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KAISER STEEL

KAISER STEEL CORPORATION
SUNNYSIDE COAL MINES
SUNNYSIDE, UTAH 84539
TELEPHONE 801-888-4421

RECEIVED
NOV 30 1982
DIVISION OF
OIL, GAS & MINING

29 November 1982

Mr. Thomas Munson
Div. of Oil, Gas & Mining
4241 State Office Bldg.
Salt Lake City, Utah, 84114

re: Manshaft Sed Pond #3
Sunnyside Mines
ACT/007/007

Dear Tom,

Attached is a resubmittal of measurements & calculations considering separate manshaft drainage areas. Kaiser Steel Corp recently secured a topographic map of the area from a 1979 photo by Olympus Aerial Survey to a scale of 1"=200'. Please disregard all former area acreage values since they were calculated from less detailed maps. (calc shts were hand del to Div 11-16-82).

The manshaft area has been divided into 6 separate sub-areas as shown on the attached map (Sht 2) with the measurements calculated on the top of Sht 1. Areas designated as "A" & "C" were considered as the contributing drainage area in former submittals. The six sub-areas are:

"A"-The upper undisturbed area above the manshaft whose waters passed into the existing sed pond.

"B"-A new area outlined that is undisturbed lying to the north of "A" with runoff contributing to the depression collecting "A"s drainage.

"C"-The area between the lower interceptor ditch & the upper access road leading to the twinshaft pad, which comprises 72% of undisturbed or reclaimed area & 28% disturbed, and includes "E" & "F". This is the area considered contributing to the proposed sediment pond.

"D"-This is the twinshaft fan site made up of a pad, steep slopes and exposed rock ledges. SMALL AREA EXEMPTION requested.

"E"-Is the exposed cut slopes created to make the manshaft pad area and includes "F".

"F"-Is the asphalt parking lot and work pad at the Manshaft.

The contributing area to the sediment pond will be reduced by creating a cut-off ditch to collect "A" & "D" drainage, which waters will be collected in a depression before entering Grassy Trail Creek. Kaiser Steel Corp hereby requests a SMALL AREA EXEMPTION for area "D" since the disturbance is less than one acre and is only 3.4% of "A". It is intended to further protect the surface runoff by the liberal use of straw-bale filters to both clean & control velocity of the drainage.

The balance of Sht 1 calculates the CN for areas "C","E" & "F" separately & securing a weighted CN value; then determines the runoff(G) & sediment yield(MUSLE) for both AMC I & II conditions.

Sht 3 shows the sed pond & ditch size determinations using the smaller 9 acre area, "C". Note the AMC-II value has been reduced to more accurately reflect local conditions, but is above the AMC-I value. The lower portion of the page lists the average monthly precipitation values from 1905 to the present for the Sunnyside Mines area.

All past submittals & calculations have attempted to reflect actual parameters at the mine site, but have often been at odds with portions of the regulations. Sht 4 shows the sediment pond size calculations using the 0.035 ac ft/acre sediment factor from UMC-817.46(b)2 with the AMC-II moisture condition. Please note figures from measuring the actual total sediment build-up in the existing sed pond over a 3yr period, which has been from total containment, is only 25% of the amount calculated using the .035 af/ac factor.

Sht 5 discusses the theory of the antecedent moisture condition (AMC) and when I, II, & III groups are used.

Sht 6 lists the 5-day rainfall totals from Apr'74 thru Aug '79 as recorded at the Sunnyside Mines area and its corresponding AMC condition.

Sht 7 shows the official NWS record of precipitation by month & year from 1905 to 1930 for the general Sunnyside area.

A comparison of 4 different methods of determining surface runoff quantities (Rational, McMath, Chow, & Cook/SCS), are shown for each of the six subareas on Sht 8, with a statement indicating that site conditions must be separately evaluated to determine the best solution, because of the variations in results from theoretical analysis.

The initial submittal that added the mine water discharge pond to the Manshaft site was by letter dated 7-9-82, with subsequent correspondence per letters: 8-4-82(DOGM), 8-17-82(KSC), 8-30-82 (DOGM), 9-1-82(KSC), 10-4-82(DOGM), 10-7-82(KSC), 10-13-82 & 10-19-82(DOGM). This present submittal should be made part of the previous proposals to determine the end result of the proposed sediment structure, since this letter addresses only those parts needing adjustment &/or clarity.

Four proposals have been submitted, including this letter, with 6 sediment pond sizes specified. A pond comparison follows;

item	subm date	sed pond size	vol	criteria
1	7-09-82	6x20x36 bot	9256cf	30ac; AMC-I w/improper factors.
2	8-17-82	5x26x40	9024	30ac; adj AMC-I & mix fig.
3	9-01-82	5x30x67	15424	30ac; AMC-II sed yield.
4	11-16-82	5x24x42	8864	9ac; adj AMC-II & I considered.
5	11-22-82	6x38x62	22240	9ac; UMC817.46(b)2 w/AMC-II.
6	11-29-82	5x40x60 bot	17524cf	9ac; max area available.

T. Munson/DOGM
29 Nov. 1982
Sheet 3 -

Kaiser Steel Corp requests that sed pond size 5x29x47 (4) be accepted since it more correctly reflects the on-site conditions. If this is unacceptable, the maximum sized pond to fit the available area is 5x45x65 (6). EPA effluent standards will be met since the sediment loading is relatively light as evidenced by past experience and the runoff is not extreme. Also please note and be aware that the surface drainage also passes thru the Mine Water Discharge Pond offering additional settlement time.

In the enlargement of the existing pond & the construction of the new sed pond, the topsoil material will be removed, stock-piled, protected, & replaced on the site in accordance with UMC817.22 -.24. The proposed sed pond (& mine water disch pond) will be constructed in strict accordance with good engineering practices & related regulations, with the embankment height being increased 5%(6") over the design height to comply with UMC817.46k, & the top width being (H+35)/5 = 9ft minimum. The embankment(dike) will be compacted to 95% optimum density minimum in 2 ft layers.

In reviewing the pond elevations to verify conformance with regulation clearances, it was determined that some adjustments were necessary. Assuming an elevation of 100.0 for the bottom of the Mine Water Discharge Pond - then the new elevations for the proposed sed pond will be:

ELEV's assm'd -	104.5	inlet to disch pond
	.5	slope diff
	105.0	@ sed pond
	2.5	for pipe bend & cover
elev.	107.5	bot sed pond
	5.0	water depth
	112.5	outflow crest
	1.0	clearance to spillway
elev.	113.5	spillway ~~crest~~ bottom

Spillway flow depth using 5'w x 18"d triangular section: $Q=3.087LH^{1.5}$ so -

$H=(Q/3.087L)^{.67}=(3.88/3.087x5)^{.67}=$	.5(.4)	flow depth
	114.0	spillway water surface
	1.0	clearance
elev.	115.0	top of embankment.

Grassy Trail Creek will be protected from the pond outflow by liberal use of large rocks and concrete blocks to act as an energy dissipator.

Hopefully this explains the calculation submittals and properly resolves the problems & questions raised. I am sending a copy of this submittal directly to Steve McNeal, State Health Dept.

Sincerely,

John S. Huenfer

John S. Huenfer, PE.
Civil Engineer

Attachment

cc:Steve McNeal

25 OCT 1982

MANSHAFT DRAINAGE

AREA	PLANIMETER RDG	SQ INCHES	CONV.	ACREAGE	
A. UPPER UNDIST	.07/22.68, - 67.79₃ = 22.57 /1.02 =	22.13 in	× 200²/43,560 =	20.32	29.32 acres (instead of 30.73 ac)
B. NORTH UNDIST	.09/14.69, - 43.95₃ = 14.62	= 14.33	× 0.9183 ac/in =	13.16	
* D. UPR DIST (part of A)	.09/.86, - 2.37₃ = 0.76	= 0.745	(map meas'd 1" = 200 scale) =	0.68	
C. LWR RECL & UNDIST	.07/10.11, - 30.06₃ = 10.00	= 9.80	=	9.00	
E. LWR DIST (part of C)	.02/2.89, - 8.59₃ = 2.86	= 2.80	=	2.57	
F. ASPH PRKG (part of C & E)	.09/1.23, - 3.48₃ = 1.13 /1.02 =	1.11	=	1.02	

1" SQ CONTROL f .06/1.09, - 3.13₃ = 1.02 f

(SEE ATTACHED MAP)

* REQUEST & APPLY FOR "SMALL AREA EXEMPTION" ON UPR DIST AREA (D) OF 0.68 acres (say .7 ac) SINCE IT IS ONLY 3.4% OF CONTRIBUTING DRAINAGE AREA, WHOSE RUNOFF WILL PASS THRU A NATURAL DEPRESSION BEFORE ENTERING GTC PROVIDING EFFL STD'S DISCH.

MANSHAFT AREA PROPER (C, E, & F): UNDIST & RECL (C) 9. - 2.57 = 6.43 ac
DISTURBED (E) 2.57 - 1.02 = 1.55 ac
ASPHALT PARKING (F) = 1.02 ac
TOTAL AREA = 9.00 ac × 43,560 / 5280² = .014 sq mi.

DETERMINE WT'D CN FACTOR – ASPHALT – CN 98 × 1.02/9 = 11.11
DISTURBED (0% Cover) 86 × 1.55/9 = 14.81
UNDIST & RECL (60% Cover) 64 × 6.43/9 = 45.72
71.64 say 72 AMC-II

∴ CN = 72 AMC-II & convert per table 10.1 pg 10.7 NEH-4 CN = 53 AMC-I

$S = \frac{1000}{72} - 10 = 3.89$ AMC-II $\qquad S = \frac{1000}{53} - 10 = 8.87$ AMC-I

$Q = \frac{(1.9 - .2 \times 3.89)^2}{1.9 + .8 \times 3.89} = .2512"$ AMC-II where P = 1.9" (10 yr/24 hr) $\qquad Q = \frac{(1.9 - .2 \times 8.87)^2}{1.9 + .8 \times 8.87} = .002$ AMC-I

HYD L (l) = $209(a)^{.6} = 209(9)^{.6} = 781'$

AMC-II	AMC-I
WTRSHD LAG $(L)_{II} = (781)^{.8}(3.89+1)^{.7}/1900(48.5)^{.5} = .047$ hrs	$(L)_I = (781)^{.8}(8.87+1)^{.7}/1900(48.5)^{.5} = .077$ hrs
DUR INCR $(\Delta D)_{II} = .4(.047) = .019$ hrs.	$(\Delta D)_I = .4(.077) = .031$ hrs
PK PERIOD $(7\Delta D)_{II} = 7(.019) = .1325$ hrs	$(7\Delta D)_I = 7(.031) = .2166$ hrs.
WRKG CV$_{II}$ · $P_B = 11.88 - 4.5(.019) = 11.79$ & $P_E = 11.88 + 7(.019) = 12.01$	WKG CV$_I$ · $P_B = 11.88 - 4.5(.031) = 11.74$ & $P_E = 11.88 + 7(.031) = 12.10$
PK DISCH$_{II}$ = 484(.014) ΔQ / .019/2 + .047 = 120.8 ΔQ$_{II}$	PK DISCH$_I$ = 484(.014) ΔQ / .031/2 + .077 = 73.8 ΔQ$_I$

AMC-II

1. INCR	2. time	3. Px/P24	4. m'd P	5. m'd Q	6. ΔQ	7. Δq	8. Y	9. Y(Δq)
	11.79	.430	.817	.0004				
ΔD₁					.0030	.362	.2	.0725
	11.82	.471	.895	.0034				
ΔD₂					.0059	.713	.4	.285
	11.85	.512	.973	.0093				
ΔD₃					.0089	1.075	.6	.645
	11.88	.554	1.053	.0182				
ΔD₄					.0110	1.329	.8	1.063
	11.92	.595	1.130	.0292				
ΔD₅					.0130	1.570	1.0	1.570
	11.95	.634	1.205	.0422				
ΔD₆					.0066	.797	.67	.5315
	11.98	.652	1.239	.0488				
ΔD₇					.0035	.423	.33	.141
	12.01	.661	1.256	.0523				
								4.308

MUSLE (Y) = $95(.2512 \times 4.308)^{.56}$ .20 (68.5) .14 (.90) = 171.4 Tons = 1857 cf/storm.

AMC-II

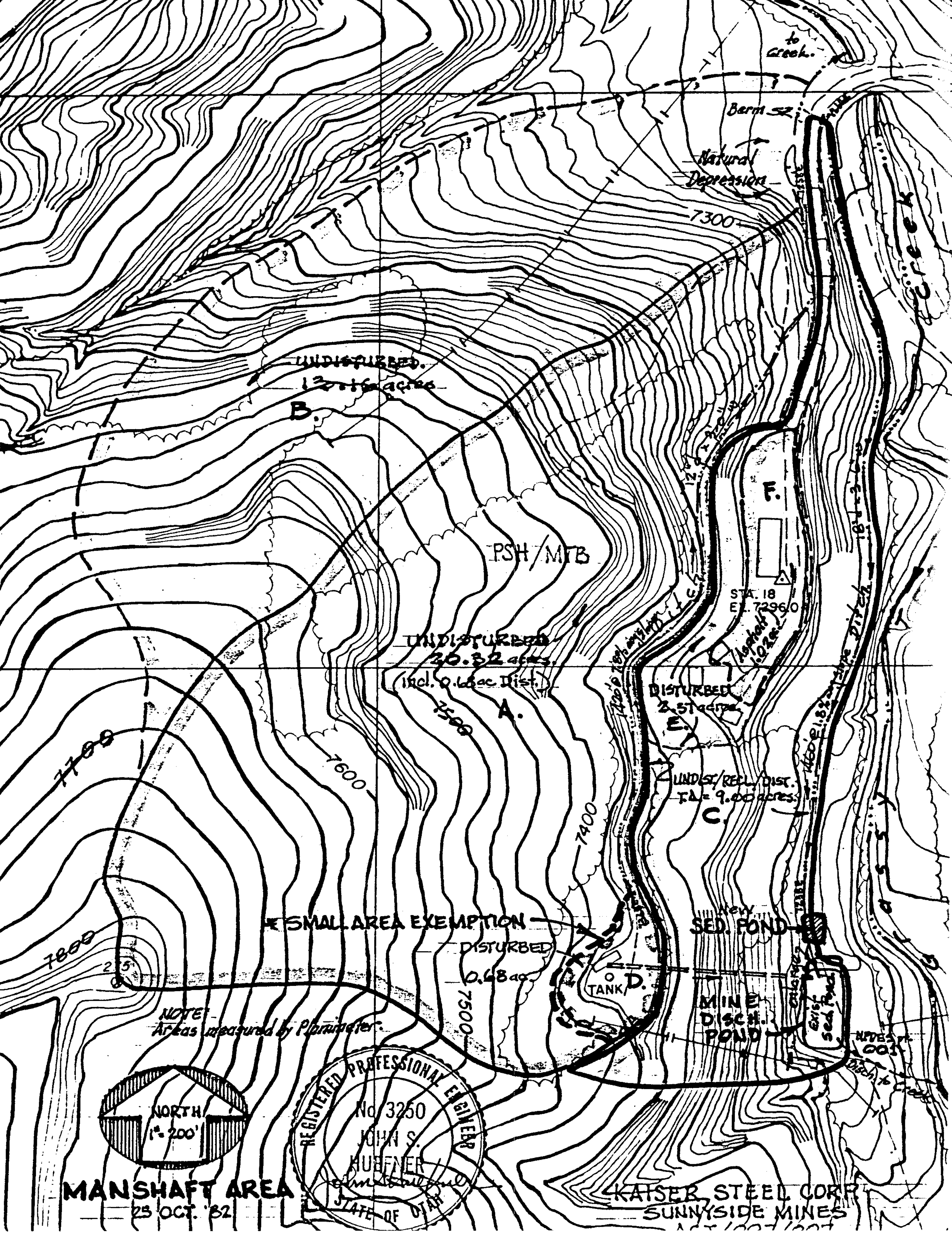
AMC-I

1. INCR	2. time	3. Px/P24	4. m'd P	5. m'd Q	6. ΔQ	7. Δq	8. Y	9. Y(Δq)
	11.74	.296	.562	(.1918)				
ΔD₁					(.076)	(5.616)	.2	(1.123)
	11.79	.430	.817	(.1157)				
ΔD₂					(.029)	(2.133)	.4	(.853)
	11.84	.494	.939	(.0868)				
ΔD₃					(.024)	(1.793)	.6	(1.076)
	11.89	.558	1.060	(.0625)				
ΔD₄					(.023)	(1.734)	.8	(1.387)
	11.95	.634	1.205	(.0390)				
ΔD₅					(.006)	(.428)	1.0	(.428)
	12.00	.657	1.248	(.0332)				
ΔD₆					(.004)	(.310)	.67	(.207)
	12.05	.674	1.281	(.0290)				
ΔD₇					(.002)	(.133)	.33	(.044)
	12.10	.682	1.296	(.0272)				
								(5.118)

NOTE: since runoff is so small NO sed develop — but if use negative fig, then →

MUSLE (Y) = $95(.002 \times 5.118)^{.56}$ .20 (68.5) .14 (.90) = 12.6 T = 210 cf

AMC - I



to Creek
Berm
Natural Depression
7300
UNDISTURBED 13.16 acres
B.
PSH / MTB
UNDISTURBED 20.32 acres (incl. 0.68 ac. Dist.)
A.
F.
STA. 18 EL. 7296.0
Asphalt .02 ac.
DISTURBED 2.51 acres
E.
UNDIST/RECL. DIST. T.A. = 9.00 acres.
C.
Ditch
Creek
7700
7600
7500
7400
7800
SMALL AREA EXEMPTION
NEW SED. POND
DISTURBED 0.68 ac.
TANK
D.
MINE DISCH. POND
Exist. Sed. Pond
NPDES pt. 001
Disch. to Creek
NOTE: Areas measured by Planimeter.
NORTH 1"=200'
REGISTERED PROFESSIONAL ENGINEER
No. 3250
JOHN S. HUEFNER
STATE OF UTAH
MANSHAFT AREA
25 OCT. '82
KAISER STEEL CORP.
SUNNYSIDE MINES

10 NOV 1982

MANSHAFT SED. POND & DITCH SIZES:

Precip. (P) = 1.9" (10yr/24hr) total.

$Q = (P-.25)^2 / P + .85$ → Q_{AMC-II} = .2512" & Q_{AMC-I} = .0018"

Y_{II} = 2857 CF/storm — TOO MUCH! for area; Y_{I} = 210 CF/storm — PERHAPS TOO SMALL.

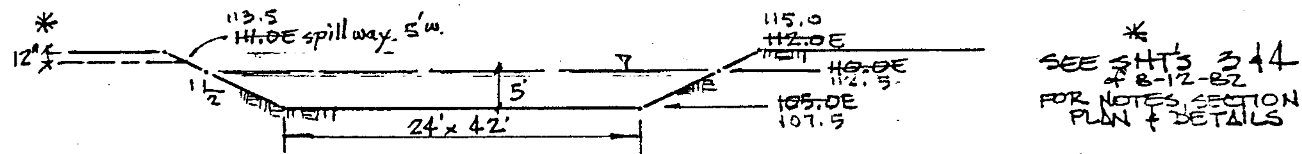
DETERMINE AVERAGE CONDITION – considering semi-arid site & precip.:

Q_{avg} = .2512 + .0018"/2 = .1265"/12" × 9 ac × 43,560 SF/ac = 4133 CF

Y_{avg} (sed yld) = 2857 + 210/2 = 1534 CF/storm × 3 yrs = 4602 CF

MIN. TOTAL POND CAPACITY = 8735 CF

∴ SED. POND SIZE = 5'd × 34'w × 52'l = 8840 CF OK.



CAPACITY = 5×24×42 + 10×5(24+42) + ⅓(5)π 7.5² = 8860 CF OK

SPILLWAY – $\frac{(2.3-.2\times3.89)^2}{2.3+.8\times3.89}$ = .428"/12 × 9 ac × 43,560 SF/ac = 13,984 CF/hr ÷ 3600 sec/hr = 3.88 cfs.

∴ use ditch 12"d × 5'-0" ▽ w/ 5% slope.

COLLECTOR DITCHES –

Sized per EESealye "DESIGN" Vol 1, pgs 18-06 & 18-05

UPPER UNDIST. AREA (A): Rational Q_{A-D} = 6.72 + .68 = 7.40 cfs.

SCS Meth Q_{A-D} = 1.86 + .53 = 2.39 cfs.

Size for 7.40 cfs @ .078 slope = D-1A (6½" × 5') = 1.35 SF ∴ 12"d × 3' ∆

LOWER DIST. AREA (C): Rational Q_{C-E-F} = 2.69 + .94 + .74 = 4.37 cfs.

SCS Meth Q_{C-E-F} = .61 + 1.24 + 1.72 = 3.45 cfs.

Size for 4.37 cfs @ .018 slope = D-1C (4½" × 10' parab) = 2.51 SF ∴ 18"d × 3'-6" ∆.

PRECIPITATION

Record for Sunnyside Mines Area: AVERAGE OF MONTHLY VALUES OVER PERIOD.

	1905–1930 (per NWS)	1953–1982 (per Arlo R. & JSH)
JAN	.98"	.81"
FEB	.88"	.88"
MAR	1.01"	1.11"
APR	.98"	.91"
MAY	1.06"	1.08"
JUN	.64"	.82"
JUL	1.49"	1.12"
AUG	1.70"	1.24"
SEP	1.76"	1.30"
OCT	1.36"	1.26"
NOV	.89	.74"
DEC	.75	.63"
ANNUAL	13.50"	11.90"
max. mo.:	5.32" (9-'27)	4.55" (9-82)
yearly range:	6.92"-19.83"	8.86"-19.02"

ANNUAL PRECIP.: 12"–14" w/ yearly less than 20"

∴ AREA IS SEMI-ARID.

REGISTERED PROFESSIONAL ENGINEER
No. 3250
JOHN S. HUEFNER
STATE OF UTAH

John S. Huefner

15 NOV. 1982

UMC 817.46(b)2 SED. POND SIZE - min. limit 0.035 a.f./ac.

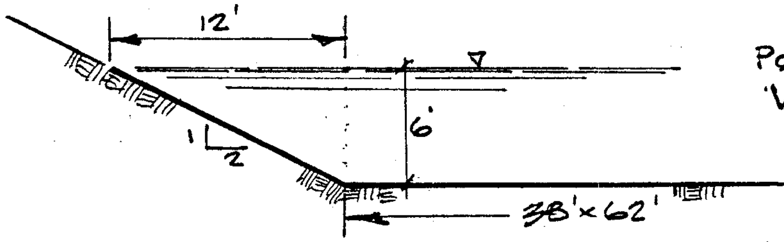
MANSHAFT DISTURBED AREA - 9.0 acres.

.035 af/ac × 9. ac × 43,560 cf/af = 13,721.4 CF FOR SEDIMENT.

Precip. .2512"/12 × 9 × 43,560 = 8,206.7 CF FOR RUNOFF

TOTAL 21,928 CF Say 21,930 CF min per regs.

∴ MIN. POND SIZE IS 6'd × 50'w × 73'l = 21,900 CF OK.



Pond Volume:

$V = 6 \times 38 \times 62 + 6 \times 12(38+62) + \frac{1}{3}\pi 12^2 (6)$

$= 14{,}136 + 7200 + 904 =$

$= 22{,}240$ CF OK.

NOTE:

EXISTING SEDIMENT POND 4' × 60' × 126' = 30,240 CF

Which collected total drainage from 29.32 acres & was TOTAL CONTAINMENT. Pond has been in service for the past 3 years & has collected less than 16" deep of silt/sediment.

∴ SED. VOL = 16"/12 × 60.5' × 126.5' = 10,204 CF over past 3 years.

OR APPROX. 10,204/3 = 3400 CF per YEAR

OR APPROX. 10,204/29.32 = 348 CF/acre SAY 350 CF/acre /3 = 117 CF/AC/YR.

Further 117 CF/AC/YR × 2 (SAFETY FACTOR) × 9 AC × 3 YR = 6318 CF say 6320 CF WHICH IS (6320/13,720) 46% OF VALUE FROM 0.035 af/ac PER REG'S.

THEREFORE, REQUEST THAT KSC BE ALLOWED TO INSTALL POND 5' × 34' × 52' (SEE SHT. 3) SINCE IT SATISFYS SITE CONDITIONS.

ALSO REQUEST DOGM RE-EVALUATE & ADJUST 0.035 ac-FT/ACRE MIN. VALUE PER UMC 817.46(b)2 DOWNWARD ACCORDINGLY.

REGISTERED PROFESSIONAL ENGINEER
No. 3250
JOHN S. HUEFNER
STATE OF UTAH

ANTECEDENT RAINFALL

Rainfalls in antecedent periods of 5 to 30 or more days prior to a storm are commonly used as indexes of watershed wetness. An increase in an index means an increase in the runoff potential. Such indexes are only rough approximations because they do not include the effects of evapotranspiration and infiltration on watershed wetness. Therefore, it is not worthwhile to try for great accuracy in computing the index described below.

ANTECEDENT MOISTURE CONDITION

The index of watershed wetness used with the runoff estimation method of chapter 10 is Antecedent Moisture Condition (AMC). Three levels of AMC are used:

AMC-I. Lowest runoff potential . The watershed soils are dry enough for satisfactory plowing or cultivation to take place.

AMC-II. The average condition.

AMC-III. Highest runoff potential. The watershed is practically saturated from antecedent rains.

The AMC can be estimated from 5-day antecedent rainfall by the use of table 4.2, which gives the rainfall limits by season categories. The table is adapted from material developed by the Fort Worth EWP Unit. The rainfall limits are plotted as boundary points for the AMC groups in figure 4.9, which illustrates the linear character of the index. No upper limit is intended for AMC-III, as table 4.2 shows. The limits for "dormant season" apply when the soils are not frozen and there is no snow on the ground.

The 5-day rainfall amount used with table 4.2 or figure 4.9 is a simple total. For example, if the AMC for a watershed is to be estimated for the date of June 8, which is in the growing season, and if the rain for the preceding five days is:

June 3	June 4	June 5	June 6	June 7
0.10	0	0.35	0.15	0.72

then the total rainfall of 1.32 inches, used with the "growing season" column of table 4.2, shows the appropriate moisure group to be AMC-I. Additional examples of the use of table 4.2 are given in chapter 10.

Table 4.2. - Seasonal rainfall limits for AMC

AMC group	Total 5-day antecedent rainfall	
	Dormant season	growing season
	Inches	Inches
I	less than 0.5	less than 1.4
II	0.5 to 1.1	1.4 to 2.1
III	over 1.1	over 2.1

Note from pg 10.5

In the SCS method the change in S (actually in CN) is based on an antecedent moisture condition (AMC) is determined by the total rainfall in the 5-day period PRECEEDING a storm.

SCS Manual NEH - 4; pages 4.10, 11 & 12.

PRECIPITATION – 5 DAY RAINFALL TOTALS (Max.):

Date	"precip.	AMC.
5 APR '74	0.47"	I
18 JUL '74	1.16"	I
25 OCT '74	0.72"	I
13 FEB '75	0.38"	I
28 MAR '75	0.83"	I sno
24 APR '75	0.81"	I
23 JUN '75	1.22"	I
18 JUL '75	1.00"	I

Date	"precip.	AMC.
10 FEB '76	0.95"	I
13 MAR '76	0.61"	I
18 APR '76	1.24"	I
25 MAY '76	1.12"	I
11 SEP '76	0.75"	I
5 JAN '77	0.54"	I
20 MAY '77	0.85"	I
5 JUL '77	1.39"	I
21 AUG '77	0.73"	I
16 SEP '77	0.64"	I
8 OCT '77	1.04"	I

Date	"precip	AMC.
20 JAN '78	1.16"	II Sno
11 FEB '78	1.19"	II Sno
6 MAR '78	1.78"	II Sno
30 APR '78	1.20"	I
21 JUL '78	0.89"	I
25 OCT '78	0.84"	I
13 NOV '78	2.45"	II Sno
20 DEC '78	1.32"	II Sno
21 MAR '79	1.52"	II Sno
3 APR '79	1.53"	II Sno
15 AUG '79	1.01"	I

Precipitation in eastern Utah: Monthly, annual, and average amounts (in inches and hundredths)—Continued

SPRINGDALE, WASHINGTON COUNTY.—Elevation, 3,981 feet

Year	January	February	March	April	May	June	July	August	September	October	November	December	Annual
1904	0.00	1.30	1.02	0.19	1.05	0.08	1.31	1.46	0.86	0.42	0.00	0.29	7.98
1905	1.45	3.32	1.81	1.23	1.65	.00	.95	1.44	1.92	*.50	2.75	.41	17.43
1906	1.87	.70	5.13	1.38	.45	.20	.83	4.11	.75	.00	1.50	2.66	19.61
1907		1.20	1.33			*.00	.25	1.46	.41	2.62	.10	.17	
1908	1.94	3.14	1.46	.61	1.24	.00	.65	1.57	1.65	1.23	.50	2.04	16.03
1909	3.12	*3.25	1.50	.30	T	.20	3.12	4.27	1.17	.00	1.85	*2.00	20.78
1910	1.59	T	*1.00	*.20	T	.20	.18	1.20	2.60	2.05	2.60	1.30	12.92
1911	2.45	*2.49	2.31	.20	.25	.31	1.31	.56	4.32	.00	.00	.60	14.71
1912	.00	.10	2.51	1.30	.00	.00	1.35			5.30			
1913	.70					.00	1.10	1.15	1.35		1.95	.80	
1914	4.88	1.90				.90	.65	.15	1.35	.00			
1915	3.55	2.46	.14	3.53	1.17	.10	.11	.64	1.09	.16	1.47	1.06	15.48
1916	*3.84	.87	2.94	1.08	.96	.00	3.16	.88	.81	2.38	.00	.73	17.65
1917	.95		.91	5.42	2.13		.30						
1918	*.50	1.17	4.26	.35	T	.00	2.55	1.55	1.16	1.02	.10	2.05	14.71
1919	.02	.72	.05	.55	*.50	.00	2.77	.15	.56	.77	1.53	1.05	8.67
1920	1.40	3.50	3.07	1.70	1.32	.44	.95	1.20	.20	3.16	.35	.75	18.04
1921	2.80	.12	1.39	.83	.73	.00	.74	3.31	.04	2.47	.80	4.67	17.90
1922	1.45	1.13	1.50	1.10	1.10	.43	1.82	5.10	.48	.95	*1.30	2.57	18.93
1923	2.04	.72	1.16	1.55	.10	.30	1.81	1.58	1.39	*.10	*.80	*.10	11.65
1924		.00	1.40			.00		T	.25	.00	.30	1.23	
1925		.30	.70				1.05	2.40	.66	2.07	.61	.40	
1926	T	1.39	.73	5.04	.16	.19	.72	2.78	1.59	.00	2.10	2.01	16.71
1927	.92	5.02	2.40	.40	.18	1.02	.06	2.21	2.99	3.01	.36	1.30	19.87
1928	.40	2.45	1.36	.30	.74	T	.10	.29	.72	.57	1.76	1.06	9.75
1929	.93	1.30	.74	.82	.04	.05	1.15	1.90	3.38	T	.00	.00	10.31
1930	1.72	1.24	1.53	.19	2.32	.63	.62	2.20	1.44	.69	.84	.00	13.42
Average	1.60	1.59	1.69	1.28	.73	.20	1.14	1.74	1.33	1.18	.98	1.22	14.68

Record 1904–6 taken at Rockville, 4 miles southwest of Springdale.

SUNNYSIDE, CARBON COUNTY.—Elevation, 6,700 feet
Sec 21, T14S, R13E, SLB&M.

Year	January	February	March	April	May	June	July	August	September	October	November	December	Annual
1905	*0.60	0.45	3.05	1.01	2.83	0.13	0.64	1.63	4.72	0.20	0.97	0.40	16.63
1906	.75	.40	2.25	4.30	1.52	.20	2.59	1.15	1.83	.47	3.80	.57	19.83
1907	.85	1.20	.26	.78	1.45	1.45	.66	1.97	.40	.55	.80	.80	11.17
1908	.80	1.45	.80	.50	1.74	1.42	.16	1.30	1.60	1.05	1.25	1.00	13.07
1909	2.65	1.45	.80	.69	.61	*.30	1.64	3.13	1.92	T	.17	1.00	14.36
1910	.90	.80	.35	.14	.17	.45	1.46	.42	1.29	2.39	1.18	.95	10.50
1911	2.70	1.42	.91	1.10	1.10	2.19	1.30	.47	3.23	.54	.35	*1.00	16.31
1912			2.45	.50									
1913													
1914											T	.51	
1915	1.54	2.09	1.25	1.49	3.44	1.56	.57	.40	2.12	T	1.48	1.11	17.05
1916	4.08	.79	2.25	.55	T	.00	1.72	2.75	.98	4.24	.20	1.35	18.91
1917	.61	1.70	.55	2.00		.00	2.53						
1918	.10	.65	1.27	.36	.25	.86	2.79	.40	.46	1.04	.73	.27	9.18
1919	.02	.40	.11	.29	.42	.35	.87	.59	1.33	.10	1.90	*.80	7.18
1920	*.75	.80	1.23	1.32	.97	.33	.30	2.41	.50	2.25	.14	.58	11.58
1921	1.73	.30	.16	1.38	.67	.75	1.49	4.01	.35	1.11	.28	1.26	13.50
1922	.67	1.47	.91	.82	1.02	.06	.30	3.20	.64	.46	2.47	.90	12.92
1923	.63	.67	.30	2.17	.70	T	2.51	1.52	1.16	1.53	.29	.50	11.98
1924	.29	.10	.74	T	1.78	T	3.22	1.45	1.75	2.24	.37	1.05	12.99
1925	.15	.51	.40	.57	.33	*2.00	2.63	3.89	2.61	3.40	.49	.38	17.36
1926	.06	.74	.19	1.32	.82	T	.52	.56	.73	.29	.64	1.05	6.92
1927	.42	1.27	1.33	.51	.10	1.46	.58	1.04	5.32	1.54	.53	.33	14.43
1928	.17	.61	.86	T	1.60	.47	.46	1.84	.67	4.39	1.53	.68	13.28
1929	.64	.59	.81	.82	.79	.07	3.79	1.47	3.34	.68	.02	.08	13.10
1930	1.49	.47											
Average	.98	.88	1.01	.98	1.06	.64	1.49	1.70	1.76	1.36	.89	.75	13.50

TEASDALE, WAYNE COUNTY.—Elevation, 7,000 feet

Year	January	February	March	April	May	June	July	August	September	October	November	December	Annual
1893	*0.45	0.90	1.95	0.17	0.26	0.03	1.04	3.66	1.51	T	0.75	0.91	11.63
1894	T	1.05	.82	.20	.35	.65	3.59	1.11	.86	0.04	.00	.37	9.04
1895	.50	.70	.02	.03	1.22	.80	2.29	1.09	.13	1.28	1.25	T	9.31
1896	.35	T	.50	.80	.72	.05	.80	1.02	1.17	.65	.30	.15	6.51
1897	3.80	1.60	1.00										
1899	.10	.15	.21	.29	.02	.91	3.07	1.51	.24	.40	.40	.42	7.72
1900	.20	.00	.32	1.84	.09	.33	.04	.68	1.12	.35	.30	.00	5.27
1901	.30	.67	.40	.45	.63	.20	.44	1.89	T	.06	T	.25	5.29
1902	.80	1.00	1.55	.42	.45	T	.58	.66	.57	.10	2.45	.30	8.88
1903	T	.40	.36	.30	.32	.80	.88	.33	.55	.52	.00	T	4.46
1904	T	.40	.35	1.65		.65	.39						
1905		1.20	.63	.95	.54								
1907							1.00	3.94					
1908	*.68	*.41	.10	.91	.60	.07	1.63	1.77	1.19	*.76	.10	.55	8.77
1909							1.19	3.07	1.75	.00	1.20		
1910					.00	.70	1.04	1.69	1.42	1.68	.91	1.82	
1911	.24	1.75	.46	*.25	.02	1.35	.71	1.12	1.74	.05	.11	1.00	8.81
1912	*.20	1.60	2.97	.29	.58	.06	1.34	.21	.69	2.27	.22	.20	10.63
1913	.20	.70	.20	.20	T			1.90	.86	.00			
1914	*1.05	.20	T	.30	T	.90	2.22	.23	.47	.11	T	.50	5.98
1915	.95	1.42	.61	1.18	1.50	.09	.36	.37	.53	.32	.27	.31	7.94
1916	.93	T	.34	.46	.03	.13	2.13	1.01	.10	4.13	T	.07	9.35
1917	.63	.11	.62	1.65	2.06	T	1.49	*.60	1.72	.00	.00	.00	8.88
1918			.50		.00	1.42	2.22	.73	1.55		.62	1.28	
1919	.05	1.52	.30	.35									
Average	.57	.75	.65	.63	.47	.48	1.35	1.36	.90	.67	.47	.51	8.81

Station located at ranch on Singletree Creek, about 14 miles southeast, in 1893 and 1894; record from 1895 to April 1904 and February 1912 to July 1917, inclusive, at Fish Creek Ranch, about 5 miles southeast; from April 1908 to December 1911 and after July 1917, record made at Teasdale. Station known as Grover from 1895 to April 1904.

Precipitation in eastern Utah: Monthly, annual, and average amounts (in inches and hundredths)—Continued

THOMPSONS, GRAND COUNTY.—Elevation, 5,150 feet

Year	January	February	March	April	May	June	July	August	September	October	November	December	Annual
1911					T	1.07	0.94	0.18	2.26	1.89	0.15	0.35	
1912	0.06	0.42	2.38	1.14	0.54	.15	1.22	.18	T	*2.25	.54	.31	9.19
1913	.18	.98	.26	.05	.03	.80	2.02	*.25	1.36	T	1.54	.59	8.06
1914				T	.03								
1915	.43	.71	.00	.50	1.00	.50	.30	.03	1.40	.00	1.08	1.10	7.05
1916		T	1.83	T	T	.00	.12	.20	.14				
1918	.60	.10	.09	.16					1.05				
1919	.00	.35	.07	.00				.82	.34	.33	1.20	.60	
1920	.47	1.09	1.57	.78	.70	.55	.00	.60	.00	1.85	.65	.60	8.86
1921	.85	.10	.19	1.40	.42	.60	.85	3.47	.00	.67	.50	.77	9.82
1922	.30	.90	1.37	.43	.36	.01	.30	1.37	.72	.10	1.10	.50	7.46
1923	.55	.16	.35	.80	.92	.00	1.70	1.90	1.10	.58	1.20	.56	9.82
1924	.20	.00	.75	.10	1.15	T	.20	.06	1.60	1.30	.10	1.30	6.76
1925	.18	.20	.40	.10	.15	.75	1.36	1.83	1.10	.95	.02	.10	7.14
1926	T	.50	.42	1.00	1.25	.00	1.60	.20	1.32	.70	T	2.10	9.09
1927	*.10	1.37	1.36	.00	.00	.85	.65	1.76	4.88	2.40	.00	.30	13.67
1928	.00	T	.35	.24	1.24	.00	T	1.13	.23	2.43	1.22	1.32	8.16
1929	.99	.90	.32	.42	.30	.10	1.55	1.27	2.15	.35	.40	.08	8.83
1930	2.11	.30	.68	1.62	.69	.10	1.33	1.15	1.43	.00	.73	.00	10.12
Average	.44	.48	.73	.51	.52	.34	.88	.96	1.17	.99	.65	.66	8.33

TROPIC, GARFIELD COUNTY.—Elevation, 7,000 feet

Year	January	February	March	April	May	June	July	August	September	October	November	December	Annual
1889					0.35	0.15	5.25	2.42	0.40	1.10	T	8.50	
1890	1.10	2.40	0.55	0.40	.40	.00	3.30	1.20	1.50	.90	1.15	.80	13.70
1891	T	1.30	.45	1.60	1.10	1.20	1.40	1.50	3.60	.00	.00	1.50	13.05
1892	1.70	1.45	1.40	.10	2.20	T	.50	T	T	1.00	.00	.20	8.55
1893	.90	.30	2.65	T	.40	.00	1.20	4.50	.80	T	.40	1.30	12.45
1894	.30	.40	1.40	T	.03	T	1.00	1.70	.80	.03	*.00	*.40	6.06
1897			1.30	.20	.92	.26			3.77	1.50			
1898	*1.00	.40	T	.88	1.21	.81	.58	.52	T	.00	T	T	5.40
1899	1.40	T	.10	.34	.14	.69	1.50	.55	T	1.34	.38	.18	6.62
1900	.06	T	.22	4.83	.12	.27	.15	.76	3.40	.88	.98	.00	11.67
1901	1.20	4.80	T	.30	.73	T	1.20	1.72	.00	.52	T	*.20	10.67
1902	.30	.49	*2.00	*1.10	.86	.00	.57	1.31	.22	.22	1.93	.46	9.46
1903	T	.95	.32	.74	.53	.87	.59	.20	1.98	.00	.00	T	6.18
1904	T	T	T	T	1.25	.81	.92	2.69	T	T	.00	.10	5.77
1905	.90	2.71	1.25	.70	1.11	T	.83	.10	*2.00	T	4.97	.40	14.97
1906	.67	.70	4.87	1.95	.86	T	2.99	3.64	1.31	T	1.90	2.89	21.78
1907	3.60	.16	.39	1.21	1.33	.67	.34	3.48	.26	2.97	T	.08	14.49
1908	.19	.23	.07	.08	.90	.26	*1.45	1.27	1.36	*1.50	.01	.15	7.47
1909	.15	.25	.12	.01	T	T	.91	5.39	2.45	T	1.79	3.62	14.69
1910	2.40	.14	1.13	.20	.00	1.08	1.04	1.45	3.47	2.18	1.45	.09	14.63
1911	2.88	1.30	.52	*.00	T	.99	1.73	1.00	2.50	.84	*.40	.17	12.33
1912	.30	.30	1.67	1.20	T	.21	1.75	1.28	.00	4.25	.02	.10	11.08
1913	.08	1.70	.40	T	T	.48	1.30	1.38	1.69	.11	1.16	1.60	9.90
1914	2.41	1.20	.48	.97	1.30	*1.05	5.17	.72	.05	.81	*T	.80	14.95
1915	2.59	3.72	T	1.54	1.24	.12	.43	1.22	.84	.00	.92	1.84	14.46
1916	4.92	.39	.61	.34	.13	.00	2.32						
1917		2.00					.39	.89	.00	.00	.00	.00	
1918	.20	.10	1.50	*.35	.00	.15	.93	.00	.10	*.95	.23	T	4.51
1919	.60												
1920				.24	.82						T	.75	
1921	2.11	.50	.94										
1922									T	.71	.54	.90	
1923	.79	.53	.38	1.47	.30	.03	1.18	2.08	.80	*.50	1.00	.50	9.56
1924	.60	T	.95										
1925	T	.39	*.40	*1.00	.00	.64	.71	3.37	3.03	2.21	.78	.19	12.72
1926	T	.94											
1927				.05	.00	.53	2.99	3.59	3.49	.19	.03	1.10	
1928	.00	.60	.35										
Average	1.04	.95	.85	.71	.59	.38	1.49	1.66	1.28	.80	.67	.96	11.38

Record for 1920 at Cannonville, 4 miles south of Tropic; 1889–94 at Losee, 2 miles east of Tropic.

TROUT CREEK RANGER STATION, JUAB COUNTY.—Elevation, 9,200 feet

Year	January	February	March	April	May	June	July	August	September	October	November	December	Annual
1910						0.45	3.05	3.22	1.77	2.85	0.45	0.75	
1911	4.00	2.90				2.01	1.87	.61	1.70	1.57			
1912						1.87	3.16	2.97	1.38	2.28			
1913						2.08	3.24	2.45					
1914						1.87	2.34	3.62	1.40	3.00	.20	.94	
1915						2.24	.79	2.00	3.21	2.90	1.77		
1916						.01	2.12	2.40	.85	4.28	.34		
1917							.90				1.35		
1918							5.01	1.61	2.23	3.16	.50		
1919							2.28	1.56		1.90			
1920							.98	3.03	1.64				
1921							2.13	2.38	1.49				
1922							.19	3.94	.46				
1923							2.79	1.48	2.04	2.81	1.50		
1924							1.23	.61	2.08	2.76			
1925							3.65	2.73	3.65	1.23			
1926						.75	3.49	2.09	2.66	.64			
1927						3.27		3.85	6.41				
1928							1.40	1.30	1.00	8.70			
1929							3.35	4.52	4.07				
1930							3.78	5.62					
Average						1.62	2.39	2.60	2.24	2.93			

About 25 miles northwest of Vernal.

10 NOV '82

MANSHAFT AREA (GEN)

CONSIDERATIONS:

RATIONAL FORMULA

$Q = C i A$ = cfs peak.

Q_A = .45 (.76"/hr) 19.64 ac = 6.72 cfs
Q_B = .45 (.76) 13.16 = 4.50 cfs
Q_C = .55 (.76) 6.43 = 2.69 cfs
Q_D = .80 (.76) 0.68 = 0.41 cfs
Q_E = .80 (.76) 1.55 = 0.94 cfs
Q_F = .95 (.76) 1.02 = 0.74 cfs.

McMATH FORMULA

$Q = A C' i \sqrt[5]{S/A}$ = CFS

Q_A = 19.64 (.45) .76 (530/1.8 ÷ 19.64)$^{.2}$ = 11.54 cfs.
Q_B = 13.16 (.45) .76 (440/1.5 ÷ 13.16)$^{.2}$ = 8.37 cfs
Q_C = 6.43 (.55) .76 (130/.6 ÷ 6.43)$^{.2}$ = 5.43 cfs
Q_D = 0.68 (.80) .76 (39/.25 ÷ 0.68)$^{.2}$ = 1.16 cfs.
Q_E = 1.55 (.80) .76 (69/.6 ÷ 1.55)$^{.2}$ = 2.17 cfs.
Q_F = 1.02 (.95) .76 (4/.5 ÷ 1.02)$^{.2}$ = 1.11 cfs.

CHOW METHOD

$Q = 1.008\, R_e A Z / t_d$ = cfs. where $t_d = t/t_p$ = 1.9/.76 = 2.50.

Q_A = 1.008 (.76) 19.64 (.80) / 2.50 = 4.81 cfs.
Q_B = 1.008 (.76) 13.16 (.75) / 2.50 = 3.02 cfs.
Q_C = 1.008 (.76) 6.43 (.85) / 2.50 = 1.67 cfs
Q_D = 1.008 (.76) 0.68 (.95) / 2.50 = 0.20 cfs.
Q_E = 1.008 (.76) 1.55 (.92) / 2.50 = 0.44 cfs.
Q_F = 1.008 (.76) 1.02 (.98) / 2.50 = 0.31 cfs.

COOK (SCS) METHOD

$Q = (P-.2S)^2 / P+.8S$ = " /12 × A × 43,560/60×60 = CFS. where $S = \frac{1000}{CN} - 10$.

$Q_A = \frac{(1.9-.2\times5.62)^2}{1.9+.8\times5.62}$ = 0.0941"/12 × 19.64 × 43,560/60×60 = 1.86 cfs. where CN = 64
$Q_B = \frac{(1.9-.2\times5.62)^2}{1.9+.8\times5.62}$ = .0941"/12 × 13.16 × 43,560/3600 = 1.25 cfs. where CN = 64
$Q_C = \frac{(1.9-.2\times5.62)^2}{1.9+.8\times5.62}$ = .0941"/12 × 6.43 × 43,560/3600 = 0.61 cfs. where CN = 64
$Q_D = \frac{(1.9-.2\times1.63)^2}{1.9+.8\times1.63}$ = .7732"/12 × 0.68 × 43,560/3600 = 0.53 cfs. where CN = 86
$Q_E = \frac{(1.9-.2\times1.63)^2}{1.9+.8\times1.63}$ = .7732"/12 × 1.55 × 43,560/3600 = 1.21 cfs where CN = 86
$Q_F = \frac{(1.9-.2\times.204)^2}{1.9+.8\times.204}$ = 1.6754"/12 × 1.02 × 43,560/3600 = 1.72 cfs. where CN = 98

NOTE: FOUR (4) METHODS – FOUR (4) DIFFERENT ANSWERS!

WHICH PROVES THAT HYDROLOGY IS NOT AN EXACT SCIENCE SINCE THERE ARE SO MANY VARIABLES (ie. RAIN INTENSITY & DURATION & PATTERN, SOIL CHARACTERISTICS, VEG TYPE & COVER, ETC) THAT SUGGEST DIFFERENT CONSIDERATIONS &/or IDEAS. THEREFORE, ONE MUST USE JUDGEMENT & EVALUATE SITE SPECIFIC CONDITIONS TO PROPERLY DETERMINE A REASONABLE SOLUTION.

J.S. Huefner, P.E.