APPENDIX D

CALCULATIONS FOR POND 1 CHANNEL PROTECTION CHANNEL DESIGN CONFIGURATION CALCULATIONS

JOB NO. 6900030-300 **JOB TITLE** Quivira **DATE** 3/1/02 **BY** RLH
SUBJECT Task 3 - Discharge Channel **CHECKED** ______ **SHEET** 1 **OF** 5

Flow Sections:

- Method: 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

$\boxed{L_{1+2} = 2,706 \text{ ft}}$

B) PMP = 9.6" (1hr-1mi^2) (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.

$AL_1 + L_2 = \boxed{15.7 \text{ Acres}}$

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. 6900.31-300 **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:

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

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

$H = El_1 - El_2$

$H = 7026 - 6926$

$H = 100\ ft = Del$

$t_{c_{L_2}} = 0.2036\ hrs = 12.21\ min$

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

@ 12.21 min the % of 1-hour PMP:

$\underline{67\%}$ of 1-hour PMP

∴ 12.21 min PMP = 0.67 × 9.6" = 6.5"

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

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

C) Discharge:

Q = CiA

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

$$Q = 1.0\,(15.7)(31.7) = \boxed{498.0\ cfs}$$

(Continued)

JOB NO. 1690030-300 **JOB TITLE** Quivira **DATE** 3/1/01 **BY** RLH
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 1mi²
- 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

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

Note: 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)

JOB NO. 1690030-300 **JOB TITLE** Quivira **DATE** 3/1/01 **BY** RLH

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 = $D_{50} \times 1.2$

$D_{50} = 7.0" \times 1.2 = 8.4"$

$D_{50} = 8.4"$

⊛ Per Rio Algom - A $\boxed{D_{50} = 9.2"}$ 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)

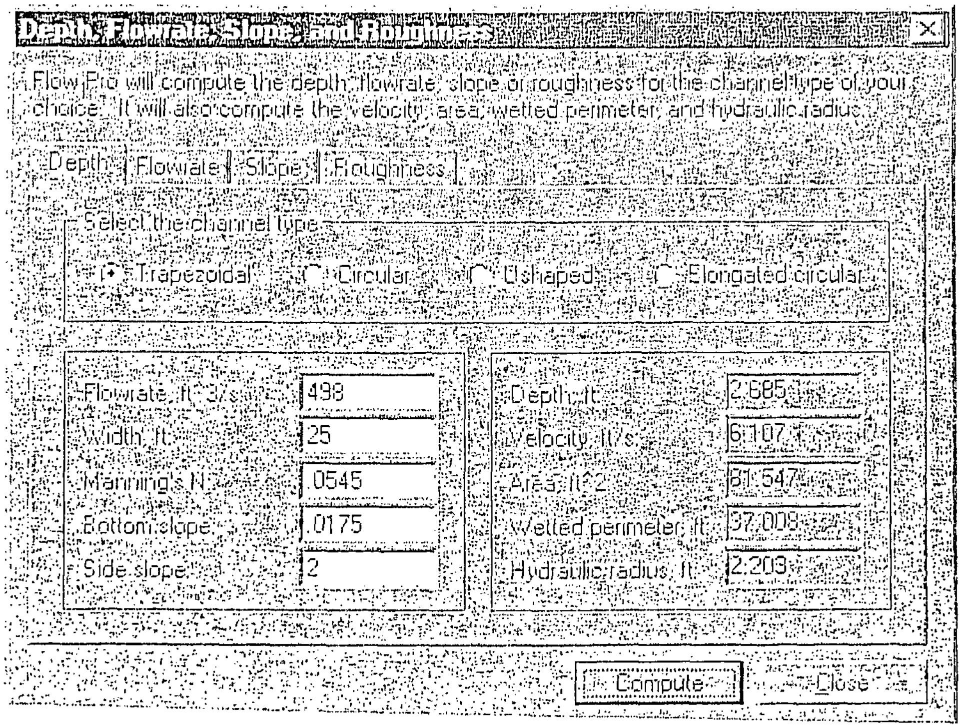
Note: Army Corp. of Engineers - Hydraulic Design of Flood Control Channels (1991)

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



Depth, Flowrate, Slope, and Roughness

Flow Pro will compute the depth, flowrate, slope or roughness for the channel type of your choice. It will also compute the velocity, area, wetted perimeter, and hydraulic radius.

Select the channel type

● Trapezoidal ○ Circular ○ U shaped ○ Elongated circular

Flowrate, ft^3/s: 498

Width, ft: 25

Manning's N: .0545

Bottom slope: .0175

Side slope: 2

Depth, ft: 2.685

Velocity, ft/s: 6.107

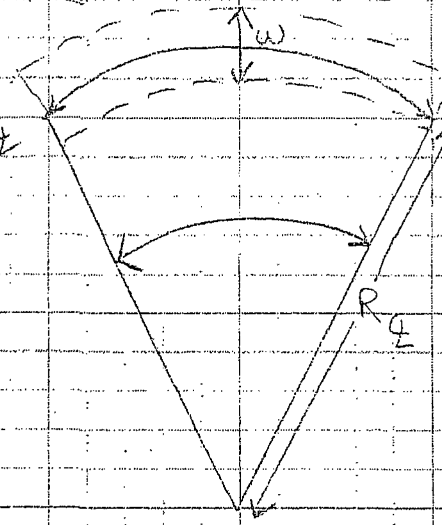
Area, ft^2: 81.547

Wetted perimeter, ft: 37.008

Hydraulic radius, ft: 2.203

JOB NO. 1690030-300 **JOB TITLE** Rio Algom **DATE** 3/7/03 **BY** RLH
SUBJECT Discharge Channel Curve **CHECKED** ______ **SHEET** 1 **OF** ______

Channel Curve - To Maintain Velocities Use For Rock Sizing In Straight Channel of 92% Velocity at 20% of side slope, V_{SS} must be equal to the average velocity of the channel.



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

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

$$R_{℄} = 8w \quad \text{(Trapezoidal Channel)}$$

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

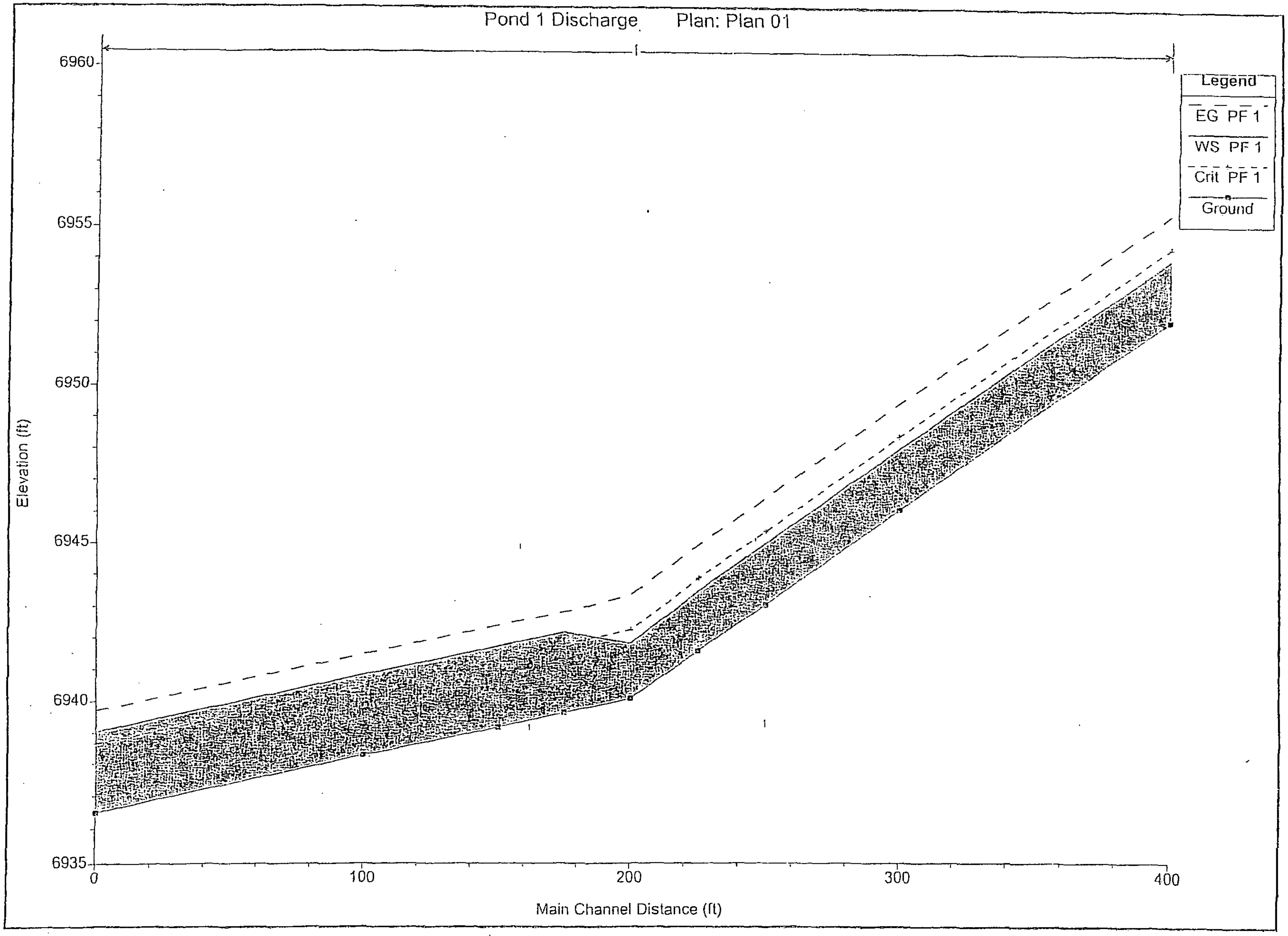
Wetted Width = 37.5

$$R_{℄} = 8w = 8(37.5) = 300'$$

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

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)	
	400	498.00	6952.00	6953.94	6954.32	6955.37	0.060015	9.61	51.84	33.55	1.36
	300	498.00	6946.00	6947.94	6948.32	6949.37	0.060015	9.61	51.84	33.55	1.36
	250	498.00	6943.00	6944.94	6945.32	6946.37	0.060015	9.61	51.84	33.55	1.36
	225	496.00	6941.50	6943.44	6943.82	6944.87	0.060015	9.61	51.84	33.55	1.36
	200	498.00	6940.00	6941.75	6942.17	6943.30	0.064753	9.99	49.84	32.00	1.41
	175	498.00	6939.56	6942.11	6941.73	6942.77	0.017541	6.48	76.89	35.21	0.77
	150	498.00	6939.12	6941.67		6942.33	0.017576	6.48	76.83	35.21	0.77
	100	498.00	6938.24	6940.80	6940.41	6941.45	0.017506	6.47	76.94	35.22	0.77
	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
Elevation (ft)
6960
6955
6950
6945
6940
6935
0
100
200
300
400
Main Channel Distance (ft)

WMB
3/12/02

Scour Depth at Apron End

For 1-hr local storm, PMP = 9.6"
Pond 1 area = 32 acres in both diversion channels. Assume impermeable surface.
Then $9.6/12 \times 32 \times 43500 = 1{,}115{,}000$ 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:

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

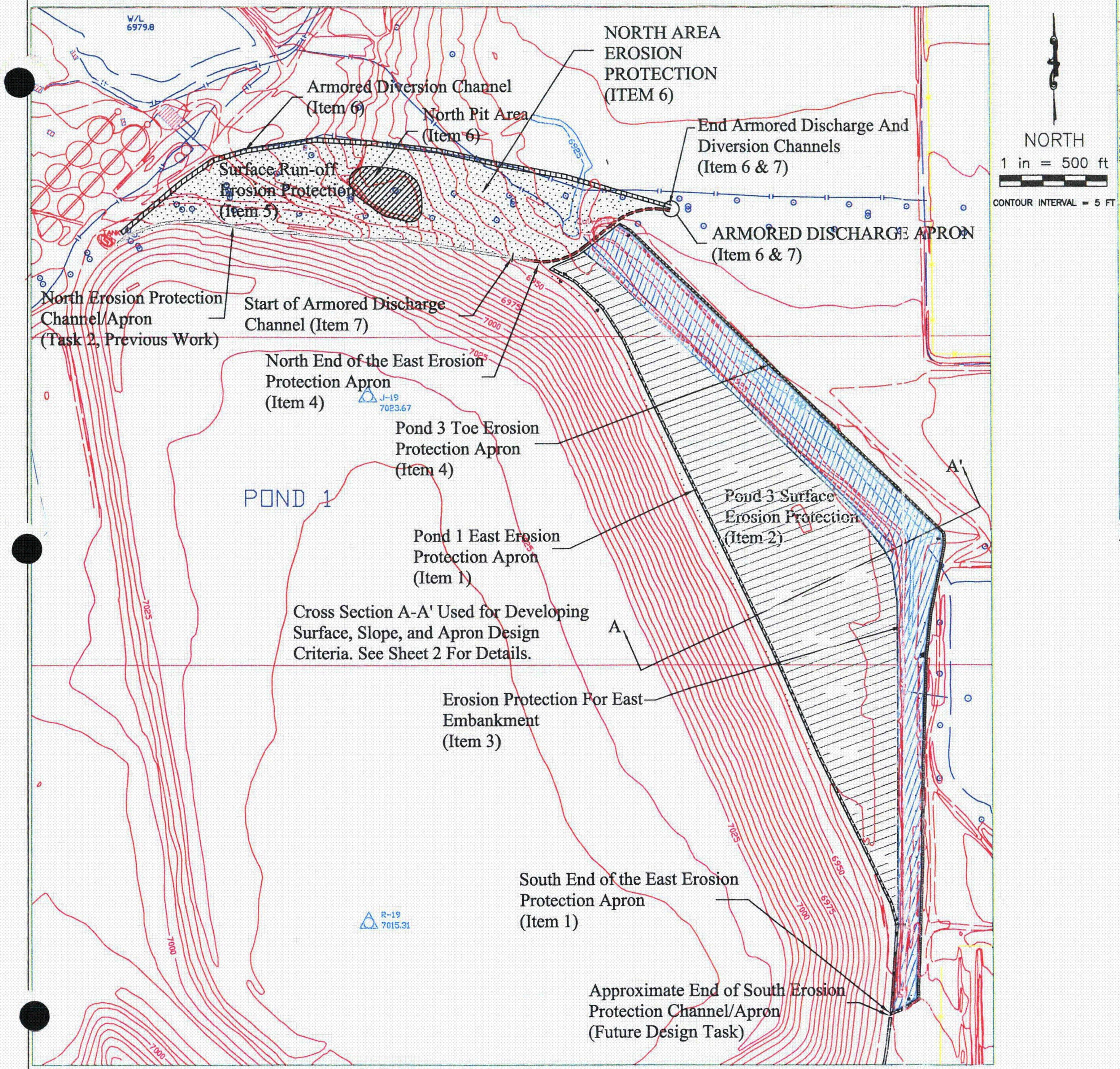
d_s = scour depth
R_h = hydraulic radius = 1.5'
C_s = slope coefficient = 1.03 for 2% slope
α = 2.27
β = 0.39
θ = 0.06
σ = coefficient of uniformity = 2.8
g = 32.2 ft/sec²
Q = ~~497 + 498 = 995~~ 310 cfs ave flow
t = 1 hr.

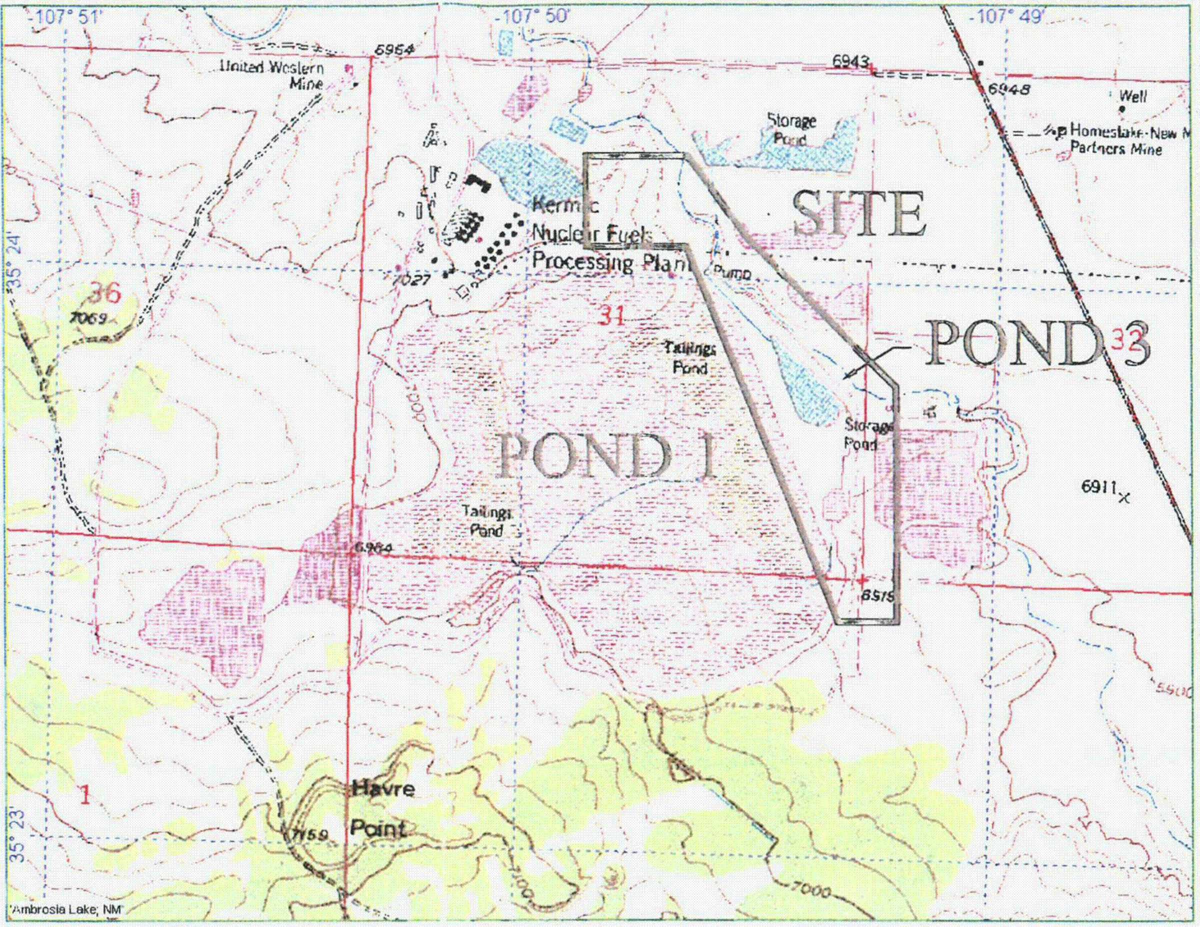
$$d_s = 1.5 \times 1.03 \frac{2.27}{2.8^{1/3}} \left(\frac{310}{32.2^{1/2} \times 1.5^{5/2}} \right)^{0.39} \left(\frac{1}{316} \right)^{0.06}$$

$= \underline{5.7'}$

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.

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NEW MEXICO
15489
REGISTERED PROFESSIONAL ENGINEER

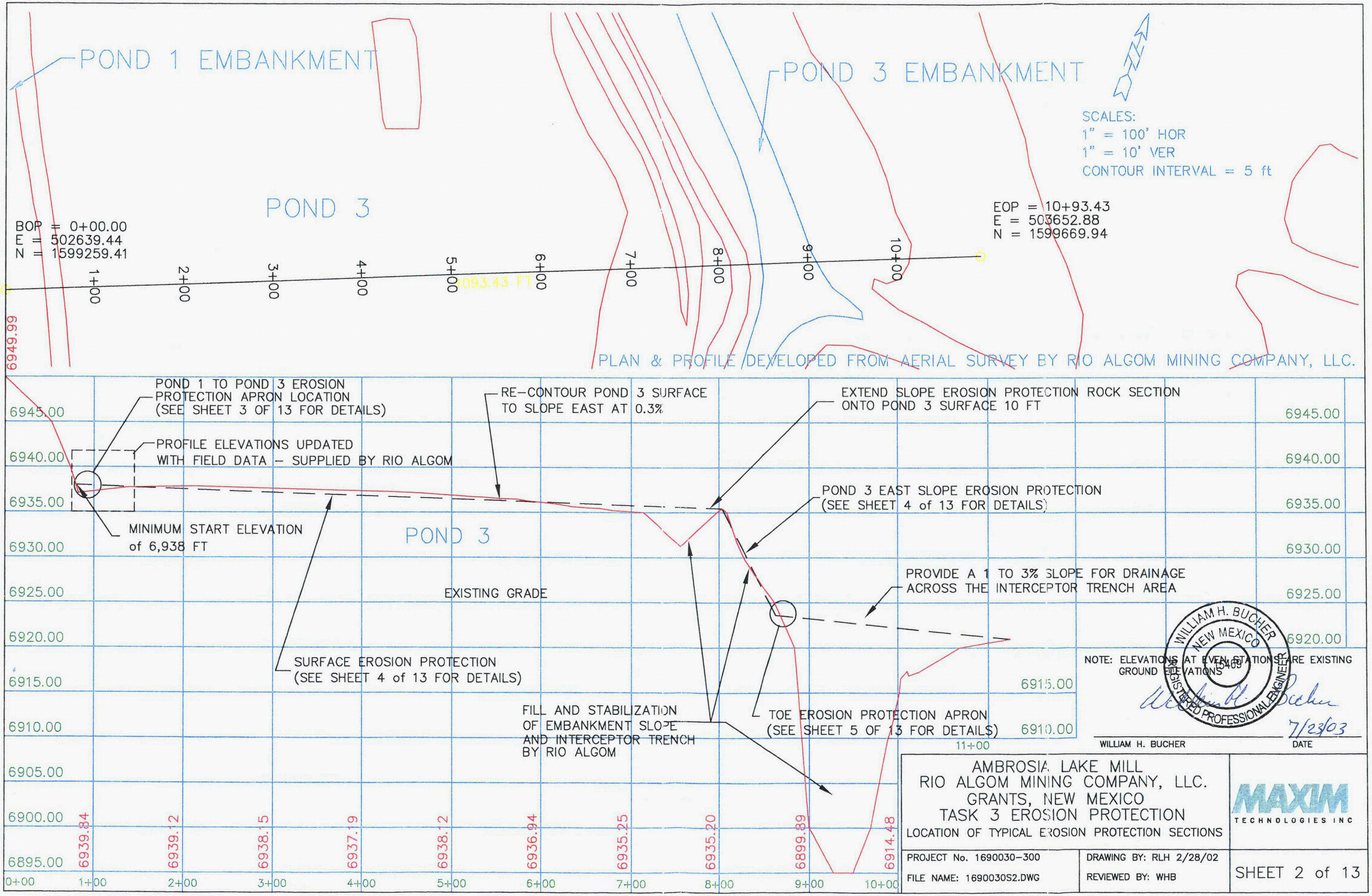
William H. Bucher
7/23/03

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
FILE NAME: 1690030S1.DWG
REVIEWED BY: WHB
SHEET 1 of 13

WILLIAM H. BUCHER
DATE



NOTE: ELEVATIONS AT EVEN STATIONS ARE EXISTING GROUND ELEVATIONS

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7/23/03

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AMBROSIA LAKE MILL
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TASK 3 EROSION PROTECTION
LOCATION OF TYPICAL EROSION PROTECTION SECTIONS

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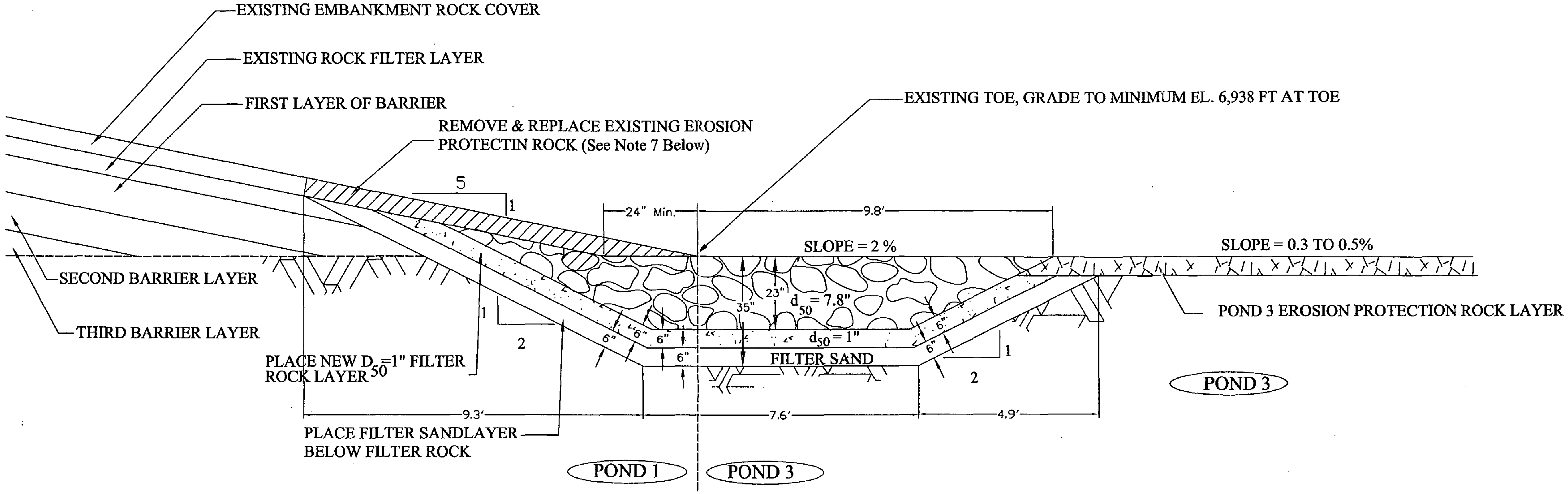
TECHNOLOGIES INC

PROJECT No. 1690030–300
FILE NAME: 1690030S2.DWG
DRAWING BY: RLH 2/28/02
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}= 7.8" conforming to the following gradation:

Sieve Designation	Percent Passing
12"	100
9"	60 - 85
6"	5 - 30
4"	0 - 5

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.

1 in = 3 ft

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7/23/03
DATE

AMBROSIA LAKE MILL
RIO ALGOM MINING COMPANY, LLC.
GRANTS, NEW MEXICO
TASK 3 EROSION PROTECTION
POND 1 TOE EROSION PROTECTION APRON

MAXIM
TECHNOLOGIES INC

PROJECT No. 1690030-300
FILE NAME: 1690030S3.DWG

DRAWING BY: RLH 2/28/02
REVISION BY: RLH 1/8/03

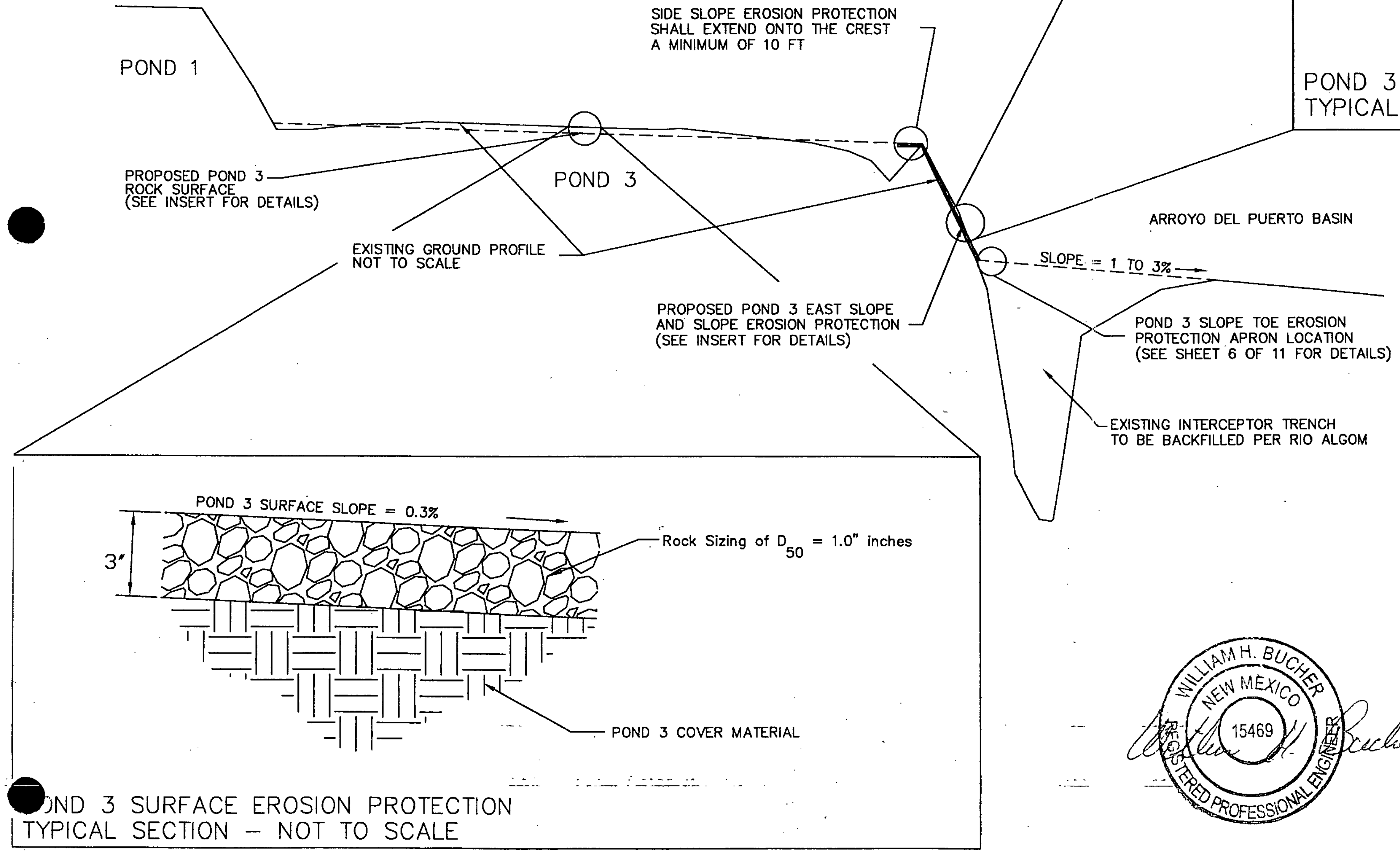
SHEET 3 of 13

POND 3 - POND SURFACE AND EAST EMBANKMENT EROSION PROTECTION

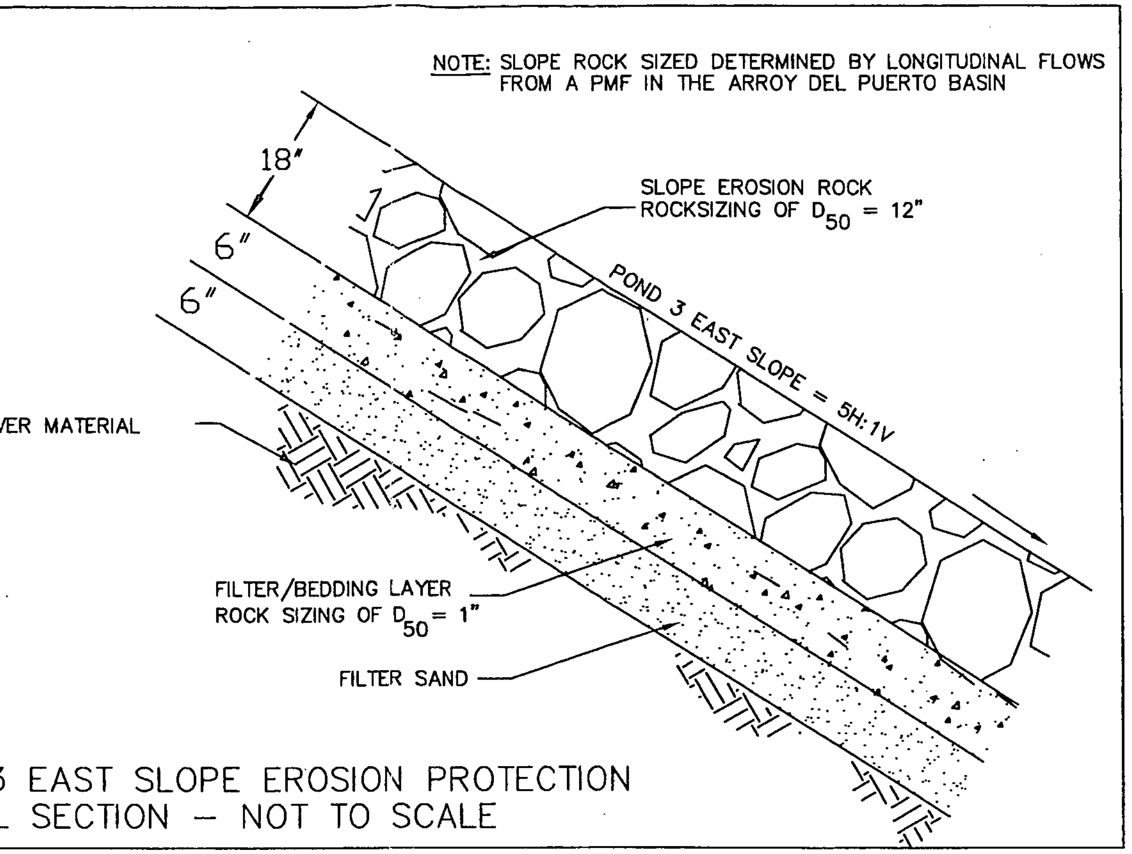
Typical Sections

REVISED

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



ND 3 SURFACE EROSION PROTECTION
TYPICAL SECTION – NOT TO SCALE



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.

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DATE

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

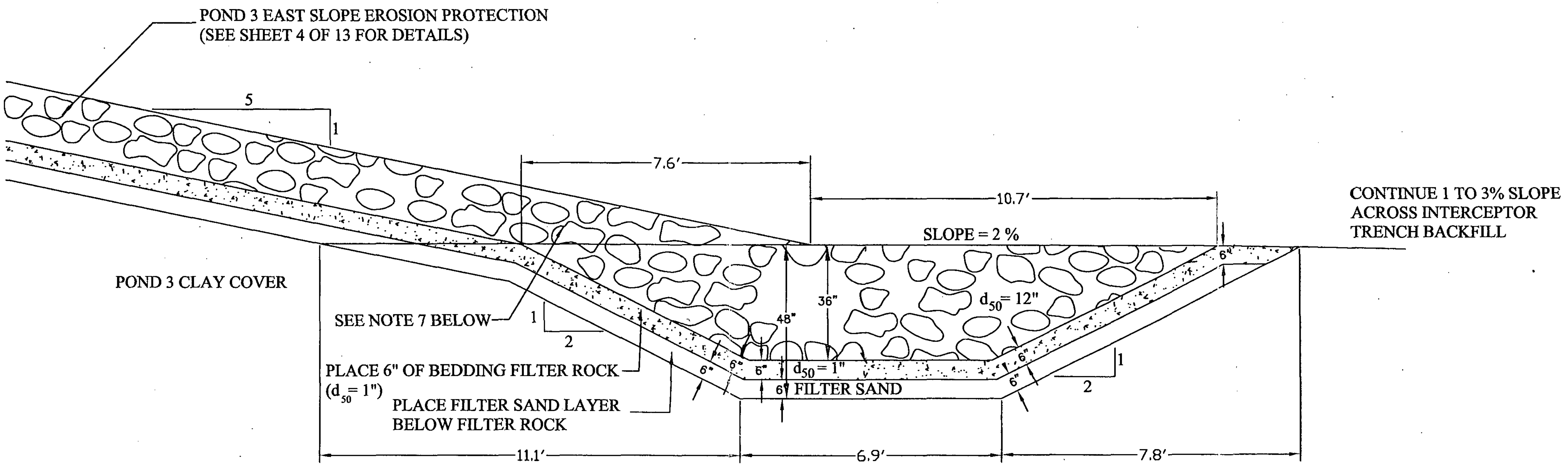
MAXIM
TECHNOLOGIES INC

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

SHEET 4 of 13

POND 3 - TOE EROSION PROTECTION APRON - EAST EMBANKMENT
FOR RUN-OFF FROM POND 3 EMBANKMENT SLOPE

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 to the surface of the ground.
4. The erosion protection apron shall be constructed of a rock diameter d_{50}= 12" conforming to the following gradation:

Sieve Designation	Percent Passing
18"	100
14"	60 - 90
12"	25 - 50
10"	10 - 30
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 2H:1V 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		Filter Sand	
Sieve Designation	Percent Passing	Sieve Designation	Percent Passing
3"	100	No.4	100
2"	80 - 100	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

7. If the erosion protection apron is not constructed at the time of the slope rock erosion protection placement, the existing erosion protection disturbed during construction of the erosion protection aprons shall be replaced in a manner that maintains existing slopes and riprap conditions. 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 to match the existing longitudinal slopes. Areas of longitudinal slopes greater than 1% shall have a rock soil matrix placed within the apron. The soil for the rock soil matrix shall be placed into the rock voids after placement of each rock lift. The soil shall consist of on-site silty sands.

1 In = 3 ft

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7/23/03

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DATE

AMBROSIA LAKE MILL
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TASK 3 EROSION PROTECTION
POND 3 TOE EROSION PROTECTION APRON

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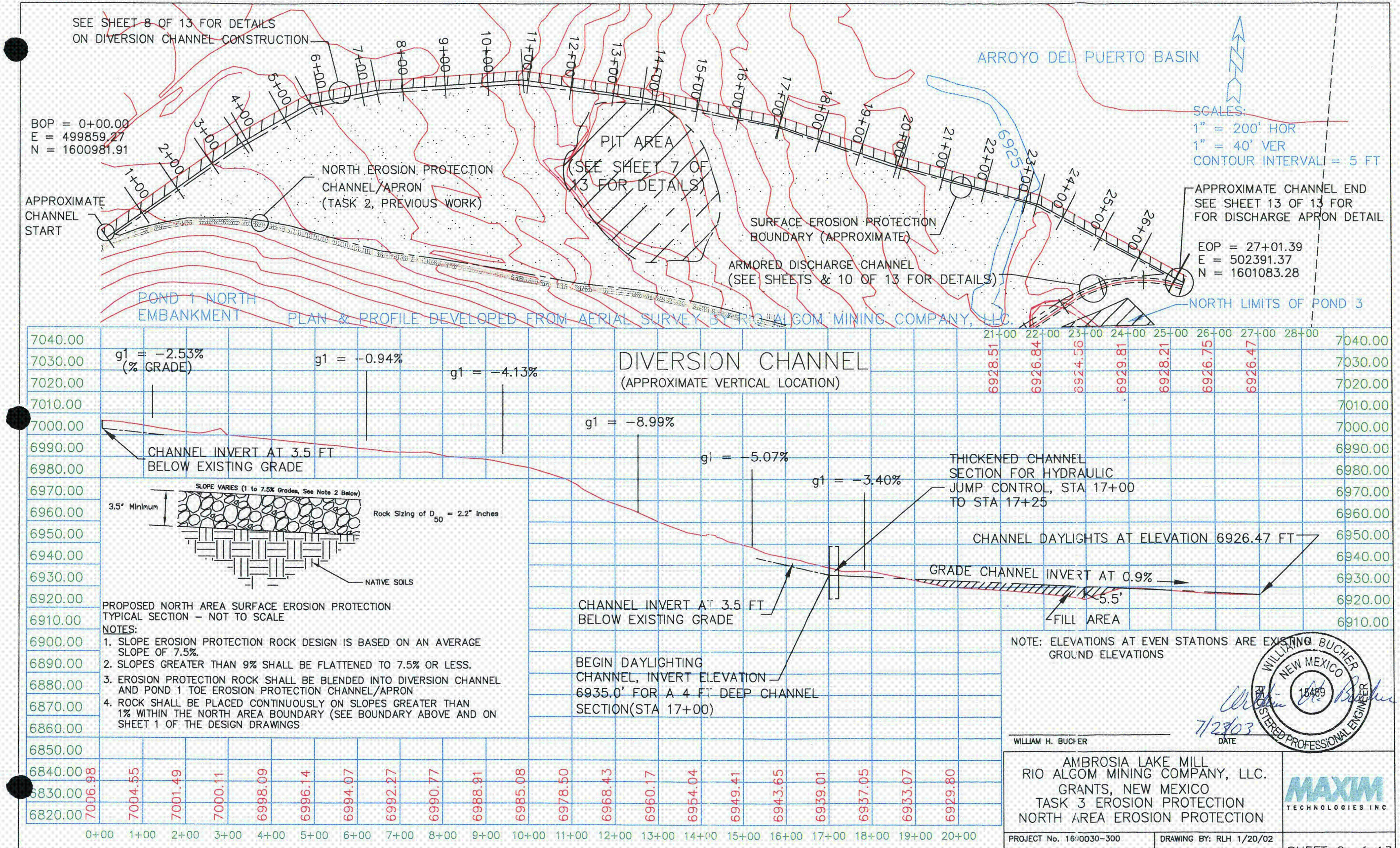
TECHNOLOGIES INC

PROJECT No. 1690030-300
DRAWING BY: RLH 1/19/02
SHEET 5 of 13



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

NOTE: ELEVATIONS AT EVEN STATIONS ARE EXISTING GROUND ELEVATIONS

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7/23/03

DATE

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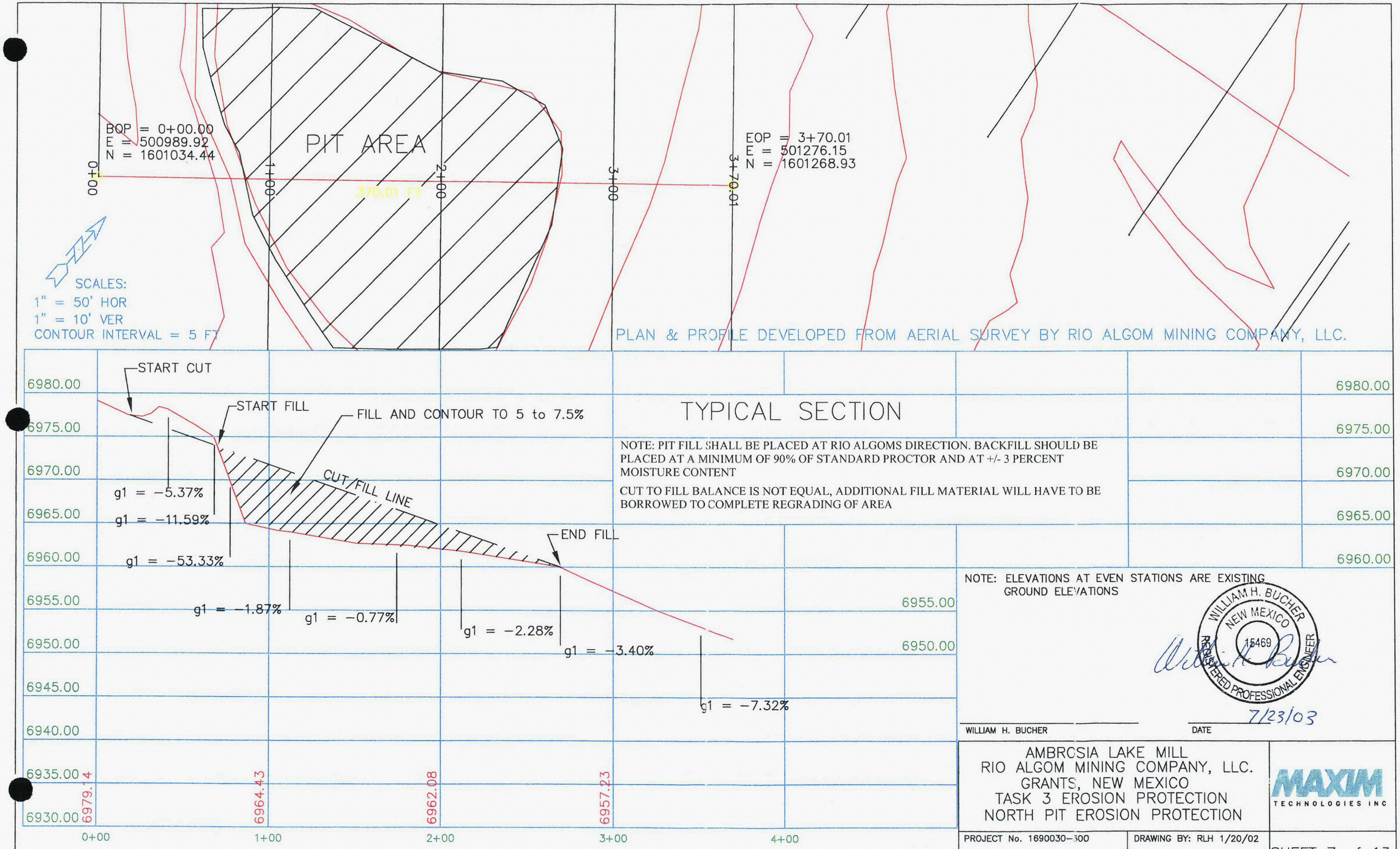
TASK 3 EROSION PROTECTION
NORTH AREA EROSION PROTECTION

MAXIM TECHNOLOGIES INC

PROJECT No. 1690030-300
FILE NAME: 169003OS6.DWG

DRAWING BY: RLH 1/20/02
REVIEWED BY: WHB

SHEET 6 of 13



TYPICAL SECTION

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

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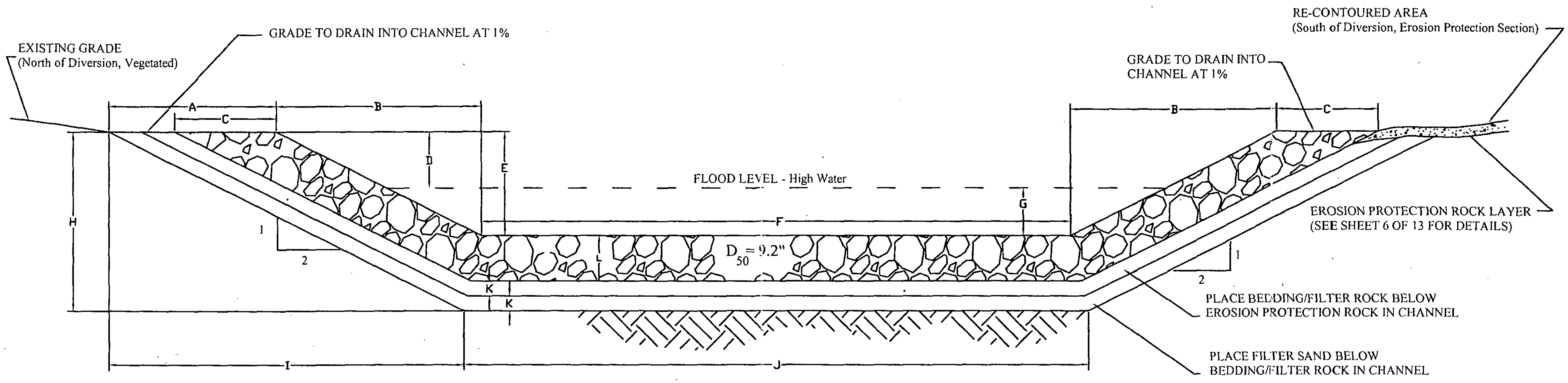
DATE 7/23/03

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
FILE NAME: 1690030S7.DWG
DRAWING BY: RLH 1/20/02
REVIEWED BY: WHB
SHEET 7 of 13

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 rock thickness designated in the table. 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 conforming to the following gradations:

D_{50}= 9.2"		D_{50}= 7.8"	
Sieve Designation	Percent Passing	Sieve Designation	Percent Passing
15"	100	12"	100
12"	70 - 90	9"	60 - 85
9"	30 - 55	6"	5 - 30
6"	0 - 10	4"	0 - 5

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 gradations:

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)												Rock Size d_{50}
CHANNEL SECTION	A	B	C	D	E	F	G	H	I	J	K	L	
STA 0+00 To STA 9+00	5.3	7.0	3.1	1.3	3.5	4.0	2.2	5.8	11.7	5.2	0.5	1.3	7.8
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	9.2
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	9.2

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

MAXIM
TECHNOLOGIES INC

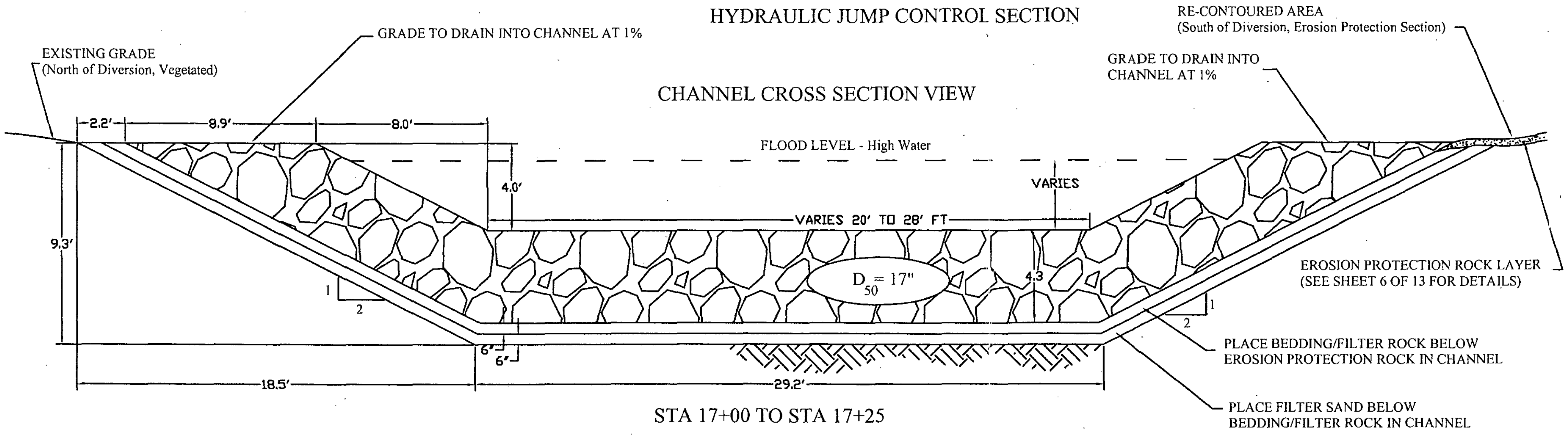
PROJECT No. 1690030-300
FILE NAME: 1690030S8.DWG

DRAWING BY: RLH 2/28/02
REVISION BY: RLH 1/10/03
REVIEWED BY: WHB

SHEET 8 of 13

DIVERSION CHANNEL - NORTH AREA
HYDRAULIC JUMP CONTROL SECTION

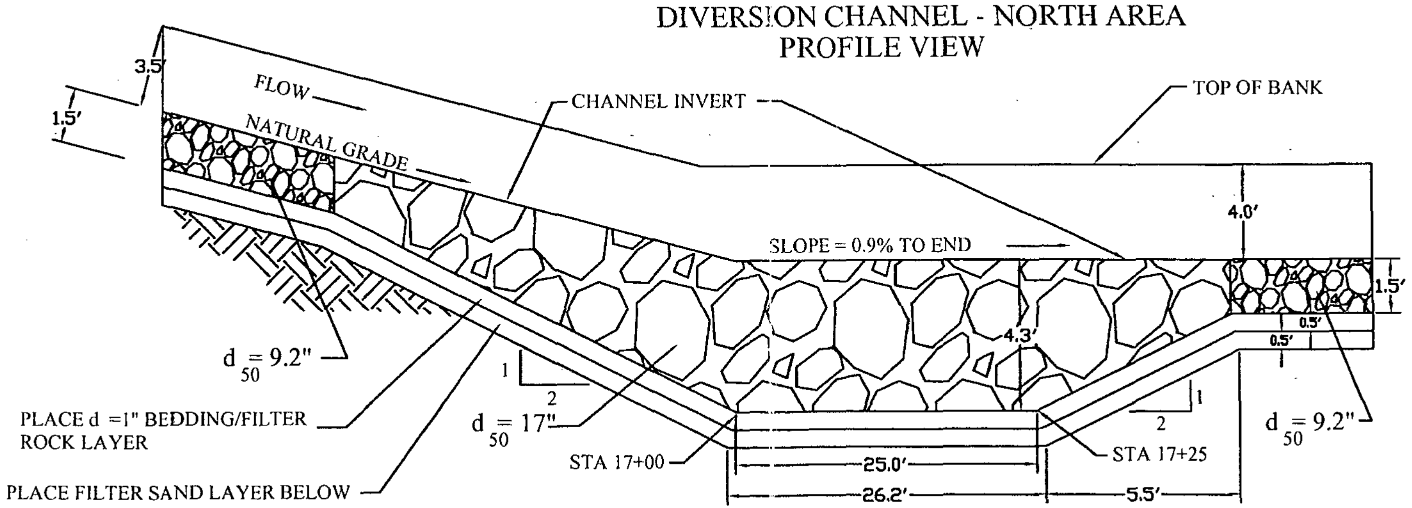
CHANNEL CROSS SECTION VIEW



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

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AMBROSIA LAKE MILL
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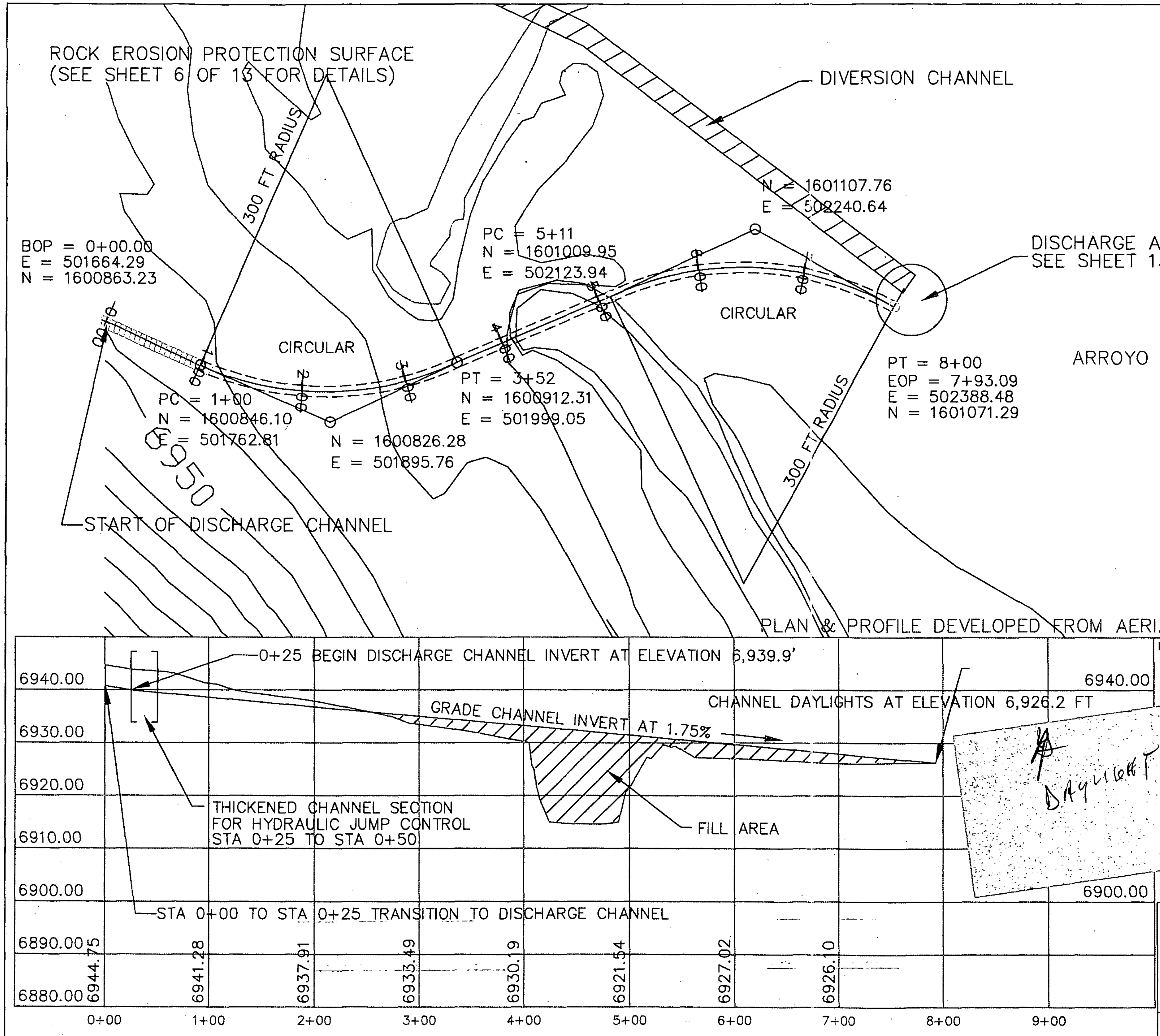
GRANTS, NEW MEXICO
TASK 3 EROSION PROTECTION
DIVERSION CHANNEL – NORTH AREA

MAXIM
TECHNOLOGIES INC

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

SHEET 9 of 13



A DAYLIGHT

PLAN & PROFILE DEVELOPED FROM AERIAL SURVEY BY RIO ALGOM MINING COMPANY, LLC.

SCALES:
1" = 100' HOR
1" = 20' VER
CONTOUR INTERVAL = 5 FT

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
EXTERIOR BERM SLOPES SHALL BE ROCK COVERED USING D_{50}=1.0".
ROCK SHALL BE PLACED AT A THICKNESS OF 3".
STATION 0+00 OF DISCHARGE CHANNEL IS STATION 16+00 OF THE POND 1 EROSION PROTECTION CHANNEL/APRON.

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William H. Bucher

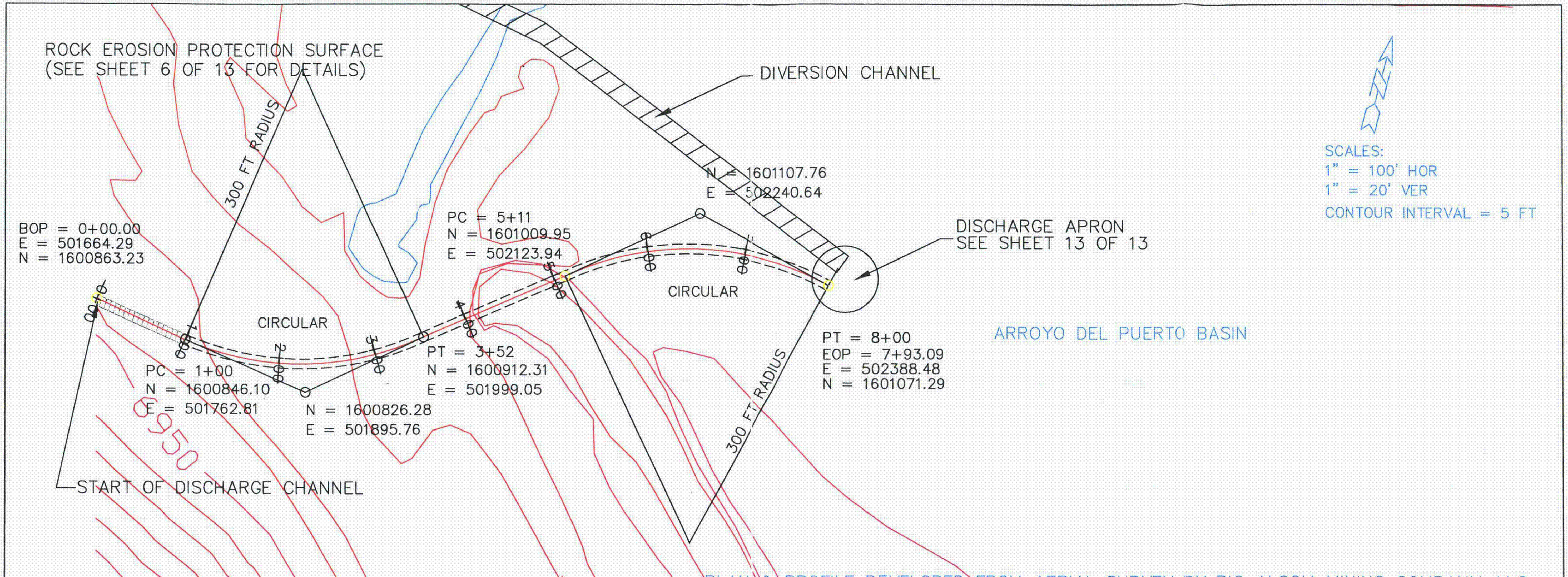
WILLIAM H. BUCHER

DATE 7/23/03

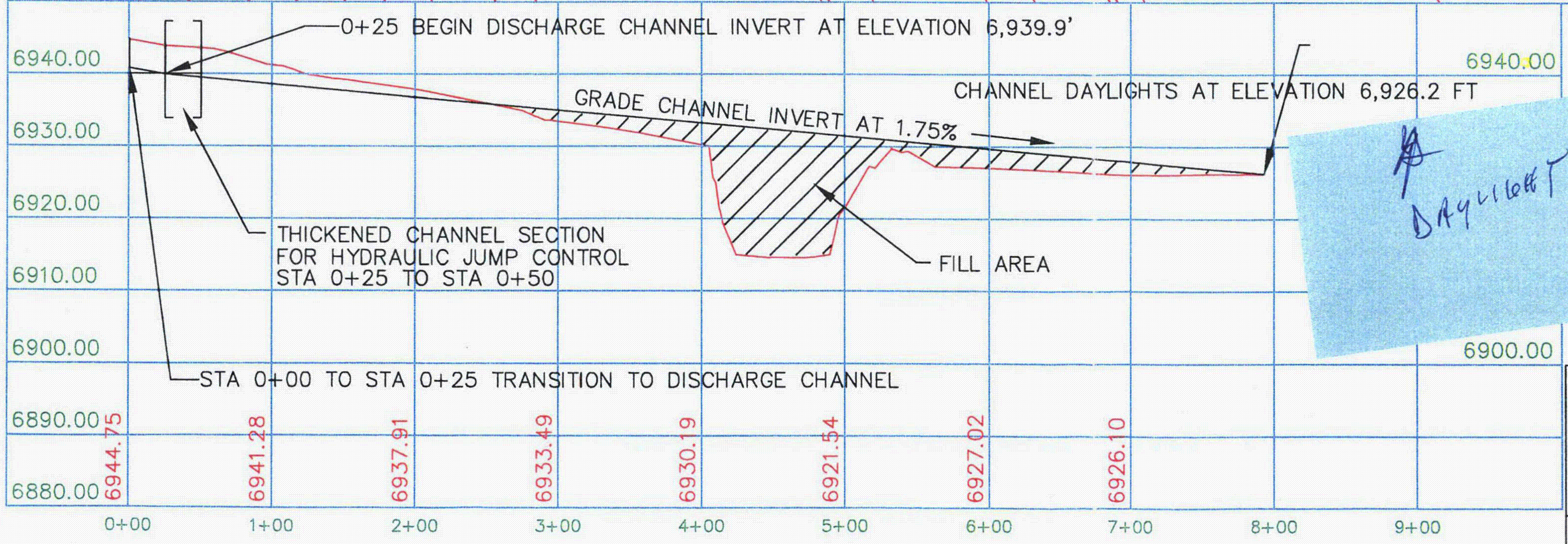
AMBROSIA LAKE MILL
RIO ALGOM MINING COMPANY, LLC.
GRANTS, NEW MEXICO
TASK 3 EROSION PROTECTION
DISCHARGE CHANNEL

MAXIM
TECHNOLOGIES INC

PROJECT No. 16900.0–300	DRAWING BY: RLH 1/20/02	SHEET 10 of 13
FILE NAME: 1690030S10.DWG	REVIEWED BY: WHB	



PLAN & PROFILE DEVELOPED FROM AERIAL SURVEY BY RIO ALGOM MINING COMPANY, LLC.



DAYLIGHT

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
EXTERIOR BERM SLOPES SHALL BE ROCK COVERED USING D_{50}=1.0". ROCK SHALL BE PLACED AT A THICKNESS OF 3".
STATION 0+00 OF DISCHARGE CHANNEL IS STATION 16+00 OF THE POND 1 EROSION PROTECTION CHANNEL/APRON.

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AMBROSIA LAKE MILL
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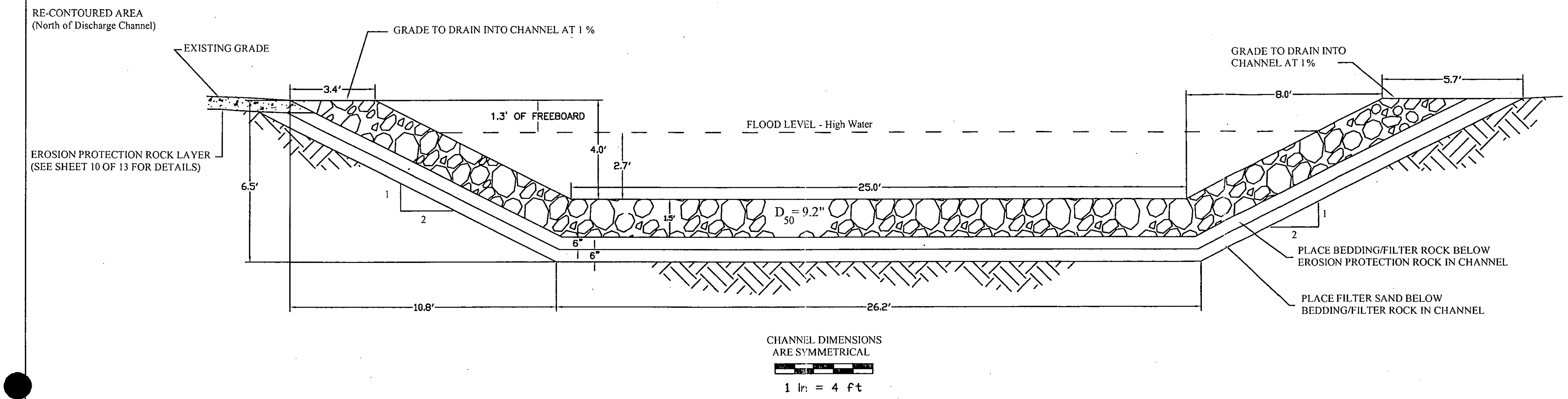
GRANTS, NEW MEXICO
TASK 3 EROSION PROTECTION
DISCHARGE CHANNEL

MAXIM TECHNOLOGIES INC

PROJECT No. 16900.0–300
FILE NAME: 1690030S10.DWG
DRAWING BY: RLH 1/20/02
REVIEWED BY: WHB
SHEET 10 of 13

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

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

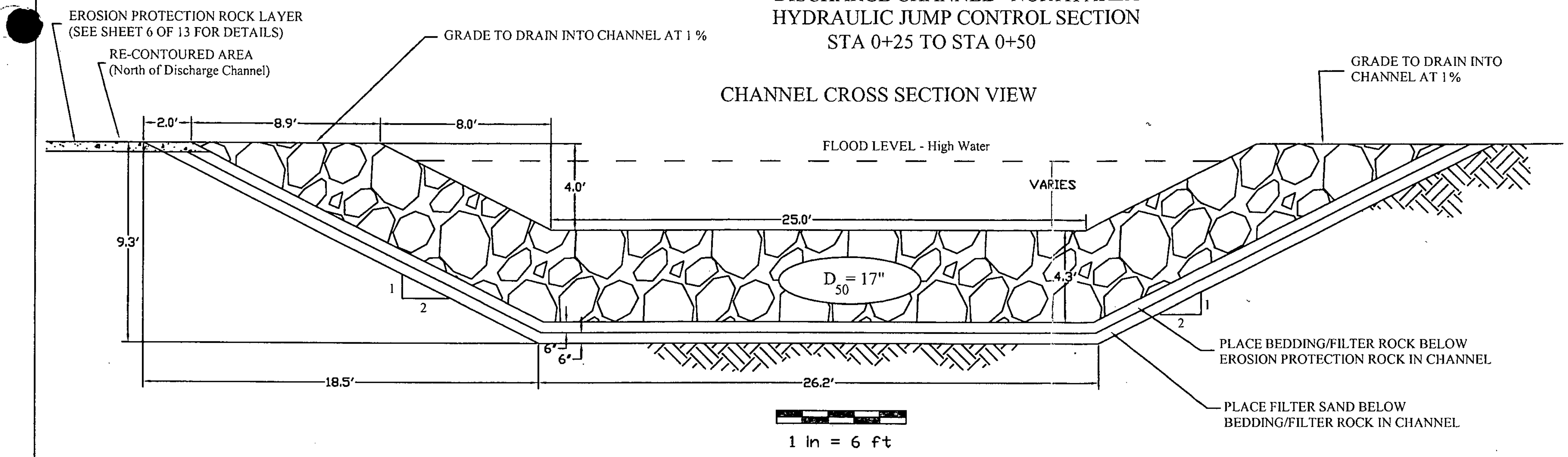
MAXIM TECHNOLOGIES INC

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

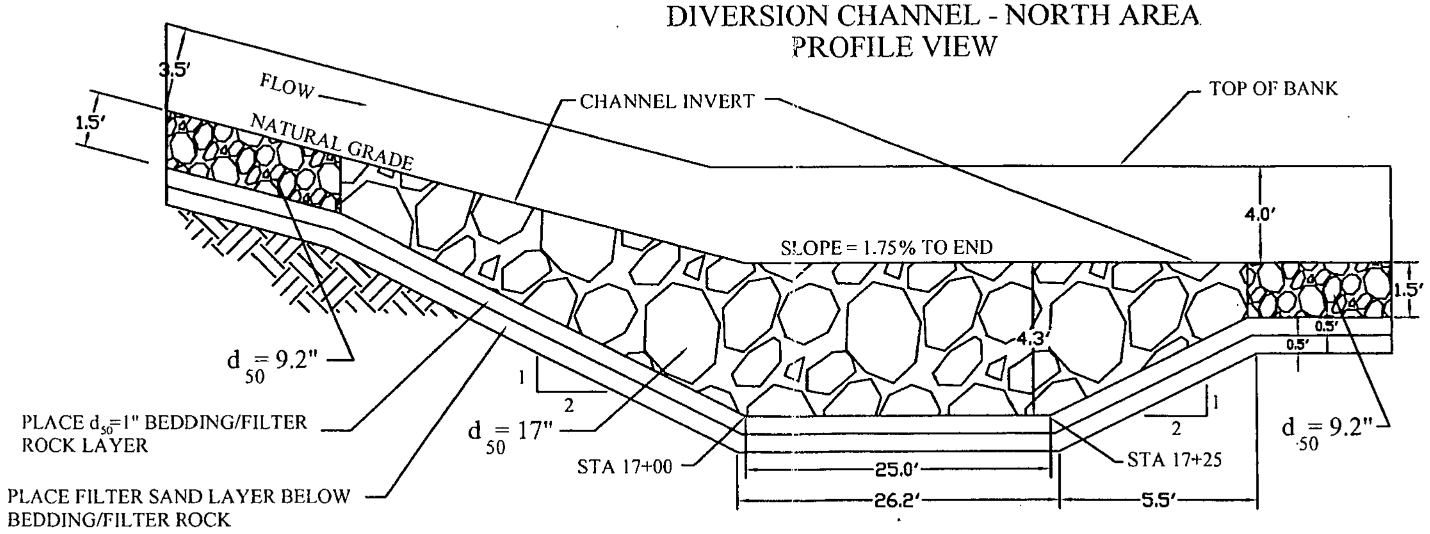
SHEET 11 of 13

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

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7/23/03
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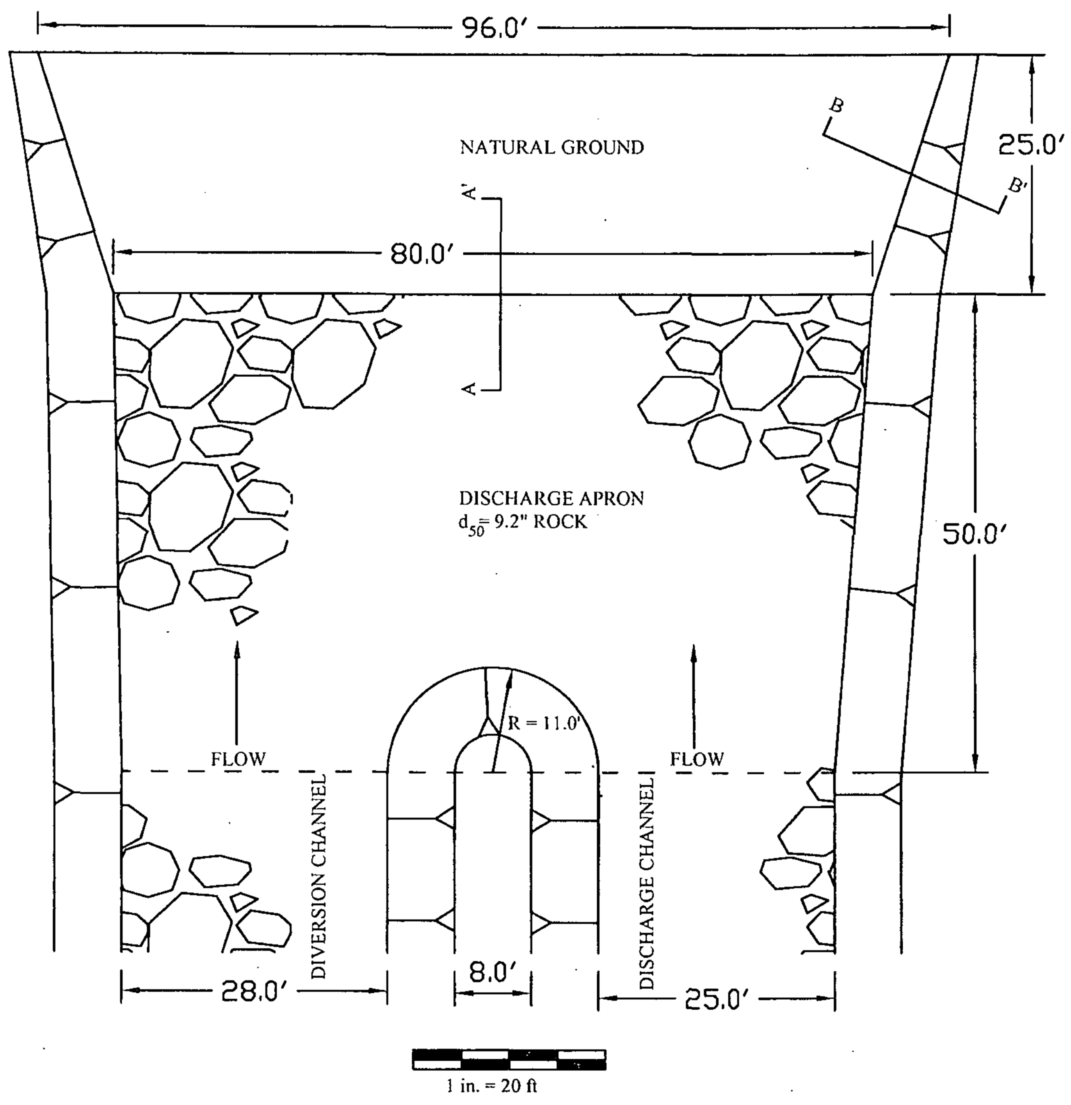
AMBROSIA LAKE MILL
RIO ALGOM MINING COMPANY, LLC.
GRANTS, NEW MEXICO
TASK 3 EROSION PROTECTION
DISCHARGE CHANNEL – NORTH AREA

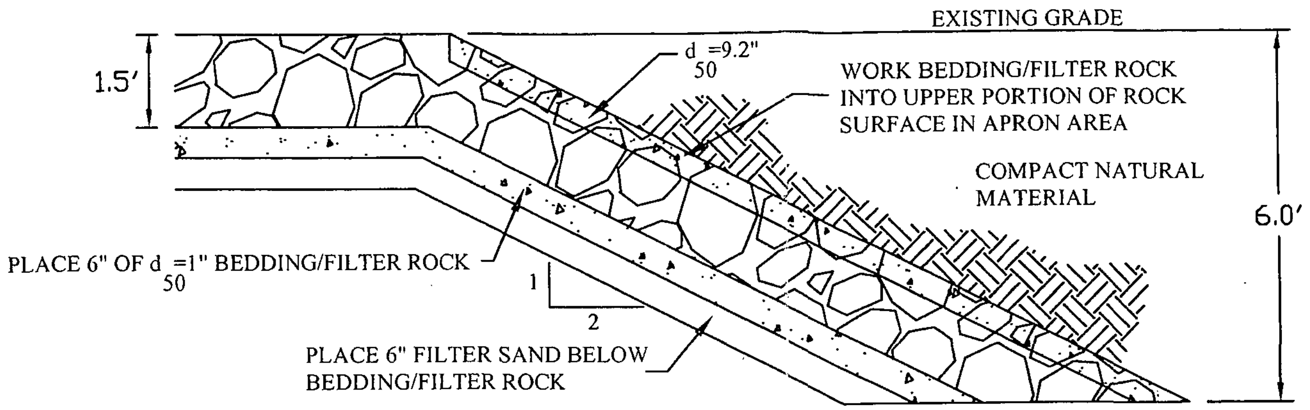
MAXIM
TECHNOLOGIES INC

PROJECT No. 1690030-300
FILE NAME: 1690030S12.DWG
DRAWING BY: RLH 2/28/02
REVIEWED BY: WHB
SHEET 12 of 13

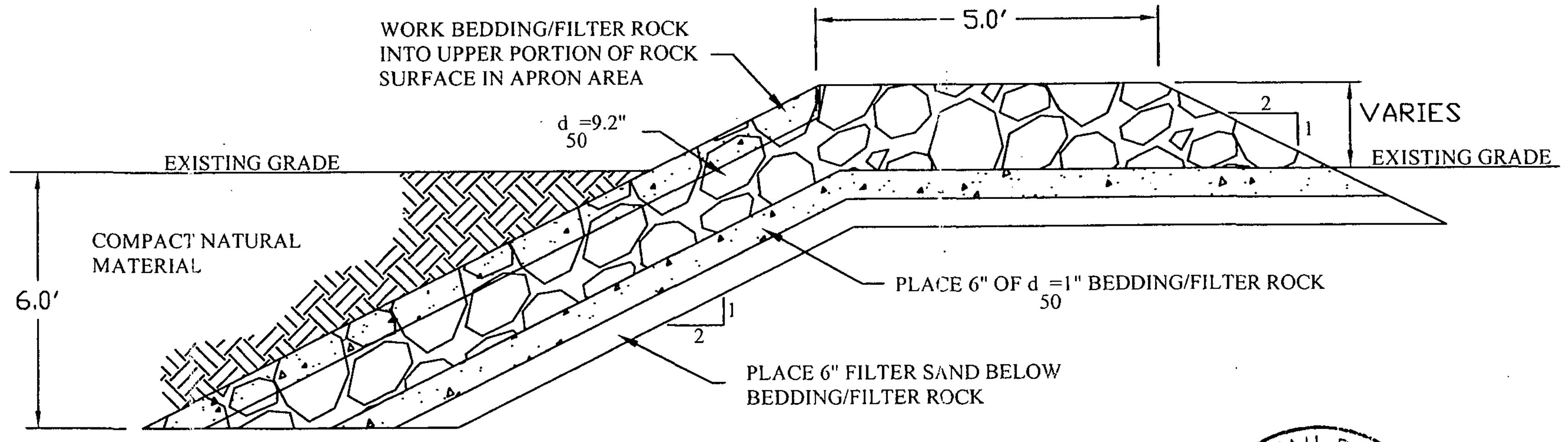
DISCHARGE APRON
PLAN VIEW



DISCHARGE APRON TOE
SECTION A-A'
NOT TO SCALE



DISCHARGE APRON WING WALL
SECTION B-B'
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 -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

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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
FILE NAME: 1690030S13.DWG
REVIEWED BY: WHB
SHEET 13 of 13

Appendix D .... Exterior Site Drainage Calculations

Appendix D.1: Calculation D.1 Design Flowrates and Erosion Protection

Appendix D.1 .... Calculation D.1 Design Flowrates and Erosion Protection

Calculation D.1
Rio Algom Mining LLC
Ambrosia Lake, New Mexico
Arroyo Del Puerto
Exterior Site Drainage Calculations
Design Flowrates and Erosion Protection

1. Probable Maximum Flood (PMF) Magnitude Discussion

Calculation of a PMF from a probable maximum precipitation (PMP) event requires information on the type of storm, the geometry of the basin, the infiltration properties of the basin as well as assumptions about the behavior of the flood peak as it travels through the basin. The number and uncertainty of variables in the calculation can lead to greatly varying results in the magnitude of the PMF.

Previous consultants to Rio Algom Mining LLC on the project developed a PMF value of 78,000 cfs which was approved by the NRC inprevious design documents. It has later been suggested by the NRC that a much larger PMF value (200,000 cfs) should be used. For purposes of the present design the PMF value of 78,000 PMF will be used without adjustment.

In a previous Maxim (Tetra Tech) design report, "Pond 3 Erosion Protection and Erosion Protection for the Area North of Pond 1, Ambrosia Lake Mill, New Mexico (Maxim, 2002)", a PMF value of 75,200 cfs was calculated using the HEC-1 model (U.S. Army Corps of Engineers, 1990). The flood analysis was modeled with the following:

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

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

a) A drainage basin of 57.6 sq. mi. would have an areal reduction factor of ~40% when modeling with only one basin and at least ~80% when subbasins are modeled. A PMP value of 9.2 inches would indicate that a reduction factor of 96% was used which would be very conservative.
b) Modeling with only one basin instead of several subbasins would also produce a conservative result. A more appropriate depiction of the drainage area with delineated subbasins in shown in Worksheet Tab "PMF Drainage Area", (calc. Sheet 4 of 73)
c) It is also noted in the delineated subbasin map that Subbasin 4D (comprising 11% of the drainage area) enters the site at Pond 9 which is below the present area of design and therefore would ot impact the design.
d) Also the Geomorphic Report by Jerry Lindsay, Appendix E, Design Report, would tend to suggest that due to high infiltration rates that a curve number of 73.4 might be on the conservative side.

2. Design Options

Given the location of comtaminated tailings materials located in Ponds 1, 3, 4, 5, & 6, three options for evaluated to provide protection measures for flood flows associated with the Arroyo Del Puerto.

These options were as follows:

Option 1	Relocate the Arroyo Del puerto to its historical alignment and provide erosion protection of the channel and the overbank areas for the PMF flood flows.
Option 2	Provide a diversion embankment/channel to route the PMF flood flows of the Arroyo del Puerto to the northeast side of Pond areas 4, 5, & 6. Interior site drainage would be provided by a channel located in the historical alignment of the Arroyo Del Puerto. The PMF flood flows of the Arroyo Del Puerto would not directly impact any of the contaminated areas.
Option 3	This option involved Option 1 with a weir embankment feature located on the downstream side of Pond Areas 4, 5, & 6. The purpose would be to back up flood flows within the comtaminated zones of Pond Areas 4, 5, & 6, thus reducing flow velocities and reducing rock protection sizes.

It was determined that Option 2 provided a better technical solution as well as a better economic solution.

3. Diversion Embankment/Channel Design Layout

An initial design used a 15 ft high embankment with 3:1 side slopes, and a channel width of 250 ft with the bottom sloping 1 1/2% down and away from the berm.
The final design varies the height of the embankment from a maximum of 16.62 feet down to 12.50 feet.
The embankment has 3:1 side slopes on both sides from the upstream end down to Station 27+50. From that point until the end of the embankment at ~1+75 the diversion channel side of the embankment will transition to a 4:1 slope that is continued to scour depth with buried rock protection.
The diversion channel width is 250 feet sloping 2% down and away from the embankment from the upstream end at the entrance road down to Station 5+00. At this point the channel transitions to a wider cross-section. The wider cross-section maintains the 2% downslope for 250 feet and then continues with a level channel bottom beyond this point.
This is shown in the cross-section on "Drawing Sheet 6".
The alignment is shown on "Drawing Sheet 4".

The layout of the diversion embankment/channel is driven primarily by balancing the cut and fill, and approximately matching the upstream and downstream existing elevations. Another consideration is matching the converging elevations of the interior and exterior channels as they come together at the northeast corner on Pond # 9.
The slope of the diversion channel was adjusted along its course so as to best balance the cut and fill.
The geometric data and volume of cut and fill for the Diversion Embankment/Channel is shown on Worksheet Tab "Cut-Fill Volumes", (calc. Sheets 45 thru 50 of 73).
The approximate cut and fill estimate down to the confluence area has more cut volume (330,000 cy) than the fill volume requirements (210,000 CY).

The geometric data along with additional topography data was utilized as input into the HEC-RAS Model (USACE, 2003) A summary of this input data is contained on Worksheet Tab "HEC-RAS Input Data", (calc. Sheets 51 thru 56 of 73)

4. HEC-RAS Results

Continued evaluation of the HEC-RAS analysis has indicated that the flow regime transitioned from subcritical flow to supercritical flow at approximate Statiion 27+50. This has resulted in higher velocities in the supercritical area which promted the change to a buried 4H:1V rock protected slope within this area.

The summary results of the HEC-RAS analysis, rock size calculations, and depth scour calculations for the Diversion Embankment/Channel are contained on Worksheet Tab "Rock-Scour Depth Summary", (calc. Sheet 5 thru 6 of 73).
The detailed results of the HEC-RAS analysis and subsequent calculations are summarized on the table of Worksheet Tab "HEC-RAS Results", (calc. Sheets 7 thru 34 of 73). Erosion protection sizes have been estimated on this table by the Abt and Johnson Method and then oversizing by 4% to determine the D_{50} size rock before applying slope correction factors. The size of rock after applying the slope factors determines whether an apron will be used or a buried rock slope taken down past the scour depth. The scour depths along the diversion channel have also been estimated on this table.

The extent of the PMF is illustrated on "Drawing Sheet 3".
The extent of the PMF is also illustrated by the graphic cross-sections of the flood flow taken from the HEC-RAS Model and shown on Worksheet Tab "PMF X-Sections", (calc. Sheets 35 thru 43 of 73).
Also, a profile of the flow regime is shown on Worksheet Tab "PMF Profile", (calc. Sheets 44 of 73).

The raw data taken directly from the HEC-RAS model is contained on the following worksheets:

Worksheet Tab "HEC-RAS Profile Output"	Calc. Sheet 57 of 73
Worksheet Tab "HEC-RAS Flow Dist Output"	Calc. Sheets 58 thru 61 of 73
Worksheet Tab "HEC-RAS Cross-Sect Output"	Calc. Sheets 62 thru 64 of 73

4. Scour Depth Calculations

See the detailed evaluation of scour depth methods in the main report.
Thd USDOT HEC-14 method was initially used and was evaluated in more detail.
Additional methods were applied for comparison.

1. The USDOT HEC-14 equation is sensitive to the concentration of Q as in a circular small culvert. It is deemed more reasonable in a wide open channel (similar to a wide rectangular culvert) that discharge per unit width be used in the equation. However, since this method was originally developed for small circular culverts it is questionable whether its use with discharge per unit width for a wide open channel is applicable.
2. The USACE Equilibrium scour depth equation was used. The value of used for grain size is sensitive. A value of very fine sand was used. This method seems to be most appropriate for a wide open channel.
3. The CSU equation for piers was used. To make this method applicable it was assumed that one of the rocks would act as a pier with a round nose and a zero angle of attack to the flow since the channel is primarily in a straight alignment in the worst area of supercritical flow. The parameter that is sensitive is the width of the pier that is used. In this evaluation the width of the 12-inch rock size was doubled to use a more conservative width of 24 inches. This method does not seem applicable for a wide open channel with rock protection.
4. The final equation used was the USDOT HEC-18 Froelich Equation for live bed scour. For the abutment shape, considering the rock apron or the buried rock slope, a correction factor for shape assumed a flow through abutment. The flow area of approach cross-section obstructed by the apron or buried slope was an odd parameter to assume. It was assumed that for the apron or the buried slope that 6 inches of the layer would be sticking up enough to impact flows when impacted by the scour flow forces. This method does not seem applicable for a wide open channel with rock protection.

Therefore, the USACE Equilibrium scour depth method was deemed most appropriate and was used for final design.

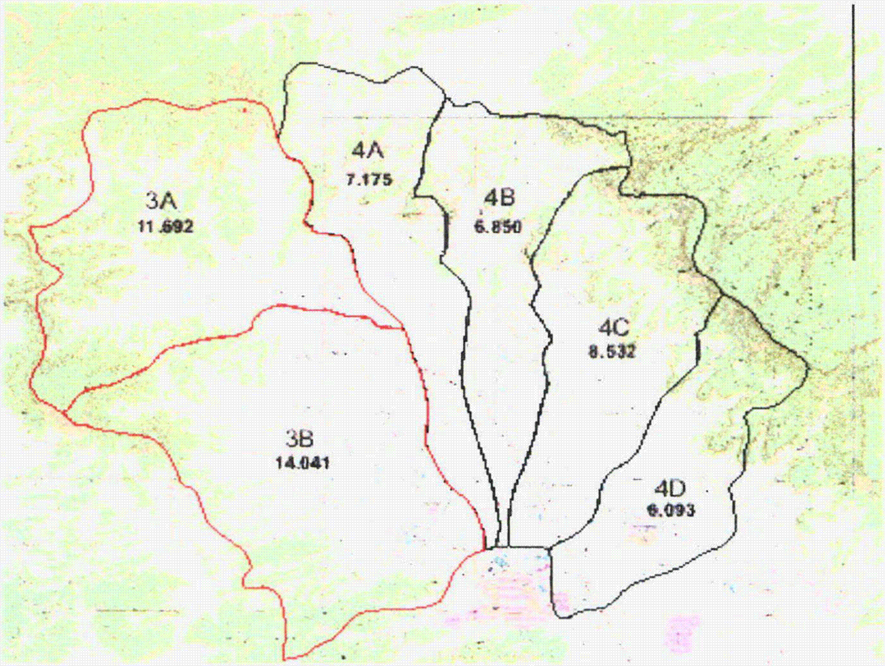
5. Magnitude of Rock Sizing and Scour Depth at the Right Channel and Bank Location of the Diversion Channel

Given the magnitude of the flood flow used in the HEC-RAS analysis it was expected that the rock sizing and scour depth would have been larger that the final calculations. The effect of Manning's 'n' calculated from the rock sizes used on the above grade slope, apron, and below grade slope appears to have a great effect on the relative values of hydraulic depth, velocity, rock size, and scour depth at the right channel and bank location.
This effect is visually illustrated in the attached graphs of the relative data as follows:

Worksheet Tab "X-Section 8"	Calc. Sheet 65 of 73
Worksheet Tab "X-Section 7"	Calc. Sheet 66 of 73
Worksheet Tab "X-Section 6"	Calc. Sheet 67 of 73
Worksheet Tab "X-Section 5"	Calc. Sheet 68 of 73
Worksheet Tab "X-Section 4"	Calc. Sheet 69 of 73
Worksheet Tab "X-Section 3"	Calc. Sheet 70 of 73
Worksheet Tab "X-Section 2"	Calc. Sheet 71 of 73
Worksheet Tab "X-Section 1"	Calc. Sheet 72 of 73
Worksheet Tab "X-Section 0"	Calc. Sheet 73 of 73

6 Conclusion:

The resulting rock sizes indicate D_{50}=7.8-inch rock size for the 3H:1V side slopes, D_{50}=12.0-inch rock size for the aprons and 4H:1V slopes. Scour depth is less than 7.0 feet for the subcritical flow region, and less than 10.0 feet for the supercritical flow region. Freeboard along the Diversion Embankment is primarily between 3.0 to 4.0 feet.


3A
11.692
4A
7.175
4B
6.850
4C
8.532
3B
14.041
4D
6.093

		Embankment Slope / Apron D_{50} (inches)					
1	2	3	4	5	6	7	8
			D_{50} ROCK SIZE CALCULATION w/ SLOPE CORRECTION FACTORS (inches)				
River Section	Station	Channel X-Section Position	Abt and Johnson Method (inches)	Add Riprap Oversize 4%	2H:1V Apron Slope: Abt and Johnson D_{50} / Slope Factor (0.72)	3H:1V Slope: Abt and Johnson D_{50} / Slope Factor (0.88)	4H:1V Slope: Abt and Johnson D_{50} / Slope Factor (1.00)
21	9675						
20	9175						
19	8675	R. Chan. Apron	2.24	2.33	3.24	2.65	2.33
18	8350	R. Chan. C3	3.46	3.60	5.00	4.09	3.60
		R. Chan. C1 (Apron)	3.07	3.19	4.43	3.62	3.19
17	8000	R. Chan. C3	2.89	3.00	4.17	3.41	3.00
		R. Chan. C1 (Apron)	2.56	2.66	3.70	3.03	2.66
16	7500	R. Chan. C3	3.72	3.86	5.37	4.39	3.86
		R. Chan. C1 (Apron)	3.30	3.43	4.76	3.90	3.43
15	7000	R. Chan. C3	4.73	4.92	6.83	5.59	4.92
		R. Chan. C1 (Apron)	4.19	4.36	6.05	4.95	4.36
14	6500	R. Chan. C3	5.09	5.30	7.36	6.02	5.30
		R. Chan. C1 (Apron)	4.51	4.69	6.51	5.33	4.69
13	6000	R. Chan. C3	4.80	4.99	6.93	5.67	4.99
		R. Chan. C1 (Apron)	4.24	4.41	6.13	5.01	4.41
12	5500	R. Chan. C3	4.64	4.82	6.70	5.48	4.82
		R. Chan. C1 (Apron)	4.10	4.26	5.92	4.85	4.26
11	5000	R. Chan. C3	4.82	5.01	6.96	5.69	5.01
		R. Chan. C1 (Apron)	4.25	4.42	6.14	5.03	4.42
10	4500	R. Chan. C3	4.88	5.08	7.05	5.77	5.08
		R. Chan. C1 (Apron)	4.30	4.47	6.22	5.09	4.47
9	4000	R. Chan. C3	6.97	7.24	10.06	8.23	7.24
		R. Chan. C1 (Apron)	6.13	6.38	8.86	7.25	6.38
8	3500	R. Chan. C3	6.91	7.19	9.98	8.17	7.19
		R. Chan. C1 (Apron)	6.09	6.33	8.80	7.20	6.33
7	3000	R. Chan. C3	7.19	7.48	10.38	8.50	7.48
		R. Chan. C1 (Apron)	6.34	6.60	9.16	7.50	6.60
6	2500	R. Chan. C7	10.24	10.65	14.79	12.10	10.65
		R. Chan. C1 (Slope)	8.82	9.17	12.73	10.42	9.17
5	2000	R. Chan. C7	11.34	11.79	16.38	13.40	11.79
		R. Chan. C1 (Slope)	10.23	10.64	14.77	12.09	10.64
4	1500	R. Chan. C7	12.15	12.63	17.55	14.36	12.63
		R. Chan. C1 (Slope)	11.20	11.64	16.17	13.23	11.64
3	1000	R. Chan. C7	12.29	12.78	17.75	14.52	12.78
		R. Chan. C1 (Slope)	11.31	11.76	16.34	13.37	11.76
2	500	R. Chan. C7	12.33	12.82	17.81	14.57	12.82
		R. Chan. C1 (Slope)	11.34	11.79	16.37	13.40	11.79
1	0	R. Chan. C2	6.67	6.94	9.63	7.88	6.94
		R. Chan. C1 (Slope)	5.03	5.23	7.26	5.94	5.23
0	-100	R. Chan. C2	6.32	6.57	9.13	7.47	6.57
		R. Chan. C1 (Slope)	4.89	5.09	7.07	5.78	5.09
-1	-500						
-2	-1000						
-3	-1500						
-4	-2000						

🟥 D_{50} = 3.2 inch rock nominal (3.24 inch actual)

🟧 D_{50} = 7.8 inch rock nominal (7.95 inch actual)

🟦 D_{50} = 9.2 inch rock nominal (9.33 inch actual)

🟨 D_{50} = 12 inch rock nominal (12.97 inch actual)

🟩 D_{50} > 12.97 inch rock

		Embankment Slope / Apron D_{50} (inches)								
1	2	9	10	11	12	13	14	15	16	17
		D50 ROCK SIZE FOR BERM ABOVE GRADE SLOPES		D50 ROCK SIZE FOR BERM APRONS or BURIED SLOPES		DEPTH SCOUR (FT)				
River Section	Station	Minimum Required D_{50} to Use	Proposed D_{50} to Use for Slope	Minimum Required D_{50} to Use	Proposed D_{50} to Use for Apron/ Buried Slope	USDOT HEC-14 Scour Depth	USACE Equilibrium Scour Depth	CSU Equation for Piers	USDOT HEC-18 Froelich Equation for Live Bed Scour	Average Scour Depth
21	9675									
20	9175									
19	8675	3.20	3.24	3.24	3.24	4.3	3.7	4.821	5.520	4.6
18	8350			7.80	12.97	5.0	0.4	5.461	5.603	4.1
		7.80	7.95							
17	8000			7.80	12.97	4.9	4.9	5.225	5.338	5.1
		3.20	7.95							
16	7500			7.80	12.97	5.3	5.8	5.655	5.484	5.6
		7.80	7.95							
15	7000			7.80	12.97	5.5	6.5	6.041	5.763	5.9
		7.80	7.95							
14	6500			7.80	12.97	5.5	6.5	6.132	5.938	6.0
		7.80	7.95							
13	6000			7.80	12.97	5.3	6.0	5.995	5.952	5.8
		7.80	7.95							
12	5500			7.80	12.97	5.2	5.7	5.906	5.991	5.7
		7.80	7.95							
11	5000			7.80	12.97	5.1	5.6	5.925	6.161	5.7
		7.80	7.95							
10	4500			7.80	12.97	5.0	5.3	5.892	6.330	5.6
		7.80	7.95							
9	4000			12.00	12.97	5.5	6.4	6.526	6.825	6.3
		7.80	7.95							
8	3500			12.00	12.97	5.6	6.6	6.552	6.692	6.4
		7.80	7.95							
7	3000			12.00	12.97	5.8	7.0	6.650	6.616	6.5
		7.80	7.95							
6	2500			12.00	12.97	6.5	9.1	7.534	6.845	7.5
		9.20	12.97							
5	2000			12.00	12.97	6.5	9.1	7.862	7.082	7.6
		12.00	12.97							
4	1500			12.63	12.97	6.4	8.9	8.034	7.351	7.7
		12.00	12.97							
3	1000			12.78	12.97	6.5	9.1	8.072	7.327	7.7
		12.00	12.97							
2	500			12.82	12.97	6.6	9.4	8.112	7.217	7.8
		12.00	12.97							
1	0			7.80	12.97	2.6	1.3	5.031	8.717	4.4
		7.80	12.97							
0	-100			7.80	12.97	2.9	1.7	5.214	7.477	4.3
		7.80	12.97							
-1	-500									
-2	-1000									
-3	-1500									
-4	-2000									

🟥 D_{50} = 3.2 inch rock nominal (3.24 inch actual)

🟧 D_{50} = 7.8 inch rock nominal (7.95 inch actual)

🟦 D_{50} = 9.2 inch rock nominal (9.33 inch actual)

🟨 D_{50} = 12 inch rock nominal (12.97 inch actual)

🟩 D_{50} > 12.97 inch rock

INPUT DATA VALUES TO HEC-RAS

River Section	Station	Flow (cfs)	Proposed Top of Berm Elevation	Estimated Freeboard on Diversion Berm	Elevation at Base of Right Berm	Depth of Flow at Base of Right Berm	Channel Slope (ft/ft)	Right Bank & Apron Rock Sizes	Right Bank & Buried Slope Rock Sizes	Channel X-Section Position	Manning's n Value
1	2	3	4	5	6	7	8	9	10	11	12
21	9675	78000	No Berm	N/A	N/A	N/A	0.0032			LOB	0.0350
										L. Channel	0.0300
										Main Channel	0.0300
										R. Channel	0.0300
										ROB	0.0350
20	9175	78000	No Berm	N/A	N/A	N/A	0.0032			LOB	0.0350
										L. Channel	0.0300
										Main Channel	0.0300
										R. Channel	0.0300
										ROB	0.0350
19	8675	78000	No Berm	N/A	N/A	N/A	0.0032			LOB	0.0300
										L. Channel	0.0300
										Main Channel	0.0300
								3.2		R. Chan. Apron	0.0317
								3.2		R. Bank Slope	0.0317
18	8350	78000	6965.00	5.43	6948.39	11.19	0.0032			R. Chan. C5	0.0300
										R. Chan. C4	0.0300
										R. Chan. C3	0.0300
								12		R. Chan. C2 (Apron)	0.0395
								12		R. Chan. C1 (Apron)	0.0395
								7.8		R. Bank Slope	0.0368
17	8000	78000	6962.27	2.90	6947.27	12.10	0.0032			R. Chan. C5	0.0300
										R. Chan. C4	0.0300
										R. Chan. C3	0.0300
								12		R. Chan. C2 (Apron)	0.0395
								12		R. Chan. C1 (Apron)	0.0395
								7.8		R. Bank Slope	0.0368
16	7500	78000	6961.22	2.64	6946.22	12.36	0.001			R. Chan. C5	0.0300
										R. Chan. C4	0.0300
										R. Chan. C3	0.0300
								12		R. Chan. C2 (Apron)	0.0395
								12		R. Chan. C1 (Apron)	0.0395
								7.8		R. Bank Slope	0.0368
15	7000	78000	6960.47	2.99	6945.72	11.76	0.001			R. Chan. C5	0.0300
										R. Chan. C4	0.0300
										R. Chan. C3	0.0300
								12		R. Chan. C2 (Apron)	0.0395
								12		R. Chan. C1 (Apron)	0.0395
								7.8		R. Bank Slope	0.0368

INPUT DATA VALUES TO HEC-RAS

River Section	Station	Flow (cfs)	Proposed Top of Berm Elevation	Estimated Freeboard on Diversion Berm	Elevation at Base of Right Berm	Depth of Flow at Base of Right Berm	Channel Slope (ft/ft)	Right Bank & Apron Rock Sizes	Right Bank & Buried Slope Rock Sizes	Channel X-Section Position	Manning's n Value
1	2	3	4	5	6	7	8	9	10	11	12
14	6500	78000	6959.72	3.38	6945.22	11.12	0.001			R. Chan. C5	0.0300
										R. Chan. C4	0.0300
										R. Chan. C3	0.0300
								12		R. Chan. C2 (Apron)	0.0395
								12		R. Chan. C1 (Apron)	0.0395
								7.8		R. Bank Slope	0.0368
13	6000	78000	6958.97	3.50	6944.72	10.75	0.001			R. Chan. C5	0.0300
										R. Chan. C4	0.0300
										R. Chan. C3	0.0300
								12		R. Chan. C2 (Apron)	0.0395
								12		R. Chan. C1 (Apron)	0.0395
								7.8		R. Bank Slope	0.0368
12	5500	78000	6958.22	3.61	6944.22	10.39	0.001			R. Chan. C5	0.0300
										R. Chan. C4	0.0300
										R. Chan. C3	0.0300
								12		R. Chan. C2 (Apron)	0.0395
								12		R. Chan. C1 (Apron)	0.0395
								7.8		R. Bank Slope	0.0368
11	5000	78000	6957.47	3.98	6943.72	9.77	0.001			R. Chan. C5	0.0300
										R. Chan. C4	0.0300
										R. Chan. C3	0.0300
								12		R. Chan. C2 (Apron)	0.0395
								12		R. Chan. C1 (Apron)	0.0395
								7.8		R. Bank Slope	0.0368
10	4500	78000	6956.72	4.38	6943.22	9.12	0.005			R. Chan. C5	0.0300
										R. Chan. C4	0.0300
										R. Chan. C3	0.0300
								12		R. Chan. C2 (Apron)	0.0395
								12		R. Chan. C1 (Apron)	0.0395
								7.8		R. Bank Slope	0.0368
9	4000	78000	6953.72	4.25	6940.72	8.75	0.005			R. Chan. C5	0.0300
										R. Chan. C4	0.0300
										R. Chan. C3	0.0300
								12		R. Chan. C2 (Apron)	0.0395
								12		R. Chan. C1 (Apron)	0.0395
								7.8		R. Bank Slope	0.0368
8	3500	78000	6951.22	3.83	6938.22	9.17	0.005			R. Chan. C5	0.0300
										R. Chan. C4	0.0300
										R. Chan. C3	0.0300
								12		R. Chan. C2 (Apron)	0.0395
								12		R. Chan. C1 (Apron)	0.0395
								7.8		R. Bank Slope	0.0368

INPUT DATA VALUES TO HEC-RAS

River Section	Station	Flow (cfs)	Proposed Top of Berm Elevation	Estimated Freeboard on Diversion Berm	Elevation at Base of Right Berm	Depth of Flow at Base of Right Berm	Channel Slope (ft/ft)	Right Bank & Apron Rock Sizes	Right Bank & Buried Slope Rock Sizes	Channel X-Section Position	Manning's n Value
1	2	3	4	5	6	7	8	9	10	11	12
7	3000	78000	6948.72	3.42	6935.72	9.58	0.010			R. Chan. C5	0.0300
										R. Chan. C4	0.0300
										R. Chan. C3	0.0300
								12		R. Chan. C2 (Apron)	0.0395
								12		R. Chan. C1 (Apron)	0.0395
								7.8		R. Bank Slope	0.0368
6	2500	78000	6943.72	3.14	6930.72	9.86	0.010			R. Chan. C7	0.0300
									12	R. Chan. C6 (Slope)	0.0395
									12	R. Chan. C5 (Slope)	0.0395
									12	R. Chan. C4 (Slope)	0.0395
									12	R. Chan. C3 (Slope)	0.0395
									12	R. Chan. C2 (Slope)	0.0395
									12	R. Chan. C1 (Slope)	0.0395
									12	R. Bank Slope	0.0395
5	2000	78000	6938.72	3.33	6925.72	9.67	0.010			R. Chan. C7	0.0300
									12	R. Chan. C6 (Slope)	0.0395
									12	R. Chan. C5 (Slope)	0.0395
									12	R. Chan. C4 (Slope)	0.0395
									12	R. Chan. C3 (Slope)	0.0395
									12	R. Chan. C2 (Slope)	0.0395
									12	R. Chan. C1 (Slope)	0.0395
									12	R. Bank Slope	0.0395
4	1500	78000	6933.22	3.34	6920.72	9.16	0.010			R. Chan. C7	0.0300
									12	R. Chan. C6 (Slope)	0.0395
									12	R. Chan. C5 (Slope)	0.0395
									12	R. Chan. C4 (Slope)	0.0395
									12	R. Chan. C3 (Slope)	0.0395
									12	R. Chan. C2 (Slope)	0.0395
									12	R. Chan. C1 (Slope)	0.0395
									12	R. Bank Slope	0.0395
3	1000	78000	6928.22	3.19	6915.72	9.31	0.010			R. Chan. C7	0.0300
									12	R. Chan. C6 (Slope)	0.0395
									12	R. Chan. C5 (Slope)	0.0395
									12	R. Chan. C4 (Slope)	0.0395
									12	R. Chan. C3 (Slope)	0.0395
									12	R. Chan. C2 (Slope)	0.0395
									12	R. Chan. C1 (Slope)	0.0395
									12	R. Bank Slope	0.0395

INPUT DATA VALUES TO HEC-RAS

River Section	Station	Flow (cfs)	Proposed Top of Berm Elevation	Estimated Freeboard on Diversion Berm	Elevation at Base of Right Berm	Depth of Flow at Base of Right Berm	Channel Slope (ft/ft)	Right Bank & Apron Rock Sizes	Right Bank & Buried Slope Rock Sizes	Channel X-Section Position	Manning's n Value
1	2	3	4	5	6	7	8	9	10	11	12
2	500	78000	6923.22	2.83	6910.72	9.67	0.010			R. Chan. C7	0.0300
									12	R. Chan. C6 (Slope)	0.0395
									12	R. Chan. C5 (Slope)	0.0395
									12	R. Chan. C4 (Slope)	0.0395
									12	R. Chan. C3 (Slope)	0.0395
									12	R. Chan. C2 (Slope)	0.0395
									12	R. Chan. C1 (Slope)	0.0395
									12	R. Bank Slope	0.0395
1	0	78000	No Berm	N/A	N/A	N/A	0.009			R. Chan. C2	0.0300
									12	R. Chan. C1 (Slope)	0.0395
									12	R. Bank Slope	0.0395
0	-100	78000	No Berm	N/A	N/A	N/A	0.009			R. Chan. C2	0.0300
									12	R. Chan. C1 (Slope)	0.0395
									12	R. Bank Slope	0.0395
-1	-500	78000	No Berm	N/A	N/A	N/A	0.009			R. Chan. C5	0.0300
										R. Chan. C4	0.0300
										R. Chan. C3	0.0300
										R. Chan. C2	0.0300
										R. Chan. C1	0.0300
										R. Bank Slope	0.0350
-2	-1000	78000	No Berm	N/A	N/A	N/A	0.009			R. Chan. C5	0.0300
										R. Chan. C4	0.0300
										R. Chan. C3	0.0300
										R. Chan. C2	0.0300
										R. Chan. C1	0.0300
										R. Bank Slope	0.0350
-3	-1500	78000	No Berm	N/A	N/A	N/A	0.009			R. Chan. C5	0.0300
										R. Chan. C4	0.0300
										R. Chan. C3	0.0300
										R. Chan. C2	0.0300
										R. Chan. C1	0.0300
										R. Bank Slope	0.0350
-4	-2000	78000	No Berm	N/A	N/A	N/A	0.009			R. Chan. C5	0.0300
										R. Chan. C4	0.0300
										R. Chan. C3	0.0300
										R. Chan. C2	0.0300
										R. Chan. C1	0.0300
										R. Bank Slope	0.0350

	HEC-RAS DATA RESULTS										
River Section	Water Surface Elevation (ft)	E.G. Slope (ft/ft)	Position	Left Station (ft)	Right Station (ft)	Split Section Flow (cfs)	Flow Area (sq ft)	Wetted Perimeter (ft)	Percentage of Conveyance	Hydraulic Depth (ft)	Velocity (ft/s)
1	13	14	15	16	17	18	19	20	21	22	23
21	6964.69	0.001487	LOB	1175	3350	5158.32	1532.61	519.86	6.61	2.95	3.37
		0.001487	Chan	3350	3416.67	7863.49	793.02	66.79	10.08	11.9	9.92
		0.001487	Chan	3416.67	3483.33	9645.45	895.8	66.67	12.37	13.44	10.77
		0.001487	Chan	3483.33	3550	7547.07	773.58	66.76	9.68	11.6	9.76
		0.001487	ROB	3550	5225	47785.67	9179.87	1618.88	61.26	5.67	5.21
20	6962.62	0.003442	LOB	1010	3350	22118.85	3729.76	1015.11	28.36	3.67	5.93
		0.003442	Chan	3350	3416.67	10166.68	720.48	66.93	13.03	10.81	14.11
		0.003442	Chan	3416.67	3483.33	13227.46	842.42	66.67	16.96	12.64	15.7
		0.003442	Chan	3483.33	3550	9718.07	701.03	66.88	12.46	10.52	13.86
		0.003442	ROB	3550	4975	22768.95	4255.32	1351.37	29.19	3.15	5.35
19	6960.19	0.000659	LOB	605	2720	974.44	704.66	493.06	1.25	1.43	1.38
		0.000659	Chan	2720	3180	16384.05	3428.77	460.02	21.01	7.45	4.78
		0.000659	Chan	3180	3640	32285.77	5151.02	460.02	41.39	11.2	6.27
		0.000659	Chan	3640	4100	28143.84	4744.63	460.25	36.08	10.31	5.93
		0.000659	ROB	4100	4875	211.88	137.3	81.5	0.27	1.69	1.54
18	6959.57	0.001125	Chan	3468.45	3474.76	633.37	74.11	6.31	0.81	11.75	8.55
		0.001125	Chan	3474.76	3481.07	622.08	73.31	6.31	0.8	11.62	8.49
		0.001125	Chan	3481.07	3487.38	555.72	72.52	6.31	0.71	11.49	7.66
		0.001125	Chan	3487.38	3493.69	455.48	71.72	6.31	0.58	11.37	6.35
		0.001125	Chan	3493.69	3500	447.08	70.93	6.31	0.57	11.24	6.3
		0.001125	ROB	3500	4825	771.37	187.3	35.33	0.99	5.59	4.12
17	6959.36	0.000788	Chan	3468.45	3474.76	600.36	79.84	6.31	0.77	12.65	7.52
		0.000788	Chan	3474.76	3481.07	590.4	79.05	6.31	0.76	12.53	7.47
		0.000788	Chan	3481.07	3487.38	528.09	78.25	6.31	0.68	12.4	6.75
		0.000788	Chan	3487.38	3493.69	433.45	77.45	6.31	0.56	12.28	5.6
		0.000788	Chan	3493.69	3500	426.05	76.66	6.31	0.55	12.15	5.56
		0.000788	ROB	3500	3560	795.51	219.12	38.22	1.02	6.04	3.63
16	6958.57	0.001093	Chan	3468.45	3474.76	731.47	81.49	6.31	0.94	12.91	8.98
		0.001093	Chan	3474.76	3481.07	719.61	80.69	6.31	0.92	12.79	8.92
		0.001093	Chan	3481.07	3487.38	643.89	79.89	6.31	0.83	12.66	8.06
		0.001093	Chan	3487.38	3493.69	528.68	79.1	6.31	0.68	12.54	6.68
		0.001093	Chan	3493.69	3500	519.84	78.3	6.31	0.67	12.41	6.64
		0.001093	ROB	3500	3560	991.55	228.66	39.04	1.27	6.17	4.34
15	6957.47	0.001635	Chan	3468.45	3474.76	826.55	77.71	6.31	1.06	12.32	10.64
		0.001635	Chan	3474.76	3481.07	812.5	76.91	6.31	1.04	12.19	10.56
		0.001635	Chan	3481.07	3487.38	726.43	76.11	6.31	0.93	12.06	9.54
		0.001635	Chan	3487.38	3493.69	595.94	75.32	6.31	0.76	11.94	7.91
		0.001635	Chan	3493.69	3500	585.47	74.52	6.31	0.75	11.81	7.86
		0.001635	ROB	3500	3560	1062.42	207.01	37.15	1.36	5.87	5.13

	HEC-RAS DATA RESULTS										
River Section	Water Surface Elevation (ft)	E.G. Slope (ft/ft)	Position	Left Station (ft)	Right Station (ft)	Split Section Flow (cfs)	Flow Area (sq ft)	Wetted Perimeter (ft)	Percentage of Conveyance	Hydraulic Depth (ft)	Velocity (ft/s)
1	13	14	15	16	17	18	19	20	21	22	23
14	6956.33	0.001953	Chan	3468.45	3474.76	825.67	73.65	6.31	1.06	11.67	11.21
		0.001953	Chan	3474.76	3481.07	810.87	72.86	6.31	1.04	11.55	11.13
		0.001953	Chan	3481.07	3487.38	724.29	72.06	6.31	0.93	11.42	10.05
		0.001953	Chan	3487.38	3493.69	593.57	71.26	6.31	0.76	11.29	8.33
		0.001953	Chan	3493.69	3500	582.56	70.47	6.31	0.75	11.17	8.27
		0.001953	ROB	3500	3560	999.18	184.98	35.12	1.28	5.55	5.4
13	6955.46	0.001872	Chan	3468.45	3474.76	766.89	71.36	6.31	0.98	11.31	10.75
		0.001872	Chan	3474.76	3481.07	752.7	70.56	6.31	0.96	11.18	10.67
		0.001872	Chan	3481.07	3487.38	671.94	69.76	6.31	0.86	11.06	9.63
		0.001872	Chan	3487.38	3493.69	550.32	68.97	6.31	0.71	10.93	7.98
		0.001872	Chan	3493.69	3500	539.77	68.17	6.31	0.69	10.8	7.92
		0.001872	ROB	3500	3558.1	895.25	173.04	33.96	1.15	5.37	5.17
12	6954.6	0.001866	Chan	3468.45	3474.76	725.12	69.08	6.31	0.93	10.95	10.5
		0.001866	Chan	3474.76	3481.07	711.26	68.28	6.31	0.91	10.82	10.42
		0.001866	Chan	3481.07	3487.38	634.56	67.49	6.31	0.81	10.7	9.4
		0.001866	Chan	3487.38	3493.69	519.36	66.69	6.31	0.67	10.57	7.79
		0.001866	Chan	3493.69	3500	509.07	65.89	6.31	0.65	10.44	7.73
		0.001866	ROB	3500	3556.3	817.08	161.82	32.86	1.05	5.19	5.05
11	6953.48	0.002132	Chan	3468.45	3474.76	702.19	65.13	6.31	0.9	10.32	10.78
		0.002132	Chan	3474.76	3481.07	687.96	64.34	6.31	0.88	10.2	10.69
		0.002132	Chan	3481.07	3487.38	613.05	63.54	6.31	0.79	10.07	9.65
		0.002132	Chan	3487.38	3493.69	501.12	62.74	6.31	0.64	9.94	7.99
		0.002132	Chan	3493.69	3500	490.56	61.95	6.31	0.63	9.82	7.92
		0.002132	ROB	3500	3554.4	739.7	142.89	30.88	0.95	4.88	5.18
10	6952.33	0.002372	Chan	3468.45	3474.76	664.48	61.04	6.31	0.85	9.67	10.89
		0.002372	Chan	3474.76	3481.07	650.12	60.25	6.31	0.83	9.55	10.79
		0.002372	Chan	3481.07	3487.38	578.54	59.45	6.31	0.74	9.42	9.73
		0.002372	Chan	3487.38	3493.69	472.2	58.66	6.31	0.61	9.3	8.05
		0.002372	Chan	3493.69	3500	461.56	57.86	6.31	0.59	9.17	7.98
		0.002372	ROB	3500	3552.5	648.91	124.4	28.8	0.83	4.55	5.22
9	6949.46	0.004123	Chan	3468.45	3474.76	821.02	58.73	6.31	1.05	9.31	13.98
		0.004123	Chan	3474.76	3481.07	802.57	57.93	6.31	1.03	9.18	13.85
		0.004123	Chan	3481.07	3487.38	713.59	57.13	6.31	0.91	9.06	12.49
		0.004123	Chan	3487.38	3493.69	581.87	56.34	6.31	0.75	8.93	10.33
		0.004123	Chan	3493.69	3500	568.23	55.54	6.31	0.73	8.8	10.23
		0.004123	ROB	3500	3552.5	766.6	114.57	27.64	0.98	4.37	6.69
8	6947.38	0.003838	Chan	3468.45	3474.76	853.54	61.4	6.31	1.09	9.73	13.9
		0.003838	Chan	3474.76	3481.07	835.2	60.61	6.31	1.07	9.61	13.78
		0.003838	Chan	3481.07	3487.38	743.33	59.81	6.31	0.95	9.48	12.43
		0.003838	Chan	3487.38	3493.69	606.79	59.01	6.31	0.78	9.35	10.28
		0.003838	Chan	3493.69	3500	593.2	58.22	6.31	0.76	9.23	10.19
		0.003838	ROB	3500	3552.5	839.19	125.96	28.98	1.08	4.58	6.66

	HEC-RAS DATA RESULTS										
River Section	Water Surface Elevation (ft)	E.G. Slope (ft/ft)	Position	Left Station (ft)	Right Station (ft)	Split Section Flow (cfs)	Flow Area (sq ft)	Wetted Perimeter (ft)	Percentage of Conveyance	Hydraulic Depth (ft)	Velocity (ft/s)
1	13	14	15	16	17	18	19	20	21	22	23
7	6945.29	0.003877	Chan	3468.45	3474.76	907.31	63.93	6.31	1.16	10.13	14.19
		0.003877	Chan	3474.76	3481.07	888.58	63.14	6.31	1.14	10.01	14.07
		0.003877	Chan	3481.07	3487.38	791.53	62.34	6.31	1.01	9.88	12.7
		0.003877	Chan	3487.38	3493.69	646.73	61.55	6.31	0.83	9.75	10.51
		0.003877	Chan	3493.69	3500	632.85	60.75	6.31	0.81	9.63	10.42
		0.003877	ROB	3500	3554.4	946.67	137.37	30.28	1.21	4.78	6.89
6	6940.57	0.005996	Chan	3455.83	3462.14	1065.04	67.3	6.31	1.43	10.67	16.57
		0.005996	Chan	3462.14	3468.45	903.54	66.51	6.31	1.16	10.54	13.59
		0.005996	Chan	3468.45	3474.76	885.58	65.71	6.31	1.14	10.41	13.48
		0.005996	Chan	3474.76	3481.07	867.77	64.91	6.31	1.11	10.29	13.37
		0.005996	Chan	3481.07	3487.38	850.06	64.11	6.31	1.09	10.16	13.26
		0.005996	Chan	3487.38	3493.69	832.57	63.32	6.31	1.07	10.04	13.15
		0.005996	Chan	3493.69	3500	815.19	62.52	6.31	1.05	9.91	13.04
		0.005996	ROB	3500	3556.3	1185.07	145.6	31.17	1.52	4.92	8.14
5	6935.38	0.007584	Chan	3455.83	3462.14	1066.49	66.1	6.31	1.56	10.48	18.4
		0.007584	Chan	3462.14	3468.45	985.38	65.3	6.31	1.26	10.35	15.09
		0.007584	Chan	3468.45	3474.76	965.44	64.51	6.31	1.24	10.22	14.97
		0.007584	Chan	3474.76	3481.07	945.65	63.71	6.31	1.21	10.1	14.84
		0.007584	Chan	3481.07	3487.38	926	62.91	6.31	1.19	9.97	14.72
		0.007584	Chan	3487.38	3493.69	906.58	62.12	6.31	1.16	9.85	14.59
		0.007584	Chan	3493.69	3500	887.29	61.32	6.31	1.14	9.72	14.47
		0.007584	ROB	3500	3558.1	1263.25	139.82	30.53	1.62	4.83	9.03
4	6929.87	0.009252	Chan	3455.83	3462.14	1035.64	62.9	6.31	1.58	9.97	19.64
		0.009252	Chan	3462.14	3468.45	999.83	62.1	6.31	1.28	9.84	16.1
		0.009252	Chan	3468.45	3474.76	978.56	61.31	6.31	1.25	9.72	15.96
		0.009252	Chan	3474.76	3481.07	957.46	60.51	6.31	1.23	9.59	15.82
		0.009252	Chan	3481.07	3487.38	936.52	59.71	6.31	1.2	9.46	15.68
		0.009252	Chan	3487.38	3493.69	915.83	58.92	6.31	1.17	9.34	15.54
		0.009252	Chan	3493.69	3500	895.29	58.12	6.31	1.15	9.21	15.4
		0.009252	ROB	3500	3560	1208.54	125.54	28.93	1.55	4.57	9.63
3	6925.02	0.009183	Chan	3455.83	3462.14	1063.18	63.87	6.31	1.62	10.12	19.78
		0.009183	Chan	3462.14	3468.45	1022.46	63.07	6.31	1.31	10	16.21
		0.009183	Chan	3468.45	3474.76	1001.03	62.27	6.31	1.28	9.87	16.07
		0.009183	Chan	3474.76	3481.07	979.79	61.48	6.31	1.26	9.74	15.94
		0.009183	Chan	3481.07	3487.38	958.69	60.68	6.31	1.23	9.62	15.8
		0.009183	Chan	3487.38	3493.69	937.85	59.89	6.31	1.2	9.49	15.66
		0.009183	Chan	3493.69	3500	917.15	59.09	6.31	1.18	9.36	15.52
		0.009183	ROB	3500	3560	1258.6	129.78	29.41	1.61	4.65	9.7

	HEC-RAS DATA RESULTS										
River Section	Water Surface Elevation (ft)	E.G. Slope (ft/ft)	Position	Left Station (ft)	Right Station (ft)	Split Section Flow (cfs)	Flow Area (sq ft)	Wetted Perimeter (ft)	Percentage of Conveyance	Hydraulic Depth (ft)	Velocity (ft/s)
1	13	14	15	16	17	18	19	20	21	22	23
2	6920.38	0.008764	Chan	3455.83	3462.14	1108.34	66.12	6.31	1.68	10.48	19.79
		0.008764	Chan	3462.14	3468.45	1059.79	65.32	6.31	1.36	10.35	16.22
		0.008764	Chan	3468.45	3474.76	1038.35	64.53	6.31	1.33	10.23	16.09
		0.008764	Chan	3474.76	3481.07	1017.08	63.73	6.31	1.3	10.1	15.96
		0.008764	Chan	3481.07	3487.38	995.94	62.93	6.31	1.28	9.97	15.83
		0.008764	Chan	3487.38	3493.69	975.06	62.14	6.31	1.25	9.85	15.69
		0.008764	Chan	3493.69	3500	954.32	61.34	6.31	1.22	9.72	15.56
		0.008764	ROB	3500	3560	1359.39	139.94	30.54	1.74	4.83	9.71
1	6907.16	0.039376	Chan	3475	3487.5	231.2	19.51	12.5	0.3	1.56	11.85
		0.039376	Chan	3487.5	3500	139.66	16.38	12.5	0.18	1.31	8.52
		0.039376	ROB	3500	4502.11	980.59	108.81	93.75	1.26	1.16	9.01
0	6906.81	0.023508	Chan	3473.1	3486.55	336.14	28.82	13.46	0.43	2.14	11.66
		0.023508	Chan	3486.55	3500	212.96	25.2	13.46	0.27	1.87	8.45
		0.023508	ROB	3500	4475	23.02	4.54	5.5	0.03	0.87	5.07
-1	6902.32	0.015811	Chan	3655.95	3679.76	392.8	44.62	23.81	0.5	1.87	8.8
		0.015811	Chan	3679.76	3703.57	316.89	39.23	23.81	0.41	1.65	8.08
		0.015811	Chan	3703.57	3727.38	247.64	33.83	23.81	0.32	1.42	7.32
		0.015811	Chan	3727.38	3751.19	185.38	28.44	23.81	0.24	1.19	6.52
		0.015811	Chan	3751.19	3775	129.97	22.98	23.81	0.17	0.97	5.66
		0.015811	ROB	3775	5025	3.16	1.08	2.69	0	0.43	2.91
-2	6898.51	0.007777	Chan	3832.14	3860.71	516.64	69.48	28.57	0.66	2.43	7.44
		0.007777	Chan	3860.71	3889.29	448.86	63.86	28.57	0.58	2.24	7.03
		0.007777	Chan	3889.29	3917.86	384.87	58.23	28.57	0.49	2.04	6.61
		0.007777	Chan	3917.86	3946.43	324.87	52.6	28.57	0.42	1.84	6.18
		0.007777	Chan	3946.43	3975	268.5	46.92	28.57	0.34	1.64	5.72
		0.007777	ROB	3975	5375	10.84	3.57	4.88	0.01	0.77	3.04
-3	6893.62	0.010203	Chan	3832.14	3860.71	436.46	58.25	28.57	0.56	2.04	7.49
		0.010203	Chan	3860.71	3889.29	368.53	52.63	28.57	0.47	1.84	7.00
		0.010203	Chan	3889.29	3917.86	305.21	47	28.57	0.39	1.65	6.49
		0.010203	Chan	3917.86	3946.43	246.74	41.37	28.57	0.32	1.45	5.96
		0.010203	Chan	3946.43	3975	192.87	35.69	28.57	0.25	1.25	5.4
		0.010203	ROB	3975	5125	5.67	1.98	3.63	0.01	0.57	2.86
-4	6889.52	0.007742	Chan	3832.14	3860.71	517.97	69.68	28.57	0.66	2.44	7.43
		0.007742	Chan	3860.71	3889.29	450.2	64.06	28.57	0.58	2.24	7.03
		0.007742	Chan	3889.29	3917.86	386.21	58.43	28.57	0.5	2.04	6.61
		0.007742	Chan	3917.86	3946.43	326.19	52.8	28.57	0.42	1.85	6.18
		0.007742	Chan	3946.43	3975	269.8	47.11	28.57	0.35	1.65	5.73
		0.007742	ROB	3975	5025	10.95	3.6	4.9	0.01	0.77	0

		D_{50} ROCK SIZE CALCULATION w/ SLOPE CORRECTION FACTORS (inches)					D50 ROCK SIZE FOR BERM ABOVE GRADE SLOPES		D50 ROCK SIZE FOR BERM APRONS or BURIED SLOPES	
River Section	Channel X-Section Position	Abt and Johnson Method (inches)	Add Riprap Oversize 4%	2H:1V Apron Slope: Abt and Johnson D_{50} / Slope Factor (0.72)	3H:1V Slope: Abt and Johnson D_{50} / Slope Factor (0.88)	4H:1V Slope: Abt and Johnson D_{50} / Slope Factor (1.00)	Minimum Required D_{50} to Use	Proposed D_{50} to Use for Slope	Minimum Required D_{50} to Use	Proposed D_{50} to Use for Apron/ Buried Slope
1	25	26	27	28	29	30	31	32	33	34
21	LOB									
	L. Channel									
	Main Channel									
	R. Channel									
	ROB	2.12	2.20	3.06	2.50	2.20				
20	LOB									
	L. Channel									
	Main Channel									
	R. Channel									
	ROB	2.22	2.31	3.21	2.62	2.31				
19	LOB									
	L. Channel									
	Main Channel									
	R. Chan. Apron	2.24	2.33	3.24	2.65	2.33	3.2	3.24	3.24	3.24
	R. Bank Slope	0.38	0.40	0.55	0.45	0.40				
18	R. Chan. C5	3.73	3.88	5.38	4.41	3.88				
	R. Chan. C4	3.69	3.84	5.33	4.36	3.84				
	R. Chan. C3	3.46	3.60	5.00	4.09	3.60			7.80	12.97
	R. Chan. C2 (Apron)	3.10	3.22	4.48	3.66	3.22				
	R. Chan. C1 (Apron)	3.07	3.19	4.43	3.62	3.19	7.8	7.95		
	R. Bank Slope	1.59	1.65	2.29	1.87	1.65				
17	R. Chan. C5	3.10	3.23	4.48	3.67	3.23				
	R. Chan. C4	3.07	3.20	4.44	3.63	3.20				
	R. Chan. C3	2.89	3.00	4.17	3.41	3.00			7.80	12.97
	R. Chan. C2 (Apron)	2.59	2.69	3.74	3.06	2.69				
	R. Chan. C1 (Apron)	2.56	2.66	3.70	3.03	2.66	3.2	7.95		
	R. Bank Slope	1.33	1.38	1.91	1.57	1.38				
16	R. Chan. C5	3.99	4.15	5.76	4.72	4.15				
	R. Chan. C4	3.95	4.11	5.71	4.67	4.11				
	R. Chan. C3	3.72	3.86	5.37	4.39	3.86			7.80	12.97
	R. Chan. C2 (Apron)	3.33	3.46	4.81	3.93	3.46				
	R. Chan. C1 (Apron)	3.30	3.43	4.76	3.90	3.43	7.8	7.95		
	R. Bank Slope	1.71	1.77	2.46	2.02	1.77				
15	R. Chan. C5	5.08	5.28	7.34	6.01	5.28				
	R. Chan. C4	5.03	5.23	7.27	5.95	5.23				
	R. Chan. C3	4.73	4.92	6.83	5.59	4.92			7.80	12.97
	R. Chan. C2 (Apron)	4.23	4.40	6.11	5.00	4.40				
	R. Chan. C1 (Apron)	4.19	4.36	6.05	4.95	4.36	7.8	7.95		
	R. Bank Slope	2.17	2.25	3.13	2.56	2.25				

		D_{50} ROCK SIZE CALCULATION w/ SLOPE CORRECTION FACTORS (inches)					D50 ROCK SIZE FOR BERM ABOVE GRADE SLOPES		D50 ROCK SIZE FOR BERM APRONS or BURIED SLOPES	
River Section	Channel X-Section Position	Abt and Johnson Method (inches)	Add Riprap Oversize 4%	2H:1V Apron Slope: Abt and Johnson D_{50} / Slope Factor (0.72)	3H:1V Slope: Abt and Johnson D_{50} / Slope Factor (0.88)	4H:1V Slope: Abt and Johnson D_{50} / Slope Factor (1.00)	Minimum Required D_{50} to Use	Proposed D_{50} to Use for Slope	Minimum Required D_{50} to Use	Proposed D_{50} to Use for Apron/ Buried Slope
1	25	26	27	28	29	30	31	32	33	34
14	R. Chan. C5	5.48	5.70	7.92	6.48	5.70				
	R. Chan. C4	5.43	5.64	7.84	6.41	5.64				
	R. Chan. C3	5.09	5.30	7.36	6.02	5.30			7.80	12.97
	R. Chan. C2 (Apron)	4.56	4.74	6.58	5.38	4.74				
	R. Chan. C1 (Apron)	4.51	4.69	6.51	5.33	4.69	7.8	7.95		
	R. Bank Slope	2.33	2.43	3.37	2.76	2.43				
13	R. Chan. C5	5.16	5.37	7.46	6.10	5.37				
	R. Chan. C4	5.11	5.32	7.38	6.04	5.32				
	R. Chan. C3	4.80	4.99	6.93	5.67	4.99			7.80	12.97
	R. Chan. C2 (Apron)	4.29	4.46	6.19	5.07	4.46				
	R. Chan. C1 (Apron)	4.24	4.41	6.13	5.01	4.41	7.8	7.95		
	R. Bank Slope	2.19	2.28	3.17	2.59	2.28				
12	R. Chan. C5	5.00	5.20	7.22	5.91	5.20				
	R. Chan. C4	4.94	5.14	7.14	5.84	5.14				
	R. Chan. C3	4.64	4.82	6.70	5.48	4.82			7.80	12.97
	R. Chan. C2 (Apron)	4.15	4.31	5.99	4.90	4.31				
	R. Chan. C1 (Apron)	4.10	4.26	5.92	4.85	4.26	7.8	7.95		
	R. Bank Slope	2.12	2.21	3.06	2.51	2.21				
11	R. Chan. C5	5.20	5.41	7.51	6.14	5.41				
	R. Chan. C4	5.14	5.34	7.42	6.07	5.34				
	R. Chan. C3	4.82	5.01	6.96	5.69	5.01			7.80	12.97
	R. Chan. C2 (Apron)	4.30	4.48	6.22	5.09	4.48				
	R. Chan. C1 (Apron)	4.25	4.42	6.14	5.03	4.42	7.8	7.95		
	R. Bank Slope	2.20	2.29	3.18	2.60	2.29				
10	R. Chan. C5	5.28	5.49	7.62	6.24	5.49				
	R. Chan. C4	5.21	5.42	7.53	6.16	5.42				
	R. Chan. C3	4.88	5.08	7.05	5.77	5.08			7.80	12.97
	R. Chan. C2 (Apron)	4.36	4.53	6.30	5.15	4.53				
	R. Chan. C1 (Apron)	4.30	4.47	6.22	5.09	4.47	7.8	7.95		
	R. Bank Slope	2.23	2.31	3.21	2.63	2.31				
9	R. Chan. C5	7.53	7.84	10.88	8.90	7.84				
	R. Chan. C4	7.44	7.74	10.75	8.79	7.74				
	R. Chan. C3	6.97	7.24	10.06	8.23	7.24			12.00	12.97
	R. Chan. C2 (Apron)	6.21	6.46	8.97	7.34	6.46				
	R. Chan. C1 (Apron)	6.13	6.38	8.86	7.25	6.38	7.8	7.95		
	R. Bank Slope	3.17	3.30	4.58	3.75	3.30				
8	R. Chan. C5	7.47	7.77	10.79	8.82	7.77				
	R. Chan. C4	7.38	7.67	10.66	8.72	7.67				
	R. Chan. C3	6.91	7.19	9.98	8.17	7.19			12.00	12.97
	R. Chan. C2 (Apron)	6.17	6.41	8.91	7.29	6.41				
	R. Chan. C1 (Apron)	6.09	6.33	8.80	7.20	6.33	7.8	7.95		
	R. Bank Slope	3.15	3.28	4.55	3.72	3.28				

		D_{50} ROCK SIZE CALCULATION w/ SLOPE CORRECTION FACTORS (inches)					D50 ROCK SIZE FOR BERM ABOVE GRADE SLOPES		D50 ROCK SIZE FOR BERM APRONS or BURIED SLOPES	
River Section	Channel X-Section Position	Abt and Johnson Method (inches)	Add Riprap Oversize 4%	2H:1V Apron Slope: Abt and Johnson D_{50} / Slope Factor (0.72)	3H:1V Slope: Abt and Johnson D_{50} / Slope Factor (0.88)	4H:1V Slope: Abt and Johnson D_{50} / Slope Factor (1.00)	Minimum Required D_{50} to Use	Proposed D_{50} to Use for Slope	Minimum Required D_{50} to Use	Proposed D_{50} to Use for Apron/ Buried Slope
1	25	26	27	28	29	30	31	32	33	34
7	R. Chan. C5	7.76	8.07	11.21	9.17	8.07				
	R. Chan. C4	7.67	7.98	11.08	9.06	7.98				
	R. Chan. C3	7.19	7.48	10.38	8.50	7.48			12.00	12.97
	R. Chan. C2 (Apron)	6.42	6.68	9.27	7.59	6.68				
	R. Chan. C1 (Apron)	6.34	6.60	9.16	7.50	6.60	7.8	7.95		
	R. Bank Slope	3.30	3.43	4.77	3.90	3.43				
6	R. Chan. C7	10.24	10.65	14.79	12.10	10.65			12.00	12.97
	R. Chan. C6 (Slope)	9.34	9.71	13.49	11.04	9.71				
	R. Chan. C5 (Slope)	9.23	9.60	13.34	10.91	9.60				
	R. Chan. C4 (Slope)	9.13	9.50	13.19	10.79	9.50				
	R. Chan. C3 (Slope)	9.03	9.39	13.04	10.67	9.39				
	R. Chan. C2 (Slope)	8.92	9.28	12.89	10.54	9.28				
	R. Chan. C1 (Slope)	8.82	9.17	12.73	10.42	9.17	9.2	12.97		
	R. Bank Slope	4.44	4.62	6.42	5.25	4.62				
5	R. Chan. C7	11.34	11.79	16.38	13.40	11.79			12.00	12.97
	R. Chan. C6 (Slope)	10.85	11.28	15.67	12.82	11.28				
	R. Chan. C5 (Slope)	10.72	11.15	15.49	12.67	11.15				
	R. Chan. C4 (Slope)	10.60	11.02	15.31	12.53	11.02				
	R. Chan. C3 (Slope)	10.47	10.89	15.13	12.38	10.89				
	R. Chan. C2 (Slope)	10.35	10.77	14.95	12.23	10.77				
	R. Chan. C1 (Slope)	10.23	10.64	14.77	12.09	10.64	12.0	12.97		
	R. Bank Slope	5.16	5.36	7.45	6.09	5.36				
4	R. Chan. C7	12.15	12.63	17.55	14.36	12.63			12.63	12.97
	R. Chan. C6 (Slope)	11.91	12.39	17.20	14.08	12.39				
	R. Chan. C5 (Slope)	11.77	12.24	17.00	13.91	12.24				
	R. Chan. C4 (Slope)	11.63	12.09	16.79	13.74	12.09				
	R. Chan. C3 (Slope)	11.48	11.94	16.59	13.57	11.94				
	R. Chan. C2 (Slope)	11.34	11.79	16.38	13.40	11.79				
	R. Chan. C1 (Slope)	11.20	11.64	16.17	13.23	11.64	12.0	12.97		
	R. Bank Slope	5.65	5.87	8.15	6.67	5.87				
3	R. Chan. C7	12.29	12.78	17.75	14.52	12.78			12.78	12.97
	R. Chan. C6 (Slope)	12.02	12.50	17.36	14.21	12.50				
	R. Chan. C5 (Slope)	11.88	12.36	17.16	14.04	12.36				
	R. Chan. C4 (Slope)	11.74	12.21	16.96	13.87	12.21				
	R. Chan. C3 (Slope)	11.60	12.06	16.75	13.70	12.06				
	R. Chan. C2 (Slope)	11.45	11.91	16.54	13.54	11.91				
	R. Chan. C1 (Slope)	11.31	11.76	16.34	13.37	11.76	12.0	12.97		
	R. Bank Slope	5.70	5.93	8.24	6.74	5.93				

		D_{50} ROCK SIZE CALCULATION w/ SLOPE CORRECTION FACTORS (inches)					D50 ROCK SIZE FOR BERM ABOVE GRADE SLOPES		D50 ROCK SIZE FOR BERM APRONS or BURIED SLOPES	
River Section	Channel X-Section Position	Abt and Johnson Method (inches)	Add Riprap Oversize 4%	2H:1V Apron Slope: Abt and Johnson D_{50} / Slope Factor (0.72)	3H:1V Slope: Abt and Johnson D_{50} / Slope Factor (0.88)	4H:1V Slope: Abt and Johnson D_{50} / Slope Factor (1.00)	Minimum Required D_{50} to Use	Proposed D_{50} to Use for Slope	Minimum Required D_{50} to Use	Proposed D_{50} to Use for Apron/ Buried Slope
1	25	26	27	28	29	30	31	32	33	34
2	R. Chan. C7	12.33	12.82	17.81	14.57	12.82			12.82	12.97
	R. Chan. C6 (Slope)	12.02	12.50	17.36	14.21	12.50				
	R. Chan. C5 (Slope)	11.89	12.36	17.17	14.05	12.36				
	R. Chan. C4 (Slope)	11.75	12.22	16.97	13.88	12.22				
	R. Chan. C3 (Slope)	11.61	12.08	16.77	13.72	12.08				
	R. Chan. C2 (Slope)	11.47	11.93	16.57	13.56	11.93				
	R. Chan. C1 (Slope)	11.34	11.79	16.37	13.40	11.79	12.0	12.97		
	R. Bank Slope	5.71	5.94	8.25	6.75	5.94				
1	R. Chan. C2	6.67	6.94	9.63	7.88	6.94			7.80	12.97
	R. Chan. C1 (Slope)	5.03	5.23	7.26	5.94	5.23	7.8	12.97		
	R. Bank Slope	4.85	5.04	7.00	5.73	5.04				
0	R. Chan. C2	6.32	6.57	9.13	7.47	6.57			7.80	12.97
	R. Chan. C1 (Slope)	4.89	5.09	7.07	5.78	5.09	7.8	12.97		
	R. Bank Slope	2.32	2.42	3.36	2.75	2.42				
-1	R. Chan. C5									
	R. Chan. C4									
	R. Chan. C3									
	R. Chan. C2									
	R. Chan. C1									
	R. Bank Slope									
-2	R. Chan. C5									
	R. Chan. C4									
	R. Chan. C3									
	R. Chan. C2									
	R. Chan. C1									
	R. Bank Slope									
-3	R. Chan. C5									
	R. Chan. C4									
	R. Chan. C3									
	R. Chan. C2									
	R. Chan. C1									
	R. Bank Slope									
-4	R. Chan. C5									
	R. Chan. C4									
	R. Chan. C3									
	R. Chan. C2									
	R. Chan. C1									
	R. Bank Slope									

	USACE EQUILBRIUM SCOUR DEPTH								
River Section	he = Equilibrium Scour Depth (ft)	qe = equilibrium discharge (cfs/ft)	**g (ft/sec^2)**	Ss = Sediment Specific Gravity	de = median grain-size diameter (mm)	$0.234*qe^{8/9}$	g(Ss-1)	$[g(Ss-1)]^{4/9}$	$de^{1/3}$
1	49	50	51	52	53	54	55	56	57
21									
20									
19									
	3.69	61.1	32.2	2.65	0.074	9.060	53.130	5.845	0.420
18									
	0.45	5.7	32.2	2.65	0.074	1.099	53.130	5.845	0.420
17									
	4.88	83.7	32.2	2.65	0.074	11.975	53.130	5.845	0.420
16									
	5.82	102.0	32.2	2.65	0.074	14.282	53.130	5.845	0.420
15									
	6.48	115.1	32.2	2.65	0.074	15.899	53.130	5.845	0.420

Job Title:
Rio Algom Mining LLC
Arroyo Del Puerto
Erosion Protection Measures

Calculation D.1:
Exterior Site Drainage
Design Flowrates and Erosion Protection

By: M. Bone
1/25/2008
File Name:
Calculation D.1 -Exteriorn Design_Rev_1

	USACE EQUILBRIUM SCOUR DEPTH								
River Section	he = Equilibrium Scour Depth (ft)	qe = equilibrium discharge (cfs/ft)	**g (ft/sec^2)**	Ss = Sediment Specific Gravity	de = median grain-size diameter (mm)	0.234*qe$^{8/9}$	g(Ss-1)	[g(Ss-1)]$^{4/9}$	de$^{1/3}$
1	49	50	51	52	53	54	55	56	57
14									
	6.46	114.8	32.2	2.65	0.074	15.857	53.130	5.845	0.420
13									
	6.04	106.5	32.2	2.65	0.074	14.834	53.130	5.845	0.420
12									
	5.74	100.6	32.2	2.65	0.074	14.098	53.130	5.845	0.420
11									
	5.57	97.2	32.2	2.65	0.074	13.673	53.130	5.845	0.420
10									
	5.29	91.7	32.2	2.65	0.074	12.986	53.130	5.845	0.420
9									
	6.38	113.1	32.2	2.65	0.074	15.649	53.130	5.845	0.420
8									
	6.61	117.8	32.2	2.65	0.074	16.227	53.130	5.845	0.420

Worksheet Name:
HEC-RAS Results

	USACE EQUILBRIUM SCOUR DEPTH								
River Section	he = Equilibrium Scour Depth (ft)	qe = equilibrium discharge (cfs/ft)	**g (ft/sec^2)**	Ss = Sediment Specific Gravity	de = median grain-size diameter (mm)	$0.234*qe^{8/9}$	g(Ss-1)	$[g(Ss-1)]^{4/9}$	$de^{1/3}$
1	49	50	51	52	53	54	55	56	57
7									
	6.99	125.4	32.2	2.65	0.074	17.159	53.130	5.845	0.420
6	9.10	168.8	32.2	2.65	0.074	22.339	53.130	5.845	0.420
5	9.11	169.0	32.2	2.65	0.074	22.366	53.130	5.845	0.420
4	8.88	164.1	32.2	2.65	0.074	21.790	53.130	5.845	0.420
3	9.09	168.5	32.2	2.65	0.074	22.305	53.130	5.845	0.420

USACE EQUILBRIUM SCOUR DEPTH

River Section	he = Equilibrium Scour Depth (ft)	qe = equilibrium discharge (cfs/ft)	**g (ft/sec^2)**	Ss = Sediment Specific Gravity	de = median grain-size diameter (mm)	0.234*qe$^{8/9}$	g(Ss-1)	[g(Ss-1)] $^{4/9}$	de$^{1/3}$
1	49	50	51	52	53	54	55	56	57
2	9.43	175.6	32.2	2.65	0.074	23.145	53.130	5.845	0.420
1	1.28	18.5	32.2	2.65	0.074	3.130	53.130	5.845	0.420
0	1.67	25.0	32.2	2.65	0.074	4.087	53.130	5.845	0.420
-1									
-2									
-3									
-4									

	USDOT HEC-14 DEPTH OF SCOUR													
River Section	d_s = Scour Depth (ft)	R_h = hydraulic radius = depth of flow (ft)	C_s = slope correction coeeficient (Table 5.3^5)	σ = coeeficient (Table 5.1^5)	σ = (D84/D16)0.5, material standard deviation (sand = 1.87)	$\sigma^{1/3}$	Q_d = Design Flowrate (cfs)	g (ft/sec^2)	$Q/g^{1/2}R_h^{5/2}$	β = coeeficient (Table 5.1^5)	$(Q/g^{1/2}R_h^{5/2})^\beta$	t = time (min)	θ = coeeficient (Table 5.1^5)	$(t/316)^\theta$
1	35	36	37	38	39	40	41	42	43	44	45	46	47	48
21														
20														
19														
	4.3	10.31	1.0048	2.27	1.87	1.23	61.1	32.2	0.032	0.39	0.259856	30	0.06	0.8683
18														
	5.0	11.49	1.0048	2.27	1.87	1.23	88.1	32.2	0.035	0.39	0.269549	30	0.06	0.8683
17														
	4.9	12.4	1.0048	2.27	1.87	1.23	83.7	32.2	0.027	0.39	0.245316	30	0.06	0.8683
16														
	5.3	12.66	1.0015	2.27	1.87	1.23	102.0	32.2	0.032	0.39	0.259729	30	0.06	0.8683
15														
	5.5	12.06	1.0015	2.27	1.87	1.23	115.1	32.2	0.040	0.39	0.285436	30	0.06	0.8683

	USDOT HEC-14 DEPTH OF SCOUR													
River Section	d_s = Scour Depth (ft)	R_h = hydraulic radius = depth of flow (ft)	C_s = slope correction coeeficient (Table 5.3^5)	σ = coeeficient (Table 5.1^5)	σ = (D84/D16)0.5, material standard deviation (sand = 1.87)	$\sigma^{1/3}$	Q_d = Design Flowrate (cfs)	g (ft/sec^2)	$Q/g^{1/2}R_h^{3/2}$	β = coeeficient (Table 5.1^5)	$(Q/g^{1/2}R_h^{5/2})^\beta$	t = time (min)	θ = coeeficient (Table 5.1^5)	$(t/316)^\theta$
1	35	36	37	38	39	40	41	42	43	44	45	46	47	48
14														
	5.5	11.42	1.0015	2.27	1.87	1.23	114.8	32.2	0.046	0.39	0.300676	30	0.06	0.8683
13														
	5.3	11.06	1.0015	2.27	1.87	1.23	106.5	32.2	0.046	0.39	0.301269	30	0.06	0.8683
12														
	5.2	10.7	1.0015	2.27	1.87	1.23	100.6	32.2	0.047	0.39	0.304279	30	0.06	0.8683
11														
	5.1	10.07	1.0015	2.27	1.87	1.23	97.2	32.2	0.053	0.39	0.318512	30	0.06	0.8683
10														
	5.0	9.42	1.0075	2.27	1.87	1.23	91.7	32.2	0.059	0.39	0.332328	30	0.06	0.8683
9														
	5.5	9.06	1.0075	2.27	1.87	1.23	113.1	32.2	0.081	0.39	0.374629	30	0.06	0.8683
8														
	5.6	9.48	1.0075	2.27	1.87	1.23	117.8	32.2	0.075	0.39	0.364191	30	0.06	0.8683

USDOT HEC-14 DEPTH OF SCOUR

River Section	d_s = Scour Depth (ft)	R_h = hydraulic radius = depth of flow (ft)	C_s = slope correction coeeficient (Table 5.3[5])	α = coeeficient (Table 5.1[5])	σ = (D84/D16)0.5, material standard deviation (sand = 1.87)	$\sigma^{1/3}$	Q_d = Design Flowrate (cfs)	g (ft/sec^2)	$Q/g^{1/2}R_h^{5/2}$	β = coeeficient (Table 5.1[5])	$(Q/g^{1/2}R_h^{5/2})^\beta$	t = time (min)	θ = coeeficient (Table 5.1[5])	$(t/316)^\theta$
1	35	36	37	38	39	40	41	42	43	44	45	46	47	48
7														
	5.8	9.88	1.0150	2.27	1.87	1.23	125.4	32.2	0.072	0.39	0.358485	30	0.06	0.8683
6	6.5	10.67	1.0150	2.27	1.87	1.23	168.8	32.2	0.080	0.39	0.373395	30	0.06	0.8683
5	6.5	10.48	1.0150	2.27	1.87	1.23	169.0	32.2	0.084	0.39	0.380196	30	0.06	0.8683
4	6.4	10	1.0150	2.27	1.87	1.23	164.1	32.2	0.091	0.39	0.393449	30	0.06	0.8683
3	6.5	10.12	1.0150	2.27	1.87	1.23	168.5	32.2	0.091	0.39	0.3929	30	0.06	0.8683