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APPENDIX 7-5

Crandall Creek Flow Calculations

I hereby certify that the design contained herein was prepared by myself and is true and correct to the best of my knowledge.

REGISTERED ENGINEER
No. 7102
RICHARD B. WHITE
STATE OF UTAH

Richard B. White, P.E.

Mid-Term Revisions 5-30-1986

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CRANDALL CREEK FLOOD FLOW ADJACENT TO SED. POND

Watershed Characteristics

Area = 3480 ac (5.44 mi^2) – see watershed area on page 2 of this calc.

$$\text{Avg. slope} = \left[\frac{(187{,}400\ ft)(400\ ft)}{(3480\ ac)(43{,}560\ ft^2/ac)}\right](100) = 49.4\%$$

Avg. CN = 69 (see sed. pond calcs.)

Time of concentration:

$$T_c = 1.67\,L$$

$$L = \frac{l^{0.8}\,(s+1)^{0.7}}{1900\,Y^{0.5}} \quad \left\{ \begin{array}{l} l = 17{,}000\ ft \\ s = \frac{1000}{CN} - 10 = 4.49 \\ Y = 49.4\% \end{array} \right.$$

$$L = \frac{(17{,}000)^{0.8}\,(5.49)^{0.7}}{(1900)(49.4)^{0.5}} = 0.60\ hr$$

$$T_c = (1.67)(0.60) = 1.00\ hr$$

Average basin elevation ⟶ determine at grid points on 1000-ft centers across basin. Grid points shown on page 3 of this calc. Avg. of 143 pts = 9330 ft.

Return-Period / Peak-Flow Estimates

With an avg. basin elevation > 8000 ft, Crandall Cr. is in the High Plateaus flood region of Thomas and Lindskov (1983). Flood peak flows in this region can be estimated from the equations:

$$Q_{10} = 680\,A^{0.706}\,E^{-1.30}$$

$$Q_{25} = 10{,}300\,A^{0.672}\,E^{-2.33}$$

$$Q_{50} = 64{,}200\,A^{0.651}\,E^{-3.03}$$

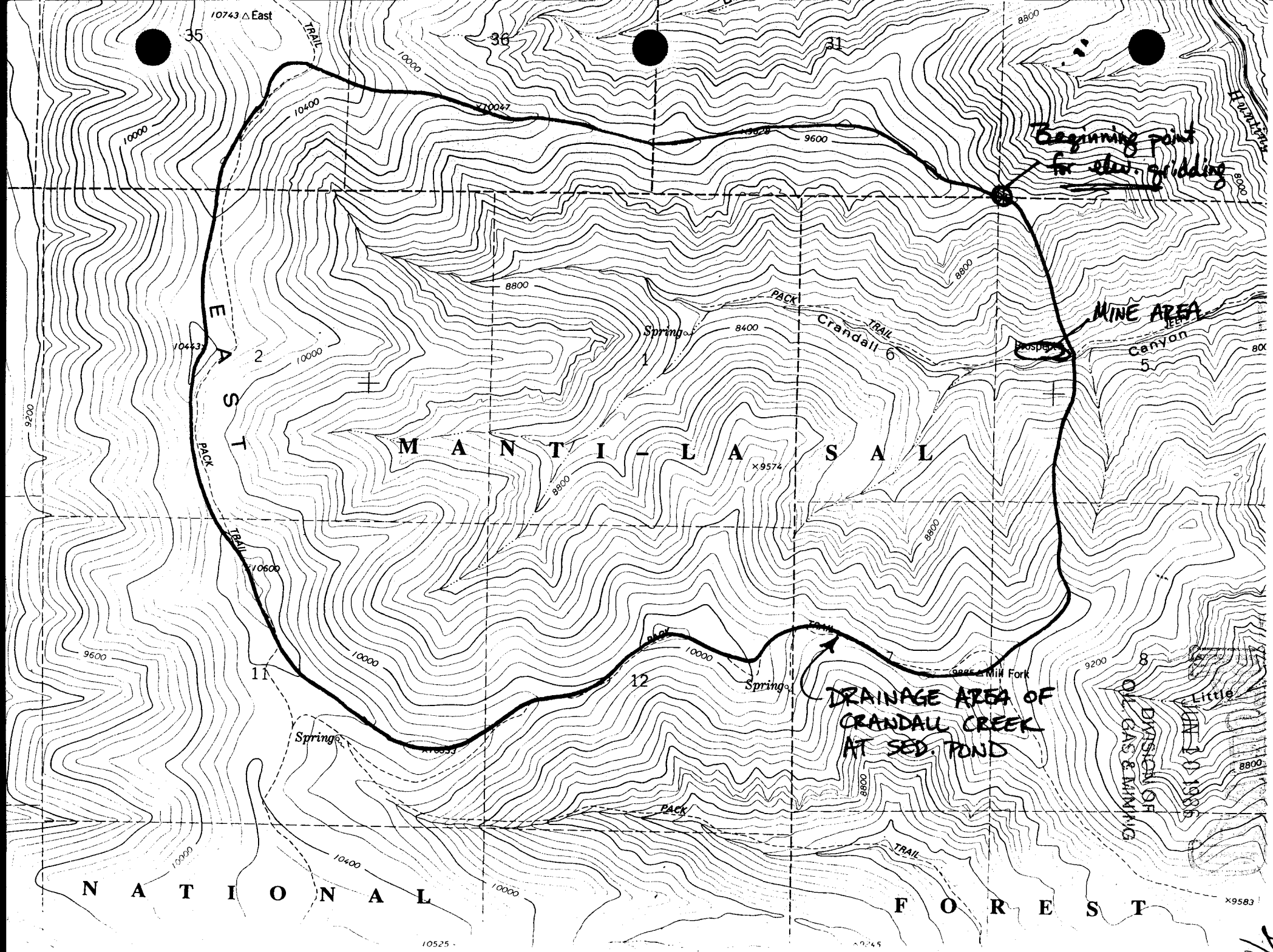
$$Q_{100} = 347{,}000\,A^{0.631}\,E^{-3.68}$$

Q_N = peak flow with a return period of N years (cfs)

A = drainage area (mi^2)

E = avg. basin elev. (thousands of feet)

Equations from Thomas and Lindskov (1983)


Beginning point for elev. gridding
MINE AREA
DRAINAGE AREA OF CRANDALL CREEK AT SED. POND
MANTI-LA SAL
EAST
NATIONAL FOREST
Crandall
Canyon
Mill Fork
Little
Spring
PACK TRAIL
10743 △ East
10443
10047
9574
9583
9525
10525
35
36
31
1
2
5
6
7
8
11
12
8800
8400
9600
9200
10000
10400
10600
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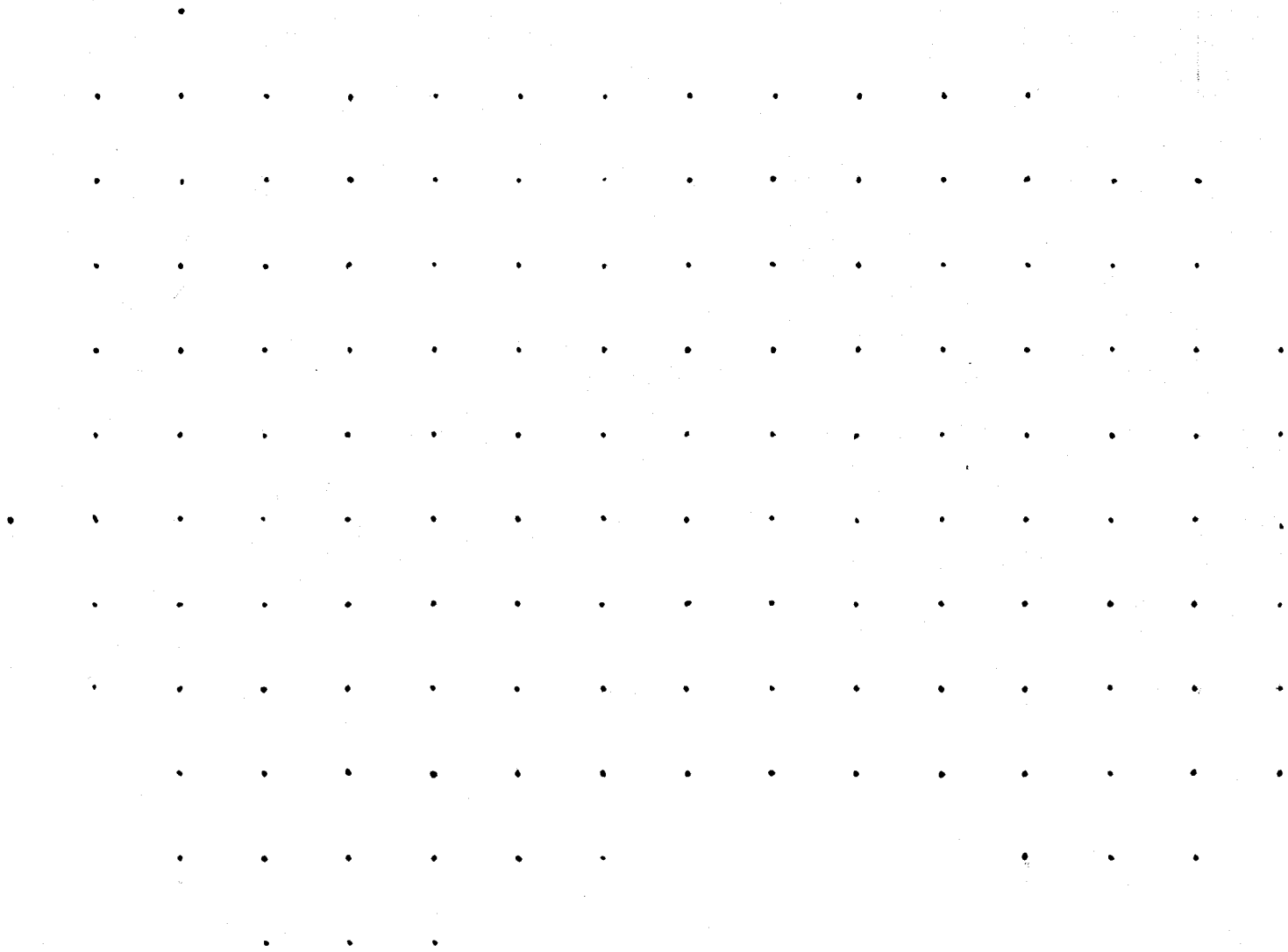

143 points → Mean elev. = 9330 ft

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For the Crandall Cr. watershed → Q_{10} = 123 cfs
Q_{25} = 177 cfs
Q_{50} = 223 cfs
Q_{100} = 272 cfs

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Design Storm

Examine effects of peak flow from 100-yr, 24-hr storm on Crandall Cr. adjacent to the sed. pond.

100-yr, 24-hr storm = 3.70 in (Miller et al., 1973)

Storm distribution → use Farmer-Fletcher, SCS Type B, and SCS Type II. Compare results with the return-period results above and determine most appropriate storm distribution.

Hydrograph Results

Printouts contained on pages 5-7 of this calc. for the three storm distributions. Peaks flows were:

Farmer-Fletcher → 487 cfs
Type B → 714 cfs
Type II → 1621 cfs

Comparison chart:

Storm Distribution	Peak Flow (cfs)	Return Period (yr)
Farmer/Fletcher	487	1000
Type B	714	7000
Type II	1621	>10,000

See probability plot on pg. 8 of this calc.

Although the above data indicate that all of the storm distributions yield conservative results, DOGM unequivocally requires the use of the Type II distribution for 24-hr events (ref. telecon with Dave Cline, 5 Jun 1986). Thus, the Type II data will be used.

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*******************************
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*                             *
* HYDROGRAPH GENERATION MODEL *
*   USING SCS CURVE NUMBER    *
*         METHODOLOGY         *
*******************************
```

IDENTIFICATION: CRANDALL CREEK - FARMER/FLETCHER

INPUT SUMMARY:

```
*************************************************************
     STORM:                    WATERSHED:
        DIST. = FARMER-FLETCHER        AREA =  5.440 SQ. MI.
        DEPTH =  3.70 IN.              CN = 69.0
        DURATION = 24.0 HR.            TIME OF CONC. =  1.00 HR.
*************************************************************
```

```
*************************************************************
```

OUTPUT SUMMARY:

```
*************************************************************
     TOTAL RUNOFF DEPTH =  1.0759 INCHES
     INITIAL ABSTRACTION =  0.8986 INCHES
     PEAK FLOW =   487.11 CFS  ( 0.1388 IN/HR)
     TIME TO PEAK =   5.04 HOURS
     RUNOFF VOLUME CHECK =  1.0781 INCHES
*************************************************************
```

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*                             *
* HYDROGRAPH GENERATION MODEL *
*   USING SCS CURVE NUMBER    *
*         METHODOLOGY         *
*******************************
```

IDENTIFICATION: CRANDALL CREEK - TYPE B

INPUT SUMMARY:

```
*************************************************************
     STORM:                    WATERSHED:
        DIST. = SCS TYPE B          AREA =  5.440 SQ. MI.
        DEPTH =  3.70 IN.           CN = 69.0
        DURATION = 24.0 HR.         TIME OF CONC. =  1.00 HR.
*************************************************************
```

```
*************************************************************
```

OUTPUT SUMMARY:

```
*************************************************************
     TOTAL RUNOFF DEPTH =  1.0759 INCHES
     INITIAL ABSTRACTION =  0.8986 INCHES
     PEAK FLOW =   714.38 CFS  ( 0.2035 IN/HR)
     TIME TO PEAK =  10.26 HOURS
     RUNOFF VOLUME CHECK =  1.0781 INCHES
*************************************************************
```

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```
*******************************
* EARTHFAX ENGINEERING, INC.  *
*                             *
* HYDROGRAPH GENERATION MODEL *
*   USING SCS CURVE NUMBER    *
*         METHODOLOGY         *
*******************************
```

IDENTIFICATION: CRANDALL CREEK - TYPE II

INPUT SUMMARY:

```
*************************************************************
     STORM:                    WATERSHED:
        DIST. = SCS TYPE II          AREA =  5.440 SQ. MI.
        DEPTH =  3.70 IN.            CN = 69.0
        DURATION = 24.0 HR.          TIME OF CONC. =  1.00 HR.
*************************************************************
```

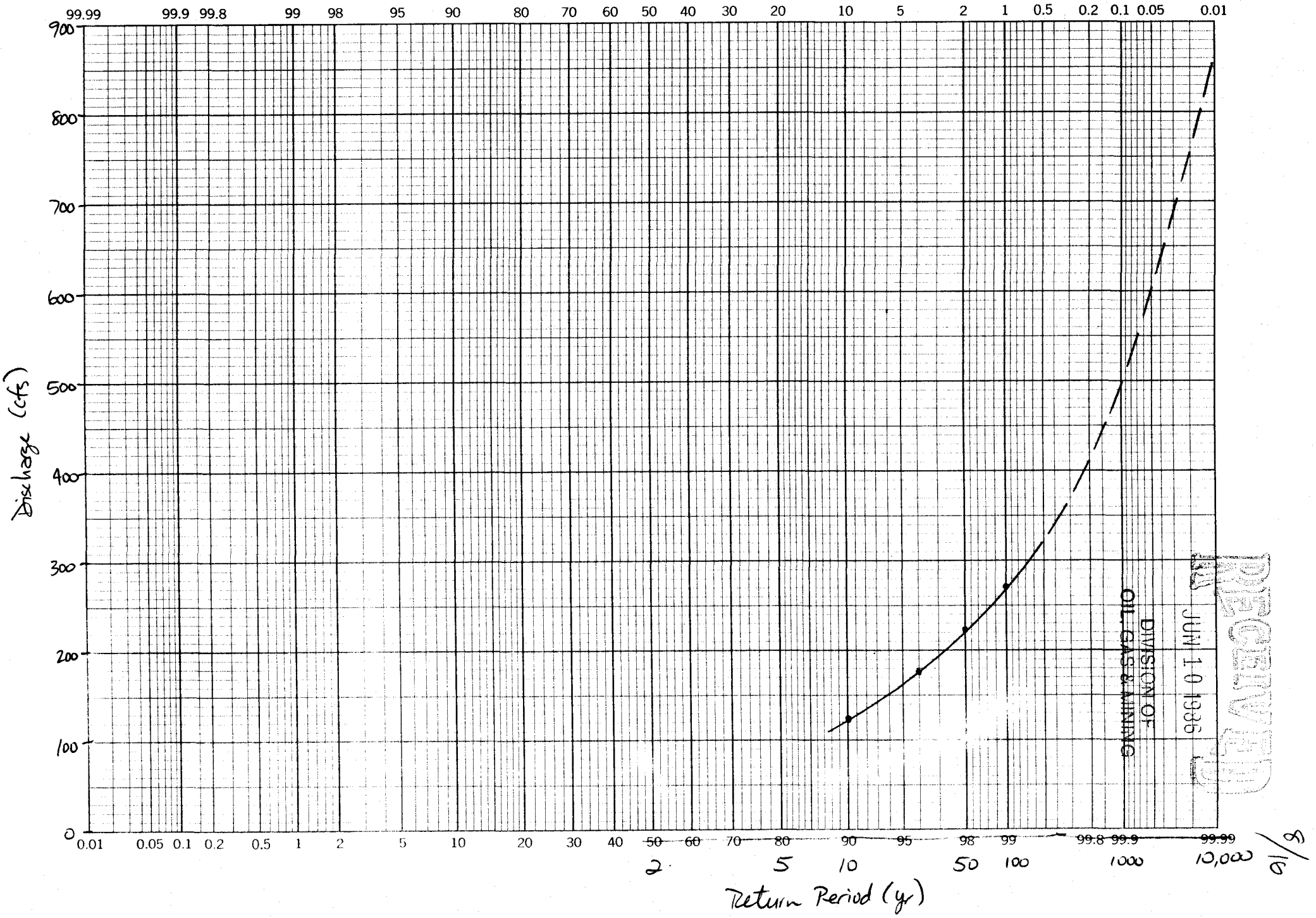
```
*************************************************************
```

OUTPUT SUMMARY:

```
*************************************************************
     TOTAL RUNOFF DEPTH =  1.0759 INCHES
     INITIAL ABSTRACTION =  0.8986 INCHES
     PEAK FLOW =  1620.90 CFS  ( 0.4617 IN/HR)
     TIME TO PEAK =  12.55 HOURS
     RUNOFF VOLUME CHECK =  1.0781 INCHES
*************************************************************
```

K+E PROBABILITY X 90 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.

46 8000



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Stage-Discharge Relations

Selection of "n" value — Based on methodology of U.S. SCS (1956).

① Basic n = 0.026 (coarse gravel/rock)

② Minor irregularity (slightly eroded side slopes)
Modifying value = 0.005

③ Only minor changes in cross section
Modifying value = 0.000

④ Negligible number of obstructions
Modifying value = 0.000

⑤ Minor amt of vegetation along banks
Modifying value = 0.005

⑥ Minor meandering
Modifying value = 0.000

⑦ $n = 0.026 + 0.005 + 0.000 + 0.000 + 0.005 + 0.000$
$= \underline{\underline{0.036}}$

$$Q = \left[\frac{1.486}{n} R^{2/3} S^{\frac{1}{2}}\right](A)$$

$$S = \left(\frac{7760' - 7750'}{170\ ft}\right)(100) = 5.9\%$$ } From contours on plate 3-1

$$Q = \left(\frac{1.486}{0.036}\right)\left(0.059\right)^{\frac{1}{2}} R^{2/3} A$$

$$= 10.026\, A R^{2/3}$$

See cross section adjacent to sed. pond shown on page 10 of this calc.

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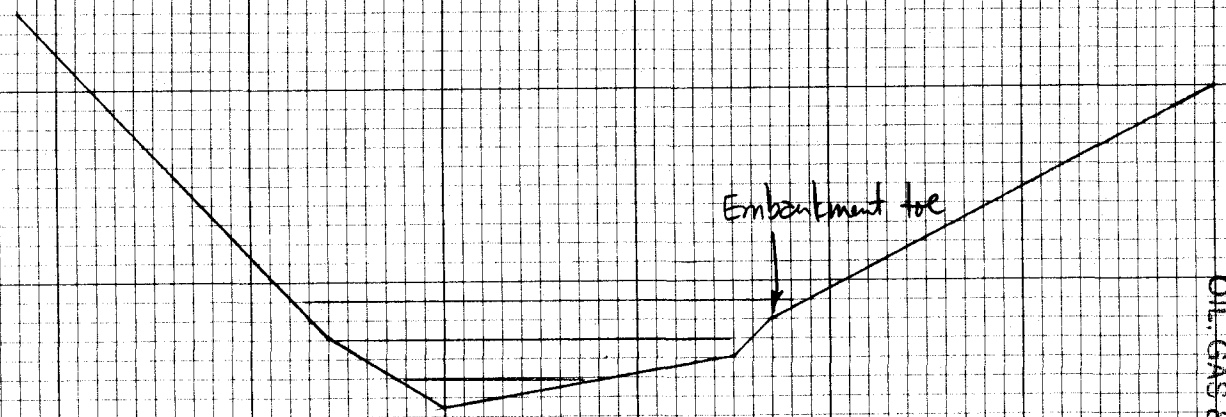
42-381 50 SHEETS 5 SQUARE
42-382 100 SHEETS 5 SQUARE
42-389 200 SHEETS 5 SQUARE
NATIONAL Made in U.S.A.

K+E 10 X 10 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

46 0700

Channel Cross Section
Crandall Cr. at sed. pond
Cross Section B-B' on Plate 7-4 (Creek section)



1" = 10'

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For $d = 1.5$ ft:

$A = 8.2$ ft^2
$P = 17.5$ ft
$R = 0.47$ ft
} $Q = 50$ cfs

For $d = 3.5$ ft:

$A = 44.8$ ft^2
$P = 23.1$ ft
$R = 1.94$ ft
} $Q = 699$ cfs

For $d = 5.5$ ft

$A = 92.8$ ft^2
$P = 29.5$ ft
$R = 3.15$ ft
} $Q = 1999$ cfs

Flow depth at $q = 1621$ cfs $\longrightarrow$ 5.1 ft (see stage-discharge curve on page 12 of this calc.), Needs riprap on toe (base of toe = 4.5 ft)

Stage-velocity curves $\longrightarrow$ see page 13 of this calc. Design V = 20.8 ft/s

Maximum permissible velocity (see page 14 of this calc.):

Assume design d_{75} (riprap on toe) = 20 in

Basic V = 21.6 ft/s

D = 1.12 (flow depth = 5.5 ft)

A = 1.00

B = 0.86 (average cot. = 3.5)

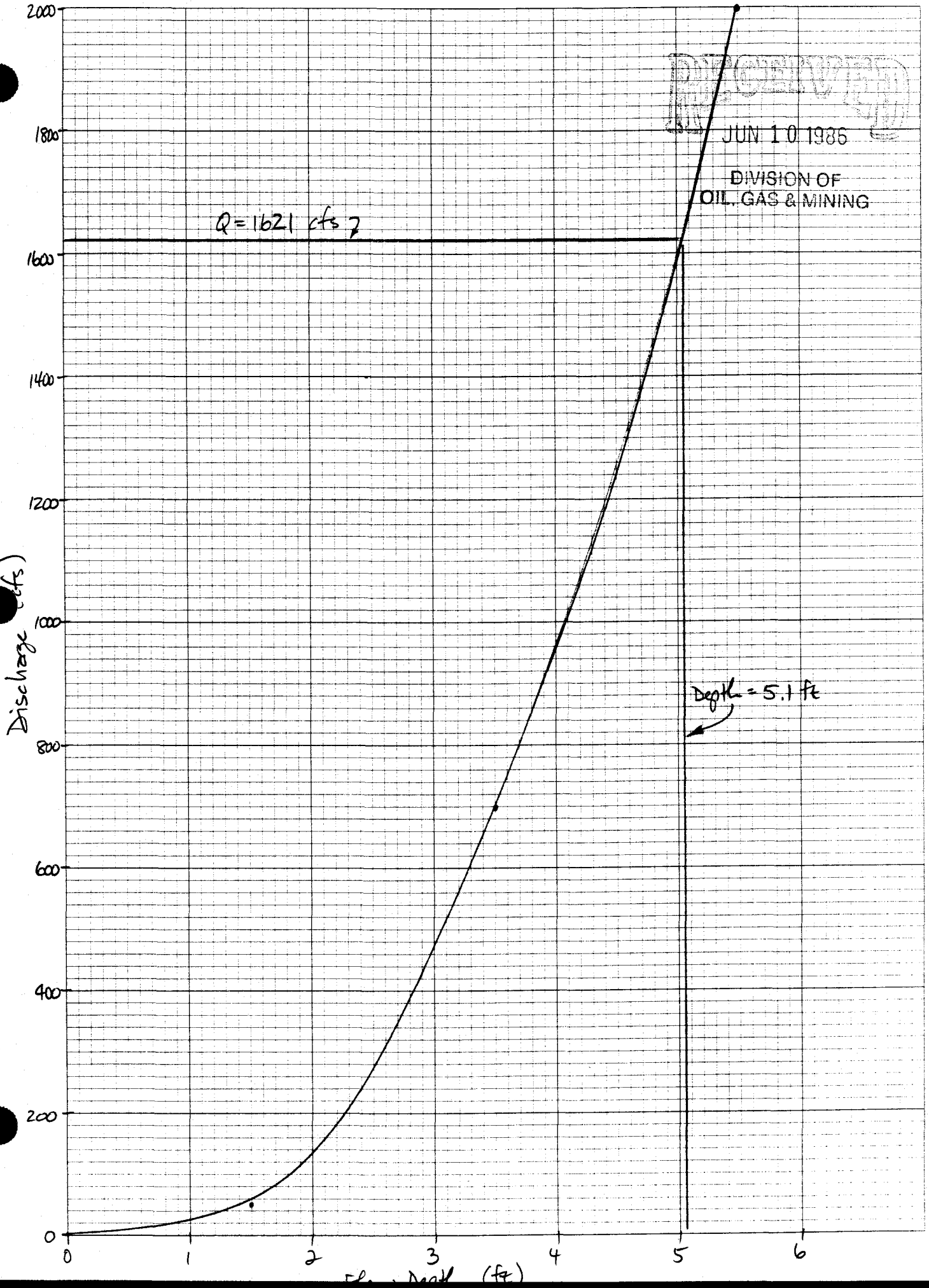
Permissible velocity = (21.6)(1.12)(1.00)(0.86)

= 20.8 ft/s

= Design velocity $\Rightarrow$ d_{75} <u>OK</u>

Riprap gradation $\longrightarrow$ see page 15 of this calc (from Barfield et al., 1981 dimensionless curve). Place riprap along bottom 2.0 ft of embankment (0.6 ft flow depth + freeboard). Great amount of freeboard is provided incidentally due to large riprap size.

12/16



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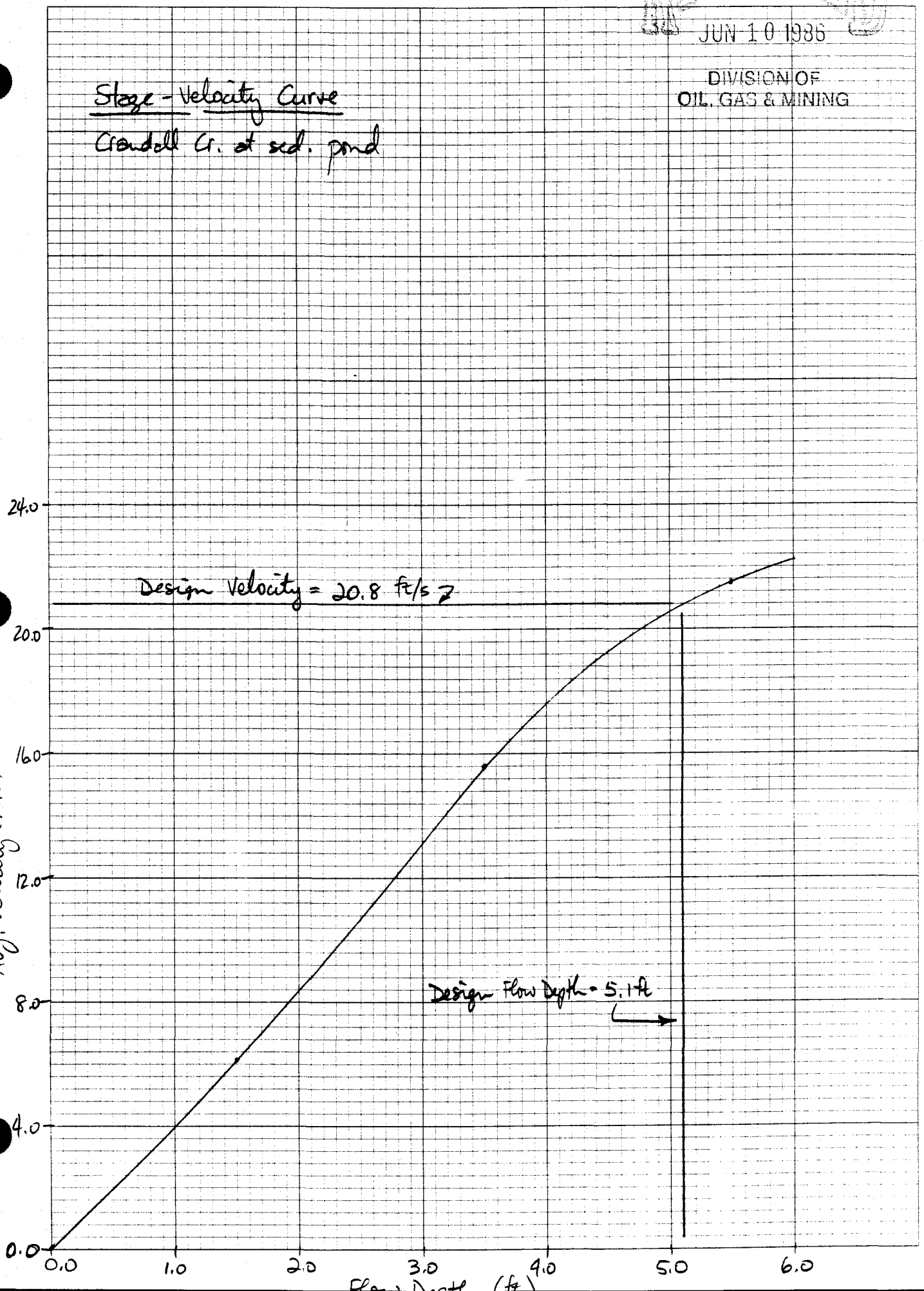
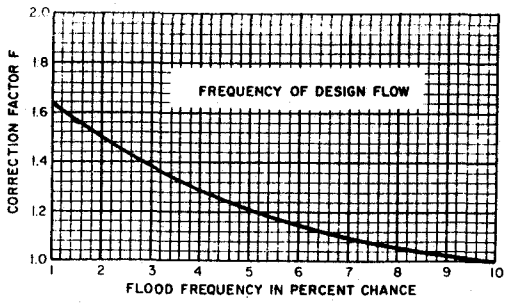
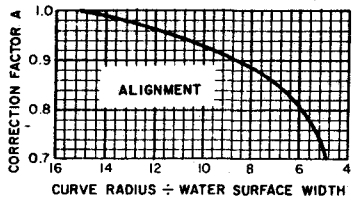
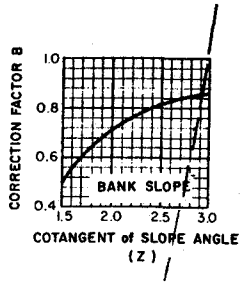
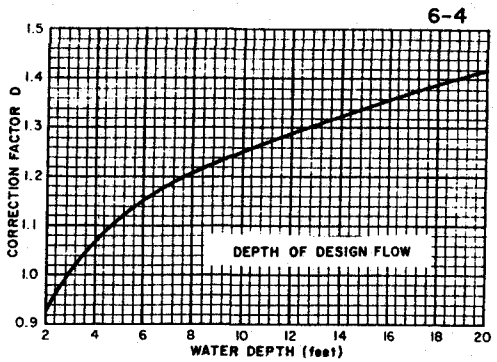


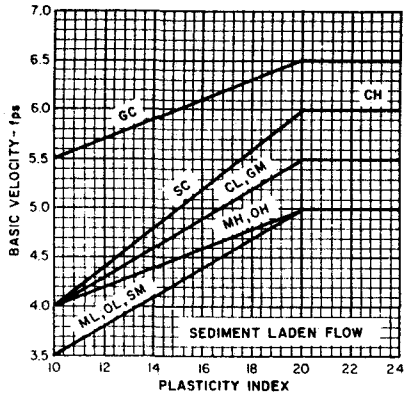
46 0700
K+E 10 X 10 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.



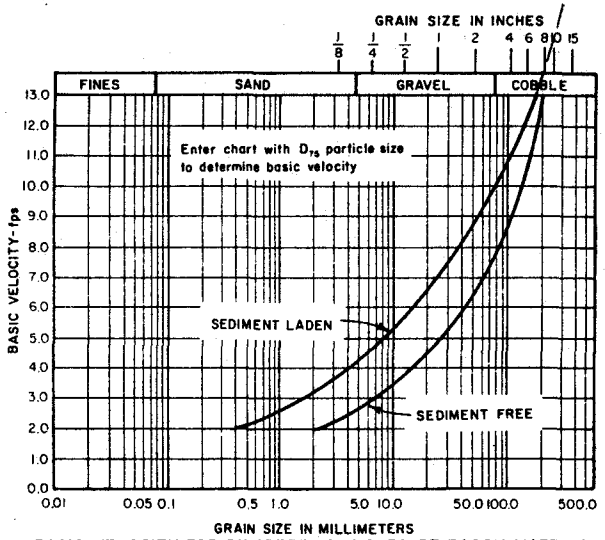




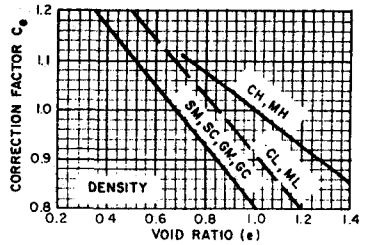


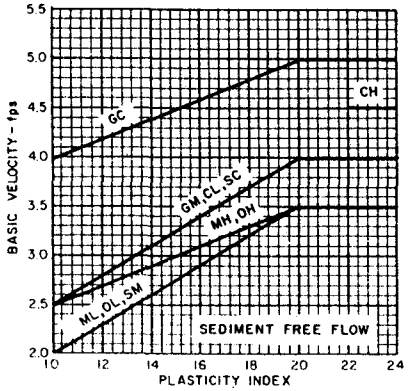


BASIC VELOCITIES FOR COHERENT EARTH MATERIALS (v_b)



BASIC VELOCITY FOR DISCRETE PARTICLES OF EARTH MATERIALS (v_b)





BASIC VELOCITIES FOR COHERENT EARTH MATERIALS (v_b)

ALLOWABLE VELOCITIES FOR UNPROTECTED EARTH CHANNELS	
CHANNEL BOUNDARY MATERIALS	ALLOWABLE VELOCITY
DISCRETE PARTICLES	
Sediment Laden Flow	
$D_{75} > 0.4$ mm	Basic velocity chart value x D x A x B
$D_{75} < 0.4$ mm	2.0 fps
Sediment Free Flow	
$D_{75} > 2.0$ mm	Basic velocity chart value x D x A x B
$D_{75} < 2.0$ mm	2.0 fps
COHERENT EARTH MATERIALS	
PI > 10	Basic velocity chart value x D x A x F x C_e
PI < 10	2.0 fps

NOTES:

1. In no case should the allowable velocity be exceeded when the 10% chance discharge occurs, regardless of the design flow frequency.

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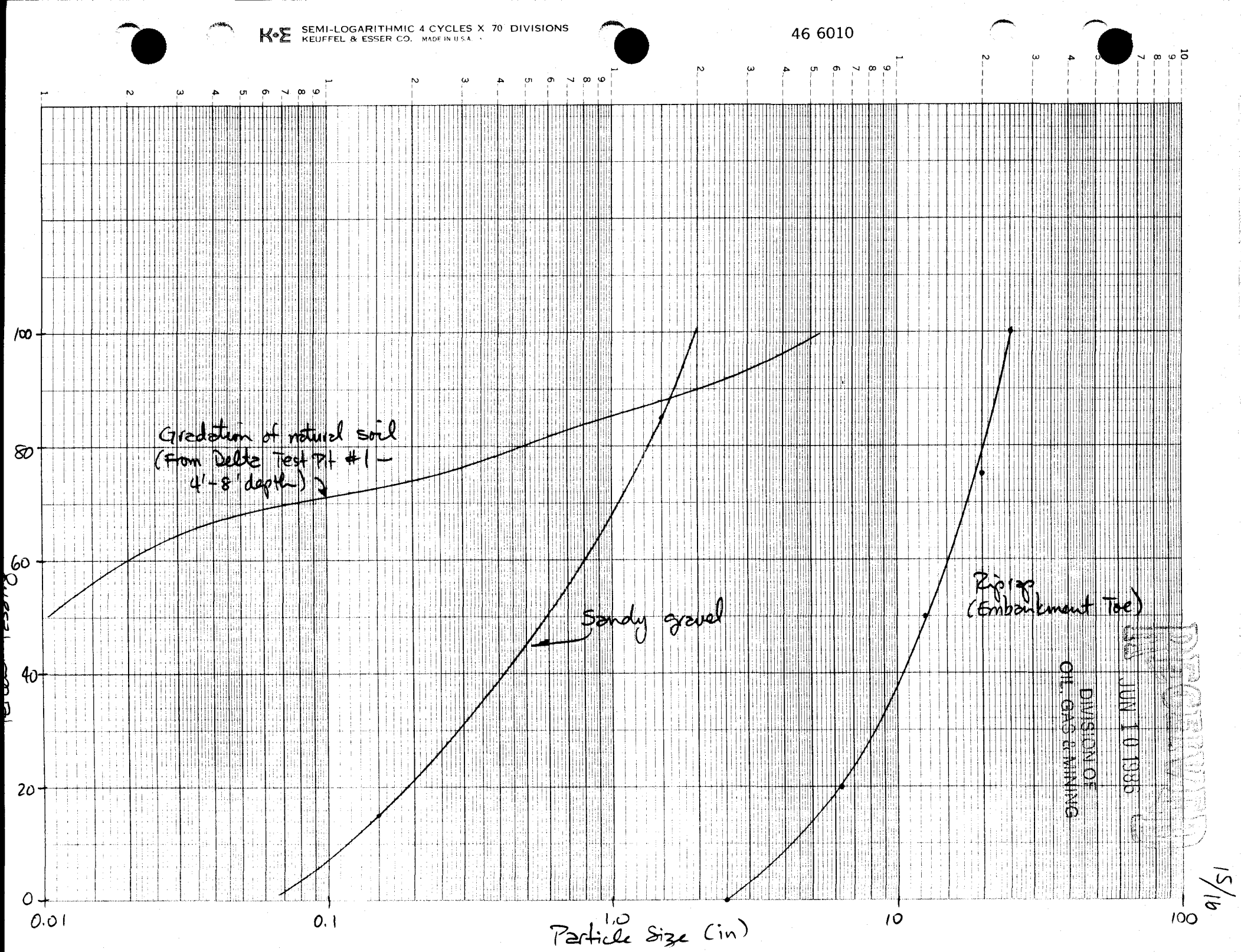
FIGURE 6-2

ALLOWABLE VELOCITIES FOR UNPROTECTED EARTH CHANNELS

Revised -

Source: U.S. Soil Cons. Service (1975)


K+E SEMI-LOGARITHMIC 4 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.
46 6010
Gradation of natural soil
(From Delta Test Pit #1 –
4'-8' depth)
Sandy gravel
Riprap
(Embankment Toe)
Percent Finer
Particle Size (in)
0
20
40
60
80
100
0.01
0.1
1.0
10
100
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91/51

A filter blanket will be needed beneath the riprap to provide erosional stability. Check design of blanket shown on page 15 of this calc.

$$\frac{D_{15}\ (\text{riprap})}{D_{85}\ (\text{filter})} = \frac{5.2\ \text{in}}{1.5\ \text{in}} = 3.5 < 5 \quad \underline{\text{OK}}$$

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$$\frac{D_{15}\ (\text{riprap})}{D_{15}\ (\text{blanket})} = \frac{5.2\ \text{in}}{0.15\ \text{in}} = 34.7 < 40 \quad \underline{\text{OK}}$$

$$\frac{D_{15}\ (\text{blanket})}{D_{85}\ (\text{soil})} = \frac{0.15\ \text{in}}{1.0\ \text{in}} = 0.15 < 5 \quad \underline{\text{OK}}$$

$$\frac{D_{15}\ (\text{blanket})}{D_{15}\ (\text{soil})} = \frac{0.15\ \text{in}}{0.0021\ \text{in}} = 71.4 > 40$$

Although the last criterion indicates some erosional instability, this blanket will be used due to the unliklihood of occurrence (RP > 10,000 yr) of the design event.

References

Barfield, B.J., R.C. Warner, and C.T. Haan. 1981. Applied Hydrology and Sedimentology for Disturbed Areas. Oklahoma Technical Press. Stillwater, Oklahoma.

Miller, J.F., R.H. Frederick, and R.J. Tracey. 1973. Precipitation-Frequency Atlas of the Western United States: Volume VI - Utah. NOAA Atlas 2. National Weather Service. Silver Spring, Maryland.

Thomas, B.E. and K.L. Lindskov. 1983. Methods for Estimating Peak Discharge and Flood Boundaries of Streams in Utah. Water-Resources Inv. Rpt. 83-4129. U.S.G.S. Salt Lake City, UT.

U.S. Soil Conservation Service. 1956. National Engineering Handbook: Section 5 - Hydraulics. Washington D.C.

U.S. Soil Conservation Service. 1975. Design of Open Channels. Technical Release No. 25. Washington, D.C.