 100 \left(\frac{18 ft}{900 ft}\right) = 2.0\%$

A.) PMP For Local Storm = 9.6" (1hr - 1mi²)

Calculate PMF Using Rational Method

1.) Area = 2.9 Acres

- Area Between Diversion Channel & Erosion Protection Channel / Apron of Pond 1 That May Drain Into The Diversion Channel. Most Run-Off Will Run North East On Area Noted, Without Entering The Channel As Sheet Flow, Draining Into The Discharge Channel Or Beyond Station 9+00. Assuming 75% Of RunOff To Enter Channel From This Area and Will Do So Above station 9+00.

- Area North of Diversion Channel Shall Flow Away From Channel As Determined From Topographic Information Provided By Rio Algom.

(Continued) Actual Area = 75% of 2.9 Acres = 2.2 acres

Continued STA 0+00 to STA 9+00 (Diversion Channel)

2.) Time of Concentration, t_c:

$$t_c = \left(11.9 \cdot L^3 / H\right)^{0.385}$$

$$t_c = \left(11.9 \cdot \left(\frac{900}{5280}\right)^3 / 18\text{ ft}\right)^{0.385}$$

t_c = 0.110 hrs = 6.63 minutes

3.) Intensity, i:

Incremental Rainfall From Table 2.1 (Nelson, 1986)

6.63 min PMP = 51% (9.6 in) = 4.9"

$i = 60 \times 4.9/6.63 = 43.9$ in/hr

4.) Flow, Q:

$Q = CiA$ C = 1.0 - (Rock Covered Surface)

$Q = 1.0 \times 43.9 \times 2.2$ acres

Q = 96.6 CFS

5.) Channel Configurations:

Parameters:

- See Attached Spreadsheet No. 1
- 3 ft Wide - Trapezoidal
- 2H:1V Side Slopes
- Average Slope = 20% (From Quivira)
- 2.2 acre Area (75% of Total Area)
- PMP = 9.6" /hr - 1 mi²
- Flow = 96.6 cfs

(Continued)

MAXIM TECHNOLOGIES INC

JOB NO. 16900300300 JOB TITLE Quivira DATE 1/10/02 BY RLH

SUBJECT North Area Erosion Diversion Channel CHECKED ______ SHEET 3 OF 10

Continued STA 0+00 to STA 9+00 (Diversion Channel)

6.) Sizing Of Rock

Using Johnson & Abt et al (1998)

$D_{50} = 5.23\, q_u^{0.56} * S^{0.43}$

$q_u = \frac{Q}{\text{width}}$ = Unit Flow

$q_u = 96.6 / 3\text{ ft} = 32.2\text{ cfs/ft}$

$D_{50} = 5.23 (32.2)^{0.56} * (0.02)^{0.43}$

6.18597

$D_{50} = 6.8''$ For Bottom of Channel

Side Slope Factors Per ACE Hydraulic Design of Flood Control Channels Sec. 3.7 Stone Size (1995)

Side Slope Factor = 1.2 x Bottom Size D_{50}

$D_{50 \text{ Side Slopes}} = 1.2 \times 6.8 = 8.2''$

$D_{50} = 8.2''$ Use For Side & Bottom of Channel

II Station 9+00 to Station 17+00 (Diversion Channel)

- Channel Length = 800 ft (t_c Length = 1700 ft)
- Start EL = 7,007 ΔEl = 68 ft For t_c
  End EL = 6,939
- Average Slopes = 8% For Rock Sizing & 5% For Channel Sizing
- PMP = 9.6''

1.) Area = 6.5 Acres + Area of Sta 0+00 to 9+00

Area = 6.5 + 2.9 Acres) = 9.4 acres

Notes: Assume 70% Flows into Channel From 6.5 Acre Area

Assume 100% Flows Into Channel From 2.9 Acre Area

(continued) $A = (.7)6.5 + 2.9 = 7.4$ Acres

Continued STA 9+00 to 17+00 (Diversion Channel)

2.) $t_c = \left(11.9 \times \left(\frac{1700}{5280}\right)^3 / 68\ ft\right)^{0.385}$

$t_c = 0.138$ hrs = **8.3** minutes

3.) Intensity, i:

Incremental Rainfall From Table 21 (Nelson 1986)

8.3 min PMP = 0.56 × 9.6" = 5.4"

$i = 60 \times \frac{5.4}{8.3} = $ **39.0** in/hr

4.) Flow, Q:

Q = 1.0 x 39.0 x 7.4

C = 1.0 Rock Covered Surface

Q = **288** cfs

5.) Channel Configurations:

Parameters:

- Depth - See Attached Spreadsheet, No. 2
- 20 ft Wide - Trapezoidal
- 2H:1V Side Slopes
- Average Slope = 5% (Channel Sizing)
- PMP = 9.6" /hr-Mi²
- Flow = 288 cfs

6.) Sizing of Rock

- Average Slope = 8% (Rock Sizing)

Using Johnson & Abt et al (1993)

$q_u = 288/20 = 14.4$ cfs/ft

$D_{50} = 5.23 (14.4)^{0.56} * (0.08)^{0.43}$

continued.

Continued STA 9+00 to 17+00 (Diversion Channel)

6.) Continued

$D_{50} = 7.8$ For Bottom of Channel

$D_{50_{SS}} = 1.2 \times D_{50_{Bottom}}$

$D_{50_{SS}} = 9.3''$ For Side Slopes.

$\boxed{D_{50} = 9.3''}$ Use For Side & Bottom of Channel

III Station 17+00 to Station 27+01 (End) (Diversion Channel)

- Channel Length = 1,001 ft (t_c length = 2,701 ft)
- Start El = 7,007 ft ΔEl = <u>81</u> ft for t_c
  End El = 6,926 ft
- Average Slope = <u>0.9%</u> For Rock Sizing <u>0.9%</u> For Channel Sizing
- PMP = 9.6" /hr - 1 mi²

1.) Area = 9.2 Acres (75% Into Div. Channel, 20% Into Discharge Channel)
+ 6.5 Acres Area (100%)
+ 2.9 Acres Area (100%)

$A = (0.75 \times 9.2) + 6.5 + 2.9 = \underline{16.3}$ acres

2.) $t_c = \left(11.9 \times \left(\frac{2701}{5280}\right)^3 / 81\right)^{0.385} \times 60 = \underline{13.2}$ min.

3.) intensity, i:

Incremental Rainfall From Table 2.1 (Nelson 1986)

13.2 min PMP = 0.70 × 9.6 = 6.72"

$i = 60 \times \frac{6.72}{13.2} = 30.5$ in/hr

4.) Flow, Q:

$Q = 1.0\,(30.5)(16.3) = \underline{497 \text{ cfs}}$

C = 1.0 (Rock Covered Surface)

Continued STA 17+00 to Station 27+01 (End) (Diversion Channel)

5.) Channel Configurations:

Parameters:
- Depth - see Attached Spreadsheet, No. 3
- 28 ft Wide - Trapezoidal
- 2H:1V Side Slopes.
- Average Slope = 0.9% For Channel Sizing
- PMP = 9.6" 1hr - 1mi²
- Flow = 497 cfs.

6.) Sizing of Rock
- Average Slope = 0.9% (Rock Sizing)

Using Johnson & Abt et al (1998)

$$q_u = \frac{497}{28'} = 17.75 \text{ cfs/ft}$$

$$D_{50} = 5.23\,(17.75)^{0.56}\,(0.009)^{0.43}$$

.13192

D_{50} = 7.2 inches For Bottom of Channel

D_{50} = 7.2 (1.2) = 8.7 inches Side Slopes

D_{50} = 8.7 inches For Side & Bottom of Channel

IV Channel Summary: (Diversion Channel)

Location	D_{50}	Width	Depth
STA 0+00 to STA 09+00	8.2*	3 ft	3.5 min**
STA 09+00 to STA 17+00	9.3*	20 ft	2.5 min**
STA 17+00 to STA 27+01	8.7*	28 ft	3.5 min**

* Per Rio Algom - A D_{50} = 9.2" Rock Size has been used in other design tasks @ Ambrosia Lake Mill. To Reduce Rock Gradings For Erosion Protection @ the Mill Site - D_{50} = 9.2 in. Will Be Used Throughout

(Continued)

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JOB NO. 1690030-300 **JOB TITLE** Quivira **DATE** 1/10/02 **BY** RLA

SUBJECT North Diversion Channel **CHECKED** ______ **SHEET** 7 **OF** 10

** Depth: The Channel Depth was Determined Using a Channel Hydraulics Modeling Program, Flow Pro 2.0. Summary Sheets Are Attached.

Task 3 Channel Design - Channel - Inputs to get channel Depth

No.1

1. MANNING OUTPUT

OPEN CHANNEL DESIGN - STRICKLER'S EQUATION

ASSUMPTIONS & EQUATIONS Where K=Ave Flume Data (ACE 1994)

Mannings Value, n ~ K(D90)^0.16667

D90 of D50 = 9.2 inch Rock Particle Distribution = 12" (See Design Report For Gradation)

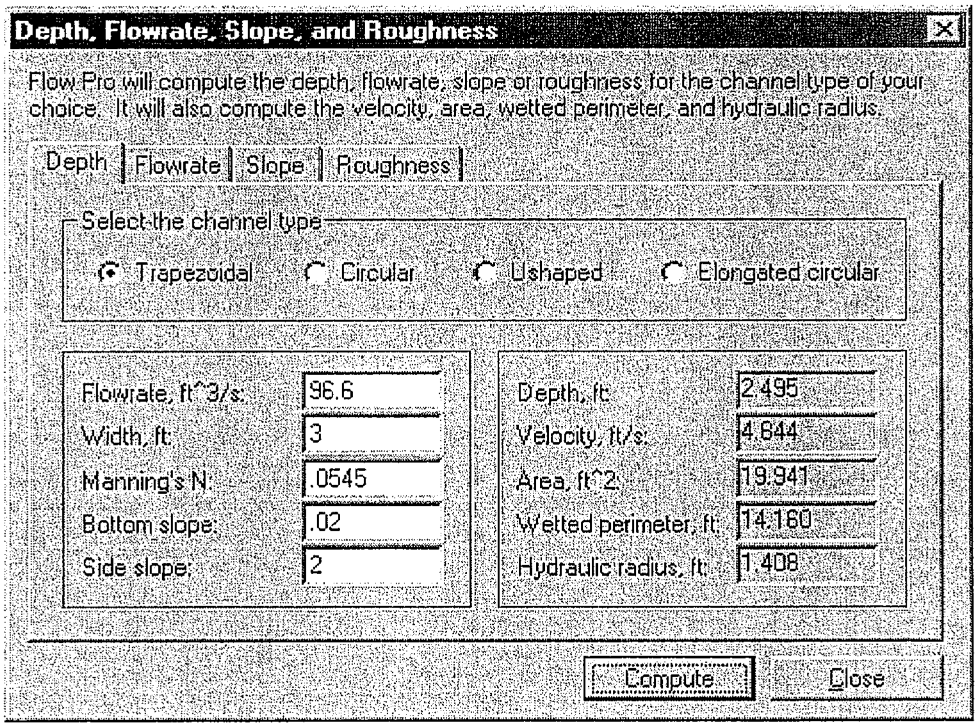
Note: Army Corp. of Engineers - Hydraulic Design of Flood Control Channels (1991)

CALCULATION: Using Army Corp. Of Engineers (ACE) Method (ACE, 1991)

Inputs	Value	Units
D50'	12	inches

Output	Value	Units
n	0.0545	

2. CHANNEL DEPTH OUTPUT



Task 3 Channel Design - Channel - Inputs to get channel Depth

No. 2

1. MANNING OUTPUT

OPEN CHANNEL DESIGN - STRICKLER'S EQUATION

ASSUMPTIONS & EQUATIONS Where K=Ave Flume Data (ACE 1994)

Mannings Value, n ~ K(D90)^0.16667

D90 of D50 = 9.2 inch Rock Particle Distribution = 12" (See Design Report For Gradation)

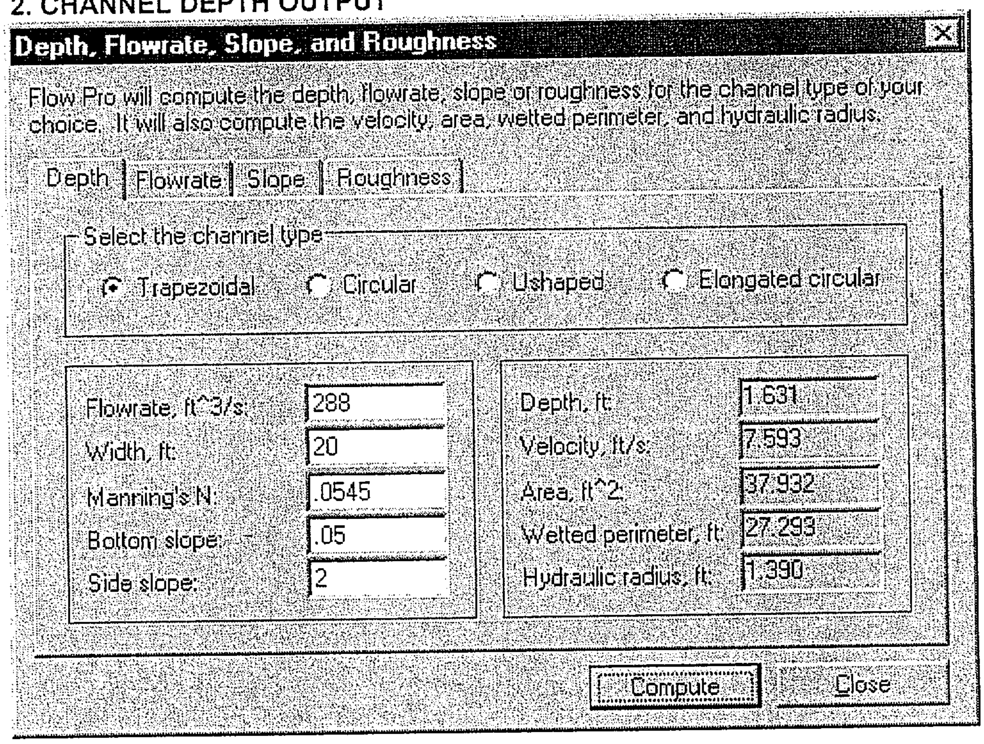
Note: Army Corp. of Engineers - Hydraulic Design of Flood Control Channels (1991)

CALCULATION: Using Army Corp. Of Engineers (ACE) Method (ACE, 1991)

Inputs	Value	Units
D50'	12	inches

Output	Value	Units
n	0.0545	

2. CHANNEL DEPTH OUTPUT



10/10

Task 3 Channel Design - Channel - Inputs to get channel Depth

No.3

1. MANNING OUTPUT

OPEN CHANNEL DESIGN - STRICKLER'S EQUATION

ASSUMPTIONS & EQUATIONS Where K=Ave Flume Data (ACE 1994)

Mannings Value, n ~ K(D90)^0.16667

D90 of D50 = 9.2 inch Rock Particle Distribution = 12" (See Design Report For Gradation)

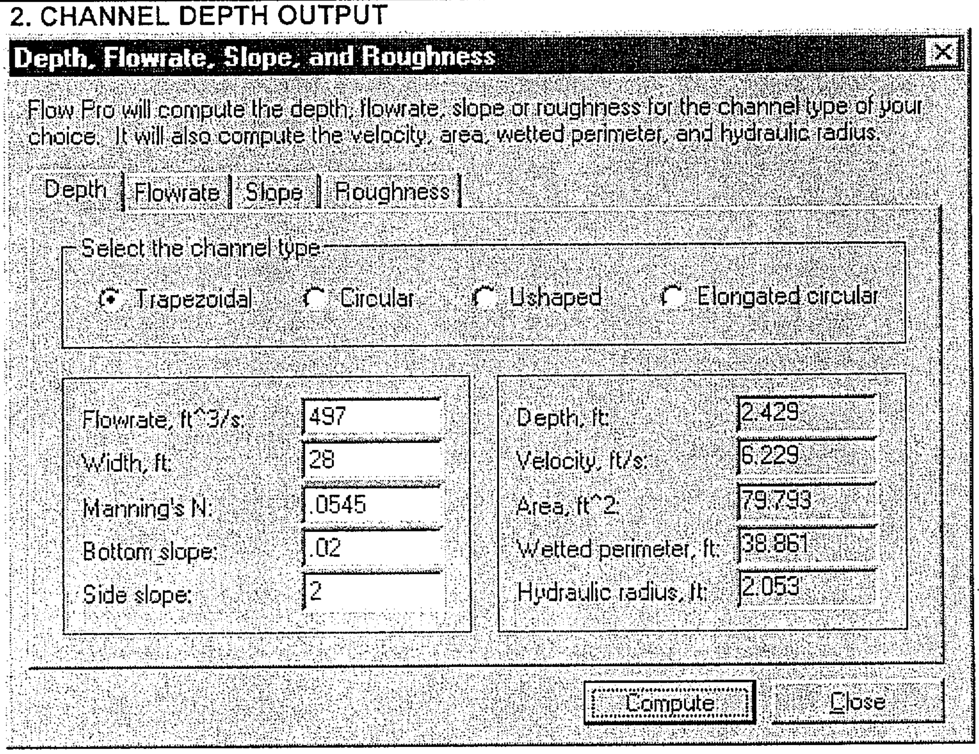
Note: Army Corp. of Engineers - Hydraulic Design of Flood Control Channels (1991)

CALCULATION: Using Army Corp. Of Engineers (ACE) Method (ACE, 1991)

Inputs	Value	Units
D50'	12	inches

Output	Value	Units
n	0.0545	

2. CHANNEL DEPTH OUTPUT



— D_{50} Gradation Determination:

Method: Hydraulic Design of Flood Control Channels Section 3-2 Chapt. 3, Army Corp of Eng. 1995

Hydraulic Jump Section On Channels Require Rock Size of D_{50} = 17".

1.) D_{50} = 17", Per Figure 3-2 ⇒ 250 lbs

2.) From Table 3-1 - Gradations For RipRap.

With $D_{50} \Rightarrow W_{50}$ = 250 lbs.

Using D_{100} = 27" Gradation Max Size

Size	Weight Range (Gradation) lbs Max	Min
D_{100}	984 (27")	394 (20")
D_{50}	292 (18")	197 (15")
D_{15}	146 (14")	62 (10")

∴ D_{100} = 27"

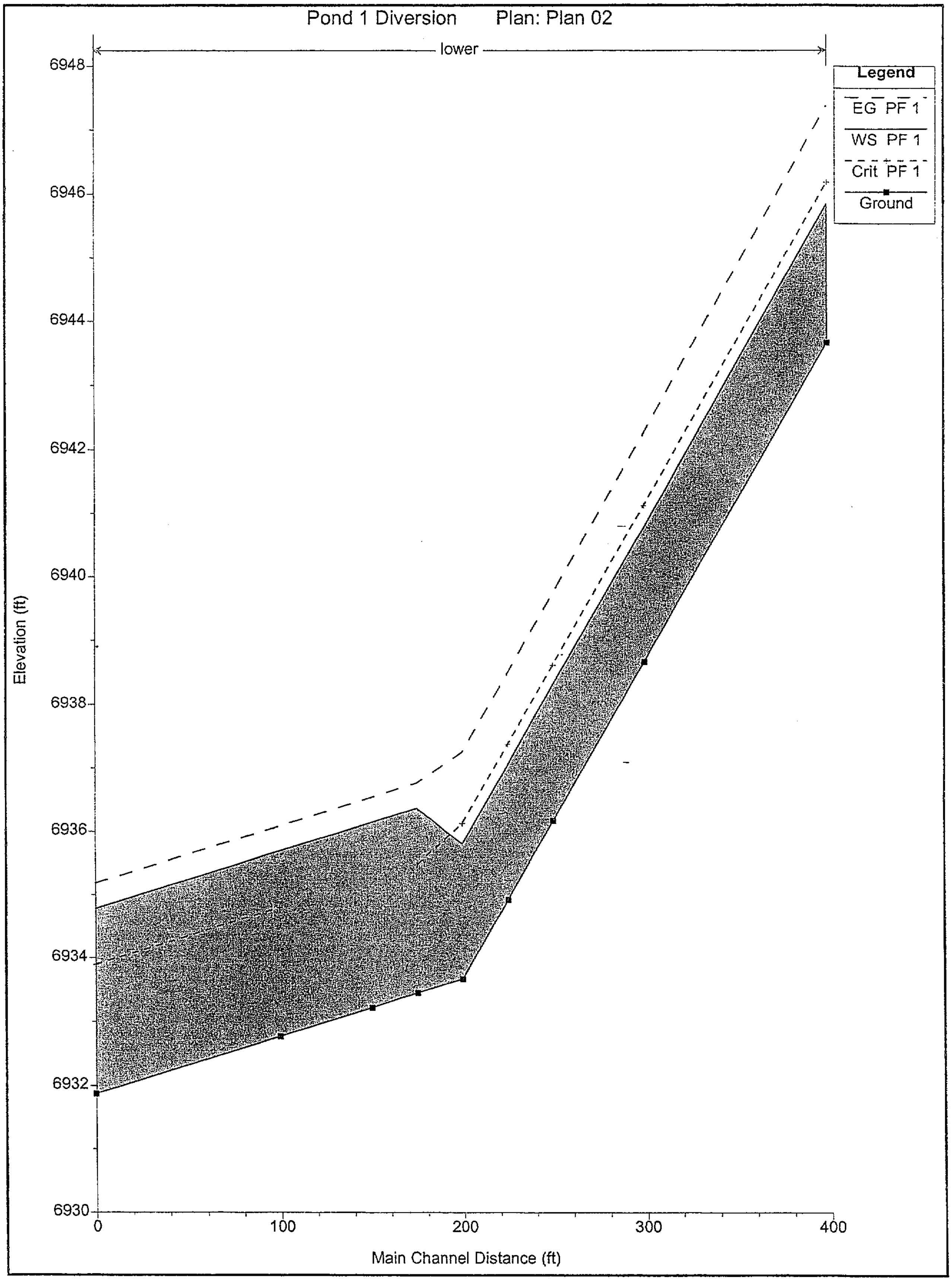
D_{50} = 17"

3.) Gradation:

Sieve Designation	% Passing
27	100%
18"	50-93%
14"	15-56%
10"	0-15%

HEC-RAS Plan: Plan 02 River: Pond1diversion Reach: lower Profile: PF 1

Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
lower	400	498.00	6943.67	6945.85	6946.18	6947.38	0.050065	9.93	50.16	26.09	1.26
lower	300	498.00	6938.67	6940.77	6941.12	6942.26	0.052044	9.78	50.93	28.42	1.29
lower	250	498.00	6936.17	6938.32	6938.62	6939.73	0.048539	9.55	52.14	28.59	1.25
lower	225	498.00	6934.92	6937.05	6937.37	6938.49	0.049952	9.64	51.64	28.52	1.26
lower	200	498.00	6933.67	6935.80	6936.12	6937.24	0.049952	9.64	51.64	28.52	1.26
lower	175	498.00	6933.45	6936.36	6935.47	6936.76	0.008986	5.05	98.56	39.65	0.56
lower	150	498.00	6933.22	6936.14		6936.53	0.008939	5.04	98.73	39.67	0.56
lower	100	498.00	6932.77	6935.68	6934.80	6936.08	0.008986	5.05	98.56	39.65	0.56
lower	0	498.00	6931.87	6934.78	6933.90	6935.18	0.009007	5.06	98.48	39.65	0.57



Pond 1 Diversion Plan: Plan 02
lower
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
6948
6946
6944
6942
6940
6938
6936
6934
6932
6930
Elevation (ft)
0
100
200
300
400
Main Channel Distance (ft)

APPENDIX D

DISCHARGE CHANNEL AND APRON CALCULATIONS

Flow Sections:

– Methods: Calculate Flow Rate For Discharge Channel Located North of Pond 3 That Will Discharge Flow From The Pond 1 Channel / Toe Apron Into The Arroyo del Puerto.

A) Lengths: Toe Channel/Apron (see Task 2):

$L_1 = 2,100$ Ft

Discharge Length From Channel/Apron To End of Discharge Channel:

$L_2 = 606$ Ft

$L_{1+2} = 2,706$ ft

B.) PMP = 9.6" (1hr - 1mi²) (As Previously Determined In Task 1 and Task 2.)

Calculate PMF From Rational Method

1.) Area: Draining Into L_1 = 13.4 Acres.
Draining Into L_2 = 2.3 Acres (25% of 9.6 Acres.)

Note: AL_1 Area => Pond 1 Embankment Adjacent
AL_2 Area => Area Within North Area Erosion Protection Boundary & NorthWest of Discharge Channel.

Note: L_2 Area is 25% of 9.2 acres depicted in Diversion Channel Design Section. 75% Flows Into Diversion Channel.

$AL_1 + L_2$ = 15.7 Acres

2.) Time of Concentration, t_c:

Computed For Length of Flow Starting at the beginning of Pond 1 Channel/ Apron @ Elev. 7026 ft.
(continue)

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JOB NO. 690030-300 **JOB TITLE** Quivira **DATE** 3/1/02 **BY** RLH

SUBJECT Task 3 - Discharge Channel **CHECKED** ______ **SHEET** 2 **OF** 5

(Continued)

2) Time of Concentration t_c:

$$t_c = \left(11.9 \times L^3/H\right)^{0.385}$$

$$t_c = \left(11.9 \times \left(\frac{2706}{5280}\right)^3 / 100\right)^{0.385}$$

$H = El._1 - El._2$

$H = 7026 - 6926$

$H = 100 ft = \Delta el.$

$t_{c_{L2}} = 0.2036 hrs = 12.21 min.$

Using Available Increments From Table 2.1 (Nelson et al, 1986)

@ 12.21 min the % of 1-hour PMP:

<u>67%</u> of 1-hour PMP

∴ 12.21 min PMP = 0.67 × 9.6" = 6.5"

3) Intensity, i: (Based on $t_{c_{Total}}$)

$$i = 60 \times \frac{6.5}{12.21} = \underline{\underline{31.7}} \text{ in/hr}$$

C) Discharge:

Q = CiA

A = 15.7 Acres
i = 31.7 in/hr
C = 1.0 - Rock Covered Surfaces.

Q = 1.0 (15.7)(31.7) = **498.0 cfs**

(Continued)

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SUBJECT Task 3 - Discharge Channel **CHECKED** ________ **SHEET** 3 **OF** 5

(Continued)

D.) Channel Sizing: (Configuration)

Methods: Johnson & Abt et al NUREG 1623 Section 3 Appendix D

1.) Channel Parameters

- 25' Wide Trapezoidal Channel
- 2H:1V Side Slopes
- Channel Slope: Flatter Slope For Sizing

Slope = 1.5% (Flat Slope For Channel Sizing)

- Area = 15.7 Acres
- PMP = 9.6" For 1hr 1 mi^2
- Q = 498.0 cfs

2.) Using Johnson & Abt et al (1998)

$D_{50} = 5.23\, q^{0.56} * S^{0.43}$

Slope = 4% (For Rock Sizing)

q = Unit Width Flow In Channel

$q = \frac{Q}{Width} = 498\ cfs / 25 = 19.9\ cfs/ft$

Notes: Flatter Slope In Section Used For Channel Sizing, Steepest Slope In Section Used For Rock Sizing!

$D_{50} = 5.23 \times (19.9)^{0.56} * (0.04)^{0.43}$

D_{50} = 7.0 inches For Channel Bottom

(Continued)

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SUBJECT Task 3- Discharge Channel **CHECKED** ______ **SHEET** 4 **OF** 5

2. (Continued)

D_{50} = 7.0 For Channel Bottom

Per ACE Hydraulic Design of Flood Channels Sec. 3.7 - Stone Sizing (1995)

D_{50} Side Slope Factor = D_{50} x 1.2

D_{50} = 7.0" x 1.2 = 8.4"

D_{50} = 8.4"

(*) Per Rio Algom - A D_{50} = 9.2" Rock Size has been used in other design tasks at Ambrosia Lake mill. To Reduce Rock Gradings for erosion protection at the Ambrosia Lake Mill a D_{50} = 9.2 in will be placed in the Discharge Channel Section. Channel Configurations will be sized to the 9.2" D_{50} Rock Size.

3.) Configuration

- See Attached Spreadsheet Channel Depth Obtained From Flow Pro 2.0 Hydraulic design software program for steady state open channel flow using the above results and parameters.

Task 3 Channel Design - Channel - Inputs to get channel Depth

DISCHARGE CHANNEL

1. MANNING OUTPUT

OPEN CHANNEL DESIGN - STRICKLER'S EQUATION

ASSUMPTIONS & EQUATIONS Where K=Ave Flume Data (ACE 1994)

Mannings Value, n ~ K(D90)^0.16667

D90 of D50 = 9.2 inch Rock Particle Distribution = 12" (See Design Report For Gradation)

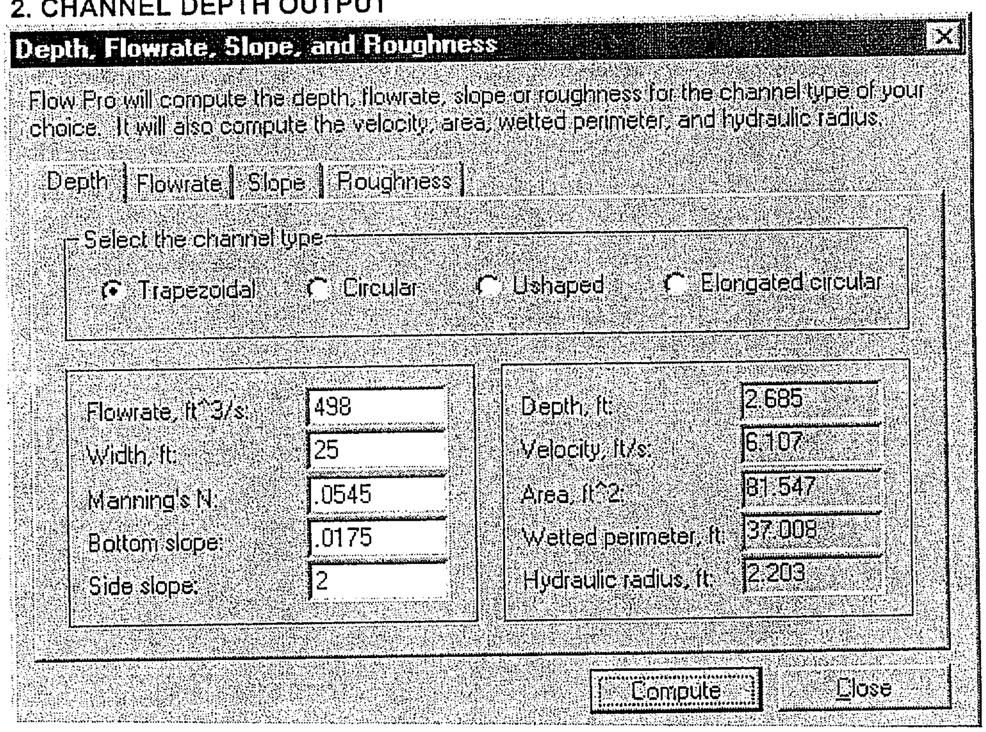
Note: Army Corp. of Engineers - Hydraulic Design of Flood Control Channels (1991)

CALCULATION: Using Army Corp. Of Engineers (ACE) Method (ACE, 1991)

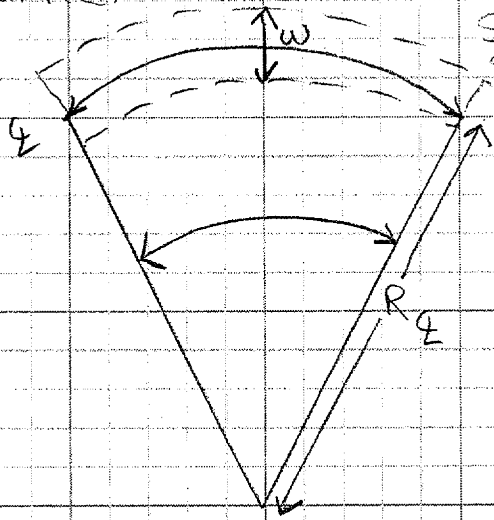
Inputs	Value	Units
D50'	12	inches

Output	Value	Units
n	0.0545	

2. CHANNEL DEPTH OUTPUT



Channel Curve - To Maintain Velocities Use For Rock Sizing In Straight Channel of 9.2% Velocity at 20% of side slope, V_{SS} must be equal to the average velocity of the channel.



$\therefore \; V_{ss}/V_{ave} = 1.0$

To Maintain V_{ss}/V_{ave} of 1.0 the radius must equal 8 times the channel flow width.

$R_℄ = 8w$ (Trapezoidal Channel)

Ref 8 Fig 3-3 - Riprap Design Velocities Hydraulic Design of Flood Control Channels - Army Corp of Engineers, (1995)

Width, W = Water Width In Channel

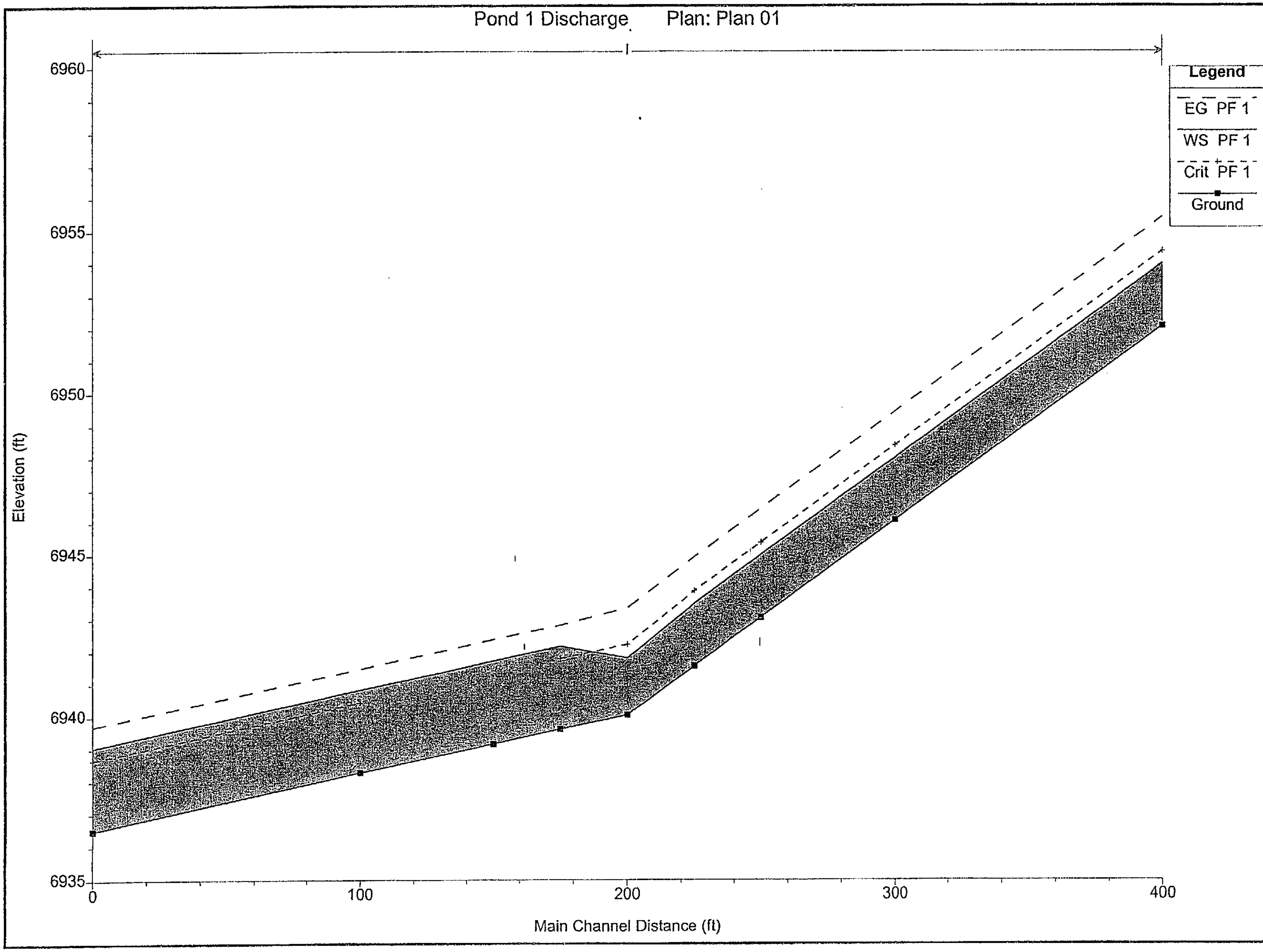
Wetted Width = 37.5

$R_℄ = 8w = 8(37.5) = 300'$

$R_{CL} = \underline{300}$ ft.

HEC-RAS Plan: Plan 01 River: Pond 1 Discharge Reach: I Profile: PF 1

Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
I	400	498.00	6952.00	6953.94	6954.32	6955.37	0.060015	9.61	51.84	33.55	1.36
I	300	498.00	6946.00	6947.94	6948.32	6949.37	0.060015	9.61	51.84	33.55	1.36
I	250	498.00	6943.00	6944.94	6945.32	6946.37	0.060015	9.61	51.84	33.55	1.36
I	225	498.00	6941.50	6943.44	6943.82	6944.87	0.060015	9.61	51.84	33.55	1.36
I	200	498.00	6940.00	6941.75	6942.17	6943.30	0.064753	9.99	49.84	32.00	1.41
I	175	498.00	6939.56	6942.11	6941.73	6942.77	0.017541	6.48	76.89	35.21	0.77
I	150	498.00	6939.12	6941.67		6942.33	0.017576	6.48	76.83	35.21	0.77
I	100	498.00	6938.24	6940.80	6940.41	6941.45	0.017506	6.47	76.94	35.22	0.77
I	0	498.00	6936.49	6939.05	6938.66	6939.70	0.017506	6.47	76.94	35.22	0.77



Pond 1 Discharge Plan: Plan 01
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
6960
6955
6950
6945
6940
6935
Elevation (ft)
0
100
200
300
400
Main Channel Distance (ft)

WMB
3/12/02

Scour Depth at Apron End

For 1hr local storm, PMP = 9.6"
Pond 1 area = 32 acres in both diversion channels. Assume impermeable surface.
Then 9.6/12 × 32×43500 = 1,115,000 ft³
runoff in about 1 hr. or

$$\frac{1,115,000}{3600}\frac{ft^3}{sec} = \underline{310\ cfs} \text{ ave. flow}$$

Use Abt et al (1996) scour equation to estimate scour depth:

$$d_s = R_h C_s \frac{\alpha}{\sigma^{1/3}} \left(\frac{Q}{g^{1/2} R_h^{5/2}}\right)^{\beta} \left(\frac{t}{316}\right)^{\theta}$$

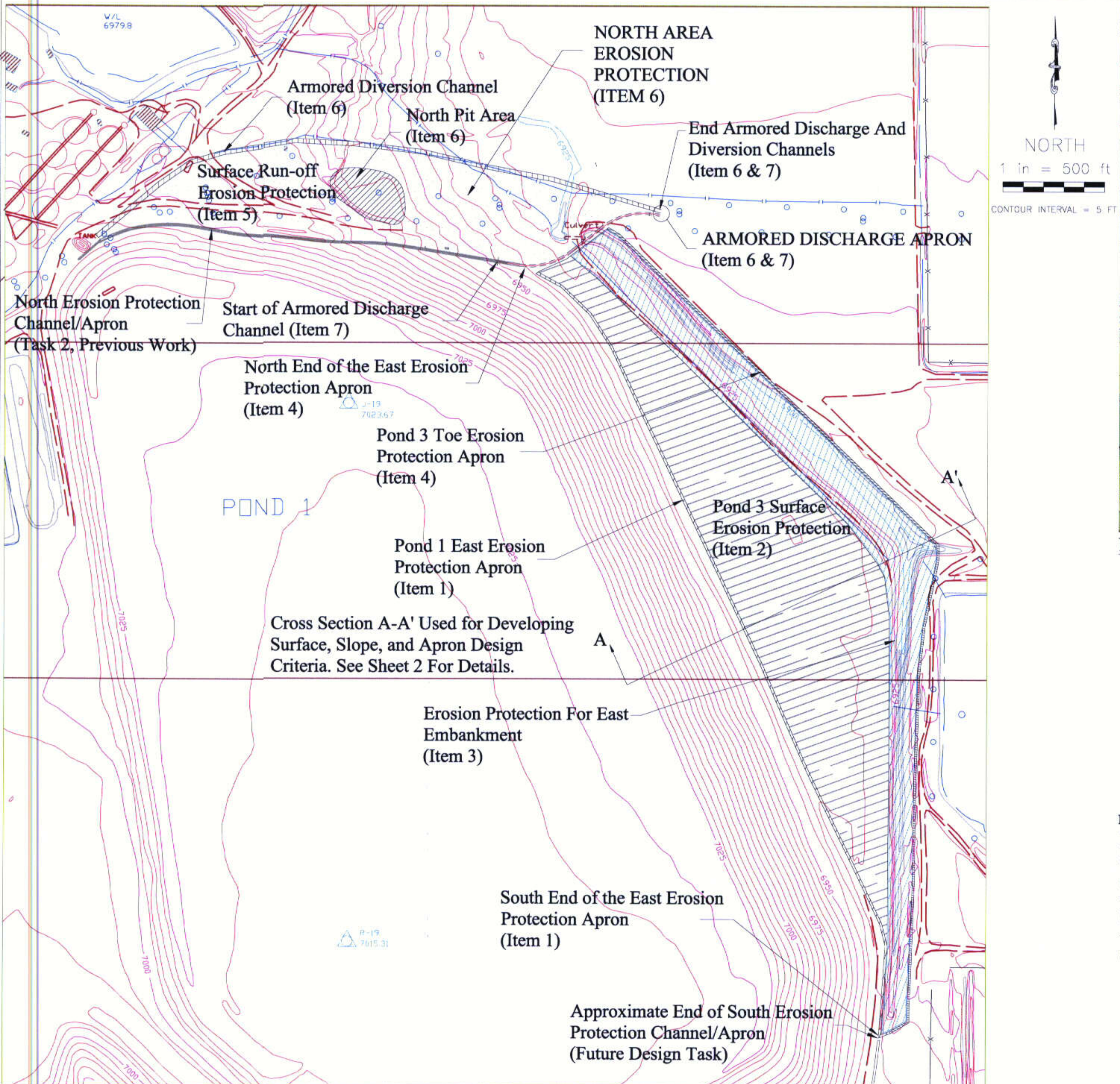
d_s = scour depth
R_h = hydraulic radius = 1.5'
C_s = slope coefficient = 1.03 for 2% slope
α = 2.27
β = 0.39
θ = 0.06
σ = coefficient of uniformity = 2.8
g = 32.2 ft/sec²
Q = ~~197 + 198 = 995~~ 310 cfs ave. flow
t = 1 hr.

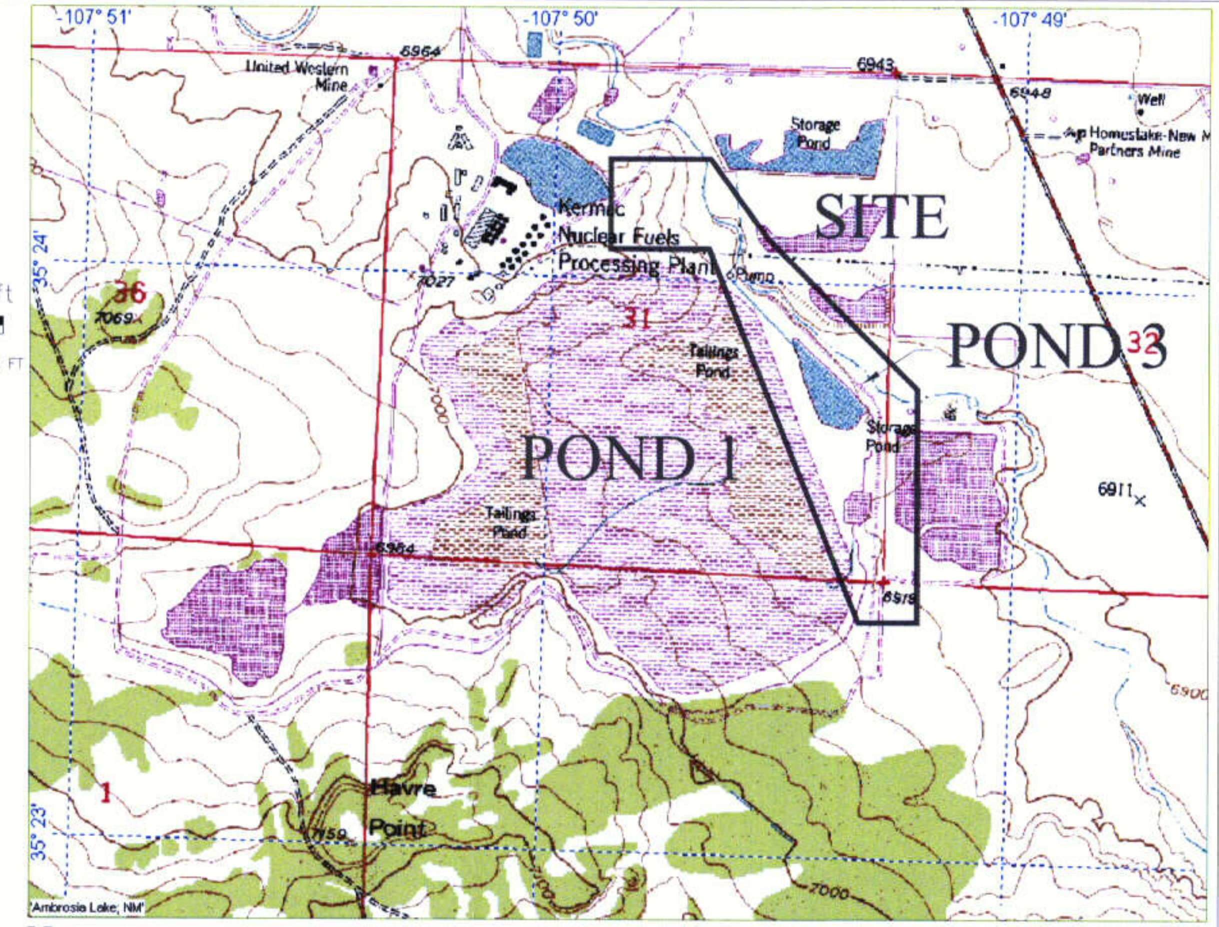
$$d_s = 1.5 \times 1.03 \frac{2.27}{2.8^{1/3}} \left(\frac{310}{32.2^{1/2} \times 1.5^{5/2}}\right)^{0.39} \left(\frac{1}{316}\right)^{0.06}$$

$= \underline{5.7'}$

APPENDIX E

DESIGN DRAWINGS





Notes:

Task 3 Consists of Seven (7) Design Items; (See Item Areas Located On This Drawing)

1. Erosion Protection Apron Along The Toe of The East Embankment of Pond 1, (See Sheets 2 and 3)
2. Surface Erosion Protection For Pond 3, (See Sheets 2 and 4)
3. Erosion Protection for The East Embankment Slope for Pond 3, (See Sheets 2 and 4)
4. Erosion Protection Apron for The Toe of Pond 3, East Embankment, (See Sheets 2 and 5)
5. Surface Run-off Erosion Protection of The Area North of Pond 1, (See Sheets 6 and 7)
6. Diversion Channel Constructed Along the North Limits of Item 5 That Drains Into The Arroyo del Puerto Channel, (See Sheets 6, 8 and 9) See Sheet 13 for Discharge Apron.
7. and, Discharge Channel Constructed From the End of The North Erosion Protection Channel/Apron of Pond 1 For Discharging Into The Arroyo del Puerto Channel, (See Sheets 10, 11 and 12) See Sheet 13 For Discharge Apron Construction

Background:

The North Embankment Toe Erosion Protection Channel/Apron Was Part Of Previous Design Work (Task 2) for The Quivira Mill Site Erosion Protection Plan. The Flow From This Channel Will Be Discharged Into the Arroyo del Puerto Channel Via An Extention Described In Item 7 Above.

The South Embankment Erosion Protection Channel/Apron for Pond 1 is Part of Future Design Tasks to Prevent Erosion At the Quivira Mill Site.

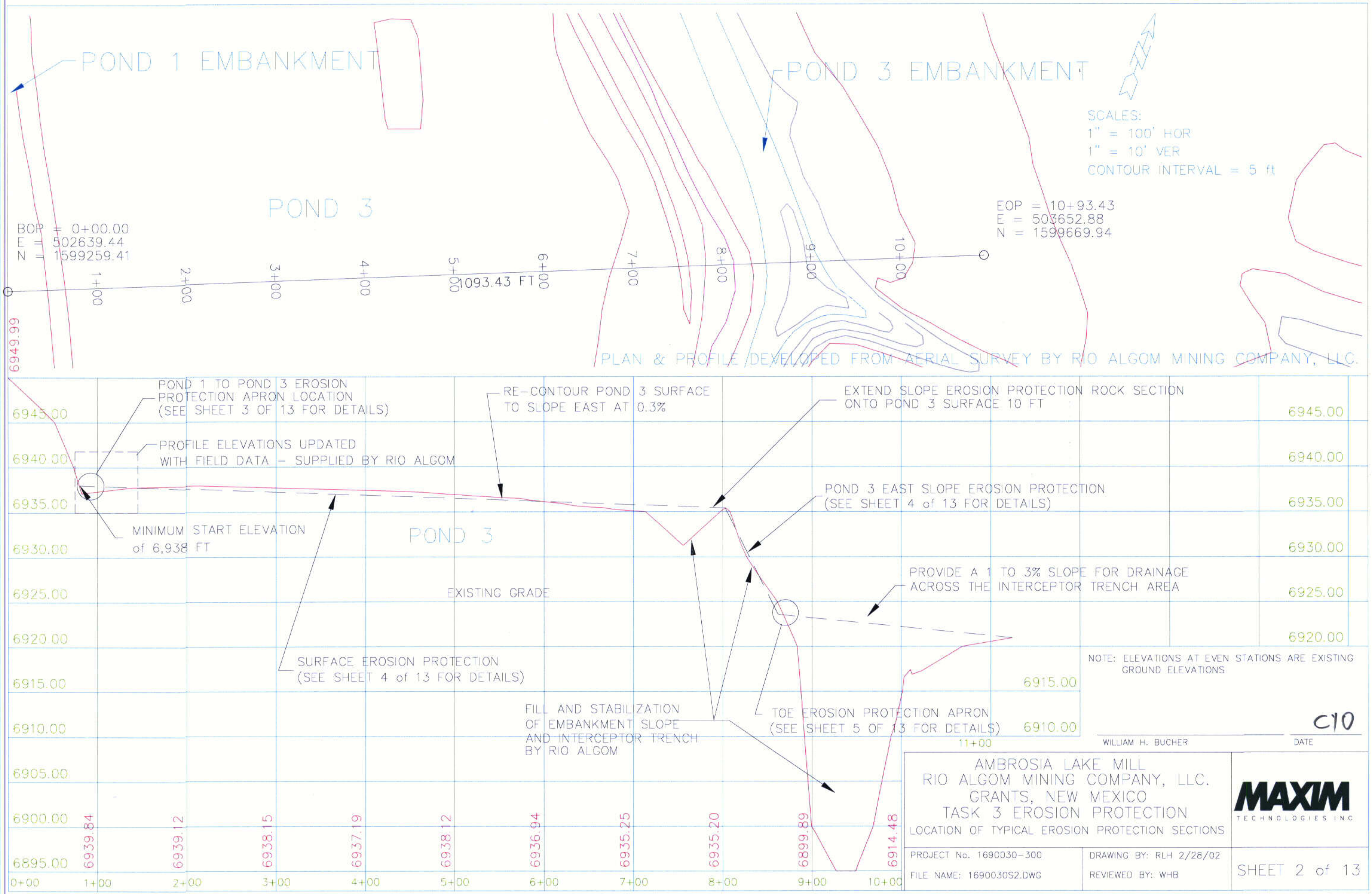
The Arroyo del Puerto Armored Channel Is Part of Future Design Tasks For Erosion Control at The Quivira Mill Site.

C09

AMBROSIA LAKE MILL RIO ALGOM MINING COMPANY, LLC. GRANTS, NEW MEXICO TASK 3 – GENERAL EROSION PROTECTION PLAN		MAXIM TECHNOLOGIES INC
PROJECT No. 1690030-300	DRAWING BY: RLH 2/28/02	SHEET 1 of 13
FILE NAME: 1690030S1.DWG	REVIEWED BY: WHB	

WILLIAM H. BUCHER

DATE



WILLIAM H. BUCHER

DATE C10

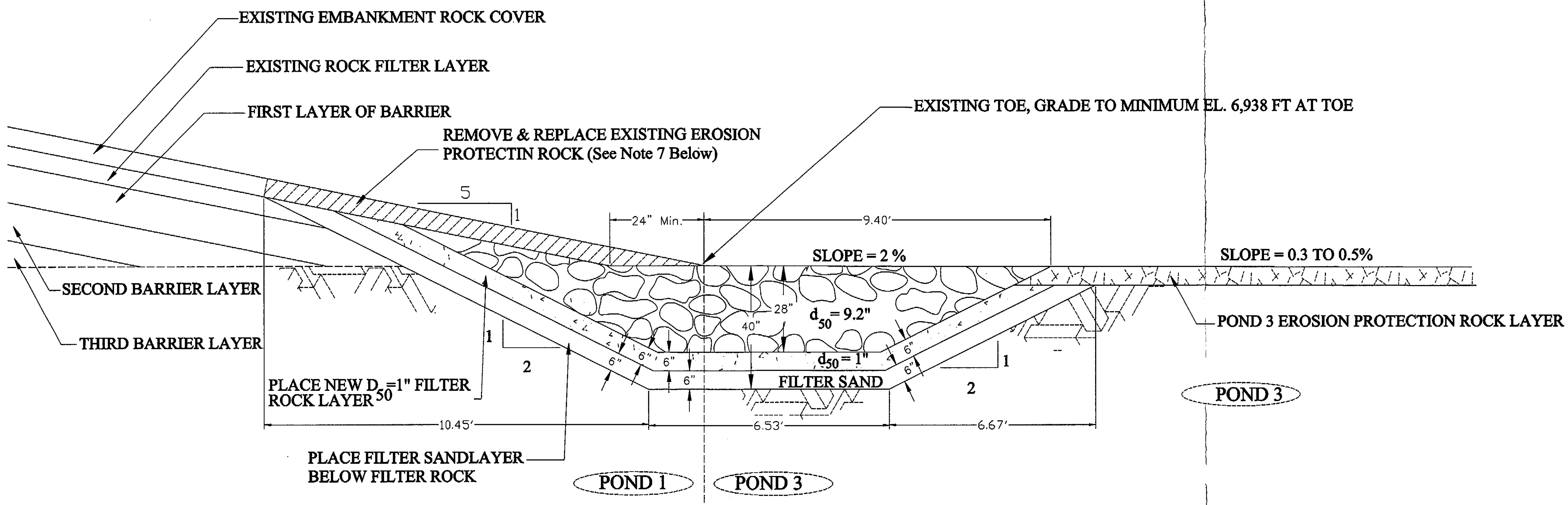
AMBROSIA LAKE MILL
RIO ALGOM MINING COMPANY, LLC.
GRANTS, NEW MEXICO
TASK 3 EROSION PROTECTION
LOCATION OF TYPICAL EROSION PROTECTION SECTIONS

MAXIM TECHNOLOGIES INC

PROJECT No. 1690030-300
DRAWING BY: RLH 2/28/02
FILE NAME: 1690030S2.DWG
REVIEWED BY: WHB

SHEET 2 of 13

POND 1 EROSION PROTECTION APRON
FOR RUN-OFF FROM POND 1 EMBANKMENT SLOPE ONTO POND 3 SURFACE
Typical Section



NOTES:

1. Rock Riprap for erosion protection aprons 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 Draft Report unless otherwise specified in the Task 3 Erosion Control Design Report or the Design Drawings.
2. Erosion protection aprons shall be sloped to the downstream edge with a minimum slope of two percent or at a slope that matches the slope of the natural ground, should it be steeper than two percent.
3. Erosion protection apron excavations shall be constructed with 2H:1V slopes to permit placement of the filter materials as shown above.
4. The erosion protection apron shall be constructed of a rock diameter d_{50} = 9.2" conforming to the following gradation:

Sieve Designation	Percent Passing
15"	100
12"	70 - 90
9"	30 - 55
6"	0 - 10

5. Each layer of erosion protection bedding/filter material shall be placed at a minimum thickness of 6" along the length of the apron. The bedding/filter material shall extend up the 2V:1H sides and end below the Pond 3 erosion protection rock. Bedding/filter material shall be spread and compacted in one layer.
6. Erosion protection apron riprap bedding/filter material shall meet the following gradation:

Filter Gravel

Sieve Designation	Percent Passing
3"	100
2"	80 - 100
3/4"	20 - 70
3/8"	10 - 30
No.4	0 - 10

Filter Sand

Sieve Designation	Percent Passing
No.4	100
No. 10	80 - 100
No. 20	36 - 76
No. 40	10 - 20
No.100	0 - 10

7. Existing erosion protection disturbed during construction of the erosion protection aprons shall be replaced in a manner that maintains existing slopes and riprap conditions as approved previously by the U.S. Nuclear Regulatory Commission. Care shall be taken in removing and stockpiling the riprap such that the material is not degraded or otherwise damaged. Rock degraded or otherwise out of conformance with the NUREG 1623 due to removal and replacement methods shall be replaced with similar approved materials. Care should be taken so that existing tailings are not disturbed during erosion protection apron construction.
8. The erosion protection apron shall be constructed continuously from the north embankment erosion protection channel/apron (north end of Pond 3) to the south embankment erosion protection channel/apron (south end of Pond 3). (See Sheet 1 of 13 for start and ending locations).
9. The erosion protection apron shall be constructed level from the north end to the south end to prevent longitudinal flows within the apron. The erosion protection apron shall be constructed such that flow from the embankment will flow perpendicular to the apron and onto the Pond 3 surface where it will drain away from the erosion protection apron.
10. The erosion protection apron width was designed based on NUREG recommendations in conjunction with local storm run off parameters and calculations. Per NUREG methods, the required rock size for the apron with a local storm PMF is equal to a D_{50}= 7.5". To minimize rock types required to complete erosion protection systems at the site, the rock size detailed in this apron is similar to the rock size used in other design tasks at the site, D_{50}=9.2".

1 in = 3 ft

WILLIAM H. BUCHER

DATE

AMBROSIA LAKE MILL
QUIVIRA MINING COMPANY
GRANTS, NEW MEXICO
TASK 3 EROSION PROTECTION
POND 1 TOE EROSION PROTECTION APRON

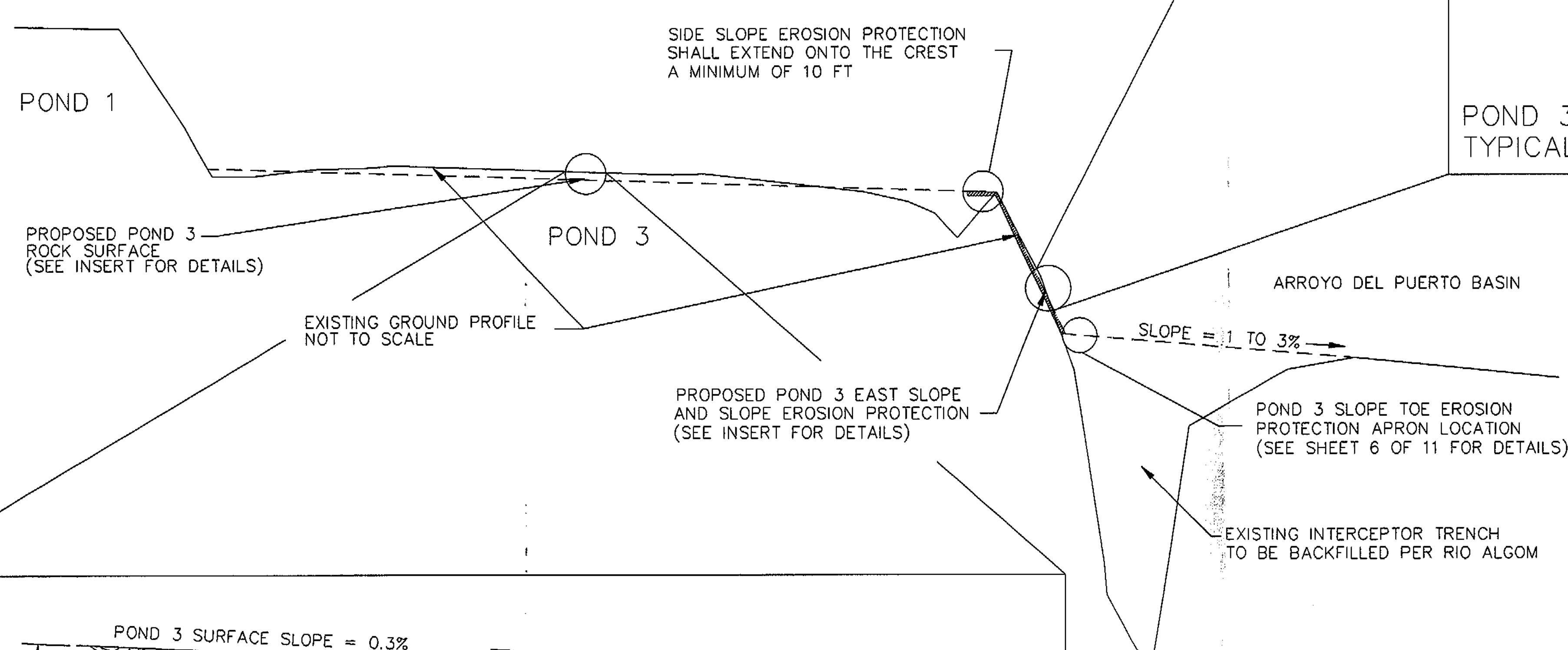
MAXIM TECHNOLOGIES INC

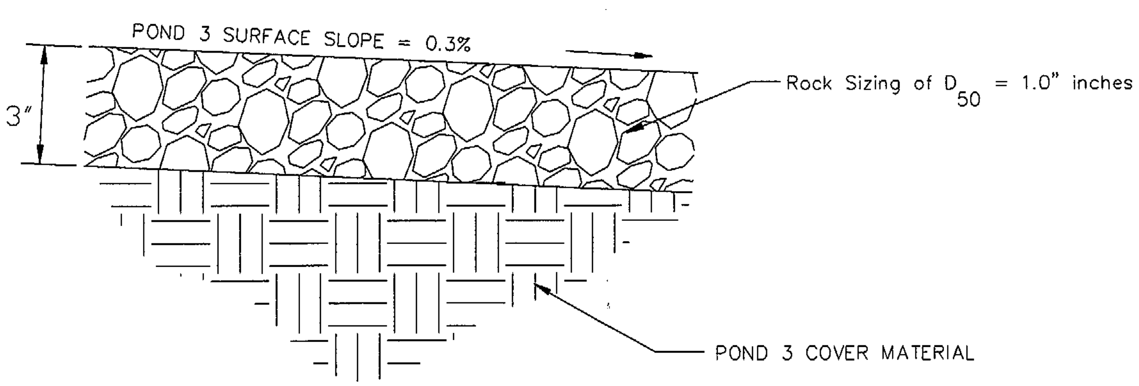
PROJECT No. 1690030-300	DRAWING BY: RLH 2/28/02
FILE NAME: 1690030S3.DWG	REVIEWED BY: WHB

POND 3 - POND SURFACE AND EAST EMBANKMENT EROSION PROTECTION

Typical Sections

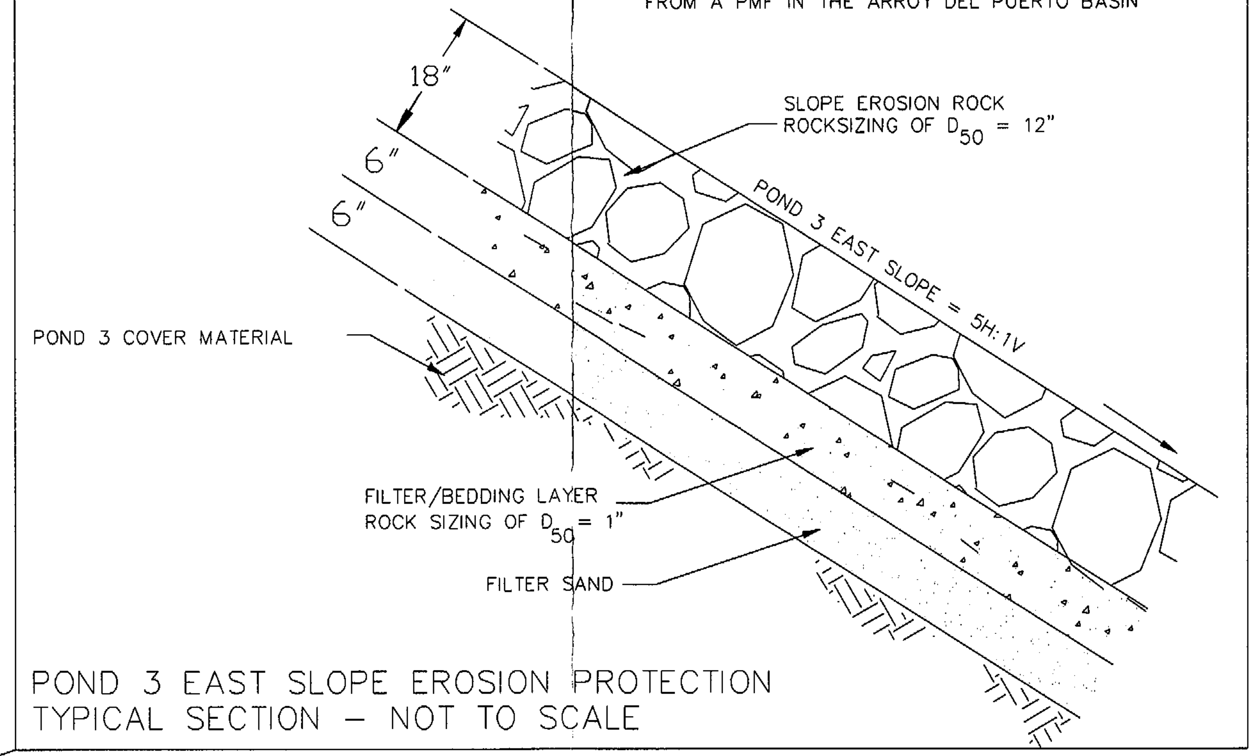
PROPOSED POND 3 SURFACE & SIDE SLOPE EROSION PROTECTION
PROFILE VIEW – NOT TO SCALE





POND 3 SURFACE EROSION PROTECTION
TYPICAL SECTION – NOT TO SCALE

NOTE: SLOPE ROCK SIZED DETERMINED BY LONGITUDINAL FLOWS FROM A PMF IN THE ARROY DEL PUERTO BASIN



POND 3 EAST SLOPE EROSION PROTECTION
TYPICAL SECTION – NOT TO SCALE

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 Draft Report unless otherwise specified in the Task 3 Erosion Control Design Report or the Design Drawings.

2. The erosion protection for the surface of Pond 3 shall be constructed of a rock diameter $d_{50} = 1.0"$ conforming to the following gradation:

Erosion Protection Rock

Sieve Designation	Percent Passing
3"	100
2"	80 - 100
3/4"	20 - 70
3/8"	10 - 30
No.4	0 - 10

3. Erosion protection on the east embankment slope of Pond 3 shall be constructed of a rock diameter $d_{50} = 12.0"$ and shall be placed on a minimum of 6" of bedding/filter rock, each conforming to the following gradations:

Erosion Protection Rock

Sieve Designation	Percent Passing
18"	100
14"	60 - 90
12"	25 - 50
10"	10 - 30
6"	0 - 10

Bedding\Filter Gravel (d_{50} = 1.0")

Sieve Designation	Percent Passing
3"	100
2"	80 - 100
3/4"	20 - 70
3/8"	10 - 30
No.4	0 - 10

Filter Sand

Sieve Designation	Percent Passing
No. 4	100
No. 10	80 - 100
No. 20	36 - 76
No. 40	10 - 20
No. 100	0 - 10

4. The layer of erosion protection bedding/filter material shall be placed at a minimum thickness of 6" along the length of the slope. The bedding/filter material shall extend the full slope length. Bedding/filter material shall be spread and compacted in one layer.

WILLIAM H. BUCHER

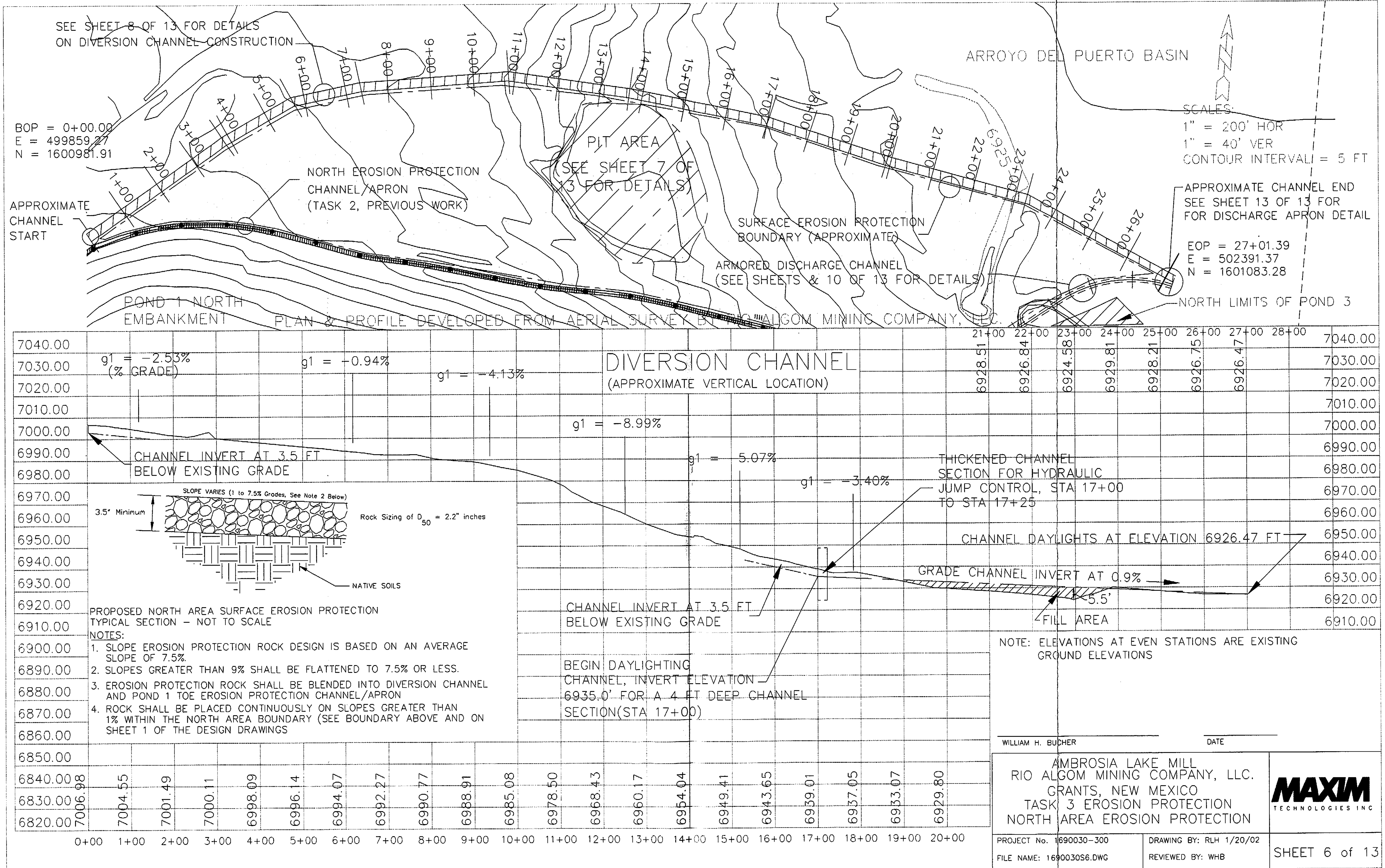
DATE

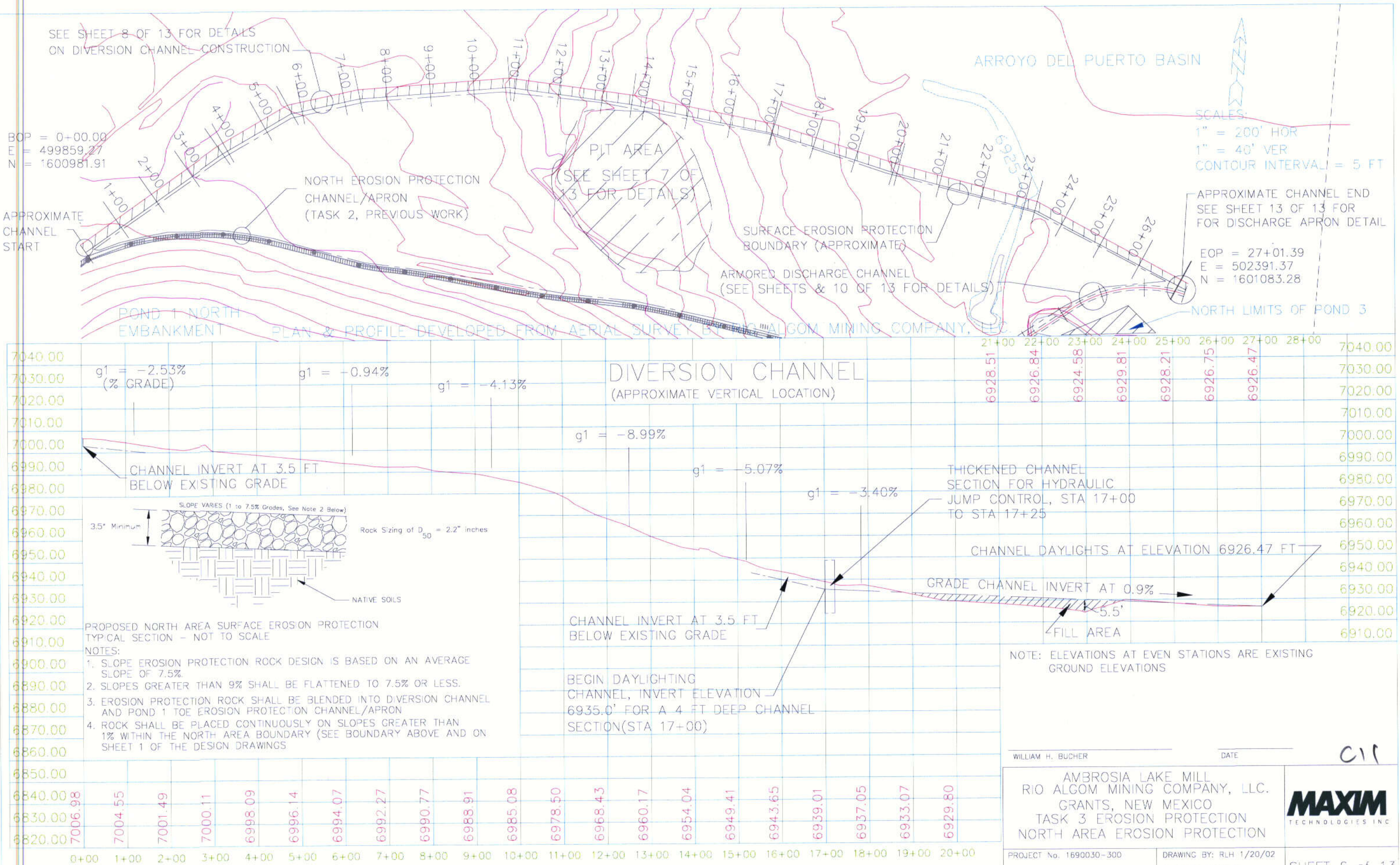
AMBROSIA LAKE MILL
RIO ALGOM MINING COMPANY, LLC.
GRANTS, NEW MEXICO
TASK 3 – EROSION PROTECTION
POND 3 EROSION PROTECTION DETAILS

MAXIM TECHNOLOGIES INC

PROJECT No. 1690030-300
FILE NAME: 1690030S4.DWG
DRAWING BY: RLH 2/25/02
REVIEWED BY: WHB

SHEET 4 of 13


SEE SHEET 8 OF 13 FOR DETAILS ON DIVERSION CHANNEL CONSTRUCTION
BOP = 0+00.00
E = 499859.27
N = 1600981.91
APPROXIMATE CHANNEL START
NORTH EROSION PROTECTION CHANNEL/APRON (TASK 2, PREVIOUS WORK)
POND 1 NORTH EMBANKMENT
PLAN & PROFILE DEVELOPED FROM AERIAL SURVEY BY RIO ALGOM MINING COMPANY, LLC.
PIT AREA (SEE SHEET 7 OF 13 FOR DETAILS)
SURFACE EROSION PROTECTION BOUNDARY (APPROXIMATE)
ARMORED DISCHARGE CHANNEL (SEE SHEETS & 10 OF 13 FOR DETAILS)
ARROYO DEL PUERTO BASIN
6925
SCALES:
1" = 200' HOR
1" = 40' VER
CONTOUR INTERVAL = 5 FT
APPROXIMATE CHANNEL END SEE SHEET 13 OF 13 FOR FOR DISCHARGE APRON DETAIL
EOP = 27+01.39
E = 502391.37
N = 1601083.28
NORTH LIMITS OF POND 3
1+00 2+00 3+00 4+00 5+00 6+00 7+00 8+00 9+00 10+00 11+00 12+00 13+00 14+00 15+00 16+00 17+00 18+00 19+00 20+00 21+00 22+00 23+00 24+00 25+00 26+00
DIVERSION CHANNEL
(APPROXIMATE VERTICAL LOCATION)
7040.00 7030.00 7020.00 7010.00 7000.00 6990.00 6980.00 6970.00 6960.00 6950.00 6940.00 6930.00 6920.00 6910.00 6900.00 6890.00 6880.00 6870.00 6860.00 6850.00 6840.00 6830.00 6820.00
g1 = -2.53% (% GRADE)
g1 = -0.94%
g1 = -4.13%
g1 = -8.99%
g1 = 5.07%
g1 = -3.40%
CHANNEL INVERT AT 3.5 FT BELOW EXISTING GRADE
THICKENED CHANNEL SECTION FOR HYDRAULIC JUMP CONTROL, STA 17+00 TO STA 17+25
CHANNEL DAYLIGHTS AT ELEVATION 6926.47 FT
GRADE CHANNEL INVERT AT 0.9%
5.5'
FILL AREA
CHANNEL INVERT AT 3.5 FT BELOW EXISTING GRADE
BEGIN DAYLIGHTING CHANNEL, INVERT ELEVATION 6935.0' FOR A 4 FT DEEP CHANNEL SECTION(STA 17+00)
SLOPE VARIES (1 to 7.5% Grades, See Note 2 Below)
3.5' Minimum
Rock Sizing of D_{50} = 2.2" inches
NATIVE SOILS
PROPOSED NORTH AREA SURFACE EROSION PROTECTION TYPICAL SECTION - NOT TO SCALE
NOTES:
1. SLOPE EROSION PROTECTION ROCK DESIGN IS BASED ON AN AVERAGE SLOPE OF 7.5%.
2. SLOPES GREATER THAN 9% SHALL BE FLATTENED TO 7.5% OR LESS.
3. EROSION PROTECTION ROCK SHALL BE BLENDED INTO DIVERSION CHANNEL AND POND 1 TOE EROSION PROTECTION CHANNEL/APRON
4. ROCK SHALL BE PLACED CONTINUOUSLY ON SLOPES GREATER THAN 1% WITHIN THE NORTH AREA BOUNDARY (SEE BOUNDARY ABOVE AND ON SHEET 1 OF THE DESIGN DRAWINGS
0+00 7006.98
1+00 7004.55
2+00 7001.49
3+00 7000.11
4+00 6998.09
5+00 6996.14
6+00 6994.07
7+00 6992.27
8+00 6990.77
9+00 6988.91
10+00 6985.08
11+00 6978.50
12+00 6968.43
13+00 6960.17
14+00 6954.04
15+00 6949.41
16+00 6943.65
17+00 6939.01
18+00 6937.05
19+00 6933.07
20+00 6929.80
21+00 6928.51
22+00 6926.84
23+00 6924.58
24+00 6929.81
25+00 6928.21
26+00 6926.75
27+00 6926.47
28+00
NOTE: ELEVATIONS AT EVEN STATIONS ARE EXISTING GROUND ELEVATIONS
WILLIAM H. BUCHER
DATE
AMBROSIA LAKE MILL
RIO ALGOM MINING COMPANY, LLC.
GRANTS, NEW MEXICO
TASK 3 EROSION PROTECTION
NORTH AREA EROSION PROTECTION
MAXIM TECHNOLOGIES INC
PROJECT No. 1690030-300
FILE NAME: 1690030S6.DWG
DRAWING BY: RLH 1/20/02
REVIEWED BY: WHB
SHEET 6 of 13



NOTES:

1. SLOPE EROSION PROTECTION ROCK DESIGN IS BASED ON AN AVERAGE SLOPE OF 7.5%.
2. SLOPES GREATER THAN 9% SHALL BE FLATTENED TO 7.5% OR LESS.
3. EROSION PROTECTION ROCK SHALL BE BLENDED INTO DIVERSION CHANNEL AND POND 1 TOE EROSION PROTECTION CHANNEL/APRON
4. ROCK SHALL BE PLACED CONTINUOUSLY ON SLOPES GREATER THAN 1% WITHIN THE NORTH AREA BOUNDARY (SEE BOUNDARY ABOVE AND ON SHEET 1 OF THE DESIGN DRAWINGS

NOTE: ELEVATIONS AT EVEN STATIONS ARE EXISTING GROUND ELEVATIONS

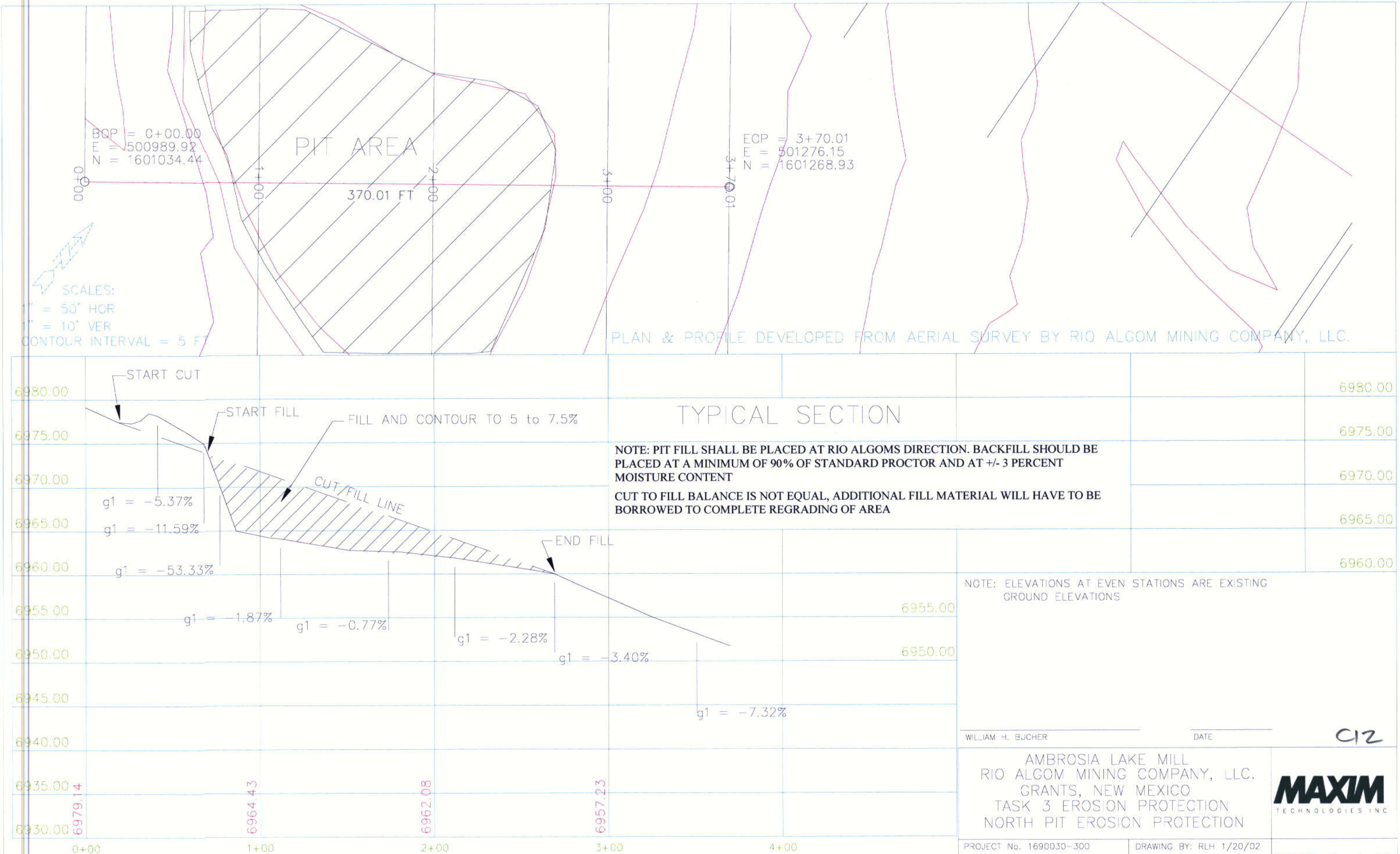
WILLIAM H. BUCHER | DATE

AMBROSIA LAKE MILL
RIO ALGOM MINING COMPANY, LLC.
GRANTS, NEW MEXICO
TASK 3 EROSION PROTECTION
NORTH AREA EROSION PROTECTION

MAXIM TECHNOLOGIES INC

PROJECT No. 1690030-300
FILE NAME: 1690030S6.DWG
DRAWING BY: RLH 1/20/02
REVIEWED BY: WHB

SHEET 6 of 13



NOTE: PIT FILL SHALL BE PLACED AT RIO ALGOMS DIRECTION. BACKFILL SHOULD BE PLACED AT A MINIMUM OF 90% OF STANDARD PROCTOR AND AT +/- 3 PERCENT MOISTURE CONTENT

CUT TO FILL BALANCE IS NOT EQUAL, ADDITIONAL FILL MATERIAL WILL HAVE TO BE BORROWED TO COMPLETE REGRADING OF AREA

NOTE: ELEVATIONS AT EVEN STATIONS ARE EXISTING GROUND ELEVATIONS

WILLIAM H. BUCHER

DATE

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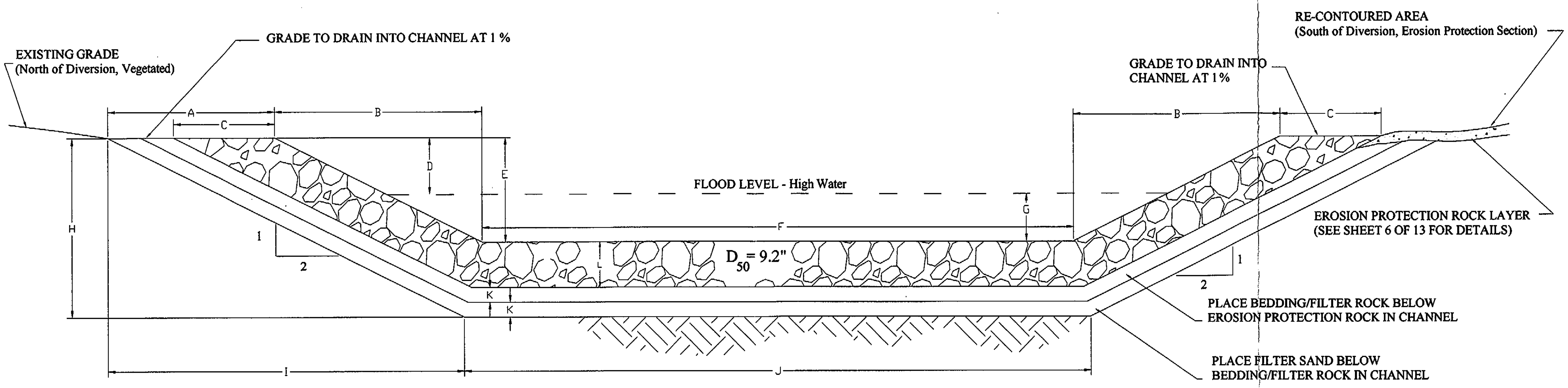
AMBROSIA LAKE MILL
RIO ALGOM MINING COMPANY, LLC.
GRANTS, NEW MEXICO
TASK 3 EROSION PROTECTION
NORTH PIT EROSION PROTECTION

MAXIM TECHNOLOGIES INC

PROJECT No. 1690030-300	DRAWING BY: RLH 1/20/02	SHEET 7 of 13
FILE NAME: 1690030S7.DWG	REVIEWED BY: WHB	

DIVERSION CHANNEL - NORTH AREA



STA 9+00 TO STA 17+00 SHOWN

1 in = 4 ft

NOTES:

1. The diversion channel shall be constructed along the existing "gully" where erosion is occurring due to small local storms. The horizontal and vertical location of the cross section developed for design calculations is approximate. The diversion channel shall be "field" adjusted to the natural flow line.
2. The diversion channel shall be extended to the end of the proposed discharge channel as shown on Sheet 1 of 13.
3. The immediate surrounding areas shall be graded such that run-off flows into the channel. Low areas adjacent to the diversion channel shall be regraded to provide positive drainage into the diversion channel.
4. The bottom of the channel shall be constructed flat from side slope to side slope to prevent concentrated flows.
5. 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 -CR1623 Draft Report unless otherwise specified in the TASK 3 Erosion Protection Report or the included Design Drawings.
6. Surface erosion protection rock placed south of the diversion shall be tied into the south crest of the diversion channel. Areas disturbed during construction, north of the diversion channel, shall be revegetated.
7. The channel excavation shall be constructed with bottoms free of loose debris, vegetation and muddy surfaces.
8. The erosion protection bedding/filter material shall be placed at a minimum thickness of 6" along the length of the channel. The bedding/filter material shall extend up the 2H:1V side slopes to the existing grade and end below the erosion protection rock layer on the south side. Bedding/filter materials shall be spread and compacted in one layer.
9. Existing erosion protection rock disturbed during construction of the channel shall be replaced in a manner that maintains existing slopes and riprap conditions as approved by the U.S. Nuclear Regulatory Commission. Care shall be taken in removing and stockpiling the riprap such that the material is not degraded or otherwise damaged. Rock degraded or otherwise out of conformance with the NUREG 1623 due to removal and replacement methods shall be replaced with similar approved materials.
10. The channel shall be constructed with a minimum of 18" of d_{50}=9.2" rock. The rock shall be extended up the side slopes to the existing grade on the exterior and interlocked with the existing rock placed for surface erosion protection on the south side of the diversion channel.
11. The channel erosion protection rock shall be constructed of a rock diameter d_{50}=9.2" conforming to the following gradation:

Sieve Designation	Percent Passing
15"	100
12"	70 - 90
9"	30 - 55
6"	0 - 10

12. The channel/apron erosion protection rock shall be constructed on 6" of bedding/filter rock and 6" of filter sand conforming to the following gradation:

Bedding/Filter Gravel (d_{50}=1.0")		Filter Sand	
Sieve Designation	Percent Passing	Sieve Designation	Percent Passing
3"	100	No. 4	100
2"	80 - 90	No. 10	80 - 100
3/4"	20 - 70	No. 20	36 - 76
3/8"	10 - 30	No. 40	10 - 20
No.4	0 - 10	No. 100	0 - 10

13. EACH CHANNEL SECTION SHALL BE CONSTRUCTED TO THE FOLLOWING DIMENSIONS. SEE SHEET 10 FOR DETAILS ON CHANNEL SECTION STA 17+00 TO 17+25.

	CHANNEL SECTION DIMENSIONS (DIMENSIONS IN FEET)											
CHANNEL SECTION	A	B	C	D	E	F	G	H	I	J	K	L
STA 0+00 To STA 9+00	5.7	7.0	3.4	1.0	3.5	3.0	2.5	6.0	12.1	4.2	0.5	1.5
STA 9+00 To STA 17+00	5.7	7.0	3.4	1.9	3.5	20.0	1.6	6.0	12.1	21.2	0.5	1.5
SEE SHEET 10 FOR DETAILS ON STA 17+00 TO STA 17+25												
STA 17+25 To STA 27+01	5.7	8.0	3.4	1.6	4.0	28.0	2.4	6.5	13.1	29.2	0.5	1.5

WILLIAM H. BUCHER

DATE

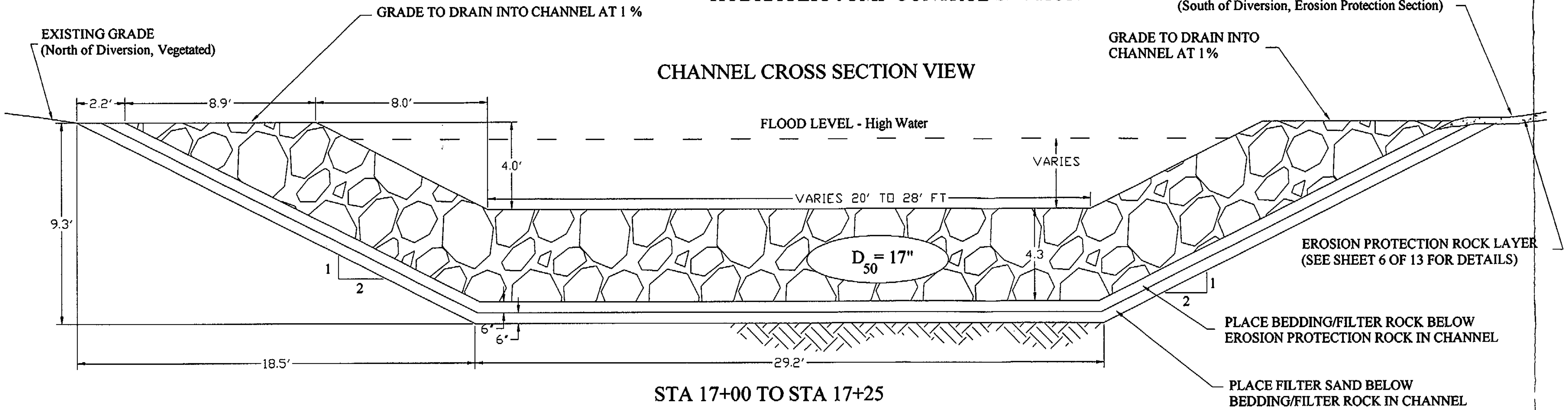
AMBROSIA LAKE MILL
RIO ALGOM MINING COMPANY, LLC.
GRANTS, NEW MEXICO
TASK 3 EROSION PROTECTION
DIVERSION CHANNEL – NORTH AREA

MAXIM TECHNOLOGIES INC

PROJECT No. 1690030-300	DRAWING BY: RLH 2/28/02	SHEET 8 of 13
FILE NAME: 1690030S8.DWG	REVIEWED BY: WHB	

DIVERSION CHANNEL - NORTH AREA
HYDRAULIC JUMP CONTROL SECTION

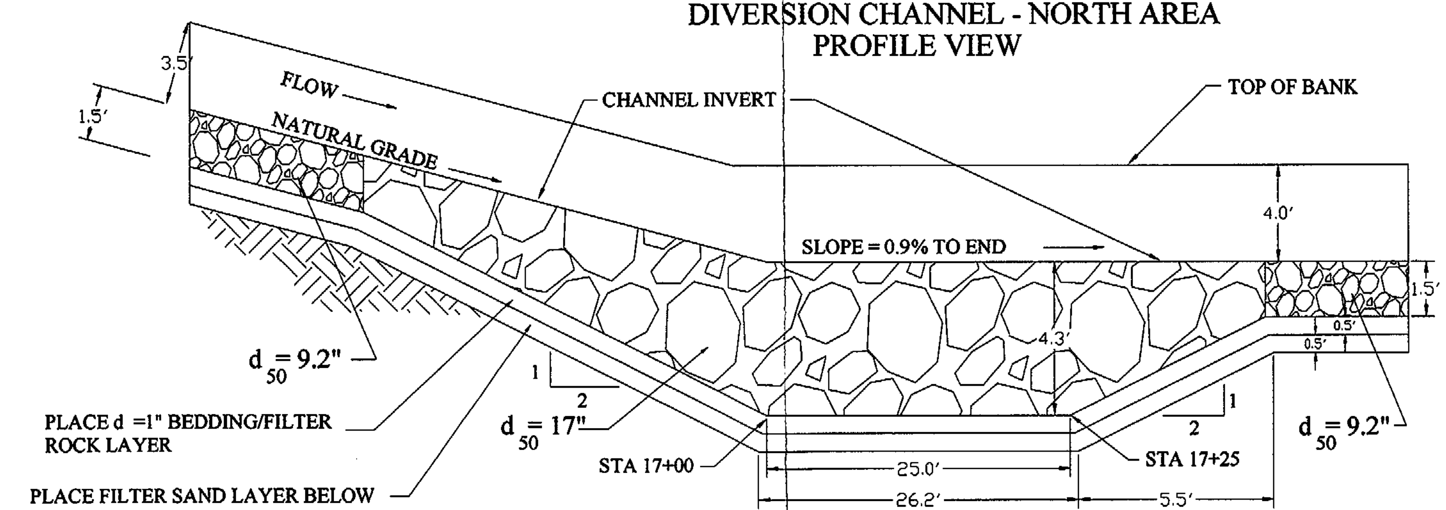
CHANNEL CROSS SECTION VIEW



STA 17+00 TO STA 17+25

1 in = 6 ft

DIVERSION CHANNEL - NORTH AREA
PROFILE VIEW



PROFILE VIEW NOT TO SCALE

NOTES:

1. This section of the diversion channel shall be constructed from STA 17+00 to STA 17+25 to control the hydraulic jump that could occur at the transition between the grades at this location.
2. This section shall be transitioned from 20 ft wide channel bottom at STA 17+00 to 28 ft wide at STA 17+25.
3. The immediate surrounding areas shall be graded such that run-off flows into the channel. Low areas adjacent to the diversion channel shall be regraded to provide positive drainage into the diversion channel.
4. The bottom of the channel shall be constructed flat from side slope to side slope to prevent concentrated flows.
5. 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 -CR1623 Draft Report unless otherwise specified in the TASK 3 Erosion Protection Report or the included Design Drawings.
6. Surface erosion protection rock placed south of the diversion shall be tied into the south crest of the diversion channel. Areas disturbed during construction, north of the diversion channel, shall be revegetated.
7. The channel excavation shall be constructed with bottoms free of loose debris, vegetation and muddy surfaces.
8. The erosion protection bedding/filter material shall be placed at a minimum thickness of 6" along the length of the channel. The bedding/filter material shall extend up the 2H:1V side slopes to the existing grade and end below the erosion protection rock layer on the south side. Bedding/filter materials shall be spread and compacted in one layer.
9. Existing erosion protection rock disturbed during construction of the channel shall be replaced in a manner that maintains existing slopes and riprap conditions as approved by the U.S. Nuclear Regulatory Commission. Care shall be taken in removing and stockpiling the riprap such that the material is not degraded or otherwise damaged. Rock degraded or otherwise out of conformance with the NUREG 1623 due to removal and replacement methods shall be replaced with similar approved materials.
10. The channel shall be constructed with a minimum of 51" of d_{50}=17" rock. The rock shall be extended up the side slopes to the existing grade on the exterior and interlocked with the existing rock placed for surface erosion protection on the south side of the diversion channel.
11. The channel erosion protection rock shall be constructed of a rock diameter d_{50}=17" conforming to the following gradation:

Sieve Designation	Percent Passing
27"	100
18"	50- 88
14"	15 - 56
10"	0 - 15

12. The channel/apron erosion protection rock shall be constructed on 6" of bedding/filter rock and 6" of filter sand conforming to the following gradation:

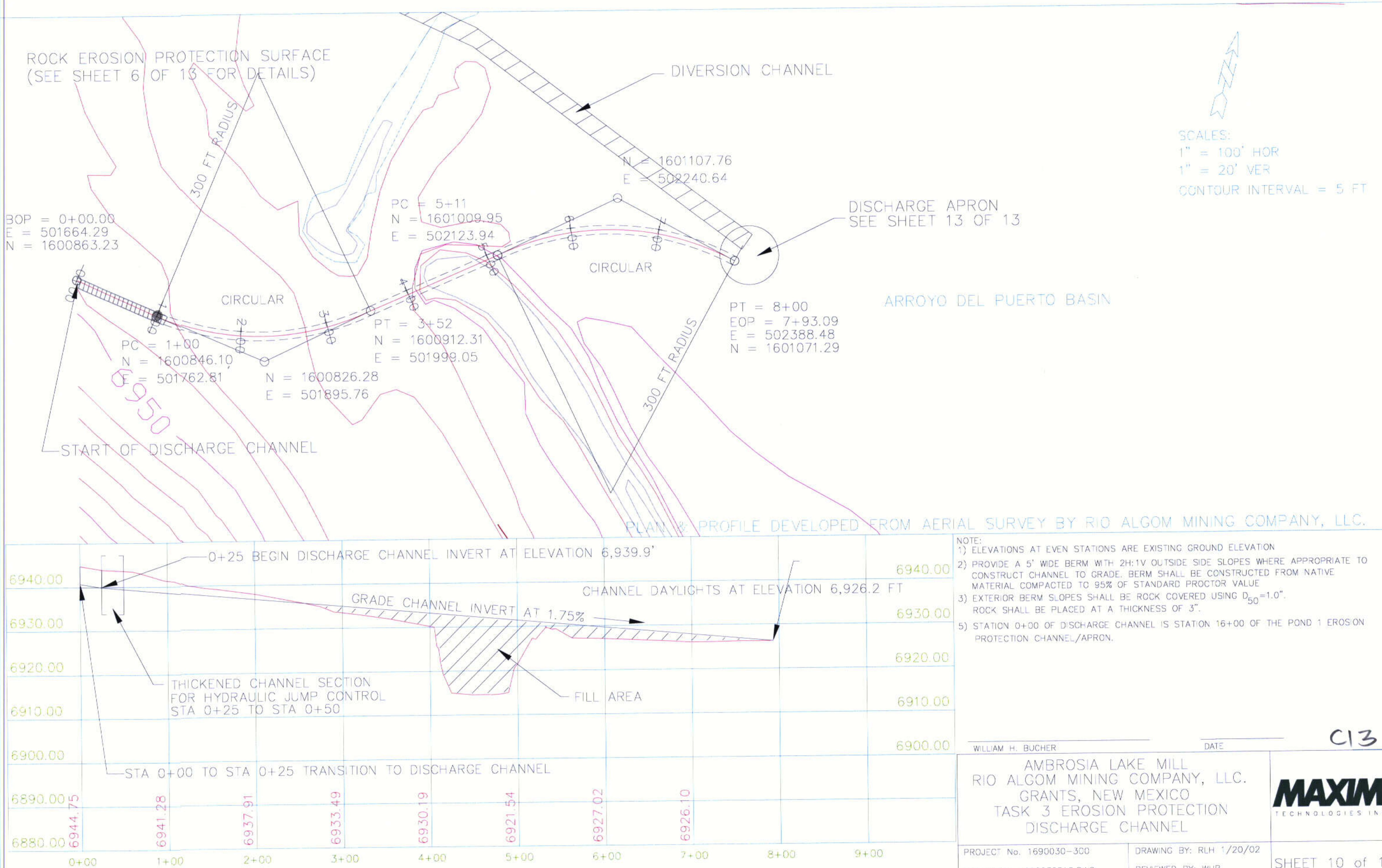
Bedding/Filter Gravel (d_{50}=1.0")		Filter Sand	
Sieve Designation	Percent Passing	Sieve Designation	Percent Passing
3"	100	No. 4	100
2"	80 - 90	No. 10	80 - 100
3/4"	20 - 70	No. 20	36 - 76
3/8"	10 - 30	No. 40	10 - 20
No.4	0 - 10	No. 100	0 - 10

WILLIAM H. BUCHER DATE

AMBROSIA LAKE MILL
RIO ALGOM MINING COMPANY, LLC.
GRANTS, NEW MEXICO
TASK 3 EROSION PROTECTION
DIVERSION CHANNEL – NORTH AREA

MAXIM TECHNOLOGIES INC

PROJECT No. 1690030-300	DRAWING BY: RLH 2/28/02	SHEET 9 of 13
FILE NAME: 1690030S9.DWG	REVIEWED BY: WHB	



NOTE:
1) ELEVATIONS AT EVEN STATIONS ARE EXISTING GROUND ELEVATION
2) PROVIDE A 5' WIDE BERM WITH 2H:1V OUTSIDE SIDE SLOPES WHERE APPROPRIATE TO CONSTRUCT CHANNEL TO GRADE. BERM SHALL BE CONSTRUCTED FROM NATIVE MATERIAL COMPACTED TO 95% OF STANDARD PROCTOR VALUE
3) EXTERIOR BERM SLOPES SHALL BE ROCK COVERED USING D_{50}=1.0". ROCK SHALL BE PLACED AT A THICKNESS OF 3".
5) STATION 0+00 OF DISCHARGE CHANNEL IS STATION 16+00 OF THE POND 1 EROSION PROTECTION CHANNEL/APRON.

WILLIAM H. BUCHER

DATE

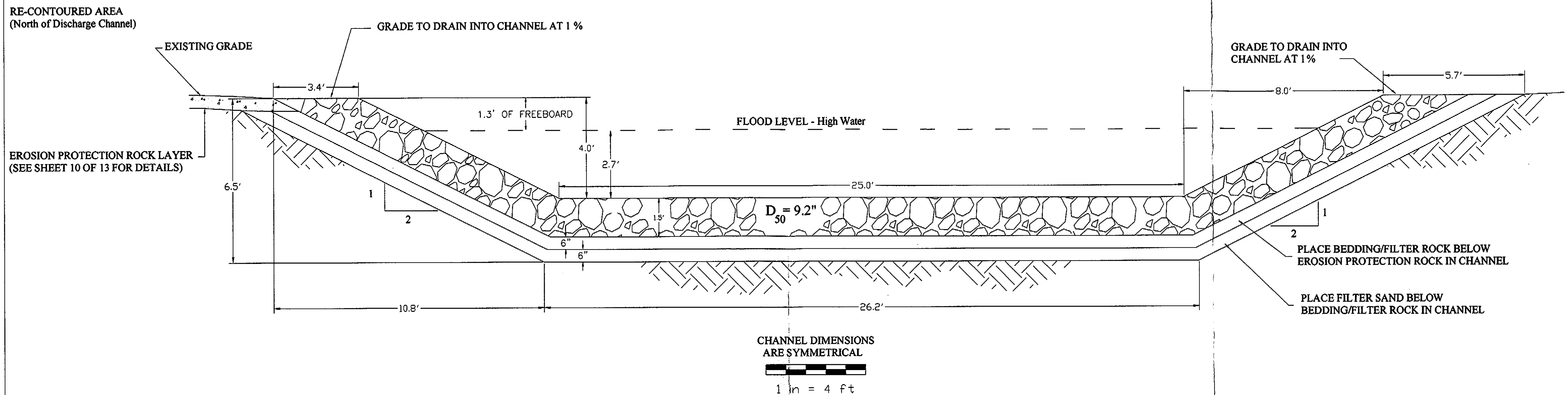
C13

AMBROSIA LAKE MILL
RIO ALGOM MINING COMPANY, LLC.
GRANTS, NEW MEXICO
TASK 3 EROSION PROTECTION
DISCHARGE CHANNEL

MAXIM TECHNOLOGIES INC

PROJECT No. 1690030-300	DRAWING BY: RLH 1/20/02	SHEET 10 of 13
FILE NAME: 1690030S10.DWG	REVIEWED BY: WHB	

DISCHARGE CHANNEL
TYPICAL SECTION
FROM STATION 0+50 TO DISCHARGE APRON



NOTES:

1. The discharge channel shall be constructed such that it will control the flows from the Pond 1 Erosion Protection Channel/Apron, starting at Station 16+00 of the Channel/Apron. The channel transition from the Channel/Apron to the Discharge Channel configuration shall begin at 16+00 of the Channel/Apron and end at STA 0+25 of the Discharge Channel. The interior 5H:1V slope of the Channel/Apron shall be steepened to the 2H:1V slope of the discharge channel within the above noted transition section.
2. The discharge channel shall be extended to the end of the proposed diversion channel as shown on Sheet 10 of 13.
3. The immediate surrounding areas shall be graded such that run-off flows into the channel. Low areas adjacent to the channel shall be regraded to provide positive drainage into the channel.
4. The bottom of the channel shall be constructed flat from side slope to side slope to prevent concentrated flows.
5. 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 -CR1623 Draft Report unless otherwise specified in the TASK 3 Erosion Protection Report or the included Design Drawings.
6. Surface erosion protection rock placed north of the discharge channel shall be tied into the north crest of the channel.
7. The channel excavation shall be constructed with bottoms free of loose debris, vegetation and muddy surfaces.
8. The erosion protection bedding/filter material shall be placed at a minimum thickness of 6" along the length of the channel. The bedding/filter material shall extend up the 2H:1V side slopes to the existing grade and end below the erosion protection rock layer on the north side. Bedding/filter materials shall be spread and compacted in one layer.
9. Existing erosion protection rock disturbed during construction of the channel shall be replaced in a manner that maintains existing slopes and riprap conditions as approved by the U.S. Nuclear Regulatory Commission. Care shall be taken in removing and stockpiling the riprap such that the material is not degraded or otherwise damaged. Rock degraded or otherwise out of conformance with the NUREG 1623 due to removal and replacement methods shall be replaced with similar approved materials.
10. The channel shall be constructed with a minimum of 18" of d_{50}=9.2" rock. The rock shall be extended up the side slopes to the existing grade on the exterior and interlocked with the existing rock placed for surface erosion protection on the north side of the discharge channel.
11. The channel erosion protection rock shall be constructed of a rock diameter d_{50}=9.2" conforming to the following gradation:

Sieve Designation	Percent Passing
15"	100
12"	70 - 90
9"	30 - 55
6"	0 - 10

12. The channel/apron erosion protection rock shall be constructed on 6" of bedding/filter rock and 6" of filter sand conforming to the following gradation:

Bedding/Filter Gravel (d_{50}=1.0")		Filter Sand	
Sieve Designation	Percent Passing	Sieve Designation	Percent Passing
3"	100	No. 4	100
2"	80 - 90	No. 10	80 - 100
3/4"	20 - 70	No. 20	36 - 76
3/8"	10 - 30	No. 40	10 - 20
No.4	0 - 10	No. 100	0 - 10

WILLIAM H. BUCHER   DATE

AMBROSIA LAKE MILL
RIO ALGOM MINING COMPANY, LLC.
GRANTS, NEW MEXICO
TASK 3 EROSION PROTECTION
DISCHARGE CHANNEL

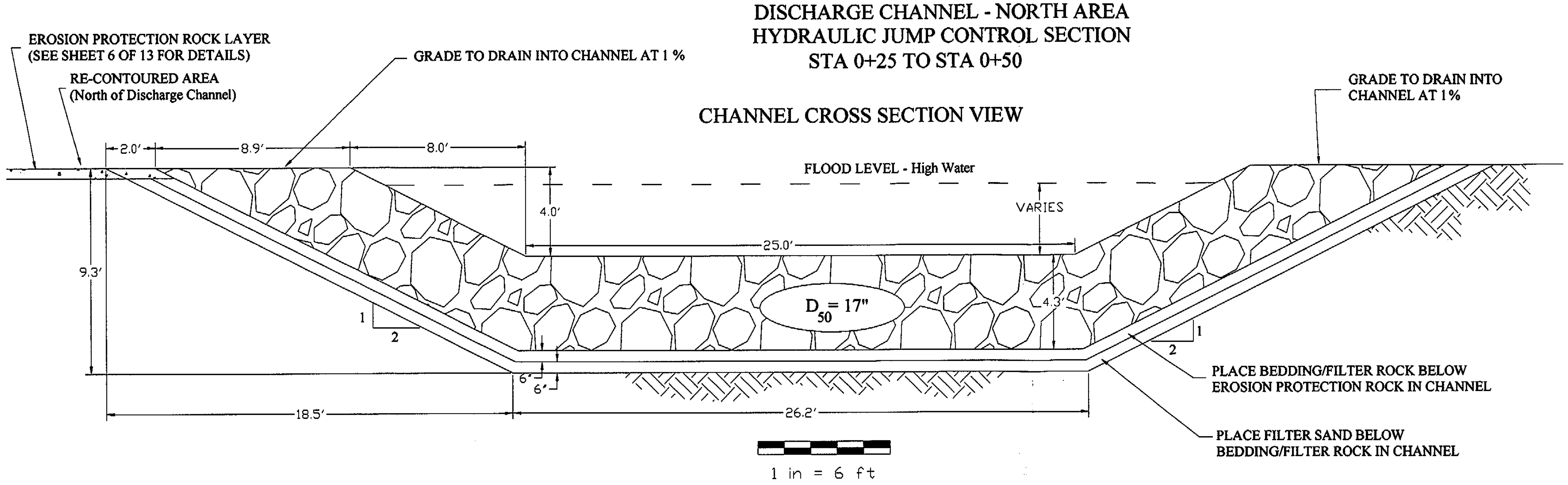
MAXIM TECHNOLOGIES INC

PROJECT No. 1690030-300	DRAWING BY: RLH 2/28/02
FILE NAME: 1690030S9.DWG	REVIEWED BY: WHB

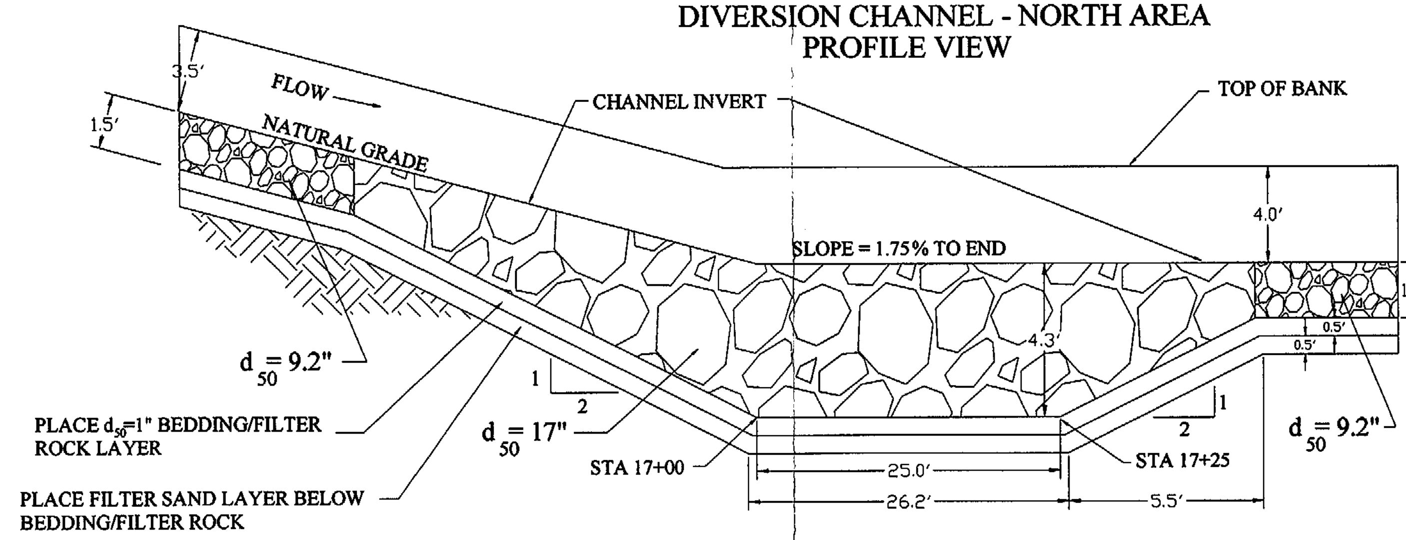
SHEET 11 of 13

DISCHARGE CHANNEL - NORTH AREA
HYDRAULIC JUMP CONTROL SECTION
STA 0+25 TO STA 0+50

CHANNEL CROSS SECTION VIEW



DIVERSION CHANNEL - NORTH AREA
PROFILE VIEW



PROFILE VIEW NOT TO SCALE

NOTES:

1. This section of the discharge channel shall be constructed from STA 0+25 to STA 0+50 to control the hydraulic jump that could occur at the transition between the grades at this location.
3. The immediate surrounding areas shall be graded such that run-off flows into the channel. Low areas adjacent to the discharge channel shall be regraded to provide positive drainage into the discharge channel.
4. The bottom of the channel shall be constructed flat from side slope to side slope to prevent concentrated flows.
5. 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 -CR1623 Draft Report unless otherwise specified in the TASK 3 Erosion Protection Report or the included Design Drawings.
6. Surface erosion protection rock placed north of the discharge channel shall be tied into the crest of the discharge channel. Areas disturbed during construction, south of the discharge channel, shall be revegetated.
7. The channel excavation shall be constructed with bottoms free of loose debris, vegetation and muddy surfaces.
8. The erosion protection bedding/filter material shall be placed at a minimum thickness of 6" along the length of the channel. The bedding/filter material shall extend up the 2H:1V side slopes to the existing grade and end below the erosion protection rock layer on the south side. Bedding/filter materials shall be spread and compacted in one layer.
9. Existing erosion protection rock disturbed during construction of the channel shall be replaced in a manner that maintains existing slopes and riprap conditions as approved by the U.S. Nuclear Regulatory Commission. Care shall be taken in removing and stockpiling the riprap such that the material is not degraded or otherwise damaged. Rock degraded or otherwise out of conformance with the NUREG 1623 due to removal and replacement methods shall be replaced with similar approved materials.
10. This channel section shall be constructed with a minimum of 51" of d_{50} =17" rock. The rock shall be extended up the side slopes to the existing grade on the exterior and interlocked with the existing rock placed for surface erosion protection on the north side of the discharge channel.
11. The channel erosion protection rock shall be constructed of a rock diameter d_{50}=17" conforming to the following gradation:

Sieve Designation	Percent Passing
27"	100
18"	50- 88
14"	15 - 56
10"	0 - 15

12. The channel/apron erosion protection rock shall be constructed on 6" of bedding/filter rock and 6" of filter sand conforming to the following gradation:

Bedding/Filter Gravel (d_{50}=1.0")		Filter Sand	
Sieve Designation	Percent Passing	Sieve Designation	Percent Passing
3"	100	No. 4	100
2"	80 - 90	No. 10	80 - 100
3/4"	20 - 70	No. 20	36 - 76
3/8"	10 - 30	No. 40	10 - 20
No.4	0 - 10	No. 100	0 - 10

WILLIAM H. BUCHER DATE

AMBROSIA LAKE MILL
RIO ALGOM MINING COMPANY, LLC.
GRANTS, NEW MEXICO
TASK 3 EROSION PROTECTION
DISCHARGE CHANNEL — NORTH AREA

MAXIM TECHNOLOGIES INC

PROJECT No. 1690030-300	DRAWING BY: RLH 2/28/02
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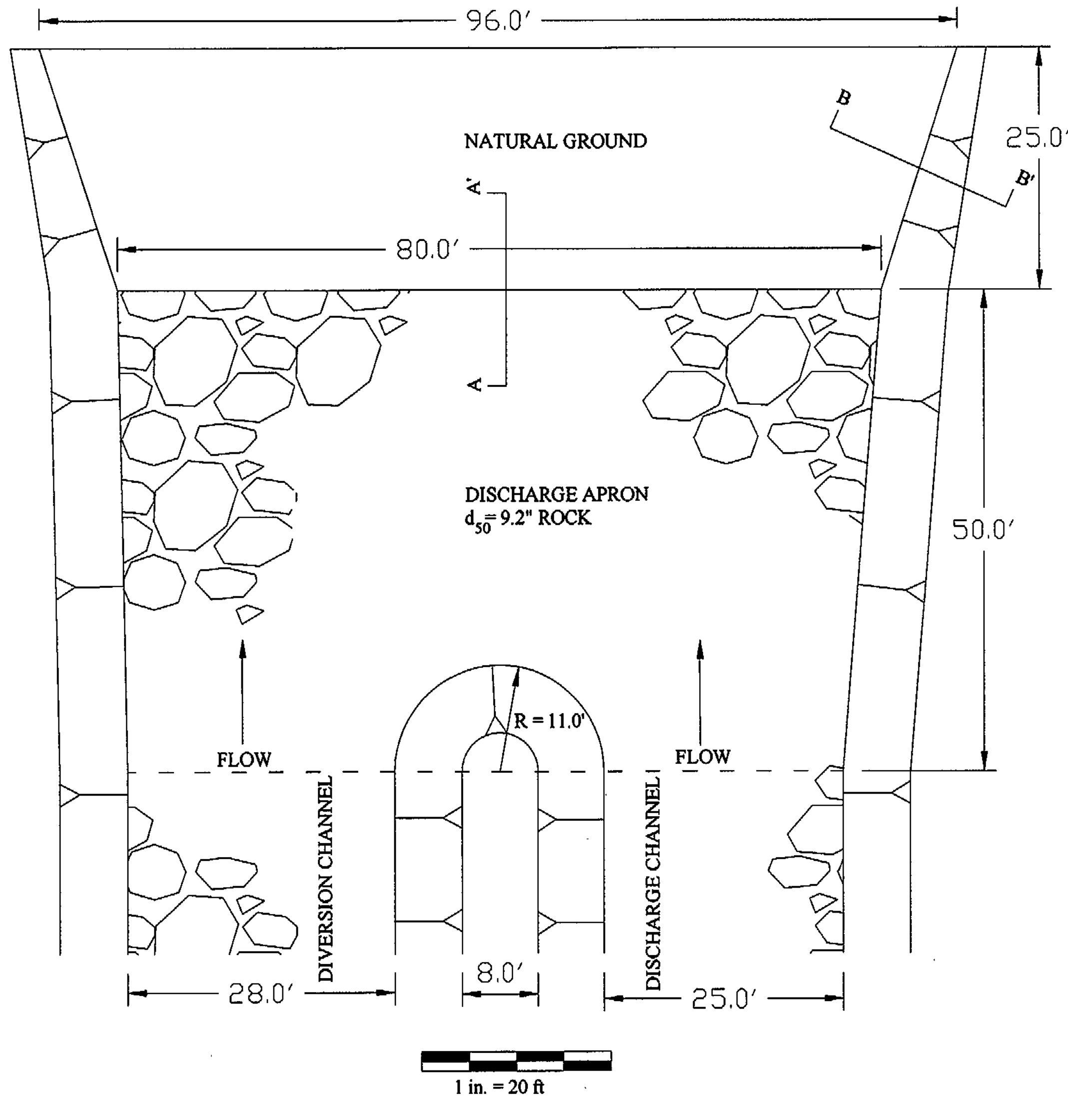

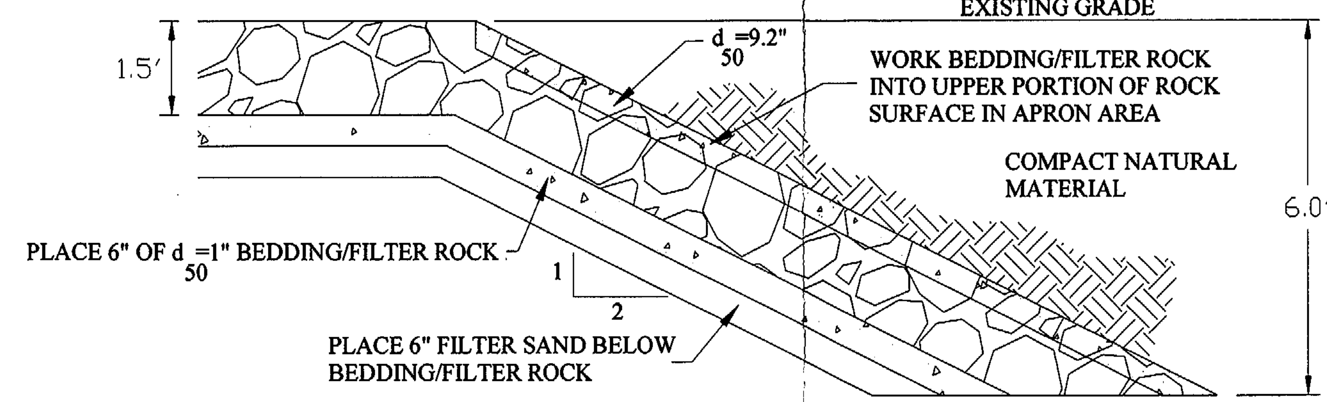

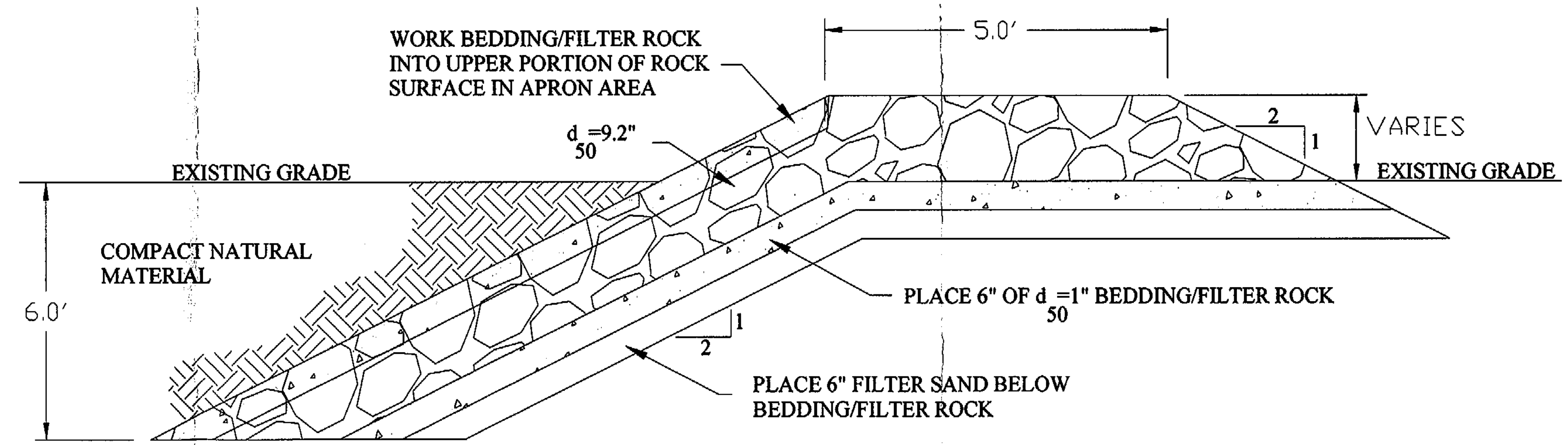

NOTES:

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 -CR1623 Draft Report unless otherwise specified in the TASK 3 Erosion Protection Report or the included Design Drawings.
2. The bottom of the channel shall be constructed flat from side slope to side slope to prevent concentrated flows.
3. The channel excavation shall be constructed with bottoms free of loose debris, vegetation and muddy surfaces.
4. Apron erosion protection rock shall be tied into the diversion channel and the discharge channel rock. Areas disturbed during construction of the apron shall be revegetated.
5. The erosion protection bedding/filter material shall be placed at a minimum thickness of 6" along the length of the apron. The bedding/filter material shall extend up the 2H:1V side slopes to the existing grade and end below the erosion protection rock layer on the side slopes and crests as shown above. Bedding/filter materials shall be spread and compacted in one layer.
6. Existing erosion protection rock disturbed during construction of the channel shall be replaced in a manner that maintains existing slopes and riprap conditions as approved by the U.S. Nuclear Regulatory Commission. Care shall be taken in removing and stockpiling the riprap such that the material is not degraded or otherwise damaged. Rock degraded or otherwise out of conformance with the NUREG 1623 due to removal and replacement methods shall be replaced with similar approved materials.
7. The apron shall be constructed with a minimum of 18" of d_{50}=9.2" rock.
8. The height of the wing wall varies from 3.5 ft at the upstream end to the ground elevation at the down stream end.
9. The channel erosion protection rock shall be constructed of a rock diameter d_{50}=9.2" conforming to the following gradation:

Sieve Designation	Percent Passing
15"	100
12"	70- 90
9"	30 - 55
6"	0 - 10

12. The apron erosion protection rock shall be constructed on 6" of bedding/filter rock and 6" of filter sand conforming to the following gradation:

Bedding/Filter Gravel (d_{50}=1.0")		Filter Sand	
Sieve Designation	Percent Passing	Sieve Designation	Percent Passing
3"	100	No. 4	100
2"	80 - 90	No. 10	80 - 100
3/4"	20 - 70	No. 20	36 - 76
3/8"	10 - 30	No. 40	10 - 20
No.4	0 - 10	No. 100	0 - 10

WILLIAM H. BUCHER

DATE

AMBROSIA LAKE MILL
RIO ALGOM MINING COMPANY, LLC.
GRANTS, NEW MEXICO
TASK 3 EROSION PROTECTION
DISCHARGE APRON

MAXIM TECHNOLOGIES INC

PROJECT No. 1690030-300

DRAWING BY: RLH 3/9/02

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