D-6. Hydrology

The hydrology information for the proposed amendment area was prepared using Land Quality Division Guideline 7, March 1979, R. Dorn. All water rights, both surface and groundwater, are presented at the end of this appendix.

The hydrology information is divided into subregions and thence further divided into pit specific information. The subregions consist of the Red Hole, Wind, and Coal areas. Pit specific areas associated with the Red Hole subregion includes pit 73T, phase 2, pit 98T, phases 2 through 4, pit 104T, phases 1, 5, 6 and 7, and pit 75T, phase 2. The Wind area pit specific data consists of pit 108T, phases 1 through 17. Finally, the Coal area contains pit 102T, phases 1 through 3, pit specific data.

Existing pits mined under permit 321C are detailed on the maps containing pit specific information as well as the maps detailing subregions. Calculations and characteristics affected by existing pits are identified and the necessary details and calculations are presented. Original calculations and text by Joe Hereford with additional calculations by Greg Sweetser.

Groundwater

Data collected during developmental drilling activity has been reviewed on a pit by pit basis to determine both the maximum depth drilled and whether or not sub-surface water was encountered. This information is summarized in Table D-6.1.A.

Proposed Pit No.	Date Drilled	Max. Depth Drilled	Max. Highwall Depth	Groundwater Encountered Yes	Groundwater Encountered No	Shallowest Water Encountered	Average Water First Encountered
73T ph2	7-79 8-79	43'	36'		X	NA	NA
75T ph2	8-8	64'	58'	X		14'	26' [1]
98T ph2-4	11-81 12-81	55'	28'		X	NA	NA
102T ph1-3	12-80	72'	64'	X		13'	31' [2]
104T ph 1, 5-7	4-79 11-80 7-82	50'	39'		X	NA	NA
108T ph1-17	4-81	14'	13.5'		X	NA	NA

[1]Average of 10 cross-sections on 100 foot centers. Does not include 10 additional cross-sections of the pit where water was not found.

[2]Average of 25 cross sections drilled on 100 foot centers. Does not include 8 additional cross-sections of the pit where water was not found.

Table D-6.1.A

No adverse groundwater impacts are anticipated from mining operations in the proposed amendment area. No groundwater was encountered during developmental drilling of pits 73T ph2, 98T ph2-4, 104T ph 1,5-7, and 108T ph 1-17. The regional geologic framework discussed in Appendix D-5, Geology provides further evidence that generally, the bentonite beds as well as the overlying and underlying shale and clay beds, to the deepest extent mined, are above regional groundwater tables.

However, subsurface water was encountered during developmental drilling of two of the proposed pits, 75T ph2 and 102T ph 1-3.

Existing pit 55T lies immediately adjacent to proposed pit 102T ph 1-3. Some minor amounts of water accumulated in this pit during its initial stripping in October, 1976. Those initial accumulations were removed from the pit and no new accumulations have occurred. It is believed that the subsurface water in this formation is a small perched water table forming when water saturates the top layers of the bentonite bed causing it to swell and form a semi-impervious layer. Mining removes this semi-impervious layer preventing further accumulations. Once pit 102T has been opened, the bentonite will be pulled away from the highwall for several feet to allow any initial discharge from the adjacent unmined portion of the bentonite bed along the highwall to be collected and used for haul road watering.

Subsurface water was also encountered during developmental drilling for proposed Pit 75T ph 2. It is probable that subsurface water is accumulated in the same manner as described for pit 102T ph 1-3. The revised mine plan for proposed Pit 75T ph 2 calls for providing the active pit with through drainage into the immediately adjacent Rock Springs Draw (see the Mine Plan discussion, page 264). Therefore, any subsurface water draining into the pit will not accumulate but will flow westward out of the pit. Following stripping of the proposed pit, the bentonite will be pulled away from the highwall to allow drainage to occur without affecting the mining operations.

If unexpected excessive accumulations of water do occur in any pit, additional mitigation plans will be developed.

During field investigations in August, 1982, one minor seep with an estimated flow rate of 1 GPD, was observed on the Mowry escarpment below proposed pit 98T, phases 2 through 4 (See Mine Plan Map 1 of 4 for location). The seep is located stratigraphically below the bentonite bed to be mined in that pit and, as such, is below the deepest depth of mining. Developmental drilling did not encounter any groundwater in the area of the seep. The excavated portion of pit 98T, phase 1, has not affected the seep and the pit has had no groundwater flow. We conclude that the seep is hydrologically distinct from the strata affected by mining and will remain unaffected in the future.

Surface Water

There are no perennial or intermittent streams within the proposed amendment area. As a result no mean annual flow or flood estimates are provided for major streams.

All drainages within the proposed amendment area are classified as ephemeral. Personal communication with the Bureau of Land Management and the U.S. Soil Conservation Service confirms that there are no known crest gauges or other flow recording instruments on any of the ephemeral drainages within the proposed amendment area. During field investigations in August and September, 1982, and during incidental observations over the preceeding two year period, no gauges were observed in or adjacent to the proposed amendment area. Due to the absence of surface water quantity measurements all peak flow and volume data are estimates based on methods presented in Craig and Rankl (1977), Lowham (1976), or Soil Conservation Service publications. Other sources are referenced as appropriate for incidental details and/or calculations.

As all drainages are ephemeral no systematic water quality sampling program was used. All proposed mining operations take place within geologic formations exposed in the drainages and all geologic strata outcrop in the immediate area and contribute to the surface drainage water quality of the area. No specific water quality change can be reasonably expected as the proposed affected areas are small in relation to the total drainage area size and are of a similar character as the surrounding surface area. Further, the proposed overburden stockpile revegetation procedures will reduce possible adverse water quality affects to a level similar to surrounding undisturbed areas.

Ephemeral drainage characteristics are presented on a subregion basis following this narrative. Bedrock profiles (dip) and lithologic characteristics are presented in Appendix D-5, geology. Alluvial deposit locations and extent are detailed in Appendix D-7, soils. Certain soil hydrologic characteristics used in estimating flow and volume quantities are based, in part, on soil data presented in Appendix D-7. Vegetation data for channels and floodplains, if present, is detailed in Appendix D-8, vegetation.

Wherever possible the Craig and Rankl (1977) method is used to estimate hydrologic events. Standard engineering principles, satisfactory to meet State Engineer requirements, and methods satisfactory to the Bureau of Land Management, as landowner, will be used for design of diversion structures and sizing of culverts, where proposed. Precipitation frequency values for each subregion are presented in Table D-6.1, page 47, and were calculated after Miller, et.al. (1973).

Erosion control measures are addressed in the Reclamation Plan. Flow control structures, if appropriate, are presented in the Mine Plan. In all cases hydrologic considerations during reclamation will stress retention of moisture in the soil profile to maximize vegetation establishment and, as an additional benefit, to reduce water erosion rates to levels similar to undisturbed adjacent areas.

<u>Methods</u>

The Craig and Rankl (1977) method is used to determine flood volumes and flood peaks for specific recurrence intervals. The method is based on rainfall and runoff data collected for nine years on a seasonal basis. The data was used to calibrate a rainfall-runoff model of 22 small basins. Flood volumes and peaks were then related to basin characteristics such as drainage area, maximum relief, and basin slope. Flood peaks were related to drainage area, maximum relief, basin slope and channel slope. The size of the drainage areas studied ranged from 0.69 to 10.8 square miles and the area of investigation was limited to the plains and large-valley areas of Wyoming.

Use of the Craig and Rankl method is limited to drainages greater than 0.5 square miles. The ten year recurrence interval was selected based on Land Quality Division Rules and Regulations, Chapter IV, section 2.e.(2)(f) and Guideline 8 recommendations. The mathematical model with coefficients for the 10 year event are:

$$\text{Flow Volume (10 Year)} = 552\ A^{1.168}\ S_B^{0.750}\ R_M^{-1.380}$$

$$\text{Peak Flow (10 Year)} = 32.99\ A^{1.094}\ S_B^{1.080}\ R_M^{-1.308}\ S_{10/85}^{0.603}$$

Where
A = drainage area in square miles
S_B = basin slope in feet per mile
R_M = maximum relief in basin in feet
$S_{10/85}$ = main channel slope in feet per mile.

For drainage areas that are less than 0.5 square mile, the Soil Conservation Service has developed methods of estimating volume and flow. The National Engineering Handbook, Section 4, Hydrology and Design of Small Dams, USBR (1977) contains descriptions of the method which will be used here. The general procedure for a 10 year 6 hour precipitation event is outlined below:

1. The design precipitation event is determined from Miller, et.al. (1973). See Table D-6.1, for the 10 year-6 hour precipitation event which is the design event for all diversions proposed for use during mining.

2. The incremental precipitation is determined and the order of magnitude is assigned to the incremental precipitation values in the following order 0, 3, 2, 1, 4.

3. Soil and cover data are translated into an appropriate cover complex numbers (CN) which the direct runoff volume is determined using the following formula:

$$Q = \frac{(P - 0.2\ (S))^2}{P + 0.8\ (S)}$$

where Q = actual runoff, P = potential maximum runoff (accumulated precipitation) and S = retention based on the relationship

$$S = \frac{1000}{CN} - 10$$

4. Time of concentration (Tc) is determined from the following relationship:

$$Tc = \left(\frac{11.9\ (L)^3}{H}\right)^{0.385}$$

where L is the length of the longest watercourse in miles and H is the elevation difference in feet.

5. Based on the concept of representing hydrographs as triangles, a triangular hydrograph for 1 inch of runoff (unitgraph) is computed using the following relationship:

   (1) $Tp = D/2 + 0.6\ Tc$

   (2) $Tb = 2.67\ Tp$

   (3) $qp = \frac{484\ A\ Q}{Tp}$

   where:

   Tp = time to peak in hours,
   D = rainfall excess period in hours, .25 for thunderstorms,
   Tc = time of concentration in hours,
   Tb = time length of base of hydrograph in hours,
   qp = peak discharge in second-feet,
   Q = volume of runoff in inches and
   A = area of watershed in square miles.

6. The triangular hydrograph for each interval, D, is computed by direct ratio of the runoff for that interval to the unitgraph and plotted as in USBR (1977).

7. The total runoff hydrograph is obtained by graphical addition of the incremental hydrographs.

For all proposed pits local existing channel geometry was analyzed to determine the maximum volume and potential flow rate that each major channel could handle without overflowing its banks. The drainage area for each major channel was then determined using aerial photographs, USGS topographic maps and topographic surveys conducted by Wyo-Ben, Inc. Based upon this information, and assuming 100% runoff, 0% infiltration, the number of inches of precipitation necessary for each drainage area to create the maximum channel flow was calculated for each channel. These figures were then compared with Table D-6.1, page 47, by precipitation zone. In all cases it was determined that a 10 year, 6 hour precipitation event closely duplicated the type of event necessary to create maximum, non-flood flow in the major undisturbed channels in the area of each proposed pit. From Table D-6.1 it can be seen that for all precipitation zones, the values for 5 year-12 hour, 10 year-6 hour, 25 year-2 hour, 50 year-1 hour, and 100 year-30 minute precipitation events are approximately equal. For consistency we have selected the 10 year-6 hour event for the design event for all hydrologic structures.In doing so we have designed all structures to a level equal to the pre-existing natural drainage systems maximum capacity to handle drainage flow.

TABLE D-6.1.

Precipitation Frequency Values

Red Hole Area
Zone number 1
Elevation 4800 feet

108° 2' 30" longitude
43° 41' 39" latitude

	5min	10min	15min	30min	1hr	2hr	3hr	6hr	12hr	24hr
2 yrs	.15	.23	.29	.40	.50	.57	.62	.76	.93	1.09
5 yrs	.21	.32	.41	.57	.72	.80	.87	1.04	1.28	1.52
10 yrs	.26	.40	.50	.70	.88	.96	1.03	1.21	1.53	1.85
25 yrs	.32	.49	.62	.86	1.09	1.19	1.27	1.47	1.88	2.29
50 yrs	.37	.57	.72	1.00	1.26	1.36	1.45	1.66	2.14	2.62
100 yrs	.41	.64	.81	1.12	1.42	1.53	1.63	1.86	2.41	2.95

Wind Area
Zone number 1
Elevation 4900 feet

108° 19' 25" longitude
43° 40' 15" latitude

	5min	10min	15min	30min	1hr	2hr	3hr	6hr	12hr	24hr
2 yrs	.13	.21	.26	.36	.46	.54	.60	.76	.97	1.18
5 yrs	.20	.32	.40	.55	.70	.79	.86	1.05	1.34	1.63
10 yrs	.26	.40	.50	.70	.88	.98	1.06	1.27	1.62	1.97
25 yrs	.33	.51	.64	.89	1.13	1.24	1.33	1.56	1.99	2.42
50 yrs	.38	.59	.75	1.03	1.31	1.43	1.52	1.77	2.27	2.76
100 yrs	.43	.67	.85	1.18	1.49	1.62	1.72	1.99	2.55	3.10

Coal Area
Zone number 1
Elevation 5000 feet

108° 23' 32" longitude
43° 45' 00" latitude

	5min	10min	15min	30min	1hr	2hr	3hr	6hr	12hr	24hr
2 yrs	.14	.22	.28	.39	.49	.56	.62	.77	.96	1.15
5 yrs	.21	.32	.40	.56	.71	.80	.87	1.05	1.33	1.60
10 yrs	.26	.40	.51	.70	.89	.98	1.06	1.25	1.60	1.94
25 yrs	.32	.50	.63	.88	1.11	1.22	1.31	1.53	1.96	2.39
50 yrs	.37	.58	.74	1.02	1.29	1.40	1.50	1.74	2.24	2.73
100 yrs	.42	.66	.83	1.15	1.46	1.58	1.69	1.95	2.51	3.07

Red Hole Subregion

Surface water drainages within the proposed amendment area in the Red Hole subregion are shown on Figure D-6.1, page 49.They consist of the Rock Springs draw drainage and the Red Springs draw drainage. Locations of operations, specific to each pit, that will directly affect portions of drainages are shown on Mine Plan Maps 1 and 2.

The Red Hole, Wyo., (1960) U.S.G.S. topographic contour map, Map No. 1 of 4, locates Red Springs near the center of Section 17, T43N, R93W. During field investigations in August, 1982, and incidental observations over a two year period preceeding field investigations, the Red Springs could not be identified at or adjacent to the indicated location. No moist condition was observed in the ephemeral channel at or adjacent to the indicated location nor was flowing water observed in the drainage to indicate a perennial classification.

The mapped location of the spring appears to be both topographically and stratigraphically below the proposed pit area. Additionally, the proposed pit area is on the opposite side of a hydrologic divide from the mapped spring location and it is highly probable that the two areas are hydrogically distinct. Mining in the proposed pit area should have no impact on Red Springs if, in fact, the spring still exists.

Red Springs Draw Drainage

Figure D-6.1 illustrates the surface drainage area of Red Springs Draw Drainage which contains the affected area for Pit 98T, phases 2-4 and a small portion of both Pit 104T, phase 7, and Pit 73, phase 2. Red Springs Draw Drainage is classified as an ephemeral drainage and is a tributary of Kirby Creek which is a tributary of the Big Horn River.

Peak flow rate and volume for Red Springs Draw Drainage can be estimated using the drainage basin characteristics method from Craig and Rankl (1977). Specific parameters and results follow.

Red Springs Draw drainage.

1. A = 5.45 square miles.
2. R_m = 1,480 feet.
3. S_b = 1,345.88 feet/mile.
4. $S_{10/85}$ = 142.45 feet/mile.

Using the coefficients for a ten year flood peak yields:

Q_{10} = 716.61 cu. ft./sec.

Using the coefficients for a ten year flood volume yields:

V_{10} = 37.48 acre feet.

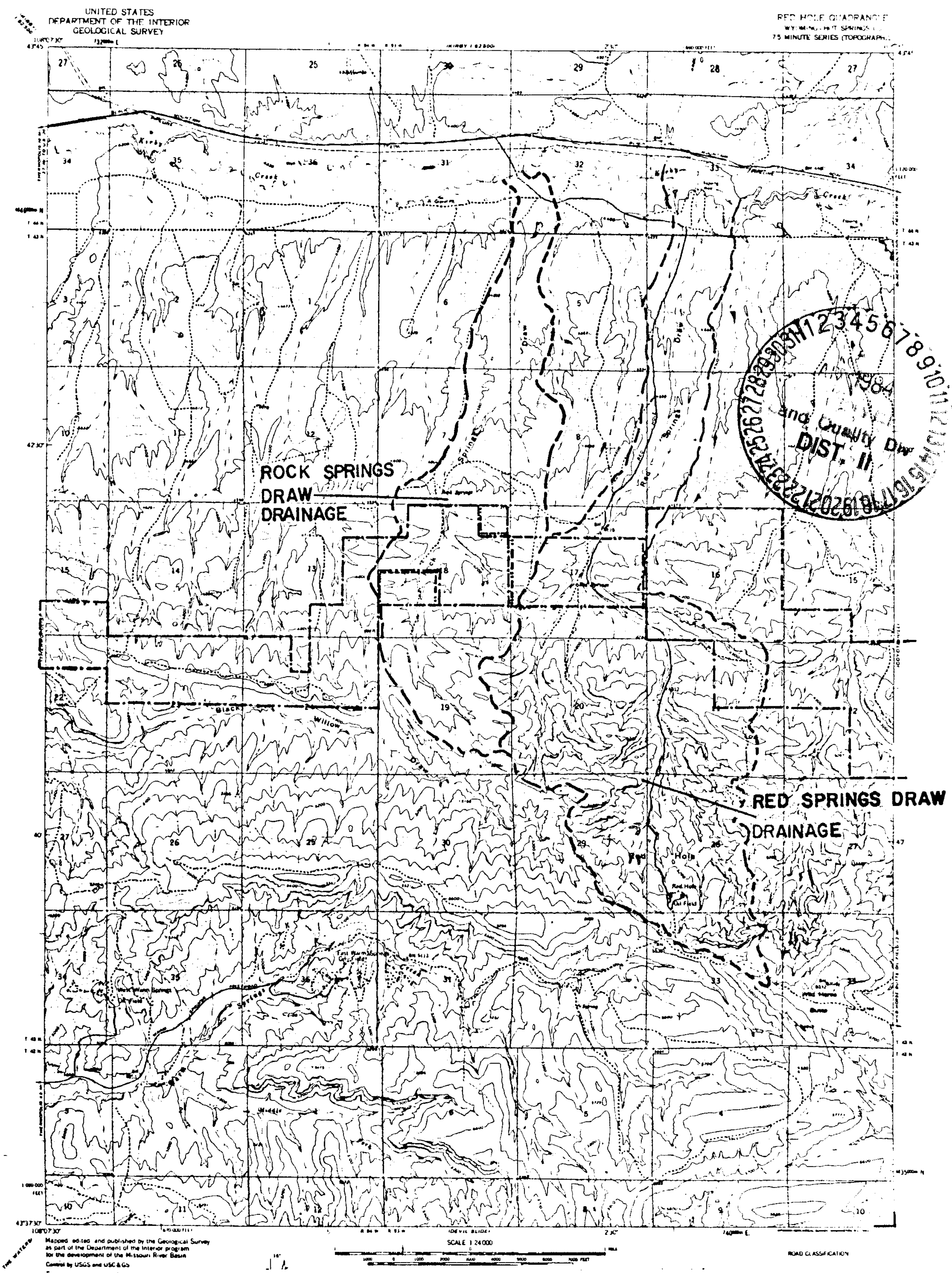

FIGURE D-6.1

<u>LEGEND</u>

—·—·— 321-C PERMIT BOUNDARY

—··—··— PROPOSED AMENDMENT BOUNDARY

— — — — DRAINAGE BASIN BOUNDARY

Table D-6.2

Summary of Drainage Characteristics.
Red Hole Subregion[a]

I. Red Springs Draw Drainage[b]

Total drainage area: 3,485.77 acres
Pit 98T phases 2 through 4: 12.38 acres
Pit 104T phase 7 (part): 4.71 acres
Pit 73T phase 2 (part): 5.24 acres
Total proposed and affected area: 22.33 acres

II. Rock Springs Draw Drainage[b]

Total drainage area: 1,971.20 acres
Pit 104T phases 1, 5, 6 and 7 (part): 15.19 acres
Pit 104T phase 2: 17.63 acres
Pit 104T phase 3: 17.74 acres
Pit 73T phase 1: 13.46 acres (9.39 reclaimed with permanent vegetative cover).
Pit 73T phase 2: 8.81 acres
Pit 75T phase 2: 13.08 acres
Pit 75T phase 1: 16.49 acres
Total proposed and affected area: 102.40 acres

III. Percent of Total Drainage Affected or Proposed to be Affected:

1. Red Springs Draw Drainage: 0.64%
3. Rock Springs Draw Drainage: 5.19%

[a] See Figure D-6.1 for location of each drainage basin considered in this subregion.

[b] All acreage figures are for the drainage area within each listed drainage that is affected by each pit. This includes the disturbed area for each pit or pit phase plus all of the drainage area lying upstream from the affected area whose flow must pass through the affected area. Where the affected drainage includes other disturbance areas, the affected drainage for these other areas is excluded and dealt with separately.

The locations of Pit 98T, phases 2 through 4, and the eastern parts of Pit 104T, phase 7, and Pit 73T Phase 2, which together affects 22.33 acres of the Red Springs Draw drainage, are stratigraphically above the Mowry escarpment and contribute runoff primarily to the portion of the drainage north of the escarpment. Of this area only a small portion of Pit 98T, phase 2, contributes runoff to the drainage south of the escarpment. Although the total drainage area of Red Springs Draw Drainage is necessary for consideration of total flow in the Red Springs Draw channel, the portion of the drainage north of the Mowry escarpment will recieve almost all of the flow from the proposed disturbance area with only a small fraction of the total flow going over the divide to the south.

It must be noted that the location of the proposed pits are at the upper portion of a ridge, at the Mowry escarpment, while the estimated flow and volume are for the confluance of the drainage with Kirby Creek which is at the extreme north end of the drainage area. Thus the affected area will never be subject to the flow and volume concentrations from the entire drainage. Further the method used to derive the coefficients for estimating flow and volume considers transmission loss, antecedent moisture, and soil cover variation to be in the average chance variation or residuals of the multiple regression process and are not measured basin characteristics. In actual field conditions transmission losses reduce the flow contributed to the gauging location by the upper reaches of the drainage area.

Pit 98T, phases 2 through 4, affecting Red Springs Drainage.

Active Mine: All hydrologic considerations for the active mine are the same as for the final reclaimed pit as presented below.

Final Reclamation: The final reclamation contours, as depicted on Reclamation Map 1, result in a drainage configuration which divides Pit 98T, phases 2-4, into two distinct areas; one, which includes only the easternmost 0.88 acres of phase 2 and one which includes the remainder of the pit (11.50 acres).

Drainage from the eastern part of phase 2 will be entirely in the form of surface sheet flow. Applying the triangular hydrograph method to this drainage area yields the following results for a 10 year-6/hour precipitation event:

Basin Characteristics
Drainage area (sq. mi.) = 0.001
Stream length (mi.) = None, all sheet flow
Stream elevation diff. (ft.) = 15
Curve number = 94
Minimum infiltration rate (in/15 min) = 0.02

Precipitation
Adjusted point precipitation (in.) = 0.74

Unit Hydrograph Parameters
Time of concentration (hrs) = 0.10
Lagtime (hrs) = 0.06

Hydrograph
Discharge peak (cfs) = 0.92 off of entire area as sheet flow
Discharge volumes (ac. ft.) = 0.01

Drainage from the remainder of Pit 98T, phases 2-4, will become channelized near the confluence of the phase 4 and phases 2-3 sides of the drainage area at the primary outflow point from the pit. An existing bedrock based ephemeral stream channel will receive all flow from this portion of the pit. See Reclamation Plan Map 1 for location of drainage channels. Applying the triangular hydrograph method to each side of this drainage area yields the following results for a 10 year-6 hour precipitation event:

East Side Drainage Area

Basin Characteristics
Drainage area (sq. mi.) = 0.01
Stream length (mi.) = 0.21
Stream elevation diff. (ft.) = 110
Curve number = 94
Minimum infiltration rate (in/15 min) = 0.02

Precipitation
Adjusted point precipitation (in.) = 0.74

Unit Hydrograph Parameters
Time of concentration (hrs) = 0.09
Lagtime (hrs) = 0.06

Hydrograph
Discharge peak (cfs) = 4.70
Discharge volumes (ac. ft.) = 0.09

West Side Drainage Area

Basin Characteristics
Drainage area (sq. mi.) = 0.006
Stream length (mi.) = 0.15
Stream elevation diff. (ft.) = 40
Curve number = 94
Minimum infiltration rate (in/15 min) = 0.02

Precipitation
Adjusted point precipitation (in.) = 0.74

Unit Hydrograph Parameters
Time of concentration (hrs) = 0.10
Lagtime (hrs) = 0.06

Hydrograph
Discharge peak (cfs) = 1.30
Discharge volumes (ac. ft.) = 0.05

Summary figures for both sides of the major drainage area of Pit 98T, phases 2-4, at the common outlet for the area for a 10 year-6hour precipitation event are as follows:

<u>Basin Characteristics</u>
Drainage area (sq. mi.) = 0.016
Stream length (mi.) = 0.36 (combined total)
Stream elevation diff. (ft.) = 110 (maximum)
Curve number = 94
Minimum infiltration rate (in/15 min) = 0.02

<u>Precipitation</u>
Adjusted point precipitation (in.) = 0.74

<u>Unit Hydrograph Parameters</u>
Time of concentration (hrs) = 0.09
Lagtime (hrs) = 0.06

<u>Hydrograph</u>
Discharge peak (cfs) = 6.00
Discharge volumes (ac. ft.) = 0.14

Pit 104T, Phase 7, affecting Red Springs Drainage

Active Mine: See Mine Plan Map 2 for location of pit berms. Applying the triangular hydrograph method to the drainage area above active phase 7 yields the following results for a 10 year-6 hour precipitation event:

<u>Basin Characteristics</u>
Drainage area above active area (sq. mi.) = 0.006
Stream length (mi.) = None all sheet flow
Stream elevation diff. (ft.) = 86 (maximum)
Curve number = 83
Minimum infiltration rate (in/15 min) = 0.02

<u>Precipitation</u>
Adjusted point precipitation (in.) = 0.74

<u>Unit Hydrograph Parameters</u>
Time of concentration (hrs) = 0.07
Lagtime (hrs) = 0.05

<u>Hydrograph</u>
Discharge peak (cfs) = 2.44
Discharge volumes (ac. ft.) = 0.05

Final Reclamation: See Reclamation Map 2 for final drainage channel locations. Applying the triangular hydrograph method to the drainage of reclaimedphase 7 yields the following results for a 10 year-6hour precipitation event.

<u>Basin Characteristics</u>
Drainage area above active area (sq. mi.) = 0.01
Stream length (mi.) = 0.19
Stream elevation diff. (ft.) = 87

Curve number = 82
Minimum infiltration rate (in/15 min) = 0.02

Precipitation
Adjusted point precipitation (in.) = 0.74

Unit Hydrograph Parameters
Time of concentration (hrs) = 0.08
Lagtime (hrs) = 0.07

Hydrograph
Discharge peak (cfs) = 2.82
Discharge volumes (ac. ft.) = 0.10

Pit 73, Phase 2, affecting Red Springs Drainage

Active Mine: All hydrologic considerations for the active mine are the same as for the final reclaimed pit area as presented below.

Final Reclamation: All flow from this pit will be as sheet flow. Applying the triangular hydrograph method to the drainage area of reclaimed Pit 73T, phase 2, yields the following results for a 10 year-6 hour precipitation event:

Basin Characteristics
Drainage area above active area (sq. mi.) = 0.008
Stream length (mi.) = 0.13
Stream elevation diff. (ft.) = 63
Curve number = 82
Minimum infiltration rate (in/15 min) = 0.02

Precipitation
Adjusted point precipitation (in.) = 0.74

Unit Hydrograph Parameters
Time of concentration (hrs) = 0.08
Lagtime (hrs) = 0.07

Hydrograph
Discharge peak (cfs) = 1.70
Discharge volumes (ac. ft.) = 0.06

Rock Springs Draw Drainage

Figure D-6.1 illustrates the surface drainage area of Rock Springs Draw Drainage which contains the affected areas of most of Pit 73T, phase 2, all of 75T, phase 2, and all of Pit 104T, phases 1, 5 through 7, except for a small portion of phase 7. Rock Springs Draw is classified as an ephemeral drainage and is a tributary of Kirby Creek.

Peak flow rate and volume for Rock Springs Draw Drainage can be estimated using the drainage basin characteristics method from Craig and Rankl (1977). Specific parameters and results follow:

Rock Springs Draw Drainage

1. A = 3.08 square miles

2. R_m = 932 feet

3. S_b = 178.29 feet/mile

4. $S_{10/85}$ = 142.45 feet/mile

Using the coefficients for a ten year flood peak yields:

Q_{10} = 145.20 cu.ft./sec.

Using the coefficients for a ten year flood volume yields:

V_{10} = 58.15 acre feet.

The locations of that portion of pits 73T and 104T, which are within this drainage area, are located stratigraphically above the Mowry escarpment and, therefore, contribute run off only to that portion of the drainage north of the escarpment. Pit 75T, phase 2, lies south of the escarpment and stratigraphically below it. It contributes run off only to that portion of the drainage to the north of the pit. It should be noted that the locations of the proposed pits are toward the upper end of the drainage basin and off of the main channel. Thus, the affected areas will never be subject to the flow and volume concentrations from the entire drainage. Further the method used to derive the coefficients for estimating flow and volume considers transmission loss, antecedent moisture, and soil cover variation to be in the average chance variation or residuals of the multiple regression process and are not measured basin characteristics. In actual field conditions transmission losses reduce the flow contributed to the gauging location by the upper reaches of the drainage area.

Pit 104T, Phases 1, 5 through 7, affecting Rock Spring Drainage

Active Mine: The following results are based on the hypothetical "worst case" situation which assumes that all phases of this pit would be open at the same time, and as a consequence, all flow from the area above the pit would have to be channeled around the full length of the pit. In actuality, only one phase will be open at any one time and will need to be protected with a berm to prevent water from entering the pit area. See Mine Plan Map 2 for location of pit berms. Applying the triangular hydrograph to the drainage area above the active area of Pit 104T, phases 1, 5 through 7, yields the following results for a 10 year-6 hour precipitation event.

<u>Basin Characteristics</u>
Drainage area (sq. mi.) = 0.04
Stream length (mi.) = 0.53
Stream elevation diff. (ft.) = 125
Curve number = 86
Minimum infiltration rate (in/15 min) = 0.02

<u>Precipitation</u>
Adjusted point precipitation (in.) = 0.74

Unit Hydrograph Parameters
Time of concentration (hrs) = 0.12
Lagtime (hrs) = 0.08

Hydrograph
Discharge peak (cfs) = 6.43
Discharge volumes (ac. ft.) = 0.28

Final Reclamation: Drainage will be provided through existing natural drainage channels at the northwest corner of each of phases 1, 5 and 6. See Reclamation Plan Map 2 for the location of the drainage channels. Applying the triangular hydrograph method to the drainage areas for each of these drainage channels (essentially phases 1, 5, and 6 plus a part of 7) yields the following results for a 10 year-6 hour precipitation event.

Phases:	1	5	6&7 (part)
Basin Characteristics			
Drainage area (sq. mi.) =	0.019	0.023	0.025
Stream length (mi.) =	0.22	0.23	0.24
Stream elevation diff. (ft.) =	115	125	100
Curve number =	89	87	86
Minimum infiltration rate (in/15 min) =	0.02	0.02	0.02
Precipitation			
Adjusted point precipitation (in.) =	0.74	0.74	0.74
Unit Hydrograph Parameters			
Time of concentration (hrs) =	0.08	0.10	0.12
Lagtime (hrs) =	0.06	0.07	0.08
Hydrograph			
Discharge peak (cfs) =	4.20	3.13	5.40
Discharge volumes (ac. ft.) =	0.15	0.17	0.19

Pit 75T, Phase 2 affecting Rock Springs Drainage

Active Mine: All hydrologic considerations for the active mine are the same as for the final reclaimed pit area as presented below.

Final Reclamation: See Reclamation Plan Map 2 for location of drainage channels. Applying the triangular hydrograph method to Pit 75T, Phase 2 yields the following results:

Basin Characteristics
Drainage area (sq. mi.) = 0.02
Stream length (mi.) = 0.22
Stream elevation diff. (ft.) = 60
Curve number = 85
Minimum infiltration rate (in/15 min) = 0.02

Precipitation
Adjusted point precipitation (in.) = 0.74

Unit Hydrograph Parameters
Time of concentration (hrs) = 0.05
Lagtime (hrs) = 0.03

Hydrograph
Discharge peak (cfs) = 2.14
Discharge volumes (ac. ft.) = 0.16

WIND SUBREGION

Surface water drainage within the proposed amendment area in the Wind subregion is as shown on Figure D-6.2, page 58, Locations of proposed disturbances specific to proposed pit 108T, that will directly affect portions of some of these drainages are shown on Mine Plan Map 3 of 4. Portions of drainages directly affected by the proposed pit are also shown on Figure D-6.2.

The principal drainage affected by Pit 108T is an unnamed ephemeral drainage of Owl Creek. The affected unnamed drainage is immediately north and west of the Rattlesnake Gulch drainage and immediately east of the Mud Creek drainage. Owl Creek is a tributary of the Big Horn River.

The acreage associated with the drainage area containing pit 108T is itemized below:

Total drainage area: 927.46 acres

Total proposed affected drainage: 80.22 acres

Percent of total drainage proposed to be affected: 8.65%

Using the Craig and Rankl method of drainage basin characteristics results in the following parameter values for the total drainage area:

1. A = 1.45 square miles.
2. R_m = 500 feet.
3. S_b = 713.17 feet per mile.
4. $S_{10/85}$ = 162.46 feet per mile.

Using the appropriate coefficients for a 10 year-6 hour runoff volume results in V_{10} = 98.16 acre feet total runoff for the entire drainage. Peak flow estimation results in Q_{10} = 379.49 cubic feet per second at the drainage basin outlet.

PIT 108T, Phases 1 through 17

Active Mine: Maximum surface runoff for any part of the proposed area of disturbance will be achieved at the phase 5 end of the phase 5-14 series. This is essentially the same area as drainage area #2 in Figure RP-10, page 333. The results of applying the triangular hydrograph method to this area are given below in the section on final reclamation. All berms used to protect any of the various pit phases will be designed to withstand this maximum volume and flow rate.

Final Reclamation: Drainage will be provided in six drainages areas as illustrated in Figure RP-10. See also Reclamation Plan Map 3 for drainage

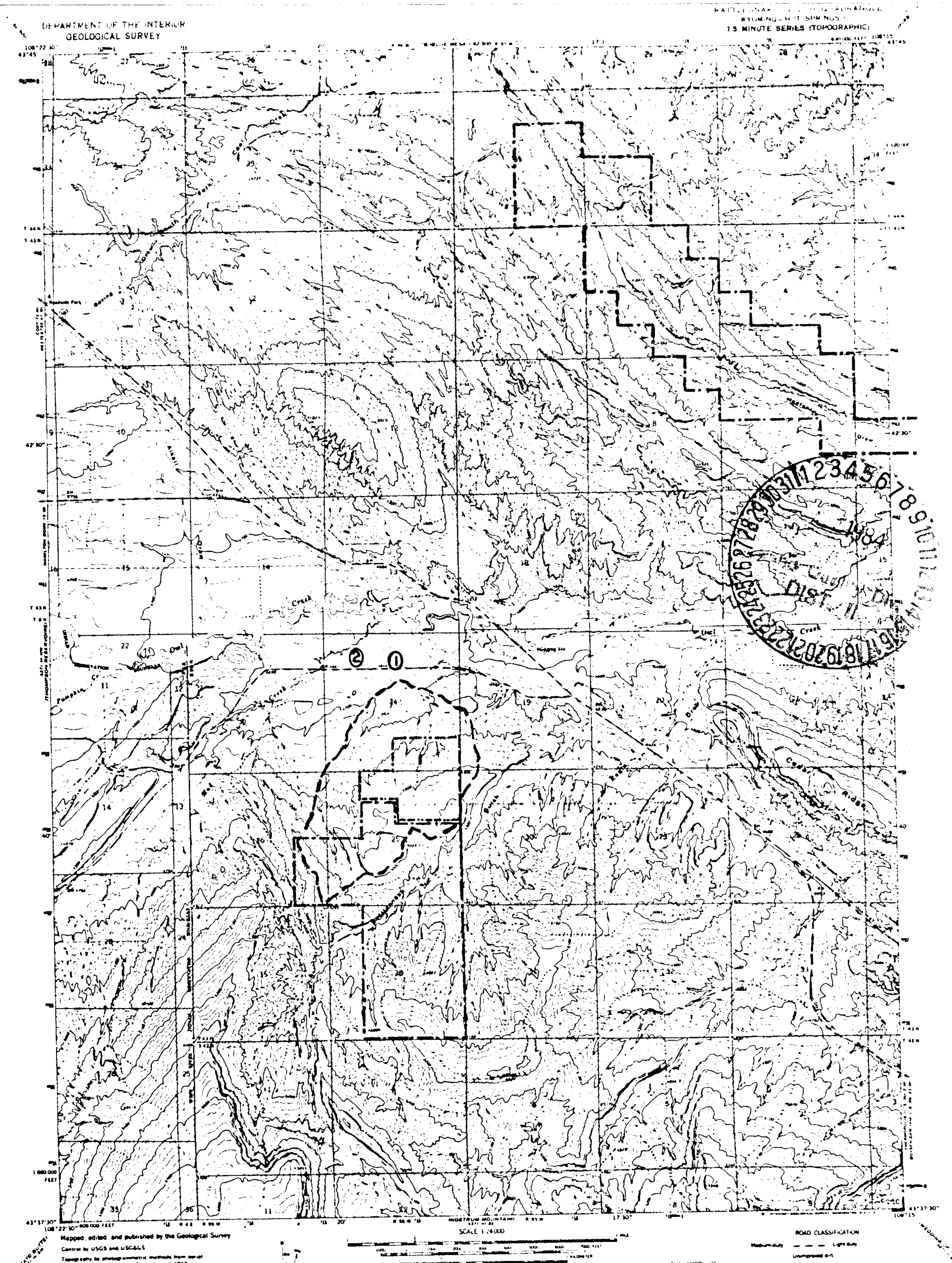

FIGURE D-62

LEGEND

- 321-C PERMIT BOUNDARY
- PROPOSED AMENDMENT BOUNDARY
- DRAINAGE BASIN BOUNDARY
- ① ② FILED WATER WELLS

channel locations. Applying the triangular hydrograph method for a 10 year-6 hour precipitation event to each of these areas yields the following results.

Drainage Area:	1	2	3	4	5	6
Basin Characteristics						
Drainage area (sq. mi.) =	0.04	0.03	0.02	0.007	0.01	0.01
Stream length (mi.) =	0.58	0.33	0.28	0.18	0.31	0.40
Stream elevation diff. (ft.) =	145	105	85	35	110	115
Curve number =	89	89	89	89	89	89
Minimum infiltration rate (in/15 min)=	0.02	0.02	0.02	0.02	0.02	0.02
Precipitation						
Adjusted point precipitation (in.) =	0.74	0.74	0.74	0.74	0.74	0.74
Unit Hydrograph Parameters						
Time of concentration (hrs) =	0.07	0.07	0.07	0.11	0.07	0.08
Lagtime (hrs) =	0.05	0.04	0.04	0.09	0.04	0.05
Hydrograph						
Discharge peak (cfs) =	4.03	3.71	2.43	1.29	1.98	2.13
Discharge volumes (ac. ft.) =	0.34	0.27	0.18	0.06	0.08	0.09

Drainage areas 1 and 2 are the only areas which will have channelized flow. All other areas will have unchannelized sheet flow for all runoff.

COAL SUBREGION

Surface water drainage within the proposed amendment area in the Coal subregion is as shown on Figures D-6.3 and D-6.4, pages 61 and 62. Location of the disturbance, specific to proposed pit 102T, that will directly affect portions of drainages is shown on Mine Plan Map 4 of 4. Portions of drainages directly affected by the proposed pit are also shown on Figures D-6.3 and D-6.4.

The drainage affected by Pit 102T is an unnamed ephemeral drainage and tributary of the South Fork of Coal Draw which is a tributary of the Big Horn River.

The acreage associated with the drainage area containing pit 102T is detailed below:

Total drainage area: 421.57 acres

Total proposed affected drainage: 115.20 acres

Percent of total drainge proposed to be affected: 27.33%

Using the Craig and Rankl method of drainage basin characteristics results in the following parameter values for the total drainage area:

1. A = 0.66 square miles

2. R_m = 270 feet

3. S_b = 197.45 feet per mile

4. $S_{10/85}$ = 153.57 feet per mile

Using the appropriate coefficients for a 10 year-6 hour runoff volume results in V_{10} = 17.94 acre feet total runoff vlume for the entire drainage. Peak flow estimation results in Q_{10} = 265.13 cubic feet per second at the drainage basin outlet.

PIT 102T, Phases 1 through 3

Active Mine: The hydrologic considerations for the active disturbance area are esentially the same as those for final reclamation. The principal difference is that phases 1 and 2 are considered together for final reclamation calculations but must be considered separately for the active mining calculations. As with the final reclamation calculations each active phase must be broken up into two drainage areas: 1) The pit and spoilpile area east of the spoilpile drainage divide and; 2) The area west of the spoilpile divide to the limit of the drainage basin upstream from each spoilpile. Applying the triangular hydrograph method to each of the drainage areas within each pit phase yields the following results for a 10 year-6 hour precipitation event.

Phases:	1		2		3	
Drainage Area:	Pit	West	Pit	West	Pit	West
Basin Characteristics						
Drainage area (sq. mi.) =	0.01	0.03	0.01	0.03	0.03	0.06
Stream length (mi.) =	0.23	0.21	0.22	0.21	0.30	0.40
Stream elevation diff. (ft.)	37	40	25	45	45	78
Curve number =	86	89	86	89	89	89
Minimum infiltration rate (in/15 min) =	0.02	0.02	0.02	0.02	0.02	0.02
Precipitation						
Adjusted point precipitation (in.) =	0.74	0.74	0.74	0.74	0.74	0.74
Unit Hydrograph Parameters						
Time of concentration (hrs) =	0.08	0.07	0.07	0.07	0.07	0.08
Lagtime (hrs) =	0.03	0.04	0.03	0.04	0.04	0.07
Discharge peak (cfs) =	2.18	2.75	1.02	2.71	2.97	8.30
Discharge volumes (ac. ft.) =	0.10	0.24	0.08	0.24	0.25	0.46

Final Reclamation: Drainage from phases 1 and 2 are combined. Drainage from phase 3 reamins separate. Each of the two phase areas is broken up into two drainage areas, pit and west of spoilpile, as discussed above. Drainage from each of the drainage areas within each phase area will be combined at the south end of each phase area (See Figure RP-9, page 332). Applying the triangular hydrograph method to each of the drainage areas within each pit phase area yields the following results for a 10 year-6 hour precipitation event:

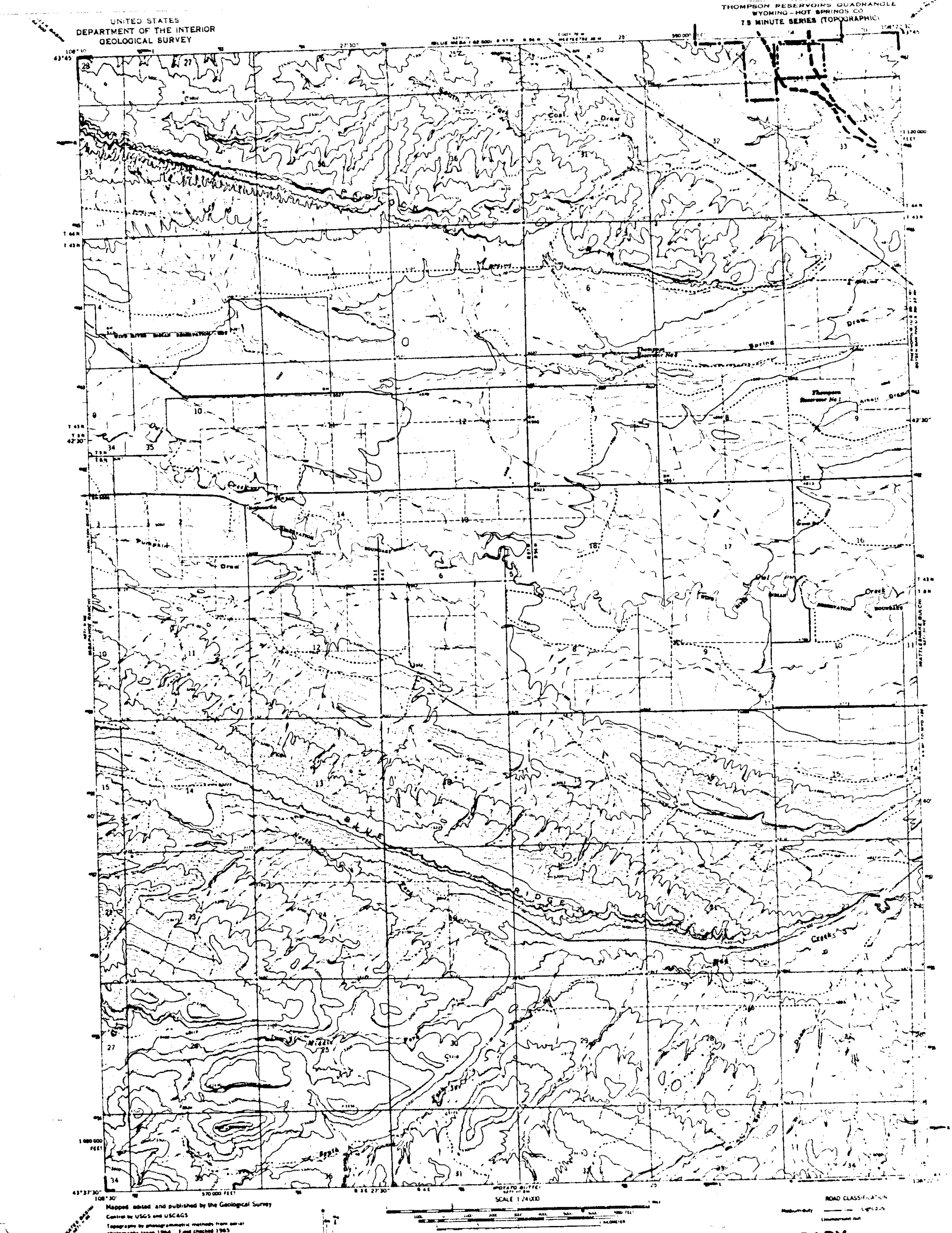

FIGURE D-6.3

LEGEND

—·—· 321-C PERMIT BOUNDARY

—··— PROPOSED AMENDMENT BOUNDARY

------ DRAINAGE BASIN BOUNDARY

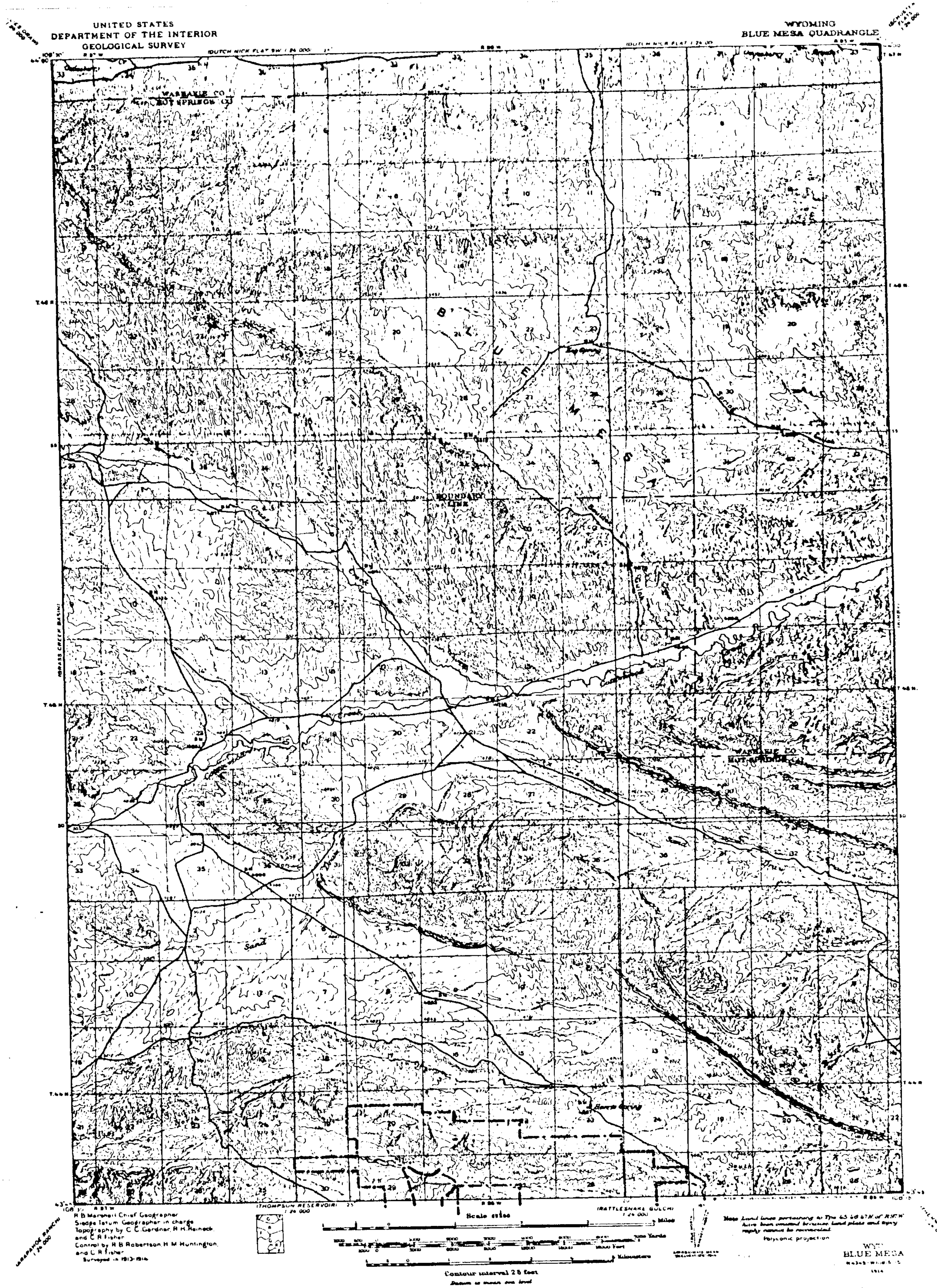

FIGURE D-6.4 **LEGEND**

— · — · 321-C PERMIT BOUNDARY

— — — — DRAINAGE BASIN BOUNDARY

Phases:	1 & 2		3	
Drainage Area:	Pit	West	Pit	West
Basin Characteristics				
Drainage area (sq. mi.) =	0.03	0.06	0.03	0.06
Stream length (mi.) =	0.40	0.42	0.30	0.28
Stream elevation diff. (ft.)	45	85	48	78
Curve number =	89	86	89	89
Minimum infiltration rate (in/15 min) =	0.02	0.02	0.02	0.02
Precipitation				
Adjusted point precipitation (in.) =	0.84	0.74	0.74	0.74
Unit Hydrograph Parameters				
Time of concentration (hrs) =	0.07	0.08	0.08	0.08
Lagtime (hrs) =	0.04	0.07	0.05	0.07
Discharge peak (cfs) =	2.71	5.84	2.77	8.30
Discharge volumes (ac. ft.) =	0.24	0.44	0.21	0.46

Water Wells Filed
with the Wyoming State Engineer (Figure D-6.2)

Within 1/2 Mile of Proposed Amendment Boundary

Location	Quar./Quar.	Permit #	Applicant	Map Unit Number
T43N, R96W Section				
24	NW/NE	P5300W	Donald O. Ray	1
24	NW/NE	P29825W	Diamond Bar Ranch	2

There are no surface water rights within 1/2 mile of the proposed amendment boundary filed with the State Engineer's office.

Literature Cited

Craig, Gordon S., Jr. and James G. Rankl. 1978. Analysis of Runoff from Small Drainage Basins in Wyoming. U.S. Department of Interior. Geological Survey Water Supply Paper 2056. 70 p.

Lowham, H.W. 1976. Techniques for Estimating Flow Characteristics of Wyoming Streams. U.S. Department of Interior. Geological Survey Water-Resources Investigations 76-112. 83 p.

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____________________, USBR. 1977. Design of Small Dams. 816 p.

Wyoming Department of Environmental Quality - Land Quality Division. March 1979. Guideline No. 7 - Bentonite. 7 p.

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Wyoming State Engineer. 1981. Wyoming Water Rights Well Study. 614 p.

Addendum No. 1 to Appendix D-6, Hydrology

This addendum has been prepared as a direct response to comments made by the Land Quality Division during their initial completeness review of this proposed Amendment.

The University of Kentucky's Computer design model of surface mine hydrology and sedimentology (SEDIMOT; Version date 9-23-83) was used to prepare the following Hydrology information for each pit proposed in this Amendment. The Pit Specific parameters used for each computer run are identified within each print out and each pit specific watershed, including branch and structure numbers and locations, are illustrated on Mine Plan Maps 1 of 4 through 4 of 4.

This data is specifically presented to supplement cross-sections MP-4 and MP-9 of the existing channels in justifying the use of 10 year 6 hour events as design criteria for final reclamation channels and to justify berm design.

Addendum No. 2 to Appendix D-6, Hydrology

No perennial or intermittent streams will be affected by the proposed disturbances. Through drainage will be reestablished during final reclamation. Significant ephemeral channels (drainage basins of greater than 5 acres) will be temporarily directed around open pits during active mining stages. Channel design for both temporary and permanent diversions will match premine channel gradients and cross-sectional shapes.

Temporary diversions will comply with Noncoal rules, chapter 3, section 2(e)(ii)(F) to allow passage of peak runoff from a 2 year, 6 hour precipitation event in a nonerosive manner. Permanent diversions (including reconstructed channels and adjacent topography) will comply with Noncoal rules, chapter 3, section 2(e)(iv), to be erosionally stable during the passage of the peak runoff from a 100 year, 6 hour precipitation event. If necessary, sediment control fabric fences will be installed at discharge points into natural channels. These structures will be moved periodically to accommodate active mining areas.

Haul Road Culverts

Three new spur haul roads are proposed with this requested revision of the original Amendment 6 submitted in 1984. Proposed haul road HR-29.1 will access pit 75T. Wyo-Ben is proposing the construction of this road using a low-water crossing. In this case no culvert will be placed in the drainage because it is very wide and deep (> 4-feet). Instead, the road will be constructed through the drainage by laying the sides of the bank back enough to achieve a gentle approach and exit on either side of the drainage. Figure D-6.1 shows the drainage to be crossed by proposed haul road HR-29.1. The other two proposed spur haul roads (HR- 31.1 and 31.2) that will access pit 98T Phases 2-6 will not require culverts as they do not cross any appreciable drainages (see Mine Plan Map 1)

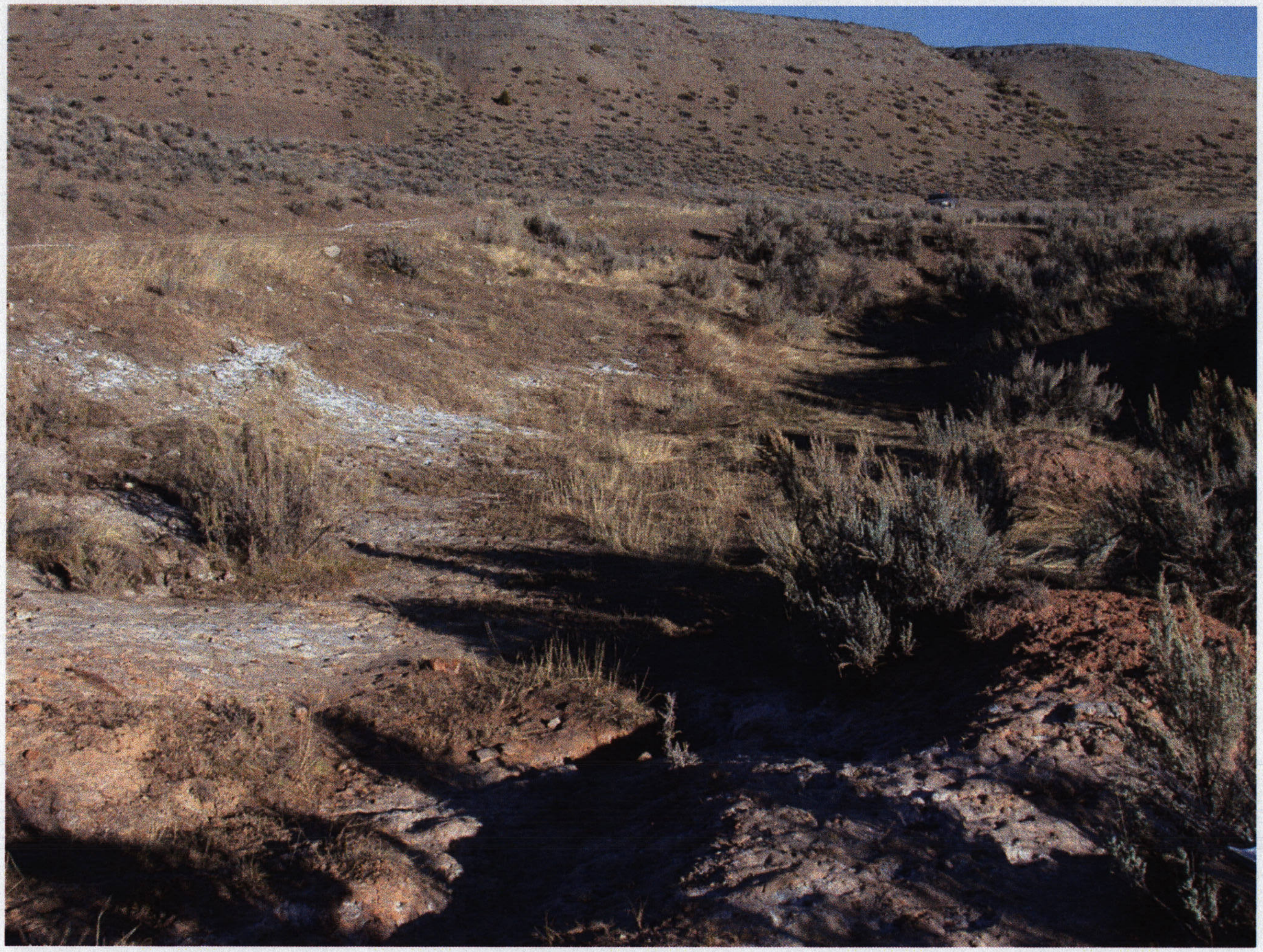

Fig. D-6.1. Location of drainage crossing to access proposed pit 75T