As the sediment pond embankment is being constructed, it will be inspected on a regular basis and at critical construction phases by a certified, professional engineer. Following construction, the pond will be inspected and the as-built design will be certified.

During routine operation, the pond will be visually inspected daily for unusual conditions. The pond and disturbed area ditches will be cleaned as needed, depending on the rate of sediment accumulation. Prior to removal, material in the pond will be tested for toxic and acid-forming constituents. Following receipt of the analysis results, the sediment material will then be removed from the pond and stockpiled at the north end of the mine yard in the designated refuse storage area. The stockpiled material will later be used as fill in the reclamation process.

731.300 #2

Material will be sampled and analyzed according to Table 6 "Recommended Laboratory Methods" listed in DOGM's Guidelines For Management Of Topsoil And Overburden For Underground And Surface Coal Mining. Additional analyses will be performed depending on other possible contaminants such as metals or petroleum products.

Approximately 1.872 acre-feet (3,020 cubic yards) of sediment per year is estimated as the potential sediment accumulation in the sediment pond based on the Sedimentation and Drainage Control Plan (Appendix VII-5). The pond has been designed for a maximum storage capacity of 5.616 acre-feet of sediment. Sediment accumulation will be monitored by means of sediment markers located within the pond. When 60% of the maximum 3 year sediment volume has accumulated within the sediment pond, it will be removed and stored in the refuse storage area located at the north end of the main mine yard. Over the 5 year permit term, approximately 9.36 acre-feet or 15,100 cubic yards of material could be collected. The capacity of the refuse pile has been designed at 16,500 cubic yards to adequately store this volume of pond cleanout sediment.

The Universal Soil Loss Equation (Appendix VII-7) estimates the expected volume of accumulated sediment for the first five year permit term will be 15,100 cubic yards at 3,020 cubic yards per year. However, experience at central Utah coal operations has shown this equation often over-estimates the sediment yield, especially in a relatively flat mine surface such as proposed for the Smoky Hollow mine. Sediment accumulation will be monitored during the initial five year permit term and the results will be used to determine future storage requirements. Even though the plan presently shows refuse (sediment) storage for the estimated five-year sediment accumulation, the theoretical life-of-mine (30 year) sediment accumulation of 90,600 cubic yards (3,020 cubic yards x 30 years) could be stored in the same area of the mine yard by merely extending and heightening the refuse pile.

731.300 #3

Demonstrate stability?

The storage yard east of the Kane County road from Section E 1+00 to E 9+00 would be dedicated to refuse (sediment) storage as needed throughout the life of the operation. This 800 foot long storage area could support a pile with a flattened top effectively 600 feet long, with 100 foot side-slopes on the north and south end. Cross-sections E 2+00 through E 8+00, as depicted on Exhibit V-7G, show an average usable width of 160 feet through the body of the elongated pile. Therefore, a trapezoidal pile 24 feet high and 160 feet wide could hold in excess of the theoretical life-of-mine refuse (sediment) storage volume of 90,600 cubic yards.

Life of Mine Sediment Storage Requirement:

Body of Pile: 24' high x 160' wide x 600' long =
2,304,000 cubic feet

Endslopes: 2 each at 1/2 x 24' high x 160' wide x 75' long = 288,00
cubic feet

Total storage capacity: 2,592,000 cubic feet = 96,000 cubic yards

Refer to Exhibit V-6 for the location of the refuse storage area. The sediment accumulation rate in the pond should be highest following initial construction. Storage needs for the future will be evaluated based on sediment accumulation rates observed during the first five year permit term. Exhibit V-13 shows the design of the temporary storage site which has a designed capacity of 16,500 cubic yards. This volume has been used in the final reclamation mass-balance and permanent disposal plan. Exhibit V-14 shows the design and location for final placement of the refuse material.

Details of the sediment pond design are shown on Exhibit VII-3. The pond will have two separate devices for dewatering the pond. The lowest is a four inch (minimum) pipe with a decant located at elevation 4645'. This decant pipe will have a manual valve and lock so that water can be released only when desired. The pond's principal water

553.260 No coal processing wastes or underground development waste will be disposed of in any mined-out surface areas.

553.300 All exposed coal seams will be covered with at least four feet of nontoxic, noncombustible materials during reclamation activities to prevent spontaneous combustion of the seam and to assist with revegetation of the site. None of the exposed materials are acid-producing or toxic.

Any refuse stored within the regraded fill will be covered with a minimum of four feet of noncombustible material. Exhibit V-14 shows the proposed procedure.

Exhibits V-7A through V-7G, which are construction/reclamation cross sections, show the extent of the coal seam which may be in the faceup earthwork. Solid coal is expected to be encountered primarily in the highwall excavation within the "C" cross sections. Based on prior site investigations, solid coal outcrop is expected to be encountered at an average depth of about 15 feet below the original surface due to weathering and "burn" which is extensive in this area. Based on this, an estimated 40,000 cubic yards of coal may be mixed with the 508,000 cubic yards of fill material used in the construction of mine yard. This would amount to less than 8% of the total fill material.

No attempt will be made to segregate this coal during construction of the mine pad. During the earthwork phase of construction coal will become pulverized and co-mingled with the rock and earth material comprising the fill.

731.300 #3

Coal from the outcrops in the canyon has been tested and analyzed according to Table 6 "Recommended Laboratory Methods" listed in DOGM's Guidelines For Management Of Topsoil And Overburden For Underground And Surface Coal Mining. The results of these tests can be found in Appendix VI-1.

553.400 Terracing is not currently being proposed in the reclamation design.

553.500 Previously Mined Areas

APPENDIX 1

SOIL REFERENCE DATA

26 - Rock outcrop - Rubble land complex

MAP UNIT SETTING

Landscape: escarpments

Elevation: 4400 to 5600 feet

Climatic data (average annual): precipitation - 5 to 8 inches; air temperature - 55 to 57 degrees F; frost-free season - 160 to 180 days.

COMPOSITION

Rock outcrop, shale - 35 percent

Rock outcrop, sandstone - 30 percent

Rubble land - 15 percent

The components of this unit are so intricately intermingled that it is not possible or practical to map them separate. The percentage varies from one area to another.

Dissimilar inclusions - 20 percent

DESCRIPTION OF ROCK OUTCROP, SHALE

Position on landscape: back slopes; ridges

Parent material: mostly Tropic shale

Slope features: percent - 35 to 60; shape - steep

Typical rock outcrop, shale consists of eroding, weathering, gray and olive gray shale. It will have a thin surface layer of soil.

Runoff: very rapid

Hydrologic group: D

Hazard of erosion: by water - high; by wind - moderate; sediment yield - high

Agricultural capability subclass: VIIIs

Range site: none

DESCRIPTION OF ROCK OUTCROP, SANDSTONE

Position on landscape: cliffs, ledges

Parent material: mostly Dakota sandstone

Slope features: percent - 35 to 60; shape - steep

Typical rock outcrop, sandstone consists of exposed brownish and grayish sandstone. It will have a thin surface layer of soil.

Runoff: very rapid

Hydrologic group: D

Hazard of erosion: by water - slight; by wind - slight; sediment yield - low

Agricultural capability subclass: VIIIs

Range site: none

DESCRIPTION OF RUBBLE LAND

Position of landscape: talus slopes, ridges, back slopes

Parent material: colluvium

Slope features: percent - 15 to 60 percent; shape - hilly to steep

Typical Rubble land consists of land areas covered with stones, boulders, cobbles and gravel

Runoff: rapid to medium

Hydrologic group: D

Hazard of erosion: by water - moderate; by wind - slight; sediment yield - medium

Agricultural capability subclass: VIIIs

Range site: none

INCLUDED AREAS

Dissimilar inclusions:

10 percent - deep gravelly and cobbly loamy soils on ridges, knolls, and back slopes; range site - unclassified

5 percent - shallow to shale channery, and stony loamy soils on ridges, back slopes and benches; range site - unclassified

5 percent - shallow to sandstone channery and stony loamy soils on ridges, back slopes and benches, range site unclassified

USE OF THE UNIT

Current major uses: very limited rangeland, possible source of bentonite material

MAJOR MANAGEMENT FACTORS

Soil related factors: slope, boulders, cobbles, depth to bedrock, water erosion, rock outcroppings, sediment yield, salinity

General management considerations: mostly unsuitable for cattle grazing and management practices. Grazing occurs on the accessible areas.

VEGETATION

Where vegetation occurs, it is extremely variable and vegetation cover generally does not exceed 10 percent. The most common species are:

Grasses: galleta, Indian ricegrass, sand dropseed, cheatgrass, needle and thread, threeawn, bottlebrush squirreltail, desertneedle grass

Forbs: globemallow, buckwheat, daisy, mustard

Shrubs: shadescale, Douglas rabbitbrush, broom snakeweed, fourwing saltbush, bud sagebrush, Mormontea, blackbrush, winterfat, cactus

40 - Mellenthin - Rock outcrop complex, 2 to 8 percent slopes

MAP UNIT SETTING

Landscape: structural bench

Elevation: 5200 to 5800 feet

Climatic data (average annual): precipitation - 8 to 10 inches; air temperature - 53 to 55 degrees F; frost-free season - 155 to 165 days

COMPOSITION

Mellenthin gravelly sandy loam and similar inclusions - 55 percent

Rock outcrop, sandstone - 20 percent

Dissimilar inclusions - 25 percent

The range use and management of this unit does not dictate separation of the major components. The percentages varies from one area to another.

DESCRIPTION OF MELLENTHIN SOIL

Position on landscape: ridges, breaks, swales

Parent material: residuum from sandstone

Slope features: percent - 2 to 8; shape - undulating

Dominant present vegetation: Utah juniper and singleleaf pinyon trees, galleta, needle and thread, blue grama, Indian ricegrass, sand dropseed, Mexican cliffrose, Douglas rabbitbrush, Mormontea, roundleaf buffaloberry

Typical profile: (no. 50)

Surface to 8 inches - brown gravelly sandy loam
8 to 20 inches - pink very gravelly sandy loam
18 inches - sandstone bedrock

Depth class: shallow (10 to 20 inches)

Drainage class: well drained

Permeability: moderately rapid

Available water capacity: 1 to 3 inches

Runoff: medium

Hazard to flooding: none

Hydrologic group: D

Erosion factor (surface): SSF - slight 21 to 41; K-value - .10; T value - 1; wind erodibility group - 8

Hazard of erosion: by water - moderate; by wind - slight; sediment yield: low

Potential rooting depth: 10 to 20 inches

Organic matter content of surface layer: less than 1 percent

Salinity: nonsaline

Agricultural capability subclass: VIIs, nonirrigated

Range site: semidesert shallow loam (juniper-pinyon)

DESCRIPTION OF ROCK OUTCROP, SANDSTONE

Position on landscape: ledges, cliffs, slick rock

Parent material: straight cliffs sandstone

Slope features: percent - 2 to 65; shape - undulating to steep

Dominant present vegetation: barren to widely scattered Utah juniper and singleleaf pinyon trees, shrubs and grasses

Typical Rock outcrop, sandstone consists of exposed yellowish brown sandstone. It will have a thin surface layer of soil material

Runoff: very rapid

Hydrologic group: D

Hazard of erosion: by water - slight; by wind - slight; sediment yield: low

Agricultural capability subclass: VIIIs

Range site: none

INCLUDED AREAS

Dissimilar inclusions:

10 percent - shallow loamy or gravelly loamy soils without carbonate accumulation under same vegetation and range site as the Mellenthin soil

10 percent - shallow loamy soil with carbonate accumulation under same vegetation and range site as the Mellenthin soil

5 percent - shallow loamy soil over shale under same vegetation and range site as Mellenthin soil

USE OF THE UNIT

Current major uses: rangeland

MAJOR MANAGEMENT FACTORS

Soil related factors: available water capacity, depth to bedrock, rock outcroppings, slope in some areas

RANGELAND

Mellenthin gravelly sandy loam and similar inclusions - semidesert shallow loam (pinyon-juniper)

Composition of the potential plant community; 30 percent grasses; 5 percent forbs; 65 percent shrubs

Important plants: galleta, Indian ricegrass, needle and thread, sand dropseed, bottlebrush squirreltail, scarlet globemallow, antelope bitterbrush, Mexican cliffrose, Utah serviceberry, black sagebrush

General management considerations: range practices are limited because of the shallow soils and Rock outcrop.

Suitable management practices: Management that maintain or improve the rangeland vegetation include conservative stocking rates, proper graving systems, consistent implementation of the grazing system, fencing, proper location of water developments, water hauling, and proper placement of salt.

RATINGS FOR SELECTED USES

(Mellenthin Soil)

Suitability and limitations for the following use:

Rangeland seeding: unsuited - low precipitation

Rangeland equipment: moderate - depth to rock.

Fences: severe - depth to rock

Unsurfaced roads: severe - depth to rock

Shallow excavations: severe - depth to rock

Sand: unsuited

Gravel: unsuited

Pond reservoir areas: severe - depth to rock

Embankments, dikes, and levees: severe - thin layer, piping, seepage

Off-road motorcycle trails: slight

(Rock Outcrop, Sandstone)

Rock Outcrop, sandstone is unsuitable for most common uses.

44 - Windwistle - Palma - Rinzo complex, 2 to 3 percent slopes

MAP UNIT SETTING

Landscape: structural bench

Elevation: 5000 to 5600 feet

Climatic data (average annual): precipitation - 8 to 10 inches; air temperature - 53 to 55 degrees F; frost-free season - 155 to 165 days

COMPOSITION

Windwistle fine sandy loam and similar inclusions - 35 percent

Palma loamy fine sand and similar inclusions - 20 percent

Rizno sandy loam and similar inclusions - 20 percent

The components of this unit are so intricately intermingled that it is not possible or practical to map them separate. The percentage varies from one area to another.

Dissimilar inclusions - 25 percent

DESCRIPTION OF WINDWISTLE SOIL

Position on landscape: swales, ridges

Parent material: eolian and alluvium from sandstone and shale

Slope features: percent - 2 to 4; shape - undulating

Dominant present vegetation: galleta, Indian ricegrass, blue grama, needle and thread, black grama, scarlet globemallow, spiny hopsage, Mormontea, blackbrush, broom snakeweed

Typical profile: (no. 193)

Surface to 2 inches - reddish brown fine sandy loam
2 to 13 inches - yellowish red fine sandy loam
13 to 17 inches - reddish yellow loam
17 to 26 inches - reddish yellow sandy loam
26 inches - sandstone bedrock

Depth class: moderately deep (20 to 40 inches)

Drainage class: well drained

Permeability: moderately rapid

Available water capacity: 2.5 to 4 inches

Runoff: slow

Hazard of flooding: none

Hydrologic group: C

Erosion factor (surface): SSF - slight 21 to 40; K-value - .24; T value - 3; wind erodibility group - 3

Hazard of erosion: by water - slight; by wind - moderate; sediment yield: low

Potential rooting depth: 20 to 40 inches

Organic matter content of surface layer: less than 1 percent

Salinity: nonsaline

Agricultural capability subclass: VIIe, nonirrigated

Range site: semidesert sandy loam

DESCRIPTION OF PALMA SOIL

Position on landscape: swales, ridges

Parent material: eolian and alluvium from sandstone and shale

Slope features: percent - 2 to 4; shape - undulating

Dominant present vegetation: galleta, blue grama, Indian ricegrass, needle and thread, scarlet globemallow, spiny hopsage, Mormontea, fourwing saltbush, broom snakeweed

Typical profile: (no. 140)

Surface to 3 inches - brown loamy fine sand
3 to 8 inches - yellowish red fine sandy loam
8 to 27 inches - reddish yellow fine sandy loam
27 to 36 inches - reddish yellow sandy loam
36 to 60 inches - very pale brown clay loam

Depth class: very deep (60 inches or more)

Drainage class: somewhat excessively drained

Permeability: moderately rapid

Available water capacity: 6 to 8 inches

Runoff: slow

Hazard of flooding: none

Hydrologic group: B

Erosion factor (surface): SSF - slight 21 to 40; K-value - .24; T value - 5; wind erodibility group - 2

Hazard of erosion: by water - slight; by wind - high; sediment yield: low

Potential rooting depth: 60 inches or more

Organic matter content of surface layer: less than 1 percent

Salinity: nonsaline

Agricultural capability subclass: VIe, nonirrigated

Range site: semidesert sandy loam

DESCRIPTION OF RIZNO SOIL

Position on landscape: ridges, breaks

Parent material: residuum from sandstone and shale

Slope features: percent - 2 to 8; shape - undulating

Dominant present vegetation: Indian ricegrass, galleta, bottlebrush squirreltail, scarlet globemallow, blackbrush, Mormontea

Typical profile: (no. 138)

Surface to 2 inches - strong yellow gravelly loam
2 to 9 inches - reddish yellow gravelly loam
9 to 12 inches - pink very gravelly loam
12 inches - sandstone bedrock

Depth class: shallow (10 to 20 inches)

Drainage class: well drained

Permeability: moderately rapid

Available water capacity: 1 to 2 inches

Runoff: medium

Hazard of flooding: none

Hydrologic group: D

Erosion factor (surface): SSF - moderate 41 to 60; K-value - .20; T-value - 1; wind erodibility group - 3

Hazard of erosion: by water - slight; by wind - moderate; sediment yield: low

Potential rooting depth: 10 to 20 inches

Organic matter content of surface layer: less than 1 percent

Salinity: nonsaline

Agricultural capacity subclass: VIIs, nonirrigated

Range site: semidesert shallow sandy loam (blackbrush)

INCLUDED AREAS

Dissimilar inclusions:

15 percent - shallow loamy and gravelly loamy soils on ridges with a carbonate layer under blackbrush, Indian ricegrass or shadescale - mostly semidesert shallow sandy loam (black brush)

5 percent - Rock outcrop, sandstone as slick rock or ledges under sparse brush - no range site

5 percent - moderately deep loamy soils on ridges under spiny hopsage, galleta, Indian ricegrass - semidesert sandy loam

USE OF THE UNIT

Current major uses: rangeland

MAJOR MANAGEMENT FACTORS

Soil related factors: depth to bedrock, wind erosion, available water capacity, rock outcroppings in some areas, hazard of seepage

RANGELAND

Windwistle fine sandy loam and Palma loamy fine sand and similar inclusions - semidesert sandy loam

Composition of the potential plant community; 65 percent grasses; 5 percent forbs; 30 percent shrubs

Important plants: Indian ricegrass, needle and thread, sand dropseed, scarlet globemallow, Mormontea, fourwing saltbush, winterfat, spiny hopsage

Rizno sandy loam and similar inclusions - semidesert shallow sandy loam (blackbrush)

Composition of the potential plant community; 15 percent grasses; 5 percent forbs; 80 percent shrubs

Important plants: Indian ricegrass, galleta, sand dropseed, scarlet globemallow, erigonum, Mormontea, winterfat

General management considerations: a good plant cover needs to be maintained to control wind erosion

Suitable management practices: Management that maintain or improve the rangeland vegetation include conservative stocking rates, proper grazing system, consistent implementation of the grazing system, fencing, proper location of water developments, water hauling, and proper placement of salt.

RATINGS FOR SELECTED USES

(Windwistle Soil)

Suitability and limitations for the following use:

Rangeland seeding: unsuited - low precipitation

Rangeland equipment: slight

Fences: moderate - depth to rock

Unsurfaced roads: moderate - depth to rock

Shallow excavations: severe - depth to rock

Sand: unsuited

Gravel: unsuited

Pond reservoir areas: severe - seepage

Embankments, dikes, and levees: severe - seepage

Off-road motorcycle trails: slight

(Palma Soil)

Suitability and limitations for the following use:

Rangeland seeding: unsuited - low precipitation

Rangeland equipment: slight

Fences: slight

Unsurfaced roads: moderate - low strength

Shallow excavations: slight

Sand: unsuited

Gravel: unsuited

Pond reservoir areas: severe - seepage

Embankments, dikes, and levees: severe - piping

Off-road motorcycle trails: slight

(Rizno Soil)

Suitability and limitations for the following use:

Rangeland seeding: unsuited - low precipitation, droughty

Rangeland equipment: severe - depth to rock

Fences: severe - depth to rock

Unsurfaced roads: severe - depth to rock

Shallow excavations: severe - depth to rock

Sand: unsuited

Gravel: unsuited

Pond reservoir areas: severe - depth to rock

Embankments, dikes and levees: severe - thin layer
Off-road motorcycle trail: slight

APPENDIX 2A

COMPUTER BACKUP DATA

FOR

TABLE 3

```
DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD7
  ject Title          = UD-1 10/6                                                :
:WATERSHED HYDROGRAPH                                                            :
:      Inflow into structure #  1                                                :
:      Structure type:          Null                                             :
:                                                                                :
:                                                                                :
:-- Watershed data for watershed # 1                                             :
:     Curve number            =    82.0                                          :
:     Area                    =  2990.4 acres                                    :
:     Hydraulic length        =    0.00 feet                                     :
:     Elevation change        =     0.0 feet.                                    :
:     Concentration time      =    2.60 hours                                    :
:     Unit hydrograph type = Disturbed                                           :
:                                                                                :
:-- Total Area               =  2990.4 acres                                     :
:                                                                                :
:-- Storm data                                                                   :
:     Total precipitation     =      1.5 inches                                  :
:     Storm type              = SCS 6 hour design storm                          :
:     Peak Discharge          =  249.57 cfs                                      :
:     Discharge volume        =   88.88 acre ft                                  :
:                                                                                :
: <press return to continue or {esc} to skip detail printout>                    :
SDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD=

     DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD7
: oject Title          = UD-1 25/10                                              :
:WATERSHED HYDROGRAPH                                                            :
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:      Structure type:          Null                                             :
:                                                                                :
:                                                                                :
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:     Curve number            =    82.0                                          :
:     Area                    =  2990.4 acres                                    :
:     Hydraulic length        =    0.00 feet                                     :
:     Elevation change        =     0.0 feet.                                    :
:     Concentration time      =    2.60 hours                                    :
:     Unit hydrograph type = Disturbed                                           :
:                                                                                :
:-- Total Area               =  2990.4 acres                                     :
:                                                                                :
:-- Storm data                                                                   :
:     Total precipitation     =      1.8 inches                                  :
:     Storm type              = SCS 6 hour design storm                          :
:     Peak Discharge          =  372.10 cfs                                      :
:     Discharge volume        =  129.80 acre ft                                  :
:                                                                                :
: <press return to continue or {esc} to skip detail printout>                    :
SDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD=
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 DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD7
: ject Title          = UD-1 100/6                                      :
:WATERSHED HYDROGRAPH                                                     :
:     Inflow into structure #  1                                          :
:     Structure type:          Null                                       :
:                                                                         :
:                                                                         :
:-- Watershed data for watershed # 1                                      :
:    Curve number           =    82.0                                     :
:    Area                   =  2990.4 acres                               :
:    Hydraulic length       =    0.00 feet                                :
:    Elevation change       =     0.0 feet.                               :
:    Concentration time     =    2.60 hours                               :
:    Unit hydrograph type = Disturbed                                     :
:                                                                         :
:-- Total Area             =  2990.4 acres                                :
:                                                                         :
:-- Storm data                                                            :
:    Total precipitation    =      2.2 inches                             :
:    Storm type             = SCS 6 hour design storm                     :
:    Peak Discharge         =  590.56 cfs                                 :
:    Discharge volume       =  200.53 acre ft                             :
:                                                                         :
: <press return to continue or {esc} to skip detail printout>            :
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 DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD7
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:                                                                         :
:-- Watershed data for watershed # 1                                      :
:    Curve number           =    82.0                                     :
:    Area                   =  2990.4 acres                               :
:    Hydraulic length       =    0.00 feet                                :
:    Elevation change       =     0.0 feet.                               :
:    Concentration time     =    2.60 hours                               :
:    Unit hydrograph type = Disturbed                                     :
:                                                                         :
:-- Total Area             =  2990.4 acres                                :
:                                                                         :
:-- Storm data                                                            :
:    Total precipitation    =      1.9 inches                             :
:    Storm type             = SCS Type 2 storm, 24 hour storm             :
:    Peak Discharge         =  413.80 cfs                                 :
:    Discharge volume       =  150.29 acre ft                             :
:                                                                         :
: <press return to continue or {esc} to skip detail printout>            :
SDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD=
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/L    DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD7
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:    Curve number            =     82.0                                      :
:    Area                    =  2990.4 acres                                 :
:    Hydraulic length        =     0.00 feet                                 :
:    Elevation change        =      0.0 feet.                                :
:    Concentration time      =     2.60 hours                                :
:    Unit hydrograph type = Disturbed                                        :
:                                                                            :
:-- Total Area              =  2990.4 acres                                  :
:                                                                            :
:-- Storm data                                                               :
:    Total precipitation     =      2.3 inches                               :
:    Storm type              = SCS Type 2 storm, 24 hour storm               :
:    Peak Discharge          =  621.66 cfs                                   :
:    Discharge volume        =  216.31 acre ft                               :
:                                                                            :
: <press return to continue or {esc} to skip detail printout>               :
SDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD=
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ſ     ⁊DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD7
:.  ect Title             = UD-2 10/6                                               :
:WATERSHED HYDROGRAPH                                                               :
:      Inflow into structure #  1                                                   :
:      Structure type:          Null                                                :
:                                                                                   :
:                                                                                   :
:-- Watershed data for watershed # 1                                                :
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:     Area                      =    64.8 acres                                     :
:     Hydraulic length          =    0.00 feet                                      :
:     Elevation change          =     0.0 feet.                                     :
:     Concentration time        =    0.25 hours                                     :
:     Unit hydrograph type = Disturbed                                              :
:                                                                                   :
:-- Total Area                =    64.8 acres                                       :
:                                                                                   :
:-- Storm data                                                                      :
:     Total precipitation       =      1.5 inches                                   :
:     Storm type                = SCS 6 hour design storm                           :
:     Peak Discharge            =   30.98 cfs                                       :
:     Discharge volume          =    3.49 acre ft                                   :
:                                                                                   :
: <press return to continue or {esc} to skip detail printout>                      :
SDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD=

ſ     DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD7
:Project Title            = UD-2 25/6                                               :
:WATERSHED HYDROGRAPH                                                               :
:      Inflow into structure #  1                                                   :
:      Structure type:          Null                                                :
:                                                                                   :
:                                                                                   :
:-- Watershed data for watershed # 1                                                :
:     Curve number              =    89.0                                           :
:     Area                      =    64.8 acres                                     :
:     Hydraulic length          =    0.00 feet                                      :
:     Elevation change          =     0.0 feet.                                     :
:     Concentration time        =    0.25 hours                                     :
:     Unit hydrograph type = Disturbed                                              :
:                                                                                   :
:-- Total Area                =    64.8 acres                                       :
:                                                                                   :
:-- Storm data                                                                      :
:     Total precipitation       =      1.8 inches                                   :
:     Storm type                = SCS 6 hour design storm                           :
:     Peak Discharge            =   42.66 cfs                                       :
:     Discharge volume          =    4.67 acre ft                                   :
:                                                                                   :
: <press return to continue or {esc} to skip detail printout>                      :
SDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD=
```

```
Project Title        = UD-2 100/6
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number            =    89.0
    Area                    =    64.8 acres
    Hydraulic length        =    0.00 feet
    Elevation change        =     0.0 feet.
    Concentration time      =    0.25 hours
    Unit hydrograph type = Disturbed

-- Total Area             =    64.8 acres

-- Storm data
    Total precipitation     =     2.2 inches
    Storm type              = SCS 6 hour design storm
    Peak Discharge          =   61.66 cfs
    Discharge volume        =    6.59 acre ft

 <press return to continue or {esc} to skip detail printout>
```

```
Project Title        = UD-2 10/24
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number            =    89.0
    Area                    =    64.8 acres
    Hydraulic length        =    0.00 feet
    Elevation change        =     0.0 feet.
    Concentration time      =    0.25 hours
    Unit hydrograph type = Disturbed

-- Total Area             =    64.8 acres

-- Storm data
    Total precipitation     =     1.9 inches
    Storm type              = SCS Type 2 storm, 24 hour storm
    Peak Discharge          =   53.76 cfs
    Discharge volume        =    5.24 acre ft

 <press return to continue or {esc} to skip detail printout>
```

```
VΓ⁻⁻DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD7
  ject Title          = UD-2 25/24                                         :
:WATERSHED HYDROGRAPH                                                       :
:      Inflow into structure #  1                                           :
:      Structure type:         Null                                         :
:                                                                           :
:                                                                           :
:-- Watershed data for watershed # 1                                        :
:     Curve number            =    89.0                                     :
:     Area                    =    64.8 acres                               :
:     Hydraulic length        =    0.00 feet                                :
:     Elevation change        =     0.0 feet.                               :
:     Concentration time      =    0.25 hours                               :
:     Unit hydrograph type = Disturbed                                      :
:                                                                           :
:-- Total Area               =    64.8 acres                                :
:                                                                           :
:-- Storm data                                                              :
:     Total precipitation     =     2.3 inches                              :
:     Storm type              = SCS Type 2 storm, 24 hour storm             :
:     Peak Discharge          =   71.93 cfs                                 :
:     Discharge volume        =    7.01 acre ft                             :
:                                                                           :
: <press return to continue or {esc} to skip detail printout>               :
SDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD=
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```
VDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD7
   ject Title         = UD-3 10/6                                          :
:WATERSHED HYDROGRAPH                                                      :
:      Inflow into structure #  1                                          :
:      Structure type:         Null                                        :
:                                                                          :
:                                                                          :
:-- Watershed data for watershed # 1                                       :
:     Curve number           =    82.0                                     :
:     Area                   =   173.3 acres                               :
:     Hydraulic length       =    0.00 feet                                :
:     Elevation change       =     0.0 feet.                               :
:     Concentration time     =    0.53 hours                               :
:     Unit hydrograph type = Disturbed                                     :
:                                                                          :
:-- Total Area             =   173.3 acres                                 :
:                                                                          :
:-- Storm data                                                             :
:     Total precipitation    =     1.5 inches                              :
:     Storm type             = SCS 6 hour design storm                     :
:     Peak Discharge         =   27.34 cfs                                 :
:     Discharge volume       =    5.15 acre ft                             :
:                                                                          :
: <press return to continue or {esc} to skip detail printout>              :
SDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD=

    DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD7
:  ject Title         = UD-3 25/6                                          :
:WATERSHED HYDROGRAPH                                                      :
:      Inflow into structure #  1                                          :
:      Structure type:         Null                                        :
:                                                                          :
:                                                                          :
:-- Watershed data for watershed # 1                                       :
:     Curve number           =    82.0                                     :
:     Area                   =   173.3 acres                               :
:     Hydraulic length       =    0.00 feet                                :
:     Elevation change       =     0.0 feet.                               :
:     Concentration time     =    0.53 hours                               :
:     Unit hydrograph type = Disturbed                                     :
:                                                                          :
:-- Total Area             =   173.3 acres                                 :
:                                                                          :
:-- Storm data                                                             :
:     Total precipitation    =     1.8 inches                              :
:     Storm type             = SCS 6 hour design storm                     :
:     Peak Discharge         =   43.89 cfs                                 :
:     Discharge volume       =    7.52 acre ft                             :
:                                                                          :
: <press return to continue or {esc} to skip detail printout>              :
SDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD=
```

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 `DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD7
: ject Title          = UD-3 100/6                                          :
:WATERSHED HYDROGRAPH                                                        :
:     Inflow into structure #  1                                             :
:     Structure type:          Null                                          :
:                                                                            :
:                                                                            :
:-- Watershed data for watershed # 1                                         :
:    Curve number           =    82.0                                        :
:    Area                   =   173.3 acres                                  :
:    Hydraulic length       =    0.00 feet                                   :
:    Elevation change       =     0.0 feet.                                  :
:    Concentration time     =    0.53 hours                                  :
:    Unit hydrograph type = Disturbed                                        :
:                                                                            :
:-- Total Area            =   173.3 acres                                    :
:                                                                            :
:-- Storm data                                                               :
:    Total precipitation    =     2.2 inches                                 :
:    Storm type             = SCS 6 hour design storm                        :
:    Peak Discharge         =   74.29 cfs                                    :
:    Discharge volume       =   11.62 acre ft                                :
:                                                                            :
: <press return to continue or {esc} to skip detail printout>                :
SDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD=

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:Project Title          = UD-3 10/24                                         :
:WATERSHED HYDROGRAPH                                                        :
:     Inflow into structure #  1                                             :
:     Structure type:          Null                                          :
:                                                                            :
:                                                                            :
:-- Watershed data for watershed # 1                                         :
:    Curve number           =    82.0                                        :
:    Area                   =   173.3 acres                                  :
:    Hydraulic length       =    0.00 feet                                   :
:    Elevation change       =     0.0 feet.                                  :
:    Concentration time     =    0.53 hours                                  :
:    Unit hydrograph type = Disturbed                                        :
:                                                                            :
:-- Total Area            =   173.3 acres                                    :
:                                                                            :
:-- Storm data                                                               :
:    Total precipitation    =     1.9 inches                                 :
:    Storm type             = SCS Type 2 storm, 24 hour storm                :
:    Peak Discharge         =   62.82 cfs                                    :
:    Discharge volume       =    8.71 acre ft                                :
:                                                                            :
: <press return to continue or {esc} to skip detail printout>                :
SDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD=
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V     DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD7
:Project Title          = UD-3 25/24                                              :
:WATERSHED HYDROGRAPH                                                             :
:      Inflow into structure #  1                                                 :
:      Structure type:          Null                                              :
:                                                                                 :
:                                                                                 :
:-- Watershed data for watershed # 1                                              :
:    Curve number           =    82.0                                             :
:    Area                   =   173.3 acres                                       :
:    Hydraulic length       =    0.00 feet                                        :
:    Elevation change       =     0.0 feet.                                       :
:    Concentration time     =    0.53 hours                                       :
:    Unit hydrograph type = Disturbed                                             :
:                                                                                 :
:-- Total Area             =    173.3 acres                                       :
:                                                                                 :
:-- Storm data                                                                    :
:    Total precipitation    =      2.3 inches                                     :
:    Storm type             = SCS Type 2 storm, 24 hour storm                     :
:    Peak Discharge         =   93.60 cfs                                         :
:    Discharge volume       =   12.53 acre ft                                     :
:                                                                                 :
: <press return to continue or {esc} to skip detail printout>                     :
SDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD=
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 DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD7
  ject Title          = UD-4 10/6                                          :
:WATERSHED HYDROGRAPH                                                      :
:     Inflow into structure #  1                                           :
:     Structure type:          Null                                        :
:                                                                          :
:                                                                          :
:-- Watershed data for watershed # 1                                       :
:    Curve number            =    84.0                                     :
:    Area                    =    20.6 acres                               :
:    Hydraulic length        =    0.00 feet                                :
:    Elevation change        =     0.0 feet.                               :
:    Concentration time      =    0.07 hours                               :
:    Unit hydrograph type = Disturbed                                      :
:                                                                          :
:-- Total Area              =    20.6 acres                                :
:                                                                          :
:-- Storm data                                                             :
:    Total precipitation   =      1.5 inches                               :
:    Storm type            = SCS 6 hour design storm                       :
:    Peak Discharge        =    7.83 cfs                                   :
:    Discharge volume      =    0.73 acre ft                               :
:                                                                          :
: <press return to continue or {esc} to skip detail printout>              :
SDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD=

 DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD7
  oject Title         = UD-4 25/6                                          :
:WATERSHED HYDROGRAPH                                                      :
:     Inflow into structure #  1                                           :
:     Structure type:          Null                                        :
:                                                                          :
:                                                                          :
:-- Watershed data for watershed # 1                                       :
:    Curve number            =    84.0                                     :
:    Area                    =    20.6 acres                               :
:    Hydraulic length        =    0.00 feet                                :
:    Elevation change        =     0.0 feet.                               :
:    Concentration time      =    0.07 hours                               :
:    Unit hydrograph type = Disturbed                                      :
:                                                                          :
:-- Total Area              =    20.6 acres                                :
:                                                                          :
:-- Storm data                                                             :
:    Total precipitation   =      1.8 inches                               :
:    Storm type            = SCS 6 hour design storm                       :
:    Peak Discharge        =   11.39 cfs                                   :
:    Discharge volume      =    1.04 acre ft                               :
:                                                                          :
: <press return to continue or {esc} to skip detail printout>              :
SDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD=
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V  DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD7
:  ,ect Title          = UD-4 100/6                                               :
:WATERSHED HYDROGRAPH                                                             :
:      Inflow into structure #  1                                                 :
:      Structure type:          Null                                              :
:                                                                                 :
:                                                                                 :
:-- Watershed data for watershed # 1                                              :
:    Curve number             =    84.0                                           :
:    Area                     =    20.6 acres                                     :
:    Hydraulic length         =    0.00 feet                                      :
:    Elevation change         =     0.0 feet.                                     :
:    Concentration time       =    0.07 hours                                     :
:    Unit hydrograph type = Disturbed                                             :
:                                                                                 :
:-- Total Area               =    20.6 acres                                      :
:                                                                                 :
:-- Storm data                                                                    :
:    Total precipitation      =     2.2 inches                                    :
:    Storm type               = SCS 6 hour design storm                           :
:    Peak Discharge           =   17.33 cfs                                       :
:    Discharge volume         =    1.57 acre ft                                   :
:                                                                                 :
: <press return to continue or {esc} to skip detail printout>                     :
SDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD=

V   DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD7
:r. ject Title          = UD-4 10/24                                              :
:WATERSHED HYDROGRAPH                                                             :
:      Inflow into structure #  1                                                 :
:      Structure type:          Null                                              :
:                                                                                 :
:                                                                                 :
:-- Watershed data for watershed # 1                                              :
:    Curve number             =    84.0                                           :
:    Area                     =    20.6 acres                                     :
:    Hydraulic length         =    0.00 feet                                      :
:    Elevation change         =     0.0 feet.                                     :
:    Concentration time       =    0.07 hours                                     :
:    Unit hydrograph type = Disturbed                                             :
:                                                                                 :
:-- Total Area               =    20.6 acres                                      :
:                                                                                 :
:-- Storm data                                                                    :
:    Total precipitation      =     1.9 inches                                    :
:    Storm type               = SCS Type 2 storm, 24 hour storm                   :
:    Peak Discharge           =   14.86 cfs                                       :
:    Discharge volume         =    1.19 acre ft                                   :
:                                                                                 :
: <press return to continue or {esc} to skip detail printout>                     :
SDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD=
```

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V⁻⁻⁻DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD7
.     ect Title          = UD-4 25/24                                          :
:WATERSHED HYDROGRAPH                                                          :
:      Inflow into structure #  1                                               :
:      Structure type:         Null                                            :
:                                                                              :
:                                                                              :
:-- Watershed data for watershed # 1                                           :
:    Curve number           =    84.0                                          :
:    Area                   =    20.6 acres                                    :
:    Hydraulic length       =    0.00 feet                                     :
:    Elevation change       =     0.0 feet.                                    :
:    Concentration time     =    0.07 hours                                    :
:    Unit hydrograph type = Disturbed                                          :
:                                                                              :
:-- Total Area             =     20.6 acres                                    :
:                                                                              :
:-- Storm data                                                                 :
:    Total precipitation    =      2.3 inches                                  :
:    Storm type             = SCS Type 2 storm, 24 hour storm                  :
:    Peak Discharge         =   20.67 cfs                                      :
:    Discharge volume       =    1.68 acre ft                                  :
:                                                                              :
: <press return to continue or {esc} to skip detail printout>                  :
SDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD=
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VΓ ⁿDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD7
.    ject Title         = UD-5 10/6                                           :
:WATERSHED HYDROGRAPH                                                         :
:     Inflow into structure #  1                                              :
:     Structure type:          Null                                           :
:                                                                             :
:                                                                             :
:-- Watershed data for watershed # 1                                          :
:    Curve number            =    86.0                                        :
:    Area                    =    27.4 acres                                  :
:    Hydraulic length        =    0.00 feet                                   :
:    Elevation change        =     0.0 feet.                                  :
:    Concentration time      =    0.08 hours                                  :
:    Unit hydrograph type = Disturbed                                         :
:                                                                             :
:-- Total Area              =    27.4 acres                                   :
:                                                                             :
:-- Storm data                                                                :
:    Total precipitation     =      1.5 inches                                :
:    Storm type              = SCS 6 hour design storm                        :
:    Peak Discharge          =   12.70 cfs                                    :
:    Discharge volume        =    1.15 acre ft                                :
:                                                                             :
: <press return to continue or {esc} to skip detail printout>                 :
SDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD=

V     )DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD7
:.  ject Title          = UD-5 25/6                                           :
:WATERSHED HYDROGRAPH                                                         :
:     Inflow into structure #  1                                              :
:     Structure type:          Null                                           :
:                                                                             :
:                                                                             :
:-- Watershed data for watershed # 1                                          :
:    Curve number            =    86.0                                        :
:    Area                    =    27.4 acres                                  :
:    Hydraulic length        =    0.00 feet                                   :
:    Elevation change        =     0.0 feet.                                  :
:    Concentration time      =    0.08 hours                                  :
:    Unit hydrograph type = Disturbed                                         :
:                                                                             :
:-- Total Area              =    27.4 acres                                   :
:                                                                             :
:-- Storm data                                                                :
:    Total precipitation     =      1.8 inches                                :
:    Storm type              = SCS 6 hour design storm                        :
:    Peak Discharge          =   17.84 cfs                                    :
:    Discharge volume        =    1.60 acre ft                                :
:                                                                             :
: <press return to continue or {esc} to skip detail printout>                 :
SDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD-
```

```
Project Title          = UD-5 100/6
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number             =    86.0
    Area                     =    27.4 acres
    Hydraulic length         =    0.00 feet
    Elevation change         =     0.0 feet.
    Concentration time       =    0.08 hours
    Unit hydrograph type = Disturbed

-- Total Area              =    27.4 acres

-- Storm data
    Total precipitation      =     2.2 inches
    Storm type               = SCS 6 hour design storm
    Peak Discharge           =   26.26 cfs
    Discharge volume         =    2.34 acre ft

 <press return to continue or {esc} to skip detail printout>
```

```
Project Title          = UD-5 10/24
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number             =    86.0
    Area                     =    27.4 acres
    Hydraulic length         =    0.00 feet
    Elevation change         =     0.0 feet.
    Concentration time       =    0.08 hours
    Unit hydrograph type = Disturbed

-- Total Area              =    27.4 acres

-- Storm data
    Total precipitation      =     1.9 inches
    Storm type               = SCS Type 2 storm, 24 hour storm
    Peak Discharge           =   22.65 cfs
    Discharge volume         =    1.82 acre ft

 <press return to continue or {esc} to skip detail printout>
```

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VI  DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD7
:: ject Title          = UD-5 25/24                                          :
:WATERSHED HYDROGRAPH                                                        :
:     Inflow into structure #  1                                             :
:     Structure type:          Null                                          :
:                                                                            :
:                                                                            :
:-- Watershed data for watershed # 1                                         :
:    Curve number           =    86.0                                        :
:    Area                   =    27.4 acres                                  :
:    Hydraulic length       =    0.00 feet                                   :
:    Elevation change       =     0.0 feet.                                  :
:    Concentration time     =    0.08 hours                                  :
:    Unit hydrograph type = Disturbed                                        :
:                                                                            :
:-- Total Area             =    27.4 acres                                   :
:                                                                            :
:-- Storm data                                                               :
:    Total precipitation    =     2.3 inches                                 :
:    Storm type             = SCS Type 2 storm, 24 hour storm                :
:    Peak Discharge         =   30.79 cfs                                    :
:    Discharge volume       =    2.51 acre ft                                :
:                                                                            :
: <press return to continue or {esc} to skip detail printout>                :
SDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD=
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DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD7
: ject Title           = UD-6 10/6
:WATERSHED HYDROGRAPH
:     Inflow into structure #  1
:     Structure type:         Null
:
:
:-- Watershed data for watershed # 1
:    Curve number            =    87.0
:    Area                    =     4.8 acres
:    Hydraulic length        =    0.00 feet
:    Elevation change        =     0.0 feet.
:    Concentration time      =    0.02 hours
:    Unit hydrograph type = Disturbed
:
:-- Total Area             =      4.8 acres
:
:-- Storm data
:    Total precipitation    =     1.5 inches
:    Storm type             = SCS 6 hour design storm
:    Peak Discharge          =    1.83 cfs
:    Discharge volume        =    0.22 acre ft
:
: <press return to continue or {esc} to skip detail printout>
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DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD7
:Project Title          = UD-6 25/6
:WATERSHED HYDROGRAPH
:     Inflow into structure #  1
:     Structure type:         Null
:
:
:   Watershed data for watershed # 1
:    Curve number            =    87.0
:    Area                    =     4.8 acres
:    Hydraulic length        =    0.00 feet
:    Elevation change        =     0.0 feet.
:    Concentration time      =    0.02 hours
:    Unit hydrograph type = Disturbed
:
:-- Total Area             =      4.8 acres
:
:-- Storm data
:    Total precipitation    =     1.8 inches
:    Storm type             = SCS 6 hour design storm
:    Peak Discharge          =    2.51 cfs
:    Discharge volume        =    0.30 acre ft
:
: <press return to continue or {esc} to skip detail printout>
SDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD=
```

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V   DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD7
:  ect Title            = UD-6 100/6                                     :
:WATERSHED HYDROGRAPH                                                    :
:      Inflow into structure #  1                                        :
:      Structure type:          Null                                     :
:                                                                        :
:                                                                        :
:-- Watershed data for watershed # 1                                     :
:     Curve number             =    87.0                                 :
:     Area                     =     4.8 acres                           :
:     Hydraulic length         =    0.00 feet                            :
:     Elevation change         =     0.0 feet.                           :
:     Concentration time       =    0.02 hours                           :
:     Unit hydrograph type = Disturbed                                   :
:                                                                        :
:-- Total Area               =      4.8 acres                            :
:                                                                        :
:-- Storm data                                                           :
:     Total precipitation      =     2.2 inches                          :
:     Storm type               = SCS 6 hour design storm                 :
:     Peak Discharge           =    3.62 cfs                             :
:     Discharge volume         =    0.43 acre ft                         :
:                                                                        :
: <press return to continue or {esc} to skip detail printout>            :
SDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD=

V    DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD7
:P. ject Title          = UD-6 10/24                                     :
:WATERSHED HYDROGRAPH                                                    :
:      Inflow into structure #  1                                        :
:      Structure type:          Null                                     :
:                                                                        :
:                                                                        :
:-- Watershed data for watershed # 1                                     :
:     Curve number             =    87.0                                 :
:     Area                     =     4.8 acres                           :
:     Hydraulic length         =    0.00 feet                            :
:     Elevation change         =     0.0 feet.                           :
:     Concentration time       =    0.02 hours                           :
:     Unit hydrograph type = Disturbed                                   :
:                                                                        :
:-- Total Area               =      4.8 acres                            :
:                                                                        :
: - Storm data                                                           :
:     Total precipitation      =     1.9 inches                          :
:     Storm type               = SCS Type 2 storm, 24 hour storm         :
:     Peak Discharge           =    3.13 cfs                             :
:     Discharge volume         =    0.34 acre ft                         :
:                                                                        :
: <press return to continue or {esc} to skip detail printout>            :
SDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD=
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 ?DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD7
.  oject Title         = UD-6 25/24                                            :
:WATERSHED HYDROGRAPH                                                           :
:     Inflow into structure #  1                                                :
:     Structure type:         Null                                              :
:                                                                               :
:                                                                               :
:-- Watershed data for watershed # 1                                            :
:    Curve number           =    87.0                                           :
:    Area                   =     4.8 acres                                     :
:    Hydraulic length       =    0.00 feet                                      :
:    Elevation change       =     0.0 feet.                                     :
:    Concentration time     =    0.02 hours                                     :
:    Unit hydrograph type = Disturbed                                           :
:                                                                               :
:-- Total Area             =     4.8 acres                                      :
:                                                                               :
:-- Storm data                                                                  :
:    Total precipitation    =     2.3 inches                                    :
:    Storm type             = SCS Type 2 storm, 24 hour storm                   :
:    Peak Discharge         =    4.18 cfs                                       :
:    Discharge volume       =    0.46 acre ft                                   :
:                                                                               :
: <press return to continue or {esc} to skip detail printout>                   :
SDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD=
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```
ÚDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD7
: roject Title          = UD-7 10/6                                        :
:WATERSHED HYDROGRAPH                                                       :
:      Inflow into structure #  1                                           :
:      Structure type:          Null                                        :
:                                                                           :
:                                                                           :
:-- Watershed data for watershed # 1                                        :
:     Curve number            =    89.0                                     :
:     Area                    =     4.8 acres                               :
:     Hydraulic length        =    0.00 feet                                :
:     Elevation change        =     0.0 feet.                               :
:     Concentration time      =    0.05 hours                               :
:     Unit hydrograph type = Disturbed                                      :
:                                                                           :
:-- Total Area               =      4.8 acres                               :
:                                                                           :
:-- Storm data                                                              :
:     Total precipitation     =     1.5 inches                              :
:     Storm type              = SCS 6 hour design storm                     :
:     Peak Discharge          =    2.76 cfs                                 :
:     Discharge volume        =    0.26 acre ft                             :
:                                                                           :
: <press return to continue or {esc} to skip detail printout>              :
SDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD=

ÚDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD7
:Project Title          = UD-7 25/6                                         :
:WATERSHED HYDROGRAPH                                                       :
:      Inflow into structure #  1                                           :
:      Structure type:          Null                                        :
:                                                                           :
:                                                                           :
:-- Watershed data for watershed # 1                                        :
:     Curve number            =    89.0                                     :
:     Area                    =     4.8 acres                               :
:     Hydraulic length        =    0.00 feet                                :
:     Elevation change        =     0.0 feet.                               :
:     Concentration time      =    0.05 hours                               :
:     Unit hydrograph type = Disturbed                                      :
:                                                                           :
:-- Total Area               =      4.8 acres                               :
:                                                                           :
:-- Storm data                                                              :
:     Total precipitation     =     1.8 inches                              :
:     Storm type              = SCS 6 hour design storm                     :
:     Peak Discharge          =    3.70 cfs                                 :
:     Discharge volume        =    0.35 acre ft                             :
:                                                                           :
: <press return to continue or {esc} to skip detail printout>              :
SDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD=
```

```
V  DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD7
   ject Title          = UD-7 100/6                                          :
.WATERSHED HYDROGRAPH                                                         :
:      Inflow into structure #  1                                             :
:      Structure type:          Null                                          :
:                                                                             :
:                                                                             :
:-- Watershed data for watershed # 1                                          :
:     Curve number           =    89.0                                        :
:     Area                   =     4.8 acres                                  :
:     Hydraulic length       =    0.00 feet                                   :
:     Elevation change       =     0.0 feet.                                  :
:     Concentration time     =    0.05 hours                                  :
:     Unit hydrograph type = Disturbed                                        :
:                                                                             :
:-- Total Area              =     4.8 acres                                   :
:                                                                             :
:-- Storm data                                                                :
:     Total precipitation    =     2.2 inches                                 :
:     Storm type             = SCS 6 hour design storm                        :
:     Peak Discharge         =    5.18 cfs                                    :
:     Discharge volume       =    0.49 acre ft                                :
:                                                                             :
: <press return to continue or {esc} to skip detail printout>                 :
SDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD=

    DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD7
   ject Title          = UD-7 10/24                                          :
:WATERSHED HYDROGRAPH                                                         :
:      Inflow into structure #  1                                             :
:      Structure type:          Null                                          :
:                                                                             :
:                                                                             :
:-- Watershed data for watershed # 1                                          :
:     Curve number           =    89.0                                        :
:     Area                   =     4.8 acres                                  :
:     Hydraulic length       =    0.00 feet                                   :
:     Elevation change       =     0.0 feet.                                  :
:     Concentration time     =    0.05 hours                                  :
:     Unit hydrograph type = Disturbed                                        :
:                                                                             :
:-- Total Area              =     4.8 acres                                   :
:                                                                             :
:-- Storm data                                                                :
:     Total precipitation    =     1.9 inches                                 :
:     Storm type             = SCS Type 2 storm, 24 hour storm                :
:     Peak Discharge         =    4.50 cfs                                    :
:     Discharge volume       =    0.39 acre ft                                :
:                                                                             :
: <press return to continue or {esc} to skip detail printout>                 :
SDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD=
```

APPENDIX 2C

COMPUTER BACKUP DATA

FOR

TABLE 9

Title of run: D-1 (MIN)

Solving for................=	Depth Normal	
Trapedeziod		
Flow depth (ft)............=	0.78	
First Side slope...........=	2.0	
Second Side slope..........=	2.0	
Bottom width (ft)..........=	0.10	
Slope of diversion.........=	0.0050	
Manning"s n................=	0.025	
CFS........................=	2.73	
Cross section area (sqft)..=	1.28	
Hydrualic radius...........=	0.36	
fps........................=	2.13	
Froude number..............=	0.63	

```
Title of run: D-1 (MAX)
   Solving for................= Depth Normal
Trapedeziod
   Flow depth (ft)............=    0.59
   First Side slope...........=     2.0
   Second Side slope..........=     2.0
   Bottom width (ft)..........=    0.10
   Slope of diversion.........=  0.0200
   Manning"s n................=   0.025
   CFS........................=    2.73
   Cross section area (sqft)..=    0.76
   Hydrualic radius...........=    0.28
   fps........................=    3.58
   Froude number..............=    1.20
```

Title of run: D-2 (MIN)

Solving for................= Depth Normal

Trapedeziod

Flow depth (ft)............=	0.41
First Side slope...........=	2.0
Second Side slope..........=	2.0
Bottom width (ft)..........=	0.10
Slope of diversion.........=	0.0050
Manning"s n................=	0.025
CFS........................=	0.55
Cross section area (sqft)..=	0.39
Hydrualic radius...........=	0.20
fps........................=	1.43
Froude number..............=	0.57

```
Title of run: D-2 (MAX)
   Solving for................= Depth Normal
Trapedeziod
   Flow depth (ft)............=    0.33
   First Side slope...........=     2.0
   Second Side slope..........=     2.0
   Bottom width (ft)..........=    0.10
   Slope of diversion.........=  0.0150
   Manning"s n................=   0.025
   CFS........................=    0.55
   Cross section area (sqft)..=    0.26
   Hydrualic radius...........=    0.16
   fps........................=    2.16
   Froude number..............=    0.95
```

Title of run: D-3 (MIN)

Solving for................=	Depth Normal
Trapedeziod	
Flow depth (ft)............=	1.02
First Side slope...........=	2.0
Second Side slope..........=	2.0
Bottom width (ft)..........=	0.10
Slope of diversion.........=	0.0050
Manning"s n................=	0.025
CFS........................=	5.59
Cross section area (sqft)..=	2.20
Hydrualic radius...........=	0.47
fps........................=	2.55
Froude number..............=	0.65

Title of run: D-3 (MAX)

Solving for.................=	Depth Normal
Trapedeziod	
Flow depth (ft)............=	0.83
First Side slope...........=	2.0
Second Side slope..........=	2.0
Bottom width (ft)..........=	0.10
Slope of diversion.........=	0.0150
Manning"s n................=	0.025
CFS........................=	5.59
Cross section area (sqft)..=	1.45
Hydrualic radius...........=	0.38
fps........................=	3.85
Froude number..............=	1.10

```
Title of run: D-4 (MIN)
   Solving for................= Depth Normal
Trapedeziod
   Flow depth (ft)............=    1.15
   First Side slope...........=     2.0
   Second Side slope..........=     2.0
   Bottom width (ft)..........=    0.10
   Slope of diversion.........=  0.0050
   Manning"s n................=   0.025
   CFS........................=    7.51
   Cross section area (sqft)..=    2.74
   Hydrualic radius...........=    0.52
   fps........................=    2.74
   Froude number..............=    0.67
```

Title of run: D-4 (MAX)

Solving for................=	Depth Normal

Trapedeziod

Flow depth (ft)............=	0.93
First Side slope...........=	2.0
Second Side slope..........=	2.0
Bottom width (ft)..........=	0.10
Slope of diversion.........=	0.0150
Manning"s n................=	0.025
CFS........................=	7.51
Cross section area (sqft)..=	1.81
Hydrualic radius...........=	0.43
fps........................=	4.14
Froude number..............=	1.12

Title of run: D-5 (MIN)

```
   Solving for................= Depth Normal
Trapedeziod
   Flow depth (ft)............=    1.45
   First Side slope...........=     2.0
   Second Side slope..........=     2.0
   Bottom width (ft)..........=    0.10
   Slope of diversion.........=  0.0050
   Manning"s n................=   0.025
   CFS........................=   13.96
   Cross section area (sqft)..=    4.36
   Hydrualic radius...........=    0.66
   fps........................=    3.20
   Froude number..............=    0.69
```

Title of run: D-5 (MAX)

```
   Solving for................= Depth Normal
Trapedeziod
   Flow depth (ft)............=    1.18
   First Side slope...........=     2.0
   Second Side slope..........=     2.0
   Bottom width (ft)..........=    0.10
   Slope of diversion.........=  0.0150
   Manning"s n................=   0.025
   CFS........................=   13.96
   Cross section area (sqft)..=    2.89
   Hydrualic radius...........=    0.54
   fps........................=    4.83
   Froude number..............=    1.16
```

Title of run: D-13 (MIN)
Solving for................= Depth Normal
Trapedeziod

Flow depth (ft)............=	0.49
First Side slope...........=	2.0
Second Side slope..........=	2.0
Bottom width (ft)..........=	0.10
Slope of diversion.........=	0.0190
Manning"s n................=	0.025
CFS........................=	1.66
Cross section area (sqft)..=	0.53
Hydrualic radius...........=	0.23
fps........................=	3.10
Froude number..............=	1.13

```
Title of run: D-13 (MAX)
   Solving for................= Depth Normal
Trapedeziod
   Flow depth (ft)............=    0.45
   First Side slope...........=     2.0
   Second Side slope..........=     2.0
   Bottom width (ft)..........=    0.10
   Slope of diversion.........=  0.0290
   Manning"s n................=   0.025
   CFS........................=    1.66
   Cross section area (sqft)..=    0.46
   Hydrualic radius...........=    0.21
   fps........................=    3.64
   Froude number..............=    1.38
```

APPENDIX 2D

COMPUTER BACKUP DATA

FOR

TABLE 9A

```
Title of run: D-6 (MIN - LINED)
   Solving for................= Depth Normal
Trapedeziod
   Flow depth (ft)............=    0.73
   First Side slope...........=     2.0
   Second Side slope..........=     2.0
   Bottom width (ft)..........=    0.10
   Slope of diversion.........=  0.0550
   Manning"s n................=   0.015
   CFS........................=   12.71
   Cross section area (sqft)..=    1.13
   Hydrualic radius...........=    0.34
   fps........................=   11.27
   Froude number..............=    3.42
```

Title of run: D-6 (MAX - LINED)

Solving for................= Depth Normal

Trapedeziod

Flow depth (ft)............=	0.70
First Side slope...........=	2.0
Second Side slope..........=	2.0
Bottom width (ft)..........=	0.10
Slope of diversion.........=	0.0650
Manning"s n................=	0.015
CFS........................=	12.71
Cross section area (sqft)..=	1.06
Hydrualic radius...........=	0.33
fps........................=	12.00
Froude number..............=	3.70

Title of run: D-7 (MIN - LINED)

Solving for................=	Depth Normal

Trapedeziod

Flow depth (ft)............=	0.99
First Side slope...........=	2.0
Second Side slope..........=	2.0
Bottom width (ft)..........=	0.10
Slope of diversion.........=	0.0160
Manning"s n................=	0.015
CFS........................=	15.41
Cross section area (sqft)..=	2.07
Hydrualic radius...........=	0.46
fps........................=	7.44
Froude number..............=	1.94

Title of run: D-7 (MAX - LINED)

Solving for................= Depth Normal

Trapedeziod

Flow depth (ft)............=	0.90
First Side slope...........=	2.0
Second Side slope..........=	2.0
Bottom width (ft)..........=	0.10
Slope of diversion.........=	0.0260
Manning"s n................=	0.015
CFS........................=	15.41
Cross section area (sqft)..=	1.73
Hydrualic radius...........=	0.42
fps........................=	8.93
Froude number..............=	2.44

Title of run: D-8 (MIN - LINED)

Solving for................=	Depth Normal
Trapedeziod	
Flow depth (ft)............=	1.27
First Side slope...........=	2.0
Second Side slope..........=	2.0
Bottom width (ft)..........=	0.10
Slope of diversion.........=	0.0160
Manning"s n................=	0.015
CFS........................=	29.21
Cross section area (sqft)..=	3.34
Hydrualic radius...........=	0.58
fps........................=	8.73
Froude number..............=	2.02

Title of run: D-8 (MAX - LINED)

Solving for................=	Depth Normal
Trapedeziod	
Flow depth (ft)............=	1.09
First Side slope...........=	2.0
Second Side slope..........=	2.0
Bottom width (ft)..........=	0.10
Slope of diversion.........=	0.0360
Manning"s n................=	0.015
CFS........................=	29.21
Cross section area (sqft)..=	2.47
Hydrualic radius...........=	0.50
fps........................=	11.84
Froude number..............=	2.96

Title of run: D-9 (MIN - LINED)

Solving for................=	Depth Normal
Trapedeziod	
Flow depth (ft)............=	1.50
First Side slope...........=	2.0
Second Side slope..........=	2.0
Bottom width (ft)..........=	0.10
Slope of diversion.........=	0.0160
Manning"s n................=	0.015
CFS........................=	45.20
Cross section area (sqft)..=	4.64
Hydrualic radius...........=	0.68
fps........................=	9.74
Froude number..............=	2.08

Title of run: D-9 (MAX - LINED)

Solving for................=	Depth Normal
Trapedeziod	
Flow depth (ft)............=	1.37
First Side slope...........=	2.0
Second Side slope..........=	2.0
Bottom width (ft)..........=	0.10
Slope of diversion.........=	0.0260
Manning"s n................=	0.015
CFS........................=	45.20
Cross section area (sqft)..=	3.87
Hydrualic radius...........=	0.62
fps........................=	11.68
Froude number..............=	2.61

```
Title of run: D-10 (MIN - LINED)
   Solving for...............= Depth Normal
Trapedeziod
   Flow depth (ft)...........=    0.87
   First Side slope..........=     2.0
   Second Side slope.........=     2.0
   Bottom width (ft).........=    0.10
   Slope of diversion........=  0.0160
   Manning"s n...............=   0.015
   CFS.......................=   10.92
   Cross section area (sqft)..=   1.60
   Hydrualic radius..........=    0.40
   fps.......................=    6.83
   Froude number.............=    1.90
```

Title of run: D-10 (MAX - LINED)

Solving for................= Depth Normal

Trapedeziod

Flow depth (ft)............=	0.79
First Side slope...........=	2.0
Second Side slope..........=	2.0
Bottom width (ft)..........=	0.10
Slope of diversion.........=	0.0260
Manning"s n................=	0.015
CFS........................=	10.92
Cross section area (sqft)..=	1.33
Hydrualic radius...........=	0.37
fps........................=	8.20
Froude number..............=	2.39

```
Title of run: D-11 (MIN - LINED)
   Solving for................= Depth Normal
Trapedeziod
   Flow depth (ft)............=    0.43
   First Side slope...........=     2.0
   Second Side slope..........=     2.0
   Bottom width (ft)..........=    0.10
   Slope of diversion.........=  0.0450
   Manning"s n................=   0.015
   CFS........................=    2.94
   Cross section area (sqft)..=    0.41
   Hydrualic radius...........=    0.20
   fps........................=    7.26
   Froude number..............=    2.85
```

Title of run: D-11 (MAX - LINED)

Solving for................=	Depth Normal
Trapedeziod	
Flow depth (ft)............=	0.41
First Side slope...........=	2.0
Second Side slope..........=	2.0
Bottom width (ft)..........=	0.10
Slope of diversion.........=	0.0550
Manning"s n................=	0.015
CFS........................=	2.94
Cross section area (sqft)..=	0.38
Hydrualic radius...........=	0.19
fps........................=	7.83
Froude number..............=	3.13

Title of run: D-12 (MIN - LINED)

Solving for................=	Depth Normal
Trapedeziod	
Flow depth (ft)............=	1.18
First Side slope...........=	2.0
Second Side slope..........=	2.0
Bottom width (ft)..........=	0.10
Slope of diversion.........=	0.0950
Manning"s n................=	0.015
CFS........................=	59.43
Cross section area (sqft)..=	2.92
Hydrualic radius...........=	0.54
fps........................=	20.34
Froude number..............=	4.87

```
Title of run: D-12 (MAX - LINED)
   Solving for................= Depth Normal
Trapedeziod
   Flow depth (ft)............=    1.11
   First Side slope...........=     2.0
   Second Side slope..........=     2.0
   Bottom width (ft)..........=    0.10
   Slope of diversion.........=  0.1340
   Manning"s n................=   0.015
   CFS........................=   59.43
   Cross section area (sqft)..=    2.57
   Hydrualic radius...........=    0.51
   fps........................=   23.15
   Froude number..............=    5.72
```

APPENDIX 2E

COMPUTER BACKUP DATA

FOR

TABLE 10A

```
_DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD7
:Project Title          = C-9 100/6                                          :
:WATERSHED HYDROGRAPH                                                        :
:     Inflow into structure #  1                                             :
:     Structure type:         Null                                           :
:                                                                            :
:                                                                            :
:-- Watershed data for watershed # 1                                         :
:    Curve number            =    90.0                                       :
:    Area                    =    39.6 acres                                 :
:    Hydraulic length        =    0.00 feet                                  :
:    Elevation change        =     0.0 feet.                                 :
:    Concentration time      =    0.04 hours                                 :
:    Unit hydrograph type = Disturbed                                        :
:                                                                            :
:-- Total Area              =    39.6 acres                                  :
:                                                                            :
:-- Storm data                                                               :
:    Total precipitation     =     2.2 inches                                :
:    Storm type              = SCS 6 hour design storm                       :
:    Peak Discharge          =   42.68 cfs                                   :
:    Discharge volume        =    4.26 acre ft                               :
:                                                                            :
: <press return to continue or {esc} to skip detail printout>                :
SDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD=

VDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD7
:Project Title          = C-10 100/6                                         :
:WATERSHED HYDROGRAPH                                                        :
:     Inflow into structure #  1                                             :
:     Structure type:         Null                                           :
:                                                                            :
:                                                                            :
:-- Watershed data for watershed # 1                                         :
:    Curve number            =    90.0                                       :
:    Area                    =     1.1 acres                                 :
:    Hydraulic length        =    0.00 feet                                  :
:    Elevation change        =     0.0 feet.                                 :
:    Concentration time      =    0.02 hours                                 :
:    Unit hydrograph type = Disturbed                                        :
:                                                                            :
:-- Total Area              =     1.1 acres                                  :
:                                                                            :
:-- Storm data                                                               :
:    Total precipitation     =     2.2 inches                                :
:    Storm type              = SCS 6 hour design storm                       :
:    Peak Discharge          =    0.98 cfs                                   :
:    Discharge volume        =    0.12 acre ft                               :
:                                                                            :
: <press return to continue or {esc} to skip detail printout>                :
SDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD=
```

```
VDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD7
:Project Title          = C-6 10/6                                              :
:WATERSHED HYDROGRAPH                                                           :
:      Inflow into structure #  1                                               :
:      Structure type:          Null                                            :
:                                                                               :
:                                                                               :
:-- Watershed data for watershed # 1                                            :
:    Curve number            =    90.0                                          :
:    Area                    =     6.3 acres                                    :
:    Hydraulic length        =    0.00 feet                                     :
:    Elevation change        =     0.0 feet.                                    :
:    Concentration time      =    0.18 hours                                    :
:    Unit hydrograph type = Disturbed                                           :
:                                                                               :
   Total Area              =      6.3 acres                                     :
                                                                                :
:-- Storm data                                                                  :
:    Total precipitation     =      1.5 inches                                  :
:    Storm type              = SCS 6 hour design storm                          :
:    Peak Discharge          =    3.47 cfs                                      :
:    Discharge volume        =    0.37 acre ft                                  :
:                                                                               :
: <press return to continue or {esc} to skip detail printout>                   :
SDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD=
```

APPENDIX 2F

COMPUTER BACKUP DATA

FOR

TABLE 11

Title of run: D-12 (MIN)
Solving for................= Depth Normal
Trapedeziod

Flow depth (ft)............=	1.50
First Side slope...........=	2.0
Second Side slope..........=	2.0
Bottom width (ft)..........=	0.10
Slope of diversion.........=	0.0950
Manning"s n................=	0.015
CFS........................=	111.31
Cross section area (sqft)..=	4.68
Hydrualic radius...........=	0.69
fps........................=	23.79
Froude number..............=	5.07

Title of run: D-12 (MAX)

Solving for................=	Depth Normal
Trapedeziod	
Flow depth (ft)............=	1.41
First Side slope...........=	2.0
Second Side slope..........=	2.0
Bottom width (ft)..........=	0.10
Slope of diversion.........=	0.1340
Manning"s n................=	0.015
CFS........................=	111.31
Cross section area (sqft)..=	4.11
Hydrualic radius...........=	0.64
fps........................=	27.07
Froude number..............=	5.95

```
Title of run: D-13 (MIN)
   Solving for...............= Depth Normal
Trapedeziod
   Flow depth (ft)...........=    0.63
   First Side slope..........=     2.0
   Second Side slope.........=     2.0
   Bottom width (ft).........=    0.10
   Slope of diversion........=  0.0190
   Manning"s n...............=   0.025
   CFS.......................=    3.13
   Cross section area (sqft)..=   0.86
   Hydrualic radius..........=    0.29
   fps.......................=    3.64
   Froude number.............=    1.18
```

Title of run: D-13 (MAX)

Solving for................=	Depth Normal
Trapedeziod	
Flow depth (ft)............=	0.58
First Side slope...........=	2.0
Second Side slope..........=	2.0
Bottom width (ft)..........=	0.10
Slope of diversion.........=	0.0290
Manning"s n................=	0.025
CFS........................=	3.13
Cross section area (sqft)..=	0.73
Hydrualic radius...........=	0.27
fps........................=	4.26
Froude number..............=	1.44

APPENDIX 2G

COMPUTER BACKUP DATA

FOR

TABLE 15A

```
VDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD7
:Project Title          = RD-1 10/6                                           :
:WATERSHED HYDROGRAPH                                                         :
:     Inflow into structure #  1                                              :
:     Structure type:          Null                                           :
:                                                                             :
:                                                                             :
:-- Watershed data for watershed # 1                                          :
:    Curve number            =    90.0                                        :
:    Area                    =     3.8 acres                                  :
:    Hydraulic length        =    0.00 feet                                   :
:    Elevation change        =     0.0 feet.                                  :
:    Concentration time      =    0.05 hours                                  :
:    Unit hydrograph type = Disturbed                                         :
:                                                                             :
:-- Total Area              =     3.8 acres                                   :
:                                                                             :
:-- Storm data                                                                :
:    Total precipitation     =     1.5 inches                                 :
:    Storm type              = SCS 6 hour design storm                        :
:    Peak Discharge          =    2.37 cfs                                    :
:    Discharge volume        =    0.22 acre ft                                :
:                                                                             :
:   ress return to continue or {esc} to skip detail printout>                 :
SDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD=

VDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD7
:Project Title          = RD-1 100/6                                          :
:WATERSHED HYDROGRAPH                                                         :
:     Inflow into structure #  1                                              :
:     Structure type:          Null                                           :
:                                                                             :
:                                                                             :
:-- Watershed data for watershed # 1                                          :
:    Curve number            =    90.0                                        :
:    Area                    =     3.8 acres                                  :
:    Hydraulic length        =    0.00 feet                                   :
:    Elevation change        =     0.0 feet.                                  :
:    Concentration time      =    0.05 hours                                  :
:    Unit hydrograph type = Disturbed                                         :
:                                                                             :
:-- Total Area              =     3.8 acres                                   :
:                                                                             :
:-- Storm data                                                                :
:    Total precipitation     =     2.2 inches                                 :
:    Storm type              = SCS 6 hour design storm                        :
:    Peak Discharge          =    4.31 cfs                                    :
:    Discharge volume        =    0.41 acre ft                                :
:                                                                             :
:  press return to continue or {esc} to skip detail printout>                 :
SDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD=
```

```
VDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD7
:Project Title          = RD-2 10/6                                             :
:WATERSHED HYDROGRAPH                                                           :
:     Inflow into structure #  1                                                :
:     Structure type:         Null                                              :
:                                                                               :
:                                                                               :
:-- Watershed data for watershed # 1                                            :
:    Curve number            =    90.0                                          :
:    Area                    =     6.7 acres                                    :
:    Hydraulic length        =    0.00 feet                                     :
:    Elevation change        =     0.0 feet.                                    :
:    Concentration time      =    0.06 hours                                    :
:    Unit hydrograph type = Disturbed                                           :
:                                                                               :
:-- Total Area              =     6.7 acres                                     :
:                                                                               :
:-- Storm data                                                                  :
:    Total precipitation     =     1.5 inches                                   :
:    Storm type              = SCS 6 hour design storm                          :
:    Peak Discharge          =    4.27 cfs                                      :
:    Discharge volume        =    0.39 acre ft                                  :
:                                                                               :
:    ess return to continue or {esc} to skip detail printout>                   :
SDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD=

VDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD7
:Project Title          = RD-2 100/6                                            :
:WATERSHED HYDROGRAPH                                                           :
:     Inflow into structure #  1                                                :
:     Structure type:         Null                                              :
:                                                                               :
:                                                                               :
:-- Watershed data for watershed # 1                                            :
:    Curve number            =    90.0                                          :
:    Area                    =     6.7 acres                                    :
:    Hydraulic length        =    0.00 feet                                     :
:    Elevation change        =     0.0 feet.                                    :
:    Concentration time      =    0.06 hours                                    :
:    Unit hydrograph type = Disturbed                                           :
:                                                                               :
:-- Total Area              =     6.7 acres                                     :
:                                                                               :
:-- Storm data                                                                  :
:    Total precipitation     =     2.2 inches                                   :
:    Storm type              = SCS 6 hour design storm                          :
:    Peak Discharge          =    7.78 cfs                                      :
:    Discharge volume        =    0.72 acre ft                                  :
:                                                                               :
    ess return to continue or {esc} to skip detail printout>                    :
SDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD=
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```
VDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD7
:Project Title          = RD-3 10/6                                               :
:WATERSHED HYDROGRAPH                                                             :
:     Inflow into structure #  1                                                  :
:     Structure type:          Null                                               :
:                                                                                 :
:                                                                                 :
:-- Watershed data for watershed # 1                                              :
:    Curve number             =    90.0                                           :
:    Area                     =     8.7 acres                                     :
:    Hydraulic length         =    0.00 feet                                      :
:    Elevation change         =     0.0 feet.                                     :
:    Concentration time       =    0.07 hours                                     :
:    Unit hydrograph type = Disturbed                                             :
:                                                                                 :
:-- Total Area               =     8.7 acres                                      :
:                                                                                 :
:-- Storm data                                                                    :
:    Total precipitation      =     1.5 inches                                    :
:    Storm type               = SCS 6 hour design storm                           :
:    Peak Discharge           =    5.59 cfs                                       :
:    Discharge volume         =    0.50 acre ft                                   :
:                                                                                 :
    ress return to continue or {esc} to skip detail printout>                     :
DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD=

VDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD7
:Project Title          = RD-3 100/6                                              :
:WATERSHED HYDROGRAPH                                                             :
:     Inflow into structure #  1                                                  :
:     Structure type:          Null                                               :
:                                                                                 :
:                                                                                 :
:-- Watershed data for watershed # 1                                              :
:    Curve number             =    90.0                                           :
:    Area                     =     8.7 acres                                     :
:    Hydraulic length         =    0.00 feet                                      :
:    Elevation change         =     0.0 feet.                                     :
:    Concentration time       =    0.07 hours                                     :
:    Unit hydrograph type = Disturbed                                             :
:                                                                                 :
:-- Total Area               =     8.7 acres                                      :
:                                                                                 :
:-- Storm data                                                                    :
:    Total precipitation      =     2.2 inches                                    :
:    Storm type               = SCS 6 hour design storm                           :
:    Peak Discharge           =   10.20 cfs                                       :
:    Discharge volume         =    0.93 acre ft                                   :
:                                                                                 :
    ress return to continue or {esc} to skip detail printout>                     :
SDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD=
```

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VDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD7
:Project Title          = RD-4 10/6                                               :
:WATERSHED HYDROGRAPH                                                             :
:     Inflow into structure #  1                                                  :
:     Structure type:          Null                                               :
:                                                                                 :
:                                                                                 :
:-- Watershed data for watershed # 1                                              :
:    Curve number            =     90.0                                           :
:    Area                    =      8.5 acres                                     :
:    Hydraulic length        =     0.00 feet                                      :
:    Elevation change        =      0.0 feet.                                     :
:    Concentration time      =     0.07 hours                                     :
:    Unit hydrograph type = Disturbed                                             :
:                                                                                 :
:-- Total Area              =      8.5 acres                                      :
:                                                                                 :
:-- Storm data                                                                    :
:    Total precipitation     =      1.5 inches                                    :
:    Storm type              = SCS 6 hour design storm                            :
:    Peak Discharge          =     5.49 cfs                                       :
:    Discharge volume        =     0.50 acre ft                                   :
:                                                                                 :
:   ress return to continue or {esc} to skip detail printout>                     :
SDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD=

VDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD7
:Project Title          = RD-4 100/6                                              :
:WATERSHED HYDROGRAPH                                                             :
:     Inflow into structure #  1                                                  :
:     Structure type:          Null                                               :
:                                                                                 :
:                                                                                 :
:   Watershed data for watershed # 1                                              :
:    Curve number            =     90.0                                           :
:    Area                    =      8.5 acres                                     :
:    Hydraulic length        =     0.00 feet                                      :
:    Elevation change        =      0.0 feet.                                     :
:    Concentration time      =     0.07 hours                                     :
:    Unit hydrograph type = Disturbed                                             :
:                                                                                 :
:-- Total Area              =      8.5 acres                                      :
:                                                                                 :
:-- Storm data                                                                    :
:    Total precipitation     =      2.2 inches                                    :
:    Storm type              = SCS 6 hour design storm                            :
:    Peak Discharge          =    10.02 cfs                                       :
:    Discharge volume        =     0.92 acre ft                                   :
:                                                                                 :
:   ress return to continue or {esc} to skip detail printout>                     :
SDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD=
```

```
VDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD7
:Project Title          = RD-5 10/6                                                        :
:WATERSHED HYDROGRAPH                                                                       :
:      Inflow into structure #  1                                                          :
:      Structure type:          Null                                                       :
:                                                                                           :
:                                                                                           :
:-- Watershed data for watershed # 1                                                        :
:     Curve number            =     90.0                                                    :
:     Area                    =     25.5 acres                                              :
:     Hydraulic length        =     0.00 feet                                               :
:     Elevation change        =      0.0 feet.                                              :
:     Concentration time      =     0.03 hours                                              :
:     Unit hydrograph type = Disturbed                                                      :
:                                                                                           :
:-- Total Area               =    25.5 acres                                                :
:                                                                                           :
:-- Storm data                                                                              :
:     Total precipitation     =      1.5 inches                                             :
:     Storm type              = SCS 6 hour design storm                                     :
:     Peak Discharge          =    13.93 cfs                                                :
:     Discharge volume        =     1.49 acre ft                                            :
:                                                                                           :
   ress return to continue or {esc} to skip detail printout>                                :
    DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD=

VDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD7
:Project Title          = RD-5 100/6                                                       :
:WATERSHED HYDROGRAPH                                                                       :
:      Inflow into structure #  1                                                          :
:      Structure type:          Null                                                       :
:                                                                                           :
:                                                                                           :
:-- Watershed data for watershed # 1                                                        :
:     Curve number            =     90.0                                                    :
:     Area                    =     25.5 acres                                              :
:     Hydraulic length        =     0.00 feet                                               :
:     Elevation change        =      0.0 feet.                                              :
:     Concentration time      =     0.03 hours                                              :
:     Unit hydrograph type = Disturbed                                                      :
:                                                                                           :
:-- Total Area               =    25.5 acres                                                :
:                                                                                           :
:-- Storm data                                                                              :
:     Total precipitation     =      2.2 inches                                             :
:     Storm type              = SCS 6 hour design storm                                     :
:     Peak Discharge          =    25.30 cfs                                                :
:     Discharge volume        =     2.75 acre ft                                            :
:                                                                                           :
    ss return to continue or {esc} to skip detail printout>                                 :
    DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD=
```

```
Project Title            = RD-6 10/6
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number            =     90.0
    Area                    =      2.2 acres
    Hydraulic length        =     0.00 feet
    Elevation change        =      0.0 feet.
    Concentration time      =     0.08 hours
    Unit hydrograph type = Disturbed

-- Total Area              =      2.2 acres

-- Storm data
    Total precipitation     =      1.5 inches
    Storm type              = SCS 6 hour design storm
    Peak Discharge          =     1.44 cfs
    Discharge volume        =     0.13 acre ft

     ss return to continue or {esc} to skip detail printout>
```

```
Project Title            = RD-6 100/6
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


   Watershed data for watershed # 1
    Curve number            =     90.0
    Area                    =      2.2 acres
    Hydraulic length        =     0.00 feet
    Elevation change        =      0.0 feet.
    Concentration time      =     0.08 hours
    Unit hydrograph type = Disturbed

-- Total Area              =      2.2 acres

   Storm data
    Total precipitation     =      2.2 inches
    Storm type              = SCS 6 hour design storm
    Peak Discharge          -     2.63 cfs
    Discharge volume        =     0.24 acre ft

     ss return to continue or {esc} to skip detail printout>
```

```
VDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD7
:Project Title          = RD-7 10/6                                             :
:WATERSHED HYDROGRAPH                                                           :
:     Inflow into structure #  1                                                :
:     Structure type:         Null                                              :
:                                                                               :
:                                                                               :
:-- Watershed data for watershed # 1                                            :
:    Curve number            =     90.0                                         :
:    Area                    =      7.9 acres                                   :
:    Hydraulic length        =     0.00 feet                                    :
:    Elevation change        =      0.0 feet.                                   :
:    Concentration time      =     0.07 hours                                   :
:    Unit hydrograph type = Disturbed                                           :
:                                                                               :
:-- Total Area              =      7.9 acres                                    :
:                                                                               :
:-- Storm data                                                                  :
:    Total precipitation     =      1.5 inches                                  :
:    Storm type              = SCS 6 hour design storm                          :
:    Peak Discharge          =     5.12 cfs                                     :
:    Discharge volume        =     0.46 acre ft                                 :
:                                                                               :
:    ess return to continue or {esc} to skip detail printout>                   :
SDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD=

VDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD7
:Project Title          = RD-7 100/6                                            :
:WATERSHED HYDROGRAPH                                                           :
:     Inflow into structure #  1                                                :
:     Structure type:         Null                                              :
:                                                                               :
:                                                                               :
:-- Watershed data for watershed # 1                                            :
:    Curve number            =     90.0                                         :
:    Area                    =      7.9 acres                                   :
:    Hydraulic length        =     0.00 feet                                    :
:    Elevation change        =      0.0 feet.                                   :
:    Concentration time      =     0.07 hours                                   :
:    Unit hydrograph type = Disturbed                                           :
:                                                                               :
:   Total Area              =      7.9 acres                                    :
:                                                                               :
:-- Storm data                                                                  :
:    Total precipitation     =      2.2 inches                                  :
:    Storm type              = SCS 6 hour design storm                          :
:    Peak Discharge          =     9.36 cfs                                     :
:    Discharge volume              0.86 acre ft                                 :
:                                                                               :
     ess return to continue or {esc} to skip detail printout>                   :
SDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD=
```

```
:Project Title            = RD-8 10/6
:WATERSHED HYDROGRAPH
:      Inflow into structure #  1
:      Structure type:          Null
:
:
:-- Watershed data for watershed # 1
:     Curve number              =     90.0
:     Area                      =      1.2 acres
:     Hydraulic length          =     0.00 feet
:     Elevation change          =      0.0 feet.
:     Concentration time        =     0.03 hours
:     Unit hydrograph type = Disturbed
:
:-- Total Area                 =      1.2 acres
:
:-- Storm data
:     Total precipitation       =      1.5 inches
:     Storm type                = SCS 6 hour design storm
:     Peak Discharge            =     0.65 cfs
:     Discharge volume          =     0.07 acre ft
:
:     ess return to continue or {esc} to skip detail printout>
```

```
:Project Title            = RD-8 100/6
:WATERSHED HYDROGRAPH
:      Inflow into structure #  1
:      Structure type:          Null
:
:
:-- Watershed data for watershed # 1
:     Curve number              =     90.0
:     Area                      =      1.2 acres
:     Hydraulic length          =     0.00 feet
:     Elevation change          =      0.0 feet.
:     Concentration time        =     0.03 hours
:     Unit hydrograph type = Disturbed
:
:-- Total Area                 =      1.2 acres
:
:-- Storm data
:     Total precipitation       =      2.2 inches
:     Storm type                = SCS 6 hour design storm
:     Peak Discharge            =     1.18 cfs
:     Discharge volume          =     0.13 acre ft
:
     ess return to continue or {esc} to skip detail printout>
```

```
:Project Title            = RD-9 10/6
:WATERSHED HYDROGRAPH
:     Inflow into structure #  1
:     Structure type:          Null
:
:
:-- Watershed data for watershed # 1
:    Curve number             =    90.0
:    Area                     =     0.7 acres
:    Hydraulic length         =    0.00 feet
:    Elevation change         =     0.0 feet.
:    Concentration time       =    0.03 hours
:    Unit hydrograph type = Disturbed
:
:-- Total Area               =    0.7 acres
:
:-- Storm data
:    Total precipitation      =     1.5 inches
:    Storm type               = SCS 6 hour design storm
:    Peak Discharge           =    0.40 cfs
:    Discharge volume         =    0.04 acre ft
:
: <press return to continue or {esc} to skip detail printout>
```

```
:Project Title            = RD-9 100/6
:WATERSHED HYDROGRAPH
:     Inflow into structure #  1
:     Structure type:          Null
:
:
:-- Watershed data for watershed # 1
:    Curve number             =    90.0
:    Area                     =     0.7 acres
:    Hydraulic length         =    0.00 feet
:    Elevation change         =     0.0 feet.
:    Concentration time       =    0.03 hours
:    Unit hydrograph type = Disturbed
:
:-- Total Area               =    0.7 acres
:
:   Storm data
:    Total precipitation      =     2.2 inches
:    Storm type               = SCS 6 hour design storm
:    Peak Discharge           =    0.73 cfs
:    Discharge volume         =    0.08 acre ft
:
:    <press return to continue or {esc} to skip detail printout>
```

```
VDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD7
:Project Title          = RD-10 10/6                                            :
:WATERSHED HYDROGRAPH                                                           :
:     Inflow into structure #  1                                                :
:     Structure type:          Null                                             :
:                                                                               :
:                                                                               :
:-- Watershed data for watershed # 1                                            :
:    Curve number            =    90.0                                          :
:    Area                    =     1.1 acres                                    :
:    Hydraulic length        =    0.00 feet                                     :
:    Elevation change        =     0.0 feet.                                    :
:    Concentration time      =    0.06 hours                                    :
:    Unit hydrograph type = Disturbed                                           :
:                                                                               :
:-- Total Area              =      1.1 acres                                    :
:                                                                               :
:-- Storm data                                                                  :
:    Total precipitation     =     1.5 inches                                   :
:    Storm type              = SCS 6 hour design storm                          :
:    Peak Discharge          =    0.70 cfs                                      :
:    Discharge volume        =    0.06 acre ft                                  :
:                                                                               :
:    ess return to continue or {esc} to skip detail printout>                   :
S  DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD=

VDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD7
:Project Title          = RD-10 100/6                                           :
:WATERSHED HYDROGRAPH                                                           :
:     Inflow into structure #  1                                                :
:     Structure type:          Null                                             :
:                                                                               :
:                                                                               :
:   Watershed data for watershed # 1                                            :
:    Curve number            =    90.0                                          :
:    Area                    =     1.1 acres                                    :
:    Hydraulic length        =    0.00 feet                                     :
:    Elevation change        =     0.0 feet.                                    :
:    Concentration time      =    0.06 hours                                    :
:    Unit hydrograph type = Disturbed                                           :
:                                                                               :
:-- Total Area              =      1.1 acres                                    :
:                                                                               :
:   Storm data                                                                  :
:    Total precipitation     =     2.2 inches                                   :
:    Storm type              = SCS 6 hour design storm                          :
:    Peak Discharge          =    1.28 cfs                                      :
:    Discharge volume        =    0.12 acre ft                                  :
:                                                                               :
:    ss return to continue or {e c} to skip detail printout>                    :
S  DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD=
```

APPENDIX 2H

COMPUTER BACKUP DATA

FOR

TABLE 16

Title of run: RD-1 10/6
Solving for................= Depth Normal
Trapedeziod

Flow depth (ft)............=	0.74
First Side slope...........=	2.0
Second Side slope..........=	2.0
Bottom width (ft)..........=	0.10
Slope of diversion.........=	0.0231
Manning"s n................=	0.025
CFS........................=	5.13
Cross section area (sqft)..=	1.16
Hydrualic radius...........=	0.34
fps........................=	4.42
Froude number..............=	1.33

Title of run: RD-1 100/6

Solving for................=	Depth Normal

Trapedeziod

Flow depth (ft)............=	0.93
First Side slope...........=	2.0
Second Side slope..........=	2.0
Bottom width (ft)..........=	0.10
Slope of diversion.........=	0.0231
Manning"s n................=	0.025
CFS........................=	9.49
Cross section area (sqft)..=	1.84
Hydrualic radius...........=	0.43
fps........................=	5.16
Froude number..............=	1.39

Title of run: RD-2 10/6

Solving for................=	Depth Normal
Trapedeziod	
Flow depth (ft)............=	0.76
First Side slope...........=	2.0
Second Side slope..........=	2.0
Bottom width (ft)..........=	0.10
Slope of diversion.........=	0.0361
Manning"s n................=	0.025
CFS........................=	7.03
Cross section area (sqft)..=	1.24
Hydrualic radius...........=	0.35
fps........................=	5.66
Froude number..............=	1.68

```
Title of run: RD-2 100/6
   Solving for...............= Depth Normal
Trapedeziod
   Flow depth (ft)...........=    0.97
   First Side slope..........=     2.0
   Second Side slope.........=     2.0
   Bottom width (ft).........=    0.10
   Slope of diversion........=  0.0361
   Manning"s n...............=   0.025
   CFS.......................=   12.96
   Cross section area (sqft)..=    1.97
   Hydrualic radius..........=    0.44
   fps.......................=    6.59
   Froude number.............=    1.74
```

```
Title of run: RD-3 10/6
   Solving for................= Depth Normal
Trapedeziod
   Flow depth (ft)............=    0.88
   First Side slope...........=     2.0
   Second Side slope..........=     2.0
   Bottom width (ft)..........=    0.10
   Slope of diversion.........=  0.0423
   Manning"s n................=   0.025
   CFS........................=   10.91
   Cross section area (sqft)..=    1.63
   Hydrualic radius...........=    0.40
   fps........................=    6.70
   Froude number..............=    1.86
```

Title of run: RD-3 100/6

Solving for................= Depth Normal

Trapedeziod

Flow depth (ft)............=	1.11
First Side slope...........=	2.0
Second Side slope..........=	2.0
Bottom width (ft)..........=	0.10
Slope of diversion.........=	0.0423
Manning"s n................=	0.025
CFS........................=	20.18
Cross section area (sqft)..=	2.58
Hydrualic radius...........=	0.51
fps........................=	7.82
Froude number..............=	1.93

Title of run: RD-4 10/6

Solving for................	= Depth Normal

Trapedeziod

Flow depth (ft)............ =	0.89
First Side slope........... =	2.0
Second Side slope.......... =	2.0
Bottom width (ft).......... =	0.10
Slope of diversion......... =	0.0423
Manning"s n................ =	0.025
CFS........................ =	11.16
Cross section area (sqft).. =	1.66
Hydrualic radius........... =	0.41
fps........................ =	6.74
Froude number.............. =	1.86

```
Title of run: RD-4 100/6
   Solving for...............= Depth Normal
Trapedeziod
   Flow depth (ft)...........=    1.13
   First Side slope..........=     2.0
   Second Side slope.........=     2.0
   Bottom width (ft).........=    0.10
   Slope of diversion........=  0.0423
   Manning"s n...............=   0.025
   CFS.......................=   20.93
   Cross section area (sqft)..=   2.65
   Hydrualic radius..........=    0.52
   fps.......................=    7.89
   Froude number.............=    1.94
```

Title of run: RD-5 10/6

Solving for................= Depth Normal

Trapedeziod

Flow depth (ft)............=	1.40
First Side slope...........=	2.0
Second Side slope..........=	2.0
Bottom width (ft)..........=	0.10
Slope of diversion.........=	0.0302
Manning"s n................=	0.025
CFS........................=	31.16
Cross section area (sqft)..=	4.06
Hydrualic radius...........=	0.64
fps........................=	7.68
Froude number..............=	1.69

```
Title of run: RD-5 100/6
   Solving for................= Depth Normal
Trapedeziod
   Flow depth (ft)............=    1.78
   First Side slope...........=     2.0
   Second Side slope..........=     2.0
   Bottom width (ft)..........=    0.10
   Slope of diversion.........=  0.0302
   Manning"s n................=   0.025
   CFS........................=   58.91
   Cross section area (sqft)..=    6.55
   Hydrualic radius...........=    0.81
   fps........................=    9.00
   Froude number..............=    1.76
```

Title of run: RD-6 10/6

Solving for.................	= Depth Normal

Trapedeziod

Flow depth (ft)............	= 0.76
First Side slope...........	= 2.0
Second Side slope..........	= 2.0
Bottom width (ft)..........	= 0.10
Slope of diversion.........	= 0.0100
Manning"s n................	= 0.025
CFS........................	= 3.68
Cross section area (sqft)..	= 1.24
Hydrualic radius...........	= 0.35
fps........................	= 2.98
Froude number..............	= 0.88

Title of run: RD-6 100/6

Solving for................=	Depth Normal	
Trapedeziod		
Flow depth (ft)............=	0.97	
First Side slope...........=	2.0	
Second Side slope..........=	2.0	
Bottom width (ft)..........=	0.10	
Slope of diversion.........=	0.0100	
Manning"s n................=	0.025	
CFS........................=	6.81	
Cross section area (sqft)..=	1.96	
Hydrualic radius...........=	0.44	
fps........................=	3.47	
Froude number..............=	0.92	

```
Title of run: RD-7 10/6
   Solving for................= Depth Normal
Trapedeziod
   Flow depth (ft)............=    1.00
   First Side slope...........=    2.0
   Second Side slope..........=    2.0
   Bottom width (ft)..........=    0.10
   Slope of diversion.........=  0.0400
   Manning"s n................=  0.025
   CFS........................=  14.81
   Cross section area (sqft)..=    2.09
   Hydrualic radius...........=    0.46
   fps........................=    7.08
   Froude number..............=    1.84
```

Title of run: RD-7 100/6

Solving for................=	Depth Normal	
Trapedeziod		
Flow depth (ft)............=	1.28	
First Side slope...........=	2.0	
Second Side slope..........=	2.0	
Bottom width (ft)..........=	0.10	
Slope of diversion.........=	0.0400	
Manning"s n................=	0.025	
CFS........................=	28.32	
Cross section area (sqft)..=	3.40	
Hydrualic radius...........=	0.58	
fps........................=	8.33	
Froude number..............=	1.92	

Title of run: RD-8 10/6

Solving for................=	Depth Normal
Trapedeziod	
Flow depth (ft)............=	0.31
First Side slope...........=	2.0
Second Side slope..........=	2.0
Bottom width (ft)..........=	0.10
Slope of diversion.........=	0.0731
Manning"s n................=	0.025
CFS........................=	1.05
Cross section area (sqft)..=	0.23
Hydrualic radius...........=	0.15
fps........................=	4.59
Froude number..............=	2.07

```
Title of run: RD-8 100/6
   Solving for................= Depth Normal
Trapedeziod
   Flow depth (ft)............=     0.40
   First Side slope...........=      2.0
   Second Side slope..........=      2.0
   Bottom width (ft)..........=     0.10
   Slope of diversion.........=   0.0731
   Manning"s n................=    0.025
   CFS........................=     1.98
   Cross section area (sqft)..=     0.37
   Hydrualic radius...........=     0.19
   fps........................=     5.38
   Froude number..............=     2.16
```

Title of run: RD-9 10/6

Solving for................=	Depth Normal
Trapedeziod	
Flow depth (ft)............=	0.31
First Side slope...........=	2.0
Second Side slope..........=	2.0
Bottom width (ft)..........=	0.10
Slope of diversion.........=	0.0731
Manning"s n................=	0.025
CFS........................=	1.01
Cross section area (sqft)..=	0.22
Hydrualic radius...........=	0.15
fps........................=	4.54
Froude number..............=	2.07

```
Title of run: RD-9 100/6
   Solving for................= Depth Normal
Trapedeziod
   Flow depth (ft)............=    0.40
   First Side slope...........=     2.0
   Second Side slope..........=     2.0
   Bottom width (ft)..........=    0.10
   Slope of diversion.........=  0.0731
   Manning"s n................=   0.025
   CFS........................=    1.87
   Cross section area (sqft)..=    0.35
   Hydrualic radius...........=    0.19
   fps........................=    5.30
   Froude number..............=    2.15
```

Title of run: RD-10 10/6

Solving for................	= Depth Normal
Trapedeziod	
Flow depth (ft)............	= 0.49
First Side slope...........	= 2.0
Second Side slope..........	= 2.0
Bottom width (ft)..........	= 0.10
Slope of diversion.........	= 0.0243
Manning"s n................	= 0.025
CFS........................	= 1.82
Cross section area (sqft)..	= 0.52
Hydrualic radius...........	= 0.23
fps........................	= 3.48
Froude number..............	= 1.28

```
Title of run: RD-10 100/6
   Solving for................= Depth Normal
Trapedeziod
   Flow depth (ft)............=    0.62
   First Side slope...........=     2.0
   Second Side slope..........=     2.0
   Bottom width (ft)..........=    0.10
   Slope of diversion.........=  0.0243
   Manning"s n................=   0.025
   CFS........................=    3.43
   Cross section area (sqft)..=    0.84
   Hydrualic radius...........=    0.29
   fps........................=    4.08
   Froude number..............=    1.33
```

```
Title of run: RD-11 10/6
   Solving for................= Depth Normal
Trapedeziod
   Flow depth (ft)............=    1.66
   First Side slope...........=     2.0
   Second Side slope..........=     2.0
   Bottom width (ft)..........=    0.10
   Slope of diversion.........=  0.0300
   Manning"s n................=   0.025
   CFS........................=   48.47
   Cross section area (sqft)..=    5.67
   Hydrualic radius...........=    0.75
   fps........................=    8.55
   Froude number..............=    1.74
```

Title of run: RD-11 100/6

Solving for................=	Depth Normal

Trapedeziod

Flow depth (ft)............=	2.11
First Side slope...........=	2.0
Second Side slope..........=	2.0
Bottom width (ft)..........=	0.10
Slope of diversion.........=	0.0300
Manning"s n................=	0.025
CFS........................=	91.08
Cross section area (sqft)..=	9.10
Hydrualic radius...........=	0.95
fps........................=	10.01
Froude number..............=	1.81

APPENDIX 2I

COMPUTER BACKUP DATA

FOR

TABLE 19A

```
Project Title          = RC-1 100/6
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number              =    90.0
    Area                      =    54.6 acres
    Hydraulic length          =    0.00 feet
    Elevation change          =     0.0 feet.
    Concentration time        =    0.08 hours
    Unit hydrograph type = Disturbed

-- Total Area                 =    54.6 acres

-- Storm data
    Total precipitation       =     2.2 inches
    Storm type                = SCS 6 hour design storm
    Peak Discharge            =   65.19 cfs
    Discharge volume          =    5.88 acre ft

<press return to continue or {esc} to skip detail printout>
```

```
Project Title          = RC-3 100/6
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number              =    90.0
    Area                      =    17.2 acres
    Hydraulic length          =    0.00 feet
    Elevation change          =     0.0 feet.
    Concentration time        =    0.07 hours
    Unit hydrograph type = Disturbed

-- Total Area                 =    17.2 acres

-- Storm data
    Total precipitation       =     2.2 inches
    Storm type                = SCS 6 hour design storm
    Peak Discharge            =   20.22 cfs
    Discharge volume          =    1.85 acre ft

<press return to continue or {esc} to skip detail printout>
```

```
 DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD7
:  ject Title          = RC-5 100/6                                          :
:WATERSHED HYDROGRAPH                                                        :
:     Inflow into structure #  1                                             :
:     Structure type:          Null                                          :
:                                                                            :
:                                                                            :
:-- Watershed data for watershed # 1                                         :
:    Curve number             =    90.0                                      :
:    Area                     =     3.5 acres                                :
:    Hydraulic length         =    0.00 feet                                 :
:    Elevation change         =     0.0 feet.                                :
:    Concentration time       =    0.03 hours                                :
:    Unit hydrograph type = Disturbed                                        :
:                                                                            :
:-- Total Area               =     3.5 acres                                 :
:                                                                            :
:-- Storm data                                                               :
:    Total precipitation      =     2.2 inches                               :
:    Storm type               = SCS 6 hour design storm                      :
:    Peak Discharge           =    3.52 cfs                                  :
:    Discharge volume         =    0.38 acre ft                              :
:                                                                            :
: <press return to continue or {esc} to skip detail printout>                :
SDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD=
```

APPENDIX 2J

COMPUTER BACKUP DATA

FOR

TABLE 20

```
Title of run: RC-1 100/6
   Solving for...............= Depth Normal
Trapedeziod
   Flow depth (ft)...........=    3.28
   First Side slope..........=     3.0
   Second Side slope.........=     3.0
   Bottom width (ft).........=   15.00
   Slope of diversion........=  0.0252
   Manning"s n...............=   0.040
   CFS.......................=  835.29
   Cross section area (sqft)..=  81.52
   Hydrualic radius..........=    2.28
   fps.......................=   10.25
   Froude number.............=    1.20
```

Title of run: RC-2 100/6

Solving for................=	Depth Normal	
Trapedeziod		
Flow depth (ft)............=		0.89
First Side slope...........=		3.0
Second Side slope..........=		3.0
Bottom width (ft)..........=		5.00
Slope of diversion.........=		0.1067
Manning"s n................=		0.040
CFS........................=		61.66
Cross section area (sqft)..=		6.81
Hydrualic radius...........=		0.64
fps........................=		9.05
Froude number..............=		1.99

Title of run: RC-3 100/6

Solving for................=	Depth Normal
Trapedeziod	
Flow depth (ft)............=	1.41
First Side slope...........=	3.0
Second Side slope..........=	3.0
Bottom width (ft)..........=	5.00
Slope of diversion.........=	0.0420
Manning"s n................=	0.040
CFS........................=	94.51
Cross section area (sqft)..=	12.96
Hydrualic radius...........=	0.93
fps........................=	7.29
Froude number..............=	1.33

Title of run: RC-4 100/6

Solving for................=	Depth Normal

Trapedeziod

Flow depth (ft)............=	0.40
First Side slope...........=	3.0
Second Side slope..........=	3.0
Bottom width (ft)..........=	5.00
Slope of diversion.........=	0.1533
Manning"s n................=	0.040
CFS........................=	17.33
Cross section area (sqft)..=	2.49
Hydrualic radius...........=	0.33
fps........................=	6.97
Froude number..............=	2.14

Title of run: RC-5 100/6

Solving for	=	Depth Normal
Trapedeziod		
Flow depth (ft)	=	0.63
First Side slope	=	3.0
Second Side slope	=	3.0
Bottom width (ft)	=	5.00
Slope of diversion	=	0.0872
Manning"s n	=	0.040
CFS	=	29.78
Cross section area (sqft)	=	4.38
Hydrualic radius	=	0.49
fps	=	6.80
Froude number	=	1.72

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EXHIBIT LIST

CHAPTER VII
R645-301-700 HYDROLOGY

R645-301-711 GENERAL REQUIREMENTS

This permit application includes descriptions of:

711.100 Existing hydrologic resources according to R645-301-720.

711.200 Proposed operations and potential impacts to the hydrologic balance according to R645-301-730.

711.300 The methods and calculations utilized to achieve compliance with hydrologic design criteria and plans according to R645-301-740.

711.400 Applicable hydrologic performance standards according to R645-301-750.

711.500 Reclamation activities according to R645-301-760.

R645-301-712 CERTIFICATION

Cross-sections, maps and plans required by R645-301-722 and R645-301-731.700 will be prepared and certified according to R645-301-512.

R645-301-713 INSPECTION

Impoundments will be inspected as described under R645-301-514.300.

R645-301-720 ENVIRONMENTAL DESCRIPTION

R645-301-721 GENERAL REQUIREMENTS

This section presents a description of the premining hydrologic resources within the permit and adjacent areas that may be affected or impacted by the proposed coal mining and reclamation operation.

Definition of Adjacent Area

722.100 #1

Subsidence from the underground workings, at an average depth of approximately 650 feet, could potentially affect an area extending approximately 350 feet beyond the perimeter of the projected mine workings based on a draw angle of 30°. Therefore, for the purpose of this hydrologic resource discussion, the adjacent area is defined as the area that extends approximately one-quarter mile beyond the boundary of the thirty year mine plan shown on Exhibit V-5A. This allows for a substantial buffer zone, and includes an area in excess of the area subject to subsidence. - surface + impact subsidence -

Groundwater

Groundwater occurs at varying depths throughout the region. The groundwater ranges in quality from fresh to moderately saline. Depths to the regional water table range from shallow in the alluvium beneath the larger drainages to more than 2,000 feet beneath the plateau tops. Shallow perched saturated zones occur locally in rock strata of the Straight Cliffs formation. The lenses containing water are generally bounded by less permeable strata thus limiting recharge of the perched aquifer. These perched zones generally flow for a limited time, until the water in them is dissipated, and are not capable of supporting large sustained withdrawal by wells (BLM, 1976).

Beneath the benches of the plateau one or more shallow perched groundwater bodies may be penetrated by a well before the regional water table is reached. However, the low yielding perched zones are not likely to sustain a significant withdrawal because of their limited areal extent and low permeability (Kaiser Engineers, 1975).

Groundwater could occur in many of the rock units underlying the plateaus of the region. Groundwater may be perched, or impeded from vertical and horizontal movement by one or more rock layers that have relatively low permeability. The quantity of water available varies with depth, formation, and location. Data collected during core drilling within the permit and adjacent areas indicate that the principal coal bed in the proposed permit area is above the regional water table. However, some limited occurrences of perched water were noted above the coal seam in some of the drill holes.

The perched, saturated strata are chiefly composed of fine- to medium-grained sandstone that yield water slowly (generally from less than 1 to maximum of about 20 gallons per minute to small-diameter core holes). The sandstone is generally associated with a fluvial type structure such as a stream channel enclosed by impermeable strata such as mudstone. When the saturated sandstone lens is encountered through drilling or mining, the water contained in the sandstone drains off. Should discharge from the sandstone occur, it is expected to diminish quite rapidly within a period of several weeks due to a lack of hydraulic conductivity or recharge to supplement the flow.

Topography, geology and structure appear to have the greatest effect on groundwater occurrence in sandstone units of the Straight Cliffs formation. Direct infiltration is limited by the impermeable strata enclosing the discontinuous sandstone lenses. The amount of water moving downward through a unit area of the less permeable strata is small (see the hydrogeologic description of the Straight Cliffs Formation in Section 724.100 of this document).

Recharge to perched saturated zones within the Straight Cliffs formation in the permit area would be limited due to their enclosure within relatively impermeable strata. It appears that the area is a poor recharge area for other exposed sandstones as well due to the low annual precipitation, rapid runoff, and the proximity to deeply incised canyons and plateau margins. Drilling conducted in the initial five year mining area during 1990 (400 series drill holes) showed the sandstone units above the coal seam to be dry. All nine drill holes were drilled with air alone and were dry with the exception of hole 401, which was damp at the base of the Red seam.

721
p VII-3
#1

The permit area is located near the crest of the Smoky Mountain anticline. Based on information provided by past drilling, noted encounters with subsurface water appear to be basically in structurally low areas east and west of the permit area and areas of greater surface precipitation to the north.

The most extensive and productive aquifer in the region is the Navajo Sandstone where that formation extends beneath the regional water table. The Navajo lies at depths of 2,000 to 4,000 feet beneath Fourmile and Nipple Benches and has not been tapped by wells in those areas. In the lower Wahweap Creek area south-southwest of the lease where the formation is exposed or lies just below the surface, several wells have been drilled that reportedly yield several hundred to more than 1,000 gallons per minute (BLM, 1976).

721 pVII-3 #2

Aquifers in the Navajo Sandstone have been tapped by several wells in the surrounding area. Wells supply water for domestic use and for a fish hatchery in the Big Water, Utah area. One well in Wahweap Creek near Big Water reportedly yields more than 1,000 gpm, apparently from fractures and joints in the Navajo Sandstone (BLM, 1976) that provide an enhancement effect of porosity.

The regional groundwater table and principal aquifers in the Navajo Sandstone lie more than 2,000 feet beneath the lowest coal-bearing beds that would be mined, and appear to have no hydraulic connection with the coal-bearing strata above due to the intervening thickness of the impervious Tropic Shale. Therefore, groundwater in the main zone of saturation and the principal aquifers of the Navajo would not be directly affected by mining or subsidence (BLM, 1976).

721 pVII-4 #1

A hydrologic investigation was performed by Roger Holland, Consulting Geologist, during September 1990 to assess seeps, springs, and groundwater resources in the proposed permit area. (Refer to Appendix VII-1 of this report). The entire permit and adjacent areas were searched for both active seeps and springs and for evidence of discharges of both short and long duration. Another field survey was conducted in February 1992 which resurveyed the previous area and also sampled other seeps and springs in the region. Although the other seeps and springs are not part of the baseline sampling program due to their distance away from the permit area, they were monitored to help gain a regional perspective of the ground water hydrology.

Water samples have been collected from the Calico sandstone seep in Smoky Hollow canyon south of the proposed mine site. The Calico Sandstone lies approximately 150 feet below the coal seam to be mined separated by a sequence of interbedded sandstone and shale. The

Calico seep is the most significant seep in the vicinity of the proposed minesite, although its location is outside the permit area. Refer to Exhibit VII-1 for the location of the Calico seep.

Water at the Calico seep appears to emanate from the bottom of the Calico Sandstone of the Smoky Hollow Member over a broad area of the canyon wall. The seepage evaporates or infiltrates into the alluvium at the base of the outcrop. More detail regarding baseline conditions associated with this and other groundwater resources in the area is provided in Section 724.100 of this document.

Surface Water

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The Colorado River and Lake Powell are the primary sources of surface water in the southern Kaiparowits Plateau area. The proposed mine site is approximately 11 miles north of Lake Powell.

Streams within the permit area are ephemeral in nature and flow only in response to heavy rainfall or snowmelt. Summer precipitation is received in the form of intense, localized thunderstorms. Intense rainfall may cause flooding at times but the areas affected are usually small and well drained thus minimizing the duration of the high waters. The streams are of little value as water supplies because they are dry much of the year. Runoff, when it occurs, tends to be rapid, of short duration and has a very high level of suspended solids.

The magnitude of the 100 year, 6 hour precipitation event ranges from 2 inches near Lake Powell to 3 inches in the higher elevations. Snowmelt is a major contributor to streamflow in the region. Snow is generally stored through most of the winter at higher altitudes and gradually melts during the spring and early summer. Springs provide small amounts of flow for short distances in some of the channels before seeping into the alluvium (USGS, 1978).

The Glen Canyon Dam impounds a section of the Colorado River to form Lake Powell. Lake Powell is a multipurpose storage reservoir which inundates the southeastern side of the Kaiparowits Plateau. Usable storage capacity (including bank storage) is about 33 million acre feet.

Water in Lake Powell contains 550 to 815 mg/l dissolved solids (BLM, 1976). Water in Warm and Last Chance creeks contains 3,500 to

5,000 mg/l dissolved solids, making it marginally suitable for wildlife and livestock use (USGS, 1978).

In general, the chemical quality of surface water is relatively good in the headwater areas but deteriorates downstream. The dissolved solids content of surface water ranges from 100 to 500 mg/l in headwater areas and 500 to 5,000 mg/l in the lower reaches of most streams. The dominant ions in the headwaters are calcium and bicarbonate; in the middle reaches calcium, magnesium, sodium, and bicarbonate, and in the lower reaches sodium, calcium, and sulfate predominate. In the lower reaches concentrations of heavy metals and trace elements cadmium, lead, manganese, and selenium frequently exceed the maximum allowable limits recommended by the EPA (1973). Streams are usually saturated with respect to suspended sediment during snowmelt and storm runoff (USGS, 1978).

The concentration of dissolved solids in streams is usually inversely proportional to flow. Thus, the chemical quality of water is usually best during high flow and worst during low flow (USGS, 1978). Dissolved solids also increase downstream as a function of geology. Lower marine formations such as the Tropic shale have a high content of soluble minerals and are easily eroded by rapid runoff events.

R645-301-722 CROSS-SECTIONS AND MAPS

722.100 Cross-sections showing the location and extent of subsurface water, within the permit area, can be found on Exhibits VII-4A, VII-4B and VII-4C. Also refer to Figures VII-2 and VII-10 for a generalized depiction of the areal extent of ground water encountered in the vicinity of the permit area.

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Figure VII-15 illustrates the potentiometric surface and the general direction of ground water movement in the Navajo Sandstone.

In 1990, a monitoring well (MW-1) was drilled, on the southern boundary of the proposed permit area, to monitor and sample the Calico Sandstone. Refer to Exhibit VII-5 for the location of the monitoring well. Temporal variations in the hydraulic head at MW-1 are discussed in Section 724.100 of this document.

722.200 The location of surface water sources can be viewed on Exhibit VII-5. No surface water exists in the proposed permit area other than during significant precipitation events. The largest surface water body in the area is Lake Powell which lies approximately 11 miles to southeast. Drainage from Smoky Mountain and the surrounding area flows toward Lake Powell.

Stock ponds in Smoky Hollow are depicted on Exhibit V-2. Observations made during May 1992 indicate the stockpond at the minesite has been silted in and drainage is now diverting around it.

724.200 p VII-50 #1

Range improvements outside of the permit area are shown on Figure VII-16.

722.300 The locations and elevations of monitoring stations used to gather baseline date for water quality and quantity are shown on Exhibit VII-5 and Figure VII-1.

722.300 #1

Exhibits VII-4A, VII-4B and VII-4C depict the occurrence of water in drill holes in and adjacent to the permit area. Exhibit VI-3 shows the drill holes in plan view coded by color to emphasize the occurrence of groundwater within each hole. The drill holes have been depicted in black on Exhibit VI-3 where records made no mention of water.

722.400 No producing water wells exist in the permit or adjacent areas. The nearest municipal water well is located near Big Water, Utah and produces out of the Navajo sandstone.

Water rights in and around the permit area are listed in Appendix VII-6 and shown on Exhibit VII-2. Information presented in Exhibit VII-2 and in Appendix VII-6 is a composite of information received from the Division of Water Rights for each section. Water rights shown on Exhibit VII-2 may or may not be utilized. Specifically, the AMCA water rights, shown as U.G. Water Well on Exhibit VII-2 have not been drilled.

722.500 Exhibits V-1, VII-1 and VII-1A contain contours of the areas of interest that are sufficient to determine the existing configuration and slope of the proposed permit area.

R645-301-723 **SAMPLING AND ANALYSES**

723

Water quality sampling and analyses have been and will be done according to "Standard Methods For The Examination Of Water And Wastewater", current edition.

In February, 1992 EarthFax Engineering, Inc. spent a week in the area around the proposed mine site evaluating ground and surface water resources, performing a seep and spring inventory, collecting samples from seeps and the monitoring well and performing a slug test on the monitoring well. EarthFax followed their field investigations by reviewing drill hole logs and reports as well as all existing hydrologic information collected by Andalex and the U.S.G.S in and around the region of the proposed mine site. The following section, R645-301-724, was prepared by EarthFax Engineering, Inc. for the purpose of compiling and summarizing available ground and surface water data for the region in and adjacent to the permit area.

R645-301-724 BASELINE INFORMATION

Groundwater, surface water, and climatic resource information is presented in this section to assist in determining the baseline hydrologic conditions which exist in and around the permit area. This information provides a basis to determine if mining operations can be expected to have a significant impact on the hydrologic balance of the area.

724 PV11-26 #2

To aid in understanding the geologic descriptions contained in this section, refer to Figure VII-13 (Generalized Geologic Section) and Figure VII-14 (Geology Map and Spring Locations).

724.100 Groundwater Information

This section presents a discussion of baseline groundwater conditions in the permit and adjacent areas. The location of the monitoring well and seeps and springs in the vicinity of the permit area are presented on Exhibit VII-5 and Figure VII-1. Groundwater rights for the permit and adjacent region are presented in Appendix VII-6 of this PAP and are shown on Exhibit VII-2 and Figure VII-16. Currently, all groundwater use in the area (seeps and springs) is limited to stock watering and wildlife use.

724 #1

Potential Aquifers

Geologic conditions in the permit and adjacent areas are discussed in detail in Chapter VI of this PAP. Groundwater in the permit and adjacent areas occurs predominantly at great depth in the Navajo

Sandstone and in the Calico Sandstone of the Straight Cliffs Formation. However, perched aquifers of limited areal extent are present in overlying stratigraphy. Hydrogeologic conditions within the permit area and adjacent areas are summarized below.

Springs and Seeps

Spring and seep surveys were conducted in the permit and adjacent areas in September 1990 and February 1992. The September 1990 survey was designed to cover an area that extended at least one-quarter mile beyond the boundary of the 30-year mine plan shown on Exhibit V-5A. The survey was enhanced using topographic and geologic structure maps, aerial photographs, and on site visual observations from plateau promontories and canyon bottoms. Anomalous vegetation clusters and canyon wall coatings of efflorescence and/or manganese oxide (desert varnish) were used as possible "wet area" indicators. A detailed description of the September 1990 survey is included in Appendix VII-1.

The February 1992 survey included those seeps located in the September 1990 survey. In addition, the February 1992 survey included all springs shown to exist on topographic maps within 5 miles of the permit boundary. The purpose of the 1992 survey was to gain a broader knowledge of the regional hydrology extending beyond the permit area and to augment the findings of the 1990 survey of the permit and adjacent areas. Data collected from springs located outside the adjacent area were meant to provide a better regional understanding of groundwater conditions. These remote springs should not be construed as being part of the baseline monitoring for the permit and adjacent areas.

During the initial visit to each seep and spring, observations were made regarding the flow, the geologic occurrence of the water, and sign of usage (e.g., wildlife, stock watering, etc.). If sufficient water was present, water-quality samples were collected for both field and laboratory analyses as discussed in Section R645-301-731.200 of this document. Seeps identified during the September 1990 survey have been sampled approximately once each calendar quarter since initial discovery.

Five seeps or damp areas were located during the September 1990 survey. An additional 10 seeps and springs were visited during the expanded February 1992 survey. These seeps and springs were not included in the 1990 survey because they are located a considerable distance from the permit area boundary. Although it is very unlikely that mining would have any affect on these springs and seeps, they were visited to enhance the hydrologist's understanding of the regional groundwater system in the permit and surrounding areas. Again, these remote springs are not considered part of the baseline monitoring program for the permit and adjacent areas.

The locations of the remote springs which were visited in February 1992 are shown on Figure VII-1. The locations of all the seeps and several of the springs are shown on Exhibit VII-5. A summary of data collected from the seeps and springs during the initial surveys is presented on Table VII-1. "Seeps" S-3 and S-5 consist only of efflorescent salts and damp sandstone. The seep S-1 consists only of moist soil and anomalous vegetation. No dripping or pooled water has been observed at any of these locations.

The spring shown in T42S, R3E, Section 10 on the USGS 7 1/2 minute topography map was visited in October 1988, September 1990 and during the field work in February 1992. Neither water nor moist soil was found to be associated with the Section 10 spring during any of these visits. No cottonwood trees (or particularly large or anomalous vegetation) were observed at this location or anywhere along the canyon bottom either above or below this site. There was no efflorescence nor alkali deposits present which invariably accompany springs and seeps in this area.

Wahweap Formation

The Wahweap Formation overlies the Straight Cliffs Formation conformably and is an interbedded sandstone-mudstone unit (Doelling and Davis, 1989). The Wahweap Formation outcrops approximately 1 mile west of the northwest corner of the permit area but is absent over the permit area. Plantz (1985) indicates that the Wahweap generally yields water slowly to springs; flows range from less than 1 to about 5 gpm. However, no seeps or springs were found to exist in the Wahweap Formation within the area covered by the spring and seep surveys.

There are no known wells in the Wahweap Formation in the permit or adjacent areas. A review of drilling logs indicate that none of the exploratory drill holes encountered groundwater in the Wahweap Formation. Due to the absence of the formation over the permit area, the absence of seeps or springs issuing from the Wahweap within the survey areas, and the generally limited water resources of the formation, the Wahweap is not considered an aquifer in the permit and adjacent areas.

Straight Cliffs Formation - General

According to Doelling and Davis (1989) and as indicated in Table VI-1, the Straight Cliffs Formation is divided into four members in the region. In descending order these are the Drip Tank, John Henry, Smoky Hollow, and Tibbet Canyon Members, named after canyons in the southern Kaiparowits region. The water bearing properties and general lithology of each member of the Straight Cliffs Formation is discussed below. The Straight Cliffs Formation in the region is folded into the Smoky Mountain Anticline and the Last Chance and Warm Creek Synclines. The structure of the permit and adjacent areas, as well as wet and dry drill hole information, is depicted on Exhibit VI-3.

Exploratory drill-hole data from the coal lease area reveal the presence of discontinuous, perched saturated zones in and above the coal-bearing beds that would be mined (U.S. Bureau of Land Management, 1976). The depth from the ground surface to the point at which groundwater was first encountered was noted on the logs as the holes were drilled with air. Once groundwater was encountered, a change to drilling with mud was usually made to facilitate hole advancement. Several holes note the occurrence of water in multiple locations in the hole but flow quantity is not noted.

During a period of ten years (1964 - 1974) 202 drill holes were drilled by the Resources Company (a partnership of three large utility companies who originally acquired the coal leases) to evaluate the coal reserves and groundwater resources of their 47,777 acre lease area. The Resources Company contracted Kaiser Engineers, Oakland, California to conduct the resource evaluation program. Their scope of involvement included managing the drilling programs and performing data logging and interpretation in order to create a resource recovery and management plan as well as mine planning and design.

The primary interest of the Resource Company was to build and operate a large coal fired power plant on Nipple Bench. Water, being very essential to the operation of a power plant, was researched extensively. Operators noted the location of water encountered during the drilling program as well as an approximation of the flow volume observed. This information was summarized by Kaiser Engineers and plotted on a regional map. Figure VII-10 presented herein is reprinted from Kaiser Engineers' geologic report prepared for the Kaiparowits Power Project. As shown on Figure VII-10, water was frequently encountered in the drill holes in the northern part of the lease area. The wet area wraps around both sides of the Smoky Mountain anticline and generally follows the synclinal troughs on either side of the anticline.

The wet area resembles a horseshoe wrapping around both sides of the Smoky Mountain anticline, as well as the plunging nose of the anticline to the north. As shown on Figure VII-11, the center of this horseshoe is the higher crest of the Smoky Mountain anticline. This area is relatively dry and comprises nearly all of the permit area.

Figure VII-11 is also reprinted from the Kaiser Engineers' geologic report and shows the broad-scale structural trends of the area, including the Warm Creek syncline, Smoky Mountain anticline, and Last Chance syncline. The hydrology interpretation of Figure VII-10 has been superimposed on Figure VII-11 to demonstrate the relationship of the structural trends of the area to the regional occurrence of groundwater.

Samples were taken by Kaiser Engineers from a representation of the holes where water yields appeared to be sufficient to pump for use. The water was encountered at varying locations in the holes. Samples were taken from the holes at the depth of the inflow. Water chemistry suggests that the sources were not all the same. Refer to Table VII-3.

A further indication of the groundwater trends in the area as delineated by the extensive drilling program of the 1970's is the location of water well applications which were filed with the State Engineer by the utility companies. Based on the knowledge of groundwater occurrence in the lease area gleaned from their drilling experience, the utility companies concentrated their applications for water wells within the previously described horseshoe zone around the Smoky Mountain anticline (refer to Figure VII-12).

In an effort to better quantify groundwater within the permit area, nine exploratory holes were drilled in 1990, with air only, to the bottom of the Red seam (drill holes 401 through 409, shown on Exhibit VI-3). Most of these holes extended through at least 600 feet of overburden and extended at least 5 feet below the coal seam to be mined. No water was encountered in drill holes 402 through 409; in the very bottom of drill hole No. 401 (i.e., the bottom of the Red Seam) was damp.

Although the inflow information noted on the drill hole logs in the permit and adjacent areas is often only qualitative (e.g.,"damp", "wet", "some water", "much water", etc.), certain inferences can be made as to the location and general quantities of the perched water zones. The occurrence and availability of groundwater in the Straight Cliffs Formation appears to be controlled primarily by structure. As depicted on Exhibit VI-3, the Smoky Mountain Anticline plunges to the northwest against the regional drainage pattern. This minimizes the potential for groundwater to accumulate in the beds of the anticline. Water instead migrates toward the Warm Creek and Last Chance Synclines from the structural high (Smoky Mountain Anticline).

The exploratory drilling program in the region provides strong evidence for this groundwater model. As discussed above, inflow information noted on the drill hole logs is often only qualitative. However, qualitative assessments of groundwater indicate water was encountered more often and in greater quantities in drill holes located near the bottom of the Warm Creek and Last Chance Synclines and near the plunging nose of the Smoky Mountain Anticline, as can be seen on Figure VII-2 and Exhibit VI-3. Water was encountered much less frequently and in lesser quantities in holes drilled in the permit area near the axis of the Smoky Mountain Anticline.

A total of 202 drill holes were drilled on 1/4 mile spacing through out the lease area. Of the 84 drill holes in the permit area (averaging one every 112 acres), only 24 drill holes exhibited moisture. Of these 24 holes, nine (38 percent) are located in the extreme western portion of the permit area near the axis of the Warm Creek Syncline. According to the conceptual model, groundwater would be expected to occur near the syncline where it accumulates in the structural trough. Eight of the 24 holes (33 percent) that exhibited moisture occur within or adjacent to the bottom of Smoky Hollow. Localized recharge is suspected to occur in this topographic low.

The remaining seven holes that exhibited some moisture occur at various locations within the permit area. In only one case did two such holes occur adjacent to each other. In all other cases, a hole that exhibited some moisture was adjacent to a hole that exhibited no moisture. Thus, saturated zones are discontinuous and correlation of perched zones between drill holes has not proven successful (refer to Exhibits VII-4A through VII-4C), indicating that the perched zones are generally isolated and of limited extent. Of the 24 holes that exhibited some moisture, 12 (50 percent) encountered water above the coal seam.

724 p VII-14 #1

Recharge to these perched zones is limited. Direct infiltration is limited by the high evapotranspiration and the low precipitation within the region. According to Blanchard (1986), the potential groundwater recharge for the drainages in the Kaiparowits Plateau between the Escalante and Paria River drainages (i.e., the region that includes the permit and adjacent areas) is estimated to be approximately 3,000 acre-feet per year. Over the 1,670 square mile area, this represents an average of only 1 gpm/mi^2. Based on these estimates, the potential recharge for the permit and adjacent areas, approximately 15 square miles, accounts for less than 1 percent of the regional recharge. The insignificance of the area for recharge potential is reflected by the limited use, except for sporadic wildlife use, of the emanating water, its variable quality, and inconsistent occurrence (mostly as restricted perched zones).

Regional discharge, including springs draining the Drip Tank Member four to five miles north and west of the permit area, is estimated to be in a state of equilibrium (Blanchard, 1986). Thus, groundwater discharge from the permit and adjacent areas is estimated to total only about 20 gpm. Based on data collected during the seep and spring surveys and subsequent quarterly monitoring, discharges to seeps and springs are expected to account for only about 10 percent of this total. The remainder of the groundwater is discharged via evapotranspiration or as underflow out of the permit and adjacent areas to downgradient areas.

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Direct infiltration of precipitation is also restricted by low permeability beds within the Straight Cliffs Formation. Doelling and Davis (1989) describe the barren zones (immediately above and below the coal seam to be mined) as thick-bedded to massive cliff-forming sandstones with interbeds of mudstone, thin, friable to blocky sandstone beds, and thin limestone beds. The U.S. Bureau of Land

Management (1976) estimates the Straight Cliffs Formation in the area of Smoky Mountain to be possibly more than 50 percent shale, mudstone, carbonaceous shale and coal. These repeated sequences of shales and mudstones limit the recharge potential of the Straight Cliffs Formation.

A bulk sample of the mudstone immediately above the coal seam to be mined (obtained on February 6, 1992 from an exposure at the face of the old mine workings at the location of the proposed minesite - see Exhibit II-2) was laboratory tested for horizontal and vertical hydraulic conductivity. The results of this test are presented in Appendix VII-8 (as OBS-1) and summarized in Table VII-2. As noted, the horizontal and vertical hydraulic conductivity of the mudstone unit was 3.8×10^{-5} ft/day and 9.3×10^{-5} ft/day, respectively. As a point of comparison, the U.S. Environmental Protection Agency (1989) requires clay liners beneath hazardous-waste landfills to possess a hydraulic conductivity of 2.8×10^{-4} ft/day or less. Thus the hydraulic conductivity of the mudstone unit is considered very low.

Plantz (1985) reported the results of laboratory horizontal and vertical hydraulic conductivity analyses of six siltstone core samples collected from exploratory holes drilled into the Straight Cliffs Formation at locations 9 to 25 miles north-northeast of the proposed mine workings (shown on Figure VII-3). These results are summarized in Table VII-4. As noted, the horizontal and vertical horizontal conductivity of the siltstone units ranged from 1.3×10^{-7} to 1.1×10^{-4} ft/day. These results compare favorably with those of the mudstone sample presented in Table VII-2, and again indicate that mudstones in the region exhibit very low hydraulic conductivities.

An X-ray diffraction analyses was also performed on the mudstone overburden sample discussed in Table VII-2. Results of this analysis are presented in Appendix VII-7 and are summarized in Table VII-5. As indicated, smectite comprises a major portion of the clay minerals that make up the mudstone. Since smectite swells when wetted, this mudstone could be expected to seal itself upon fracturing, thus further reducing the potential for recharge. Similar conditions are expected in mudstones throughout the Straight Cliffs Formation.

As described by Doelling and Davis (1989), the Drip Tank member is mostly yellow brown to yellow gray, fine to medium grained, poorly sorted, lenticular sandstone in medium to thick beds. The sandstone is interlensed with minor mudstone and pebble conglomerate.

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Exploratory drill-hole data indicate that discontinuous, perched groundwater zones exist within the Drip Tank Member outside of the permit and adjacent areas. These discontinuous groundwater zones support the flow to a limited number of seeps and springs within region (see Table VII-1). Flow from these perched groundwater zones to springs is generally less than 1 to about 20 gallons per minute (Price, 1977a), although none of the seeps and springs observed during the February 1992 sampling event had a flow greater than approximately 4 gpm. Flow from the Drip Tank Member seeps and springs support the structural groundwater model discussed above. As shown on Table VII-1, the five seeps within the permit area (seeps S-1 through S-5) and the Needle Eye Water spring all had no measurable flow. This indicates, that within the permit and adjacent areas, even restricted perched groundwater zones contain limited water resources . These five seeps are all on the western flank of the Smoky Mountain Anticline and the Needle Eye Water spring is located on the eastern flank of the anticline. All other springs in the Drip Tank Member having a measurable flow during the February 1992 survey issue outside of the permit and adjacent areas within approximately one mile of the Warm Creek or Last Chance Synclines.

When describing the general water bearing properties of the Straight Cliffs Formation, Plantz (1985) considers the Drip Tank Member to be the principle water bearing unit. However, the Drip Tank Member is deeply incised by drainage channels in the vicinity of the permit area and the member itself is discontinuous in the permit and adjacent areas. Groundwater in sandstone ~~beds is discontinuous~~ and is drained near the deeply incised cliff faces (USGS, 1979). As a result, the Drip Tank Member contains limited water resources, and is not considered to be an aquifer in the permit and adjacent areas.

John Henry Member of the Straight Cliffs Formation

As described by Doelling and Davis (1989), the John Henry Member is a slope- and ledge-forming unit of sandstone, mudstone, carbonaceous mudstone, and coal. The coal seam to be mined (the Red seam) is within the John Henry Member. As discussed above, mudstone interbeds with the sandstones of the barren zones above and below the coal seam. Groundwater was encountered in exploratory drill holes outside of the permit and adjacent areas as discontinuous perched zones within the John Henry Member. As can be seen on Table VII-1, only the Section 10 Spring is shown to occur in the John

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Henry Member in the permit or adjacent areas. However, as noted previously the Section 10 Spring had no appearance of past or present flow during the October 1988, September 1990 or February 1992 surveys. This site will be rechecked in March and October, at a minimum, for signs of flow. Refer to discussion under R645-301-724. Because of the limited and discontinuous nature of the perched groundwater zones and the lack of seeps or springs, the John Henry Member is not considered to be an aquifer in the permit and adjacent areas.

Smoky Hollow Member of the Straight Cliffs Formation

Peterson (1969) divided the Smoky Hollow Member of the Straight Cliffs Formation into three informal subdivisions: a basal coal zone, a middle barren zone, and the Calico Sandstone at the top. According to Doelling and Davis (1989), the coal zone of the Smoky Hollow Member contains dark gray carbonaceous mudstone, thin coal beds, and very thin-bedded sandstone. The barren zone consists of yellowish gray to white sandstone beds and gray shale or mudstone. Some of the mudstones are bentonitic.

The Calico Sandstone, which intertongues with the upper beds of the barren zone, consists of fine to coarse grained, poorly sorted, occasionally pebbly sandstone. This sandstone, which lies approximately 150 feet below the coal seam to be mined, averages 25 feet in thickness and attains a maximum thickness of 51 feet (Doelling and Davis, 1989). The top of the Calico Sandstone represents a regional unconformity and the bed itself is missing near Wahweap Creek about 3 miles east-southeast of Big Water. The Calico Sandstone was also eroded from the northeastern part of the region prior to the deposition of the John Henry Member (Peterson, 1969). There are no known water supply wells in the Calico Sandstone or the other units of the Smoky Hollow Member within the permit or adjacent areas. The February 1992 spring and seep survey identified two springs (14 South and 14 North) issuing from the Calico Sandstone in Tibbet Canyon (see Figure VII-1). Both springs had a flow of less than 1 gpm.

In September 1990, a groundwater monitoring well (MW-1) was installed into the Calico Sandstone. The monitoring well is located approximately 3500 feet south-southwest of the proposed mine disturbed area (see Exhibit VII-5). This site was selected, in consultation with Division hydrologists, because it lies generally down-dip from the initial mining area and along a direct line between the initial mining area and the Calico Seep. The Calico Seep represents the closest surface manifestation of any hydrologic resource to the initial mining area. A log of this monitoring well is provided in Figure VII-4.

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Temporal variations in the hydraulic head at MW-1 are apparent (see quarterly water level measurements in Appendix VII-2). These fluctuations appear to have a seasonal component, and range between seven feet (depth to water 126 - 132.7 feet in 1991) and thirty-three feet (depth to water 129.8 - 163 feet in 1992). There is a noticeable lag time between increased precipitation and elevated water levels in MW-1. In comparing precipitation data from three surrounding BLM rain gauge stations (Wesses Canyon, Nipple Bench and Ahlstrom Point) with water levels in MW-1, the lag time is estimated to be about seven months. The elevated water level, as detected in the March 1993 sample (depth to water surface is 97 feet) is attributed to the above average precipitation during the summer of 1992 (158% of normal; BLM, 1992). Some of the temporal variation (i.e. that between the 1991 and 1992 data) may be attributed to water level measuring error. A submersible pump was installed in the well on April 7, 1992. Prior to the installation, water level measurements were made using a calibrated baling instrument. Subsequent to installation of the pump, however, water level measurements were made using a pressure transducer. A systematic change was noted in the data collected using the latter system (the average water level dropped from 128 feet below top of casing to about 152 feet below casing). It is not certain whether these changes are attributable to poor calibration of the system or procedural changes in measuring the water level. Currently endeavors are being made to cross-check the most recent quarterly depth measurement using an electronic Solinst water level detection system.

Smcomments on calico

A slug test of MW-1 was conducted in February 1992 in order to determine the hydraulic conductivity of the Calico Sandstone in the vicinity of the well. A discussion of the slug test procedures and results is presented in Appendix VII-4. This slug test indicated that the hydraulic conductivity of the Calico Sandstone at MW-1 is 0.2 ft/day.

In March, 1992, a short term pumping test was performed on MW-1 in order to determine the maximum discharge of the well. The pump was lowered into the well and the water level was pumped down. The pump was operated at a steady rate, making adjustments to equal well inflow. After a steady rate was established, the pump was allowed to operate at that rate for 2 hours. Water outflow from the discharge pipe was measured once every fifteen minutes. The pumping rate was measured at 1/2 gallon per minute during this test.

In addition to the slug and pumping test results, bulk rock samples of both stratified and massive sections of the Calico Sandstone were collected from the location of the Calico seep as noted on Exhibit VII-5 and laboratory tested for horizontal and vertical conductivity. Results of these permeability tests are provided in Appendix VII-8 and summarized on Table VII-2.

The data presented in Table VII-2 indicate that the laboratory-determined hydraulic conductivity of the Calico Sandstone is approximately 3 to 7 times lower than the field-determined (slug test) hydraulic conductivity. This difference is probably due to natural spatial variations within the fluvial sandstone deposit. Plantz (1985) reported the results of laboratory hydraulic conductivity analyses of 10 sandstone core samples collected from exploratory holes drilled into the Straight Cliffs Formation at locations 9 to 25 miles north-northeast of the proposed mine workings. These results are summarized in Table VII-4. As noted, the horizontal hydraulic conductivity of the sandstone units ranged from $<3.7\times10^{-4}$ to 12.6×10^{-1} ft/day, averaging 0.35 ft/day. This range includes the range of laboratory values reported herein for the horizontal hydraulic conductivity of the Calico Sandstone, with the average value being similar to the Calico Sandstone hydraulic conductivity determined from the slug test. Both Table VII-2 and Table VII-4 indicate that the horizontal and vertical hydraulic conductivities are similar for the sandstone units.

According to Doelling and Davis (1989), the average thickness of the Calico Sandstone in the mine vicinity is 25 feet. Using the hydraulic conductivity determined from the slug test at MW-1 (0.2 ft/day) and this average aquifer thickness, the transmissivity of the Calico Sandstone is calculated to be 5.0 ft^2/day. This value is approximately one order of magnitude lower than the transmissivity of the John Henry Member (66 ft^2/day) and two orders of magnitude lower than the transmissivity of the Drip Tank Member (630 ft^2/day) as determined from two pumping tests in the region (Plantz, 1985). The calculated transmissivity of the Calico Sandstone is sufficiently low to be classified as having a poor potential for development as a water supply (U.S. Bureau of Reclamation, 1977).

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The lack of water supply development in the region precludes the availability of sufficient water-level measurements to prepare a potentiometric surface map for the permit and adjacent areas. However, the geologic structure of the area (with the dip generally to the southwest and west [see Exhibit VI-3]) and the location of the permit area with respect to recharge areas (higher elevation plateaus and mountains to the north) and discharge areas (lower elevation lands and Lake Powell to the south) suggest that the flow of groundwater within the Calico Sandstone is to the south or southwest.

To approximate the rate of groundwater flow within the Calico Sandstone, the hydraulic gradient of the Calico potentiometric surface was estimated between MW-1 and the upstream-most portion of the Calico seep (located approximately 5000 feet south-southwest of MW-1). The elevation of the uppermost portion of the Calico seep was measured on February 5, 1992 using a Brunton hand level relative to a USGS benchmark at the base of the seep. This measurement resulted in an approximate seep elevation of 4286 feet.

On February 3, 1992, the water level in MW-1 was measured using a Solinst electric water-level indicator. The depth to water on this occasion was 131.82 feet below the top of the casing. With an approximate casing elevation of 4520 feet (as determined from the 1" = 2000' scale USGS topographic map of the area), the elevation of groundwater in MW-1 is approximately 4388 feet. Thus, the difference in groundwater elevations between MW-1 and the Calico seep is about 102 feet. With a distance of 5000 feet separating the two measurement points, the hydraulic gradient within the Calico Sandstone is 0.02 ft/ft.

The rate of groundwater flow within the Calico Sandstone was estimated using the modified Darcy equation (Freeze and Cherry, 1979):

$$v = KI/n \qquad (1)$$

where	v	=	average linear groundwater flow velocity (ft/day)
	K	=	hydraulic conductivity (ft/day)
	I	=	hydraulic gradient (ft/ft)
	n	=	porosity (fraction)

A hydraulic conductivity of 0.2 ft/day was assumed as determined from the slug test of MW-1. The hydraulic gradient was assumed to be 0.02 ft/ft as determined above. A porosity of 0.20 was assumed based on the average sandstone porosity reported by Plantz (1985) for the Straight Cliffs Formation (see Table VII-4). Using these values, the average linear groundwater velocity was calculated to be 0.02 ft/day (7.3 ft/year).

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Based on observations made at the monitoring well, the groundwater velocity for the Calico Sandstone has been calculated to be 7.3 feet per year. At such a low flow rate, it is likely that potential effects on the Calico Sandstone resulting from mining activities might not be observable at the monitoring well or the Calico seep for many decades. Therefore, Andalex now proposes to monitor any potential effects of mining on the Calico sandstone by establishing monitoring wells within the underground mine workings to monitor for any changes in groundwater quality or quantity. The monitoring wells would be located underground inside the active mine workings in main and gate entries and would be drilled down to the Calico as mining progresses. The initial drill hole will be located underground within 1,000 feet of the mine portal entrance. Spacing of the subsequent monitoring holes will be determined in consultation with Division hydrologists based on the results of the initial monitoring program. These additional wells will also provide the additional potentiometric data necessary to more accurately determine the direction of local groundwater flow.

724 p VII-23 #2

724.100 p VII-25 #1

Due to the cliff-forming nature of the Calico Sandstone, this unit has only limited, near-vertical outcrops. Thus, recharge at the outcrops is insignificant. Local groundwater conditions are such that recharge to the Calico is probably proximal to discharge, in the vicinity of the Calico Seep. In this area, between the seep and Squaw Canyon, there exists only a thin veneer of overlying interbedded clays. Thus, recharge may occur from infiltration of local precipitation. In the vicinity of the Calico Seep, it is uncertain to what degree fractures contribute to hydraulic conductivity. However, it would be reasonable to assume, given the absence of a substantial thickness of the John Henry Member, that fractures may enhance local recharge.

As discussed above, the potential groundwater recharge for the drainages in the Kaiparowits Plateau is estimated to be only 1 gpm/mi^2. Due to the low potential recharge of the semi-arid permit and adjacent areas, recharge to the Calico Sandstone from downward infiltration is probably minimal. As also discussed above, low permeability beds in the strata above the Calico Sandstone are likely to further restrict downward recharge. Primary surface discharge from the Calico Sandstone in the permit region is to the broad Calico seep where the Calico Sandstone outcrops along a deeply incised cliff face in the Warm Creek drainage and the lower springs in Tibbet Canyon (i.e., 14 North and 14 South springs).

The limited recharge to the Calico Sandstone, low hydraulic conductivity (as determined from both the well test and from the bulk rock samples), low transmissivity, and very low flow from the Calico seep all indicate that the aquifer in the relatively thin Calico Sandstone is not likely to produce significant sustained yields of water. There is no current or historical use of the Calico water from wells in the region and none of the seeps associated with the Calico have been developed for livestock use.

Tibbet Canyon Member of the Straight Cliffs Formation

The Tibbet Canyon Member is mostly a cliffy littoral sandstone with gray mudstone and siltstone partings dividing the sandstone beds (Doelling and Davis, 1989). The Tibbet Canyon Member ranges in thickness from 70 to 185 feet in the permit and adjacent areas.

Only limited hydrogeologic information is available concerning the Tibbet Canyon Member. Doelling and Davis (1989) estimate that the regional transmissivity of the Tibbet Canyon Member is similar to that of the Smoky Hollow Member. Thus the hydrologic data presented previously for the Calico Sandstone are probably also representative of the Tibbet Canyon Member.

Data regarding the occurrence of groundwater within the Tibbet Canyon Member are not available. However, it is reasonable to assume that the Tibbet Canyon Member fits the conceptual model presented previously for the Straight Cliffs Formation. The presence of the relatively impermeable Tropic Shale beneath the Tibbet Canyon Member probably promotes saturation of the member in structural troughs.

Tropic Shale

According to Doelling and Davis (1989), the Tropic Shale is a thinly laminated to thin-bedded mudstone and shale unit with lesser amounts of sandstone, bentonitic claystone, siltstone, and limestone. The Tropic Shale is 610 to 705 feet thick in the permit and adjacent areas. According to Plantz (1985), the Tropic Shale transmits water slowly and is not considered to be an aquifer; the Tropic Shale is commonly a hindrance to vertical percolation of groundwater.

Dakota Formation

The Dakota formation is the oldest Cretaceous unit exposed in the southern Kaiparowits Plateau area. This ledge-forming sandstone lies unconformably above the older Entrada Sandstone of Jurassic age. The Dakota formation consists of interbedded sandstone and mudstone with varying amounts of conglomerate, claystone, bentonite and coal.

Entrada Sandstone

Conspicuous for its color and massiveness, the Entrada is mostly an orange to reddish fine-grained sandstone with lesser amounts of reddish shale. Thickness of the unit ranges from 200 to 900 feet.

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#1

Carmel Formation

The Carmel is found overlying the Navajo Sandstone and consists of interbedded shale, sandstone, limestone and gypsum. It is mainly a reddish brown very fine- to coarse-grained quartzose sandstone and pale reddish brown to grayish red mudstone. The thickness ranges from 80 to 520 feet but is the thinnest in the eastern extent.

Navajo Sandstone

The Navajo Sandstone, where exposed, is a recognizable cliff-former composed mostly of a fine-grained sandstone with aeolian cross-bedding. The Navajo is strongly jointed. It ranges in thickness from 1,100 to 1,700 feet and intertongues with the overlying Carmel Formation.

The principal regional aquifer beneath the permit and adjacent areas exists in the Navajo Sandstone. The potentiometric surface in this formation lies at least 1000 feet below the lowest coal-bearing beds that would be mined (Blanchard, 1986). The Navajo Sandstone is generally a light colored, fine- to medium-grained friable and massive sandstone, that is weakly cemented with carbonate and iron oxide (Doelling and Davis, 1989). The Navajo is estimated to be 1100 to 1700 feet thick beneath the permit and adjacent areas and its entire thickness is probably saturated (Price, 1977a). Several wells that tap the Navajo where it lies at or near the land surface around the margins of the Kaiparowits Plateau yield more than 1,000 gallons per minute to large diameter wells (Bureau of Land Management, 1976). The relatively impermeable Tropic Shale (approximately 600-700 feet thick) hydraulically separates the lower Straight Cliffs Formation from the Navajo Sandstone.

According to Blanchard (1986), recharge to the regional groundwater system of the Navajo Sandstone takes place primarily in three areas- the southern flank of Boulder Mountain approximately 50 miles north of the permit area, the Paria Plateau approximately 20 miles southwest of the permit area, the outcrop area west of the Kaiparowits Plateau approximately 30 miles northwest of the permit area. (According to Doelling and Davis, 1989, water also enters the Navajo from seepage from the Colorado River.) Recharge in these areas is primarily by precipitation directly into the fractured Navajo outcrop or into the Navajo from overlying unconsolidated deposits.

Groundwater Quality

According to Price (1977b), little or no groundwater quality data are available for large areas in the Kaiparowits coal basin. The data compiled by Price (1977b) depicts the dissolved solids concentrations in groundwater within the permit and adjacent areas area to range from 500 to 3,000 mg/l while the dissolved solids concentrations in groundwater south (down gradient) of the permit area were estimated to range from 1,000 to 10,000 mg/l.

In order to more accurately determine the baseline groundwater quality in the permit and adjacent areas, groundwater has been sampled periodically from the monitoring well (MW-1), the Calico seep, seep S-2, and seep S-4 and submitted for laboratory analyses. No flow has occurred at the other "seeps" (S-3 and S-5) during the period of record. Several additional springs were sampled in the surrounding region in February 1992 and are discussed below. These springs were sampled to provide information regarding regional groundwater characteristics. These remote springs are not part of the permit area baseline monitoring program. Details of monitoring/sampling methods are discussed in Section R645-301-731.200 of this document. All laboratory data are presented in Appendix VII-2. A summary of the results for the 1992 seep and spring survey is presented in Appendix VII-6. An evaluation of the ground water quality is based upon recommended primary (PDW) and secondary (SDW) drinking water standards as found in R449-103-1 and R449-103-2 of the 8th edition of the State of Utah Public Drinking Water Rules, published by the Division of Drinking Water (Utah Department of Environmental Quality, 1991).

With the exception of the Calico seep discussed above, springs outside the permit area will be field surveyed in the spring and the fall (high and low flow periods) during 1993 and 1994 as a continuation of the regional groundwater resource characterization. These springs will not be incorporated into the baseline monitoring program but will be sampled during high and low flow during mid-term permit reviews. These springs are fed by isolated perched groundwater zones that are not hydraulically connected to the perched groundwater zones within the permit area. The closest spring to the permit area (Needle Eye Water) is located more than 2 miles outside the predicted zone of subsidence for the 30 year plan as shown on Exhibit VII-8. Thus, the springs outside the permit area will not be affected by the mining operation.

Because field measurements of pH and specific conductance are considered to be more representative of in-situ conditions, they are included when available. Cation-anion balances fell within an accepted range (±5%) for all analyses. Calculated total dissolved solids (TDS) concentrations were used when laboratory error was detected (as noted by comparisons of measured TDS, calculated TDS, and measured specific conductance).

Drip Tank Member

Baseline quality of groundwater perched in the Drip Tank Member above the coal seam within the permit area is represented by S-2 and S-4 sample data. As shown on tables presented in Appendix VII-2, TDS concentrations are higher at S-2 (1419 mg/l average) than at S-4 (178 mg/l average). Total iron ranged from below detection to 0.22 mg/l at S-2 and from below detection to 0.08 mg/l at S-4. Total manganese was below detection in all samples from S-2 and ranged from below detection to 0.02 mg/l in S-4. Field measurements of pH from both S-2 and S-4 ranged from 6.4 to 8.8 and averaged 7.4 for S-2 and 7.9 for S-4.

As a point of comparison only, sulfate concentrations exceeded the state Secondary Drinking Water (SDW) standard of 250 mg/l, as set in R449-103, in every sample collected from S-2 and zinc exceeded the SDW standard of 5.0 mg/l in one of the nine samples collected from S-2. No significant seasonal variations or trends in groundwater quality at seeps S-2 or S-4 are apparent. All other parameters were below set MCL limits of the SDW and PDW (Primary Drinking Water Standards).

In order to expand the baseline quality data base for the perched groundwater above the coal seam in the region, five additional springs issuing from the Drip Tank Member were sampled as part of the February 1992 survey. These springs are all located outside the proposed permit and adjacent areas as indicated on Figure VII-1. All laboratory data are presented in Appendix VII-2 and a summary of the laboratory data for the springs sampled between September 1990 and December 1992 is presented on Table VII-6. These springs will be monitored at mid-term, and during spring and fall surveys during 1993 and 1994 to provide additional regional data.

These data, while not imperative for the baseline study, will serve to augment data required for the CHIA (Cumulative Hydrologic Impact Assessment) conducted by the Division.

The average TDS concentration (740 mg/l) and the average pH (7.9) from the samples collected at the five additional springs issuing from the Drip Tank Member are comparable with the range of observations from the samples collected at S-2 and S-4 (discussed above). As discussed above, total iron and total manganese concentrations in all samples from both S-2 and S-4 were below the SDW standards of 0.3 mg/l and 0.05 mg/l for iron and manganese, respectively. Total iron and total manganese concentrations exceeded the SDW standards in the Drip Tank, Clint, Brett, and John Henry Springs, suggesting an increase in iron and manganese concentrations in the structural troughs. Sulfate, which exceeded the SDW standard in all samples collected at S-2, also exceeded the SDW standard in the sample collected from the Drip Tank Spring. The sample collected from the Clint Spring was the only sample from the Drip Tank Member to exceed the PDW standard of 0.002 mg/l for mercury.

A review of U.S. Geological Survey information indicates groundwater was sampled in the Kaiparowits Plateau region in the spring of 1974 and analyzed by the U.S. Geological Survey (Bureau of Land Management, 1976). The locations of the sampling sites are shown on Figure VII-5. A summary of the analytical results is presented on Table VII-7. As shown on Table VII-7, sample locations included three springs (Drip Tank, Tibbet, and Wesses Springs) issuing from the Drip Tank Member. Because Wesses Spring is not shown to exist on the topographic maps (and because the USGS data were discovered after the February 1992 spring and seep survey), Wesses Spring was not visited during the February 1992 spring and seep survey to verify its existence. (The USGS data indicate that Wesses Spring is located several miles west of the permit area in Wesses Canyon in the vicinity of John Henry Spring.) Efforts will be made during the 1993 spring survey to locate and sample Wesses Spring. Wesses Spring, as well as the other springs-Drip Tank, Tibbet, Bretts, Clints, 14 North and South, and John Henry, are not meant to be incorporated into the baseline monitoring program. The intent behind including them into the 1992 spring and seep survey was to gain a more regional perspective of the geohydrology. It was concluded that these springs were too far outside of the permit and adjacent areas to possibly be affected by mining activities but would be useful in interpreting regional hydrologic control. Andalex will monitor these regional springs during spring and fall (high and low flow) of 1993 and 1994 to provide additional detail on a regional scale for the geohydrology of the area.

In a comparison of the water quality data as shown in Appendix VII-2 and Table VII-7 (as obtained by USGS in 1974) some systematic changes with time are apparent. There was a noticeable increase in dissolved constituents at the Drip Tank Spring during the 1992 sampling period, while the Tibbet Spring data shows a corresponding decrease in TDS and other parameters from levels measured in 1974. This systematic, temporal and spatial inconsistency in water chemistry, as observed at the Drip Tank and Tibbet Springs, reveals the variable nature of the water quality that emanates from the Drip Tank Member.

John Henry Member

A review of Utah Division of Water Rights records indicate that no wells exist in the John Henry Member in the permit or adjacent areas. The U.S.G.S. 7 1/2 minute quadrangle map shows a spring in Section 10 approximately 2 miles southwest of the permit area. According to the geologic map prepared by Doelling and Davis (1989) this spring would be located in the John Henry Member. However, no evidence of a spring was found at this location during the February 1992 survey. No other seeps or springs were found to issue from the John Henry Member during the September 1990 or February 1992 surveys. The Section 10 location will be rechecked during the spring and fall 1993 field surveys for any evidence of water.

Calico Sandstone

The baseline groundwater quality of the Calico Sandstone is represented by the Calico seep and MW-1 sample data. Groundwater quality data for the Calico Seep and MW-1 are presented in table form in Appendix VII-2. Total dissolved solids (TDS) concentrations in the groundwater from both MW-1 and the Calico seep range from 707 to 1,330 mg/l and average 946 mg/l. Total iron concentrations range from below detection to 0.67 mg/l at the Calico seep and from below detection to 1.97 mg/l in MW-1. Total iron concentrations exceeded the SDW standard in three of the ten samples collected from the Calico seep and in four of the eleven samples collected from MW-1. Total manganese concentrations range from below detection to 0.10 mg/l at the Calico seep and from below detection to 0.12 mg/l in MW-1. Total manganese concentrations exceeded the SDW standard in one of the ten samples collected from the Calico seep and in two of the eleven samples collected from MW-1.

Additionally, fluoride concentrations in MW-1 exceeded the SDW standard of 2.0 mg/l on eight of the eleven sample events and zinc exceeded the SDW standard in one of the eleven sample events. Mercury equalled the PDW standard in one of the eleven samples collected from MW-1. Fluoride concentrations in the Calico Seep exceeded the SDW standard in two of the ten sample events. All other parameters fell under PDW and SDW limits. No significant seasonal variations or trends in groundwater quality at the Calico Seep or MW-1 are apparent.

Two additional springs (14 North and 14 South Springs sampled as part of the February 1992 survey) issue from the Calico Sandstone. These two springs are located outside the proposed permit area as indicated on Figure VII-1 and are not intended to be part of the baseline monitoring points. They are located a considerable distance from the permit area. Laboratory data for all springs sampled during the February 1992 survey are summarized on Table VII-6.

Total dissolved solids concentrations in the 14 North and 14 South Springs (1,179 and 2,668 mg/l, respectively) are higher than the average TDS concentration (857 mg/l) from both MW-1 and the Calico Seep, suggesting an increase in the TDS concentration in the downgradient direction. Although some of the samples from MW-1 and the Calico Seep (discussed above) exceeded the SDW standards for iron and manganese, samples from the 14 North and 14 South Springs did not. Fluoride concentrations exceeded the SDW standard in the 14 South Spring sample, as was the case in two of the seven samples from the Calico Seep and four of the seven samples from MW-1.

Tibbet Canyon Member

A review of Utah Division of Water Rights records indicate that no wells exist in the Tibbet Canyon Member in the permit or adjacent areas. No seeps or springs were found to issue from the Tibbet Canyon Member during the September 1990 or February 1992 surveys.

A discussion of samples collected from undifferentiated zones of the Straight Cliffs Formation, which may include groundwater samples from the Tibbet Canyon Member, is included below. Although it is unclear if samples from the undifferentiated Straight Cliffs Formation includes samples from the Tibbet Canyon Member, it is probable that groundwater in the Tibbet Canyon Member, where it occurs, contains high TDS due to dissolution of gypsum in the underlying Tropic Shale.

Undifferentiated Straight Cliffs Formation

As discussed above, groundwater was sampled in the Kaiparowits Plateau region in the spring of 1974 and analyzed by the U.S. Geological Survey (Bureau of Land Management, 1976). As shown on Table VII-7 and Figure VII-5, sample locations included four El Paso

Natural Gas Company core holes. No information is available concerning sample collection techniques. Other than describing the samples as being from the Straight Cliffs Formation, no detailed information is available regarding the geologic source of the groundwater samples (i.e., from which member of the Straight Cliffs Formation the groundwater was sampled). As can be seen on Table VII-7, concentrations of fluoride exceeded SDW standards in three of the four El Paso Natural Gas Company core holes and concentrations of sulfate and iron exceeded SDW standards in one of the four core holes. Dissolved solids concentrations in waters sampled from the four El Paso Natural Gas Company core holes ranged from 866 to 1380 mg/l and averaged 1164 mg/l.

The USGS Watstore data base was also consulted for groundwater information in the permit and adjacent areas. As with the El Paso Natural Gas Company core holes, the USGS Watstore data consist of water analyses from drill holes that were sampled from undifferentiated zones of the Straight Cliffs Formation. Information regarding methods used to sample these holes is not available. The drill hole numbers correspond to the drill holes shown on Exhibit VI-3. A summary of the chemical analyses is presented in Table VII-3. Dissolved solids concentrations in waters sampled from these drill holes ranged from 272 to 5920 mg/l and averaged 1045 mg/l. Two of the 20 samples exceeded the SDW standard for manganese. Four of the 20 samples exceeded the SDW standard for sulfate and four samples exceeded the SDW standard for fluoride.

Similarities exist between the El Paso Gas Company and the USGS Watstore undifferentiated Straight Cliffs Formation sample data and the sample data collected from the differentiated members of the Straight Cliffs Formation discussed previously. These include fluoride, which exceeded the SDW standard in 29 percent of the undifferentiated Straight Cliffs Formation samples as compared with 23 percent of the differentiated Straight Cliffs Formation samples. Sulfate exceeded the SDW standard in 21 percent of the undifferentiated Straight Cliffs Formation samples as compared with 29 percent of the differentiated samples. Similar average TDS concentrations were also noted.

Differences include iron, which exceeded the SDW standard in only 4 percent of the undifferentiated Straight Cliffs Formation samples as compared with 26 percent of the differentiated samples. Manganese exceeded the SDW standard in 8 percent of the undifferentiated samples as compared with 19 percent of the differentiated samples from the Straight Cliffs Formation.

Navajo Sandstone

Due to the depth of the Navajo Sandstone beneath the permit and adjacent areas, no water samples have been collected from the Navajo aquifer within the permit area. However, data from nearby wells that tap the Navajo Sandstone in the community of Big Water produce water containing about 500 mg/l to slightly over 1,000 mg/l of dissolved solids (Price, 1977b). Refer to Figure VII-15 for the location of these wells. Based on available data (including chemical analyses of base flows at the mouths of Wahweap, Warm, and Last Chance creeks prior to filling of Lake Powell), it is assumed that the Navajo, even where deeply buried beneath younger rocks in the Kaiparowits Plateau, contains fresh water, with local pockets of slightly saline water (Price, 1977b).

According to Blanchard (1986), information regarding the chemical quality of water in the Navajo Sandstone beneath the Kaiparowits Plateau is scarce, and what is available from records of oil-test holes is qualitative. Blanchard (1986) indicates that groundwater in the Navajo Sandstone beneath the Kaiparowits Plateau may be saline and the degree of salinity probably varies with location. In the Wahweap Bay area, the water type is generally sodium calcium sulfate bicarbonate.

724.200 Surface Water Information

The general configuration of surface drainages in the vicinity of the proposed permit area is shown in Exhibit VII-5. The major drainages through the permit area are Smoky Hollow and Wesses Canyon, both tributaries of Warm Creek. Primary additional drainages in the region include Wahweap Creek to the west of the permit area and Last Chance Creek east of the permit area. All streams in the permit and adjacent areas eventually drain to Lake Powell on the Colorado River. With the exception of Lake Powell (located approximately 11 miles south of the permit area), no lakes or impoundments exist in the region.

Within the permit and adjacent areas, Warm Creek and its tributaries are most accurately classified as ephemeral as defined in Section R645-100-200 of the State of Utah Coal Mining Rules (i.e., "a stream which flows only in direct response to precipitation in the immediate watershed, or in response to the melting of a cover of snow and ice, and which has a channel bottom that is always above the local water table"). Although the regulatory definition (R645-100-200) considers a stream reach with drainage areas greater than one square mile in size to be classified as intermittent, there is no size criteria associated with ephemeral channels. Channels within the permit area best fit the regulatory definition of ephemeral (i.e. the channel bottom is always above the local water table and the channel flows only in response to direct precipitation in the immediate watershed) no stream within the permit and adjacent areas is classified as being hydrologically intermittent. Thus, all stream channels within the permit and adjacent areas will be termed "ephemeral" in this document. According to Doelling and Davis (1989), Warm Creek, Wahweap and Last Chance Creek are all truly intermittent near their mouths (i.e., "a stream or reach of a stream, that is below the water table for at least some part of the year and obtains its flow from both surface runoff and groundwater discharge" [see R645-100-200]).

The significant tributaries to the Warm Creek drainage within or near the permit area include John Henry Canyon, Tibbet Canyon, and Smoky Hollow. The Smoky Hollow tributary of Warm Creek flows through the proposed disturbed area and, as depicted in Exhibit VII-1A and discussed in Section R645-301-730 of this document, will be the receiving drainage for all planned disturbed-area discharges.

Surface water rights for the permit area and surrounding region are presented in Appendix VII-6 and are depicted on Exhibit VII-2 and Figure VII-16.

Surface Water Quantity

As all streams in the permit and adjacent areas flow only in response to snow melt or heavy precipitation events, there is a large variation in streamflow throughout the area. Most of the runoff in the higher elevations occurs during late spring and summer when streams are being fed by melting of winter snowpack and seasonal rains (Price, 1978). Most of the peak flow runoff in lower elevations, such as the mine site area, is generated by localized summer thunderstorms or cloudbursts. Even though the cloudbursts are generally of limited extent, they may be of great magnitude. Periodic discharges of several hundred to a few thousand cubic feet per second from drainages of only a few square miles are not uncommon during such cloudburst activity (U.S. Bureau of Land Management, 1976). As an example, the magnitude of annual peak discharges near the mouth of Coyote Creek (which drains about 90 square miles in the Wahweap Creek basin approximately 12 miles southwest of the permit area) compiled from measurements by the U.S. Geological Survey from 1959 to 1976, is shown in Figure VII-6. According to the analysis, a flow of about 1,300 cfs can be expected to occur about once every 2 years (U.S. Bureau of Land Management, 1976).

Appendix VII-5 contains the calculations used to predict the design discharge for the Smoky Hollow drainage above the downstream edge of the proposed disturbed area for several frequency-duration storm events. A summary of the calculated discharge values for the undisturbed areas not draining to the sedimentation pond is presented on Table VII-8. The 6-hour events can be considered more representative of the typical short-duration, high-intensity storms for the area than are the 24-hour events.

Four stream monitoring points (single stage samplers and crest stage gages) were installed in the summer of 1989 within the permit area (see Exhibit VII-5 for monitoring locations) to collect water quality samples and to monitor stream flow. These locations were determined in consultation with Division hydrologists. An additional five single stage samplers were installed in February 1992. These additional samplers were installed beyond the permit area boundary to provide a wider geographic range of flow data collection. The five new samplers are shown on Exhibit VII-5 as SS-5, SS-6, SS-7, SS-8 and SS-9. Details regarding the construction and operation of these stations are presented in Section R645-301-731.200 of this document.

High water marks on the single stage samplers and/or the crest stage gages from flow events during the period of record were converted to maximum discharge rates using the Manning equation:

$$V = \frac{1.49 R^{2/3} S^{1/2}}{n} \qquad (10)$$

where V = the average flow velocity (ft/s)
R = the hydraulic radius (ft)
S = slope of the water surface (ft/ft)
n = Manning roughness coefficient

The stream channel cross-section was measured at each single stage sampler. The measured stream channel cross sections were used with the measured flow depths to obtain the cross-sectional area of flow. The ratio of the cross-sectional area of flow to the wetted perimeter of the stream channel is then used as the hydraulic radius. The slope of the stream bed was calculated from 1" = 2000' scale USGS topographic maps of the area. The Manning roughness coefficient for Smoky Hollow Creek was estimated using the U.S. Soil Conservation Service (1963) techniques (see Appendix VII-12). Based on this evaluation, a roughness coefficient of 0.054 was used for the stream channels at the samplers/gages. The stream channel cross-sectional measurements and the results of the Manning equation calculations are presented in Appendix VII-13.

The measured flow depths and calculated maximum discharge rates from the four initial monitoring locations for flow events that occurred between the summer of 1989 and December 1992 are presented on Table VII-9. In addition, data from stations SS-5, SS-6, SS-7, SS-8, and SS-9 have been added to Appendix VII-3.

The Manning equation was also used to predict the 100 year-6 hour peak flow depth at surface water monitoring stations SS-1 thru SS-7. Results of these calculations are presented in Appendix VII-13. Because stations SS-8 and SS-9 are located in side canyons outside the permit area (and thus will not be impacted by the mining operation), 100 year-6 hour peak flow depths were not calculated. The calculated 100 year-6 hour peak flow discharge of 770.1 ft^3/s was used for surface water monitoring stations in Smoky Hollow Creek (SS-1, SS-3, SS-4, SS-5, and SS-7). The calculated 100 year-6 hour peak flow discharge of 104.86 ft^3/s was used for the monitoring stations in the side tributary to Smoky Hollow Creek (SS-2 and SS-6). The stream channel cross-sections showing the calculated 100 year-6 hour peak flow depths are depicted in Exhibit VII-6.

The calculated 100 year-6 hour peak flow depths for the surface water monitoring stations in Smoky Hollow Creek range from 3.41 ft. at SS-4 to 6.57 ft. at SS-3. The maximum measured flow depth in Smoky Hollow Creek was 17 inches at SS-4 on 8/29/92. The calculated 100 year-6 hour peak flow depths for the tributary to Smoky Hollow Creek is 1.44 ft. and 1.34 ft. for stations SS-2 and SS-6, respectively. The maximum measured flow depth in the tributary to Smoky Hollow Creek was 28.5 inches at SS-2 on 7/27/90.

As discussed previously, summer runoff is generated by localized thunderstorms or cloudbursts. The convective summer precipitation amounts in the Kaiparowits Basin are highly variable in time, space, and intensity (Grey, 1974). These variations in summer precipitation result in spatial variations in streamflow, as can be seen from the maximum discharge data on Table VII-9. For example, the July 1990 peak flow was larger at station SS-2 (monitoring a small Smoky Hollow tributary) than at station SS-1 (in the main stem of Smoky Hollow), even though the drainage area above SS-1 is larger.

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In addition to precipitation-induced streamflow variations, channel transmission losses also result in variations in the downstream direction. For example, the December 1989 event resulted in flow at stations SS-1 and SS-2 but not downstream at SS-3. The concept of channel transmission losses has been discussed by the U.S. Soil Conservation Service (1983).

Because streamflow in the permit and adjacent areas is the direct result of precipitation or snowmelt, seasonal variations in streamflow result from seasonal variations in climate. As discussed above, most of the runoff volume in the region occurs during late spring and summer when streams are being fed by seasonal rains and melting of winter snow. The highest peak flows are typically generated by localized summer thunderstorms or cloudbursts. As can be seen from Table VII-9, flows measured since the installation of the four initial stations have occurred in December, May and June (due most likely to seasonal rains), and in July, August and September (due to summer thunderstorm activity). The hydrologic investigation conducted in February, 1992 took place after several snow storms had occurred in January. Even though the seasonal precipitation had been greater than normal during the winter, the snow melt did not create runoff in any of the drainages that were investigated. Snowmelt does not appear to contribute to the lower ephemeral drainages to the same extent it would in the higher elevations.

Surface Water Quality

Previous Studies

Previous studies on surface water quality of select drainages in southern Utah were conducted by the USGS (1979) and Price (1979). The USGS concluded that in general, natural runoff in the region has a high suspended and dissolved solids content. In addition, they found that the suspended solids concentrations are proportional to flow, while the concentration of dissolved solids in streams is usually inversely proportional to flow.

As noted in the Final Environmental Impact Statement for the Development of Coal Resources in Southern Utah (USGS,1979), during periods of very low runoff, salts precipitate on the beds and banks of streams in the region. These salts are readily dissolved in the initial periods of subsequent runoff events, thus causing initially high concentrations of dissolved solids. As runoff continues, fewer precipitates are reconstituted, resulting in lower concentrations of dissolved solids in the surface runoff (USGS, 1979).

The U.S. Geological Survey (1979) also notes that the general chemical quality of surface water in the region deteriorates downstream. This same document states that, in the lower reaches of Last Chance and Wahweap Creeks, concentrations of the trace elements arsenic, cadmium, lead, manganese, and selenium frequently and naturally exceed the maximum allowable limits recommended by the State (see Table VII-10). As a point of comparison only, select data from the USGS study are included in Table VII-11. The principal factors contributing to the salinity of the runoff in the Kaiparowits coal-basin area is seepage of saline groundwater (especially in or downstream from the Tropic Shale) and evapotranspiration (Price, 1979). The dissolved solids concentrations of surface waters in the Wahweap, Warm, and Last Chance drainage vary from 500 and are generally in the range of 3,000 mg/l in the location of the proposed disturbed area (Smoky Hollow Creek) to 3,000 to 10,000 mg/l in the lower reaches of all three drainage (Price, 1979).

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Current Investigation

During the period of record (8/16/89 through 11/1/92), 27 water samples were collected from single stage samplers installed at the proposed mine site, while 12 grab samples were collected from 7 distinct locations in, and around the permit area. The sampling and analytical protocols followed during baseline water quality evaluation are presented in R645-301-723, and will not be further addressed in this section.

Analytical results are presented in full in Appendix VII-3 and summarized in Table VII-12. The standards used, as a point of comparison only, in evaluating the surface water quality are based upon recommended primary (PDW) and secondary (SDW) drinking water standards as found in R449-103-1 and R449-103-2 of the 8th edition of the State of Utah Public Drinking Water Rules, published by the Division of Drinking Water (Utah Department of Environmental Quality, 1991). In addition to concentration determinations of total dissolved solids (TDS), total suspended solids (TSS), iron, manganese and pH measurements, concentrations of major and trace elements are reported.

A charge balance check of the validity of the chemical analyses was also performed. The cation-anion balance, which is an indication of the analytical precision, was calculated as:

$$\frac{(\text{Cations}[\text{meq/l}] - \text{Anions}[\text{meq/l}])}{(\text{Cations}[\text{meq/l}] + \text{Anions}[\text{meq/l}])} \times 100$$

Analyses with a charge balance in excess of ±5% are considered unreliable and are not used to characterize the site. A sample collected at SS-4 on September 7, 1992 (5.7%) exceeded the analytical precision requirement. In addition, a sample collected from SS-4 on July 27, 1990 was not analyzed for chloride, thus precluding an accurate charge balance calculation.

Calculated TDS values were inserted to replace laboratory reported values when analytical error was determined (as noted by comparisons of measured TDS and specific conductance). Analyses of samples collected at SS-3 on August 16 1989, SS-1 on July 27 1990, and SS-2 on August 29 1992, include calculated TDS values derived using the method of Hem (1985). In addition, it is recognized that the field measurements of TSS, pH and specific conductance are somewhat qualitative due to the lag time between storm events and sample collection (caused by site inaccessibility). These issues aside, the data are considered adequate for baseline determination of general site conditions.

Single Stage Samplers:

SS-1

SS-1, located in Smoky Hollow above the proposed disturbed area, was sampled six times between August 16, 1989 and November 1, 1992. As can be seen in Appendix VII-3, there is no correlation between elevated TSS and TDS values and flow depth measurements. In three analyses, TDS exceeds the Secondary Drinking Water (SDW) standard of 500 mg/l (650 mg/l - 8/16/89; 535 mg/l (calculated) - 7/27/90; 512 mg/l - 8/29/92). However, the average TDS level, 446 mg/l, is below the standard for the sampling period under consideration. Total iron exceeds the SDW standard in two samples (10.6 mg/l - 8/16/89; 3.08 mg/l - 7/27/90). High iron concentrations show a strong correlation with elevated TDS values. In addition, there appears to be a decrease in iron concentration with each subsequent sampling event. Manganese is in excess of the SDW standard of 0.05 mg/l in three samples (5.3 mg/l - 8/16/89; 0.14 mg/l - 8/29/92; 0.42 mg/l - 11/1/92).

SS-2

High stream flow conditions during the July 27, 1990 precipitation event dislodged the stoppers in sample bottles, filling the bottles with sediment and prevented collection of water quality data. Four samples were collected between August 15, 1992 and November 1, 1992. The sample collected on August 15 has a TDS concentration of 1,420 mg/l, an iron concentration of 5.36 mg/l and elevated manganese of 0.14 mg/l. All three parameters are in excess of the respective SDW standard. Iron and manganese concentrations show a decrease with time. The August 29 sample had a nitrate concentration of 13.55 mg/l. The PDW standard for nitrate is 10 mg/l. As with SS-1, there is no correlation between increased water depth and elevated concentrations of stream constituents.

SS-3

Samples were collected at SS-3 (Smoky Hollow below the proposed mine site) on August 16, 1989 and September 7, 1992. The sample collected on August 16, after the crest gauge measured a storm flow of 9 cfs, had concentrations of TDS (594 mg/l - calculated), iron (0.58 mg/l) and manganese (2.9 mg/l) that exceeded SDW standards. All other analyses were within PDW and SDW standards.

SS-4

SS-4, located in Smoky Hollow approximately a mile and a quarter below the proposed mine site, was sampled twice during the monitoring period (7/27/90 and 8/29/92). An incomplete analysis of the earlier sample prohibits full water quality assessment, with the exception of manganese (0.52 mg/l) which exceeds the SDW standard (0.05 mg/l). The sample collected at the end of August 1992, after a flow event of 124.6 cfs, had a TSS level of 180,000 mg/l, and a TDS level of 640 mg/l (exceeds SDW standard of 500 mg/l). In addition the concentration of selenium and sulfate were in excess of recommended drinking water standards.

SS-5

SS-5, the lower station above the proposed mine workings in Smoky Hollow, yielded four samples during the monitoring period. All of these samples were collected following precipitation events during the spring and fall of 1992. Total suspended solids were of moderately high levels (average 31,433 mg/l), and TDS levels exceeded the SDW standard on only one occasion (808 mg/l - 5/30/92). Manganese was below the SDW standard for all samples except the August 29 sample (0.86 mg/l). In the sample collected on May 30, sulfate (367 mg/l) exceeded the SDW standard (250 mg/l).

SS-6

A sample from SS-6, located in a minor drainage at the proposed mine site, was collected on only one occasion, August 15, 1992, during the period monitored. Total dissolved solids (1,240 mg/l) and iron (0.88 mg/l) levels exceeded SDW standards. In addition, the sulfate concentration (722 mg/l) exceeds the PDW standard.

SS-8

The four samples collected from sampler SS-8, located at the mouth of Wesses Canyon, showed a wide range in suspended solid levels (TSS ranged from 27 mg/l to 206,000 mg/l). TDS concentrations fluctuated randomly, and were in excess of the recommended regulatory level of 500 mg/l on three occasions (832 mg/l - 7/11/92, 512 mg/l - 9/7/92 and 756 mg/l - 11/1/92). Iron levels exceeded SDW standard on two occasions (3.56 mg/l - 7/11/92 and 0.59 mg/l - 9/7/92), while manganese was elevated above the SDW standard of 0.05 mg/l on July 11, 1992 (1.15 mg/l). The pH, while not in excess of the recommended permissible range (6.5 - 8.5), exhibited the broadest range (7.3 - 8.1) of any site sampled during the monitoring period. Due to missing depth data, it was difficult to correlate between flow rate and TSS, TDS or the concentration of other chemical parameters.

SS-9

SS-9, situated at the distal end of John Henry Canyon, yielded four samples during the summer and fall of 1992 (7/11/92 through 11/1/92). However, flow depth was preserved only once, 36-inches on November 1. Total suspended solids levels ranged from 33 mg/l (11/1/92) to 58,800 mg/l (9/20/92). However, with one exception (684 mg/l - 7/11/92), TDS concentrations were consistent, and within the recommended range (average of remaining three - 447 mg/l). As with the SS-8 sample, both iron and manganese were above the SDW standard in the July sample.

Grab Samples:

101 - 112

Grab samples were collected from pooled water at five different sites during the fall of 1992 (101 through 112). (Refer to Figure VII-17 for grab sample locations.) Samples were collected from flood pools following a particular precipitation event, and results for TSS, TDS pH, iron and manganese are reported in Table VII-12. TSS levels are generally low due to the lag time between the runoff and sample collection. -> then why do them here

There appears to be an inverse relationship between elevated TDS concentrations and concentrations of iron and manganese. With two exceptions, sample 105 (8/15/92) where iron is 0.11 mg/l, and sample 109 (9/7/92) which has a TDS concentration of 928 mg/l, samples with a TDS value above 1000 mg/l are coincident with iron and manganese levels at, or below detection limits. For example, sample 108 (9/7/92) has a TDS concentration of 2,900 mg/l and iron and manganese concentrations of <0.05 and <0.02 mg/l respectively.

Discussion:

The steep topography and easily erodible formations in the permit and adjacent areas cause runoff, when it occurs, to be swift and sediment laden. The temporal and spatial variations in surface water chemistry within and adjacent to the permit area can be ascribed to a number of factors. Acting in concert, these factors cause the wide range of concentrations observed, and elevate certain constituents above the recommended primary and secondary drinking water standards.

The precipitation runoff, in the vicinity of the permit area, occurs within the Upper Cretaceous Straight Cliffs Formation. The Straight Cliffs Formation is made up of four members (discussed in more detail in Chapter VI, R645-301-624) consisting of interbedded sandstones and mudstones of variable thicknesses and mineral affinities (Peterson, 1969). The sandstones are well indurated, and consequently not susceptible to erosion. However, the heterogeneous mudstone intervals are readily eroded, providing the surface waters with an available source of both suspended and dissolvable constituents. Table VII-5, Mudstone Overburden Bulk X-Ray Diffraction Analyses Results, lists silica, potassium-feldspar, gypsum ($CaSO_4.2H_2O$), kaolinite ($Al_4(Si_4O_{10})(OH_8)$), illite/smectite ($(Al,Mg)_8(Si_4O_{10})_3(OH)_{10}.12H_2O$) as being present in the mudstone. Added to this is the variable, and restricted, nature of the summer precipitation events. In addition, channel transmission losses result in variations in surface water quantity measured at nearby stations, while evapotranspiration causes salts to build up on stream sediments. These factors combined lead to temporal and spatial variations in the surface water chemistry.

Within the permit and adjacent areas, the data collected for this baseline investigation do not appear to fully support two observations made in 1979 USGS study. The USGS suggests that TDS increases downstream, and that high flow conditions cause a decrease in TDS, while low flow results in elevated TDS. A close analysis of the results in Appendix VII-3, reveal that, within the permit area, there is no increase in TDS downstream. The increased TDS referred to in the USGS study is probably due to presence of the Tropic Shale, which outcrops downstream of the permit area. However, within the study area, there are systematic chemical differences that correlate well with variations in precipitation. In contrast to the USGS study, the data from the current investigation suggest that elevated flow results in elevated levels of ionic constituents in the stream waters.

A comparison of the data from SS-1 with SS-4 on July 7, 1990 and August 29, 1992, shows that the elevated ionic concentration at SS-4 in 1990 (about 2.5 times greater than SS-1) is a direct result of increased flow (3.7 times that measured at SS-1). The 1992 data show an increase in the TDS concentration of SS-4 of 1.3 times that at SS-1. This corresponds to a flow differential of 1.3.

The data do, however, support the USGS finding that, after prolonged dry spells, the TDS is elevated in the initial sampling of ensuing runoff events. Thereafter, the TDS concentration shows a systematic decrease with each subsequent precipitation event. This is manifested in the data from SS-9, collected during the late summer of 1992. TDS, initially 684 mg/l (7/11/92) decreases to 512 mg/l (9/7/92), and finally 326 mg/l on the third sample collected from this site (9/20/92). An anomaly to this trend is observed in the data gathered at SS-1 between August 15 and August 29, 1992. The second precipitation event would be expected to have lower concentrations of TDS. However, TDS is 1.4 times greater in the later sample. Thus, water quality data collected to date from the permit and adjacent areas indicate a high degree of both spatial and temporal variability in the ephemeral system.

724.300 **Geologic Information**

Applicable geologic information can be referenced in Chapter VI, R645-301-624.

724.400 **Climatological Information**

724.410 The closest operating weather station to the permit area is located in Page, Arizona. Although some limited climatic information exists from Big Water, Utah, complete records are not available. Precipitation information was collected in the Kaiparowits Plateau region as part of a Brigham Young University study between 1971 and 1974 and is included herein as Figure VII-7 and Figures VII-8a through VII-8e.

724.411 Precipitation

According to Blanchard (1986), the normal annual precipitation at the proposed surface facilities is 8 inches. Approximately 3.6 inches (45 percent) of this precipitation falls during the period of May through September, with the remaining 4.4 inches (55 percent) falling during the period of October through April (Blanchard, 1986). Thus, a slight majority of the precipitation at the site can normally be expected to occur during the fall and winter months, predominantly as snow.

The annual precipitation at Page, Arizona from 1967 to 1982 averaged 6.35 inches/year. Seasonal averages for the same years at Page, Arizona are spring (March, April, and May) 1.48 inches/year, summer (June, July, and August) 1.31 inches/ year, fall (September, October, and November) 1.83 inches/ year, and winter (December, January, and February) 1.75 inches/year.

Brigham Young University collected precipitation information from five locations in the Kaiparowits Plateau region as shown on Figure VII-7 from 1971 through 1974. Precipitation patterns for the four years of study as published by Brigham Young University (Murdock et al., 1975), are depicted on Figures VII-8a through VII-8e. Precipitation at the five locations of study ranged from 3.94 to 15.12 inches/year and averaged 7.31 inches/year for the period of record. The precipitation distribution depicted on Figures VII-8a through VII-8e indicate that a higher percentage of the yearly precipitation often occurs during the cooler months (October through March) than during the warmer months (April through September) and that the lowest percentage of yearly precipitation typically occurs during the months of April through June. This agrees with data presented by Blanchard (1986).

724.412 Surface Winds

The irregular terrain of the proposed permit area exerts a pronounced influence on the low level wind patterns. There are numerous air mass circulations within individual valleys, canyons, and along mountain slopes that occur as a result of the diurnal heating and cooling cycles (Kaiser Engineers, 1975).

The most significant surface wind effects occur from high wind velocities that are manifest as sand or dust storms during which visibility in the area is noticeably reduced and wind erosion may occur (Kaiser Engineers, 1975).

A wind measurement program was conducted on Fourmile bench during 1974 and was supplemented with information obtained from Nipple Bench since November 1971 in order to characterize low level wind patterns. The data indicate that westerly and west southwesterly winds predominate during all months. Wind speeds are greatest during the fall, with an average annual wind speed of 6.6 mph (Kaiser Engineers, 1975).

Upper Level Winds

Wind measurements have been collected since April 1970 at Page, Arizona, 15 miles south of the proposed surface facilities. Simultaneous measurements were made at both Page, Arizona and Nipple Bench during November 1973 and May 1974 and found to correlate sufficiently in speed and direction to justify the use of wind data gathered at Page (Kaiser Engineers, 1975).

Based on the long-term Page wind data, the net air movement over the site area is generally from the west and southwest, with the most frequent winds occurring from the west. Figure VII-9 shows a summary of morning and afternoon wind activity at Page at an altitude of 7,300 feet. Winds are expected to occur from the south-southwest to the west- northwest quadrant approximately 50 percent of the time, with the remaining 50 percent distributed nearly uniformly in the remaining quadrants (Kaiser Engineers, 1975).

724.413 Seasonal Temperature Ranges

Temperatures in the mine vicinity range from averages of 30 to 35°F in the winter to 70 to 80°F in the summer. Extremes vary from less than 0°F to more than 100°F. Table VII-13 presents the monthly mean maximum and minimum temperatures recorded at the Big Water weather station between 1962 and 1970 (Kaiser Engineers, 1975).

R645-301-724.600 SURVEY OF RENEWABLE RESOURCE LANDS

Renewable resources for the permit and adjacent areas were evaluated for the purposes of this section. The survey information is presented in Appendix VII-10.

R645-301-724.700 The proposed minesite has been evaluated with regard to alluvial valley floors. Based on 17 soil test pits and surface mapping observations, a determination was made that an alluvial valley floor is not present in the mine site or adjacent areas. Refer to Chapter II (page II-17), R645-302-320 Alluvial Valley Floor Determination.

R645-301-725 BASELINE CUMULATIVE IMPACT AREA INFORMATION

Hydrologic and geologic information necessary to assess the probable cumulative hydrologic impacts of the proposed coal mining and reclamation operation is presented in Chapter VI, Chapter VII and the Probable Hydrologic Consequences portion of the permit.

Through their work in preparing the baseline summary, EarthFax Engineering, Inc. was able to review all existing data for the region and prepare their findings in the form of a Probable Hydrologic Consequences report. The Probable Hydrologic Consequences for the Smoky Hollow Mine, prepared by EarthFax Engineering, Inc., is presented below in section R645-301-728.

R645-301-728 PROBABLE HYDROLOGIC CONSEQUENCES (PHC) DETERMINATION

This section addresses the probable hydrologic consequences ("PHC") of coal mining and reclamation operations in the mine permit and adjacent areas. Mitigating measures are discussed generally in this section and in detail in Section R645-301-730 of this document.

728.100 Potential Impacts to Surface and Groundwater

Potential impacts of coal mining on the quality and quantity of surface and groundwater flow may include:

- o Contamination from acid- or toxic-forming materials,
- o increased sediment yield from disturbed areas,
- o flooding or streamflow alteration,
- o impacts to groundwater or surface water availability,
- o hydrocarbon contamination from above-ground storage tanks or from the use of hydrocarbons in the permit area,
- o contamination of surface water from coal spillage due to hauling operations, and
- o removal of water from the Navajo Sandstone for use at the mine.

These potential impacts are addressed in the following sections of this document.

728.200 **Baseline Hydrologic and Geologic Information**

Baseline hydrologic information is presented in Sections R645-301-724.100 and R645-301-724.200 of this document. Baseline geologic information is presented in Chapter 6 of this document.

728.300 **PHC Determination**

Potential Impacts to the Hydrologic Balance. Potential impacts to the hydrologic balance are addressed in the following subsections of this document.

Acid- or Toxic- Forming Materials. Core samples of the strata above the coal seam were collected from drill holes 401, 403 and 404 and tested for acid/toxic forming materials. The results of the chemical analyses are included in Appendix VI-1 and are summarized on Table VII-14. The sampling locations are shown on Exhibit VII-5. In addition, samples of the exposed coal seam, as well as samples of the exposed overburden and underburden, were collected by hand from the proposed disturbed area in February 1992 and submitted for chemical analyses.

Included in the overburden outcrop samples (OB-1 and OB-2) was a thin interval of coal which is likely to be representative of the coal seam below. The roof of drill hole 401 was analyzed in October, 1990 by lithologic unit. The samples for drill holes 401, 403 and 404 were composites of the roof and floor approximately 0-10 feet above the coal seam and approximately 0-5 feet below the coal seam.

The acid/base potential of the February 1992 coal sample and floor sample from drill hole 404 were below the minimum acceptable level of -5 tons $CaCO_3$/1000 tons soil as set by DOGM reclamation guidelines. All other samples fell within acceptable ranges for acid/base potential as determined by the DOGM. In the case of the coal, stockpiled material will be combined in the mine yard, thus minimizing the effects of the less alkaline coals. In addition, storage will be short-term. If, however, a precipitation event occurs, coal fines which are washed from the stockpile will drain into the sediment pond and treated as discussed in Section R645-301-731.100. Additionally, any acidity in the run-off will be neutralized by the alkaline nature of the mine yard substrate. It should be noted that coal is a very natural and abundant constituent in the area. Coal from numerous outcrops

in Smoky Hollow has weathered and washed into the drainages as part of the natural geologic process which has been occurring for millions of years. With the construction of the sediment pond, the amount of coal fines from the immediate area into the natural drainage will be less than under naturally existing conditions. In the case of the floor sample from drill hole 404, no waste rock will be removed from the mine. Instead, all waste rock will be stored underground. Since all remaining rock samples indicated acceptable acid/base potentials, the generally alkaline materials will serve to neutralize any acid-forming materials that may be encountered. In addition, by storing the materials underground, oxidation of the material will be minimized.

Some chemical analyses were performed according to methods other than described by the State of Utah Division of Oil, Gas and Mining (DOGM) Guidelines for Management of Topsoil and Overburden for Underground and Surface Coal Mining (1988). In these cases, the method used was an EPA approved (EPA 3050) nitric acid digestion procedure instead of the DOGM recommended hot water extraction. The total selenium present, not just that available to plant life (as with the hot water extraction) is thus reported. This resulted in selenium being reported as a higher value. Even so, only 5 of the 14 samples presented in Table VII-14 exceeded the DOGM recommended selenium level of 0.1 mg/kg. Hence, if recommended analytical methods had been used in all cases, it is possible that selenium concentrations would not be above the recommended levels.

With regard to the SAR values, the soluble cations are actually lower than that found in the native soils. Hence, from the results of the analyses, there does not appear to be reason for concern with regard to acid or toxic materials in the coal or surrounding strata.

As discussed in Section R645-301-724 of this document, the potential for groundwater being intercepted by mining operations is minimal. Therefore, the potential for mine drainage to affect groundwater or surface water is low.

Waste material generated during the mining operation, such as through installation of overcasts, will be permanently stored underground in cross-cuts or storage rooms. Since this material will not be brought to the surface for storage or disposal, it will not be a factor in the reclamation of the minesite.

728.300
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#2

The drillholes utilized for the analyses of roof and floor were selected because they provided information on the first five year mining area and are representative of the strata that could be encountered elsewhere in the mine plan area. Sampling of roof and floor rock will be conducted on a routine basis during the mining operation. Roof and floor samples, consisting of a minimum of one foot of rock material above and below the coal seam, will be collected and analyzed according to Table 6 of the "Guidelines for Management of Topsoil and Overburden" on an annual basis from the mains and submains of the underground mine.

Sediment Yield. Undisturbed drainage from Smoky Hollow and most of its tributaries, above the mine site, will be diverted beneath and discharged below the disturbed area via a properly sized bypass culvert. Runoff from the entire disturbed area, and portions of the undisturbed area not diverted, will be drained into a sedimentation pond. Details of the sedimentation and drainage control plan for the disturbed area are presented in Appendix VII-5.

728
#8

During precipitation events in excess of the 10 year, 24 hour event, disturbed area drainage which is captured by the sedimentation pond and discharged as overflow into the main channel will have a lower sediment yield than the natural undisturbed drainage flow. The lower suspended sediment concentration of the water discharged from the sedimentation pond will mix with sediment-laden water in the stream channel, thus minimizing the erosive effects of the sediment pond overflow. Due to the infrequency of precipitation in the region, the high net rate of evaporation, and the design of the sedimentation pond for total retention of the 10-year 24-hour storm, it is likely that only limited quantities of water could be discharged from the sedimentation pond below the disturbed area. Excess water collected in the pond after runoff events may be released in a controlled manner by means of the decant device. To ensure that increased erosion does not change the downstream profile, the scouring effects of the released water will be monitored. In the case that increased erosion occurs, the rate at which the decant water is released from the sediment pond will be reduced. The energy dissipator designed for the sedimentation pond outlet will further decrease potential scouring of the natural channel downstream from the disturbed area.

Using the Universal Soil Loss Equation (USLE), an estimate of the yearly sediment yield from the proposed disturbed area (in the premining condition) is 0.491 acre feet. An estimate of the yearly sediment yield from the disturbed area (in the operational phase) upstream from the sedimentation pond is 1.872 acre feet (see Appendix VII-5 for sediment yield calculations). The sedimentation pond has been designed to meet the effluent limitations of R645-301-751.

The higher precipitation in late summer months could mean a more rapid build-up of sediment during those periods. In addition, water levels in the sediment pond may rise in the months following seasonal storms, and may result in discharge (decant) from the sediment pond.

It is difficult to predict the sediment yield of the disturbed area during the construction and reclamation phases because of the continually changing erodibility factor in the USLE. However, the sedimentation pond will be installed during the first phase of construction and will remain in place until the final phase of reclamation. Thus, both construction- and reclamation-period sediment yields should be less than natural conditions at the site. The characteristics of the stream channel below the disturbed area will be monitored during the life of the operation to evaluate hydrologic impacts to the stability of the natural channel below. Details of the construction and reclamation phases are discussed in Section R645-301-526 of this document.

Acidity, Total Suspended and Dissolved Solids. Probable impacts of mining and reclamation operations to the acidity of surface and groundwater were discussed previously in this section. Probable impacts to total suspended solids concentrations of surface water in the permit and adjacent areas have likewise been previously discussed.

As discussed in Section R645-301-724.200, the baseline chemical quality of surface water in the region generally deteriorates in the downstream reaches of the streams in the region. Surface water flow from Warm Creek crosses the Tropic Shale below the permit area. Total dissolved solids concentrations are naturally high in areas underlain by this unit.

As noted in Section R645-301-724 of this document, no significant quantities of groundwater will be encountered in the underground mine workings. Thus, there will be no discharges of groundwater to the surface during mining activities. As a result, TDS concentrations in surface water within the permit and adjacent areas will not be impacted by groundwater discharges.

728 #5 Soils to be used in construction of the surface facilities within the permit and adjacent areas will be obtained primarily from the immediate area. High salinity soils that may impact TDS concentrations in local surface water will not be imported to the area, thus precluding impacts to TDS concentrations from this source. Additionally, as discussed in Section R645-301-731.100, the generally alkaline nature of the soils in the permit and adjacent areas will neutralize any possible contamination from acidic- or toxic-bearing materials should they be encountered and stored on the surface.

As currently designed, water used in underground mining activities will be obtained from a water-supply well that will be drilled into the Navajo Sandstone. As noted in Section R645-301-724 of this document, the TDS concentrations of water from the Navajo Sandstone are expected to be significantly less than concentration of water obtained from the Calico Sandstone (the uppermost aquifer beneath the coal seam). Thus, seepage of imported water from the mine workings to adjacent rock will not degrade the TDS concentration of in-situ groundwater.

<u>Flooding or Streamflow Alteration</u>. Runoff from the disturbed area will flow through the sedimentation pond prior to discharge to the undisturbed Smoky Hollow drainage. Three factors indicate that the sedimentation pond will minimize or preclude flooding impacts to downstream areas as a result of mining operations. First, the sedimentation pond has been designed to be geotechnically stable, minimizing the potential for breaches of the sedimentation pond that could cause downstream flooding. Second, the flow routing that occurs through the sedimentation pond reduces the peak flow from the disturbed area. This precludes flooding impacts to downstream areas.
728 #9 Third, by retaining sediment on site in the sedimentation pond, the bottom elevations of the stream channel downstream from the disturbed area will not be artificially raised. Thus, the hydraulic capacity of the stream channel will not be altered.

Interim sediment-control measures and maintenance of the construction and reclaimed areas during the pre- and post-mining periods will preclude deposition of significant amounts of sediment in the downstream channel, thus maintaining the hydraulic capacity of the channels and precluding adverse flooding impacts. Following reclamation, stream channels will be returned to a stable state as described in the sedimentation and drainage control plan in Appendix VII-5. The reclamation channels have been designed to safely pass the peak flow resulting from the 100 year - 6 hour storm event, precluding flooding in the reclaimed areas.

As discussed in Section R645-301-525 of this document, appropriate methods will be used in the vicinities of main channels (Smoky Hollow and Wesses Canyon) to minimize the potential effects of subsidence. However, it is possible that subsidence will occur in areas occupied by small, upland ephemeral stream channels. Although surface cracks that result from subsidence tend to heal with time, ephemeral stream flows may be partially intercepted prior to completion of the healing process. Should subsidence occur, the following factors indicate that the impact on ephemeral stream flow will be minimized:

1. Ephemeral streamflow in the area is sporadic, allowing significant periods of time for surface cracks to heal between flow events.

2. Ephemeral streamflow typically carries a high sediment load. This sediment will fill remaining cracks. As the cracks fill, the potential for interception of streamflow is minimized.

3. The depressions created by subsidence are generally sufficiently broad that changes in slope are not typically of an ample magnitude to cause ponding. This is especially true given the hummocky nature and the regional gradient of the benchlands overlying the mine workings.

<u>Groundwater and Surface Water Availability</u>. The potential impacts of mining on surface-water availability are discussed above. As indicated, these impacts are not considered to be significant.

It is possible that perched groundwater zones will be encountered during the mining process. As indicated in Section R645-301-724.100 of this document, interbedding of sandstone and shale impede movement of water into or out of the perched groundwater lenses. The lenticular nature of the sandstone and low recharge capacity (due to the high evapotranspiration of the area and the interbedding of relatively impermeable strata) indicates these perched zones contain limited quantities of water and are likely to dewater rapidly. Because the perched groundwater zones are isolated and not hydraulically connected to any regional aquifer, the effect of dewatering these perched zones on the hydrologic balance is minimal.

728.300
p VII-77
#1

724.100
p VII-25
#2

728 #11

It is possible that the seeps within the permit area that are fed by the perched groundwater zones could dry out if subsidence cracks intersected the surface at these three locations. However, none of the seeps have produced a measurable flow during the baseline monitoring period. None of the seeps within the permit area are accessible by livestock. Because the seeps are located near the top of the plateau where subsidence should be uniform, the formation of subsidence cracks is doubtful and the effects on the seeps due to mining should be negligible. Should subsidence cracks intercept any seeps, it is a very strong possibility that the clays within the strata will swell and seal the crack. Table VII-5 lists clays found in the mudstone overburden. The overburden has a high level of bentonitic, or swelling clays (16 percent smectite) that can increase up to eight times in volume, thus prohibiting substantial downward loss of water. Bentonitic clays have been known to form an effective barrier to vertical movement of groundwater within the Blackhawk Formation (Utah Fuel Company, 1992). The John Henry Member is chemically similar to the Blackhawk because the units are stratigraphically equivalent.

It is not likely that the seeps and springs located outside the permit area will be affected by the mining process because they are outside the zone of subsidence and are not hydraulically connected to the perched zones within the permit area. The closest spring to the permit area is the Needle Eye Water Spring which is located more than 2 miles outside the zone of subsidence for the life of the mine (see Exhibit V-8 and VII-5).

728 #6

The Calico sandstone, which lies approximately 150 feet below the coal seam and appears to contain saturated zones beneath much of the permit and adjacent areas, should not be affected by the mining process because it underlies the coal seam at a considerable depth. Depth, plus the considerable thickness of the intervening mudstone beds observable on the outcrop, would present a fairly impermeable barrier and prevent degradation of groundwater in the Calico sandstone. As discussed in Section R645-301-724.100 of this document, recharge to the Calico sandstone from above, in the vicinity of the mine area, is probably minimal due to the thick sequence of mudstone, low precipitation rate, and high evapotranspiration rate in the area.

<u>Potential Hydrocarbon Contamination</u>. Noncoal mine wastes will be placed and stored in a controlled manner in a designated portion of the permit area as described in Section R645-301-528.330 of this

728 #2

document. A list of proposed chemicals to be used in general mining applications is shown in Table VII-15.

728 #6

Diesel and oil stored in above-ground tanks at the mine surface facilities could spill onto the ground during filling of the storage tank, leakage of the storage tank, or filling of the vehicle tank. Similarly, greases and other oils may be spilled during use in surface and underground operations.

728.300 p VII-78 #1

The probable extent of contamination caused by diesel and oil spillage is expected to be small. Because storage tanks will be located above ground and contained within impermeable concrete containment structures, leakage from the tanks will be readily detected and contained and the tanks repaired. Furthermore, spillage during filling of the storage or vehicle tank will be minimized to avoid loss of an economically valuable product. As a last line of defense, accidental spillage from anywhere within the minesite would be caught and contained within the sediment pond in accordance with the SPCC plan (Spill Prevention Control and Countermeasure Plan) located in Appendix V-7.

Coal Haulage. Coal will be hauled from the mine portal area via covered highway trucks. These trucks will be equipped with mechanically sealed discharge gates. If a spill should occur, it would be cleaned up as soon and completely as practical, including broom sweeping. Residual coal following the cleanup of the spill may wash into local streams during a runoff event. Possible impacts to the surface water may be a temporary slight increase in total suspended solids and turbidity from the fine coal particulates. Coal in itself contains no hazardous or toxic elements. Coal has weathered from the outcrops in this area for millions of years occurs naturally in the local streams without adverse effects. Due to the probable infrequence of spillage and the rapidity with which the spill will be remedied, the probable impact of coal spillage on the hydrologic system will be minimal.

728 #3

The probable increased air particulate content due coal transportation on cut and fill roads will be minimized by using covered haulage trucks. Within the permit and adjacent areas, total suspended solids in surface waters are frequently several tens of thousands of mg/l. The very nature of the region, its aridness, limited ground and crowncover, lends itself to high levels of airborne particulates. A qualitative assessment of the impacts of the proposed mining operations reveals a low potential for significant increases in TSS levels in local streams due to fugitive dust from coal haulage and surface-facility operation.

728 #3

The expected concentration of air particulates (TSP, total suspended particulates) from the proposed mining operation has bee determined as part of the Notice of Intent (NOI) for the Smoky Hollow mine on file with the Utah Division of Air Quality (DAQ). The potential TSP emissions have been determined in the NOI by North American Weather Consultants using the approved EPA air quality modelling programs COMPLEX1 and ISCST2 as required by Utah DAQ. These computer model runs have incorporated all potential TSP sources associated with the proposed facility, including the coal pile, material transfers, disturbed areas (including road cuts and fills), access road traffic, and the truck loading facility. All emission factors were derived using accepted EPA formulas from the AP-42 Handbook. "Worst-case" metereologic data (met-set) was utilized.

Based on the computer modelling, the highest annual concentration of TSP expected in the natural drainage beyond either the upstream or downstream ends of the disturbed area is less than 10 percent of the allowable PSD (Prevention of Significant Deterioration) increment established for Class II areas under State and EPA criteria. For further details refer to the Smoky Hollow Mine NOI on file with the Utah Division of Air Quality.

728.300 #1

Projected Water Needs. Projected total water usage on a continuous basis from the Navajo aquifer is 248 gal/min (400 acre feet per year). Broken down into categories projected consumption is as follows: underground mine usage is projected to be 238 gpm, projected culinary and sanitary consumption is 4 gpm, while other surface usage (dust suppression, washing, etc.) will account for the remaining 6 gpm.

724 p VII-43 #1

Current usage for domestic and irrigation purposes from the Navajo, within the Kaiparowits Plateau, is about 1,700 ac-ft per year (1050 gpm), while total estimated recoverable water from the Navajo (at an estimated yield of 10%) is 140 million acre-feet (Blanchard, 1986). Under current recharge and discharge conditions, the ground water within the Kaiparowits plateau is considered to be in a state of equilibrium (Blanchard, 1986). In light of this, the small amount withdrawn for proposed mining and related activities is considered

#1

insignificant, and will not adversely affect the state of equilibrium of the Kaiparowits ground water.

Summary

The potential impacts of mining operations upon the hydrologic balance are summarized on Table VII-16. The potential magnitude of the impacts are low to moderate and the probability of occurrence for all potential impacts are minimal.

R645-301-729

CUMULATIVE HYDROLOGIC IMPACT ASSESSMENT (CHIA)

The Division will provide an assessment of the probable cumulative hydrologic impacts of the proposed coal mining and reclamation operation and all anticipated coal mining and reclamation operations upon surface and groundwater systems in the cumulative impact area.

R645-301-730 OPERATION PLAN

R645-301-731 GENERAL REQUIREMENTS

A plan has been included to minimize disturbance to the hydrologic balance, to prevent material damage, and to support postmining land use.

731.100 Hydrologic Balance Protection

Groundwater Protection

Although testing has shown that no significant impacts from acid or toxic producing materials should occur, groundwater quality will be protected by handling earth materials and runoff in a manner which minimizes the infiltration into the groundwater system. Examples of techniques that may be utilized to accomplish this would include routing disturbed area drainage to the sediment pond through properly sized ditches and culverts and diverting undisturbed drainage past the disturbed area.

Within the disturbed area, drainage will be directed to ditches by sloping the yard areas. The ditches will be appropriately sized to handle flow from the 10 year/6 hour event. Culverts within the drainage system have also been sized to meet or exceed the design criteria.

730
p VII-80 →
VII-81
#1

At the refuse pile location, undisturbed drainage will be diverted around the pile. Although the material stored in the pile should not be acid or toxic forming, drainage from the pile will be diverted into ditches that will convey the flow to the sediment pond. To assess the possible build-up of acid- or toxic-precipitates from the sedimentation pond, sediments will be sampled, before removal, when capacity is reached. Acidic drainage from the sediment pond is unlikely due to the alkaline nature of the unsaturated zone. The natural high alkalinity of soil in the area, as observed in chemical data from the coal overburden (Table VII-14), will neutralize any acid drainage in the unlikely event that it occurs.

Surface Water Protection

Although limited amounts of surface water exist in the permit area, coal mining and reclamation activities will be conducted according to the following plan.

A sediment pond or other treatment facilities will be installed prior to disturbance of the proposed facility area. The pond will be appropriately sized to handle the design storm event for the mine site.

Protection of surface water will incorporate measures cited under Groundwater Protection. All surface runoff from the disturbed area will be diverted to the sediment pond for treatment. The sediment pond has been designed to provide total containment for the 10 year/24 hour storm plus three years of sediment accumulation. Based on sampling of the soils in the area and the fact that waste rock material will not be stored on the surface, it is unlikely that the sediment pond will impound acid- or toxic-drainage.

731 p VII-80 → VII-81 #1

It is anticipated, based on the climate of the area, that the sediment pond will remain dry most of the time. (This has been demonstrated to be true for existing coal mining operations in central Utah.) Following heavy precipitation events water in the pond should evaporate rapidly. Infiltration into ground water zones is not expected because of the interbedded nature of the strata below the pond. Shale sequences of the interbedded strata below the pond will greatly limit the vertical movement of water. Also, the alkaline nature of other sediment flowing to the sediment pond would serve to neutralize any low pH materials when mingled together.

To minimize disturbance to the undisturbed drainage, large diameter bypass culverts will be installed beneath the mine yard facility to allow runoff upstream from the mine site to continue downstream without coming in contact with the mine yard area.

The bypass culvert system will be the first structure to be installed during construction of the mine site facility. Undisturbed area drainage will be bypassed under the disturbed area to minimize the amount of drainage that must be treated by the sediment pond. The bypass culverts will allow natural drainage to continue down the drainage course unaffected by the mining operation.

Topsoil piles will be surrounded by a ditch-berm system designed to limit loss from the piles due to run off. The ditches will divert water away from the stockpile.

Even though analyses show no acidic or toxic-forming materials are present in the coal or overburden materials, drainage will diverted away from storage piles and noncoal waste storage areas. All surface drainage will be contained in an adequately sized sediment pond.

The following Water Monitoring Plan, presented in R645-301-731.200, was developed by EarthFax Engineering, Inc.. The monitoring plan is based on their extensive review of the ground and surface water systems along with their evaluation of the potential impacts mining operations could have on resources in the area.

R645-301-731.200 WATER MONITORING

Groundwater

As discussed in Section R645-301-724.100, groundwater in proximity to the coal seam exists in the Calico Sandstone and in isolated perched zones in and above the coal seam. Groundwater will be monitored on a quarterly basis from the Calico Sandstone from both monitoring well MW-1 and the Calico seep. Groundwater samples representative of the perched zones will be collected on a quarterly basis from seeps S-2 and S-4. Due to the limited recharge to the Calico Sandstone and the perched groundwater zones, the seeps may not always produce sufficient amounts of water for sampling. Additionally, as discussed in Section R645-301-728.300, these perched groundwater zones may be intercepted by subsidence cracks and dewatered. Sampling of these seeps is contingent on sufficient water being available at the time of monitoring.

731.200 #1

Groundwater samples collected during the mining and post-mining periods will be analyzed for the parameters listed on Table VII-17. This table was derived from a review of the historic monitoring data provided in this PAP. Chemical parameters included in previous monitoring efforts that have consistently been below the detection limit and/or below the drinking-water standard have not been included in Table VII-17. Hardness was also dropped from the list since the primary ions that cause hardness (calcium, magnesium, iron, and manganese) will be individually monitored. All other previous monitoring parameters have been included.

During the mid-term review of the permit the baseline parameter list will be performed on ground water samples once during that year to reverify the original data.

731.200 p VII-64 #1

As monitoring progresses, data will be reviewed for significant fluctuations of groundwater quantity and quality. Environmental

731.200
PVII-84
#1

factors (such as climate patterns) will be considered, as well as the mining operation, to determine the cause of changes in groundwater quantity or quality, should they occur. If analysis of any groundwater sample indicates noncompliance with the permit conditions, the Division will be notified and actions will be taken as determined necessary by the Division and as provided for in R645-300-145 and R645-301-731.

By the end of each month following each calendar quarter (i.e., April 30, July 31, October 31, and January 31), a report will be submitted to the Division summarizing hydrologic monitoring activities during the previous quarter. These reports will include field measurements, observations, and analytical results received during the previous quarter.

As indicated in Section R645-301-724, significant sustained inflows to the mine workings are not anticipated. However, if an inflow of water is encountered, and that flow exceeds 1 gpm for a period of at least 30 days, flow and water quality data will be collected from that inflow once each quarter as long as the inflow point remains accessible during mining operations. Data will be collected as close to the point of issuance as possible to prevent contamination by mining operations. During the first two years of monitoring, the data listed in Table VII-18 will be collected from mine inflows. Table VII-18 was developed to coincide with the previous baseline monitoring list to provide consistency.

Following the initial baseline period for the mine inflows, future monitoring will continue on a quarterly basis as long as the inflow is sustained and the location is accessible. This continued, post-baseline monitoring will be in accordance with Table VII-17 unless the data indicate that an alternative monitoring program is necessary. Any alternative to Table VII-17 for the mine inflows will be proposed to the Division prior to implementation.

With the exception of the Calico seep discussed above, springs outside the permit area will not be monitored. These springs are fed by isolated perched groundwater zones that are not hydraulically connected to the perched groundwater zones within the permit area. The closest spring to the permit area (Needle Eye Water) is located more than 2 miles outside the predicted zone of subsidence for the 30 year plan as shown on Exhibit VII-8. Thus, the springs outside the permit area will not be affected by the mining operation.

In accordance with R645-300-145, should noncompliant sample analyses be received, additional sampling will be done , if necessary, to determine the nature and extent of noncompliance. Once the problem has been identified, measures will be implemented to correct the problem. Any person who's health or safety is in imminent danger due to the noncompliance will be notified as soon as possible. Andalex Resources will pursue action to minimize disturbance to the hydrologic balance within the permit and adjacent areas, to prevent material damage outside of the permit area, to support approved postmining land use plans, to comply with the Clean Water Act and applicable federal and Utah state water quality laws and regulations.

Groundwater monitoring will proceed through mining and continue during reclamation until bond release or until modifications of the monitoring plan are made and approved by the Division in accordance with the procedures of R645-303-220. For the year preceding a permit renewal, sample analyses will be performed according to the baseline list on Table VII-18.

Groundwater Monitoring Equipment

Monitoring well MW-1 will be sampled with a dedicated 1/3 horsepower stainless steel submersible pump. Water will be pumped to the surface via a 1-inch diameter PVC riser pipe. Sampling procedures will include purging the well of a volume of water equivalent to three casing volumes (or until water quality stabilizes) prior to collecting the groundwater samples. The samples will be collected directly into laboratory-supplied sample bottles. Field chemistries of pH, temperature, and specific conductance will be recorded periodically during purging to monitor the chemical stability of the water prior to sampling. Baseline groundwater samples collected from MW-1 prior to the April 1992 installation of the dedicated submersible pump were obtained using a PVC bailer with minimal pre-sample purging.

As noted in Section R645-301-724, flow from seep S-4 and the Calico seep has historically consisted of periodic dripping, while seep S-2 consist of a small ponded area with no apparent flow. To allow accumulation of sufficient water for sampling, clean dedicated plastic buckets will be left under drips from seep S-4 and the Calico seep. A sheet of thin plastic with a hole in the center will be placed over the mouths of the plastic buckets to reduce evaporation during the

collection period. Samples will then be collected from water retained in these buckets.

Because there may be considerable lag time between when the buckets fill and when the samples are collected, field chemistries taken from these seeps may not be absolutely valid. However, these field results will be considered generally representative of local conditions.

All groundwater samples will be stored and shipped to the laboratory in ice packed coolers. Samples will be preserved in accordance with standard protocols recommended by the Environmental Protection Agency.

731.220 Surface Water Monitoring

731.200 p VII-88 #1

The surface water monitoring plan will include the monitoring of nine stream stations in the Smoky Hollow drainage system. The monitoring stations will consist of single stage samplers and are described below. The locations of the nine single stage samplers (identified as SS-1 through SS-9) as presently located, are shown on Exhibit VII-5. Since construction of the mine surface facilities may require relocation of several these sites, an updated map of the sampling stations will be provided following construction of surface facilities.

As runoff only occurs during precipitation events, the stations will be checked periodically or after observed precipitation events to collect samples and record measured flow. Surface water parameters to be measured are listed on Table VII-17. For point source discharge, such as the sediment pond, monitoring will be conducted in accordance with the appropriate regulations and the UPDES permit issued for the site.

By the end of each month following each calendar quarter (i.e., April 30, July 31, October 31, and January 31), a report will be submitted to the Division summarizing hydrologic monitoring activities during the previous quarter. These reports will include field measurements, observations, and analytical results received during the previous quarter.

731.200 p VII-84 #1

As monitoring progresses, data will be reviewed for significant fluctuations of surface water quantity and quality. Due to the large degree of natural variation in surface water quantity and quality in

731.200 pVII-84 #1

ephemeral systems, climatic variations and stream flow will be considered, as well as the mining operation, to determine the cause of the impact to the surface water. When analysis of any surface water sample indicates noncompliance with the permit conditions, the Division will be notified and actions will be taken as determined necessary by the Division provided for in R645-300-145 and R645-301-731.

Water data reports will include: the storm date (for single stage sampler data), sample date and time, analysis date and time, analytical method, detection limit, field parameters, name of individual collecting the sample and the name of the laboratory and person conducting the sample analysis.

760 d1

During reclamation, a water monitoring station will be added to the inlet of the sedimentation pond. Water at this station will be collected by a single stage sampler system during runoff events. Samples will be analyzed in accordance with Table VII-17.

731.200 #1

Surface water monitoring will proceed through mining and continue during reclamation until bond release or until modifications of the monitoring plan are made and approved by the Division in accordance with the procedures of R645-303-220. During the year preceding the mid-term permit review, two samples will be taken (one at high flow and one at low flow) to be analyzed according to the surface baseline monitoring parameter list Table VII-18.

731.225 Surface Water Monitoring Equipment

Surface water monitoring is conducted with nine single stage samplers. These samplers were constructed in general accordance with Guy and Norman (1970). The single stage samplers consist of 2 bottles attached to posts anchored in the stream channel bottom. The bottles are equipped with rubber stoppers to prevent sample evaporation. Two copper tubes passing through each stopper are situated such that a water sample can be collected in the bottle through one tube while displaced air escapes through the other.

Surface water samples are transferred from the single stage sampler bottles directly into laboratory supplied sample bottles. Field chemistries of pH, temperature, and specific conductance are measured and recorded. Samples are stored and shipped to the laboratory in ice packed coolers.

742 #1

The primary limiting factor in ensuring collection of representative water quality samples is site accessibility. During precipitation events access to the proposed mine site is inhibited by poor driving conditions. Factors that are most likely to be affected by a prolonged lag between a precipitation event and sample collection and analysis include concentrations of total suspended solids and pH. The applicants are currently endeavoring to quantify the possible affects of such a lag time on the analites. Additional limiting factors include the occasional loss of samples due to spillage of collection device (in times of particularly high discharge).

The sediment laden stream flow in the region leaves an easily identifiable mark on the single stage sampler anchor post. This flow depth is measured and converted to flow in cubic feet per second using the Manning equation. Crest stage gages have also been installed in accordance with Buchanan and Somers (1969) to measure peak flow depth at several of the single stage samplers. The crest stage gages consist of a vertical piece of galvanized pipe perforated near the bottom and containing a wood or aluminum staff held in a fixed position. Granulated cork placed inside the galvanized pipe floats on the rising surface of the water. When the water reaches its peak and starts to recede, the cork adheres to the staff inside the pipe, thereby retaining the crest stage of the flood. This crest stage is also converted to flow in cubic feet per second using the Manning equation. A detailed discussion of the single stage sampler stream flow measurements and calculations is presented in Section R645-301-724.200 of this document.

731.300 Based on testing of roof and floor materials, formation of acid- or toxic-materials does not appear to be a concern. Roof and floor materials will be permanently stored underground and will not brought to the surface for disposal.

731.300 #1 #2

Should materials be located on the surface by testing prior to final reclamation which have adverse properties, the material will be relocated to the portal fill area, placed at the bottom of the fill and compacted. The remaining fill placed over it will serve to isolate it from the revegetation operation and any other surface exposure.

731.400 All well utilized during the operating phase will be abandoned in accordance with the rules outlined in "Administrative Rules For Water Well Drillers, State of Utah, Division of Water Rights, 1987". Closure of the wells will be conducted by a licensed well driller.

Final abandonment of the proposed supply well (at the mine site) will be conducted prior to completion of final reclamation. The well will be filled with cement to within one foot of the top of the hole. Native material will be compacted into the top foot of the hole.

731.500 Discharges

731.510 No discharge into the underground mine is anticipated.

731.520 Gravity Discharges From Underground Mining Activities

Surface entries and accesses to underground workings will be located and managed to prevent or control gravity discharge from the mine. It is anticipated that the mine will be relatively dry but in the event that discharge becomes necessary, the discharge will comply with the performance standards of the regulations and requirements of the NPDES permit before being discharged off the permit area.

Refer to Exhibit V-10 for the as-built contour configuration and Exhibit VII-1A for the direction of overland flow within the disturbed area.

731.600 Stream Buffer Zones

Mining activities will not occur within 100 feet of a perennial or intermittent stream.

731.700 Cross Sections and Maps

There is no flowing surface water within the permit area and no water supply intakes. All disturbed area drainage will flow into the sediment pond. Surface receiving waters include the Smoky Hollow/Warm

Creek drainage system. Refer to Exhibit VII-5 for the locations of the receiving drainages.

731.700 #1 The location of the water supply well, water pump, conveyance, water storage tanks and leach fields to be used is shown on Exhibit V-6. As-built drawings will be provided following construction to show water distribution lines.

#2 The substitute soil borrow site will be treated with silt fencing and straw bales. Drainage form this site would ultimately flow to the Smoky Hollow/Warm Creek drainage system.

Shown on Exhibit VII-5 are the locations and elevations of surface water monitoring stations, the monitoring borehole, and seeps.

Exhibit V-6 shows the location of the proposed sediment pond and refuse storage site.

Cross sections for the proposed sedimentation pond presented on Exhibits VII-3A and VII-3B.

731.800 Water Rights and Replacement

No surface coal mining and reclamation activities (strip mining) will occur in the affected permit area.

Mining should not have any impact on the existing water rights in and around the proposed mining area.

R645-301-732 SEDIMENT CONTROL MEASURES

732.100 Siltation structures will be constructed and maintained in accordance with the applicable regulations. Siltation structures will not be removed until authorized by the Division of Oil, Gas and Mining.

Alternative sediment control measures will be used in areas where the surface disturbance is minor and sediment control is expected to be restored fairly rapidly with revegetation. One such site where alternate sediment control (silt fencing and straw bales) will be used is the Substitute Soil Borrow Site on top of Smoky Mountain.

Based on projected needs at the mine site and the depth of soil in the air strip area, only a limited area of disturbance may be necessary at the Substitute Soil Borrow Site. The area will be fenced off with silt fence prior to any disturbance taking place. As soil is removed, a depression will be created in the center of the excavated area to assist in retaining sediment within the disturbed area. Once the soil removal process has been completed, the area will be regraded to minimize side slopes. Seed will be raked into the regraded surface. The silt fence will be left in-place until vegetation has become reestablished.

732.200 The sedimentation pond will be designed in compliance with the appropriate regulations. Refer to Exhibits VII-3, VII-3A and VII-3B for specific details of the pond. Reclamation of the sediment pond will be done in phase II of the reclamation and revegetation plan. Refer to Chapter V, section R645-301-540 Reclamation for additional information regarding reclamation of the sediment pond and sediment control structures.

732.300 Diversions will be constructed and maintained with respect to R645-301-742.100 and 742.300.

732.400 Road Drainage

Roads within the disturbed area will be designed and constructed to utilize standard designs for surface drainage control, culvert size and spacing and grade. Refer to Exhibits V-6, VII-1A and V-15 for additional details on the Kane County road design.

Roads will be located to minimize downstream sedimentation and flooding and insofar as practical, located on the most stable available surface.

The drainage control system will be designed to pass the peak runoff from a 10-year, 6-hour precipitation event. Pipes and culverts will be constructed to avoid plugging or collapse and erosion at inlets and outlets. All culverts and ditches within the proposed disturbed area have been sized for the required precipitation event. Refer to Exhibit VII-1A for the locations of the ditches and culverts. Appendix VII-5 provides calculations and sizing for drainage controls structures in the proposed disturbed area.

Drainage ditches and culverts (except C-9 and C-10) have been designed to handle a 10 year, 6 hour event. Culverts C-9 and C-10 will remain as permanent structures in the road following reclamation and thus have been sized to pass the 100 year, 6 hour event. The larger design capacity will also provide additional capacity above what is required by the regulations, for the mine yard drainage during operations.

Rock headwalls and/or manufactured flared inlet bells will be used to protect the inlet end of culverts. Rip rap will be placed around the flared inlet structure and above it to a height of at least six inches above the required headwall for each culvert. The main canyon bypass culvert (U1) will be equipped with a flared inlet of concrete construction. Refer to Figures 4 and 5 in Appendix VII-5. A trash rack will be ramped over the inlet to prevent clogging of the diversion pipe. The trash rack will be of heavy-duty structural steel construction with 18 inch grate opening.

Trash racks will be placed on all other bypass culvert inlets to prevent floating debris and rocks from plugging the culvert. The trash racks will be slanted 3/4 inch steel bars welded on six inch centers across the flared inlet structures of each culvert. The bars will be sloped from the from the front of the inlet up to the top of the culvert. Use of trash racks on the smaller culverts within the mine yard drainage system will be at the discretion of the operator and based on site specific conditions.

Temporary diversions will be removed when no longer needed to achieve the purpose for which they were authorized and removal is authorized by the Division of Oil, Gas and Mining. The site will be reclaimed to restore the stream channel. No permanent structures will remain.

Alteration of stream channels such as the use of a bypass pipe and restoration of the channel after mining is designed to be stable, provide protection against flooding and resultant damage to life and property, prevent, to the extent possible using the best technology currently available, additional contributions of suspended solids to streamflow outside the permit area and comply with applicable local, state and federal laws and regulations. The reclaimed stream channel will be sized to handle the 100 year, 6 hour event. Rip rap will be placed on the outside bends of the restored channel to prevent bank erosion. Natural sediment will be allowed to fill in the voids between the rip rap.

R645-301-733 IMPOUNDMENTS

733.100 General Plans

A sediment impoundment structure is proposed for treatment of disturbed area runoff and contributing undisturbed area runoff. The pond will be located near the southern end of the mine yard (refer to Exhibit VII-1A) and has been designed to contain and treat drainage from the 10 year, 24 hour event. The associated conveyance structures, such as culverts and ditches, have been sized to convey drainage from the 10 year, 6 hour event into the sediment pond. Appendix VII-5 provides the detailed designs and calculations used to derive the pond capacity, ditch and culvert sizes.

733.110 The designs and calculations have been certified by a registered, professional engineer experience in the design and construction of sediment ponds.

733.120 Exhibit VII-3, VII-3A and VII-3B depict the pond design in plan view and cross-section. Calculations made in Appendix VII-5 are based on the design dimensions presented in the above-mention Exhibits.

733.130 In addition to containment of runoff from the 10 year, 24 hour precipitation event, the pond will sized to hold 3 years of sediment storage. Sediment contribution was calculated based on the Universal Soil Loss Equation and estimated at 1.872 acre feet/year. The total sediment storage capacity for the sediment pond is 5.616 acre feet, however, the sediment will be clean out when the storage capacity reached 60% of the maximum. Five sediment indicator stakes will be placed at various location in the pond bottom so an approximation of the 60% can be made.

The required volume for the sediment pond is calculated at 15.752 acre feet, including 3 years of sediment storage. Refer to Appendix VII-5 for the calculations. Pond dimensions will be approximately 200' wide x 500' long x 13' deep at the spillway with a volume of approximately 16.94 acre feet (at the elevation of 4651, open spillway).

This pond does not meet the size requirements to be regulated by MSHA under 30 CFR 77.216(a).

731.100 PVII-78 #1

The pond will provide a theoretical detention time of 24 hours and is equipped with a single open channel spillway which meets the requirements for the primary (principal) and emergency overflow. The pond is also equipped with a decant pipe. Discharge from the pond will be in accordance with the UPDES permit issued for the facility. A water sample would be collected and analyzed prior to decanting from the pond to ensure that water quality will meet the required standards. A small amount of water would be drawn out of the decant pipe for this purpose.

The decant pipe will be an inverted elbow mounted within the pond, the inlet a minimum of 1' above the maximum sediment level. A manual control valve will be secured in a closed position and locked to prevent unauthorized discharge from the pond.

Inlets to the pond (i.e. Culvert C-10 and Ditch D-12) will be protected from erosion by using concrete liners and/or rip rap to convey drainage down to the pond bottom.

An open channel spillway, constructed of concrete, will be utilized to convey flow in excess of the 100 year, 6 hour precipitation out of the pond. Dimensions on the spillway will be a minimum depth of 4' and have a minimum bottom width of 15'. The spillway, although only required by law to be a 25 year, 6 hour design, has been design to handle a 100 year, 6 hour event to allow for a greater margin of safety. The spillway, designed for the 100 year, 6 hour event should be capable of handling a flow of 114.44 cfs. Using the Broad Crested Weir Formula, the spillway would carry this flow at a depth of 1.83', leaving 2.17' of freeboard to the top of the dam. Given the fact that the side slopes will be 2:1, an even higher safety factor will actually be present.

733.140 No previous mining has occurred under the sediment pond location, nor is mining proposed under that site. Therefore, there should be no effect on the sediment pond due to past or future mining activities.

The pond will be constructed according to design criteria listed in Appendix VII-5 under "Construction Specifications For Sedimentation Ponds". Following cessation of mining and phase I reclamation operations and upon approval by the Division of Oil, Gas and Mining, the sediment pond will be removed.

733.150 A structural stability analysis was performed on the pond embankment slopes. The results of the analysis are presented in Appendix V-4.

The pond embankment (the east slope of the pond) will be keyed into bedrock. The upper end and west side of the pond will be incised into bedrock. Interbedded sandstone and shale are the predominant lithologies at this location. The bedrock appears to be competent and there are no faults or fractures present that would impair the operation of the pond.

733.160 A certified plan containing design details (Appendix VII-5) along with certified maps, Exhibit VII-3, VII-3A and VII-3B, are presented in this permit application package.

733.200 Permanent and Temporary Impoundments

Maps and cross-sections for the sediment pond have been prepared and certified. Refer to Exhibits VII-3, VII-3A and VII-3B.

The sediment pond will collect runoff from the disturbed area during mining operations. Because the pond is a temporary structure, it has been sized according to requirements for the 10 year, 24 hour storm event. The calculated required volume for this storm event is 15.752 acre-feet, which includes a volume for three years of sediment storage. The pond will have a combination principal/emergency spillway. The maximum pond volume will be 16.94 acre-feet at the spillway and the maximum height water could be impounded is 13 feet. The pond therefore does not meet the criteria for MSHA regulation.

The pond design, as presented in Appendix VII-5, incorporates a decant pipe with a manual valve if decanting becomes necessary. The combination principal/emergency spillway has been designed to safely pass the 100 year, 6 hour precipitation event.

No mining will occur underneath the sediment pond nor has any mining been done beneath this location in the past. The potential

effect on the structure from subsidence of subsurface strata would be nonexistent.

Temporary impoundments will be constructed and maintained to comply with the appropriate requirements. No permanent impoundments are being proposed. Reclamation of the structures will be as presented in the reclamation portions of Chapters III and V.

R645-301-734 **DISCHARGE STRUCTURES**

Discharge structures will be constructed and maintained to comply with R645-301-744. Refer to the discussion under R645-301-744.

R645-301-735 **DISPOSAL OF EXCESS SPOIL**

No areas are presently designated for disposal of excess spoil. No excess spoil is anticipated during the life of the mine. Refer to the discussion in Chapter V, section R645-301-553 under Spoil and Waste (553.200).

R645-301-736 **COAL MINE WASTE**

An area has been designed in the mine yard for temporary storage of refuse material, materials clean out of ditches, culverts and the sediment pond structure during routine maintenance. A detailed plan is presented in Appendix V-5. The refuse pile is discussed in Chapter V under section R645-301-528.322 and R645-310-536.900. The designated area will be constructed and maintained to comply with R645-301-746.

R645-301-737 **NONCOAL MINE WASTE**

Noncoal mine waste will be stored, should the need arise, in the designated portion of the disturbed area (material storage area). Final disposal of noncoal mine waste will comply with R645-301-747.

R645-301-738 **TEMPORARY CASING AND SEALING OF WELLS**

Sealing of the groundwater monitoring well and water supply well will comply with R645-301-748. Refer to R645-301-765 for the well abandonment plan. The groundwater monitoring well will be used for monitoring only and is locked in a closed position between sampling events. The supply well at the mine site will be within a restricted mine yard area and enclosed within a pump house building. The building will be locked when unattended to prevent access to unauthorized persons.

R645-301-740 **DESIGN CRITERIA AND PLANS**

Site specific plans that incorporate design criteria for control of drainage from disturbed and undisturbed areas are presented below.

R645-301-742 **SEDIMENT CONTROL MEASURES**

Sediment control measures have been designed to prevent, to the extent possible, additional contributions of sediment to stream flow or off the permit area, to meet effluent limitations and to minimize erosion.

The most significant sediment control measure will be to collect all disturbed area runoff and divert it into a sediment pond designed for total containment of the 10 year, 24 hour event. Runoff from undisturbed areas above the mining site will be diverted as much as possible to reduce the amount of water to be treated. Refer to Appendix VII-5 for the Sedimentation and Drainage Control Plan For The Smoky Hollow Mine and Exhibit VII-1A for the mine site drainage and bypass culvert configurations.

Additional measures to be taken may include: interim reclamation of disturbance, where practical, to reduce runoff and erosion; rip rapping or lining diversion ditches to reduce erosion; and using straw bales and check dams to control flow, sediment and erosion.

742.220 Minimizing contributions of suspended solids and sediment to streamflow or runoff outside the permit area will be accomplished by constructing a single sediment pond to store and treat runoff from the disturbed area. The sediment pond has been designed to provide adequate sediment storage and detention time for the 10 year, 24 hour precipitation event. The pond has a combination open channel spillway designed to pass a greater event than required by the regulations. The design will accommodate the peak flow from a 100 year, 6 hour event.

The pond will also be equipped with a decant device so the water in the pond can be drawn down in an emergency or for cleaning. The decant device will be locked in a closed position to allow water to settle for 24 hours prior to discharge. Water will be decanted in accordance with the UPDES permit for the facility.

The sediment in the pond will be removed when it reaches 60% of the maximum design sediment level of the pond. Five sediment markers will be installed at various locations in the bottom of the pond for evaluation of the sediment level. Refer to Exhibit V-3 for the location of the markers. The markers will be placed at various locations in the bottom of the pond so that an average sediment level can be determined. The random locations of the stakes should promote a representative reading and eliminate bias based on uneven sediment deposition. Refer to Appendix VII-5 for the Sedimentation and Drainage Control Plan For The Smoky Hollow Mine for design calculations.

The sediment pond will be cleaned out upon reaching the 60% of the maximum sediment capacity. Clean out will be done during late fall or early winter, October-December, when the chance of thunderstorms is the lowest. Decanting of the pond prior to cleanout will probably be unnecessary due to the arid nature of the climate. However, if decanting is necessary, the water will be allowed to settle for a minimum of 24 hours. The water will be drawn down as much as possible.

Sediment samples will be collected from the bottom of the pond. A minimum of two composites will be collected and analyzed prior to sediment cleanout to determine if toxic, hazardous or acid-forming materials are present in a significant quantity. Should unsuitable materials be found, they would be excavated and disposed of as a toxic or hazardous waste. Acid-forming materials could be treated on-site depending on the nature of the acid-forming conditions.

Cleanout will begin on the upper end of the pond. Once an area has been cleaned out, any water remaining in the pond will be diverted into the depression. Cleanout will continue to the lower end of the pond until sediment removal has been completed.

Prior to sediment removal, samples will be taken from the sediment on the bottom to determine the depth of sediment as well as the nature of the material to be removed. Samples will be composited and analyzed according to Table 6 of DOGM's "Guidelines For Management Of Topsoil And Overburden For Underground And Surface Coal Mining".

The sediment pond does not meet the size criteria of MSHA 30 CFR 77.216(a).

The spillway has been designed as an open-channel spillway capable of safely discharging a 100 year, 6 hour precipitation event. This should provide an additional measure of safety over the 25 year, 6 hour design required by the regulations.

The construction site for the sediment pond will be cleared of all vegetation and debris prior to the removal of topsoil. Topsoil will be removed from the pond site and stockpiled in the storage area located at the office pad. Silt fencing and straw bales will be used to treat drainage from the site until the sediment pond embankment is constructed.

To prevent short circuiting, the pond has been designed to maximize the flow distance from the pond inlet (on the north end) to the spillway (near the southeast corner). Refer to Exhibit VII-3 for details of the sediment pond design.

Vegetation and debris will be removed from fill materials prior to construction. Compaction of the fill will be done in two foot lifts.

742.300 Diversions

General Requirements

Flow from undisturbed areas will be diverted away, where possible, from disturbed areas by means of temporary diversions (i.e. undisturbed drainage culverts). The diversions have been designed to minimize impacts to the hydrologic balance of the permit and adjacent areas.

All of the undisturbed drainage diversions (bypass culverts) have been sized to meet the 100 year, 6 hour event even though the regulations only require temporary diversions to handle the flow from the 10 year, 6 hour event. An additional margin of safety has been added by increasing the size of the main bypass culvert from about 6.5 feet to 8 feet in diameter thus providing an additional capacity of approximately 50% over and above the 100 year/6 hour design. The design incorporates structural stability and protection against flooding and damage to life and property. Providing this extra margin of safety should substantially reduces the threat of damage to drainage structures in the mine yard during a major precipitation event. Designs for all diversions are presented in Appendix VII-5 and on Exhibit VII-1A and have been certified by a registered, professional engineer.

The sediment pond has been designed and located such that if any of the temporary drainage structures (disturbed area culverts and ditches) within the disturbed area were to exceed their capacity, all drainage would still flow to and be treated by the sediment pond. Two inlets will allow drainage to flow into the sediment pond. These inlets, culverts C-9 and C-10, have been designed to pass the flow from a 100 year, 6 hour precipitation event.

Following completion of mining activities, the undisturbed drainage diversion pipes, which will bypass the undisturbed drainage past the disturbed area, will be removed and the natural channel restored. Restoration of the channel will seek to reestablish a natural appearance to the drainage channel while providing a suitable channel configuration.

Currently the Kane county road follows the channel bottom up Smoky Hollow canyon to the top of the Smoky Mountain plateau. The Kane

County road will be relocated along the west side of the canyon within the mine yard. The only exception will in the vicinity of the sediment pond where the road forms the embankment of the pond along the east side of the canyon. Following the cessation of mining activities the Kane County road will remain in place and the channel will be restored to the approximate pre-existing location and configuration.

Based on the flow calculations, measurements taken during field investigations in February and May of 1992, and topographic maps of the present channel configuration, it will be possible to restore the channel to a configuration similar to what previously existed. The restored channel will be riprapped where necessary to prevent undue erosion.

Vegetation surveys conducted during August 1990 and May 1992 indicate that there is no riparian zone in the existing main or side drainage channels. Refer to Appendix III-1 and III-6 in Chapter III for information regarding vegetation.

742.400 Road Drainage

Roads within the disturbed area will be designed and constructed to provide environmental protection and safety and will adequately provide for surface drainage control, sufficient culvert design and spacing.

The placement of the road will seek to minimize downstream sedimentation and disturbance to the road due to runoff. The road will be located on the most stable available surface.

Primary Roads

Structures on the road will be designed and constructed to pass the peak runoff from a minimum of the 10 year, 6 hour precipitation event.

Culverts will be designed so as to avoid plugging, collapse or erosion at the inlets and outlets. Trash racks will be installed where deemed appropriate by the operator.

Following acceptance of phase I reclamation, the restored channel will be completed by removing a portion of the sediment pond embankment, excavation that portion of the bypass culvert running along the inside of the sediment pond area and regrading portions of the sediment pond to reestablish the channel in this area. The restored channel will convey drainage to a culvert in the lower portion of the sediment pond/road embankment. Upon emerging from the downstream end of the road culvert, the drainage will flow in the undisturbed channel below. The gradient of the channel and the side slopes will be similar to the premining channel.

No riparian area exists along the present drainage channel. The proposed seed mix to be used for final reclamation will incorporate species that presently exist in and adjacent to the channel area. The seed will be applied to the regraded channel side slopes by hydroseeding.

R645-301-743 **IMPOUNDMENTS**

The proposed sediment pond is less than the size criteria listed in MSHA, 30 CFR 77.216(a). It has been designed and certified according to R645-301-512. Since the impoundment (sediment pond) is a temporary structure, regulations require the principal and emergency spillway to be designed to safely pass the 25 year, 6 hour precipitation event. However, Andalex has designed the spillway to pass the 100 year, 6 hour event as an additional measure of safety.

The impoundment will be inspected as described under R645-301-514.300.

R645-301-744 **DISCHARGE STRUCTURES**

Discharge from the sediment pond and diversion pipe will be controlled by energy dissipators such as a grouted, rip rapped channel beneath, around and downstream from the culvert outlet. The spillway will be constructed according to standard design procedures. The calculations are presented in Appendix VII-5 for the spillway design.

R645-301-745 **DISPOSAL OF EXCESS SPOIL**

No areas are presently designated for disposal of excess spoil. No excess spoil is anticipated during the life of the mine. Refer to the discussion in Chapter V, section R645-301-553 under Spoil and Waste (553.200).

No valley fills or head-of-hollow fills are being proposed.

No durable rock fills are included in the operation plan.

R645-301-746 **COAL MINE WASTE**

746.100 General Requirements

An area has been designed in the mine yard for temporary storage of refuse material, materials cleaned out of ditches, culverts and the sediment pond structure during routine maintenance. The clean out material will be placed in lifts on the refuse pile and compacted. A detailed plan is presented in Appendix V-5. The refuse pile is discussed in Chapter V under section R645-301-528.322 and R645-310-536.900. The designated area will be constructed and maintained to comply with R645-301-746 and the applicable regulations listed in R645-301-746.210.

The refuse pile will be located in the northern end of the mine yard. A berm/ditch system, capable of conveying runoff from the 100 year, 6 hour event will be constructed around the refuse pile to convey runoff from the pile to the sediment pond and to divert undisturbed area runoff away from the refuse pile location. Diversion of undisturbed runoff will promote surface water protection by minimizing contact of runoff water with the refuse pile materials. Also, ditches will catch runoff from the refuse pile surface and convey the surface drainage into the sediment pond for treatment.

Impacts to ground water will be minimized by reducing contact between the pile and surface water to only that precipitation falling directly on the pile. In this area it may range from between 6 to 10 inches per year. Compaction of the pile and sloping surfaces will help minimized surface water infiltration. Also, the maximum areal extent of the pile will be limited to approximately one acre. Leachate from the refuse pile into ground water is not considered to be a potential problem. The depth to observed ground water is over 200' deep at this location and, the intervening materials, interbedded sandstone and shales, would effectively prevent water from vertically migrating into the Calico Sandstone.

Prior to placement of materials on the refuse pile, the material will be sampled and sent to the laboratory for analysis. Unsuitable material would be treated prior to placement in the refuse pile or disposed of properly in a commercial facility.

746.200 The refuse pile plan, presented in Appendix V-5, has been developed in accordance with the requirements of R645-301-512.230, R645-301-515.200, R645-301-528.320, R645-301-536 through R645-301-536.200, R645-301-536.500,R645-301-542.730,R645-301-746.100,R645-301-210, R645-301-513.400, R645-301-514.200, R645-301-528.322, R645-301-536.900, R645-301-553.250 and R645-301-746.200. MSHA requirements listed in 30 CFR 77.214 and 77.215 have been addressed as well. Refer to Appendix V-5 and Chapter V sections R645-301-528.322 and R645-310-536.900.

No seeps or springs exist within the proposed location. Undisturbed drainage will be routed around or bypass the site. Refer to the surface drainage control plan presented in Appendix V-5.

R645-301-747 DISPOSAL OF NONCOAL MINE WASTE

Noncoal mine waste, including but not limited to grease, lubricants, paints, flammable liquids, garbage, machinery, lumber and other combustible materials generated during coal mining and reclamation operations will be placed and stored in a controlled manner at the designated location, the material storage yard (see Exhibit V-6) within the disturbed area or in a state-approved solid waste disposal area. No noncoal waste will be permanently disposed of within the permit area. Dumpsters will be used for collection and disposal of trash.

Lubricants, solvents, and grease will be stored in a covered area with limited access to prevent accidental contact from machinery. The storage area will be in the vicinity of the warehouse.

731.100
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#2

Any leakage at the storage site will be contained within concrete lined containment structures. Surface runoff will be diverted away from the storage site. Should any uncontrolled discharge of oil or petroleum products occur within the general mine yard area, the sediment pond would act as a last line of defense for the containment of any such spills and prevent flow into the natural drainage system. A Spill Prevention Control and Countermeasure (SPCC) Plan is presented in Appendix V-7.

A dumpster will be placed in a convenient location for disposal of nonhazardous trash. Used/broken equipment will be stored within the storage area of the mine yard. As the entire storage area reports to the sediment pond, the exact location of storage will be left to the discretion of the operator as long as the storage of materials does not block ditches or roadways.

The shop will not have any nondischarging or discharging sumps.

R645-301-748 **CASING AND SEALING OF WELLS**

The water supply well and monitoring well (MW-1) will be cased, sealed or plugged to prevent acid or toxic drainage from entering ground or surface water, to minimize disturbance to the hydrologic balance and to ensure safety when no longer utilized.

Upon cessation of monitoring activities, the groundwater monitoring well will be permanently sealed by filling the hole with cement to within two feet of the top of the hole. Two feet of compacted native material will be placed above the sealed hole and the area reseeded.

Upon cessation of use of the water supply well, the hole will be cemented to within 2' of the ground surface. The remainder of the hole will be filled to ground lever with compacted soil.

Any future water or monitoring wells will be abandoned in a similar manner.

R645-301-750 **PERFORMANCE STANDARDS**

750 #1

All mining and reclamation operations will be conducted to minimize disturbances to the hydrologic balance within the permit and adjacent areas, to prevent material damage to the hydrologic balance outside the permit area and support approved postmining land uses.

R645-301-751 **WATER QUALITY STANDARDS AND EFFLUENT LIMITATIONS**

Andalex Resources will obtain a UPDES discharge permit to cover any possible discharge from the mine or sediment pond prior to construction of the mine facility.

R645-301-752 **SEDIMENT CONTROL MEASURES**

Sediment control measures must be located, maintained, constructed and reclaimed according to plans and designs given under R645-301-732, R645-301-742 and R645-301-760.

752.100 **Siltation Structures and Diversions**

Siltation structures and diversions will be located, maintained, constructed and reclaimed according to plans and designs given under R645-301-732, R645-301-742 and R645-301-763.

752.200 **Road Drainage**

750 #1

The relocated Kane County road will be located, designed, reconstructed and maintained to control erosion, minimize contributions to stream flow, minimize diminution of the surface and ground water systems and refrain from significantly altering the normal flow of water in the drainage channel in accordance with R645-301-732.400, R645-301-742.400 and R645-301-762.

Drainage for the road through the mine yard has been addressed in Appendix VII-5. The road design and configuration is presented in detail on Exhibit V-15.

Chapter V, section R645-301-527 provides a narrative on the Kane County road through the mine yard area.

R645-301-753 **IMPOUNDMENTS AND DISCHARGE STRUCTURES**

Impoundments and discharge structures will be located, maintained, constructed and reclaimed to comply with R645-301-733, R645-301-734, R645-301-743, R645-301-745 and R645-301-760.

R645-301-754 **DISPOSAL OF EXCESS SPOIL, COAL MINE WASTE AND NONCOAL MINE WASTE**

750 #1

Disposal for coal mine waste and noncoal mine waste will be located, maintained, constructed and reclaimed as described in R645-301-735, R645-301-736, R645-301-745, R645-301-746, R645-301-747 and R645-301-760.

R645-301-755 **CASING AND SEALING OF WELLS**

All wells will be managed to comply with R645-301-748 and R645-301-765. Water monitoring wells will be managed on a temporary basis according to R645-301-738.

R645-301-760 **RECLAMATION**

R645-301-761 **GENERAL REQUIREMENTS**

760 #1

All temporary structures will be removed and reclaimed before bond release is sought. Permanent structures will meet the applicable requirements before bond release is sought. Permanent structures will be renovated to meet the requirements of R645-301 and R645-302 and conform to the approved reclamation plan. A monitoring station will be added at the inlet of the sediment pond.

The reclaimed (restored) channel will be sized to handle a 100 year/6 hour event. The restored channel will follow the grade, alignment and sinuosity of the original natural channel as nearly as possible while still allowing for protection of the Kane County road which will remain in place as a post-mining land use. Rip rap will be installed as necessary to protect the outside bends of the restored channel and to protect the embankments of the county road. Natural sediment will be allowed to fill in the voids between the rip rap.

Within the constraints of protecting the county road and re-establishing approximate original contour of the mine site, the restored channel will be designed so that it may achieve a flexible and dynamic stability within the confines of its 100 year flood plain similar to the stream channel morphology existing naturally in Smoky Hollow. During operation of the mine Andalex will establish a long range monitoring program to quantify the elements of natural stream morphology such as channel width, stream bank displacement and replacement, braiding characteristics, sediment sizing and gradation and stream bank vegetation migration patterns. In consultation with the Division, the results of these long range observations will be incorporated into subsequent mining and reclamation plan renewals to reflect this expanding data base of stream channel information.

R645-301-762 **ROADS**

The access road, because it is a Kane County public road, will be left in place and maintained by Kane County.

R645-301-763 **SILTATION STRUCTURES**

Siltation structures will be maintained until removal is authorized by the Division and the disturbed area has been stabilized and revegetated.

When the sedimentation structure is removed, the land on which the siltation structure was located will be regraded and revegetated. Refer to Chapter V for the regrading plans of siltation structures and Chapter III regarding the revegetation plan for phase I and phase II reclamation.

760 #1 A water monitoring station will be established in the sediment pond inlet ditch during phase I reclamation to monitor water quality from the reclaimed disturbed area.

R645-301-764 **STRUCTURE REMOVAL**

Appendix V-1 presents a detailed timetable and outline for the removal of all structures on the minesite area. Removal of the siltation structures will be contingent upon DOGM approval. The sediment pond will be removed in conjunction with phase II of the reclamation plan and DOGM approval.

R645-301-765 **PERMANENT CASING AND SEALING OF WELLS**

Permanent closure of the water supply well for the mine and monitoring well MW-1 will be in accordance with the requirements of "Administrative Rules for Water Well Drillers", July 15, 1987, State of Utah, Division of Water Rights.

The abandoned wells will be filled to within two feet of the surface with Neat Cement conforming to ASTM standard C150, a cement grout consisting of equal parts of cement conforming to ASTM standard C150 and sand/aggregate with no more than 6 gallons of water per sack of cement or bentonite-based products specifically designed for permanent well abandonment.

The cement will be introduced at the bottom of the well and placed progressively upward to within two feet of the surface. The casing will be severed a minimum of 2 feet below the ground surface. A minimum of 2 feet of compacted native material will be placed above the abandoned well upon completion.

Within 30 day of the completion of well abandonment procedures, a report will be submitted to the state engineer by the responsible licensed driller giving data related to the abandonment of the well. The report shall be made on forms furnished by the state engineer and shall contain the information required, including but not limited to:

1) Name of licensed driller or other person(s) performing abandonment procedures,

2) Name of well owner at time of abandonment,

3) Address or location of well by section, township and range,

4) Abandonment materials, equipment and procedures used,

5) Water right or file number covering the well,

6) Final disposition of the well,

7) Date of completion.

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LIST OF TABLES

TABLE VII-1
SPRING AND SEEP SURVEY SUMMARY

3/30/93

SPRING/SEEP	DATE	APPROXIMATE FLOW	GEOLOGIC OCCURRENCE	APPARENT USE
S-1	9/90	No Flow	Paleochannel sandstones within Drip Tank	None
S-2	9/90	No Flow*	Paleochannel sandstone at Base of Drip Tank	None
S-3	9/90	No Flow	Paleochannel sandstone in upper portion of Drip Tank	None
S-4	9/90	Drip	Paleochannel sandstone in upper portion of Drip Tank	Wildlife
S-5	9/90	No Flow	Paleochannel sandstone in upper portion of Drip Tank	None
Calico	2/92	Drip	Fractures along bedding planes at base of Calico bed	None
Needle Eye	2/92	No Flow	Base of Drip Tank	Stock
Drip Tank	2/92	2 gpm	Lower bedding planes of Drip Tank	Stock, Wildlife
John Henry	2/92	4 gpm	Bedding planes within Drip Tank	Stock
Clint	2/92	4 gpm	Base of Drip Tank	Stock
Tibbet	2/92	No Flow*	Base of Drip Tank	Stock
Brett	2/92	1 gpm	Base of Drip Tank	Stock
Section 10	2/92	No Flow	Within John Henry Member	None
14 South	2/92	<1 gpm	Top of Calico Sandstone	Stock, Wildlife
14 North	2/92	<1 gpm	Top of Calico Sandstone	Stock, Wildlife

*Small pool of water with no apparent flow.

TABLE VII-2
RESULTS OF BULK SAMPLE LABORATORY
HYDRAULIC CONDUCTIVITY TESTS

Location	Hydraulic Conductivity (ft/day)
Red Seam Mudstone Overburden	3.8×10^{-5} (horizontal) 9.3×10^{-5} (vertical)
Calico Bed (massive)	5.5×10^{-2} (horizontal) 6.9×10^{-2} (vertical)
Calico Bed (stratified)	2.8×10^{-2} (horizontal) 5.4×10^{-3} (vertical)

TABLE VII-3
CHEMICAL ANALYSIS OF GROUNDWATER FROM EXPLORATORY DRILL HOLES IN THE STRAIGHT CLIFFS FORMATION

Parameters	Units	Drill Holes									
		308	310	318	320	323	325	330	331	332	333
Date of Collection		1/5/75	10/26/74	1/16/75	2/13/75	2/1/75	2/23/75	2/11/75	1/28/75	4/21/75	3/20/75
Depth to Water	ft	590	192	420	438	461	500	a	225	430	200
Total Dissolved Solids	mg/l	2160	459	1240	421	1060	1530	1100	466	272	436
Sodium	mg/l	850	70	460	51	400	610	70	48	54	66
Potassium	mg/l	17	9.8	13	7.1	12	26	13	9.8	11	7.3
Calcium	mg/l	13	58	15	54	14	8.0	180	60	19	54
Magnesium	mg/l	19	22	17	29	8.2	16	77	33	0.8	25
Sulfate	mg/l	110	140	69	120	77	140	560	190	130	110
Bicarbonate	mg/l HCO3	1910	297	1280	295	1060	1350	370	234	50	324
Chloride	mg/l	200	3.6	26	4.9	14	55	7.3	4.7	3.6	3.8
pH (Lab)	S.U.	8.4	7.9	8.3	8.0	8.2	8.6	7.5	8.1	a	8.0
Conductivity (Lab)	umhos/cm @ 25c	3310	759	1980	681	1680	2500	1560	744	404	706
Sodium Absorption Ratio		35	2.0	19	1.4	21	29	1.1	1.2	3.3	1.9
Total Nitrates and Nitrites	mg/l	0.08	0.01	0.18	0.01	0.05	0.02	0.04	0.01	0.05	0.12
Fluoride	mg/l	2.6	0.4	2.9	0.3	3.4	1.8	0.4	0.6	0.6	0.3

Comments:

(A) No data available.

TABLE VII-3 (Continued)
CHEMICAL ANALYSIS OF GROUNDWATER
FROM EXPLORATORY DRILL HOLES IN THE STRAIGHT CLIFFS FORMATION

		Drill Holes									
Parameters	**Units**	308	310	318	320	323	325	330	331	332	333
Hardness as CaCO3	mg/l	110	240	110	250	69	86	770	290	51	240
Hardness As CaCO3	mg/l	0.0	0.0	0.0	12	0.0	0.0	460	94	10	0.0
Phosphate	mg/l	0.03	0.06	0.00	0.03	0.03	0.00	0.00	0.00	0.06	0.09
Boron	mg/l	0.55	0.16	1.0	0.13	1.0	0.36	0.17	0.15	0.13	0.14
Iron	mg/l	0.05	0.02	0.01	0.06	0.01	0.02	0.01	0.02	0.02	0.05
Manganese	mg/l	0.00	0.05	0.00	0.00	0.01	0.00	0.19	0.02	0.00	0.01
Silica	mg/l	7.6	8.4	7.8	9.3	5.5	5.0	7.5	4.4	28	8.8

Comments:

(a) No data available.

TABLE VII-.. (Continued)
CHEMICAL ANALYSIS OF GROUNDWATER FROM EXPLORATORY DRILL HOLES IN THE STRAIGHT CLIFFS FORMATION

Parameters	Units	Drill Hole									
		337	340	344	345	348	349	357	360	361	377
Date of Collection		3/11/75	2/28/75	3/24/75	5/6/75	5/6/75	6/23/75	10/22/74	2/13/75	12/9/74	12/9/74
Depth of Water	ft	590	192	420	438	461	500	a	225	430	200
Total Dissolved Solids	mg/l	1500	362	561	488	730	934	5920	398	446	426
Sodium	mg/l	550	39	160	120	160	320	1800	51	61	51
Potassium	mg/l	22	6.6	12	9.0	16	13	11	7.5	7.4	8.5
Calcium	mg/l	49	49	22	30	46	11	120	51	54	58
Magnesium	mg/l	11	28	9.9	15	29	7.3	33	28	26	27
Sulfate	mg/l	180	89	190	160	290	260	3500	100	150	120
Bicarbonate	mg/l HCO3	1030	279	313	283	328	600	715	298	259	299
Chloride	mg/l	61	3.3	5.3	6.5	8.0	16	88	3.5	3.6	3.5
pH (Lab)	S.U.	8.8	8.1	8.3	a	a	a	7.9	7.9	8.0	7.9
Conductivity (Lab)	umhos/cm @ 25c	2290	594	901	781	1120	a	7850	650	708	714
Sodium Absorption Ratio		18	1.1	7.1	4.5	4.6	18	38	1.4	1.7	1.4
Total Nitrates and Nitrites	mg/l	0.05	0.01	0.06	0.01	0.00	0.06	0.00	0.02	0.01	0.03
Fluoride	mg/l	3.9	0.4	1.8	0.5	1.5	2.0	0.6	0.4	0.2	0.2

Comments:
(a) No data available.

TABLE VII-3 (Continued)
CHEMICAL ANALYSIS OF GROUNDWATER
FROM EXPLORATORY DRILL HOLES IN THE STRAIGHT CLIFFS FORMATION

Parameters	Units	Drill Hole									
		337	340	344	345	348	349	357	360	361	377
Hardness as CaCO3	mg/l	170	240	96	140	230	a	440	240	240	260
Noncarbonate Hardness	mg/l	0.0	9.0	0.0	0.0	0.0	a	0.0	0.0	29	11
Phosphate	mg/l	0.06	0.03	0.03	0.03	0.12	0.00	0.06	0.00	0.00	0.00
Boron	mg/l	0.35	0.16	0.27	0.18	0.34	0.39	a	0.15	0.09	0.10
Iron	mg/l	0.04	0.02	0.02	0.02	0.02	0.04	0.02	0.01	0.01	0.01
Manganese	mg/l	0.00	0.00	0.00	0.01	0.00	a	0.13	0.00	0.00	0.05
Silica	mg/l	6.1	8.8	4.7	7.4	17	7.8	10	9.0	16	9.9

Comments:
(a) No data available.

TABLE VII-4 3/30/93

POROSITY AND HYDRAULIC CONDUCTIVITY OF CORE SAMPLES FROM THREE TEST HOLES IN THE COAL-BEARING STRAIGHT CLIFFS SANDSTONE ON THE KAIPAROWITS PLATEAU

(Determinations by Core Laboratories, Inc., Dallas, Texas)

Lithology: Very fine grained, 0.0625 to 0.125 millimeter; fine grained, 0.125 to 0.250 millimeter; medium grained, 0.250 to 0.50 millimeter.

Site Identification	Depth below land surface (feet)	Porosity (percent)		Hydraulic conductivity (feet per day)		Lithology
		Horizontal	Vertical	Horizontal	Vertical	
H	590.6	12.3	-	1.3×10^{-7}	-	Siltstone, slightly indurated, very shaly
	655.2	-	31.9	-	8.9×10^{-1}	Sandstone, slightly indurated, fine to very fine grained, moderately well to well sorted
	750.5	12.9	-	1.1×10^{-4}	-	Siltstone, slightly indurated, shaly
	831.2	18.7	18.4	3.6×10^{-3}	2.1×10^{-3}	Sandstone, moderately indurated, very fine to medium grained, moderately well to well sorted, slightly calcareous, slightly silty
	846.5	28.5	28.9	12.6×10^{-1}	8.8×10^{-1}	Sandstone, slightly indurated, very fine to medium grained, moderately well to well sorted
	927.3	25.7	23.8	10.6×10^{-1}	9.1×10^{-1}	Sandstone, moderately indurated, very fine to medium grained, moderately well to well sorted, calcareous
	1,088.3	21.5	21.1	1.8×10^{-2}	9.0×10^{-3}	Sandstone, slightly indurated, very fine to medium grained, moderately well to well sorted, calcareous
I	853.4	25.2	25.7	3.7×10^{-1}	2.0×10^{-1}	Sandstone, moderately indurated, fine grained

From: Plantz, 1985

TABLE VII-4 (Continued)
POROSITY AND HYDRAULIC CONDUCTIVITY OF CORE SAMPLES FROM THREE TEST HOLES IN THE COAL-BEARING STRAIGHT CLIFFS SANDSTONE ON THE KAIPAROWITS PLATEAU

(Determinations by Core Laboratories, Inc., Dallas, Texas)

Lithology: Very fine grained, 0.0625 to 0.125 millimeter; fine grained, 0.125 to 0.250 millimeter; medium grained, 0.250 to 0.50 millimeter.

Site Identification	Depth below land surface (feet)	Porosity (percent)		Hydraulic conductivity (feet per day)		Lithology
		Horizontal	Vertical	Horizontal	Vertical	
	1,023.5	4.9	4.2	<3.7 x 10^{-4}	<3.7 x 10^{-4}	Sandstone, well indurated, very fine to fine grained, calcareous, slightly laminated
	1,165.6	5.6	6.2	<3.7 x 10^{-4}	<3.7 x 10^{-4}	Siltstone, well indurated, slightly laminated
	1,260.5	14.7	13.6	6.3 x 10^{-4}	3.4 x 10^{-4}	Sandstone, moderately indurated, medium grained, slightly calcareous
J	631.2	22.9	22.4	8.5 x 10^{-2}	2.7 x 10^{-2}	Sandstone, moderately indurated, medium grained, coal lens
	658.0	6.0	5.2	<3.7 x 10^{-4}	<3.7 x 10^{-4}	Siltstone, moderately indurated, slightly dolomitic
	720.9	19.3	19.7	3.9 x 10^{-3}	3.9 x 10^{-3}	Sandstone, moderately indurated, medium grained, slightly calcareous
	814.7	9.3	7.6	<3.7 x 10^{-4}	<3.7 x 10^{-4}	Siltstone, well indurated, slightly carbonaceous, calcareous
	878.5	6.3	.77	<3.7 x 10^{-4}	<3.7 x 10^{-4}	Siltstone, well indurated, calcareous, slightly fractured

From: Plantz, 1985

TABLE VII-5 **3/30/93**

MUDSTONE OVERBURDEN BULK SAMPLE
X-RAY DIFFRACTION ANALYSES RESULTS

MINERAL	APPROXIMATE WEIGHT PERCENTAGE
Quartz	40
Potassium Feldspar	4
Gypsum	1
Kaolin	15
Illite	2
Smectite	16*
Amorphous/Below detection	22+

* Smectite is poorly crystalline and may also contain some mixed-layer illite-smectite.

\+ Organic matter and possibly poorly crystalline clay.

TABLE VII-6
GROUND WATER QUALITY
DATA SUMMARY: 1989 - 1992

3/30/93

Sampler	Period Sampled	TSS (mg/l)		TDS (mg/l)		pH		Iron (mg/l)		Manganese (mg/l)	
		Range	Avg.	Range	Avg.	Range	Avg.	Range	Avg.	Range	Avg.
SEEP S-2	9/30/90 - 12/4/92	3 - 52	30.50	1,320 -1,705	1,418.78	6.4 - 8.7	7.38	<0.02 - 0.18	0.09	<0.01 - 0.02	0.02
SEEP S-4	2/9/91 - 12/4/92	<1.0 - 4.0	2.5	158 - 208	178.29	6.8 - 8.8	7.90	<0.05 - 0.08	0.06	<0.01 - 0.02	0.02
CALICO SEEP	12/27/89 - 12/4/92	2 - 190	73	820 - 936	886.40	7.5 - 8.9	8.39	<0.02 - 0.67	0.24	<0.01 - 0.04	0.03
MW-1	9/30/90 - 12/4/92	18	18	707 - 1,330	1,006.45	7.5 - 10.9	9.51	0.22 -1.97	0.79	<0.01 - 0.08	0.03

TABLE VII-7 3/30/93
CHEMICAL ANALYSIS OF WATER IN THE KAIPAROWITS PLATEAU AREA

U.S. Bureau of Land Management (1976)

Parameters	Units	EPNG #1 (4/4/74)	EPNG #2 (4/30/74)	EPNG #3 (4/30/74)	EPNG #4 (4/30/74)	Drip Tank (5/30/74)	Wesses Spring (5/14/74)	Tibbet Spring (5/30/74)
Total Dissolved Solids	mg/l	866	1230	1180	1380	531	1230	1140
Sodium	mg/l	72	480	380	530	44	150	160
Potassium	mg/l	9.4	19	15	22	5.8	8.6	9.8
Calcium	mg/l	130	21	50	25	85	130	110
Magnesium	mg/l	65	4.4	22	5.7	39	97	73
Sulfate	mg/l	320	10	97	6.4	160	560	550
Chloride	mg/l	10	31	22	33	4.1	34	22
Carbonate	mg/l HCO3	0	0	0	0	0	0	0
Bicarbonate	mg/l HCO3	504	1310	1180	1490	367	486	411
pH (Lab)	S.U.	7.1	7.4	7.3	7.2	8.0	7.5	7.7
Conductivity (Lab)	umhos/cm@ 25c	1290	1950	1860	2170	837	1770	1600
Sodium Absorption Ratio		1.3	25	11	25	1.0	2.4	2.9
Total Nitrate and Nitrite	mg/l	0.01	0.00	0.03	0.00	0.03	0.12	0.10
Fluoride	mg/l	1.1	7.3	3.9	7.5	0.4	0.4	0.5
Hardness As CaCO3	mg/l	590	71	220	86	370	720	580
Noncarbonate Hardness	mg/l	180	0	0	0	72	330	240
Phosphate	mg/l	0.00	0.03	0.03	0.00	0.00	0.06	0.06
Boron	mg/l	0.350	0.650	0.560	0.710	0.160	0.270	0.250
Iron	mg/l	0	0.340	0.250	0.030	0.030	a	0.010
Manganese	mg/l	0.038	0	0.010	0	0.080	a	0.010
Silica	mg/l	9.2	11	11	11	11	8.4	15

Comments:

(a) Not analyzed.

(EPNG) El Paso Natural Gas Company core hole.

TABLE VII-8

3/30/93

SUMMARY OF CALCULATED PEAK FLOW VALUES FOR THE UNDISTURBED AREAS NOT DRAINING TO THE SEDIMENTATION POND (ft^3/s)

STORM	SMOKY HOLLOW DRAINAGE	TRIBUTARY TO SMOKY HOLLOW
10 year-6 hour	328.40	43.37
25 year-6 hour	487.88	65.51
100 year-6 hour	770.10	104.86
10 year-24 hour	567.89	89.42
25 year-24 hour	838.65	128.71

TABLE VII-9
SINGLE STAGE SAMPLER
PEAK FLOW MEASUREMENTS

	SS-1		SS-2		SS-3		SS-4	
	DEPTH (in.)	FLOW (cfs)	DEPTH (in.)	FLOW (cfs)	DEPTH (in.)	FLOW (cfs)	DEPTH (in.)	FLOW (cfs)
8/16/89	7	13.8	0	0	11	9.0	2	0.02
12/27/89	7	13.8	8	21.6	11	9.0	0	0
7/27/90	3	2.7	28.5	430.0	*	-	11	54.5
9/30/90	0	0	0	0	0	0	0	0
2/9/91	0	0	0	0	0	0	0	0
5/13/91	0	0	0	0	0	0	0	0
6/13/91	2	1.2	0	0	6	2.4	1	0
7/25/91	0	0	0	0	0	0	0	0
8/23/91	0	0	0	0	4	0.9	0	0
9/25/91	0	0	0	0	0	0	0	0
12/17/91	0	0	0	0	0	0	0	0
2/7/92	0	0	0	0	0	0	0	0
5/30/92	4	4.8	0	0	8	4.7	2	0.02
7/11/92	*	-	*	-	*	-	*	-
8/15/92	8.5	20.1	*	-	*	-	2	0.02
8/29/92	13	47.0	12	50.4	*	-	17	124.6
9/7/92	*	-	*	-	*	-	0	0
9/18/92	0	0	0	0	0	0	0	0
9/20/92	13	47.0	8	21.6	*	-	11	54.5
11/1/92	4.5	6.3	6	11.7	*	-	7	21.3

* Water depth measurement not available

TABLE VII-9 (Continued)
SINGLE STAGE SAMPLER
PEAK FLOW MEASUREMENTS

	SS-5		SS-6		SS-7		SS-8		SS-9	
	DEPTH (in.)	FLOW (cfs)	DEPTH (in.)	FLOW (cfs)	DEPTH (in.)	FLOW (cfs)	DEPTH (in.)	FLOW (cfs)	DEPTH (in.)	FLOW (cfs)
5/30/92	4	2.9	0	0	8	9.6	*	-	*	-
7/11/92	0	0	0	0	8	9.6	*	-	*	-
8/15/92	8	16.9	*	-	*	-	*	-	*	-
8/29/92	*	-	*	-	*	-	*	-	*	-
9/7/92	1	0.05	*	-	*	-	*	-	*	-
9/18/92	0	0	0	0	0	0	*	-	*	-
9/20/92	12	43.1	*	-	*	-	*	-	*	-
11/1/92	6	7.8	6	17.5	*	-	*	-	*	-

* Water depth measurement not available
- Calculation not possible due to lack of depth information

TABLE VII-10
UTAH DRINKING WATER STANDARDS

3/30/93

PRIMARY DRINKING WATER STANDARDS	
Contaminant	Level mg/l
Arsenic	0.05
Barium	1.0
Cadmium	0.010
Chromium	0.05
Fluoride	4.0
Lead	0.05
Mercury	0.002
Nitrate (as N)	10.0
Selenium	0.01
Silver	0.05
Sulfate	1000
Total Dissolved Solids	2000
SECONDARY DRINKING WATER STANDARDS	
Contaminant	Level mg/l
Chloride	250
Copper	1.0
Iron	0.3
Manganese	0.05
Zinc	5.0

From the State of Utah Public Drinking Water Rules, 1991 (Part I - Administrative Rules, pages 103-1 and 103-5)

TABLE VII-11 **3/30/93**

RESULTS OF SELECTED CHEMICAL ANALYSES OF WATER COLLECTED IN 1975-76 FROM LAST CHANCE AND WAHWEAP CREEKS NEAR LAKE POWELL

	Last Chance Creek		Wahweap Creek	
Constituents (mg/l)	min.	max.	min.	max.
Total dissolved Solids	1,830	5,985	1,580	12,030
Calcium	178	484	108	572
Magnesium	25	242	51	314
Sodium	283	1,030	293	2,890
Potassium	2.3	26.1	7.4	19.5
Chloride	28	66	80	612
Sulfate	1,050	3,940	810	7,500
Bicarbonate	200	232	71	373
Arsenic	0.001	0.055	0.001	0.853
Cadmium	0.001	0.160	0.001	0.058
Chromium	0.001	0.030	0.001	0.001
Selenium	0.01	0.353	0.01	1.170
Zinc	0.003	0.048	0.010	0.092

From the Development of Coal Resources in Southern Utah, Final Environmental Impact Statement, 1979 (Part 1, page II-19)

TABLE VII-12
SURFACE WATER QUALITY
DATA SUMMARY: 1989 - 1992

Sampler	Period Sampled	TSS (mg/l)		TDS (mg/l)		pH		Iron (mg/l)		Manganese (mg/l)	
		Range	Avg.	Range	Avg.	Range	Avg.	Range	Avg.	Range	Avg.
SS-1	8/16/89 - 11/1/92	294 - 75,380	30,587	282 - 650[2]	446	7.3 - 7.5	7.5	<0.05 - 10.6[3]	2.3[1,3]	<0.01 - 5.3[4]	1.0[1,4]
SS-2	8/15/92 - 11/1/92	8,260 - 148,000	65,665	200 - 1,400[2]	550[2]	7.5 - 7.8	7.65	<0.05 - 5.36[3]	1.4[1,3]	<0.02 - 0.14[4]	0.05[1,4]
SS-3	8/16/89 & 9/7/92	3,970 - >90,000	46,985	332 - 594[2]	463	7.3 - 7.5	7.4	<0.05 - 0.58[3]	0.3[1]	<0.02 - 2.9[4]	1.5[1,4]
SS-4	7/27/90 & 8/29/92	180,000		640[2]		7.1		<0.05		<0.02 - 0.52[4]	0.3[1,4]
SS-5	5/30/92 - 9/20/92	11,500 - 65,000	31,433	290 - 808[2]	465	7.1 - 7.6	7.4	<0.05 - 0.13	0.06[1]	<0.02 - 0.86[4]	0.2[1,4]
SS-6	8/15/92	9,750		1,240[2]		7.7		0.08		0.02	
SS-7	No Samples	No Samples									
SS-8	7/11/92 - 11/1/92	27 - 206,000	54,848	326 - 832[2]	606.5[2]	7.3 - 8.1	7.7	<0.05 - 3.94[3]	1.0[1,3]	<0.02 - 1.1[4]	0.3[1,4]
SS-9	7/11/92 - 11/1/92	33 - 50,800	28,833	410 - 684[2]	506[2]	7.5 - 7.9	7.7	<0.05 - 3.56[3]	1.1[1,3]	<0.02 - 1.15[1,4]	0.3[1,4]
101	7/11/92	49,200		826[2]		7.1		19.2[3]		3.58[4]	
102	7/11/92	252		426		6.6		14.3[3]		0.34[4]	
103	7/11/92	41,700		490		7.4		38.5[3]		4.55[4]	
104	8/15/92	22,800		976[2]		7.5		3.88[3]		0.40[4]	
105	8/15/92	24		1,560[2]		7.3		0.11		<0.02	
106	8/29/92	6		1,320[2]		8.1		<0.05		<0.02	
107	8/29/92	20		1,260[2]		7.6		<0.05		<0.02	

Comments

(1) Average calculated using "(detection limit)*0.5" if amount present as "<detection limit".

(2) Exceeds SDW standard of 500 mg/l for TDS.

(3) Exceeds SDW standard of 0.3 mg/l for Iron.

(4) Exceeds SDW standard of 0.05 mg/l for Manganese

TABLE VII-12 (Continued)
SURFACE WATER QUALITY
DATA SUMMARY: 1989 - 1992

3/30/93

Sampler	Period Sampled	TSS (mg/l) Range	TSS (mg/l) Avg.	TDS (mg/l) Range	TDS (mg/l) Avg.	pH Range	pH Avg.	Iron (mg/l) Range	Iron (mg/l) Avg.	Manganese (mg/l) Range	Manganese (mg/l) Avg.
108	9/7/92	528		2,900[2]		7.8		<0.05		<0.02	
109	9/18/92	8		928[2]		7.9		<0.05		<0.02	
110	9/18/92	67		1,130[2]		7.7		<0.05		<0.02	
111	9/20/92	10		2,140[2]		8.1		<0.05		<0.02	
112	11/1/92	8		1,850[2]		8.3		<0.05		0.02	

Comments

(1) Average calculated using "(detection limit)*0.5" if amount present as "<detection limit".

(2) Exceeds SDW standard of 500 mg/l for TDS.

(3) Exceeds SDW standard of 0.3 mg/l for Iron.

(4) Exceeds SDW standard of 0.05 mg/l for Manganese

TABLE VII-13
MONTHLY MINIMUM AND MAXIMUM TEMPERATURE
BIG WATER, UTAH 1962-1970
Elevation 4100 Feet

3/30/93

MONTH	MAXIMUM	MINIMUM
January	50	12
February	59	20
March	66	27
April	74	34
May	87	46
June	94	54
July	102	66
August	98	60
September	88	51
October	80	40
November	61	31
December	49	16
ANNUAL MEAN	71.2	42.4

TABLE VII-14

SUMMARY OF CHEMICAL ANALYSES OF OVERBURDEN, UNDERBURDEN AND COAL FROM THE PROPOSED SMOKY HOLLOW MINE SITE

	DRILL HOLE 401 CORE SAMPLES			FEBRUARY 1992 SURFACE SAMPLES				
	46.9-48.8' SHALE	48.8-49.3' COAL	49.3-50.5' SHALE	OVERBURDEN OB-1	OVERBURDEN OB-2	UNDERBURDEN UB-1	UNDERBURDEN UB-2	COAL
pH	7.4	7.7	8.2	7.51	4.57	7.41	7.97	5.29
EC mmhos/cm @25°C	24.4	5.4	4.4	2.337	2.734	1.112	0.706	0.474
SAR	35.3	58.1	12.6	0.903	0.444	0.361	0.330	0.203
Selenium, mg/Kg	total <0.1*	total <0.1*	total <0.1*	0.114	0.035	0.079	0.079	<.01
Boron, mg/Kg	total 2.39*	total 0.84*	total <0.1*	4.2	4.0	0.97	<.1	4.7
Acid/Base Potential tons $CaCO_3$/tons soil	19.37	3.75	-3.13	138	-1.28	101.48	177	-10.8

* EPA Method 3050

TABLE VII-14 (Continued)
SUMMARY OF CHEMICAL ANALYSES OF OVERBURDEN, UNDERBURDEN AND COAL FROM THE PROPOSED SMOKY HOLLOW MINE SITE

	DRILL HOLE 401 CORE SAMPLES		DRILL HOLE 403 CORE SAMPLES		DRILL HOLE 404 CORE SAMPLES	
	40.0-50.7' ROOF	77.6-80.8' FLOOR	576.0-586.2' ROOF	593.5-596.5' FLOOR	563.0-570.6' ROOF	586.0-587.6' FLOOR
pH	7.7	7.8	7.7	8.3	8.1	7.2
EC mmhos/cm @25°C	5.01	4.39	5.22	3.6	3.67	5.11
SAR	37.5	36.2	44.0	35.1	40.0	31.3
Selenium, total mg/Kg	0.07[a]	0.19[a]	0.25[a]	0.07[a]	0.19[a]	0.28[a]
Boron, total mg/Kg	0.66[a]	0.59[a]	0.62[a]	0.40[a]	0.71[a]	1.01[a]
Acid/Base Potential tons $CaCO_3$/tons soil	174.0	192.0	50.0	226.0	161.0	-14.1

[a] EPA Method 3050

TABLE VII-15 3/30/93

CHEMICALS TO BE USED DURING MINING-RELATED ACTIVITIES

Machinery/Mining	Dust Control	Miscellaneous
Motor Oil	Rock Dust (limestone/gypsum)	Industrial Detergents (Biodegradable)
Gear Lubricating Oil		Paint
Water-based longwall hydraulic fluids		Paint Thinner
Other Hydraulic Fluids		
Antifreeze		
Transmission Oil		
Diesel		
Brake Fluid		

TABLE VII-16 3/30/93
SUMMARY OF POTENTIAL IMPACTS AND MITIGATIONS

Risk

POTENTIAL IMPACT	POTENTIAL EFFECT	POTENTIAL MAGNITUDE OF IMPACT	PROBABILITY OF OCCURRENCE	MITIGATION MEASURES
Leaching of acid- or toxic-forming materials	Degradation of surface and groundwater quality	Low	Low moderate Based on Avail Data	Monitoring, ~~materials~~ handled in an approved manner → How -
Groundwater availability	Decrease in seep flow due to subsidence	Low (seeps not significant source of water in area)	Low to moderate	Monitoring
Groundwater availability	Interception of groundwater by mine workings	Low	Low	Monitoring
Groundwater quality	Decrease in quality due to hydrocarbon usage	Low	Low	Monitoring, inspections and maintenance
Sediment yield	Increase in TSS	Moderate	Low	Sedimentation pond, diversion, monitoring
Flooding	Damage to downstream areas	Moderate - to High Due to Public Road Location	~~Low~~ Based on what	Sedimentation pond, diversion, monitoring
Streamflow alteration → Reclamation Channel	Damage to streams due to subsidence	Low → may Based on	Low	Protection of ephemeral streams, monitoring
Surface water quality	Decrease in quality due to hydrocarbon usage	~~Low~~ moderate to low due to Flooding only	Low same as Flooding.	Monitoring, inspections, maintenance
Surface water quality	Increase in TSS due to coal spills	Low	Low	Monitoring, safety measure

TDS -?

TABLE VII-17

GROUNDWATER AND SURFACE WATER-QUALITY PARAMETERS OPERATIONAL/POSTMINING PARAMETER LIST

Field Measurements
Water level or flow
pH
Specific Conductance
Temperature
Laboratory Measurements (all metals dissolved)
Total dissolved solids
Total suspended solids (surface water only)
Cation/Anion Balance
Bicarbonate
Carbonate
Calcium
Chloride
Fluoride
Iron
Lead
Magnesium
Manganese
Potassium
Sodium
Sulfate
Zinc

TABLE VII-18
BASELINE WATER-QUALITY PARAMETERS

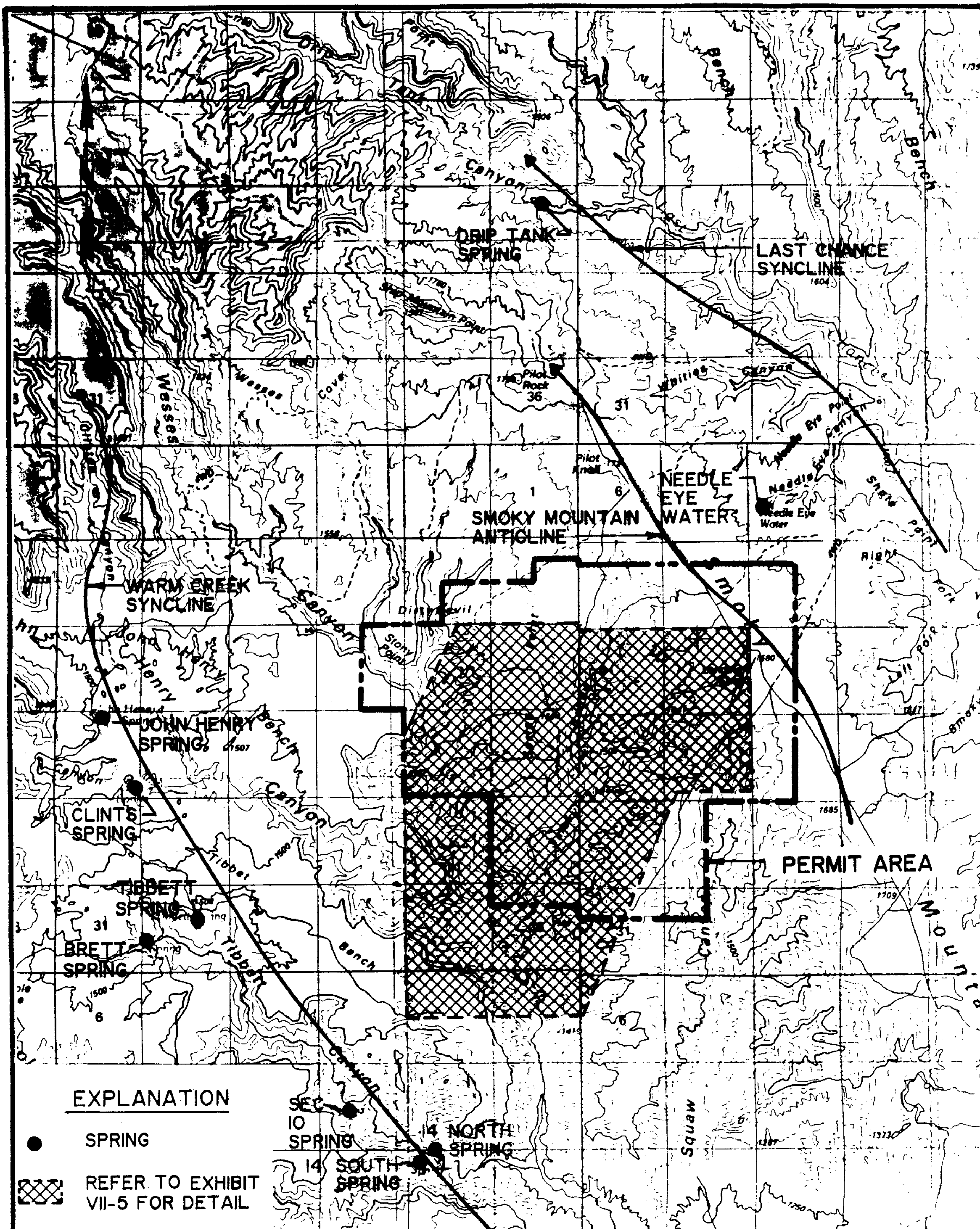
Field Measurements
Water level or flow
pH
Specific conductance
Temperature
Laboratory Measurements (all metals dissolved)
Aluminum
Alkalinity, Bicarbonate
Alkalinity, Carbonate
Arsenic
Anions, Total
Barium
Boron
Cadmium
Calcium
Cations, Total
Cation/Anion Balance
Chloride
Chromium
Copper
Fluoride
Iron
Lead
Magnesium
Manganese
Mercury
Molybdenum
Nickel

TABLE VII-18 (Continued)
BASELINE WATER-QUALITY PARAMETERS

Laboratory Measurements (all metals dissolved)
Nitrogen, Ammonia
Nitrogen, Nitrate
Nitrogen, Nitrite
Oil and Grease
Phosphorous, Total
Potassium
Selenium
Sodium
Sulfate
Sulfide
Total dissolved solids
Total suspended solids (surface water only)
Total settleable solid (surface water only)
Zinc

FIGURES

FIGURES (Continued)



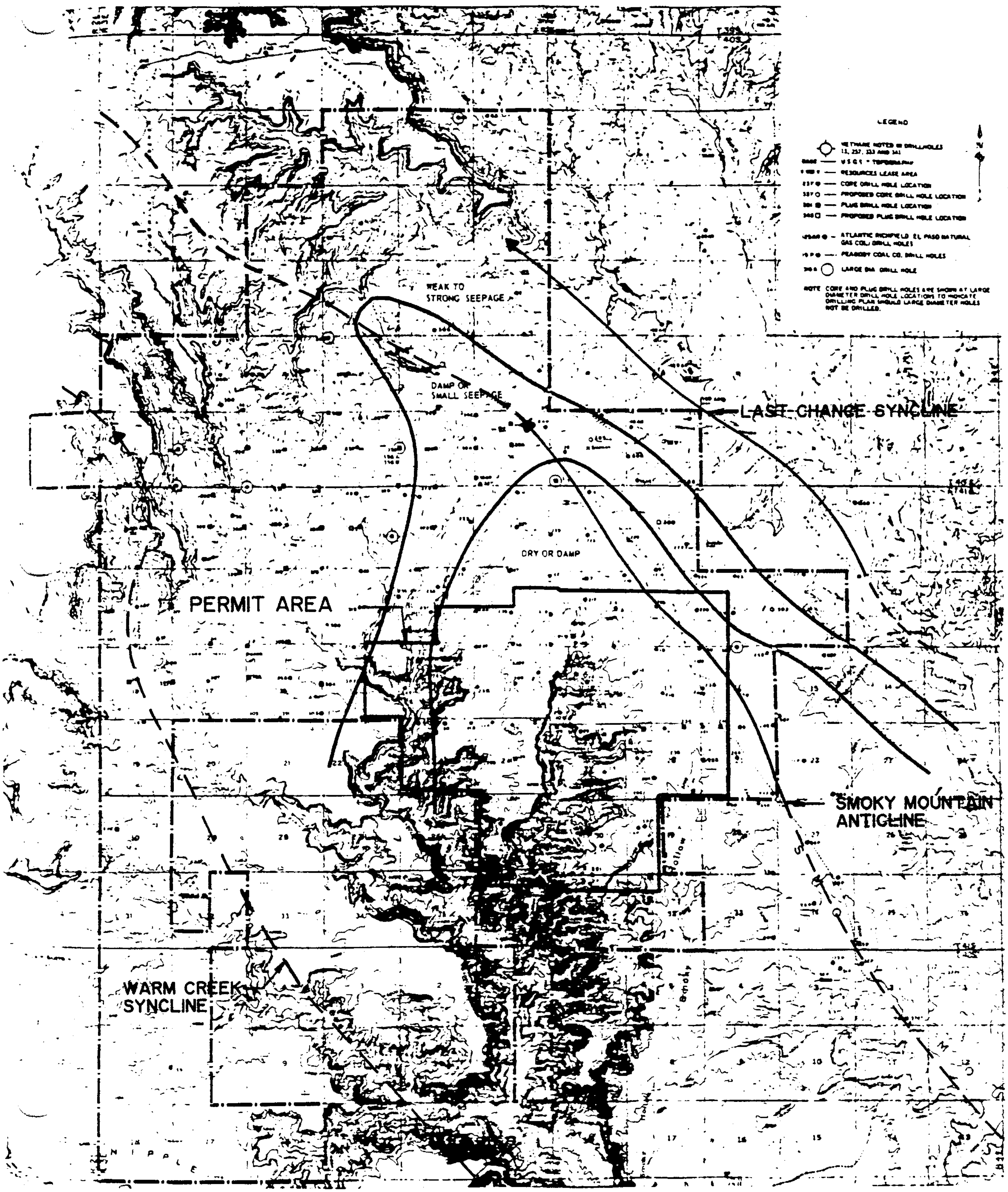
BASE MAP: USGS 1:100,000 SERIES ENTITLED
"SMOKY MOUNTAIN, UTAH-ARIZONA"
1985

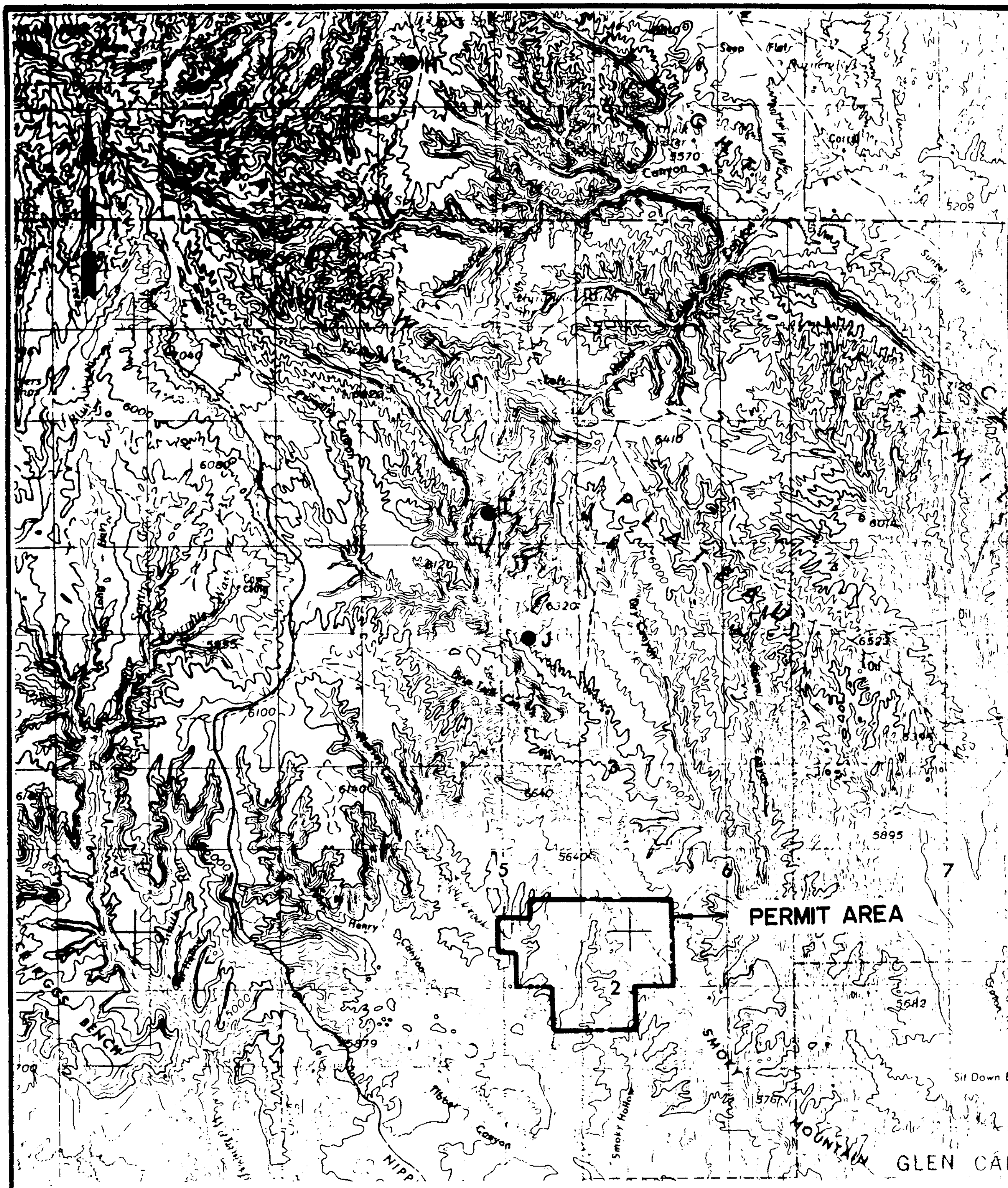
SCALE: 1:100,000

FIGURE VII-1 LOCATIONS OF SPRINGS

FIGURE VII-2
GENERALIZED CONFIGURATION OF DRY AND WATER-BEARING AREAS ENCOUNTERED DURING DRILLING

5/15/92





EXPLANATION

● EXPLORATORY HOLE

BASE MAP: USGS 1:250,000 SERIES ENTITLED "WESTERN UNITED STATES, ESCALANTE, UTAH; ARIZONA 1956, REVISED 1970

SCALE: 1:250,000

FIGURE VII-3 LOCATIONS OF EXPLORATORY HOLES TESTED BY PLANTZ

DRILLING LOG

Project Name: SMOKY HOLLOW Owner/Client: ANDALEX RESOURCES, INC.	Boring/Well Number: MW-1 Boring/Well Location: NE 1/4 CORNER, SEC. 36, T41S, R3E
Project Number: MW-1	Reference Elevation: 4520 Feet Reference Point: TOP OF STEEL CASING
Date Drilled: 11 - 18 SEPTEMBER 1990 Logged By: ROGER HOLLAND BASED ON DRILL CUTTINGS	Drilling Contractor: BOYLES BROTHERS Drilling Method: ROTARY Rig Type: ROTARY
First occurrence of G.W.: 190' Static W.L.: 4388 Feet Dates Measured: SEP 90 3 FEB 92	Boring Depth (Ft): 263 Well Depth (Ft): 261 Boring Diameter (in): 8

DEPTH (FT)	LITHOLOGIC DESCRIPTION AND OBSERVATIONS		SAMPLE LOC	WELL COMPLETION DETAILS
0	ALLUVIUM	Sandstone, orange tan, medium grained. With claystone, dark gray and red clinker fragments. Calcareous		
	SANDSTONE	With claystone, tan to medium gray with minor clinker and coal fragments, noncalcareous. Alluvial Fill?		
10				Cement Grout
	SANDSTONE	Light to medium gray, very fine grained, calcareous with claystone, medium to dark gray, fissile and coal, black, medium bright, hackly		
20	CLAYSTONE	Dark gray to black, very carbonaceous to coaly to noncarbonaceous, fissile, noncalcareous.		4" I.D. PVC Blank
		Medium to dark gray, fissile, noncalcareous		
30	SANDSTONE	Medium to dark gray, very fine grained, some carbonaceous material along bedding planes, noncalcareous. With minor claystone as above		
	COAL	Black, medium bright, concoidal to hackly, silk luster. With claystone, dark gray, carbonaceous		
40	CLAYSTONE	Dark gray to black, carbonaceous, with +/- 10% Coal as above.		
	SANDSTONE	Light tannish gray, coarse to very coarse grained, frosted, subrounded quartz grains and minor feldspar (?) With 10-20% dull coal fragments.		
50		As above, only lighter in color, with minor Claystone fragments - cuttings slightly damp.		
		As above decreasing sharply: Light tan to medium gray, very fine grained to fine grained, with minor claystone fragments.		
60		Light gray, fine to medium, salt & pepper, quartzose, noncalcareous, slightly clayey.		
70		As above only coarser grained, quartzose with white (kaolinite) fragments. probably altered feldspars, pyrite noted.		
		Minor black claystone fragments.		
80		Sandstone and claystone, pyrite noted		
	CLAYSTONE	Claystone, dark gray to black, fissile, noncalcareous, minor brown. With gray fine grained sandstone.		
90	SANDSTONE	Greenish gray, very fine grained, fissile, noncalcareous		
		Interbedded sandstone, dark greenish gray, fine grained, and claystone, medium to dark greenish gray, fissile		
100				

FIGURE VII-4

DRILLING LOG

Project Name: SMOKY HOLLOW Owner/Client: ANDALEX RESOURCES, INC.	Boring/Well Number: MW-1 Boring/Well Location: NE 1/4 CORNER, SEC. 36, T41S, R3E
Project Number: MW-1	Reference Elevation: 4520 Feet Reference Point: TOP OF STEEL CASING
Date Drilled: 11 - 18 SEPTEMBER 1990 Logged By: ROGER HOLLAND BASED ON DRILL CUTTINGS	Drilling Contractor: BOYLES BROTHERS Drilling Method: ROTARY Rig Type: ROTARY
First occurrence of G.W.: 190' Static W.L.: 4388 Feet Dates Measured: SEP 90 3 FEB 92	Boring Depth (Ft): 263 Well Depth (Ft): 261 Boring Diameter (in): 8

DEPTH (FT)	GRAPHICAL LOG	LITHOLOGIC DESCRIPTION AND OBSERVATIONS		SAMPLE LOC.	WELL COMPLETION DETAILS
100			Light gray, fine to medium grained, salt & pepper, slightly clayey, noncalcareous. Cuttings damp.		
110			Light gray, coarse grained, salt & pepper, quartzose, clayey, very slightly calcareous. With claystone, dark gray, fissile		Cement Grout
		CLAYSTONE	Medium to dark gray, medium soft, fissile, sticky		
120					4" I.D. PVC Blank
		SANDSTONE	Interbedded sandstone, light to medium gray, fine to medium grained. With claystone, medium to dark gray, fissile, noncalcareous. Sandstone strongly dominates.		
130					▽
			Claystone strongly dominates.		
140		CLAYSTONE	Greenish gray, soft, fissile, noncalcareous.		
			Claystone as above decreasing. Sandstone, light gray, fine grained, quartzose with green specs, calcareous.		
150			Claystone, dark gray, fissile with minor sandstone as above.		
			Claystone with sandstone, light to medium gray, very fine grained, quartzose, felspathic, calcareous.		
160		SANDSTONE	As above, decreasing claystone, dark gray to black, carbonaceous to coaly, fissile.		
		COAL	Black, dull to medium bright.		
		SANDSTONE	Light to medium gray, very fine to fine grained, calcareous, fissile. With claystone, medium to dark gray, fissile, calcareous.		
170					
180		CLAYSTONE	Dark gray, fissile, noncalcareous. With Coal, black, medium bright to dull. 30% +/-		
		SANDSTONE	Claystone as above decreasing. Coal as above decreasing sharply. Sandstone, medium gray, very fine grained, calcareous, clayey.		
190			Sandstone content increasing. Cuttings damp		
		SANDSTONE	Light gray, fine grained, salt & pepper, quartzose. Cuttings damp. Let well stand 20 minutes - blow 30 +/- gallons water. Continue blowing - 1.5 gpm.		
200					

FIGURE VII-4 (Con't)

5/15/92

DRILLING LOG

Project Name: SMOKY HOLLOW Owner/Client: ANDALEX RESOURCES, INC.	Boring/Well Number: MW-1 Boring/Well Location: NE 1/4 CORNER, SEC. 36, T41S, R3E
Project Number: MW-1	Reference Elevation: 4520 feet Reference Point: TOP OF STEEL CASING
Date Drilled: 11 - 18 SEPTEMBER 1990 Logged By: ROGER HOLLAND BASED ON DRILL CUTTINGS	Drilling Contractor: BOYLES BROTHERS Drilling Method: ROTARY Rig Type: ROTARY
First occurrence of G.W.: 190' Static W.L.: 4388 feet Dates Measured: SEP 90 3 FEB 92	Boring Depth (ft): 263 Well Depth (ft): 261 Boring Diameter (in): 8

DEPTH (FT)	GRAPHICAL LOG	LITHOLOGIC DESCRIPTION AND OBSERVATIONS	SAMPLE LOG	WELL COMPLETION DETAILS
200		No recovery.		
210	SANDSTONE	Light to medium gray, very fine grained, salt & pepper, quartzose, carbonaceous to coaly laminae, minor green specks, highly calcareous. Sandstone as above with claystone, dark gray to black to greenish gray (contamination?)		
220		As above with increase in clay content.		
		Sandstone, light to medium to dark gray, very fine grained, calcareous, fissile(?) with claystone, dark gray, fissile, noncalcareous.		
230		Mostly light gray, dark gray as above, very fine grained, calcareous, clean. Gypsum? Noted.		
240				
250		Sandstone as above with 10-20% very fine grained to silty dark gray sandstone		
		Sandstone, dark gray, very fine to silty, micaceous, very thin bedded, highly calcareous, carbonaceous fragments.		
260				
270				
280				
290				
300				

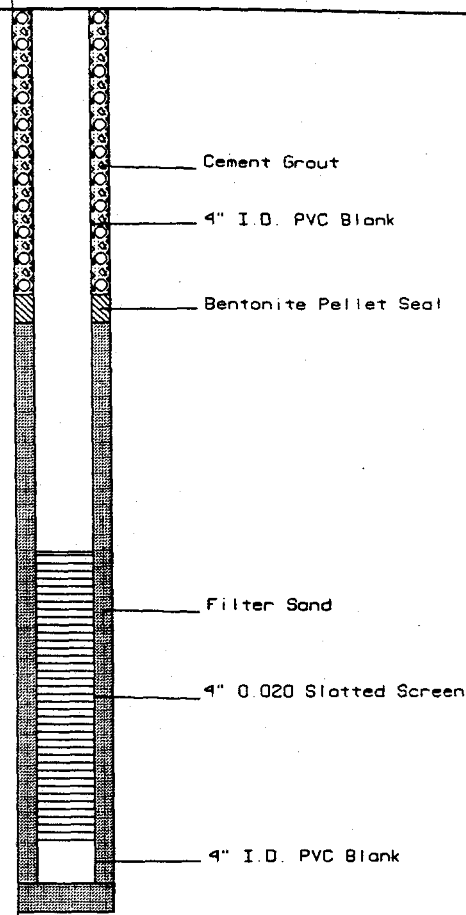
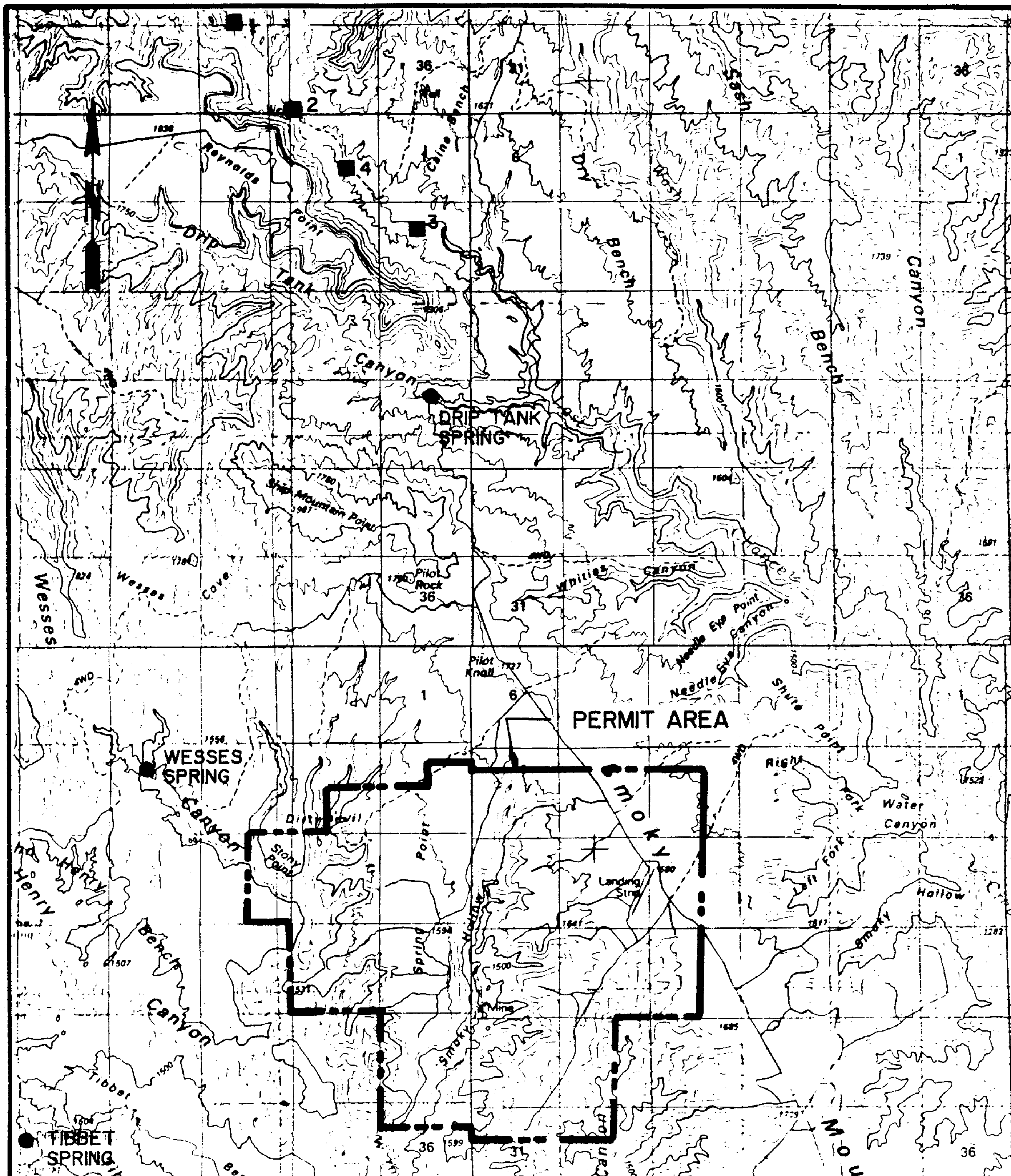


FIGURE VII-4 (Con't)



EXPLANATION

- ● SPRING
- ■ EL PASO NATURAL GAS CO. CORE HOLE

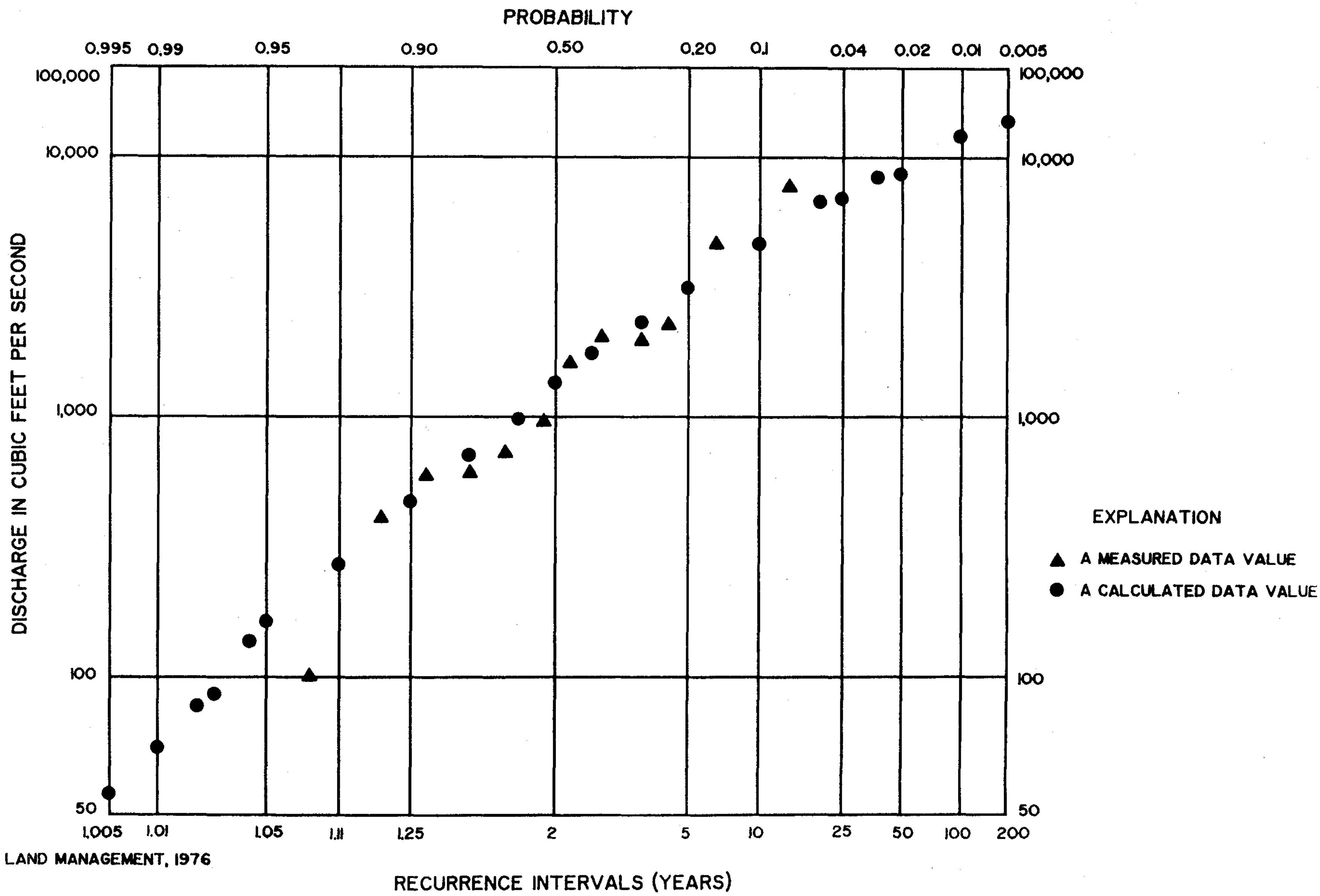
BASE MAP: USGS 1:100,000 SERIES ENTITLED "SMOKY MOUNTAIN, UTAH-ARIZONA" 1985

SCALE: 1:100,000

FIGURE VII-5 USGS SAMPLING LOCATIONS SPRING 1974

FIGURE VII-6

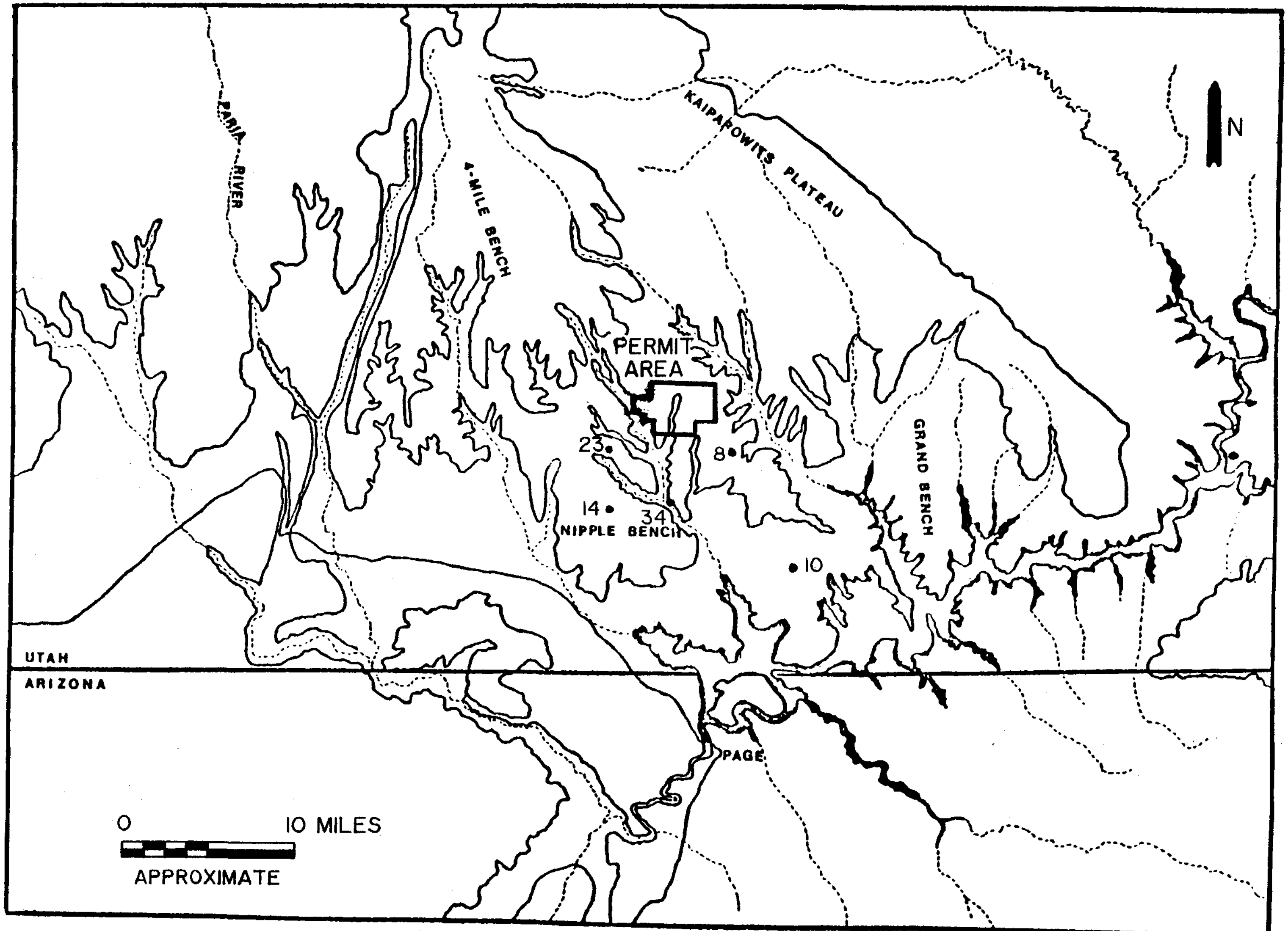
MAGNITUDE AND FREQUENCY OF ANNUAL PEAK DISCHARGE IN COYOTE CREEK



U.S. BUREAU OF LAND MANAGEMENT, 1976

FIGURE VII-7

BRIGHAM YOUNG UNIVERSITY STUDY SITE LOCATIONS

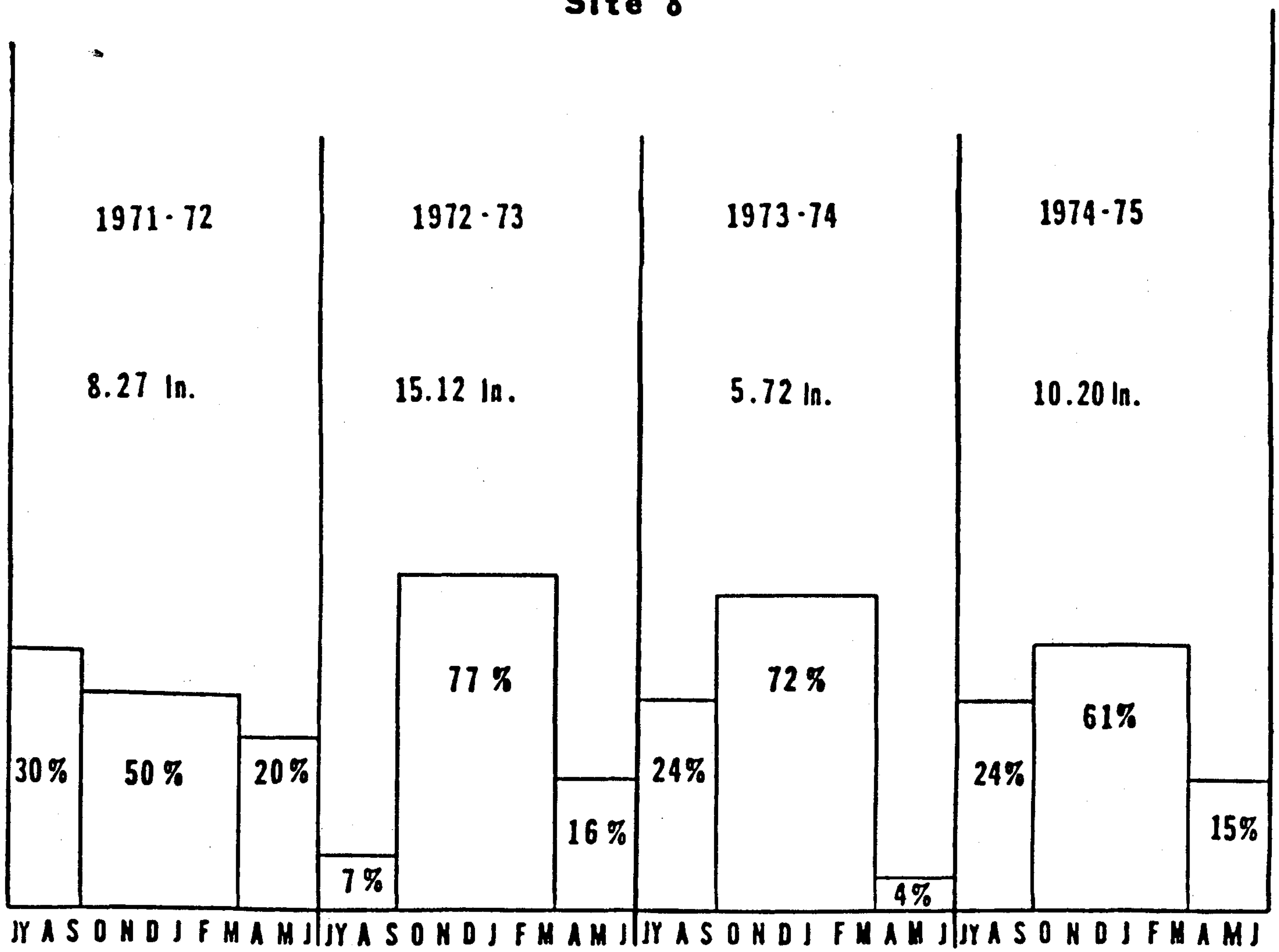


BRIGHAM YOUNG UNIVERSITY (1975)

FIGURE VII-8a

Precipitation Patterns Throughout Moisture Year

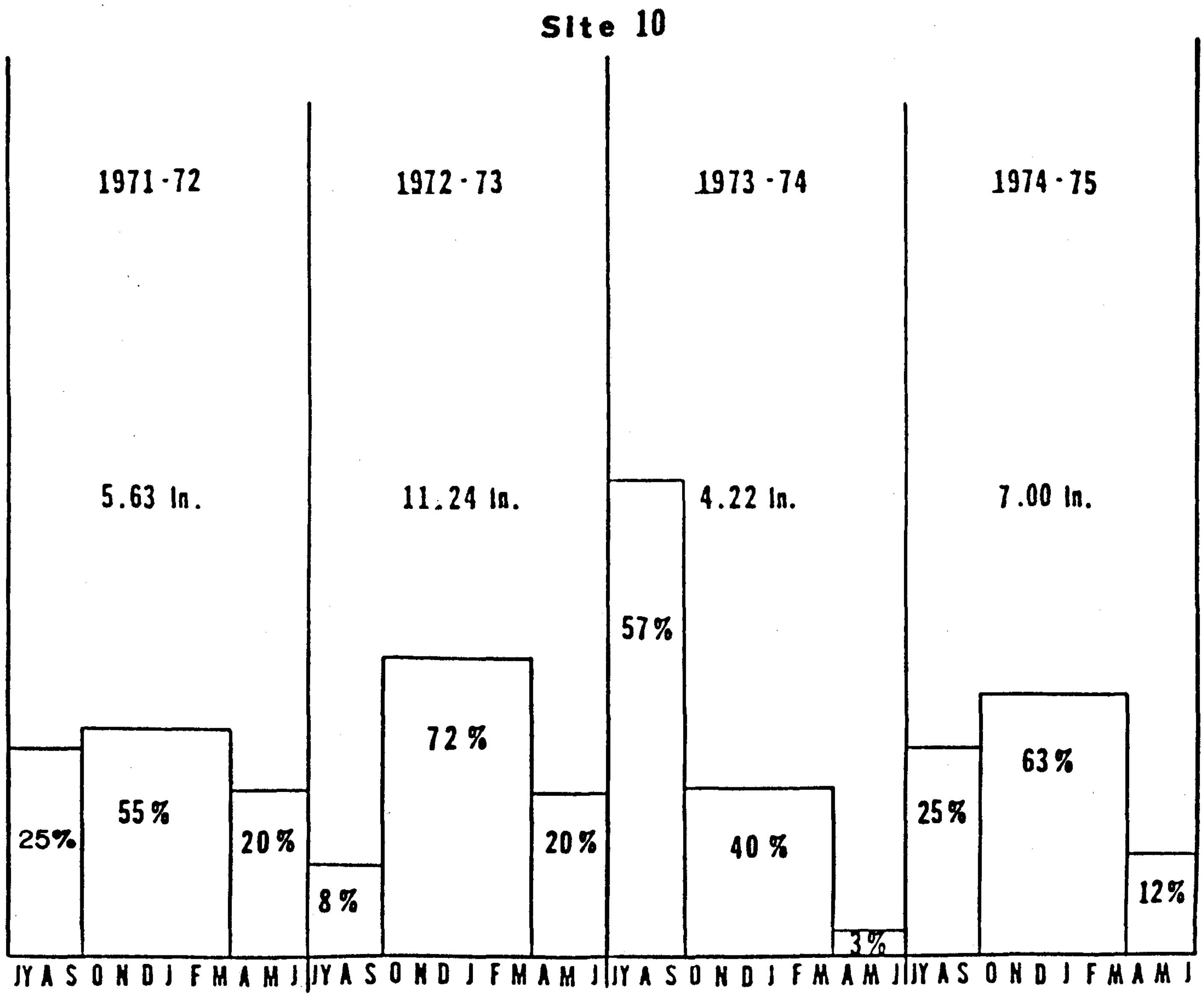
Site 8



BRIGHAM YOUNG UNIVERSITY (1975)

FIGURE VII-8b

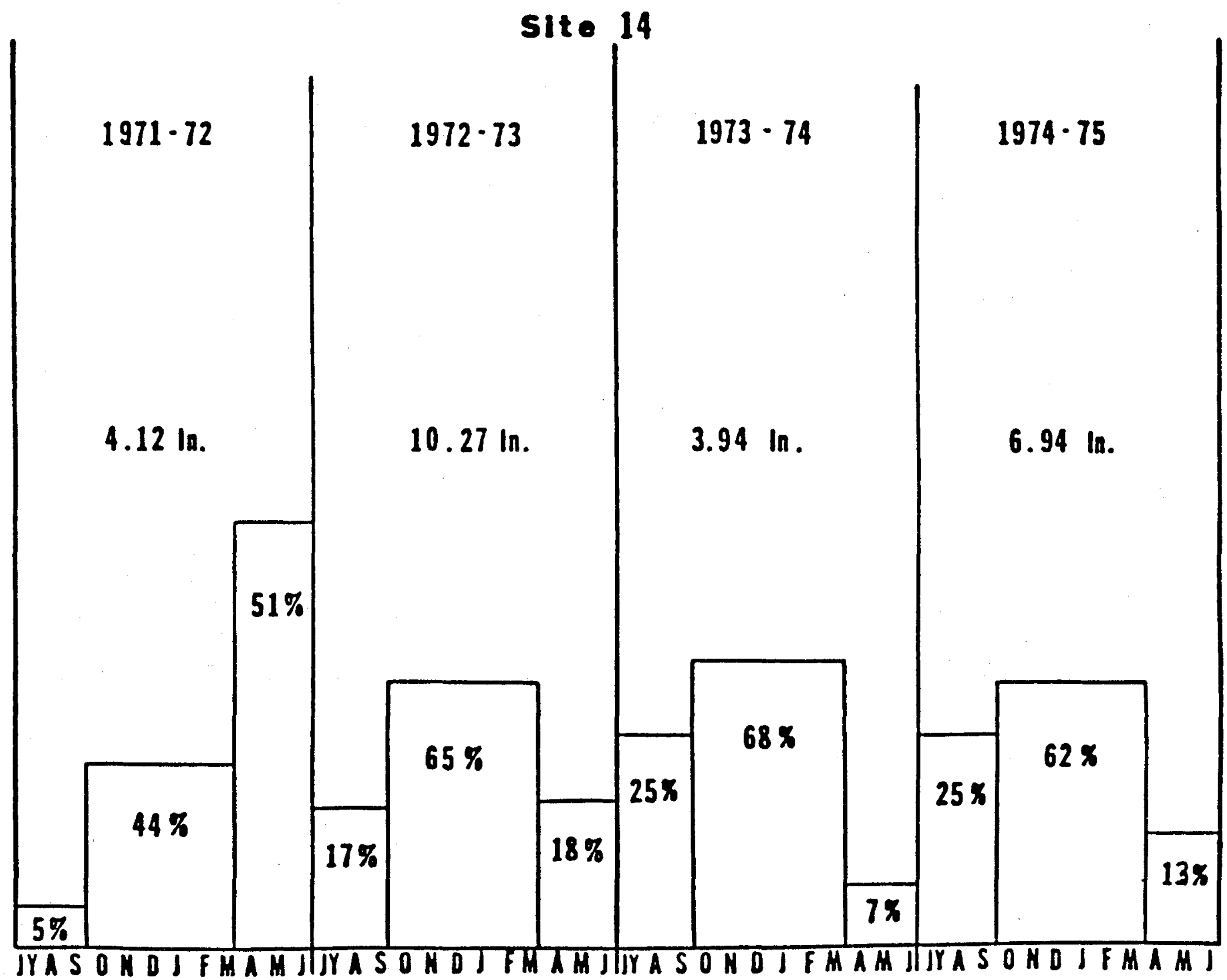
Precipitation Patterns Throughout Moisture Year



BRIGHAM YOUNG UNIVERSITY (1975)

FIGURE VII-8c

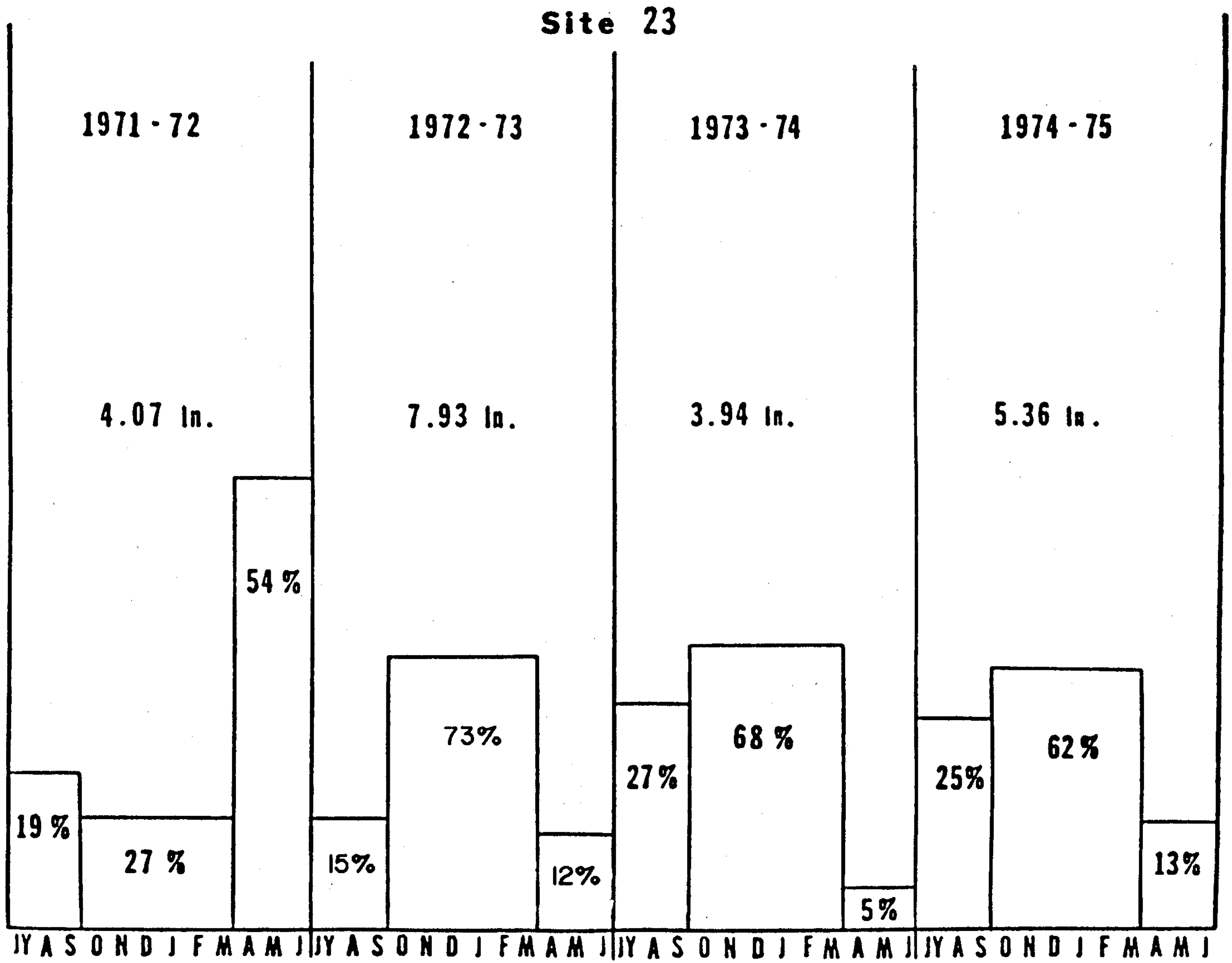
Precipitation Patterns Throughout Moisture Year



BRIGHAM YOUNG UNIVERSITY (1975)

FIGURE VII-8d

Precipitation Patterns Throughout Moisture Year

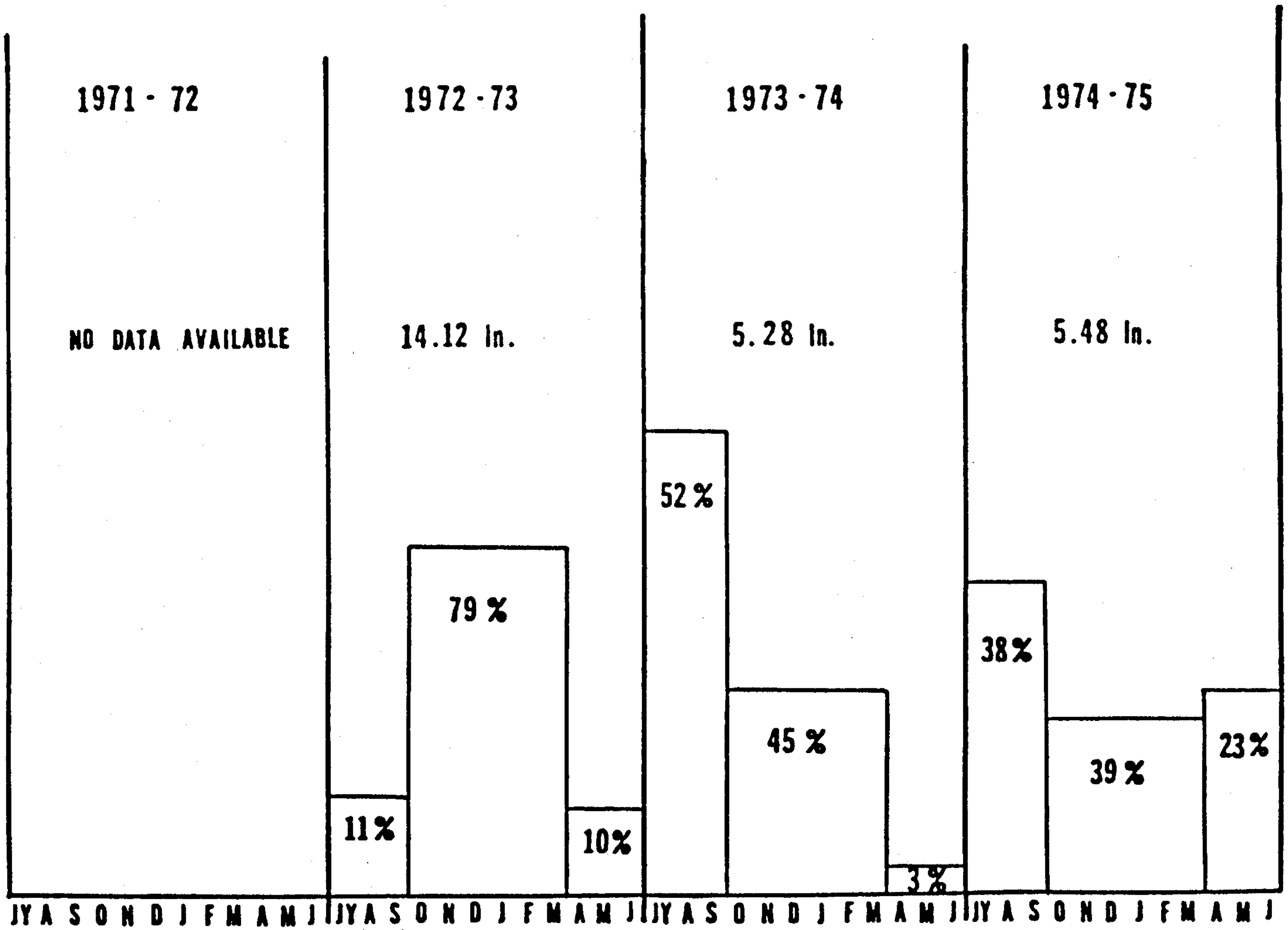


BRIGHAM YOUNG UNIVERSITY (1975)

FIGURE VII-8e

Precipitation Pattern Throughout Moisture Year

Site 34

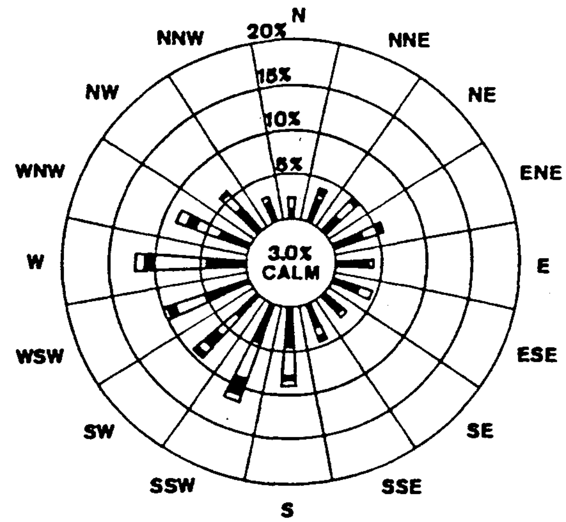


BRIGHAM YOUNG UNIVERSITY (1975)

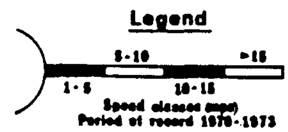
FIGURE VII-9

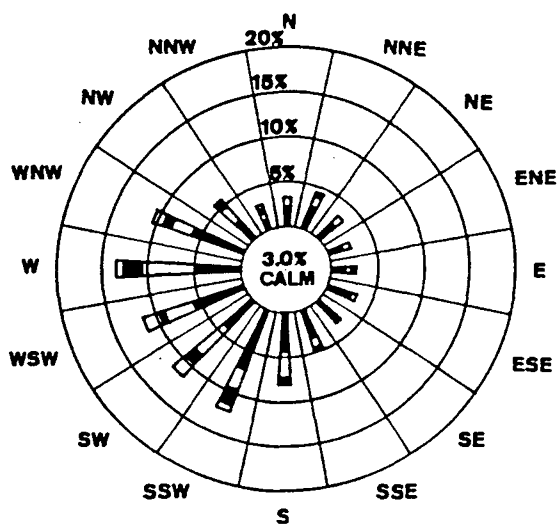
5/15/92

PERCENTAGE FREQUENCY OF WIND SPEED AND DIRECTION



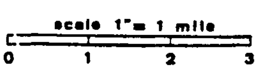
MORNING





AFTERNOON

PERCENTAGE FREQUENCY OF WIND SPEED AND DIRECTION
at 7300 ft. msl, over Page, Arizona
no scale

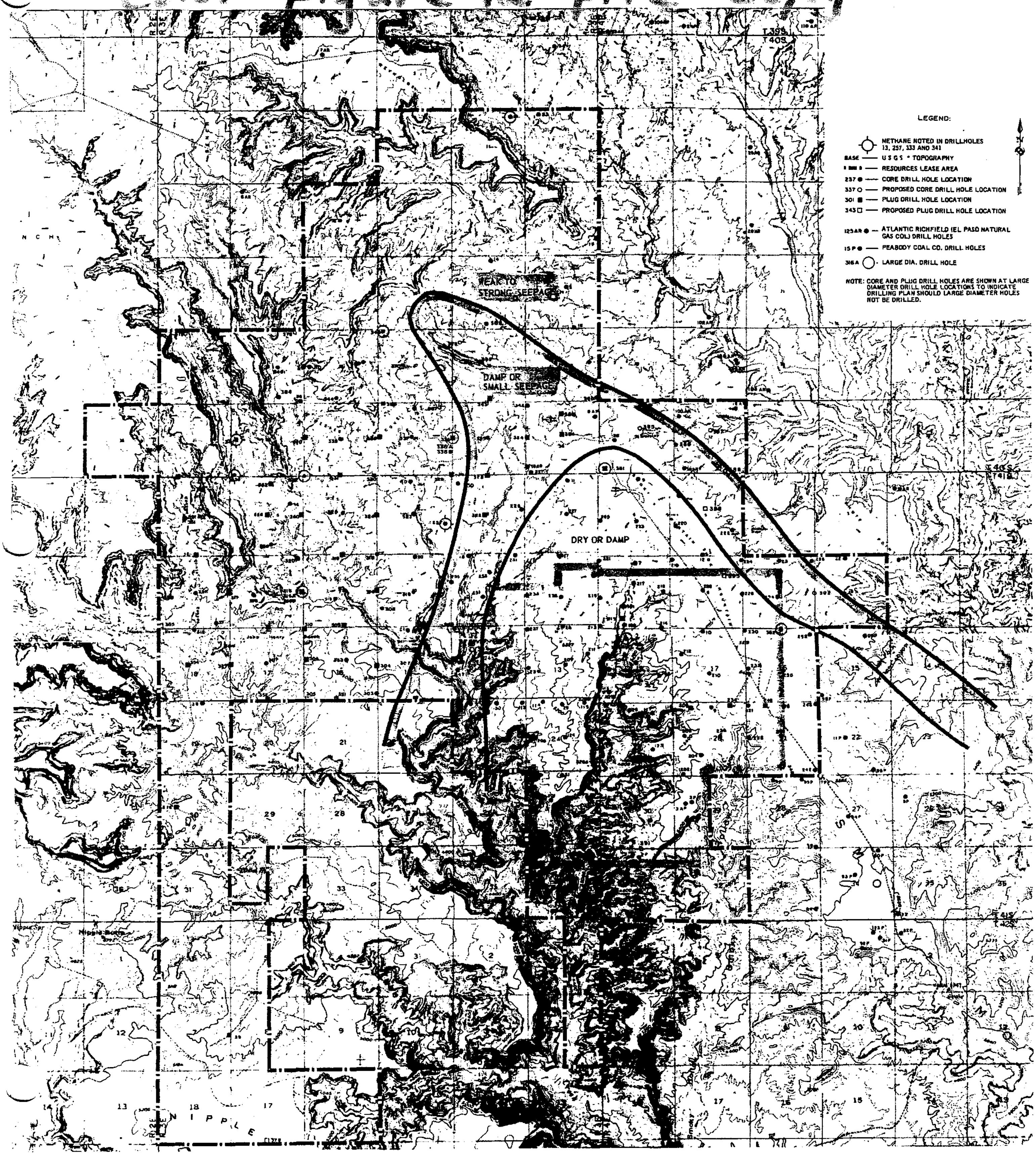


(Source: United States Bureau of Land Management, 1976)

5/15/92

GENERALIZED CONFIGURATION OF DRY AND WATER-BEARING AREAS OF THE LEASE AREA ENCOUNTERED DURING DRILLING

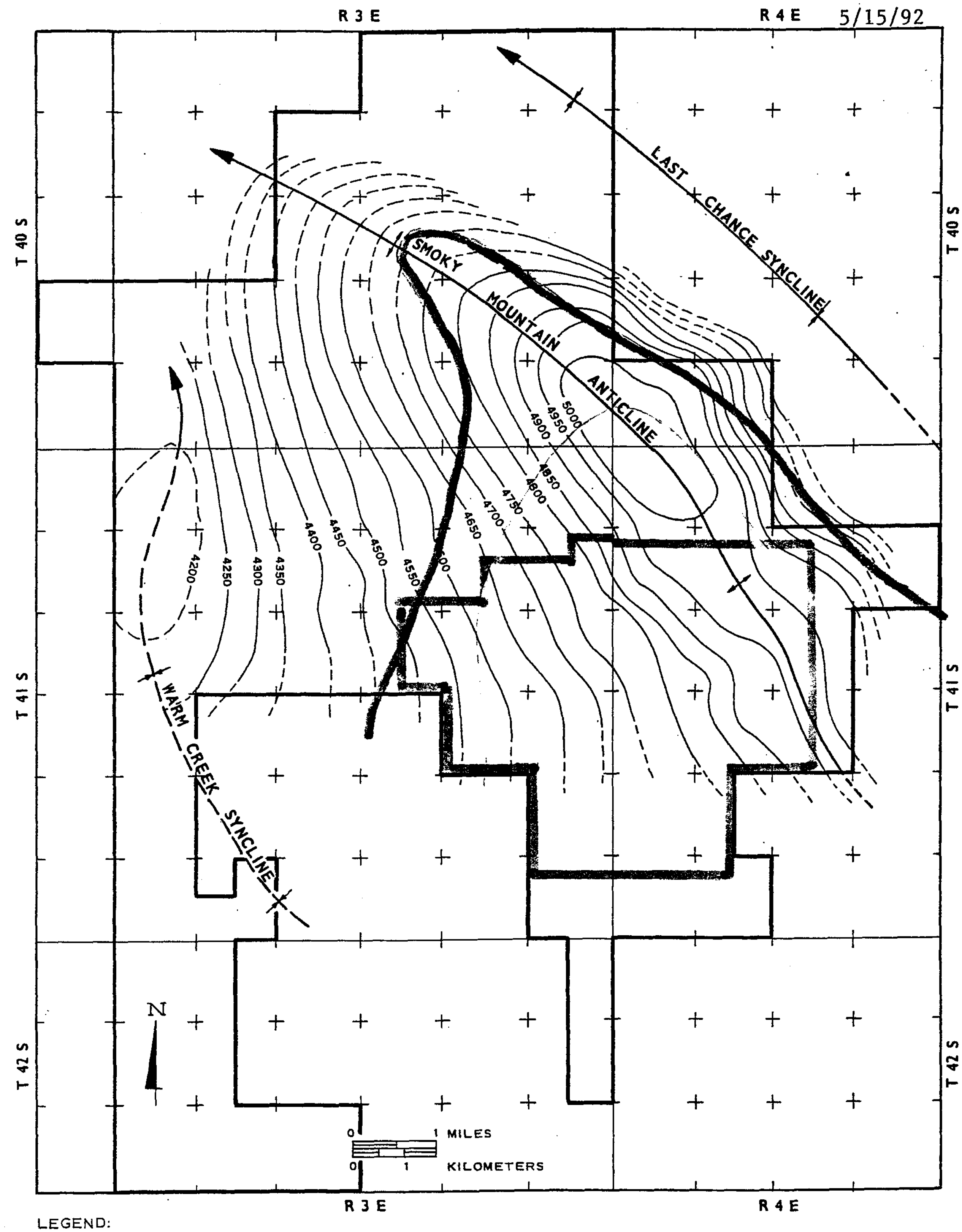
Color figure in file copy



REPRINTED FROM KAISER ENGINEER'S GEOLOGIC REPORT
KAIPAROWITS POWER PROJECT
1976

FIGURE VII-10

5/15/92



LEGEND:

LEASE BOUNDARY

ANTICLINE, ARROWS IN DIRECTION OF DIP & PLUNGE

SYNCLINE, ARROWS IN DIRECTION OF DIP & PLUNGE

5000 STRUCTURE COUNTOUR LINE CONTOUR INTERVAL 50 FEET

GENERALIZED STRUCTURE CONTOURS

REPRINTED FROM KAISER ENGINEER'S GEOLOGIC REPORT
KAIPAROWITS POWER PROJECT
1976

FIGURE VII-11

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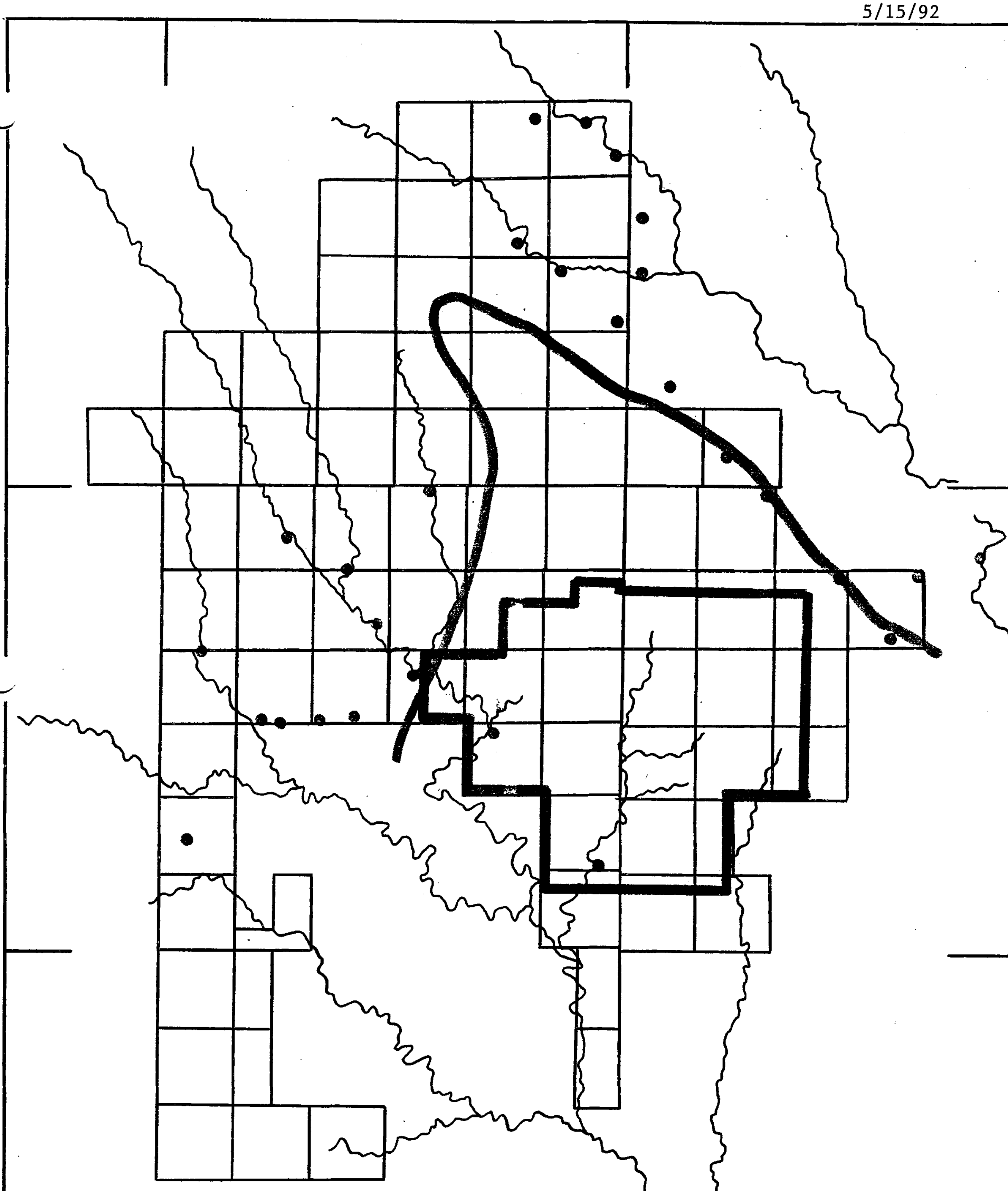


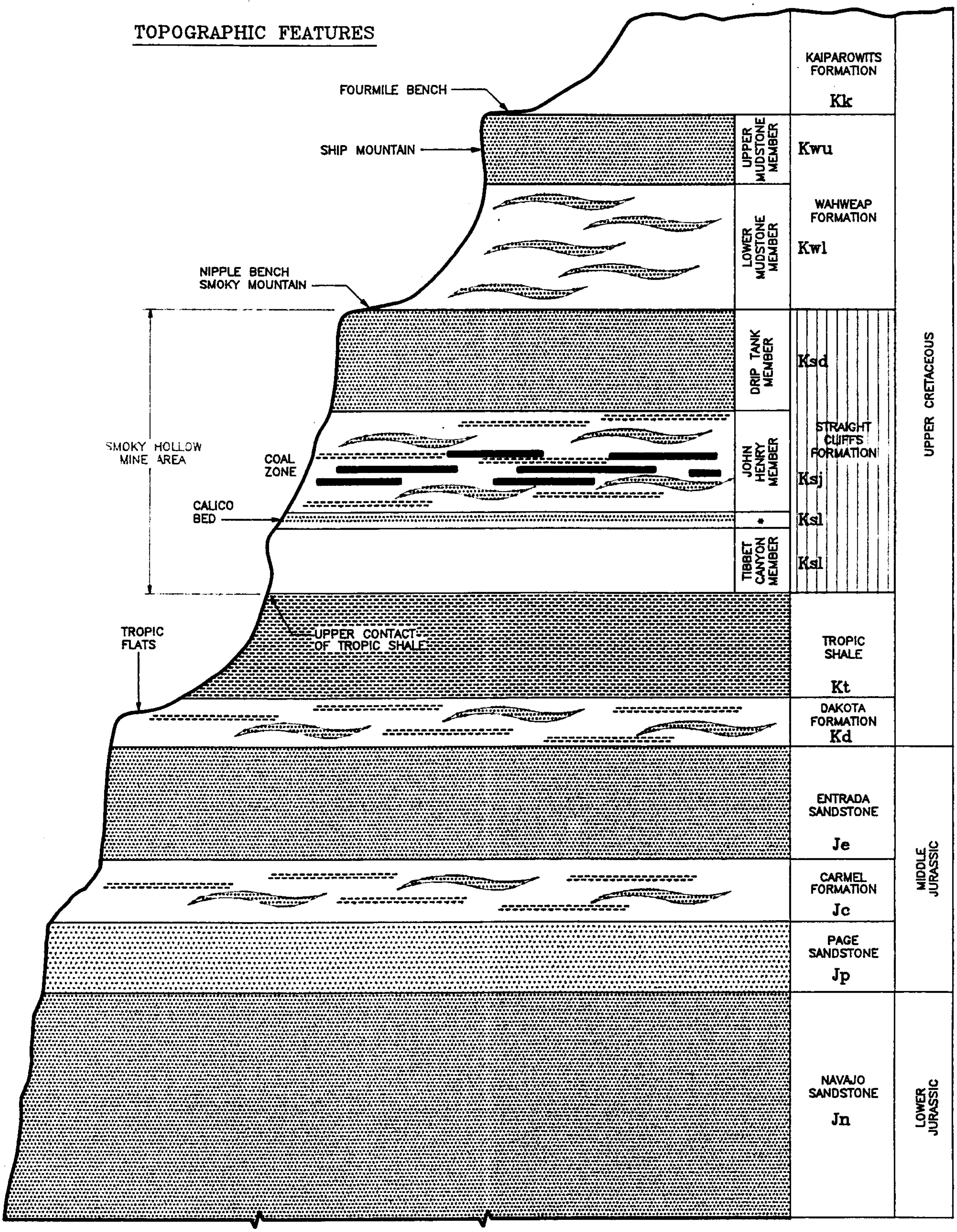
WATER WELL APPLICATIONS
KAIPAROWITS POWER PROJECT
1974

Color figure in file copy

FIGURE VII-12

03/30/93

GENERALIZED GEOLOGIC SECTION



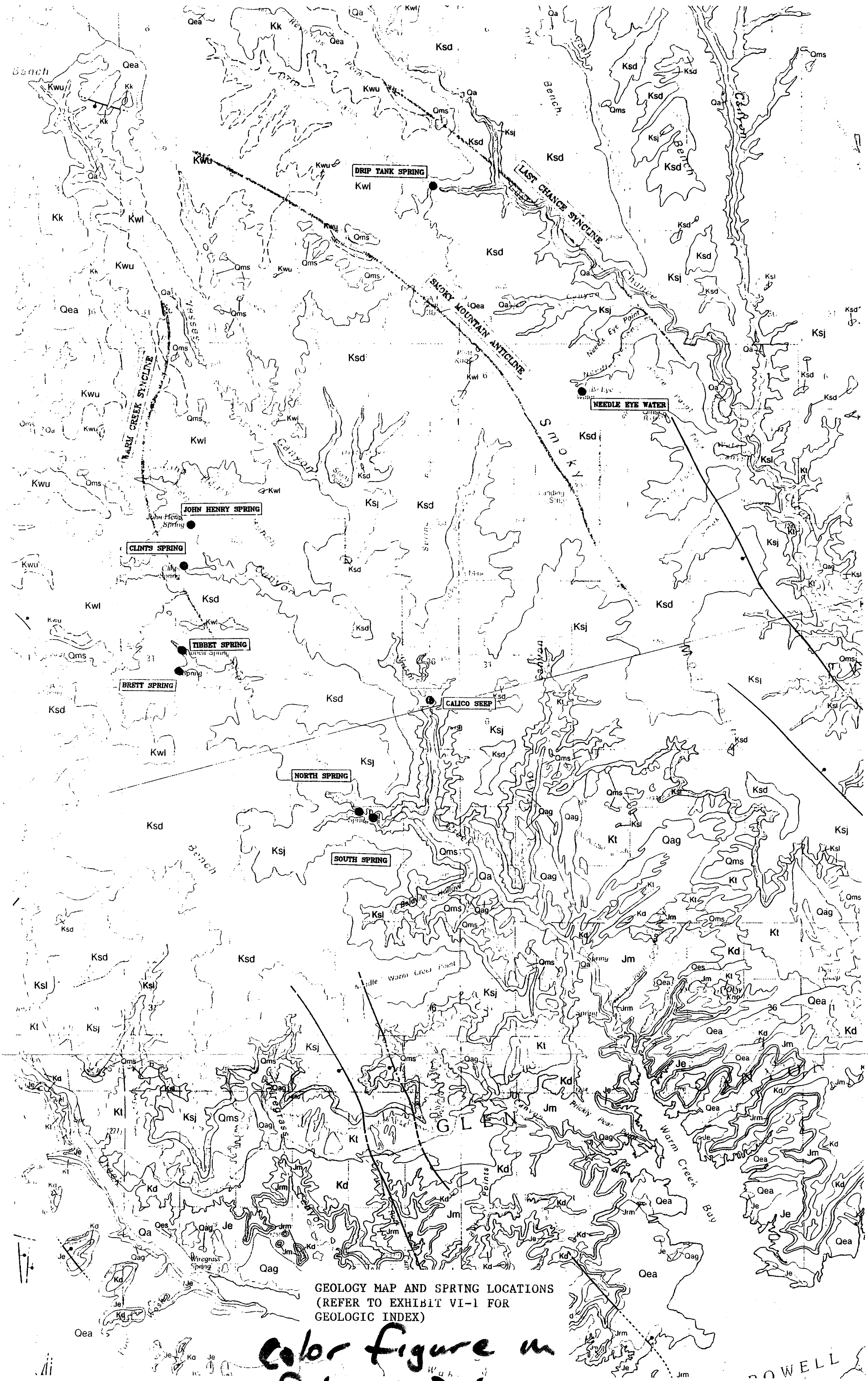
* SMOKY HOLLOW MEMBER

NOTE: MODIFIED FROM KAISER ENGINEERS GEOLOGIC REPORT, 1976

FIGURE VII–13

Color copy in file copy

5/15/92



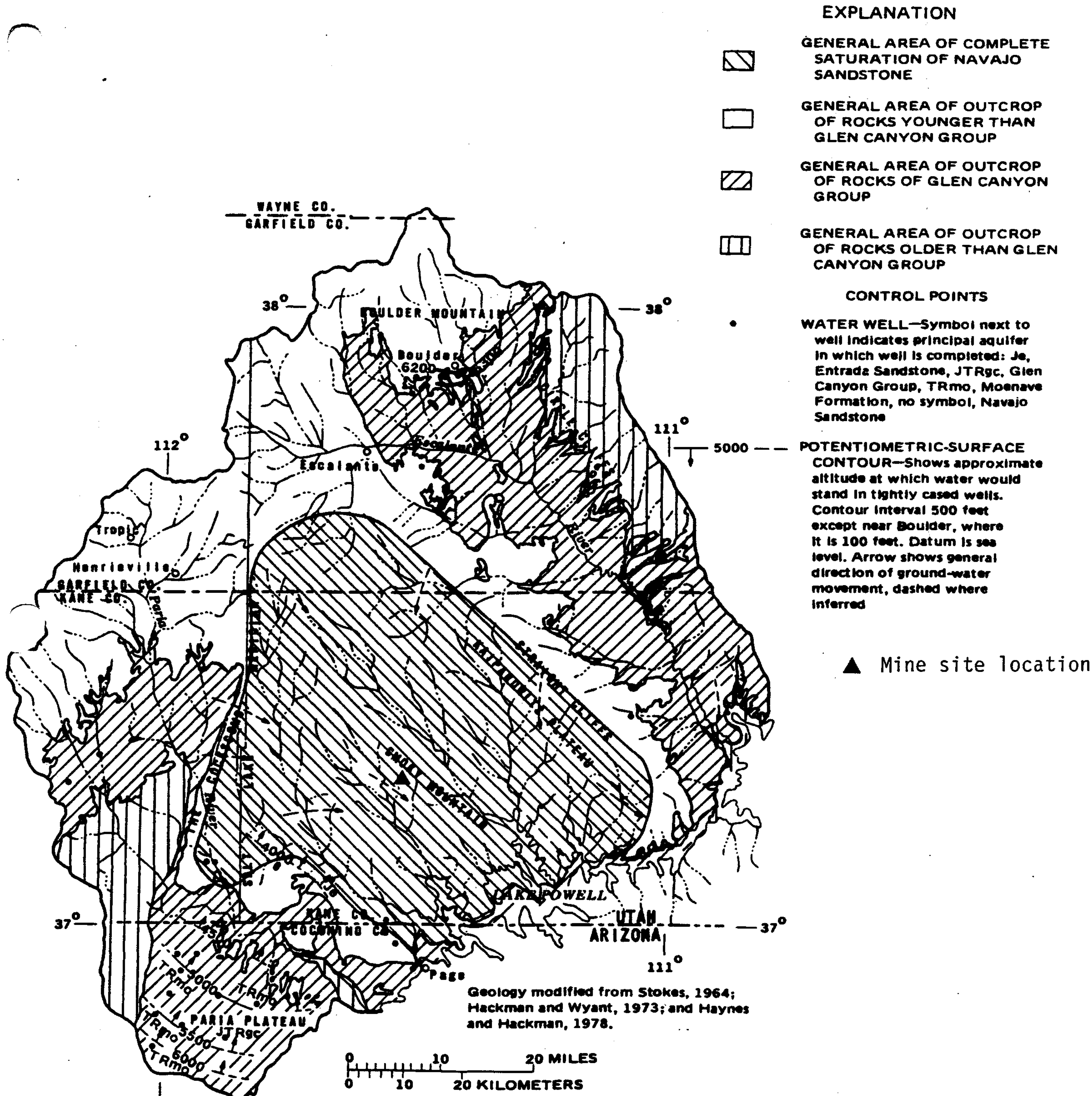
GEOLOGY MAP AND SPRING LOCATIONS
(REFER TO EXHIBIT VI-1 FOR
GEOLOGIC INDEX)

color figure in file copy

(Modified from Doelling and Davis, Map 121, 1989)

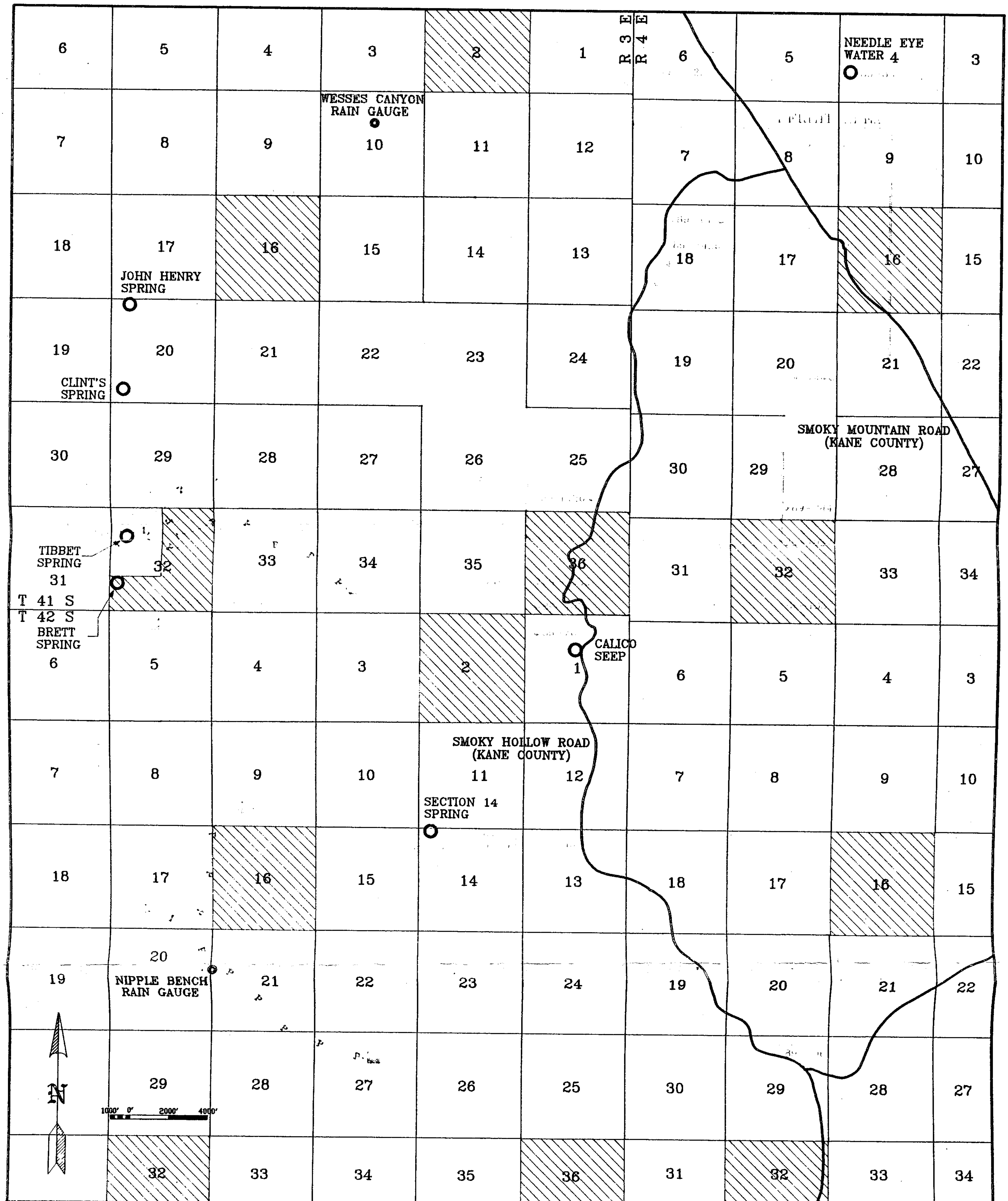
FIGURE VII-14

FIGURE VII-15



Approximate potentiometric surface and general direction of movement of water in the Navajo Sandstone and related formations.

(From Blanchard, 1986)



SMOKY HOLLOW MINE
WATER RIGHTS/
RANGE IMPROVEMENTS
FIGURE VII–16

Acad Reference: VIIFIG16

LEGEND:
- UTAH STATE LAND
- BUREAU OF LAND MANAGEMENT
- STOCK PONDS
- PIPELINE
- WATER TANKS
- PERFECTED WATER RIGHTS

NOTE: SOURCE = UTAH STATE DIVISION OF WATER RIGHTS, FEB. 1993
BLM (KANAB), MAR. 1993

ANDALEX RESOURCES, INC.
Tower Division

Color figure in file copy

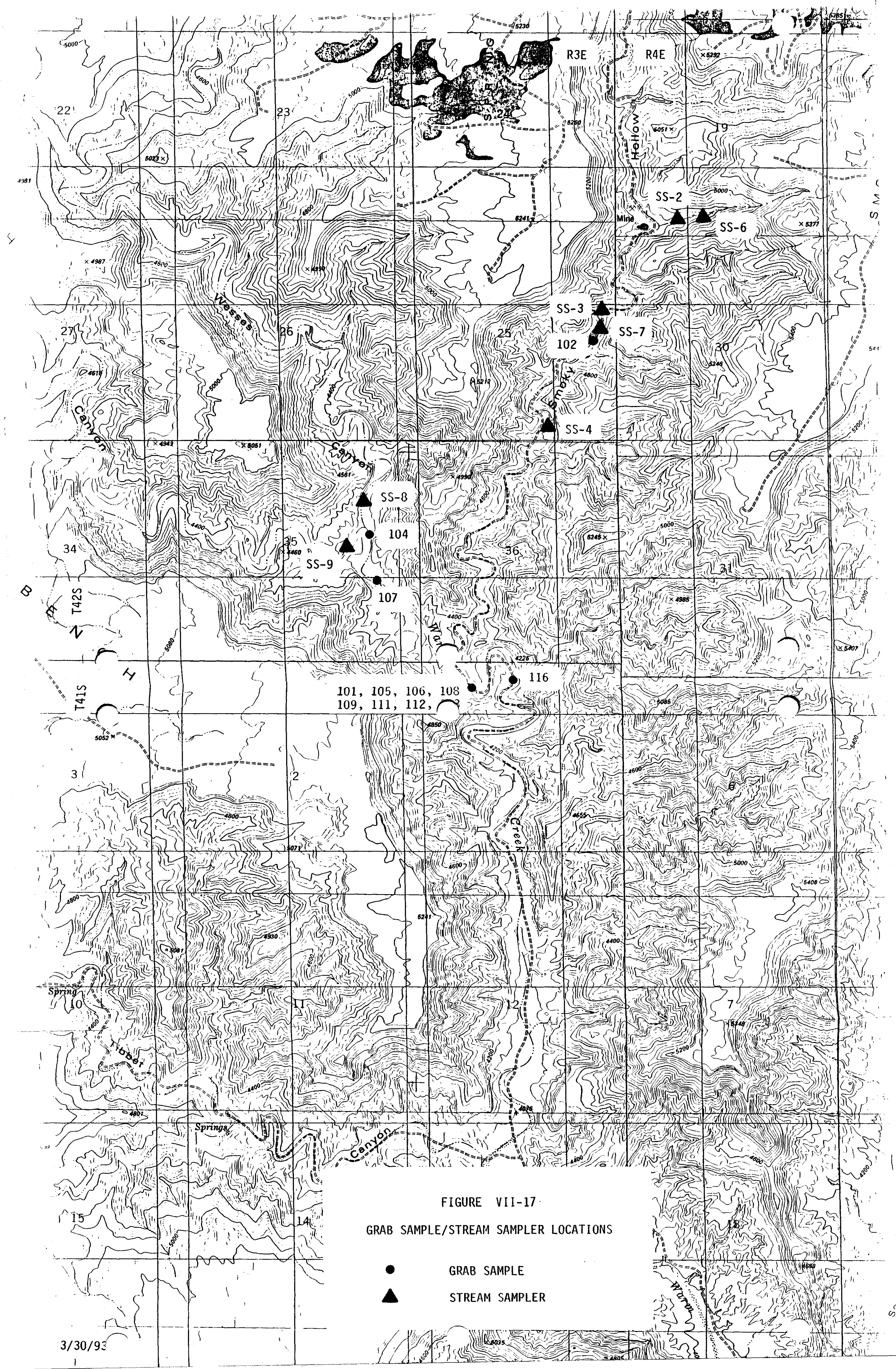


FIGURE VII-17

GRAB SAMPLE/STREAM SAMPLER LOCATIONS

● GRAB SAMPLE

▲ STREAM SAMPLER

3/30/93