# ENGINEERING RESPONSE TO NRC COMMENTS ON THE DURANGO DRAP

NOTE: Responses are based upon the TAC conceptual design.

Comment — Response

1. Rocks in perimeter ditches surrounding the pile will be designed for the maximum sheer stresses. See attached calculation set: DUR-10-85-05-02-02, Erosion Protection, Finalized Embankment Perimeter Ditches.

2. a) Plan views and cross-sections are being prepared by M-K as part of their design efforts. This information will be available for the NRC during the design review process and will be incorporated into the final RAP/SCD. Drawing for areas where gully erosion protection will be provided and where perimeter ditches merge and transition into the gully erosion will be shown.

   b) The pile configuration has been modified so that ditch-to-gully transition areas will not be a problem. Calculations showing that hydraulic jumps will not occur are presented in the attached calculation set, DUR-10-85-05-01-02, Erosion Protection, Top and Sideslopes, Hydraulic Jumps.

   c) The design at the gully erosion protection blankets has been re-evaluated and new calculations preformed. The RAP/SCD will be revised to reflect these changes. See attached calculation set: DUR-10-85-05-03-02. Erosion Protection, Gully Erosion Control Blanket.

   d) Figure B.4.1. in the DRAP/SCD show sub-watersheds 1 and 2 contributing to the north drainage, however these drainage areas do not impact the pile due to a ridge that borders the north side of the pile. The north gully erosion protection blanket will be keyed into bedrock in the area of the north drainage which will eliminate further headcutting in the direction of one pile. The design is based upon stabilizing the pile for 1000 years and not the surrounding area unless the erosion of off site areas will effect the pile. Further headcutting along the north drainage is not a major concern. For information it should be noted that the geomorphic evaluation presented in the Disposal Site Characterization Report for Bodo Canyon states that although the north channel is within allvium near the site, further incision is prevented by a knickpoint that is down stream in resistant bedrock. Thus, future incision rates are likely to be less then the rate of base-level lowering along the Animas River. Since the last glaciation, this rate has averaged roughly 1 foot/1000 years.

   In regards to drawings indicating drainage areas used to compute peak runoff rates, see the revised calculation on Erosion Control.

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PDR WASTE
WM-48 PDR

3. The concentration of flows have been factored into the revised pile design. See revised calculations: DUR-10-85-05-01-02, Erosion Protection, Top and Side Slopes.

4. Attached is a copy of the Durango Riprap Source Investigation Report prepared by M-K and the Trip Report prepared by TAC member Paul Darr. Burnett Construction Company owns the gravel pit addressed in the DRAP/SCD north of Durango and Animas Aggregate owns the other gravel pit south of Durango.

5. Calculations shall be made with the revised rainfall intensity distributions as recommended in HMR-49 and the National Weather Service.

6. The question of differential settlement was addressed on page B-28 of the DRAP. Calculations indicated that 95% of the total settlement in the foundation and embankment materials would occur within the first two months of final loading. The maximum total settlement at the location considered to be the worst case was 1.3 feet (boring no. 604). It is further estimated that 90% of the settlement in the unsaturated material would occur during construction. To exemplify this differential settlement across the site, assume the point of maximum settlement in the pile to exhibit 1.3 feet of the total settlement. Assume also that the perimeter of the pile would conservatively experience zero total settlement. If 95% of the settlement occurred before cover placement and final grading, only .06 feet (.76 inches) would be expected to occur after placement. This .06 feet is expected to be approximately uniform across the piles 2300 feet by 1100 feet; however, if the remaining settlement was not uniform, the magnitude of the remaining settlement would not be sufficient to cause cover cracking or channeling to the extent necessary to concentrate runoff.

GP/tlk

## Calculation Cover Sheet

rec'd w/ Eng. response to NRC Comments on the Durango Draft

Dur-10-85-05-02-02

Calc. No. ________ rec'd date 11/18/85 Wm-48

No. of Sheets 11

Contract No. UMTRA    Discipline CIVIL

**Project** UMTRA - BODO CANYON

**Feature** SITE DRAINAGE / EROSION PROTECTION

**Item** Erosion Protection - Finalized embankment perimeter ditches

**Sources of Data** Derived
- revision of previously submitted calc No 8

**Sources of Formulae & References**

Procedure for the Design of a Protective Cover System over Radon Barriers for Uranium Mill Tailings Piles, Keshian - June 1985

Preliminary Calc.    Final Calc. [X]    Supersedes Calc. No. 8

| Rev. No. | Revision | Calculation By | Date | Checked By | Date | Approved By | Date |
|---|---|---|---|---|---|---|---|
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| 2 | Dur-10-85-05-02-0[illegible] | [illegible] Aggarwal | 12/-[illegible] | [illegible] | 12/2/85 | | |

# Introduction

**Purpose**

This set of calculations was developed to provide analysis that will be used to respond to comments received from the NRC on 9/06/85. These calculations address only those comments concerning design of drainage characteristics after remedial action.

Areas of concern expressed by NRC and addressed in this calculation include:

1) Re-estimation of riprap designed for perimeter ditches: Previous calculations used average shear stresses rather than the maximum shear stresses. Calculations presented herein will assume that the Hydraulic radius (R) in the design equations is equal to the depth of flow in the center of the channel. (Comment #1)

2) The need for details concerning areas where gully erosion protection is provided and in those areas where the perimeter ditches merge and transition into the gully erosion.

The possible need for increasing rock sizes in the ditch-to-gully transition areas, in ditch junctions, and in those areas where hydraulic jumps may occur. (Comment #s 2A & 2B)

JACOBS ENGINEERING

DATE ______ SUBJECT



JOB NO. ______

BY ______ CHKD. ______

3) Re-Evaluation of the rock sized for the gully erosion. Under the design presented in DRAP/SCD there is concern whether sheet flow will occur over the gully erosion protection blanket. Also clarification as to the effectiveness of such a design needs to be addressed. (Comment # 2C)

4) Erosion protection need to be designed to take into account any concentrations of flow on the sides and toe of the pile (Comment # 3)

5) All calculations shall be made with the revised rainfall intensity distributions as recommended in HMR-49 and by the National Weather Service staff rather than those provided in NRC Staff Technical Position Paper WM-8201. (Comment # 5)

Note: Comment #2D states that drainage areas are not clear. This issue will be clarified when presenting the following calculations. Comment #4 regarding local available rock will be briefly discussed herein. For further details refer to the written response to this comment. For comment #6 see also the written response.

Summary of rock sizes for ditches, side & top slopes and gullys are presented in Calc. No. DUR-10-85-05-01-02 page 40

FORM 91-005-1 (4/81)

## Procedure

Due to the restricting topography of the Bodo Canyon disposal site and the capacity required for the 1,753,000 CY of tailings (Calc. No 1 ) the toe of the embankment is basically fixed. However, the pile configuration has been slightly modified in order to promote sheet flow and reduce the number of ditches. By reducing the number of ditches especially on the steep side slopes of Bodo Canyon rock sizes can be kept down to a minimum. Keeping rock sizes down has been a concern addressed by the NRC due to the limited amount of locally available rocks over 15 inches in diameter.

Figure 1 , next page, will be referred to in all of the following calculations. This figure is basically an enlargement of figure B.1.12 presented in the DRAP/SCD. Modifications (ie revised grading, ditches, gully erosion protection etc) are reflected on this drawing.

JE JACOBS ENGINEERING

DATE ______ SUBJECT Ditch Design 

BY ______ CHKD. ______ JOB NO. ______

## South Ditch

The South Ditch has been broken up into reach 1 with a slope of 7.3% and reach 2 with a slope of 2.4%

Reach 1

Contributing Areas (See figure 1)
are shown in pink

Area A ⇒ 74,800 SF = 1.72 Ac
Area B ⇒ 72,100 SF = 1.66
Total 3.38 AC

TC = 2.5 min. % of 1hr = $t_c(.0089 \times t_c + .0686) = 27.5\%$

$i = (8.1)(.275)\frac{60}{2.5} = 53.46$ in/hr

$Q = CIA = (53.46)(3.38) = \underline{180.69 \text{ cfs}}$

slope = 7.3%

note:

1) Mannings n is dermined from the following calculation

$n = .0395 (d_{50})^{1/6}$ where $d_{50}$ is the mean rock size. A graphical representation for determining n is presented in Fig 5.10.

2) % of 1hr → formula is derived from a least-squares curve fit for the rainfall intensity distribution as recommended in HMR-49

3) $TC_{min} = .0078\, L_{FT}^{.77}\left(\frac{L_{FT}}{H}\right)^{.385}$ where L = max length of travel = 400'
H = change in elevation = 20'
(Formula From Design of Small Dams)

$TC = .0078(400)^{.77}\left[\frac{400}{20}\right]^{.385} = 2.49$ min

FORM 91-008-1 (4/81)

JE JACOBS ENGINEERING

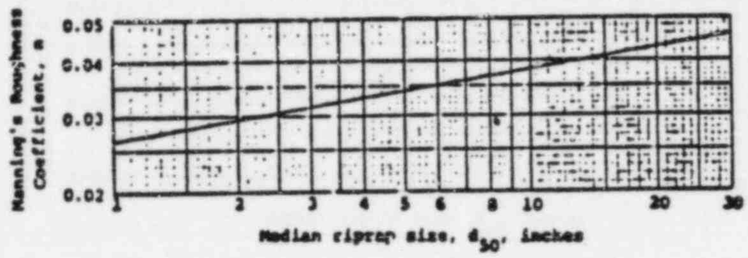
DITCH DESIGN

DATE ______ SUBJECT South Ditch



BY ______ CHKD. ______ JOB NO. ______

Fig. 5.10 - Manning's Coefficient for Riprap



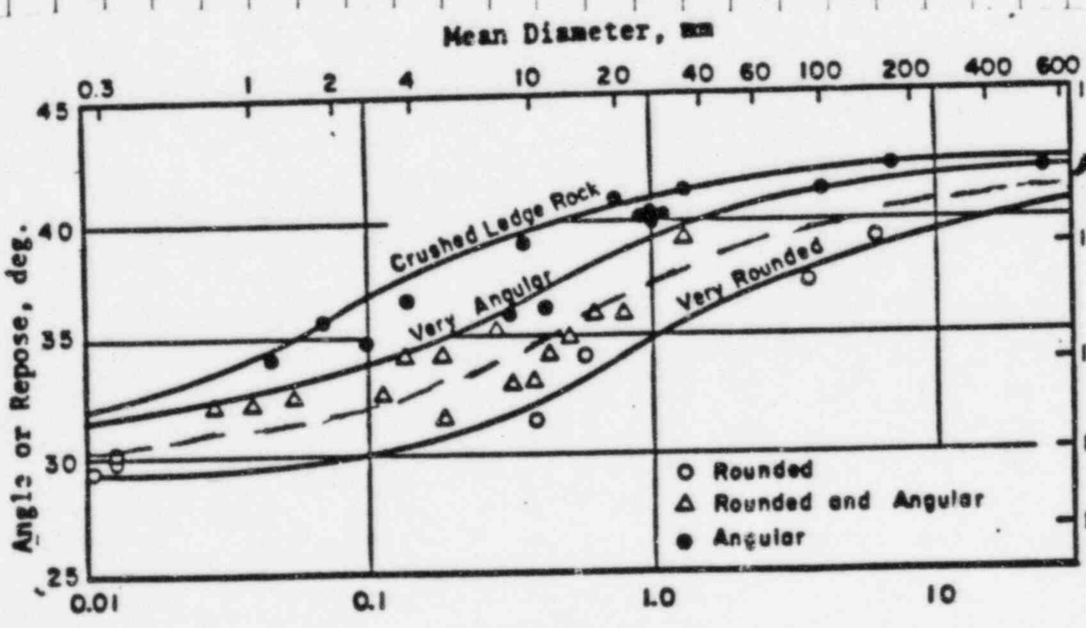

USDA, SCS "Standards And Specifications for Soil Erosion and Sediment Control in Developing Areas" 1975 APPENDIX A

For Reach 1 Assume $D_{50} = 20''$

then $n = .0395\left(\frac{20}{12}\right)^{1/6} = .043$

for reach 1 assuming 20" rock use 42 as the angle of repose (see figure below)

TO determine rock angle of repose use Fig 5.7




Assume rock is between very Angular & very rounded

Fig. 5.7 Angle of repose.

BEGINNING DITCH ELEVATION INPUT AS -.073 (~~SLOPE IF < 1.0~~)

DISCHARGE INPUT AS 180.69 CFS

DITCH SHAPES INCLUDE THE FOLLOWING:

1. VEE
2. TRAPEZOIDAL
3. RECTANGULAR
4. CIRCULAR
5. PARABOLIC

ENTER THE APPROPRIATE SHAPE NUMBER 1

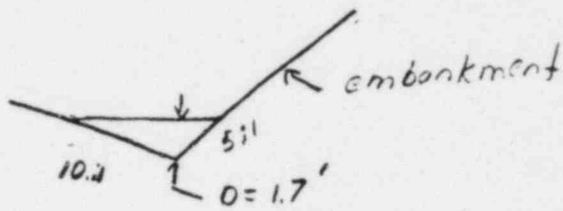
LEFT SIDE SLOPE (-1) INPUT AS 10

RIGHT SIDE SLOPE (-1) INPUT AS 5

VALUE OF 'N' INPUT AS .043

Durango (South Ditch)

Reach 1




cross section of proposed ditch

DITCH CALCULATIONS
------------------

S = 0.0730 FT/FT
Sc= 0.0271 FT/FT

V = 8.32243 fps
Vc= 5.74255 fps

D = 1.70142 FT
Dc= 2.04825 FT

A = 21.7112 SQ FT
Ac= 31.4651 SQ FT

P= 25.7746 FT
Pc= 31.0288 FT

Q= 180.69 cfs
L= 0 ft
n= .043
Tt= 0 min

VEE CHANNEL

B = 0 FT
Lt SS= 10 :1
Rt SS= 5 :1
DO YOU WISH TO DO ANOTHER PROBLEM (Y/N) N

****** HORIZONTAL FLOW ADJACENT TO A SIDE SLOPE ******

DURANGO (SOUTH DITCH)

REACH 1

| | | |
|---|---|---|
| BED SLOPE | = | .073 |
| SIDE SLOPE | = | 5 TO 1 |
| DEPTH OF FLOW | = | 1.7 |
| ROCK SPECIFIC GRAVITY | = | 2.7 |
| ROCK ANGLE OF REPOSE | = | 42 |
| REQUIRED SAFETY FACTOR | = | 1 |
| MANNINGS 'N' | = | .043 |

| DEPTH (FT) | MANNINGS N | VELOCITY (FPS) | FRICTION (DEGREES) | D50 (IN) | SAFETY FACTOR |
|---|---|---|---|---|---|
| 1.700 | 0.043 | 13.336 | 42.000 | 20.711 | 1.00 |

velocity used to determine Lc for reach 2

# South Ditch

## Reach 2

For contributing areas (see figure 7) as shown in light green

Area C ⇒ 215,800 SF = 4.95 AC
Area D ⇒ 90,700 SF = 2.08 AC
TOTAL 7.03

$TC = 2.5\,min + [700/13\,ft/sec]/60 = 3.4\,min.$

(TC for reach 1 plus time to travel along reach 1 and 2 velocity was determined from computer program for reach 1)

$\%\ of\ 1hr = 3.4/[.0089(3.4) + .0686] = 34.39\%$

$i = (8.1)(.3439)\,60/3.4 = 49.16$

$Q = CIA = (49.16)(7.03) = 345.59\ cfs$

$Q_{TOTAL} = Q_{Reach\,1} + Q_{Reach\,2} = 180.69 + 345.54$

$= 526.3\ cfs$

SLOPE = 2.4%

For reach 2 Assume $D_{50} = 12''$

then $n = .0395(1)^{1/6} = .0395 \Rightarrow .04$

For reach 2 From Fig 5.7 use an angle of repose of 41°.

DITCH LENGTH INPUT AS 0 (IF BLANK, STATION INTERVAL IS USED)

BEGINNING STATION INPUT AS 0 FEET

ENDING STATION INPUT AS 0 FEET

BEGINNING DITCH ELEVATION INPUT AS .024 (SLOPE IF < 1.0)

DISCHARGE INPUT AS 526.3 CFS

DITCH SHAPES INCLUDE THE FOLLOWING:

1. VEE
2. TRAPEZOIDAL
3. RECTANGULAR
4. CIRCULAR
5. PARABOLIC

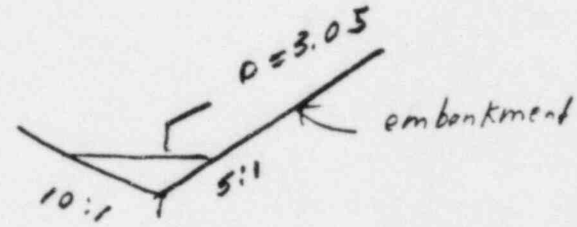
Durango (South Ditch)
Reach 2

ENTER THE APPROPRIATE SHAPE NUMBER 1

LEFT SIDE SLOPE (-1) INPUT AS 10

RIGHT SIDE SLOPE (-1) INPUT AS 5

VALUE OF 'N' INPUT AS .04




cross section of proposed ditch

DITCH CALCULATIONS
------------------

S = 0.0240 FT/FT
Sc= 0.0203 FT/FT

V = 7.56428 fps
Vc= 7.11156 fps

D = 3.04581 FT
Dc= 3.14126 FT

A = 69.577 SQ FT
Ac= 74.0063 SQ FT

P= 46.1406 FT
Pc= 47.5866 FT

Q= 526.3 cfs
L= 0 ft
n= .04
Tt= 0 min

VEE CHANNEL

B = 0 FT
Lt SS= 10 :1

****** HORIZONTAL FLOW ADJACENT TO A SIDE SLOPE ******

DURANGO (SOUTH DITCH)

REACH 2

| | | |
|---|---|---|
| BED SLOPE | = | .024 |
| SIDE SLOPE | = | 5 TO 1 |
| DEPTH OF FLOW | = | 3.05 |
| ROCK SPECIFIC GRAVITY | = | 2.7 |
| ROCK ANGLE OF REPOSE | = | 41 |
| REQUIRED SAFETY FACTOR | = | 1 |
| MANNINGS 'N' | = | .04 |

| DEPTH (FT) | MANNINGS N | VELOCITY (FPS) | FRICTION (DEGREES) | D50 (IN) | SAFETY FACTOR |
|---|---|---|---|---|---|
| 3.050 | 0.040 | 12.137 | 41.000 | 12.305 | 1.00 |

**JE** JACOBS ENGINEERING

DATE ________ SUBJECT



BY ______ CHKD. ______ JOB NO. ______

## Summary of rock sizes for Ditches ★
(v ditches)

| Ditch | Depth | Flow cfs | Bed slope | Side Slope | Rock D50 |
|---|---|---|---|---|---|
| South Ditch | | | | | |
| Reach 1 | 1.70' | 180.7 | .073 | 5:1 | 21" |
| Reach 2 | 3.05' | 526.3 | .024 | 5:1 | 12" |

★ See also Summary of Rock sizes to be used in Bodo Canyon at the back of calculations on erosion protection for top and side Slopes

FORM 91-006-1 (4/81)

## Calculation Cover Sheet

Contract No. UMTRA   Discipline CIVIL   Calc. No. Dur-10-85-05-03-02   No. of Sheets 18

**Project** UMTRA - BODO CANYON

**Feature** SITE DRAINAGE / EROSION PROTECTION

**Item** EROSION PROTECTION - Gully erosion control blanket

**Sources of Data** Derived

- revision of previously submitted calc No 9

**Sources of Formulae & References**

1. Procedure for the Design of a Protective Cover System over Radon Barriers for Uranium Mill Tailings piles, Keshian - June 1985

Preliminary Calc. Final Calc. ☒ Supersedes Calc. No. 9

| Rev. No. | Revision | Calculation By | Date | Checked By | Date | Approved By | Date |
|---|---|---|---|---|---|---|---|
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| | | | | | | | |
| | | | | | | | |
| 2 | Dur-10-85-05-03-02 | KAyogino | 10/12/85 | [signature] | 10/24/85 | | |

**JE** JACOBS ENGINEERING

DATE ______ SUBJECT Gully Erosion SHEET NO. 1 of 18

BY ______ CHKD. ______ JOB NO. ______

# South Gully Erosion

**Procedure**

On large scale drawing (Fig 1) arrows indicate estimated direction of flow across the south gully erosion blanket. Main sources of flow will be from the south ditch (526 cfs) and the indicated drainage area (lavender) just north of the south gully erosion blanket (213 cfs). The combined flow is (739 cfs) and will be used in sizing the rock blanket.

Cross sections 1, 2, 3 & 4 are shown on pages 2 & 3. Cross section 4 approaches the worst case situation and approaches a cross section of a trapezoidal with 5:1 side slopes, a base of 45 feet and a bed slope of 12.5% (8:1). This cross section was used when sizing the rocks for the south gully erosion blanket.

Note: For procedures used to determine Mannings n and the angle of repose see calculations on Ditch Design

Flow from contributing area just north of south gully erosion blanket

A = 173,300 SF = 3.98 Ac

Assume minimum Tc of 2.5 min  %1h = 27.5%

$i = (8.1)(.275)\frac{(60)}{2.5} = 53.46$

$Q = CIA = (53.46)(3.98) = 212.77$

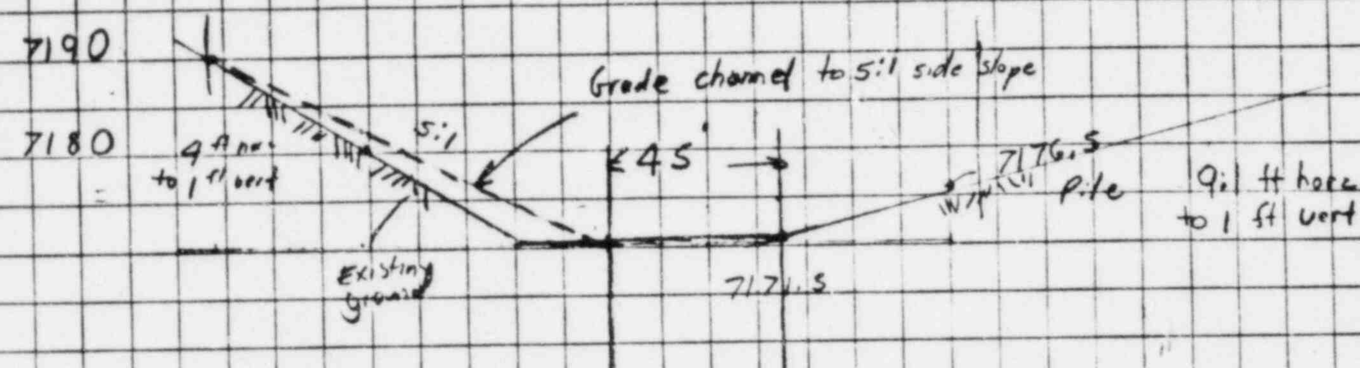
FORM 91-006-1 (4/81)

JE JACOBS ENGINEERING — Gully Erosion

DATE ______ SUBJECT ______ SHEET NO. 2 of 18

BY ______ CHKD. ______ JOB NO. ______

# South Gully Erosion Protection




Cross Section (1)

1" = 50 Horz
1" = 20' Vert


1" = 50 Horz
1" = 20 vert

Cross Section 2

LEGEND
[hatched line] Existing Ground prior to grading
- - - - - Final grading

FORM 91-005-1 (4/81)

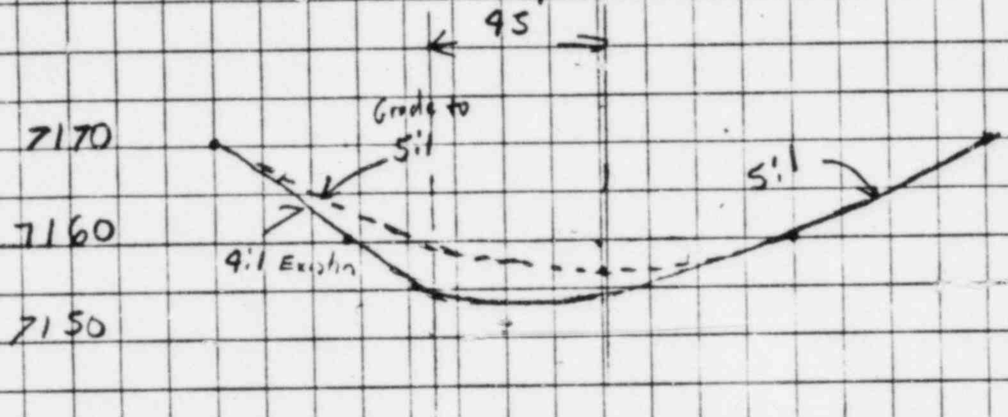
**JE JACOBS ENGINEERING** Gully Erosion

DATE ____________ SUBJECT

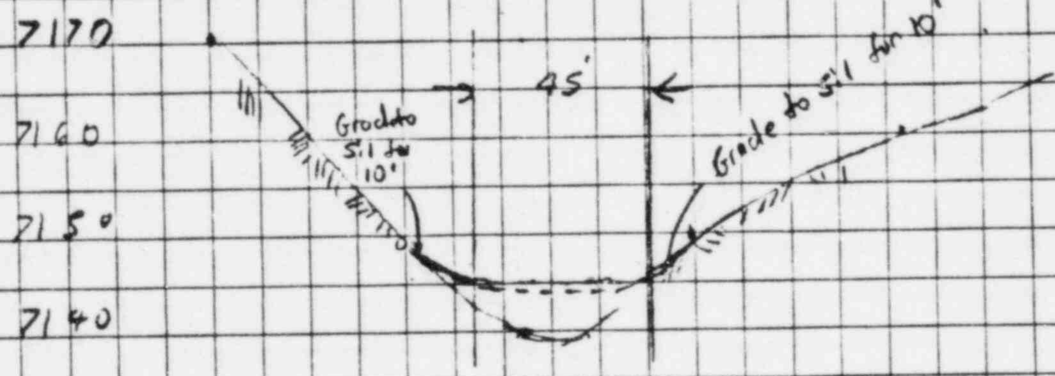


BY ________ CHKD. ________ South Gully

JOB NO. ____________




CROSS SECTION 3




CROSS SECTION 4

BEGINNING DITCH ELEVATION INPUT AS .125 (SLOPE IF < 1.0)

DISCHARGE INPUT AS 739 CFS

South Gully

DITCH SHAPES INCLUDE THE FOLLOWING:

Cross Section 4

1. VEE
2. TRAPEZOIDAL
3. RECTANGULAR
4. CIRCULAR
5. PARABOLIC

ENTER THE APPROPRIATE SHAPE NUMBER 2

BOTTOM WIDTH OR DIAMETER INPUT AS 45
LEFT SIDE SLOPE (-1) INPUT AS 5

RIGHT SIDE SLOPE (-1) INPUT AS 5

VALUE OF 'N' INPUT AS .043

DITCH CALCULATIONS

S = 0.1250 FT/FT

Sc= 0.0232 FT/FT

V = 12.5272 fps
Vc= 7.19585 fps

D = 1.16112 FT
Dc= 1.88668 FT

A = 58.9915 SQ FT
Ac= 102.698 SQ FT

P= 56.8412 FT
Pc= 64.2404 FT

Q= 739 cfs
L= 0 ft
n= .043
Tt= 0 min

TRAPEZOIDAL CHANNEL

B = 45 FT
Lt SS= 5 :1
Rt SS= 5 :1

DO YOU WISH TO DO ANOTHER PROBLEM (Y/N) N

****** HORIZONTAL FLOW ADJACENT TO A SIDE SLOPE ******

DURANGO

SOUTH GULLY EROSION PROTECTION

| | | |
|---|---|---|
| BED SLOPE | = | .125 |
| SIDE SLOPE | = | 5 TO 1 |
| DEPTH OF FLOW | = | 1.16 |
| ROCK SPECIFIC GRAVITY | = | 2.7 |
| ROCK ANGLE OF REPOSE | = | 42 |
| REQUIRED SAFETY FACTOR | = | 1 |
| MANNINGS 'N' | = | .043 |

| DEPTH (FT) | MANNINGS N | VELOCITY (FPS) | FRICTION (DEGREES) | D50 (IN) | SAFETY FACTOR |
|---|---|---|---|---|---|
| 1.160 | 0.043 | 13.525 | 42.000 | 24.199 | 1.00 |

****** FLOW OVER A PLAIN SLOPING BED ******

DURANGO

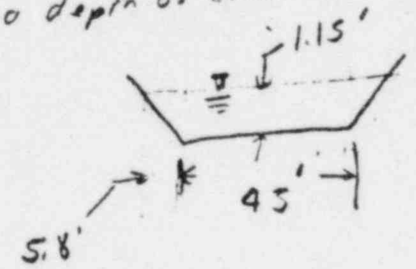
SOUTH GULLY EROSION PROTECTION

| | | |
|---|---|---|
| SIDE SLOPE | = | 8 TO 1 |
| FLOW RATE | = | 14.55 CFS/FEET |
| ROCK SPECIFIC GRAVITY | = | 2.7 |
| ROCK ANGLE OF REPOSE | = | 42 |
| REQUIRED SAFETY FACTOR | = | 1 |
| MANNINGS 'N' | = | .043 |

| DEPTH (FT) | MANNINGS N | VELOCITY (FPS) | FRICTION (DEGREES) | D50 (IN) | SAFETY FACTOR |
|---|---|---|---|---|---|
| 1.109 | 0.043 | 13.123 | 42.000 | 24.044 | 1.00 |

flow rate was determined as follows:

1) have a trapezoidal Ditch with 5:1 side slope and a depth of flow of 1.16 as shown below




2) flow per unit width is $\frac{739 \text{ cfs}}{(45+5.8)} = 14.55 \frac{\text{cfs}}{\text{ft}}$

JE JACOBS ENGINEERING

DATE ________ SUBJECT

BY ______ CHKD. ______



JOB NO. ______

## South West Gully Erosion Protection

Sheet flow will occur over the south West Gully erosion protection blanket. In order to take into account flow concentrations lines are drawn perpendicular to the contours indicating the direction that flow will travel. The area within these lines is determined. This area is then divided by the width where flow concentrations occur to determine a flow per unit width. (See figure 1)
(for a more detailed explanation of this procedure see also calculations on top and side slopes)

Area of I C = 49,500 SF concentrated over 20 feet

Assuming a $t_c$ of 2.5 min

% of 1hr = $t_c / (.0089 \cdot t_c + .0686)$ = 27.5%

$I = (.275)(8.1)\,60/2.5 = 53.46$

↑ Intensity was determined from previously submitted calculations

$$Q = CIA = \frac{(53.45)(49{,}500/20)}{43560} = 3.04\ \frac{cfs}{ft}$$

slope > 6:1

Interstitial flow can be considered when designing the rock for this gully erosion protection. The procedures for taking into account interstitial flow are presented in the calculations for erosion protection / side slopes. The actual calculations are presented as follows:

FORM 91-005-1 (4/81)

# JE JACOBS ENGINEERING

DATE ________ SUBJECT

SHEET NO. 8 of 18

JOB NO. ________

BY ______ CHKD. ______

Step 1 based upon no intersitial flow a rock size of 12 inches was determined. For trial No 1 assume a 10" rock

From Table 2 in calcs for side slopes →

$Wm^{0.5} = 35.25$

$V = (35.25)(.167)^{.54} = 13.40$

$Q_i = V/12 \times .33 \times$ thickness (assume 2') $= .74$

$Q_{overland} = 3.04 - .74 = 2.30$

run riprap program with a flow of 2.3 cfs/ft
- obtained $D_{50}$ of 10" ✓

check $t_c$ $V = 7.25$
$L = 650$

$t_c = (650/7.25)/60 = 1.49$

use 2.5 min ✓

****** FLOW OVER A PLAIN SLOPING BED ******

South West Gully

DURANGO

[illegible] GULLY EROSION PROTECTION

| | | |
|---|---|---|
| SIDE SLOPE | = | 6 TO 1 |
| FLOW RATE | = | 3.04 CFS/FEET |
| ROCK SPECIFIC GRAVITY | = | 2.7 |
| ROCK ANGLE OF REPOSE | = | 40 |
| REQUIRED SAFETY FACTOR | = | 1 |
| MANNINGS 'N' | = | .039 |

| DEPTH (FT) | MANNINGS N | VELOCITY (FPS) | FRICTION (DEGREES) | D50 (IN) | SAFETY FACTOR |
|---|---|---|---|---|---|
| 0.375 | 0.039 | 8.109 | 40.000 | 11.719 | 1.00 |

****** FLOW OVER A PLAIN SLOPING BED ******

SIDE SLOPE = 6 TO 1
FLOW RATE = 2.3 CFS/FEET
ROCK SPECIFIC GRAVITY = 2.7
ROCK ANGLE OF REPOSE = 40
REQUIRED SAFETY FACTOR = 1
MANNINGS 'N' = .039

| DEPTH (FT) | MANNINGS N | VELOCITY (FPS) | FRICTION (DEGREES) | D50 (IN) | SAFETY FACTOR |
|---|---|---|---|---|---|
| 0.317 | 0.039 | 7.253 | 40.000 | 9.913 | 1.00 |

North Gully Erosion Protection

Cross Sections 5 and 6 are shown on pages 12 & 13. The contributing drainage area for cross section No. 5 is 15.1 Ac. (Area outlined in Green) Assuming a tc of 2.5 min the flow for cross section 5 is as follows:

$$Q_5 = (1)(53.46)(15.1) = 807 \text{ cfs}$$

The contributing drainage area for cross section No. 6 is 18.4 Ac. (Area outlined in yellow). Assuming a tc of 2.5 min the flow for cross section 6 is as follows:

$$Q_6 = (1)(53.46)(18.4) = 984 \text{ cfs}$$

Rock has been sized for both cross sections. The rocks for the north Gully erosion protection will be based upon the cross section which requires the largest size rocks

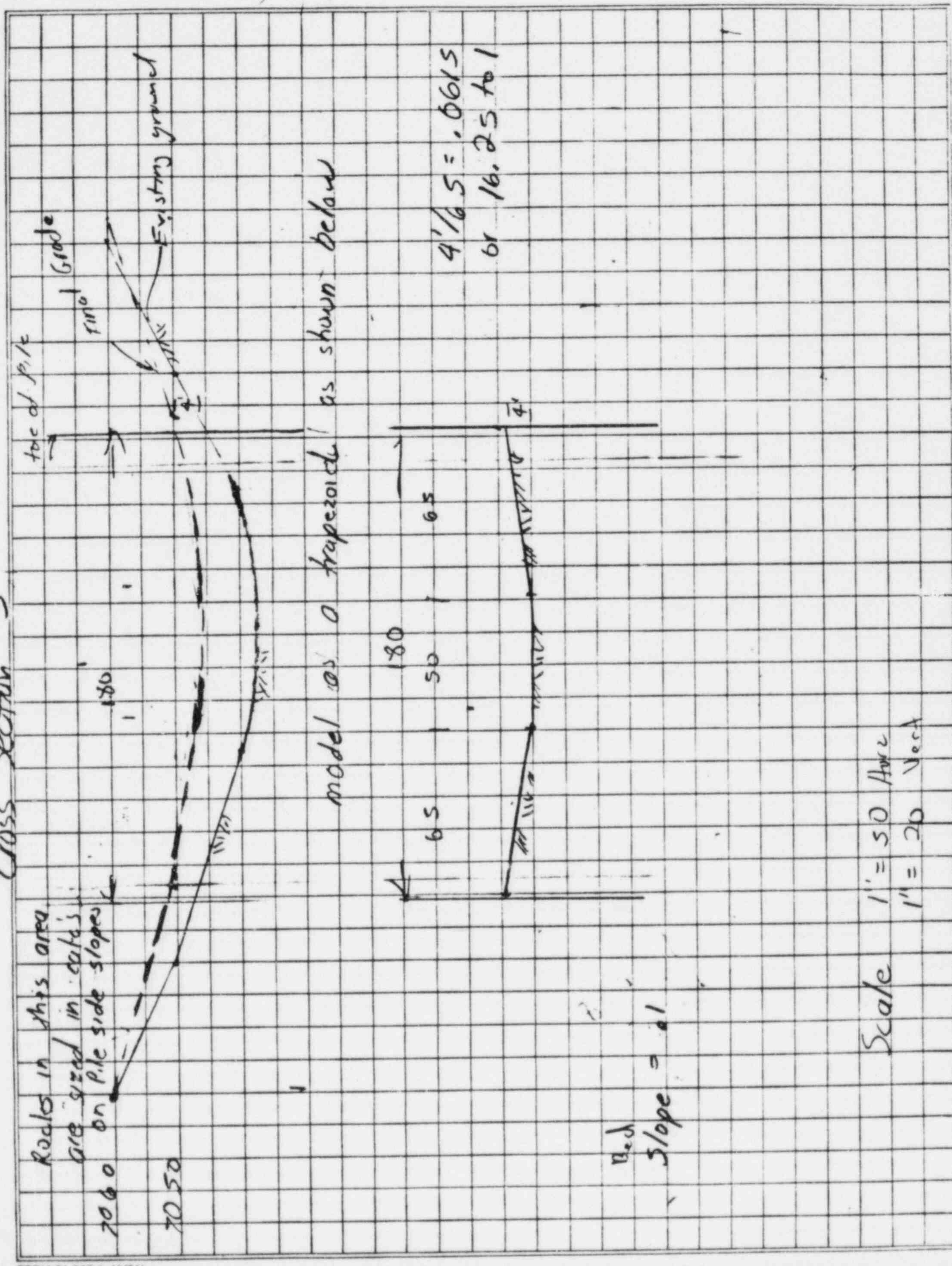
JE JACOBS ENGINEERING

DATE ________ SUBJECT

SHEET NO. 12 of 18

BY ____ CHKD. ____

JOB NO. ____




FORM 91-005-1 (4/81)

```
BEGINNING DITCH ELEVATION INPUT AS  .1  (SLOPE IF < 1.0)
DISCHARGE INPUT AS  807  CFS

DITCH SHAPES INCLUDE THE FOLLOWING:

          1.  VEE
          2.  TRAPEZOIDAL
          3.  RECTANGULAR
          4.  CIRCULAR
          5.  PARABOLIC

ENTER THE APPROPRIATE SHAPE NUMBER  2

BOTTOM WIDTH OR DIAMETER INPUT AS  50
LEFT SIDE SLOPE (-1) INPUT AS  16.25

RIGHT SIDE SLOPE (-1) INPUT AS  16.25

VALUE OF 'N' INPUT AS  .043


    DITCH CALCULATIONS
    ------------------

S =     0.1000 FT/FT
Sc=     0.0252 FT/FT

V =  10.2116  fps
Vc=  6.29642  fps

D =  1.15043  FT
Dc=  1.66375  FT

A =  79.0281  SQ FT
Ac=  128.168  SQ FT

P=  87.4597 FT
Pc=  104.174 FT


Q=  807  cfs
L=  0  ft
n=  .043




Tt=  0  min


TRAPEZOIDAL CHANNEL

B     =  50  FT
Lt SS=  16.25 :1
Rt SS=  16.25 :1


DO YOU WISH TO DO ANOTHER PROBLEM (Y/N) N
```

JE JACOBS ENGINEERING

DATE ______ SUBJECT

BY ______ CHKD. ______



JOB NO. ______

RIPRAP/BAS

****** HORIZONTAL FLOW ADJACENT TO A SIDE SLOPE ******

DURANGO

NORTH GULLY EROSION PROTECTION

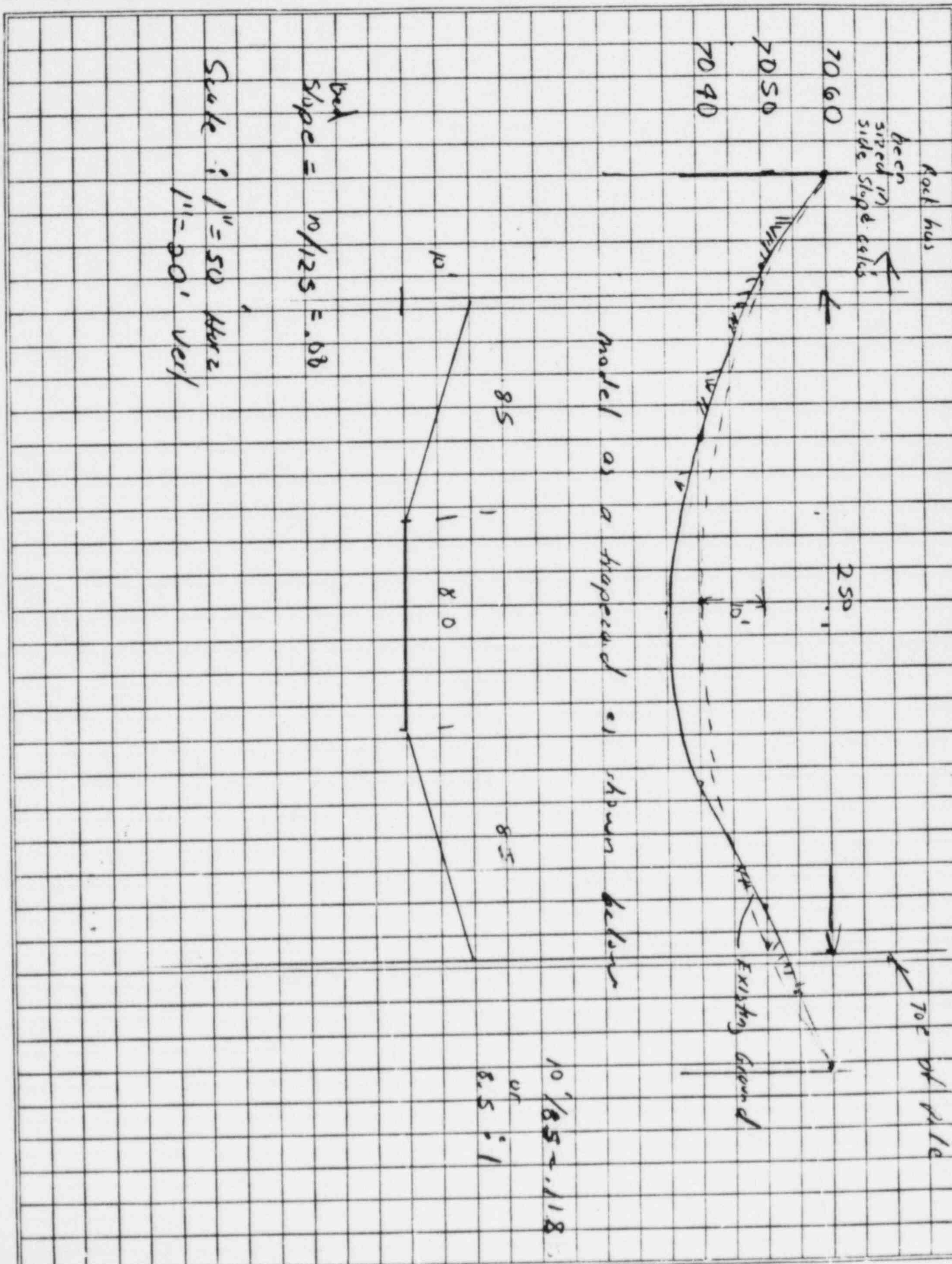
| | | |
|---|---|---|
| BED SLOPE | = | .1 |
| SIDE SLOPE | = | 16.25 TO 1 |
| DEPTH OF FLOW | = | 1.15 |
| ROCK SPECIFIC GRAVITY | = | 2.7 |
| ROCK ANGLE OF REPOSE | = | 41 |
| REQUIRED SAFETY FACTOR | = | 1 |
| MANNINGS 'N' | = | .043 |

| DEPTH (FT) | MANNINGS N | VELOCITY (FPS) | FRICTION (DEGREES) | D50 (IN) | SAFETY FACTOR |
|---|---|---|---|---|---|
| 1.150 | 0.043 | 12.028 | 41.000 | 17.252 | 1.00 |

**JE** JACOBS ENGINEERING

DATE ____________ SUBJECT ____________ SHEET NO. 15 of 18

BY ________ CHKD. ________ JOB NO. ____________




FORM 91-008-1 (4/81)

BEGINNING DITCH ELEVATION INPUT AS .08 (SLOPE IF < 1.0)

DISCHARGE INPUT AS 984 CFS

DITCH SHAPES INCLUDE THE FOLLOWING:

1. VEE
2. TRAPEZOIDAL
3. RECTANGULAR
4. CIRCULAR
5. PARABOLIC

ENTER THE APPROPRIATE SHAPE NUMBER 2

BOTTOM WIDTH OR DIAMETER INPUT AS 80
LEFT SIDE SLOPE (-1) INPUT AS 8.5

RIGHT SIDE SLOPE (-1) INPUT AS 8.5

VALUE OF 'N' INPUT AS .043

DITCH CALCULATIONS

S = 0.0800 FT/FT
Sc= 0.0243 FT/FT

V = 9.83572 fps
Vc= 6.66848 fps

D = 1.11779 FT
Dc= 1.57944 FT

A = 100.043 SQ FT
Ac= 147.56 SQ FT

P= 99.1335 FT
Pc= 107.036 FT

Q= 984 cfs
L= 0 ft
n= .043

Tt= 0 min

TRAPEZOIDAL CHANNEL

B = 80 FT
Lt SS= 8.5 :1
Rt SS= 8.5 :1

RIPRAP/BAS

****** HORIZONTAL FLOW ADJACENT TO A SIDE SLOPE ******

DURANGO

NORTH GULLY EROSION PROTECTION

| | | |
|---|---|---|
| BED SLOPE | = | .06 |
| SIDE SLOPE | = | 8.5 TO 1 |
| DEPTH OF FLOW | = | 1.12 |
| ROCK SPECIFIC GRAVITY | = | 2.7 |
| ROCK ANGLE OF REPOSE | = | 41 |
| REQUIRED SAFETY FACTOR | = | 1 |
| MANNINGS 'N' | = | .043 |

| DEPTH (FT) | MANNINGS N | VELOCITY (FPS) | FRICTION (DEGREES) | D50 (IN) | SAFETY FACTOR |
|---|---|---|---|---|---|
| 1.120 | 0.043 | 10.570 | 41.000 | 13.873 | 1.00 |

check $t_c$ length of travel = 600

$t = \left(\frac{600}{10.57}\right)/60 = .94$ <

JE JACOBS ENGINEERING

DATE ________ SUBJECT

BY ________ CHKD. ________



JOB NO. ________

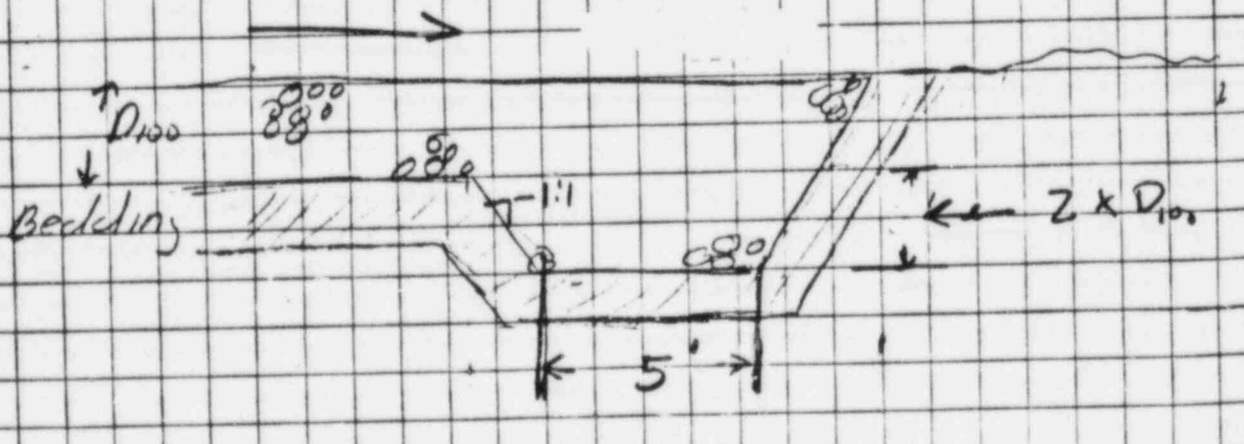
Summary of rock sizes for Gully Erosion Protection ★

| Gully | Rock Size $D_{50}$ |
|---|---|
| South | 24" |
| Southwest | 10" |
| North | 17" |

★ see also summary of Rock Sizes to be used in Dodo Canyon at the back of calculations on erosion protection for top E side slopes

Orange areas on fig1 indicate limits of Gully Erosion Protection

note: The north Gully erosion control blanket is to be to tied into bedrock as shown in Figure 1. On slopes where the rocks armoring ends and on the Southwest and South gully erosion control blankets the construction shall be as shown below.



**Calculation Cover Sheet**

**Contract No.** UMTRA **Discipline** CIVIL **Calc. No.** Dr-10-85-05-01-02 **No. of Sheets** 43

**Project**

UMTRA - BODO CANYON

**Feature**

SITE DRAINAGE / EROSION PROTECTION

**Item**

EROSION PROTECTION - TOP AND SIDE SLOPES
- Hydraulic Jumps

**Sources of Data**

Derived
- REVISION OF PREVIOUSLY SUBMITTED CALC NO 11

**Sources of Formulae & References**

① Procedure for the Design of a Protective Cover System Over Radon Barriers for Uranium Mill Tailings Piles, Keshian - June 1985

② Fluid Mechanics with Engineering Applications
Daugherty, 1977

**Preliminary Calc.** ☐ **Final Calc.** ☒ **Supersedes Calc. No.** 11

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| 2 | Dr-10-85-05-01-02 | KAgogino | 11/12/85 | [illegible signature] | 11/21/85 | | |
| **Rev. No.** | **Revision** | **Calculation By** | **Date** | **Checked By** | **Date** | **Approved By** | **Date** |

## PURPOSE

The purpose of the following calculation is to determine the rock diameter for the top slope of the pile configuration. The rock sized will be used for protection against erosion.

## Procedure

The erosion protection rock sizes were calculated by utilizing the computer program "RIPRAP". The flow per unit width was calculated first for the input parameter applied to the "Riprap" program. The rational formula was used. The intensity (I) was calculated as follows:

The % of 1-hr PMP was determined from the following table:

| RAINFALL DURATION MINUTES | HOURS | PERCENT OF TOTAL |
|---|---|---|
| 0 | 0 | 0 |
| 5 | .0833333 | 45 |
| 10 | .1666667 | 65 |
| 15 | .25 | 74 |
| 20 | .3333333 | 80 |
| 25 | .4166667 | 85 |
| 30 | .5 | 89 |
| 35 | .5833333 | 92 |
| 40 | .6666667 | 94 |
| 45 | .75 | 95 |
| 50 | .8333333 | 97 |
| 55 | .9166667 | 99 |
| 60 | 1 | 100 |

The curve fit for this table is as follows 

CURVEFIT/BAS

5 VALUES WITH OUTPUT CODE = 1 :

X( 1 ),Y( 1 ) = 60 , 100
X( 2 ),Y( 2 ) = 45 , 95
X( 3 ),Y( 3 ) = 30 , 89
X( 4 ),Y( 4 ) = 15 , 74
X( 5 ),Y( 5 ) = 5 , 45

L E A S T - S Q U A R E S   C U R V E F I T

| CURVE TYPE | INDEX | A | B |
|---|---|---|---|
| ********** | ***** | *** | *** |
| 1. Y=A+(B*X) | 0.8249 | 52.4797 | 0.9071 |
| 2. Y=A*EXP(B*X) | 0.7483 | 52.3859 | 0.0127 |
| 3. Y=A*(X**B) | 0.9603 | 28.4971 | 0.3207 |
| 4. Y=A+(B/X) | 0.9595 | 99.8576 | -284.1280 |
| 5. Y=1/(A+B*X) | 0.6715 | 0.0193 | -0.0002 |
| 6. Y=X/(A*X+B) | 0.9998 | 0.0089 | 0.0686 |

TABLE FOR CURVE NUMBER 6

6. Y=X/(A*X+B) IS A HYPERBOLIC FUNCTION
A = 8.91491E-03 B = .0685532

| X-ACTUAL | Y-ACTUAL | Y-CALCULATED | RELATIVE ERROR |
|---|---|---|---|
| 5 | 45 | 44.1978 | .0178259 |
| 15 | 74 | 74.1558 | -2.10561E-03 |
| 30 | 89 | 89.2856 | -3.20915E-03 |
| 45 | 95 | 95.8009 | -8.43096E-03 |
| 60 | 100 | 99.4287 | 5.7132E-03 |

TABLE FOR CURVE NUMBER 0

% of 1hr = $t_c / (.0089 \cdot t_c + .0686)$

for 2½ min = 27.5 %

In order to determine the time of concentration one must first estimate a velocity or a time of concentration. The computer program "RIPRAP" uses mannings equation to determine a velocity, this is an iterative process described as follows:

TRIAL #1

STEP 1 ASSUME a time of concentration (Assume 3 min)

STEP 2 - Determine the Intensity

% of 1 hr = $t_c / (.0089 * t_c + .0686)$

$= 3 / [(.0089 * 3) + .0686] = 31.5\%$

$I = .315 \times 8.1 \times 60/3 = 51.03$

^ the PMP has been provided from previously submitted calculations

From the rational formula C = 1.0

$$Q = CIA = \frac{(1)(51.03)(900)}{43560} = 1.05 \text{ cfs/ft}$$

the longest length that sheet flow will occur on the 3% slope is 900.'

STEP 3 - Check assumed tc against computed tc - may need to go back to step 1

From Riprap Program

$V = 3.71$ ft/sec ∴ $t_c = \left(\frac{900'}{3.71'/sec}\right)/60 = 4.04$ min

4.04 min is greater than the assumed 3 min - go back to step 1

RIPRAP/BAS

****** FLOW OVER A PLAIN SLOPING BED ******

SIDE SLOPE = 33.33 TO 1
FLOW RATE = 1.05 CFS/FEET
ROCK SPECIFIC GRAVITY = 2.65
ROCK ANGLE OF REPOSE = 35
REQUIRED SAFETY FACTOR = 1
MANNINGS 'N' = .03

| DEPTH (FT) | MANNINGS N | VELOCITY (FPS) | FRICTION (DEGREES) | D50 (IN) | SAFETY FACTOR |
|---|---|---|---|---|---|
| 0.283 | 0.030 | 3.709 | 35.000 | 1.356 | 1.00 |

**JE** JACOBS ENGINEERING

DATE ________ SUBJECT



BY ______ CHKD. ______ JOB NO. ______

TRIAL #2

Assume $t_c = 4\ min$ % of 1hr = $4/[(.0089 \cdot 4) + .0686]$

= 38.39

$I = .3834 \times 8.1 \times 60/4 = 46.64$

$Q = CIA = \frac{(1)(46.64)(900)}{43560} = .96$ cfs/ft

$V = 3.6$ ft/sec $t_c = (900/3.6)/60 = 4.2$

****** FLOW OVER A PLAIN SLOPING BED ******

SIDE SLOPE = 33.33 TO 1
FLOW RATE = .96 CFS/FEET
ROCK SPECIFIC GRAVITY = 2.65
ROCK ANGLE OF REPOSE = 35
REQUIRED SAFETY FACTOR = 1
MANNINGS 'N' = .03

| DEPTH (FT) | MANNINGS N | VELOCITY (FPS) | FRICTION (DEGREES) | D50 (IN) | SAFETY FACTOR |
|---|---|---|---|---|---|
| 0.268 | 0.030 | 3.578 | 35.000 | 1.285 | 1.00 |

$0.10' \leq D_{15} \leq .5$

$1.5 \leq D_{50} \leq 2.0$

$2 \leq D_{100} \leq 3.0$

## Purpose

The purpose of the following calculations is to determine the rock diameter for the side slopes of the pile configuration. The rock will be sized for protection against erosion during a PMP event and will take into account areas where concentration of flows may occur.

## Procedure

The erosion protection rock sizes were calculated by utilizing the computer program "RIPRAP". The flow per unit width was calculated first for the input parameter applied to the "RIPRAP" program. The rational formula was used. The intensity (I) was computed as follows:

The time of concentration will vary. The % of 1-hr PMP was determined from the following table

| RAINFALL DURATION MINUTES | HOURS | PERCENT OF TOTAL |
|---|---|---|
| 0 | 0 | 0 |
| 5 | .0833333 | 45 |
| 10 | .1666667 | 65 |
| 15 | .25 | 74 |
| 20 | .3333333 | 80 |
| 25 | .4166667 | 85 |
| 30 | .5 | 89 |
| 35 | .5833333 | 92 |
| 40 | .6666667 | 94 |
| 45 | .75 | 95 |
| 50 | .8333333 | 97 |
| 55 | .9166667 | 99 |
| 60 | 1 | 100 |

formula:

% of 1 hr = $t_c / [(.0089)(t_c) + .0686]$

# JE JACOBS ENGINEERING

DATE ______ SUBJECT

BY ______ CHKD. ______



JOB NO. ______

DETERMINATON OF ROCK WHERE FLOW CONCENTRATIONS DO NOT OCCUR

The PMP detimination has been provided in previously submitted calculations.
The 1hr PMP is 8.1 inches

The longest length that sheet flow will occur on the 5:1 slopes is 800 ft

FORM 91-008-1 (4/81)

JE JACOBS ENGINEERING

DATE ______ SUBJECT



BY ______ CHKD. ______ JOB NO. ______

In order to determine the time of concentration ($t_c$) one must first estimate a $t_c$ or a velocity. The computer program "Riprop" uses manning equation to determine a velocity. This is an iterative process described as follows:

Step 1 - Assume a time of concentration (Assume 3 min)

Step 2 - Determine the Intensity

$$\% \text{ of } 1 \text{ hr} = t_c / (.0089 * t_c + .0686)$$
$$= 3 / [(.0089 * 3) + .0686] = 31.5\%$$

$$I = .315 \times 8.1 \times 60/3 = 51.03$$

↑ The PMP has been provided from previously submitted calculations

From the rational formula where C = 1.0

$$Q = CIA = \frac{(1)(51.03)(800)}{43560}$$

← The longest length that sheet flow will occur on the 5:1 slopes is 800 ft

$$= .94 \text{ cfs/ft}$$

note: This flow does not take into account interstitial flow which is determined as follows and is also an iterative process

Step 3 Assume a rock size

(running the program "Rip rap" assuming no interstitial flow was done to determine a reasonable 1st guess)

FORM 91-006-1 (4/81)

JACOBS ENGINEERING

DATE ______ SUBJECT



BY ______ CHKD. ______ JOB NO. ______

step 4 Based on this rock size and using table 2 p.11 determine the velocity of flow in the rocks by the following equation.

$$V = (W_m^{0.5})(\text{Slope})^{0.54}$$

↑ obtain from table 2 - p. 11

step 5 Determine the amount of interstitial flow by the following formula.

$$Q_i = \frac{V}{12} \times \text{thickness of bed layer} \times .33$$

note: To be conservative only the rock layer not including the filter bed will be considered when determining the amount of interstitial flow, even though some interstitial flow will also occur in the filter bedding

Step 6 $Q_o$ (overland flow to be entered into riprap program) $= Q_T - Q_i$

↑ Determined from rational formula

Step 7 Enter $Q_o$ into "Riprap" program and see if assumed rock size is the same as rock size generated from the riprap program. If yes, then go on to next step. if no then assume a new rock size and go back to step 3

FORM 91-008-1 (4/81)

step 8 check $t_c$ by using the velocity obtained from "Riprap Program"

Table 2 Empirical correlations for flow in rock

| Rock size (inches) | $Wm^{0.5}$ (in/sec) |
|---|---|
| 2 | 16 |
| 6 | 28 |
| 8 | 32 |
| 24 | 58 |
| 48 | 84 |

TRIAL 1 Based upon 800 ft of length

$Q_T$ = .94 cfs rock size = D = 7.77"

with interstitial flow try 6"

$V = 5.3$ $t_c = \left(\frac{800}{5.3}\right)60 = 2.5 min$

$V = (28)(.20)^{.54} = 11.74$

$Q_i = V/12 \times .33 \times 1 = .32$

$Q_0 = .94 - .32 = .62$

Check $t_c$

$V = 4.6$ $t_c = \left(\frac{800}{4.6}\right)/60 = 2.90$ ✓

RIPRAP/BAS

****** FLOW OVER A PLAIN SLOPING BED ******

Rock size with
no interstitial flow

| | | |
|---|---|---|
| SIDE SLOPE | = | 5 TO 1 |
| FLOW RATE | = | .94 CFS/FEET |
| ROCK SPECIFIC GRAVITY | = | 2.65 |
| ROCK ANGLE OF REPOSE | = | 40 |
| REQUIRED SAFETY FACTOR | = | 1 |
| MANNINGS 'N' | = | .038 |

| DEPTH (FT) | MANNINGS N | VELOCITY (FPS) | FRICTION (DEGREES) | D50 (IN) | SAFETY FACTOR |
|---|---|---|---|---|---|
| 0.173 | 0.038 | 5.440 | 40.000 | 7.069 | 1.00 |

****** FLOW OVER A PLAIN SLOPING BED ******

SIDE SLOPE = 5 TO 1
FLOW RATE = .62 CFS/FEET
ROCK SPECIFIC GRAVITY = 2.65
ROCK ANGLE OF REPOSE = 40
REQUIRED SAFETY FACTOR = 1
MANNINGS 'N' = .038

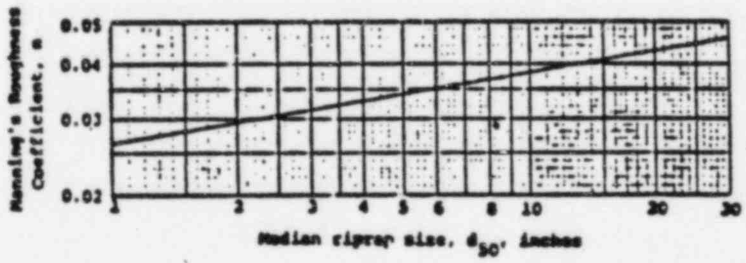
| DEPTH (FT) | MANNINGS N | VELOCITY (FPS) | FRICTION (DEGREES) | D50 (IN) | SAFETY FACTOR |
|---|---|---|---|---|---|
| 0.135 | 0.038 | 4.606 | 40.000 | 5.507 | 1.00 |

# DETERMINATION OF ROCK WHERE FLOW CONCENTATION OCCUR

Areas of concern and there associated drainages are numbed on Figure 2 and the rock sizes calculated as follows:

In order to take into account flow concentrations lines are drawn perpendicular to the contours indicating the direction that flow will travel. The area within these lines is determined. This area is then divided by the width where flow concentrations occur to determine a flow per unit width.
Figures 5.10 & 5.7 were used to estimate manning n and the angle of repose, respectively

**Fig. 5.10 - Manning's Coefficient for Riprap**




USDA, SCS "Standards And Specifications for Soil Erosion and Sediment Control in Developing Areas" 1975 APPENDIX A

$n = .0395 (d_{50})^{1/6}$

FORM 91-005-1 (4/81)

7/29/85
15/43

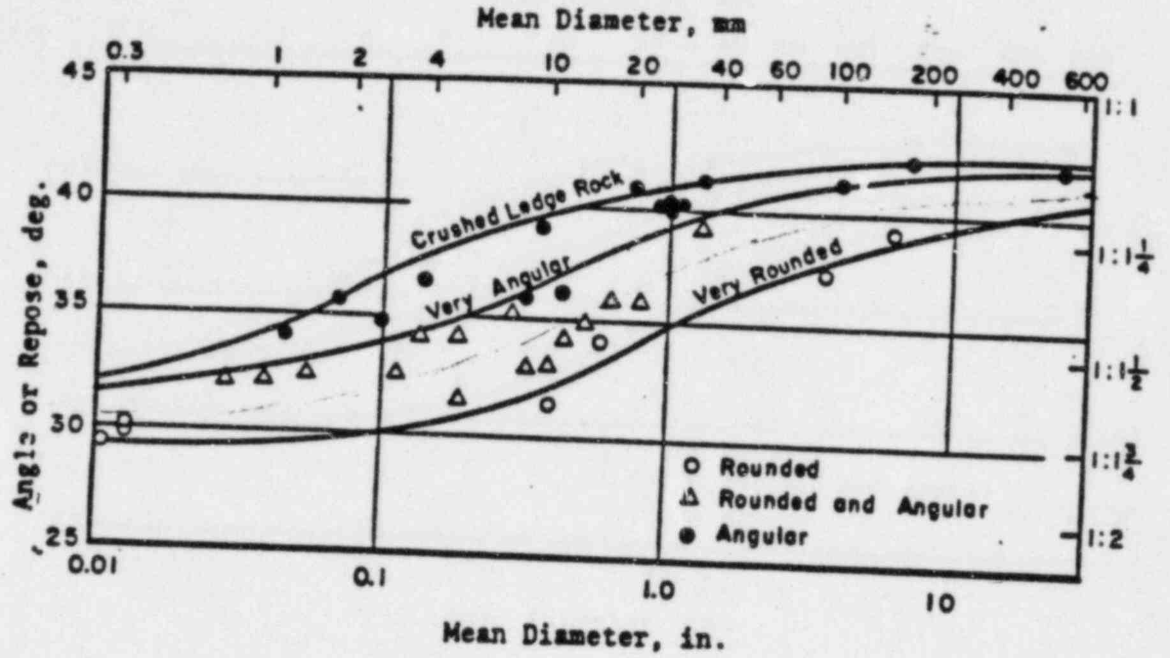



Fig. 5.7 Angle of repose.

**JE JACOBS ENGINEERING** Side Slopes

SUBJECT Flow Concentration on Pile near North drainage

DATE ______ BY ______ CHKD. ______



JOB NO. ______

SEE Figure 1 and p. 17

Area 1A-1 = 56,000 SF

concentrating into 10' ∴ Area / unit width = 56,000/10 = 5,600

$Q = CIA = \frac{(1)(53.46)(5,600)}{43560} = 6.87$ cfs/ft

Slope = $\frac{10}{85}$ = .118

length from most remote point is ≈ 850' - assume $t_c$ = 2.5

⇒ % of 1hr = 27.5%

I = (.275)(8.1) 60/2.5 = 53.46

Assume 12" rock

$V = (W m^{0.5})(\text{Slope})^{.54}$

$= (38)(.118)^{.54} = 11.98$

with 12" rock thickness ⇒ 18" = 1.5'

use n = .04

angle of repose = 41

$Q_i = \frac{V}{12} \times .33 \times \text{thickness}_{1.5} = .49$

$Q_o = 6.87 - .49 = 6.38$ cfs

Assume 13" ROCK thickness ⇒ 2 ft

$V = (40.123)(.118)^{.54} = 12.65$

$Q_i = \frac{12.65}{12} \times .33 \times 2 = .70$

$Q_o = 6.87 - .70 = 6.17$

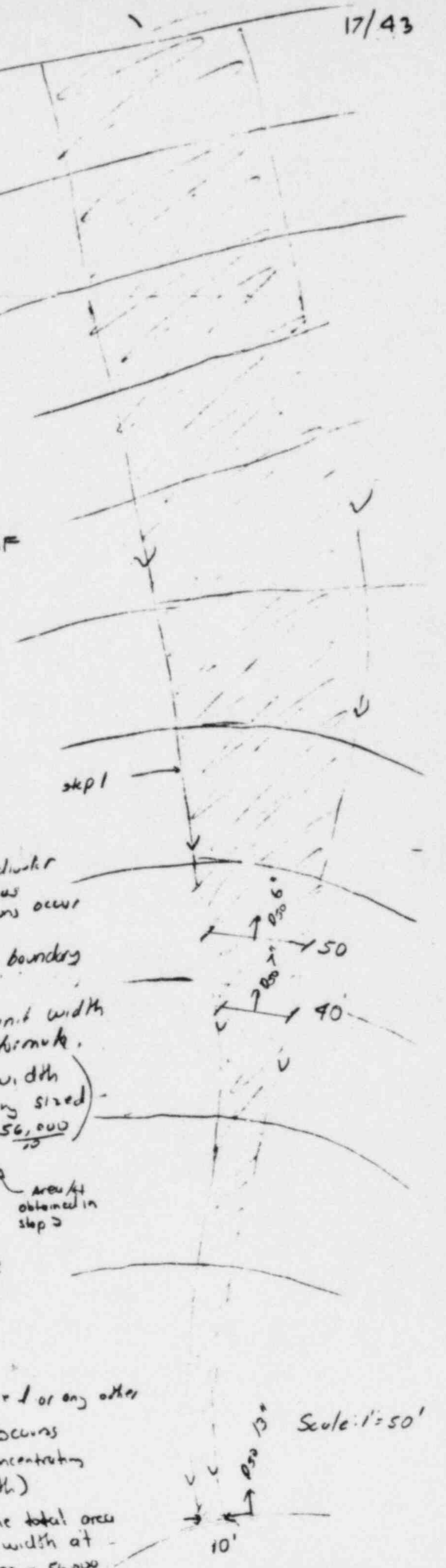
V = 9.55

$t_c = (850/9.55)/60$

= 1.98 min

use $t_c$ = 2.5 or 0 min

FORM 91-005-1 (4/81)




Area 1A-1 = 56,000 SF

This Figure has been copied from Figure 1 and will be used as an example in describing the procedure for determining the rock sizes.

step 1) Draw lines in the direction of flow (perpendicular to the contours) in areas where flow concentrations occur

Step 2 Determine area within boundary of flow lines.

Step 3 Determine area per unit width to use in rational formula. (Area divided by width where rock is being sized) - in this case = $\frac{56,000}{13}$

step 4 - Determine Q = CIA — Area/ft obtained in step 3

step 5 Determine rock size taking into account interstitial flow

step 6 Determine where $D_{50}$ = 6" is required or any other size of interest (in this case it occurs when flow is concentrating onto a 50' width)

For ease of calculations the total area (56,000 SF) was divided by width at point of interest (Ex: Area = $\frac{56,000}{50}$ was used to determine limit of 6" rock). This may result in a slightly

RIPRAP/BAS

18/43

****** FLOW OVER A PLAIN SLOPING BED ******

program run assuming 12" rock

SIDE SLOPE = 8.5 TO 1
FLOW RATE = 6.38 CFS/FEET
ROCK SPECIFIC GRAVITY = 2.7
ROCK ANGLE OF REPOSE = 41
REQUIRED SAFETY FACTOR = 1
MANNINGS 'N' = .04

| DEPTH (FT) | MANNINGS N | VELOCITY (FPS) | FRICTION (DEGREES) | D50 (IN) | SAFETY FACTOR |
|---|---|---|---|---|---|
| 0.659 | 0.040 | 9.678 | 41.000 | 13.389 | 1.00 |

****** FLOW OVER A PLAIN SLOPING BED ******

program run
assuming 13 inch rock ✓

SIDE SLOPE = 8.5 TO 1
FLOW RATE = 6.17 CFS/FEET
ROCK SPECIFIC GRAVITY = 2.7
ROCK ANGLE OF REPOSE = 41
REQUIRED SAFETY FACTOR = 1
MANNINGS 'N' = .04

| DEPTH (FT) | MANNINGS N | VELOCITY (FPS) | FRICTION (DEGREES) | D50 (IN) | SAFETY FACTOR |
|---|---|---|---|---|---|
| 0.646 | 0.040 | 9.549 | 41.000 | 13.123 | 1.00 |

Determine extent of 13" Rock required in Area 1A
For example the nearer the top of the pile the less the concentration of flow

TRIAL 1 where flow concentrations occur over 50' the flow is 6.87/5 = 1.37 cfs

note: This is conservative since the actual drainage area occuring at a width of 50' is less than that used to calculate the 6.87 cfs

Assume 6" rock ✓ thickness ≥ 1'

$V = 28(.20)^{.54} = 11.74$

$Q_i = V/12 \times .33 \times 1 = .32$

$Q_o = 1.37 - .32 = 1.05$ cfs

use $n = .035$
angle of repose = 40

TRIAL 2 where flow concentrations occur over 40' the flow is 6.87/4 = 1.72 cfs ✓

Assume 7" rock

$V = 30(.20)^{.54} = 12.58$

$Q_i = .35$

$Q_o = 1.72 - .35 = 1.37$

Trial 3 where flow concentrations occur over 20' the flow is 6.87/2 = 3.44

Assume 9" rock

$V = 33.63(.125)^{.54} = 10.94$ ft/sec

$Q_i = V/12 \times .33 \times 1.5 = .45$

(1.5 = thickness of rock layer)

$Q_o = 3.44 - .45 = 2.99$

****** FLOW OVER A PLAIN SLOPING BED ******



SIDE SLOPE = 6 TO 1
FLOW RATE = 1.05 CFS/FEET
ROCK SPECIFIC GRAVITY = 2.7
ROCK ANGLE OF REPOSE = 40
REQUIRED SAFETY FACTOR = 1
MANNINGS 'N' = .038

| DEPTH (FT) | MANNINGS N | VELOCITY (FPS) | FRICTION (DEGREES) | D50 (IN) | SAFETY FACTOR |
|---|---|---|---|---|---|
| 0.195 | 0.038 | 5.384 | 40.000 | 6.097 | 1.00 |

RIPRAP/BAS

****** FLOW OVER A PLAIN SLOPING BED ******

22/43

| | | |
|---|---|---|
| SIDE SLOPE | = | 6 TO 1 |
| FLOW RATE | = | 1.37 CFS/FEET |
| ROCK SPECIFIC GRAVITY | = | 2.7 |
| ROCK ANGLE OF REPOSE | = | 40 |
| REQUIRED SAFETY FACTOR | = | 1 |
| MANNINGS 'N' | = | .039 |

| DEPTH (FT) | MANNINGS N | VELOCITY (FPS) | FRICTION (DEGREES) | D50 (IN) | SAFETY FACTOR |
|---|---|---|---|---|---|
| 0.232 | 0.039 | 5.895 | 40.000 | 7.264 | 1.00 |

****** FLOW OVER A PLAIN SLOPING BED ******

SIDE SLOPE = 8 TO 1
FLOW RATE = 2.99 CFS/FEET
ROCK SPECIFIC GRAVITY = 2.7
ROCK ANGLE OF REPOSE = 40
REQUIRED SAFETY FACTOR = 1
MANNINGS 'N' = .038

| DEPTH (FT) | MANNINGS N | VELOCITY (FPS) | FRICTION (DEGREES) | D50 (IN) | SAFETY FACTOR |
|---|---|---|---|---|---|
| 0.396 | 0.038 | 7.506 | 40.000 | 8.742 | 1.00 |

Area 2A ± = 90,500 SF

Concentrating into 15' ∴ Area / unit width = 90,500 / 15 = 6033

Q = CIA

= (1)(53.46)(6033) / 43560

= 7.4 cfs

length from most remote point is = 850' ∴ Assume tc = 2.5

⇒ %/hr = 27.5%

I = (.275)(8.1)(60/2.5) = 53.46

Assume 14" ROCK : thickness ⇒ 2'

V = (41.75)(.118)^.54 = 13.17

Qi = 13.17 / 12 × .33 ft = .72

Qo = 7.40 − .72 = 6.68

V = 9.86  tc = (850 / 9.86)/(60) = 1.44 use tc = 2.5 min

Determine extent of 14" Rock required in Area 2A  Try 100 of a 5:1 slope = 100 / 15 = 6.66

TRIAL #1

Q = 7.4 / 6.66 = 1.11 cfs

V = 5.08  tc = (850 / 5.08)/60 = 2.79

Assume 6" rock

V = 11.79

Qi = .32

Qo = 1.11 − .32 = .79 cfs/ft

****** FLOW OVER A PLAIN SLOPING BED ******

| | | |
|---|---|---|
| SIDE SLOPE | = | 8.5 TO 1 |
| FLOW RATE | = | 6.68 CFS/FEET |
| ROCK SPECIFIC GRAVITY | = | 2.7 |
| ROCK ANGLE OF REPOSE | = | 41 |
| REQUIRED SAFETY FACTOR | = | 1 |
| MANNINGS 'N' | = | .04 |

| DEPTH (FT) | MANNINGS N | VELOCITY (FPS) | FRICTION (DEGREES) | D50 (IN) | SAFETY FACTOR |
|---|---|---|---|---|---|
| 0.678 | 0.040 | 9.857 | 41.000 | 13.764 | 1.00 |

RIPRAP/BAS



****** FLOW OVER A PLAIN SLOPING BED ******

SIDE SLOPE = 5 TO 1
FLOW RATE = .79 CFS/FEET
ROCK SPECIFIC GRAVITY = 2.7
ROCK ANGLE OF REPOSE = 40
REQUIRED SAFETY FACTOR = 1
MANNINGS 'N' = .038

| DEPTH (FT) | MANNINGS N | VELOCITY (FPS) | FRICTION (DEGREES) | D50 (IN) | SAFETY FACTOR |
|---|---|---|---|---|---|
| 0.156 | 0.038 | 5.075 | 40.000 | 6.181 | 1.00 |

TRIAL #2 Try 80' of a 5:1 slope
80/15 = 5.33

Q = 7.4/5.33 = 1.38

Assume 2" rock

V = (30)(.20)^.54 = 12.58
Qi = 4/12 × .33 × 1 = .35
Qo = 1.38 - .35 = 1.03

Trial #3 Try 40' of a 7:1 slope
40/15 = 2.67

Q = 7.4/2.67 = 2.77 cfs/ft

Assume 9" rock
V = 33.63 (.143)^.54 = 11.76 ft/sec
Qi = 4/12 × .33 × 1.5 = .49
thickness of rock layer
Qo = 2.77 - .49 = 2.28

# ****** FLOW OVER A PLAIN SLOPING BED ******

SIDE SLOPE = 5 TO 1
FLOW RATE = 1.03 CFS/FEET
ROCK SPECIFIC GRAVITY = 2.7
ROCK ANGLE OF REPOSE = 40
REQUIRED SAFETY FACTOR = 1
MANNINGS 'N' = .039

| DEPTH (FT) | MANNINGS N | VELOCITY (FPS) | FRICTION (DEGREES) | D50 (IN) | SAFETY FACTOR |
|---|---|---|---|---|---|
| 0.185 | 0.039 | 5.555 | 40.000 | 7.361 | 1.00 |

****** FLOW OVER A PLAIN SLOPING BED ******

SIDE SLOPE = 7 TO 1
FLOW RATE = 2.28 CFS/FEET
ROCK SPECIFIC GRAVITY = 2.7
ROCK ANGLE OF REPOSE = 40
REQUIRED SAFETY FACTOR = 1
MANNINGS 'N' = .038

| DEPTH (FT) | MANNINGS N | VELOCITY (FPS) | FRICTION (DEGREES) | D50 (IN) | SAFETY FACTOR |
|---|---|---|---|---|---|
| 0.325 | 0.038 | 7.009 | 40.000 | 8.367 | 1.00 |

**JE** JACOBS ENGINEERING

DATE ______ SUBJECT

SHEET NO. 30 of 43

BY ______ CHKD. ______

JOB NO. ______

Area 3A-1 = 41,250
concentrating into a 30' width o%

Area / unit width =
41,250/30 = 1375

$Q = CIA = \frac{(1)(53.46)(1375)}{43560}$

= 1.69 cfs

length from most remote point = 550'

Assume $t_c$ = 2.5 min

⇒ I = 53.46

Slope ≥ 6:1

TRIAL #1 Assume 10" rock

layer = 1.5'

n = .039

∠ of repose = 41

$V = (36.88)(.1667)^{.54} = 14.01$

$Q_i$ = 4/12 × .33 × 1.5 = .58

$Q_o$ = 1.69 − .58 = 1.11

TRIAL #2 Assume 7" rock

$V = (30)(.1667)^{.54} = 11.4$

$Q_i$ = 4/12 × .33 × 1.5 = .47

$Q_o$ = 1.69 − .47 = 1.22

V = 5.9

$t_c$ = (550/5.9)/60 = 1.55 use $t_c$ = 2.5

FORM 91-006-1 (4/81)

****** FLOW OVER A PLAIN SLOPING BED ******



DURANGO

SIDE SLOPE = 6 TO 1
FLOW RATE = 1.11 CFS/FEET
ROCK SPECIFIC GRAVITY = 2.7
ROCK ANGLE OF REPOSE = 41
REQUIRED SAFETY FACTOR = 1
MANNINGS 'N' = .039

| DEPTH (FT) | MANNINGS N | VELOCITY (FPS) | FRICTION (DEGREES) | D50 (IN) | SAFETY FACTOR |
|---|---|---|---|---|---|
| 0.205 | 0.039 | 5.419 | 41.000 | 6.348 | 1.00 |

****** FLOW OVER A PLAIN SLOPING BED ******

DURANGO

[illegible]

SIDE SLOPE = 6 TO 1
FLOW RATE = 1.22 CFS/FEET
ROCK SPECIFIC GRAVITY = 2.7
ROCK ANGLE OF REPOSE = 39
REQUIRED SAFETY FACTOR = 1
MANNINGS 'N' = .036

| DEPTH (FT) | MANNINGS N | VELOCITY (FPS) | FRICTION (DEGREES) | D50 (IN) | SAFETY FACTOR |
|---|---|---|---|---|---|
| 0.207 | 0.036 | 5.905 | 39.000 | 6.517 | 1.00 |

Determine extent of 7" rock required in area 3A

Try 50 @ 5:1 slope

50/30 = 1.67

1.69/1.67 = 1.01 cfs

Assume 6" rock

V = 11.74

Qi = .32

Qo = 1.01 - .32 = .69

****** FLOW OVER A PLAIN SLOPING BED ******

SIDE SLOPE = 5 TO 1
FLOW RATE = .69 CFS/FEET
ROCK SPECIFIC GRAVITY = 2.7
ROCK ANGLE OF REPOSE = 40
REQUIRED SAFETY FACTOR = 1
MANNINGS 'N' = .038

| DEPTH (FT) | MANNINGS N | VELOCITY (FPS) | FRICTION (DEGREES) | D50 (IN) | SAFETY FACTOR |
|---|---|---|---|---|---|
| 0.144 | 0.038 | 4.807 | 40.000 | 5.699 | 1.00 |

JACOBS ENGINEERING

DATE ______ SUBJECT Erosion Protection SHEET NO. 35 / 43

BY ______ CHKD. ______ SIDE SLOPES JOB NO. ______

WEST SIDE OF PILE (concentrations)

Area 1B = 31,400 SF concentrated over 20

Assuming a $t_c$ of 2.5 min

$$Q = \frac{(53.46)(31{,}400/20)}{43560} = 1.93 \frac{cfs}{ft}$$

$$Slope = \frac{95'}{10} = 9.5 \text{ to } 1$$

1st run without taking into account intersitial flow required $D_{50}$ = 6"

Try 5" rock

$$V = (25)(.105)^{.54} = 7.4$$

$$Q_i = 5/12 \times .33 = .20$$

$$Q_{overland} = 1.93 - .20 = 1.73$$

FORM 91-006-1 (4/81)

****** FLOW OVER A PLAIN SLOPING BED ******

DURANGO

NORTH GULLY EROSION PROTECTION

| | | |
|---|---|---|
| SIDE SLOPE | = | 9.5 TO 1 |
| FLOW RATE | = | 1.93 CFS/FEET |
| ROCK SPECIFIC GRAVITY | = | 2.7 |
| ROCK ANGLE OF REPOSE | = | 39 |
| REQUIRED SAFETY FACTOR | = | 1 |
| MANNINGS 'N' | = | .038 |

| DEPTH (FT) | MANNINGS N | VELOCITY (FPS) | FRICTION (DEGREES) | D50 (IN) | SAFETY FACTOR |
|---|---|---|---|---|---|
| 0.323 | 0.038 | 5.983 | 39.000 | 5.818 | 1.00 |

****** FLOW OVER A PLAIN SLOPING BED ******

DURANGO

NORTH GULLY EROSION PROTECTION

| | | |
|---|---|---|
| SIDE SLOPE | = | 9.5 TO 1 |
| FLOW RATE | = | 1.73 CFS/FEET |
| ROCK SPECIFIC GRAVITY | = | 2.7 |
| ROCK ANGLE OF REPOSE | = | 38 |
| REQUIRED SAFETY FACTOR | = | 1 |
| MANNINGS 'N' | = | .036 |

| DEPTH (FT) | MANNINGS N | VELOCITY (FPS) | FRICTION (DEGREES) | D50 (IN) | SAFETY FACTOR |
|---|---|---|---|---|---|
| 0.292 | 0.036 | 5.916 | 38.000 | 5.303 | 1.00 |

check tc L=600

$t_c = \left(\frac{600}{5.916}\right)/60 = 1.69 < 2.5$ ✓

JACOBS ENGINEERING

DATE ______ SUBJECT ______ 

BY ______ CHKD. ______ JOB NO. ______

Computer results ON EROSION PROTECTION FOR SIDE SLOPES (SEE p for the final rock sizes presented in this set of calculations)

| AREA | WIDTH OF FLOW CONCENTRATION | SIDE SLOPE | Q per ft of width | Rock Size $D_{50}$ |
|---|---|---|---|---|
| 1A-1 | 10 | 8.5:1 | 6.17 | 13" |
| note areas | 50 | 6:1 | 1.05 | 6" |
| 1A-2, & 1A-3 | 40 | 6:1 | 1.37 | 7" |
| should have the | 20 | 8:1 | 2.99 | 9" |
| same rock sizes | | | | |
| 2A-1 | 15 | 8.5:1 | 6.68 | 14" |
| include also | 100 | 5:1 | .79 | 6" |
| 2A-2 | 80 | 5:1 | 1.03 | 7" |
| | 40 | 7:1 | 2.28 | 9" |
| 3A-1 includes | 30 | 6:1 | 1.22 | 7" |
| also 3A-2, | 50 | 5:1 | 1.01 | 6" |
| 3A-3, 3A-4 | | | | |
| 3A-5, 3A-6 | | | | |
| 3A-7 | | | | |
| 1B | 20 | 9.5:1 | 1.73 | 6" |
| SIDE SLOPES without flow concentrations | — | 5:1 | .62 | 6" |

FORM 91-006-1 (4/81)

JE JACOBS ENGINEERING

DATE ________ SUBJECT

BY ________ CHKD. ________



JOB NO. ________

# Summary of ROCK SIZES TO BE USED IN BODO CANYON

ROCK SIZE NO

## Ditches

South Ditch

*A (1) Reach 1 — $19 \le D_{50} \le 24$, $30 \le D_{100} \le 36$ ✓

* (2) Reach 2 — $12 \le D_{50} \le 18$, $18 \le D_{100} \le 24$ ✓

## Gully Erosion

**D (3) South — $24 \le D_{50} \le 28$, $30 \le D_{100} \le 36$ ✓

* (4) Southwest — $10 \le D_{50} \le 15$, $18 \le D_{100} \le 24$

** (5) North — $17 \le D_{50} \le 22$, $26 \le D_{100} \le 30$

## Pile

(6) Top slopes — $0.10 \le D_{15} \le 0.5$, $1.5 \le D_{50} \le 2.0$, $2.0 \le D_{100} \le 3.0$ ✓

SIDE SLOPES

(7) A) $6.0 \le D_{50} \le 8.0$, $8.0 \le D_{100} \le 12$ ✓

*D (8) B) $14 \le D_{50} \le 18$, $24 \le D_{100} \le 30$

FORM 91-005-1 (4/81)

JACOBS ENGINEERING

DATE SUBJECT SHEET NO. 40/43

BY CHKD. JOB NO.

# Summary of ROCK SIZES TO BE USED IN BODO CANYON CONTINUED

Since the majority of these rocks will require blasting, for ease of construction the various size rock will be combined into 5 groups as follows:

**Group 1**

Rocks for Top slopes will be

$.10 \le D_{15} \le .5$
$1.5 \le D_{50} \le 2.0$
$2.0 \le D_{100} \le 3.0$

**Group 2**

Rocks for Side Slopes (A)

$6.0 \le D_{50} \le 8.0$
$8 \le D_{100} \le 12$

**Group 3**

Rocks for South ditch - reach 2 & Southwest Gully Erosion

$12 \le D_{50} \le 18$
$18 \le D_{100} \le 24$

**Group 4**

Rocks for south Ditch - reach 1, north gully erosion and sides Slopes (B)

$19 \le D_{50} \le 24$
$30 \le D_{100} \le 36$

**Group 5** Rocks for South Gully Erosion

$24 \le D_{50} \le 28$
$30 \le D_{100} \le 36$

FORM 91-005-1 (4/81)

**JE** JACOBS ENGINEERING

DATE ________ SUBJECT ________ SHEET NO. 41/43

BY ______ CHKD. ______ JOB NO. ______

## SUMMARY OF ROCK SIZES TO BE USED IN BODO CANYON

Based upon results presented on pages __ to __ there will also be a transition zone from group 2 rocks to group 4 rocks as shown in red on figure 1.

Rock shall also be extended 20' feet from the embankment toe except in the vicinity of the south ditch. [This is based upon information presented in Appendix A of the Disposal Site Characterization Report for Bodo Canyon which indicated that potential rates of hillslope erosion are from 10 to 20 feet per 1000 years with no rock armoring. Therefore 20 feet of erosion protection extended past the toe of the pile should be ample protection for a 1000 years.

FORM 91-006-1 (4/81)

The potential for the occurance of any hydraulic jumps on the revised Bodo Canyon Pile is minimal. However in response to NRC comments, calculations will be presented herein for those areas where an hydraulic jump would most likely occur.

1) North Drainage area – the 5:1 side slopes of the pile near the north drainage concentrates its flows onto the North Gully erosion blanket which is designed at approx. 11:1 slopes

Examining Area 3A-1 at the toe of the pile on the 5:1 side slopes the flow is 1.22 cfs with a depth of .207' (see calcs for side slopes) If the slope was changed to 11:1 the depth of flow would be .231 ft. deep ——

the critical depth is calculated as follows $y_c = \left(\frac{q^2}{g}\right)^{1/3}$ where q is flow per ft of width

$$y_c = \left(\frac{1.11^2}{32.2}\right)^{1/3} = .33 \text{ ft}$$

since the depth of flow at a 11:1 slope is less than .33 ft a hydraulic jump will not occur.

2) At all other locations the slopes at the toe of the pile is about the same as the side slopes of the pile itself and the runoff will continue as sheet flow and no hydraulic jumps effecting the pile will occur

****** FLOW OVER A PLAIN SLOPING BED ******

SIDE SLOPE = 11 TO 1
FLOW RATE = 1.12 CFS/FEET
ROCK SPECIFIC GRAVITY = 2.7
ROCK ANGLE OF REPOSE = 35
REQUIRED SAFETY FACTOR = 1
MANNINGS 'N' = .035

| DEPTH (FT) | MANNINGS N | VELOCITY (FPS) | FRICTION (DEGREES) | D50 (IN) | SAFETY FACTOR |
|---|---|---|---|---|---|
| 0.031 | 0.035 | 4.839 | 35.000 | 3.600 | 1.00 |

**ADVANCED SYSTEMS DIVISION ALBUQUERQUE OPERATIONS**

TO: RRager

FROM: PDarr *PSd*

DATE: May 8, 1985

SUBJECT: Durable Rock Source - Durango

On Thursday, May 2, 1985, I was in Durango, Colorado for the purpose of locating areas that could be used as a source for large diameter, durable rock.

I met with Ron Pettigrew of Burnett Construction, a large general contractor in Durango, to discuss the availability of large diameter, durable rock sources in the Durango area. Ron tells me that Burnett Construction and Animas Aggregate (a local sand and gravel operator) have gravel pits in the Animas River Valley, north of Durango, that yield this type material (8 in. to 20 in. diameter). The locations of these gravel pits are in a 4.5 mile stretch along the Animas River, north of Durango, between the Trimble Bridge and Bakers Bridge (Figure 1).

Apparently, past fluvial conditions have occurred upstream of the present Trimble Bridge that created an area along the ancient Animas River that acted as a distilling basin where large diameter rock dropped out of the flow regime of the river. Thirty feet or more of sandy gravel to bouldery alluvium is present in this 4.5 mile stretch of river. According to Ron, pilings driven for a bridge in this area went down to 70 feet and still did not encounter bedrock.

The composition of this alluvium appears to be quartzites, granites with some limestones, sandstones and siltstone. All but the last two rock types would be durable enough for use as riprap.

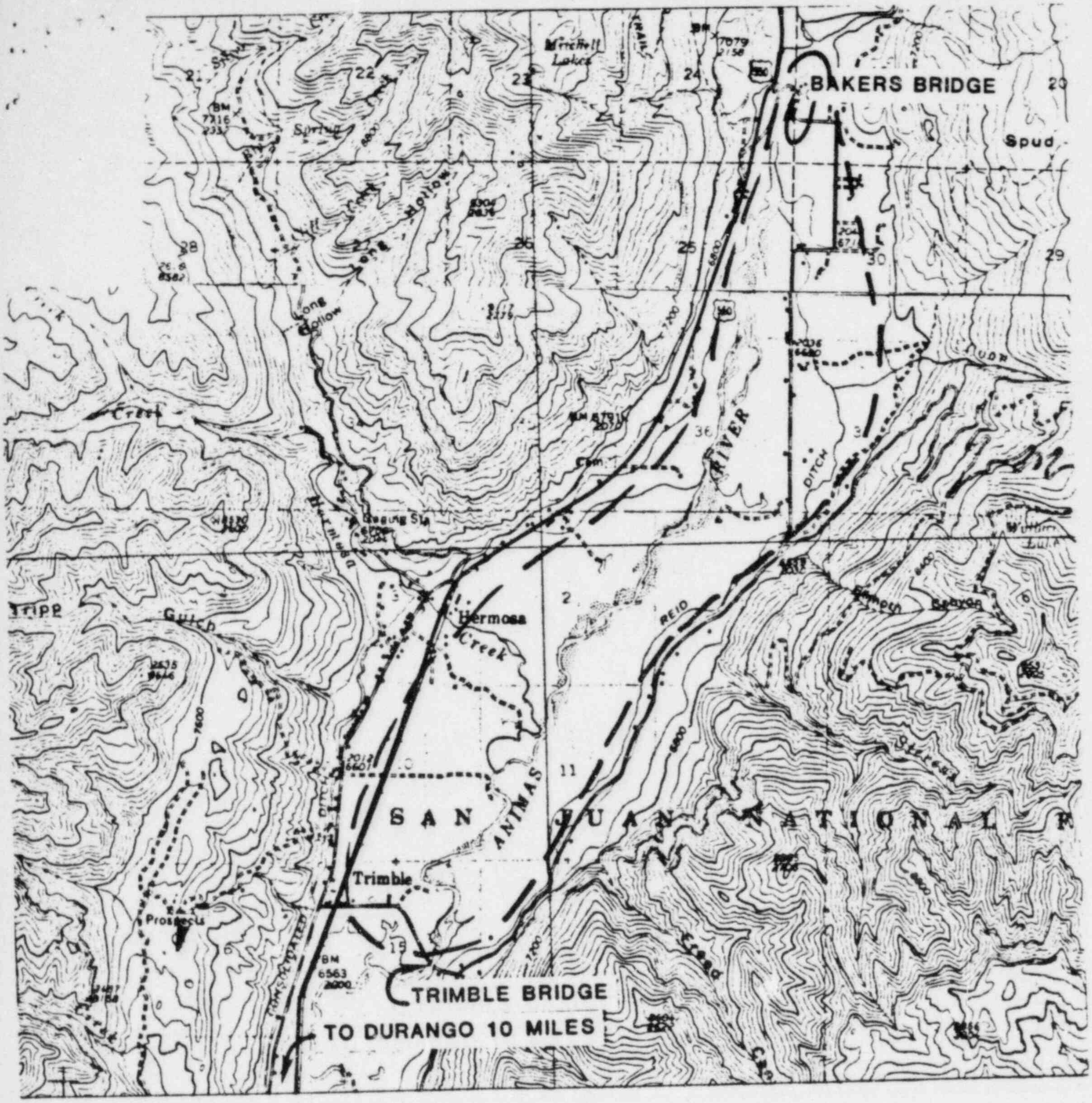
The probability of finding the required quantity of oversized material in a pit opened up to provide all the required gravel products (especially 8+in. material) for the engineering design is not likely.

Other potential areas for oversized rock are to be found south of Durango, on Florida Mesa, along the east side of the Animas River (Figure 2). Several gravel pits are located on this mesa which show large, 8+in. diameter, material in the sidewalls of the excavated pits.

PD/11

cc: KAgogino
GParker

**JACOBS WESTON TEAM**




DASHED LINE INDICATES AREA
WHERE LARGE DIAMETER ROCK
IS AVAILABLE.

FIGURE 1
LARGE DIAMETER BORROW MATERIAL
DURANGO, COLORADO

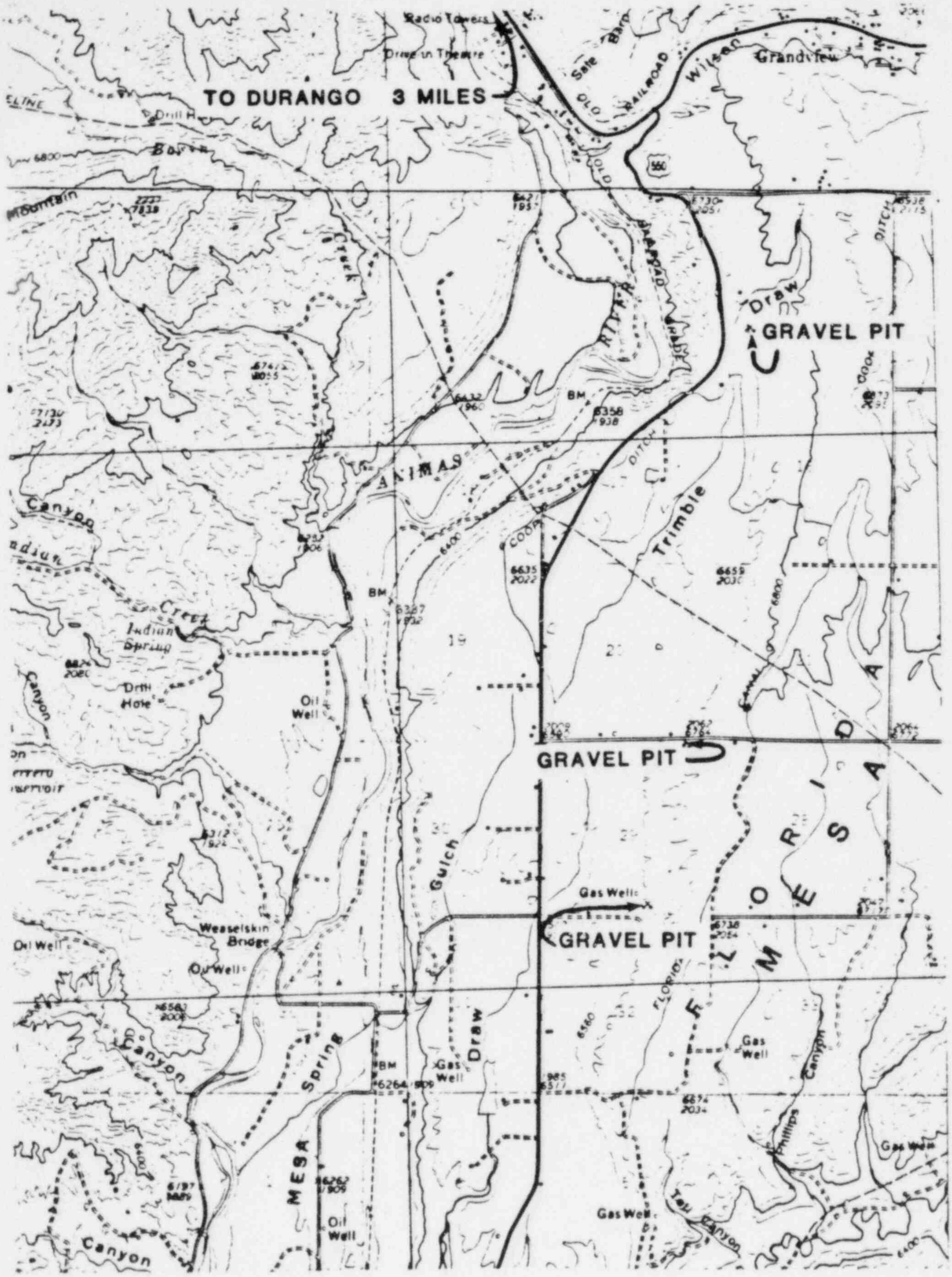



FIGURE 2
LARGE DIAMETER BORROW MATERIAL
DURANGO, COLORADO

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON-KNUDSEN COMPANY
UMTRA PROJECT
180 HOWARD ST. SAN FRANCISCO, CA 94105

4005-DUR-L-01-00367-00

9 September 1985

Gary Parker
Jacobs Engineering Group, Inc.
Advanced Systems Division
5301 Central Avenue, N.E., Suite 1700
Albuquerque, NM 87108

Dear Mr. Parker:

Enclosed is a copy of the "Durango Riprap Source Investigation Report," MKE Document No. 4005-DUR-I-01-00278-00, which you and Fred Feliz discussed earlier.

Should you have any questions before Fred returns from vacation on 16 September, please feel free to contact me.

Very truly yours,

Edward C. Tom
Task Engineer

ECT:tmd

Enclosure

cc w/enclosure: J. G. Oldham

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON-KNUDSEN COMPANY

# UMTRA PROJECT

# INTER-OFFICE CORRESPONDENCE

| | |
|---|---|
| TO: T. R. Wathen | DATE: 5 August 1985 |
| | DOC. NO.: 4005-DUR-I-01-00278-00 |
| LOCATION: San Francisco | FROM: F. C. Kintzer |
| SUBJECT: UMTRA PROJECT - DUR Trip Report, Riprap Source Investigation | LOCATION: San Francisco |
| | FCK |

From 23 July through 26 July 1985, I was in Durango for the purpose of locating and confirming sources of riprap and gravel material for erosion control.

The various agencies and people listed in Table 1 were contacted, not in the order listed. Particularly informative individuals were Wayne Dunn, Animas Ranger District; Bill Ehler, U.S.B.R.; and Ron Pettigrew, Burnett Construction Co. Numerous gravel pits and potential quarry locations were inspected as described briefly in Table 2. Pertinent laboratory test results obtained from the U.S.B.R., Colorado D.O.H., and two aggregate companies are summarized in Table 3 and compiled in Appendix II.

Three bucket samples consisting of 12-inch to 3-inch sized rock blocks were collected for laboratory testing:

Sample 1: Dark gneissic quartz diorite from Chris Park Campground area, see Map 1, Apppendix I.

Sample 2: Lightly to moderately cemented sandstone from Bodo Canyon, see Map 2.

Sample 3: Moderately cemented sandstone from Wildcat Canyon, see Map 3.

Of these only Sample 1 is expected to meet durability criteria established for the Canonsburg UMTRA site (Reference Document No. 3093-CAN-K-01-01365-01). Samples were not collected at the other sites listed in Table 2 for one or more of the following reasons: the site had been ruled out for quarrying for political reasons (10. Vallecito), permission to trespass was not readily obtainable (5. Rockwood-Shalona and 9. La Plata Canyon), or haul distance or road conditions appeared to be prohibitive (8. Lime Creek and 11. Barlow Creek).

## Summary of Findings

1. The light colored sandstones that are exposed on Smelter Mountain, all along the Animas Valley near Durango, and in Wildcat Canyon are unlikely to meet durability criteria.

2. The gravels and cobbles dredged from local pits on the Animas River are sufficiently durable. The quantities available are more than sufficient to provide the approximate 155,000 c.y. of coarse gravel required according to the Draft RAP, Appendix B.

3. Existing aggregate pits do not recover enough riprap sized boulders to supply the estimated 27,000 c.y. of mean 6- to 8-inch and 15- to 17-inch material required. The combined resources of all available producers appear to be insufficient to supply this quantity.

4. Numerous sources of durable rock exist in the area. However, each of the sites identified in Table 2 presents some non-technical obstacle to quarry development.

5. La Plata Canyon is particularly attractive because suitable rock is abundant, the haul distance and conditions are favorable, and the route is sparsely populated and away from resorts and developments. However, Forest Service personnel foresee opposition from local private property owners.

6. Areas to the north of the Animas Valley such as Rockwood and Chris Park contain excellent rock, but public sentiment is likely to be against quarry development and cooperative property owners have not yet been identified.

7. Vallecito and Barlow Creek appear to be unfeasible.

8. Lime Creek may be unfeasible because of rough forest road access but the rock is excellent for riprap. Excavation of talus slopes would be difficult.

Recommendations

1. Both Burnett Construction Co. and Animas Aggregates, Inc. dredge pits are recommended as sources of durable coarse gravel and cobbles. Dry land pits are not recommended.

2. Rock of suitable quality for quarrying is present on private property and on U.S. Forest Service land in La Plata Canyon and just north of the Animas River Valley near Rockwood. Government officials should be contacted regarding quarry permitting possibilities. Cooperative landowners should be sought.

3. The cost and construction feasibility of improving the road access to the Lime Canyon site should be studied.

4. Pending confirmation with laboratory tests, it is thought that the local light brown sandstones will not be recommended for use as riprap.

5. When candidate hard rock quarry sites are identified, samples should be taken according to ASTM D75 and the following minimum suite of tests should be performed:

   - Specific gravity and absorption - ASTM C127
   - Los Angeles Abrasion - ASTM C131
   - Sodium Sulfate Soundness - ASTM C88
   - Petrographic Examination - ASTM C295

6. Freeze/thaw testing according to AASHTO Test 103 shall be used as an auxiliary test. It is thought to be a good guide to weathering particularly at high altitude, but data for establishing project standards and comparing test results have not been assembled.

F C Kintzer By FJ Feliz 8/6/85

F. C. Kintzer

FCK:FJF:kfb

Attachments

Table 1

LIST OF CONTACTS

1. Agency: U.S. Bureau of Reclamation
Upper Colorado Region

Names: Jerry Robins and Bill Ehler, Geologists
Don Moomaw, Environmentalist

Address: 635 2nd Avenue, Durango

Telephone: (303) 247-0247

Notes: Obtained local geologic information and potential quarry rock test data that had been assembled in late 50's for feasibility study of Animas-La Plata Project. Interest in this project is renewed and one feature, the Ridges Basin Reservoir, would be located in a drainage just to the south of Bodo Canyon. Also discussed the Dolores Project, McPhee Dam, and availability of quarry sties.

2. Agency: U.S. Forest Service
San Juan National Forest

Names: Wayne Dunn, Animas Ranger District, Durango
Dick Hepler, Geologist for all districts
Dick Bell, Bayfield Ranger District, Bayfield

Address: Federal Building, Camino Del Rio, Durango

Notes: Discussed sources of durable riprap in the region. They concurred that the political/environmental climate today would make it difficult to quarry. Timber sales have been stopped by public outcry. All of the good hard rock quarry opportunities are on Forest Service land and tied up or restricted by private property. In La Plata Canyon land ownership and boundaries are contested among U.S. Forest Service, wealthy private owners, and hostile miners. At Lime Creek talus rock is available and being sold for $10/ton although there are few takers because of difficult haul road. See notes on Table 2 and Map 4, Appendix I. Rule out Vallecito area for quarry sites. Relay Creek in the same area also has available talus rock but it is softer sandstone. Discussed Barlow Creek quarry used for Dolores Project, 100 miles away. They suggested contacting Bob Kershaw, B.L.M., Durango but he was out for the week. Ted Lemay is the head forester of the district. He is the person to contact regarding permission to quarry or improve Forest Service roads.

3. Agency: Colorado Dept. of Highways

Name: Walt Walker, Head of Materials Lab

Location: 6th Street, Durango

Telephone: (303) 259-1241

Notes: For riprap Colorado D.O.H. only specifies S.G. greater than 2.25. No riprap test records are available. River bank riprap along the Animas River in town was quarried from Bodo Canyon near sample location #2 in 1976. The S.G. was reportedly greater than 2.35. Obtained test data for concrete aggregate from various pits used on D.O.H. pavement jobs.

4. Company: Burnett Construction Co.

Name: Ron Pettigrew

Address: 999 E. 6th Street, Durango

Telephone: (303) 247-2172

Notes: Toured Burnett's various gravel pits both river dredging and dry land, and discussed production.

5. Company: Animas Aggregates, Inc.

Name: Jack Williams

Location: Hwy. 550, 11 miles north of Durango

Telephone: (303) 247-2707

Notes: Visited river dredge pit and plant, and discussed production.

6. Company: C&J Gravel Products

Name: Manager's name unknown

Location: Hwy. 160 east of Hwy. 550 intersection, 5 miles south of Durango

Telephone: (303) 385-4112

Notes: Visited dry land pit, observed small scale production. Discussed with manager by phone.

7. Company: TAC

Name: Paul Darr, Geologist

Location: Albuquerque

Telephone: (505) 846-4030

Notes: Phone contact, discussed local geology, origin of gravels in river valley and mesa sites, probable durability of local sandstone, and possible contacts at U.S.B.R. and Colorado D.O.H.

8. Agency: U.S. Bureau of Land Management

Name: Bob Kershaw

Location: Durango

Telephone: (303) 247-4082

Notes: Contacted by phone, will send copies of maps showing B.L.M. properties and mineral rights in Durango area.

Table 2

NOTES ON POTENTIAL RIPRAP SOURCES

1. Name: Bar-D and Knupple Pits

Operator: Burnett Construction Co.

Rock Type: Various hard rocks including quartzite, gneiss, and granite.

Comments: These two river dredge pits produce high quality well-rounded cobbles for aggregate plus an estimated 5% material larger than 15-inches and 20% larger than 8-inches. Apparently capable of large volume production, but short supply of riprap sized bulders. Sand is dredged at Trimble Lane plant and utility gravel is excavated at dry land pits.

2. Name: Animas Pit #1

Operator: Animas Aggregates, Inc.

Rock Type: Various hard rocks including quartzite, gneiss, and granite.

Comments: River dredge pit near the above pits and essentially the same proudct. Total annual production has been about 100,000 cu. yd. Short supply of riprap sized boulders.

3. Name: Dry Land Pits

Operators: Various and some abandoned

Rock Type: Various hard rocks as above plus additional admixture of weak to very weak sandstones, siltstones, and conglomerates.

Comments: Not recommended for project because of small production capability and presence of weak rock types. Weak rocks do not generally influence the available lab test results because aggregate samples are crushed and washed before testing.

4. Area: Chris Park Campground

Ownership: U.S. Forest Service adjacent to Tamarron Resort.

Rock Type: Dark gneissic quartz diorite

Test Sample: #1

Comments: Excellent rock similar to last item in Table 3. Permit to quarry unlikely because of proximity to private resort and campground. See Map 1, Appendix I.

Haul Distance: 25 miles

Quantity of Rock: Sufficient

5. Area: Rockwood - Shalona Lake

Ownership: Various private parties, several high-priced development tracts, railroad right-of-way.

Rock Type: Various hard rocks including pink coarse-grained granite, limestone, and others.

Comments: Excellent rock , several were tested by U.S.B.R. (see Table 3). In addition brown sandstone of apparently durable quality outcrops all along the west side of County Road 250 and the railroad (see Map 1, Appendix I) but it will not be suitable as riprap because fractures are closely spaced throughout the formation.

Haul Distance: 21 miles

Quantity: Probably sufficient

6. Area: Bodo Canyon, above raffinate ponds

Ownership: Hecla

Rock Type: Sandstone, moderately cemented

Test Sample: #2

Comments: Rock is not very dense or durable. Colorado Dept. of Highways used this rock as river bank riprap near the junction of Highways 550 and 160 in Durango. No test results are available, S.G. is greater than 2.35. See Map 2. The riprap has been in place since 1976 and is weathering and degrading visibly.

Haul Distance: On site

Quantity: The required quantity of rock probably could be obtained by highwall excavation and removal of a large amount of waste rock and overburden.

7. Area: Wildcat Canyon

Ownership: Unknown

Rock Type: Sandstone, moderately cemented

Test Sample: #3

Comments: Rock is similar to the sandstone in Bodo Canyon, item 6 above. Available quantity is clearly sufficient. Similar rocks may lie at shallow depth on the south slope of Smelter Mountain. See Map 3.

Haul Distance: 5 miles

Quantity: Sufficient

8. Area: Lime Creek

Ownership: U.S. Forest Service

Rock Type: Gneiss

Comments: Excellent rock is available for sale from Forest Service land. It consists of large talus blocks piled steeply along the canyon wall. Access road is steep 6-mile downgrade from Highway 550. Road would have to be rebuilt at great expense because of precipitous terrain. In addition excavating talus slope would be difficult. See Map 4.

| | |
|---|---|
| Haul Distance: | 40 miles, after the first 6 miles haul all downhill on 550 to Durango |
| Quantity: | Probably sufficient |

9. Area: La Plata Canyon

| | |
|---|---|
| Ownership: | Various, U.S. Forest Service, patented and unpatented mining claims, some private land. |
| Rock Type: | Diorite, quartzite, and other hard rocks. |
| Comments: | Excellent rock is present north of the community of La Plata. Access is on good Forest Service roads, but several miles of road would have to be developed. Property boundaries are reportedly unsettled and there is some controversy. This may be an obstacle to opening a quarry. See Map 5. |
| Haul Distance: | 22 miles, all downhill through unpopulated land. |
| Quantity: | Sufficient |

10. Area: North end of Vallecito Reservoir

| | |
|---|---|
| Ownership: | Private, U.S. Forest Service, National Wilderness |
| Rock Type: | Banded gneiss and quartzite |
| Comments: | Excellent rock was quarried here in the 50's for the riprap facing of Vallecito Dams (see Table 3). However, the degree of private development and political climate wouuld undoubtedly prevent opening a quarry. The Forest Service has been prevented from selling timber here because of public outcry. |
| Haul Distance: | 30 miles through numerous small resort towns |
| Quantity: | Sufficient |

11. Area: Barlow Creek near Rico

Ownership: U.S. Forest Service

Rock Type: Igneous, excellent

Comments: Probably not feasible because of distance, but rock is excellent and available from Forest Service land. This quarry was worked recently for construction of McPhee Dam, Dolores River Project, U.S.B.R.

Haul Distance: 100 miles, through Dolores and Mancos

Quantity: Sufficient

TABLE 3
SUMMARY OF TEST RESULTS
IN APPENDIX II

(Sheet 1 of 2)

| Agency | Source | Material | S.G. (SSD) | Absorption (%) | Sodium Sulfate Soundness | L.A. Abrasion (%) | Freeze Thaw** |
|---|---|---|---|---|---|---|---|
| Colo. D.O.H. | Ewing Pit (dry land), 1972 | Various rock types 1 1/2"-3/4" | 2.66 | 1.4 | 2.0 | 28.3 | — |
| Colo. D.O.H. | Animas Aggregate Pit (river dredge), 1978 | Various rock types | | | | 23.5 | — |
| | | 1 1/2"-3/4", 50% | 2.64 | 1.1 | 1.5 | | |
| | | 3/4" - #4, 50% | 2.70 | 0.6 | — | | |
| Colo. D.O.H. | Animas Aggregate Pit (river dredge), 1983 | Various rock types | | | | | |
| | | 1 1/2"-3/4", 50% | 2.74 | 0.45 | — | 23.2 | — |
| | | 3/4" - #4, 50% | 2.71 | 0.58 | — | | — |
| Colo. D.O.H. | Burnett Construction*, 1977 | 3/4" - #4 | 2.62 | 1.2 | — | 22.9 | — |
| Colo. D.O.H. | Burnett Construction*, 1978 | Various rock types | | | | | |
| | | 1 1/2"-3/4", 40% | 2.64 | 1.2 | 1.10 | 23.1 | — |
| | | 3/4" - #4, 60% | 2.64 | 1.0 | — | | |
| Colo. D.O.H. | Burnett Construction*, 1980 | Various rock types | | | | | |
| | | 2"-3/4", 50% | — | — | — | 23.7 | — |
| | | 1" - #4, 50% | — | — | | | |
| — | Burnett Construction*, 1985 | Various rock types 1 1/2"-3/4" | 2.65 | 0.86 | 0.00 | 22.0 | — |
| — | Animas Aggregate Pit, 1983 | Various rock types 1" | 2.71 | 0.7 | — | 20.2 | — |

TABLE 3

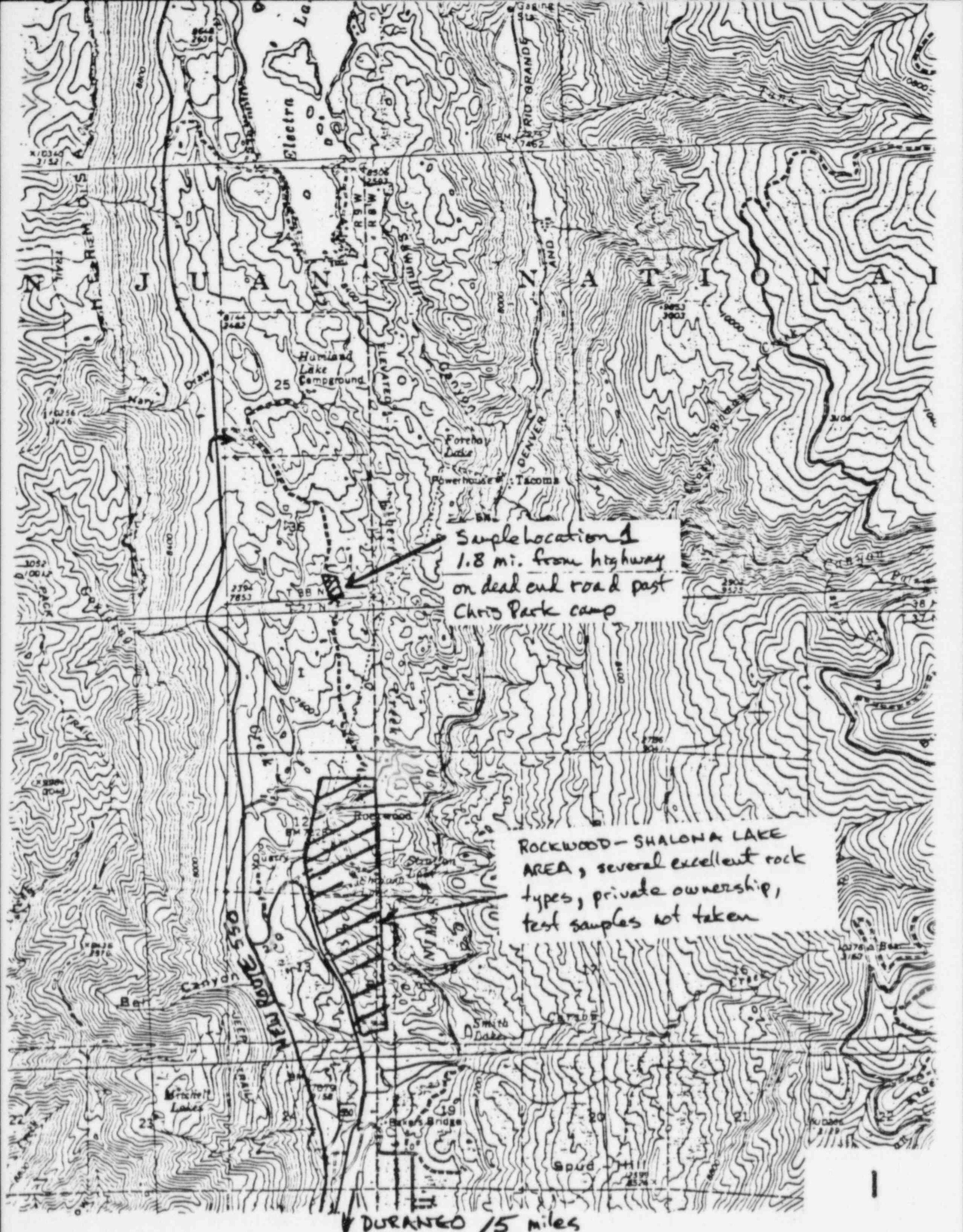
(Sheet 2 of 2)

| Agency | Source | Material | S.G. (SSD) | Absorption (%) | Sulfate Soundness | L.A. Abrasion (%) | Freeze Thaw** |
|---|---|---|---|---|---|---|---|
| U.S.B.R. | Vallecito Dam Quarry, 1958 | Quartzite 3"-1 1/2" | 2.71 | 0.2 | 1.3 | 26.9 | 0.05 |
| U.S.B.R. | Railroad fill near Rockwood, 1958 | Pink Granite 3"-1 1/2" | 2.66 | 0.2 | 1.9 | 33.2 | 0.03 |
| U.S.B.R. | Near Rockwood, 1958 | Limestone 3"-1 1/2" | 2.70 | 0.2 | 4.7 | 33.8 | 2.1 |
| U.S.B.R. | Railroad cut near Rockwood, 1958 | Black Gneissic Quartz-Monzonite 3"-1 1/2" | 2.92 | 0.1 | 0.4 | 21.3 | 0.05 |

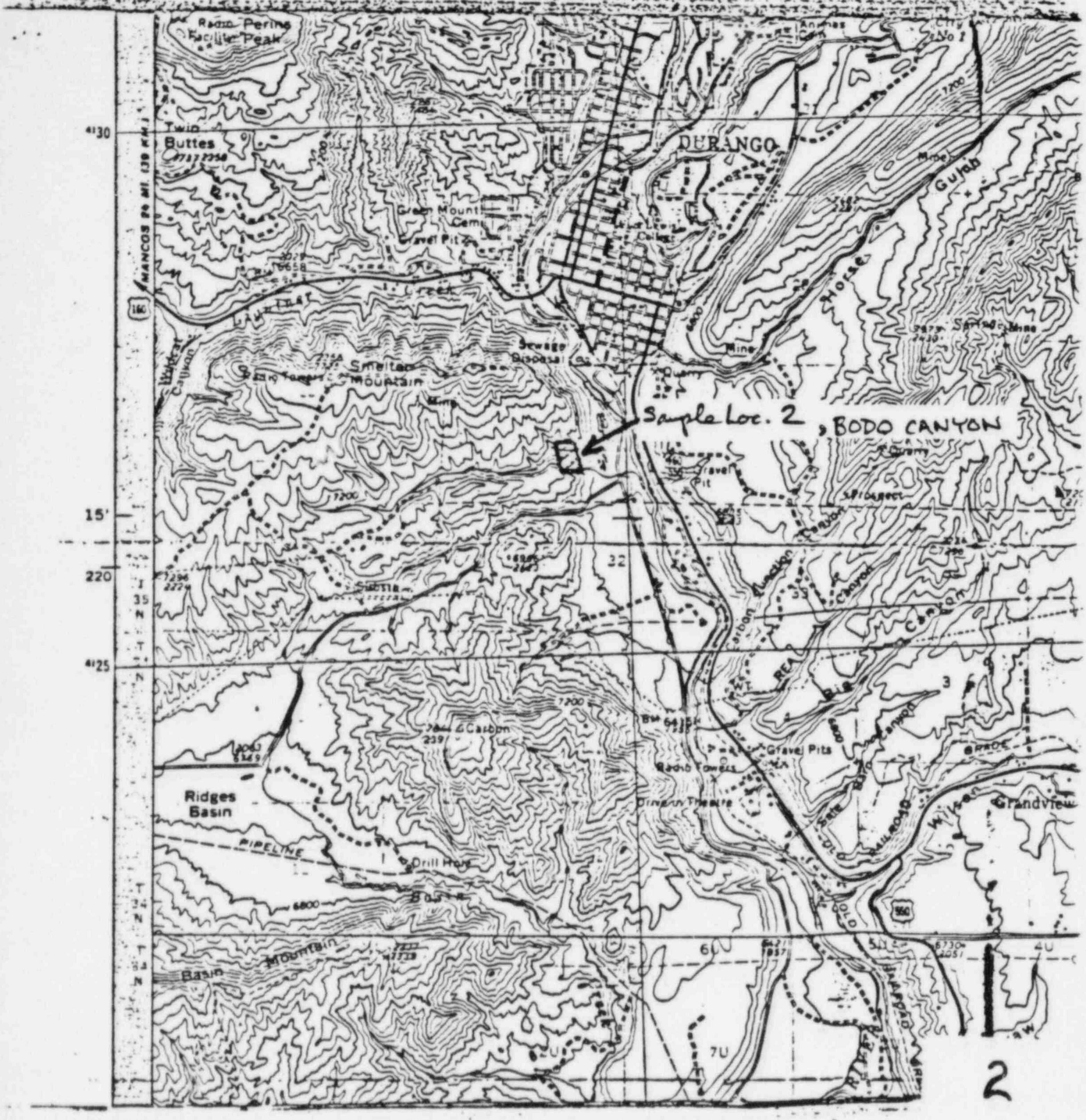
* Location of pit is unspecified. Burnett usually uses river dredge sources for concrete aggregate.
** Freeze/thaw tests were performed on 3-inch rock cubes.

# APPENDIX I

# LOCATION MAPS FOR POTENTIAL QUARRY SITES VISITED


Sample Location 1
1.8 mi. from highway
on dead end road past
Chris Park camp
ROCKWOOD – SHALONA LAKE
AREA, several excellent rock
types, private ownership,
test samples not taken
NEW ROUTE 550
DURANGO 15 miles
Haviland
Lake
Campground
Forebay
Lake
Powerhouse
Tacoma
Rockwood
Quarry
Electra
Bear
Canyon
Spud Hill
Smith
Lakes
Baker's Bridge

1




SCALE 1:50 000

1 ½ 0 1 2 3 4 MILES

3000 0 3000 6000 9000 12000 15000 18000 21000 FEET

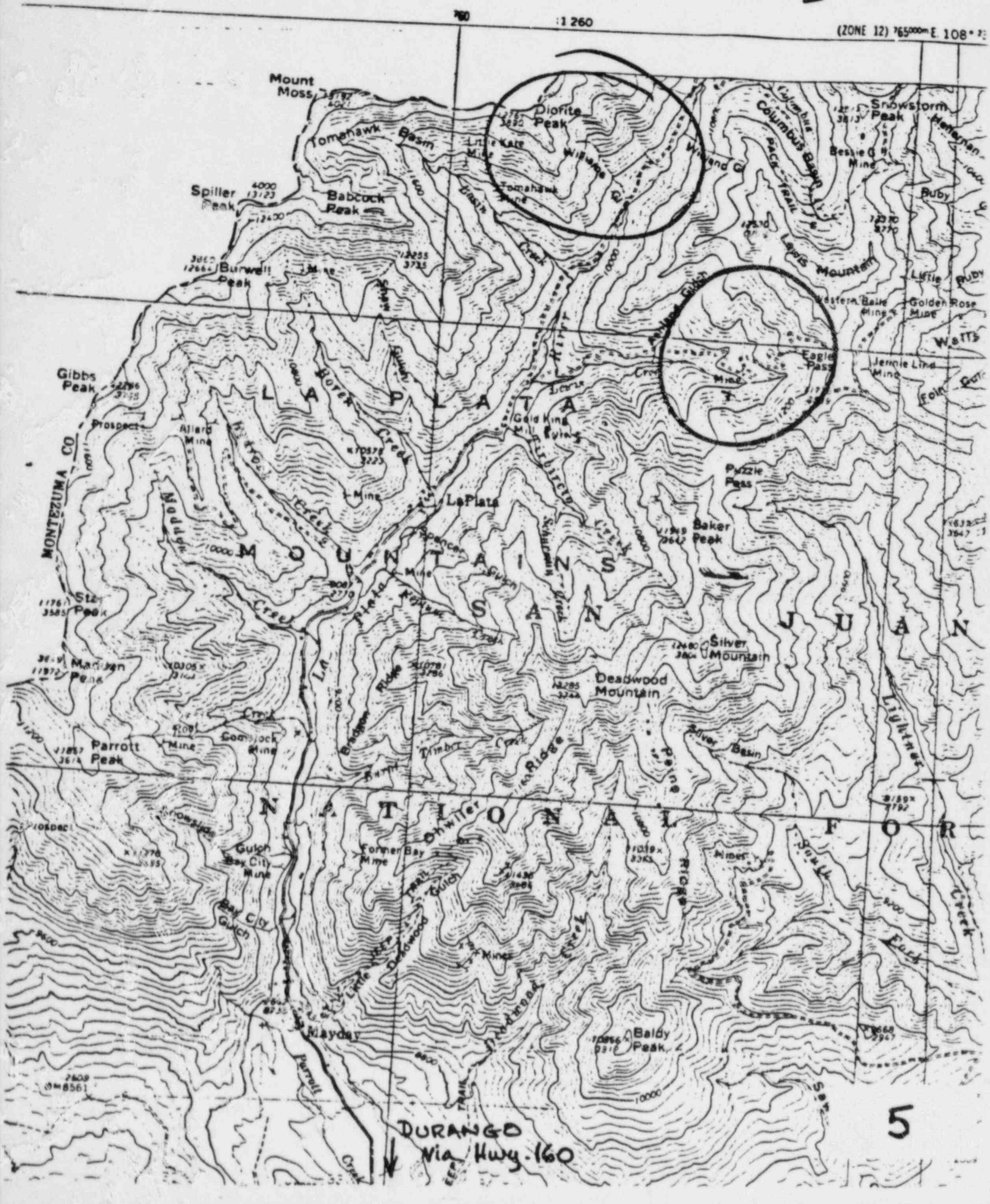
1 .5 0 1 2 3 4 5 KILOMETERS

CONTOUR INTERVAL 80 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929


WILDCAT CANYON, Sample Loc. 3
Bodo Cy
2 miles
RAILROAD
GRADE
Wildcat
PIPELINE
Creek
Ridges
Basin
Basin
Mountain
East Gap
West Gap
Box
Canyon
Cottonwood
Canyon
Indian
Creek
Peabody Well
McCullogh Reservoir
McCullogh
Canyon
McCullogh Spring
Springs Canyon
Sullivan Reservoir
Sawmill
Canyon
Dads Reservoir
Montoya Reservoir
Oil Well
Goat
Gravel Pit
Timber
Mountain
La Posta
3


Jura Knob
Engineer Mountain
Coal Bank Pass
Potato Hill
Potato Lake
Lime Creek Campground
Spring
Gravel Pit
Scout Lake
Boyce Lake
AQUEDUCT
Twilight Peak
DURANGO 27 MI. 43 KM
Lime Creek source area
no sample taken,
tough access, material
is talus slope

LaPlata Canyon Area



# APPENDIX II
# EXAMPLE TEST RESULTS

DIVISION OF HIGHWAYS
STATE OF COLORADO
DOH Form No. 330
Prev. Lab. No. 12
August 1969



Project F 019-2 (14)
Location Durango - South
Fine Aggregate Sample No. B 14137
Coarse Aggregate Sample No. B 14137
Date Submitted 3-17-72

# TEST OF CONCRETE AGGREGATES

Location of Aggregate Source and Supplier:

Fine Aggregate Ewing Pit Dry land pit, abandoned, east side of highway 550 near Durango city limits
Coarse Aggregate Same

## Screen Analysis (FINE AGGREGATE)

| Passing | As Rec'd | | Spec's. |
|---|---|---|---|
| 3/8" | | | 100 |
| #4 | | | 95-100 |
| #8 | | | |
| 16 | | | 45-80 |
| 30 | | | |
| 50 | | | 10-30 |
| 100 | | | 2-10 |
| Fineness Modulus | | | |

| | |
|---|---|
| Wt./cu.ft. (Rodded) | |
| Sp. Gr. Bulk sat. surface dry | |
| % Voids | |
| % Elutriation | |
| % Absorption | |
| Colorimetric | |
| % Soundness (Sodium Sulfate) | |
| Sand Equivalent | |

## Screen Analysis (COARSE AGGREGATE)

| Primary Size | 1 1/2" to 3/4" | to | Combined | Specs. Class A | Specs. |
|---|---|---|---|---|---|
| Passing | | | | | |
| 2½" | | | | | |
| 2" | | | | 100 | |
| 1½" | 100 | | | 95-100 | |
| 1" | 80 | | | | |
| 3/4" | 60 | | | 35-70 | |
| 1/2" | 33 | | | | |
| 3/8" | 22 | | | 10-30 | |
| #4 | 3 | | | 0-5 | |

| | |
|---|---|
| Wt./cu.ft. (Rodded) | |
| Sp. Gr. Bulk sat. surface dry | 2.66 |
| % Voids | |
| % Abrasion | 28.3 |
| % Absorption | 1.4 |
| % Soundness (Sodium Sulfate) | 2.0 |

Non Alkali Reactive
% Passing #200 0.3

Aggregate Size { ____ to ____ ____ % ; ____ to ____ ____ % }

*Indicates deviation from specifications.

Acceptable for concrete agg.

C. R. [illegible]
STAFF MATERIALS [illegible]

cc: Pearson
Croonenberghs-Foster Dutton Bevee (2)
as: 3-31-72

- DIVISION OF HIGHWAYS
STATE OF COLORADO
DOH Form No. 330
Revised: February, 1977

Page 1

Project FC 160-2(22)
Location South of Durango
Fine Aggregate Field Sheet No. C6446
Coarse Aggregate Field Sheet No. C6446
Date Submitted 11-22-78

# TEST OF CONCRETE AGGREGATES

Animas Pit

LOCATION OF AGGREGATE SOURCE AND SUPPLIER:

FINE AGGREGATE Animas — Animas Aggregates Inc. pit 11 miles north of Durango on

COARSE AGGREGATE Same — highway 550

## SCREEN ANALYSIS (Fine Aggregate)

| % Passing | As Rec'd. | | Specs. |
|---|---|---|---|
| 3/8" | 100 | | 100 |
| #4 | 99 | | 95-100 |
| #8 | 77 | | |
| 16 | 54 | | 45-80 |
| 30 | 33 | | |
| 50 | 15 | | 10-30 |
| 100 | 6 | | 2-10 |
| Fineness Modulus | 3.16 | | 2.50-3.25 |

| | | After Washing |
|---|---|---|
| Sp. Gr. (Bulk, Sat. Surface Dry) | 2.64 | |
| % -#200 | **3.39 | 0.99 |
| % Absorption | 1.8 | |
| Colorimetric | 1 | |
| % Soundness (Sodium Sulfate) | 1.93 | |
| Sand Equivalent | ** 73.3 | 95.0 |
| | | 3.29 F.M. |

## SCREEN ANALYSIS (Coarse Aggregate)

| Primary Size | 1 1/2 to 3/4 | 3/4 to #4 | Combined | Specs. A&AZ | Specs. B&D |
|---|---|---|---|---|---|
| Passing | | | | | |
| 2" | | | | 100 | |
| 1½" | 100 | | 100 | 95-100 | |
| 1" | 83* | 100 | 92 | | 100 |
| 3/4" | 16* | 99 | 58 | 35-70 | 90-100 |
| 1/2" | 1 | 68 | 35 | | |
| 3/8" | 0.6 | 37 | 19 | 10-30 | 20-55 |
| #4 | 0.5 | 3 | 2 | 0-5 | 0-10 |
| #8 | | | | | 0-5 |

| | |
|---|---|
| Sp. Gr. Bulk, SSD 3/4" | 2.70 |
| Sp. Gr. Bulk, SSD 1½" | 2.64 |
| % Abrasion | 23.52 |
| % Absorption 3/4" | 0.6 |
| % Absorption 1½" | 1.1 |
| % Soundness (Sodium Sulfate) | 1.50 |

Aggregate Size 1 1/2 to 3/4 50 %
3/4 to #4 50 %

* Indicates Minor deviation from specifications.
**Indicates major deviation from specifications.

cc: Fritts
Morain-Foster ✓
Mayfield(3)

cl 12-07-78

STATE OF COLORADO
DEPARTMENT OF HIGHWAYS
DIVISION OF HIGHWAYS
DOH Form No. 330
Revised: August, 1982

Project FC 160-2(32) & FCU 160-2(33)
Location South of Durango
Fine Aggregate Field Sheet No. 14576
Coarse Aggregate Field Sheet No. 14576
Date Submitted 3/18/83

PAGE 1

# TEST OF CONCRETE AGGREGATES

LOCATION OF AGGREGATE SOURCE AND SUPPLIER:

FINE AGGREGATE Animas #1

COARSE AGGREGATE Same

## SCREEN ANALYSIS (Fine Aggregate)

| % Passing | As Rec'd. | | Specs. |
|---|---|---|---|
| 3/8" | | | 100 |
| #4 | 100 | | 95-100 |
| #8 | 84 | | |
| 16 | 62 | | 45-80 |
| 30 | 38 | | |
| 50 | 15 | | 10-30 |
| 100 | 3 | | 2-10 |
| Fineness Modulus | 2.99 | | 2.50-3.25 |

| | |
|---|---|
| Sp. Gr. (Bulk, Sat. Surface Dry) | 2.66 |
| % -#200 | 0.5 |
| % Absorption | 1.2 |
| Colorimetric | 1.0 |
| % Soundness (Sodium Sulfate) | |
| Sand Equivalent | 88.2 |

## SCREEN ANALYSIS (Coarse Aggregate)

| Primary Size | 1½" to 3/4" | 3/4" to #4 | Combined | Specs. #467 | Specs. #67 |
|---|---|---|---|---|---|
| Passing | | | | | |
| 2" | | | | 100 | |
| 1½" | 100 | | 100 | 95-100 | |
| 1" | 45 | | 73 | — | 100 |
| 3/4" | 4 | 100 | 52 | 35-70 | 90-100 |
| 1/2" | 1 | 62 | 32 | — | — |
| 3/8" | 1 | 30 | 16 | 10-30 | 20-55 |
| #4 | 1 | 1 | 1 | 0-5 | 0-10 |
| #8 | | | | | |

| | |
|---|---|
| Sp. Gr. Bulk, SSD 3/4" | 2.71 |
| Sp. Gr. Bulk, SSD 1½" | 2.74 |
| % Abrasion | 23.2 |
| % Absorption 3/4" | 0.58 |
| % Absorption 1½" | 0.45 |
| % Soundness (Sodium Sulfate) | |

Aggregate Size 1½" to 3/4" 50 %
3/4" to #4 50 %

* Indicates ______ deviation from specifications. ✓
Meets specification requirements for item 601. ✓

cc: Fritts
Shablo-Walker
Andrew
Durfee(2)
lb: 4/11/83

CJD 4-14

4/15

RECEIVED
DIST. 5-DURANGO
APR 12 1983

DIVISION OF HIGHWAYS
STATE OF COLORADO
DOH Form No. 330
Prev. Lab. No. 12
August 1969

cc: Clevenger
Morain-Foster
Mayfield
Sweat (2)
ki 5-23-77

Project DP&F 550-2(8)
Location Hermosa-Rockwood
Fine Aggregate Sample No. C6433
Coarse Aggregate Sample No. C6433
Date Submitted April 27, 1977

Davis Color

# TEST OF CONCRETE AGGREGATES

Location of Aggregate Source and Supplier:

Fine Aggregate Burnett Commercial — pit location unspecified
Durango
Coarse Aggregate Same

## Screen Analysis (FINE AGGREGATE)

| Passing | As Rec'd | | Spec's. |
|---|---|---|---|
| 3/8" | 100 | | 100 |
| #4 | 99 | | 95-100 |
| #8 | 82 | | |
| 16 | 62 | | 45-80 |
| 30 | 35 | | |
| 50 | 11 | | 10-30 |
| 100 | 3 | | 2-10 |
| Fineness Modulus | 3.09 | | |

| | |
|---|---|
| Wt./cu.ft. (Rodded) | - |
| Sp. Gr. Bulk sat. surface dry | 2.64 |
| % Voids | - |
| % Elutriation | 0.9 |
| % Absorption | 1.3 |
| Colorimetric | 1 |
| % Soundness (Sodium Sulfate) | - |
| Sand Equivalent | 86.0 |

## Screen Analysis (COARSE AGGREGATE)

| | Primary Size 3/4 to #4 | to | Combined | Specs. D | Specs. |
|---|---|---|---|---|---|
| Passing | | | | | |
| 2½" | | | | | |
| 2" | | | | | |
| 1½" | | | | | |
| 1" | 100 | | | 100 | |
| 3/4" | 97 | | | 90-100 | |
| 1/2" | 43 | | | | |
| 3/8" | 22 | | | 20-55 | |
| #4 | 1 | | | 0-10 | |

| | |
|---|---|
| Wt./cu.ft. (Rodded) | - |
| Sp. Gr. Bulk sat. surface dry | 2.62 |
| % Voids | - |
| % Abrasion | 22.92 |
| % Absorption | 1.2 |
| % Soundness (Sodium Sulfate) | - |

Aggregate Size { 3/4 to #4 100 %
_____ to _____ _____ %

*Indicates deviation from specifications.

DIVISION OF HIGHWAYS
STATE OF COLORADO
DOH Form No. 330
Revised: February, 1977

Page 1

Project FC 160-2(22) Foster Corp
Location South of Durango
Fine Aggregate Field Sheet No. C6445
Coarse Aggregate Field Sheet No. C6445
Date Submitted 11-20-78

# TEST OF CONCRETE AGGREGATES

LOCATION OF AGGREGATE SOURCE AND SUPPLIER:

FINE AGGREGATE Burnett

COARSE AGGREGATE Burnett

## SCREEN ANALYSIS (Fine Aggregate)

| % Passing | As Rec'd. | | Specs. |
|---|---|---|---|
| 3/8" | | | 100 |
| #4 | 100 | | 95-100 |
| #8 | 84 | | |
| 16 | 66 | | 45-80 |
| 30 | 43 | | |
| 50 | 16 | | 10-30 |
| 100 | 5 | | 2-10 |
| Fineness Modulus | 2.86 | | 2.50-3.25 |

| | |
|---|---|
| Sp. Gr. (Bulk, Sat. Surface Dry) | 2.65 |
| % -#200 | 2.24 |
| % Absorption | 1.1 |
| Colorimetric | 1 |
| % Soundness (Sodium Sulfate) | 0.82 |
| Sand Equivalent | 78.0* |

## SCREEN ANALYSIS (Coarse Aggregate)

| Primary Size | 1 1/2 to 3/4 | 3/4 to #4 | Combined | Specs. A&AZ | Specs. B&D |
|---|---|---|---|---|---|
| Passing | | | | | |
| 2" | | | | 100 | |
| 1½" | 100 | | 100 | 95-100 | |
| 1" | 68* | 100 | 87 | | 100 |
| 3/4" | 9 | 88 | 56 | 35-70 | 90-100 |
| 1/2" | 0.6 | 41 | 25 | | |
| 3/8" | 0.4 | 17 | 10 | 10-30 | 20-55 |
| #4 | 0.2 | 2 | 1 | 0-5 | 0-10 |
| #8 | | | | | 0-5 |

| | |
|---|---|
| Sp. Gr. Bulk, SSD 3/4" | 2.64 |
| Sp. Gr. Bulk, SSD 1½" | 2.64 |
| % Abrasion | 23.14 |
| % Absorption 3/4" | 1.0 |
| % Absorption 1½" | 1.2 |
| % Soundness (Sodium Sulfate) | 1.10 |

| Aggregate Size | |
|---|---|
| 1 1/2 to 3/4 | 40 % |
| 3/4 to #4 | 60 % |

* Indicates Minor deviation from specifications.

cc: Fritts
Morain-Foster
Mayfield(3)

cl 12-14-78

DIVISION OF HIGHWAYS
STATE OF COLORADO
DOH Form No. 330
Revised: February, 1977

Page 1

Project FC 160-2(27)
Location 8th. St. Conn. in Durango
Fine Aggregate Field Sheet No. 03409
Coarse Aggregate Field Sheet No. 03409
Date Submitted Sept. 30, 1980

# TEST OF CONCRETE AGGREGATES

LOCATION OF AGGREGATE SOURCE AND SUPPLIER:

FINE AGGREGATE Burnett Comm.

COARSE AGGREGATE Burnett Comm.

## SCREEN ANALYSIS (Fine Aggregate)

| % Passing | As Rec'd. | | Specs. |
|---|---|---|---|
| 3/8" | 100 | | 100 |
| #4 | 99 | | 95-100 |
| #8 | 85 | | |
| 16 | 67 | | 45-80 |
| 30 | 41 | | |
| 50 | 17 | | 10-30 |
| 100 | 5 | | 2-10 |
| Fineness Modulus | 2.85 | | 2.50-3.25 |

| | |
|---|---|
| Sp. Gr. (Bulk, Sat. Surface Dry) | |
| % -#200 | 1.77 |
| % Absorption | |
| Colorimetric | Clear |
| % Soundness (Sodium Sulfate) | |
| Sand Equivalent | 86.8 |

## SCREEN ANALYSIS (Coarse Aggregate)

| Primary Size | 1½" to 3/4" | 1" to #4 | Combined | Specs. 467 | Specs. 67 |
|---|---|---|---|---|---|
| Passing | | | | | |
| 2" | 100 | | 100 | 100 | |
| 1½" | 100 | | 100 | 95-100 | |
| 1" | 57 | 100 | 78 | | 100 |
| 3/4" | 4 | 90 | 47 | 35-70 | 90-100 |
| 1/2" | 1 | 48 | 24 | | |
| 3/8" | 1 | 27 | 14 | 10-30 | 20-55 |
| #4 | | 3 | 2 | 0-5 | 0-10 |
| #8 | | | | | |

| | |
|---|---|
| Sp. Gr. Bulk, SSD 3/4" | |
| Sp. Gr. Bulk, SSD 1½" | |
| % Abrasion | 23.72 |
| % Absorption 3/4" | |
| % Absorption 1½" | |
| % Soundness (Sodium Sulfate) | |

Aggregate Size 2 to 3/4 50 %
1 to #4 50 %

* Indicates ______________ deviation from specifications.

Meets specification requirements for item 601.

cc: Fritts
Walker
Mayfield
Andrew(2)

lh: 10/7/80

CLIENT: Burnett Construction
PROJECT: Plant Mixes
ATL LAB NO.: 1-08380-85
DATE: June 3, 1985

TABLE NO. 1
AGGREGATE TEST RESULTS

SIEVE ANALYSIS TEST: (ASTM C-136 & C-117 - Cumulative Percent Passing)

| Sieve Size | Sand | ASTM C-33 Specs | Size 8 (3/8") | ASTM C-33 Specs | Size 67 (3/4") | ASTM C-33 Specs | Size 4 (1 1/2") | ASTM C-33 Specs | Size 467 (50/50 Blend) | ASTM C-33 Specs |
|---|---|---|---|---|---|---|---|---|---|---|
| 2" | | | | | | | | 100 | | 100 |
| 1-1/2" | | | | | | | 100 | 90-100 | 100 | 95-100 |
| 1" | | | | | 100 | 100 | 54 | 20-55 | 77 | |
| 3/4" | | | | | 96 | 90-100 | 11 | 0-15 | 54 | 35-70 |
| 1/2" | | | | 100 | 56 | | 1 | | 29 | |
| 3/8" | 100 | 100 | 100 | 85-100 | 28 | 20-55 | 0.8 | 0-5 | 14 | 10-30 |
| No. 4 | 99 | 95-100 | 42* | 10-30 | 4 | 0-10 | | | 2 | 0-5 |
| No. 8 | 83 | 80-100 | 10 | 0-10 | 1 | 0-5 | | | | |
| No. 16 | 66 | 50-85 | 2 | 0-5 | | | | | | |
| No. 30 | 40 | 25-60 | 0 | | | | | | | |
| No. 50 | 14 | 10-30 | | | | | | | | |
| No. 100 | 5 | 2-10 | | | | | | | | |
| No. 200 | 2.4 | | | | | | | | | |
| Material Finer Than No. 200 by Washing | 2.0 | 3, max | 0.7 | 1, max | 0.3 | 1, max | 0.2 | 1, max | | |
| DRY RODDED UNIT WEIGHT: (ASTM C-29) | | | 94.2 | | 95.1 | | 98.8 | | 97.0 | |
| SPECIFIC GRAVITY: (ASTM C-127 & C-128) | 2.64 | | 2.63 | | 2.63 | | 2.65 | | 2.64 | |
| ABSORPTION: (ASTM C-127 & C-128) | 1.6 | | 1.4 | | 1.8 | | 0.86 | | | |
| FINENESS MODULUS: (ASTM C-125) | 2.94 | 2.3-3.1 | | | | | | | | |
| ORGANIC IMPURITIES: | Between Plates 1&2 | Less Than Plate 1 | | | | | | | | |

CLIENT: Burnett Construction
PROJECT: Plant Mixes
ATL LAB NO.: 1-08380-85
DATE: June 7, 1985

TABLE NO. 1 (continued)
AGGREGATE TEST RESULTS

CLAY LUMPS AND FRIABLE PARTICLES: (ASTM C-142)

| | Percent Clay Lumps & Friable Particles by Weight | ASTM C-33 Specifications |
|---|---|---|
| Sand | 0.5 | 3, maximum |
| 3/8" Aggregate | 0 | 10, maximum |
| 3/4" Aggregate | 0 | 10, maximum |
| 1 1/2" Aggregate | 0 | 10, maximum |

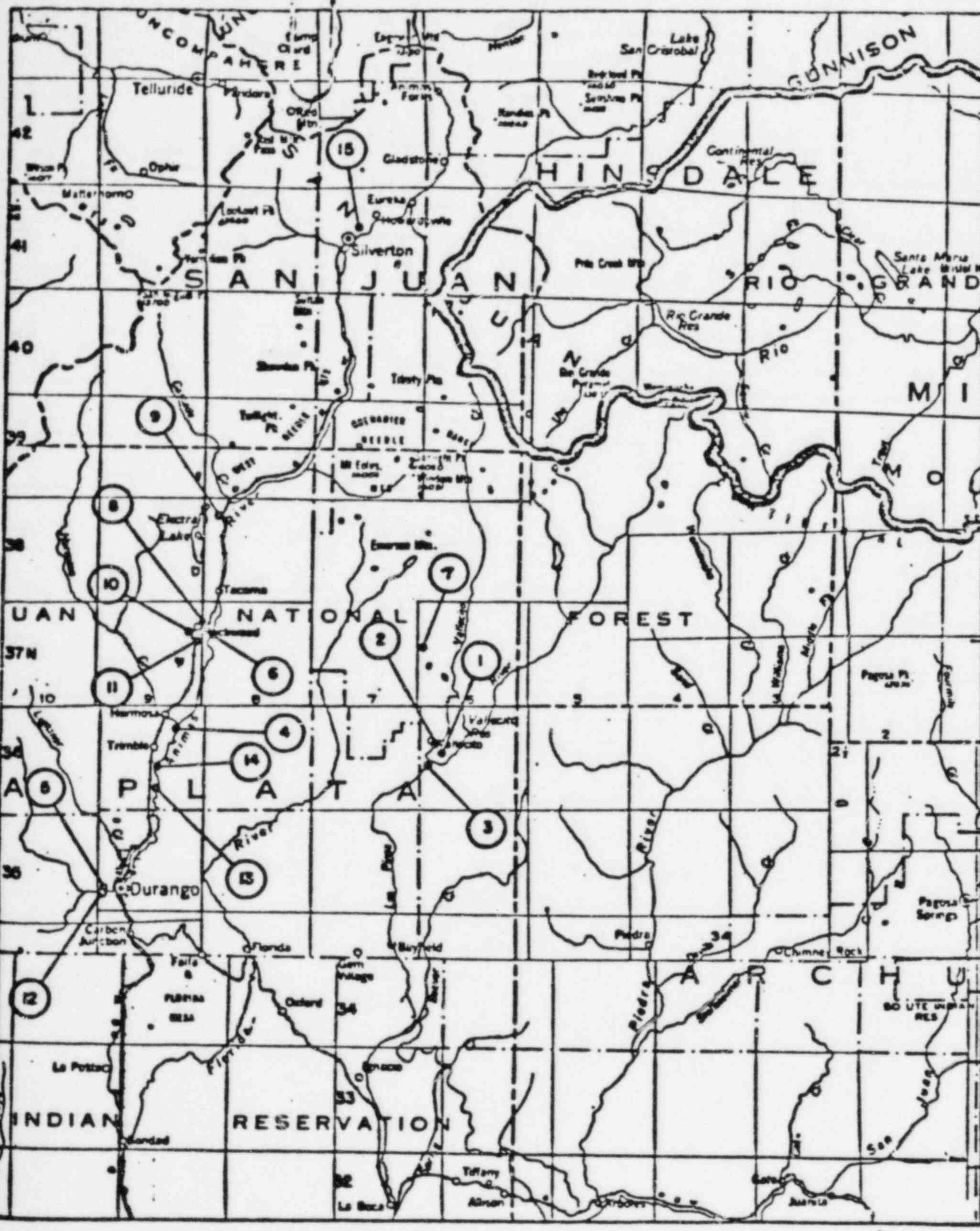
LOS ANGELES ABRASION: (ASTM C-131)
500 Revolutions

Coarse Aggregate Blend: Loss = 22% 50, maximum

5-CYCLE MAGNESIUM SULFATE SOUNDNESS: (ASTM C-88)

| Coarse Aggregate Sieve Size | Original Grading of Sample, % Retained | Loss, % | Weighted Loss, % | ASTM C-33 Specification |
|---|---|---|---|---|
| 1-1/2" to 3/4" | 47 | 0.00 | 0.00 | |
| 3/4" to 3/8" | 41 | 0.22 | 0.09 | |
| 3/8" to No. 4 | 12 | 0.57 | 0.07 | |
| Totals | 100 | | 0.16 | 18, maximum |

| Fine Aggregate Sieve Size | Original Grading of Sample, % Retained | Loss, % | Weighted Loss, % | ASTM C-33 Specification |
|---|---|---|---|---|
| 3/8" to No. 4 | 1 | 3.0 | 0.08 | |
| No. 4 to No. 8 | 16 | 8.0 | 1.28 | |
| No. 8 to No. 16 | 17 | 4.5 | 0.77 | |
| No. 16 to No. 30 | 26 | 7.5 | 1.95 | |
| No. 30 to No. 50 | 26 | 8.5 | 2.21 | |
| No. 50 to No. 100 | 9 | --- | ---- | |
| Minus No. 100 | 5 | --- | ---- | |
| Totals | 100 | | 6.29 | 15, maximum |




COLORADO

37-107

PLATE 6 - LOCATION OF TESTED MATERIAL SOURCES

ORADO NEW MEXICO PRINCIPAL MERIDIAN 37 ° N, 107 ° W

| urce No. | Deposit | Laboratory No. | Location |
|---|---|---|---|
| 1 | Deposit "B" | None | SW1/4NW1/4 sec 17, T 36 N, R 6 W |
| 2 | Deposit "D" | None | NE1/4NE1/4 sec 18, T 36 N, R 6 W |
| 3 | Deposit "A" | None | Sec 19, T 36 N, R 6 W |
| 4 | Fair Oaks Ranch | 1 | *Sec 11, T 36 N, R 9 W |
| 5 | Wood, Morgan and Burnett Pit | 5106A, 5106B | *Sec 30, T 35 N, R 9 W |
| 6 | Rockwood, Colorado Quarry | M-3205 | Secs 7 and 18, T 37 N, R 8 |
| 7 | Vallecito Dam Quarry | M-3206 | Sec 18, T 37 N, R 6 W |
| 8 | Rockwood, Colorado, Railroad Fill, Field Sample R-1 | M-3215 | NW1/4 sec 7, T 37 N, R 8 W |
| 9 | Rockwood, Colorado, Railroad Cut, Field Sample R-2 | M-3216 | S1/8SE1/4 sec 6, T 38 N, R 8 W |
| 10 | English | M-3217 | NW1/16SW1/4 sec 12, T 37 N R 9 W |
| 11 | Roadside Quarry | M-3218 | SE1/4 sec 13, T 37 N, R 9 |
| 12 | Burnett Construction Company | M-3267 | Sec 30, T 35 N, R 9 W |
| 13 | (Miles M.) Mitchell | M-3268 | Sec 27, T 36 N, R 9 W |
| 14 | Animas Valley Sand and Gravel | M-3269 | Sec 22, T 36 N, R 9 W |
| 15 | Animas River Gravel Bar, deposit Hole No. 200 | M-3781 | NW1/4 sec 16, T 41 N, R 7 |

*Approximate location

PLATE 5 - TESTED MATERIAL SOURCES

COMMISSIONER'S OFFICE, DENVER
DIVISION OF ENGINEERING LABORATORIES
CONCRETE LABORATORY BRANCH

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

| | | | |
|---|---|---|---|
| STATE Colorado | SOURCE NO. 7 | RIPRAP | REPORT NO. C-438-C — DATE 7-23-58 |
| LAT 37° N | LONG. 107° W | | LAB. SAMPLE NO. M-3206 — SPEC 4 |
| TYPE OF MATERIAL Quarry rock, quartzite | | | DATE REC'D 4-14-58 |
| LTR. TRANSMITTAL Field Engineer, Farmington, New Mexico | | | DATE 4-11-58 |
| NAME OF DEPOSIT Vallecito Dam Quarry | | | |
| LOCATION 7 miles north of Vallecito Dam, Colorado | | | |
| SEC. 18 — T. 37 N — R. 6 W | | MERIDIAN New Mexico Principal | |
| OWNERSHIP U. S. Government--Public Domain | | | |
| VOLUME Not furnished | | OVERBURDEN Not furnished | |
| FEATURE Navajo Dam--Specifications No. DC-5056 | | | |
| PROJECT Upper Colorado River Basin | | | COMPILED BY H. E. D |
| REMARKS Sample was obtained from riprap in place on Vallecito Dam. Rock was crushed in the laboratory.* | | | CHECKED BY L. C. P |
| | | | REVIEWED BY |
| | | | SUBMITTED BY |

GRADING (DES 4,5,6,11 CUM % RETAINED)

| SIEVE | PIT RUN | 3"-1½" | 1½"-¾" | ¾"-⅜" | ⅜"-No. 4 | FINE AGG. |
|---|---|---|---|---|---|---|
| 6 IN. | | | | | | |
| 3½ IN. | | | | | | |
| 3 IN. | | | | | | |
| 2½ IN. | | | | | | |
| 1¾ IN. | | | | | | |
| 1½ IN. | 11 | | | | | |
| 1¼ IN. | -- | | | | | |
| ⅞ IN. | -- | | | | | |
| ¾ IN. | 56 | | | | | |
| ⅝ IN. | -- | | | | | |
| ⅜ IN. | 83 | | | | | |
| NO. 4 | 100 | | | | | |
| NO. 6 | | | | | | |
| NO. 8 | | | | | | |
| NO. 16 | | | | | | |
| NO. 30 | | | | | | |
| NO. 50 | | | | | | |
| NO. 100 | | | | | | |
| PAN | | | | | | |
| F.M. | 7.50 | | | | | |
| % SAND | 19 | | | | | |

TEST RESULTS *

| | 6"-3" | 3"-1½" | 1½"-¾" | ¾"-⅜" | ⅜"-No. 4 | FINE AGG. |
|---|---|---|---|---|---|---|
| SP GR, S S D (DES 9,10) | -- | 2.71 | 2.71 | 2.70 | 2.71 | -- |
| ABSORPTION, PERCENT (DES 9,10) | -- | 0.2 | 0.2 | 0.1 | 0.1 | -- |
| ORGANIC IMPURITIES, COLOR (DES 14) | — | — | — | — | — | -- |
| PERCENT SILT (DES 16) | -- | -- | -- | -- | -- | -- |
| PERCENT LIGHTER THAN SP GR. | -- | -- | -- | -- | -- | -- |
| CLAY LUMP, % (DES 13) | -- | -- | -- | -- | -- | -- |
| $Na_2SO_4$ LOSS, 5 CYC WGTD % LOSS (DES 19) | — | — | 1.3 | | | -- |
| L.A. ABRASION "A" GRADING (DES 21) | | | | | | -- |
| % LOSS, 100 REV. | 5.7 | | | | | -- |
| % LOSS 500 REV. | 26.9 | | | | | -- |

FREEZING AND THAWING 3-inch rock cubes

| W/C RATIO | SLUMP INCHES | % AIR METER | $H_2O$ LBS/YD³ | 28-DAY STR. | WGT LOSS % | CYCLES |
|---|---|---|---|---|---|---|
| -- | -- | -- | -- | -- | 0.05 | 250 |

ALKALI-AGGREGATE REACTIVITY DATA

| MATERIALS | SAND | | | | GRAVEL | | | |
|---|---|---|---|---|---|---|---|---|
| CEMENT NO | | | | | | | | |
| SODA EQUIVALENT | | | | | | | | |
| TEST AGG. % | 100 | 100 | 50 | 25 | 100 | 100 | 50 | 25 |
| 6-MONTHS AGE | | | | | | | | |
| 12-MONTHS AGE | | | | | | | | |

PETROGRAPHIC DESCRIPTION: MEMORANDUM NO. 58-80 DATE: 6-1-58 BY: G. W. DePuy

The rock fragments are angular and blocky in shape with dulled edges and rough flat sides. A few tight fractures are present and have a moderate influence on breakage.

The rock is a medium-grained well-cemented quartzite. The rock is composed primarily of quartz and small amounts of interstitial hornblende, chlorite and chalcedony.

Conclusions: Rock comparable to Sample No. M-3206 meets specifications requirements for riprap provided it can be obtained in the desired sizes.

PLATE 13 – LABORATORY ANALYSIS OF RIPRAP SOURCE No. 7

COMMISSIONER'S OFFICE DENVER
DIVISION OF ENGINEERING LABORATORIES
CONCRETE LABORATORY BRANCH

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

| | | | |
|---|---|---|---|
| STATE Colorado | SOURCE NO. 8 | RIPRAP | REPORT NO. C-[illegible] DATE 7-[illegible]-58 |
| LAT. 37° N | LONG. 107° W | | LAB. SAMPLE NO. M-3215 REG. [illegible] |

TYPE OF MATERIAL Quarry rock, red granite — DATE REC'D. 4-[illegible]-58
LTR. TRANSMITTAL Field Engineer, Farmington, New Mexico — DATE 4-21-58
NAME OF DEPOSIT Rockwood Colorado Railroad fill, Field Sample R-1
LOCATION Railroad fill 1/4 mile east of Rockwood, Colorado
NW 1/4 SEC 7 T 37 N R 8 W MERIDIAN New Mexico Principal
OWNERSHIP U. S. Government--National Forest land
VOLUME Not furnished — OVERBURDEN Not furnished
FEATURE Navajo Dam--Specifications No. DC-5056
PROJECT Upper Colorado River Basin — COMPILED BY H. E. D.
REMARKS Rock was crushed in the laboratory.* — CHECKED BY L. C. P.
REVIEWED BY
SUBMITTED BY

GRADING (CPS & SAT'D. CUM. %. RETAINED)

| SIEVE | PIT RUN | 3"-1½" | 1½"-¾" | ¾"-No. 4 | FINE AGG. |
|---|---|---|---|---|---|
| 6 in. | | | | | |
| 3½ in. | | | | | |
| 3 in. | | | | | |
| 2½ in. | | | | | |
| 1¾ in. | | | | | |
| 1½ in. | 14 | | | | |
| 1¼ in. | -- | | | | |
| ⅞ in. | -- | | | | |
| ¾ in. | 64 | | | | |
| ⅝ in. | -- | | | | |
| ⅜ in. | 87 | | | | |
| No. 4 | 100 | | | | |
| No. 8 | | | | | |
| No. 8 | | | | | |
| No. 16 | | | | | |
| No. 30 | | | | | |
| No. 50 | | | | | |
| No. 100 | | | | | |
| PAN | | | | | |
| F.M. | 7.65 | | | | |
| % SAND | 16 | | | | |

TEST RESULTS

| TEST RESULTS | 6"-3" | 3"-1½" | 1½"-¾" | ¾"-⅜" | ⅜"-No. 4 | FINE AGG. |
|---|---|---|---|---|---|---|
| SP. GR. S.S.D. (DES. 9, 10) | -- | 2.66 | 2.67 | 2.66 | 2.66 | -- |
| ABSORPTION, PERCENT (DES. 9, 10) | -- | 0.2 | 0.3 | 0.3 | 0.3 | -- |
| ORGANIC IMPURITIES, COLOR (DES. 14) | — | -- | -- | — | — | -- |
| PERCENT SILT (DES. 16) | -- | -- | -- | -- | -- | -- |
| PERCENT LIGHTER THAN SP. GR. | -- | -- | -- | -- | -- | -- |
| CLAY LUMP, % (DES. 13) | -- | -- | -- | -- | -- | -- |
| $Na_2SO_4$ LOSS, 5 CYC. WGTD. % LOSS (DES. 19) | — | — | 1.9 | | | -- |
| L. A. ABRASION "A" GRADING (DES. 21) | | | | | | -- |
| % LOSS, 100 REV. | 7.1 | | | | | -- |
| % LOSS, 500 REV. | 33.2 | | | | | - |

FREEZING AND THAWING ~~MIX~~ OF 3-inch rock cubes

| W/C RATIO | SLUMP INCHES | % AIR METER | $H_2O$ LBS./YD.³ | 28-DAY STR. 3"x6" CYL. | WT. LOSS % | CYCLES |
|---|---|---|---|---|---|---|
| -- | -- | -- | -- | -- | 0.3 | 250 |

ALKALI-AGGREGATE REACTIVITY DATA

| MATERIALS | SAND | | | | GRAVEL | | | |
|---|---|---|---|---|---|---|---|---|
| CEMENT NO. | | | | | | | | |
| SODA EQUIVALENT | | | | | | | | |
| TEST AGG. % | 100 | 100 | 50 | 25 | 100 | 100 | 50 | 25 |
| 6-MONTHS AGE | | | | | | | | |
| 12-MONTHS AGE | | | | | | | | |

PETROGRAPHIC DESCRIPTION: MEMORANDUM NO. 58-81 DATE: 7-1-58 BY: G. W. DePuy

The sample consisted of 16 angular and somewhat blocky fragments ranging in size from 3 by 3 by 5 to 5 by 5 by 11 inches. Breakage of the fragments appears to be moderately influenced by roughly parallel tight fractures occurring 3 to 8 inches apart.

The rock is a coarse-grained pink granite composed of feldspar and quartz with some hornblende. This rock is similar to that in previously examined Sample No. M-3205, except that this sample did not contain the deeply weathered and crumbly granite portions observed in Sample No. M-3205.

The rock is moderately sound and breaks with moderate hammer blows. The feldspars are somewhat weathered along cleavage planes, which tends to facilitate breakage. Breakage is also influenced by the coarseness of the grains.

Conclusions: Rock comparable to Sample No. M-3215 meets specifications requirements for riprap provided it can be obtained in the desired sizes.

PLATE 14 – LABORATORY ANALYSIS OF RIPRAP SOURCE No. 8

COMMISSIONER'S OFFICE DENVER
DIVISION OF ENGINEERING LABORATORIES
CONCRETE LABORATORY BRANCH

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

| | | | | |
|---|---|---|---|---|
| STATE Colorado | SOURCE NO. 9 | AGGREGATE RIPRAP | REPORT NO. C-438-C | DATE 7-23-58 |
| LAT. 37° N | LONG. 107° W | | LAB. SAMPLE NO. M-3216 | REC. |
| TYPE OF MATERIAL Quarry rock, black granite | | | DATE REC'D. 4-22-58 | |
| LTR. TRANSMITTAL Field Engineer, Farmington, New Mexico | | | | DATE 4-21-58 |
| NAME OF DEPOSIT Rockwood, Colorado railroad cut. Field Sample R-2 | | | | |
| LOCATION Railroad cut 1/4 mile north of Mile Post D-470 | | | | |
| S1/8 SE1/4 SEC. 6 | T 38 N | R 8 W | MERIDIAN New Mexico Principal | |
| OWNERSHIP Private property | | | | |
| VOLUME Not furnished | | OVERBURDEN Not furnished | | |
| FEATURE Navajo Dam--Specifications No. DC-5056 | | | | |
| PROJECT Upper Colorado River Basin | | | COMPILED BY H. E. D | |
| REMARKS Rock was crushed in the laboratory.* | | | CHECKED BY L. C. P | |
| | | | REVIEWED BY | |
| | | | SUBMITTED BY | |

GRADING (DES 4,5,6) (CUM % RETAINED)

| SIEVE | PIT RUN* | 3"-1 1/2" | 1 1/2"-3/4" | 3/4"-No.4 | FINE AGG. |
|---|---|---|---|---|---|
| 6 IN | | | | | |
| 3 1/2 IN | | | | | |
| 3 IN. | | | | | |
| 2 1/2 IN. | | | | | |
| 1 3/4 IN | | | | | |
| 1 1/2 IN | 12 | | | | |
| 1 1/4 IN | -- | | | | |
| 7/8 IN | -- | | | | |
| 3/4 IN | 47 | | | | |
| 5/8 IN | -- | | | | |
| 3/8 IN | 85 | | | | |
| NO. 4 | 100 | | | | |
| NO. 8 | | | | | |
| NO. 8 | | | | | |
| NO. 16 | | | | | |
| NO. 30 | | | | | |
| NO. 50 | | | | | |
| NO. 100 | | | | | |
| PAN | | | | | |
| F.M. | 7.45 | | | | |
| % SAND | 17 | | | | |

TEST RESULTS

| | 6"-3" | 3"-1 1/2" | 1 1/2"-3/4" | 3/4"-3/8" | 3/8"-No.4 | FINE AGG. |
|---|---|---|---|---|---|---|
| SP. GR., S.S.D. (DES. 9,10) | -- | 2.92 | 2.93 | 2.93 | 2.93 | -- |
| ABSORPTION, PERCENT (DES. 9,10) | -- | 0.1 | 0.2 | 0.1 | 0.2 | -- |
| ORGANIC IMPURITIES, COLOR (DES 14) | — | — | — | — | — | -- |
| PERCENT SILT (DES. 16) | -- | -- | -- | -- | -- | -- |
| PERCENT LIGHTER THAN SP GR. | -- | -- | -- | -- | -- | -- |
| CLAY LUMP, % (DES. 13) | -- | -- | -- | -- | -- | -- |
| $Na_2SO_4$ LOSS, 5 CYC. WGTD % LOSS (DES. 19) | — | — | | 0.4 | | -- |
| L.A. ABRASION "A" GRADING (DES. 21) | | | | | | -- |
| % LOSS, 100 REV. 4.7 | | | | | | -- |
| % LOSS 500 REV. 21.3 | | | | | | — |

FREEZING AND THAWING TEST OF 3-inch rock cubes

| W/C RATIO | SLUMP INCHES | % AIR METER | $H_2O$ LBS/YD$^3$ | 28-DAY | WGT LOSS % | CYCLES |
|---|---|---|---|---|---|---|
| -- | -- | -- | -- | -- | 0.05 | 250 |

ALKALI-AGGREGATE REACTIVITY DATA

| MATERIALS | SAND | | | | GRAVEL | | | |
|---|---|---|---|---|---|---|---|---|
| CEMENT NO. | | | | | | | | |
| SODA EQUIVALENT | | | | | | | | |
| TEST AGG. % | 100 | 100 | 50 | 25 | 100 | 100 | 50 | 25 |
| 6-MONTHS AGE | | | | | | | | |
| 12-MONTHS AGE | | | | | | | | |

PETROGRAPHIC DESCRIPTION: MEMORANDUM NO. 58-81 DATE: 7-1-58 BY: G. W. DePuy

The sample consisted of 16 angular and somewhat blocky fragments ranging in size from 3 by 5 by 5 to 5 by 6 by 10 inches. A few tight fractures about about 6 to 8 inches apart were observed in several of the fragments, but appear to have only a moderate effect on breakage. The gneissocity of the rock is minor and does not appear to influence breakage.

The rock is a medium-grained black gneissic quartz-monzonite composed of quartz, potash feldspar, plagioclase feldspar, hornblende and biotite.

The rock is hard, dense and durable. It is very competent and resistant to breakage by hammer blows.

Conclusions: Rock comparable to Sample No. M-3216 meets specifications requirements for riprap provided it can be obtained in the desired sizes.

PLATE 15 – LABORATORY ANALYSIS OF RIPRAP SOURCE No. 9

COMMISSIONER'S OFFICE, DENVER
DIVISION OF ENGINEERING LABORATORIES
CONCRETE LABORATORY BRANCH

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

| | | | |
|---|---|---|---|
| STATE Colorado | SOURCE NO. 10 | RIPRAP | REPORT NO. C-438-C DATE 7-23-58 |
| LAT. 37° N | LONG. 107° W | | LAB. SAMPLE NO. M-3217 PEG 4 |
| TYPE OF MATERIAL Quarry rock, limestone | | | DATE REC'D. 4-22-58 |
| LTR. TRANSMITTAL Field Engineer, Farmington, New Mexico | | | DATE 4-21-58 |
| NAME OF DEPOSIT English | | | |
| LOCATION Near Rockwood, Colorado in NW 1/16 of the | | | |
| SW 1/4 SEC. 12 | T 37 N | R 9 W | MERIDIAN New Mexico Principal |
| OWNERSHIP Ruby D. English | | | |
| VOLUME Extensive | | | OVERBURDEN Not furnished |
| FEATURE Navajo Dam--Specifications No. DC-5056 | | | |
| PROJECT Upper Colorado River Basin | | | COMPILED BY H. E. D. |
| REMARKS Rock was crushed in the laboratory.* | | | CHECKED BY L. C. P. |
| | | | REVIEWED BY |
| | | | SUBMITTED BY |

GRADING (DES 4,5,6) (CUM % RETAINED)

| SIEVE | PIT RUN* | 3"-1½" | 1½"-¾" | ¾"-#4 | FINE AGG. |
|---|---|---|---|---|---|
| 6 IN. | | | | | |
| 3½ IN. | | | | | |
| 3 IN. | | | | | |
| 2½ IN. | | | | | |
| 1¾ IN. | | | | | |
| 1½ IN. | 11 | | | | |
| 1¼ IN. | -- | | | | |
| ⅞ IN. | -- | | | | |
| ¾ IN. | 60 | | | | |
| ⅝ IN. | -- | | | | |
| ⅜ IN. | 86 | | | | |
| NO. 4 | 100 | | | | |
| NO. 8 | | | | | |
| NO. 8 | | | | | |
| NO. 16 | | | | | |
| NO. 30 | | | | | |
| NO. 50 | | | | | |
| NO. 100 | | | | | |
| PAN | | | | | |
| F.M. | 7.57 | | | | |
| % SAND | 16 | | | | |

TEST RESULTS

| * | 6"-3" | 3"-1½" | 1½"-¾" | ¾"-⅜" | ⅜"-#4 | FINE AGG. |
|---|---|---|---|---|---|---|
| SP. GR., S.S.D. (DES. 9,10) | -- | 2.70 | 2.70 | 2.69 | 2.70 | -- |
| ABSORPTION, PERCENT (DES. 9,10) | -- | 0.2 | 0.2 | 0.2 | 0.2 | -- |
| ORGANIC IMPURITIES, COLOR (DES. 14) | — | — | — | — | — | -- |
| PERCENT SILT (DES 16) | -- | -- | -- | -- | -- | -- |
| PERCENT LIGHTER THAN SP. GR. | -- | -- | -- | -- | -- | -- |
| CLAY LUMP, % (DES. 13) | -- | -- | -- | -- | -- | -- |
| $Na_2SO_4$ LOSS, 5 CYC. WGTD % LOSS (DES. 19) | — | — | 4.7 | | | -- |
| L.A. ABRASION "A" GRADING (DES. 21) | | | | | | — |
| % LOSS, 100 REV. 7.7 | | | | | | — |
| % LOSS 500 REV. 33.8 | | | | | | — |

FREEZING AND THAWING DATA of 3-inch rock cubes

| W/C RATIO | SLUMP INCHES | % AIR METER | $H_2O$ LBS/YD.³ | 28-DAY STR. 3"x6" CYL. | WGT LOSS % | CYCLES |
|---|---|---|---|---|---|---|
| | | | | | 2.1 | 250 |

ALKALI-AGGREGATE REACTIVITY DATA

| MATERIALS | SAND | | | | GRAVEL | | | |
|---|---|---|---|---|---|---|---|---|
| CEMENT NO. | | | | | | | | |
| SODA EQUIVALENT | | | | | | | | |
| TEST AGG. % | 100 | 100 | 50 | 25 | 100 | 100 | 50 | 25 |
| 6-MONTHS AGE | | | | | | | | |
| 12-MONTHS AGE | | | | | | | | |

PETROGRAPHIC DESCRIPTION: MEMORANDUM NO. 58-81 DATE: 7-1-58 BY: G. W. DePuy

The sample is composed of about 20 angular and blocky fragments ranging in size from 3 by 3 by 4 to 4 by 10 by 13 inches. Numerous small tight fractures well cemented by calcium carbonate are present and have a moderate effect on breakage.

There are two rock types present. About 75 percent of the sample is composed of a massive, dense, light-gray-colored, fine-grained limestone. Acid insoluble constituents constitute a little less than 1 percent of the limestone and were identified by X-ray diffraction analysis as quartz and kaolin-type clay. The remainder of the sample is a rubble breccia composed chiefly of light gray, fine-grained fragments of limestone (similar to the massive limestone), with some fragments of siliceous limestone, chalcedony, and quartz. The fragments vary in size from about 15 cm to less than 1 mm in diameter. The fragments are well cemented by a dark red-brown-colored mixture of calcite, kaolin, and iron oxide.

The massive limestone is moderately hard and competent. The breccia is well cemented and in places tends to break across fragments (as well as in the cement).

Conclusions: Rock comparable to Sample No. M-3217 meets specifications requirements for riprap provided it can be obtained in the desired sizes.

PLATE 16 – LABORATORY ANALYSIS OF RIPRAP SOURCE No. 10