# CHAPTER 6

# GEOLOGY

CHAPTER 6

Table of Contents

6.1 Scope

6.2 Methodology

6.3 Regional geologic framework

6.4 Project vicinity

6.4.1 Stratigraphy

6.4.2 Structure

6.5 Coal beds and adjacent units

6.5.1 Exploration and drilling

6.5.2 Geology

6.5.4 Columns

6.5.5 Coal reserves

6.5.6 Floor and roof rock

6.6.1 Mining hazards

6.6.2 Surface hazards

6.6.3 Impacts of mining

## 6.1 SCOPE

The geology section of this report describes the general geological conditions of the Co-Op Mining permit area and adjacent areas and identifies whether the conditions are acceptable for recovery of the coal by underground methods. The following major topics are covered: methodology, regional geologic framework, stratigraphy and structure of the project vacinity, extent of coal reserves, coal quality and characteristics, characteristics of the adjacent units, and the geologic hazards and impacts of mining.

## 6.2 METHODOLOGY

The information used in preparing the geology section of this report includes available literature from surrounding mines, and up-to-date mapping and reserve estimates by the Co-Op Mining Company personnel. Physical and chemical analyses were performed in a certified laboratory.

## 6.3 REGIONAL GEOLOGIC FRAMEWORK

The mining site lies at the base of an erosional escarpment that forms the eastern face of the Wasatch Plateau, a subdivision of the Colorado Plateau pysiographic province. East of the Wasatch Plateau is Castle Valley, a relatively

flat area over 80 miles long and 10 miles wide trending northeast-southwest. East of Castle Valley lies the San Rafael Swell, a great upfold marked by rings of hogback hills and intervening valleys.

The Wasatch Plateau is a high, broad, flat area dissected by numerous streams. The high plateaus of Utah, which include the Wasatch Plateau, are thought to be a transition zone containing geologic structures common to both the Colorado Plateau Province and the Basin and Range Province to the west.

The Co-Op Mining Company site is located near the east central edge of what is known as the Wasatch Plateau coal field. The plateau edge is a steep cliff with a maximum relief of about 1,000 ft. Coal outcrops appear in the canyon walls and along the cliffs. Rock types at the site are late Cretaceous in age and are generally composed of gray sandstone of fine to medium grain, interbedded with subordinate gray and dark gray carbonaceous shale and coal seams. These represent continental and/or transitional sediments. Marine sediments occur below the sequence and are exposed to the east of the escarpment in Castle Valley.

Table 6-1 gives the generalized stratigraphic sequence and unit description for the Wasatch Plateau. The oldest rocks

are of early Upper Cretaceous age. The major commercial coal seams occur in the Blackhawk Formation and are of Companion age.

Structurally, strata in the eastern Wasatch Plateau generally dip southerly (sometimes slightly southeast or southwest) at low angles of 1 to 3 degrees. Locally, near faults, the dip increases to about 20 degrees. Three major north-south trrending fault zones have been defined in the Wasatch Plateau Coal Field (see Fig. 6-1). Each zone is the product of a high angle block fault with extensive minor fracturing within the graben. The Joes Valley Fault is the largest zone. As shown in Fig. 6-1, the zone lies several miles west of the Co-Op permit area. The Pleasant Valley Fault Zone is approximately 3 to 5 miles wide. In most areas the fault planes of the Pleasant Valley Zone are vertical with between a few feet to 100 feet displacement (Doelling, 1972), although greater displacement occurs locally. The North Gordon Fault Zone, which occurs near the eastern boundary of the Wasatch Plateau field, is the least extensive of the zones. The trends of the faults have a complex pattern. Displacement is generally less than 800 feet (See Plate 2-1 for a larger scale view of faults within the permit area.)

## 6.4 GEOLOGY OF THE PROJECT VICINITY

Plates 2-3, and 3-1 show the topography of the area. The permit area is generally rugged, with elevations varying from 7,000 to about 10,000 feet above sea level. Slopes within the permit area vary from more than 210% (65 degrees) east of Star Point to less than 4% (2 degrees) on Gentry Ridge.

### 6.4.1 Stratigraphy

All of the geologic formations exposed on or adjacent to the permit area are Cretaceous members of the Mesaverde group, with the exception of the North Horn Formation, which is Tertiary (See Table 6-1 & Figure 6-2). The minable coal seams are located in the Upper Cretaceous Blackhawk Formation.

#### Star Point Sandstone

The Star Point Sandstone, the basal formation of the Meseverde group (Doelling, 1972), is a light-colored, fairly well-sorted marine sandstone of medium to fine grain (Spieker, 1931). North of the Wattis

Canyon area, the Star Point Sandstone divides into three tongues. In the project vicinity, the tongues are essentially fused into one massive cliff-forming unit. The Star Point becomes thicker to the southeast, ranging from 400 to 460 feet near the eastern edge of the lease area to 600 feet or more near the central part of Huntington Canyon (Spieker, 1931).

## Blackhawk Formation

Overlying the Star Point Sandstone is the coal-bearing Blackhawk Formation, the middle division of the Mesaverde group. The Blackhawk consists of alternating sandstone, shale, and coal beds, with thin beds of argillaceous freshwater limestone occurring occasionally. The sequence represents deposition alterations between littoral and lagoonal sediments. The formation is approximately 1,000 feet thick, with the valuable coal seams located within the lower 400 feet (Doelling, 1972).

The sandstone beds are fine to medium-grained (Spieker, 1931) and yellow-gray to tan in color (Doelling, 1972). The sands of the Blackhawk are generally cemented by calcium carbonate or silica, with the exception of a few localized areas in which the cement is almost entirely clay. Iron is also present in the cement of all but the pure white sandstone (Spieker,

1931). An exception to above mentioned sandstone is the Aberdeen Sandstone, a coarse-grained, white sand that is traceable from the northern part of theWasatch Plateau coal field southward to the northwestern slopes of Gentry Mountain (Spieker, 1931). The generally discontinuous nature of the Balckhawk and apparent low specific water yield (Cordova, 1964) indicates that the water yielding capabilities of the Blackhawk are only of local importance.

Three general types of shale, all continental in origin, have been identified in the Blackhawk Formation (Spieker, 1931): ordinary clay shale, carbonaceous shale, and smoke-gray shale. The ordinary clay shale is gray or green, granular, and normally soft at the outcrop; the carbonaceous shale is brown to black, massive, and laminated; and the smoke-gray shale is tough and leathery, and in its unweathered state is hard and homogeneous (Spieker, 1931). Shale acts as an effective barrier to the vertical movement of water within the Blackhawk Formation. Therefore, a significant portion of the water that reaches the Blackhawk probably percolates downward until it reaches a shale layer, which causes horizontal movement to the surface or another "drain" (i.e. sandstone finger) within the formation.

## Castlegate Sandstone

The Castlegate Sandstone, generally considered the basal member of the Price River Formation (Spieker, 1931) consists of massive, highly resistant medium to coarse-grained sandstone beds containing, in places, conglomerate with a matrix of grit (Doelling, 1972). It is thought to be of marine origin (Paul Wier Company, 1977). Although the Castlegate overlies the Blackhawk Formation, it appears barren of coal in the Plateau lease area.

## Price River Formation

The lithologic characteristics of the Price River Formation and the underlying Castlegate Sandstone are similar; however, the Castlegate member is differentiated from the Price River by its cliff-forming characteristic (Spieker, 1931). Like the Castlegate, the Price River Formation consists of medium to coarse-grained sandstone beds with occasional lenses of shale. Although the unit has a high porosity, its apparent low permeability (Cordova, 1964) reduces its water yielding capabilities except through fractures.

## North Horn Formation

The youngest geologic formation within the lease area is the North Horn Formation, which caps the Price River Formation on Gentry Mountain (Doelling, 1972). The North Horn, the lowest member of the Wasatch Group, consists of variegated shales, irregular beds of gray, brown, or cream colored sandstone of various textures, and thin beds of steel-gray and cream colored limestone (Spieker, 1931).

## Surficial Deposits

A few small areas in the eastermost permit area are covered with Quaternary gravel. There are no alluvial deposits within the area to be affected by the mining. Likewise, the permit area is not prone to slides.

### 6.4.2 Structure

Structurally the strata in the Wasatch Plateau generally dip southerly (slightly southeast or southwest) at angles of 1 to 3 degrees. Three major north-south trending fault zones have been defined in the Wasatch

Plateau Coal Field. Each zone is the product of a high block fault with extensive minor fracturing within the graben. The Bear Canyon Mine is located in the Pleasant Valley Fault Zone. The vertical displacement between a few feet and 200 feet plus. A major fault separates the Bear Canyon Mine from the Trail Canyon Mine. (Note: Geotechnical section and the mine map for Bear Canyon are located in the appendix.) Displacement on this particular fault is estimated to be 220 feet. During the mining of the Bear Canyon Seam several minor faults were discovered in the Trail Canyon Mine. These faults may effect the mining of other seams.

## 6.5 GEOLOGY OF THE COAL BEDS AND ADJACENT UNITS

### Stratigraphy

All of the geologic formation exposed on or adjacent to the permit area are Cretaceous members of the Mesaverde group, with the exception of the North Horn Formation, which is Tertiary. The minable coal seams are located in the Upper Cretaceous Blackhalwk Formation.

### 6.5.1 Exploration and Drilling

#### 6.5.1.1 Test Borings

Co-Op has not done any test borings. A request was made to Northwest Carbon for the information from Northwest Carbon concerning drilling North of the permit boundary which would be incorporated into the plan, but the request was not granted.

The applicant respectfully requests that the division supply the applicant with the Utah Geological and Mineral Survey reports referred to in the ACR. See Appendix G1.

### 6.5.2 GEOLOGY

General Stratigraphy

The exposed geologic column, in ascending order, consists of the Mancos Shale, the Star Point Sandstone, the coal-bearing Blackhawk Formation and the Castlegate Sandstone Member of the Price River Formation. All of these geologic units are Cretaceous in age. The Star Point Sandstone through the Price River Formation

composes the Mesaverde Group in this locality.

The Mancos Shale forms the initial steep slopes rising from the washes which in turn is overlain by the initial cliff-forming Star Point Sandstone (".... thick-bedded to massive beds separated by subordinate Mancos-like shale".)[1]

The Blackhawk Formation is composed of alternating sandstones, shales, mudstones and coal representing marine, transitional and terrestrial varieties of sedimentation. Depositional environments of the Blackhawk Formation include littoral, lagoonal, estaurine and swamp type environments. The Blackhawk outcrops to form a step and slope topography slightly less resistant than the Star Point below and the Castlegate above. Multiple coal seams are found within the lower 350 feet of the Blackhawk.

The Castlegate Member of the Price River Formation makes up a massive, resistent cliff-former above the Blackhawk.

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[1] 1972, Central Utah Coal Fields: Sevier-Sanpete, Wasatch Plateau, Book Cliffs and Emery, Monograph Series No. 3, U.G.M.S., H.H. Doelling.

## Structure

The Bear Canyon fault, which is part of the north-south trending Pleasant Valley fault zone, is the only major structural feature in the study area which has any effect on the mineability and continuity of the coal. Displacement on this particular fault is estimated by the author to be 200'+ in the vicinity of Bear Creek Campground on the north side of State Highway 31. The west side of the fault is down relative to the east side. In the vicinity of the Bear Canyon Mine, Section 24, Township 16 South, Range 7 East, the fault is buried by alluvium, however, the fault trace expresses itself in the falls in the NW¼, NW¼ of Section 24, Township 16 South, Range 7 East and displacement at this point is apparently less than five feet. Strata immediately bordering the fault is disturbed and inconsistent in spatial attitude with equivalent strata in the study area east of the Bear Canyon fault. This will no doubt have a limiting effect on the extent to which coal can be mined in the immediate vicinity of the fault. The Bear Canyon fault marks the western boundary of the study area.

Strata east of the fault are nearly horizontal in attitude providing excellent mining conditions.

Coal outcrops slightly lower in elevation in the southern portion of the area than in the northern portion.

Small faults noted in the field along outcrop were interpreted to be largely of non-tectonic origin (e.g. landslide and slump) by the author. Other faults observed did not express displacement of sufficient magnitude to be prohibitive to mining.

Coal

Multiple coal seams are found in the lower 350 feet of the Blackhawk Formation as was previously mentioned. In ascending order the seams are as follows: Hiawatha, Blind Canyon, Bear Canyon and the upper beds,[1] (see Table 1 - following).

None of the coal lies at depths of more than 1,800 in the study area. Depth should not be a limiting factor in mining.

It was noted in the field that strata situated at elevations consistent with the upper beds structual horizon were badly burned and not of economic importance.

| LOWER HUNTINGTON CANYON | FEET |
|---|---|
| Upper beds | 0-6 |
| Interval | 200 |
| Bear Canyon bed | 0-10 |
| Interval | 40-60 |
| Blind Canyon bed | 0-10 |
| Interval | 40-60 |
| Hiawatha | 5-8 |
| Star Point Sandstone | |

Author's Note: Hiawatha to Blind Canyon interval can be as great as 110 feet.

TABLE 1 (AFTER DOELLING, 1972)

The Blind Canyon and Bear Canyon seams were measured and observed at various points in the study area by the author, however, these seams were traceable only locally in Bear Canyon. Limited traceability of these two seams is attributed to the lenticular nature of the seams, the extent of slope debris acting as cover and/or depositional irregularities.[2] H.H. doelling indicates the Bear Canyon seam is present in Left Fork of Fish Creek Canyon (east of Bear Creek Canyon) with a thickness of 6.5 feet, however, this measurement was not verified.[1] Doelling also has a 17.3 foot measurement in the Bear Canyon seam in Bear Canyon that was not verified in the field possibly because this particular exposure has since been covered by slope debris.

A small adit approximately 50 feet in length and interpreted as penetrating the Bear Canyon seam (measurement M-5), and a longer adit approximately 300 feet in length and interpreted as penetrating the Blind Canyon seam (measurement M-7), were discovered in Bear Creek Canyon, Section 24, Township 16 South, Range 7 East. The full extent and history of these workings is not known. The fact that these two seams

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[2] 1931, The Wasatch Plateau Coal Field, Utah, U.S.G.S. Bulletin 819, E.M. Spieker.

are not traceable for any significant area beyond these old workings indicates the subordinate nature of the Bear and Blind Canyon seams.

In the SW¼, SW¼ of Section 24, Township 16 South, Range 7 East the Bear Canyon Mine is located. Two seams were worked there, the upper of which is the Bear Canyon seam (elevation 7,420 feet) and the lower of which is the Hiawatha seam (elevation 7,340 feet). This interpretation is based on the seams stratigraphic position above the Star Point Sandstone. The Blind Canyon seam apparently has pinched out or been replaced in this locality. The mine lies on the west side of the Bear Canyon fault. The presence of the Hiawatha and Bear Canyon seams at the mine lend credence to the author's opinion that these seams are probably present across canyon to the east where they were not traceable nor measurable due to slope cover.

The Hiawatha seam was identified throughout the majority of the study area based on its stratigraphic relationship with the underlying Star Point Sandstone. The Star Point Sandstone is continuous and conspicuous within the area covered by this report. While the Hiawatha seam was not measured in Left Fork of Fish

Creek Canyon by this author or previous investigators (i.e. E.M. Spieker, H.H. Doelling), the presence of the Reichert Mine (Hiawatha seam - after Doelling) in Section 20, Township 16 South, Range 8 East suggests the interstitial presence of the Hiawatha seam in Left Fork. Where identified and measured, the Hiawatha seam achieved mineable thickness in all but one instance (3.3 feet - measurement M-2). However, coal thickness at outcrop is invariably thinner than the subsurface thickness. The Hiawatha seam averages 5.96 feet in thickness in the area inspected. Specific work accomplished is shown on the geologic map (Enclosure 1) and columnar outcrop sections (Figure 2 - following pages).

Well consolidated sandstone forms the roof and floor of the Hiawatha seam in the majority of locations inspected along outcrop. This situation provides excellent mining conditions and high coal recovery percentages as is demonstrated by 90 to 96 percent recovery of the Hiawatha seam at the King Mine approximately five miles NNE of the study area.[1]

Doelling states that "extensive mining under Gentry Mountain (a short distance due north of Bear Creek Canyon) reveals that the Hiawatha is continuous in the anticipated thickness".[1]

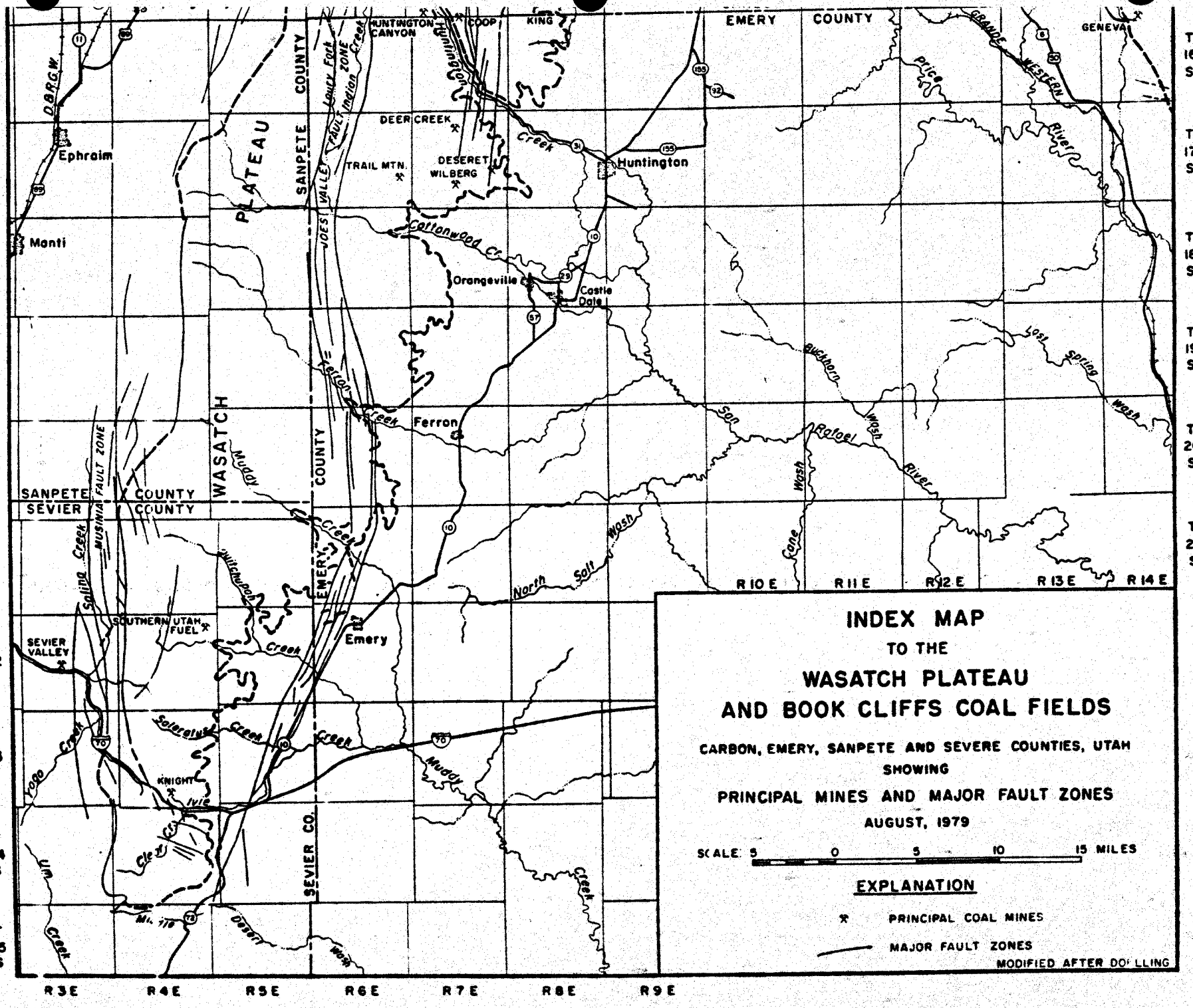
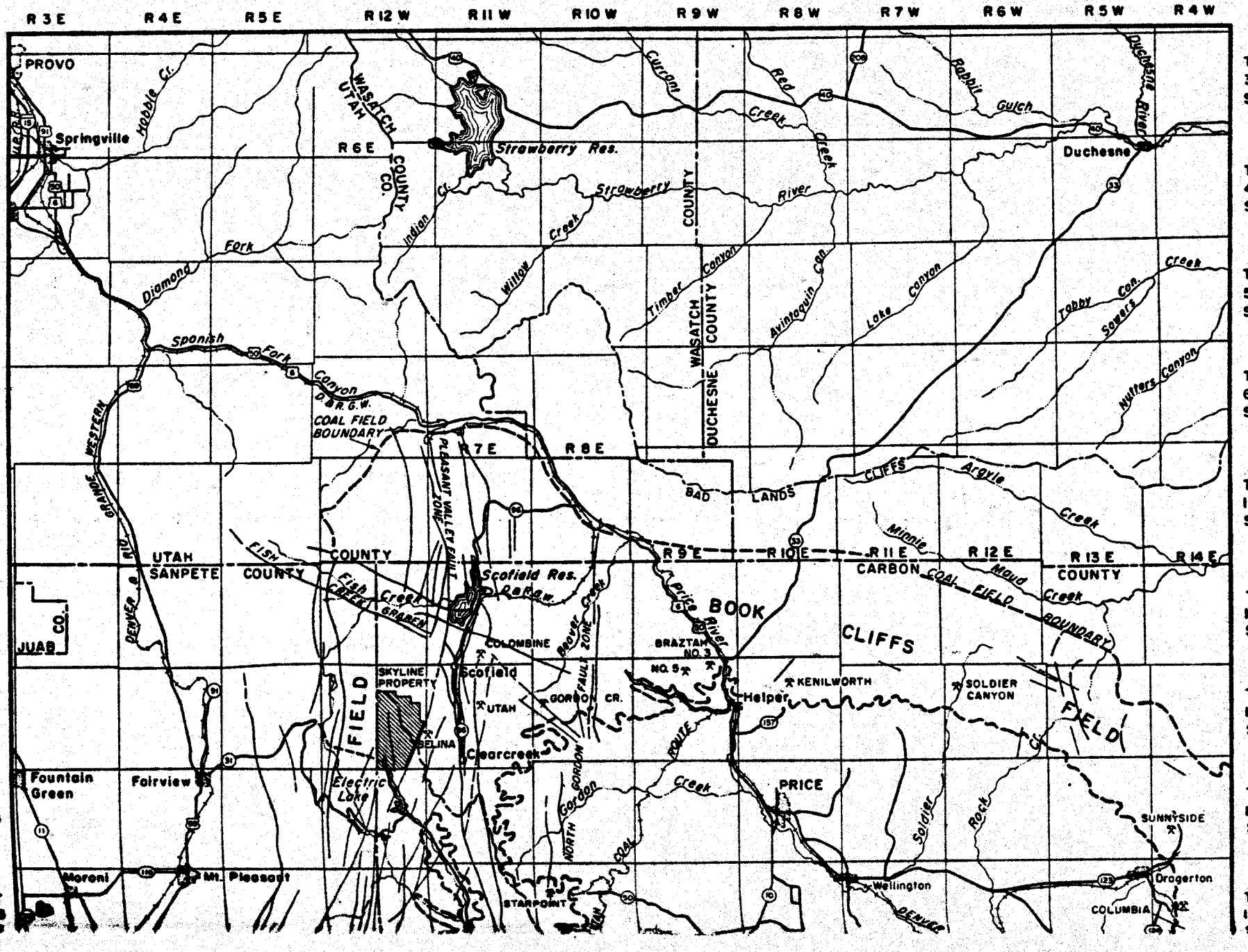

INDEX MAP
TO THE
WASATCH PLATEAU
AND BOOK CLIFFS COAL FIELDS
CARBON, EMERY, SANPETE AND SEVERE COUNTIES, UTAH
SHOWING
PRINCIPAL MINES AND MAJOR FAULT ZONES
AUGUST, 1979
SCALE: 5 0 5 10 15 MILES
EXPLANATION
PRINCIPAL COAL MINES
MAJOR FAULT ZONES
MODIFIED AFTER DOELLING
EMERY COUNTY
SANPETE COUNTY
SEVIER COUNTY
WASATCH PLATEAU
SEVIER CO.
D&RGW
GRANDE WESTERN
Ephraim
Manti
Huntington
Castle Dale
Orangeville
Ferron
Emery
GENEVA
KING
COOP
HUNTINGTON CANYON
DEER CREEK
TRAIL MTN.
DESERET
WILBERG
SOUTHERN UTAH FUEL
SEVIER VALLEY
KNIGHT
JOES VALLEY FAULT ZONE
MUSINIA FAULT ZONE
Lowry Fork
Indian Creek
Huntington Creek
Cottonwood Cr.
Ferron Creek
Muddy Creek
Quitchupah Creek
Saleratus Creek
Saline Creek
Ivie Cr.
Cleveland Cr.
Lost Spring Wash
Buckhorn Wash
San Rafael River
Price River
Cane Wash
North Salt Wash
Desert Wash
Ute Creek
Mill Creek
T 16 S
T 17 S
T 18 S
T 19 S
T 20 S
T 21 S
T 22 S
T 23 S
T 24 S
T 25 S
R 3 E
R 4 E
R 5 E
R 6 E
R 7 E
R 8 E
R 9 E
R 10 E
R 11 E
R 12 E
R 13 E
R 14 E

FIGURE 6-1


R 3 E
R 4 E
R 5 E
R 12 W
R 11 W
R 10 W
R 9 W
R 8 W
R 7 W
R 6 W
R 5 W
R 4 W
T 7 S
T 8 S
T 9 S
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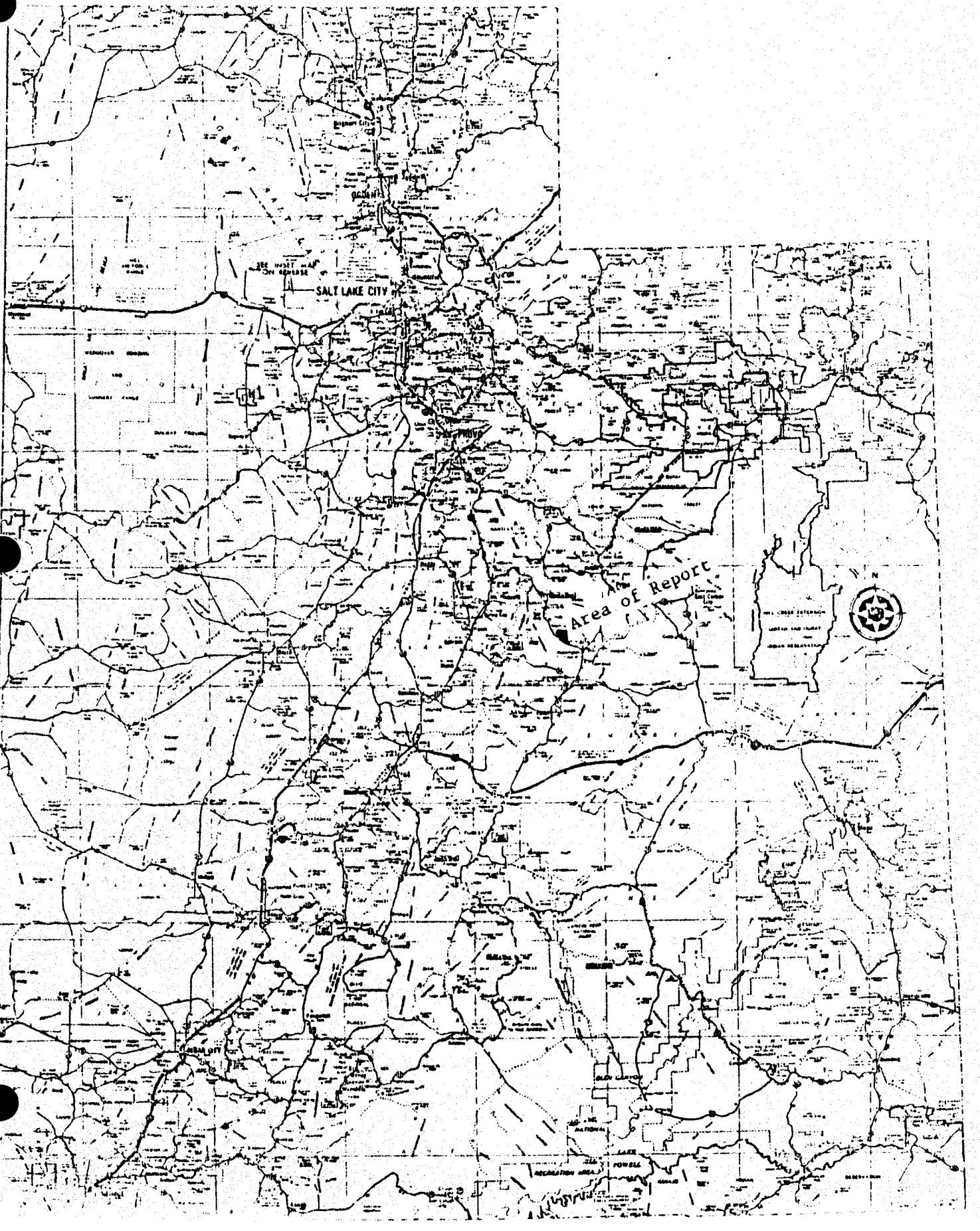
T 11 S
T 12 S
T 13 S
T 14 S
T 15 S
T 3 S
T 4 S
T 5 S
T 6 S
T 11 S
T 12 S
T 13 S
T 14 S
T 15 S
PROVO
Springville
Hobble Cr.
WASATCH COUNTY
UTAH CO.
R 6 E
Strawberry Res.
Current Creek
Red Creek
Rabbit Gulch
Duchesne River
Duchesne
Strawberry River
Indian Cr.
Willow Creek
Diamond Fork
Sponish Fork
Canyon
D. & R. G. W.
COAL FIELD BOUNDARY
WESTERN
GRANDE
RIO
DENVER &
Timber Canyon
Avintaquin Can.
Lake Canyon
Tabby Can.
Sowers Creek
Nutters Canyon
WASATCH COUNTY
DUCHESNE COUNTY
R 7 E
R 8 E
BAD LANDS
CLIFFS
Argyle Creek
Minnie Maud Creek
PLEASANT VALLEY FAULT ZONE
UTAH COUNTY
SANPETE COUNTY
FISH CREEK GRABEN
Fish Creek
Scofield Res.
R 9 E
R 10 E
R 11 E
R 12 E
R 13 E
R 14 E
CARBON COUNTY
COAL FIELD BOUNDARY
BOOK CLIFFS
Price River
Beaver Creek
BEAVER ZONE FAULT
COLOMBINE
BRAZTAN NO. 3
NO. 5
JUAB CO.
SKYLINE PROPERTY
Scofield
UTAH
GORDON CR.
Helper
KENILWORTH
SOLDIER CANYON
FIELD
BELINA
Clearcreek
Electric Lake
Fountain Green
Fairview
NORTH GORDON
COAL
ROUTE
Creek
PRICE
Soldier Rock
SUNNYSIDE
Moroni
Mt. Pleasant
STARPOINT
Wellington
DENVER
Dragerton
COLUMBIA


SALT LAKE CITY
Area of Report
N

6.5.4 Columns and Cross-Sections (Appendix 6-A)

6.5.5 Coal Reserves (See page 1-3)

6.5.5.2 Coal characteristics (App. 6-B)

6.5.6 Coal and rock sample sites (See Plate 2-2)

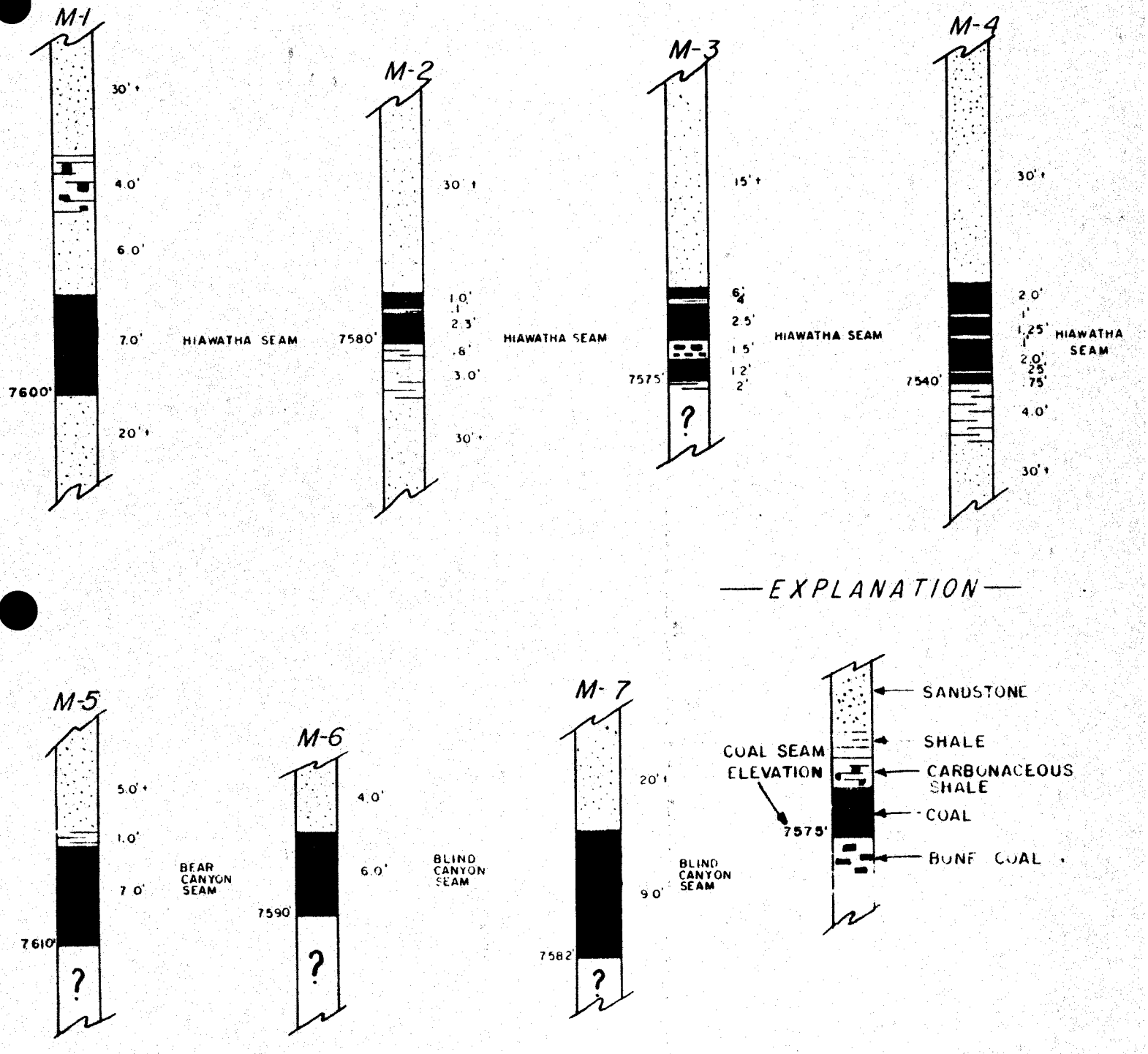
6.5.6.1 Rock characteristics (App. 6.C)

6.6.1 Mining hazards (See Appendix 3-B)

6.6.2 Surface hazards (See Sec. 3.5.8)

6.6.3 Impacts of mining (See Sec. 3.5)

# APPENDIX 6-A

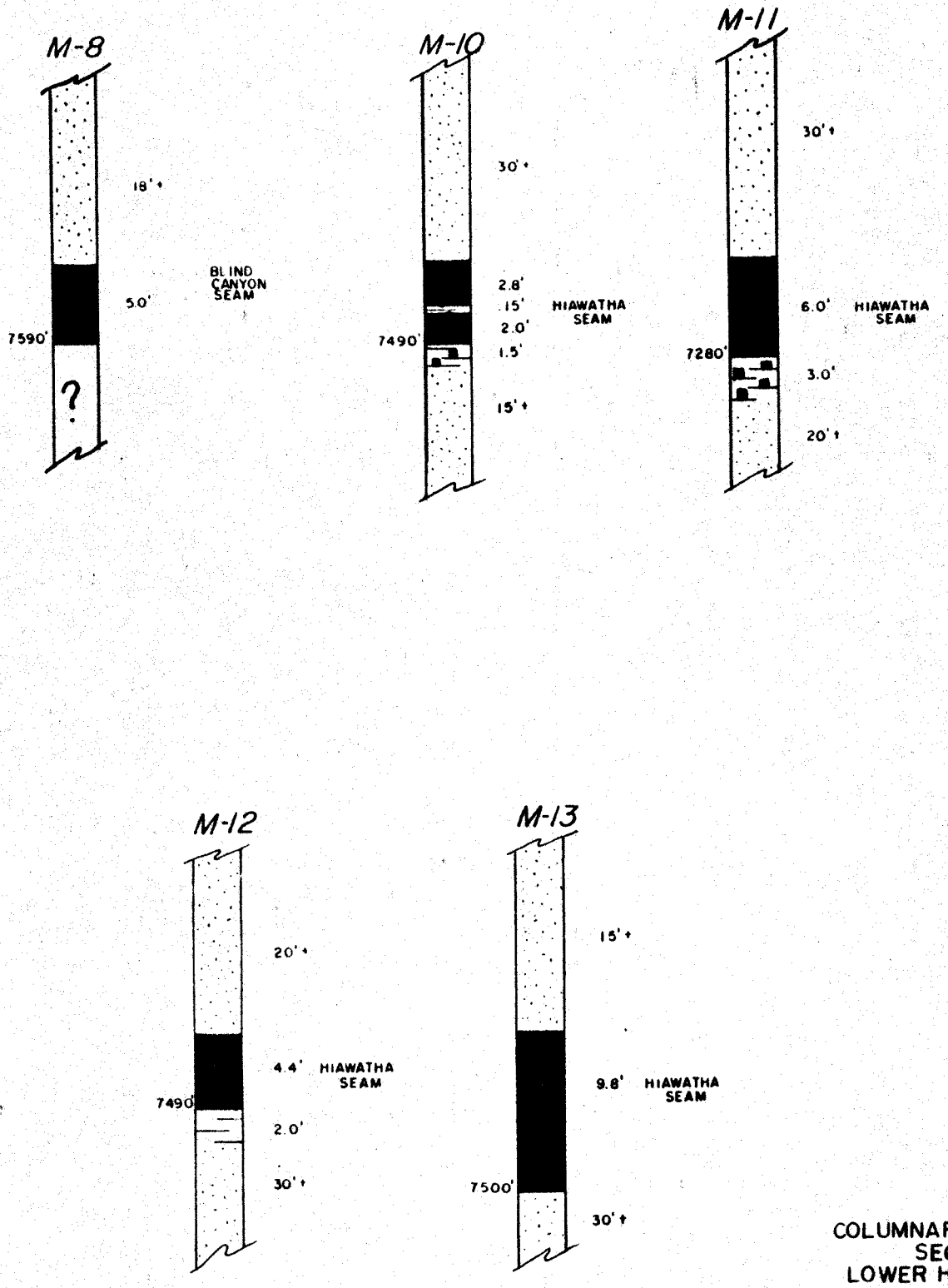



COLUMNAR OUTCROP SECTIONS
LOWER HUNTINGTON CANYON EMERY COUNTY, UTAH



Figure 2

Vertical Scale 1" = 10'

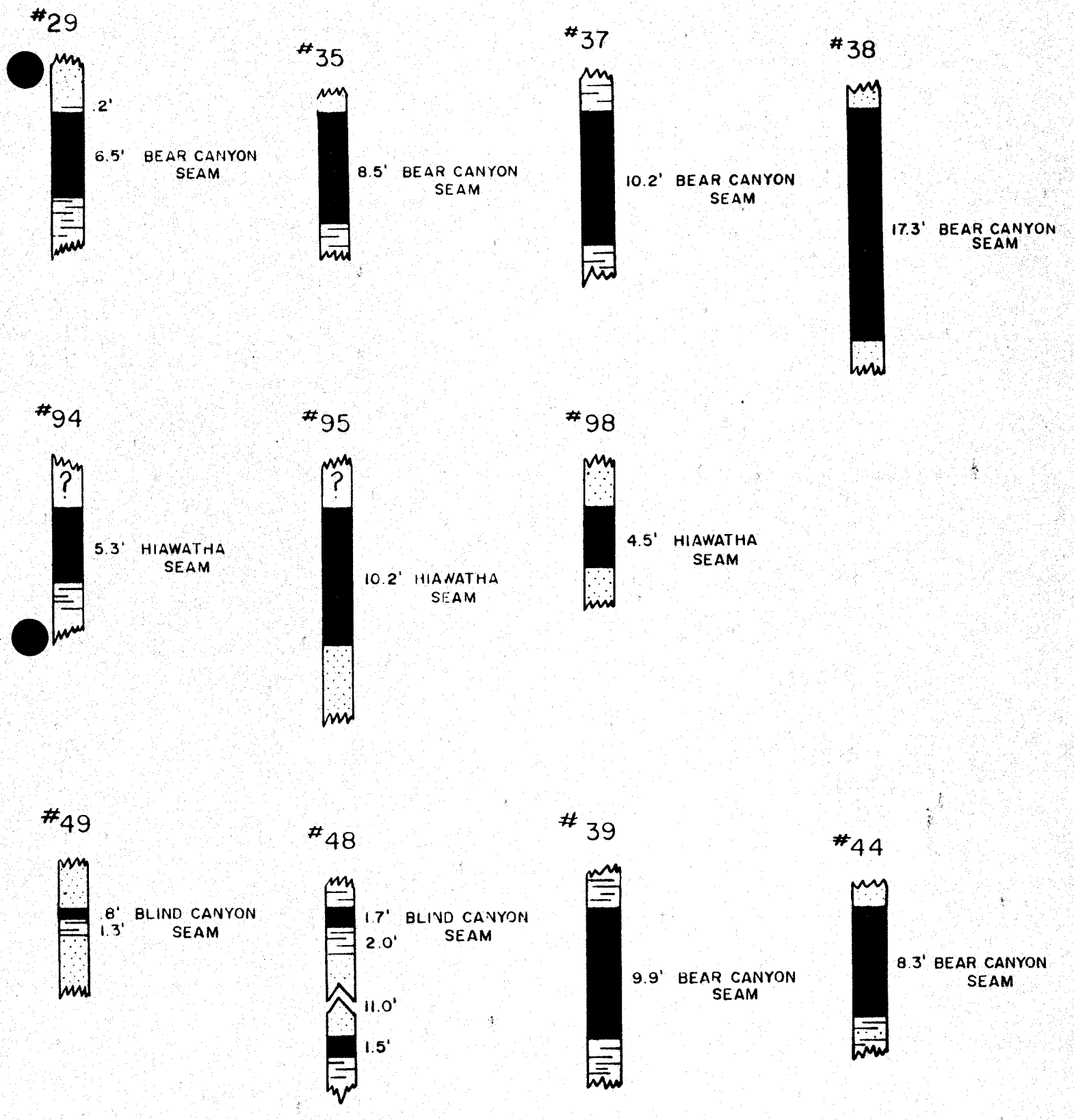



COLUMNAR OUTCROP SECTIONS LOWER HUNTINGTON CANYON EMERY COUNTY, UTAH



Figure 2

Vertical Scale 1"=10'




Vertical Scale 1" = 10'

COLUMNAR OUTCROP SECTIONS
(after Doelling, 1972)
LOWER HUNTINGTON CANYON
EMERY COUNTY, UTAH



Figure 2

| System | Series | Stratigraphic Unit | | Thickness (feet) | Description |
|---|---|---|---|---|---|
| TERTIARY | Eocene | Green River Formation | | – | Chiefly greenish lacustrine shale and siltstone. |
| | | Wasatch Group | Colton Formation | 300-1,500 | Varicolored shale with sandstone and limestone lenses, thickest to the north. |
| | Paleocene | | Flagstaff Limestone | 200-1,500 | Dark yellow-gray to cream limestone, evenly bedded with minor amounts of sandstone, shale and volcanic ash, ledge former. |
| | | | North Horn Formation (Lower Wasatch) | 500-2,500 | Variegated shales with subordinate sandstone, conglomerate and freshwater limestone, thickens to north, slope former. |
| CRETACEOUS | ? | | | | |
| | Maestrichthian | Mesaverde Group | Price River Formation | 600-1,000 | Gray to white gritty sandstone interbedded with subordinate shale and conglomerate, ledge and slope former. |
| | Campanian | | Castlegate Sandstone | 150- 500 | White to gray, coarse-grained often conglomeratic sandstone, cliff former, weathers to shades of brown. |
| | | | Blackhawk Formation *MAJOR COAL SEAMS* | 700-1,000 | Yellow to gray, fine- to medium-grained sandstone, interbedded with subordinate gray and carbonaceous shale, several thick *coal* seams. |
| | | | Star Point Sandstone | 90-1,000 | Yellow-gray massive cliff-forming sandstone, often in several tongues separated by Masuk Shale, thickens westward. |
| | Santonian | Mancos Shale | Masuk Shale | 300-1,300 | Yellow to blue-gray sandy shale, slope former, thick in north and central plateau area, thins southward. |
| | | | Emery Sandstone *COAL (?)* | 50- 800 | Yellow-gray friable sandstone tongue or tongues, cliff former, may contain *coal* (?) in south part of plateau if mapping is correct, thickens to west and south. *Coal* may be present in subsurface to west. |
| | Coniacian | | Blue Gate Member | 1,500-2,400 | Pale blue-gray, nodular and irregularly bedded marine mudstone and siltstone with several arenaceous beds, weathers into low rolling hills and badlands, thickens northerly. |
| | Turonian | | Ferron Sandstone Member *MAJOR COAL SEAMS* | 50- 950 | Alternating yellow-gray sandstone, sandy shale and gray shale with important *coal* beds of Emery coal field, resistant cliff former, thickens to the south. |
| | Cenomanian | | Tununk Shale Member | 400- 650 | Blue-gray to black sandy marine slope forming mudstone. |
| | Albian | Dakota Sandstone *MINOR COAL* | | 0- 60 | Variable assemblages of yellow-gray sandstone, conglomerate shale and *coal*. Beds lenticular and discontinuous. |

Figure 5. Generalized section of rock formations, Wasatch Plateau coal field.

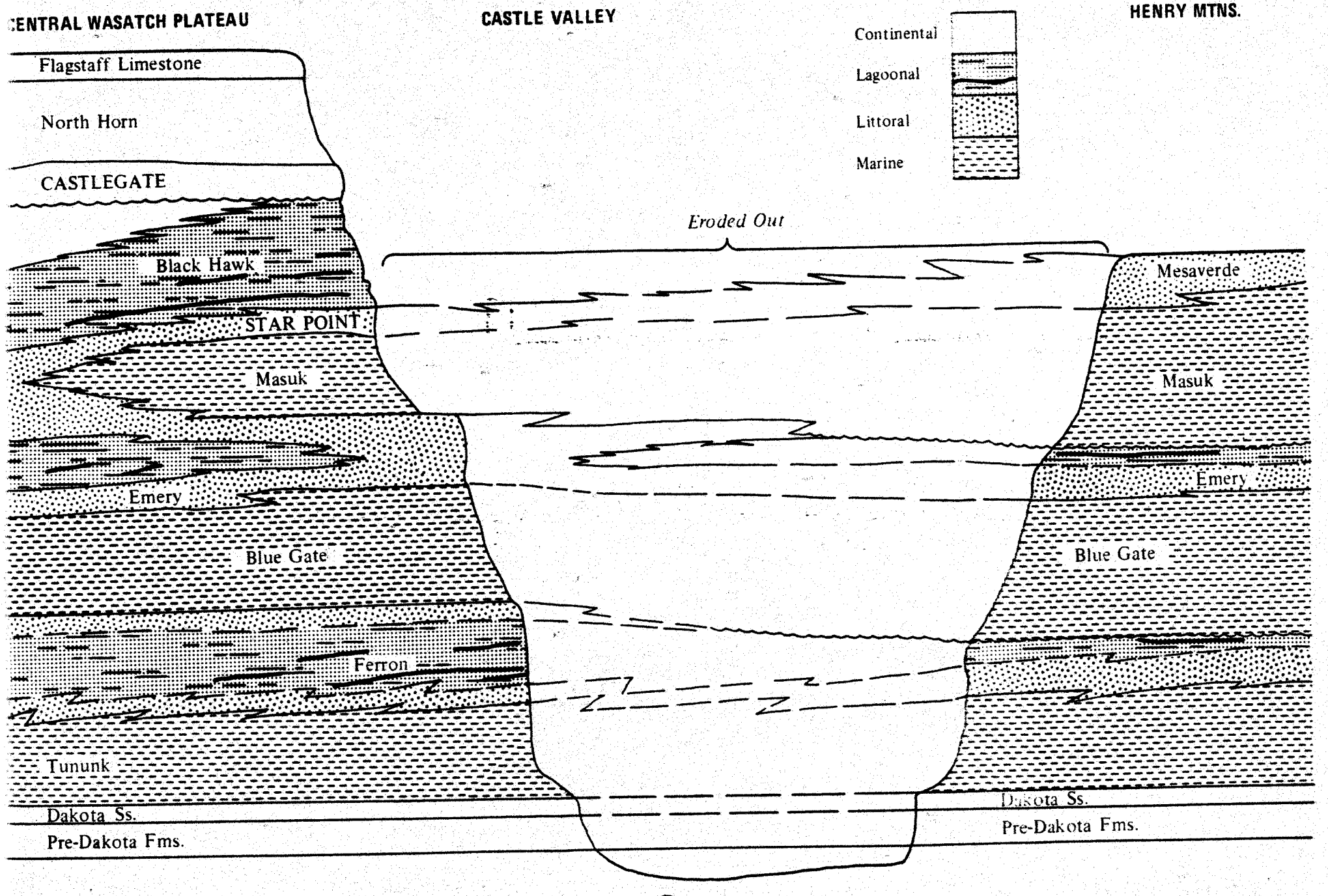



Figure 13. Stratigraphic correlation diagram from Central Wasatch Plateau to the Henry Mountains.

## Blackhawk Formation

The Blackhawk in the Mesaverde Group of the Wasatch Plateau contains important coal seams in the lower half of the formation. The 700- to 1,000-foot unit, less resistant than the units that contain it, consists of alternating slope- and cliff-forming units (figure 6). The cliff-forming sandstones are generally yellow-gray or white-gray on fresh surfaces and weather to shades of tan, yellow or brown. In places they are reddened by the natural burning of nearby coal seams. Sands are fine- to medium-grained and cemented by either calcite or silica. In a few places they are argillaceous. Iron colors the cement. Occasionally the iron has been leached by organic acids from covering swamps and the sandstone is white.

Slopes of the formation are made of various types of shale and coal. The shales, continental in origin, consist of three kinds: clay shale—soft, granular, gray to green in color and the most common; carbonaceous shale in various shades of brown and black; and smoke gray shale usually associated with the coal.

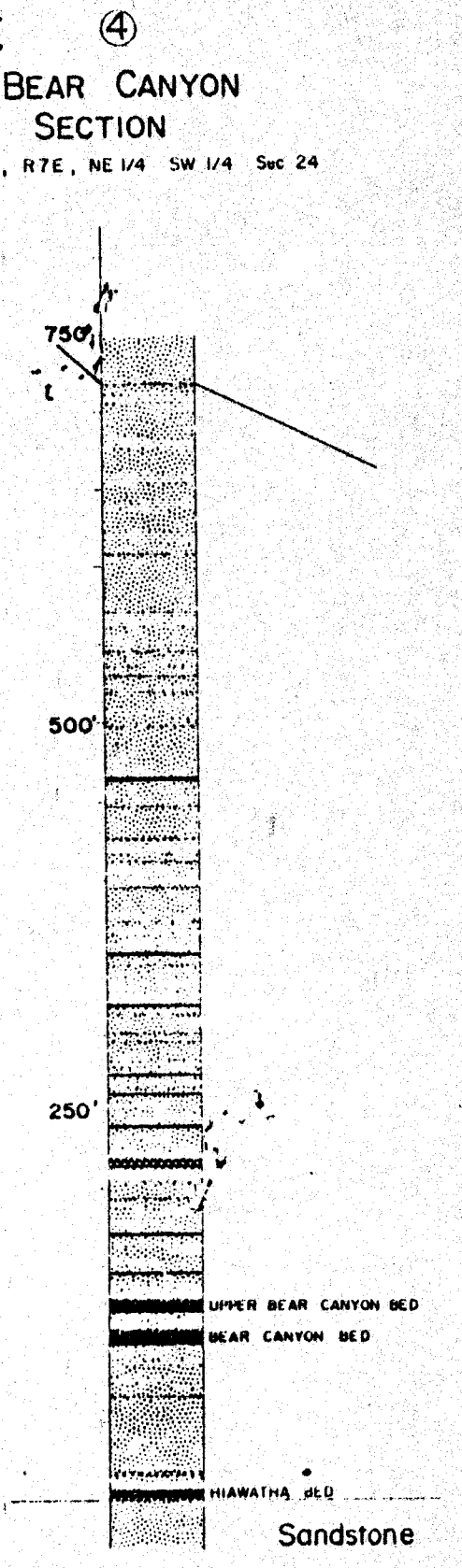
Other strata include friable shaley sandstones, usually thin and platy, that are cemented loosely by calcium carbonate. In some places the rock grades into an impure limestone.

The proportion of shale to sandstone is greater in the north part of the field as compared to the south, but total change in character of the formation is slight. In a section measured by Spieker (1931, p. 30-33) the unit consists of one-third shale and two-thirds sandstone. Key beds are local in extent and each area has its own grouping. An exception is the Aberdeen Sandstone Member. It underlies the Castlegate "A" coal bed and can be traced from the Gordon Creek area southward to Gentry Ridge near Wattis.

The lower contact of the Blackhawk was defined by Spieker (1931, p. 35) as "the clear-cut upper surface of the Star Point Sandstone," but Young (1955, p. 183) redefined the base as the bottom of the Spring Canyon Tongue. Young's work concentrated on the Book Cliffs coal field to the east, but his reports add to the understanding of the Blackhawk in the Wasatch Plateau field. Excerpts from his report follow:

> The redefined Blackhawk formation consists of some prominent littoral marine sandstone tongues and many lesser ones, all projecting eastward into the Mancos, where they lose their identity by grading into shale. Above each of them and below the next succeeding littoral marine sandstone, lagoonal deposits of sandstone, shale and coal were developed behind barrier bars, and where these deposits occur the underlying sandstone is almost everywhere white-capped. . .Division (of six members) is possible only where the basal littoral marine sandstones are developed at the extreme western end of the Book Cliffs at Storrs, Utah (simultaneously the northern end of the Wasatch Plateau field); only the basal sandstones of the Spring Canyon and Aberdeen members are present and between them is about 60 feet of coal-bearing rocks of the Spring Canyon Member. Above the basal sandstone of the Aberdeen Member are about 800 feet of undifferentiated coal measures of the Blackhawk, which are largely lagoonal but may include some inland floodplain deposits in the upper portion.

The commercial coal beds lie in the lower 250 to 350 feet of the formation; some thin units are in the upper part. Two of the more important coal beds are the Hiawatha and Castlegate "A" bed.



# APPENDIX 6-B

r-404

# COMMERCIAL TESTING & ENGINEERING CO.

GENERAL OFFICES: 228 NORTH LA SALLE STREET, CHICAGO, ILLINOIS 60601 · AREA CODE 312 726-8434

WESTERN DIVISION MANAGER
GAIL D. PALMER

SINCE 1908

PLEASE ADDRESS ALL CORRESPONDENCE TO:
224 South Carbon Avenue
Price, Utah 84501
Phone: (801) 637-7540

CO-OP MINING CO
P.O. Box 300
Huntington, Utah 84528

March 2, 1982

Sample identification by
Co-op Mining Co.
#2

| | |
|---|---|
| Kind of sample reported to us | Coal |
| Sample taken at | xxxx |
| Sample taken by | Co-op Mining Co. |
| Date sampled | xxxx |
| Date received | 2-26-82 |

Analysis report no. 57-8990

## SHORT PROXIMATE ANALYSIS

| | As Received | Dry Basis |
|---|---|---|
| % Moisture | 4.70 | xxxxx |
| % Ash | 7.49 | 7.86 |
| Btu/lb | 12937 | 13575 |
| % Sulfur | 0.41 | 0.43 |

| | |
|---|---|
| % Air Dry Loss = | 3.07 |
| Moisture, Ash-free Btu = | 14733 |
| Pounds of SO2 per 10^6 Btu = | 0.63 |
| Moist, Mineral matter free Btu * = | 14088 |
| (Based on as rec'd moisture)* | |
| Pounds of Sulfur per 10^6 Btu = | 0.32 |

JB/dt

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

Jack Blair

JACK D. BLAIR, Manager, Price Laboratory

Original Copy Watermarked
For Your Protection

Charter Member

Sample No. WP-8-75 U.S.G.S. Serial No. D174679

Location Co-op Mine

Face channel Sample

Sec. 22, T. 16 S., R. 7 E.

Seam Bear Canyon Seam Formation Blackhawk

Thickness Sampled 7' Date Sampled May 8, 1975

**Proximate Analysis**

| | AD | AR | Dry | MAF |
|---|---|---|---|---|
| M | 4.4 | 6.1 | | |
| VM | 45.6 | 44.8 | 47.7 | 50.8 |
| FC | 44.1 | 43.3 | 46.2 | 49.2 |
| Ash | 5.9 | 5.8 | 6.1 | |
| Btu/lb. | 13140 | 12910 | 13740 | 14640 |

**Ultimate Analysis**

| | AD | AR | Dry | MAF |
|---|---|---|---|---|
| H | 5.9 | 5.9 | 5.6 | 6.0 |
| C | 72.6 | 71.4 | 76.0 | 80.9 |
| N | 1.3 | 1.3 | 1.4 | 1.5 |
| O | 13.8 | 15.1 | 10.4 | 11.1 |
| S | 0.5 | 0.5 | 0.5 | 0.5 |

| FORMS OF SULFUR: | Sulfate | Pyritic | Organic |
|---|---|---|---|
| As-received | 0.02 | 0.16 | 0.30 |
| Moist.-free | 0.02 | 0.17 | 0.32 |
| M. and ash-free | 0.02 | 0.18 | 0.35 |

Free-swelling index No. 2 1/2

TRACE ELEMENTS BY VARIOUS DETERMINATIONS (Coal as received)

As (ppm) 1 F (ppm) <20 Hg (ppm) 0.03 Sb (ppm) ~~0.1~~ Se (ppm) 1.3

TRACE ELEMENTS, MOSTLY ATOMIC ABSORPTION ON ASH

MgO % 2.33 Cu (ppm) 97 Zn (ppm) 19

$Na_2O$ % 2.96 Li (ppm) 84 Mn (ppm) 200

Ag (ppm) <1 Pb (ppm) 25

DELAYED NEUTRON DETERMINATION OF URANIUM AND THORIUM

ppm Th 5.0247 ppm U

SEMIQUANTITATIVE 6-STEP SPECTROGRAPHIC ANALYSIS OF THE ASH

G=Greater than 10%; N=Not detected; L=Detected, but below limit of determination

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Fe % | 5.0 | Be (ppm) | N | Pb (ppm) | 30 | W (ppm) | N | Ho | N |
| Mg % | 1.5 | Bi | N | Pd | N | Y | 30 | Ta | N |
| Ca % | G | Cd | N | Pt | N | Zn | N | Th | N |
| Ti % | 0.3 | Co | 10 | Sb | N | Zr | 200 | Tl | N |
| Si % | --- | Cr | 70 | Sc | 15 | Ce | N | Yb | 3 |
| Mn (ppm) | 150 | Cu | 70 | Sn | N | Ga | 20 | Zn | N |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| As (ppm) | N | La (ppm) | N | Sr (ppm) | 500 | Ge (ppm) | 20 | Al % | 7.0 |
| Au | N | Mo | 15 | Te | N | Hf | N | Na % | --- |
| B | 1500 | Nb | L20 | U | N | In | N | K % | N |
| Ba | 1500 | Ni | 20 | V | 70 | Li | N | P % | N |

LOOKED FOR ONLY WHEN La OR Ce FOUND:

| | | |
|---|---|---|
| Pr | | Fusibility of ash temp. °F. |
| Nd | | Initial Deform. ------2190 |
| Sm | | Softening ----------2250 |
| Eu | N | Fliud ----------2300 |

Ash Composition

| | | |
|---|---|---|
| AL2O3 -------11.0% | | |
| SO3 ---------~~1.9%~~ | 8.4% | |
| CL ---------<0.10% | | |
| CAO ---------24.0% | | |
| SIO2 --------~~25.0%~~ | 24.0% | |
| P2O5 --------0.74% | | |
| TIO2 --------0.71% | | |
| MnO --------<0.020% | | |
| FE2O3 -------7.6% | | |
| K2O ---------0.17% | | |

% Ash determined gravimetrically ashed at 525° C. -6.8%

## AVERAGE COAL ANALYSES, HIAWATHA NE QUADRANGLE

| | No. Analyses | As-received (percent) | |
|---|---|---|---|
| | | Average | Range |
| **BEAR CANYON BED** | | | |
| Moisture | 6 | 6.8 | 4.5-10.9 |
| Volatile matter | 6 | 43.8 | 37.4-46.0 |
| Fixed carbon | 6 | 45.7 | 44.9-46.0 |
| Ash | 6 | 4.5 | 3.8- 5.8 |
| Sulfur | 6 | 0.53 | 0.5- 0.6 |
| Btu/lb | 6 | 13,014 | 10,840-13,530 |
| **BLIND CANYON BED** | | | |
| Moisture | 10 | 4.8 | 3.8- 5.3 |
| Volatile matter | 9 | 41.7 | 40.2-44.7 |
| Fixed carbon | 9 | 44.3 | 39.2-48.3 |
| Ash | 10 | 8.9 | 5.8-12.4 |
| Sulfur | 8 | 0.58 | 0.5- 0.6 |
| Btu/lb | 9 | 12,492 | 11,700-13,080 |
| **HIAWATHA BED** | | | |
| Moisture | 370 | 5.6 | 0.7 -11.0 |
| Volatile matter | 357 | 42.3 | 36.3 -46.4 |
| Fixed carbon | 357 | 45.7 | 38.3 -52.7 |
| Ash | 359 | 6.2 | 3.3 -11.2 |
| Sulfur | 330 | 0.61 | 0.29- 1.1 |
| Btu/lb | 365 | 12,719 | 11,521-13,600 |

TABLE 2 (AFTER DOELLING, 1972)

# APPENDIX 6-C

# COMMERCIAL TESTING & ENGINEERING CO.

GENERAL OFFICES: 228 NORTH LA SALLE STREET, CHICAGO, ILLINOIS 60601 · AREA CODE 312 726-8434

WESTERN DIVISION MANAGER
LLOYD W. TAYLOR, JR.

SINCE 1908

PLEASE ADDRESS ALL CORRESPONDENCE TO:
10775 EAST 51st AVE., DENVER, COLO. 80239
OFFICE TEL. (303) 373-4772

CO-OP MINING COMPANY
Box No. 300
Huntington, Utah 84528

June 25, 1979

Sample identification by

Kind of sample reported to us: Floor Rock

Sample taken at: xxxxx

Sample taken by: CO-OP Mining Co.

Date sampled: xxxxx

Date received: 5-24-79

CO-OP Mining Co.

Sample No. 57-2162 (CT&E Helper)
CO-OP Mine No. 2
Huntington Canyon

Analysis report no. 72-82660

## SOIL ANALYSIS

| | |
|---|---|
| pH | 8.4 |
| Sodium | 5.4 |
| Calcium | .61 |
| Mangesium | 4.4 |
| Sodium Adsorption Ratio | 6.4 |
| Pyrite (as S-$CaCO_3$ eq t/1000T | 0.0 |
| Sand % | 65 |
| Silt % | 26 |
| Clay % | 9 |

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

Gail D Palmer

G. D. PALMER, Manager, Denver Laboratory

GDP/vt

Original Copy Watermarked For Your Protection

Charter Member

F-404

# COMMERCIAL TESTING & ENGINEERING CO.

GENERAL OFFICES: 228 NORTH LA SALLE STREET, CHICAGO, ILLINOIS 60601 · AREA CODE 312 726-8434

WESTERN DIVISION MANAGER
LLOYD W. TAYLOR, JR.

PLEASE ADDRESS ALL CORRESPONDENCE TO
10775 EAST 51st AVE., DENVER, COLO. 80239
OFFICE TEL. (303) 373-4772

SINCE 1908

CO-OP MINING COMPANY
Box No. 300
Huntington, Utah

June 25, 1979

Sample identification by

Ben Lyon
Sam

| | | |
|---|---|---|
| Kind of sample reported to us | Roof Rock | CO-OP Mining Co. |
| Sample taken at | xxxxx | Sample No. 57-2163 (CT&E Helper)<br>CO-OP Mine No. 2<br>Huntington Canyon |
| Sample taken by | CO-OP Mining Co. | |
| Date sampled | xxxxx | |
| Date received | 5-24-79 | |

Analysis report no. 72-82661

## SOIL ANALYSIS

| | |
|---|---|
| pH | 8.7 |
| Sodium | 12.5 |
| Calcium | .34 |
| Magnesium | .76 |
| Sodium Adsorption Ratio | 16.9 |
| Pyrite (as S-$CaCO_3$ eq t/1000T) | 0.0 |
| Sand % | |
| Silt % | |
| Clay % | |

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

Gail D. Palmer

G. D. PALMER, Manager, Denver Laboratory

GDP/vt

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Charter Member

H/C
4-27-84

# SECTION 7

# HYDROLOGY

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OIL, GAS & MINING

## SCOPE AND INVESTIGATIONS

The purpose of this section is to provide background information on the hydrogeology characteristics of the Co-Op Mining Company's Bear Canyon Mine permit area and the surrounding regional area. Also to present a plan of action for complying with the requirements of the Office of Surface Mining (OSM) and the Utah Division of Oil, Gas and Mining (DOGM). In particular, this section includes an evaluation of the geological and hydrological setting of the mine, its relation to the regional ground water and surface water hydrology and its probable impact on the groundwater and surface water systems.

Information gained from field reconnaissance and a review of data from various sources was used in compiling this section. The data sources included information from the Co-Op Mining Company, reports by the U. S. Geological Survey, Utah Geological and Mineral Survey, U. S. Forest Service and mine application permits on file with OSM (specifically those in the Huntington Canyon area).

## 7.1 GROUNDWATER HYDROLOGY

### 7.1.1 REGIONAL AREA

The Bear Canyon Mine is part of the Wasatch Plateau coal field which in turn is part of the High Plateaus area of the Upper Colorado River Region. Available data on groundwater resources for this area is rather scarce. Most of the water supply development has been limited almost entirely to surface water. In general, what records are available are the result of information gathering on specific problems, mostly gas and oil wells, rather than as part of a continuous data-gathering program. Previous experiences at local area mines are the best data sources.

The Wasatch Plateau has been characterized as a groundwater recharge area. The high elevations with the resulting large snowfalls combine with the generally flat profile of the plateau in enhancing infiltration of water. Despite this, practically all precipitation is consumed at or near the place of fall by sublimation and evapo-transpiration or becomes overland run-off. The water that does infiltrate into the ground generally discharges within a short distance as springs or seeps. Only about 4 percent of precipitation is estimated to become groundwater recharge (Price and Arhow,'74).

The groundwater yield from the Wasatch Plateau strata is usually very low. For the most part, the strata consist of consolidated and semi--consolidated sedimentary rock which have low hydraulic conductivities and specific yields between .2 and 2.0 percent. Yields to individual wells are generally less than 50 gpm. Higher yields might be available

from the Star Point Sandstone stratum or from local perched water zones. Ordinarily, however, perched water bodies could not sustain large perennial yields (Price and Waddell,'73).

### 7.1.2 MINE PLAN AND ADJACENT AREAS

Groundwater for the area seems to be derived from snowmelt. The recharge occurs on the plateau top with the snowmelt infiltrating the strata through faults and rock fractures. In order to determine the source of recharge; samples of water from rain, snow, springs, seeps and mines were analyzed for concentrations of deuterium. The results of the analyses showed that deuterium concentrations were similar in snow, spring and mine water but were different in rain water (snow and spring values: -120 to -154, rain values: -54 to -85; Danielson,'81). See Table 7-1.

Recharge for the Bear Canyon area comes from water percolation and infiltration on Gentry Mountain and Ridge. The downward vertical movement of water is commonly impeded by low permeability beds of shale and mudstone in the North Horn, Price River, and Blackhawk Formations. Much of the recharge from snowmelt in the higher parts of the region is discharged by a large number of springs close to the original recharge areas. The water is discharged by springs and seeps where the low permeability rocks outcrop at the land surface, particularly along the sides of the many deep canyons' walls.

Groundwater generally moves from areas of recharge in the higher parts of the region in a southerly direction to areas of discharges.

TABLE 7–1

--Concentrations of deuterium in rain, snow, spring waters, and waters in mines
[Analyses by Centre D'Etudes Nucleaires de Saclay, France]

Location: See explanation of data-site-numbering system in text, plate 1, and figure 16.
Source: 1, rain; 2, snow; 3, spring water; 4, Wilberg Mine water; 5, Deer Creek Mine water.
Date: As shown except for source 1, accumulated rain June-October 1978; source 2, core of accumulated snow October 1978-May 1979.
Altitude: In feet above National Geodetic Vertical Datum of 1929.
Value: Value = $\frac{(D/H)\ \text{sample} - (D/H)\ \text{SMOW}}{(D/H)\ \text{SMOW}} \times 1{,}000$;

where

H = hydrogen content,
D = deuterium content, and
SMOW = Standard Mean Ocean Water (Craig, 1961).

| Location | Source | Date | Altitude | Value | Location | Source | Date | Altitude | Value |
|---|---|---|---|---|---|---|---|---|---|
| (D-14-6)7cbb | 2 | – | 8,520 | –147.1 | (D-16-7)35abc-S1 | 3 | 8- 9-79 | 6,620 | –123.2 |
| 13cdb | 2 | – | 8,520 | –147.1 | (D-16-8)5bac-S1 | 3 | 5-16-79 | 8,400 | –120.8 |
| 14daa | 1 | – | 8,350 | –84.5 | (D-17-6)11cdc | 2 | – | 8,100 | –141.7 |
| 21dca | 2 | – | 9,020 | –121.2 | 23aaa-S1 | 3 | 8- 9-79 | 7,766 | –127.6 |
| 28abc | 1 | – | 8,860 | –84.3 | 25bdd | 1 | – | 7,280 | –54.4 |
| (D-15-6)13dad-S1 | 3 | 8-23-79 | 8,320 | –129.9 | (D-17-7)5cad-S1 | 3 | 5-16-79 | 9,320 | –153.7 |
| (D-15-7)5dbb | 2 | – | 8,020 | –140.3 | 10cbd | 5 | 8- 2-79 | – | –125.8 |
| 29dca | 2 | – | 7,520 | –125.5 | 10ccb | 5 | 8- 2-79 | – | –122.5 |
| 34cdd-S1 | 3 | 8-22-79 | 8,000 | –125.9 | 16aad | 5 | 8- 2-79 | – | |
| 34dac | 2 | – | 8,000 | –122.8 | 16cdd | 5 | 8- 2-79 | – | –123.2 |
| 35cbc-S1 | 3 | 8- 4-78 | 8,010 | –126.7 | 18abb-S1 | 3 | 8- 8-79 | 8,980 | –125.1 |
| 35dba | 2 | – | 9,060 | –145.8 | 18dcd-S1 | 3 | 8- 8-79 | 8,960 | –125.7 |
| (D-16-5)16ddb | 2 | – | 9,820 | –148.0 | 20cca | 4 | 7- 5-79 | – | –121.6 |
| (D-16-6)1aca-S1 | 3 | 11- 8-78 | 8,320 | –125.5 | 20ccb | 4 | 7- 5-79 | – | –122.7 |
| | 3 | 7-19-79 | 8,320 | –124.9 | 20dcc | 4 | 7- 5-79 | – | –122.2 |
| 23cad | 2 | – | 10,200 | –145.2 | 21aab | 5 | 8- 2-79 | – | –123.2 |
| 27aaa | 2 | – | 9,250 | –137.0 | 21bad | 5 | 8-30-78 | – | –123.7 |
| 27adb | 1 | – | 9,120 | –77.8 | 21cbc | 4 | 7- 5-79 | – | –122.2 |
| (D-16-7)9cbd-S1 | 3 | 10-13-78 | 7,600 | –124.7 | 21dbd | 5 | 8- 2-79 | – | –122.5 |
| | 3 | 8- 3-79 | 7,600 | –124.1 | 21dda | 4 | 8-30-78 | – | –123.8 |
| 13bac-S1 | 3 | 5-16-79 | 9,180 | –119.8 | 22abd | 5 | 8- 2-79 | – | –122.3 |
| 17ccb-S1 | 3 | 9- 5-78 | 8,060 | –122.5 | 22cab | 4 | 7- 5-79 | – | –121.8 |
| 21bbb-S1 | 3 | 9- 5-78 | 7,600 | –124.8 | 22ccb | 4 | 8-30-78 | – | –122.1 |
| 22bbb-S1 | 3 | 9- 7-78 | 7,220 | –127.9 | 22cdc | 4 | 7- 5-79 | – | –121.7 |
| 23ccb | 2 | – | 7,020 | –136.6 | 27bac | 4 | 7- 5-79 | – | –123.1 |
| 26adc-S1 | 3 | 5-11-79 | 7,120 | –124.0 | | 4 | 7- 5-79 | – | –122.3 |
| 26bca-S1 | 3 | 8- 9-79 | 6,860 | –125.5 | 28abc | 4 | 8-30-78 | – | –122.2 |
| 28cba | 2 | – | 7,680 | –123.7 | 28bad | 4 | 7- 5-79 | – | –121.9 |

Except where folded, the regional dip of rocks in the area generally is in a southerly direction at angles that rarely exceed 4 degrees (Danielson,'81). Most of the horizontal movement of groundwater of any significant distance is in the Star Point-Blackhawk aquifer. The Star Point formation seems to be the limit of vertical movement for local groundwater because of the impermeability and thickness of the underlying Mancos shale.

The rate of groundwater moves varies greatly throughout the area as pointed out below.

> "The rate at which water moves through the groundwater system depends largely on the permeability of the rock through which water flows. It may take only a few days for water to flow through solution cavities in the Flagstaff Limestone from recharge area to discharge point; it may take years for water to travel the same distance through the less permeable Blackhawk Formation. Six water samples from the Star Point-Blackhawk aquifer were collected in 1979 from seepage areas...and from springs... All six samples contained detectable concentration of tritium, indicating that at least some of the water had been recharged to the system within the past 10 to 30 years.
>
> Rapid movement of water through the groundwater system is indicated by the rapid response of spring discharge to changes in recharge. Generally, prior to construction of Electric Lake in 1972, most of the discharge of Huntington Creek during the fall of each year was derived from groundwater discharge. The magnitude of base flow at gaging station 09328000 during November correlates well with the water content of the previous April 1 snowpack; it reflects a rapid response in base flow to melting of the snow and resulting groundwater recharge." (Danielson,'81)

The relative imperviousness of most of the rock strata of the area inhibits groundwater movement, what rapid movement there is is along fault lines and through fractured rock.

## 7.1.2.1 MINE PLAN AQUIFERS

The only regionally recharged aquifer in the mine plan or adjacent areas is the Star Point-Blackhawk aquifer. This aquifer is the source for the Bear Canyon Spring and most of the large perennial springs in the vicinity. According to Mr. Bruce N. Kaliser, State Hydrologist (see Appendix 7-A), what is happening with the aquifer in the vicinity of the mine is "...to the north where principally the snow accumulates on Gentry Mountain, there is a recharge that is vertical down to the water table through the Blackhawk, and there is a recharge also from those channels which are from those drainages which are lying along the joint and fault bed. That vertical migration then reaches the Star Point and travels laterally along shear zones, prominent joint or faults and emerges where topography dissects the formation. I think all this is happening well below the mine."

Mr. Kaliser also mentioned, "I don't believe that at that locality (Bear Canyon Mine) there is precipitation recharging the aquifer, and so I am of the opinion that the mining operation will not affect the discharge on the spring (Bear Canyon Spring)."

The water in the aquifer is mainly used indirectly where it is the supply source for numerous springs. Groundwater development for the whole region is very low, with most water development being associated with surface water.

Other than Star Point, any aquifers in the mine plan area would be local perched water zones. Recharge available to any perched zone would be limited because of the topography and stratum geology of the area. The majority of water movement in the region is through faults and fractures, "But in entering the mine that Co-Op will be going into, it appears that faults evident in that mine underground are tight..." (Kaliser,'80), again limiting the amount of water available to any perched water zones present.

### 7.1.2.2 QUALITY AND QUANTITY OF GROUNDWATER

In 1981 the U. S. Geological Survey conducted a hydrological study of the upper drainages of the Huntington and Cottonwood Creeks (W.R.I. Open-file Report 81-539, Danielson). As part of this study spring water from various geological stratum units in the region were measured, sampled and analyzed. A summary of the results are shown in Table 7-2. Figure 7-1 shows the relationships of the formations.

It should be noted that none of the formations yielded a total dissolved solids higher than 750 mg/l and anything less than 1,000 mg/l T.D.S. is considered fresh water. Table 7-3 shows the comparison between the results of a chemical analysis (Danielson) done on Bear Canyon Spring and Federal and State water standards. It should be noted that the spring was within standards for all parameters measured.

Only a very small amount of groundwater quality information is available for the Bear Canyon Mine Vicinity. As part of the above mentioned study, field measurements and chemical analysis were performed on

TABLE 7-2

Summary of chemical characteristics of spring waters from different water-bearing zones in and adjacent to the upper drainages of Huntington and Cottonwood Creeks

| | pH (units) | Temperature (°C) | Milligrams per liter | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Dissolved calcium | Dissolved magnesium | Dissolved sodium | Dissolved potassium | Dissolved chloride | Dissolved sulfate | Dissolved solids | Bicarbonate |
| **North Horn Formation** | | | | | | | | | | |
| No. Samples | 51 | 51 | 51 | 51 | 51 | 51 | 51 | 51 | 43 | 51 |
| Mean | 7.5 | 6.3 | 61 | 29 | 19 | .9 | 9.8 | 32 | 290 | 320 |
| Minimum | 6.3 | .1 | 15 | 2.0 | 1.2 | .2 | 1.2 | 2.1 | 63 | 49 |
| Maximum | 8.5 | 17.0 | 100 | 63 | 94 | 1.9 | 54 | 180 | 633 | 500 |
| **Price River Formation** | | | | | | | | | | |
| No. Samples | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 17 | 18 |
| Mean | 7.5 | 6.3 | 63 | 18 | 5.7 | 1.3 | 5.1 | 23 | 220 | 260 |
| Minimum | 6.5 | 3.8 | 12 | 2.9 | 1.4 | .4 | 1.5 | 3.7 | 50 | 39 |
| Maximum | 8.2 | 16.0 | 87 | 51 | 39 | 3.4 | 18 | 120 | 524 | 427 |
| **Castlegate Sandstone** | | | | | | | | | | |
| No. Samples | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| Mean | 7.5 | 5.6 | 60 | 29 | 7.1 | 1.3 | 5.6 | 33 | 290 | 300 |
| Minimum | 7.1 | 2.2 | 41 | 14 | 2.1 | .9 | 3.6 | 4.0 | 163 | 183 |
| Maximum | 8.1 | 7.5 | 79 | 41 | 23 | 2.4 | 14 | 110 | 385 | 370 |
| **Blackhawk Formation** | | | | | | | | | | |
| No. Samples | 31 | 31 | 31 | 31 | 31 | 31 | 31 | 31 | 30 | 31 |
| Mean | 7.4 | 6.1 | 57 | 19 | 4.1 | 1.1 | 4.3 | 21 | 220 | 250 |
| Minimum | 6.3 | .1 | 15 | 2.0 | 1.2 | .2 | 1.2 | 2.1 | 53 | 49 |
| Maximum | 8.1 | 13.0 | 98 | 52 | 16 | 3.5 | 16 | 120 | 539 | 460 |
| **Star Point Sandstone** | | | | | | | | | | |
| No. Samples | 19 | 19 | 19 | 19 | 19 | 19 | 19 | 19 | 18 | 19 |
| Mean | 7.3 | 6.6 | 75 | 40 | 8.0 | 2.0 | 6.9 | 77 | 370 | 350 |
| Minimum | 6.8 | 2.8 | 48 | 3.0 | .1 | .9 | 2.7 | 13 | 213 | 244 |
| Maximum | 8.4 | 11.0 | 120 | 89 | 26 | 4.9 | 27 | 300 | 750 | 427 |
| **All Units** | | | | | | | | | | |
| No. Samples | 128 | 128 | 128 | 128 | 128 | 128 | 128 | 128 | 132 | 128 |
| Mean | 7.5 | 6.3 | 62 | 27 | 11.0 | 1.2 | 7.1 | 34 | 295 | 300 |
| Minimum | 6.3 | .1 | 12 | 2.0 | .1 | .2 | 1.2 | 2.1 | 50 | 39 |
| Maximum | 8.5 | 17.0 | 120 | 89 | 94 | 4.9 | 54 | 300 | 750 | 500 |

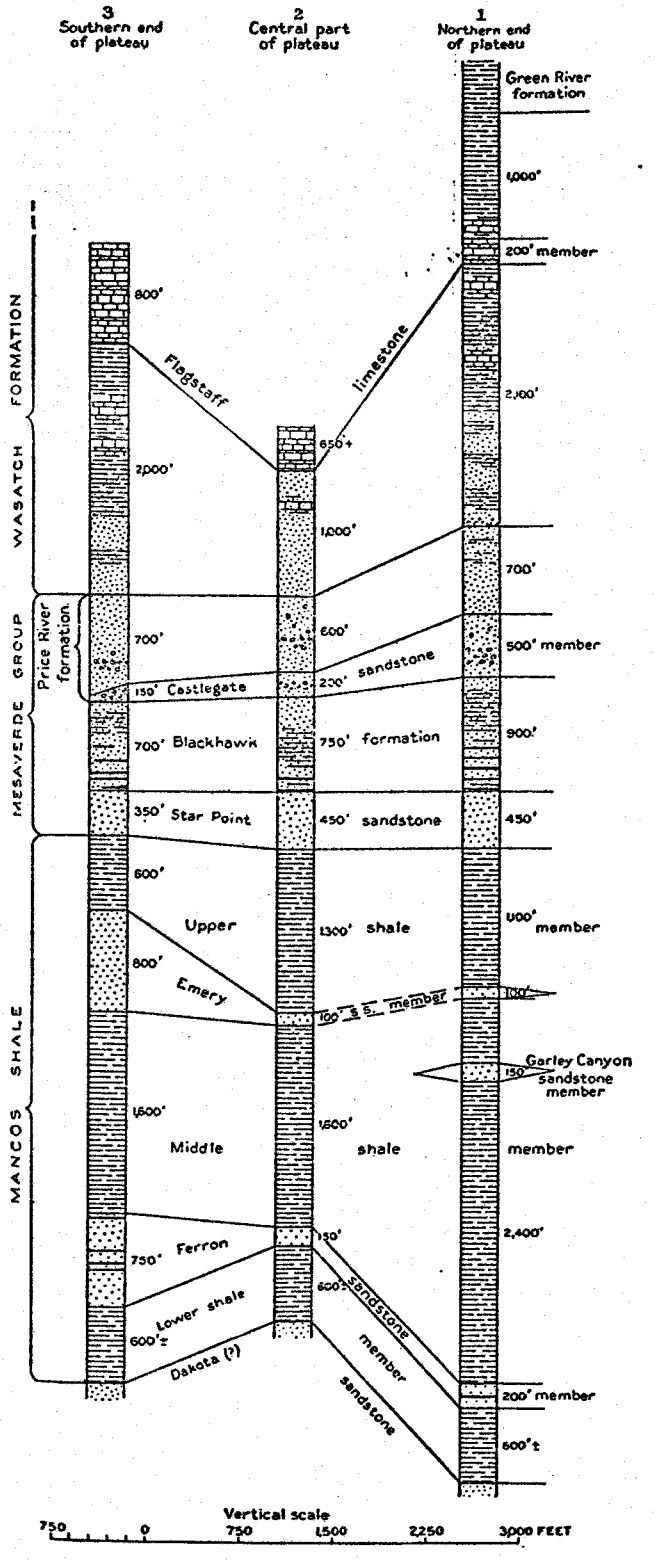



FIGURE 7-1 - COLUMNAR SECTIONS OF ROCKS IN THE WASATCH PLATEAU COAL FIELDS

TABLE 7-3

COMPARISON OF BEAR CANYON SPRING WATER QUALITY DATA W/STANDARDS
OCTOBER 3, 1977

| | Spring | Federal Drinking Water Criteria | Utah Division of Health Water Standards: Domestic Water Class 1A | Utah Division of Health Water Standards: Aquatic Life Class 3A |
|---|---|---|---|---|
| pH (units) | 6.8 | 6.5 - 8.5 | 6.5 - 9.0 | 6.5 - 9.0 |
| Temp (C°) | 9.5 | ---- | ---- | less than 20 |
| Spec Cond (umhos) | 550 | ---- | ---- | ---- |
| TDS (mg/l) | 303 | 500 | Case by case basis | |
| Iron (mg/l) (total-dissolved dissolved) | ---- | 0.3 total | ---- | 0.05 |
| Sulfate (mg/l) | 26 | 250 | ---- | ---- |
| Chloride (mg/l) | 4 | 250 | ---- | ---- |
| Calcium (mg/l) | 78 | 200 | ---- | 0.002 |
| Magnesium (mg/l) | 30 | 150 | ---- | ---- |
| Sodium (mg/l) | 4.1 | 200 | ---- | ---- |
| Bicarbonate (mg/l) | 310 | 500 | ---- | ---- |
| Carbonate (mg/l) | 0 | ---- | ---- | ---- |
| Fluoride (mg/l) | .1 | 0.7 - 1.2 | 1.4 - 2.4 | ---- |
| Silica (mg/l) | 6.6 | ---- | ---- | ---- |
| Total ALK as $CaCo_3$ | 250 | ---- | ---- | ---- |
| Boron (mg/l) | .02 | ---- | ---- | ---- |
| Potassium (mg/l) | 1.1 | ---- | ---- | ---- |
| Strontium (mg/l) | .28 | ---- | ---- | ---- |

TABLE 7-4

Field determinations of discharge, specific conductance, pH, water temperature and alkalinity at selected springs -- Continued

NO DATA

| LOCATION | GEO-LOGIC UNIT | DATE OF SAMPLE | ALTI-TUDE | DIS-CHARGE (GAL/MIN) | SPE-CIFIC CON-DUCT-ANCE (UMHOS) | PH (UNITS) | TEMPER-ATURE (DEG C) | ALKA-LINITY FIELD (MG/L) AS $CACO_3$ |
|---|---|---|---|---|---|---|---|---|
| (D-16-7)26ADC-S1 | 211SRPN | 78-04-27 | 7120.00 | 110 | -- | -- | -- | -- |
| | 211SRPN | 78-05-26 | 7120.00 | 110 | -- | -- | -- | -- |
| | 211SRPN | 78-06-09 | 7120.00 | 120 | -- | -- | -- | -- |
| | 211SRPN | 78-06-23 | 7120.00 | 130 | -- | -- | -- | -- |

TABLE 7-4

Field determinations of discharge, specific conductance, pH, water temperature and alkalinity at selected springs -- Continued

| LOCATION | GEO-LOGIC UNIT | DATE OF SAMPLE | ALTI-TUDE | DIS-CHARGE (GAL/MIN) | SPE-CIFIC CON-DUCT-ANCE (UMHOS) | PH (UNITS) | TEMPER-ATURE (DEG C) | ALKA-LINITY FIELD (MG/L) AS $CACO_3$ |
|---|---|---|---|---|---|---|---|---|
| (D-16-7)26ADC-S1 | 211SRPN | 78-04-27 | 7120.00 | 110 | -- | -- | -- | -- |
| | 211SRPN | 78-05-26 | 7120.00 | 110 | -- | -- | -- | -- |
| | 211SRPN | 78-06-09 | 7120.00 | 120 | -- | -- | -- | -- |
| | 211SRPN | 78-06-23 | 7120.00 | 130 | -- | -- | -- | -- |
| | 211SRPN | 78-07-06 | 7120.00 | 150 | -- | -- | -- | -- |
| | 211SRPN | 78-07-28 | 7120.00 | 150 | -- | -- | -- | -- |
| | 211SRPN | 78-08-10 | 7120.00 | 160 | -- | -- | -- | -- |
| | 211SRPN | 78-08-30 | 7120.00 | 155 | -- | -- | -- | -- |
| | 211SRPN | 78-10-13 | 7120.00 | 165 | -- | -- | -- | -- |
| | 211SRPN | 78-10-25 | 7120.00 | 160 | -- | -- | -- | -- |
| | 211SRPN | 78-11-01 | 7120.00 | 155 | -- | -- | -- | -- |
| | 211SRPN | 78-12-13 | 7120.00 | 145 | -- | -- | -- | -- |
| | 211SRPN | 79-03-07 | 7120.00 | 135 | -- | -- | -- | -- |
| (D-16-7)26BCA-S1 | 211SRPN | 78-05-25 | 6860.00 | 23 | -- | -- | -- | -- |
| | 211SRPN | 78-08-10 | 6860.00 | 19 | -- | -- | 11.0 | -- |
| | 211SRPN | 78-10-11 | 6860.00 | 19 | -- | -- | 11.0 | -- |
| | 211SRPN | 78-11-07 | 6860.00 | 19 | -- | -- | 10.5 | -- |
| | 211SRPN | 78-12-13 | 6860.00 | 19 | -- | -- | 10.0 | -- |
| | 211SRPN | 79-06-14 | 6860.00 | 10 | -- | -- | 11.0 | -- |
| | 211SRPN | 79-06-28 | 6860.00 | 10 | 720 | 8.0 | 11.0 | -- |
| | 211SRPN | 79-07-20 | 6860.00 | 9.3 | 660 | 7.0 | 11.5 | -- |
| | 211SRPN | 79-08-22 | 6860.00 | 21 | 750 | -- | 10.5 | -- |
| | 211SRPN | 79-09-17 | 6860.00 | 19 | 750 | -- | 10.5 | -- |
| | 211SRPN | 79-10-16 | 6860.00 | 20 | 680 | -- | 11.5 | -- |
| (D-16-7)26CBB-S1 | 211SRPN | 78-08-10 | 6950.00 | 57 | -- | -- | 11.0 | -- |
| | 211SRPN | 78-10-11 | 6950.00 | 57 | -- | -- | 10.0 | -- |
| | 211SRPN | 78-11-07 | 6950.00 | 57 | -- | -- | 10.0 | -- |
| | 211SRPN | 78-12-13 | 6950.00 | 57 | -- | -- | 10.0 | -- |
| | 211SRPN | 79-05-10 | 6950.00 | 44 | -- | -- | -- | -- |
| | 211SRPN | 79-06-28 | 6950.00 | 30 | 820 | 7.6 | 10.5 | -- |
| | 211SRPN | 79-07-16 | 6950.00 | 27 | 710 | 7.0 | 12.5 | -- |
| | 211SRPN | 79-09-18 | 6950.00 | 65 | 760 | -- | 9.5 | -- |
| | 211SRPN | 79-10-18 | 6950.00 | 60 | 750 | -- | 11.0 | -- |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 211SRPN | 78-07-06 | 7120.00 | 150 | -- | -- | -- | -- |
| | 211SRPN | 78-07-28 | 7120.00 | 150 | -- | -- | -- | -- |
| | 211SRPN | 78-08-10 | 7120.00 | 160 | -- | -- | -- | -- |
| | 211SRPN | 78-08-30 | 7120.00 | 155 | -- | -- | -- | -- |
| | 211SRPN | 78-10-13 | 7120.00 | 165 | -- | -- | -- | -- |
| | 211SRPN | 78-10-25 | 7120.00 | 160 | -- | -- | -- | -- |
| | 211SRPN | 78-11-01 | 7120.00 | 155 | -- | -- | -- | -- |
| | 211SRPN | 78-12-13 | 7120.00 | 145 | -- | -- | -- | -- |
| | 211SRPN | 79-03-07 | 7120.00 | 135 | -- | -- | -- | -- |
| (D-16-7)26BCA-S1 | 211SRPN | 78-05-25 | 6860.00 | 23 | -- | -- | -- | -- |
| | 211SRPN | 78-08-10 | 6860.00 | 19 | -- | -- | 11.0 | -- |
| | 211SRPN | 78-10-11 | 6860.00 | 19 | -- | -- | 11.0 | -- |
| | 211SRPN | 78-11-07 | 6860.00 | 19 | -- | -- | 10.5 | -- |
| | 211SRPN | 78-12-13 | 6860.00 | 19 | -- | -- | 10.0 | -- |
| | 211SRPN | 79-06-14 | 6860.00 | 10 | -- | -- | 11.0 | -- |
| | 211SRPN | 79-06-28 | 6860.00 | 10 | 720 | 8.0 | 11.0 | -- |
| | 211SRPN | 79-07-20 | 6860.00 | 9.3 | 660 | 7.0 | 11.5 | -- |
| | 211SRPN | 79-08-22 | 6860.00 | 21 | 750 | -- | 10.5 | -- |
| | 211SRPN | 79-09-17 | 6860.00 | 19 | 750 | -- | 10.5 | -- |
| | 211SRPN | 79-10-16 | 6860.00 | 20 | 680 | -- | 11.5 | -- |
| (D-16-7)26CBB-S1 | 211SRPN | 78-08-10 | 6950.00 | 57 | -- | -- | 11.0 | -- |
| | 211SRPN | 78-10-11 | 6950.00 | 57 | -- | -- | 10.0 | -- |
| | 211SRPN | 78-11-07 | 6950.00 | 57 | -- | -- | 10.0 | -- |
| | 211SRPN | 78-12-13 | 6950.00 | 57 | -- | -- | 10.0 | -- |
| | 211SRPN | 79-05-10 | 6950.00 | 44 | -- | -- | -- | -- |
| | 211SRPN | 79-06-28 | 6950.00 | 30 | 820 | 7.6 | 10.5 | -- |
| | 211SRPN | 79-07-16 | 6950.00 | 27 | 710 | 7.0 | 12.5 | -- |
| | 211SRPN | 79-09-18 | 6950.00 | 65 | 760 | -- | 9.5 | -- |
| | 211SRPN | 79-10-18 | 6950.00 | 60 | 750 | -- | 11.0 | -- |

TABLE 7-4
Continued

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| (D-16-7)27ADC-S1 | 211SRPN | 78-08-10 | 7000.00 | 15 | -- | -- | 11.0 | -- |
| | 211SRPN | 78-10-11 | 7000.00 | 5.8 | -- | -- | 11.0 | -- |
| | 211SRPN | 78-11-07 | 7000.00 | 4.9 | -- | -- | 10.0 | -- |
| | 211SRPN | 78-12-13 | 7000.00 | 5.4 | -- | -- | 10.0 | -- |
| | 211SRPN | 79-05-10 | 7000.00 | .0 | -- | -- | -- | -- |
| | 211SRPN | 79-06-28 | 7000.00 | .0 | -- | -- | -- | -- |
| | 211SRPN | 79-08-22 | 7000.00 | 2.0 | 870 | -- | 10.0 | -- |
| | 211SRPN | 79-09-18 | 7000.00 | 3.4 | 780 | -- | 10.0 | -- |
| | 211SRPN | 79-10-18 | 7000.00 | 3.1 | 730 | -- | 11.5 | -- |
| (D-16-7)35ABC-S1 | 111ALVM | 78-10-13 | 6620.00 | 22 | -- | -- | -- | -- |
| | 111ALVM | 78-11-08 | 6620.00 | 20 | -- | -- | -- | -- |
| | 111ALVM | 78-12-11 | 6620.00 | 23 | -- | -- | -- | -- |
| | 111ALVM | 79-05-11 | 6620.00 | 26 | -- | -- | -- | -- |
| | 111ALVM | 79-06-28 | 6620.00 | 20 | 960 | 8.1 | 10.5 | -- |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 111ALVM | 79-07-20 | 6620.00 | 21 | 900 | 7.2 | 10.5 | -- |
| 111ALVM | 79-08-07 | 6620.00 | 35 | 760 | 7.3 | 11.0 | -- |
| 111ALVM | 79-08-22 | 6620.00 | 38 | 1080 | -- | 10.0 | -- |
| 111ALVM | 79-08-31 | 6620.00 | 35 | -- | -- | -- | -- |
| 111ALVM | 79-09-17 | 6620.00 | 40 | 1090 | -- | 9.5 | -- |
| 111ALVM | 79-10-16 | 6620.00 | 32 | 850 | -- | 11.0 | -- |

TABLE 7-5

Chemical Analyses of Water from Selected Springs

| Location | (D-16-7) 26adc-S1 | (D-16-7) 26bca-S1 | (D-16-7) 26cbb-S1 | (D-16-7) 35abc-S1 |
|---|---|---|---|---|
| Geologic Unit | 211SRPN | 211SRPN | 211SRPN | 111ALVM |
| Date of Sample | 10-3-77 | 8-9-79 | 8-22-79 | 8-9-79 |
| Altitude | 7,120 | 6,860 | 6,950 | 6,620 |
| Hardness (as $CaCO_3$) | 320 | 380 | 440 | 510 |
| Noncarbonate Hardness (as $CaCO_3$) | 64 | 61 | 94 | 200 |
| Discharge (gpm) | 75 | 15 | 54 | 9.5 |
| Specific Conductance | 550 | 690 | 830 | 900 |
| pH | 6.8 | 7.5 | 7.2 | 7.7 |
| Water Temperature (°C) | 9.5 | 11.0 | 10.0 | 10.0 |
| Dissolved* Calcium (as Ca) | 78 | 83 | 82 | 92 |
| Dissolved* Magnesium (as Mg) | 30 | 42 | 58 | 69 |
| Dissolved* Sodium (as Na) | 4.1 | 6.6 | 21 | 24 |
| Sodium* Absorption Ratio | .1 | .1 | .4 | .5 |
| Dissolved* Potassium (as K) | 1.1 | 2.3 | 2.7 | 3.9 |
| Bicarbonate* (as $HCO_3$) | 310 | -- | -- | -- |
| Carbonate* (as $CO_3$) | 0 | -- | -- | -- |

TABLE 7-5
(continued)

| Location | (D-16-7) 26adc-S1 | (D-16-7) 26bca-S1 | (D-16-7) 26cbb-S1 | (D-16-7) 35abc-S1 |
|---|---|---|---|---|
| Alkalinity* (as $CaCO_3$) | 250 | 320 | 350 | 310 |
| Dissolved* Sulfate (as $SO_H$) | 26 | 71 | 140 | 190 |
| Dissolved* Chloride (as Cl) | 4.0 | 8.1 | 7.3 | 15 |
| Dissolved* Fluoride (as F) | .1 | .2 | .2 | .2 |
| Dissolved* Silica (as $SiO_2$) | 6.6 | 7.6 | 7.4 | 10 |
| Dissolved Solids,* Sum of Constituents | 303 | 414 | 530 | 591 |
| Dissolved** Boron (as B) | 20 | 80 | 30 | 70 |
| Dissolved** Iron (as Fe) | -- | 0 | 20 | 0 |
| Dissolved** Strontium (as Sr) | 280 | 360 | 430 | 490 |

*units of milligrams/liter
**units of micrograms/liter

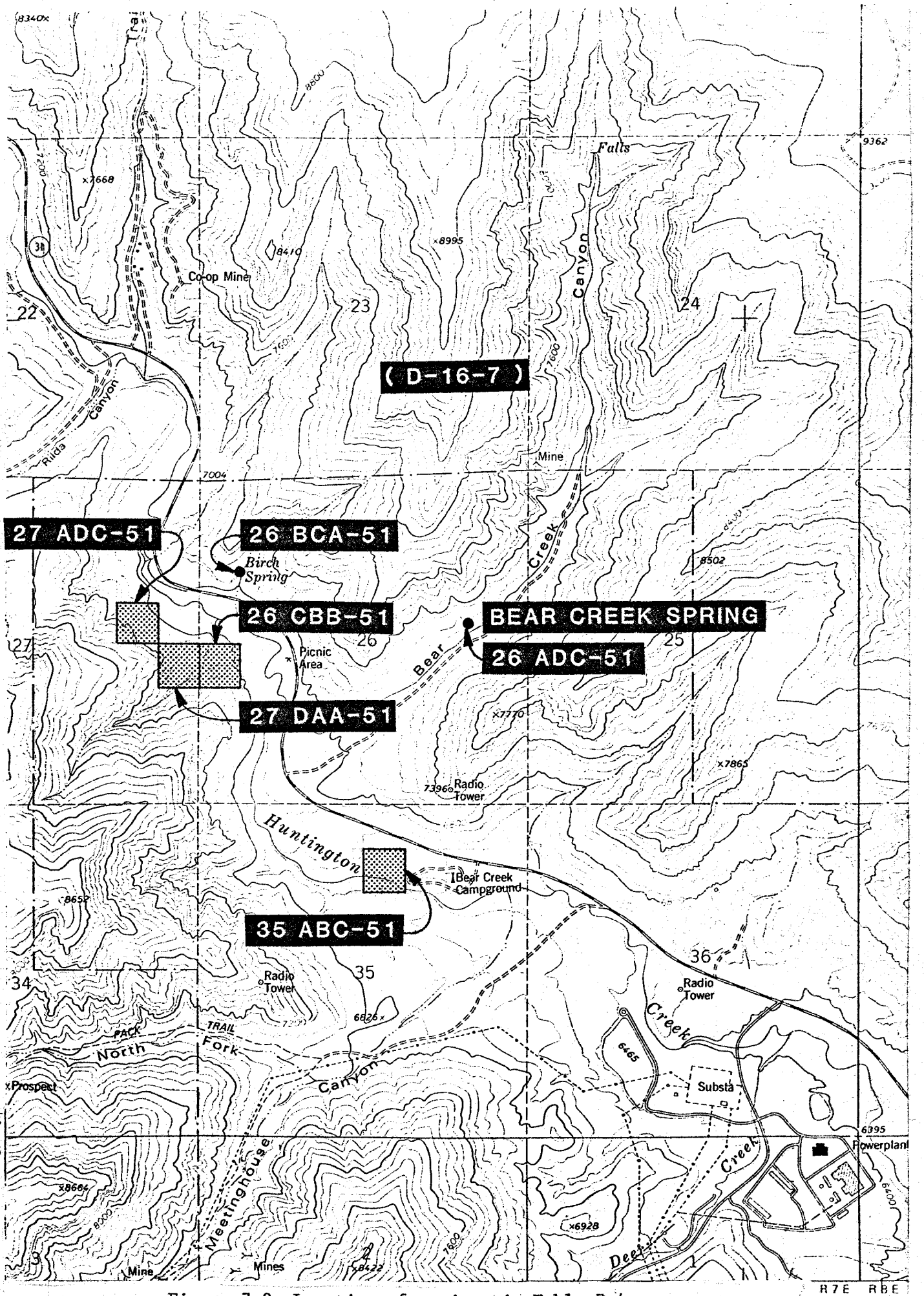



Figure 7-2 Location of springs in Table 7-4

selected springs. Tables 7-4 and 7-5 list the results of those measurements and analysis for the Bear Canyon Spring and for adjacent springs that were analyzed. (See Figure 7-2 for general locations of springs.)

### 7.1.3 EFFECTS OF MINING OPERATIONS ON GROUNDWATER

Danielson in the U.S.G.S. Open-file Report 81-539 states that:

> "The effects of underground coal mining on the water resources of the study area mainly are dependent on the amount of mine dewatering and the magnitude and a real extent of mine-related land subsidence....Where subsidence has not been extensive and where water-bearing zones that overlie the Star Point-Blackhawk aquifer are perched, it is unlikely that mine dewatering induces greater recharge to the groundwater system. Neither is it likely under these conditions that the flow of springs that issue from the perched zones or the rate of natural downward leakage into the Star Point-Blackhawk aquifer are affected by mine dewatering....It is unlikely that mine dewatering in the study area has had any adverse effect on the chemical quality of the groundwater."

The Bear Canyon Mine is a prime example of a mine with little subsidence and little mine dewatering, and what dewatering there is is from perched water zones. In addition Mr. Kaliser expressed the following:

> "In brief, my conclusion is that it is highly unlikely that the mine plan as presented to me by the Co-Op Company would interfere with the quantity or quality of any of those springs, particularly the one in question, the Bear Canyon Spring."

#### 7.1.3.1 MINE DEWATERING

Water entering the mine will be stored in an underground tank and utilized for dust control on the roads and surface coal facilities and for

the mine bathhouse. Co-Op Mining Company possesses water rights for this purpose at the Trail Canyon portal and currently has an application before the State Water Rights Division to change the point of diversion to the Bear Canyon portal. If it becomes necessary to discharge the minewater other than as noted above it will be discharged to the sedimentation ponds. Co-Op Mining will monitor these discharges for quantity and quality.

### 7.1.3.2 MITIGATION AND CONTROL PLANS

An agreement between Huntington City and Co-Op Mining Company has been established to replace to the City any lost of culinary water from the Bear Canyon Spring, either in quality or quantity, due to mining operations, even though mining is highly unlikely to affect this spring.

Appendix 7-B contains a copy of this agreement between Huntington City and Co-Op Mining Company.

In the event that Co-Op Mining would need to replace water to Huntington City, the Company presently owns 300+ shares in the Huntington-Cleveland Irrigation Company and will purchase additional shares at some future date if necessary. In addition, Co-Op Mining Company carries liability insurance that includes coverage of water wells and springs (see Appendix 7-C).

### 7.1.3.3 GROUNDWATER MONITORING PLANS

If during mine operations, an inflow of groundwater is encountered from a point source with a sustained quantity of 1 gpm or greater over a 30-day period, a regular monitoring point of this groundwater will be maintained. Monitoring will be on a monthly basis. Samples will be taken of water quality and quantity with reporting done on a standard sampling chart. This monitoring will be carried out for a base-line period of one year or until the area is rendered inaccessible. In addition, the underground storage water will be monitored, and in the event discharging from the mine becomes necessary; discharged water will be monitored for quality and quantity. On a quarterly basis, a summary report will be submitted to DOGM which includes: a map of the underground working showing monitoring locations, identification of the source, sample qualities and quantities, and a narrative discussing current inflows, discharges, storage and uses of mine groundwater.

COP Development Spring, a small intermittent spring 300 feet northeast of Bear Creek Spring, will be monitored by Co-Op Mining (see plate 7-4).

Refer to 7.2.4 Surface Water Monitoring Plans for specifics on flow calculations and parameters tested for and refer to Figure 7-4 for reporting format.

## 7.2 SURFACE WATER HYDROLOGY

### 7.2.1 REGIONAL AND ADJACENT AREAS

The San Rafael River Basin of the Upper Colorado River Region is generally classified as an arid basin. The upper drainages along the Wasatch Plateau receive enough snow precipitation to be classified as semi-arid to sub-humid with the amount of precipitation increasing with altitude.

There are eight major reservoirs in the basin. Seven are mainly for irrigation with a total capacity of 85,000 acre-feet and one, with a capacity of 30,530 acre-feet, is used as the water supply for a powerplant. Diversions during irrigation season, April to November, from Huntington, Cottonwood, and Ferron Creeks nearly deplete flows downstream from these diversions. The flows downstream during this period are mainly irrigation return flows along with some groundwater seepage.

At points of major diversions on the Huntington, Cottonwood, and Ferron Creeks the water quality is excellent for irrigation, with dissolved-solids concentrations of less than 500 milligrams per liter. But water at the mouths of these creeks has markedly larger dissolved-solids concentrations. This is mainly due to two factors: 1) in the area between major diversions and the mouths of the creeks, they cross a belt of exposed Manos Shale 10 to 15 miles wide, 2) this area is

also where practically all the intensive irrigation in the San Rafael River Basin is practiced. (Mundoff,'82)

The upper drainage of Huntington Creek encompasses about 200 square miles of mountainous country in the Wasatch Plateau. About 90 percent of the area is higher than 8,000 feet. The average channel gradient along the stream in the area is about 100 feet per mile. In its lower reaches the stream is in deep, narrow canyons, and surface relief between the stream channel and the top of adjacent canyon walls is typically 2,000 feet or more. (Danielson,'81)

### 7.2.1.1 QUANTITY AND QUALITY OF SURFACE WATER

According to Danielson, "...about 65 percent of the annual discharge at the Huntington Creek station (0931800) occurs during the snowmelt period (April-July). Because most of the streamflow is derived from snowmelt, annual discharge at the gaging station correlates well with the April 1 snowpack water content," as shown in Figure 7-2. Figure 7-3 shows the discharge rate into Huntington Creek of the Tie Fork and Crandall Canyon streams, both major tributaries to Huntington Creek. Approximately 80 percent of the discharge from these streams is during the snowmelt from April to July. Table 7-6 is provided to show discharges on a daily basis for a few years, water years 1966-70 (Water Supply Paper #2125).

As part of the Danielson study, chemical analyses were performed on selected surface water samples from the area. Table 7-7 is a tabulation

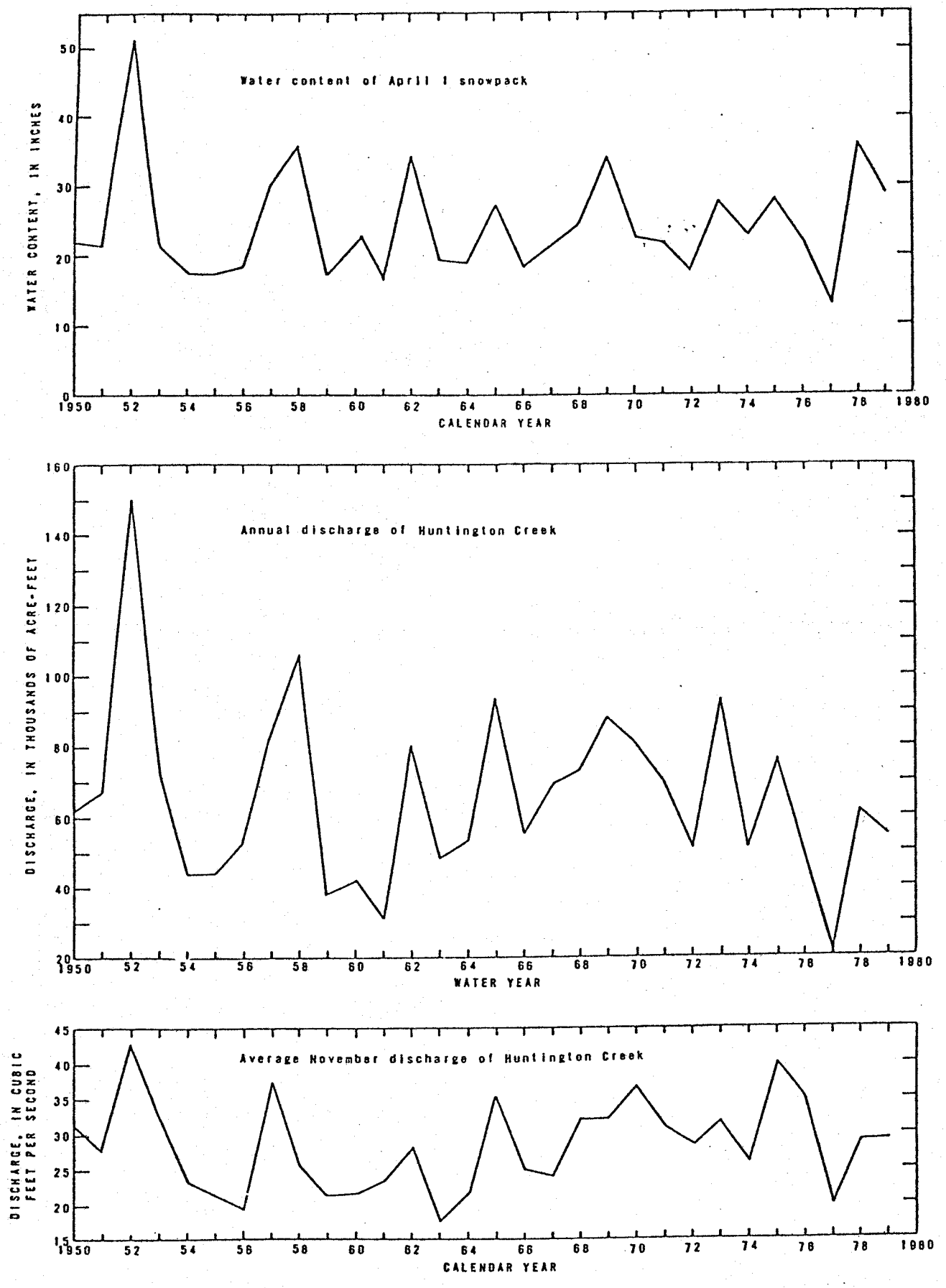



Figure 7-2-Water content of April 1 snowpack at the Huntington Horseshoe snow course and the annual discharge of Huntington Creek at gaging station 09318000, 1950-79.

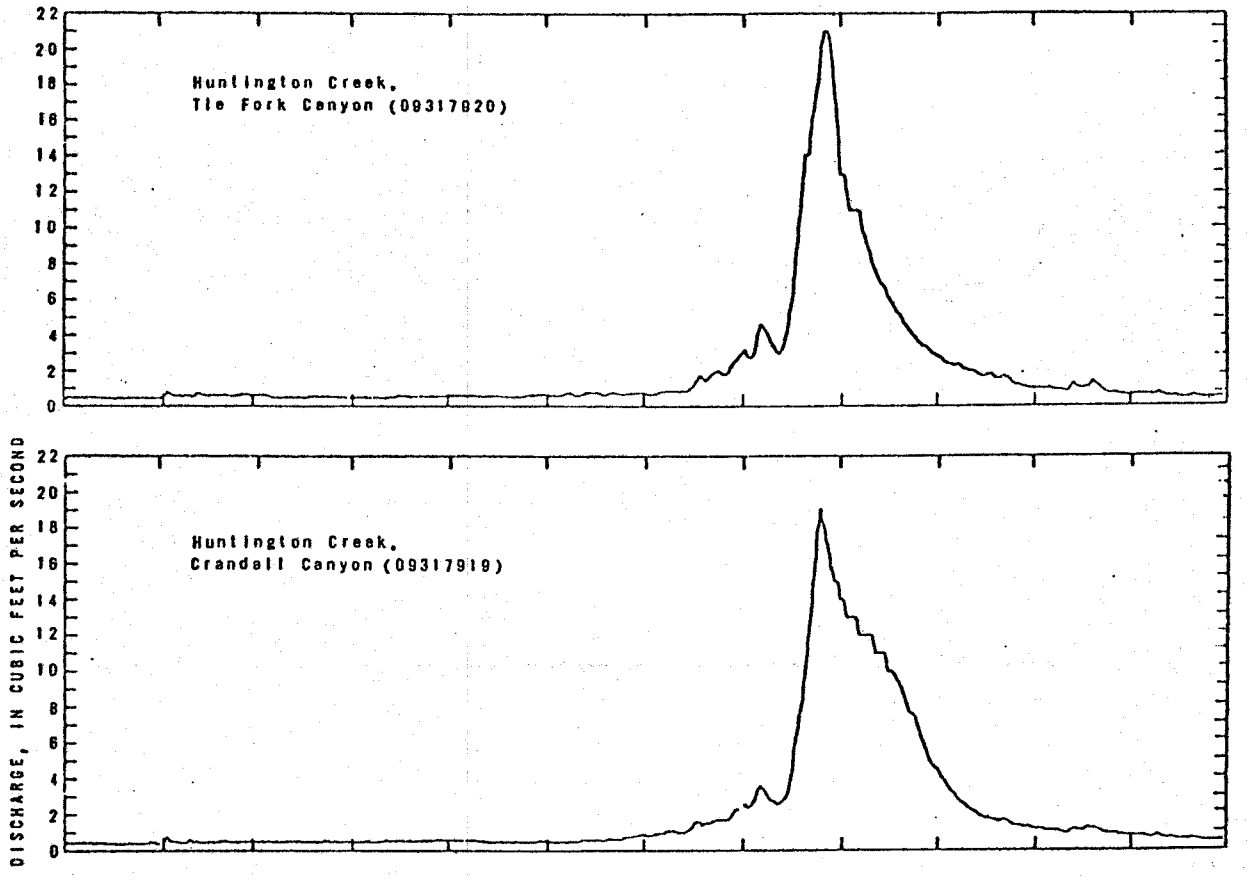



Figure 7-3. —Stream discharge at gaging stations in the drainage of Huntington Creek, water year 1979.

# TABLE 7-6

## 09318000 HUNTINGTON CREEK NEAR HUNTINGTON, UTAH

LOCATION.--Lat 39°22'17", long 111°03'43", in SW¼NE¼SE¼ sec.6, T.17 S., R.8 E., Emery County, on left bank 300 ft (revised) downstream from farm road bridge, 1 mile upstream from Fish Creek, and 7 miles northwest of Huntington.

DRAINAGE AREA.--190 sq mi, approximately.

PERIOD OF RECORD.--May 1909 to September 1917, October 1918 to November 1920 (fragmentary), April 1921 to May 1930, October 1930 to September 1970.

GAGE.--Water-stage recorder. Altitude of gage is 6,210 ft (from river-profile map). Prior to Apr. 30, 1913, nonrecording gage 5 ft downstream at different datum. May 1, 1913, to Sept. 10, 1917, water-stage recorder at site 95 ft upstream at same datum as preceding gage.

AVERAGE DISCHARGE.--55 years (1910-17, 1921-29, 1930-70), 96.7 cfs (70,060 acre-ft per year).

EXTREMES.--Maximums and minimums (discharge in cubic feet per second, gage height in feet).

Annual maximum discharge (*) and peak discharges above base (400 cfs), water years 1966-70

| Date | Time | Disch. | G.H. | Date | Time | Disch. | G.H. | Date | Time | Disch. | G.H. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| July 11, 1966 | 1300 | *387 | 5.97 | May 30, 1968 | 2300 | 724 | 4.74 | Sept.10, 1969 | 0400 | 757 | 4.65 |
| | | | | June 19, 1968 | 0100 | 548 | 4.31 | Sept.15, 1969 | 1500 | 617 | 4.35 |
| May 22, 1967 | 2230 | 604 | 4.42 | July 30, 1968 | 2030 | *1,640 | 6.33 | | | | |
| Sept. 8, 1967 | 2200 | 556 | 4.34 | Aug. 1, 1968 | 1730 | 408 | 3.92 | May 19, 1970 | 0100 | *817 | 4.83 |
| Sept. 9, 1967 | 2100 | *782 | 4.83 | | | | | June 10, 1970 | 1700 | 622 | 4.48 |
| | | | | May 13, 1969 | 2300 | *777 | 4.71 | | | | |
| May 21, 1968 | 2400 | 526 | 4.32 | July 19, 1969 | 1900 | 644 | 4.55 | | | | |

Annual minimum discharge, water years 1966-70

| Wtr yr | Date | Disch. | G.H. | Wtr yr | Date | Disch. | G.H. |
|---|---|---|---|---|---|---|---|
| 1966 | Mar. 3, 1966 | 11 | 2.07 | 1969 | Jan. 24, 1969 | 7.8 | 1.70 |
| 1967 | Feb. 20, 1967 | 6.1 | 1.96 | 1970 | Feb. 19, 1970 | 8.7 | 1.64 |
| 1968 | Nov. 27, 1967 | 12 | 2.03 | | | | |

Period of record: Maximum discharge, 2,500 cfs Aug. 2 or 3, 1930 (gage height, 7.5 ft, from floodmark), from rating curve extended above 600 cfs; minimum recorded, 2 cfs Nov. 5, 1926.

REMARKS.--Records good except those for winter periods and those for periods of no gage-height record, which are fair. Small diversions for irrigation above station, including transmountain diversions to tributaries of San Pitch River (Sevier Lake basin). Slight regulation by small reservoirs above station.

REVISIONS.--WSP 1925: Drainage area.

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1965 TO SEPTEMBER 1966

| DAY | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 51 | 37 | 32 | 35 | 38 | 28 | 79 | 147 | 130 | 143 | 112 | 78 |
| 2 | 62 | 36 | 36 | 30 | 39 | 27 | 96 | 179 | 124 | 150 | 87 | 64 |
| 3 | 73 | 36 | 39 | 31 | 30 | 21 | 101 | 192 | 143 | 146 | 97 | 58 |
| 4 | 70 | 36 | 39 | 34 | 34 | 24 | 87 | 208 | 150 | 143 | 108 | 58 |
| 5 | 78 | 36 | 38 | 36 | 37 | 27 | 77 | 220 | 146 | 141 | 82 | 57 |
| 6 | 78 | 36 | 35 | 36 | 40 | 33 | 78 | 228 | 143 | 132 | 82 | 58 |
| 7 | 78 | 36 | 34 | 36 | 45 | 36 | 84 | 246 | 141 | 141 | 79 | 70 |
| 8 | 78 | 36 | 38 | 36 | 40 | 36 | 97 | 255 | 146 | 139 | 79 | 58 |
| 9 | 76 | 36 | 37 | 36 | 30 | 36 | 116 | 268 | 148 | 132 | 81 | 57 |
| 10 | 73 | 35 | 38 | 36 | 25 | 37 | 122 | 284 | 135 | 120 | 79 | 58 |
| 11 | 60 | 35 | 36 | 36 | 23 | 37 | 108 | 255 | 146 | 135 | 79 | 60 |
| 12 | 60 | 36 | 30 | 36 | 22 | 36 | 94 | 217 | 137 | 128 | 79 | 61 |
| 13 | 60 | 37 | 37 | 36 | 21 | 37 | 90 | 187 | 132 | 110 | 79 | 57 |
| 14 | 58 | 35 | 37 | 36 | 20 | 40 | 94 | 172 | 132 | 103 | 78 | 62 |
| 15 | 60 | 35 | 27 | 36 | 19 | 41 | 106 | 162 | 141 | 103 | 78 | 62 |
| 16 | 68 | 36 | 33 | 33 | 19 | 41 | 122 | 172 | 160 | 103 | 81 | 57 |
| 17 | 66 | 44 | 35 | 29 | 20 | 37 | 148 | 182 | 162 | 104 | 81 | 55 |
| 18 | 62 | 38 | 38 | 25 | 21 | 37 | 150 | 177 | 148 | 101 | 81 | 54 |
| 19 | 60 | 37 | 40 | 23 | 22 | 38 | 128 | 182 | 141 | 101 | 84 | 54 |
| 20 | 58 | 36 | 40 | 22 | 22 | 37 | 120 | 172 | 143 | 97 | 82 | 52 |
| 21 | 57 | 34 | 41 | 27 | 23 | 37 | 114 | 172 | 152 | 96 | 79 | 52 |
| 22 | 57 | 30 | 41 | 31 | 24 | 34 | 110 | 172 | 150 | 94 | 78 | 51 |
| 23 | 57 | 40 | 35 | 32 | 27 | 35 | 106 | 162 | 146 | 92 | 73 | 51 |
| 24 | 56 | 39 | 30 | 33 | 29 | 36 | 118 | 152 | 143 | 96 | 52 | 50 |
| 25 | 55 | 39 | 31 | 34 | 30 | 36 | 137 | 162 | 139 | 84 | 52 | 48 |
| 26 | 62 | 30 | 33 | 35 | 28 | 38 | 160 | 146 | 135 | 84 | 54 | 47 |
| 27 | 64 | 28 | 35 | 36 | 29 | 44 | 157 | 132 | 128 | 92 | 51 | 49 |
| 28 | 39 | 25 | 37 | 36 | 27 | 48 | 150 | 135 | 124 | 89 | 48 | 55 |
| 29 | 37 | 29 | 38 | 36 | ------ | 52 | 150 | 150 | 128 | 94 | 49 | 55 |
| 30 | 37 | 30 | 40 | 37 | ------ | 58 | 160 | 146 | 132 | 101 | 52 | 55 |
| 31 | 36 | ------ | 39 | 38 | ------ | 66 | ------ | 137 | ------ | 99 | 80 | ------ |
| TOTAL | 1,886 | 1,053 | 1,119 | 1,033 | 784 | 1,170 | 3,459 | 5,791 | 4,245 | 3,493 | 2,336 | 1,703 |
| MEAN | 60.8 | 35.1 | 36.1 | 33.3 | 28.0 | 37.7 | 115 | 187 | 142 | 113 | 76.0 | 56.8 |
| MAX | 78 | 44 | 41 | 38 | 45 | 66 | 160 | 284 | 162 | 150 | 112 | 78 |
| MIN | 36 | 25 | 27 | 22 | 19 | 21 | 77 | 132 | 124 | 84 | 48 | 47 |
| AC-FT | 3,740 | 2,090 | 2,220 | 2,050 | 1,560 | 2,320 | 6,860 | 11,490 | 8,420 | 6,930 | 4,630 | 3,380 |

CAL YR 1965 TOTAL 49,126 MEAN 135 MAX 646 MIN 15 AC-FT 97,440
WTR YR 1966 TOTAL 28,092 MEAN 77.0 MAX 284 MIN 19 AC-FT 55,720

TABLE 7-6 Continued

09318000 HUNTINGTON CREEK NEAR HUNTINGTON, UTAH--CONTINUED

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1966 TO SEPTEMBER 1967

| DAY | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 52 | 24 | 22 | 19 | 22 | 25 | 36 | 58 | 353 | 244 | 152 | 118 |
| 2 | 73 | 24 | 24 | 19 | 18 | 27 | 34 | 57 | 346 | 238 | 159 | 110 |
| 3 | 73 | 24 | 24 | 19 | 18 | 27 | 34 | 57 | 342 | 235 | 139 | 91 |
| 4 | 57 | 24 | 19 | 19 | 18 | 27 | 36 | 57 | 342 | 220 | 124 | 89 |
| 5 | 45 | 23 | 22 | 19 | 18 | 27 | 38 | 56 | 371 | 200 | 118 | 89 |
| 6 | 40 | 26 | 30 | 19 | 18 | 24 | 37 | 68 | 375 | 180 | 118 | 87 |
| 7 | 35 | 26 | 28 | 19 | 18 | 28 | 38 | 79 | 346 | 170 | 118 | 84 |
| 8 | 32 | 27 | 27 | 19 | 17 | 25 | 41 | 104 | 334 | 160 | 124 | 104 |
| 9 | 32 | 21 | 22 | 19 | 18 | 31 | 38 | 124 | 314 | 150 | 124 | 110 |
| 10 | 32 | 28 | 20 | 19 | 20 | 28 | 38 | 135 | 308 | 145 | 118 | 81 |
| 11 | 32 | 27 | 20 | 19 | 18 | 29 | 41 | 126 | 311 | 148 | 120 | 70 |
| 12 | 32 | 28 | 20 | 19 | 18 | 30 | 40 | 97 | 336 | 150 | 118 | 59 |
| 13 | 38 | 24 | 20 | 19 | 17 | 30 | 37 | 90 | 339 | 150 | 114 | 56 |
| 14 | 35 | 27 | 20 | 19 | 17 | 29 | 37 | 81 | 357 | 154 | 110 | 55 |
| 15 | 32 | 27 | 20 | 19 | 16 | 27 | 40 | 89 | 368 | 159 | 120 | 55 |
| 16 | 29 | 27 | 20 | 19 | 16 | 32 | 44 | 135 | 346 | 171 | 120 | 54 |
| 17 | 27 | 27 | 20 | 19 | 17 | 33 | 41 | 196 | 336 | 176 | 120 | 53 |
| 18 | 27 | 27 | 20 | 19 | 18 | 37 | 44 | 288 | 339 | 148 | 116 | 53 |
| 19 | 27 | 24 | 20 | 19 | 17 | 36 | 52 | 353 | 368 | 137 | 116 | 53 |
| 20 | 27 | 26 | 20 | 20 | 16 | 32 | 46 | 412 | 386 | 126 | 116 | 52 |
| 21 | 27 | 28 | 20 | 21 | 17 | 31 | 44 | 434 | 378 | 110 | 116 | 61 |
| 22 | 27 | 27 | 19 | 22 | 18 | 33 | 41 | 465 | 378 | 137 | 120 | 70 |
| 23 | 27 | 23 | 19 | 22 | 18 | 35 | 38 | 493 | 386 | 150 | 120 | 91 |
| 24 | 27 | 18 | 19 | 23 | 19 | 35 | 37 | 485 | 364 | 157 | 116 | 64 |
| 25 | 27 | 17 | 19 | 22 | 20 | 36 | 38 | 457 | 353 | 141 | 118 | 64 |
| 26 | 27 | 24 | 19 | 22 | 21 | 36 | 36 | 427 | 342 | 139 | 118 | 64 |
| 27 | 27 | 21 | 19 | 22 | 23 | 35 | 58 | 465 | 332 | 135 | 124 | 63 |
| 28 | 27 | 25 | 19 | 22 | 24 | 34 | 66 | 461 | 314 | 137 | 122 | 64 |
| 29 | 27 | 29 | 19 | 22 | ------ | 36 | 62 | 446 | 291 | 152 | 118 | 63 |
| 30 | 25 | 26 | 19 | 23 | ------ | 33 | 58 | 415 | 278 | 157 | 122 | 61 |
| 31 | 25 | ------ | 19 | 23 | ------ | 34 | ------ | 382 | ------ | 154 | 122 | ------ |
| TOTAL | 1,070 | 749 | 648 | 625 | 515 | 962 | 1,270 | 7,592 | 10,335 | 5,030 | 3,780 | 2,178 |
| MEAN | 34.5 | 25.0 | 20.9 | 20.2 | 18.4 | 31.0 | 42.3 | 245 | 345 | 162 | 122 | 72.6 |
| MAX | 73 | 29 | 30 | 23 | 24 | 37 | 66 | 493 | 386 | 244 | 159 | 118 |
| MIN | 25 | 17 | 19 | 19 | 16 | 24 | 34 | 56 | 278 | 110 | 110 | 52 |
| AC-FT | 2,120 | 1,490 | 1,290 | 1,240 | 1,020 | 1,910 | 2,520 | 15,060 | 20,500 | 9,980 | 7,500 | 4,320 |

CAL YR 1966 TOTAL 24,501 MEAN 72.6 MAX 284 MIN 17 AC-FT 52,560
WTR YR 1967 TOTAL 34,754 MEAN 95.2 MAX 493 MIN 16 AC-FT 68,930

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1967 TO SEPTEMBER 1968

| DAY | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 59 | 29 | 19 | 22 | 22 | 30 | 46 | 114 | 539 | 188 | 146 | 65 |
| 2 | 55 | 29 | 18 | 21 | 22 | 31 | 50 | 145 | 539 | 176 | 121 | 72 |
| 3 | 55 | 21 | 19 | 19 | 22 | 31 | 43 | 161 | 548 | 166 | 74 | 70 |
| 4 | 55 | 25 | 20 | 19 | 22 | 32 | 40 | 184 | 548 | 161 | 65 | 89 |
| 5 | 54 | 32 | 21 | 18 | 22 | 31 | 41 | 207 | 626 | 154 | 70 | 92 |
| 6 | 58 | 27 | 22 | 17 | 22 | 31 | 41 | 221 | 626 | 150 | 69 | 91 |
| 7 | 53 | 26 | 22 | 16 | 22 | 32 | 34 | 191 | 543 | 150 | 69 | 91 |
| 8 | 53 | 26 | 23 | 16 | 22 | 31 | 36 | 174 | 497 | 141 | 75 | 96 |
| 9 | 53 | 26 | 23 | 16 | 22 | 30 | 34 | 184 | 434 | 137 | 68 | 108 |
| 10 | 53 | 27 | 23 | 16 | 22 | 30 | 38 | 191 | 397 | 135 | 75 | 106 |
| 11 | 53 | 26 | 23 | 16 | 22 | 28 | 42 | 184 | 386 | 124 | 80 | 108 |
| 12 | 48 | 26 | 23 | 17 | 22 | 27 | 50 | 202 | 386 | 116 | 84 | 112 |
| 13 | 48 | 26 | 23 | 18 | 22 | 31 | 53 | 191 | 434 | 112 | 82 | 112 |
| 14 | 48 | 26 | 23 | 19 | 22 | 29 | 45 | 168 | 461 | 104 | 104 | 112 |
| 15 | 46 | 26 | 23 | 20 | 22 | 28 | 51 | 154 | 465 | 110 | 89 | 87 |
| 16 | 47 | 26 | 21 | 20 | 22 | 30 | 52 | 157 | 473 | 122 | 80 | 87 |
| 17 | 47 | 26 | 19 | 21 | 22 | 30 | 49 | 159 | 481 | 122 | 58 | 86 |
| 18 | 47 | 23 | 20 | 21 | 22 | 29 | 44 | 194 | 493 | 124 | 60 | 86 |
| 19 | 46 | 22 | 22 | 21 | 22 | 29 | 42 | 230 | 510 | 122 | 50 | 86 |
| 20 | 45 | 24 | 22 | 21 | 22 | 24 | 42 | 311 | 493 | 124 | 46 | 82 |
| 21 | 45 | 24 | 21 | 21 | 23 | 28 | 42 | 393 | 457 | 148 | 45 | 82 |
| 22 | 45 | 21 | 20 | 21 | 24 | 29 | 61 | 438 | 423 | 152 | 47 | 78 |
| 23 | 45 | 22 | 19 | 21 | 24 | 30 | 61 | 382 | 397 | 148 | 52 | 76 |
| 24 | 45 | 23 | 18 | 21 | 25 | 30 | 64 | 304 | 364 | 135 | 45 | 76 |
| 25 | 41 | 24 | 19 | 22 | 27 | 32 | 61 | 272 | 328 | 157 | 43 | 74 |
| 26 | 36 | 16 | 19 | 22 | 28 | 32 | 61 | 304 | 278 | 141 | 56 | 74 |
| 27 | 33 | 17 | 20 | 22 | 29 | 30 | 63 | 371 | 241 | 139 | 59 | 72 |
| 28 | 32 | 19 | 21 | 22 | 29 | 32 | 61 | 449 | 238 | 139 | 68 | 72 |
| 29 | 28 | 20 | 22 | 22 | 30 | 34 | 86 | 514 | 230 | 122 | 67 | 80 |
| 30 | 28 | 20 | 22 | 22 | ------ | 41 | 99 | 560 | 213 | 143 | 65 | 82 |
| 31 | 31 | ------ | 23 | 22 | ------ | 43 | ------ | 582 | ------ | 124 | 65 | ------ |
| TOTAL | 1,432 | 725 | 653 | 612 | 679 | 957 | 1,532 | 8,291 | 13,048 | 4,268 | 2,177 | 2,604 |
| MEAN | 46.2 | 24.2 | 21.1 | 19.7 | 23.4 | 30.9 | 51.1 | 267 | 435 | 138 | 70.2 | 86.8 |
| MAX | 59 | 32 | 23 | 22 | 30 | 43 | 99 | 582 | 626 | 188 | 146 | 112 |
| MIN | 28 | 16 | 18 | 16 | 22 | 24 | 34 | 114 | 213 | 104 | 43 | 65 |
| AC-FT | 2,840 | 1,440 | 1,300 | 1,210 | 1,350 | 1,900 | 3,040 | 16,450 | 25,880 | 8,470 | 4,320 | 5,170 |

CAL YR 1967 TOTAL 35,097 MEAN 96.2 MAX 493 MIN 16 AC-FT 69,610
WTR YR 1968 TOTAL 36,978 MEAN 101 MAX 626 MIN 16 AC-FT 73,350

* NOTE.--NO GAGE-HEIGHT RECORD OCT. 9 TO NOV. 8, JAN. 6 TO FEB. 14.

TABLE 7-6 Continued

09318000 HUNTINGTON CREEK NEAR HUNTINGTON, UTAH--CONTINUED

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1968 TO SEPTEMBER 1969

| DAY | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 75 | 72 | 25 | 26 | 26 | 33 | 62 | 335 | 489 | 171 | 102 | 63 |
| 2 | 74 | 72 | 25 | 26 | 26 | 30 | 63 | 389 | 449 | 154 | 101 | 63 |
| 3 | 68 | 72 | 25 | 26 | 26 | 28 | 64 | 417 | 427 | 150 | 99 | 65 |
| 4 | 74 | 35 | 25 | 26 | 26 | 31 | 60 | 420 | 404 | 145 | 104 | 78 |
| 5 | 72 | 31 | 25 | 26 | 26 | 30 | 67 | 411 | 386 | 141 | 102 | 67 |
| 6 | 68 | 32 | 26 | 26 | 26 | 28 | 74 | 502 | 375 | 135 | 99 | 63 |
| 7 | 68 | 27 | 26 | 26 | 26 | 31 | 61 | 624 | 346 | 135 | 99 | 76 |
| 8 | 68 | 28 | 26 | 26 | 26 | 29 | 59 | 591 | 332 | 161 | 110 | 56 |
| 9 | 67 | 34 | 26 | 26 | 26 | 22 | 58 | 598 | 318 | 159 | 108 | 58 |
| 10 | 65 | 32 | 26 | 26 | 26 | 25 | 65 | 631 | 298 | 154 | 110 | 101 |
| 11 | 63 | 28 | 26 | 26 | 26 | 27 | 74 | 658 | 272 | 152 | 112 | 75 |
| 12 | 63 | 30 | 26 | 26 | 27 | 26 | 84 | 659 | 253 | 148 | 110 | 47 |
| 13 | 63 | 30 | 26 | 26 | 27 | 25 | 91 | 656 | 247 | 148 | 101 | 44 |
| 14 | 80 | 24 | 26 | 26 | 27 | 30 | 82 | 652 | 235 | 148 | 86 | 43 |
| 15 | 84 | 27 | 26 | 26 | 27 | 29 | 72 | 631 | 247 | 143 | 84 | 47 |
| 16 | 80 | 28 | 26 | 26 | 27 | 34 | 64 | 545 | 272 | 137 | 86 | 42 |
| 17 | 76 | 26 | 26 | 26 | 27 | 35 | 62 | 554 | 272 | 130 | 86 | 43 |
| 18 | 76 | 29 | 26 | 26 | 24 | 35 | 82 | 569 | 266 | 130 | 89 | 42 |
| 19 | 72 | 31 | 26 | 26 | 30 | 34 | 93 | 574 | 244 | 150 | 93 | 40 |
| 20 | 64 | 26 | 26 | 26 | 31 | 32 | 109 | 569 | 224 | 145 | 91 | 39 |
| 21 | 64 | 24 | 26 | 26 | 32 | 34 | 143 | 559 | 213 | 132 | 72 | 42 |
| 22 | 61 | 28 | 26 | 26 | 30 | 34 | 187 | 573 | 197 | 126 | 70 | 45 |
| 23 | 61 | 30 | 26 | 26 | 28 | 35 | 225 | 535 | 196 | 108 | 69 | 41 |
| 24 | 61 | 22 | 26 | 26 | 31 | 34 | 258 | 503 | 291 | 102 | 67 | 44 |
| 25 | 60 | 24 | 26 | 26 | 30 | 30 | 246 | 516 | 259 | 101 | 67 | 80 |
| 26 | 59 | 21 | 26 | 26 | 29 | 34 | 210 | 539 | 235 | 96 | 67 | 78 |
| 27 | 58 | 23 | 26 | 26 | 23 | 36 | 190 | 591 | 213 | 87 | 65 | 75 |
| 28 | 59 | 23 | 26 | 26 | 32 | 40 | 199 | 600 | 204 | 89 | 68 | 74 |
| 29 | 58 | 23 | 26 | 26 | ------ | 43 | 236 | 582 | 191 | 116 | 76 | 64 |
| 30 | 70 | 23 | 26 | 26 | ------ | 48 | 287 | 578 | 184 | 120 | 75 | 64 |
| 31 | 74 | ------ | 26 | 26 | ------ | 50 | ------ | 548 | ------ | 104 | 67 | ------ |
| TOTAL | 2,105 | 955 | 801 | 806 | 768 | 1,012 | 3,627 | 17,109 | 8,541 | 4,117 | 2,741 | 1,759 |
| MEAN | 67.9 | 31.8 | 25.8 | 26.0 | 27.4 | 32.6 | 121 | 552 | 285 | 133 | 88.4 | 58.6 |
| MAX | 84 | 72 | 26 | 26 | 32 | 50 | 287 | 659 | 489 | 171 | 112 | 101 |
| MIN | 58 | 21 | 25 | 26 | 23 | 22 | 58 | 335 | 184 | 87 | 65 | 39 |
| AC-FT | 4,180 | 1,890 | 1,590 | 1,600 | 1,520 | 2,010 | 7,190 | 33,940 | 16,940 | 8,170 | 5,440 | 3,490 |

CAL YR 1968 TOTAL 38,029 MEAN 104 MAX 626 MIN 16 AC-FT 75,430
WTR YR 1969 TOTAL 44,341 MEAN 121 MAX 659 MIN 21 AC-FT 87,959

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1969 TO SEPTEMBER 1970

| DAY | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 63 | 60 | 30 | 25 | 30 | 36 | 24 | 110 | 493 | 182 | 136 | 85 |
| 2 | 64 | 55 | 29 | 25 | 30 | 38 | 24 | 113 | 495 | 170 | 104 | 77 |
| 3 | 67 | 36 | 29 | 25 | 30 | 36 | 55 | 125 | 505 | 156 | 101 | 73 |
| 4 | 64 | 33 | 36 | 25 | 30 | 35 | 49 | 146 | 473 | 150 | 100 | 72 |
| 5 | 59 | 33 | 29 | 25 | 33 | 36 | 42 | 177 | 513 | 152 | 108 | 107 |
| 6 | 60 | 33 | 30 | 25 | 37 | 34 | 42 | 213 | 457 | 148 | 113 | 97 |
| 7 | 75 | 35 | 30 | 25 | 34 | 38 | 45 | 239 | 450 | 159 | 109 | 84 |
| 8 | 70 | 31 | 30 | 25 | 33 | 39 | 41 | 223 | 482 | 139 | 105 | 79 |
| 9 | 58 | 33 | 30 | 25 | 32 | 39 | 58 | 224 | 485 | 137 | 83 | 75 |
| 10 | 74 | 33 | 30 | 25 | 37 | 38 | 79 | 224 | 549 | 141 | 89 | 83 |
| 11 | 75 | 30 | 30 | 25 | 36 | 38 | 84 | 238 | 470 | 119 | 92 | 90 |
| 12 | 75 | 32 | 30 | 25 | 37 | 38 | 73 | 245 | 410 | 118 | 105 | 93 |
| 13 | 72 | 31 | 30 | 25 | 37 | 36 | 72 | 259 | 376 | 108 | 111 | 97 |
| 14 | 72 | 30 | 30 | 25 | 35 | 35 | 73 | 301 | 342 | 101 | 111 | 91 |
| 15 | 76 | 30 | 30 | 25 | 35 | 37 | 70 | 322 | 319 | 129 | 110 | 87 |
| 16 | 79 | 35 | 30 | 30 | 34 | 33 | 67 | 405 | 311 | 125 | 108 | 87 |
| 17 | 84 | 26 | 30 | 30 | 34 | 34 | 68 | 503 | 318 | 124 | 109 | 86 |
| 18 | 85 | 25 | 32 | 30 | 29 | 31 | 65 | 584 | 332 | 115 | 108 | 86 |
| 19 | 78 | 28 | 35 | 30 | 23 | 32 | 66 | 623 | 367 | 114 | 110 | 85 |
| 20 | 43 | 38 | 34 | 35 | 36 | 34 | 62 | 572 | 377 | 178 | 115 | 85 |
| 21 | 42 | 30 | 34 | 35 | 47 | 35 | 64 | 495 | 375 | 176 | 116 | 74 |
| 22 | 46 | 27 | 35 | 40 | 36 | 34 | 63 | 468 | 352 | 183 | 109 | 75 |
| 23 | 44 | 25 | 34 | 43 | 37 | 33 | 62 | 493 | 345 | 176 | 77 | 73 |
| 24 | 45 | 26 | 35 | 39 | 36 | 33 | 63 | 490 | 300 | 172 | 73 | 72 |
| 25 | 48 | 29 | 33 | 37 | 36 | 32 | 108 | 500 | 283 | 171 | 70 | 69 |
| 26 | 41 | 29 | 34 | 37 | 36 | 31 | 129 | 491 | 265 | 173 | 71 | 65 |
| 27 | 38 | 24 | 20 | 37 | 36 | 30 | 129 | 497 | 250 | 143 | 74 | 64 |
| 28 | 43 | 24 | 25 | 28 | 37 | 29 | 118 | 521 | 230 | 140 | 73 | 63 |
| 29 | 60 | 30 | 25 | 30 | ------ | 29 | 114 | 488 | 220 | 132 | 72 | 63 |
| 30 | 56 | 30 | 25 | 30 | ------ | 27 | 112 | 469 | 200 | 142 | 71 | 65 |
| 31 | 59 | ------ | 25 | 30 | ------ | 26 | ------ | 500 | ------ | 140 | 82 | ------ |
| TOTAL | 1,916 | 961 | 939 | 916 | 963 | 1,058 | 2,123 | 11,258 | 11,344 | 4,511 | 3,015 | 2,402 |
| MEAN | 61.8 | 32.0 | 30.3 | 29.5 | 34.4 | 34.1 | 70.8 | 363 | 378 | 146 | 97.3 | 80.1 |
| MAX | 85 | 60 | 36 | 43 | 47 | 39 | 129 | 623 | 549 | 183 | 136 | 107 |
| MIN | 38 | 24 | 20 | 25 | 23 | 26 | 24 | 110 | 200 | 101 | 70 | 63 |
| AC-FT | 3,800 | 1,910 | 1,860 | 1,820 | 1,910 | 2,100 | 4,210 | 22,330 | 22,500 | 8,950 | 5,980 | 4,760 |

CAL YR 1969 TOTAL 44,296 MEAN 121 MAX 659 MIN 20 AC-FT 87,860
WTR YR 1970 TOTAL 41,406 MEAN 113 MAX 623 MIN 20 AC-FT 82,130

TABLE 7-7

# Chemical Analyses of Selected Surface Water Samples 1977-79

Concentration: In milligrams per liter, unless otherwise indicated; <, less than.
Site No.: Shown on plate 1.
Discharge: Measured except E, estimated.
Specific conductance: In micromhos per centimeter at 25 degrees Celsius.
Other data available: SQS, semiquantitative determination of trace elements reported in table 12.

| Stream | Site No. | Date | Temperature (degrees C) | Discharge ($ft^3/s$) | Alkalinity (as $CaCO_3$) | Bicarbonate | Dissolved boron (µg/L) | Dissolved calcium | Carbonate | Dissolved chloride | Dissolved fluoride |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Huntington Creek | 21 | 8-15-77 | 15.0 | 16 | 140 | 200 | 10 | 49 | 0 | 2.5 | 0.1 |
| | | 6- 6-78 | 5.5 | 45 | 160 | 190 | 20 | 49 | 0 | 2.9 | .1 |
| Spring Creek | 22 | 8-15-77 | 15.0 | 0.25 | 110 | 140 | 20 | 38 | 0 | 2.9 | .1 |
| | | 6- 6-78 | 4.5 | 25.0 | 130 | 160 | 10 | 45 | 0 | 2.9 | .1 |
| Left Fork of Huntington Creek | 23 | 8-15-77 | 19.5 | 1.8 | 110 | 130 | 40 | 50 | 0 | 3.5 | .1 |
| Lake Canyon | 24 | 8-15-77 | 15.0 | 1.6 | 160 | 200 | 20 | 57 | 0 | 2.1 | .1 |
| Left Fork of Huntington Creek | 34 | 10-12-77 | 4.0 | 8E | 170 | 210 | 5 | 54 | 1 | 2.3 | .1 |
| | | 7-28-78 | 16.1 | – | 130 | 160 | 20 | 45 | 1 | 1.7 | .1 |
| | | 10-17-78 | 3.4 | 10E | 190 | – | 20 | 49 | – | 2.1 | .1 |
| | | 7-18-79 | 8.0 | 70 | 130 | – | 30 | 40 | – | 1.7 | .1 |
| | | 10-15-79 | 11.0 | 45E | 131 | 160 | 20 | 36 | – | 1.5 | .1 |
| | 39 | 10-12-77 | 5.6 | 10E | 200 | 240 | 10 | 55 | 1 | 2.8 | .1 |
| | | 7-26-78 | – | – | 140 | 170 | 10 | 44 | 0 | 1.7 | .1 |
| | | 10-17-78 | 4.7 | 12E | 180 | – | 20 | 50 | – | 2.8 | .1 |
| | | 7-19-79 | 7.5 | 80 | 140 | – | 40 | 41 | – | 1.8 | .1 |
| | | 10-15-79 | 10.0 | 45E | 146 | 178 | 20 | 38 | – | 1.7 | .1 |
| Huntington Creek | 41 | 7-26-78 | 18.5 | – | 140 | 170 | 30 | 47 | 0 | 2.6 | .1 |
| | | 10-17-78 | 5.5 | 30E | 180 | – | 30 | 51 | – | 3.4 | .1 |
| | | 7-19-79 | 7.5 | 100 | 140 | – | 20 | 43 | – | 2.2 | .1 |
| | | 10-15-79 | 9.5 | 65 | 153 | 186 | 20 | 41 | – | 2.1 | .1 |
| Crandall Canyon (gaging station 09317919) | 51 | 10-12-77 | 3.0 | 1.0E | 220 | 270 | 30 | 59 | 1 | 7.8 | .2 |
| | | 7-26-78 | 18.2 | – | 190 | 230 | 20 | 54 | 0 | 3.8 | .1 |
| | | 10-18-78 | 4.9 | .7E | 230 | – | 30 | 53 | – | 4.7 | .1 |
| | | 7-19-79 | 9.5 | 1.9 | 200 | – | 40 | 48 | – | 4.4 | .1 |
| | | 10-15-79 | 6.0 | .54 | – | 288 | 20 | 54 | – | 4.7 | .1 |
| Wild Cattle Hollow | 61 | 10-13-77 | 7.5 | 70E | 200 | 240 | 10 | 67 | 0 | 5.0 | .1 |
| | | 7-27-78 | 10.1 | – | 210 | 250 | 20 | 60 | 0 | 5.5 | .1 |
| | | 10-17-78 | 6.0 | .1E | 250 | – | 50 | 64 | – | 5.2 | .1 |
| | | 7-19-79 | 9.0 | 1.5 | 210 | – | 30 | 48 | – | 4.1 | .1 |
| | | 10-15-79 | 8.0 | .25 | 249 | 303 | 20 | 62 | – | 4.8 | .1 |
| Tie Fork (gaging station 09317920) | 67 | 10-13-77 | 6.3 | .43 | 190 | 230 | 30 | 63 | 1 | 4.4 | .1 |
| | | 6- 9-78 | 5.3 | 8.8 | – | – | – | 68 | – | 3.6 | – |
| | | 7-26-78 | 16.3 | – | 200 | 240 | 20 | 53 | – | 4.4 | .1 |
| | | 10-17-78 | 6.4 | 50E | 250 | – | 30 | 64 | – | 4.6 | .1 |
| | | 7-19-79 | 12.5 | 1.8 | 200 | – | 50 | 49 | – | 4.3 | .1 |
| | | 10-15-79 | 8.0 | .51 | – | 302 | 20 | 58 | – | 4.5 | .1 |
| Huntington Creek | 68 | 7-27-78 | 16.1 | 420 | 150 | 170 | 20 | 47 | 4 | 2.2 | .1 |
| | | 10-18-78 | 6.0 | 30E | 180 | – | 30 | 51 | – | 3.2 | .1 |
| | | 7-19-79 | 12.0 | 105 | 150 | – | 30 | 51 | – | 2.4 | .1 |
| | | 10-15-79 | 9.5 | 70E | 156 | 190 | 30 | 42 | – | 2.3 | .1 |
| | 69 | 7-27-78 | 15.8 | – | 150 | 180 | 20 | 46 | 0 | 2.1 | .1 |
| | | 10-18-78 | 5.7 | 30E | 190 | – | 30 | 53 | – | 3.0 | .1 |
| | | 7-19-79 | 11.5 | 110 | 140 | – | 20 | 40 | – | 2.1 | .1 |
| | | 10-16-79 | 6.5 | 70E | 159 | 194 | 20 | 44 | – | 2.2 | .1 |
| Little Bear Canyon | 70 | 7-27-78 | 15.5 | – | 230 | 280 | 30 | 54 | 0 | 5.6 | .1 |
| | | 10-18-78 | 7.1 | .5E | 190 | 230 | 40 | 65 | – | 6.3 | .2 |
| | | 7-19-79 | 13.5 | 1.0 | 240 | – | 40 | 47 | – | 6.5 | .1 |
| | | 10-16-79 | 5.0 | .75 | 276 | 337 | 30 | 58 | – | 6.2 | .1 |
| Huntington Creek | 71 | 7-27-78 | 17.6 | – | 140 | 170 | 20 | 49 | 0 | 4.7 | .1 |
| | | 10-18-78 | 5.6 | 30E | 180 | – | 20 | 52 | – | 3.1 | .1 |
| | | 7-19-79 | 13.5 | 110 | 140 | – | 50 | 40 | – | 2.2 | .1 |
| | | 10-16-79 | 7.0 | 70E | 160 | 195 | 20 | 43 | – | 2.3 | .1 |
| Mill Fork | 76 | 7-27-78 | 18.2 | – | 250 | 300 | 30 | 53 | 0 | 7.9 | .1 |
| | | 7-19-79 | 14.5 | 14 | 250 | – | 60 | 46 | – | 9.4 | .2 |
| | | 10-16-79 | 6.0 | .04 | 295 | 360 | 40 | 58 | – | 10 | .1 |
| Huntington Creek | 77 | 7-28-78 | 13.2 | – | 150 | 180 | 20 | 49 | 0 | 2.5 | .1 |
| | | 10-18-78 | 5.7 | 30E | 160 | – | 30 | 50 | – | 4.6 | .1 |
| | | 7-19-79 | 14.0 | 110 | 140 | – | 50 | 40 | – | 2.3 | .1 |
| | | 10-16-79 | 8.0 | 75E | 157 | 191 | 20 | 44 | – | 2.4 | .1 |
| Rilda Canyon | 78 | 7-15-76 | 12.0 | .50 | 279 | 340 | 40 | 62 | – | 11 | .2 |
| | | 7-26-78 | 15.2 | – | 230 | 280 | 40 | 59 | 0 | 6.6 | .1 |
| | | 10-18-78 | 6.4 | .35E | 360 | – | 80 | 73 | – | 8.6 | .2 |
| | | 7-18-79 | 11.5 | 2.0 | 170 | – | 60 | 50 | – | 7.6 | .2 |
| | | 10-16-79 | 7.0 | < 1.0 | 336 | 410 | 50 | 75 | – | 10 | .2 |
| Huntington Creek | 80 | 8-15-77 | 17.0 | 25 | 160 | 200 | 30 | 43 | 0 | 3.8 | .1 |
| | | 6- 6-78 | 6.0 | 360 | 150 | 180 | 10 | 50 | 0 | 2.7 | .1 |
| Meetinghouse Canyon | 84 | 8- 6-79 | 18.5 | .21 | 180 | – | 50 | 39 | 12 | 5.8 | .2 |
| Deer Creek | 86 | 8-26-79 | 8.6 | .26 | 270 | – | 110 | 110 | – | 7.2 | .2 |
| | 87 | 7-28-78 | 15.2 | – | 210 | 260 | 60 | 55 | 0 | 22 | .7 |
| | | 7-18-79 | 17.0 | 1.0 | 230 | 0 | 120 | 65 | – | 16 | .2 |
| Huntington Creek (gaging station 09318000) | 88 | 6- 9-77 | 15.0 | – | 160 | 190 | 30 | 55 | 0 | 3.9 | .1 |
| | | 8-15-77 | 19.0 | 13 | 170 | 210 | 40 | 57 | 0 | 15 | .2 |
| | | 6- 6-78 | 6.5 | 360 | 160 | 190 | 20 | 51 | 0 | 9.1 | .1 |
| | | 11-14-78 | 2.5 | 16 | 210 | 250 | 50 | 60 | 0 | 6.8 | .1 |
| | | 6-13-79 | 13.0 | 216 | 140 | – | 20 | 52 | 2 | 3.3 | .2 |
| | | 11-11-79 | 0 | 19 | 250 | – | 20 | 59 | 0 | 4.4 | .1 |
| Cottonwood Creek | 103 | 10-13-77 | 2.8 | 1.0E | 180 | 210 | 30 | 66 | 7 | 7.6 | .1 |
| | | 7-27-78 | 10.0 | – | 220 | 270 | 30 | 57 | 0 | 8.2 | .1 |
| | | 10-19-78 | 4.7 | .28 | 284 | – | 40 | 59 | – | 8.6 | .1 |
| | | 7-18-79 | 14.0 | .97 | 240 | – | 60 | 47 | – | 9.9 | .2 |
| | | 10-16-79 | 5.0 | – | 287 | 350 | 30 | 60 | – | 9.4 | .1 |
| Cottonwood Creek (gaging station 09324200) | 104 | 10-13-77 | 2.3 | 1.0E | 220 | 260 | 30 | 56 | 1 | 7.8 | .1 |
| | | 7-27-78 | 12.4 | – | 220 | 270 | 30 | 46 | 0 | 8.2 | .1 |
| | | 10-19-78 | 4.7 | .8E | 260 | – | 50 | 52 | – | 9.8 | .1 |
| | | 7-18-79 | 16.0 | .97 | 210 | – | 50 | 37 | – | 9.9 | .2 |
| | | 10-16-79 | 5.0 | .51 | 277 | 330 | 30 | 51 | 4 | 9.5 | .1 |
| Grimes Wash | 107 | 8-26-79 | 13.3 | .10 | 260 | – | 40 | 78 | – | 12 | .2 |
| | 108 | 9-29-76 | 14.5 | < .01 | 256 | 312 | 110 | 97 | 0 | 22 | .2 |

TABLE 7- 7 Continued

| Concentration | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hardness (as $CaCO_3$) | Noncarbonate hardness (as $CaCO_3$) | Dissolved iron (µg/L) | Dissolved magnesium | Dissolved potassium | Dissolved silica | Dissolved sodium | Dissolved solids | Dissolved sulfate | Dissolved strontium (µg/L) | Sodium adsorption ratio | pH (units) | Specific conductance | Other data available |
| 180 | 20 | – | 1.3 | 0.8 | 3.3 | 2.9 | 154 | 5.7 | – | 0.1 | 8.2 | 330 | – |
| 180 | 20 | – | .9 | 1.3 | 3.1 | 2.5 | 193 | 20 | – | .1 | 7.8 | 300 | – |
| 120 | 3 | – | 5.5 | .8 | 2.7 | 2.0 | 130 | 8.9 | – | .1 | 7.5 | 220 | – |
| 140 | 8 | – | 6.6 | .7 | 3.9 | 1.6 | 147 | 7.5 | – | .1 | 7.5 | 230 | – |
| 150 | 42 | – | 5.8 | 1.2 | 22 | 2.8 | 191 | 41 | – | .1 | 7.3 | 300 | – |
| 180 | 13 | – | 8.5 | .6 | 3.9 | 1.9 | 179 | 6.6 | – | .1 | 8.0 | 290 | – |
| 200 | 31 | – | 17 | .8 | 5.2 | 1.5 | 192 | 6.5 | – | 0 | 8.7 | 340 | – |
| 150 | 15 | – | 8.7 | .6 | 2.7 | 1.5 | 147 | 6.1 | – | .1 | 8.8 | 240 | – |
| 170 | 2 | 20 | 12 | .7 | 3.3 | 1.7 | 176 | 4.2 | 100 | .1 | 8.7 | 303 | – |
| 130 | 1 | 10 | 7.6 | .5 | 3.1 | 1.2 | 140 | 7.7 | – | 0 | 7.8 | 273 | – |
| 140 | 4 | 10 | 11 | .5 | 1.0 | 1.6 | 136 | 5.5 | – | .1 | 8.1 | 270 | – |
| 220 | 25 | – | 21 | 1.2 | 5.6 | 3.3 | 220 | 12 | – | .1 | 8.4 | 420 | – |
| 150 | 12 | – | 10 | .7 | 2.6 | 1.7 | 152 | 6.6 | – | .1 | 8.4 | 260 | – |
| 200 | 15 | < 10 | 17 | .9 | 3.7 | 2.8 | 197 | 11 | 120 | .1 | 8.4 | 400 | – |
| 140 | 0 | 10 | 8.7 | .7 | 3.0 | 1.5 | 150 | 8.8 | – | .1 | 7.9 | 285 | – |
| 140 | 0 | 10 | 12 | .5 | 1.4 | 1.7 | 150 | 7.2 | – | .1 | 8.1 | 267 | – |
| 170 | 31 | – | 13 | 1.1 | 3.4 | 2.2 | 169 | 15 | – | .1 | 8.8 | 300 | SOS |
| 190 | 9 | 40 | 15 | 1.1 | 3.5 | 2.6 | 201 | 16 | 100 | .1 | 8.3 | 380 | – |
| 150 | 6 | 60 | 9.4 | .8 | 3.0 | 1.4 | 154 | 10 | – | .1 | 7.8 | 307 | – |
| 160 | 3 | 20 | 13 | .7 | 2.1 | 1.9 | 165 | 12 | – | .1 | 8.1 | 290 | – |
| 290 | 68 | – | 35 | 2.0 | 7.0 | 7.2 | 287 | 35 | – | .2 | 8.6 | 470 | SOS |
| 220 | 33 | – | 21 | 1.3 | 5.6 | 4.3 | 234 | 30 | – | .1 | 8.6 | 480 | – |
| 250 | 22 | 10 | 29 | 1.3 | 6.1 | 4.9 | 273 | 35 | 180 | .1 | 7.8 | 509 | – |
| 220 | 23 | 0 | 25 | 1.2 | 5.2 | 5.2 | 240 | 31 | – | .1 | 7.9 | 450 | – |
| 260 | 22 | 20 | 30 | 1.4 | 6.2 | 5.3 | 282 | 38 | – | .1 | 8.2 | 470 | – |
| 260 | 61 | – | 22 | 1.4 | 6.5 | 4.4 | 251 | 26 | – | .1 | 8.3 | 520 | – |
| 260 | 52 | – | 26 | 1.3 | 5.8 | 3.8 | 266 | 38 | – | .1 | 7.8 | 390 | – |
| 280 | 29 | < 10 | 29 | 1.3 | 6.1 | 4.5 | 273 | 26 | 200 | .1 | 7.9 | 560 | – |
| 210 | 0 | 0 | 21 | 1.1 | 5.4 | 3.3 | 224 | 15 | – | .1 | 7.6 | 426 | – |
| 270 | 17 | 40 | 27 | 1.4 | 6.0 | 4.3 | 281 | 26 | – | .1 | 8.0 | 485 | – |
| 310 | 120 | – | 36 | 1.8 | 6.9 | 3.8 | 265 | 35 | – | .1 | 8.6 | 500 | SOS |
| 250 | – | – | 19 | 3.3 | – | 2.6 | 185 | 13 | – | – | 8.6 | 410 | – |
| 250 | 55 | – | 29 | 1.6 | 5.9 | 3.8 | 247 | 30 | – | .1 | 8.8 | 450 | – |
| 290 | 62 | 20 | 32 | 1.8 | 6.7 | 3.0 | 289 | 38 | 270 | .1 | 8.2 | 543 | – |
| 230 | 29 | 10 | 26 | 7.3 | 6.3 | 3.9 | 234 | 23 | – | .1 | 8.1 | 450 | – |
| 270 | 25 | 40 | 31 | 1.8 | 6.3 | 4.1 | 293 | 38 | – | .1 | 8.2 | 501 | – |
| 170 | 21 | – | 12 | .8 | 2.9 | 1.9 | 166 | 11 | – | .1 | 8.5 | 260 | – |
| 200 | 18 | 40 | 17 | 1.1 | 3.6 | 3.1 | 201 | 19 | 120 | .1 | 8.4 | 378 | – |
| 170 | 23 | 10 | 11 | .8 | 3.2 | 1.8 | 174 | 13 | – | .1 | 8.0 | 308 | – |
| 160 | 7 | 10 | 14 | .8 | 2.2 | 2.1 | 171 | 14 | – | .1 | 8.3 | 301 | – |
| 160 | 17 | – | 12 | .8 | 2.9 | 1.8 | 165 | 10 | – | .1 | 8.2 | 280 | – |
| 210 | 21 | 30 | 18 | 1.2 | 3.5 | 3.4 | 209 | 18 | 120 | .1 | 8.3 | 380 | – |
| 140 | 1 | 10 | 10 | .6 | 3.1 | 1.7 | 154 | 12 | – | .1 | 7.9 | 273 | – |
| 170 | 8 | 10 | 14 | .8 | 2.1 | 2.1 | 175 | 14 | – | .1 | 8.1 | 309 | – |
| 290 | 62 | – | 38 | 1.8 | 6.6 | 7.1 | 291 | 39 | – | .2 | 8.7 | 500 | – |
| 210 | 22 | < 10 | 12 | 1.8 | 6.8 | 7.4 | 250 | 36 | 250 | .2 | 8.2 | 575 | – |
| 270 | 34 | 10 | 38 | 1.8 | 6.5 | 8.1 | 292 | 40 | – | .2 | 7.8 | 548 | – |
| 300 | 25 | < 10 | 38 | 1.7 | 6.7 | 7.5 | 326 | 42 | – | .2 | 8.2 | 538 | – |
| 180 | 36 | – | 13 | .9 | 2.9 | 2.0 | 175 | 18 | – | .1 | 8.8 | 270 | – |
| 200 | 24 | 30 | 18 | 1.1 | 3.2 | 3.1 | 205 | 16 | 120 | .1 | 8.6 | 370 | – |
| 150 | 5 | 10 | 11 | .4 | 3.1 | 2.0 | 155 | 12 | – | .1 | 8.1 | 296 | – |
| 170 | 5 | 20 | 14 | .8 | 2.1 | 2.1 | 174 | 13 | – | .1 | 8.2 | 302 | – |
| 280 | 39 | – | 37 | 2.0 | 7.1 | 11 | 318 | 52 | – | .3 | 8.7 | 440 | – |
| 280 | 34 | 0 | 41 | 5.2 | 6.8 | 10 | 327 | 58 | – | .3 | 8.0 | 514 | – |
| 340 | 47 | 10 | 48 | 3.0 | 7.4 | 12 | 391 | 75 | – | .3 | 8.3 | 612 | – |
| 170 | 24 | – | 12 | .9 | 2.8 | 2.2 | 170 | 11 | – | .1 | 8.4 | 285 | – |
| 200 | 39 | 30 | 18 | 1.2 | 3.2 | 3.6 | 203 | 26 | 120 | .1 | 8.3 | 390 | – |
| 140 | – | 10 | 10 | .8 | 3.1 | 1.7 | 154 | 12 | – | .1 | 8.4 | 302 | – |
| 170 | 11 | < 10 | 14 | .8 | 2.0 | 2.3 | 176 | 16 | – | .1 | 8.2 | 316 | – |
| 380 | 98 | 20 | 54 | 2.5 | 8.2 | 17 | 424 | 100 | – | .4 | – | – | – |
| 310 | 82 | – | 40 | 2.0 | 6.4 | 10 | 326 | 63 | – | .2 | 8.9 | 500 | – |
| 410 | 65 | 20 | 54 | 3.1 | 8.8 | 18 | 429 | 99 | 430 | .4 | 8.1 | 840 | – |
| 290 | 120 | – | 39 | 1.1 | 6.7 | 13 | 292 | 72 | – | .3 | 8.1 | 620 | – |
| 420 | 82 | 20 | 56 | 3.2 | 8.6 | 18 | 503 | 130 | – | .4 | 8.1 | 730 | – |
| 180 | 17 | – | 18 | 1.7 | 4.3 | 4.1 | 196 | 22 | – | .1 | 8.3 | 332 | – |
| 170 | 27 | – | 12 | .6 | 3.0 | 2.1 | 173 | 14 | – | .1 | 7.8 | 280 | – |
| 230 | 50 | 0 | 32 | 3.9 | 5.3 | 10 | 260 | 43 | 310 | .3 | 8.6 | 438 | – |
| 410 | 140 | 190 | 33 | 1.1 | 6.4 | 19 | < 372 | 32 | – | .4 | 8.4 | 490 | – |
| 380 | 170 | – | 59 | 4.0 | 10 | 29 | 476 | 160 | – | .6 | 8.8 | 650 | SOS |
| 360 | 130 | 0 | 47 | 4.1 | 7.9 | 25 | 474 | 170 | – | .6 | 8.1 | 790 | – |
| 200 | 43 | – | 15 | 1.1 | 3.4 | 4.6 | 200 | 23 | – | .1 | 8.3 | 390 | – |
| 250 | 73 | – | 25 | 1.9 | 5.8 | 13 | 289 | 67 | – | .4 | 8.1 | 478 | – |
| 180 | 21 | – | 12 | .8 | 4.0 | 2.9 | 183 | 14 | – | .1 | 7.8 | 290 | – |
| 250 | 44 | 20 | 24 | 1.4 | 5.7 | 9.2 | 278 | 47 | 160 | .3 | 8.2 | 470 | – |
| 140 | 3 | 10 | 3.1 | .5 | 3.2 | 4.2 | 175 | 21 | 190 | .2 | 8.4 | 365 | – |
| 230 | 34 | 10 | 21 | 1.4 | 4.7 | 5.8 | 251 | 33 | 150 | .2 | 8.3 | 435 | – |
| 330 | 150 | – | 41 | 2.0 | 7.0 | 10 | 276 | 32 | – | .2 | 8.5 | 540 | – |
| 300 | 81 | – | 39 | 1.7 | 6.7 | 12 | 306 | 47 | – | .3 | 7.8 | 470 | – |
| 300 | 54 | 20 | 38 | 1.8 | 6.9 | 12 | 317 | 40 | 330 | .3 | 8.6 | 620 | – |
| 280 | 38 | 10 | 39 | 1.8 | 6.9 | 18 | 319 | 52 | – | .5 | 7.9 | 640 | – |
| 310 | 23 | 20 | 39 | 2.0 | 6.8 | 14 | 355 | 51 | – | .3 | 8.0 | 583 | – |
| 310 | 94 | – | 41 | 2.1 | 7.0 | 11 | 286 | 32 | – | .3 | 8.5 | 540 | SOS |
| 280 | 58 | – | 40 | 1.8 | 6.5 | 12 | 294 | 45 | – | .3 | 8.3 | 470 | – |
| 290 | 31 | 10 | 39 | 2.0 | 6.9 | 12 | 319 | 40 | 330 | .3 | 8.7 | 512 | – |
| 240 | 35 | 0 | 37 | 2.1 | 6.2 | 18 | 290 | 53 | – | .5 | 8.0 | 610 | – |
| 290 | 15 | 20 | 40 | 2.1 | 6.7 | 15 | 343 | 52 | – | .4 | 8.4 | 550 | – |
| 370 | 110 | 150 | 43 | 1.4 | 8.0 | 22 | < 384 | 63 | – | .5 | 8.3 | 580 | SOS |
| 580 | 320 | 20 | 82 | 4.8 | 8.9 | 31 | 763 | 360 | 700 | .6 | 8.0 | 1,200 | – |

of the results. It should be noted that none of the analyzed chemical constituents were found in concentrations that exceeded the drinking water standards of the U. S. Environmental Protection Agency (1976). Danielson also noted that, "The predominant dissolved chemical constituents in water in Huntington Creek upstream from gaging station 0931800 were calcium and bicarbonate...The predominant dissolved chemical constituents in water in tributaries to Huntington Creek were usually calcium, magnesium, and bicarbonate. However, during periods of base flow the concentrations of sulphate in water at the mouths (of the tributaries)...were significantly higher than sufphate concentrations in water in Huntington Creek...Water from the Star Point commonly contains slightly higher concentrations of both dissolved solids and sulphate than water from younger rocks in the area."

### 7.2.1.2 WATER USES

Most of the surface water from the drainage is diverted for use as crop irrigation. The only other major use is supply water to the Huntington Powerplant. The reservoirs in the area have been built to supplement this use. Some water in the area, particularly springs, is used for livestock watering or as culinary water.

## 7.2.2 MINE PLAN AREA SURFACE WATER

The channel of Bear Creek is straddled by the mine plan area with the vast majority of the area, disturbed and undisturbed, west of the creek. Bear Creek is an intermittent stream with flows often frozen during the

winter. An intermittent tributary flows into Bear Creek from the east in the mine plan area, but this tributary does not pass through any disturbed area.

The Bear Canyon Springs' discharge is diverted by pipeline to Huntington City, never becoming "surface water." The different discharge characteristics of Bear Canyon Spring and Bear Creek denote the differences of their sources. Bear Canyon Spring which issues from the Star Point Sandstone has had relatively high, constant discharges rates, between 110 and 160 gpm (see Table 7-4), without predominant seasonal changes typical of a snowmelt impact. On the other hand, measurements at the mouth of Bear Creek made during Danielson study indicate a significant impact to streamflow from snowmelt, between 18 and 153 gpm (see below),. The headwater springs of Bear Creek issue from the North Horn Formation, a locally recharged water zone. The Star Point Aquifer is a regionally recharged aquifer which explains the consistency of Bear Canyon Springs flows.

Streamflow measurements made during 1977-79

(Danielson,'81)

| | Date | Discharge (cfs) |
|---|---|---|
| Bear Creek (site no. 81) | 8-10-78 | .09 |
| | 10-25-78 | .08 |
| | 11- 8-78 | .06 |
| | 12-13-78 | .04 |
| | 6-27-79 | .34 |
| | 7-16-79 | .21 |
| | 10-30-79 | .05 |

Measurement of suspended sediments were collected during the Danielson study. Below are the results from selected tributaries of Huntington Creek.

| Stream | Site No. | Date | Concentration (mg/l) | Load (tons per day) |
|---|---|---|---|---|
| Huntington Creek (gaging station 09318000) | 88 | 8-13-78 | 104 | 27 |
| | | 11-17-78 | 72 | 2.5 |
| | | 6-13-79 | 114 | 66 |
| | | 8- 7-79 | 44 | 15 |
| Crandall Canyon (gaging station 09317919) | 51 | 8-12-78 | 49 | .14 |
| | | 11-18-78 | 60 | .08 |
| | | 6-14-79 | 15 | .41 |
| | | 8- 6-79 | 56 | .15 |
| Tie Fork Canyon (gaging station 09317920) | 67 | 8-13-78 | 12 | .03 |
| | | 11-18-78 | 57 | .12 |
| | | 6-14-79 | 38 | .68 |
| | | 8- 6-79 | 66 | .17 |
| Bear Creek | 81 | 10-25-78 | 8,860 | 1.9 |
| | | 6-14-79 | 2,140 | 4.0 |
| Deer Creek | 87 | 6-14-79 | 609 | 3.1 |

Concerning the unusually high sediment loads in Bear Creek, Danielson stated the following:

> "Bear Creek transported large quantities of suspended sediment during 1978 and 1979. Springs emerging from the North Horn Formation in the headwaters of Bear Creek continuously erode the shales and mudstone and permit sloughing of large amounts of fine-grained material from the escapements."

As part of Co-Op Mining Company's monitoring program, water samples from Bear Creek, both above and below the mine plan area, have been chemically analyzed for the past 1½ years. The results are presented in Table 7-8. During the snowmelt (April-July) there is an increased in suspended sediments, as expected, due to the increased flows. The reasons for such poor quality water and changes in chemical concentrations are not

TABLE 7-8

Chemical Analysis of Water Samples Taken
by Co-Op Mining Company from Bear Creek

| Date | Location* | Flow (gpm) | Temp. (°C) | pH | Iron (mg/l) | Manganese (mg/l) | Suspended Solids (mg/l) |
|---|---|---|---|---|---|---|---|
| 11-15-82 | 1 | 25 | -- | 8.0 | 1.50 | .32 | 706 |
| | 2 | 30 | -- | 7.9 | 1.51 | .33 | 688 |
| 12-20-82 | 1 | no flow | | | | | |
| | 2 | no flow | | | | | |
| 2-22-83 | 1 | no flow | | | | | |
| | 2 | no flow | | | | | |
| 3-22-83 | 1 | 400 | -- | -- | 1.91 | .35 | 5,581 |
| | 2 | 400 | -- | 8.0 | 1.80 | .30 | 7,980 |
| 4-25-83 | 1 | 425 | -- | 7.5 | .17 | .36 | 20,000 |
| | 2 | 425 | -- | 7.5 | .15 | .07 | 20,000 |
| 5-24-83 | 1 | 1,125 | -- | 7.7 | 43.10 | 5.00 | 15,880 |
| | 2 | 1,125 | -- | 7.9 | 36.30 | 3.80 | 14,740 |
| 6-17-83 | 1 | 1,125 | -- | 8.1 | 7.63 | .05 | 8,326 |
| | 2 | 1,125 | -- | -- | 6.50 | .05 | 14,060 |
| 7-31-83 | 1 | N/A | | | | | |
| | 2 | N/A | | | | | |
| 8-26-83 | 1 | N/A | | | | | |
| | 2 | N/A | | | | | |
| 9-20-83 | 1 | 9.4 | 17 | 8.2 | 5.40 | .80 | 3,437 |
| | 2 | 11.8 | 17 | 8.2 | *.05 | *.08 | 2,616 |
| 10-24-83 | 1 | 32.6 | 1 | 7.4 | 2.66 | .35 | 1,349 |
| | 2 | 36.0 | 1 | 7.7 | 2.66 | .32 | 1,238 |
| 11-29-83 | 1 | no flow | 0 | 8.2 | .80 | .18 | 686 |
| | 2 | 40 | 0 | 8.3 | .86 | .13 | 512 |
| 12-29-83 | 1 | 1.2 | -- | 8.1 | 1.17 | .20 | 553 |
| | 2 | --- | 0 | 8.05 | 1.13 | .21 | 500 |
| 1-26-84 | 1 | --- | 2 | 7.8 | 6.57 | 1.19 | 4,928 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | 2 | --- | 2 | 8.05 | 4.41 | .94 | 4,020 |

TABLE 7-8 Continued

| Date | Location* | Flow (gpm) | Temp. (°C) | pH | Iron (mg/l) | Manganese (mg/l) | Suspended Solids (mg/l) |
|---|---|---|---|---|---|---|---|
| 2-14-84 | 1 | 13.8 | 2 | *1.9 | 1.65 | .27 | 830 |
| | 2 | 14 | 2 | 7.85 | 2.50 | .27 | 1,168 |
| 3-7-84 | 1 | 16.7 | 2 | 8.0 | 1.49 | .07 | 342 |
| | 2 | 14.2 | 1 | 8.2 | 3.00 | .44 | 1,568 |
| 4-11-84 | 1 | 27.0 | -- | 8.1 | 2.36 | .60 | 4,950 |
| | 2 | 28.2 | -- | 8.1 | 1.68 | .33 | 1,922 |

*Location #1 is upstream, below Bear Creek Falls. Location #2 is downstream, at Bear Creek Weir W-4.

understood at this time. Further monitoring will be necessary before any conclusions can be drawn.

### 7.2.3 EFFECTS OF MINING ON SURFACE WATER

The operation of Bear Canyon Mine by Co-Op Mining Company is expected to have only a very minimal effect on surface water on the area. The quality of Bear Creek before passing through the mine plan area is poor. After passing through the mine area, as often as not, the quality is improved or unchanged. Generally, there is little difference in the surface water quality after passing through the mine site area. The greatest impact of mining operations is probably an increase in sediment loading to Bear Creek. Several control and diversions structures have been constructed to prevent sediment laden water from the roads and disturbed area from mixing with local surface water, to minimize the mining impacts on the receiving stream waters.

The headwater springs of Bear Creek are to the north and east of the mine plan area. Since groundwater movement in the area is in a southerly direction, any mine dewatering, which should be minimal, would have little or no effect on quantity or quality of flows in Bear Creek.

### 7.2.4 MONITORING PLANS

In the past, Co-Op Mining Company has monitored two stations on Bear Creek, one above (north) the mine plan area and one below (southwest). The monitoring location above the mining area is approximately 3000'

upstream from where the mine road crosses Bear Creek in the mine plan area. The monitoring location downstream is a Weir W-4. In addition to these a third monitoring location is being added. In the future the right-hand tributary of Bear Creek will be monitored just above its confluence with Bear Creek. (see plate 7-4)

Monitoring of the following parameters will be performed monthly: flow (gpm), ph, temperature (°C), total dissolved solids (mg/l), iron , magnesium potassium, chloride, nitrate sulphate, carbonates, bicarbonates, calcium, magnesium, sodium and total suspended solids (all in mg/l).

Flows will be determined by direct measurement (depth times width times 2/3 velocity) or, whenever feasible, by timed filling of a unit volume container. Chemical analyses will be performed by a certified laboratory. Reporting format will be as shown in Figure 7-4.

### 7.2.5 SURFACE WATER CONTROL AND DIVERSIONS

The vast majority of the disturbed area of the Bear Canyon Mine is on the west side of Bear Canyon (same side as the mine portal and to the south). The all run-off from this west side disturbed area is collected and channelled to Sedimentation Pond "A". The small amount of run-off from the disturbed area east of Bear Creek is channelled to Sedimentation Pond "B". In order to minimize the amount of water crossing the disturbed area, run-off from the undisturbed area above is diverted around or channelled through the disturbed area and into Bear Creek.

H/C
4-27-84

Co-Op Mining Company

Bear Canyon Mine

-Water Sample Analysis-

Date:

Station Location:
(circle one)

Bear Creek Upstream
Bear Creek Downstream (Weir W-4)
Bear Creek Right-hand Tributary
C O P Development Spring
Mine Underground Storage
Mine Discharge
Mine Inflow - Point #_____

Parameters and Quantities

Flow (gpm)_____ Temperature (°C) _____

pH _____ Total Suspended Solids (mg/l)_____

-Chemicals-

| Cations (mg/l) | | Anions (mg/l) | |
|---|---|---|---|
| Calcium | _____ | Carbonate | _____ |
| Magnesium | _____ | Bicarbonate | _____ |
| Iron | _____ | Sulphate | _____ |
| Sodium | _____ | Chloride | _____ |
| Potassium | _____ | Nitrate | _____ |

Total Dissolved Solids (mg/l) _____

Figure 7-4
Water Analysis Reporting Format

In addition, Co-Op Mines implemented an extensive interim revegetation program in October, 1983 wherein soil tackifiers and mulches were utilized to stabilize the soil until vegetation is established.

Plate 7-1 shows the arrangement of the various sedimentation and diversion structures.

### 7.2.5.1 SEDIMENTATION PONDS

Two sedimentation ponds have been constructed to hold the run-off from the disturbed area of the Mine Plan to facilitate settling and filtering of contaminated surface water from the mine site. In addition, any excess groundwater from the mine will be discharged to the sedimentation ponds (it is anticipated that practically all groundwater produced in the mine will be used on site -- see 7.1.3.1 Mine Dewatering).

The disturbed area west of Bear Creek was split into three section to facilitate calculations. The design calculations for both Pond "A" and "B" are as follows:

## SEDIMENT STORAGE FROM DISTURBED AREA

Design Data

| | | |
|---|---|---|
| Site elevation | : | 7150 feet (U.S.G.S.) |
| Runoff Area | : | See 1" = 50' map for individual areas |

H/C
4-27-84

| | | |
|---|---|---|
| Average Slope Length | : | See table below |
| Average Slope Gradient | : | See table below |
| 6 Hour-10 year Storm | : | 1.4 inches |
| Soil Characteristics | : | 12% silt, 24% fine sand, 36% sand, 0% organic matter, course graded soil, moderate permeability |

TABLE

| Area # | Area* (acres) | Average Slope Length (feet) | Average Slope Gradient (%) |
|---|---|---|---|
| A1 | 2.24 | 420 | 36 |
| A2 | 4.96 | 560 | 14 |
| A3 | 3.51 | 640 | 11 |
| B | 1.79 | 520 | 10 |

*By Planimeter

Determinations

Use uniform soil loss equation, A=RKLSPC

R : From Figure 1 "Universal Soil Loss Equation", SCS, Jan. 1976, use R=40 (see figure included)
K : From "A Soil Erodability Nomograph", where % site plus % fine sand = 36%, K=0.32
LS : From Table 1, "Universal Soil Loss Equation", SCS, Jan. 1976, (see table included) for A1, LS = 22.06
A2, LS = 5.42
A3, LS = 4.14
B , LS = 3.12
C : Assume bare ground, USC, C=1
P : Assume no erosion control, USC, P=1

$A_{A1}$=(40)(0.32)(22.06)(1)(1)=282.4 tons/acre/year

$A_{A2}$=(40)(0.32)( 5.42)(1)(1)= 69.4 tons/acre/year

$A_{A3}$=(40)(0.32)( 4.14)(1)(1)= 53.0 tons/acre/year

$A_{B}$ =(40)(0.32)( 3.12)(1)(1)= 39.9 tons/acre/year

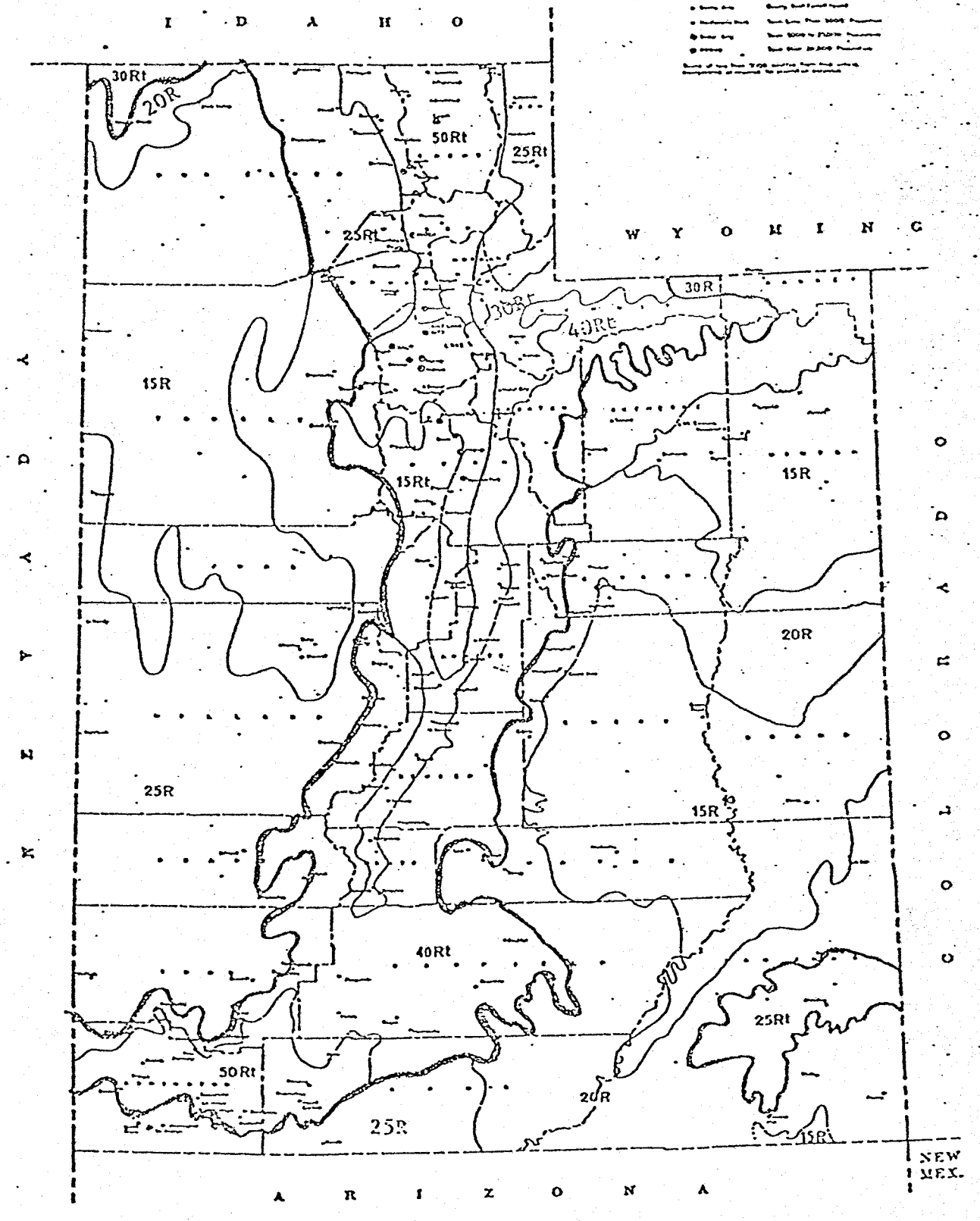
For areas, 3 years [OSM regulations 817.46(bx1)], Soil = 90 lbs/ft$^3$

FIGURE 1.

SOIL CONSERVATION SERVICE

# UNIVERSAL SOIL LOSS EQUATION

## AVERAGE ANNUAL VALUES FACTOR R and Rt




R - Rainfall Only

Rt - Rainfall and Snowmelt

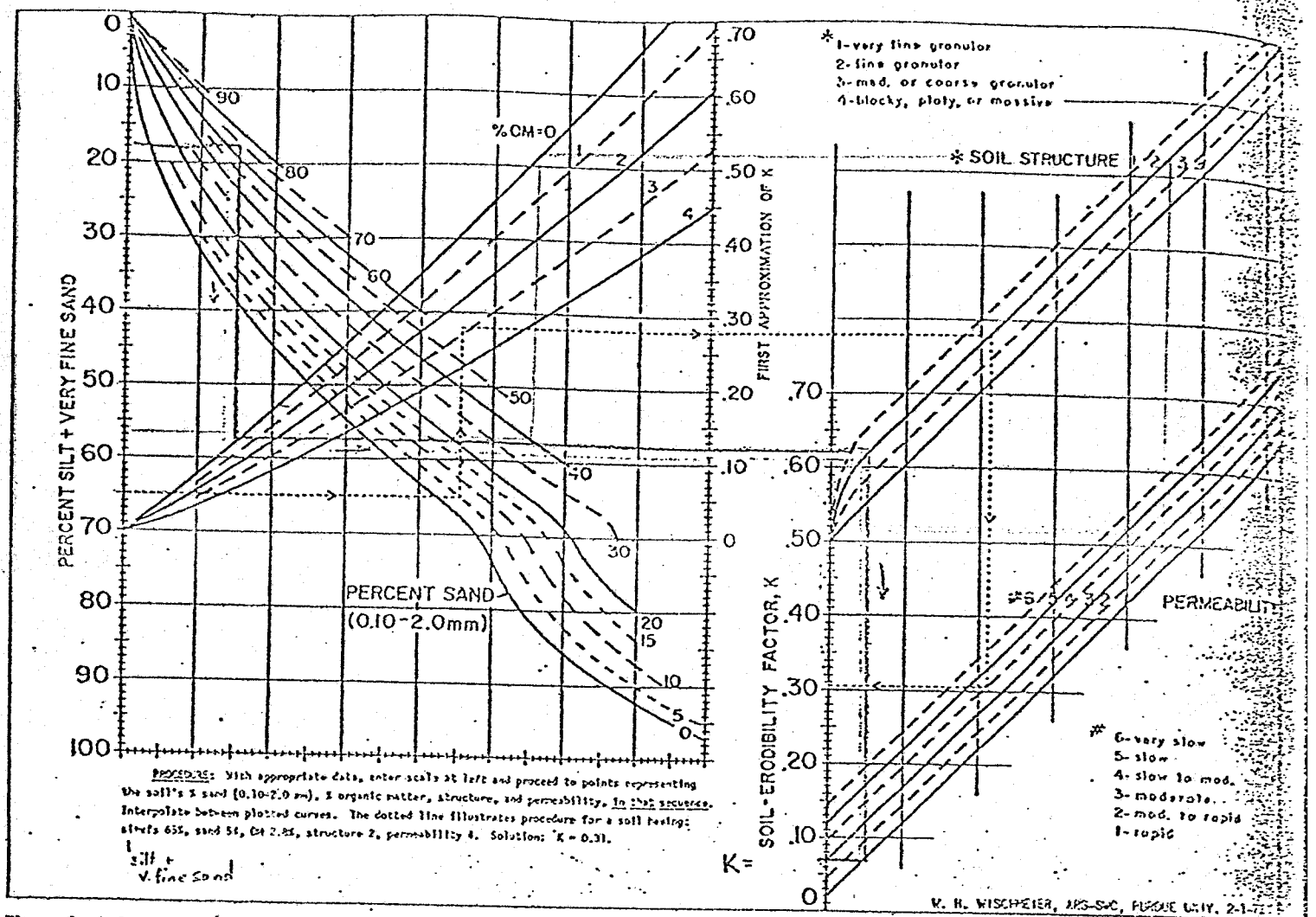



Figure 1. Soil erodibility nomograph.

line between sand and silt classifications and a new particle-size distribution parameter.

Analyses of the rainulator and natural-rain soil-erodibility data showed conclusively that particles in the very fine sand classification (0.05-0.10 mm) behave more like silt than like larger sand. When we redefined silt to include very fine sand and defined sand as particles from 0.10 to 2.0 mm, the prediction values of the two parameters improved appreciably.

This revised classification concept is not entirely new. Family groupings in the U. S. Department of Agriculture's Soil Classification System, Seventh Approximation, recognize very fine sand as having silt properties. The American Association of State Highway Officials, in a 1961 report (*1*), used the midpoint of the very fine sand category as the dividing line between their granular and silt-clay classifications.

Even with the improved classification criteria, however, the relation of erodibility to a given percent silt or percent clay depends considerably on the particle-size distribution in the remainder of the soil mass. The erodibility of a 60-percent-silt soil relative to that of a 40-percent-silt soil, for example, depends on the associated sand-to-clay ratios and the levels at which other properties are combined in the soil. The number and complexity of these interrelations account for the large number of terms in the previously published multiple regression equation for soil erodibility (*6*). Discovery of a parameter that adequately describes the whole particle-size distribution for a given soil sample made it possible to drop many of the previously significant terms from the equation without appreciable loss in accuracy.

The new particle-size parameter, which we have designated as M, is the product of percent silt and percent sand-and-silt. When the very fine sand component was included in the percent silt, the M accounted for 85 percent of the variance in observed K values for the 55 rainulator-tested soils. Its relationship to erodibility was curvilinear.

Close consideration of the parameter M showed that it is quite descriptive. For soils with a low or medium silt fraction, the M increase for each additional percent silt depends very much on the soil's sand-to-clay ratio. As sand content becomes high, silt content decreases and M declines in value, but it remains a function of the silt-to-clay ratio. When clay content is high, M assumes a low value which is a function of the sand-to-silt ratio.

Even though the parameter is not identified in the nomograph (Figure 1), the left-hand section of the graph is based on the relation of M to K. The scale on the horizontal axis is the M scale, with values from 0 to 8,000. The K-approximation curves for five levels of organic matter were plotted against this scale. The curve marked "%OM = 2" shows the relationship that accounted for 85 percent of the variance in observed K values. To eliminate manual computation of M for

TABLE 1 (Continued)

| Percent Slope | Slope Length in Feet 300 | 400 | 500 | 600 | 700 | 800 | 900 | 1000 | 1100 | 1200 | 1300 | 1500 | 1700 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.2 | 0.11 | 0.12 | 0.13 | 0.14 | 0.15 | 0.15 | 0.16 | 0.16 | 0.17 | 0.17 | 0.18 | 0.19 | 0.19 | 0.20 |
| 0.3 | 0.12 | 0.13 | 0.14 | 0.15 | 0.16 | 0.16 | 0.17 | 0.18 | 0.18 | 0.18 | 0.19 | 0.20 | 0.21 | 0.22 |
| 0.4 | 0.13 | 0.14 | 0.15 | 0.16 | 0.17 | 0.17 | 0.18 | 0.19 | 0.19 | 0.20 | 0.20 | 0.21 | 0.22 | 0.23 |
| 0.5 | 0.14 | 0.15 | 0.16 | 0.17 | 0.18 | 0.18 | 0.19 | 0.20 | 0.20 | 0.21 | 0.21 | 0.22 | 0.23 | 0.24 |
| 1.0 | 0.18 | 0.20 | 0.21 | 0.22 | 0.23 | 0.24 | 0.25 | 0.26 | 0.27 | 0.27 | 0.28 | 0.29 | 0.30 | 0.32 |
| 2.0 | 0.28 | 0.31 | 0.33 | 0.34 | 0.36 | 0.38 | 0.39 | 0.40 | 0.41 | 0.42 | 0.43 | 0.45 | 0.47 | 0.49 |
| 3.0 | 0.40 | 0.44 | 0.47 | 0.49 | 0.52 | 0.54 | 0.56 | 0.57 | 0.59 | 0.61 | 0.62 | 0.65 | 0.67 | 0.71 |
| 4.0 | 0.62 | 0.70 | 0.76 | 0.82 | 0.87 | 0.92 | 0.96 | 1.01 | 1.04 | 1.08 | 1.12 | 1.18 | 1.24 | 1.33 |
| 5.0 | 0.93 | 1.07 | 1.20 | 1.31 | 1.42 | 1.52 | 1.61 | 1.69 | 1.78 | 1.86 | 1.93 | 2.07 | 2.21 | 2.40 |
| 6.0 | 1.17 | 1.35 | 1.50 | 1.65 | 1.78 | 1.90 | 2.02 | 2.13 | 2.23 | 2.33 | 2.43 | 2.61 | 2.77 | 3.01 |
| 8.0 | 1.72 | 1.98 | 2.22 | 2.43 | 2.62 | 2.81 | 2.98 | 3.14 | 3.29 | 3.44 | 3.58 | 3.84 | 4.09 | 4.44 |
| 10.0 | 2.37 | 2.74 | 3.06 | 3.36 | 3.62 | 3.87 | 4.11 | 4.33 | 4.54 | 4.74 | 4.94 | 5.30 | 5.65 | 6.13 |
| 12.0 | 3.13 | 3.61 | 4.04 | 4.42 | 4.77 | 5.10 | 5.41 | 5.71 | 5.99 | 6.25 | 6.51 | 6.99 | 7.44 | 8.07 |
| 14.0 | 3.98 | 4.59 | 5.13 | 5.62 | 6.07 | 6.49 | 6.88 | 7.26 | 7.61 | 7.95 | 8.27 | 8.89 | 9.46 | 10.26 |
| 16.0 | 4.92 | 5.68 | 6.35 | 6.95 | 7.51 | 8.03 | 8.52 | 8.98 | 9.42 | 9.83 | 10.24 | 11.00 | 11.71 | 12.70 |
| 18.0 | 5.95 | 6.87 | 7.68 | 8.41 | 9.09 | 9.71 | 10.30 | 10.86 | 11.39 | 11.90 | 12.38 | 13.30 | 14.16 | 15.36 |
| 20.0 | 7.07 | 8.16 | 9.12 | 9.99 | 10.79 | 11.54 | 12.24 | 12.90 | 13.53 | 14.13 | 14.71 | 15.80 | 16.82 | 18.24 |
| 25.0 | 10.20 | 11.78 | 13.17 | 14.43 | 15.59 | 16.66 | 17.67 | 18.63 | 19.54 | 20.41 | 21.24 | 22.82 | 24.29 | 26.35 |
| 30.0 | 13.78 | 15.91 | 17.79 | 19.48 | 21.04 | 22.50 | 23.86 | 25.15 | 26.38 | 27.55 | 28.68 | 30.81 | 32.80 | |
| 40.0 | 21.92 | 25.31 | 28.30 | 31.00 | 33.48 | | | | | | | | | |
| 50.0 | 30.87 | | | | | | | | | | | | | |
| 60.0 | | | | | | | | | | | | | | |

$V_{A1}$=(282.4)(2.24)(3)(2000/1)(1/90)=42,172 $ft^3$*

$V_{A2}$=( 69.4)(4.96)(3)(2000/1)(1/90)=22,948 $ft^3$

$V_{A3}$=( 53.0)(3.51)(3)(2000/1)(1/90)=12,402 $ft^3$

$V_B$ =( 39.9)(1.79)(3)(2000/1)(1/90)= 4,761 $ft^3$

*To high, this calculated figure is higher than will ever occur in practice because the soil type for this hillside would consist of large rocks and other particle sizes being larger also. This figure is reduced to the amount calculated for one (1) year, 14,057 $ft^3$

For $A_1+A_2+A_3$, sediment storage volume = 14,057 + 22,948 + 12,402 = 49,407 $ft^3$

For B, sediment storage = 4,761 $ft^3$

RUNOFF STORAGE FROM DISTURBED AREA

Design Data
CN=80±, from Table 9.1, "SCS National Engineering Handbook", Section 4, "Hydrology"

Runoff from Figure 10.1, reference as above = 0.7 inches

Volume of runoff in $ft^3$

$V_{A1}$=(2.24)(43,560)(0.7)(1/12)= 5,692 $ft^3$

$V_{A2}$=(4.96)(43,560)(0.7)(1/12)=12,603 $ft^3$

$V_{A3}$=(3.51)(43,560)(0.7)(1/12)= 8,919 $ft^3$

$V_B$ =(1.79)(43,560)(0.7)(1/12)= 4,548 $ft^3$

Total volume in ponds required for sediment and runoff:

Pond A = 49,407 + 27,214 = 76,621 $ft^3$
Pond B = 4,761 + 4,548 = 9,309 $ft^3$

In a discussion with John Whitehead, hydrologist for DOGM, on 2-27-84 it was agreed to use his numbers in sizing Pond "A". The final design criteria for Pond "A" became as follows:

Design Criteria Pond "A"

Drainage Area: 14.35 Acres
SCS Curve #82
3-Year Sediment Storage: 41,444 $ft^3$
10-Year 24-Hour Runoff Storage: 42,714 $ft^3$
Total Storage Volume: 84,158 $ft^3$
Use Existing Spillway: 10 Foot Wide Broad Crested Weir
Rainfall Data Base: Hiawatha Data by E. Arlo Richardson

Also, in a letter to Wendell Owen, of Co-Op Mining, from DOGM, dated 6-16-83, the following design parameters were presented and have been used herein.

Design Criteria Pond "B"

Drainage Area: 1.82 Acres
SCS Curve #82
3-Year Sediment Storage: 2,156 $ft^3$
10-Year 24-Hour Runoff Storage: 8,182 $ft^3$
Total Storage Volume: 10,338 $ft^3$
Use Existing Spillway: 4 Foot Wide Broad Crested Weir
Rainfall Data Base: Hiawatha Data by E. Arlo Richardson

Plates 7-2 & 7-3 shows the required plan and sections of Sedimentation Ponds "A" and "B", respectively.

7.2.5.2 DIVERSION STRUCTURES

A number of ditches and culverts are utilized in the mine plan area. Ditches are used to: divert "undisturbed" run-off around the disturbed area and back into natural drainage channels, collect "disturbed" run-off and convey it to the sedimentation ponds, and to convey run-off, collected next to roads, between culverts. Culverts are used to: transfer undisturbed run-off underneath roads and into natural drainage, carry

undisturbed run-off through disturbed areas, and move disturbed run-off across areas of high erosion.

Following are the computer programs and printouts used in sizing the ditches and culverts. Refer to Plate 7-1 for locations of the various structures and Plate 7-5 for areas used in calculations.

Ditch and Culvert Sizing

The ditch and culvert sizing requirements were generated from two computer programs, one developed for general uniform flow calculations using the Manning equation, and one for uniform flow in circular conduits, again using the Manning equation. These programs were developed by Bradley M. Powell, P.E. in house at Horrocks Engineers, and are referenced in house under the terminology "UFICC" for the uniform flow in circular conduits. And "GUF" for the general uniform flow or open channel computations. These programs allow the hydrologist through either direct computations or interative computations using the method of successive approximations to determine the required characteristics and sizes of the required channels or conduit as the case may be to convey the projected discharges.

## HYDROGRAPHS AND SEDIMENTATION PONDS

The peak runoff and the runoff hydrographs were generated by a computer program written by Derick Darby, P.E. of Plus III Software, Inc., P.O. Box 88276, Atlanta, Georgia 30338 and contained in a copyrighted program Hydro Plus III Stormwater Detension Programs. The specific element of the program used to generate the hydrographs is explained in more detail below.

## SOIL CONSERVATION SERVICE HYDROGRAPH

### PROGRAM DESCRIPTION

This program produces hydrographs by the methods of the U.S. Department of Agriculture, Soil Conservation Service. The hydrographs produced may be routed through a storage reservoir, combined with a previously generated hydrograph, or stored for later use.

### LIMITATIONS

The methods of the Soil Conservation Service should be used for medium sized basins. The area range should generally be between 200 and 1000 acres. In some instances the methods may be successfully used for larger basins.

The S.C.S. Method uses several parameters bases on basin configuration to generate incremental hydrographs and produce an outflow hydrograph for the basin. The method is a volumetric determination; therefore, the selection of

the curve number (CN) is critical. The physical programming limitations are as follows:

1. The first outflow and the first storage volume must be set equal to zero (0).
2. The storage volume and outflow rate must increase with each subsequent set of data pairs.
3. Routing time is preselected at one half of the time to the peak of the incremental hydrograph.
4. Basin lag must be greater than 0.25 hours and less than 6.6 hours.

SYMBOLS AND EQUATIONS

| Symbol | Description | Units |
|---|---|---|
| A | Basin Area | Acres |
| A$ | Basin Identifier | ----- |
| B$ | Down Stream Identifier | ----- |
| CN | Curve Number | ----- |
| C$ | Storage Pond Identifier | ----- |
| D | Storm Duration | Hours |
| E | Storage Pond Elevations | Feet |

SYMBOLS AND EQUATIONS (CONT'D

| Symbol | Description | Units |
|---|---|---|
| H | Hydraulic Length | Feet |
| I | Storage Pond Inflows | CFS |
| Ia | Initial Abstraction | Inches |
| L | Basin Lag | Hours |
| O | Storage Pond Outflows | CFS |
| P-24 | 24-Hours Precipitation | Inches |
| P | Accumulated Rainfall | Inches |
| Q | Accumulated Direct Runoff | Inches |
| q | Incremental Peak Rate of Discharge | CFS |
| qp | Peak of Discharge | CFS |
| S | Storage Pond Volumes | Cu. Ft. |
| Tp | Time to Peak | Hours |

H/C
4-27-84

| | | |
|---|---|---|
| T | Routing Period | Sec. |
| V | Incremental 2S/T + 0 | CFS |
| Y | Average Basin Slope | % |

EQUATIONS

Q = (P - Ia)^2 / ((P - Ia) + S)

Cn = 1000 / (10 +S)

Ia = 0.25

H = 209 * A^0.6

L = ((H^0.8) * (S +1)^0.7) / 1900 * Y^0.7

Tp = D/s + L

O2 = I1 + (2S1/T-01) - 2S2T

H/C
4-27-84

PROGRAM REFERENCES


1. Soil Conservation Service; SCS - TP - 149, A Method for Estimating Volume and Rate of Runoff in Small Watersheds, Revised April, 1973.

2. _____, Technical Release No. 55, Urban Hydrology for Small Watersheds, January, 1975.

3. _____, National Engineering Handbook, Section 4, Hydrology, August, 1972.

4. United States Department of the Interior, Bureau of Reclamation, Design of Small Dams, U.S. Government Printing Office, 2nd Edition 1973.

1. "National Symposium on Urban Hydrology, Hydraulics, and Sediment Control", Urban Runoff Hydrographs - Basic Principles, by Haan, C.T., 1976.

Summary of Ditch Sizes

All ditches ar triangular "V ditch" with 1:1 side slopes.

| | Flow(cfs) | Slope(%) | Depth* |
|---|---|---|---|
| D-1R | 10.2 | 6.0 | 2'-0" |
| D-2R | 12.1 | 6.0 | 2'-0" |
| D-3R | 10.4 | 6.0 | 2'-0" |
| D-1U | 1.5 | 4.0 | 1'-3" |
| D-2U | 1.5 | 5.0 | 1'-3" |
| D-3U | 6.1 | 5.0 | 1'-9" |
| D-4U | 11.8 | 5.0 | 2'-0" |
| D-5U | .9 | 7.0 | 1'-0" |
| D-6U | .9 | 7.0 | 1'-0" |
| D-7U | 10.3 | 5.0 | 2'-0" |
| D-8U | 2.3 | 6.25 | 1'-3" |
| D-9U | 1.8 | 8.3 | 1'-3" |
| D-10U | 1.5 | 18.0 | 1'-0" |
| D-11U | 7.6 | 14.0 | 1'-6" |
| D-1D | .8 | 9.0 | 1'-0" |
| D-2D | 1.5 | 10.0 | 1'-3" |
| D-3D | 1.0 | 15.0 | 1'-0" |
| D-4D | 4.8 | 6.25 | 1'-6" |
| D-5D | 7.2 | 6.4 | 1'-9" |
| D-6D | 1.2 | 6.25 | 1'-3" |

*6" freeboard added to required flow depth.

-Summary of Culvert Sizes-

| | Flow(cfs) | Slope(%) | Diameter | Required Headwater** |
|---|---|---|---|---|
| C-1R | 10.2 | 8.0 | 18 | 27" |
| C-2R | 12.1 | 8.0 | 18" | 36" |
| C-3R | 16.4 | 8.0 | 18" | 27" |
| C-1U | 8.8 | 15.0 | 30" | 18" |
| C-2U | 1.5 | 15.0 | 15" | 9" |
| C-3U | 7.9 | 5.0 | 12" | 36"* |
| C-4U | 6.1 | 5.1 | 10" | 36"* |
| C-5U | 6.1 | 4.8 | 10" | 36"* |
| C-6U | .9 | 3.7 | 10" | 12" |
| CV-7U | 10.3 | 8.3 | 12"***(18") | 27" |
| C-8U | 8.8 | 15.0 | 18" | 24" |
| C-9U | 1.5 | 7.3 | 15" | 9" |
| C-1D | 1.5 | 20.0 | 15" | 9" |
| C-2D | 4.8 | 12.0 | 18" | 15" |
| C-3D | 1.2 | 4.2 | 12" | 9" |
| 60" CMP | 231.2 | 3.4 | 60" | 102" |

*When capacity of culvert is exceeded flow continues down ditch to next culvert.

**From invert elevation.

***Existing 12" CMP to be replaced with 18" CMP at 8.3% slope.

# RIPRAP REQUIREMENTS

## RIPRAP

Where the velocity of flow exceeds 5 fps but is less than 15 fps riprap will be placed. The size of riprap used will be based on the following graph, by Peterka. For flows above 15 fps an energy dissipating device will be used.

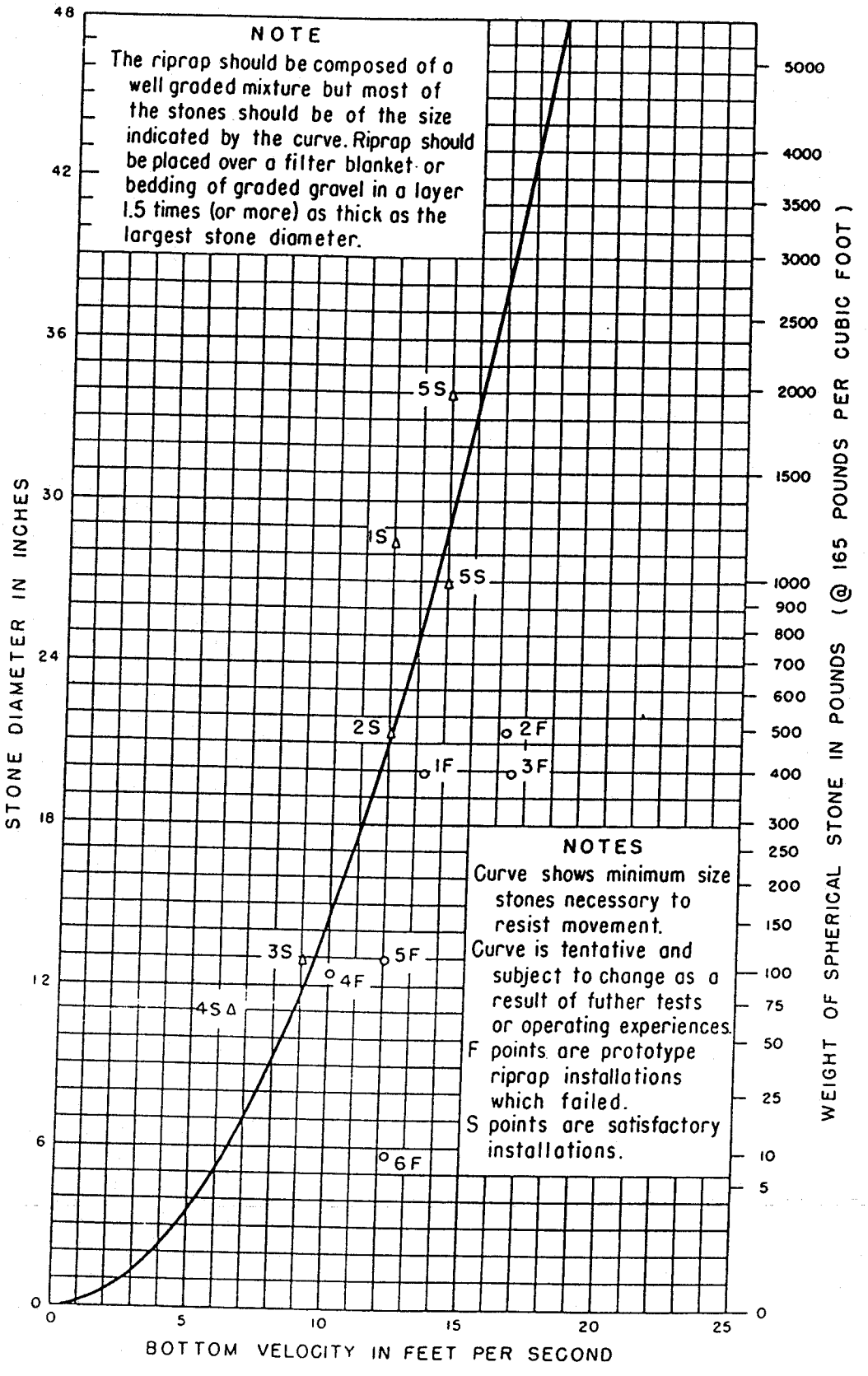



FIGURE 165.—*Curve to determine maximum stone size in riprap mixture.*

From: Peterka, A.J., "Hydraulic Design of Stilling Basins and Energy Dissipators", U.S. Bureau of Reclamation, Engineering Monograph No. 25.

## 7.3 REFERENCES

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A Guide to Hydrologic Analysis Using SCS Methods
Richard H. McCuen

SECTION 5

CURVE NUMBER ESTIMATION

The volume and rate of runoff depends on both meteorologic and watershed characteristics, and the estimation of runoff requires an index to represent these two factors. The precipitation volume is probably the single most important meteorological characteristic in estimating the volume of runoff. The soil type, land use, and the hydrologic condition of the cover are the watershed factors that will have the most significant impact in estimating the volume of runoff. The antecedent soil moisture will also be an important determinant of runoff volume.

The SCS developed an index, which was called the runoff curve number (CN), to represent the combined hydrologic effect of soil, land use, agricultural land treatment class, hydrologic condition, and antecedent soil moisture. These factors can be assessed from soil surveys, site investigations, and land use maps; when using the SCS hydrologic methods for design the specification of the antecedent soil moisture condition is often a policy decision that suggests average watershed conditions rather than a recognition of a hydrologic condition at a particular time and place.

## Soil Group Classification

SCS developed a soil classification system that consists of four groups, which are identified by the letters A, B, C, and D. Soil characteristics that are associated with each group are as follows:

Group A: deep sand, deep loess, aggregated silts

Group B: shallow loess, sandy loam

Group C: clay loams, shallow sandy loam, soils low in organic content, and soils usually high in clay

Group D: soils that swell significantly when wet, heavy plastic clays, and certain saline soils

The SCS soil group can be identified at a site using one of three ways:

1. soil characteristics
2. county soil surveys
3. minimum infiltration rate

The soil characteristics associated with each group are listed above. County soil surveys, where they are made available by Soil Conservation Districts, give a detailed description of the soils at locations within a county; these surveys are usually the best means of identifying the soil group. Soil

analyses can be used to estimate the minimum infiltration rates, which can be used to classify the soil using the following values:

| Group | Minimum Infiltration Rate (in/hr) |
|---|---|
| A | 0.30 - 0.45 |
| B | 0.15 - 0.30 |
| C | 0.05 - 0.15 |
| D | 0 - 0.05 |

## Cover Complex Classification

The SCS cover complex classification consists of three factors: land use, treatment or practice, and hydrologic condition. There are approximately fifteen different land uses that are identified in the tables for estimating curve number. Agricultural land uses are often subdivided by treatment or practices, such as contoured or straight row; this separation reflects the different hydrologic runoff potential that is associated with variation in land treatment. The hydrologic condition reflects the level of land management; it is separated with three classes: poor, fair, and good. Not all of the land uses are separated by treatment or condition.

## Curve Number Estimation

Table 2, which is a compilation of the CN tables provided in NEH-4 and TR-55, show the CN values for the different land uses, treatment, and hydrologic condition; separate values are given for each soil group. For example, the CN for a wooded area with good cover and soil group B is 55; for soil group C, the CN would increase to 70. If the cover (on soil group B) is poor, then the CN will be 66.

## Antecedent Soil Moisture Condition

Antecedent soil moisture is known to have a significant effect on both the volume and rate of runoff. Recognizing that it is a significant factor, SCS developed three antecedent soil moisture conditions, which were labeled I, II, and III. The soil condition for each is as follows:

Condition I: soils are dry but not to wilting point; satisfactory cultivation has taken place.

Condition II: average conditions

Condition III: heavy rainfall, or light rainfall and low temperatures have occurred within the last 5 days; saturated soil.

The following table gives seasonal rainfall limits for the three antecedent soil moisture conditions:

| | Total 5-day Antecedent Rainfall (inches) | |
|---|---|---|
| AMC | Dormant Season | Growing Season |
| 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 |

TABLE 2. Runoff Curve Numbers for Hydrologic Soil-Cover Complexes
(Antecedent Moisture Condition II, and $I_a = 0.2\ S$)

| Land Use Description/Treatment/Hydrologic Condition | | | Hydrologic Soil Group | | | |
|---|---|---|---|---|---|---|
| Residential:[1] | | | A | B | C | D |
| Average lot size | Average % Impervious[2] | | | | | |
| 1/8 acre or less | 65 | | 77 | 85 | 90 | 92 |
| 1/4 acre | 38 | | 61 | 75 | 83 | 87 |
| 1/3 acre | 30 | | 57 | 72 | 81 | 86 |
| 1/2 acre | 25 | | 54 | 70 | 80 | 85 |
| 1 acre | 20 | | 51 | 68 | 79 | 84 |
| Paved parking lots, roofs, driveways, etc.[3] | | | 98 | 98 | 98 | 98 |
| Streets and roads: | | | | | | |
| paved with curbs and storm sewers[3] | | | 98 | 98 | 98 | 98 |
| gravel | | | 76 | 85 | 89 | 91 |
| dirt | | | 72 | 82 | 87 | 89 |
| Commercial and business areas (85% impervious) | | | 89 | 92 | 94 | 95 |
| Industrial districts (72% impervious) | | | 81 | 88 | 91 | 93 |
| Open Spaces, lawns, parks, golf courses, cemeteries,etc. | | | | | | |
| good condition: grass cover on 75% or more of the area | | | 39 | 61 | 74 | 80 |
| fair condition: grass cover on 50% to 75% of the area | | | 49 | 69 | 79 | 84 |
| Fallow | Straight row | --- | 77 | 86 | 91 | 94 |
| Row crops | Straight row | Poor | 72 | 81 | 88 | 91 |
| | Straight row | Good | 67 | 78 | 85 | 89 |
| | Contoured | Poor | 70 | 79 | 84 | 88 |
| | Contoured | Good | 65 | 75 | 82 | 86 |
| | Contoured & terraced | Poor | 66 | 74 | 80 | 82 |
| | Contoured & terraced | Good | 62 | 71 | 78 | 81 |
| Small grain | Straight row | Poor | 65 | 76 | 84 | 88 |
| | | Good | 63 | 75 | 83 | 87 |
| | Contoured | Poor | 63 | 74 | 82 | 85 |
| | | Good | 61 | 73 | 81 | 84 |
| | Contoured & terraced | Poor | 61 | 72 | 79 | 82 |
| | | Good | 59 | 70 | 78 | 81 |
| Close -seeded legumes[4] or rotation meadow | Straight row | Poor | 66 | 77 | 85 | 89 |
| | Straight row | Good | 58 | 72 | 81 | 85 |
| | Contoured | Poor | 64 | 75 | 83 | 85 |
| | Contoured | Good | 55 | 69 | 78 | 83 |
| | Contoured & terraced | Poor | 63 | 73 | 80 | 83 |
| | Contoured & terraced | Good | 51 | 67 | 76 | 80 |
| Pasture or range | | Poor | 68 | 79 | 86 | 89 |
| | | Fair | 49 | 69 | 79 | 84 |
| | | Good | 39 | 61 | 74 | 80 |
| | Contoured | Poor | 47 | 67 | 81 | 88 |
| | Contoured | Fair | 25 | 59 | 75 | 83 |
| | Contoured | Good | 6 | 35 | 70 | 79 |
| Meadow | | Good | 30 | 58 | 71 | 78 |
| Woods or Forest land | | Poor | 45 | 66 | 77 | 83 |
| | | Fair | 36 | 60 | 73 | 79 |
| | | Good | 25 | 55 | 70 | 77 |
| Farmsteads | | --- | 59 | 74 | 82 | 86 |

[1] Curve numbers are computed assuming the runoff from the house and driveway is directed towards the street with a minimum of roof water directed to lawns where additional infiltration could occur.

[2] The remaining pervious areas (lawn) are considered to be in good pasture condition for these curve numbers.

[3] In some warmer climates of the country a curve number of 95 may be used.

[4] Close -drilled or broadcast.

# HYDROLOGICAL STUDY FOR

# CO-OP Mine Undisturbed Area

Undisturbed Run-off Diversions

Bear Canyon Mine Site

BY

HORROCKS/CAROLLO ENGINEERS

ONE WEST MAIN

AMERICAN FORK, UTAH 84003

April 25, 1984

REGISTERED PROFESSIONAL ENGINEER
No. 3535
HAROLD LEE
WIMMER
STATE OF UTAH

HORROCKS/CAROLLO ENGINEERS
AMERICAN FORK, UTAH
April 25, 1984

# HYDROLOGIC REPORT FOR

# CO-OP Mine Undisturbed Area

# S. C. S. HYDROGRAPH

BASIN IDENTIFICATION AU-1
BASIN DISCHARGES INTO D-11U

| | | | |
|---|---|---|---|
| BASIN AREA | = | 25.00 | ACRES |
| BASIN CURVE NUMBER | = | 73.00 | |
| 24-HOUR PRECIPITATION | = | 2.25 | INCHES |
| AVERAGE BASIN SLOPE | = | 62.0 | % |
| HYDRAULIC LENGTH | = | 1,950.0 | FEET |
| BASIN LAG | = | 0.25 | HOURS |

HYDROGRAPH RUNOFF VALUES
10 YEAR STORM FREQUENCY

| TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. |
|---|---|---|---|---|---|---|---|
| 11.20 | 0.0 | 11.30 | 0.0 | 11.40 | 0.0 | 11.50 | 0.0 |
| 11.60 | 0.0 | 11.70 | 0.0 | 11.80 | 0.3 | 11.90 | 1.5 |
| 12.00 | 4.1 | 12.10 | 7.0 | 12.20 | * 7.6 | 12.30 | 6.5 |
| 12.40 | 4.9 | 12.50 | 4.0 | 12.60 | 3.4 | 12.70 | 2.9 |
| 12.80 | 2.4 | 12.90 | 2.1 | 13.00 | 1.9 | 13.10 | 1.8 |
| 13.20 | 1.7 | 13.30 | 1.4 | 13.40 | 1.3 | 13.50 | 1.3 |
| 13.60 | 1.2 | 13.70 | 1.2 | 13.80 | 1.1 | 13.90 | 1.0 |
| 14.00 | 1.0 | 14.10 | 1.0 | 14.20 | 0.9 | 14.30 | 0.8 |
| 14.40 | 0.8 | 14.50 | 0.8 | 14.60 | 0.7 | 14.70 | 0.7 |
| 14.80 | 0.7 | 14.90 | 0.7 | 15.00 | 0.6 | 15.10 | 0.5 |
| 15.20 | 0.4 | 15.30 | 0.3 | 15.40 | 0.2 | 15.50 | 0.1 |
| 15.60 | 0.0 | 15.70 | 0.0 | 15.80 | 0.0 | 15.90 | 0.0 |
| 16.00 | 0.0 | 16.10 | 0.0 | 16.20 | 0.0 | 16.30 | 0.0 |

HORROCKS/CAROLLO ENGINEERS
AMERICAN FORK, UTAH
April 25, 1984

# HYDROLOGIC REPORT FOR

# CO-OP Mine Undisturbed Area

# S. C. S. HYDROGRAPH

BASIN IDENTIFICATION AU-1B
BASIN DISCHARGES INTO D-10U & C-9U

| | | | |
|---|---|---|---|
| BASIN AREA | = | 5.00 | ACRES |
| BASIN CURVE NUMBER | = | 73.00 | |
| 24-HOUR PRECIPITATION | = | 2.25 | INCHES |
| AVERAGE BASIN SLOPE | = | 62.0 | % |
| HYDRAULIC LENGTH | = | 550.0 | FEET |
| BASIN LAG | = | 0.25 | HOURS |

HYDROGRAPH RUNOFF VALUES
10 YEAR STORM FREQUENCY

| TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. |
|---|---|---|---|---|---|---|---|
| 11.20 | 0.0 | 11.30 | 0.0 | 11.40 | 0.0 | 11.50 | 0.0 |
| 11.60 | 0.0 | 11.70 | 0.0 | 11.80 | 0.1 | 11.90 | 0.3 |
| 12.00 | 0.8 | 12.10 | 1.4 | 12.20 | * 1.5 | 12.30 | 1.3 |
| 12.40 | 1.0 | 12.50 | 0.8 | 12.60 | 0.7 | 12.70 | 0.6 |
| 12.80 | 0.5 | 12.90 | 0.4 | 13.00 | 0.4 | 13.10 | 0.4 |
| 13.20 | 0.3 | 13.30 | 0.3 | 13.40 | 0.3 | 13.50 | 0.3 |
| 13.60 | 0.2 | 13.70 | 0.2 | 13.80 | 0.2 | 13.90 | 0.2 |
| 14.00 | 0.2 | 14.10 | 0.2 | 14.20 | 0.2 | 14.30 | 0.2 |
| 14.40 | 0.2 | 14.50 | 0.2 | 14.60 | 0.1 | 14.70 | 0.1 |
| 14.80 | 0.1 | 14.90 | 0.1 | 15.00 | 0.0 | 15.10 | 0.0 |
| 15.20 | 0.0 | 15.30 | 0.0 | 15.40 | 0.0 | 15.50 | 0.0 |

HORROCKS/CAROLLO ENGINEERS
AMERICAN FORK, UTAH
April 25, 1984

# HYDROLOGIC REPORT FOR

# CO-OP Mine Undisturbed Area

# S. C. S. HYDROGRAPH

BASIN IDENTIFICATION AU-2
BASIN DISCHARGES INTO C-1U & C-8U

| | | | |
|---|---|---|---|
| BASIN AREA | = | 28.70 | ACRES |
| BASIN CURVE NUMBER | = | 73.00 | |
| 24-HOUR PRECIPITATION | = | 2.25 | INCHES |
| AVERAGE BASIN SLOPE | = | 62.0 | % |
| HYDRAULIC LENGTH | = | 2,000.0 | FEET |
| BASIN LAG | = | 0.25 | HOURS |

HYDROGRAPH RUNOFF VALUES
10 YEAR STORM FREQUENCY

| TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. |
|---|---|---|---|---|---|---|---|
| 11.20 | 0.0 | 11.30 | 0.0 | 11.40 | 0.0 | 11.50 | 0.0 |
| 11.60 | 0.0 | 11.70 | 0.0 | 11.80 | 0.3 | 11.90 | 1.7 |
| 12.00 | 4.7 | 12.10 | 8.0 | 12.20 | 8.8 | 12.30 | 7.4 |
| 12.40 | 5.6 | 12.50 | 4.6 | 12.60 | 3.9 | 12.70 | 3.3 |
| 12.80 | 2.8 | 12.90 | 2.4 | 13.00 | 2.1 | 13.10 | 2.1 |
| 13.20 | 1.9 | 13.30 | 1.6 | 13.40 | 1.5 | 13.50 | 1.5 |
| 13.60 | 1.4 | 13.70 | 1.4 | 13.80 | 1.3 | 13.90 | 1.2 |
| 14.00 | 1.2 | 14.10 | 1.1 | 14.20 | 1.1 | 14.30 | 1.0 |
| 14.40 | 0.9 | 14.50 | 0.9 | 14.60 | 0.8 | 14.70 | 0.8 |
| 14.80 | 0.8 | 14.90 | 0.8 | 15.00 | 0.7 | 15.10 | 0.6 |
| 15.20 | 0.5 | 15.30 | 0.4 | 15.40 | 0.3 | 15.50 | 0.2 |
| 15.60 | 0.1 | 15.70 | 0.0 | 15.80 | 0.0 | 15.90 | 0.0 |
| 16.00 | 0.0 | 16.10 | 0.0 | 16.20 | 0.0 | 16.30 | 0.0 |

# HYDROLOGIC REPORT FOR

# CO-OP Mine Undisturbed Area

# S. C. S. HYDROGRAPH

BASIN IDENTIFICATION AU-2B
BASIN DISCHARGES INTO D-1U

| | | | |
|---|---|---|---|
| BASIN AREA | = | 5.00 | ACRES |
| BASIN CURVE NUMBER | = | 73.00 | |
| 24-HOUR PRECIPITATION | = | 2.25 | INCHES |
| AVERAGE BASIN SLOPE | = | 62.0 | % |
| HYDRAULIC LENGTH | = | 550.0 | FEET |
| BASIN LAG | = | 0.25 | HOURS |

HYDROGRAPH RUNOFF VALUES
10 YEAR STORM FREQUENCY

| TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. |
|---|---|---|---|---|---|---|---|
| 11.20 | 0.0 | 11.30 | 0.0 | 11.40 | 0.0 | 11.50 | 0.0 |
| 11.60 | 0.0 | 11.70 | 0.0 | 11.80 | 0.1 | 11.90 | 0.3 |
| 12.00 | 0.8 | 12.10 | 1.4 | 12.20 | 1.5 | 12.30 | 1.3 |
| 12.40 | 1.0 | 12.50 | 0.8 | 12.60 | 0.7 | 12.70 | 0.6 |
| 12.80 | 0.5 | 12.90 | 0.4 | 13.00 | 0.4 | 13.10 | 0.4 |
| 13.20 | 0.3 | 13.30 | 0.3 | 13.40 | 0.3 | 13.50 | 0.3 |
| 13.60 | 0.2 | 13.70 | 0.2 | 13.80 | 0.2 | 13.90 | 0.2 |
| 14.00 | 0.2 | 14.10 | 0.2 | 14.20 | 0.2 | 14.30 | 0.2 |
| 14.40 | 0.2 | 14.50 | 0.2 | 14.60 | 0.1 | 14.70 | 0.1 |
| 14.80 | 0.1 | 14.90 | 0.1 | 15.00 | 0.0 | 15.10 | 0.0 |
| 15.20 | 0.0 | 15.30 | 0.0 | 15.40 | 0.0 | 15.50 | 0.0 |

HORROCKS/CAROLLO ENGINEERS
AMERICAN FORK, UTAH
April 25, 1984

# HYDROLOGIC REPORT FOR

# CO-OP Mine Undisturbed Area

# S. C. S. HYDROGRAPH

BASIN IDENTIFICATION AU-2C
BASIN DISCHARGES INTO D-9U

| | | | |
|---|---|---|---|
| BASIN AREA | = | 6.00 | ACRES |
| BASIN CURVE NUMBER | = | 73.00 | |
| 24-HOUR PRECIPITATION | = | 2.25 | INCHES |
| AVERAGE BASIN SLOPE | = | 41.0 | % |
| HYDRAULIC LENGTH | = | 800.0 | FEET |
| BASIN LAG | = | 0.25 | HOURS |

HYDROGRAPH RUNOFF VALUES
10 YEAR STORM FREQUENCY

| TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. |
|---|---|---|---|---|---|---|---|
| 11.20 | 0.0 | 11.30 | 0.0 | 11.40 | 0.0 | 11.50 | 0.0 |
| 11.60 | 0.0 | 11.70 | 0.0 | 11.80 | 0.1 | 11.90 | 0.4 |
| 12.00 | 1.0 | 12.10 | 1.7 | 12.20 | 1.8 | 12.30 | 1.5 |
| 12.40 | 1.2 | 12.50 | 1.0 | 12.60 | 0.8 | 12.70 | 0.7 |
| 12.80 | 0.6 | 12.90 | 0.5 | 13.00 | 0.4 | 13.10 | 0.4 |
| 13.20 | 0.4 | 13.30 | 0.3 | 13.40 | 0.3 | 13.50 | 0.3 |
| 13.60 | 0.3 | 13.70 | 0.3 | 13.80 | 0.3 | 13.90 | 0.2 |
| 14.00 | 0.2 | 14.10 | 0.2 | 14.20 | 0.2 | 14.30 | 0.2 |
| 14.40 | 0.2 | 14.50 | 0.2 | 14.60 | 0.2 | 14.70 | 0.2 |
| 14.80 | 0.2 | 14.90 | 0.2 | 15.00 | 0.1 | 15.10 | 0.0 |
| 15.20 | 0.0 | 15.30 | 0.0 | 15.40 | 0.0 | 15.50 | 0.0 |

# HYDROLOGIC REPORT FOR

# CO-OP Mine Undisturbed Area

# S. C. S. HYDROGRAPH

BASIN IDENTIFICATION AU-3
BASIN DISCHARGES INTO D-2U & C-2U

| | | | |
|---|---|---|---|
| BASIN AREA | = | 5.00 | ACRES |
| BASIN CURVE NUMBER | = | 73.00 | |
| 24-HOUR PRECIPITATION | = | 2.25 | INCHES |
| AVERAGE BASIN SLOPE | = | 64.0 | % |
| HYDRAULIC LENGTH | = | 875.0 | FEET |
| BASIN LAG | = | 0.25 | HOURS |

HYDROGRAPH RUNOFF VALUES
10 YEAR STORM FREQUENCY

| TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. |
|---|---|---|---|---|---|---|---|
| 11.20 | 0.0 | 11.30 | 0.0 | 11.40 | 0.0 | 11.50 | 0.0 |
| 11.60 | 0.0 | 11.70 | 0.0 | 11.80 | 0.1 | 11.90 | 0.3 |
| 12.00 | 0.8 | 12.10 | 1.4 | 12.20 | 1.5 | 12.30 | 1.3 |
| 12.40 | 1.0 | 12.50 | 0.8 | 12.60 | 0.7 | 12.70 | 0.6 |
| 12.80 | 0.5 | 12.90 | 0.4 | 13.00 | 0.4 | 13.10 | 0.4 |
| 13.20 | 0.3 | 13.30 | 0.3 | 13.40 | 0.3 | 13.50 | 0.3 |
| 13.60 | 0.2 | 13.70 | 0.2 | 13.80 | 0.2 | 13.90 | 0.2 |
| 14.00 | 0.2 | 14.10 | 0.2 | 14.20 | 0.2 | 14.30 | 0.2 |
| 14.40 | 0.2 | 14.50 | 0.2 | 14.60 | 0.1 | 14.70 | 0.1 |
| 14.80 | 0.1 | 14.90 | 0.1 | 15.00 | 0.0 | 15.10 | 0.0 |
| 15.20 | 0.0 | 15.30 | 0.0 | 15.40 | 0.0 | 15.50 | 0.0 |

HORROCKS/CAROLLO ENGINEERS
AMERICAN FORK, UTAH
April 25, 1984

# HYDROLOGIC REPORT FOR

# CO-OP Mine Undisturbed Area

# S. C. S. HYDROGRAPH

BASIN IDENTIFICATION AU-3 + AU-below portal
BASIN DISCHARGES INTO D-8U

| | | | |
|---|---|---|---|
| BASIN AREA | = | 7.50 | ACRES |
| BASIN CURVE NUMBER | = | 73.00 | |
| 24-HOUR PRECIPITATION | = | 2.25 | INCHES |
| AVERAGE BASIN SLOPE | = | 64.0 | % |
| HYDRAULIC LENGTH | = | 1,100.0 | FEET |
| BASIN LAG | = | 0.25 | HOURS |

HYDROGRAPH RUNOFF VALUES
10 YEAR STORM FREQUENCY

| TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. |
|---|---|---|---|---|---|---|---|
| 11.20 | 0.0 | 11.30 | 0.0 | 11.40 | 0.0 | 11.50 | 0.0 |
| 11.60 | 0.0 | 11.70 | 0.0 | 11.80 | 0.1 | 11.90 | 0.4 |
| 12.00 | 1.2 | 12.10 | 2.1 | 12.20 | 2.3 | 12.30 | 1.9 |
| 12.40 | 1.5 | 12.50 | 1.2 | 12.60 | 1.0 | 12.70 | 0.9 |
| 12.80 | 0.7 | 12.90 | 0.6 | 13.00 | 0.6 | 13.10 | 0.5 |
| 13.20 | 0.5 | 13.30 | 0.4 | 13.40 | 0.4 | 13.50 | 0.4 |
| 13.60 | 0.4 | 13.70 | 0.4 | 13.80 | 0.3 | 13.90 | 0.3 |
| 14.00 | 0.3 | 14.10 | 0.3 | 14.20 | 0.3 | 14.30 | 0.3 |
| 14.40 | 0.2 | 14.50 | 0.2 | 14.60 | 0.2 | 14.70 | 0.2 |
| 14.80 | 0.2 | 14.90 | 0.2 | 15.00 | 0.1 | 15.10 | 0.0 |
| 15.20 | 0.0 | 15.30 | 0.0 | 15.40 | 0.0 | 15.50 | 0.0 |
| 15.60 | 0.0 | 15.70 | 0.0 | 15.80 | 0.0 | 15.90 | 0.0 |

HORROCKS/CAROLLO ENGINEERS
AMERICAN FORK, UTAH
April 25, 1984

# HYDROLOGIC REPORT FOR

# CO-OP Mine Undisturbed Area

# S. C. S. HYDROGRAPH

BASIN IDENTIFICATION AU-4
BASIN DISCHARGES INTO C-3U

| | | | |
|---|---|---|---|
| BASIN AREA | = | 25.80 | ACRES |
| BASIN CURVE NUMBER | = | 73.00 | |
| 24-HOUR PRECIPITATION | = | 2.25 | INCHES |
| AVERAGE BASIN SLOPE | = | 64.0 | % |
| HYDRAULIC LENGTH | = | 2,250.0 | FEET |
| BASIN LAG | = | 0.25 | HOURS |

HYDROGRAPH RUNOFF VALUES
10 YEAR STORM FREQUENCY

| TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. |
|---|---|---|---|---|---|---|---|
| 11.20 | 0.0 | 11.30 | 0.0 | 11.40 | 0.0 | 11.50 | 0.0 |
| 11.60 | 0.0 | 11.70 | 0.0 | 11.80 | 0.3 | 11.90 | 1.5 |
| 12.00 | 4.2 | 12.10 | 7.2 | 12.20 | 7.9 | 12.30 | 6.7 |
| 12.40 | 5.1 | 12.50 | 4.1 | 12.60 | 3.5 | 12.70 | 3.0 |
| 12.80 | 2.5 | 12.90 | 2.1 | 13.00 | 1.9 | 13.10 | 1.9 |
| 13.20 | 1.7 | 13.30 | 1.5 | 13.40 | 1.4 | 13.50 | 1.3 |
| 13.60 | 1.3 | 13.70 | 1.2 | 13.80 | 1.1 | 13.90 | 1.1 |
| 14.00 | 1.0 | 14.10 | 1.0 | 14.20 | 0.9 | 14.30 | 0.9 |
| 14.40 | 0.8 | 14.50 | 0.8 | 14.60 | 0.8 | 14.70 | 0.8 |
| 14.80 | 0.7 | 14.90 | 0.7 | 15.00 | 0.6 | 15.10 | 0.5 |
| 15.20 | 0.4 | 15.30 | 0.3 | 15.40 | 0.2 | 15.50 | 0.1 |
| 15.60 | 0.0 | 15.70 | 0.0 | 15.80 | 0.0 | 15.90 | 0.0 |
| 16.00 | 0.0 | 16.10 | 0.0 | 16.20 | 0.0 | 16.30 | 0.0 |

HORROCKS/CAROLLO ENGINEERS
AMERICAN FORK, UTAH
April 25, 1984

# HYDROLOGIC REPORT FOR

# CO-OP Mine Undisturbed Area

# S. C. S. HYDROGRAPH

BASIN IDENTIFICATION AU-3 + AU-4
BASIN DISCHARGES INTO D-7U & C-7U

| | | | |
|---|---|---|---|
| BASIN AREA | = | 33.70 | ACRES |
| BASIN CURVE NUMBER | = | 73.00 | |
| 24-HOUR PRECIPITATION | = | 2.25 | INCHES |
| AVERAGE BASIN SLOPE | = | 64.0 | % |
| HYDRAULIC LENGTH | = | 2,250.0 | FEET |
| BASIN LAG | = | 0.25 | HOURS |

HYDROGRAPH RUNOFF VALUES
10 YEAR STORM FREQUENCY

| TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. |
|---|---|---|---|---|---|---|---|
| 11.20 | 0.0 | 11.30 | 0.0 | 11.40 | 0.0 | 11.50 | 0.0 |
| 11.60 | 0.0 | 11.70 | 0.0 | 11.80 | 0.4 | 11.90 | 2.0 |
| 12.00 | 5.5 | 12.10 | 9.4 | 12.20 | * 10.3 | 12.30 | 8.7 |
| 12.40 | 6.6 | 12.50 | 5.4 | 12.60 | 4.6 | 12.70 | 3.9 |
| 12.80 | 3.2 | 12.90 | 2.8 | 13.00 | 2.5 | 13.10 | 2.4 |
| 13.20 | 2.3 | 13.30 | 1.9 | 13.40 | 1.8 | 13.50 | 1.7 |
| 13.60 | 1.7 | 13.70 | 1.6 | 13.80 | 1.5 | 13.90 | 1.4 |
| 14.00 | 1.4 | 14.10 | 1.3 | 14.20 | 1.2 | 14.30 | 1.1 |
| 14.40 | 1.1 | 14.50 | 1.0 | 14.60 | 1.0 | 14.70 | 1.0 |
| 14.80 | 1.0 | 14.90 | 1.0 | 15.00 | 0.9 | 15.10 | 0.8 |
| 15.20 | 0.7 | 15.30 | 0.6 | 15.40 | 0.5 | 15.50 | 0.4 |
| 15.60 | 0.3 | 15.70 | 0.2 | 15.80 | 0.1 | 15.90 | 0.0 |
| 16.00 | 0.0 | 16.10 | 0.0 | 16.20 | 0.0 | 16.30 | 0.0 |

# HYDROLOGIC REPORT FOR

# CO-OP Mine Undisturbed Area

# S. C. S. HYDROGRAPH

BASIN IDENTIFICATION AU-5
BASIN DISCHARGES INTO D-3U & C-4U & C-5U

| | | | |
|---|---|---|---|
| BASIN AREA | = | 20.10 | ACRES |
| BASIN CURVE NUMBER | = | 73.00 | |
| 24-HOUR PRECIPITATION | = | 2.25 | INCHES |
| AVERAGE BASIN SLOPE | = | 57.0 | % |
| HYDRAULIC LENGTH | = | 1,750.0 | FEET |
| BASIN LAG | = | 0.25 | HOURS |

HYDROGRAPH RUNOFF VALUES
10 YEAR STORM FREQUENCY

| TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. |
|---|---|---|---|---|---|---|---|
| 11.20 | 0.0 | 11.30 | 0.0 | 11.40 | 0.0 | 11.50 | 0.0 |
| 11.60 | 0.0 | 11.70 | 0.0 | 11.80 | 0.2 | 11.90 | 1.2 |
| 12.00 | 3.3 | 12.10 | 5.6 | 12.20 | * 6.1 | 12.30 | 5.2 |
| 12.40 | 3.9 | 12.50 | 3.2 | 12.60 | 2.8 | 12.70 | 2.3 |
| 12.80 | 1.9 | 12.90 | 1.6 | 13.00 | 1.5 | 13.10 | 1.4 |
| 13.20 | 1.4 | 13.30 | 1.1 | 13.40 | 1.1 | 13.50 | 1.0 |
| 13.60 | 1.0 | 13.70 | 0.9 | 13.80 | 0.9 | 13.90 | 0.8 |
| 14.00 | 0.8 | 14.10 | 0.8 | 14.20 | 0.7 | 14.30 | 0.7 |
| 14.40 | 0.6 | 14.50 | 0.6 | 14.60 | 0.6 | 14.70 | 0.6 |
| 14.80 | 0.6 | 14.90 | 0.6 | 15.00 | 0.5 | 15.10 | 0.4 |
| 15.20 | 0.3 | 15.30 | 0.2 | 15.40 | 0.1 | 15.50 | 0.0 |
| 15.60 | 0.0 | 15.70 | 0.0 | 15.80 | 0.0 | 15.90 | 0.0 |

HORROCKS/CAROLLO ENGINEERS
AMERICAN FORK, UTAH
April 25, 1984

# HYDROLOGIC REPORT FOR

# CO-OP Mine Undisturbed Area

# S. C. S. HYDROGRAPH

BASIN IDENTIFICATION AU-6
BASIN DISCHARGES INTO D-4U

| | | | |
|---|---|---|---|
| BASIN AREA | = | 38.70 | ACRES |
| BASIN CURVE NUMBER | = | 73.00 | |
| 24-HOUR PRECIPITATION | = | 2.25 | INCHES |
| AVERAGE BASIN SLOPE | = | 67.0 | % |
| HYDRAULIC LENGTH | = | 2,250.0 | FEET |
| BASIN LAG | = | 0.25 | HOURS |

HYDROGRAPH RUNOFF VALUES
10 YEAR STORM FREQUENCY

| TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. |
|---|---|---|---|---|---|---|---|
| 11.20 | 0.0 | 11.30 | 0.0 | 11.40 | 0.0 | 11.50 | 0.0 |
| 11.60 | 0.0 | 11.70 | 0.0 | 11.80 | 0.5 | 11.90 | 2.3 |
| 12.00 | 6.4 | 12.10 | 10.8 | 12.20 | * 11.8 | 12.30 | 10.0 |
| 12.40 | 7.6 | 12.50 | 6.2 | 12.60 | 5.3 | 12.70 | 4.5 |
| 12.80 | 3.7 | 12.90 | 3.2 | 13.00 | 2.9 | 13.10 | 2.8 |
| 13.20 | 2.6 | 13.30 | 2.2 | 13.40 | 2.1 | 13.50 | 2.0 |
| 13.60 | 1.9 | 13.70 | 1.8 | 13.80 | 1.7 | 13.90 | 1.6 |
| 14.00 | 1.6 | 14.10 | 1.5 | 14.20 | 1.4 | 14.30 | 1.3 |
| 14.40 | 1.2 | 14.50 | 1.2 | 14.60 | 1.1 | 14.70 | 1.1 |
| 14.80 | 1.1 | 14.90 | 1.1 | 15.00 | 1.0 | 15.10 | 0.9 |
| 15.20 | 0.8 | 15.30 | 0.7 | 15.40 | 0.6 | 15.50 | 0.5 |
| 15.60 | 0.4 | 15.70 | 0.3 | 15.80 | 0.2 | 15.90 | 0.1 |
| 16.00 | 0.0 | 16.10 | 0.0 | 16.20 | 0.0 | 16.30 | 0.0 |
| 16.40 | 0.0 | 16.50 | 0.0 | 16.60 | 0.0 | 16.70 | 0.0 |

HORROCKS/CAROLLO ENGINEERS
AMERICAN FORK, UTAH
April 25, 1984

# HYDROLOGIC REPORT FOR

# CO-OP Mine Undisturbed Area

# S. C. S. HYDROGRAPH

BASIN IDENTIFICATION AU-between road loop
BASIN DISCHARGES INTO D-5U & D-6U & C-6U

| | | | |
|---|---|---|---|
| BASIN AREA | = | 3.00 | ACRES |
| BASIN CURVE NUMBER | = | 73.00 | |
| 24-HOUR PRECIPITATION | = | 2.25 | INCHES |
| AVERAGE BASIN SLOPE | = | 57.0 | % |
| HYDRAULIC LENGTH | = | 250.0 | FEET |
| BASIN LAG | = | 0.25 | HOURS |

HYDROGRAPH RUNOFF VALUES
10 YEAR STORM FREQUENCY

| TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. |
|---|---|---|---|---|---|---|---|
| 11.20 | 0.0 | 11.30 | 0.0 | 11.40 | 0.0 | 11.50 | 0.0 |
| 11.60 | 0.0 | 11.70 | 0.0 | 11.80 | 0.0 | 11.90 | 0.2 |
| 12.00 | 0.5 | 12.10 | 0.8 | 12.20 | ≍ 0.9 | 12.30 | 0.8 |
| 12.40 | 0.6 | 12.50 | 0.5 | 12.60 | 0.4 | 12.70 | 0.3 |
| 12.80 | 0.3 | 12.90 | 0.2 | 13.00 | 0.2 | 13.10 | 0.2 |
| 13.20 | 0.2 | 13.30 | 0.2 | 13.40 | 0.2 | 13.50 | 0.2 |
| 13.60 | 0.1 | 13.70 | 0.1 | 13.80 | 0.1 | 13.90 | 0.1 |
| 14.00 | 0.1 | 14.10 | 0.1 | 14.20 | 0.1 | 14.30 | 0.1 |
| 14.40 | 0.1 | 14.50 | 0.1 | 14.60 | 0.1 | 14.70 | 0.1 |
| 14.80 | 0.1 | 14.90 | 0.1 | 15.00 | 0.0 | 15.10 | 0.0 |
| 15.20 | 0.0 | 15.30 | 0.0 | 15.40 | 0.0 | 15.50 | 0.0 |

HORROCKS/CAROLLO ENGINEERS
AMERICAN FORK, UTAH
April 25, 1984

# Hiawatha RAINFALL DATA BASE

## RAINFALL INTENSITY (Inches/Hour)

| TIME (Min) | STORM FREQUENCY (Years) 2 | 5 | 10 | 25 | 50 | 100 |
|---|---|---|---|---|---|---|
| 5.0 | 0.84 | 1.56 | 1.92 | 2.76 | 3.12 | 3.72 |
| 6.0 | 0.79 | 1.49 | 1.84 | 2.63 | 2.98 | 3.55 |
| 7.0 | 0.74 | 1.42 | 1.76 | 2.50 | 2.84 | 3.38 |
| 8.0 | 0.69 | 1.35 | 1.68 | 2.37 | 2.70 | 3.21 |
| 9.0 | 0.64 | 1.28 | 1.60 | 2.24 | 2.56 | 3.04 |
| 10.0 | 0.60 | 1.20 | 1.50 | 2.10 | 2.40 | 2.88 |
| 11.0 | 0.58 | 1.16 | 1.45 | 2.03 | 2.32 | 2.78 |
| 12.0 | 0.56 | 1.12 | 1.40 | 1.96 | 2.24 | 2.68 |
| 13.0 | 0.54 | 1.08 | 1.35 | 1.89 | 2.16 | 2.58 |
| 14.0 | 0.53 | 1.04 | 1.30 | 1.82 | 2.08 | 2.48 |
| 15.0 | 0.52 | 1.00 | 1.24 | 1.76 | 2.00 | 2.40 |
| 20.0 | 0.47 | 0.90 | 1.11 | 1.59 | 1.80 | 2.16 |
| 25.0 | 0.42 | 0.80 | 0.98 | 1.42 | 1.60 | 1.92 |
| 30.0 | 0.36 | 0.70 | 0.86 | 1.24 | 1.40 | 1.68 |
| 40.0 | 0.32 | 0.61 | 0.76 | 1.09 | 1.23 | 1.48 |
| 50.0 | 0.28 | 0.52 | 0.66 | 0.94 | 1.06 | 1.28 |
| 60.0 | 0.23 | 0.44 | 0.55 | 0.78 | 0.88 | 1.06 |
| 120.0 | 0.20 | 0.31 | 0.38 | 0.50 | 0.56 | 0.65 |
| 180.0 | 0.18 | 0.26 | 0.31 | 0.40 | 0.44 | 0.51 |
| 240.0 | 0.17 | 0.24 | 0.28 | 0.36 | 0.40 | 0.46 |
| 300.0 | 0.16 | 0.22 | 0.25 | 0.32 | 0.36 | 0.41 |
| 360.0 | 0.16 | 0.20 | 0.23 | 0.28 | 0.32 | 0.35 |
| 480.0 | 0.14 | 0.18 | 0.20 | 0.25 | 0.28 | 0.31 |
| 600.0 | 0.12 | 0.16 | 0.17 | 0.22 | 0.24 | 0.27 |
| 720.0 | 0.11 | 0.13 | 0.15 | 0.18 | 0.20 | 0.22 |
| 1080.0 | 0.09 | 0.11 | 0.12 | 0.15 | 0.16 | 0.18 |
| 1440.0 | 0.07 | 0.08 | 0.09 | 0.11 | 0.12 | 0.13 |

# HYDROLOGICAL STUDY FOR

# CO-OP Mine Undisturbed Area

Main Access Road (Run-off Diversions)

Bear Canyon Mine Site

BY

HORROCKS/CAROLLO ENGINEERS

ONE WEST MAIN

AMERICAN FORK, UTAH 84003

April 25, 1984

REGISTERED PROFESSIONAL ENGINEER
No. 3535
HAROLD LEE
WIMMER
STATE OF UTAH

HORROCKS/CAROLLO ENGINEERS
AMERICAN FORK, UTAH
April 25, 1984

# HYDROLOGIC REPORT FOR

# CO-OP Mine Undisturbed Area

# S. C. S. HYDROGRAPH

BASIN IDENTIFICATION RA (above main road)
BASIN DISCHARGES INTO D-1R & C-1R

| | | | |
|---|---|---|---|
| BASIN AREA | = | 33.43 | ACRES |
| BASIN CURVE NUMBER | = | 73.00 | |
| 24-HOUR PRECIPITATION | = | 2.25 | INCHES |
| AVERAGE BASIN SLOPE | = | 61.0 | % |
| HYDRAULIC LENGTH | = | 1,975.0 | FEET |
| BASIN LAG | = | 0.25 | HOURS |

HYDROGRAPH RUNOFF VALUES
10 YEAR STORM FREQUENCY

| TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. |
|---|---|---|---|---|---|---|---|
| 11.20 | 0.0 | 11.30 | 0.0 | 11.40 | 0.0 | 11.50 | 0.0 |
| 11.60 | 0.0 | 11.70 | 0.0 | 11.80 | 0.4 | 11.90 | 2.0 |
| 12.00 | 5.5 | 12.10 | 9.3 | 12.20 | 10.2 | 12.30 | 8.6 |
| 12.40 | 6.5 | 12.50 | 5.3 | 12.60 | 4.6 | 12.70 | 3.9 |
| 12.80 | 3.2 | 12.90 | 2.7 | 13.00 | 2.5 | 13.10 | 2.4 |
| 13.20 | 2.3 | 13.30 | 1.9 | 13.40 | 1.8 | 13.50 | 1.7 |
| 13.60 | 1.7 | 13.70 | 1.6 | 13.80 | 1.5 | 13.90 | 1.4 |
| 14.00 | 1.4 | 14.10 | 1.3 | 14.20 | 1.2 | 14.30 | 1.1 |
| 14.40 | 1.1 | 14.50 | 1.0 | 14.60 | 1.0 | 14.70 | 1.0 |
| 14.80 | 1.0 | 14.90 | 1.0 | 15.00 | 0.9 | 15.10 | 0.8 |
| 15.20 | 0.7 | 15.30 | 0.6 | 15.40 | 0.5 | 15.50 | 0.4 |
| 15.60 | 0.3 | 15.70 | 0.2 | 15.80 | 0.1 | 15.90 | 0.0 |
| 16.00 | 0.0 | 16.10 | 0.0 | 16.20 | 0.0 | 16.30 | 0.0 |

HORROCKS/CAROLLO ENGINEERS
AMERICAN FORK, UTAH
April 25, 1984

# HYDROLOGIC REPORT FOR

# CO-OP Mine Undisturbed Area

# S. C. S. HYDROGRAPH

BASIN IDENTIFICATION RB (above main road)
BASIN DISCHARGES INTO D-2R & C-2R

| | | | |
|---|---|---|---|
| BASIN AREA | = | 39.67 | ACRES |
| BASIN CURVE NUMBER | = | 73.00 | |
| 24-HOUR PRECIPITATION | = | 2.25 | INCHES |
| AVERAGE BASIN SLOPE | = | 63.0 | % |
| HYDRAULIC LENGTH | = | 1,725.0 | FEET |
| BASIN LAG | = | 0.25 | HOURS |

HYDROGRAPH RUNOFF VALUES
10 YEAR STORM FREQUENCY

| TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. |
|---|---|---|---|---|---|---|---|
| 11.20 | 0.0 | 11.30 | 0.0 | 11.40 | 0.0 | 11.50 | 0.0 |
| 11.60 | 0.0 | 11.70 | 0.0 | 11.80 | 0.5 | 11.90 | 2.3 |
| 12.00 | 6.5 | 12.10 | 11.0 | 12.20 | * 12.1 | 12.30 | 10.2 |
| 12.40 | 7.8 | 12.50 | 6.3 | 12.60 | 5.5 | 12.70 | 4.6 |
| 12.80 | 3.8 | 12.90 | 3.3 | 13.00 | 3.0 | 13.10 | 2.8 |
| 13.20 | 2.7 | 13.30 | 2.3 | 13.40 | 2.1 | 13.50 | 2.0 |
| 13.60 | 2.0 | 13.70 | 1.9 | 13.80 | 1.7 | 13.90 | 1.6 |
| 14.00 | 1.6 | 14.10 | 1.6 | 14.20 | 1.5 | 14.30 | 1.3 |
| 14.40 | 1.2 | 14.50 | 1.2 | 14.60 | 1.2 | 14.70 | 1.2 |
| 14.80 | 1.1 | 14.90 | 1.1 | 15.00 | 1.0 | 15.10 | 0.9 |
| 15.20 | 0.8 | 15.30 | 0.7 | 15.40 | 0.6 | 15.50 | 0.5 |
| 15.60 | 0.4 | 15.70 | 0.3 | 15.80 | 0.2 | 15.90 | 0.1 |
| 16.00 | 0.0 | 16.10 | 0.0 | 16.20 | 0.0 | 16.30 | 0.0 |
| 16.40 | 0.0 | 16.50 | 0.0 | 16.60 | 0.0 | 16.70 | 0.0 |

HORROCKS/CAROLLO ENGINEERS
AMERICAN FORK, UTAH
April 25, 1984

# HYDROLOGIC REPORT FOR

# CO-OP Mine Undisturbed Area

# S. C. S. HYDROGRAPH

BASIN IDENTIFICATION RC (above main road)
BASIN DISCHARGES INTO D-3R & C-3R

| | | | |
|---|---|---|---|
| BASIN AREA | = | 33.87 | ACRES |
| BASIN CURVE NUMBER | = | 73.00 | |
| 24-HOUR PRECIPITATION | = | 2.25 | INCHES |
| AVERAGE BASIN SLOPE | = | 63.0 | % |
| HYDRAULIC LENGTH | = | 1,110.0 | FEET |
| BASIN LAG | = | 0.25 | HOURS |

HYDROGRAPH RUNOFF VALUES
10 YEAR STORM FREQUENCY

| TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. |
|---|---|---|---|---|---|---|---|
| 11.20 | 0.0 | 11.30 | 0.0 | 11.40 | 0.0 | 11.50 | 0.0 |
| 11.60 | 0.0 | 11.70 | 0.0 | 11.80 | 0.4 | 11.90 | 2.0 |
| 12.00 | 5.6 | 12.10 | 9.4 | 12.20 | * 10.4 | 12.30 | 8.7 |
| 12.40 | 6.6 | 12.50 | 5.4 | 12.60 | 4.7 | 12.70 | 3.9 |
| 12.80 | 3.3 | 12.90 | 2.8 | 13.00 | 2.5 | 13.10 | 2.4 |
| 13.20 | 2.3 | 13.30 | 1.9 | 13.40 | 1.8 | 13.50 | 1.7 |
| 13.60 | 1.7 | 13.70 | 1.6 | 13.80 | 1.5 | 13.90 | 1.4 |
| 14.00 | 1.4 | 14.10 | 1.3 | 14.20 | 1.2 | 14.30 | 1.1 |
| 14.40 | 1.1 | 14.50 | 1.0 | 14.60 | 1.0 | 14.70 | 1.0 |
| 14.80 | 1.0 | 14.90 | 1.0 | 15.00 | 0.9 | 15.10 | 0.8 |
| 15.20 | 0.7 | 15.30 | 0.6 | 15.40 | 0.5 | 15.50 | 0.4 |
| 15.60 | 0.3 | 15.70 | 0.2 | 15.80 | 0.1 | 15.90 | 0.0 |
| 16.00 | 0.0 | 16.10 | 0.0 | 16.20 | 0.0 | 16.30 | 0.0 |

HORROCKS/CAROLLO ENGINEERS
AMERICAN FORK, UTAH
April 25, 1984

# Hiawatha RAINFALL DATA BASE

## RAINFALL INTENSITY (Inches/Hour)

| TIME (Min) | STORM FREQUENCY (Years) 2 | 5 | 10 | 25 | 50 | 100 |
|---|---|---|---|---|---|---|
| 5.0 | 0.84 | 1.56 | 1.92 | 2.76 | 3.12 | 3.72 |
| 6.0 | 0.79 | 1.49 | 1.84 | 2.63 | 2.98 | 3.55 |
| 7.0 | 0.74 | 1.42 | 1.76 | 2.50 | 2.84 | 3.38 |
| 8.0 | 0.69 | 1.35 | 1.68 | 2.37 | 2.70 | 3.21 |
| 9.0 | 0.64 | 1.28 | 1.60 | 2.24 | 2.56 | 3.04 |
| 10.0 | 0.60 | 1.20 | 1.50 | 2.10 | 2.40 | 2.88 |
| 11.0 | 0.58 | 1.16 | 1.45 | 2.03 | 2.32 | 2.78 |
| 12.0 | 0.56 | 1.12 | 1.40 | 1.96 | 2.24 | 2.68 |
| 13.0 | 0.54 | 1.08 | 1.35 | 1.89 | 2.16 | 2.58 |
| 14.0 | 0.53 | 1.04 | 1.30 | 1.82 | 2.08 | 2.48 |
| 15.0 | 0.52 | 1.00 | 1.24 | 1.76 | 2.00 | 2.40 |
| 20.0 | 0.47 | 0.90 | 1.11 | 1.59 | 1.80 | 2.16 |
| 25.0 | 0.42 | 0.80 | 0.98 | 1.42 | 1.60 | 1.92 |
| 30.0 | 0.36 | 0.70 | 0.86 | 1.24 | 1.40 | 1.68 |
| 40.0 | 0.32 | 0.61 | 0.76 | 1.09 | 1.23 | 1.48 |
| 50.0 | 0.28 | 0.52 | 0.66 | 0.94 | 1.06 | 1.28 |
| 60.0 | 0.23 | 0.44 | 0.55 | 0.78 | 0.88 | 1.06 |
| 120.0 | 0.20 | 0.31 | 0.38 | 0.50 | 0.56 | 0.65 |
| 180.0 | 0.18 | 0.26 | 0.31 | 0.40 | 0.44 | 0.51 |
| 240.0 | 0.17 | 0.24 | 0.28 | 0.36 | 0.40 | 0.46 |
| 300.0 | 0.16 | 0.22 | 0.25 | 0.32 | 0.36 | 0.41 |
| 360.0 | 0.16 | 0.20 | 0.23 | 0.28 | 0.32 | 0.35 |
| 480.0 | 0.14 | 0.18 | 0.20 | 0.25 | 0.28 | 0.31 |
| 600.0 | 0.12 | 0.16 | 0.17 | 0.22 | 0.24 | 0.27 |
| 720.0 | 0.11 | 0.13 | 0.15 | 0.18 | 0.20 | 0.22 |
| 1080.0 | 0.09 | 0.11 | 0.12 | 0.15 | 0.16 | 0.18 |
| 1440.0 | 0.07 | 0.08 | 0.09 | 0.11 | 0.12 | 0.13 |

# HYDROLOGICAL STUDY FOR

# CO-OP Mine Undisturbed Area

Bear Creek Main Channel (60" CMP)

Bear Canyon Mine Site

BY

HORROCKS/CAROLLO ENGINEERS

ONE WEST MAIN

AMERICAN FORK, UTAH 84003

April 25, 1984

REGISTERED PROFESSIONAL ENGINEER
No. 3535
HAROLD LEE
WIMMER
STATE OF UTAH

HORROCKS/CAROLLO ENGINEERS
AMERICAN FORK, UTAH
April 25, 1984

# HYDROLOGIC REPORT FOR

# CO-OP Mine Undisturbed Area

# S. C. S. HYDROGRAPH

BASIN IDENTIFICATION LA (Bear Creek Falls area)
BASIN DISCHARGES INTO Bear Creek

| | | | |
|---|---|---|---|
| BASIN AREA | = | 953.00 | ACRES |
| BASIN CURVE NUMBER | = | 73.00 | |
| 24-HOUR PRECIPITATION | = | 2.25 | INCHES |
| AVERAGE BASIN SLOPE | = | 19.0 | % |
| HYDRAULIC LENGTH | = | 11,000.0 | FEET |
| BASIN LAG | = | 0.61 | HOURS |

HYDROGRAPH RUNOFF VALUES
10 YEAR STORM FREQUENCY

| TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. |
|---|---|---|---|---|---|---|---|
| 10.74 | 0.0 | 10.98 | 0.0 | 11.22 | 0.0 | 11.47 | 0.0 |
| 11.71 | 0.5 | 11.96 | 23.0 | 12.20 | 84.8 | 12.44 | 139.6 |
| 12.69 | 153.6 | 12.93 | 132.0 | 13.18 | 105.1 | 13.42 | 84.3 |
| 13.66 | 69.1 | 13.91 | 57.9 | 14.15 | 49.5 | 14.40 | 42.7 |
| 14.64 | 37.3 | 14.88 | 32.6 | 15.13 | 29.9 | 15.37 | 28.7 |
| 15.62 | 28.1 | 15.86 | 27.9 | 16.10 | 27.6 | 16.35 | 26.4 |
| 16.59 | 24.1 | 16.84 | 21.6 | 17.08 | 19.7 | 17.32 | 18.7 |
| 17.57 | 18.2 | 17.81 | 17.9 | 18.06 | 17.7 | 18.30 | 17.7 |
| 18.54 | 17.6 | 18.79 | 17.5 | 19.03 | 17.4 | 19.28 | 17.3 |
| 19.52 | 17.2 | 19.76 | 17.1 | 20.01 | 17.0 | 20.25 | 16.9 |
| 20.50 | 16.7 | 20.74 | 15.2 | 20.98 | 14.0 | 21.23 | 13.3 |
| 21.47 | 12.9 | 21.72 | 12.7 | 21.96 | 12.6 | 22.20 | 12.6 |
| 22.45 | 12.5 | 22.69 | 12.4 | 22.94 | 12.3 | 23.18 | 12.2 |
| 23.42 | 12.1 | 23.67 | 11.9 | 23.91 | 9.5 | 24.16 | 6.3 |
| 24.40 | 3.7 | 24.64 | 2.1 | 24.89 | 1.2 | 25.13 | 0.7 |
| 25.38 | 0.4 | 25.62 | 0.2 | 25.86 | 0.1 | 26.11 | 0.0 |
| 26.35 | 0.0 | 26.60 | 0.0 | 26.84 | 0.0 | 27.08 | 0.0 |
| 27.33 | 0.0 | 27.57 | 0.0 | 27.82 | 0.0 | 28.06 | 0.0 |

# HYDROLOGIC REPORT FOR

# CO-OP Mine Undisturbed Area

# S. C. S. HYDROGRAPH

BASIN IDENTIFICATION LC (right-hand tributary)
BASIN DISCHARGES INTO Bear Creek

| | | | |
|---|---|---|---|
| BASIN AREA | = | 481.00 | ACRES |
| BASIN CURVE NUMBER | = | 73.00 | |
| 24-HOUR PRECIPITATION | = | 2.25 | INCHES |
| AVERAGE BASIN SLOPE | = | 32.0 | % |
| HYDRAULIC LENGTH | = | 6,600.0 | FEET |
| BASIN LAG | = | 0.61 | HOURS |

HYDROGRAPH RUNOFF VALUES
10 YEAR STORM FREQUENCY

| TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. |
|---|---|---|---|---|---|---|---|
| 10.74 | 0.0 | 10.98 | 0.0 | 11.22 | 0.0 | 11.47 | 0.0 |
| 11.71 | 0.3 | 11.96 | 11.6 | 12.20 | 42.8 | 12.44 | 70.5 |
| 12.69 | 77.5 | 12.93 | 66.6 | 13.18 | 53.1 | 13.42 | 42.6 |
| 13.66 | 34.9 | 13.91 | 29.2 | 14.15 | 25.0 | 14.40 | 21.6 |
| 14.64 | 18.8 | 14.88 | 16.4 | 15.13 | 15.1 | 15.37 | 14.5 |
| 15.62 | 14.2 | 15.86 | 14.1 | 16.10 | 14.0 | 16.35 | 13.3 |
| 16.59 | 12.2 | 16.84 | 10.9 | 17.08 | 10.0 | 17.32 | 9.4 |
| 17.57 | 9.2 | 17.81 | 9.0 | 18.06 | 9.0 | 18.30 | 8.9 |
| 18.54 | 8.8 | 18.79 | 8.7 | 19.03 | 8.6 | 19.28 | 8.5 |
| 19.52 | 8.4 | 19.76 | 8.3 | 20.01 | 8.2 | 20.25 | 8.1 |
| 20.50 | 8.0 | 20.74 | 7.7 | 20.98 | 7.1 | 21.23 | 6.7 |
| 21.47 | 6.5 | 21.72 | 6.4 | 21.96 | 6.4 | 22.20 | 6.3 |
| 22.45 | 6.3 | 22.69 | 6.2 | 22.94 | 6.1 | 23.18 | 6.0 |
| 23.42 | 5.9 | 23.67 | 5.8 | 23.91 | 4.8 | 24.16 | 3.2 |
| 24.40 | 1.8 | 24.64 | 1.1 | 24.89 | 0.6 | 25.13 | 0.3 |
| 25.38 | 0.2 | 25.62 | 0.1 | 25.86 | 0.0 | 26.11 | 0.0 |
| 26.35 | 0.0 | 26.60 | 0.0 | 26.84 | 0.0 | 27.08 | 0.0 |
| 27.33 | 0.0 | 27.57 | 0.0 | 27.82 | 0.0 | 28.06 | 0.0 |

HORROCKS/CAROLLO ENGINEERS
AMERICAN FORK, UTAH
April 25, 1984

# HYDROLOGIC REPORT FOR

## CO-OP Mine Undisturbed Area

BASIN IDENTIFIER LA + LC
DISCHARGES INTO Bear Creek (60" CMP)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 10.74 | 0.0 | 10.98 | 0.0 | 11.22 | 0.0 | 11.47 | 0.0 |
| 11.71 | 0.8 | 11.96 | 34.6 | 12.20 | 127.7 | 12.44 | 210.1 |
| 12.69 | 231.2 | 12.93 | 198.7 | 13.18 | 158.2 | 13.42 | 126.9 |
| 13.66 | 104.0 | 13.91 | 87.1 | 14.15 | 74.5 | 14.40 | 64.3 |
| 14.64 | 56.1 | 14.88 | 49.0 | 15.13 | 45.1 | 15.37 | 43.2 |
| 15.62 | 42.3 | 15.86 | 42.0 | 16.10 | 41.6 | 16.35 | 39.8 |
| 16.59 | 36.2 | 16.84 | 32.5 | 17.08 | 29.7 | 17.32 | 28.2 |
| 17.57 | 27.3 | 17.81 | 26.9 | 18.06 | 26.7 | 18.30 | 26.6 |
| 18.54 | 26.4 | 18.79 | 26.2 | 19.03 | 26.0 | 19.28 | 25.8 |
| 19.52 | 25.6 | 19.76 | 25.4 | 20.01 | 25.2 | 20.25 | 25.0 |
| 20.50 | 24.7 | 20.74 | 22.9 | 20.98 | 21.1 | 21.23 | 20.0 |
| 21.47 | 19.4 | 21.72 | 19.1 | 21.96 | 19.0 | 22.20 | 18.9 |
| 22.45 | 18.9 | 22.69 | 18.7 | 22.94 | 18.5 | 23.18 | 18.3 |
| 23.42 | 18.1 | 23.67 | 17.8 | 23.91 | 14.3 | 24.16 | 9.5 |
| 24.40 | 5.5 | 24.64 | 3.2 | 24.89 | 1.8 | 25.13 | 1.0 |
| 25.38 | 0.6 | 25.62 | 0.3 | 25.86 | 0.1 | 26.11 | 0.1 |
| 26.35 | 0.0 | 26.60 | 0.0 | 26.84 | 0.0 | 27.08 | 0.0 |
| 27.33 | 0.0 | 27.57 | 0.0 | 27.82 | 0.0 | 28.06 | 0.0 |

HORROCKS/CAROLLO ENGINEERS
AMERICAN FORK, UTAH
April 25, 1984

# Hiawatha RAINFALL DATA BASE

## RAINFALL INTENSITY (Inches/Hour)

| TIME (Min) | STORM FREQUENCY (Years) 2 | 5 | 10 | 25 | 50 | 100 |
|---|---|---|---|---|---|---|
| 5.0 | 0.84 | 1.56 | 1.92 | 2.76 | 3.12 | 3.72 |
| 6.0 | 0.79 | 1.49 | 1.84 | 2.63 | 2.98 | 3.55 |
| 7.0 | 0.74 | 1.42 | 1.76 | 2.50 | 2.84 | 3.38 |
| 8.0 | 0.69 | 1.35 | 1.68 | 2.37 | 2.70 | 3.21 |
| 9.0 | 0.64 | 1.28 | 1.60 | 2.24 | 2.56 | 3.04 |
| 10.0 | 0.60 | 1.20 | 1.50 | 2.10 | 2.40 | 2.88 |
| 11.0 | 0.58 | 1.16 | 1.45 | 2.03 | 2.32 | 2.78 |
| 12.0 | 0.56 | 1.12 | 1.40 | 1.96 | 2.24 | 2.68 |
| 13.0 | 0.54 | 1.08 | 1.35 | 1.89 | 2.16 | 2.58 |
| 14.0 | 0.53 | 1.04 | 1.30 | 1.82 | 2.08 | 2.48 |
| 15.0 | 0.52 | 1.00 | 1.24 | 1.76 | 2.00 | 2.40 |
| 20.0 | 0.47 | 0.90 | 1.11 | 1.59 | 1.80 | 2.16 |
| 25.0 | 0.42 | 0.80 | 0.98 | 1.42 | 1.60 | 1.92 |
| 30.0 | 0.36 | 0.70 | 0.86 | 1.24 | 1.40 | 1.68 |
| 40.0 | 0.32 | 0.61 | 0.76 | 1.09 | 1.23 | 1.48 |
| 50.0 | 0.28 | 0.52 | 0.66 | 0.94 | 1.06 | 1.28 |
| 60.0 | 0.23 | 0.44 | 0.55 | 0.78 | 0.88 | 1.06 |
| 120.0 | 0.20 | 0.31 | 0.38 | 0.50 | 0.56 | 0.65 |
| 180.0 | 0.18 | 0.26 | 0.31 | 0.40 | 0.44 | 0.51 |
| 240.0 | 0.17 | 0.24 | 0.28 | 0.36 | 0.40 | 0.46 |
| 300.0 | 0.16 | 0.22 | 0.25 | 0.32 | 0.36 | 0.41 |
| 360.0 | 0.16 | 0.20 | 0.23 | 0.28 | 0.32 | 0.35 |
| 480.0 | 0.14 | 0.18 | 0.20 | 0.25 | 0.28 | 0.31 |
| 600.0 | 0.12 | 0.16 | 0.17 | 0.22 | 0.24 | 0.27 |
| 720.0 | 0.11 | 0.13 | 0.15 | 0.18 | 0.20 | 0.22 |
| 1080.0 | 0.09 | 0.11 | 0.12 | 0.15 | 0.16 | 0.18 |
| 1440.0 | 0.07 | 0.08 | 0.09 | 0.11 | 0.12 | 0.13 |

# HYDROLOGICAL STUDY FOR

# CO-OP Mine Disturbed Area

Disturbed Run-off Collection

Bear Canyon Mine Site

BY

HORROCKS/CAROLLO ENGINEERS

ONE WEST MAIN

AMERICAN FORK, UTAH 84003

April 25, 1984

REGISTERED PROFESSIONAL ENGINEER
No. 3535
HAROLD LEE WIMMER
STATE OF UTAH

HORROCKS/CAROLLO ENGINEERS
AMERICAN FORK, UTAH
April 25, 1984

# HYDROLOGIC REPORT FOR

# CO-OP Mine Disturbed Area

# S. C. S. HYDROGRAPH

BASIN IDENTIFICATION Area B
BASIN DISCHARGES INTO D-6D & C-3D

| | | | |
|---|---|---|---|
| BASIN AREA | = | 1.79 | ACRES |
| BASIN CURVE NUMBER | = | 82.00 | |
| 24-HOUR PRECIPITATION | = | 2.25 | INCHES |
| AVERAGE BASIN SLOPE | = | 10.0 | % |
| HYDRAULIC LENGTH | = | 520.0 | FEET |
| BASIN LAG | = | 0.25 | HOURS |

HYDROGRAPH RUNOFF VALUES
10 YEAR STORM FREQUENCY

| TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. |
|---|---|---|---|---|---|---|---|
| 10.00 | 0.0 | 10.10 | 0.0 | 10.20 | 0.0 | 10.30 | 0.0 |
| 10.40 | 0.0 | 10.50 | 0.0 | 10.60 | 0.0 | 10.70 | 0.0 |
| 10.80 | 0.0 | 10.90 | 0.0 | 11.00 | 0.0 | 11.10 | 0.0 |
| 11.20 | 0.0 | 11.30 | 0.0 | 11.40 | 0.0 | 11.50 | 0.0 |
| 11.60 | 0.1 | 11.70 | 0.1 | 11.80 | 0.2 | 11.90 | 0.5 |
| 12.00 | 0.9 | 12.10 | 1.2 | 12.20 | 1.2 | 12.30 | 1.0 |
| 12.40 | 0.7 | 12.50 | 0.5 | 12.60 | 0.4 | 12.70 | 0.4 |
| 12.80 | 0.3 | 12.90 | 0.3 | 13.00 | 0.2 | 13.10 | 0.2 |
| 13.20 | 0.2 | 13.30 | 0.2 | 13.40 | 0.2 | 13.50 | 0.1 |
| 13.60 | 0.1 | 13.70 | 0.1 | 13.80 | 0.1 | 13.90 | 0.1 |
| 14.00 | 0.1 | 14.10 | 0.1 | 14.20 | 0.1 | 14.30 | 0.1 |
| 14.40 | 0.1 | 14.50 | 0.1 | 14.60 | 0.1 | 14.70 | 0.1 |
| 14.80 | 0.1 | 14.90 | 0.1 | 15.00 | 0.1 | 15.10 | 0.0 |
| 15.20 | 0.0 | 15.30 | 0.0 | 15.40 | 0.0 | 15.50 | 0.0 |

HORROCKS/CAROLLO ENGINEERS
AMERICAN FORK, UTAH
April 25, 1984

# HYDROLOGIC REPORT FOR

# CO-OP Mine Disturbed Area

# S. C. S. HYDROGRAPH

BASIN IDENTIFICATION AD-2 (upper road)
BASIN DISCHARGES INTO D-3D

| | | | |
|---|---|---|---|
| BASIN AREA | = | 1.50 | ACRES |
| BASIN CURVE NUMBER | = | 82.00 | |
| 24-HOUR PRECIPITATION | = | 2.25 | INCHES |
| AVERAGE BASIN SLOPE | = | 14.0 | % |
| HYDRAULIC LENGTH | = | 600.0 | FEET |
| BASIN LAG | = | 0.25 | HOURS |

HYDROGRAPH RUNOFF VALUES
10 YEAR STORM FREQUENCY

| TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. |
|---|---|---|---|---|---|---|---|
| 10.00 | 0.0 | 10.10 | 0.0 | 10.20 | 0.0 | 10.30 | 0.0 |
| 10.40 | 0.0 | 10.50 | 0.0 | 10.60 | 0.0 | 10.70 | 0.0 |
| 10.80 | 0.0 | 10.90 | 0.0 | 11.00 | 0.0 | 11.10 | 0.0 |
| 11.20 | 0.0 | 11.30 | 0.0 | 11.40 | 0.0 | 11.50 | 0.0 |
| 11.60 | 0.1 | 11.70 | 0.1 | 11.80 | 0.2 | 11.90 | 0.4 |
| 12.00 | 0.7 | 12.10 | 1.0 | 12.20 | 1.0 | 12.30 | 0.8 |
| 12.40 | 0.6 | 12.50 | 0.5 | 12.60 | 0.4 | 12.70 | 0.3 |
| 12.80 | 0.3 | 12.90 | 0.2 | 13.00 | 0.2 | 13.10 | 0.2 |
| 13.20 | 0.2 | 13.30 | 0.1 | 13.40 | 0.1 | 13.50 | 0.1 |
| 13.60 | 0.1 | 13.70 | 0.1 | 13.80 | 0.1 | 13.90 | 0.1 |
| 14.00 | 0.1 | 14.10 | 0.1 | 14.20 | 0.1 | 14.30 | 0.1 |
| 14.40 | 0.1 | 14.50 | 0.1 | 14.60 | 0.1 | 14.70 | 0.1 |
| 14.80 | 0.1 | 14.90 | 0.1 | 15.00 | 0.1 | 15.10 | 0.0 |
| 15.20 | 0.0 | 15.30 | 0.0 | 15.40 | 0.0 | 15.50 | 0.0 |

HORROCKS/CAROLLO ENGINEERS
AMERICAN FORK, UTAH
April 25, 1984

# HYDROLOGIC REPORT FOR

# CO-OP Mine Disturbed Area

# S. C. S. HYDROGRAPH

BASIN IDENTIFICATION AD-1
BASIN DISCHARGES INTO D-2D & C-1D

| | | | |
|---|---|---|---|
| BASIN AREA | = | 2.24 | ACRES |
| BASIN CURVE NUMBER | = | 82.00 | |
| 24-HOUR PRECIPITATION | = | 2.25 | INCHES |
| AVERAGE BASIN SLOPE | = | 36.0 | % |
| HYDRAULIC LENGTH | = | 420.0 | FEET |
| BASIN LAG | = | 0.25 | HOURS |

HYDROGRAPH RUNOFF VALUES
10 YEAR STORM FREQUENCY

| TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. |
|---|---|---|---|---|---|---|---|
| 10.00 | 0.0 | 10.10 | 0.0 | 10.20 | 0.0 | 10.30 | 0.0 |
| 10.40 | 0.0 | 10.50 | 0.0 | 10.60 | 0.0 | 10.70 | 0.0 |
| 10.80 | 0.0 | 10.90 | 0.0 | 11.00 | 0.0 | 11.10 | 0.0 |
| 11.20 | 0.0 | 11.30 | 0.0 | 11.40 | 0.0 | 11.50 | 0.0 |
| 11.60 | 0.1 | 11.70 | 0.2 | 11.80 | 0.3 | 11.90 | 0.6 |
| 12.00 | 1.1 | 12.10 | * 1.5 | 12.20 | 1.5 | 12.30 | 1.2 |
| 12.40 | 0.9 | 12.50 | 0.7 | 12.60 | 0.6 | 12.70 | 0.5 |
| 12.80 | 0.4 | 12.90 | 0.3 | 13.00 | 0.3 | 13.10 | 0.3 |
| 13.20 | 0.2 | 13.30 | 0.2 | 13.40 | 0.2 | 13.50 | 0.2 |
| 13.60 | 0.2 | 13.70 | 0.2 | 13.80 | 0.2 | 13.90 | 0.1 |
| 14.00 | 0.1 | 14.10 | 0.1 | 14.20 | 0.1 | 14.30 | 0.1 |
| 14.40 | 0.1 | 14.50 | 0.1 | 14.60 | 0.1 | 14.70 | 0.1 |
| 14.80 | 0.1 | 14.90 | 0.1 | 15.00 | 0.1 | 15.10 | 0.0 |
| 15.20 | 0.0 | 15.30 | 0.0 | 15.40 | 0.0 | 15.50 | 0.0 |

# HYDROLOGIC REPORT FOR

# CO-OP Mine Disturbed Area

# S. C. S. HYDROGRAPH

BASIN IDENTIFICATION AD-1S (substa. area)
BASIN DISCHARGES INTO D-1D

| | | | |
|---|---|---|---|
| BASIN AREA | = | 1.25 | ACRES |
| BASIN CURVE NUMBER | = | 82.00 | |
| 24-HOUR PRECIPITATION | = | 2.25 | INCHES |
| AVERAGE BASIN SLOPE | = | 30.0 | % |
| HYDRAULIC LENGTH | = | 250.0 | FEET |
| BASIN LAG | = | 0.25 | HOURS |

HYDROGRAPH RUNOFF VALUES
10 YEAR STORM FREQUENCY

| TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. |
|---|---|---|---|---|---|---|---|
| 10.00 | 0.0 | 10.10 | 0.0 | 10.20 | 0.0 | 10.30 | 0.0 |
| 10.40 | 0.0 | 10.50 | 0.0 | 10.60 | 0.0 | 10.70 | 0.0 |
| 10.80 | 0.0 | 10.90 | 0.0 | 11.00 | 0.0 | 11.10 | 0.0 |
| 11.20 | 0.0 | 11.30 | 0.0 | 11.40 | 0.0 | 11.50 | 0.0 |
| 11.60 | 0.0 | 11.70 | 0.1 | 11.80 | 0.2 | 11.90 | 0.3 |
| 12.00 | 0.6 | 12.10 | * 0.8 | 12.20 | 0.8 | 12.30 | 0.7 |
| 12.40 | 0.5 | 12.50 | 0.4 | 12.60 | 0.3 | 12.70 | 0.3 |
| 12.80 | 0.2 | 12.90 | 0.2 | 13.00 | 0.2 | 13.10 | 0.2 |
| 13.20 | 0.1 | 13.30 | 0.1 | 13.40 | 0.1 | 13.50 | 0.1 |
| 13.60 | 0.1 | 13.70 | 0.1 | 13.80 | 0.1 | 13.90 | 0.1 |
| 14.00 | 0.1 | 14.10 | 0.1 | 14.20 | 0.1 | 14.30 | 0.1 |
| 14.40 | 0.1 | 14.50 | 0.1 | 14.60 | 0.1 | 14.70 | 0.1 |
| 14.80 | 0.1 | 14.90 | 0.1 | 15.00 | 0.1 | 15.10 | 0.0 |
| 15.20 | 0.0 | 15.30 | 0.0 | 15.40 | 0.0 | 15.50 | 0.0 |

HORROCKS/CAROLLO ENGINEERS
AMERICAN FORK, UTAH
April 25, 1984

# HYDROLOGIC REPORT FOR

# CO-OP Mine Disturbed Area

# S. C. S. HYDROGRAPH

BASIN IDENTIFICATION AD-1
BASIN DISCHARGES INTO D-4D & C-2D also D-5D

| | | | |
|---|---|---|---|
| BASIN AREA | = | 2.24 | ACRES |
| BASIN CURVE NUMBER | = | 82.00 | |
| 24-HOUR PRECIPITATION | = | 2.25 | INCHES |
| AVERAGE BASIN SLOPE | = | 36.0 | % |
| HYDRAULIC LENGTH | = | 420.0 | FEET |
| BASIN LAG | = | 0.25 | HOURS |

HYDROGRAPH RUNOFF VALUES
10 YEAR STORM FREQUENCY

| TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. |
|---|---|---|---|---|---|---|---|
| 10.00 | 0.0 | 10.10 | 0.0 | 10.20 | 0.0 | 10.30 | 0.0 |
| 10.40 | 0.0 | 10.50 | 0.0 | 10.60 | 0.0 | 10.70 | 0.0 |
| 10.80 | 0.0 | 10.90 | 0.0 | 11.00 | 0.0 | 11.10 | 0.0 |
| 11.20 | 0.0 | 11.30 | 0.0 | 11.40 | 0.0 | 11.50 | 0.0 |
| 11.60 | 0.1 | 11.70 | 0.2 | 11.80 | 0.3 | 11.90 | 0.6 |
| 12.00 | 1.1 | 12.10 | * 1.5 | 12.20 | 1.5 | 12.30 | 1.2 |
| 12.40 | 0.9 | 12.50 | 0.7 | 12.60 | 0.6 | 12.70 | 0.5 |
| 12.80 | 0.4 | 12.90 | 0.3 | 13.00 | 0.3 | 13.10 | 0.3 |
| 13.20 | 0.2 | 13.30 | 0.2 | 13.40 | 0.2 | 13.50 | 0.2 |
| 13.60 | 0.2 | 13.70 | 0.2 | 13.80 | 0.2 | 13.90 | 0.1 |
| 14.00 | 0.1 | 14.10 | 0.1 | 14.20 | 0.1 | 14.30 | 0.1 |
| 14.40 | 0.1 | 14.50 | 0.1 | 14.60 | 0.1 | 14.70 | 0.1 |
| 14.80 | 0.1 | 14.90 | 0.1 | 15.00 | 0.1 | 15.10 | 0.0 |
| 15.20 | 0.0 | 15.30 | 0.0 | 15.40 | 0.0 | 15.50 | 0.0 |

HORROCKS/CAROLLO ENGINEERS
AMERICAN FORK, UTAH
April 25, 1984

# HYDROLOGIC REPORT FOR

# CO-OP Mine Disturbed Area

# S. C. S. HYDROGRAPH

BASIN IDENTIFICATION AD-2
BASIN DISCHARGES INTO D-4D & C-2D also D-5D

| | | | |
|---|---|---|---|
| BASIN AREA | = | 4.96 | ACRES |
| BASIN CURVE NUMBER | = | 82.00 | |
| 24-HOUR PRECIPITATION | = | 2.25 | INCHES |
| AVERAGE BASIN SLOPE | = | 14.0 | % |
| HYDRAULIC LENGTH | = | 560.0 | FEET |
| BASIN LAG | = | 0.25 | HOURS |

HYDROGRAPH RUNOFF VALUES
10 YEAR STORM FREQUENCY

| TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. |
|---|---|---|---|---|---|---|---|
| 10.00 | 0.0 | 10.10 | 0.0 | 10.20 | 0.0 | 10.30 | 0.0 |
| 10.40 | 0.0 | 10.50 | 0.0 | 10.60 | 0.0 | 10.70 | 0.0 |
| 10.80 | 0.0 | 10.90 | 0.0 | 11.00 | 0.0 | 11.10 | 0.0 |
| 11.20 | 0.1 | 11.30 | 0.1 | 11.40 | 0.1 | 11.50 | 0.1 |
| 11.60 | 0.2 | 11.70 | 0.3 | 11.80 | 0.7 | 11.90 | 1.3 |
| 12.00 | 2.4 | 12.10 | 3.3 | 12.20 | 3.3 | 12.30 | 2.7 |
| 12.40 | 1.9 | 12.50 | 1.5 | 12.60 | 1.2 | 12.70 | 1.0 |
| 12.80 | 0.8 | 12.90 | 0.7 | 13.00 | 0.6 | 13.10 | 0.6 |
| 13.20 | 0.6 | 13.30 | 0.5 | 13.40 | 0.4 | 13.50 | 0.4 |
| 13.60 | 0.4 | 13.70 | 0.4 | 13.80 | 0.3 | 13.90 | 0.3 |
| 14.00 | 0.3 | 14.10 | 0.3 | 14.20 | 0.3 | 14.30 | 0.3 |
| 14.40 | 0.2 | 14.50 | 0.2 | 14.60 | 0.2 | 14.70 | 0.2 |
| 14.80 | 0.2 | 14.90 | 0.2 | 15.00 | 0.2 | 15.10 | 0.1 |
| 15.20 | 0.0 | 15.30 | 0.0 | 15.40 | 0.0 | 15.50 | 0.0 |
| 15.60 | 0.0 | 15.70 | 0.0 | 15.80 | 0.0 | 15.90 | 0.0 |

HORROCKS/CAROLLO ENGINEERS
AMERICAN FORK, UTAH
April 25, 1984

# HYDROLOGIC REPORT FOR

## CO-OP Mine Disturbed Area

BASIN IDENTIFIER AD-1 + AD-2
DISCHARGES INTO D-4D & C-2D

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 10.00 | 0.0 | 10.10 | 0.0 | 10.20 | 0.0 | 10.30 | 0.0 |
| 10.40 | 0.0 | 10.50 | 0.0 | 10.60 | 0.0 | 10.70 | 0.0 |
| 10.80 | 0.0 | 10.90 | 0.0 | 11.00 | 0.0 | 11.10 | 0.1 |
| 11.20 | 0.1 | 11.30 | 0.1 | 11.40 | 0.1 | 11.50 | 0.2 |
| 11.60 | 0.2 | 11.70 | 0.5 | 11.80 | 1.0 | 11.90 | 1.9 |
| 12.00 | 3.5 | 12.10 | *4.8 | 12.20 | 4.8 | 12.30 | 3.9 |
| 12.40 | 2.8 | 12.50 | 2.2 | 12.60 | 1.8 | 12.70 | 1.5 |
| 12.80 | 1.2 | 12.90 | 1.0 | 13.00 | 0.9 | 13.10 | 0.9 |
| 13.20 | 0.8 | 13.30 | 0.7 | 13.40 | 0.6 | 13.50 | 0.6 |
| 13.60 | 0.6 | 13.70 | 0.5 | 13.80 | 0.5 | 13.90 | 0.5 |
| 14.00 | 0.5 | 14.10 | 0.4 | 14.20 | 0.4 | 14.30 | 0.4 |
| 14.40 | 0.3 | 14.50 | 0.3 | 14.60 | 0.3 | 14.70 | 0.3 |
| 14.80 | 0.3 | 14.90 | 0.3 | 15.00 | 0.3 | 15.10 | 0.1 |
| 15.20 | 0.0 | 15.30 | 0.0 | 15.40 | 0.0 | 15.50 | 0.0 |
| 15.60 | 0.0 | 15.70 | 0.0 | 15.80 | 0.0 | 15.90 | 0.0 |

HORROCKS/CAROLLO ENGINEERS
AMERICAN FORK, UTAH
April 25, 1984

# HYDROLOGIC REPORT FOR

# CO-OP Mine Disturbed Area

# S. C. S. HYDROGRAPH

BASIN IDENTIFICATION AD-3
BASIN DISCHARGES INTO D-5D

| | | | |
|---|---|---|---|
| BASIN AREA | = | 3.51 | ACRES |
| BASIN CURVE NUMBER | = | 82.00 | |
| 24-HOUR PRECIPITATION | = | 2.25 | INCHES |
| AVERAGE BASIN SLOPE | = | 11.0 | % |
| HYDRAULIC LENGTH | = | 640.0 | FEET |
| BASIN LAG | = | 0.25 | HOURS |

HYDROGRAPH RUNOFF VALUES
10 YEAR STORM FREQUENCY

| TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. |
|---|---|---|---|---|---|---|---|
| 10.00 | 0.0 | 10.10 | 0.0 | 10.20 | 0.0 | 10.30 | 0.0 |
| 10.40 | 0.0 | 10.50 | 0.0 | 10.60 | 0.0 | 10.70 | 0.0 |
| 10.80 | 0.0 | 10.90 | 0.0 | 11.00 | 0.0 | 11.10 | 0.0 |
| 11.20 | 0.0 | 11.30 | 0.1 | 11.40 | 0.1 | 11.50 | 0.1 |
| 11.60 | 0.1 | 11.70 | 0.2 | 11.80 | 0.5 | 11.90 | 0.9 |
| 12.00 | 1.7 | 12.10 | * 2.4 | 12.20 | 2.4 | 12.30 | 1.9 |
| 12.40 | 1.4 | 12.50 | 1.1 | 12.60 | 0.9 | 12.70 | 0.7 |
| 12.80 | 0.6 | 12.90 | 0.5 | 13.00 | 0.4 | 13.10 | 0.4 |
| 13.20 | 0.4 | 13.30 | 0.3 | 13.40 | 0.3 | 13.50 | 0.3 |
| 13.60 | 0.3 | 13.70 | 0.3 | 13.80 | 0.2 | 13.90 | 0.2 |
| 14.00 | 0.2 | 14.10 | 0.2 | 14.20 | 0.2 | 14.30 | 0.2 |
| 14.40 | 0.2 | 14.50 | 0.2 | 14.60 | 0.2 | 14.70 | 0.2 |
| 14.80 | 0.2 | 14.90 | 0.2 | 15.00 | 0.2 | 15.10 | 0.1 |
| 15.20 | 0.0 | 15.30 | 0.0 | 15.40 | 0.0 | 15.50 | 0.0 |
| 15.60 | 0.0 | 15.70 | 0.0 | 15.80 | 0.0 | 15.90 | 0.0 |

HORROCKS/CAROLLO ENGINEERS
AMERICAN FORK, UTAH
April 25, 1984

# HYDROLOGIC REPORT FOR

## CO-OP Mine Disturbed Area

BASIN IDENTIFIER AD-1 + AD-2 + AD-3
DISCHARGES INTO D-5D

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 10.00 | 0.0 | 10.10 | 0.0 | 10.20 | 0.0 | 10.30 | 0.0 |
| 10.40 | 0.0 | 10.50 | 0.0 | 10.60 | 0.0 | 10.70 | 0.0 |
| 10.80 | 0.0 | 10.90 | 0.0 | 11.00 | 0.1 | 11.10 | 0.1 |
| 11.20 | 0.1 | 11.30 | 0.2 | 11.40 | 0.2 | 11.50 | 0.2 |
| 11.60 | 0.4 | 11.70 | 0.7 | 11.80 | 1.5 | 11.90 | 2.9 |
| 12.00 | 5.2 | 12.10 | * 7.2 | 12.20 | 7.2 | 12.30 | 5.7 |
| 12.40 | 4.2 | 12.50 | 3.3 | 12.60 | 2.7 | 12.70 | 2.2 |
| 12.80 | 1.8 | 12.90 | 1.5 | 13.00 | 1.4 | 13.10 | 1.3 |
| 13.20 | 1.2 | 13.30 | 1.0 | 13.40 | 0.9 | 13.50 | 0.9 |
| 13.60 | 0.8 | 13.70 | 0.8 | 13.80 | 0.7 | 13.90 | 0.7 |
| 14.00 | 0.7 | 14.10 | 0.7 | 14.20 | 0.6 | 14.30 | 0.6 |
| 14.40 | 0.5 | 14.50 | 0.5 | 14.60 | 0.5 | 14.70 | 0.5 |
| 14.80 | 0.5 | 14.90 | 0.5 | 15.00 | 0.5 | 15.10 | 0.2 |
| 15.20 | 0.0 | 15.30 | 0.0 | 15.40 | 0.0 | 15.50 | 0.0 |
| 15.60 | 0.0 | 15.70 | 0.0 | 15.80 | 0.0 | 15.90 | 0.0 |

HORROCKS/CAROLLO ENGINEERS
AMERICAN FORK, UTAH
April 25, 1984

# Hiawatha RAINFALL DATA BASE

## RAINFALL INTENSITY (Inches/Hour)

| TIME (Min) | STORM FREQUENCY (Years) 2 | 5 | 10 | 25 | 50 | 100 |
|---|---|---|---|---|---|---|
| 5.0 | 0.84 | 1.56 | 1.92 | 2.76 | 3.12 | 3.72 |
| 6.0 | 0.79 | 1.49 | 1.84 | 2.63 | 2.98 | 3.55 |
| 7.0 | 0.74 | 1.42 | 1.76 | 2.50 | 2.84 | 3.38 |
| 8.0 | 0.69 | 1.35 | 1.68 | 2.37 | 2.70 | 3.21 |
| 9.0 | 0.64 | 1.28 | 1.60 | 2.24 | 2.56 | 3.04 |
| 10.0 | 0.60 | 1.20 | 1.50 | 2.10 | 2.40 | 2.88 |
| 11.0 | 0.58 | 1.16 | 1.45 | 2.03 | 2.32 | 2.78 |
| 12.0 | 0.56 | 1.12 | 1.40 | 1.96 | 2.24 | 2.68 |
| 13.0 | 0.54 | 1.08 | 1.35 | 1.89 | 2.16 | 2.58 |
| 14.0 | 0.53 | 1.04 | 1.30 | 1.82 | 2.08 | 2.48 |
| 15.0 | 0.52 | 1.00 | 1.24 | 1.76 | 2.00 | 2.40 |
| 20.0 | 0.47 | 0.90 | 1.11 | 1.59 | 1.80 | 2.16 |
| 25.0 | 0.42 | 0.80 | 0.98 | 1.42 | 1.60 | 1.92 |
| 30.0 | 0.36 | 0.70 | 0.86 | 1.24 | 1.40 | 1.68 |
| 40.0 | 0.32 | 0.61 | 0.76 | 1.09 | 1.23 | 1.48 |
| 50.0 | 0.28 | 0.52 | 0.66 | 0.94 | 1.06 | 1.28 |
| 60.0 | 0.23 | 0.44 | 0.55 | 0.78 | 0.88 | 1.06 |
| 120.0 | 0.20 | 0.31 | 0.38 | 0.50 | 0.56 | 0.65 |
| 180.0 | 0.18 | 0.26 | 0.31 | 0.40 | 0.44 | 0.51 |
| 240.0 | 0.17 | 0.24 | 0.28 | 0.36 | 0.40 | 0.46 |
| 300.0 | 0.16 | 0.22 | 0.25 | 0.32 | 0.36 | 0.41 |
| 360.0 | 0.16 | 0.20 | 0.23 | 0.28 | 0.32 | 0.35 |
| 480.0 | 0.14 | 0.18 | 0.20 | 0.25 | 0.28 | 0.31 |
| 600.0 | 0.12 | 0.16 | 0.17 | 0.22 | 0.24 | 0.27 |
| 720.0 | 0.11 | 0.13 | 0.15 | 0.18 | 0.20 | 0.22 |
| 1080.0 | 0.09 | 0.11 | 0.12 | 0.15 | 0.16 | 0.18 |
| 1440.0 | 0.07 | 0.08 | 0.09 | 0.11 | 0.12 | 0.13 |

# HYDROLOGICAL STUDY FOR

# CO-OP Mine Disturbed Area

Reconstructed Sediment Pond "A"

Bear Canyon Mine Site

BY

HORROCKS & CAROLLO ENGINEERS

ONE WEST MAIN

AMERICAN FORK, UTAH 84003

February 28, 1984

REGISTERED PROFESSIONAL ENGINEER
No. 3535
HAROLD LEE
WIMMER
STATE OF UTAH

HORROCKS ENGINEERS
AMERICAN FORK, UTAH
February 27, 1984

# BROAD CRESTED WEIR

WIDTH = 10.00 FEET

| ELEV. (FT.) | FLOW (CFS) |
|---|---|
| 94.20 | 0.00 |
| 94.30 | 1.20 |
| 94.40 | 3.40 |
| 94.50 | 6.24 |
| 94.60 | 9.61 |
| 94.70 | 13.44 |
| 94.80 | 17.66 |
| 94.90 | 22.26 |
| 95.00 | 27.19 |
| 95.10 | 32.44 |
| 95.20 | 38.00 |

3.0

FORMULA USED: Q = C * L * H^1.5

HORROCKS & CAROLLO ENGINEERS
AMERICAN FORK, UTAH
February 28, 1984

# HYDROLOGIC REPORT FOR
# CO-OP Mine Disturbed Area
# STAGE, STORAGE & DISCHARGE

POND IDENTIFIER Reconstructed Sed. Pond "A" -Empty-

| ELEV | STORAGE (CU.FT.) | OUTFLOW (CFS) | 2S/T+O (CFS) |
|---|---|---|---|
| 87.0 | 0.0 | 0.0 | 0.0 |
| 88.0 | 9284.0 | 0.0 | 41.3 |
| 89.0 | 19368.0 | 0.0 | 86.1 |
| 90.0 | 30284.0 | 0.0 | 134.6 |
| 91.0 | 42064.0 | 0.0 | 187.0 |
| 92.0 | 54740.0 | 0.0 | 243.3 |
| 93.0 | 68344.0 | 0.0 | 303.8 |
| 94.0 | 82908.0 | 0.0 | 368.5 |
| 94.2 | 85938.6 | 0.0 | 381.9 |
| 94.7 | 93691.6 | 13.4 | 429.8 |
| 95.2 | 101698.1 | 38.0 | 490.0 |

HORROCKS & CAROLLO ENGINEERS
AMERICAN FORK, UTAH
February 28, 1984

# HYDROLOGIC REPORT FOR

# CO-OP Mine Disturbed Area

# POND DEPTH VS STORAGE PROVIDED

POND IDENTIFIER Reconstructed Sed. Pond "A" - Empty -

| ELEV feet | DEPTH feet | AREA sq.ft. | VOLUME cu.ft. | SUM VOL cu.ft. | OUTFLOW c.f.s. |
|---|---|---|---|---|---|
| 87.0 | | 8892.0 | | 0.0 | 0.0 |
| | 1.0 | | 9284.0 | | |
| 88.0 | | 9676.0 | | 9284.0 | 0.0 |
| | 1.0 | | 10084.0 | | |
| 89.0 | | 10492.0 | | 19368.0 | 0.0 |
| | 1.0 | | 10916.0 | | |
| 90.0 | | 11340.0 | | 30284.0 | 0.0 |
| | 1.0 | | 11780.0 | | |
| 91.0 | | 12220.0 | | 42064.0 | 0.0 |
| | 1.0 | | 12676.0 | | |
| 92.0 | | 13132.0 | | 54740.0 | 0.0 |
| | 1.0 | | 13604.0 | | |
| 93.0 | | 14076.0 | | 68344.0 | 0.0 |
| | 1.0 | | 14564.0 | | |
| 94.0 | | 15052.0 | | 82908.0 | 0.0 |
| | 0.2 | | 3030.6 | | |
| 94.2 | | 15254.0 | | 85938.6 | 0.0 |
| | 0.5 | | 7753.0 | | |
| 94.7 | | 15758.0 | | 93691.6 | 13.4 |
| | 0.5 | | 8006.5 | | |
| 95.2 | | 16268.0 | | 101698.1 | 38.0 |

HORROCKS ENGINEERS
AMERICAN FORK, UTAH
February 27, 1984

# HYDROLOGIC REPORT FOR

# CO-OP Mine Disturbed Area

# POND DEPTH VS STORAGE PROVIDED

POND IDENTIFIER Reconst. Sed. Pond "A" - with 3 years accumulated Sediment -

| ELEV feet | DEPTH feet | AREA sq.ft. | VOLUME cu.ft. | SUM VOL cu.ft. | OUTFLOW c.f.s. |
|---|---|---|---|---|---|
| 90.9 | | 12176.0 | | 0.0 | 0.00 |
| | 1.1 | | 13286.7 | | |
| 92.0 | | 13132.0 | | 13286.7 | 0.00 |
| | 1.0 | | 13604.0 | | |
| 93.0 | | 14076.0 | | 26890.7 | 0.00 |
| | 1.0 | | 14564.0 | | |
| 94.0 | | 15052.0 | | 41454.7 | 0.00 |
| | 0.2 | | 3030.6 | | |
| 94.2 | | 15254.0 | | 44485.3 | 0.00 |
| | 0.5 | | 7753.0 | | |
| 94.7 | | 15758.0 | | 52238.3 | 13.44 |
| | 0.5 | | 8006.5 | | |
| 95.2 | | 16268.0 | | 60244.8 | 35.19 |

HORROCKS ENGINEERS
AMERICAN FORK, UTAH
February 27, 1984

# HYDROLOGIC REPORT FOR
# CO-OP Mine Disturbed Area
# STAGE, STORAGE & DISCHARGE

POND IDENTIFIER Reconst. Sed. Pond "A" - With 3 years accumulated sediment -

| ELEV | STORAGE (CU.FT.) | OUTFLOW (CFS) | 2S/T+O (CFS) |
|---|---|---|---|
| 90.9 | 0.0 | 0.0 | 0.0 |
| 92.0 | 13286.7 | 0.0 | 73.8 |
| 93.0 | 26890.7 | 0.0 | 149.4 |
| 94.0 | 41454.7 | 0.0 | 230.3 |
| 94.2 | 44485.3 | 0.0 | 247.1 |
| 94.7 | 52238.3 | 13.4 | 303.7 |
| 95.2 | 60244.8 | 35.2 | 369.9 |

HORROCKS & CAROLLO ENGINEERS
AMERICAN FORK, UTAH
February 28, 1984

# Hiawatha RAINFALL DATA BASE

## RAINFALL INTENSITY (Inches/Hour)

| TIME (Min) | STORM FREQUENCY (Years) 2 | 5 | 10 | 25 | 50 | 100 |
|---|---|---|---|---|---|---|
| 5.0 | 0.84 | 1.56 | 1.92 | 2.76 | 3.12 | 3.72 |
| 6.0 | 0.79 | 1.49 | 1.84 | 2.63 | 2.98 | 3.55 |
| 7.0 | 0.74 | 1.42 | 1.76 | 2.50 | 2.84 | 3.38 |
| 8.0 | 0.69 | 1.35 | 1.68 | 2.37 | 2.70 | 3.21 |
| 9.0 | 0.64 | 1.28 | 1.60 | 2.24 | 2.56 | 3.04 |
| 10.0 | 0.60 | 1.20 | 1.50 | 2.10 | 2.40 | 2.88 |
| 11.0 | 0.58 | 1.16 | 1.45 | 2.03 | 2.32 | 2.78 |
| 12.0 | 0.56 | 1.12 | 1.40 | 1.96 | 2.24 | 2.68 |
| 13.0 | 0.54 | 1.08 | 1.35 | 1.89 | 2.16 | 2.58 |
| 14.0 | 0.53 | 1.04 | 1.30 | 1.82 | 2.08 | 2.48 |
| 15.0 | 0.52 | 1.00 | 1.24 | 1.76 | 2.00 | 2.40 |
| 20.0 | 0.47 | 0.90 | 1.11 | 1.59 | 1.80 | 2.16 |
| 25.0 | 0.42 | 0.80 | 0.98 | 1.42 | 1.60 | 1.92 |
| 30.0 | 0.36 | 0.70 | 0.86 | 1.24 | 1.40 | 1.68 |
| 40.0 | 0.32 | 0.61 | 0.76 | 1.09 | 1.23 | 1.48 |
| 50.0 | 0.28 | 0.52 | 0.66 | 0.94 | 1.06 | 1.28 |
| 60.0 | 0.23 | 0.44 | 0.55 | 0.78 | 0.88 | 1.06 |
| 120.0 | 0.20 | 0.31 | 0.38 | 0.50 | 0.56 | 0.65 |
| 180.0 | 0.18 | 0.26 | 0.31 | 0.40 | 0.44 | 0.51 |
| 240.0 | 0.17 | 0.24 | 0.28 | 0.36 | 0.40 | 0.46 |
| 300.0 | 0.16 | 0.22 | 0.25 | 0.32 | 0.36 | 0.41 |
| 360.0 | 0.16 | 0.20 | 0.23 | 0.28 | 0.32 | 0.35 |
| 480.0 | 0.14 | 0.18 | 0.20 | 0.25 | 0.28 | 0.31 |
| 600.0 | 0.12 | 0.16 | 0.17 | 0.22 | 0.24 | 0.27 |
| 720.0 | 0.11 | 0.13 | 0.15 | 0.18 | 0.20 | 0.22 |
| 1080.0 | 0.09 | 0.11 | 0.12 | 0.15 | 0.16 | 0.18 |
| 1440.0 | 0.07 | 0.08 | 0.09 | 0.11 | 0.12 | 0.13 |

HORROCKS ENGINEERS
AMERICAN FORK, UTAH
February 27, 1984

# HYDROLOGIC REPORT FOR
# CO-OP Mine Disturbed Area
# S. C. S. HYDROGRAPH

BASIN IDENTIFICATION Sediment Pond "A"
BASIN DISCHARGES INTO Spillway

| | | | |
|---|---|---|---|
| BASIN AREA | = | 14.35 | ACRES |
| BASIN CURVE NUMBER | = | 82.00 | |
| 24-HOUR PRECIPITATION | = | 2.60 | INCHES |
| AVERAGE BASIN SLOPE | = | 14.0 | % |
| HYDRAULIC LENGTH | = | 640.0 | FEET |
| BASIN LAG | = | 0.25 | HOURS |

HYDROGRAPH RUNOFF VALUES
25 YEAR STORM FREQUENCY

| TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. |
|---|---|---|---|---|---|---|---|
| 9.20 | 0.0 | 9.30 | 0.0 | 9.40 | 0.0 | 9.50 | 0.0 |
| 9.60 | 0.0 | 9.70 | 0.0 | 9.80 | 0.0 | 9.90 | 0.0 |
| 10.00 | 0.0 | 10.10 | 0.0 | 10.20 | 0.0 | 10.30 | 0.0 |
| 10.40 | 0.1 | 10.50 | 0.1 | 10.60 | 0.1 | 10.70 | 0.1 |
| 10.80 | 0.2 | 10.90 | 0.2 | 11.00 | 0.2 | 11.10 | 0.3 |
| 11.20 | 0.3 | 11.30 | 0.4 | 11.40 | 0.5 | 11.50 | 0.6 |
| 11.60 | 0.8 | 11.70 | 1.6 | 11.80 | 2.9 | 11.90 | 5.5 |
| 12.00 | 9.6 | 12.10 | 13.0 | 12.20 | 12.8 | 12.30 | 10.1 |
| 12.40 | 7.3 | 12.50 | 5.7 | 12.60 | 4.6 | 12.70 | 3.8 |
| 12.80 | 3.1 | 12.90 | 2.6 | 13.00 | 2.3 | 13.10 | 2.2 |
| 13.20 | 2.0 | 13.30 | 1.7 | 13.40 | 1.5 | 13.50 | 1.5 |
| 13.60 | 1.4 | 13.70 | 1.3 | 13.80 | 1.2 | 13.90 | 1.2 |
| 14.00 | 1.1 | 14.10 | 1.1 | 14.20 | 1.0 | 14.30 | 0.9 |
| 14.40 | 0.9 | 14.50 | 0.8 | 14.60 | 0.8 | 14.70 | 0.8 |
| 14.80 | 0.8 | 14.90 | 0.8 | 15.00 | 0.8 | 15.10 | 0.8 |
| 15.20 | 0.7 | 15.30 | 0.6 | 15.40 | 0.5 | 15.50 | 0.4 |
| 15.60 | 0.3 | 15.70 | 0.2 | 15.80 | 0.1 | 15.90 | 0.0 |
| 16.00 | 0.0 | 16.10 | 0.0 | 16.20 | 0.0 | 16.30 | 0.0 |

HORROCKS ENGINEERS
AMERICAN FORK, UTAH
February 27, 1984

# HYDROLOGIC REPORT FOR
# CO-OP Mine Disturbed Area
# HYDROGRAPH RESERVOIR ROUTING

BASIN IDENTIFIER Sediment Pond "A"
POND IDENTIFIER Reconst. Sed. Pond "A"
25 YEAR STORM FREQUENCY

| T | I1 | I2 | 2S1/T | O1 | 2S2/T +O2 | O2 | 2S2/T |
|---|---|---|---|---|---|---|---|
| 11.40 | 0.0 | 0.5 | 0.0 | 0.0 | 0.5 | 0.0 | 0.5 |
| 11.50 | 0.5 | 0.6 | 0.5 | 0.0 | 1.6 | 0.0 | 1.6 |
| 11.60 | 0.6 | 0.8 | 1.6 | 0.0 | 3.0 | 0.0 | 3.0 |
| 11.70 | 0.8 | 1.6 | 3.0 | 0.0 | 5.4 | 0.0 | 5.4 |
| 11.80 | 1.6 | 2.9 | 5.4 | 0.0 | 9.9 | 0.0 | 9.9 |
| 11.90 | 2.9 | 5.5 | 9.9 | 0.0 | 18.4 | 0.0 | 18.4 |
| 12.00 | 5.5 | 9.6 | 18.4 | 0.0 | 33.6 | 0.0 | 33.6 |
| 12.10 | 9.6 | 13.0 | 33.6 | 0.0 | 56.1 | 0.0 | 56.1 |
| 12.20 | 13.0 | 12.8 | 56.1 | 0.0 | 81.8 | 0.0 | 81.8 |
| 12.30 | 12.8 | 10.1 | 81.8 | 0.0 | 104.7 | 0.0 | 104.7 |
| 12.40 | 10.1 | 7.3 | 104.7 | 0.0 | 122.2 | 0.0 | 122.2 |
| 12.50 | 7.3 | 5.7 | 122.2 | 0.0 | 135.2 | 0.0 | 135.2 |
| 12.60 | 5.7 | 4.6 | 135.2 | 0.0 | 145.5 | 0.0 | 145.5 |
| 12.70 | 4.6 | 3.8 | 145.5 | 0.0 | 153.9 | 0.0 | 153.9 |
| 12.80 | 3.8 | 3.1 | 153.9 | 0.0 | 160.8 | 0.0 | 160.8 |
| 12.90 | 3.1 | 2.6 | 160.8 | 0.0 | 166.4 | 0.0 | 166.4 |
| 13.00 | 2.6 | 2.3 | 166.4 | 0.0 | 171.3 | 0.0 | 171.3 |
| 13.10 | 2.3 | 2.2 | 171.3 | 0.0 | 175.8 | 0.0 | 175.8 |
| 13.20 | 2.2 | 2.0 | 175.8 | 0.0 | 180.0 | 0.0 | 180.0 |
| 13.30 | 2.0 | 1.7 | 180.0 | 0.0 | 183.7 | 0.0 | 183.7 |
| 13.40 | 1.7 | 1.5 | 183.7 | 0.0 | 186.9 | 0.0 | 186.9 |
| 13.50 | 1.5 | 1.5 | 186.9 | 0.0 | 189.9 | 0.0 | 189.9 |
| 13.60 | 1.5 | 1.4 | 189.9 | 0.0 | 192.8 | 0.0 | 192.8 |
| 13.70 | 1.4 | 1.3 | 192.8 | 0.0 | 195.6 | 0.0 | 195.6 |
| 13.80 | 1.3 | 1.2 | 195.6 | 0.0 | 198.1 | 0.0 | 198.1 |
| 13.90 | 1.2 | 1.2 | 198.1 | 0.0 | 200.6 | 0.0 | 200.6 |
| 14.00 | 1.2 | 1.1 | 200.6 | 0.0 | 202.9 | 0.0 | 202.9 |
| 14.10 | 1.1 | 1.1 | 202.9 | 0.0 | 205.1 | 0.0 | 205.1 |
| 14.20 | 1.1 | 1.0 | 205.1 | 0.0 | 207.2 | 0.0 | 207.2 |
| 14.30 | 1.0 | 0.9 | 207.2 | 0.0 | 209.2 | 0.0 | 209.2 |
| 14.40 | 0.9 | 0.9 | 209.2 | 0.0 | 211.0 | 0.0 | 211.0 |
| 14.50 | 0.9 | 0.8 | 211.0 | 0.0 | 212.7 | 0.0 | 212.7 |
| 14.60 | 0.8 | 0.8 | 212.7 | 0.0 | 214.4 | 0.0 | 214.4 |
| 14.70 | 0.8 | 0.8 | 214.4 | 0.0 | 216.0 | 0.0 | 216.0 |
| 14.80 | 0.8 | 0.8 | 216.0 | 0.0 | 217.6 | 0.0 | 217.6 |

# HYDROLOGIC REPORT FOR

# CO-OP Mine Disturbed Area

BASIN IDENTIFIER Sediment Pond "A"
POND IDENTIFIER Reconst. Sed. Pond "A"
25 YEAR STORM FREQUENCY (CONT'D)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 14.90 | 0.8 | 0.8 | 217.6 | 0.0 | 219.1 | 0.0 | 219.1 |
| 15.00 | 0.8 | 0.8 | 219.1 | 0.0 | 220.7 | 0.0 | 220.7 |
| 15.10 | 0.8 | 0.8 | 220.7 | 0.0 | 222.3 | 0.0 | 222.3 |
| 15.20 | 0.8 | 0.7 | 222.3 | 0.0 | 223.8 | 0.0 | 223.8 |
| 15.30 | 0.7 | 0.6 | 223.8 | 0.0 | 225.1 | 0.0 | 225.1 |

MAXIMUM OUTFLOW = 0.0 C.F.S.
MAXIMUM STORAGE = 44,485.3 CU FT.
MAXIMUM ELEVATION = 94.2 FEET

HORROCKS ENGINEERS
AMERICAN FORK, UTAH
February 27, 1984

# HYDROLOGIC REPORT FOR

# CO-OP Mine Disturbed Area

# S. C. S. HYDROGRAPH

BASIN IDENTIFICATION Sediment Pond "A"
BASIN DISCHARGES INTO Spillway

| | | | |
|---|---|---|---|
| BASIN AREA | = | 14.35 | ACRES |
| BASIN CURVE NUMBER | = | 82.00 | |
| 24-HOUR PRECIPITATION | = | 2.90 | INCHES |
| AVERAGE BASIN SLOPE | = | 14.0 | % |
| HYDRAULIC LENGTH | = | 640.0 | FEET |
| BASIN LAG | = | 0.25 | HOURS |

HYDROGRAPH RUNOFF VALUES
50 YEAR STORM FREQUENCY

| TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. |
|---|---|---|---|---|---|---|---|
| 8.80 | 0.0 | 8.90 | 0.0 | 9.00 | 0.0 | 9.10 | 0.0 |
| 9.20 | 0.0 | 9.30 | 0.0 | 9.40 | 0.0 | 9.50 | 0.0 |
| 9.60 | 0.0 | 9.70 | 0.0 | 9.80 | 0.0 | 9.90 | 0.1 |
| 10.00 | 0.1 | 10.10 | 0.1 | 10.20 | 0.1 | 10.30 | 0.1 |
| 10.40 | 0.2 | 10.50 | 0.2 | 10.60 | 0.2 | 10.70 | 0.2 |
| 10.80 | 0.3 | 10.90 | 0.3 | 11.00 | 0.4 | 11.10 | 0.4 |
| 11.20 | 0.5 | 11.30 | 0.6 | 11.40 | 0.7 | 11.50 | 0.8 |
| 11.60 | 1.2 | 11.70 | 2.1 | 11.80 | 3.9 | 11.90 | 7.1 |
| 12.00 | 12.0 | 12.10 | 15.9 | 12.20 | 15.6 | 12.30 | 12.3 |
| 12.40 | 8.8 | 12.50 | 6.8 | 12.60 | 5.6 | 12.70 | 4.5 |
| 12.80 | 3.7 | 12.90 | 3.1 | 13.00 | 2.8 | 13.10 | 2.6 |
| 13.20 | 2.4 | 13.30 | 2.0 | 13.40 | 1.8 | 13.50 | 1.7 |
| 13.60 | 1.7 | 13.70 | 1.6 | 13.80 | 1.5 | 13.90 | 1.4 |
| 14.00 | 1.3 | 14.10 | 1.3 | 14.20 | 1.2 | 14.30 | 1.1 |
| 14.40 | 1.0 | 14.50 | 1.0 | 14.60 | 1.0 | 14.70 | 0.9 |
| 14.80 | 0.9 | 14.90 | 0.9 | 15.00 | 0.9 | 15.10 | 0.9 |
| 15.20 | 0.8 | 15.30 | 0.7 | 15.40 | 0.6 | 15.50 | 0.5 |
| 15.60 | 0.4 | 15.70 | 0.3 | 15.80 | 0.2 | 15.90 | 0.1 |
| 16.00 | 0.0 | 16.10 | 0.0 | 16.20 | 0.0 | 16.30 | 0.0 |
| 16.40 | 0.0 | 16.50 | 0.0 | 16.60 | 0.0 | 16.70 | 0.0 |

HORROCKS ENGINEERS
AMERICAN FORK, UTAH
February 27, 1984

# HYDROLOGIC REPORT FOR

# CO-OP Mine Disturbed Area

# HYDROGRAPH RESERVOIR ROUTING

BASIN IDENTIFIER Sediment Pond "A"
POND IDENTIFIER Reconst. Sed. Pond "A"
50 YEAR STORM FREQUENCY

| T | I1 | I2 | 2S1/T | O1 | 2S2/T +O2 | O2 | 2S2/T |
|---|---|---|---|---|---|---|---|
| 11.20 | 0.0 | 0.5 | 0.0 | 0.0 | 0.5 | 0.0 | 0.5 |
| 11.30 | 0.5 | 0.6 | 0.5 | 0.0 | 1.7 | 0.0 | 1.7 |
| 11.40 | 0.6 | 0.7 | 1.7 | 0.0 | 3.1 | 0.0 | 3.1 |
| 11.50 | 0.7 | 0.8 | 3.1 | 0.0 | 4.6 | 0.0 | 4.6 |
| 11.60 | 0.8 | 1.2 | 4.6 | 0.0 | 6.7 | 0.0 | 6.7 |
| 11.70 | 1.2 | 2.1 | 6.7 | 0.0 | 9.9 | 0.0 | 9.9 |
| 11.80 | 2.1 | 3.9 | 9.9 | 0.0 | 15.9 | 0.0 | 15.9 |
| 11.90 | 3.9 | 7.1 | 15.9 | 0.0 | 26.8 | 0.0 | 26.8 |
| 12.00 | 7.1 | 12.0 | 26.8 | 0.0 | 45.9 | 0.0 | 45.9 |
| 12.10 | 12.0 | 15.9 | 45.9 | 0.0 | 73.7 | 0.0 | 73.7 |
| 12.20 | 15.9 | 15.6 | 73.7 | 0.0 | 105.2 | 0.0 | 105.2 |
| 12.30 | 15.6 | 12.3 | 105.2 | 0.0 | 133.1 | 0.0 | 133.1 |
| 12.40 | 12.3 | 8.8 | 133.1 | 0.0 | 154.2 | 0.0 | 154.2 |
| 12.50 | 8.8 | 6.8 | 154.2 | 0.0 | 169.9 | 0.0 | 169.9 |
| 12.60 | 6.8 | 5.6 | 169.9 | 0.0 | 182.3 | 0.0 | 182.3 |
| 12.70 | 5.6 | 4.5 | 182.3 | 0.0 | 192.4 | 0.0 | 192.4 |
| 12.80 | 4.5 | 3.7 | 192.4 | 0.0 | 200.6 | 0.0 | 200.6 |
| 12.90 | 3.7 | 3.1 | 200.6 | 0.0 | 207.3 | 0.0 | 207.3 |
| 13.00 | 3.1 | 2.8 | 207.3 | 0.0 | 213.1 | 0.0 | 213.1 |
| 13.10 | 2.8 | 2.6 | 213.1 | 0.0 | 218.5 | 0.0 | 218.5 |
| 13.20 | 2.6 | 2.4 | 218.5 | 0.0 | 223.5 | 0.0 | 223.5 |
| 13.30 | 2.4 | 2.0 | 223.5 | 0.0 | 227.8 | 0.0 | 227.8 |
| 13.40 | 2.0 | 1.8 | 227.8 | 0.0 | 231.6 | 0.0 | 231.6 |
| 13.50 | 1.8 | 1.7 | 231.6 | 0.0 | 235.2 | 0.0 | 235.2 |
| 13.60 | 1.7 | 1.7 | 235.2 | 0.0 | 238.6 | 0.0 | 238.6 |
| 13.70 | 1.7 | 1.6 | 238.6 | 0.0 | 241.8 | 0.0 | 241.8 |
| 13.80 | 1.6 | 1.5 | 241.8 | 0.0 | 244.9 | 0.0 | 244.9 |
| 13.90 | 1.5 | 1.4 | 244.9 | 0.0 | 247.7 | 0.1 | 247.6 |
| 14.00 | 1.4 | 1.3 | 247.6 | 0.1 | 250.1 | 0.7 | 249.4 |
| 14.10 | 1.3 | 1.3 | 249.4 | 0.7 | 251.3 | 1.0 | 250.3 |
| 14.20 | 1.3 | 1.2 | 250.3 | 1.0 | 251.8 | 1.1 | 250.7 |
| 14.30 | 1.2 | 1.1 | 250.7 | 1.1 | 251.9 | 1.1 | 250.8 |
| 14.40 | 1.1 | 1.0 | 250.8 | 1.1 | 251.8 | 1.1 | 250.7 |
| 14.50 | 1.0 | 1.0 | 250.7 | 1.1 | 251.6 | 1.1 | 250.5 |
| 14.60 | 1.0 | 1.0 | 250.5 | 1.1 | 251.4 | 1.0 | 250.4 |

# HYDROLOGIC REPORT FOR

# CO-OP Mine Disturbed Area

BASIN IDENTIFIER Sediment Pond "A"
POND IDENTIFIER Reconst. Sed. Pond "A"
50 YEAR STORM FREQUENCY (CONT'D)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 14.70 | 1.0 | 0.9 | 250.4 | 1.0 | 251.3 | 1.0 | 250.3 |
| 14.80 | 0.9 | 0.9 | 250.3 | 1.0 | 251.2 | 1.0 | 250.2 |
| 14.90 | 0.9 | 0.9 | 250.2 | 1.0 | 251.1 | 0.9 | 250.2 |
| 15.00 | 0.9 | 0.9 | 250.2 | 0.9 | 251.1 | 0.9 | 250.1 |
| 15.10 | 0.9 | 0.9 | 250.1 | 0.9 | 251.1 | 0.9 | 250.1 |
| 15.20 | 0.9 | 0.8 | 250.1 | 0.9 | 250.9 | 0.9 | 250.0 |
| 15.30 | 0.8 | 0.7 | 250.0 | 0.9 | 250.7 | 0.8 | 249.8 |
| 15.40 | 0.7 | 0.6 | 249.8 | 0.8 | 250.4 | 0.8 | 249.6 |
| 15.50 | 0.6 | 0.5 | 249.6 | 0.8 | 250.0 | 0.7 | 249.3 |
| 15.60 | 0.5 | 0.4 | 249.3 | 0.7 | 249.6 | 0.6 | 249.0 |
| 15.70 | 0.4 | 0.3 | 249.0 | 0.6 | 249.2 | 0.5 | 248.7 |

MAXIMUM OUTFLOW = 1.1 C.F.S.
MAXIMUM STORAGE = 45,140.6 CU FT.
MAXIMUM ELEVATION = 94.2 FEET

HORROCKS ENGINEERS
AMERICAN FORK, UTAH
February 27, 1984

# HYDROLOGIC REPORT FOR

# CO-OP Mine Disturbed Area

# S. C. S. HYDROGRAPH

BASIN IDENTIFICATION Sediment Pond "A"
BASIN DISCHARGES INTO Spillway

| | | | |
|---|---|---|---|
| BASIN AREA | = | 14.35 | ACRES |
| BASIN CURVE NUMBER | = | 82.00 | |
| 24-HOUR PRECIPITATION | = | 3.18 | INCHES |
| AVERAGE BASIN SLOPE | = | 14.0 | % |
| HYDRAULIC LENGTH | = | 640.0 | FEET |
| BASIN LAG | = | 0.25 | HOURS |

HYDROGRAPH RUNOFF VALUES
100 YEAR STORM FREQUENCY

| TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. |
|---|---|---|---|---|---|---|---|
| 8.00 | 0.0 | 8.10 | 0.0 | 8.20 | 0.0 | 8.30 | 0.0 |
| 8.40 | 0.0 | 8.50 | 0.0 | 8.60 | 0.0 | 8.70 | 0.0 |
| 8.80 | 0.0 | 8.90 | 0.0 | 9.00 | 0.0 | 9.10 | 0.0 |
| 9.20 | 0.0 | 9.30 | 0.0 | 9.40 | 0.0 | 9.50 | 0.1 |
| 9.60 | 0.1 | 9.70 | 0.1 | 9.80 | 0.1 | 9.90 | 0.1 |
| 10.00 | 0.1 | 10.10 | 0.2 | 10.20 | 0.2 | 10.30 | 0.2 |
| 10.40 | 0.2 | 10.50 | 0.3 | 10.60 | 0.3 | 10.70 | 0.4 |
| 10.80 | 0.4 | 10.90 | 0.5 | 11.00 | 0.5 | 11.10 | 0.6 |
| 11.20 | 0.7 | 11.30 | 0.8 | 11.40 | 1.0 | 11.50 | 1.1 |
| 11.60 | 1.5 | 11.70 | 2.7 | 11.80 | 4.8 | 11.90 | 8.6 |
| 12.00 | 14.2 | 12.10 | 18.8 | 12.20 | 18.3 | 12.30 | 14.4 |
| 12.40 | 10.3 | 12.50 | 7.9 | 12.60 | 6.5 | 12.70 | 5.2 |
| 12.80 | 4.2 | 12.90 | 3.5 | 13.00 | 3.2 | 13.10 | 3.0 |
| 13.20 | 2.7 | 13.30 | 2.2 | 13.40 | 2.1 | 13.50 | 2.0 |
| 13.60 | 1.9 | 13.70 | 1.8 | 13.80 | 1.7 | 13.90 | 1.6 |
| 14.00 | 1.5 | 14.10 | 1.5 | 14.20 | 1.4 | 14.30 | 1.3 |
| 14.40 | 1.2 | 14.50 | 1.1 | 14.60 | 1.1 | 14.70 | 1.1 |
| 14.80 | 1.1 | 14.90 | 1.1 | 15.00 | 1.1 | 15.10 | 1.1 |
| 15.20 | 1.0 | 15.30 | 0.9 | 15.40 | 0.8 | 15.50 | 0.7 |
| 15.60 | 0.6 | 15.70 | 0.5 | 15.80 | 0.4 | 15.90 | 0.3 |
| 16.00 | 0.2 | 16.10 | 0.1 | 16.20 | 0.0 | 16.30 | 0.0 |
| 16.40 | 0.0 | 16.50 | 0.0 | 16.60 | 0.0 | 16.70 | 0.0 |

HORROCKS ENGINEERS
AMERICAN FORK, UTAH
February 27, 1984

# HYDROLOGIC REPORT FOR

# CO-OP Mine Disturbed Area

# HYDROGRAPH RESERVOIR ROUTING

BASIN IDENTIFIER Sediment Pond "A"
POND IDENTIFIER Reconst. Sed. Pond "A"
100 YEAR STORM FREQUENCY

| T | I1 | I2 | 2S1/T | O1 | 2S2/T +O2 | O2 | 2S2/T |
|---|---|---|---|---|---|---|---|
| 11.00 | 0.0 | 0.5 | 0.0 | 0.0 | 0.5 | 0.0 | 0.5 |
| 11.10 | 0.5 | 0.6 | 0.5 | 0.0 | 1.6 | 0.0 | 1.6 |
| 11.20 | 0.6 | 0.7 | 1.6 | 0.0 | 2.9 | 0.0 | 2.9 |
| 11.30 | 0.7 | 0.8 | 2.9 | 0.0 | 4.5 | 0.0 | 4.5 |
| 11.40 | 0.8 | 1.0 | 4.5 | 0.0 | 6.3 | 0.0 | 6.3 |
| 11.50 | 1.0 | 1.1 | 6.3 | 0.0 | 8.4 | 0.0 | 8.4 |
| 11.60 | 1.1 | 1.5 | 8.4 | 0.0 | 11.0 | 0.0 | 11.0 |
| 11.70 | 1.5 | 2.7 | 11.0 | 0.0 | 15.1 | 0.0 | 15.1 |
| 11.80 | 2.7 | 4.8 | 15.1 | 0.0 | 22.6 | 0.0 | 22.6 |
| 11.90 | 4.8 | 8.6 | 22.6 | 0.0 | 35.9 | 0.0 | 35.9 |
| 12.00 | 8.6 | 14.2 | 35.9 | 0.0 | 58.7 | 0.0 | 58.7 |
| 12.10 | 14.2 | 18.8 | 58.7 | 0.0 | 91.7 | 0.0 | 91.7 |
| 12.20 | 18.8 | 18.3 | 91.7 | 0.0 | 128.8 | 0.0 | 128.8 |
| 12.30 | 18.3 | 14.4 | 128.8 | 0.0 | 161.4 | 0.0 | 161.4 |
| 12.40 | 14.4 | 10.3 | 161.4 | 0.0 | 186.1 | 0.0 | 186.1 |
| 12.50 | 10.3 | 7.9 | 186.1 | 0.0 | 204.3 | 0.0 | 204.3 |
| 12.60 | 7.9 | 6.5 | 204.3 | 0.0 | 218.6 | 0.0 | 218.6 |
| 12.70 | 6.5 | 5.2 | 218.6 | 0.0 | 230.3 | 0.0 | 230.3 |
| 12.80 | 5.2 | 4.2 | 230.3 | 0.0 | 239.8 | 0.0 | 239.8 |
| 12.90 | 4.2 | 3.5 | 239.8 | 0.0 | 247.5 | 0.1 | 247.4 |
| 13.00 | 3.5 | 3.2 | 247.4 | 0.1 | 254.1 | 1.6 | 252.4 |
| 13.10 | 3.2 | 3.0 | 252.4 | 1.6 | 256.9 | 2.3 | 254.6 |
| 13.20 | 3.0 | 2.7 | 254.6 | 2.3 | 258.0 | 2.6 | 255.4 |
| 13.30 | 2.7 | 2.2 | 255.4 | 2.6 | 257.8 | 2.5 | 255.3 |
| 13.40 | 2.2 | 2.1 | 255.3 | 2.5 | 257.1 | 2.4 | 254.7 |
| 13.50 | 2.1 | 2.0 | 254.7 | 2.4 | 256.4 | 2.2 | 254.2 |
| 13.60 | 2.0 | 1.9 | 254.2 | 2.2 | 255.9 | 2.1 | 253.8 |
| 13.70 | 1.9 | 1.8 | 253.8 | 2.1 | 255.4 | 2.0 | 253.5 |
| 13.80 | 1.8 | 1.7 | 253.5 | 2.0 | 255.0 | 1.9 | 253.1 |
| 13.90 | 1.7 | 1.6 | 253.1 | 1.9 | 254.5 | 1.7 | 252.7 |
| 14.00 | 1.6 | 1.5 | 252.7 | 1.7 | 254.1 | 1.7 | 252.4 |
| 14.10 | 1.5 | 1.5 | 252.4 | 1.7 | 253.8 | 1.6 | 252.2 |
| 14.20 | 1.5 | 1.4 | 252.2 | 1.6 | 253.5 | 1.5 | 252.0 |
| 14.30 | 1.4 | 1.3 | 252.0 | 1.5 | 253.1 | 1.4 | 251.7 |
| 14.40 | 1.3 | 1.2 | 251.7 | 1.4 | 252.7 | 1.3 | 251.4 |

HORROCKS ENGINEERS
AMERICAN FORK, UTAH
February 27, 1984

# HYDROLOGIC REPORT FOR

# CO-OP Mine Disturbed Area

BASIN IDENTIFIER Sediment Pond "A"
POND IDENTIFIER Reconst. Sed. Pond "A"
100 YEAR STORM FREQUENCY (CONT'D)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 14.50 | 1.2 | 1.1 | 251.4 | 1.3 | 252.3 | 1.2 | 251.1 |
| 14.60 | 1.1 | 1.1 | 251.1 | 1.2 | 252.1 | 1.2 | 250.9 |
| 14.70 | 1.1 | 1.1 | 250.9 | 1.2 | 251.9 | 1.1 | 250.8 |
| 14.80 | 1.1 | 1.1 | 250.8 | 1.1 | 251.8 | 1.1 | 250.7 |
| 14.90 | 1.1 | 1.1 | 250.7 | 1.1 | 251.7 | 1.1 | 250.6 |
| 15.00 | 1.1 | 1.1 | 250.6 | 1.1 | 251.6 | 1.1 | 250.6 |
| 15.10 | 1.1 | 1.1 | 250.6 | 1.1 | 251.6 | 1.1 | 250.5 |
| 15.20 | 1.1 | 1.0 | 250.5 | 1.1 | 251.5 | 1.0 | 250.5 |
| 15.30 | 1.0 | 0.9 | 250.5 | 1.0 | 251.2 | 1.0 | 250.3 |
| 15.40 | 0.9 | 0.8 | 250.3 | 1.0 | 250.9 | 0.9 | 250.0 |
| 15.50 | 0.8 | 0.7 | 250.0 | 0.9 | 250.5 | 0.8 | 249.7 |
| 15.60 | 0.7 | 0.6 | 249.7 | 0.8 | 250.1 | 0.7 | 249.4 |
| 15.70 | 0.6 | 0.5 | 249.4 | 0.7 | 249.7 | 0.6 | 249.1 |
| 15.80 | 0.5 | 0.4 | 249.1 | 0.6 | 249.3 | 0.5 | 248.8 |
| 15.90 | 0.4 | 0.3 | 248.8 | 0.5 | 248.9 | 0.4 | 248.5 |

MAXIMUM OUTFLOW = 2.6 C.F.S.
MAXIMUM STORAGE = 45,975.2 CU FT.
MAXIMUM ELEVATION = 94.3 FEET

# HYDROLOGICAL STUDY FOR

# CO-OP Mine Disturbed Area

Sediment Pond "B"

Bear Canyon Mine Site

BY

HORROCKS/CAROLLO ENGINEERS

ONE WEST MAIN

AMERICAN FORK, UTAH 84003

April 25, 1984

REGISTERED PROFESSIONAL ENGINEER
No. 3535
HAROLD LEE WIMMER
STATE OF UTAH

HORROCKS/CAROLLO ENGINEERS
AMERICAN FORK, UTAH
April 25, 1984

# BROAD CRESTED WEIR

WIDTH = 4.00 FEET

| ELEV. (FT.) | FLOW (CFS) |
|---|---|
| 7075.00 | 0.00 |
| 7075.20 | 1.36 |
| 7075.40 | 3.85 |
| 7075.60 | 7.06 |
| 7075.80 | 10.88 |
| 7076.00 | 15.20 |

FORMULA USED: Q = C * L * H^1.5

C = 3.8

HORROCKS/CAROLLO ENGINEERS
AMERICAN FORK, UTAH
April 25, 1984

# HYDROLOGIC REPORT FOR

# CO-OP Mine Disturbed Area

# POND DEPTH VS STORAGE PROVIDED

POND IDENTIFIER Sediment Pond "B" - Empty -

| ELEV feet | DEPTH feet | AREA sq.ft. | VOLUME cu.ft. | SUM VOL cu.ft. | OUTFLOW c.f.s. |
|---|---|---|---|---|---|
| 7069.0 | | 728.0 | | 0.0 | 0.00 |
| | 1.0 | | 899.0 | | |
| 7070.0 | | 1070.0 | | 899.0 | 0.00 |
| | 1.0 | | 1250.0 | | |
| 7071.0 | | 1430.0 | | 2149.0 | 0.00 |
| | 1.0 | | 1619.0 | | |
| 7072.0 | | 1808.0 | | 3768.0 | 0.00 |
| | 1.0 | | 2006.0 | | |
| 7073.0 | | 2204.0 | | 5774.0 | 0.00 |
| | 1.0 | | 2411.0 | | |
| 7074.0 | | 2618.0 | | 8185.0 | 0.00 |
| | 1.0 | | 2834.0 | | |
| 7075.0 | | 3050.0 | | 11019.0 | 0.00 |
| | 0.2 | | 619.6 | | |
| 7075.2 | | 3140.0 | | 11638.6 | 1.36 |
| | 0.2 | | 636.1 | | |
| 7075.4 | | 3230.0 | | 12274.7 | 3.85 |
| | 0.2 | | 655.6 | | |
| 7075.6 | | 3320.0 | | 12930.3 | 7.06 |
| | 0.2 | | 672.0 | | |
| 7075.8 | | 3410.0 | | 13602.3 | 10.88 |
| | 0.2 | | 691.7 | | |
| 7076.0 | | 3500.0 | | 14294.0 | 15.20 |

HORROCKS/CAROLLO ENGINEERS
AMERICAN FORK, UTAH
April 25, 1984

# HYDROLOGIC REPORT FOR

# CO-OP Mine Disturbed Area

# STAGE, STORAGE & DISCHARGE

POND IDENTIFIER Sediment Pond "B" - Empty -

| ELEV | STORAGE (CU.FT.) | OUTFLOW (CFS) | 2S/T+O (CFS) |
|---|---|---|---|
| 7069.0 | 0.0 | 0.0 | 0.0 |
| 7070.0 | 899.0 | 0.0 | 5.0 |
| 7071.0 | 2149.0 | 0.0 | 11.9 |
| 7072.0 | 3768.0 | 0.0 | 20.9 |
| 7073.0 | 5774.0 | 0.0 | 32.1 |
| 7074.0 | 8185.0 | 0.0 | 45.5 |
| 7075.0 | 11019.0 | 0.0 | 61.2 |
| 7075.2 | 11638.6 | 1.4 | 66.0 |
| 7075.4 | 12274.7 | 3.8 | 72.0 |
| 7075.6 | 12930.3 | 7.1 | 78.9 |
| 7075.8 | 13602.3 | 10.9 | 86.4 |
| 7076.0 | 14294.0 | 15.2 | 94.6 |

HORROCKS/CAROLLO ENGINEERS
AMERICAN FORK, UTAH
April 25, 1984

# HYDROLOGIC REPORT FOR

# CO-OP Mine Disturbed Area

# POND DEPTH VS STORAGE PROVIDED

POND IDENTIFIER Sediment Pond "B" - With 3 years Sediment -

| ELEV feet | DEPTH feet | AREA sq.ft. | VOLUME cu.ft. | SUM VOL cu.ft. | OUTFLOW c.f.s. |
|---|---|---|---|---|---|
| 7071.0 | | 1430.0 | | 0.0 | 0.00 |
| | 1.0 | | 1619.0 | | |
| 7072.0 | | 1808.0 | | 1619.0 | 0.00 |
| | 1.0 | | 2006.0 | | |
| 7073.0 | | 2204.0 | | 3625.0 | 0.00 |
| | 1.0 | | 2411.0 | | |
| 7074.0 | | 2618.0 | | 6036.0 | 0.00 |
| | 1.0 | | 2834.0 | | |
| 7075.0 | | 3050.0 | | 8870.0 | 0.00 |
| | 0.2 | | 619.6 | | |
| 7075.2 | | 3140.0 | | 9489.6 | 1.36 |
| | 0.2 | | 636.1 | | |
| 7075.4 | | 3230.0 | | 10125.7 | 3.85 |
| | 0.2 | | 655.6 | | |
| 7075.6 | | 3320.0 | | 10781.3 | 7.06 |
| | 0.2 | | 672.0 | | |
| 7075.8 | | 3410.0 | | 11453.3 | 10.88 |
| | 0.2 | | 691.7 | | |
| 7076.0 | | 3500.0 | | 12145.0 | 15.20 |

HORROCKS/CAROLLO ENGINEERS
AMERICAN FORK, UTAH
April 25, 1984

# HYDROLOGIC REPORT FOR

# CO-OP Mine Disturbed Area

# STAGE, STORAGE & DISCHARGE

POND IDENTIFIER Sediment Pond "B" - With 3 years Sediment -

| ELEV | STORAGE (CU.FT.) | OUTFLOW (CFS) | 2S/T+O (CFS) |
|---|---|---|---|
| 7071.0 | 0.0 | 0.0 | 0.0 |
| 7072.0 | 1619.0 | 0.0 | 9.0 |
| 7073.0 | 3625.0 | 0.0 | 20.1 |
| 7074.0 | 6036.0 | 0.0 | 33.5 |
| 7075.0 | 8870.0 | 0.0 | 49.3 |
| 7075.2 | 9489.6 | 1.4 | 54.1 |
| 7075.4 | 10125.7 | 3.8 | 60.1 |
| 7075.6 | 10781.3 | 7.1 | 67.0 |
| 7075.8 | 11453.3 | 10.9 | 74.5 |
| 7076.0 | 12145.0 | 15.2 | 82.7 |

HORROCKS/CAROLLO ENGINEERS
AMERICAN FORK, UTAH
April 25, 1984

# Hiawatha RAINFALL DATA BASE

## RAINFALL INTENSITY (Inches/Hour)

| TIME (Min) | STORM FREQUENCY (Years) 2 | 5 | 10 | 25 | 50 | 100 |
|---|---|---|---|---|---|---|
| 5.0 | 0.84 | 1.56 | 1.92 | 2.76 | 3.12 | 3.72 |
| 6.0 | 0.79 | 1.49 | 1.84 | 2.63 | 2.98 | 3.55 |
| 7.0 | 0.74 | 1.42 | 1.76 | 2.50 | 2.84 | 3.38 |
| 8.0 | 0.69 | 1.35 | 1.68 | 2.37 | 2.70 | 3.21 |
| 9.0 | 0.64 | 1.28 | 1.60 | 2.24 | 2.56 | 3.04 |
| 10.0 | 0.60 | 1.20 | 1.50 | 2.10 | 2.40 | 2.88 |
| 11.0 | 0.58 | 1.16 | 1.45 | 2.03 | 2.32 | 2.78 |
| 12.0 | 0.56 | 1.12 | 1.40 | 1.96 | 2.24 | 2.68 |
| 13.0 | 0.54 | 1.08 | 1.35 | 1.89 | 2.16 | 2.58 |
| 14.0 | 0.53 | 1.04 | 1.30 | 1.82 | 2.08 | 2.48 |
| 15.0 | 0.52 | 1.00 | 1.24 | 1.76 | 2.00 | 2.40 |
| 20.0 | 0.47 | 0.90 | 1.11 | 1.59 | 1.80 | 2.16 |
| 25.0 | 0.42 | 0.80 | 0.98 | 1.42 | 1.60 | 1.92 |
| 30.0 | 0.36 | 0.70 | 0.86 | 1.24 | 1.40 | 1.68 |
| 40.0 | 0.32 | 0.61 | 0.76 | 1.09 | 1.23 | 1.48 |
| 50.0 | 0.28 | 0.52 | 0.66 | 0.94 | 1.06 | 1.28 |
| 60.0 | 0.23 | 0.44 | 0.55 | 0.78 | 0.88 | 1.06 |
| 120.0 | 0.20 | 0.31 | 0.38 | 0.50 | 0.56 | 0.65 |
| 180.0 | 0.18 | 0.26 | 0.31 | 0.40 | 0.44 | 0.51 |
| 240.0 | 0.17 | 0.24 | 0.28 | 0.36 | 0.40 | 0.46 |
| 300.0 | 0.16 | 0.22 | 0.25 | 0.32 | 0.36 | 0.41 |
| 360.0 | 0.16 | 0.20 | 0.23 | 0.28 | 0.32 | 0.35 |
| 480.0 | 0.14 | 0.18 | 0.20 | 0.25 | 0.28 | 0.31 |
| 600.0 | 0.12 | 0.16 | 0.17 | 0.22 | 0.24 | 0.27 |
| 720.0 | 0.11 | 0.13 | 0.15 | 0.18 | 0.20 | 0.22 |
| 1080.0 | 0.09 | 0.11 | 0.12 | 0.15 | 0.16 | 0.18 |
| 1440.0 | 0.07 | 0.08 | 0.09 | 0.11 | 0.12 | 0.13 |

HORROCKS/CAROLLO ENGINEERS
AMERICAN FORK, UTAH
April 25, 1984

# HYDROLOGIC REPORT FOR

# CO-OP Mine Disturbed Area

# S. C. S. HYDROGRAPH

BASIN IDENTIFICATION Sediment Pond "B"
BASIN DISCHARGES INTO Spillway

| | | | |
|---|---|---|---|
| BASIN AREA | = | 1.82 | ACRES |
| BASIN CURVE NUMBER | = | 82.00 | |
| 24-HOUR PRECIPITATION | = | 2.25 | INCHES |
| AVERAGE BASIN SLOPE | = | 6.5 | % |
| HYDRAULIC LENGTH | = | 600.0 | FEET |
| BASIN LAG | = | 0.25 | HOURS |

HYDROGRAPH RUNOFF VALUES
10 YEAR STORM FREQUENCY

| TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. |
|---|---|---|---|---|---|---|---|
| 10.00 | 0.0 | 10.10 | 0.0 | 10.20 | 0.0 | 10.30 | 0.0 |
| 10.40 | 0.0 | 10.50 | 0.0 | 10.60 | 0.0 | 10.70 | 0.0 |
| 10.80 | 0.0 | 10.90 | 0.0 | 11.00 | 0.0 | 11.10 | 0.0 |
| 11.20 | 0.0 | 11.30 | 0.0 | 11.40 | 0.0 | 11.50 | 0.0 |
| 11.60 | 0.1 | 11.70 | 0.1 | 11.80 | 0.2 | 11.90 | 0.5 |
| 12.00 | 0.9 | 12.10 | 1.2 | 12.20 | 1.2 | 12.30 | 1.0 |
| 12.40 | 0.7 | 12.50 | 0.6 | 12.60 | 0.5 | 12.70 | 0.4 |
| 12.80 | 0.3 | 12.90 | 0.3 | 13.00 | 0.2 | 13.10 | 0.2 |
| 13.20 | 0.2 | 13.30 | 0.2 | 13.40 | 0.2 | 13.50 | 0.1 |
| 13.60 | 0.1 | 13.70 | 0.1 | 13.80 | 0.1 | 13.90 | 0.1 |
| 14.00 | 0.1 | 14.10 | 0.1 | 14.20 | 0.1 | 14.30 | 0.1 |
| 14.40 | 0.1 | 14.50 | 0.1 | 14.60 | 0.1 | 14.70 | 0.1 |
| 14.80 | 0.1 | 14.90 | 0.1 | 15.00 | 0.1 | 15.10 | 0.0 |
| 15.20 | 0.0 | 15.30 | 0.0 | 15.40 | 0.0 | 15.50 | 0.0 |

# HYDROLOGIC REPORT FOR

# CO-OP Mine Disturbed Area

# HYDROGRAPH RESERVOIR ROUTING

BASIN IDENTIFIER Sediment Pond "B"
POND IDENTIFIER Sediment Pond "B"
10 YEAR STORM FREQUENCY

| T | I1 | I2 | 2S1/T | O1 | 2S2/T +O2 | O2 | 2S2/T |
|---|---|---|---|---|---|---|---|
| 12.00 | 0.0 | 0.9 | 0.0 | 0.0 | 0.9 | 0.0 | 0.9 |
| 12.10 | 0.9 | 1.2 | 0.9 | 0.0 | 3.0 | 0.0 | 3.0 |
| 12.20 | 1.2 | 1.2 | 3.0 | 0.0 | 5.4 | 0.0 | 5.4 |
| 12.30 | 1.2 | 1.0 | 5.4 | 0.0 | 7.6 | 0.0 | 7.6 |
| 12.40 | 1.0 | 0.7 | 7.6 | 0.0 | 9.3 | 0.0 | 9.3 |
| 12.50 | 0.7 | 0.6 | 9.3 | 0.0 | 10.6 | 0.0 | 10.6 |

MAXIMUM OUTFLOW = 0.0 C.F.S.
MAXIMUM STORAGE = 8,870.0 CU FT.
MAXIMUM ELEVATION = 7,075.0 FEET

HORROCKS/CAROLLO ENGINEERS
AMERICAN FORK, UTAH
April 25, 1984

# HYDROLOGIC REPORT FOR

# CO-OP Mine Disturbed Area

# S. C. S. HYDROGRAPH

BASIN IDENTIFICATION Sediment Pond "B"
BASIN DISCHARGES INTO Spillway

| | | | |
|---|---|---|---|
| BASIN AREA | = | 1.82 | ACRES |
| BASIN CURVE NUMBER | = | 82.00 | |
| 24-HOUR PRECIPITATION | = | 2.60 | INCHES |
| AVERAGE BASIN SLOPE | = | 6.5 | % |
| HYDRAULIC LENGTH | = | 600.0 | FEET |
| BASIN LAG | = | 0.25 | HOURS |

HYDROGRAPH RUNOFF VALUES
25 YEAR STORM FREQUENCY

| TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. |
|---|---|---|---|---|---|---|---|
| 9.20 | 0.0 | 9.30 | 0.0 | 9.40 | 0.0 | 9.50 | 0.0 |
| 9.60 | 0.0 | 9.70 | 0.0 | 9.80 | 0.0 | 9.90 | 0.0 |
| 10.00 | 0.0 | 10.10 | 0.0 | 10.20 | 0.0 | 10.30 | 0.0 |
| 10.40 | 0.0 | 10.50 | 0.0 | 10.60 | 0.0 | 10.70 | 0.0 |
| 10.80 | 0.0 | 10.90 | 0.0 | 11.00 | 0.0 | 11.10 | 0.0 |
| 11.20 | 0.0 | 11.30 | 0.1 | 11.40 | 0.1 | 11.50 | 0.1 |
| 11.60 | 0.1 | 11.70 | 0.2 | 11.80 | 0.4 | 11.90 | 0.7 |
| 12.00 | 1.2 | 12.10 | 1.6 | 12.20 | 1.6 | 12.30 | 1.3 |
| 12.40 | 0.9 | 12.50 | 0.7 | 12.60 | 0.6 | 12.70 | 0.5 |
| 12.80 | 0.4 | 12.90 | 0.3 | 13.00 | 0.3 | 13.10 | 0.3 |
| 13.20 | 0.3 | 13.30 | 0.2 | 13.40 | 0.2 | 13.50 | 0.2 |
| 13.60 | 0.2 | 13.70 | 0.2 | 13.80 | 0.2 | 13.90 | 0.1 |
| 14.00 | 0.1 | 14.10 | 0.1 | 14.20 | 0.1 | 14.30 | 0.1 |
| 14.40 | 0.1 | 14.50 | 0.1 | 14.60 | 0.1 | 14.70 | 0.1 |
| 14.80 | 0.1 | 14.90 | 0.1 | 15.00 | 0.1 | 15.10 | 0.1 |
| 15.20 | 0.0 | 15.30 | 0.0 | 15.40 | 0.0 | 15.50 | 0.0 |
| 15.60 | 0.0 | 15.70 | 0.0 | 15.80 | 0.0 | 15.90 | 0.0 |

# HYDROLOGIC REPORT FOR

# CO-OP Mine Disturbed Area

# HYDROGRAPH RESERVOIR ROUTING

BASIN IDENTIFIER Sediment Pond "B"
POND IDENTIFIER Sediment Pond "B"
25 YEAR STORM FREQUENCY

| T | I1 | I2 | 2S1/T | O1 | 2S2/T +O2 | O2 | 2S2/T |
|---|---|---|---|---|---|---|---|
| 11.90 | 0.0 | 0.7 | 0.0 | 0.0 | 0.7 | 0.0 | 0.7 |
| 12.00 | 0.7 | 1.2 | 0.7 | 0.0 | 2.6 | 0.0 | 2.6 |
| 12.10 | 1.2 | 1.6 | 2.6 | 0.0 | 5.5 | 0.0 | 5.5 |
| 12.20 | 1.6 | 1.6 | 5.5 | 0.0 | 8.7 | 0.0 | 8.7 |
| 12.30 | 1.6 | 1.3 | 8.7 | 0.0 | 11.7 | 0.0 | 11.7 |
| 12.40 | 1.3 | 0.9 | 11.7 | 0.0 | 13.9 | 0.0 | 13.9 |
| 12.50 | 0.9 | 0.7 | 13.9 | 0.0 | 15.5 | 0.0 | 15.5 |
| 12.60 | 0.7 | 0.6 | 15.5 | 0.0 | 16.8 | 0.0 | 16.8 |

MAXIMUM OUTFLOW = 0.0 C.F.S.
MAXIMUM STORAGE = 8,870.0 CU FT.
MAXIMUM ELEVATION = 7,075.0 FEET

HORROCKS/CAROLLO ENGINEERS
AMERICAN FORK, UTAH
April 25, 1984

# HYDROLOGIC REPORT FOR

# CO-OP Mine Disturbed Area

# S. C. S. HYDROGRAPH

BASIN IDENTIFICATION Sediment Pond "B"
BASIN DISCHARGES INTO Spillway

| | | | |
|---|---|---|---|
| BASIN AREA | = | 1.82 | ACRES |
| BASIN CURVE NUMBER | = | 82.00 | |
| 24-HOUR PRECIPITATION | = | 2.90 | INCHES |
| AVERAGE BASIN SLOPE | = | 6.5 | % |
| HYDRAULIC LENGTH | = | 600.0 | FEET |
| BASIN LAG | = | 0.25 | HOURS |

HYDROGRAPH RUNOFF VALUES
50 YEAR STORM FREQUENCY

| TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. |
|---|---|---|---|---|---|---|---|
| 8.80 | 0.0 | 8.90 | 0.0 | 9.00 | 0.0 | 9.10 | 0.0 |
| 9.20 | 0.0 | 9.30 | 0.0 | 9.40 | 0.0 | 9.50 | 0.0 |
| 9.60 | 0.0 | 9.70 | 0.0 | 9.80 | 0.0 | 9.90 | 0.0 |
| 10.00 | 0.0 | 10.10 | 0.0 | 10.20 | 0.0 | 10.30 | 0.0 |
| 10.40 | 0.0 | 10.50 | 0.0 | 10.60 | 0.0 | 10.70 | 0.0 |
| 10.80 | 0.0 | 10.90 | 0.0 | 11.00 | 0.0 | 11.10 | 0.1 |
| 11.20 | 0.1 | 11.30 | 0.1 | 11.40 | 0.1 | 11.50 | 0.1 |
| 11.60 | 0.1 | 11.70 | 0.3 | 11.80 | 0.5 | 11.90 | 0.9 |
| 12.00 | 1.5 | 12.10 | 2.0 | 12.20 | 2.0 | 12.30 | 1.6 |
| 12.40 | 1.1 | 12.50 | 0.9 | 12.60 | 0.7 | 12.70 | 0.6 |
| 12.80 | 0.5 | 12.90 | 0.4 | 13.00 | 0.3 | 13.10 | 0.3 |
| 13.20 | 0.3 | 13.30 | 0.2 | 13.40 | 0.2 | 13.50 | 0.2 |
| 13.60 | 0.2 | 13.70 | 0.2 | 13.80 | 0.2 | 13.90 | 0.2 |
| 14.00 | 0.2 | 14.10 | 0.2 | 14.20 | 0.2 | 14.30 | 0.1 |
| 14.40 | 0.1 | 14.50 | 0.1 | 14.60 | 0.1 | 14.70 | 0.1 |
| 14.80 | 0.1 | 14.90 | 0.1 | 15.00 | 0.1 | 15.10 | 0.1 |
| 15.20 | 0.0 | 15.30 | 0.0 | 15.40 | 0.0 | 15.50 | 0.0 |
| 15.60 | 0.0 | 15.70 | 0.0 | 15.80 | 0.0 | 15.90 | 0.0 |

HORROCKS/CAROLLO ENGINEERS
AMERICAN FORK, UTAH
April 25, 1984

# HYDROLOGIC REPORT FOR

# CO-OP Mine Disturbed Area

# HYDROGRAPH RESERVOIR ROUTING

BASIN IDENTIFIER Sediment Pond "B"
POND IDENTIFIER Sediment Pond "B"
50 YEAR STORM FREQUENCY

| T | I1 | I2 | 2S1/T | O1 | 2S2/T +O2 | O2 | 2S2/T |
|---|---|---|---|---|---|---|---|
| 11.90 | 0.0 | 0.9 | 0.0 | 0.0 | 0.9 | 0.0 | 0.9 |
| 12.00 | 0.9 | 1.5 | 0.9 | 0.0 | 3.3 | 0.0 | 3.3 |
| 12.10 | 1.5 | 2.0 | 3.3 | 0.0 | 6.8 | 0.0 | 6.8 |
| 12.20 | 2.0 | 2.0 | 6.8 | 0.0 | 10.8 | 0.0 | 10.8 |
| 12.30 | 2.0 | 1.6 | 10.8 | 0.0 | 14.4 | 0.0 | 14.4 |
| 12.40 | 1.6 | 1.1 | 14.4 | 0.0 | 17.1 | 0.0 | 17.1 |
| 12.50 | 1.1 | 0.9 | 17.1 | 0.0 | 19.0 | 0.0 | 19.0 |
| 12.60 | 0.9 | 0.7 | 19.0 | 0.0 | 20.6 | 0.0 | 20.6 |
| 12.70 | 0.7 | 0.6 | 20.6 | 0.0 | 21.9 | 0.0 | 21.9 |

MAXIMUM OUTFLOW = 0.0 C.F.S.
MAXIMUM STORAGE = 8,870.0 CU FT.
MAXIMUM ELEVATION = 7,075.0 FEET

HORROCKS/CAROLLO ENGINEERS
AMERICAN FORK, UTAH
April 25, 1984

# HYDROLOGIC REPORT FOR

# CO-OP Mine Disturbed Area

# S. C. S. HYDROGRAPH

BASIN IDENTIFICATION Sediment Pond "B"
BASIN DISCHARGES INTO Spillway

| | | | |
|---|---|---|---|
| BASIN AREA | = | 1.82 | ACRES |
| BASIN CURVE NUMBER | = | 82.00 | |
| 24-HOUR PRECIPITATION | = | 3.18 | INCHES |
| AVERAGE BASIN SLOPE | = | 6.5 | % |
| HYDRAULIC LENGTH | = | 600.0 | FEET |
| BASIN LAG | = | 0.25 | HOURS |

HYDROGRAPH RUNOFF VALUES
100 YEAR STORM FREQUENCY

| TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. | TIME HOUR | RUNOFF C.F.S. |
|---|---|---|---|---|---|---|---|
| 8.00 | 0.0 | 8.10 | 0.0 | 8.20 | 0.0 | 8.30 | 0.0 |
| 8.40 | 0.0 | 8.50 | 0.0 | 8.60 | 0.0 | 8.70 | 0.0 |
| 8.80 | 0.0 | 8.90 | 0.0 | 9.00 | 0.0 | 9.10 | 0.0 |
| 9.20 | 0.0 | 9.30 | 0.0 | 9.40 | 0.0 | 9.50 | 0.0 |
| 9.60 | 0.0 | 9.70 | 0.0 | 9.80 | 0.0 | 9.90 | 0.0 |
| 10.00 | 0.0 | 10.10 | 0.0 | 10.20 | 0.0 | 10.30 | 0.0 |
| 10.40 | 0.0 | 10.50 | 0.0 | 10.60 | 0.0 | 10.70 | 0.0 |
| 10.80 | 0.1 | 10.90 | 0.1 | 11.00 | 0.1 | 11.10 | 0.1 |
| 11.20 | 0.1 | 11.30 | 0.1 | 11.40 | 0.1 | 11.50 | 0.1 |
| 11.60 | 0.2 | 11.70 | 0.3 | 11.80 | 0.6 | 11.90 | 1.1 |
| 12.00 | 1.8 | 12.10 | 2.4 | 12.20 | 2.3 | 12.30 | 1.8 |
| 12.40 | 1.3 | 12.50 | 1.0 | 12.60 | 0.8 | 12.70 | 0.7 |
| 12.80 | 0.5 | 12.90 | 0.4 | 13.00 | 0.4 | 13.10 | 0.4 |
| 13.20 | 0.3 | 13.30 | 0.3 | 13.40 | 0.3 | 13.50 | 0.3 |
| 13.60 | 0.2 | 13.70 | 0.2 | 13.80 | 0.2 | 13.90 | 0.2 |
| 14.00 | 0.2 | 14.10 | 0.2 | 14.20 | 0.2 | 14.30 | 0.2 |
| 14.40 | 0.1 | 14.50 | 0.1 | 14.60 | 0.1 | 14.70 | 0.1 |
| 14.80 | 0.1 | 14.90 | 0.1 | 15.00 | 0.1 | 15.10 | 0.1 |
| 15.20 | 0.0 | 15.30 | 0.0 | 15.40 | 0.0 | 15.50 | 0.0 |
| 15.60 | 0.0 | 15.70 | 0.0 | 15.80 | 0.0 | 15.90 | 0.0 |

# HYDROLOGIC REPORT FOR

# CO-OP Mine Disturbed Area

# HYDROGRAPH RESERVOIR ROUTING

BASIN IDENTIFIER Sediment Pond "B"
POND IDENTIFIER Sediment Pond "B"
100 YEAR STORM FREQUENCY

| T | I1 | I2 | 2S1/T | O1 | 2S2/T +O2 | O2 | 2S2/T |
|---|---|---|---|---|---|---|---|
| 11.80 | 0.0 | 0.6 | 0.0 | 0.0 | 0.6 | 0.0 | 0.6 |
| 11.90 | 0.6 | 1.1 | 0.6 | 0.0 | 2.3 | 0.0 | 2.3 |
| 12.00 | 1.1 | 1.8 | 2.3 | 0.0 | 5.2 | 0.0 | 5.2 |
| 12.10 | 1.8 | 2.4 | 5.2 | 0.0 | 9.4 | 0.0 | 9.4 |
| 12.20 | 2.4 | 2.3 | 9.4 | 0.0 | 14.1 | 0.0 | 14.1 |
| 12.30 | 2.3 | 1.8 | 14.1 | 0.0 | 18.2 | 0.0 | 18.2 |
| 12.40 | 1.8 | 1.3 | 18.2 | 0.0 | 21.3 | 0.0 | 21.3 |
| 12.50 | 1.3 | 1.0 | 21.3 | 0.0 | 23.6 | 0.0 | 23.6 |
| 12.60 | 1.0 | 0.8 | 23.6 | 0.0 | 25.5 | 0.0 | 25.5 |
| 12.70 | 0.8 | 0.7 | 25.5 | 0.0 | 27.0 | 0.0 | 27.0 |
| 12.80 | 0.7 | 0.5 | 27.0 | 0.0 | 28.2 | 0.0 | 28.2 |

MAXIMUM OUTFLOW = 0.0 C.F.S.
MAXIMUM STORAGE = 8,870.0 CU FT.
MAXIMUM ELEVATION = 7,075.0 FEET

RUNOFF

DITCH SIZING

# SUMMARY OF GENERAL UNIFORM FLOW CALCULATIONS

HORROCKS
ENGINEERS
CO-OP Mine Disturbed Area
PROJECT No. 8309-42
DATE: 4/30/84

CHANNEL IS TRIANGULAR

SOLVING FOR VELOCITY, DISCHARGE

| VELOCITY fps | DISCHARGE cfs | DEPTH ft. | MANNING COEFF. | SLOPE ft/ft | SIDE SLOPES Z:1 | | WITDH ft. |
|---|---|---|---|---|---|---|---|
| 4.01 | 1.00 | .50 | .035000 | .090000 | 1.00 | 1.00 | 0.00 |

| FROUDE NUMBER | REYNOLDS NUMBER | LIMIT SLOPE | CRITICAL DISCHARGES | |
|---|---|---|---|---|
| 1.414 | 65668.4 | .16582538 | 0.00 | 0.00 |

| CRITICAL DEPTH | SEQUENT DEPTH | ALTERNATE DEPTH |
|---|---|---|
| .83 | .83 | .83 |

THERE ARE NO EXISTING CRITICAL DISCHARGES FOR THIS CHANNEL SLOPE AND THE RANGE GIVEN.

FOR THE ABOVE-LISTED CONDITIONS, THE FLOW REGIME IS SUPERCRITICAL TURBULENT

D-1P 0.8 cfs required

# SUMMARY OF GENERAL UNIFORM FLOW CALCULATIONS

HORROCKS
ENGINEERS
CO-OP Mine Disturbed Area
PROJECT No. 8309-42
DATE: 4/30/84

CHANNEL IS TRIANGULAR

SOLVING FOR VELOCITY, DISCHARGE

| VELOCITY fps | DISCHARGE cfs | DEPTH ft. | MANNING COEFF. | SLOPE ft/ft | SIDE SLOPES Z:1 | | WITDH ft. |
|---|---|---|---|---|---|---|---|
| 5.54 | 3.12 | .75 | .035000 | .100000 | 1.00 | 1.00 | 0.00 |

| FROUDE NUMBER | REYNOLDS NUMBER | LIMIT SLOPE | CRITICAL DISCHARGES | |
|---|---|---|---|---|
| 1.595 | 136057.0 | .16582538 | 0.00 | 0.00 |

| CRITICAL DEPTH | SEQUENT DEPTH | ALTERNATE DEPTH |
|---|---|---|
| 1.30 | 1.30 | 1.30 |

THERE ARE NO EXISTING CRITICAL DISCHARGES FOR THIS CHANNEL SLOPE AND THE RANGE GIVEN.

FOR THE ABOVE-LISTED CONDITIONS, THE FLOW REGIME IS SUPERCRITICAL TURBULENT

D-2D 1.5 cfs required

# SUMMARY OF GENERAL UNIFORM FLOW CALCULATIONS

HORROCKS
ENGINEERS
CO-OP Mine Disturbed Area
PROJECT No. 8309-42
DATE: 4/30/84

CHANNEL IS TRIANGULAR

SOLVING FOR VELOCITY, DISCHARGE

| VELOCITY fps | DISCHARGE cfs | DEPTH ft. | MANNING COEFF. | SLOPE ft/ft | SIDE SLOPES Z:1 | | WITDH ft. |
|---|---|---|---|---|---|---|---|
| 5.18 | 1.29 | .50 | .035000 | .150000 | 1.00 | 1.00 | 0.00 |

| FROUDE NUMBER | REYNOLDS NUMBER | LIMIT SLOPE | CRITICAL DISCHARGES | |
|---|---|---|---|---|
| 1.825 | 84777.6 | .16582538 | 0.00 | 0.00 |

| CRITICAL DEPTH | SEQUENT DEPTH | ALTERNATE DEPTH |
|---|---|---|
| .91 | .91 | .91 |

THERE ARE NO EXISTING CRITICAL DISCHARGES FOR THIS CHANNEL SLOPE AND THE RANGE GIVEN.

FOR THE ABOVE-LISTED CONDITIONS, THE FLOW REGIME IS SUPERCRITICAL TURBULENT

D-3D 1.0 cfs required

# SUMMARY OF GENERAL UNIFORM FLOW CALCULATIONS

HORROCKS
ENGINEERS
CO-OP Mine Disturbed Area
PROJECT No. 8309-42
DATE: 4/30/84

CHANNEL IS TRIANGULAR

SOLVING FOR VELOCITY, DISCHARGE

| VELOCITY fps | DISCHARGE cfs | DEPTH ft. | MANNING COEFF. | SLOPE ft/ft | SIDE SLOPES Z:1 | | WITDH ft. |
|---|---|---|---|---|---|---|---|
| 5.31 | 5.31 | 1.00 | .035000 | .062500 | 1.00 | 1.00 | 0.00 |

| FROUDE NUMBER | REYNOLDS NUMBER | LIMIT SLOPE | CRITICAL DISCHARGES | |
|---|---|---|---|---|
| 1.323 | 173736.9 | .16582538 | 0.00 | 0.00 |

| CRITICAL DEPTH | SEQUENT DEPTH | ALTERNATE DEPTH |
|---|---|---|
| .94 | .94 | .94 |

THERE ARE NO EXISTING CRITICAL DISCHARGES FOR THIS CHANNEL SLOPE AND THE RANGE GIVEN.

FOR THE ABOVE-LISTED CONDITIONS, THE FLOW REGIME IS SUPERCRITICAL TURBULENT

D-4D 4.8 cfs required

# SUMMARY OF GENERAL UNIFORM FLOW CALCULATIONS

HORROCKS
ENGINEERS
CO-OP Mine Disturbed Area
PROJECT No. 8309-42
DATE: 4/30/84

CHANNEL IS TRIANGULAR

SOLVING FOR VELOCITY, DISCHARGE

| VELOCITY fps | DISCHARGE cfs | DEPTH ft. | MANNING COEFF. | SLOPE ft/ft | SIDE SLOPES Z:1 | | WITDH ft. |
|---|---|---|---|---|---|---|---|
| 6.23 | 9.74 | 1.25 | .035000 | .064000 | 1.00 | 1.00 | 0.00 |

| FROUDE NUMBER | REYNOLDS NUMBER | LIMIT SLOPE | CRITICAL DISCHARGES | |
|---|---|---|---|---|
| 1.389 | 255010.9 | .16582538 | 0.00 | 0.00 |

| CRITICAL DEPTH | SEQUENT DEPTH | ALTERNATE DEPTH |
|---|---|---|
| 2.05 | 2.05 | 2.05 |

THERE ARE NO EXISTING CRITICAL DISCHARGES FOR THIS CHANNEL SLOPE AND THE RANGE GIVEN.

FOR THE ABOVE-LISTED CONDITIONS, THE FLOW REGIME IS SUPERCRITICAL TURBULENT

P-5D 7.2 cfs required

# SUMMARY OF GENERAL UNIFORM FLOW CALCULATIONS

HORROCKS
ENGINEERS
CO-OP Mine Disturbed Area
PROJECT No. 8309-42
DATE: 4/30/84

CHANNEL IS TRIANGULAR

SOLVING FOR VELOCITY, DISCHARGE

| VELOCITY fps | DISCHARGE cfs | DEPTH ft. | MANNING COEFF. | SLOPE ft/ft | SIDE SLOPES Z:1 | | WITDH ft. |
|---|---|---|---|---|---|---|---|
| 4.38 | 2.46 | .75 | .035000 | .062500 | 1.00 | 1.00 | 0.00 |

| FROUDE NUMBER | REYNOLDS NUMBER | LIMIT SLOPE | CRITICAL DISCHARGES | |
|---|---|---|---|---|
| 1.261 | 107562.5 | .16582538 | 0.00 | 0.00 |

| CRITICAL DEPTH | SEQUENT DEPTH | ALTERNATE DEPTH |
|---|---|---|
| 1.19 | 1.19 | 1.19 |

THERE ARE NO EXISTING CRITICAL DISCHARGES FOR THIS CHANNEL SLOPE AND THE RANGE GIVEN.

FOR THE ABOVE-LISTED CONDITIONS, THE FLOW REGIME IS SUPERCRITICAL TURBULENT

D-6D 1.2 cfs required

# SUMMARY OF GENERAL UNIFORM FLOW CALCULATIONS

HORROCKS
ENGINEERS
CO-OP Mine Undisturbed Area
PROJECT No. 8309-42
DATE: 4/30/84

CHANNEL IS TRIANGULAR

SOLVING FOR VELOCITY, DISCHARGE

| VELOCITY fps | DISCHARGE cfs | DEPTH ft. | MANNING COEFF. | SLOPE ft/ft | SIDE SLOPES Z:1 | | WITDH ft. |
|---|---|---|---|---|---|---|---|
| 3.50 | 1.97 | .75 | .035000 | .040000 | 1.00 | 1.00 | 0.00 |

| FROUDE NUMBER | REYNOLDS NUMBER | LIMIT SLOPE | CRITICAL DISCHARGES | |
|---|---|---|---|---|
| 1.009 | 86050.0 | .16582538 | 0.00 | 0.00 |

| CRITICAL DEPTH | SEQUENT DEPTH | ALTERNATE DEPTH |
|---|---|---|
| 1.09 | 1.09 | 1.09 |

THERE ARE NO EXISTING CRITICAL DISCHARGES FOR THIS CHANNEL SLOPE AND THE RANGE GIVEN.

FOR THE ABOVE-LISTED CONDITIONS, THE FLOW REGIME IS SUPERCRITICAL TURBULENT

D-10 1.5 cfs required

# SUMMARY OF GENERAL UNIFORM FLOW CALCULATIONS

HORROCKS
ENGINEERS
CO-OP Mine Undisturbed Area
PROJECT No. 8309-42
DATE: 4/30/84

CHANNEL IS TRIANGULAR

SOLVING FOR VELOCITY, DISCHARGE

| VELOCITY fps | DISCHARGE cfs | DEPTH ft. | MANNING COEFF. | SLOPE ft/ft | SIDE SLOPES Z:1 | | WITDH ft. |
|---|---|---|---|---|---|---|---|
| 3.92 | 2.20 | .75 | .035000 | .050000 | 1.00 | 1.00 | 0.00 |

| FROUDE NUMBER | REYNOLDS NUMBER | LIMIT SLOPE | CRITICAL DISCHARGES | |
|---|---|---|---|---|
| 1.128 | 96206.8 | .16582538 | 0.00 | 0.00 |

| CRITICAL DEPTH | SEQUENT DEPTH | ALTERNATE DEPTH |
|---|---|---|
| 1.13 | 1.13 | 1.13 |

THERE ARE NO EXISTING CRITICAL DISCHARGES FOR THIS CHANNEL SLOPE AND THE RANGE GIVEN.

FOR THE ABOVE-LISTED CONDITIONS, THE FLOW REGIME IS SUPERCRITICAL TURBULENT

D-20 1.5 cfs required

# SUMMARY OF GENERAL UNIFORM FLOW CALCULATIONS

HORROCKS
ENGINEERS
CO-OP Mine Undisturbed Area
PROJECT No. 8309-42
DATE: 4/30/84

CHANNEL IS TRIANGULAR

SOLVING FOR VELOCITY, DISCHARGE

| VELOCITY fps | DISCHARGE cfs | DEPTH ft. | MANNING COEFF. | SLOPE ft/ft | SIDE SLOPES Z:1 | | WITDH ft. |
|---|---|---|---|---|---|---|---|
| 5.51 | 8.61 | 1.25 | .035000 | .050000 | 1.00 | 1.00 | 0.00 |

| FROUDE NUMBER | REYNOLDS NUMBER | LIMIT SLOPE | CRITICAL DISCHARGES | |
|---|---|---|---|---|
| 1.228 | 225399.9 | .16582538 | 0.00 | 0.00 |

| CRITICAL DEPTH | SEQUENT DEPTH | ALTERNATE DEPTH |
|---|---|---|
| 1.95 | 1.95 | 1.95 |

THERE ARE NO EXISTING CRITICAL DISCHARGES FOR THIS CHANNEL
SLOPE AND THE RANGE GIVEN.

FOR THE ABOVE-LISTED CONDITIONS, THE FLOW REGIME IS SUPERCRITICAL TURBULENT

D-3U 6.1 cfs required

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| VELOCITY fps | DISCHARGE cfs | DEPTH ft. | MANNING COEFF. | SLOPE ft/ft | SIDE SLOPES Z:1 | | WITDH ft. |
|---|---|---|---|---|---|---|---|
| 6.22 | 14.00 | 1.50 | .035000 | .050000 | 1.00 | 1.00 | 0.00 |

| FROUDE NUMBER | REYNOLDS NUMBER | LIMIT SLOPE | CRITICAL DISCHARGES | |
|---|---|---|---|---|
| 1.266 | 305437.6 | .16582538 | 0.00 | 0.00 |

| CRITICAL DEPTH | SEQUENT DEPTH | ALTERNATE DEPTH |
|---|---|---|
| 1.38 | 1.38 | 1.38 |

THERE ARE NO EXISTING CRITICAL DISCHARGES FOR THIS CHANNEL SLOPE AND THE RANGE GIVEN.

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D-4U 11.8 cfs required
D-7U 10.3 cfs required

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| VELOCITY fps | DISCHARGE cfs | DEPTH ft. | MANNING COEFF. | SLOPE ft/ft | SIDE SLOPES Z:1 | | WITDH ft. |
|---|---|---|---|---|---|---|---|
| 3.54 | .88 | .50 | .035000 | .070000 | 1.00 | 1.00 | 0.00 |

| FROUDE NUMBER | REYNOLDS NUMBER | LIMIT SLOPE | CRITICAL DISCHARGES | |
|---|---|---|---|---|
| 1.247 | 57914.1 | .16582538 | 0.00 | 0.00 |

| CRITICAL DEPTH | SEQUENT DEPTH | ALTERNATE DEPTH |
|---|---|---|
| .79 | .79 | .79 |

THERE ARE NO EXISTING CRITICAL DISCHARGES FOR THIS CHANNEL SLOPE AND THE RANGE GIVEN.

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D-5U 0.9 cfs required
D-6U 0.9 cfs required

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| VELOCITY fps | DISCHARGE cfs | DEPTH ft. | MANNING COEFF. | SLOPE ft/ft | SIDE SLOPES Z:1 | | WITDH ft. |
|---|---|---|---|---|---|---|---|
| 4.38 | 2.46 | .75 | .035000 | .062500 | 1.00 | 1.00 | 0.00 |

| FROUDE NUMBER | REYNOLDS NUMBER | LIMIT SLOPE | CRITICAL DISCHARGES | |
|---|---|---|---|---|
| 1.261 | 107562.5 | .16582538 | 0.00 | 0.00 |

| CRITICAL DEPTH | SEQUENT DEPTH | ALTERNATE DEPTH |
|---|---|---|
| 1.19 | 1.19 | 1.19 |

THERE ARE NO EXISTING CRITICAL DISCHARGES FOR THIS CHANNEL SLOPE AND THE RANGE GIVEN.

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D-80 2.3 cfs required

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SOLVING FOR VELOCITY, DISCHARGE

| VELOCITY fps | DISCHARGE cfs | DEPTH ft. | MANNING COEFF. | SLOPE ft/ft | SIDE SLOPES Z:1 | | WITDH ft. |
|---|---|---|---|---|---|---|---|
| 5.05 | 2.84 | .75 | .035000 | .083000 | 1.00 | 1.00 | 0.00 |

| FROUDE NUMBER | REYNOLDS NUMBER | LIMIT SLOPE | CRITICAL DISCHARGES | |
|---|---|---|---|---|
| 1.453 | 123953.8 | .16582538 | 0.00 | 0.00 |

| CRITICAL DEPTH | SEQUENT DEPTH | ALTERNATE DEPTH |
|---|---|---|
| 1.25 | 1.25 | 1.25 |

THERE ARE NO EXISTING CRITICAL DISCHARGES FOR THIS CHANNEL SLOPE AND THE RANGE GIVEN.

FOR THE ABOVE-LISTED CONDITIONS, THE FLOW REGIME IS SUPERCRITICAL TURBULENT

D-9U 1.8 cfs required

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| VELOCITY fps | DISCHARGE cfs | DEPTH ft. | MANNING COEFF. | SLOPE ft/ft | SIDE SLOPES Z:1 | | WITDH ft. |
|---|---|---|---|---|---|---|---|
| 5.67 | 1.42 | .50 | .035000 | .180000 | 1.00 | 1.00 | 0.00 |

| FROUDE NUMBER | REYNOLDS NUMBER | LIMIT SLOPE | CRITICAL DISCHARGES | |
|---|---|---|---|---|
| 2.000 | 92869.2 | .16582538 | 0.00 | 0.00 |

| CRITICAL DEPTH | SEQUENT DEPTH | ALTERNATE DEPTH |
|---|---|---|
| .95 | .95 | .97 |

THERE ARE NO EXISTING CRITICAL DISCHARGES FOR THIS CHANNEL SLOPE AND THE RANGE GIVEN.

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D-100 1.5 cfs required

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| VELOCITY fps | DISCHARGE cfs | DEPTH ft. | MANNING COEFF. | SLOPE ft/ft | SIDE SLOPES Z:1 | | WITDH ft. |
|---|---|---|---|---|---|---|---|
| 7.94 | 7.94 | 1.00 | .035000 | .140000 | 1.00 | 1.00 | 0.00 |

| FROUDE NUMBER | REYNOLDS NUMBER | LIMIT SLOPE | CRITICAL DISCHARGES | |
|---|---|---|---|---|
| 1.980 | 260025.6 | .16582538 | 0.00 | 0.00 |

| CRITICAL DEPTH | SEQUENT DEPTH | ALTERNATE DEPTH |
|---|---|---|
| 1.10 | 1.69 | 1.91 |

THERE ARE NO EXISTING CRITICAL DISCHARGES FOR THIS CHANNEL SLOPE AND THE RANGE GIVEN.

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D-11U 7.6 cfs required

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SOLVING FOR VELOCITY, DISCHARGE

| VELOCITY fps | DISCHARGE cfs | DEPTH ft. | MANNING COEFF. | SLOPE ft/ft | SIDE SLOPES Z:1 | | WITDH ft. |
|---|---|---|---|---|---|---|---|
| 6.81 | 15.33 | 1.50 | .035000 | .060000 | 1.00 | 1.00 | 0.00 |

| FROUDE NUMBER | REYNOLDS NUMBER | LIMIT SLOPE | CRITICAL DISCHARGES | |
|---|---|---|---|---|
| 1.387 | 334590.1 | .16582538 | 0.00 | 0.00 |

| CRITICAL DEPTH | SEQUENT DEPTH | ALTERNATE DEPTH |
|---|---|---|
| 1.43 | 1.43 | 1.43 |

THERE ARE NO EXISTING CRITICAL DISCHARGES FOR THIS CHANNEL SLOPE AND THE RANGE GIVEN.

FOR THE ABOVE-LISTED CONDITIONS, THE FLOW REGIME IS SUPERCRITICAL TURBULENT

D-3R 10.4 cfs required
D-2R 12.1 cfs required
D-1R 10.2 cfs required