ATTACHMENT B

Five Existing Diversions

- Coal Mine Wash
- J-16
- N-7/8
- N-14
- N14-S

REPORT

Coal Mine Wash Diversion Channel

Kayenta and Black Mesa Mines

Navajo County, Arizona

for

PEABODY COAL COMPANY

Registered Professional Engineer (Civil)
CERTIFICATE NO.
13376
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ARIZONA, U.S.A.

Dames & Moore
10139-011-22

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1.0 INTRODUCTION

The Coal Mine Wash diversion channel is an earth-cut channel, designed and constructed by Peabody Coal Company as a permanent realignment of a natural channel for the purpose of facilitating mining and the construction and operation of leg 25 of the Kayenta Mine overland conveyor. A schematic of the diversion channel is shown on Figure 1-1.

This inspection report contains information specific to the Coal Mine Wash diversion channel. Regional site information is presented in the "General Report, Kayenta and Black Mesa Mines, Navajo County, Arizona, for Peabody Coal Company". The methods used for hydrologic and hydraulic analyses are discussed in "Methodology for Analysis of Existing Diversions for Peabody Coal Company."

2.0 INSPECTION

The Coal Mine Wash diversion channel was inspected on October 7, 1985 by a Dames & Moore engineer. The primary purposes of the inspection were: 1) to determine the stability of the constructed channel relative to the existing natural channels upstream and downstream of the diversion channel, and 2) to collect data necessary for the hydraulic evaluation of the existing channel.

The site inspection revealed short, discontinuous stretches of channel bed that were damp or carried flows of less than 25 gpm. The majority of the inspected channel length had a dry channel bed. Because of this, the channel was classified as ephemeral, carrying short duration flows only immediately following rainfall events. The capacity and stability of the channel are therefore evaluated in this report for the 10-year, 6-hour storm as required by 30 CFR 816.43.

Results of the field inspection are included in this report as Plate A-1. In Plate A-1, regions of visible channel aggradation and degradation are delineated, and transitions between the diversion channel and existing natural channels are specifically addressed. The locations where channel hydraulic parameters (flowrate, slope, cross section, shape and roughness) change significantly are also identified in Plate A-1.

3.0 SITE DESCRIPTION

3.1 LAND USE

The Coal Mine Wash diversion channel provides drainage for runoff from the six major and minor watersheds shown on Figure 3-1, Hydrologic Areas. The major contributing area, labeled C on Figure 3-1, consists of 88 percent Pinion/Juniper, 10 percent Sagebrush/grass, and 2 percent reclaimed areas. The topography for the channel and its tributary watersheds is shown on Drawing #85405 (1 inch equals 2000 feet). Coordinates of channel cross sections are shown on Figures 3-2A and 3-2B.

5.0 REFERENCES

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Appendix A is attached and completes this report.

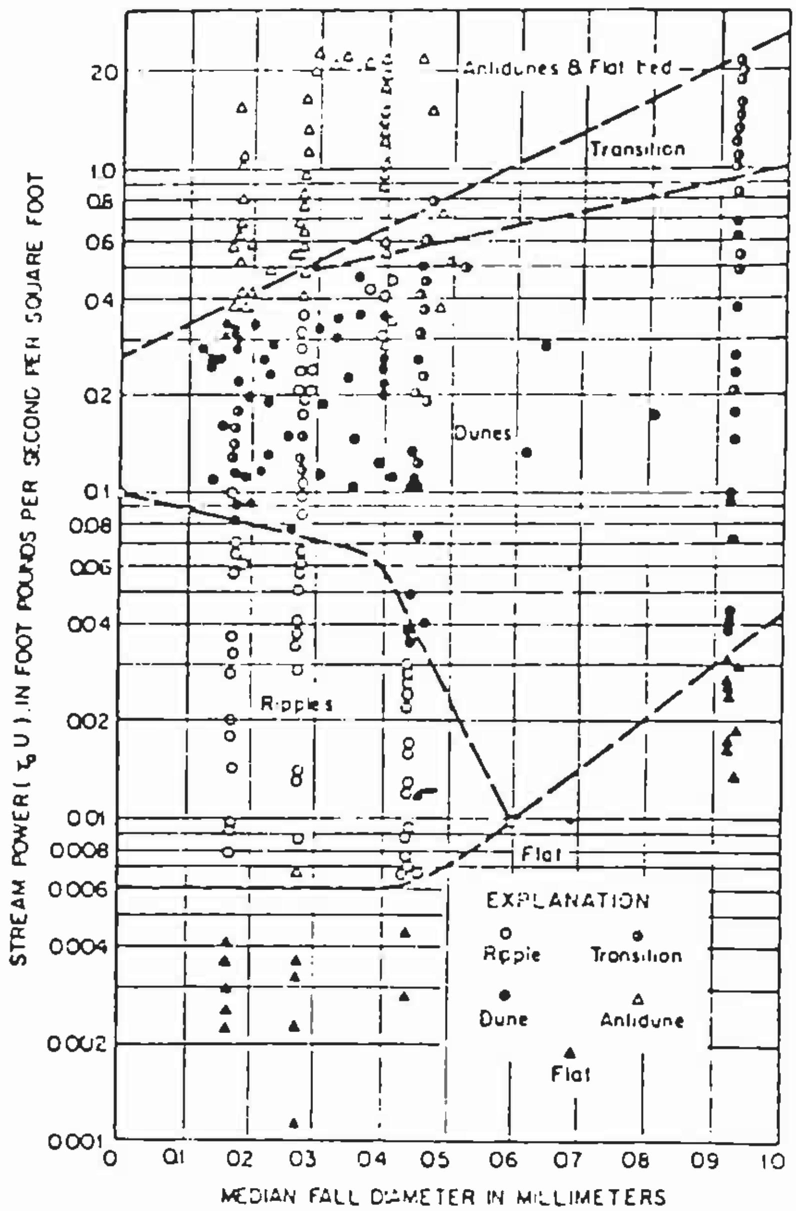
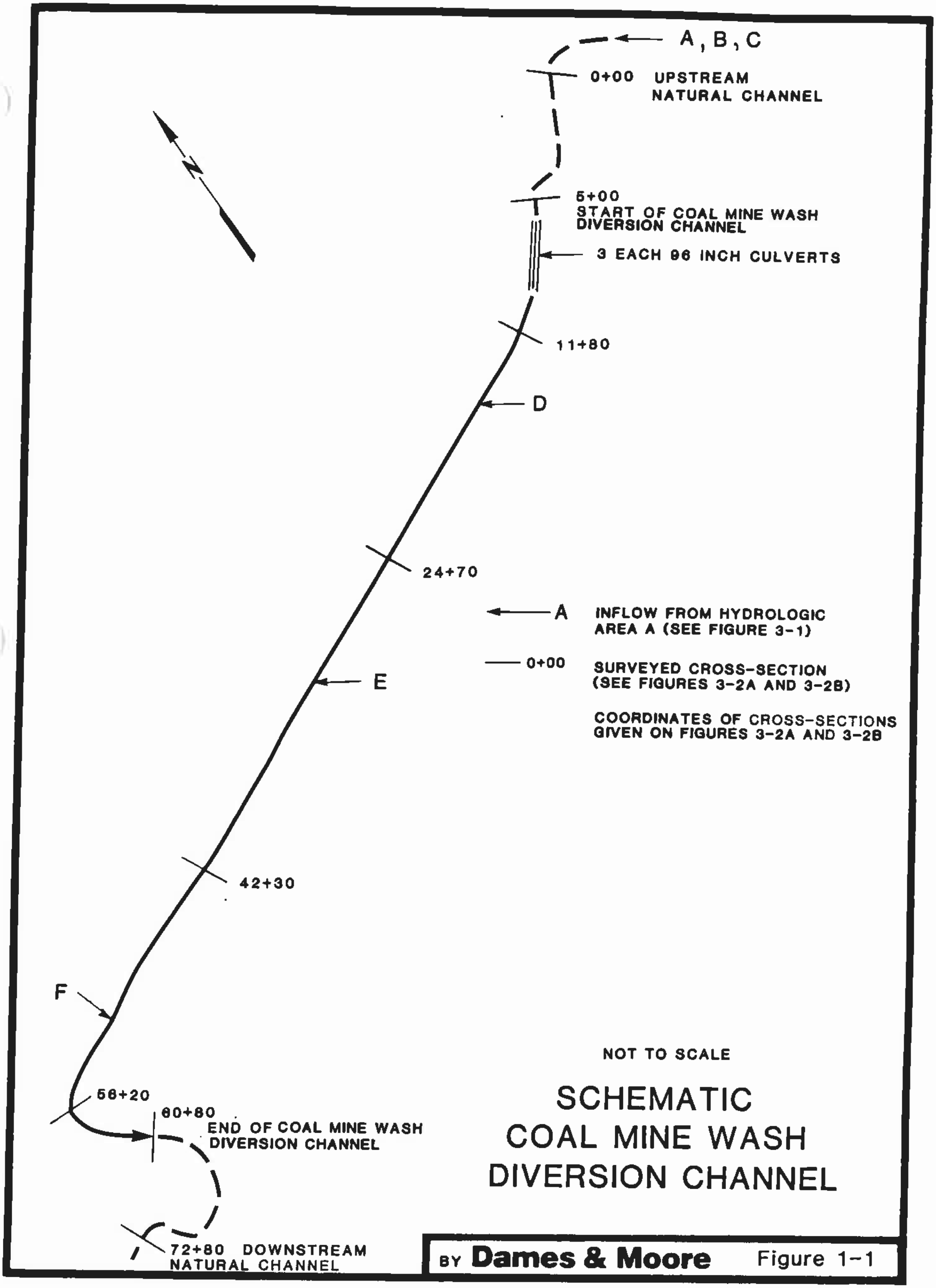


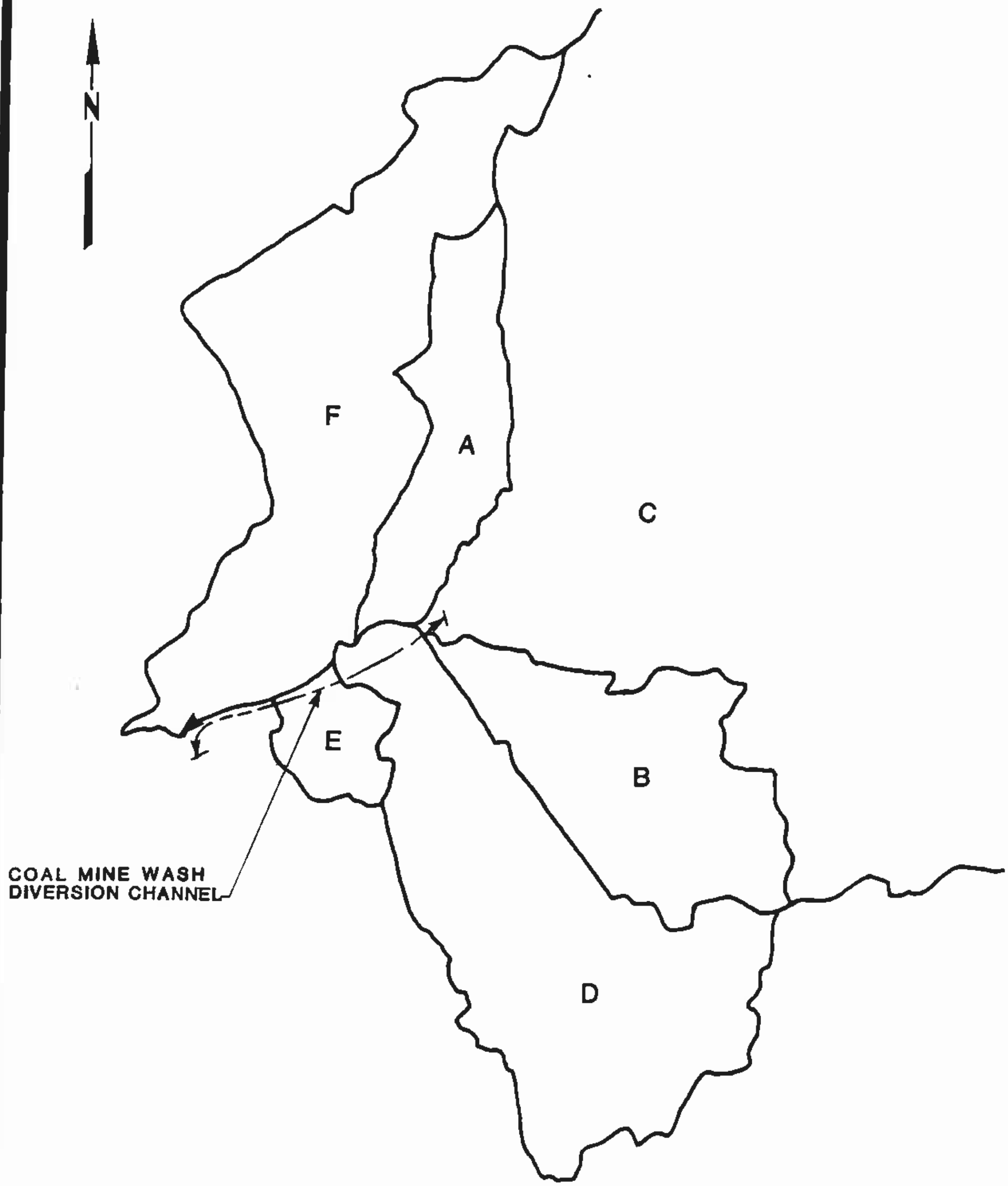
Figure 12.2. Relation of bed forms to stream power and median fall diameter of bed sediment (after Simons and Richardson, 1966).

Reproduced from Surface Mining Water Diversion Design Manual (OSM/TR-82/2)



SCHEMATIC
COAL MINE WASH
DIVERSION CHANNEL

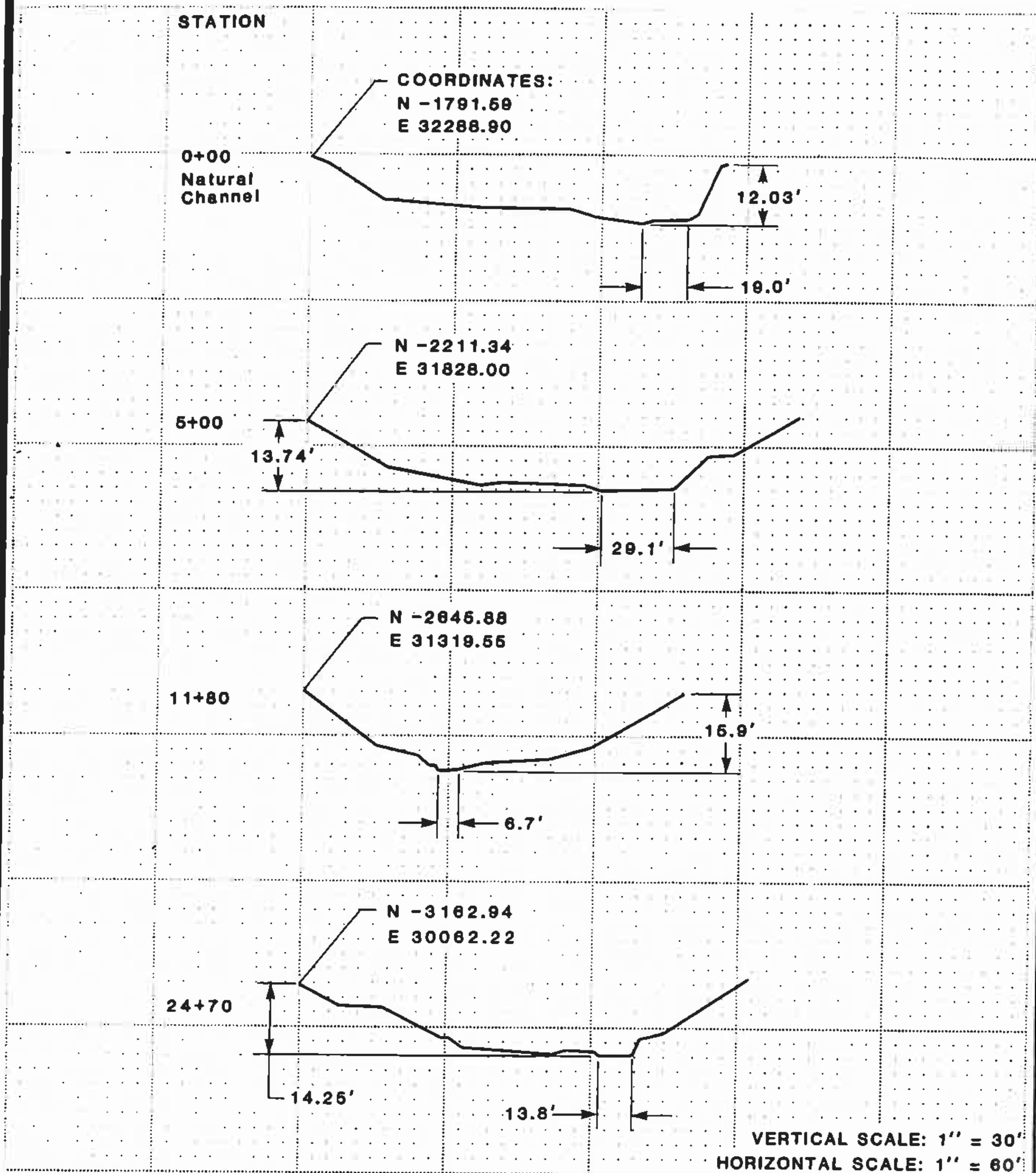
BY **Dames & Moore** Figure 1-1



HYDROLOGIC AREAS
COAL MINE WASH
DIVERSION CHANNEL

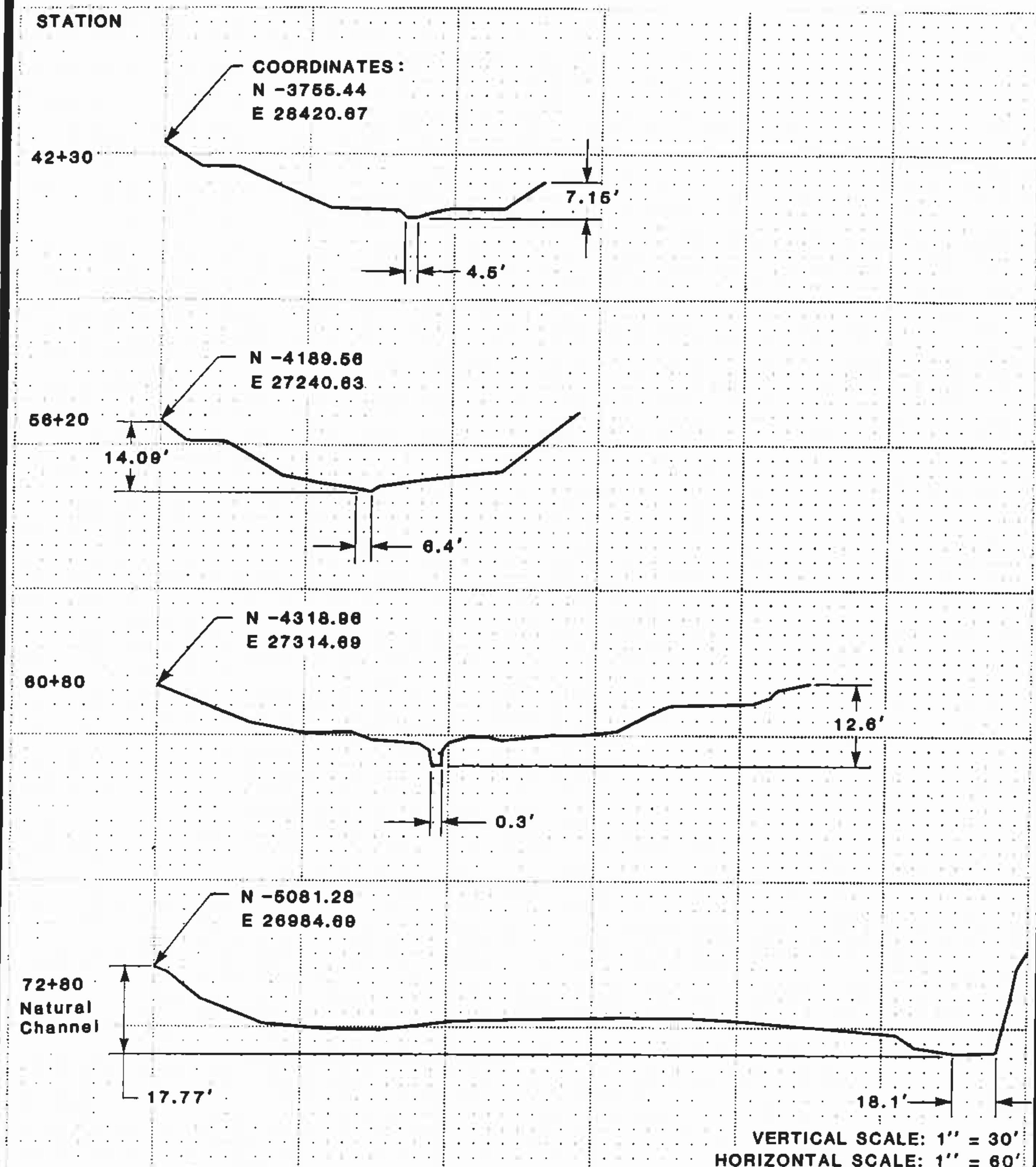
NOT TO SCALE

BY **Dames & Moore** Figure 3-1



CROSS-SECTIONS COAL MINE WASH DIVERSION CHANNEL

BY Dames & Moore — Figure 3-2A



CROSS-SECTIONS
COAL MINE WASH
DIVERSION CHANNEL

BY **Dames & Moore** Figure 3-2B

3.2 EXISTING CHANNEL DESIGN AND CROSS SECTIONS

The existing diversion cross section has 2:1 (horizontal to vertical) side slopes and a channel bed that varies in width between 4 feet (where local incision has occurred) and 29 feet with an average width of about 10 feet. Including overbank regions, the average top width is about 50 feet. The channel bed has a low flow channel of relatively clean sand and the remainder of the bed and side slopes have 5 to 60 percent vegetation (see Plate A-1). Minimum available depth of the channel and overbank region is 7 feet.

4.0 ANALYSES

4.1 HYDROLOGY

The hydrologic analysis was completed using the U.S. Army Corps of Engineers generalized computer program HEC-1, Flood Hydrograph Package. The program was set up to use the SCS dimensionless unit hydrograph method. Curve numbers derived for the tributary watersheds are shown on Figure 3-1, and tabulated in Table 1. Peak flows for each watershed (predicted by HEC-1 for the 10-year, 6-hour storm) are also shown in Table 1. Table 2 shows the results from HEC-1 after the hydrographs from each watershed are added to and routed with the main channel hydrograph utilizing appropriate lag times.

Table 1

SUMMARY OF COAL MINE WASH DIVERSION CHANNEL HYDROLOGIC ANALYSIS

	Subwatershed Identification					
	A	B	C	D	E	F
Drainage Areas (acres)	287	505	21837	860	121	951
<u>10-year, 6-hour storm</u>						
SCS Curve Number	84	81	82	84	72	74
Lag Time (hrs)	0.310	0.353	1.59	0.461	0.126	0.557
Peak Flow (cfs)	161	193	3400	376	21	119
Method of Analysis	--HEC-1, using SCS dimensionless unit hydrograph--					

Table 2

FLOWRATES AT COAL MINE WASH DIVERSION CHANNEL STATIONS

Station	HEC-1 Flowrates (cfs) Storm 10-year, 6-hour
5+00 Upstream End of Diversion Channel Inflow from A, B, C	3434
16+10 Inflow from D	3482
32+00 Inflow from E	3483
51+10 Inflow from F	3514
Downstream End of Diversion Channel 60+80	3514

4.2 HYDRAULICS

The capacity and stability of the Coal Mine Wash diversion channel and the natural channel immediately upstream of the diversion channel were evaluated. Cross sections were chosen and surveyed at the approximate midpoints between locations of major lateral inflows into the channel. With the assumption of uniform flow in the region of these cross sections, and from the Manning equation, critical hydraulic parameters were calculated. Chosen parameters and calculated results are shown in Table 3. Flow rates in Table 3 are those predicted by HEC-1 for the 10-year, 6-hour storm.

5.0 SUMMARY OF RESULTS AND RECOMMENDATIONS

This section highlights the locations in the existing diversion channel where remedial work may be needed in order to approximate the hydraulic conditions in the natural channels adjoining the diversion. First the conditions in these natural channels will be discussed, then the conditions in the diversion channel will be discussed. The cross-sectional shape of each analyzed section of natural or man-made channel is given on Figures 3-2A and 3-2B. The hydraulic performance of each section during the estimated peak flow from the 10-year, 6-hour storm is shown in Table 3. All velocities and tractive stresses discussed below pertain to this storm.

The natural channel upstream of the diversion channel (Station 0+00) has a bed slope of 0.8 percent, a velocity of 14.9 ft/sec, and a tractive power of 13.1 lb/ft-sec (see Table 3). The natural channel

Table 3

SUMMARY OF COAL MINE WASH DIVERSION CHANNEL HYDRAULIC ANALYSIS

	INPUT TO MANNING EQUATION					CALCULATED OUTPUTS					
	Roughness						Velocity (fps)				
Station	Left Over-Bank	Channel	Right Over-Bank	Bed Slope (ft/ft)	Flow* Rate (cfs)	Flow Depth (ft)	Left Over-Bank	Channel	Right Over-Bank	Tractive Stress (lb/ft^2)	Tractive Power (lb/ft-sec)
Natural Channel Upstream of Diversion Channel 0+00	.030	.022	.030	.0081	3434	5.0	4.6	14.9	4.2	1.1	13.1
5+00	.030	.022	.030	.0081	3435	4.8	6.5	15.0	0.0	1.3	14.6
11+80	.030	.022	.030	.0100	3435	5.7	6.3	18.8	8.4	1.7	23.3
24+70	.030	.022	.030	.0083	3483	4.6	3.0	13.2	4.0	1.4	18.3
42+30	.030	.022	.030	.0077	3484	5.3	8.8	16.2	8.7	1.6	17.4
56+20	.030	.022	.030	.0286	3515	4.1	4.7	21.4	6.8	3.5	69.4
60+80	.05	.022	.05	.0083	3516	9.0	5.3	18.5	5.1	1.5	11.1
Natural Channel Downstream of Diversion Channel 72+80	.030	.022	.030	.00760	3515	5.8	4.7	15.6	0.0	1.1	13.4

* Flows may vary slightly from values in Table 2 because of a 1 cfs tolerance in computations.

downstream of the diversion channel (Station 72+80) has a bed slope of 0.76 percent, a velocity of 15.6 ft/sec, and a tractive power of 13.4 lb/ft-sec. From the conditions in these two natural channels, which bound the diversion channel, one can deduce the natural processes that took place in the reach of channel replaced by the man-made diversion. Since velocities and tractive power in the natural channels upstream and downstream from the diversion are roughly equal, the natural reach would be in equilibrium. Sediment transport rates through the reach would be equal and there would be no net erosion or deposition through the reach (OSM, 1982 "Surface Mining Water Diversion Design Manual" OSM/TR-82/2, Section 13).

The transition between natural and man-made channel at the upstream end of the diversion channel is smooth (see Plate A-1). The hydraulic parameters affecting sediment transport (velocity and tractive power) are closely matched across the transition (see Table 3). Velocities and tractive powers through the reach of the channel diversion are maintained within a close range of the incoming natural values except in the region of Stations 11+80 and 56+20 (see Table 3). The diversion channel flow passes through a three-barrel (each 96 inches in diameter) culvert in the reach of Stations 5+75 to 9+40. Downstream of these culverts there is severe erosion (see Station 11+80, Figure 3-2A), which concentrates flow and raises velocity and tractive power. This area requires riprap in the central channel for a length of channel sufficient to reduce the velocity to the natural 15 to 16 ft/sec.

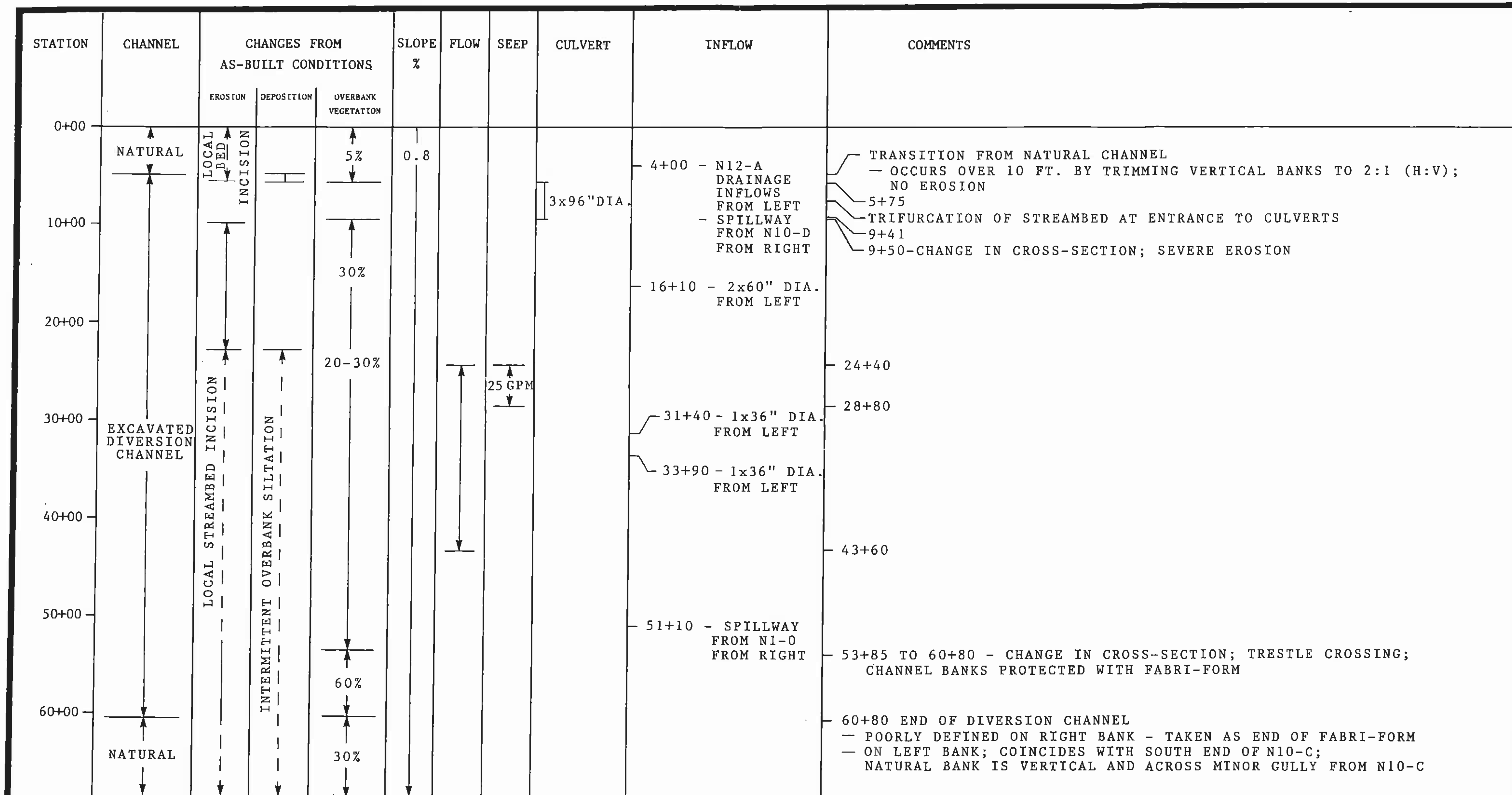
In the region of Station 56+20, the diversion channel constricts and makes a severe bend. In this reach velocity and tractive power are well above the natural values. The channel banks in this region are protected from erosion by concrete fabriform. In the reach immediately downstream from this bend there is substantial erosion (see Station 60+80, Figure 3-2B). At the transition with the natural channel downstream of the diversion channel (see Station 60+80, Table 3), the natural bed slope has been re-established, but because of the aforementioned erosion, flow is concentrated in a narrow channel and velocity is higher than the natural value. Riprap is once again required at the outlet to the Station 56+20 constriction, for a distance sufficient to reduce the velocity to the natural 15 to 16 ft/sec.

Beyond the two regions of excessive erosion where riprap is required, no substantial remedial action is necessary to make the diversion channel similar hydraulically to the replaced natural channel. Field inspection and hydraulic modeling at high flow show the channel diversion to be stable, except in the two eroding regions.

The Coal Mine Wash diversion channel has sufficient capacity to carry the runoff from 10-year, 6-hour storm. Computed depths of flow for all cross sections were within the outer limits of the overbank region.

* * *

Plate A-1 is attached and completes this report.



INSPECTION SUMMARY COAL MINE WASH DIVERSION CHANNEL

BY **Dames & Moore** Plate A-1

REPORT

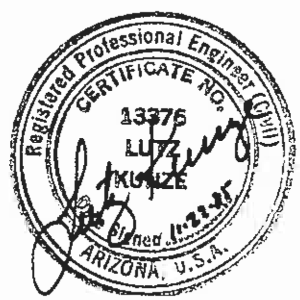
J16 Diversion Channel

Kayenta and Black Mesa Mines

Navajo County, Arizona

for

PEABODY COAL COMPANY



Dames & Moore
10139-011-22

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1.0 INTRODUCTION

The J16 diversion channel is an earth-cut channel, designed and constructed in 1982 by Peabody Coal Company as a permanent realignment of a natural channel for the purpose of facilitating mining and the regrading of spoil. A schematic of the diversion channel is shown on Figure 1-1.

This inspection report contains information specific to the J16 diversion channel. Regional site information is presented in the "General Report, Kayenta and Black Mesa Mines, Navajo County, Arizona, for Peabody Coal Company". The methods used for hydrologic and hydraulic analyses are discussed in "Methodology for Analysis of Existing Diversions for Peabody Coal Company".

2.0 INSPECTION

The J16 diversion channel was inspected on October 6, 1985 by a Dames & Moore engineer. The primary purposes of the inspection were: 1) to determine the stability of the constructed channel relative to the existing natural channels upstream and downstream of the diversion channel, and 2) to collect data necessary for the hydraulic evaluation of the existing channel.

The site inspection revealed short, discontinuous stretches of channel bed that were damp or carried flows of less than 20 gpm. The majority of the inspected channel length had a dry channel bed. Because of this, the channel was classified as ephemeral, carrying short duration flows only immediately following rainfall events. The capacity and stability of the channel are therefore evaluated in this report for the 10-year, 6-hour storm as required by 30 CFR 816.43.

Results of the field inspection are included in this report as Plate A-1. In Plate A-1, regions of visible channel aggradation and degradation are delineated, and transitions between the diversion channel and existing natural channels are specifically addressed. The locations where channel hydraulic parameters (flowrate, slope, cross section, shape and roughness) change significantly are also identified in Plate A-1.

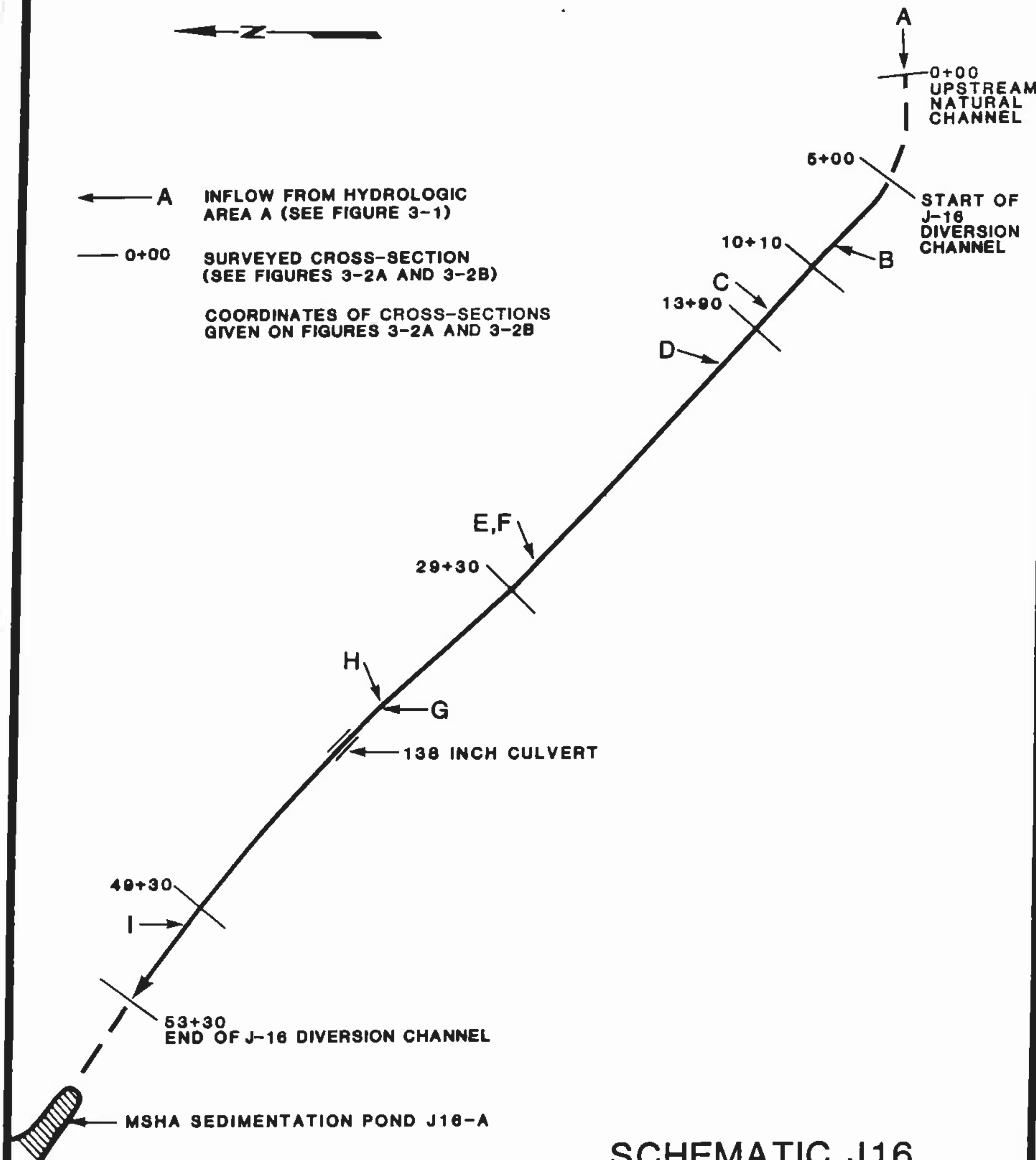
3.0 SITE DESCRIPTION

3.1 LAND USE

The J16 diversion channel provides drainage for runoff from the nine major and minor watersheds shown on Figure 3-1, Hydrologic Areas. The major contributing area, labeled A on Figure 3-1, consists of 60 percent Pinion/Juniper, 27 percent Sagebrush/grass, 10 percent roads and mine areas and 3 percent reclaimed areas. The topography of the channel and its tributary watersheds is shown on Drawing #85405 (1 inch equals 2000 feet). Coordinates for channel cross sections are given on Figures 3-2A and 3-2B.

3.2 EXISTING CHANNEL DESIGN AND CROSS SECTIONS

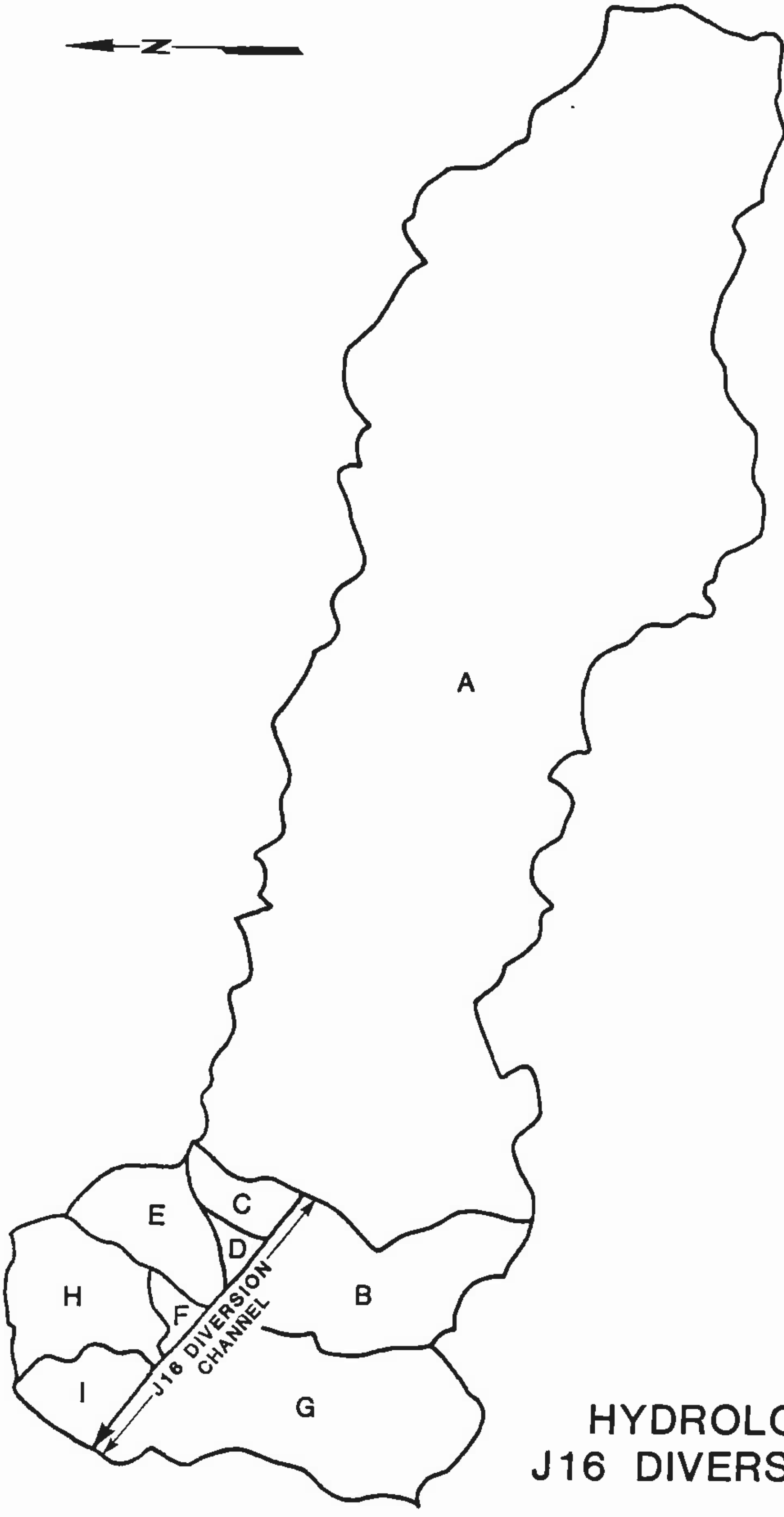
The existing diversion cross section has 3:1 (horizontal to vertical) side slopes and a channel bed that varies in width between 12 and 24 feet with an average width of about 15 feet. The channel bed has a low flow



SCHEMATIC J16 DIVERSION CHANNEL

NOT TO SCALE

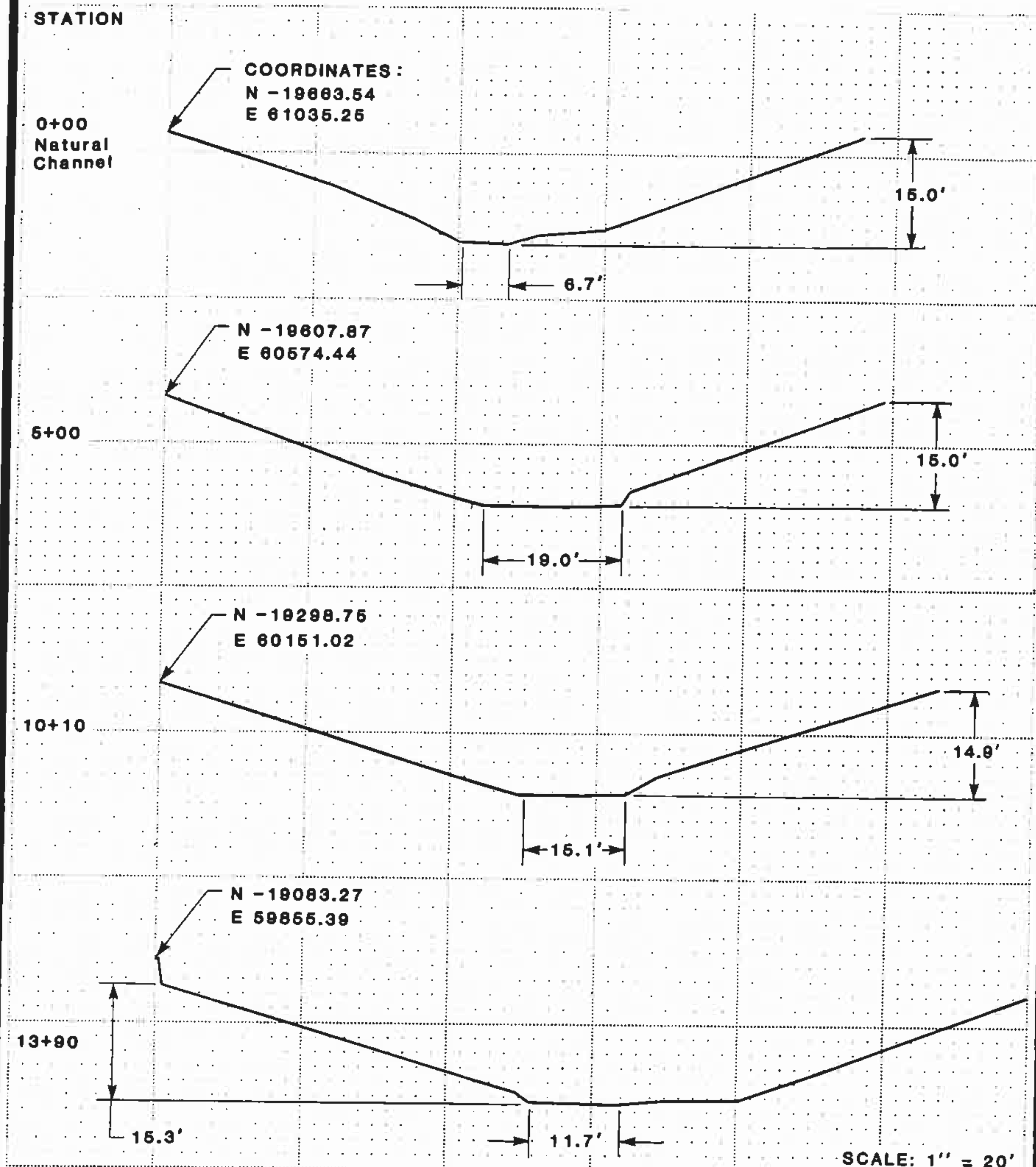
BY **Dames & Moore** Figure 1-1



HYDROLOGIC AREAS
J16 DIVERSION CHANNEL

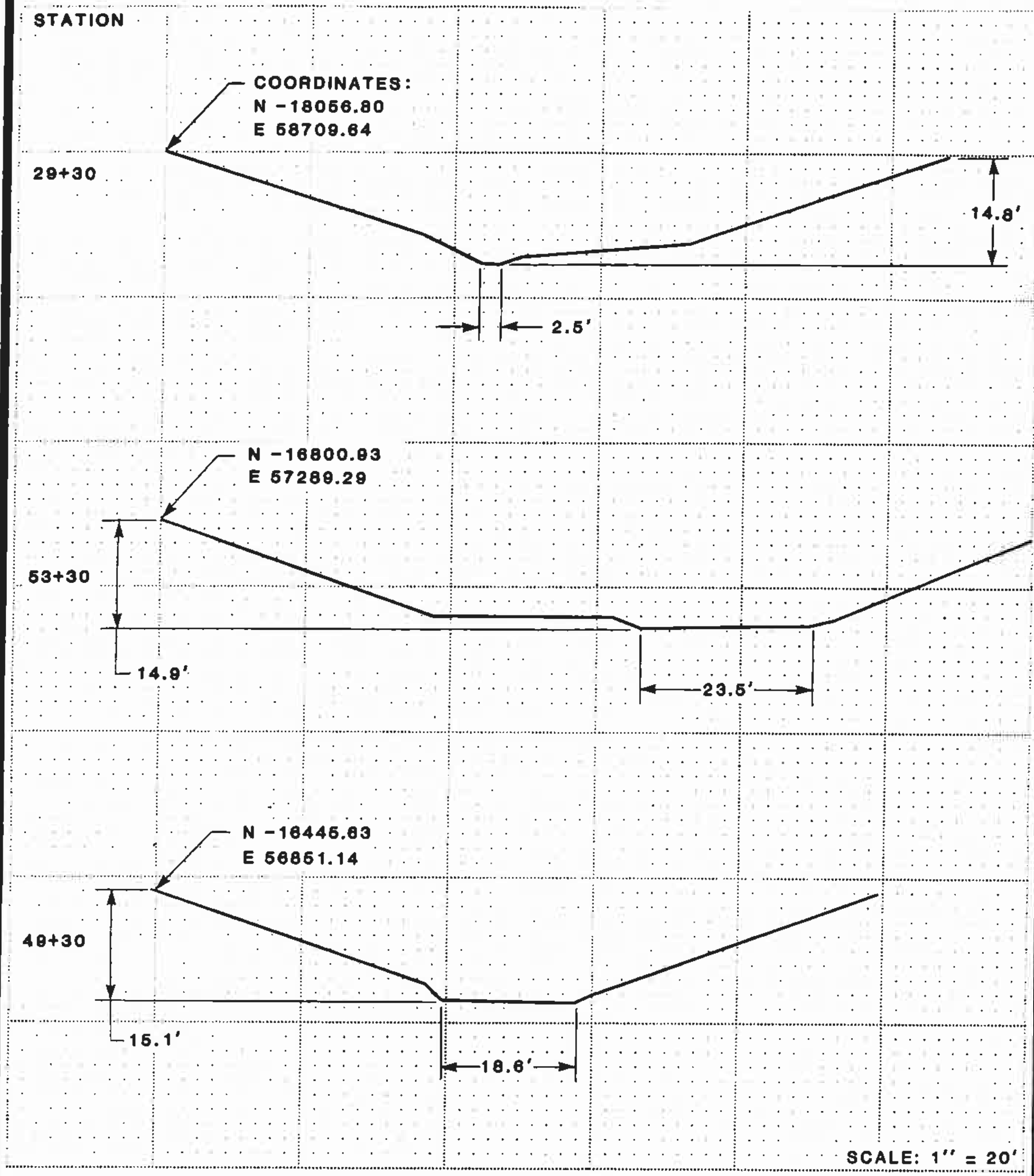
NOT TO SCALE

BY **Dames & Moore** Figure 3-1



CROSS-SECTIONS
J16 DIVERSION CHANNEL

BY **Dames & Moore** Figure 3-2A



CROSS-SECTIONS
J16 DIVERSION CHANNEL

BY **Dames & Moore** Figure 3-2B

channel of relatively clean sand and the remainder of the bed and side slopes have 10 to 25 percent vegetation. Minimum depth of the channel is 14 feet.

4.0 ANALYSES

4.1 HYDROLOGY

The hydrologic analysis was completed using the U.S. Army Corps of Engineers generalized computer program HEC-1, Flood Hydrograph Package. The program was set up to use the SCS dimensionless unit hydrograph method. Curve numbers derived for the tributary watersheds are shown on Figure 3-1, and tabulated in Table 1. Peak flows for each watershed (predicted by HEC-1 for the 10-year, 6-hour storm) are also shown in Table 1. Table 2 shows the results from HEC-1 after the hydrographs from each watershed are added to and routed with the main channel hydrograph utilizing appropriate lag times.

4.2 HYDRAULICS

The capacity and stability of the J16 diversion channel and the natural channel immediately upstream of the diversion channel were evaluated. Cross sections were chosen and surveyed at the approximate midpoints between locations of major lateral inflows into the channel. With the assumption of uniform flow in the region of these cross sections, and from the Manning equation, critical hydraulic parameters were calculated. Chosen parameters and calculated results are shown in Table 3. Flowrates in Table 3 are those predicted by HEC-1 for the 10-year, 6-hour storm.

Table 1

SUMMARY OF J16 DIVERSION CHANNEL HYDROLOGIC ANALYSIS

	Subwatershed Identification								
	A	B	C	D	E	F	G	H	I
Drainage Areas (acres)	1836	233	27	9	64	8	140	89	41
10-year, 6-hour storm									
SCS Curve Number	77	86	81	79	83	78	84	83	76
Lag Time (hrs)	0.618	0.201	0.058	0.033	0.100	0.034	0.168	0.124	0.026
Peak Flow (cfs)	311	201	23	7	56	5	110	72	21
Method of Analysis	------------HEC-1, using SCS dimensionless unit hydrograph---------------								

Table 2

FLOWRATES AT J-16 DIVERSION CHANNEL STATIONS

Station	HEC-1 Flowrates (cfs) Storm 10-year, 6-hour
5+00 Upstream end of diversion channel Inflow from A	311
8+00 Inflow from B	350
12+65 Inflow from C	352
16+05 Inflow from D	352
27+50 Inflow from E	357
28+05 Inflow from F	358
36+65 Inflow from G and H	420
50+50 Inflow from I	426
53+30 Downstream end of diversion channel	426

Table 3

SUMMARY OF J-16 DIVERSION CHANNEL HYDRAULIC ANALYSIS

	INPUT TO MANNING EQUATION					CALCULATED OUTPUTS					
	Roughness						Velocity (fps)				
Station	Left Over-Bank	Channel	Right Over-Bank	Bed Slope (ft/ft)	Flow* Rate (cfs)	Flow Depth (ft)	Left Over-Bank	Channel	Right Over-Bank	Tractive Stress (lb/ft^2)	Tractive Power (lb/ft-sec)
Existing Channel Upstream of Diversion Channel 0+00	.030	.022	.030	.0162	311	2.2	0.0	11.8	4.8	1.2	12.5
5+00	.030	.022	.030	.0230	311	1.3	0.6	11.1	0.0	1.6	18.0
10+00	.030	.022	.030	.0184	352	2.0	0.0	10.9	0.0	1.5	16.4
13+90	.030	.022	.030	.0207	353	1.6	0.0	11.2	6.7	1.4	13.5
29+30	.030	.022	.030	.0207	358	2.7	0.0	13.8	5.9	1.4	14.0
48+30	.030	.022	.030	.0166	428	1.9	0.0	11.6	3.0	1.5	17.2
53+30	.030	.022	.030	.0117	421	1.6	0.0	9.0	3.3	0.7	5.3

* Flows may vary slightly from those given in Table 2, because of a 1 cfs tolerance in computations.

5.0 SUMMARY OF RESULTS AND RECOMMENDATIONS

This section highlights the locations in the existing diversion channel where remedial work may be needed in order to approximate the hydraulic conditions in the natural channels adjoining the diversion. First the conditions in these natural channels will be discussed, then the conditions in the diversion channel will be discussed. The cross-sectional shape of each analyzed section of natural or man-made channel is given on Figure 3-2A or 3-2B. The hydraulic performance of each section during the estimated peak flow from the 10-year, 6-hour storm is shown in Table 3. All velocities and stresses discussed below pertain to this storm.

The natural channel upstream of the diversion channel (Station 0+00) has a bed slope of 1.62 percent, a velocity of 11.8 ft/sec, and a tractive power of 12.5 lb/ft-sec. The outlet of the diversion channel empties into a sedimentation pond straddling the natural channel. Two thousand feet downstream of the MSHA sedimentation pond J16A, the natural channel has a 0.6 percent slope. The diversion channel and sedimentation pond, therefore, occupy a reach of channel where, under natural conditions, a flattening of slope would lead to deposition along the length of reach.

The transition between natural and man-made cross section at Station 5+00 is smooth, without significant erosion or deposition (see Plate A-1). The hydraulic parameters (velocity and tractive power) affecting sediment transport are closely matched across this transition (see Table 3). Velocity and tractive power remain relatively constant through this reach of the channel diversion, until the channel flattens and widens as the channel discharges into the sedimentation pond. In this reach, velocity and tractive power drop rapidly and deposition occurs. At Station 39+00, the diversion channel flow passes through a 138-inch-diameter culvert beneath a light-duty vehicle, local access road. This culvert would flow approximately half full during the 10-year, 6-hour storm.

Severe erosion occurs along the diversion channel bank at Station 36+65 where a culvert discharges into the channel from an eroded, unlined channel. This area requires riprap to protect the channel bank. The downstream MSHA sedimentation pond J16A quite clearly alters the natural passage of sediment through the reach. This will lead to increased erosion below the pond outfall until the clear water discharged over the dam picks up enough sediment to reestablish an equilibrium sediment transport rate in the relatively uniform downstream natural channel. No remedial action is necessary here, as this effect is expected due to the regulatory purpose of the pond.

The diversion channel transition with the natural upstream channel is smooth, and the diversion channel itself lacks evidence of severe erosion or deposition (by physical inspection, or by mathematical modeling of performance under high flow), with the exceptions discussed in the preceding paragraph. Therefore, no substantial remedial action is necessary to make the diversion channel similar hydraulically to the replaced natural channel. Areas of local stream bed incision should be monitored for excessive erosion, and the culvert at Station 39+00 should be maintained (cleaned out when necessary) to prevent excessive upstream siltation. Riprap should be placed at the downstream end of this culvert to prevent erosion.

The J16 diversion channel has sufficient capacity to carry the runoff from the 10-year, 6-hour storm. Computed depths of flow for all cross sections were well within the outer limits of the channel.

* * *

Plate A-1 is attached and completes this report.

REPORT

N7/8 Diversion Channel

Kayenta Mine

Navajo County, Arizona

for

PEABODY COAL COMPANY

Registered Professional Engineer (Civil)
CERTIFICATE NO.
13376
LUTZ
KUNZE
ARIZONA, U.S.A.

Dames & Moore
10139-011-22

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1.0 INTRODUCTION

The N7/8 diversion channel is an earth-cut channel, designed and constructed by Peabody Coal Company as a permanent realignment of a natural channel for the purpose of facilitating mining and the regrading of spoil. A schematic of the diversion channel is shown on Figure 1-1.

This inspection report contains information specific to the N7/8 diversion channel. Regional site information is presented in the "General Report, Kayenta and Black Mesa Mines, Navajo County, Arizona, for Peabody Coal Company". The methods used for hydrologic and hydraulic analyses are discussed in "Methodology for Analysis of Existing Diversions for Peabody Coal Company".

2.0 INSPECTION

The N7/8 diversion channel was inspected on October 8, 1985 by a Dames & Moore engineer. The primary purposes of the inspection were: 1) to determine the stability of the constructed channel relative to the existing natural channels upstream and downstream of the diversion channel, and 2) to collect data necessary for the hydraulic evaluation of the existing channel.

The site inspection revealed that the entire inspected channel length had a dry channel bed. Because of this, the channel was classified as ephemeral, carrying short duration flows only immediately following rainfall events. The capacity and stability of the channel are therefore evaluated in this report for the 10-year, 6-hour storm as required by 30 CFR 816.43.

Results of the field inspection are included in this report as Plate A-1. In Plate A-1, regions of visible channel aggradation and degradation are delineated, and transitions between the diversion channel and existing natural channels are specifically addressed. The locations where channel hydraulic parameters (flowrate, slope, cross section, shape and roughness) change significantly are also identified in Plate A-1.

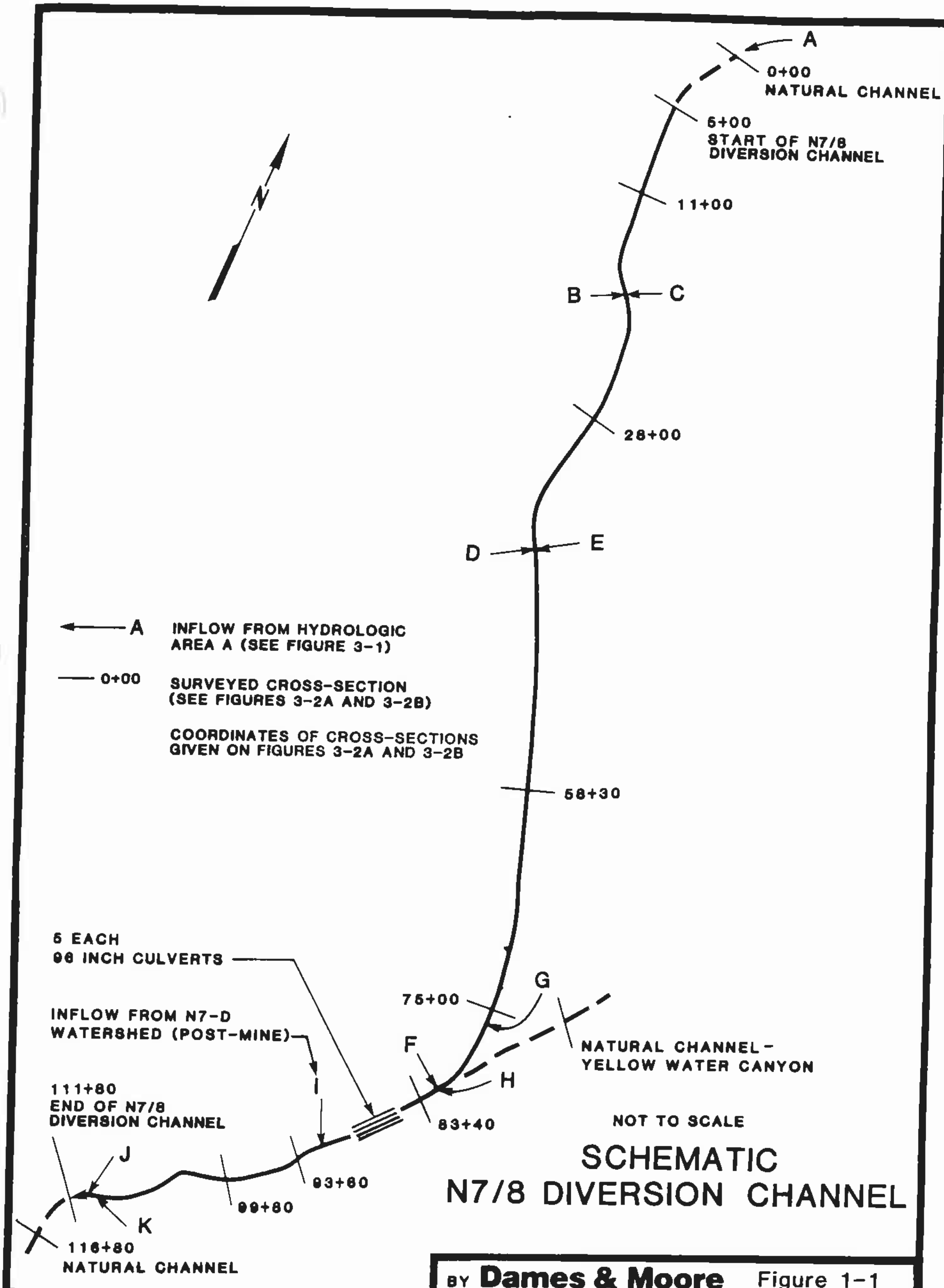
3.0 SITE DESCRIPTION

3.1 LAND USE

The N7/8 diversion channel provides drainage for runoff from the eleven major and minor watersheds shown on Figure 3-1, Hydrologic Areas. The major contributing areas are labeled A and H on Figure 3-1. Area A consists of 96 percent Pinion/Juniper and 4 percent Sagebrush/grass; area H consists of 95 percent Pinion/Juniper and 5 percent Sagebrush/grass. The topography of the channel and its tributary watersheds is shown on Drawing #85405 (1 inch equals 2000 feet). Coordinates for channel cross sections are given on Figures 3-2A and 3-2B.

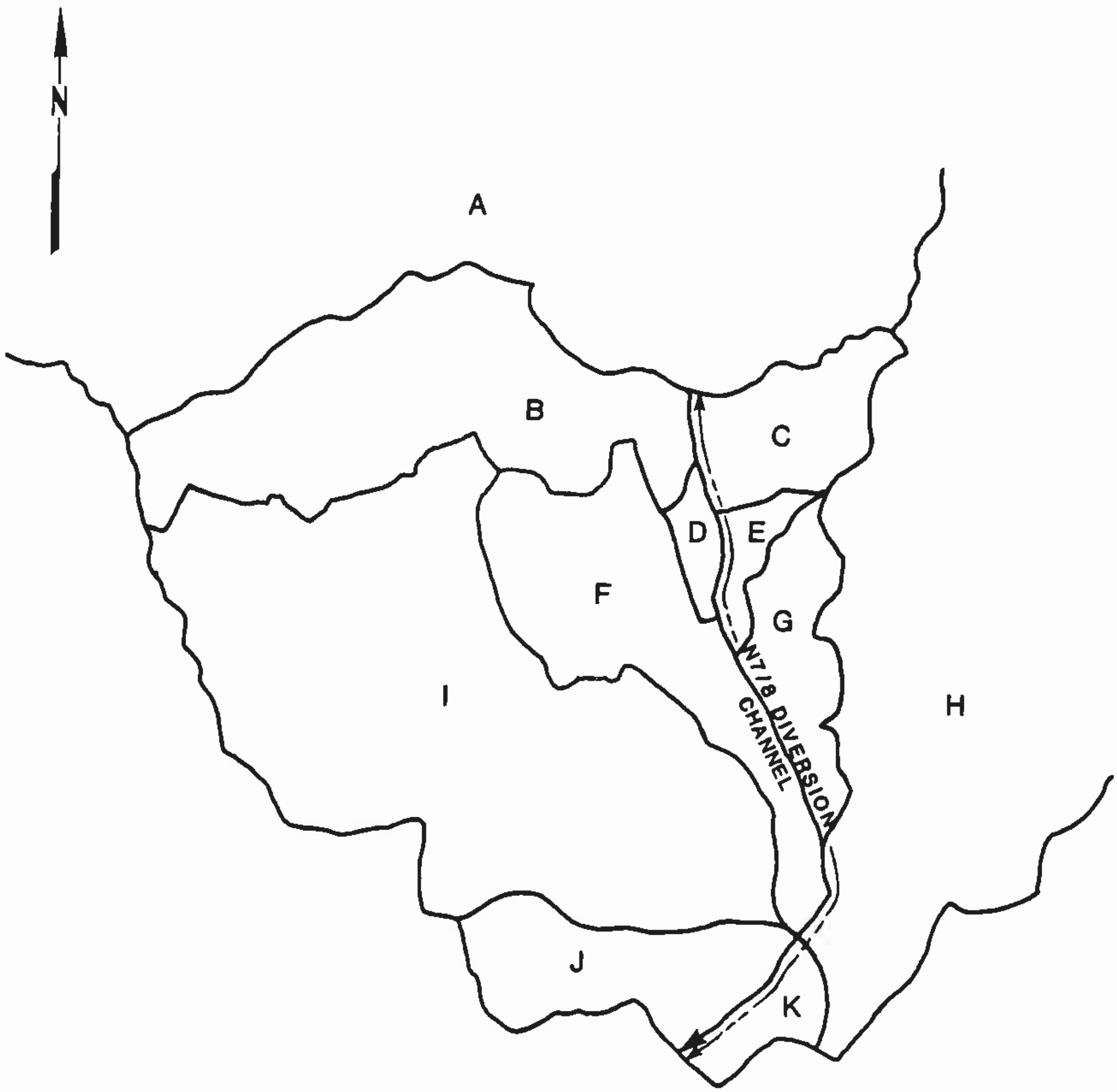
3.2 EXISTING CHANNEL DESIGN AND CROSS SECTIONS

The existing diversion cross section has side slopes varying between 1:1 and 3:1 (horizontal to vertical) and a channel bed that varies in width between 12 and 38 feet with an average width of about 15 feet. Widths including overbanks exceed 50 feet. The channel bed has a low flow channel of relatively clean sand and the remainder of the bed and side



SCHEMATIC N7/8 DIVERSION CHANNEL

BY Dames & Moore Figure 1-1

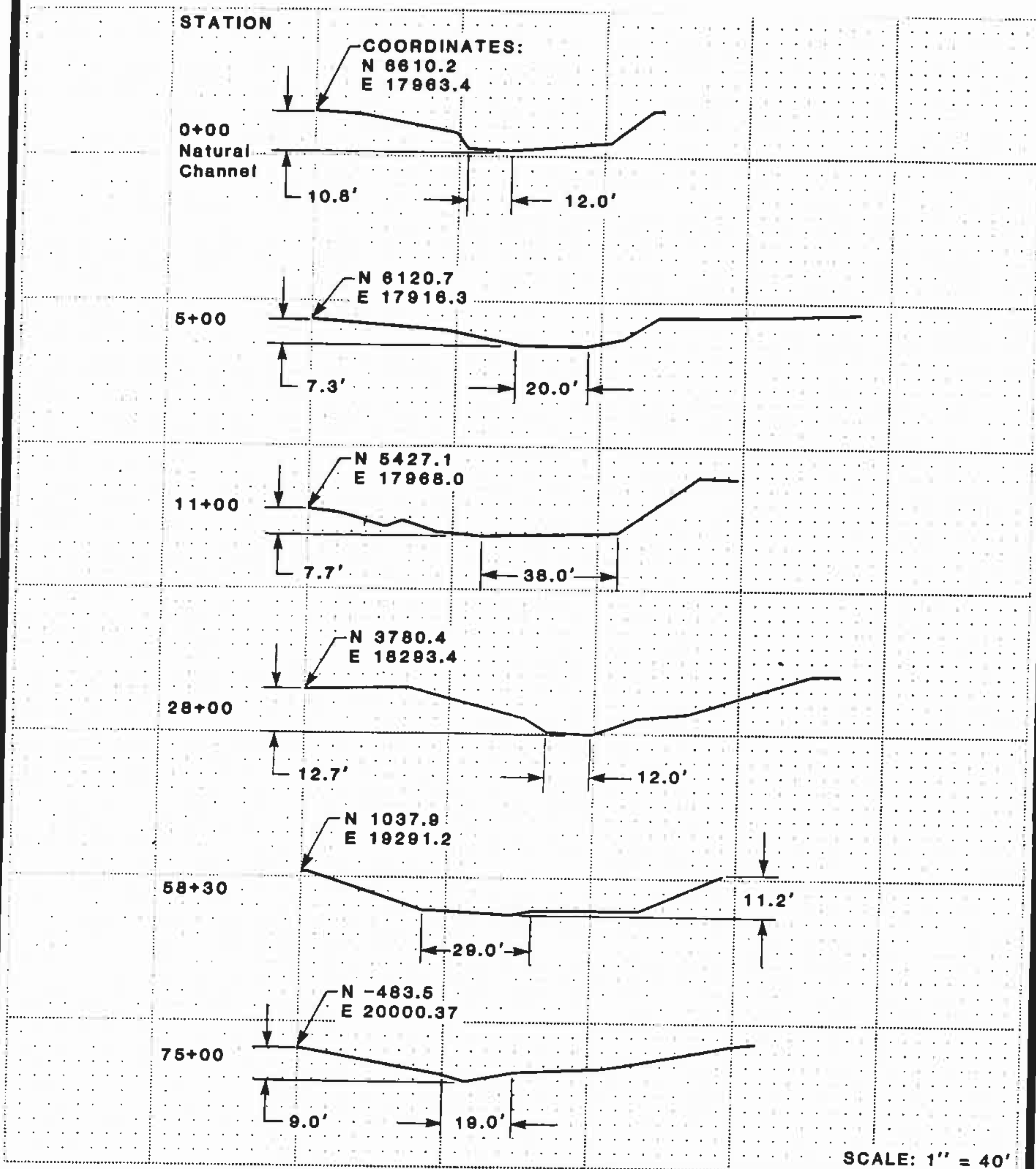


HYDROLOGIC AREAS
N7/8 DIVERSION CHANNEL

NOT TO SCALE

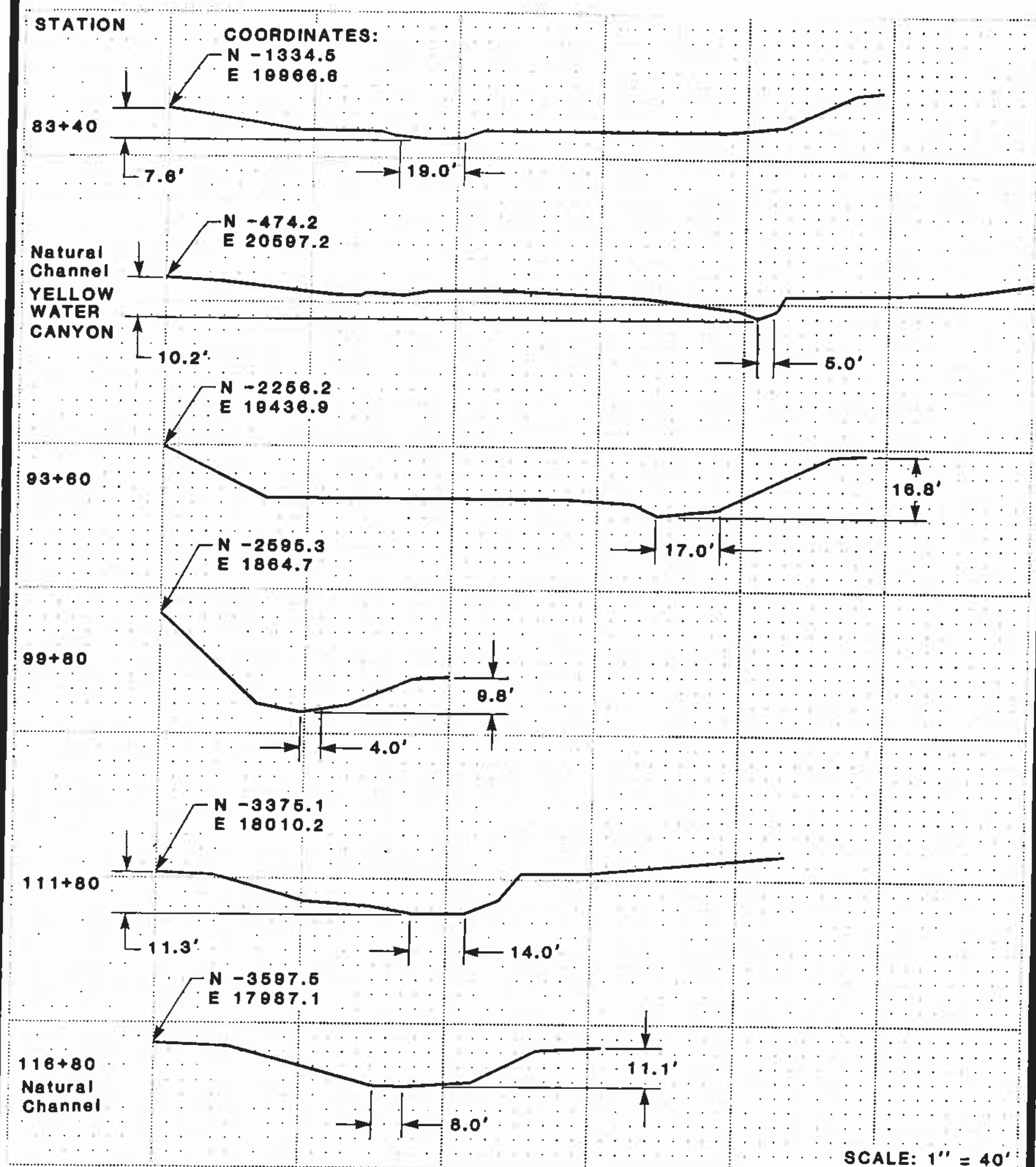
BY **Dames & Moore**

Figure 3-1



CROSS-SECTIONS
N7/8 DIVERSION CHANNEL

BY **Dames & Moore** Figure 3-2A



CROSS-SECTIONS
N7/8 DIVERSION CHANNEL

BY **Dames & Moore** Figure 3-2B

slopes generally have 10 to 40 percent vegetation. Minimum depth of the channel is 7 feet in the reach above the junction with Yellow Water Canyon, and 10 feet below the junction.

4.0 ANALYSES

4.1 HYDROLOGY

The hydrologic analysis was completed using the U.S. Army Corps of Engineers generalized computer program HEC-1, Flood Hydrograph Package. The program was set up to use the SCS dimensionless unit hydrograph method. Curve numbers derived for the tributary watersheds are shown on Figure 3-1, and tabulated in Table 1. Peak flows for each watershed (predicted by HEC-1 for the 10-year, 6-hour storm) are also shown in Table 1. Table 2 shows the results from HEC-1 after the hydrographs from each watershed are added to and routed with the main channel hydrograph utilizing appropriate lag times.

4.2 HYDRAULICS

The capacity and stability of the N7/8 diversion channel and the natural channel immediately upstream of the diversion channel were evaluated. Cross sections were chosen and surveyed at the approximate midpoints between locations of major lateral inflows into the channel. With the assumption of uniform flow in the region of these cross sections, and from the Manning equation, critical hydraulic parameters were calculated. Chosen parameters and calculated results are shown in Table 3. Flowrates in Table 3 are those predicted by HEC-1 for the 10-year, 6-hour storm.

Table 1

SUMMARY OF N7/8 DIVERSION CHANNEL HYDROLOGIC ANALYSIS

	Subwatershed Identification										
	A	B	C	D	E	F	G	H	I	J	K
Drainage Areas (acres)	10641	371	109	17	32	229	101	15894	768	136	40
10-year, 6-hour storm											
SCS Curve Number	83	83	82	81	83	87	82	82	89	80	83
Lag Time (hrs)	1.15	0.205	0.145	0.045	0.085	0.262	0.194	1.52	0.286	0.134	0.066
Peak Flow (cfs)	1970	229	72	14	8	183	58	2050	681	73	35
Method of Analysis	----------------------HEC-1, using SCS dimensionless unit hydrograph--------------------										

Table 2

FLOWRATES AT N7/8 DIVERSION CHANNEL STATIONS

Station	HEC-1 Flowrates (cfs) Storm 10-year, 6-hour
5+00 Upstream End of Diversion Channel Inflow from A	1970
18+50 Inflow from B, C	1995
38+60 Inflow from D, E	1992
78+00 Inflow from G	1993
83+00 Inflow from F, H	3987
92+60 Inflow from I	4034
111+20 Inflow from J, K	4042
Downstream End of Diversion Channel 113+20	4042

<u>Table 3</u>

SUMMARY OF N7/8 DIVERSION CHANNEL HYDRAULIC ANALYSIS

Station	INPUT TO MANNING EQUATION: Roughness Left Over-Bank	Roughness Channel	Roughness Right Over-Bank	Bed Slope (ft/ft)	Flow* Rate (cfs)	CALCULATED OUTPUTS: Flow Depth (ft)	Velocity (fps) Left Over-Bank	Velocity (fps) Channel	Velocity (fps) Right Over-Bank	Tractive Stress (lb/ft^2)	Tractive Power (lb/ft-sec)
Natural Channel Upstream of Diversion Channel											
0+00	.030	.022	.030	.0133	1970	4.0	0.0	15.7	4.0	2.3	35.0
5+00	.030	.022	.030	.0110	1971	4.0	0.0	14.2	4.6	1.8	25.7
11+00	.030	.022	.030	.0161	1972	3.3	0.0	14.9	0.0	2.3	33.9
28+00	.035	.022	.035	.0184	1996	4.8	1.3	19.5	2.4	2.9	55.5
58+30	.035	.022	.035	.0160	1993	3.1	5.1	14.7	4.7	2.0	28.4
75+00	.035	.022	.035	.0220	1993	4.5	7.3	22.8	8.0	2.7	43.1
83+40	.035	.022	.035	.0060	3987	5.0	4.3	15.3	5.0	1.2	9.7
Natural Channel: YELLOW WATER CANYON	.035	.022	.05	.0061	2051	6.2	1.9	12.7	1.5	0.6	6.6
93+60	.035	.022	.50	.0090	4035	5.6	5.6	18.5	3.6	1.7	16.2
99+80	.030	.022	.030	.0286	4036	5.8	9.9	31.9	12.2	6.2	177.6
111+80	.035	.022	.035	.0072	4043	6.1	4.0	15.9	2.9	1.8	27.2
Natural Channel Downstream of Diversion Channel											
116+80	.035	.022	.035	.00680	4043	6.5	6.4	18.4	6.3	1.8	26.9

*Fl nay vary slightly from the values in Table 2 be e of a 1 cfs tolerance in computations.

5.0 SUMMARY OF RESULTS AND RECOMMENDATIONS

This section highlights the locations in the existing diversion channel where remedial work may be needed in order to approximate the hydraulic conditions in the natural channels adjoining the diversion. First, the conditions in these natural channels will be discussed, then the conditions in the diversion channel will be discussed. The cross-sectional shape of each analyzed section of natural or man-made channel is given on Figures 3-2A and 3-2B. The hydraulic performance of each section during the estimated peak flow from the 10-year, 6-hour storm is shown in Table 3. All velocities and stresses discussed below pertain to this storm.

The natural channel upstream of the diversion channel (Station 0+00) has a bed slope of 1.3 percent, a velocity of 15.7 ft/sec, and a tractive power of 35.0 lb/ft-sec. Yellow Water Canyon, a natural channel which joins the diversion channel at Station 83+00, has a bed slope of 0.6%, a velocity of 12.6 ft/sec, and a tractive power of 6.7 lb/ft-sec. In the region of Station 99+80, the diversion channel passes through a natural rock cut which greatly increases the velocity to 31.9 ft/sec and the tractive power to 177.6 lb/ft-sec. Immediately downstream of this severe constriction the channel drops vertically 9 feet in a 40-foot reach. This stretch of channel is natural. The natural channel downstream of the diversion channel outlet has a bed slope of 0.7 percent, a velocity of 18.6 ft/sec, and a tractive power of 28.9 lb/ft-sec. From the above natural channels, which bound the diversion channel, one can hypothesize the natural processes that took place in the reach of channel replaced by the man-made diversion. Deposition occurred in the region near the junction with Yellow Water Canyon due to the drop in slope and channel velocity. Similar deposition would occur upstream of the Station 99+80 constriction due to ponding. Downstream of this constriction, erosion similar to that currently seen would happen. Following this erosion, the channel would regain stability as a constant sediment transport rate is achieved in the relatively uniform downstream channel reach.

The diversion channel matches, with local exceptions, the natural processes discussed above. Each of the transitions with natural cross sections are smooth and without significant erosion or deposition (see Plate A-1). The hydraulic parameters (velocity, tractive power) affecting sediment transport are closely matched between natural cross sections and the adjoining diversion channel cross sections, except at the upstream end of the channel (Station 5+00) where a local drop in slope produces incision of the low flow channel and deposition in the overbank regions. These changes are reflected in the sudden drop in tractive power from natural to man-made channel. The diversion channel flow passes through a five-barrel (each 96 inches in diameter) culvert at Station 88+00. For the 10-year flowrate, this would result in ponding 15 feet deep upstream of the culverts. This ponding would produce unnatural deposition upstream of the culverts. Other local erosion and deposition within the diversion channel (shown in Plate A-1), are held within bounds by the smooth transitions to natural conditions at the diversion channel extremes.

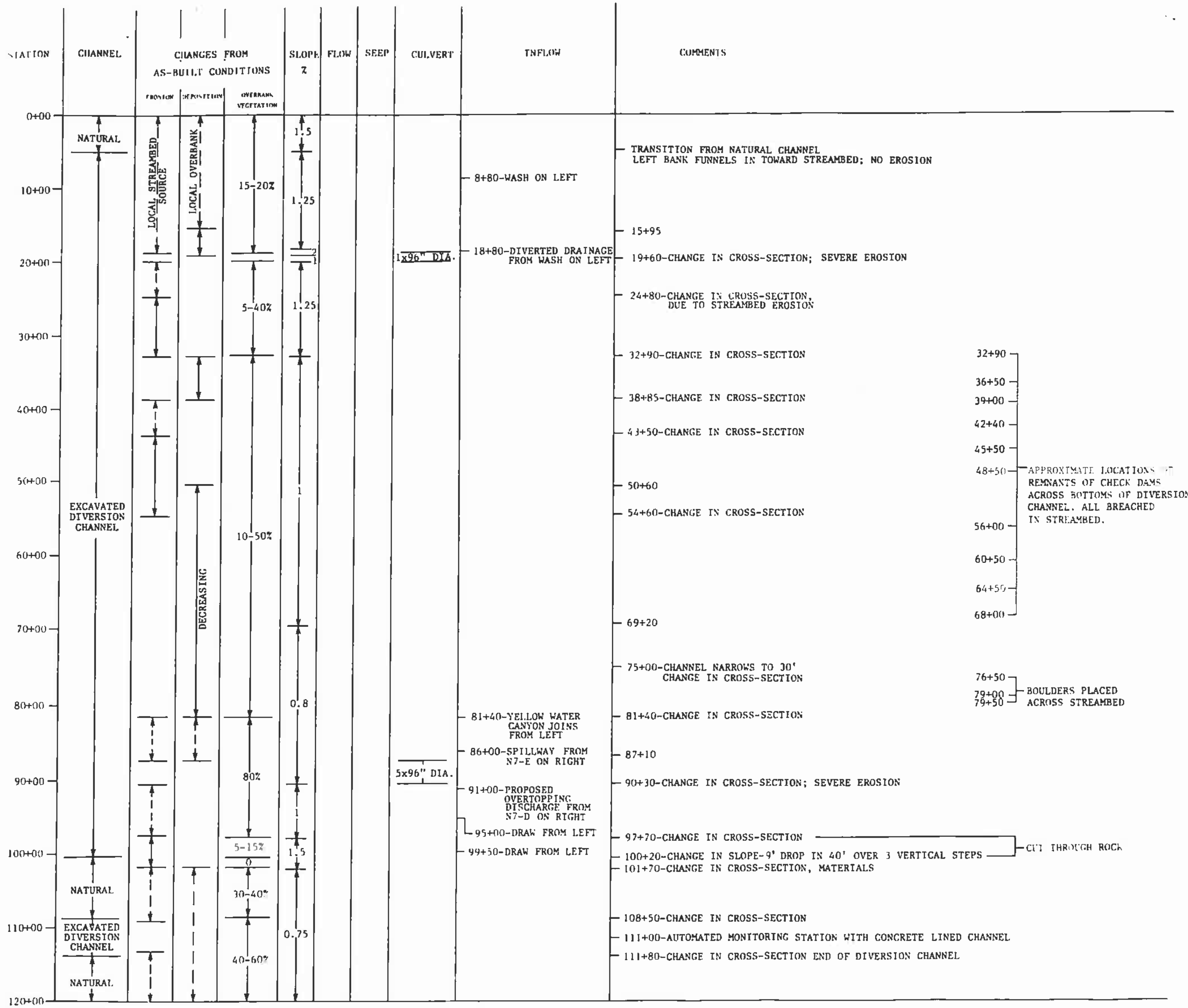
Severe erosion occurs near Stations 20+00 (where a culvert discharges into the channel) and 90+00 (after the channel passes through the culverts discussed above). These areas require riprap to protect channel and road embankments.

The diversion channel transitions with the natural channels are smooth, and the diversion channel itself lacks evidence (determined by physical inspection or mathematical modeling) of severe erosion or deposition, with the exceptions discussed in the preceding paragraph. Therefore, no substantial remedial action is necessary to make the diversion channel behave hydraulically like the replaced natural channel. Areas of local streambed incision should be monitored for excessive erosion, and the culverts at Station 88+00 should be maintained (cleaned out when necessary) to prevent excessive upstream siltation.

The N7/8 diversion channel has sufficient capacity to carry the runoff from the 10-year, 6-hour storm. Computed depths of flow for all cross sections were well within the outer limits of the overbank region.

* * *

Plate A-1 is attached and completes this report.



INSPECTION SUMMARY
N7/8
DIVERSION CHANNEL

BY Dames & Moore

Plate A-1

REPORT

N14 Diversion Channel

Kayenta and Black Mesa Mines

Navajo County, Arizona

for

PEABODY COAL COMPANY

Registered Professional Engineer
CERTIFICATE NO.
13376
LUTZ
KUNZE
Date Signed
ARIZONA, U.S.A.

Dames & Moore
10139-011-22

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1.0 INTRODUCTION

The N14 diversion channel is an earth-cut channel, designed and constructed by Peabody Coal Company as a permanent realignment of a natural channel for the purpose of facilitating mining and the regrading of spoil. A schematic of the diversion channel is shown on Figure 1-1.

This inspection report contains information specific to the N14 diversion channel. Regional site information is presented in the "General Report, Kayenta and Black Mesa Mines, Navajo County, Arizona, for Peabody Coal Company". The methods used for hydrologic and hydraulic analyses are discussed in "Methodology for Analysis of Existing Diversions for Peabody Coal Company".

2.0 INSPECTION

The N14 diversion channel was inspected on October 6 and 7, 1985 by a Dames & Moore engineer. The primary purposes of the inspection were: 1) to determine the stability of the constructed channel relative to the existing natural channels upstream and downstream of the diversion channel, and 2) to collect data necessary for the hydraulic evaluation of the existing channel.

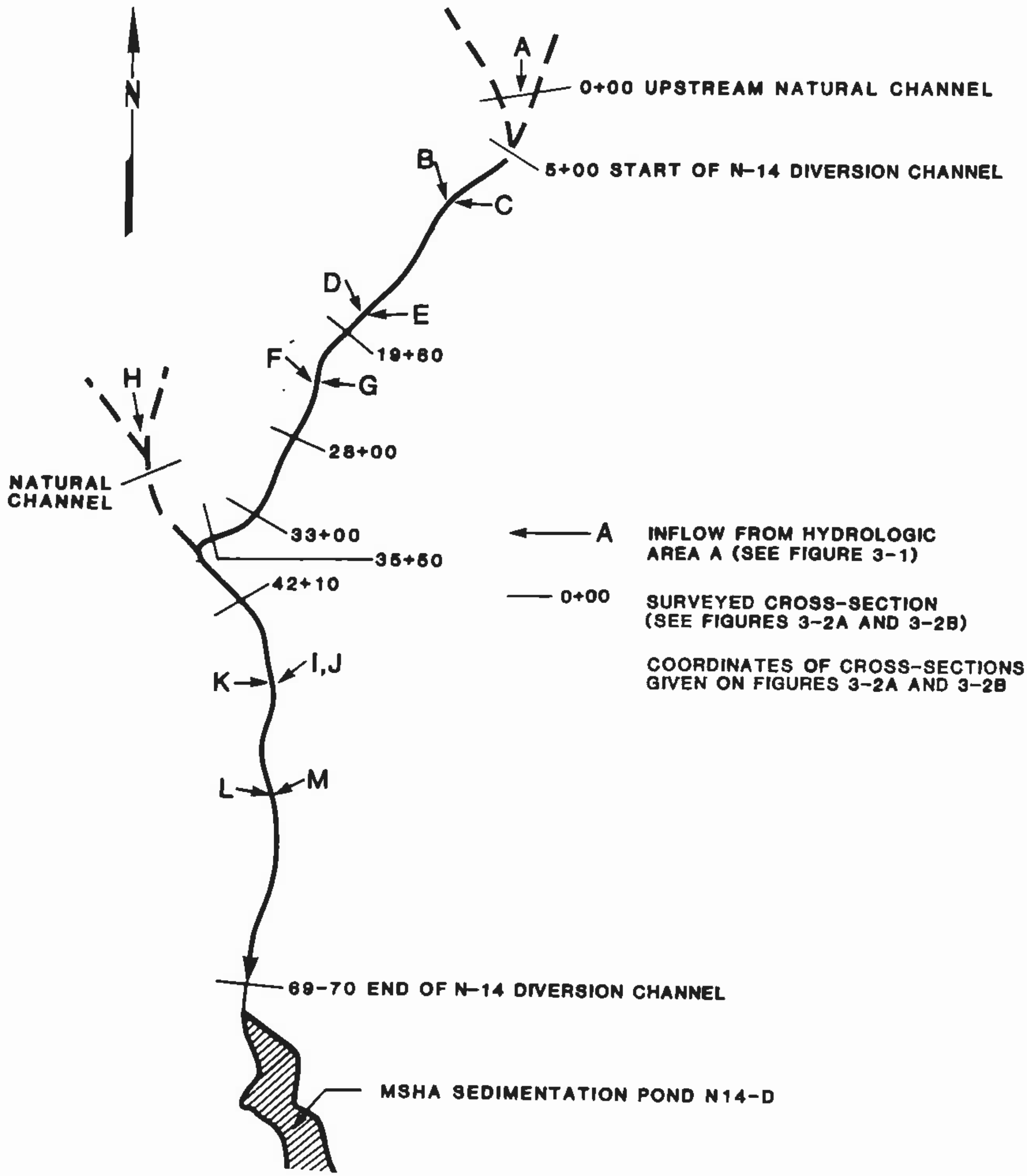
The site inspection revealed a short stretch of channel bed that was damp. The remainder of the inspected channel length had a dry channel bed. Because of this, the channel was classified as ephemeral, carrying short duration flows only immediately following rainfall events. The capacity and stability of the channel are therefore evaluated in this report for the 10-year, 6-hour storm as required by 30 CFR 816.43.

Results of the field inspection are included in this report as Plate A-1. In Plate A-1, regions of visible channel aggradation and degradation are delineated, and transitions between the diversion channel and existing natural channels are specifically addressed. The locations where channel hydraulic parameters (flowrate, slope, cross section, shape and roughness) change significantly are also identified in Plate A-1.

3.0 SITE DESCRIPTION

3.1 LAND USE

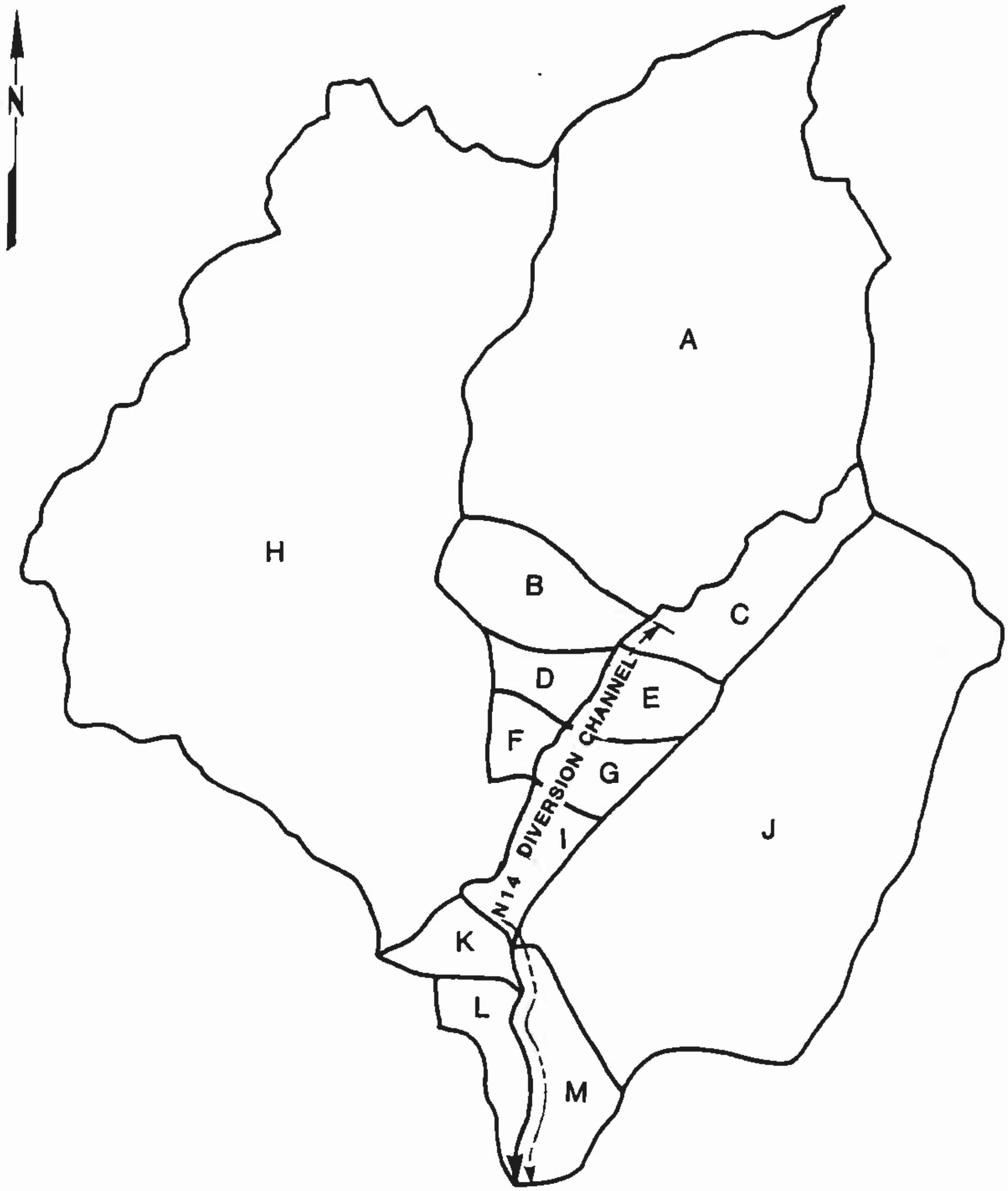
The N14 diversion channel provides drainage for runoff from the thirteen major and minor watersheds shown on Figure 3-1, Hydrologic Areas. The major contributing areas, labeled A, H, and J on Figure 3-1, have varying land uses. Area A consists of 97 percent Pinion/Juniper and 3 percent disturbed; Area H is entirely Pinion/Juniper; and Area J (currently a mine area) will be 100 percent reclaimed before it is reshaped to drain into the diversion channel. The topography of the channel and its tributary watersheds is shown on Drawing #85405 (1 inch equals 2000 feet). Coordinates of channel cross sections are shown on Figures 3-2A and 3-2B.



SCHEMATIC N14 DIVERSION CHANNEL

NOT TO SCALE

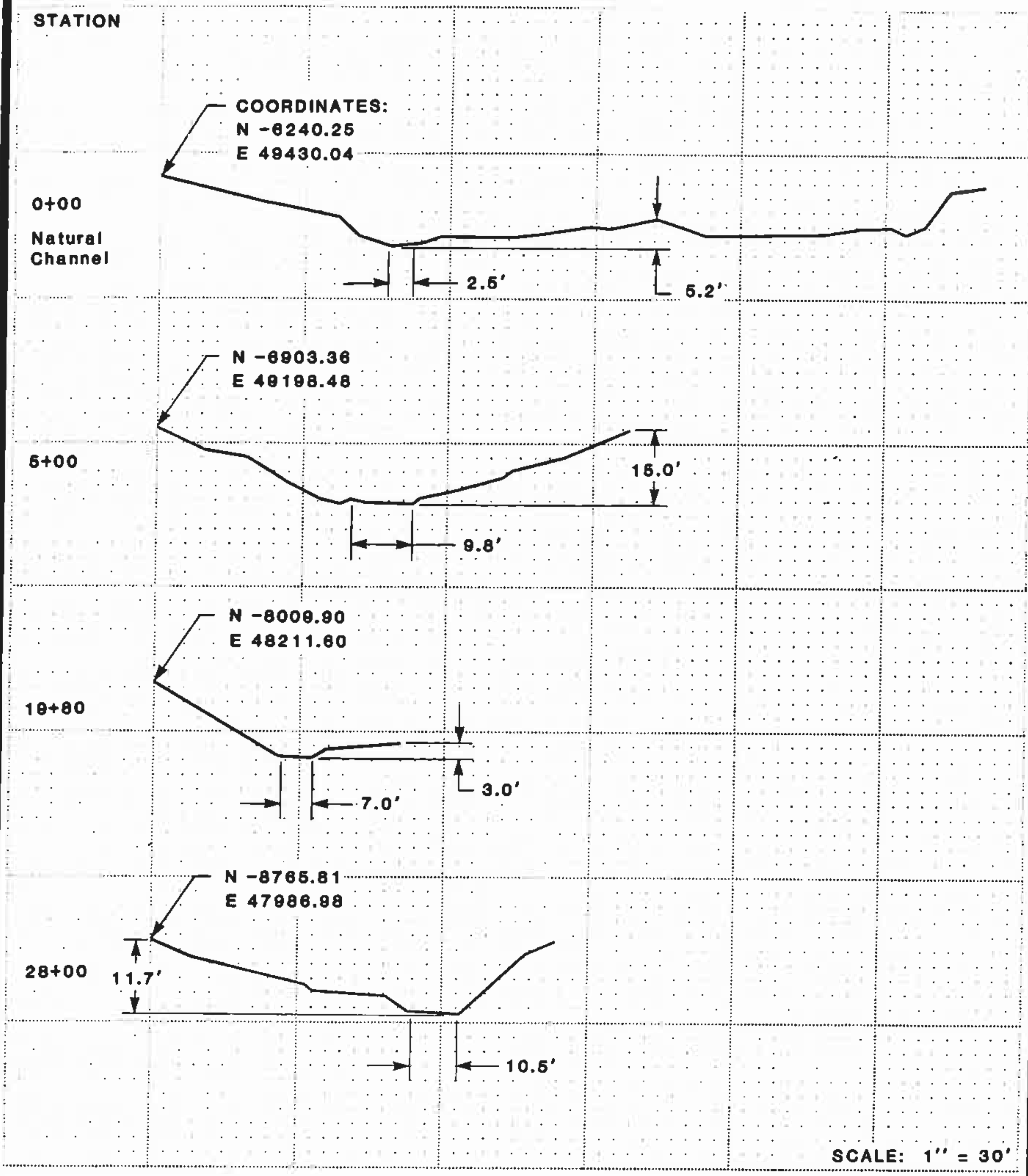
BY Dames & Moore Figure 1-1



HYDROLOGIC AREAS
N14 DIVERSION CHANNEL

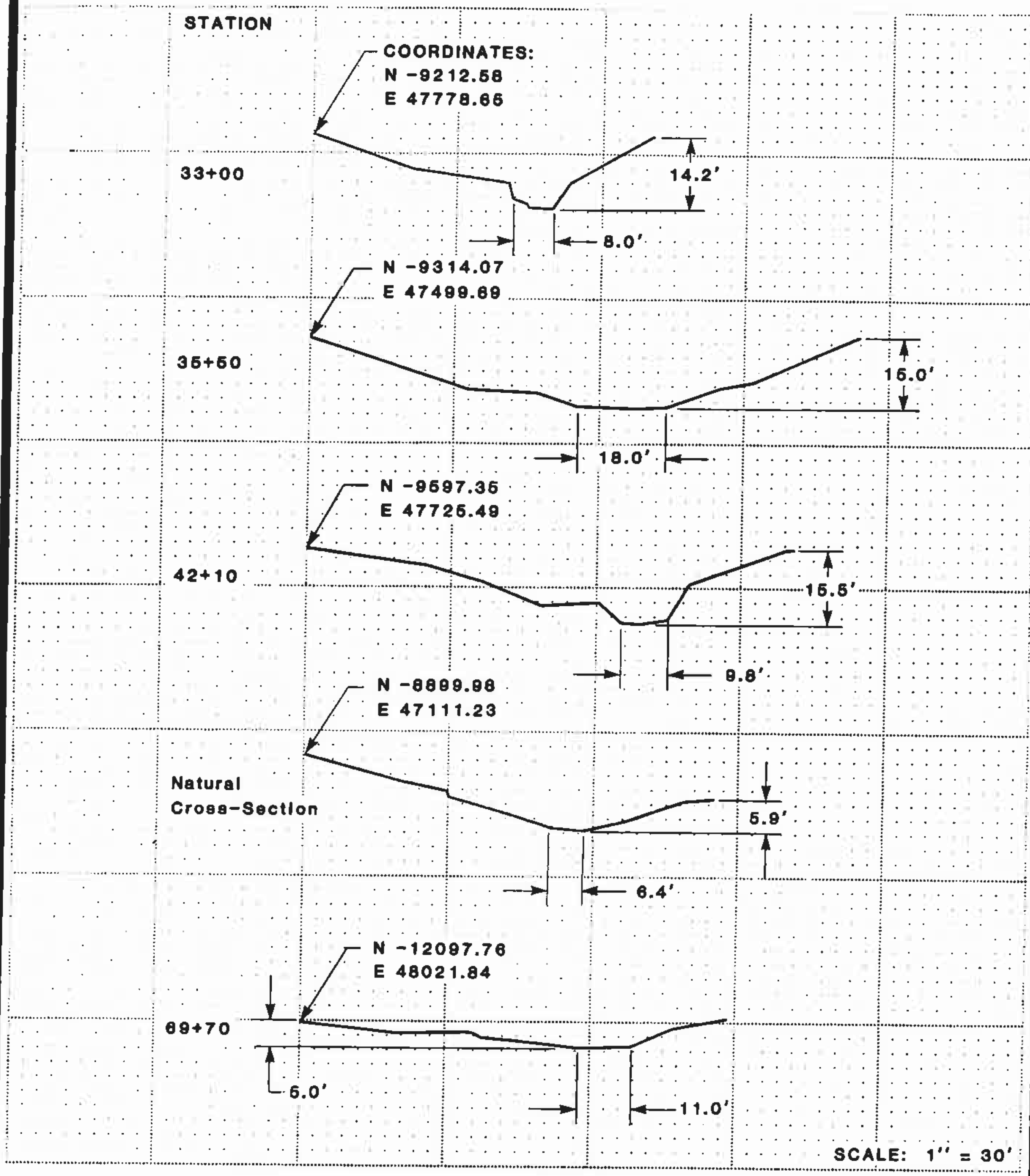
NOT TO SCALE

BY Dames & Moore Figure 3-1



CROSS-SECTIONS
N14 DIVERSION CHANNEL

BY **Dames & Moore** Figure 3-2A



CROSS-SECTIONS N14 DIVERSION CHANNEL

BY Dames & Moore Figure 3-2B

3.2 EXISTING CHANNEL DESIGN AND CROSS SECTIONS

The existing diversion cross section has side slopes varying between 1.5:1 and 3:1 (horizontal to vertical) and a channel bed that varies in width between 6 and 18 feet with an average width of about 10 feet. The channel bed has a low flow channel of relatively clean sand and the remainder of the bed and side slopes have 0 to 20 percent vegetation. Minimum depth of the channel is 3 feet at Station 19+80 (Figure 3-2A), but when grading is complete, proposed channel maximum depth will exceed 5 feet at this location. Elsewhere, current minimum channel depth generally exceeds 5 feet.

4.0 ANALYSES

4.1 HYDROLOGY

The hydrologic analysis was completed using the U.S. Army Corps of Engineers generalized computer program HEC-1, Flood Hydrograph Package. The program was set up to use the SCS dimensionless unit hydrograph method. Curve numbers derived for the tributary watersheds are shown on Figure 3-1, and tabulated in Table 1. Peak flows for each watershed (predicted by HEC-1 for the 10-year, 6-hour storm) are also shown in Table 1. Table 2 shows the results from HEC-1 after the hydrographs from each watershed are added to and routed with the main channel hydrograph utilizing appropriate lag times.

Table 1

SUMMARY OF N14 DIVERSION CHANNEL HYDROLOGIC ANALYSIS

	Subwatershed Identification											
	A	B	C	D	E	F	G	H	J + I	K	L	M
Drainage Areas (acres)	335	35	37	12	19	10	15	516	295	14	19	31
10-year, 6-hour storm												
SCS Curve Number	84	83	87	83	81	83	81	83	81	84	85	81
Lag Time (hrs)	0.194	0.061	0.075	0.040	0.065	0.027	0.065	0.267	0.065	0.043	0.028	0.032
Peak Flow (cfs)	242	37	53	14	51	13	39	285	519	18	29	93
Method of Analysis	----------------------HEC-1, using SCS dimensionless unit hydrograph--------------------------											

Table 2

FLOWRATES AT N14 DIVERSION CHANNEL STATIONS

Station	HEC-1 Flowrates (cfs) Storm 10-year, 6-hour
5+00 Upstream End of Diversion Channel Inflow from A	242
9+40 Inflow from B, C	280
18+00 Inflow from D, E	288
22+80 Inflow from F, G	291
38+20 Inflow from H	574
47+60 Inflow from K, I, J	719
51+40 Inflow from L, M	731
Downstream End of Diversion Channel 69+70	728

4.2 HYDRAULICS

The capacity and stability of the N14 diversion channel and the natural channel immediately upstream of the diversion channel were evaluated. Cross sections were chosen and surveyed at the approximate mid-points between locations of major lateral inflows into the channel. With the assumption of uniform flow in the region of these cross sections, and from the Manning equation, critical hydraulic parameters were calculated. Chosen parameters and calculated results are shown in Table 3. Flow rates in Table 3 are those predicted by HEC-1 for the 10-year, 6-hour storm.

5.0 SUMMARY OF RESULTS AND RECOMMENDATIONS

This section highlights the locations in the existing diversion channel where remedial work may be needed in order to approximate the hydraulic conditions in the natural channels adjoining the diversion. First the conditions in these natural channels will be discussed, then the conditions in the diversion channel will be discussed. The cross sectional shape of each analyzed section of natural or man-made channel is given on Figure 3-2A or 3-2B. The hydraulic performance of each section during the estimated peak flow from the 10-year, 6-hour storm is shown in Table 3. All velocities and stresses discussed below pertain to this storm.

The natural channel upstream of the diversion channel (Station 0+00) has a bed slope of 2.65 percent, a velocity of 12.1 ft/sec, and a tractive power of 18.8 lb/ft-sec. In the vicinity of Station 36+00, the diversion channel joins with another natural channel which has a bed slope

Table 3

SUMMARY OF N14 DIVERSION CHANNEL HYDRAULIC ANALYSIS

	INPUT TO MANNING EQUATION					CALCULATED OUTPUTS					
	Roughness						Velocity (fps)				
Station	Left Over-Bank	Channel	Right Over-Bank	Bed Slope (ft/ft)	Flow* Rate (cfs)	Flow Depth (ft)	Left Over-Bank	Channel	Right Over-Bank	Tractive Stress (lb/ft^2)	Tractive Power (lb/ft-sec)
Natural Channel Upstream of Diversion Channel 0+00	.030	.022	.030	.0265	243	1.9	0.0	12.1	2.3	1.6	18.8
5+00	.030	.022	.030	.0050	244	2.1	2.2	6.8	2.1	0.4	2.8
19+80	.030	.022	.030	.0118	288	2.5	0.0	10.6	2.7	0.8	7.9
28+00	.030	.022	.030	.0160	293	2.2	0.0	11.3	0.0	1.5	17.1
33+00	.030	.022	.030	.0548	291	2.1	0.0	18.8	0.0	4.4	83.3
35+50	.030	.022	.030	.0900	293	1.0	0.0	16.8	0.0	4.2	70.9
(Break in Slope) 35+50	.030	.022	.030	.0400	292	1.2	0.0	12.9	0.0	2.3	29.7
Inflow from Natural Channel	.030	.020	.030	.0192	286	1.9	2.3	11.9	1.5	1.4	16.0
42+10	.030	.022	.030	.0273	574	3.1	0.0	17.3	0.0	3.3	57.0
69+70	.030	.022	.030	.0271	728	2.4	0.0	14.7	0.0	2.6	37.5

*Flowrates may vary slightly from Table 2 because of 1 cfs tolerance in Manning Equation calculations.

of 1.92 percent, a velocity of 11.9 ft/sec, and a tractive force of 16 lb/ft-sec. The replaced natural channel below this junction originally continued 4000 feet and discharged as a major side inflow into Moenkopi Wash. As flow entered the relatively flat slope and broad cross section of Moenkopi Wash, flow velocity was reduced, leading to deposition of the N14 region sediment in Moenkopi Wash.

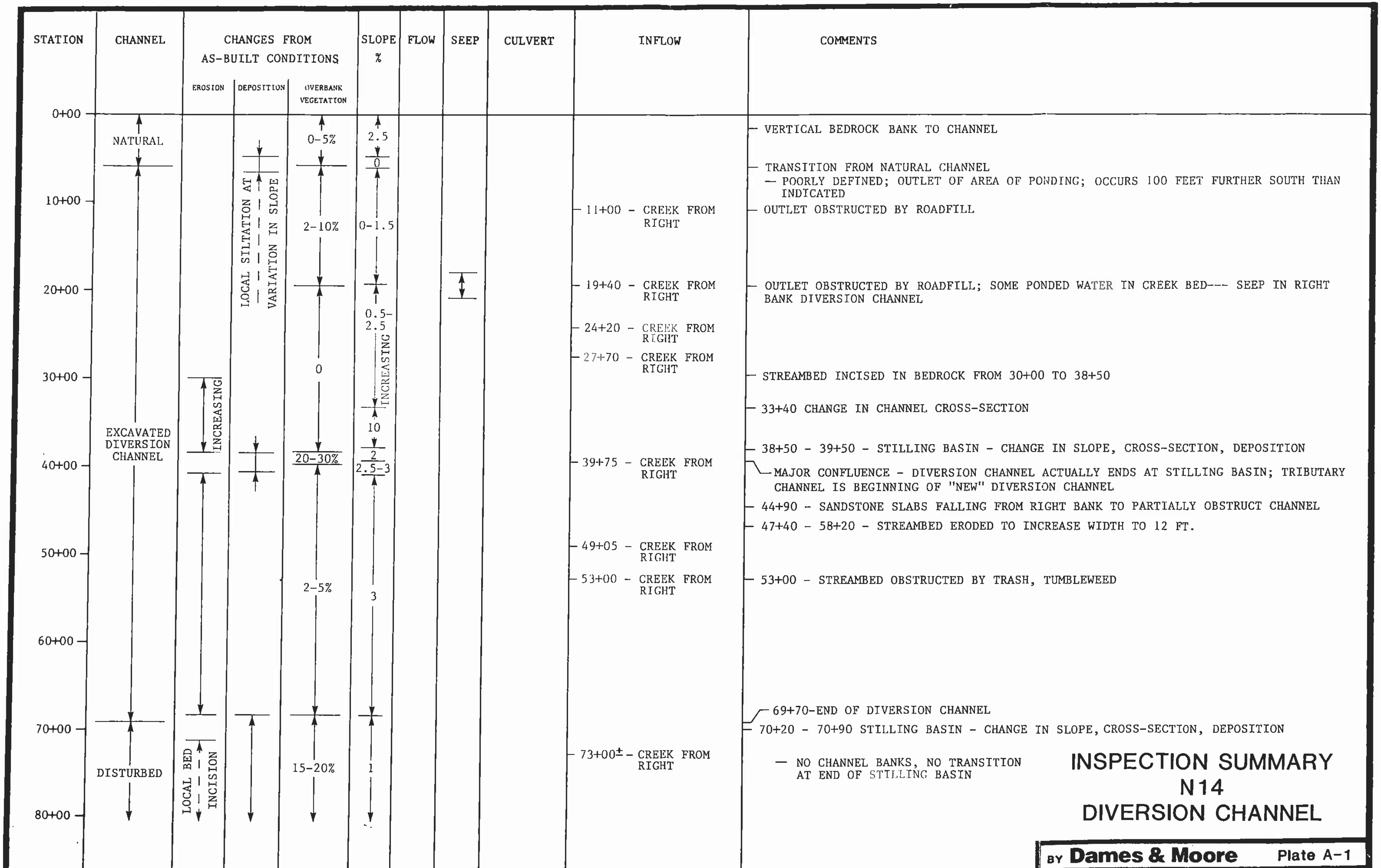
The transition between the natural and man-made channels at the upstream end of the diversion channel is not smooth (see Plate A-1). The bed slope abruptly flattens from 2.17 percent to less than 0.5 percent, with an equivalent abrupt drop in velocity and tractive power (see Stations 0+00 and 5+00 in Table 3). There is deposition in this upper reach of the diversion channel. In the region of Station 30+00, the diversion channel bed slope is increased steadily up to 10 percent so that the diversion channel can join with the natural channel bed at Station 40+00. In this reach the low flow channel has eroded down to bedrock. The steep slope immediately before the junction with the natural channel has been covered with riprap which in turn has been covered with silt during normal low flows. It can be expected that this riprap will be uncovered during high flows, such as runoff from the 10-year, 6-hour storm. From the junction with the natural channel to the end of the diversion channel, the bed slope is 2.7 percent, the velocity is 14.7 to 17.3 ft/sec, and the tractive power is 38 to 57 lb/ft-sec. All these figures are substantially increased over the corresponding figures in the upstream natural channel. The low flow channel in this region is actively eroding (see Plate A-1, Station 42+10). The channel diversion discharges into a sedimentation pond.

The N14 diversion will require earthwork if the channel diversion is required to be similar hydraulically to the natural channel it replaces. The upper channel slope is too flat, the lower channel slope is too steep, and the current channel cross sections (worsened by erosion) concentrate flow and overly accelerate channel velocities. The effect of the unnatural condition of this diversion channel on the natural condition in the downstream Moenkopi Wash is currently negligible because the diversion channel discharges into a MSHA sedimentation pond (N14-D). Any additional sediments eroded from the overly steep lower portions of the diversion channel are trapped in the pond. It is recommended that any substantial remedial action concerning this diversion be postponed until the ultimate fate of the temporary MSHA sediment pond is determined. A substantial channel redesign may be required at the end of the life of the pond.

The N14 diversion channel has sufficient capacity to handle the 10-year, 6-hour storm, although in the region of Station 19+80 there is only 0.5 foot freeboard. This situation will be corrected. In all other regions, the computed depths of flow were well within the outer limits of the overbank region.

* * *

Plate A-1 is attached and completes this report.



INSPECTION SUMMARY N14 DIVERSION CHANNEL

BY Dames & Moore

Plate A-1

REPORT

N14-S Diversion Channel

Kayenta and Black Mesa Mines

Navajo County, Arizona

for

PEABODY COAL COMPANY

Dames & Moore
10139-011-22

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1.0 INTRODUCTION

The N14-S diversion channel is an earth-cut channel, designed and constructed by Peabody Coal Company as a permanent realignment of a natural channel for the purpose of facilitating mining and construction of leg 21 of the conveyor extension. A schematic of the diversion channel is shown on Figure 1-1.

This inspection report contains information specific to the N14-S diversion channel. Regional site information is presented in the "General Report, Kayenta and Black Mesa Mines, Navajo County, Arizona, for Peabody Coal Company". The methods used for hydrologic and hydraulic analyses are discussed in "Methodology for Analysis of Existing Diversions for Peabody Coal Company".

2.0 INSPECTION

The N14-S diversion channel was inspected on October 6, 1985 by a Dames & Moore engineer. The primary purposes of the inspection were: 1) to determine the stability of the constructed channel relative to the existing natural channels upstream and downstream of the diversion channel, and 2) to collect data necessary for the hydraulic evaluation of the existing channel.

The site inspection revealed that the entire inspected channel length had a dry channel bed. Because of this, the channel was classified as ephemeral, carrying short duration flows only immediately following rainfall events. The capacity and stability of the channel are therefore evaluated in this report for the 10-year, 6-hour storm as required by 30 CFR 816.43.

Results of the field inspection are included in this report as Plate A-1. In Plate A-1, regions of visible channel aggradation and degradation are delineated, and transitions between the diversion channel and existing natural channels are specifically addressed. The locations where channel hydraulic parameters (flowrate, slope, cross section, shape and roughness) change significantly are also identified in Plate A-1.

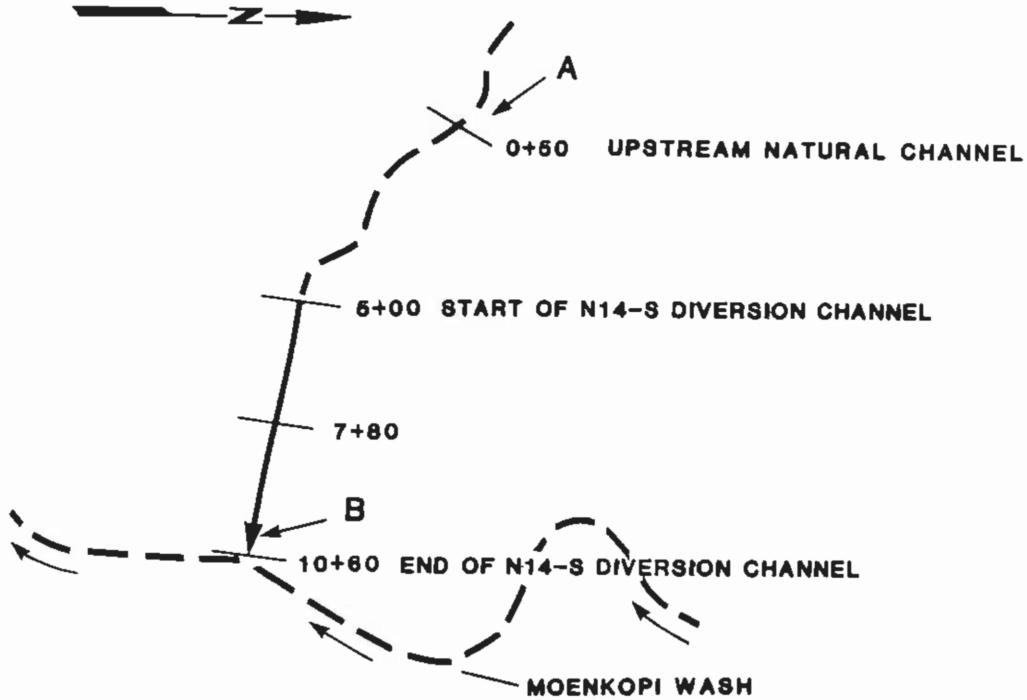
3.0 SITE DESCRIPTION

3.1 LAND USE

The N14-S diversion channel provides drainage for runoff from the two minor watersheds shown on Figure 3-1, Hydrologic Areas. The largest contributing area, labeled A on Figure 3-1, consists of 36 percent Pinion/Juniper, and 64 percent Sagebrush/grass. The topography of the channel and its tributary watersheds is shown on Drawing #85405 (1 inch equals 2000 feet). Coordinates for channel cross sections are given on Figure 3-2.

3.2 EXISTING CHANNEL DESIGN AND CROSS SECTIONS

The existing diversion cross section has side slopes varying from 1:1 to 3:1 (horizontal to vertical) and a channel bed that varies in width between 4 and 6 feet with an average width of about 5 feet. The channel bed has a low flow channel of relatively clean sand and the remainder of the bed



A — INFLOW FROM HYDROLOGIC AREA A (SEE FIGURE 3-1)

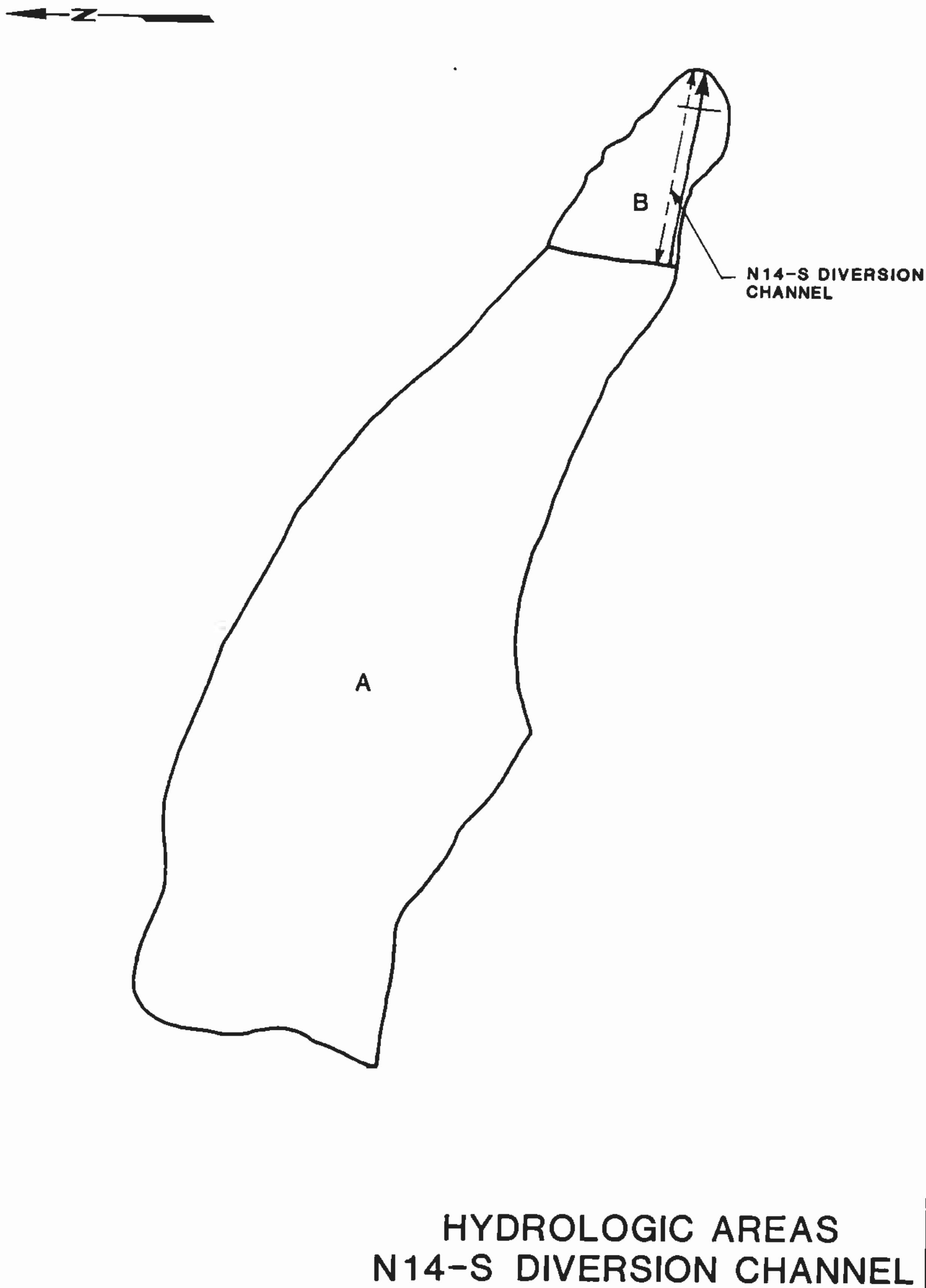
0+00 — SURVEYED CROSS-SECTION (SEE FIGURE 3-2)

COORDINATES OF CROSS-SECTIONS GIVEN ON FIGURE 3-2

SCHEMATIC
N14-S DIVERSION CHANNEL

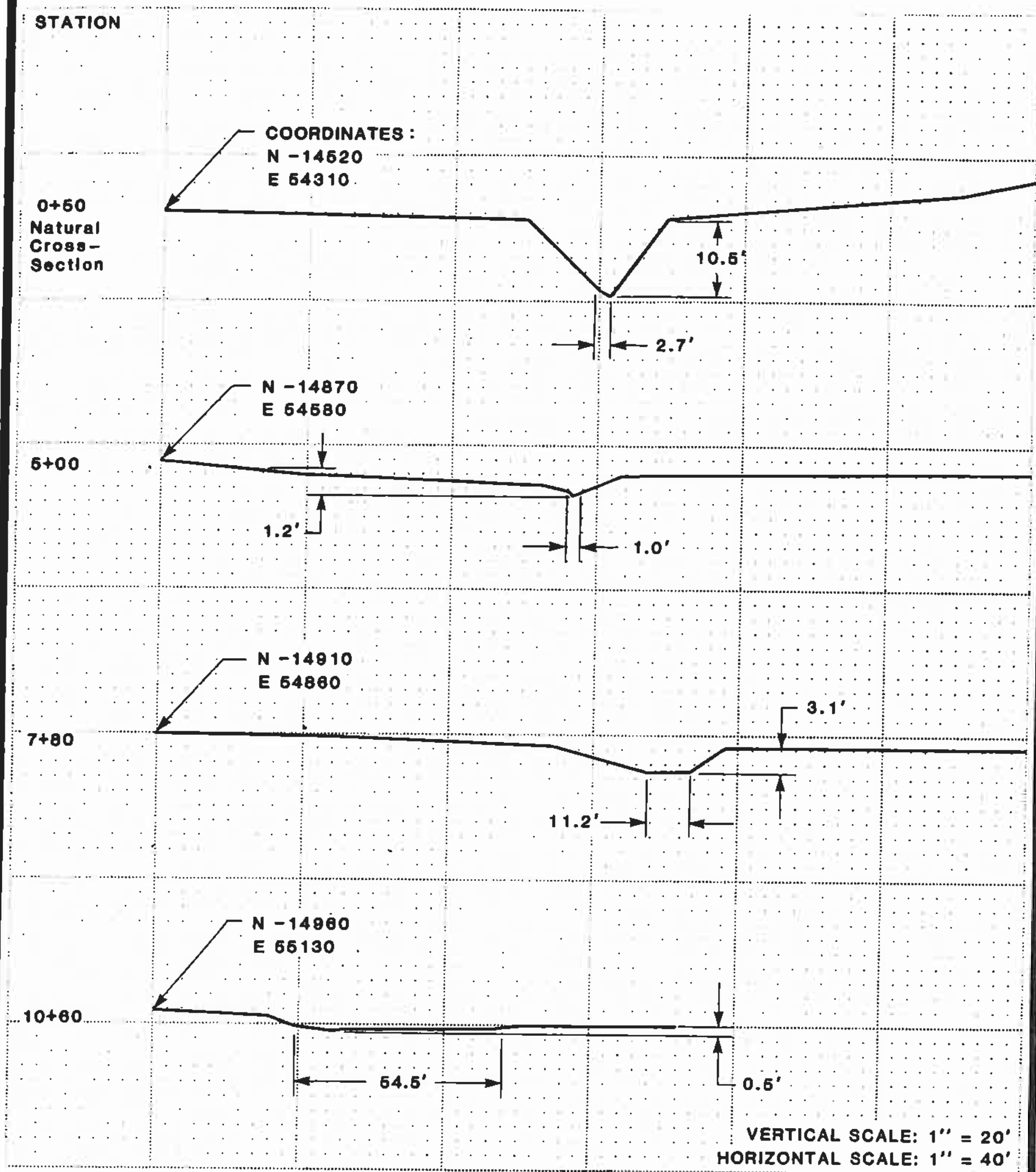
NOT TO SCALE

BY **Dames & Moore** Figure 1-1



HYDROLOGIC AREAS
N14-S DIVERSION CHANNEL

BY Dames & Moore Figure 3-1



CROSS-SECTIONS
N14-S DIVERSION CHANNEL

BY Dames & Moore Figure 3-2

and side slopes generally have 10 to 20 percent vegetation. Minimum depth of the channel is 0.5 feet, at the downstream end, where the channel discharges into Moenkopi Wash.

4.0 ANALYSES

4.1 HYDROLOGY

The hydrologic analysis was completed using the U.S. Army Corps of Engineers generalized computer program HEC-1, Flood Hydrograph Package. The program was set up to use the SCS dimensionless unit hydrograph method. Curve numbers derived for the tributary watersheds are shown on Figure 3-1, and tabulated in Table 1. Peak flows for each watershed (predicted by HEC-1 for the 10-year, 6-hour storm) are also shown in Table 1. Table 2 shows the results from HEC-1 after the hydrographs from each watershed are added to and routed with the main channel hydrograph utilizing appropriate lag times.

4.2 HYDRAULICS

The capacity and stability of the N14-S diversion channel and the natural channel immediately upstream of the diversion channel were evaluated. Cross sections were chosen and surveyed at the approximate midpoints between locations of lateral inflows into the channel. With the assumption of uniform flow in the region of these cross sections, and from the Manning equation, critical hydraulic parameters were calculated. Chosen parameters and calculated results are shown in Table 3. Flowrates in Table 3 are those predicted by HEC-1 for the 10-year, 6-hour storm.

Table 1

SUMMARY OF N14-S DIVERSION CHANNEL HYDROLOGIC ANALYSIS

	Subwatershed Identification	
	A	B
Drainage Areas (acres)	36	4
10-year, 6-hour storm		
SCS Curve Number	80	60
Lag Time (hrs)	0.099	0.032
Peak Flow (cfs)	23	<1
Method of Analysis	-HEC-1, using SCS dimensionless unit hydrograph-	

Table 2

FLOWRATES AT N14-S DIVERSION CHANNEL STATIONS

Station	HEC-1 Flowrates (cfs)
	Storm 10-year, 6-hour
5+00 Upstream End of Diversion Channel Inflow from A	23
9+50 Inflow from B	23
Downstream End of Diversion Channel 10+60	22

Table 3

SUMMARY OF N14-S DIVERSION CHANNEL HYDRAULIC ANALYSIS

	INPUT TO MANNING EQUATION					CALCULATED OUTPUTS					
	Roughness						Velocity (fps)				
Station	Left Over Bank	Channel	Right Over Bank	Bed Slope (ft/ft)	Flow* Rate (cfs)	Flow (ft)	Left Over Bank	Channel	Right Over Bank	Tractive Stress (lb/ft^2)	Tractive Power (lb/ft-sec)
Natural Channel Upstream of Diversion Channel 0+50	.035	.022	.035	.061	23	0.9	0.0	10.1	0.0	1.8	18.0
5+00	.030	.022	.030	.036	24	0.8	0.0	6.5	0.0	0.8	5.3
7+80	.030	.022	.030	.038	24	0.4	0.0	5.7	0.0	0.7	3.8
10+60	.030	.022	.030	.042	23	0.2	0.0	3.6	0.4	0.3	1.2

* Flows may differ slightly from Table 2 because of a 1 cfs tolerance in calculations.

5.0 SUMMARY OF RESULTS AND RECOMMENDATIONS

This section highlights the locations in the existing diversion channel where remedial work may be needed in order to approximate the hydraulic conditions in the natural channels adjoining the diversion. First the conditions in these natural channels will be discussed, then the conditions in the diversion channel will be discussed. The cross-sectional shape of each analyzed section of natural or man-made channel is given on Figure 3-2. The hydraulic performance of each section during the estimated peak flow from the 10-year, 6-hour storm is shown in Table 3. All velocities and stresses discussed below pertain to this storm.

The natural channel upstream of the diversion is essentially a steep natural draw rather than a channel. The natural velocity in the draw is 10.1 ft/sec and the natural tractive power is 18.0 lb/ft-sec. The channel diversion occupies the remainder of this natural draw and empties as a minor side inflow (23 cfs for the 10-year, 6-hour storm) into the substantially larger Moenkopi Wash. The natural condition is therefore erosion in the steep upper reaches of the natural draw and deposition as the draw empties into the much flatter slope of the wash.

The diversion channel is short in length (560 feet) and changes from a triangular shaped narrow upstream cross section to a trapezoidal, broad cross section downstream (see Figure 3-2). Velocity and tractive power are steadily reduced as the cross section expands (see Table 3), and deposition will occur along the full reach of the diversion channel.

No substantial remedial action is required to make the diversion channel behave hydraulically like the replaced natural draw during the 10-year, 6-hour storm. Field inspection (see Plate A-1) and hydraulic modeling at high flow show the channel diversion will provide sediment deposition in the downstream natural wash. This deposition is the natural condition.

The N14-S diversion channel has sufficient capacity to carry the runoff from the 10-year, 6-hour storm. Computed depths of flow for all cross sections were well within the outer limits of the overbank region, except in the extreme lower end of the channel where freeboard drops to less than half a foot.

* * *

Plate A-1 is attached and completes this report.

STATION	CHANNEL	CHANGES FROM AS-BUILT CONDITIONS: EROSION	DEPOSITION	OVERBANK VEGETATION	SLOPE %	FLOW	SEEP	CULVERT	INFLOW	COMMENTS
0+00 – 5+00	NATURAL	STREAMBED INCISION	LOCAL OVERBANK DEPOSITION	40%	4					
5+00										TRANSITION FROM NATURAL CHANNEL — POORLY DEFINED; NO CHANNEL BANKS AT TRANSITION
5+00 – 10+60	EXCAVATED DIVERSION CHANNEL			10-20%	3					NO EVIDENCE OF REGULAR, SEASONAL FLOW; EROSION FEATURES APPEAR RELATED TO ERRATIC RUNOFF EVENTS
				80%						
		↕		20%						
10+60										10+60–END OF DIVERSION CHANNEL — NO TRANSITION
10+60 – 15+00	MOENKOPI WASH				0.8-1					

INSPECTION SUMMARY
N14-S
DIVERSION CHANNEL

BY Dames & Moore — Plate A-1