QUARTERLY REPORT NO. 1

(FOR PERIOD ENDING NOVEMBER 30, 1974)

ENVIRONMENTAL BASELINE DATA COLLECTION
AND
MONITORING PROGRAM

FEDERAL PROTOTYPE OIL SHALE LEASING PROGRAM

TRACTS U-a and U-b

UTAH

WHITE RIVER SHALE PROJECT

vtn

United States Department of the Interior

GEOLOGICAL SURVEY
CONSERVATION DIVISION
AREA OIL SHALE SUPERVISOR
P.O.BOX 2939
GRAND JUNCTION, COLO.81501

Telephone: 303-242-0731,Ext.281,282
FTS: 303-242-3281,3282

February 12, 1975

Quart. Report #1 - Nov 30 - Ua-Ub

The attached report is the first of a planned series of reports from the Federal Oil Shale Lessees to the Area Oil Shale Supervisor describing progress under approved exploration and baseline data plans.

The purpose of these reports is to provide interested parties with a review of ongoing operations and a summary of the data being collected. Because of the sheer volume of data being generated, these reports should be considered as the first (overview) phase of planned data distribution. Parties interested in reviewing more detailed data on specific portions of the program should contact the Area Oil Shale Office in Grand Junction where such data will be kept on file.

We would appreciate receiving any comments or suggestions you may have concerning these reports.

Reese Madsen - Moderator

Peter A. Rutledge
Area Oil Shale Supervisor

ERRATA

Page	
9, Para. 3	Last line should read, "with a conductivity of 1750 mmhos/cm."
12, Para. 2	Second line should read, "with a conductivity of 1950 mmhos/cm."
22, Para. 1	Third line should read, "period ending November 30, 1974. The major part of the period was devoted to equipment construction and installation."
29, Para. 3	Delete "which measured" from first line.
35, Para. 3	Last sentence - Equisetum should be underlined.
37 and 38	Should be headed "Table 4" and "Table 4 (cont.)"
39	Should be headed "Table 5"
56	Footnote to table, second line, should read, "MM ± 250 ft. to MM -160 ft."

QUARTERLY REPORT #1

(For Period Ending November 30, 1974)

ENVIRONMENTAL BASELINE DATA COLLECTION AND MONITORING PROGRAM

FEDERAL PROTOTYPE OIL SHALE LEASING PROGRAM TRACTS U-a AND U-b, UTAH

Prepared For

WHITE RIVER SHALE PROJECT

Prepared By

VTN COLORADO

February, 1975

TABLE OF CONTENTS

		Page
I.	INTRODUCTION	1
II.	WATER RESOURCES	4
III.	AIR RESOURCES	22
IV.	BIOLOGICAL RESOURCES	31
V.	GEOLOGY AND SOILS	45
VI.	HISTORIC AND SCIENTIFIC RESOURCES	48
VII.	FISH AND WILDLIFE MANAGEMENT PLAN	54
VIII.	GEOLOGIC EXPLORATION PROGRAM	55
IX.	REVEGETATION STUDIES	59

APPENDICES

A. WATER QUALITY DATA

B. DESCRIPTION OF THE AIR QUALITY BASELINE MONITORING PROGRAM

C. GEOLOGY & SOILS

1. Soils Chemistry Data
2. Infiltration Test Results

D. SCOPE OF GEOLOGIC EXPLORATION PROGRAM

E. REVEGETATION PROGRAM

LIST OF TABLES

		Page
1.	Stream Gaging Stations White River and Evacuation Creek	10
2.	Well Data; Tracts U-a and U-b	14
3.	Log of Air Monitoring Data	25
4.	Terrestrial Vertebrate Species Observed by USU Personnel, October 1974	37
5.	Terrestrial Vertebrate Species Observed by USU Personnel, December, 1974	39
6.	Cultural Resources	50
7.	Paleontological Resources	51
8.	Proposed Drill Holes	56

I. INTRODUCTION

The lessees of the Federal Prototype Oil Shale Tracts U-a and U-b are pleased to submit the first quarterly report to the Area Oil Shale Supervisor. Tract U-a was leased from the Department of Interior by Phillips Petroleum Company and Sun Oil Company in May, 1974. Tract U-b was leased by Phillips Petroleum, Sun Oil and SOHIO Petroleum Corporation in June 1974. Since these tracts are contiguous, a joint operating group, designated as the White River Shale Project, has been charged with the responsibility of fully developing the prototype lease tracts.

Prior to undertaking this development, the Area Oil Shale Supervisor must approve an environmental baseline study and a Detailed Development Plan along with an environmental assessment of the Detailed Development Plan.

On July 1, 1974, the lessees of Tracts U-a and U-b submitted to the Area Oil Shale Supervisor a "Partial Exploration Plan Environmental Baseline Data Collection and Monitoring Element". This plan was designed to fulfill the requirements of the environmental baseline study. On August 28, 1974 the Geologic Exploration Program supplement was submitted. After extensive reviews of the plan by the Oil Shale Environmental Advisory Panel, the Area Oil Shale Supervisor conditionally approved water resources; air resources; and historic, scientific and aesthetic resources

elements of the total program on August 27, 1974; the biological resources section was approved on October 3, 1974; the Geologic Fxploration Program supplement was approved October 16, 1974; and the geology and soils element of the plan was approved November 14, 1974. A revised initial Fish and Wildlife Management Plan will be submitted to the Area Oil Shale Supervisor February 28, 1975. In the near future, guidelines for seismicity program requirements should be issued by the Area Oil Shale Supervisor.

The intent of this first quarterly report is to present an initial data summary, preliminary data interpretation and projected work schedules for programs approved prior to November 30th. Preliminary data interpretations have been attempted only when the nature of the program and the amount of data collected warranted such an effort and produced meaningful results. Finally, the status of programs not yet approved by the Area Oil Shale Supervisor and special study programs are described in this report.

The report period is generally from the start of the program approval dates through November 30, 1974; however, the subsequent progress of activities has been included where helpful in clarifying the direction of certain elements of the program. On the other hand, because of lag time required for data processing and analysis, water quality data is presented only through the month of October.

For convenience, the organization of this report is consistent with the "Partial Exploration Plan Environmental Baseline Data Collection and Monitoring Element" submitted to the Area Oil Shale Supervisor on July 1, 1974.

II. WATER RESOURCES

A. WORK COMPLETED

1. SURFACE HYDROLOGY

During this period 14 stream gaging stations and 14 standard precipitation gages were constructed and installed. Three of these stations included cable ways with cars. All recording instruments for these locations were also installed during the first quarter.

2. GROUND WATER

The ground water program consists of two elements: a drilling program and a monitoring program. The monitoring program was designed to measure water levels and water quality. The drilling program included developing aquifer test sites and drilling pilot holes. Each aquifer test site consists of a pumping well and two observation wells. Water level is measured monthly and moisture is monitored by quarterly neutron logging in 15 holes designed to anticipate spent shale locations for potential leachate migration. Water quality is monitored monthly, quarterly and semi-annually, in accordance with USGS schedules 287, 288 and 289, - respectively.

The procedure followed for the drilling program was to explore the aquifers at each of four sites (P-1, -2, -3 and -4) across the tracts. One pumping well was drilled into each aquifer. The wells were aligned along the dip of the aquifer. Sixteen wells were drilled into the first aquifer on the tracts and

within several miles of the tract boundaries (See Table 2). In order to investigate potential leachate migration, seven moisture monitoring holes were drilled on the tracts and within several miles of the tract boundaries at locations determined by potential spent shale disposal sites (See Table 2). In addition, many aquifer holes may be integrated into the moisture monitoring program as required. Alluvial wells were drilled at those drilling sites containing sufficient alluvium to carry water at least part of the year (See Table 2).

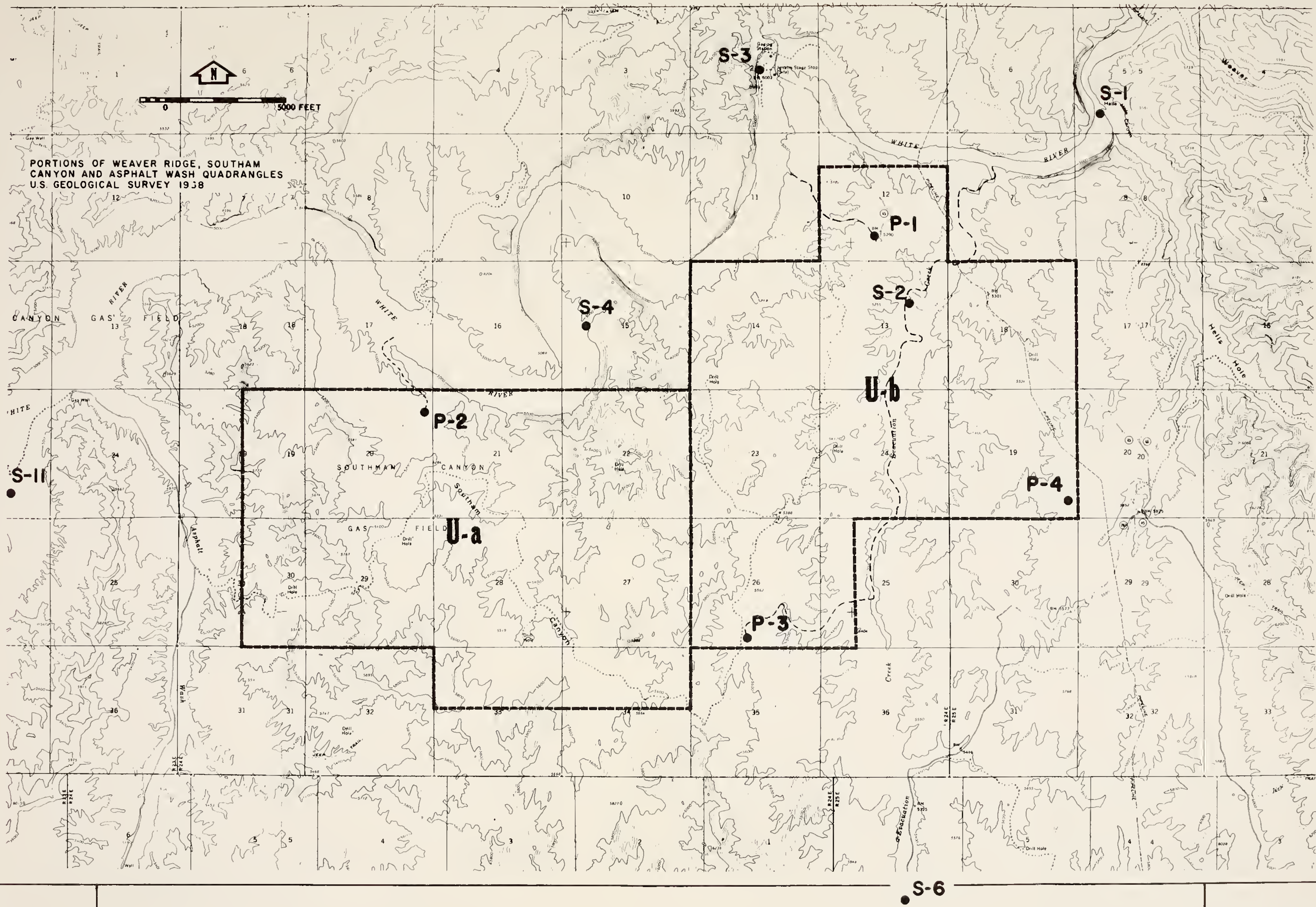
Monitoring programs included monthly measurements of water level and water quality. Water levels are recorded by monthly tape and electric probe measurements at all wells containing water on and within 20 miles of the tract boundaries. Water levels are continuously monitored at the four aquifer test sites at 15-minute intervals utilizing a pressure transducer and punch clock. The data obtained are incorporated into quarterly water level maps together with information derived from the water quality monitoring program. This information included monthly sampling for constituents listed in USGS Schedule 287 and semi-annual sampling for constituents included in USGS Schedule 289.

3. WATER QUALITY

Surface water samples were collected and analyzed during the months of July through October. Samples were taken from the White River and Evacuation Creek, the only live streams in the

project area during the sampling period.

The locations of the sampling points at S-1, S-3, S-4 and S-11 along the White River and S-2 and S-6 along Evacuation Creek are shown on Figure 1.



UTAH FEDERAL OIL SHALE TRACTS

FIGURE 1

B. DATA SUMMARY

1. SURFACE WATER

Data collected included continuous stream level, water temperature, specific conductivity, turbidity and suspended solids. Bi-monthly samples were taken for selected inorganic and organic chemical constituents at the White River and Evacuation Creek stations. Bed sediment samples were taken at all intermittent stream gaging locations.

During this period discharge measurements and sediment samples were being taken every other day at each station. A possible winter modified measuring program is now under consideration by the Area Oil Shale Supervisor due to heavy icing conditions.

Stream gaging stations on the White River and Evacuation Creek are listed in Table 1. All other stations had no recorded flow during this period.

2. GROUND WATER

a. Drilling Program

The following results were obtained from the drilling program at the aquifer test sites:

Site P-1: One aquifer was encountered with a flow of about 55 gpm and a conductivity of 5700 mmhos/cm at 25°C. The pumping hole is 400 feet deep with 8-5/8 inch plain casing used to 320 feet; the hole is open from that point to total

depth. The core hole is 1,238 feet deep. The hole was grouted back to 400 feet, slot perforated 2 1/2 inch outer diameter casing was set from 400 feet to 320 feet, and plain casing was installed to the surface. The hole was gravel-packed from 400 to 300 feet; grout-plugged from 300 feet to 250 feet, gravelled to within five feet of ground surface and grout capped. The pilot hole is 1,388 feet deep and was completed in the same manner as the core hole.

Site P-2: Two aquifers were encountered at this site. The upper aquifer pumping hole was drilled originally as the P-2 pilot hole but caving forced abandonment of the hole at 651 feet. It was grouted back to 378 feet, slotted with 4-1/2 inch outer diameter pipe set from 378 to 200 feet and grout set to surface.

This hole produces a flow of approximately 35 gpm with a conductivity of 2400 mmhos/cm. The aquifer penetrated by the lower aquifer pumping hole lies between 397 and 502 feet and will produce about 750 gpm with a conductivity of 1750 mhos/cm.

The core hole is 1,292 feet deep. It was grout plugged to 519 feet with 1-1/2 inch slotted pipe set from 502 to 397 feet and gravel packed to 380 feet. A grout cap extends between 380 and 331 feet, isolated by slotted 1-1/2 inch pipe set from 325 to 300 feet. Gravel packing was set from 333 to 279 feet with a grout cap from 279 feet to 236 feet. Fill was placed from 36 to 5 feet and a grout cap was placed at the top of the hole.

The pilot hole is 1,350 feet deep. It was completed in a manner

TABLE 1

STREAM GAGING STATIONS
WHITE RIVER AND EVACUATION CREEK

	DISCHARGE Cu. Ft./Sec.		TEMPERATURE Centigrade	CONDUCTIVITY Micro-Mhos/cm	PRECIPITATION Inches
S-1 (White River above Hells Hole Canyon) (09306400)					
OCT. --Mean	451.		6.5 Inc.	772. Inc.	0.89
Max	467.		-	-	
Min	434.		-	-	
NOV. --Mean	428.		3.5	791.	0.23
Max	527.		7.5	904.	
Min	396.		-3.7	774.	
*DEC. --Mean	310.		1.0	810.	0.12
Max	455.		8.0	916.	
Min	174.	Freeze	-5.0	792.	
S-3 (White River near Watson) (09306500)					
OCT. --Mean	439.		6.5 Inc.	790. Inc.	0.16 Inc. (1.00 Est)
Max	490.		-	-	
Min	414.		-	-	
NOV. --Mean	420.		2.8	815.	0.18
Max	463.		6.5	886.	
Min	282.		-0.15	756.	
*DEC. --Mean	300		-0.06	920.	0.16
Max	381.		0.00	948.	
Min	108.	Freeze	-0.10	886.	
S-4 (White River above Southam Canyon) (09306600)					
OCT. --Mean	430.		10.0	767.	1.04
Max	460.		13.5	840.	
Min	412.		6.5	690.	
NOV. --Mean	429.		3.7	812	0.27
Max	457		8.0	916.	
Min	353.		0.0	712.	
DEC. --Mean	320.		0.0	900. Inc.	0.10
Max	405.		7.5	-	
Min	255.	Freeze	-5.0	-	

TABLE 1 (CONT.)

	DISCHARGE Cu. Ft/Sec.		TEMPERATURE Centigrade	CONDUCTIVITY Micro-Mhos/cm		PRECIPITATION Inches
S-11 (White River below Asphalt Wash) (09306700)						
OCT. --Mean	429.		10.3	770.	Inc.	1.00
Max	455.		12.0	-		
Min	410.		7.0	-		
NOV. --Mean	410.		3.6	776.		0.22
Max	470.		8.5	868.		
Min	273.		0.0	772.		
DEC. --Mean	300		1.1	940.		0.14
Max	392.		1.5	978.		
Min	180.	Freeze	0.0	888.		

*Part of this record estimated, some data not returned from computer.
Unchecked records, subject to revision

Stations S-2, S-6 and S-7, Evacuation Creek, had less than 1.0 C.F.S. maximum flow during this period.

similar to the core hole; multiple completion using 1-1/2 inch outer diameter tubing.

Site P-3: At this site one aquifer was encountered which yielded less than 5 gpm with a conductivity of 1950 mhos/cm. The P-3 core hole is 1,220 feet deep. It was grout plugged 1,220 to 400 feet (probable aquifer 490 to 300 feet); slotted with 4-1/2 inch outer diameter pipe set between 400-300 feet and gravel packed from 400 to 296 feet. Plain casing (4-1/2 inch outer diameter) was installed and the hole was cemented to the ground surface.

The P-3 pumping hole is 540 feet deep. Plain 8-5/8 inch casing was set to 340 feet in an 11-inch hole and cemented. The remaining hole, which is 7-7/8 inches in diameter, was left open to 540 feet.

The site observation hole (Hole G-7) is 712 feet deep (4 1/2 inches outer diameter). Plain casing was cemented from 712 to 516 feet. Slotted casing (4-1/2 inches outer diameter) was set from 516 to 340 feet, the hole was gravel packed from 520 to 324 feet, and annulus cemented from 324 feet to ground surface in a 7-7/8 inch diameter hole.

Site P-4: No aquifer was observed at this site. The P-4 core hole was back-filled from total depth to 530 feet. Grout seal was placed from 530 to 500 feet, slotted 4-1/2 inch outer diameter pipe was set from 500 to 370 feet and the hole was gravel-packed to 320 feet. Grout seal was set from 320 to 280 feet and the hole was back-filled to ground surface. Slotted pipe was set to monitor potential inflows during the spring. Sixteen

upper aquifer holes, seven moisture monitoring holes, and six alluvial holes were drilled. Completion data for these holes are included in Table 2.

b. <u>Monitoring Programs</u>

<u>Water Level Monitoring Program:</u> Water levels have been measured monthly in wells drilled during the ground water drilling phase. Measuring is now done just prior to pumping for the purpose of obtaining water quality samples. The continuous monitoring equipment was installed at the P-1,-2 and-3 sites during the period from December 12 to December 18, 1974 and has been in continuous operation since that time.

No wells within 20 miles of the site are accessible except the American Gilsonite wells completed in the White River alluvium. The water in these wells would be in direct hydraulic contact with the White River, and would, therefore, fluctuate in direct response to changes in the level of the river. These wells accordingly have not been measured.

The ground water data are presently being analyzed and will be incorporated into the water level map due in the second quarter report.

<u>Water Quality Monitoring Program:</u> The program was initiated the last two weeks of November, 1974. Samples were obtained for 80 percent of the wells with water. Casing and equipment problems

TABLE 2

WELL DATA, TRACTS U-a AND U-b

WELL NO.	WELL USE	TOTAL DEPTH (Ft.)	PERFORATED INTERVAL (Ft.)	DEPTH TO WATER (Ft.)	COMPLETION DATE	QUANTITY (gpm)
G-1A	C	40	10/40	Dry	12/13/74	-
G-1B	B	200	None	-	1/2/75	-
G-2	B	136	None	Dry	1/2/75	-
G-2A	C	41	16/36	Dry	12/13/74	-
G-3	B	200	None	-	-	-
G-4	B	129	None	-	-	-
G-4A	C	20	5/20	Dry	1/2/75	-
G-5	A/B	620	500/590	456.0	11/25/74	25
*G-6	A	945	905/945	461.0	12/13/74	47
**G-7	A/B	711	340/515	358.0	11/15/74	6
G-8	A/B	127	110/127	53.8 54.6	11/15/74 12/17/74	49
G-8A	A/B	100	20/100	49.7 44.7 44.6	11/21/74 11/21/74 12/10/74	-
G-10	A/B	400	380/400	315.0 314.5 319.5	11/15/74 11/22/74 12/13/74	40
**G-11	A/B	650	500/600	485.5 482.3	11/25/74 12/13/74	32
G-12	A/B	100	30/50	40.8 46.1	11/25/74 12/17/74	10
G-13	A/B	29	19/29	9.6 9.6	11/21/74 12/10/74	16
G-13-A	C	21	6/21	Dry Dry	12/13/74 1/02/75	-

TABLE 2 (CONT.)

WELL DATA, TRACTS Ua AND Ub

WELL NO.	WELL USE	TOTAL DEPTH (Ft.)	PERFORATED INTERVAL (Ft.)	DEPTH TO WATER (Ft.)	COMPLETION DATE	QUANTITY (gpm)
G-14	A/B	90	65/90	40.3	11/15/74	
				42.3	11/21/74	150
				40.3	12/10/74	
G-15	A/B	627	547/627	513.8	10/23/74	3
				511.0	11/16/74	
				510.4	12/11/74	
G-16	A/B	77	53/77	28.6	11/26/74	82
				28.5	12/10/74	
G-16A	A	193	165/193	Flow	11/26/74	5
				Flow	12/10/74	
G-16B	C	31	10/31	Dry	12/10/74	-
				Dry	1/02/75	
G-17	B	220	200/220	79.0	12/17/74	5
G-18	B	60	None	-	-	-
G-18A	C	31	10/31	Dry	11/26/74	-
				Dry	1/02/75	-
G-19	C	800	None	Dry	12/10/74	-
				Dry	-	-
G-20	A	70	60/70	9.9	11/15/74	97
				8.8	11/26/74	
				8.7	12/10/74	
G-21	A	612	572/612	430.0	12/12/74	7
				430.0	12/30/74	
G-22	A	621	546/676	500.25	1/02/75	30

TABLE 2 (CONT.)

WELL NO.	WELL USE	TOTAL DEPTH (Ft.)	PERFORATED INTERVAL (Ft.)	DEPTH TO WATER (Ft.)	COMPLETION DATE	QUANTITY (gpm)
P-1 pump	A	400	Open Hole 320/400	279.0 279.8	11/20/74 12/12/74	58
P-2 pump 1	A(upper)	419	200/378	253.20	1/02/75	35
P-2 pump 2	A(lower)	510	390/500	159.0 158.0	11/27/74 12/11/74	450
P-3 pump	A		Open Hole 340/540	352.0 489.0 431.0	11/16/74 11/27/74 12/12/74	5
P-4	A	400	340/400	274.4	1/02/75	5

1/ A - aquifer monitoring well

B - moisture monitoring well

C - alluvial well

2/ Depths given from top of casing. Casings extend 3± feet above ground surface.

3/ Flow rates were flume measured during drilling

TABLE 2 (CONT.)

* A blockage exists in this hole at 150 feet. A water level of 97 feet was recorded when the well was completed in early November. The attempt to pump the hole on November 21, 1974 lowered the water level to 145 feet. Attempts to thief sample the hole December 22, 1974 revealed the blockage which consists of rock chips. Attempts will be made to clear the blockage with the dummy pump during the January pump program. If that method fails one of the rigs now on site will be employed.

** In the same aquifer and within 300 feet of P-3 pump; continuous monitoring equipment was installed in this well so the P-3 pump (which has a larger diameter) is available for pump sampling.

*** In the same aquifer as nearby Hole G-22. Hole G-11 will serve as the measuring and pumped sample well. Measurements were taken at Hole G-22 on January 2, 1975 while drilling was underway at Hole X-4 nearby.

prevented a full canvass of all wells in nine days. All samples were submitted to the USGS labs under Schedule 289. The December sampling program initiated on December 10, 1974 was completed in five working days. All wells were sampled. Pumped samples were obtained from all wells except Holes G-6, G-8, G-12 and G-21. These wells were thief sampled and will continue to be sampled in that manner, either because of casing irregularities or because the groundwater quantity is not sufficient to sustain a pumping rate of 8 gpm. All samples have been submitted to the USGS lab under Schedule 287. No analyses have been received to date.

Moisture Monitoring Program: The first neutron logging operation is expected to begin in March. Seven holes were designed specifically for moisture monitoring, and are included in Table 2. When the mining plan is fully developed and the location of spent shale deposits more accurately known, nine additional holes can be integrated into the moisture monitoring program as needed.

3. WATER QUALITY

Table A-1 in Appendix A, gives the maximum, minimum mean and number of samples for each constituent analyzed. Interpretation and correlation will be performed when data have been collected for a full water year. However, in light of the limited data presented in this reporting period, variance in data between stations

on the White River and on Evacuation Creek does not appear to be significant. A statistical analysis of variance will be performed after a sufficient number of samples has been analyzed over a meaningful water season. It appears that the quality of the water in Evacuation Creek is not suitable for domestic, irrigation, or industrial use without substantial treatment. Dissolved solids averaged about 5000 mg/l during the months of July through October. High concentrations of hardness, sulfates, and boron also contribute to the poor utilization potential of the Evacuation Creek water. However, this water may be used for consolidation and compaction of processed shale which would have the added benefit of a reduction of the dissolved solids load to the White River.

Limited water quality data on the White River makes it difficult to estimate its use as a domestic supply. Although relatively high concentrations of sulfate, boron, iron, manganese and aluminum were indicated in July after a substantial surface runoff, the concentrations of these constituents during the remainder of the report period were acceptable in terms of the Public Health Service Drinking Water Standards of 1962. Since July through October is a relatively low flow period, this very preliminary data indicates that the White River water may be suitable for domestic use with some treatment.

C. WORK SCHEDULED

1. SURFACE WATER

Since the installation of all the surface water stations is complete, monitoring will continue as is outlined in the approved Water Resources Program.

2. GROUND WATER

a. Aquifer Tests

Aquifer tests are tentatively scheduled at Holes P-1, 2 and 3 for the middle part of April 1975 pending approval of discharge permits by the EPA. These tests are to be run a minimum of 24 hours at each site, but longer periods of up to 30 days may be desirable in order to distribute the pumping influence over the widest area possible. The duration of each test will be determined by the stabilization of drawdown at the test sites, and at aquifer wells distributed around and near the tracts. The program will require that a pumping contractor be retained whose equipment is capable of pumping and recording flow rates ranging from 3 to 750 gallons per minute.

Continuous monitoring equipment consisting of two 50 psi pressure transducers and punch clocks set at two-minute intervals will be available to monitor drawdown at the pumping sites. In addition, at least four men will be required during the first 24 to 48 hours of each test to calibrate instruments and monitor drawdowns in other wells in the area.

b. Water Level Monitoring Program

This program will be continued in conjunction with the pumped water quality program. The most recent scheduled measurements were taken the second two weeks of January 1975.

c. Water Quality Monitoring Program

Pumped sampling began during the second two weeks of January 1975.

3. WATER QUALITY

Water quality samples will be collected and analyzed in accordance with the surface and ground water hydrology programs as approved by the Area Oil Shale Supervisor.

III. AIR RESOURCES

A. WORK PERFORMED

1. OVERVIEW

This report describes the results of the air resources monitoring program on Tracts U-a and U-b during the three-month period ending November 30, 1975. The major part of the period period was devoted to equipment construction and installation. The first measurements began on November 8 and most phases of the measurements were in progress by November 30.

Some of the details of the air monitoring system have changed since the project design was originally presented to the Area Oil Shale Supervisor. These changes have come about because of requirements by the Oil Shale Supervisor or the Bureau of Land Management, or due to practical considerations which became evident when the planned program was applied in the field. The form into which the program has evolved is summarized in Appendix B.

2. MONITORING TASKS PERFORMED

Installation of air quality and meteorological equipment began in the tract area early in October and the first usable meteorological measurements were obtained November 8, followed

by the first air quality measurements on November 12. Startup and stabilization of additional monitoring stations followed rapidly, with three of the four purely meteorological sites operational on November 23, along with five of the eight air quality sites.

Further progress in completing monitoring system startup was impeded by the unexpected failure of the electrical generators at all five of the air quality trailers between November 23 and 27, after about 500 hours (about 3 weeks) of running time. Inspection disclosed the likelihood of a subsequent repeated failures; therefore, different generators were ordered to replace these units, with installation in early December, and the defective systems were returned to the manufacturer.

Another air quality station (with a different generator) began monitoring on November 27 so that on November 30 there were three operational meteorological sites and one air quality station.

Despite the generator problems, useful data were obtained during this time. Table 3 shows which components were monitored in November and gives the first date on which data was obtained. Data was collected continuously through the end of November, 1974.

Table 3 shows that no data was obtained from Site A1, although the station became operational on November 13. Flaws in both

data recording instruments at that site has made data recovery there impossible by conventional means but some data retrieval may still be possible. Initial operating problems are to be expected in new instruments, and these difficulties are unlikely to reoccur.

In summary, this quarter was a startup period in which some useful data was obtained, even though the full scope of the air resources program could not be attained.

B. DATA SUMMARY

The data base available so far is not amenable to significant statistical treatment, so most of the following discussion is more qualitative than would ordinarily be presented. For reference, all of the data which is tabulated in the Raw Data volume are given in terms of one-hour averages, with averages over the month computed (where appropriate) for each hour of the day, as well as averages computed for each day. For pollutants, peak hourly averages and their times are displayed, as are the values and times of peak three-hour and eight-hour averages when an air quality standard is based on averages over those periods.

The treatment of wind speed data is identical to that for pollutants. For wind direction the direction at the time of peak wind speed is given, as are the daily prevailing wind direction and the monthly prevailing wind directions during each hour of the day.

1. METEOROLOGY

The most striking feature of the surface wind data is its variability and the lack of correlation in either wind speed or direction from site to site. The topography in the area is complex and rugged, and this is an expected consequence of topographic effects. In general, the mean wind speeds are quite low at this time of the year, averaging about 2.5 mph

B. DATA SUMMARY

The data base available so far is not amenable to significant statistical treatment, so most of the following discussion is more qualitative than would ordinarily be presented. For reference, all of the data which is tabulated in the Field Data volume are given in terms of one-hour averages, with averages over the month computed (where appropriate) for each hour of the day, as well as averages computed for each day. For pollutants, peak hourly averages and their times are displayed, as are the values and times of peak three-hour and eight-hour averages when an air quality standard is based on averages over those periods.

The treatment of wind speed data is identical to that for pollutants. For wind direction the direction at the time of peak wind speed is given, as are the daily prevailing wind direction and the monthly prevailing wind directions during each hour of the day.

1. METEOROLOGY

The most striking feature of the surface wind data is its variability and the lack of correlation in either wind speed or direction from site to site. The topography in the area is complex and rugged, and this is an expected consequence of topographic effects. In general, the mean wind speeds are quite low at this time of the year, averaging about 3.2 mph

in the river valleys and 4.2 mph over the more elevated ridges. Thus wind speeds over the ridges tend to average about 1.0 mph more than wind speeds in the more protected valleys, although 10 mph differences in hourly average speeds are not uncommon on windier days when 15 mph winds occur over the ridges. Periods of dead calm could occur occasionally at any hour of the day at all but the most elevated sites.

The main topographic effect on wind is on the wind direction. The prevailing daytime wind on the tracts was generally from the west, although wide variability existed from site to site. The weaker nighttime drainage winds, which are most influenced by topographical factors, could occur at the same time from a different sector at each site. Assessment of regions of convergence or divergence is not practical until more data is obtained, although the likelihood of the existence of such regions, with their prevailing updrafts or downdrafts, is high.

Average temperatures hovered around the -2°C mark, with extremes in hourly averages ranging from below -22°C to above 10°C in the canyons, with a smaller range of -15°C to 10°C in the more open elevated terrain. These large temperature differences, coupled with the generally clear skies which prevailed during November, resulted in the observed topographically controlled surface drainage flows of air.

2. AIR QUALITY

The air on the tracts is very clear, as might be expected, but surprisingly is not totally free of contamination.

Levels of the sulfur compounds (SO_2, H_2S) lie just slightly above the detection limits of the instruments. The SO_2 levels average less than 15 per cent of the 80 ug/m^3 federal annual average standard, and represent an even smaller fraction of the standards for shorter periods. There was a pronounced diurnal variability in the concentrations of the sulfur compounds, with levels in the late afternoon being higher than at any other time. Concentrations of sulfur compounds were higher at Site A-7 than at Site A5, by a factor of 2 to 3, but the smallness of the measured values makes this difference not very significant unless additional data from other stations corroborates the presence of a clear pattern of spatial variability.

Ozone levels on the tract were surprisingly high, and frequently exceeded the federal air quality standard by up to 50 percent.* These levels are above the normal ambient background levels of 60-100 ug/m^3 (3-5 pphm) but nevertheless are most probably of natural origin. Two factors which may enter into these high levels are the presence of extremely high mountains

---

*Monitoring at other sites in December has continued to show the same results.

within a few hundred miles of all sides of the tract, with turbulent air flows over them possibly causing more than normal mixing of stratospheric ozone downward to the surface. The absence of significant ozone sinks near the surface because of the low levels of reacting pollutants (e.g., NO), and the absence of vegetation, plus the expected low diffusion near the surface in the calm conditions observed, all combine to preserve the ozone which does arrive in the area. This point will be studied further as more data becomes available, and airborne soundings of O_3 are now planned for later this winter.

Hydrocarbon levels are also above the federal air quality standard of 160 ug/m^3, with values for the "reactive" hydrocarbons (total hydrocarbons less methane) being always three or more times the three-hour 6 - 9 AM standard. This is not unusual because of the considerable presence of petroleum in the area, and natural levels of hydrocarbons above the standard often exist in many areas of the United States. These high hydrocarbon levels could also be another factor contributing to the high ozone levels observed.

The carbon monoxide data from the one station which measured was of poor quality due to obvious contamination of the sample by the generator exhaust. This problem has since been eliminated by a redesign of the exhaust system.

The values which could be used ranged from the normal background level of under 0.5 mg/m^3 up to about three times that level. This range is less than about 10 percent of the federal eight-hour standard of 10 mg/m^3 and a small fraction of the standards for shorter period.

In summary, the area air quality seems to lie at near-background levels, (at least for this period) with natural effects possibly being a cause for the higher-than-normal levels of O_3 and hydrocarbons which were observed. This observation is obviously highly tentative, and further observation, including airborne surveys and measurements by the mobile unit, will be needed before definite conclusions can be made.

C. WORK SCHEDULED

Air quality and meteorological conditions will continue to be monitored in the manner and at the periodic intervals described.

A. WORK PERFORMED

1. VEGETATION

The vegetation studies through November 30, 1974, have consisted primarily of sampling study plots, and preparation of a vegetation communities map which is included in this report (see Figure 2, enclosed in back pocket). Four hundred 2x2 meter study plots, 100 within each of the major vegetation types, have been established and sampled. The parameters surveyed included character, height, number, density, crown spread, bare ground percentage, litter cover, etc. In addition, between 2,000 and 2,800 10x10 centimeter litter production samples have been weighed. All this data is currently being recorded on computer key punch data cards. An existing Utah State University Foundation computer program was modified to meet the specific requirements of the monitoring study. A trial run of approximately 75 cards is in progress to determine the sufficiency of the modified program.

2. TERRESTRIAL VERTEBRATES

Biologists from Utah State University, Logan (USU) made wildlife observation field trips in early October and early December. The first three weeks in December were spent running transacts and trapping rodents. Between December 4 and 9, mammal and bird flushing transects were run and rodent trapping was conducted at Sites WS-1, WS-2, WS-3, and SR-3. Bird and mammal flushing transects were run at Sites WR-1, WR-2, WG-3 and WJ-2 from

December 11 to 15. The same activities were performed at sites WG-1, WG-2, WJ-1, and WJ-3 between December 16 and 21. During this period the tracts were traversed by vehicle or on foot (part of Evacuation Canyon and along both sides of the White River) and observations were made throughout the area, including most of the drilling sites.

3. TERRESTRIAL INVERTEBRATES

Three working visits were made to the site during July and August 1974, July 9 to 11, July 23 to 25, and August 7 to 9. In the course of these visits, various habitats for arthropods were observed and several thousand specimens (mostly insects) were collected. These have been mounted and are being labeled in preparation for preliminary sorting. When this is done, a rough estimate of the number of species in each family will be submitted.

By November thousands of insects had been sorted, mounted, and labeled. Labeling, including locality, date and limited ecological data (such as host plant), was accomplished in September and sorting took place in October. Although identifications were only made to the family level, species were separated in a preliminary fashion.

In subsequent reports more complete classification (to genus and species) will be given to the extent possible and the taxa will be grouped according to the habitat in which they are found and the host plants (if any) on which they were collected.

4. AQUATIC BIOLOGY

Benthic macroinvertebrates were sampled quantitatively with the Surber sampler and Ekman dredge. Qualitative samples were taken by handpicking organisms from stones, sticks and debris, and by holding a section of window screen in the current and disturbing the bottom area upstream of the screen. Organisms captured in the screen were removed and placed in preservative.

Collections from the Surber sampler contained much debris. Organisims were sorted from debris under a dissecting scope and identified to the lowest practical taxonomic category. Many of the nymphs and larvae have not been associated with the adult form in the literature; hence they cannot always be identified to species (e.g., caddis fly larvae of the family Limnephilidae cannot be identified below the family level). The Surber sampler collects the material from one square foot. The number of organisms per square meter is obtained by multiplying the organisms per square foot times 10.76.

The Ekman dredge collects materials from an area 6 inches by 6 inches, or 1/4 square foot. The sample is filtered through a U.S. No. 30 screen. Organisms retained by the screen are preserved and identified in the laboratory. The number of organisms per square meter is obtained by multiplying the number in the collection times 43.1.

Following are descriptions of the monitoring stations used in the aquatic biology program.

Station F-1 is located on the White River at Hell's Hole Canyon confluence (Southwest 1/4, Section 5, T.10S, R.25E). The station includes about 700 feet of pool and 300 feet of rapids. There are several eddies at the face of shale banks and brush piles. The station is located at the bottom of a canyon which is about 300 feet wide at this point.

Station F-2 is located on the White River at its confluence with Evacuation Creek (Northwest 1/4, Section 7, T.10-S, R.-24E). The station includes glides and riffles with some temporary residual pools after periods of high discharge. During periods of low discharge there is considerable braiding (anastomosing) in the riffle area near the top of the station. The riffle is shallow and produces considerable growth of the algae, Cladophora.

Station F-3 is located on the White River, downstream from the Highway 45 bridge to a point near the center of the first bend. Most of the river in this area is a glide. At average discharge rates (320-350 cfs during this report period) the section is approximately 20 inches (50 cm) deep. Several persistent residual pools occur along the right bank. The canyon is relatively broad at this point.

Station F-4 is located on the White River at the confluence of an unnamed canyon on the southwest 1/4, Section 15, T.10-S, R.24E. The station includes a long glide, a wide riffle and several deep pools and eddies around large cottonwood trees which have fallen into the river.

Station F-5 is located on the White River at its confluence with Asphalt Wash on the Northwest 1/4, Section 24 and the Southwest 1/4, Section 18, T.10-S, R.24E. The section includes a long glide, deep rapids, shallow riffles, and meanders along the left bank. The canyon is approximately 2000 feet wide at this point.

Station F-6 is located on Evacuation Creek approximately 1500 feet upstream of the Highway 45 bridge; surface water station S-2 is included in this station. Evacuation Creek is an intermittent stream at this point. Although the flow at this point has been reduced to a negligible amount, ponded water has been present during all visits for biological sampling.

The stations contain a cross section of conditions which are representative of the other areas of the river, i.e., pools, glides, rapids, riffles, etc. Vegetation along the river is quite consistent; the most noticeable plants are cottonwood, willow, tamarisk and Phragmites (carrizo reed). Equisetum (horsetail) is plentiful and many grasses occur.

B. DATA SUMMARY

1. VEGETATION

The first sampling of phenological data is complete, but the second sampling is being postponed because of snow. The raw data from the first computer run is not included, because the printout is coded and cannot be used for trend analysis until more data is gathered. The vegetation map is enclosed.

2. TERRESTRIAL VERTEBRATES

Species observed by VTN and USU personnel during the October and December field visits are listed in Tables 4 and 5. During the December trip, at least three raptor eeries were located with others possible. The number of rodents trapped at Sites WS-1, WS-2, and WS-3 and WR-3 suggests that trapping should continue during the winter months. It may be possible to reduce mortality in the traps to between 10 and 15 per cent by using more cotton and by protecting the traps with canvas covering.

There was generally little activity on the tracts in December. No herptiles or invertebrates were sighted and only one mixed flock of passerines and a few black-billed magpies were observed in the riparian vegetation which was thought might contain some migratory birds. The most important vertebrates sighted were a Golden Eagle and eight Mule Deer. In addition, fresh beaver signs were observed along the White River.

3. TERRESTRIAL INVERTEBRATES

The productivity of the various habitats in the site was assessed on the basis of observation and collection of specimens. The most productive habitats in terms of species diversity were as follows:

a. Ignatio Stage Stop on the White River. Although not on the site, this locality is within the one-mile limit around the site included in the survey area. The principal niches examined

TABLE

TERRESTRIAL VERTEBRATE SPECIES

OBSERVED OCTOBER, 1974

I. BIRDS

	Species	Habitat Type(s)	Comments
1.	Sandhill Crane	Riparian	Flock heard calling, night of October 14.
2.	Spotted Sandpiper	Riparian	One individual.
3.	Mourning Dove	Shadscale, greasewood	Occasional individuals--less common than in Aug.-Sept. 1974.
4.	Common Flicker	Juniper	One individual. Subspecies C.a. cafer.
5.	Hairy Woodpecker	Riparian	One individual, male.
6.	Horned Lark	Shadscale, riparian	Several flocks, numbering 6-100 birds
7.	Pinyon Jay	Juniper	Several flocks, numbering 8-70 birds.
8.	Black-billed Magpie	Greasewood, riparian	Seen singly or in small flocks.
9.	Black-capped Chickadee	Riparian	One flock of about six birds.
10.	Plain Titmouse	Juniper	A couple of groups of 2-4 birds.
11.	Rock Wren	Cliffs near greasewood and juniper	Seen singly or in groups of 2-4 birds--less common than in Aug.-Sept. 1974.
12.	American Robin	Riparian	Occasional individuals.
13.	Swainson's Thrush	Riparian	One individual.
14.	Mountain Bluebird	Greasewood	One flock of about ten birds.
15.	Western Meadowlark	Riparian	Two individuals.
16.	Dark-eyed Junco	Juniper, riparian	Several flocks of 10-50 birds. Subspecies J.h. oreganus.
17.	White-crowned Sparrow	Riparian	Seen singly or in groups of 2-3 birds.

II. HERPTILES

	Species	Habitat Type(s)	Comments
1.	Eastern Fence Lizard	Shadscale, juniper, greasewood	
2.	Sagebrush Lizard	Greasewood	

III. MAMMALS

	Species	Habitat Type(s)	Comments
1.	Badger	Greasewood	Sign (diggings) only.
2.	Skunk (unidentified species)	Riparian	Sign (tracks) only.
3.	White-tail Antelope Ground Squirrel	Juniper, greasewood	
4.	Golden-mantled Squirrel	Juniper, greasewood	
5.	Ord (?) Kangaroo Rat	Greasewood	Sign (tracks) only.
6.	Deer Mouse	Greasewood, riparian	Nine individuals captured on rodent transects.
7.	Bushytail (?) Woodrat	Juniper	Sign only (evidence of hoarding activity).
8.	Desert Cottontail	Juniper, riparian	
9.	Mule Deer	Riparian	
10.	Domestic Sheep	Shadscale	Sign only.
11.	Domestic Cattle	Riparian	Sign only.

TABLE

TERRESTRIAL VERTEBRATE SPECIES

OBSERVED DECEMBER, 1974

I. BIRDS

	Species	Habitat Type(s)	Comments
1.	Golden Eagle	Cliffs near greasewood	One individual, seen Dec. 2.
2.	Black-billed Magpie	Shadscale, riparian	Seen singly or in flocks of up to eight birds.
3.	Black-capped Chickadee	Riparian	One flock of about 4 birds; also, several individuals in a mixed passerine flock.
4.	Loggerhead Shrike	Shadscale	One individual.
5.	Gray-crowned Rosy Finch	Greasewood	One flock of about 50-100 birds.
6.	Dark-eyed Junco	Riparian	Several individuals in a mixed passerine flock.

II. HERPTILES

No herptiles observed.

III. MAMMALS

1.	Badger	Greasewood	Sign (diggings) only
2.	Skunk (unidentified species)	Riparian	Sign (tracks) only.
3.	Golden-mantled Squirrel	Juniper	One Individual.
4.	Bushytail (?) Woodrat	Juniper	Sign only (evidence of hoarding activity).
5.	Beaver	Riparian	Sign only (freshly cut trees; mud slide).
6.	Desert Cottontail	Shadscale, juniper	Two individuals seen.
7.	Mule Deer	Juniper, grease-wood, riparian	Eight animals seen.
8.	Domestic Sheep	Shadscale	Sign only.

included: (1) Clematis blossoming vines, (2) Tamarix gallica, trees, (3) Cleome serrulata, (4) Chrysothamnus nauseosus, (5) Lepidium montanum, (6) marshy vegetation surrounding a water pumping station, (7) sandy shore of the river, and (8) dead cottonwoods (scorched from a recent fire).

b. Evacuation Creek (near the bridge). This habitat includes bordering plants of Tamarix and Melilotus alba in full bloom (at the time of the first visit) and Chrysothamnus (in bloom at later visits). There was also extensive nesting by various aculeate Hymenoptera, wasps, in the elevated parts of the stream bed and in the vertical clay banks between shale strata. This habitat was heavily damaged by a flash flood occurring between the first and second visits (the water ran eight feet deep in one narrow portion of the stream bed).

c. Higher slopes along the road climbing out of Evacuation Creek. The principal plants collected on this area included blossoming plants of Cirsium sp., Eriogonum sp., Petradoria sp., Cleome lutea, non-blooming shrubs of Artemesia tridentata, Atriplex confertifolia, and Sarcobatus vermiculatus. Various species of beetles, spiders, and scorpions were also collected under stones in this area.

d. Juniper highlands along road running westward through the oil shale sites. Collections were made on juniper trees, service berry, Rhus ovata, and an as-yet unidentified rosaceous shrub. This habitat was sampled less intensively than the previous three.

Sampling in the four habitats described above was done principally by sweeping bloom and other vegetation with an insect net, individually collecting insects coming to flowers, limited searching under stones and bark and in water, and one night's operation of a light trap on the White River.

4. AQUATIC BIOLOGY

a. Benthic Organisms

Invertebrate collections were composed almost entirely of insects and worms. A few microcrustaceans, (copepods) were taken in two collections of net plankton. No crayfish or pelecypods (clams) were observed; only one broken snail shell was collected. Several samples have been sent to specialists for identification or verification. Populations sampled with the Surber apparatus averaged about 23 organisms per square foot (range 2-79) equivalent to 250 per square meter (range 10-850). Organisms from soft bottom areas were collected with the Ekman dredge. These populations averaged 112 organisms per 1/4 square foot (range 20-287) equivalent to 4811 organisms per square meter (range 862 to 12,370).

b. Plankton

Quantitative plankton analysis was conducted in accordance with Standard Methods for the Examination of Water and Wastewater, U. S. Public Health Service, 13th Ed., Section 601D. Plankton was collected with a Wildco alpha sampler at a depth midway between the bottom and the surface. The alpha sampler collects

2200 milliliters of water and any organisms which may be in the water. The material is concentrated by filtration into 25 or 50 milliliters.

Organisms collected as net plankton were similar to those in quantitative samples.

c. Fisheries

Fish were collected from four stations in a cooperative effort by the Division of Wildlife Resources and VTN biologists. Minnow traps and hoop nets were set and left overnight at Station F-1. Only one fish was captured by this method and further efforts with nets were abandoned.

Favorable results were realized with electrofishing equipment (an Onan 220 volt direct current shocker without the VVP unit and 500 feet of cord). Attempts to shock upstream (against the current) were technically infeasible, therefore, shocking was done by moving downstream. Deep, swift water in the middle of the stream discouraged attempts to shock in that area and most of the fish collected were taken from near the stream banks as follows: The 500 feet of cord was laid out initially upstream from the generator. Five people, three netters and two electrode operators made up the shocking crew while two people maintained the cord, and one person was responsible for the generator. At each station the shocking crew moved downstream to the generator and continued on down the river another 500' feet. This process was

repeated on the opposite side of the river so that 2000 feet were shocked at each station.

C. WORK SCHEDULED

1. VEGETATION

During the next quarter emphasis will be placed on reduction of data gathered to date. The second on-site phenology sampling will also take place.

2. TERRESTRIAL VERTEBRATES

A second field trip is planned by USU and VTN personnel in early February. The same transect and trapping activities will be performed as in December. Pending approval of the Fish and Wildlife Management Plan, big game monitoring will also be initiated during that month.

3. TERRESTRIAL INVERTEBRATES

Further collecting will be done to make a more complete list, which is expected to reach at least 2000 species. In addition, monitoring will be established for certain key species for which data can be expected to be reasonably significant. Examples of insects would be certain species of ants, ground beetles, aquatic insects, and nesting populations of bees and aculeate wasps. Other arthropods which could be monitored would be certain species of centipedes, millipedes, isopods, spiders, and scorpions. Samples of duff , (soils litter) taken in the early

spring and late fall should also give reliable population estimates for many groups of invertebrates that inhabit such material while it is moist.

4. AQUATIC BIOLOGY

A few minor changes have been required in the aquatic biology program. An increased number of samples will be collected at each station to provide a more accurate picture of population structures. Increased collections will be taken with the Surber sampler (six to seven) to allow five for analysis and one or two as reserve in case of damage to samples (spillage, contamination, etc.) or for observation by interested individuals. Other collections will consist of three Ekman samples, two for analysis, three quantitative plankton collections and two net plankton samples. Deletion of quantitative plankton analysis may be recommended in the future,pending further investigation.

V. GEOLOGY AND SOILS

A. WORK PERFORMED

1. GEOLOGY

Preliminary surface and subsurface geologic field work has been completed.

2. SOILS

The soil survey field work has been completed for both Utah tracts. The first phase of the soil infiltration tests have been completed. Soil chemical tests have been completed. The data from the soil infiltration tests and soil chemistry tests are contained in Appendix C.

The soil survey field work is complete, which included developing descriptions of the following soil characteristics: location, land form, relief, elevation, drainage, parent material, vegetation, climate, erosion, water table, stoniness, and rockiness. Each soil profile is described completely and the following characteristics of each have been described: depth, color, texture, structure, consistency, roots, pores, coarse fragments, clay films, lime, reaction, boundary and temperature.

Soil chemical tests have been completed for texture, soil, pH, organic carbon, salinity, lime moisture tensions and extractable cations (Mg, Na, K, and P).

B. DATA SUMMARY

1. GEOLOGY

A summary of the data obtained during the field work will appear in the next quarterly report.

2. SOILS

The data available from the soil survey, soil chemical tests and infiltration tests cannot be adequately summarized at this time.

C. WORK SCHEDULED

1. GEOLOGY

Complete surface and subsurface descriptions of Tracts U-a and U-b areas will be presented in the next quarterly report. Field data is now being compiled and analyzed.

2. SOILS

Deep soil infiltration tests, soil background radiation monitoring, soil temperature and moisture monitoring and soil engineering tests will be conducted in the future.

Deep soil infiltration tests will be performed as specified by the Area Oil Shale Supervisor.

Radiation levels are to be determined by standardized scintillation methods. Radiation tests will be used for background radiation baseline information.

Soil temperature and moisture monitoring has begun. The parameters that are measured are the amount of soil moisture through the seasons and seasonal variations in soil temperature. Monitoring of soil moisture and temperature is essential to determine the type of plant, the appropriate season and the method of seeding to be used for the revegetation program.

When completed the soil engineering tests will provide an engineering classification, estimated soil properties and interpretations for selected uses. The test and field description will determine the depth to the seasonal water table, hydrologic soil group classification, percent of material less than three inches, liquid limit, plasticity index, permeability, available water capacity, soil reaction, salinity, shrink-swell potential, corrosivity, erosion factor, windy erodibility group, flooding, high water table, cement pan, bedrock, subsidence and potential frost action. The soils will be judged in regards to their suitability as source material for sanitary facilities, community development, water management, and recreation.

VI. HISTORIC AND SCIENTIFIC RESOURCES

A. WORK COMPLETED

Cultural and paleontological resource inventories and evaluations are being performed in order to assess impacts of the project on these resources and to recommend alternative mitigation measures. An inventory and evaluation consists of an on-the-ground inspection and an archival search (literature and site records) to locate and identify the resources within the impact areas of the project. Based on the ability to provide significant information for the needs of the project, recommendations are made to preserve, protect or recover any significant resources located on the tracts.

The inventories and evaluations are being conducted through two qualified institutions. The consultant for cultural (historical and archaeological) resources is the Utah Historical Society under the direction of Dr. David B. Madsen (also State Archaeologist). The paleontological study is being performed under the direction of Dr. Wade E. Miller, Zoology Department, Brigham Young University. Both have the necessary academic training and experience and affiliations with recognized institutions as required by federal and state antiquities regulations.

B. DATA SUMMARY

A number of cultural and paleontological sites have been located in the project area. Because the site descriptions are based on surface indications and preliminary laboratory analysis, their full extent and nature is not yet known. Each resource is discussed separately. Tables 6 and 7 present data on the sites located to date and provides information on types, locations, concentrations and preliminary recommendations.

Cultural sites located to date consist of prehistoric and historic sites. The earliest cultural period represented is the Archaic. The sites are open camp sites and chipping stations and rock shelters with a few diagnostic artifacts such as Elko side-notched projectile points. Most of the cultural material, however, consists of chipping waste, discarded lithic implements or fragments, charcoal, and fire-blackened cobbles. The later Fremont period sites are represented by rock art, a granary small triangular projectile points and pottery. Late prehistoric and historic Numic (Shoshoni or Ute) sites are also present. Historic sites include the remains of the Ignatio Stage Stop (42 UN 401) and ranch or homestead cabins (42 UN 352). Site 42 UN 401 is unique in that it also is located above a Fremont site with lithic artifacts and chipping waste, pottery and a possible dwelling structure. The pottery appears to be from an Anasazi culture. It may represent tradeware as Anasazi sites are not known to occur this far north.

TABLE 6

CULTURAL RESOURCES

Site Number	Township	Range	Section	Type of Site	Cultural Period
42 UN 106	(site record not available at this time)				
118					?
324	10S	24E	23	Campsite, rock overhang	?
342*?	"	"	10	Cabins	Historic 1900±20 yr.
355	"	"	12	Rock Shelter	Archaic
356*	"	"	16	Open	?
357*	"	"	"	Open	Archaic
358	"	"	"	Open	Fremont or Numic
365**	11S	"	6	Rock Shelter	Fremont
366**	10S	"	2	Rock Shelter, Rock Art	Archaic and Fremont
367*	"	"	"	" "	Archaic (?)
368*	"	"	11	Open	"
369**	"	"	"		"
371*	"	"	"	"	Fremont?
372	"	"	14	"	Archaic ?
373*	"	"	"	"	"
374*	"	"	15	"	"
375*	"	"	"	"	"
376	"	25E	7	"	Archaic, Fremont ?
377**	"	24E	17	"	Archaic ?
378*	"	"	"	"	"
379	"	"	7	"	?
380	"	"	1	"	Archaic ?
381	"	"	"	Rock Shelter	?
401*	"	"	2	Open	*Fremont-Historic Anglo
402*	"	"	16	Rock Shelter	?
403	11S	"	23	Pictograph	Historic ?
404*	10S	"	16	Rock Shelter	?

* Testing recommended in site survey record
** Excavation " " " " "

TABLE 7

PALEONTOLOGICAL RESOURCES

Site Number	Township	Range	Section	Fossil Type	Geologic Era
(None have been assigned to date)	*10S	34E	10	Vertebrates (lg. mammals)	Eocene
			13	Plants	
			15	Plants, Petrified Wood	
			16	Petrified Wood	
			17	Petrified wood, vertebrates	
			18	"	
			19	Vertebrates	
			20	Vert., plants, pet. wood	
			21	Vertebrates, pet. wood	
			22	Plants	
			28	Plants, petrified wood	
			29	Vertebrates	
			30	"	
			31	Petrified wood	
			32	Vertebrates	
			33	Vertebrates, Petrified wood	
			35	Plants	
			36	Invertebrates (insects)	
	*11S	24E	3	Vertebrates (lg. mammals)	Eocene
			4	Vertebrates	
		25	4	Invetr. (insects), plants	
			6	Invertebrates (inspects)	

*Testing recommended

Paleontological sites represent a full range of fossil types. Plants fossils consist of imprints and petrified wood. Insects are the only invertebrate fossils present. Vertebrate fossils are represented by fish scales, turtle shells and limb elements, and various mammalian bones. The majority of the fossil specimens observed to date are in poor condition and are of little scientific value. The only potentially significant finds to date are the large mammal fossils found in Township 10S, Range 24E, Section 10; and Township 11S, Range 24E, Section 3. These have not been fully identified since they have not been removed from the rock units. They have been tentatively identified as a Brontathier and a Unitathier, respectively, prehistoric mammals of the Eocene epoch (40-50 million years ago).

C. WORK TO BE SCHEDULED

The fieldwork aspects of the inventories and evaluations are to continue as weather permits during winter months with both consultants expecting to finish by April, 1975. The cultural resources consultant may finish field work this month if the ground remains clear of snow.

Once the field work is completed, the consultants will analyze the collected data (both artifactual and archival) to determine the significance of the located sites. Their results and recommendations will be contained in reports to be submitted to VTN in June, 1975. In both content and form, the reports will present this information according to current governmental and professional standards for use in the environmental baseline study as well as in any future environmental impact assessments which may be required.

VII. FISH AND WILDLIFE MANAGEMENT PLAN

On August 1, 1974 an interagency meeting was held between VTN, BLM, State Department of Water Resources, and other involved individuals to discuss the Fish and Wildlife plan as outlined by VTN. Input was received by VTN from these agencies and a draft plan was submitted for review on August 20, 1974.

At the August 20, meeting the agencies advised VTN on the necessary elements of the plan. The plan was rewritten and submitted on September 12, 1974. Certain additional criticisms of the plan were evaluated and suggestions implemented for its improvement.

During the months of October and November the plan was again rewritten and was prepared for delivery to the Area Oil Shale Supervisor. In early January copies of the final draft were submitted to the Area Oil Shale Supervisor's office for distribution among reviewing agencies. The Plan will be finalized pending receipt of their review comments. It will then be sent to the Oil Shale Environmental Advisory Panel for approval in February.

VIII. GEOLOGIC EXPLORATION PROGRAM

A. WORK PERFORMED

In late October 1974, a meeting was held between VTN and representatives of the Cleveland Cliffs Iron Company. The purpose of the meeting was to delineate the duties and responsibilities of the two companies during the exploration drilling and coring program on Tracts U-a and U-b. A detailed breakdown of those duties and responsibilities is contained in Appendix D

Proposed drill holes and their estimated depths are listed in Table 8

TABLE 8

PROPOSED DRILL HOLES

TRACTS Ua & Ub

Hole #	Sec., Tnshp. & Range	Est. Ground Elev.	Est.MM Elev.	Est.Depth to MM	Zone of Interest*	Cored Interval	Total Depth
Exploratory Holes -							
CH-1	30-10S-24E	5307	4287	1020	770-1140	890-1140	1180
CH-2	14-10S-24E	5010	4355	655	405-775	525-775	815
CH-3	18-10S-25E	5260	4820	440	190-560	310-560	600
CH-4	14-10S-24E	5250	4395	855	605-975	725-975	1015
CH-5	23-10S-24E	5380	4570	810	560 930	680-930	970
CH-6	19-10S-25E	5460	4815	645	395-765	515-765	805
CH-9	27-10S-24E	5470	4490	980	730-1100	850-1100	1140
CH-10	33-10S-24E	5495	4485	1010	760-1130	880-1130	1170
CH-11	28-10S-24E	5265	4380	885	635-1005	755-1005	1045
						TOTAL	8740

* To be logged and assayed for oil content - defined as MM + 250 ft. to MM - 470 ft. in the Pilot Test Holes, and MM = 250 ft. to MM - 160 ft. in the Exploratory Drill Holes

The drilling program was initiated November, 1974 using the two Layne-Western rigs that were employed during the ground water drilling phase of the project. Work was begun November 18, 1974 on Hole X-1 and completed December 5, 1974 upon reaching a total

depth of 1106 feet. Work was begun on Hole X-2 November 21, 1974 and was completed December 5, 1974 after a depth of 805 feet was reached.

A contract agreement was reached in December with the James Drilling Company of Denver, Colorado to drill and complete the remaining exploration holes and to complete Holes X-1 and X-2. Work is scheduled to be completed within 48 calendar days of the date of the contract.

Work began on Hole X-11 December 14, 1974 utilizing the James SS-16 rig and on Hole X-10 December 14, 1974 using the Schocke 2500 rig. Hole X-11 was completed on December 29, 1974 and reached a total depth of 1025feet, and Hole X-10 was completed December 29, 1974 at a depth of 1,098 feet.

The James Company is utilizing a T-4 rig to precede the SS-16 rig by setting surface casing and blowout preventors. To date this work has been completed on Holes X-9 and X-4. Hole X-5 is currently being completed.

C. WORK SCHEDULED

After the drilling operation is concluded, the holes will be geophysically logged and completed as planned. The SS-16 rig will be used for the necessary casing, gravel packing and cementing. This procedure was dictated by the availability of Birdwell logging equipment.

Holes X-1,2,6 and possibly 9 will be developed as water level monitoring holes. Because these holes are strategically located they will be completed with casing to insure that they remain open during the life of the project.

IX. REVEGETATION STUDIES

A program designed to determine the revegetation potential of processed shale is being undertaken jointly by the USU Foundation and VTN. In addition to the revegetation studies, the program is designed to examine aspects of ground water and surface water pollution potential. The program is outlined in Appendix E.

The following tasks have been performed or started since December 19:

1. A literature review was made of all pertinent studies relative to revegetation of harsh sites and transplanting responses of native species.
2. Space was secured in an experimental greenhouse to conduct studies of rooting cuttings of native shrubs.
3. Seeds were collected of native plants.
4. Suitable field research locations were surveyed.
5. Environmental conditions were reviewed as experienced in baseline work.

In the near future, the field research sites will be located and equipped to conduct the research. Field work is planned to begin as soon as weather permits.

APPENDIX A

WATER QUALITY DATA SUMMARY

WATER QUALITY DATA SUMMARY

FROM July TO October

STATION S-2

rameter or nstituents (Mg/L)	Maximum	Minimum	Mean	# of Samples
mperature ^{o}C	31	6.5	21.50	4
stantaneous Discharge (CFS)	.50	.02	0.22	3
lor (Platinum, Cobalt Units)	30	7	16.75	4
ecific Conductance (Micro MHOS)	5500	4250	4676.00	5
issolved Oxygen	13	11.3	12.15	2
I	8.2	7.9	8.06	5
rbon Dioxide	9.0	4.3	6.40	5
lkalinity as $CaCO_3$	382	351	364.00	5
icarbonate	466	428	443.80	5
rbonate	0	0	0	0
otal Nitrogen	1.9	1.9	1.9	1
rganic Nitrogen	.88	.88	.88	1
issolved Nitrogen Ammonia	.12	.03	0.08	4
issolved Nitrite	.02	.00	0.00	4
issolved Nitrate	.32	.00	0.14	3
otal Kjeldahl Nitrogen	1.2	.85	0.98	5
otal Nitrite + Nitrate	1.0	1.0	1.00	1
issolved Nitrite + Nitrate	.34	.00	0.11	4
issolved Ortho Phosphate	.03	.00	0.00	4
otal Phosphorus	.09	.01	0.04	5
otal Organic Carbon	13	13	13.00	2
otal Inorganic Carbon	45	43	44.00	2

WATER QUALITY DATA SUMMARY

FROM July TO October

STATION S-2

Parameter or Constituents (Mg/L)	Maximum	Minimum	Mean	# of Samples
Temperature °C	31	6.5	21.50	4
Instantaneous Discharge (CFS)	.50	.02	0.22	3
Color (Platinum, Cobalt Units)	30	7	16.75	4
Specific Conductance (Micro MHOS)	5500	4250	4676.00	5
Dissolved Oxygen	13	11.3	12.15	2
pH	8.2	7.9	8.06	5
Carbon Dioxide	9.0	4.3	6.40	5
Alkalinity as $CaCO_3$	382	351	364.00	5
Bicarbonate	466	428	443.80	5
Carbonate	0	0	0	0
Total Nitrogen	1.9	1.9	1.9	1
Organic Nitrogen	.88	.88	.88	1
Dissolved Nitrogen Ammonia	.12	.03	0.08	4
Dissolved Nitrite	.02	.00	0.00	4
Dissolved Nitrate	.32	.00	0.14	3
Total Kjeldahl Nitrogen	1.2	.85	0.98	5
Total Nitrite + Nitrate	1.0	1.0	1.00	1
Dissolved Nitrite + Nitrate	.34	.00	0.11	4
Dissolved Ortho Phosphate	.03	.00	0.00	4
Total Phosphorus	.09	.01	0.04	5
Total Organic Carbon	13	13	13.00	2
Total Inorganic Carbon	45	43	44.00	2

WATER QUALITY DATA SUMMARY

FROM July TO October

STATION S-2

Parameter or Constituents (Mg/L)	Maximum	Minimum	Mean	# of Samples
Cyanide	0	0	0	3
Dissolved Manganese (Ug/L)	100	30	62.50	4
Dissolved Molybdenum - Ug/L	70	53	61.75	4
Dissolved Nickel - Ug/L	20	2	8.25	4
Dissolved Silver - Ug/L	2	0	1.33	3
Dissolved Strontium - Ug/L	4200	3400	3833.33	3
Dissolved Vanadium - Ug/L	10	.4	3.70	4
Dissolved Zinc - Ug/L	20	10	15.00	4
Dissolved Tin - Ug/L	20	20	20.00	2
Dissolved Aluminum - Ug/L	5000	0	1257.50	4
Dissolved Gallium - Ug/L	5	5	5.00	2
Dissolved Germanium - Ug/L	20	20	20.00	2
Dissolved Lithium - Ug/L	150	120	130.00	4
Dissolved Selenium - Ug/L	2	1	1.50	2
Total Selenium - Ug/L	1	1	1.00	1
Dissolved Titanium - Ug/L	150	13	81.50	2
Dissolved Zirconium - Ug/L	20	20	20.00	2
Dissolved Gross Beta as CS-137	23	23	23.00	1
Chlorophyll A - Ug/L	13	8.5	10.75	2
Chlorophyll B - Ug/L	5.4	4.2	4.80	2
Phenols - Ug/L	4	1	2.50	4
Dissolved Solids (180 ^{o}C Residue)	3940	3570	3757.50	4

WATER QUALITY DATA SUMMARY

FROM July TO October

STATION S-2

Parameter or Constituents (Mg/L)	Maximum	Minimum	Mean	# of Samples
Dissolved Solids (Tons/Day)	4.82	.21	2.24	3
Dissolved Solids (Tons/ACF)	5.36	4.86	5.11	4
Total Ortho Phosphorus	.06	.06	0.06	1
Dissolved Ammonia	.15	.04	0.10	4
Dissolved Nitrate	1.4	.00	0.61	3
Dissolved Nitrite	.07	.00	0.02	4
Bromide	.3	.2	0.27	4
Total Nitrogen	8.6	8.6	8.60	1
Dissolved Mercury	.3	.0	0.13	3
Dissolved Sulfide	.2	.0	0.07	4
Total Hardness (Ca, MG)	1100	1000	1050.00	4
Non-Carbonate Hardness	740	660	687.50	4
Dissolved Calcium	170	140	157.50	4
Total Calcium	190	190	190.00	1
Dissolved Magnesium	170	150	160.00	4
Total Magnesium	190	190	190.00	1
Total Sodium	700	700	700.00	1
Dissolved Sodium	730	680	710.00	4
Sodium Adsorption Ratio	9.7	9.3	9.52	4
Percent Sodium	60	58	59.00	4
Dissolved Potassium	12	8.9	10.17	4
Total Potassium	16	16	16.00	1

WATER QUALITY DATA SUMMARY

FROM July TO October

STATION S-2

Parameter or Constituents (Mg/L)	Maximum	Minimum	Mean	# of Samples
Dissolved Chloride	55	49	51.20	5
Dissolved Sulfate	2200	2000	2140.00	5
Dissolved Fluoride	.9	.8	0.85	4
Total Fluoride	.8	.8	0.80	1
Dissolved Silica	14	7.9	9.86	5
Dissolved Arsenic (Ug/L)	3	2	2.33	3
Total Arsenic (Ug/L)	4	4	4.00	1
Dissolved Barium (Ug/L)	130	0	57.50	4
Dissolved Beryllium (Ug/L)	7	0	4.33	3
Dissolved Boron (Ug/L)	2200	520	1630.00	4
Dissolved Cadmium (Ug/L)	25	0	6.25	4
Dissolved Chromium (Ug/)	10	0	2.50	4
Dissolved Cobalt (Ug/L)	20	0	5.00	4
Dissolved Copper (Ug/L)	10	2	5.00	4
Total Copper (Ug/L)	20	20	20.00	1
Dissolved Iron (Ug/L)	2500	20	642.50	4
Dissolved Lead (Ug/L)	20	2	6.75	4
Total Mercury	.0	.0	0.00	1
Dissolved Gross Alpha as U-nat	52	52	52.00	1
Dissolved Gross Beta as Sr 90 (PC/L)	20	20	20.00	1

WATER QUALITY DATA SUMMARY

FROM July TO October

STATION S-1

Parameter or Constituents (Mg/L)	Maximum	Minimum	Mean	# of Samples
Temperature °C	18	11	14.9	4
Instantaneous Discharge (CFS)	466	290	397	3
Color (Platinum, Cobalt Units)	40	3	13.8	4
Specific Conductance (Micro MHOS)	900	725	813	5
Dissolved Oxygen	8.7	8	8.35	5
pH	8.2	7.5	7.94	5
Carbon Dioxide	11	2.2	5.44	5
Alkalinity as $CaCO_3$	222	185	202.6	5
Bicarbonate	271	225	247	5
Carbonate	0	0	0.00	5
Total Nitrogen	1.4	1.4	1.40	1
Organic Nitrogen	1.1	1.1	1.10	1
Dissolved Nitrogen Ammonia	0.1	.01	.03	5
Dissolved Nitrite	.01	0	.0025	4
Dissolved Nitrate	0	0	0	3
Total Kjeldahl Nitrogen	1.2	.24	0.614	5
Total Nitrite + Nitrate	.19	.19	0.19	1
Dissolved Nitrite + Nitrate	.01	0	.0025	4
Dissolved Ortho Phosphate	0	0	0	4
Total Phosphorus	.83	.03	.226	5
Total Organic Carbon	13	5.5	9.25	2
Total Inorganic Carbon	38	37	37.5	2

WATER QUALITY DATA SUMMARY

FROM July TO October

STATION S-1

Parameter or Constituents (Mg/L)	Maximum	Minimum	Mean	# of Samples
Cyanide	0	0	0	3
Dissolved Manganese (Ug/L)	720	0	180	4
Dissolved Molybdenum - Ug/L	10	3	5.5	4
Dissolved Nickel - Ug/L	65	1	22	4
Dissolved Silver - Ug/L	4	0	2.00	2
Dissolved Strontium - Ug/L	1100	1100	1100	2
Dissolved Vanadium - Ug/L	130	0.4	33	4
Dissolved Zinc - Ug/L	270	0	80	4
Dissolved Tin - Ug/L	30	30	30.00	1
Dissolved Aluminum - Ug/L	78000	0	19505.00	4
Dissolved Gallium - Ug/L	28	28	28.00	1
Dissolved Germanium - Ug/L	30	30	30.00	1
Dissolved Lithium - Ug/L	60	0	27.5	4
Dissolved Selenium - Ug/L	1	1	1.00	2
Total Selenium - Ug/L	1	1	1.00	1
Dissolved Titanium - Ug/L	4800	4800	4800.00	1
Dissolved Zirconium - Ug/L	170	170	170.00	1
Dissolved Gross Beta as CS-137	4.6	4.6	4.60	1
Chlorophyll A - Ug/L	4.3	1.0	2.65	2
Chlorophyll B - Ug/L	5.7	.6	3.15	2
Phenols - Ug/L	2	1	1.25	4
Dissolved Solids (180 ^{o}C Residue)	625	489	555	4

WATER QUALITY DATA SUMMARY

FROM July TO October

STATION S-1

Parameter or Constituents (Mg/L)	Maximum	Minimum	Mean	# of Samples
Dissolved Solids (Tons/Day)	618	481	540	4
Dissolved Solids (Tons/ACF)	615	490	563	4
Total Ortho Phosphorus	.07	.07	0.07	1
Dissolved Ammonia	.13	.01	.05	4
Dissolved Nitrate	0	0	0	3
Dissolved Nitrite	.03	0	.0075	4
Bromide	.5	.1	.2	4
Total Nitrogen	6.2	6.2	6.20	1
Dissolved Mercury	0	0	0	1
Dissolved Sulfide	.2	.0	0.10	4
Total Hardness (Ca, MG)	320	260	282.50	4
Non-Carbonate Hardness	100	76	84.50	4
Dissolved Calcium	77	61	67.50	4
Total Calcium	130	130	130.00	1
Dissolved Magnesium	31	24	27.75	4
Total Magnesium	42	42	42.00	1
Total Sodium	67	67	67.00	1
Dissolved Sodium	110	57	78.50	4
Sodium Adsorption Ratio	2.9	1.5	2.05	4
Percent Sodium	46	31	36.75	4
Dissolved Potassium	3.8	1.9	2.80	4
Total Potassium	5.9	5.9	5.90	1

WATER QUALITY DATA SUMMARY

FROM July TO October

STATION S-1

Parameter or Constituents (Mg/L)	Maximum	Minimum	Mean	# of Samples
Dissolved Chloride	68	32	45.20	5
Dissolved Sulfate	210	160	178.00	5
Dissolved Fluoride	.4	.2	0.30	4
Total Fluoride	1.5	1.5	1.50	1
Dissolved Silica	16	11	13.40	5
Dissolved Arsenic (Ug/L)	3	1	2.00	3
Total Arsenic (Ug/L)	21	21	21.00	1
Dissolved Barium (Ug/L)	830	830	207.50	4
Dissolved Beryllium (Ug/L)	7	0	3.50	2
Dissolved Boron (Ug/L)	120	50	82.50	4
Dissolved Cadmium (Ug/L)	20	0	5.25	4
Dissolved Chromium (Ug/)	75	0	18.75	4
Dissolved Cobalt (Ug/L)	18	0	4.50	4
Dissolved Copper (Ug/L)	33	0	9.00	4
Total Copper (Ug/L)	30	30	30.00	1
Dissolved Iron (Ug/L)	3600	20	915.00	4
Dissolved Lead (Ug/L)	37	1	10.75	4
Total Mercury	0	0	0.00	1
Dissolved Gross Alpha as U-nat	7.1	7.1	7.10	1
Dissolved Gross Beta as Sr 90 (PC/L)	3.70	3.70	3.70	1

WATER QUALITY DATA SUMMARY

FROM July TO October

STATION S-6

Parameter or Constituents (Mg/L)	Maximum	Minimum	Mean	# of Samples
Temperature °C	10.5	3.0	6.75	2
Instantaneous Discharge (CFS)	.02	.00	0.01	2
Color (Platinum, Cobalt Units)	20	20	20	1
Specific Conductance (Micro MHOS)	5780	5000	5390.00	2
Dissolved Oxygen	8.5	8.5	8.50	1
pH	8.2	7.5	7.85	2
Carbon Dioxide	27	5.8	16.40	2
Alkalinity as $CaCO_3$	475	442	458.50	2
Bicarbonate	579	539	559.00	2
Carbonate	0	0	0	2
Total Nitrogen	-	-	-	-
Organic Nitrogen	-	-	-	-
Dissolved Nitrogen Ammonia	.10	.06	0.08	2
Dissolved Nitrite	.01	.00	0.00	2
Dissolved Nitrate	.00	.00	0.00	1
Total Kjeldahl Nitrogen	1.0	.72	0.86	2
Total Nitrite + Nitrate	-	-	-	-
Dissolved Nitrite + Nitrate	.00	.00	0.00	2
Dissolved Ortho Phosphate	.03	.00	0.01	2
Total Phosphorus	.12	.01	0.06	2
Total Organic Carbon	22	22	22.00	1
Total Inorganic Carbon	90	90	90.00	1

WATER QUALITY DATA SUMMARY

FROM July TO October

STATION S-6

Parameter or Constituents (Mg/L)	Maximum	Minimum	Mean	# of Samples
Cyanide	.00	.00	0.00	1
Dissolved Manganese (Ug/L)	70	70	70.00	1
Dissolved Molybdenum - Ug/L	38	38	38.00	1
Dissolved Nickel - Ug/L	12	12	12.00	1
Dissolved Silver - Ug/L	1	1	1.00	1
Dissolved Strontium - Ug/L	4100	4100	4100.00	1
Dissolved Vanadium - Ug/L	2.8	2.8	2.80	1
Dissolved Zinc - Ug/L	10	10	10.00	1
Dissolved Tin - Ug/L	-	-	-	-
Dissolved Aluminum - Ug/L	10	10	10.00	1
Dissolved Gallium - Ug/L	-	-	-	-
Dissolved Germanium - Ug/L	-	-	-	-
Dissolved Lithium - Ug/L	120	120	120.00	1
Dissolved Selenium - Ug/L	0	0	0	1
Total Selenium - Ug/L	-	-	-	-
Dissolved Titanium - Ug/L	-	-	-	-
Dissolved Zirconium - Ug/L	-	-	-	-
Dissolved Gross Beta as CS-137	-	-	-	-
Chlorophyll A - Ug/L	.4	.4	.40	1
Chlorophyll B - Ug/L	.5	.5	.50	1
Phenols - Ug/L	7	1	4.00	2
Dissolved Solids (180 ^{o}C Residue)	5150	4970	5060.00	2

WATER QUALITY DATA SUMMARY

FROM July TO October

STATION S-6

Parameter or Constituents (Mg/L)	Maximum	Minimum	Mean	# of Samples
Dissolved Solids (Tons/Day)	.27	.11	0.19	2
Dissolved Solids (Tons/ACF)	7.00	6.76	6.88	2
Total Ortho Phosphorus	-	-	-	-
Dissolved Ammonia	.13	.08	0.10	2
Dissolved Nitrate	.00	.00	0.00	1
Dissolved Nitrite	.03	.00	0.01	2
Bromide	.4	.4	.20	2
Total Nitrogen	-	-	-	-
Dissolved Mercury	.0	.0	.00	1
Dissolved Sulfide	.2	.2	0.10	2
Total Hardness (Ca, MG)	1500	1400	1450.00	2
Non-Carbonate Hardness	990	950	970.00	2
Dissolved Calcium	220	210	215.00	2
Total Calcium	-	-	-	-
Dissolved Magnesium	220	210	215.00	2
Total Magnesium	-	-	-	-
Total Sodium	-	-	-	-
Dissolved Sodium	1000	980	990.00	2
Sodium Adsorption Ratio	11	11	11.00	2
Percent Sodium	60	60	60.00	2
Dissolved Potassium	11	9.2	10.10	2
Total Potassium	-	-	-	-

WATER QUALITY DATA SUMMARY

FROM July TO October

STATION S-6

Parameter or Constituents (Mg/L)	Maximum	Minimum	Mean	# of Samples
Dissolved Chloride	64	63	63.50	2
Dissolved Sulfate	3000	2900	2950.00	2
Dissolved Fluoride	.9	.9	0.90	2
Total Fluoride	-	-	-	-
Dissolved Silica	9.9	9.6	9.75	2
Dissolved Arsenic (Ug/L)	3	3	3.00	1
Total Arsenic (Ug/L)	-	-	-	-
Dissolved Barium (Ug/L)	0	0	0	1
Dissolved Beryllium (Ug/L)	0	0	0	1
Dissolved Boron (Ug/L)	2100	2100	2100.00	1
Dissolved Cadmium (Ug/L)	1	1	1.00	1
Dissolved Chromium (Ug/)	0	0	0	1
Dissolved Cobalt (Ug/L)	0	0	0	1
Dissolved Copper (Ug/L)	3	3	3.00	1
Total Copper (Ug/L)	-	-	-	-
Dissolved Iron (Ug/L)	50	50	50.00	1
Dissolved Lead (Ug/L)	2	2	2.00	1
Total Mercury	-	-	-	-
Dissolved Gross Alpha as U-nat	-	-	-	-
Dissolved Gross Beta as Sr 90 (PC/L)	-	-	-	-

WATER QUALITY DATA SUMMARY

FROM July TO October

STATION S-3

Parameter or Constituents (Mg/L)	Maximum	Minimum	Mean	# of Samples
Temperature °C	26.0	3.0	15.71	7
Instantaneous Discharge (CFS)	467	2.6	332.26	6
Color (Platinum, Cobalt Units)	40	4	17.00	3
Specific Conductance (Micro MHOS)	900	630	760.14	7
Dissolved Oxygen	9.2	7.0	8.10	4
pH	8.4	7.0	7.94	7
Carbon Dioxide	36	1.5	8.57	7
Alkalinity as $CaCO_3$	215	184	192.71	7
Bicarbonate	262	224	234.42	7
Carbonate	1	0	0.20	5
Total Nitrogen	-	-	-	-
Organic Nitrogen	-	-	-	-
Dissolved Nitrogen Ammonia	.05	.01	0.03	4
Dissolved Nitrite	.01	.00	0.00	4
Dissolved Nitrate	.04	.00	0.01	3
Total Kjeldahl Nitrogen	.48	.13	0.33	4
Total Nitrite + Nitrate	-	-	-	-
Dissolved Nitrite + Nitrate	4.9	.00	0.74	7
Dissolved Ortho Phosphate	2.6	.00	0.39	7
Total Phosphorus	.05	.03	0.04	4
Total Organic Carbon	4.5	4.5	4.50	1
Total Inorganic Carbon	32	32	32.00	1

WATER QUALITY DATA SUMMARY

FROM July TO October

STATION S-3

Parameter or Constituents (Mg/L)	Maximum	Minimum	Mean	# of Samples
Cyanide	.00	.00	.00	2
Dissolved Manganese (Ug/L)	760	00	195.00	4
Dissolved Molybdenum - Ug/L	10	2	5.00	4
Dissolved Nickel - Ug/L	72	1	19.50	4
Dissolved Silver - Ug/L	4	0	1.66	3
Dissolved Strontium - Ug/L	1100	950	1016.66	3
Dissolved Vanadium - Ug/L	130	.6	32.97	4
Dissolved Zinc - Ug/L	250	10	77.50	4
Dissolved Tin - Ug/L	30	8	19.00	2
Dissolved Aluminum - Ug/L	86000	10	21510.00	4
Dissolved Gallium - Ug/L	20	4	12.00	2
Dissolved Germanium - Ug/L	30	11	20.50	2
Dissolved Lithium - Ug/L	70	0	20.75	4
Dissolved Selenium - Ug/L	1	1	1.00	2
Total Selenium - Ug/L	-	-	-	-
Dissolved Titanium - Ug/L	5000	5	2502.50	2
Dissolved Zirconium - Ug/L	180	12	96.00	2
Dissolved Gross Beta as CS-137	3.5	3.5	3.50	1
Chlorophyll A - Ug/L	3.2	.8	2.00	2
Chlorophyll B - Ug/L	2.5	.9	1.70	2
Phenols - Ug/L	6	0	2.00	3
Dissolved Solids (180 ^{o}C Residue)	602	477	541.00	4

WATER QUALITY DATA SUMMARY

FROM July TO October

STATION S-3

Parameter or Constituents (Mg/L)	Maximum	Minimum	Mean	# of Samples
Dissolved Solids (Tons/Day)	576	3.61	442.93	6
Dissolved Solids (Tons/ACF)	.82	.61	0.70	7
Total Ortho Phosphorus	-	-	-	-
Dissolved Ammonia	.06	.01	0.04	4
Dissolved Nitrate	.18	.00	0.07	3
Dissolved Nitrite	.03	.00	0.00	4
Bromide	.1	.0	0.07	4
Total Nitrogen	-	-	-	-
Dissolved Mercury	.0	.0	0.00	3
Dissolved Sulfide	.3	.0	0.12	4
Total Hardness (Ca, MG)	310	240	278.57	7
Non-Carbonate Hardness	110	57	86.71	7
Dissolved Calcium	74	60	66.42	7
Total Calcium	-	-	-	-
Dissolved Magnesium	34	23	27.42	7
Total Magnesium	-	-	-	-
Total Sodium	-	-	-	-
Dissolved Sodium	90	55	70.28	7
Sodium Adsorption Ratio	2.3	1.5	1.82	7
Percent Sodium	40	31	35.00	7
Dissolved Potassium	3.1	.8	2.28	7
Total Potassium	-	-	-	-

WATER QUALITY DATA SUMMARY

FROM July TO October

STATION S-3

Parameter or Constituents (Mg/L)	Maximum	Minimum	Mean	# of Samples
Dissolved Chloride	53	30	37.00	7
Dissolved Sulfate	210	140	175.71	7
Dissolved Fluoride	.4	.2	0.31	7
Total Fluoride	-	-	-	-
Dissolved Silica	15	12	13.42	7
Dissolved Arsenic (Ug/L)	4	2	2.66	3
Total Arsenic (Ug/L)	-	-	-	-
Dissolved Barium (Ug/L)	870	0	217.50	4
Dissolved Beryllium (Ug/L)	7	0	3.33	3
Dissolved Boron (Ug/L)	290	70	124.28	7
Dissolved Cadmium (Ug/L)	1	0	0.33	3
Dissolved Chromium (Ug/)	82	0	20.50	4
Dissolved Cobalt (Ug/L)	15	0	3.75	4
Dissolved Copper (Ug/L)	35	2	11.25	4
Total Copper (Ug/L)	-	-	-	-
Dissolved Iron (Ug/L)	39000	20	9827.50	4
Dissolved Lead (Ug/L)	34	2	10.00	4
Total Mercury	-	-	-	-
Dissolved Gross Alpha as U-nat	6.9	6.9	6.90	1
Dissolved Gross Beta as Sr 90 (PC/L)	2.9	2.9	2.90	1

WATER QUALITY DATA SUMMARY

FROM July TO October

STATION S-4

Parameter or Constituents (Mg/L)	Maximum	Minimum	Mean	# of Samples
Temperature ^{o}C	18.0	6.8	13.57	4
Instantaneous Discharge (CFS)	466	289	405.33	3
Color (Platinum, Cobalt Units)	40	5	14.50	4
Specific Conductance (Micro MHOS)	1100	690	855.40	5
Dissolved Oxygen	8.2	8.2	8.20	1
pH	8.2	7.0	7.84	5
Carbon Dioxide	36	2.6	10.10	5
Alkalinity as $CaCO_3$	213	183	200.00	5
Bicarbonate	260	223	243.80	5
Carbonate	0	0	0.00	5
Total Nitrogen	5.2	5.2	5.20	1
Organic Nitrogen	4.8	4.8	4.80	1
Dissolved Nitrogen Ammonia	.06	.01	0.03	4
Dissolved Nitrite	.01	.00	0.00	4
Dissolved Nitrate	.09	.00	0.03	3
Total Kjeldahl Nitrogen	4.9	.26	1.31	5
Total Nitrite + Nitrate	.30	.30	.30	1
Dissolved Nitrite + Nitrate	.09	.00	0.02	4
Dissolved Ortho Phosphate	.00	.00	0.00	4
Total Phosphorus	1.5	.05	0.34	5
Total Organic Carbon	12	7.0	9.50	2
Total Inorganic Carbon	38	17	27.50	2

WATER QUALITY DATA SUMMARY

FROM July TO October

STATION S-4

Parameter or Constituents (Mg/L)	Maximum	Minimum	Mean	# of Samples
Cyanide	.01	.00	0.00	3
Dissolved Manganese (Ug/L)	1700	0	430.00	4
Dissolved Molybdenum - Ug/L	20	3	8.00	4
Dissolved Nickel - Ug/L	200	1	51.50	4
Dissolved Silver - Ug/L	7	1	3.33	3
Dissolved Strontium - Ug/L	1700	1000	1266.66	3
Dissolved Vanadium - Ug/L	370	.4	93.15	4
Dissolved Zinc - Ug/L	800	0	205.00	4
Dissolved Tin - Ug/L	600	10	305.00	2
Dissolved Aluminum - Ug/L	270000	0	67505.00	4
Dissolved Gallium - Ug/L	85	5	45.00	2
Dissolved Germanium - Ug/L	60	14	37.00	2
Dissolved Lithium - Ug/L	180	0	63.25	4
Dissolved Selenium - Ug/L	2	1	1.50	2
Total Selenium - Ug/L	0	0	0.00	1
Dissolved Titanium - Ug/L	10000	7	5003.50	2
Dissolved Zirconium - Ug/L	410	15	212.50	2
Dissolved Gross Beta as CS-137	6.1	6.1	6.10	1
Chlorophyll A - Ug/L	4.2	.9	2.55	2
Chlorophyll B - Ug/L	2.7	.0	1.35	2
Phenols - Ug/L	5	1	2.75	4
Dissolved Solids (180 ^{o}C Residue)	717	475	561.00	4

WATER QUALITY DATA SUMMARY

FROM July TO October

STATION S-4

Parameter or Constituents (Mg/L)	Maximum	Minimum	Mean	# of Samples
Dissolved Solids (Tons/Day)	626	559	594.33	3
Dissolved Solids (Tons/ACF)	.98	.65	0.76	4
Total Ortho Phosphorus	.06	.06	0.06	1
Dissolved Ammonia	.08	.01	0.06	4
Dissolved Nitrate	.40	.00	0.14	3
Dissolved Nitrite	.03	.00	0.00	4
Bromide	.4	.0	0.12	4
Total Nitrogen	23	23	23	1
Dissolved Mercury	.4	.0	0.13	3
Dissolved Sulfide	.3	.1	0.10	4
Total Hardness (Ca, MG)	320	260	290.00	4
Non-Carbonate Hardness	110	81	93.00	4
Dissolved Calcium	76	65	68.75	4
Total Calcium	210	210	210.00	1
Dissolved Magnesium	36	24	28.75	4
Total Magnesium	76	76	76.00	1
Total Sodium	67	67	67.00	1
Dissolved Sodium	130	60	82.50	4
Sodium Adsorption Ratio	3.2	1.6	2.10	4
Percent Sodium	47	33	37.25	4
Dissolved Potassium	5.0	2.0	3.07	4
Total Potassium	10	10	10.00	1

WATER QUALITY DATA SUMMARY

FROM July TO October

STATION S-4

Parameter or Constituents (Mg/L)	Maximum	Minimum	Mean	# of Samples
Dissolved Chloride	120	30	52.40	5
Dissolved Sulfate	220	160	182.00	5
Dissolved Fluoride	.3	.2	0.25	4
Total Fluoride	1.0	1.0	1.00	1
Dissolved Silica	15	11	13.20	5
Dissolved Arsenic (Ug/L)	2	2	0.66	3
Total Arsenic (Ug/L)	45	45	45.00	1
Dissolved Barium (Ug/L)	2100	0	525.00	4
Dissolved Beryllium (Ug/L)	13	0	5.33	3
Dissolved Boron (Ug/L)	440	90	187.50	4
Dissolved Cadmium (Ug/L)	0	0	0	3
Dissolved Chromium (Ug/)	240	0	60	4
Dissolved Cobalt (Ug/L)	40	0	10.00	4
Dissolved Copper (Ug/L)	90	0	23.00	4
Total Copper (Ug/L)	90	90	90.00	1
Dissolved Iron (Ug/L)	98000	30	24542.50	4
Dissolved Lead (Ug/L)	87	1	22.75	4
Total Mercury	.1	.1	.1	1
Dissolved Gross Alpha as U-nat	9.7	9.7	9.70	1
Dissolved Gross Beta as Sr 90 (PC/L)	5.0	5.0	5.00	1

WATER QUALITY DATA SUMMARY

FROM July TO October

STATION S-11

Parameter or Constituents (Mg/L)	Maximum	Minimum	Mean	# of Samples
Temperature °C	19.0	11.5	16.50	3
Instantaneous Discharge (CFS)	464	288	376.00	2
Color (Platinum, Cobalt Units)	40	4	17.75	4
Specific Conductance (Micro MHOS)	1650	650	1004.50	4
Dissolved Oxygen	8.2	8.2	8.20	1
pH	8.4	7.9	8.20	4
Carbon Dioxide	4.7	1.7	2.72	4
Alkalinity as $CaCO_3$	217	189	205.00	4
Bicarbonate	265	231	250.25	4
Carbonate	0	0	0	4
Total Nitrogen	1.3	1.3	1.30	1
Organic Nitrogen	1.1	1.1	1.10	1
Dissolved Nitrogen Ammonia	.13	.01	0.05	3
Dissolved Nitrite	.01	.00	0.00	3
Dissolved Nitrate	.03	.00	0.01	2
Total Kjeldahl Nitrogen	1.2	.31	0.71	4
Total Nitrite + Nitrate	.14	.14	0.14	1
Dissolved Nitrite + Nitrate	.03	.00	0.01	3
Dissolved Ortho Phosphate	.03	.00	0.01	3
Total Phosphorus	1.0	.05	0.32	4
Total Organic Carbon	13	7.7	10.35	2
Total Inorganic Carbon	40	33	36.50	2

WATER QUALITY DATA SUMMARY

FROM July TO October

STATION S-11

Parameter or Constituents (Mg/L)	Maximum	Minimum	Mean	# of Samples
Cyanide	.00	.00	0.00	3
Dissolved Manganese (Ug/L)	700	.00	175.00	4
Dissolved Molybdenum - Ug/L	10	3	5.00	4
Dissolved Nickel - Ug/L	76	1	20.50	4
Dissolved Silver - Ug/L	4	0	2.00	3
Dissolved Strontium - Ug/L	1300	980	1126.66	3
Dissolved Vanadium - Ug/L	140	25	35.72	4
Dissolved Zinc - Ug/L	260	10	77.50	4
Dissolved Tin - Ug/L	30	12	21.00	2
Dissolved Aluminum - Ug/L	84000	10	21010.00	4
Dissolved Gallium - Ug/L	18	6	12.00	2
Dissolved Germanium - Ug/L	30	17	23.50	2
Dissolved Lithium - Ug/L	110	13	48.25	4
Dissolved Selenium - Ug/L	2	1	1.50	2
Total Selenium - Ug/L	0	0	0	1
Dissolved Titanium - Ug/L	5000	8	2504.00	2
Dissolved Zirconium - Ug/L	140	18	79.00	2
Dissolved Gross Beta as CS-137	2.8	2.8	2.80	1
Chlorophyll A - Ug/L	4.9	1.5	3.20	2
Chlorophyll B - Ug/L	2.5	.1	1.30	2
Phenols - Ug/L	1	0	0.33	3
Dissolved Solids (180^{o}C Residue)	892	465	651.00	3

WATER QUALITY DATA SUMMARY

FROM July TO October

STATION S-11

Parameter or Constituents (Mg/L)	Maximum	Minimum	Mean	# of Samples
Dissolved Solids (Tons/Day)	694	583	638.50	2
Dissolved Solids (Tons/ACF)	1.21	.63	0.88	3
Total Ortho Phosphorus	.06	.06	0.06	1
Dissolved Ammonia	.17	.01	0.07	3
Dissolved Nitrate	.13	.00	0.06	2
Dissolved Nitrite	.03	.00	0.01	3
Bromide	.9	.0	0.53	3
Total Nitrogen	5.9	5.9	5.90	1
Dissolved Mercury	.3	.0	0.10	3
Dissolved Sulfide	.2	.0	0.10	3
Total Hardness (Ca, MG)	320	280	306.66	3
Non-Carbonate Hardness	120	88	102.66	3
Dissolved Calcium	76	70	72.00	3
Total Calcium	110	110	110.00	1
Dissolved Magnesium	36	25	30.66	3
Total Magnesium	41	41	41.00	1
Total Sodium	62	62	62.00	1
Dissolved Sodium	180	54	102.66	3
Sodium Adsorption Ratio	4.4	1.4	2.53	3
Percent Sodium	54	30	39.00	3
Dissolved Potassium	6.1	1.9	3.70	3
Total Potassium	6.0	6.0	6.00	1

WATER QUALITY DATA SUMMARY

FROM July TO October

STATION S-11

Parameter or Constituents (Mg/L)	Maximum	Minimum	Mean	# of Samples
Dissolved Chloride	230	29	83.75	4
Dissolved Sulfate	210	160	185.00	4
Dissolved Fluoride	.3	.2	0.26	3
Total Fluoride	.7	.7	0.70	1
Dissolved Silica	16	11	13.50	4
Dissolved Arsenic (Ug/L)	2	0	1.33	3
Total Arsenic (Ug/L)	20	20	20.00	1
Dissolved Barium (Ug/L)	810	0	202.50	4
Dissolved Beryllium (Ug/L)	7	0	3.66	3
Dissolved Boron (Ug/L)	20	15	17.50	2
Dissolved Cadmium (Ug/L)	1	0	0.50	2
Dissolved Chromium (Ug/)	77	0	19.25	4
Dissolved Cobalt (Ug/L)	15	0	3.75	4
Dissolved Copper (Ug/L)	31	1	9.50	4
Total Copper (Ug/L)	30	30	30.00	1
Dissolved Iron (Ug/L)	38000	20	9535.00	4
Dissolved Lead (Ug/L)	28	0	9.25	4
Total Mercury	.0	.0	0.0	1
Dissolved Gross Alpha as U-nat	6.9	6.9	6.90	1
Dissolved Gross Beta as Sr 90 (PC/L)	2.3	2.3	2.30	1

APPENDIX B

AIR RESOURCES

APPENDIX B

DESCRIPTION OF THE AIR QUALITY BASELINE MONITORING SYSTEM

The air resources monitoring system is composed of 12 fixed measurement stations, and one mobile unit, which monitor some 60 square miles on and surrounding the 16 square miles which comprise the two tracts. These stations are located as shown in Figure B-1. Eight of these monitoring stations (at Sites A1 through A8) consist of instrumented trailers which contain air pollution analyzers and meteorological equipment. Another four stations (Sites A9 through A12) are purely meteorological stations, monitoring only wind and temperature. Another monitoring unit, installed in a truck, monitors both air quality and meteorology at any desired location.

The trailer stations all obtain electrical power from integral propane-fueled generators. Tall stacks (6 meters high) carry away the exhaust at the three stations which might otherwise measure it. Sites 9 through 12 are battery-powered.

Table B-1lists the parameters measured and indicates the locations at which they are recorded. Basically, all of the twelve sites monitor wind speed and direction and record total radiation dosage, and all of the trailer sites also record the gaseous sulfur compounds (total sulfur, sulfur dioxide, and hydrogen sulfide), and collect suspended particulates. Sound level and radiation surveys are performed regularly at all sites, and continuous radiation measurements are made on a rotating basis at all sites.

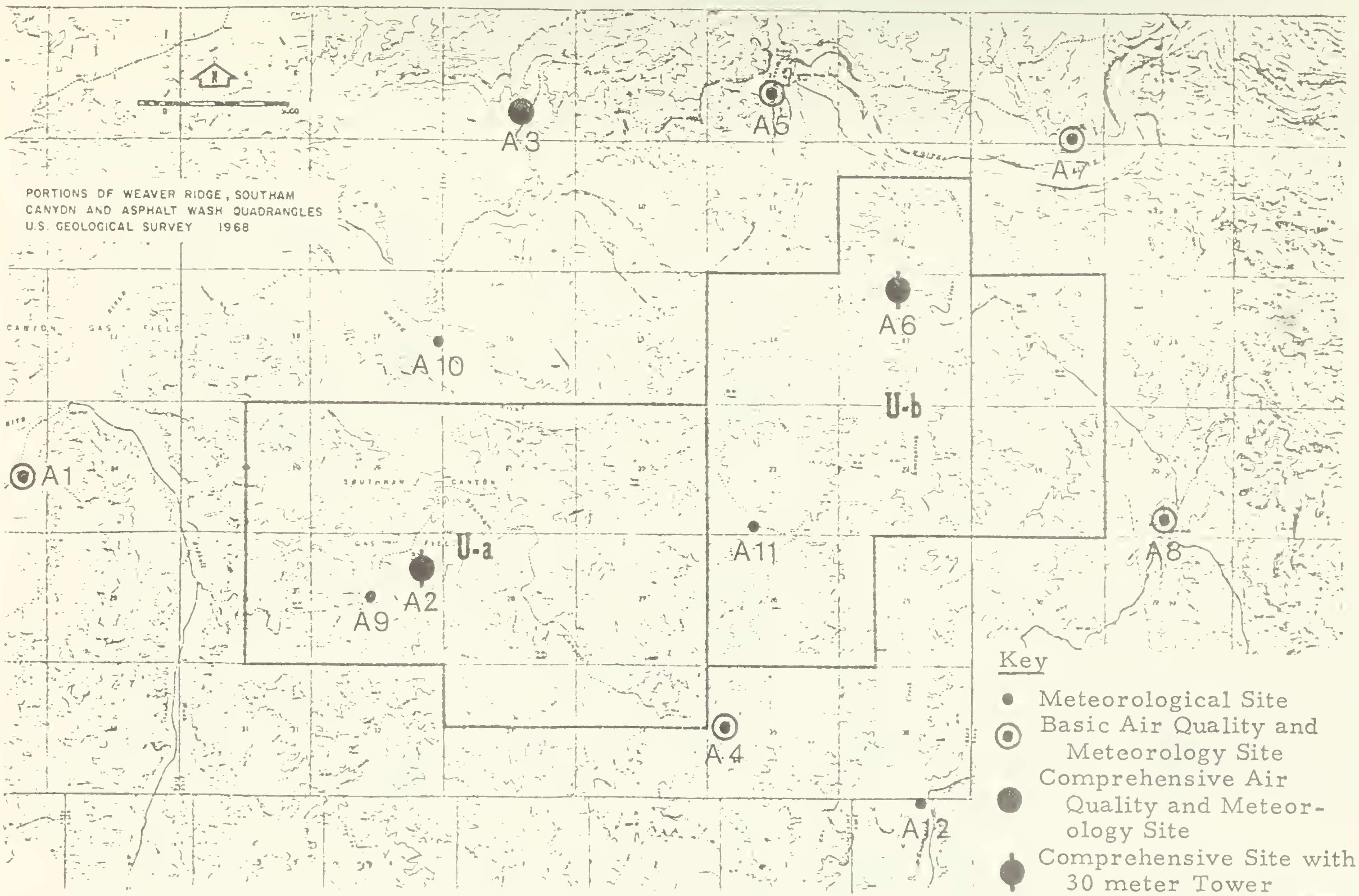


Figure B-1. Locations of Air Quality Baseline Monitoring Stations.

Table B-1 Air Resources Baseline Measurement Locations. An (X) denotes that the appropriate parameter is monitored at the given site. All measurements are continuous unless otherwise noted.

PARAMETER	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	Mobile	COMMENTS
Meteorology														
Wind Speed & Direction (10m)	X	X	X	X	X	X	X	X	X	X	X	X	X	
Wind Speed & Direction (20m)		X				X								
Wind Speed & Direction (30m)		X				X								
Temperature (10m)		X		X		X			X	X	X	X	X	
Lapse Rate (10-30m)		X				X								
Relative Humidity (10m)		X				X								
Lateral Turbulence (10m)				X									X	
Lateral Turbulence (30m)		X				X								
Vertical Turbulence (10m)				X									X	
Vertical Turbulence (30m)		X				X								
Net Thermal Radiation						X								
Barometric Pressure						X								
Acoustic Sounding		X												
Rawinsonde - T(h), RH(h)		X												Two soundings every 6th day
Air Quality														
Total Sulfur, SO_2, H_2S	X	X	X	X	X	X	X	X						
Suspended Particulates	X	X	X	X	X	X	X	X						24 hr. sample every 6th day
Total Hydrocarbons, CH_4		X	X			X								
CO		X	X			X								
O_3		X	X			X								
NO, NO_x		X	X			X								
Coefficient of Haze		X												
Scattering Coefficient		X												
Visibility									X					Monthly Observation
Trace Metals		X				X								See Note (a)
Carcinogens		X												Monthly 24 hr. sample
Size Fractionated Particulates		X												Monthly 24 hr. sample
Radiology														
Radiation Level	X	X	X	X	X	X	X	X	X	X	X			See Note (b)
Radiation Dosage	X	X	X	X	X	X	X	X	X	X	X			
Radioactivity of Particulates		X				X								Quarterly composite sample
Noise														
Sound Level	X	X	X	X	X	X	X	X	X	X	X			See Note (c)

Notes: (a) 24 hr sample every 6th day, alternating between Sites A2 and A6.

(b) Pressurized ion chamber rotated between Sites A1-A12; stationed one week at each site. Sites survey with hand-held scintillation counter and ion chamber before each installation of pressurized ion chamber.

(c) Tract survey with hand-held survey meter quarterly.

Two stations (Sites A2 and A6) have 30-meter meteorological towers which are instrumented at three levels (10, 20, and 30 meters above the ground) with various sensors to obtain wind speed and direction, wind shear, temperature, lapse rate, relative humidity, and turbulence. Inside the trailers at these two sites are included air pollution analyzers for hydrocarbons (both total hydrocarbons and methane), the oxides of nitrogen (NO and NO_x), carbon monoxide, and ozone.

Site A6 is the prime meteorological station for the area, and as such it also measures net thermal radiation and barometric pressure. Upper atmospheric structure above this site is monitored continuously by an acoustic sounder with a 1 kilometer (km) range, and rawinsonde launches in the morning and early afternoon of every sixth day provide profiles of temperature, humidity, and wind up to 2 km above the surface.

Site A2 has been established as the main aerosol monitoring station on these tracts. At this station are monitored the soiling index (coefficient of haze), the aerosol scattering coefficient for light, and nearby, at Site A9, visibility is recorded visually and photographically for one day each month. Size fractionated samples of suspended particulates are collected for 24 hours each month at Site A2, as are particulate samples for carcinogen screening. Samples of particulate matter are collected every sixth day, alternating between

Sites A2 and A6, for trace metals analysis, and quarterly composites of the regular high volume particulate samples from both of these sites are scanned for gross radioactivity.

Some additional observations are made at some of the sites. Temperature is measured at Sites A4 and at A9 through A12, in addition to the previously mentioned A2 and A6. Turbulence is measured at A4 also. Site A3 is as fully instrumented for air quality measurements as Site A6, but its only meteorological measurement capability is an anemometer at 10 m above the surface.

A wide variety of instrumentation is used to measure all of these parameters, as tabulated in Table B-2.

Data from most of these instruments is recorded in digital form on punched paper tape at five-minute intervals, from which it is computer processed to obtain one-hour averages as well as averages consistent with the computation time of air quality standards. Multipoint strip chart records serve as backup for the tapes. Some parameters are recorded solely on strip charts, which are then reduced either by hand or through a semi-manual computer digitizer.

The gaseous pollutant analyzers are calibrated using various techniques which are tabulated in Table B-3. These calibration techniques are in turn checked against other standards, as indicated in the third column of that table. Other equipment is also calibrated regularly.

Table B-2. Measurement Techniques Used for Air Resources Baseline Measurements.

PARAMETER	TECHNIQUE
Meteorology	
Wind Speed	Below 30 m - Cup anemometer Up to 2 km - Rawinsonde tracking
Wind Direction	Below 30 m - Wind vane Up to 2 km - Rawinsonde tracking
Temperature & Lapse Rate	Below 30 m - Thermistor in vacumn bottle radiation shield - Up to 2 km - Radiosonde
Relative Humidity	10 m - Thermoelectric dew point sensor Up to 2 km - Radiosonde
Lateral Turbulence	Computation of rms wind vane fluctuations by sigma meter
Vertical Turbulence	Computation of rms vertical wind speed by sigma meter from vertically oriented propeller
Net Thermal Radiation	Fritschen net radiometer
Barometric Pressure	Aneroid with electrical readout
Atmospheric Diffusion Capability	Monostatic acoustic sounder
Air Quality	
Sulfur Compounds (TS, SO_2, H_2S)	Gas chromatographic separation, flame photometric detection
Suspended Particulates	High volume sampling, weighing of filter
Hydrocarbons (THC, CH_4)	Gas chromatographic separation, flame ionization detection
Carbon Monoxide	Gas chromatographic separation, catalytic conversion to CH_4, flame ionization detection
Ozone	Chemiluminescent reaction with C_2H_4

PARAMETER	TECHNIQUE
Air Quality (Cont.)	
Nitric Oxide (NO)	Chemiluminescent reaction with O_3
Nitrogen Oxides (NO_x)	Catalytic conversion of NO_2 to NO, chemiluminescent reaction with O_3
Coefficient of Haze	Collection of sample on filter tape, measurement of light transmission
Scattering Coefficient	Integrating nephelometer
Visibility	Photography and visual observation
Trace Metals	X-ray fluorescence and arc spectrography of filter samples and suspended particulates
Carcinogens	Complex chemical extraction of polynuclear aromatic hydrocarbons from filter samples of suspended particulates
Size Fractionated Particulates	High volume cascade impactor, weighing of filters
Radiology	
Radiation Level	(1) Scintillation counter, (2) Ionization chamber, (3) Pressurized ionization chamber
Radiation Dosage	Thermoluminescent dosimetry
Radioactivity of Particulates	Gross radiation measurement of filter sample
Noise	
Sound Level	Precision sound level meter; A-weighted scale

Table B-3. Gas Analyzer Calibration Techniques

Component	Field Calibration	Primary Reference
Total sulfur, SO_2	SO_2 permeation tube	Pararosaniline method
H_2S	H_2S permeation tube in N_2 stream	Cadminum hydroxide stractan method
Total hydrocarbons CH_4	8 ppm CH_4 in air	Gas chromatography
CO	8 ppm CO in air	Gas chromatography
O_3	O_3 generator	Neutral buffered potassium iodide method
NO, NO_x	Dilution of 100 ppm NO in N_2	Oxidation by CrO_3 and triethanol-amine, followed by modified Saltz-man method

The high volume sampler flow rates are calibrated using a standard orifice. The anemometer cups are wind tunnel calibrated against an NBS traceable standard. Temperature sensors are checked against a precision thermometer with an NBS traceable calibration. The dew point hygrometers have been calibrated against a precision dew point sensor with an NBS traceable calibration. Similar quality techniques are used to assure proper calibration of other sensors.

A quality assurance program, consisting of operational checks of instruments every four days augmented by calibrations at intervals of 30 days to 12 months, with the interval depending on the specific sensor, insures that the data obtained has a high degree of reliability. Specifically, the accuracies expected for all of the air pollutants and some of the other components are tabulated in Table B-4.

Table B-4. Estimated RMS Accuracy of Some Measurements

Component	Reference Accuracy (1)	System Accuracy (1)(2)	Total Accuracy (1)
Total Sulfur, SO_2	$\pm$3% or 1 ppb	$\pm$3% or 2 ppb	$\pm$4% or 2 ppb (5 Ug/m^3 of SO_2)
H_2S	$\pm$5% or 1 ppb	$\pm$3% or 2 ppb	$\pm$6% or 2 ppb (3 Ug/m^3)
Hydrocarbons (corrected for CH_4	$\pm$2% or 0.1 ppm (3)	$\pm$3% or 0.15 ppm (4)	$\pm$4% or 0.2 ppm (130 Ug/m^3 of CH_4)
CO	$\pm$2% or 0.1 ppm	$\pm$2% or 0.1 ppm	$\pm$3% or 0.15 ppm (.17 mg/m^3)
O_3	$\pm$3% or 0.005 ppm	$\pm$2% or 0.005 ppm	$\pm$4% or 0.007 ppm (14 Ug/m^3)
NO_2	$\pm$3% or 0.005 ppm (5)	$\pm$3% or 0.007 ppm (6)	$\pm$4% or 0.01 ppm (20 Ug/m^3 of NO_2)
Suspended Particulates	$\pm$2%	$\pm$2% or 0.1 Ug/m^3	$\pm$3% or 0.1 Ug/m^3
Coefficient of Haze	$\pm$2%	$\pm$5%	$\pm$5%
Scattering Coefficient	$\pm$1%	$\pm$2% or 10^{-5} m^{-1}	$\pm$2% or 10^{-5} m^{-1}
Wind Speed	$\pm$0.1 mph	$\pm$2% or 0.5 mph	$\pm$2% or 0.5 mph
Wind Direction	$\pm 1^\circ$	$\pm$2% or 3°	$\pm$2% or 3°
Temperature	$\pm 0.05^\circ C$	$\pm 0.15^\circ C$	$\pm 0.2^\circ C$
Sound Level	$\pm$1 dB	$\pm$2 dBA	$\pm$2 dBA

Notes:

(1) The larger of the values given applies

(2) Total for all portions including recorders and readout

(3) For CH_4 standard

(4) Including subtraction of CH_4 from THC

(5) For NO standard with dilution

(6) Including subtraction of NO from NO_x

APPENDIX C

SOILS

UTAH STATE UNIVERSITY
Soils Laboratory
Logan, Utah

SOIL ANALYSIS REPORT

COLLECTED BY Dr. A. Southard DATE LOCATION

LABORATORY NUMBER	COLLECTOR'S NUMBER	DEPTH IN INCHES	HORIZON	PARTICLE SIZE DISTRIBUTION (in mm) (percent): VERY COARSE SAND 2-1	COARSE SAND 1-0.5	MEDIUM SAND 0.5-0.25	FINE SAND 0.25-0.10	VERY FINE SAND 0.10-0.05	% SILT - Hydrometer --	% CLAY	% Sand	% > 2 mm.	TEXTURAL CLASS
2	37-0-8			11	10	9	24	14	27	11	62	16	SL
3	8-22			14	9	6	20	15	29	10	61	47	SL
4	22-36			12	6	3	10	15	45	12	43	39	L
1	36-44			----	----	----	insuff. sample	--	--	--	--	57	---
5	38 0-12			8	8	11	27	9	28	10	62	28	SL
6	12-27			8	5	3	6	10	57	9	34	37	SiL
7	27-53			16	9	6	12	9	46	9	45	21	L

	pH: SATURATED PASTE	1:5	ORGANIC MATTER: ORGANIC MATTER %	ORGANIC CARBON %	NITROGEN %	C/N	TOTAL SOLUBLE SALTS %	ELECTRICAL CONDUCTIVITY EC x 10^3 MILLIMHOS PER CM @25°C	CaCO3 equivalent per cent	GYPSUM: me./100g SOIL	%	MOISTURE TENSIONS: 1/3 ATMOS. %	15 ATMOS. %
2	8.1			.9				.5	11.3			12.9	6.1
3	8.5			.8				.9	11.1			16.5	8.3
4	8.4			.8				5.8	10.8			24.3	8.2
1	8.4			.6				20	8.3			insuf. sample	
5	8.1			2.4				.6	14.8			18.3	11.4
6	8.5			1.1				.3	23.5			31.6	9.4
7	8.5			.6				.5	41.3			19.4	6.4

	CATION EXCHANGE CAPACITY	Extractable CATIONS ppm (NH4OAc): Ca	Mg	Na	K	Avail P ppm	SATURATION EXTRACT SOLUBLE (milliequivalents per liter): Na	K	CO_3	HCO_3	Cl	SO_4	PER CENT MOISTURE AT SATURATION
2			1.4	.4	.4	5.7							30
3			2.4	1.4	.1	.9							42
4			3.9	9.4	.1	.3							44
1			5.7	12.5	.1	1.4							41
5			1.0	.4	.2	4.0							49
6			2.6	.7	.1	.3							58
7			3.5	.7	<.1	.3							41

[signature]

UTAH STATE UNIVERSITY

Soils Laboratory

Logan. Utah

SOIL ANALYSIS REPORT

COLLECTED BY Dr. A. Southard DATE ______ LOCATION ______

LABORATORY NUMBER	COLLECTOR'S NUMBER	DEPTH IN INCHES	HORIZON	PARTICLE SIZE DISTRIBUTION (in mm.) (percent): VERY COARSE SAND 2-1	COARSE SAND 1-0.5	MEDIUM SAND 0.5-0.25	FINE SAND 0.25-0.10	VERY FINE SAND 0.10-0.05	% SILT (Hydrometer)	% CLAY (Hydrometer)	% Sand (Hydrometer)	% > 2 mm.	TEXTURAL CLASS
8	#39	0-4		2	11	30	29	8	9	8	83	4	LS
9		4-17		6	13	30	25	6	11	11	78	7	SL
10		17-35		11	19	27	21	5	8	10	82	25	LS
11	#40	0-6		7	9	15	27	12	22	12	66	18	SL
12		6-31		11	10	13	23	12	24	9	67	21	SL
13		31-137		12	12	14	23	11	21	9	70	23	SL

LABORATORY NUMBER	pH: SATURATED PASTE	pH: 1:5	ORGANIC MATTER: ORGANIC MATTER %	ORGANIC CARBON %	NITROGEN %	C/N	TOTAL SOLUBLE SALTS %	ELECTRICAL CONDUCTIVITY $EC \times 10^3$ MILLIMHOS PER CM @25°C	CaCO3 equivalent per cent	GYPSUM: me./100g SOIL	GYPSUM: %	MOISTURE TENSIONS: 1/3 ATMOS. %	15 ATMOS. %
8	8.1			.5				.6	3.0			8.1	4.6
9	8.2			.5				.5	3.7			9.3	5.8
10	8.5			.5				.3	6.8			10.4	6.3
11	8.0			.9				.9	13.4			13.9	6.0
12	8.3			.5				.4	9.7			11.9	5.7
13	8.2			.5				1.9	7.8			12.9	6.2

LABORATORY NUMBER	CATION EXCHANGE CAPACITY	Extractable CATIONS ppm (NH4OAc): Ca	Mg	Na	K	Avail P ppm	SATURATION EXTRACT SOLUBLE (milliequivalents per liter): Na	K	CO_3	HCO_3	Cl	SO_4	PER CENT MOISTURE AT SATURATION
8			1.0	.3	.4	16							29
9			1.3	.5	.2	3.2							32
10			1.0	.5	<.1	1.0							38
11			1.9	.4	1.1	24							34
12			1.9	.4	.7	4.9							32
13			2.3	2.8	.2	3.5							33

UTAH STATE UNIVERSITY
Soils Laboratory
Logan, Utah
SOIL ANALYSIS REPORT

COLLECTED BY Dr. A. Southard DATE ______ LOCATION ______

LABORATORY NUMBER	COLLECTOR'S NUMBER	DEPTH IN INCHES	HORIZON	PARTICLE SIZE DISTRIBUTION (in mm.) (percent) VERY COARSE SAND 2-1	COARSE SAND 1-0.5	MEDIUM SAND 0.5-0.25	FINE SAND 0.25-0.10	VERY FINE SAND 0.10-0.05	% SILT – Hydrometer --	% CLAY	% Sand	% > 2 mm.	TEXTURAL CLASS
14	#42	0-6		9	16	15	19	8	23	10	67	29	SL
15		6-13		10	15	14	20	9	28	10	62	27	SL
16		13-41		15	10	8	17	9	36	10	54	31	SL
17		41-60		14	9	5	13	14	40	13	47	28	L
18	#45	0-4		8	7	9	22	13	31	12	57	22	SL
19		4-23		9	10	12	26	12	25	12	63	31	SL
20		23-40		7	9	11	24	12	26	11	63	18	SL
21		40-76		7	7	9	22	13	26	13	61	18	SL
22		76-121		11	13	13	21	8	20	13	67	41	SL

	pH SATURATED PASTE	pH 1:5	ORGANIC MATTER ORGANIC MATTER %	ORGANIC CARBON %	NITROGEN %	C/N	TOTAL SOLUBLE SALTS %	ELECTRICAL CONDUCTIVITY $EC \times 10^3$ MILLIMHOS PER CM @25°C	$CaCO_3$ equivalent per cent	GYPSUM me./100g SOIL	GYPSUM %	MOISTURE TENSIONS 1/3 ATMOS. %	15 ATMOS. %
14	8.1			1.5				.5	7.4			15.0	8.0
15	8.1			2.4				.3	10.7			20.6	12.7
16	8.5			1.2				.4	13.6			20.3	8.7
17	8.6			.8				1.9	12.6			21.3	8.9
18	7.9			.8				.4	6.0			13.8	6.2
19	8.2			1.0				.3	8.1			12.9	7.2
20	8.3			.6				2.4	8.3			13.8	7.5
21	8.2			.4				13.0	7.6			14.9	7.8
22	8.3			.2				19.0	9.7			13.7	7.1

	CATION EXCHANGE CAPACITY	Extractable CATIONS ppm Ca (NH4OAc)	Mg	Na	K	Avail P ppm	SATURATION EXTRACT SOLUBLE (milliequivalents per liter) Na	K	CO_3	HCO_3	Cl	SO_4	PER CENT MOISTURE AT SATURATION
14			.8	.3	.2	3.8							38
15			1.0	.4	.1	2.2							58
16			2.7	1.0	.1	.5							52
17			5.2	6.4	.1	.3							51
18			.7	.3	.4	3.3							29
19			1.2	.4	.2	1.0							41
20			2.0	3.3	.1	.3							34
21			2.4	9.7	.1	.3							35
22			2.9	14.0	.1	1.5							33

R. E. [signature]

UTAH STATE UNIVERSITY
Soils Laboratory
Logan, Utah
SOIL ANALYSIS REPORT

COLLECTED BY Dr. A. Southard DATE ______ LOCATION ______

LABORATORY NUMBER	COLLECTOR'S NUMBER	DEPTH IN INCHES	HORIZON	VERY COARSE SAND 2-1	COARSE SAND 1-0.5	MEDIUM SAND 0.5-0.25	FINE SAND 0.25-0.10	VERY FINE SAND 0.10-0.05	% SILT (Hydrometer)	% CLAY (Hydrometer)	% Sand (Hydrometer)	% > 2 mm	TEXTURAL CLASS
				PARTICLE SIZE DISTRIBUTION (in mm.) (percent)									
23	#46	0-6		18	9	4	8	11	40	13	47	23	L
24		6-20		12	7	3	5	6	62	13	25	35	SiL
25		20-45		12	7	3	5	6	59	14	27	34	SiL
26	#48	0-9		1	1	3	16	33	33	10	57	1	SL
27		9-20		<1	1	2	12	26	34	27	39	1	L
28		20-34		<1	1	2	8	15	35	38	27	0	CL
29		34-55		<1	1	3	12	16	35	31	34	1	CL
30		55-89		<1	1	2	7	21	40	30	30	0	CL
31		89-158		1	2	2	8	17	46	26	28	2	L

LABORATORY NUMBER	pH SATURATED PASTE	pH 1:5	ORGANIC MATTER %	ORGANIC CARBON %	NITROGEN %	C/N	TOTAL SOLUBLE SALTS %	ELECTRICAL CONDUCTIVITY $EC \times 10^3$ MILLIMHOS PER CM @25°C	CaCO3 equivalent per cent	GYPSUM me./100g SOIL	GYPSUM %	MOISTURE TENSIONS 1/3 ATMOS. %	MOISTURE TENSIONS 15 ATMOS. %
23	8.0			1.1				.5	8.3			20.1	7.3
24	8.3			1.2				.4	23.4			28.9	9.6
25	8.7			1.0				1.1	16.4			32.5	9.1
26	8.7			.3				.9	4.5			9.8	3.6
27	8.9			.3				2.4	10.5			26.4	11.3
28	8.5			.3				14.0	15.2			26.8	14.0
29	8.2			.2				33.0	15.5			20.2	10.5
30	8.1			.2				22.0	15.4			18.9	8.3
31	8.3			.1				20.0	11.7			18.9	8.3

LABORATORY NUMBER	CATION EXCHANGE CAPACITY	Extractable CATIONS ppm Ca (NH4OAc)	Mg	Na	K	Avail P ppm	Saturation Extract Soluble Na (milliequivalents per liter)	K	CO_3	HCO_3	Cl	SO_4	% Moist. at Sat.
23			2.2	.4	.3	7.3							39
24			5.0	.9	.1	1.5							56
25			8.6	3.0	.1	1.5							57
26			2.4	1.7	.9	6.4							28
27			3.9	11.4	.3	3.4							48
28			5.7	19.8	.2	1.8							62
29			5.7	19.6	.2	1.0							48
30			5.0	15.7	.1	1.0							48
31			5.0	13.5	.2	.6							49

UTAH STATE UNIVERSITY
Soils Laboratory
Logan, Utah
SOIL ANALYSIS REPORT

COLLECTED BY Dr. A. Southard DATE ______ LOCATION ______

LABORATORY NUMBER	COLLECTOR'S NUMBER	DEPTH IN INCHES	HORIZON	PARTICLE SIZE DISTRIBUTION (in mm.) (percent) VERY COARSE SAND 2-1	COARSE SAND 1-0.5	MEDIUM SAND 0.5-0.25	FINE SAND 0.25-0.10	VERY FINE SAND 0.10-0.05	% SILT – Hydrometer –	% CLAY	% Sand	% > 2 mm.	TEXTURAL CLASS
23	#46	0-6		18	9	4	8	11	40	13	47	23	L
24		6-20		12	7	3	5	6	62	13	25	35	SiL
25		20-45		12	7	3	5	6	59	14	27	34	SiL
26	#48	0-9		1	1	3	16	33	33	10	57	1	SL
27		9-20		<1	1	2	12	26	34	27	39	1	L
28		20-34		<1	1	2	8	15	35	38	27	0	CL
29		34-55		<1	1	3	12	16	35	31	34	1	CL
30		55-89		<1	1	2	7	21	40	30	30	0	CL
31		89-158		1	2	2	8	17	46	26	28	2	L

	pH SATURATED PASTE	pH 1:5	ORGANIC MATTER: ORGANIC MATTER %	ORGANIC CARBON %	NITROGEN %	C/N	TOTAL SOLUBLE SALTS %	ELECTRICAL CONDUCTIVITY EC x 10^3 MILLIMHOS PER CM @25°C	CaCO3 equivalent per cent	GYPSUM me./100g SOIL	GYPSUM %	MOISTURE TENSIONS 1/3 ATMOS. %	15 ATMOS. %
23	8.0			1.1				.5	8.3			20.1	7.3
24	8.3			1.2				.4	23.4			28.9	9.6
25	8.7			1.0				1.1	16.4			32.5	9.1
26	8.7			.3				.9	4.5			9.8	3.6
27	8.9			.3				2.4	10.5			26.4	11.3
28	8.5			.3				14.0	15.2			26.8	14.0
29	8.2			.2				33.0	15.5			20.2	10.5
30	8.1			.2				22.0	15.4			18.9	8.3
31	8.3			.1				20.0	11.7			18.9	8.3

	CATION EXCHANGE CAPACITY	Extractable CATIONS ppm (NH4OAc) Ca	Mg	Na	K	Avail P ppm	SATURATION EXTRACT SOLUBLE (milliequivalents per liter) Na	K	CO3	HCO3	Cl	SO4	% Moist. at Sat.
23			2.2	.4	.3	7.3							39
24			5.0	.9	.1	1.5							56
25			8.6	3.0	.1	1.5							57
26			2.4	1.7	.9	6.4							28
27			3.9	11.4	.3	3.4							48
28			5.7	19.8	.2	1.8							62
29			5.7	19.6	.2	1.0							48
30			5.0	15.7	.1	1.0							48
31			5.0	13.5	.2	.6							49

[signature]

UTAH STATE UNIVERSITY
Soils Laboratory
Logan, Utah
SOIL ANALYSIS REPORT

COLLECTED BY Dr. A. Southard DATE ______ LOCATION ______

LABORATORY NUMBER	COLLECTOR'S NUMBER	DEPTH IN INCHES	HORIZON	PARTICLE SIZE DISTRIBUTION (in mm.) (percent) VERY COARSE SAND 2-1	COARSE SAND 1-0.5	MEDIUM SAND 0.5-0.25	FINE SAND 0.25-0.10	VERY FINE SAND 0.10-0.05	% SILT (Hydrometer)	% CLAY (Hydrometer)	% Sand (Hydrometer)	% > 2 mm.	TEXTURAL CLASS
32	#50	0-11		4	3	2	10	18	44	16	40	21	L
33		11-30		12	6	3	10	13	44	15	41	41	L
34		30-42		21	13	6	11	8	35	14	51	60	L
35		42-49		23	14	6	16	7	27	17	56	57	SL

LABORATORY NUMBER	pH SATURATED PASTE	pH 1:5	ORGANIC MATTER %	ORGANIC CARBON %	NITROGEN %	C/N	TOTAL SOLUBLE SALTS %	ELECTRICAL CONDUCTIVITY $EC \times 10^3$ MILLIMHOS PER CM @25°C	CaCO3 equivalent per cent	GYPSUM me./100g SOIL	GYPSUM %	MOISTURE TENSIONS 1/3 ATMOS. %	MOISTURE TENSIONS 15 ATMOS. %
32	8.0			1.1				.8	3.9			19.4	9.4
33	8.2			1.1				.4	15.9			20.7	9.8
34	9.0			.8				1.1	10.9			26.1	11.2
35	8.5			.7				5.4	8.5			24.2	11.4

LABORATORY NUMBER	CATION EXCHANGE CAPACITY	Extractable CATIONS ppm (NH4OAc) Ca	Mg	Na	K	Avail P ppm	SATURATION EXTRACT SOLUBLE (milliequivalents per liter) Na	K	CO_3	HCO_3	Cl	SO_4	PER CENT MOISTURE AT SATURATION
32			2.9	1.0	.8	7.4							36
33			2.9	1.4	.1	1.1							56
34			2.6	10.9	.8	1.0							46
35			3.5	13.5	.2	3.5							46

UTAH STATE UNIVERSITY · LOGAN, UTAH 84322

COLLEGE OF NATURAL RESOURCES

WATERSHED SCIENCE UNIT

January 20, 1975

Mr. Jim Walsh
Parker Place 4
2600 South Parker Rd.
Denver, Colorado 80232

Dear Mr. Walsh:

Enclosed find the infiltration data which you requested through Dr. Cy McKell. Methodology used was as follows:

> A Rocky Mountain infiltrometer was used to generate runoff from small, moveable plots 76 cm x 30 cm in size (.23 square meters of soil surface coverage). Plots were installed by driving the edges into the soil surface about 9 cm with a specially constructed hammer. An adjustable canvas wind shield was used to prevent wind disturbance and raindrop drift. Plots were either prewet to field capacity prior to an infiltrometer run (termed "wet" plots) or were run under existing antecedent moisture conditions (termed "dry" plots). Artificial rainfall was applied to the plots for 28 minutes. Rainfall and runoff rates were determined at 5-minute intervals, and infiltration was considered to be the difference between these two measures. All samples were taken during the period October 9-12, 1974.

The data and supplementary information are shown as envelope curves in the attached graphs. The envelope curves simply indicate minimum and maximum infiltration rates based on a set of three plots run under conditions as described. It would have been desirable to have had more plots in the "dry" condition (surface soils dry to start), but a rain during the evening of October 10 eliminated the possibility of running further "dry" plots. Forty-five infiltrometer plots were run of which 9 were "dry" and 36 were "wet" (soils at field capacity to start).

Infiltration rates per plot for select time intervals are given below:

	Time Intervals (minutes)				
Plot #1 (Dry)	3-8	8-13	13-18	18-23	23-28
Infiltration Rate (in/hr)	3.02	3.21	2.61	2.73	2.18

Sediment yield = 0.20 tons per acre

Plot #1 (Wet)					
Infiltration Rate (in/hr)	2.71	2.92	2.65	2.39	2.53

Sediment yield = 0.25 tons per acre)

	Time Intervals (minutes)				
	3-8	8-13	13-18	18-23	23-28
Plot #2 (Dry)					
Infiltration Rate (in/hr)	3.42	3.19	2.95	2.79	2.64
Sediment yield = 0.15 tons per acre					
Plot #2 (Wet)					
Infiltration Rate (in/hr)	1.33	1.95	2.04	0.68	1.07
Sediment yield = 0.20 tons per acre					
Plot #3 (Dry)					
Infiltration Rate (in/hr)	3.89	2.79	2.95	2.93	3.25
Sediment yield = 0.01 tons per acre					
Plot #3 (Wet)					
Infiltration Rate (in/hr)	2.93	2.89	3.06	2.73	2.87
Sediment yield = 0.03 tons per acre					
Plot #4 (Dry)					
Infiltration Rate (in/hr)	3.02	2.86	3.04	3.00	2.43
Sediment yield = 0.22 tons per acre					
Plot #4 (Wet)					
Infiltration Rate (in/hr)	2.47	2.36	2.06	2.43	2.25
Sediment yield = 0.42 tons per acre					
Plot #5 (Dry)					
Infiltration Rate (in/hr)	3.56	3.43	2.75	2.62	2.48
Sediment yield = 0.47 tons per acre					
Plot #5 (Wet)					
Infiltration Rate (in/hr)	1.54	1.26	1.52	1.87	1.22
Sediment yield = 2.35 tons per acre					
Plot #6 (Dry)					
Infiltration Rate (in/hr)	3.47	2.72	3.30	1.76	2.06
Sediment yield = 0.68 tons per acre					
Plot #6 (Wet)					
Infiltration Rate (in/hr)	2.01	1.58	1.76	1.96	1.92
Sediment yield = 0.42 tons per acre					

	Time Intervals (minutes)				
	3-8	8-13	13-18	18-23	23-28
Plot #7 (Dry)					
Infiltration rate (in/hr)	2.74	1.75	2.16	1.59	1.47
Sediment yield = 0.18 tons per acre					
Plot #7 (Wet)					
Infiltration Rate (in/hr)	1.88	1.49	1.76	1.44	1.46
Sediment yield = 0.38 tons per acre					
Plot #8 (Dry)					
Infiltration Rate (in/hr)	2.51	1.87	1.73	1.49	1.36
Sediment yield = 0.27 tons per acre					
Plot #8 (Wet)					
Infiltration Rate (in/hr)	1.61	1.65	1.63	1.53	1.39
Sediment yield = 0.79 tons per acre					
Plot #9 (Dry)					
Infiltration Rate (in/hr)	2.97	1.95	1.50	1.28	1.13
Sediment yield = 0.16 tons per acre					
Plot #9 (Wet)					
Infiltration Rate (in/hr)	1.85	1.48	1.31	1.49	1.14
Sediment yield = 0.33 tons per acre					
Plot #10 (Wet)					
Infiltration Rate (in/hr)	1.47	1.27	1.43	1.39	1.53
Sediment yield = 0.32 tons per acre					
Plot #11 (Wet)					
Infiltration Rate (in/hr)	1.39	1.26	1.69	1.51	1.35
Sediment yield = 0.67 tons per acre					
Plot #12 (Wet)					
Infiltration Rate (in/hr)	2.06	2.00	2.20	2.11	2.28
Sediment yield = 0.78 tons per acre					
Plot #13 (Wet)					
Infiltration Rate (in/hr)	2.83	2.20	2.26	2.25	1.94
Sediment yield = 0.34 tons per acre					

	Time Intervals (minutes)				
	3-8	8-13	13-18	18-23	23-28
Plot #14 (Wet)					
Infiltration Rate (in/hr)	3.14	3.09	2.97	3.05	2.71
Sediment yield = 0.25 tons per acre					
Plot #15 (Wet)					
Infiltration Rate (in/hr)	2.49	2.42	2.20	2.12	2.07
Sediment yield = 0.28 tons per acre					
Plot #16 (Wet)					
Infiltration Rate (in/hr)	3.05	2.89	2.79	2.40	2.60
Sediment yield = 0.01 tons per acre					
Plot #17 (Wet)					
Infiltration Rate (in/hr)	4.09	3.42	3.38	3.42	2.93
Sediment yield = 0.00 tons per acre					
Plot #18 (Wet)					
Infiltration Rate (in/hr)	3.42	2.68	2.81	2.44	2.01
Sediment yield = 0.00 tons per acre					
Plot #19 (Wet)					
Infiltration Rate (in/hr)	3.54	4.13	2.91	2.71	2.68
Sediment yield = 0.09 tons per acre					
Plot #20 (Wet)					
Infiltration Rate (in/hr)	3.88	4.05	3.22	3.72	3.52
Sediment yield = 0.17 tons per acre					
Plot #21 (Wet)					
Infiltration Rate (in/hr)	2.82	2.80	2.01	2.12	2.22
Sediment yield = 0.28 tons per acre					
Plot #22 (Wet)					
Infiltration Rate (in/hr)	1.61	0.98	1.13	1.41	0.98
Sediment yield = 0.86 tons per acre					
Plot #23 (Wet)					
Infiltration Rate (in/hr)	1.78	1.38	1.53	1.45	1.47
Sediment yield = 0.59 tons per acre					

	Time Intervals (minutes)				
	3-8	8-13	13-18	18-23	23-28
Plot #24 (Wet)					
Infiltration Rate (in/hr)	2.12	2.20	2.11	1.93	1.72
Sediment yield = 0.23 tons per acre					
Plot #25 (Wet)					
Infiltration Rate (in/hr)	0.82	0.60	0.82	0.59	0.72
Sediment yield = 0.69 tons per acre					
Plot #26 (Wet)					
Infiltration Rate (in/hr)	2.31	0.75	1.01	0.72	0.74
Sediment yield = 0.80 tons per acre					
Plot #27 (Wet)					
Infiltration Rate (in/hr)	1.74	0.75	1.01	.62	.74
Sediment yield = 0.57 tons/acre					
Plot #28 (Wet)					
Infiltration Rate (in/hr)	3.68	3.14	3.68	3.43	2.56
Sediment yield = 0.59 tons per acre					
Plot #29 (Wet)					
Infiltration Rate (in/hr)	2.19	2.09	2.35	1.76	1.79
Sediment yield = 4.72 tons per acre					
Plot #30 (Wet)					
Infiltration Rate (in/hr)	3.96	1.98	2.48	2.01	1.65
Sediment yield = 2.02 tons per acre					
Plot #31 (Wet)					
Infiltration Rate (in/hr)	1.70	1.44	1.09	1.26	1.00
Sediment yield = 0.03 tons per acre					
Plot #32 (Wet)					
Infiltration Rate (in/hr)	3.41	3.04	2.59	2.74	2.08
Sediment yield = 0.17 tons per acre					
Plot #33 (Wet					
Infiltration Rate (in/hr)	1.63	1.37	1.10	1.54	0.43
Sediment yield = 0.51 tons per acre					

	Time Intervals (minutes)				
	3-8	8-13	13-18	18-23	23-28
Plot #34 (Wet)					
Infiltration Rates (in/hr)	2.33	2.20	1.85	1.75	1.72
Sediment yield = 0.26 tons per acre					
Plot #35 (Wet)					
Infiltration Rate (in/hr)	1.55	1.09	1.10	0.98	0.85
Sediment yield = 1.14 tons per acre					
Plot #36 (Wet)					
Infiltration Rate (in/hr)	1.79	1.45	1.22	1.12	1.03
Sediment yield = 0.43 tons per acre					

Due to the small number of replications (3) per sampling location it is probably best to simply use the information to indicate certain possible trends. From the graphs it is obvious that infiltration rates are highest on very gentle slopes and decrease somewhat with increased slope and also with increased rock cover on the soil surface. It is interesting that steep slopes with favorable soil conditions maintained reasonably high infiltration rates (Figure 10) whereas more gentle slopes with less permeable soils had lower infiltration rates (Figure 9). Influence of antecedent moisture conditions were apparent throughout an infiltrometer run on gentle slopes (Figure 1) but on steeper slopes infiltration rates were influenced by antecedent soil moisture only during the first 15 minutes or so of an infiltrometer run (Figure 2, 3).

Attempts will be made to correlate infiltrometer data with detailed soils information, once the latter is available.

If you have any questions, please let me know.

Sincerely,

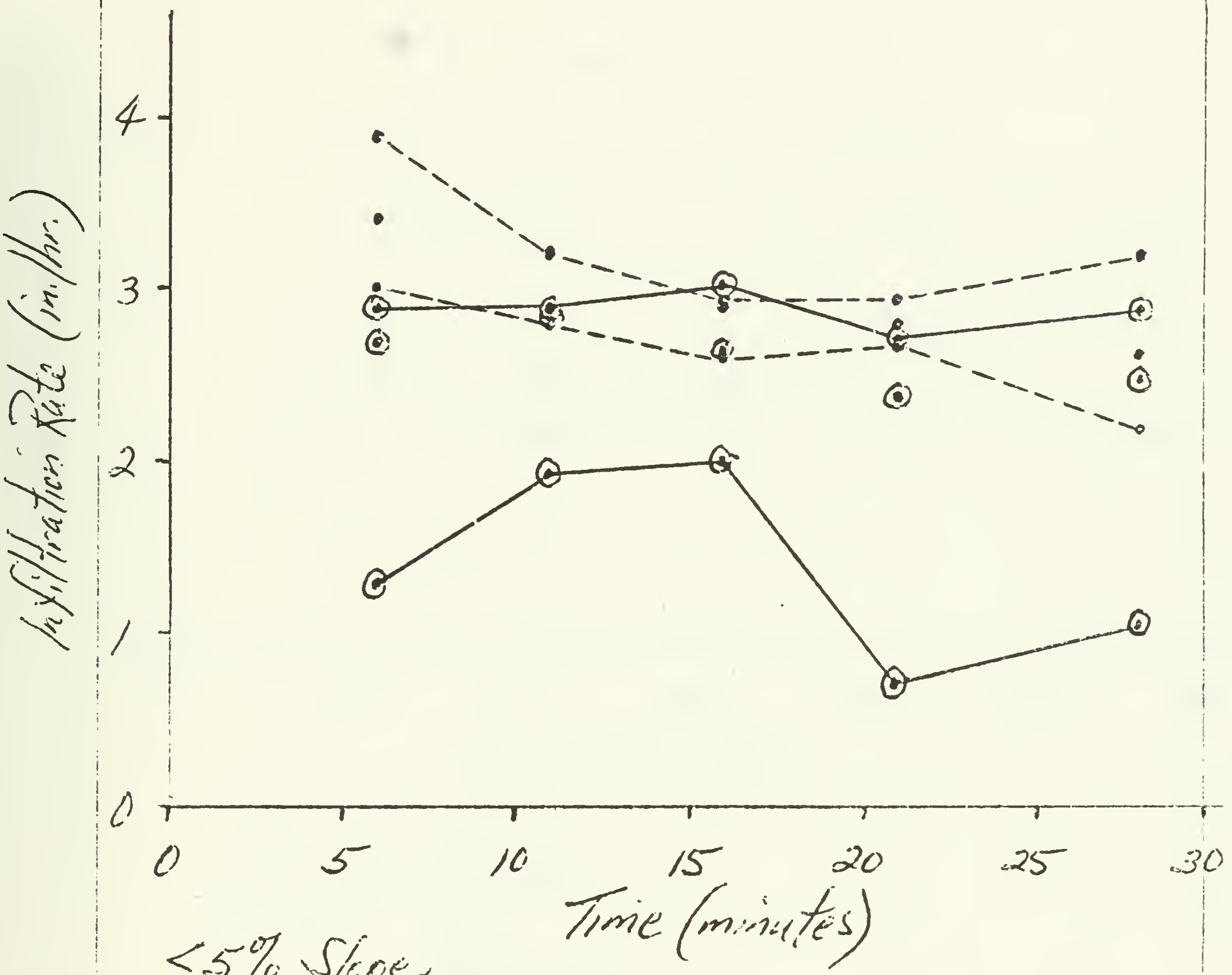
Gerald F. Gifford

Gerald F. Gifford
Chairman, Watershed Science Unit

GFG:ja

cc: Cy McKell

Figure 1 (Plots 1,2,3 wet; 1,2,3 dry)



<5% Slope

Vegetation: Greasewood
Black Sage
Shadscale
Stipa
Indian Rice Grass

Antecedent Moisture: ——— Wet

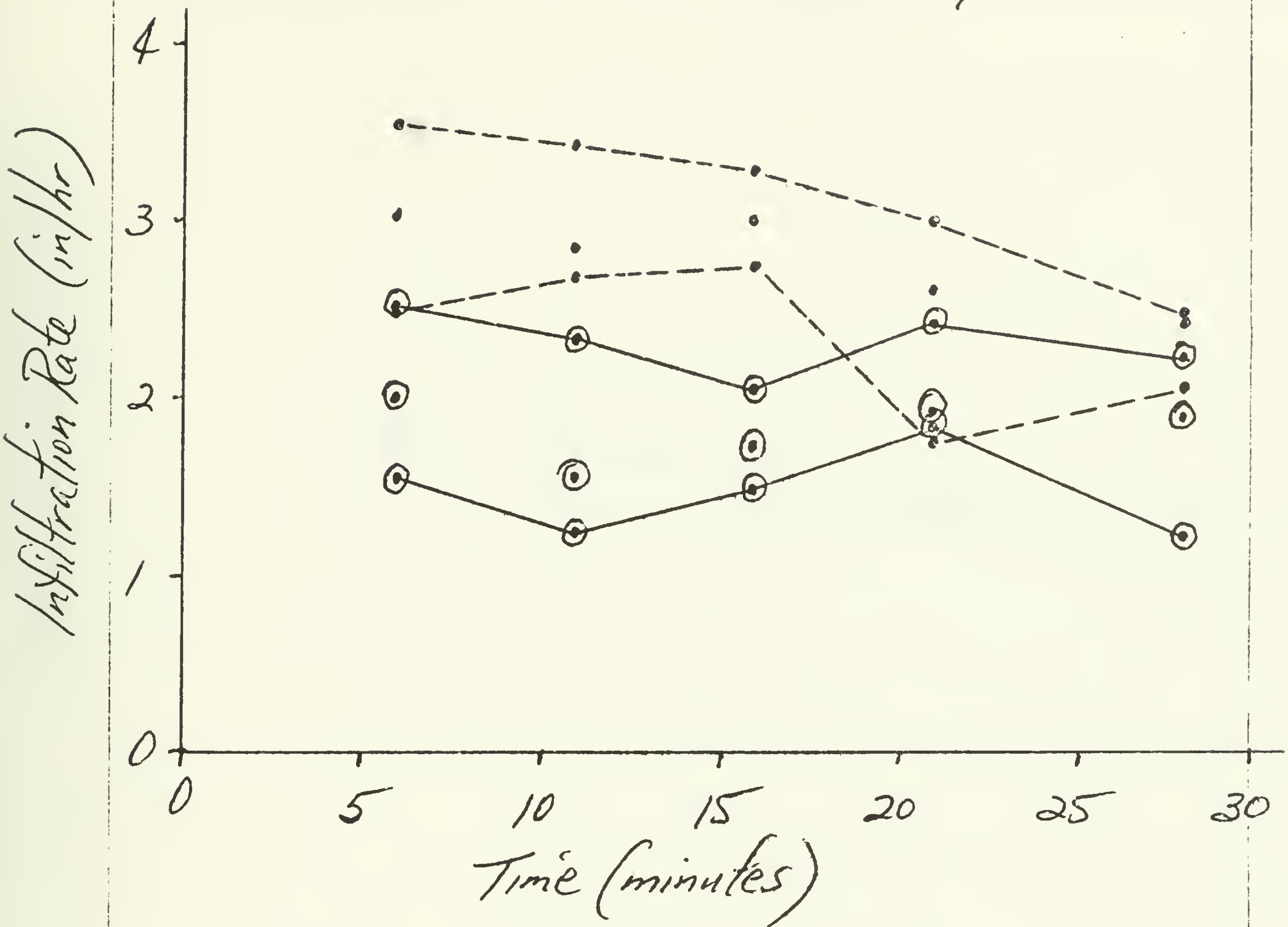
------ Dry

Average Percent Bare Soil: 28%

Sediment Yields: Dry $\bar{x}$ = 0.12 tons/acre

Wet $\bar{x}$ = 0.16 tons/acre

Figure 2 (Plots 4,5,6 wet; 4,5,6 dry)



60% Slope (Rocky)

Vegetation: Stipa
Blacksage

Antecedent Moisture: ——— Wet

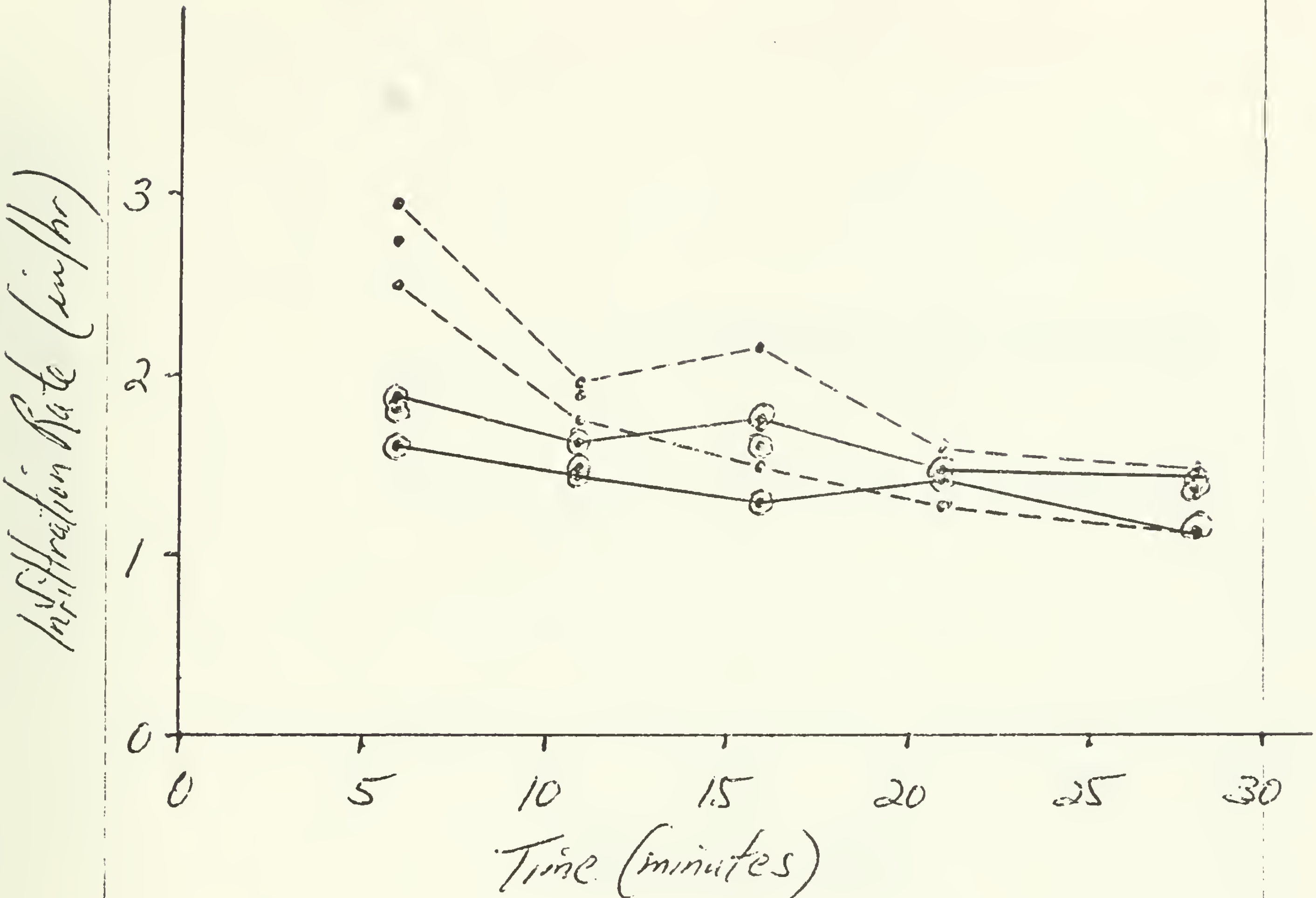
------ Dry

Average Percent Bare Soil: 12%

Sediment Yields: Dry $\bar{x}$ = 0.46 tons/acre

Wet $\bar{x}$ = 1.06 tons/acre

Figure 3 (Plots 7,8,9 wet; 7,8,9 dry)



20-30% Slope

Vegetation: Greasewood
Shadscale
Blacksage
Stipa
Indian Rice Grass

Antecedent Moisture: ——— Wet

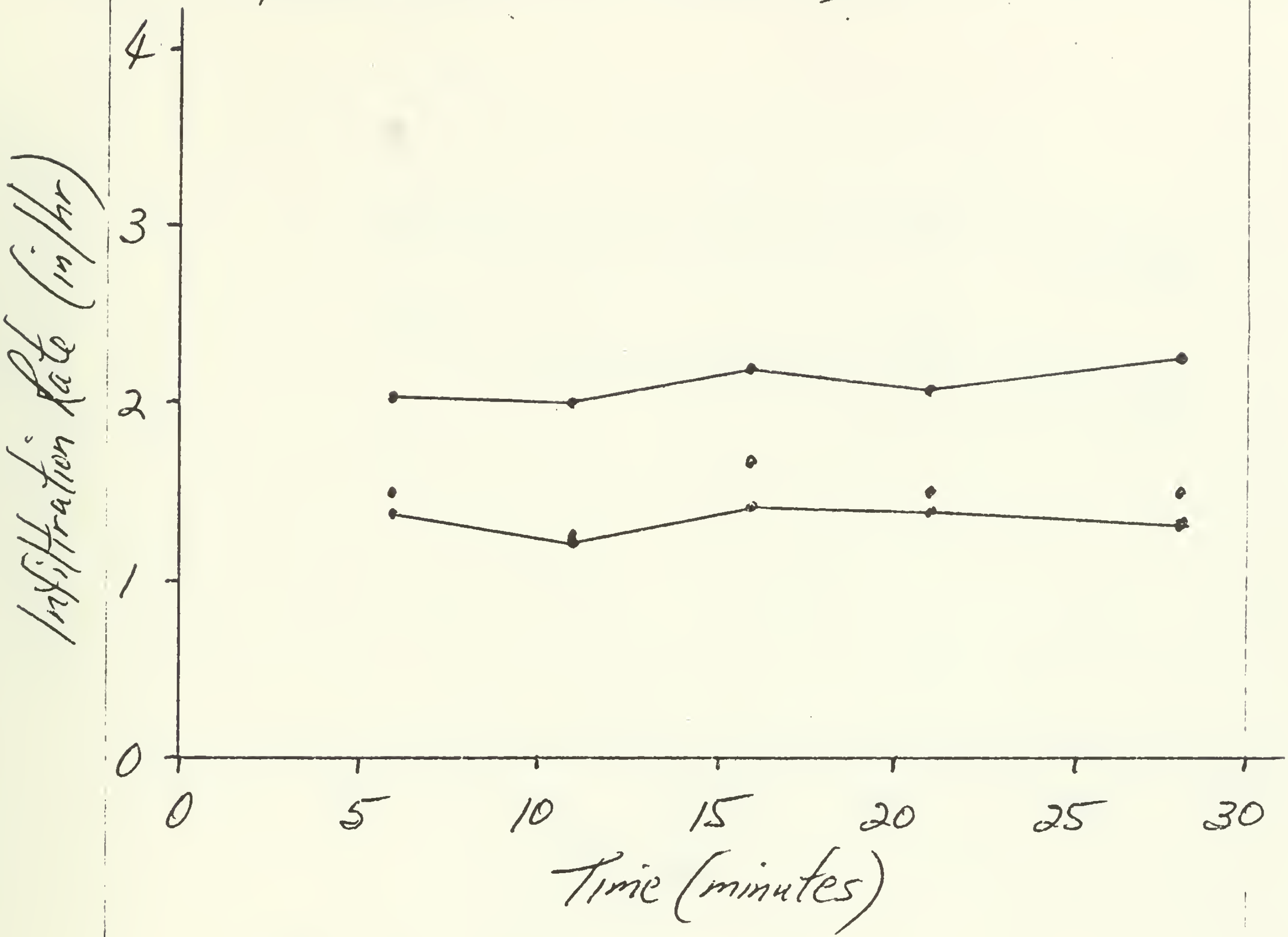
- - - - Dry

Average Percent Bare Soil: 16%

Sediment Yields: Dry $\bar{x}$ = 0.20 tons/acre

Wet $\bar{x}$ = 0.50 tons/acre

Figure 4 (Plots 10, 11, 12 wet)



15% Slope (Alluvial fan)

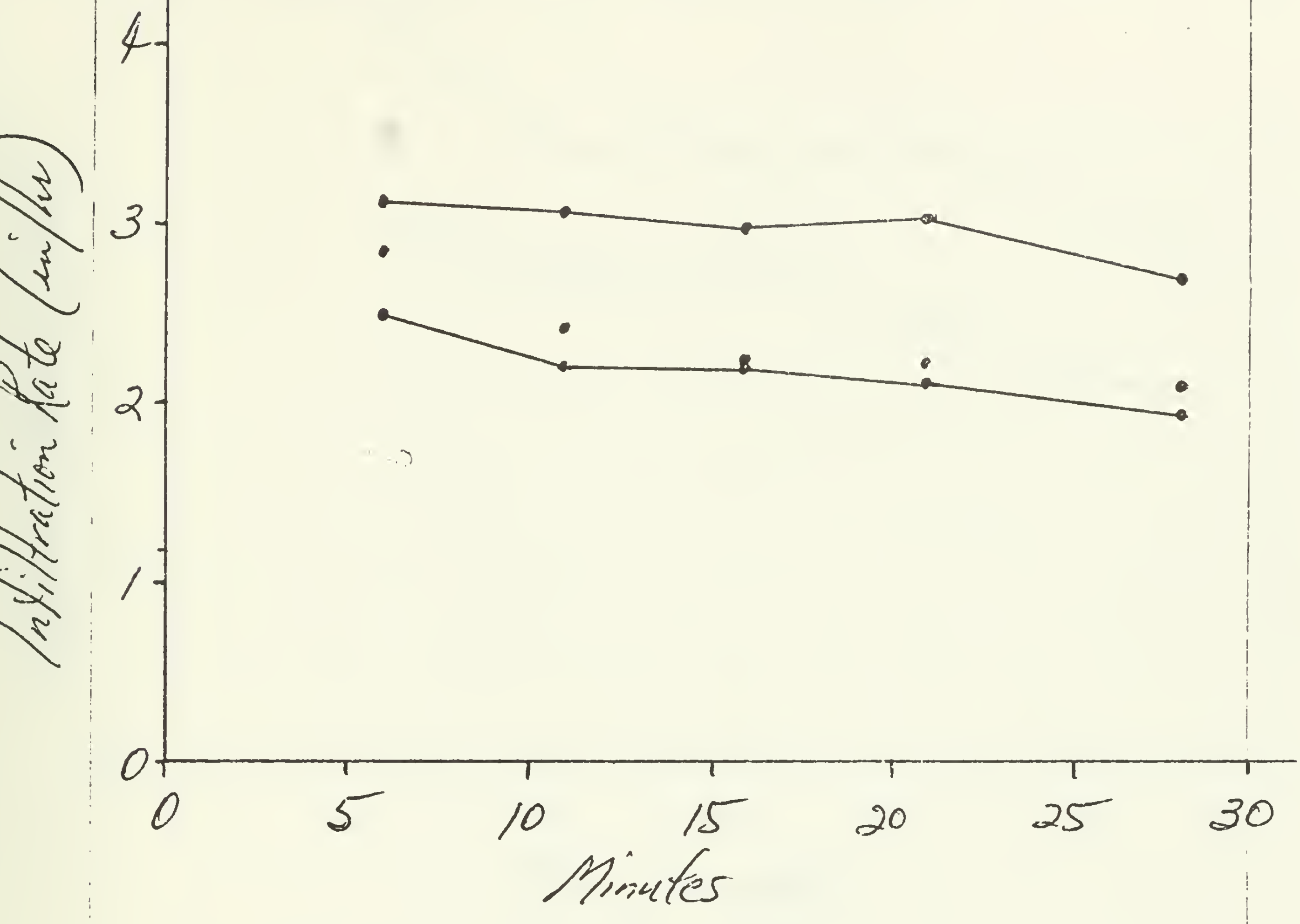
Vegetation: Blacksage
Greasewood
Tetrademia
Indian Rice Grass

Antecedent Moisture (Wet)

Average Percent Bare Soil: 21%

Sediment Yield: Wet $\bar{x}$ = 0.59 tons/acre

Figure 5 (Plots 13, 14, 15 wet)



15% Slope (Alluvial fan)

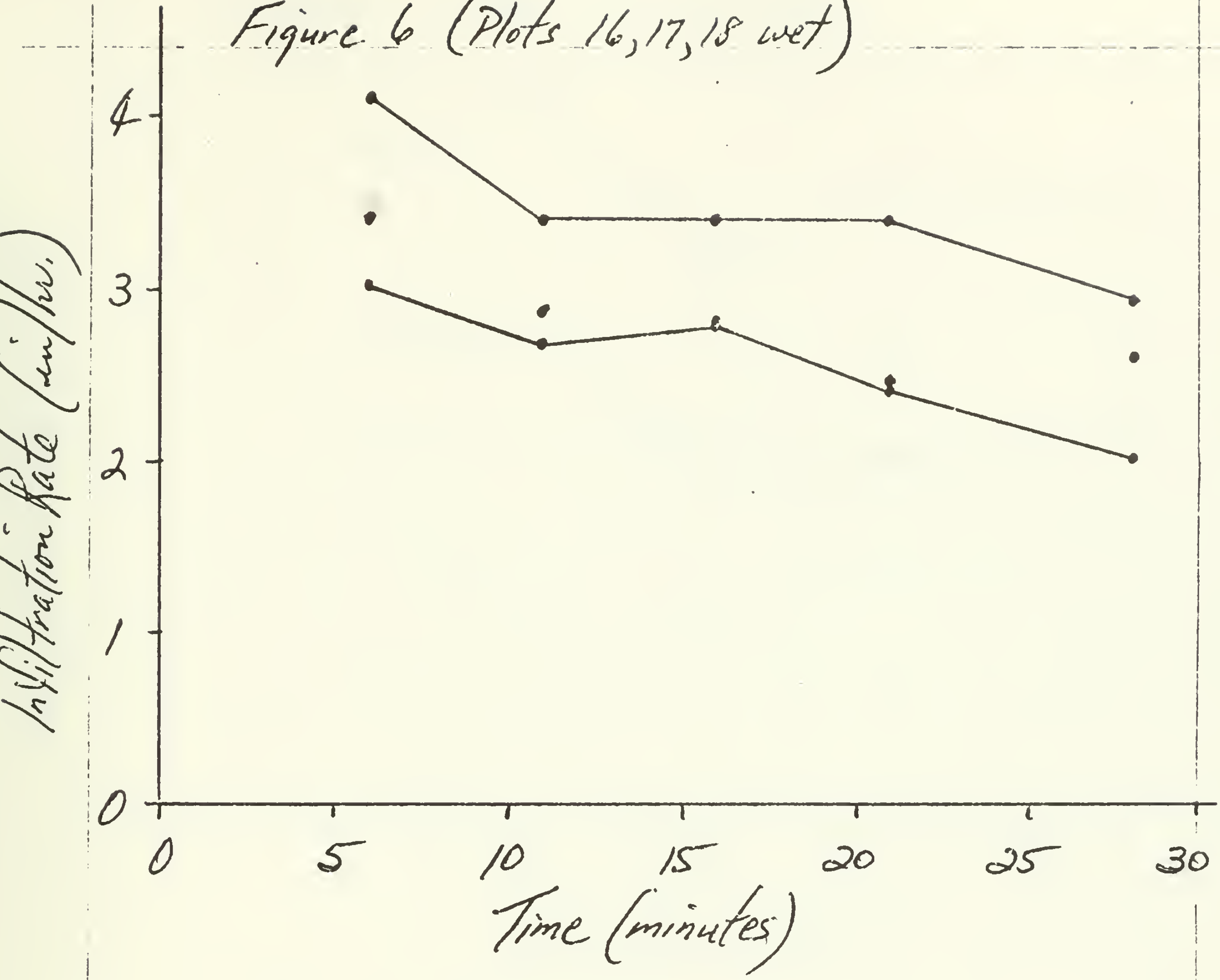
Vegetation: Blacksage
Greasewood
Tetradymia
Indian Rice Grass

Antecedent Moisture (wet)

Average Percent Bare Soil: 19%

Sediment Yield: Wet $\bar{x} = 0.29$ tons/acre

Figure 6 (Plots 16, 17, 18 wet)



0-5% Slope (Alluvial slope)

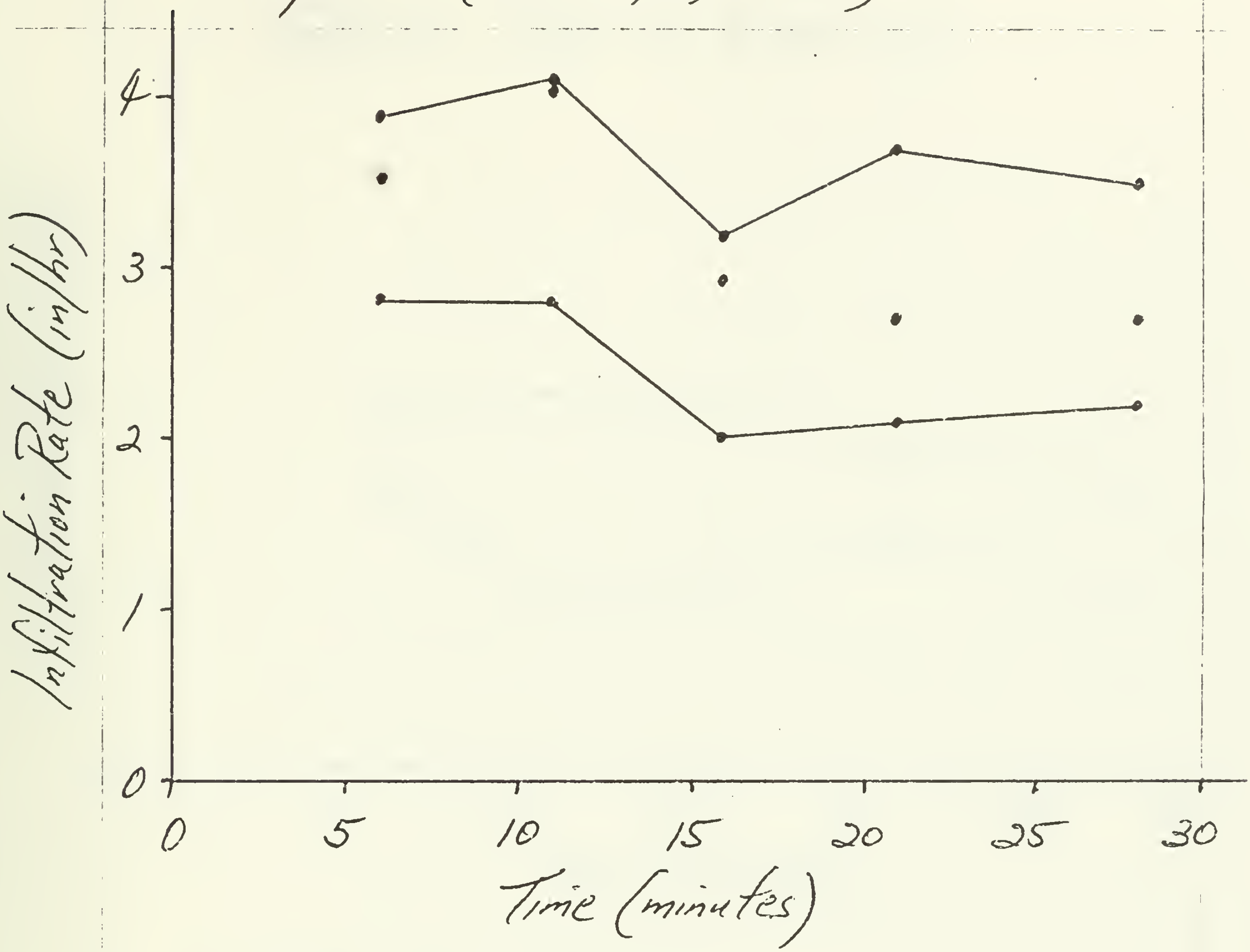
Vegetation: Greasewood
Sagebrush
Cheatgrass
Indian Rice Grass

Antecedent Moisture (Wet)

Average Percent Bare Soil: 30%

Sediment Yield: Wet $\bar{x}$ = <.01 tons/acre

Figure 7 (Plots 19, 20, 21 wet)



0-5% Slope

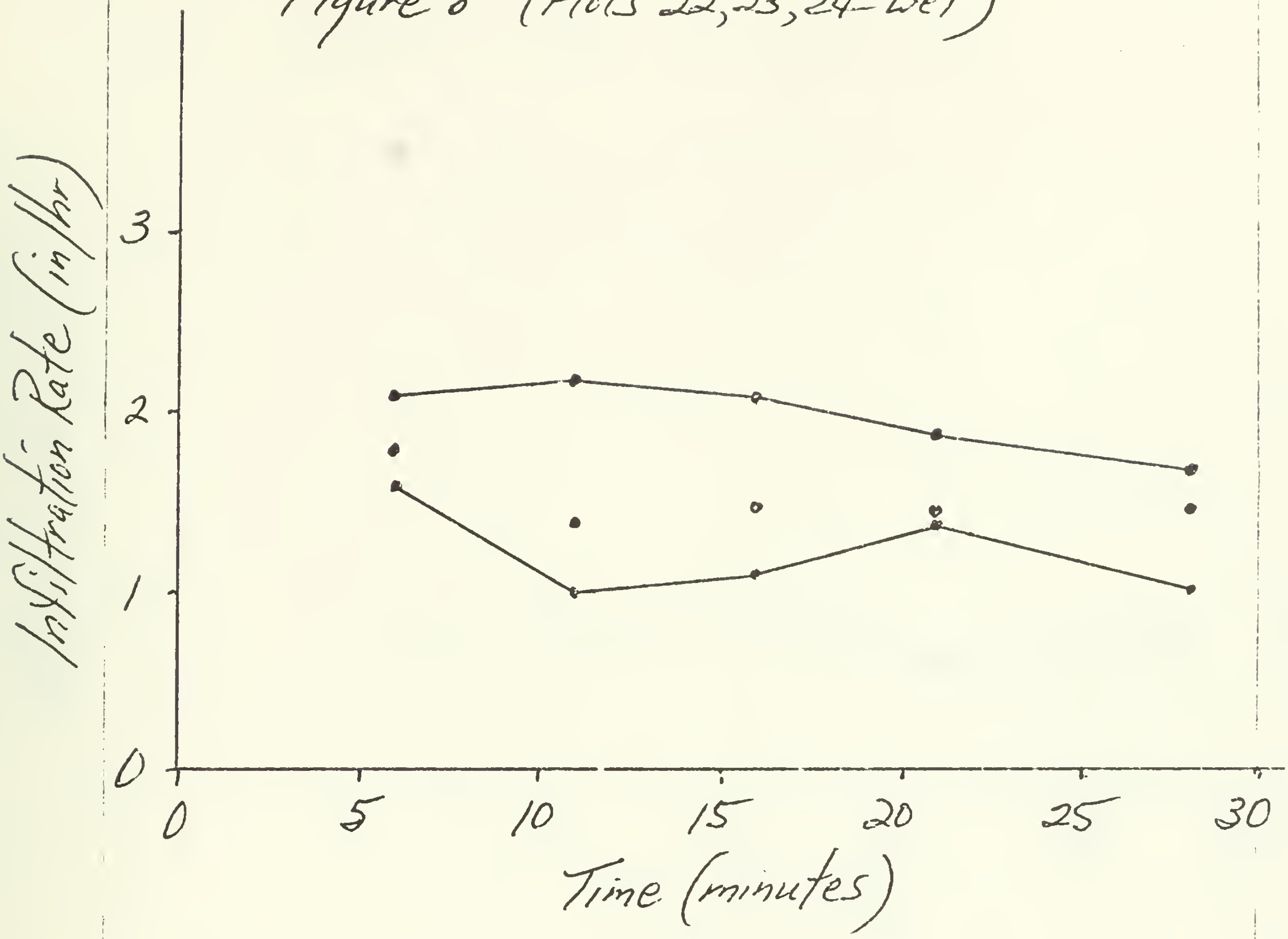
Vegetation: Greasewood
Blacksage
Cheatgrass

Antecedent Moisture (Wet)

Average Percent Bare Soil = 65%

Sediment Yield: Wet $\bar{x}$ = 0.18 tons/acre

Figure 8 (Plots 22, 23, 24-wet)



30-40% Slope (Rocky)

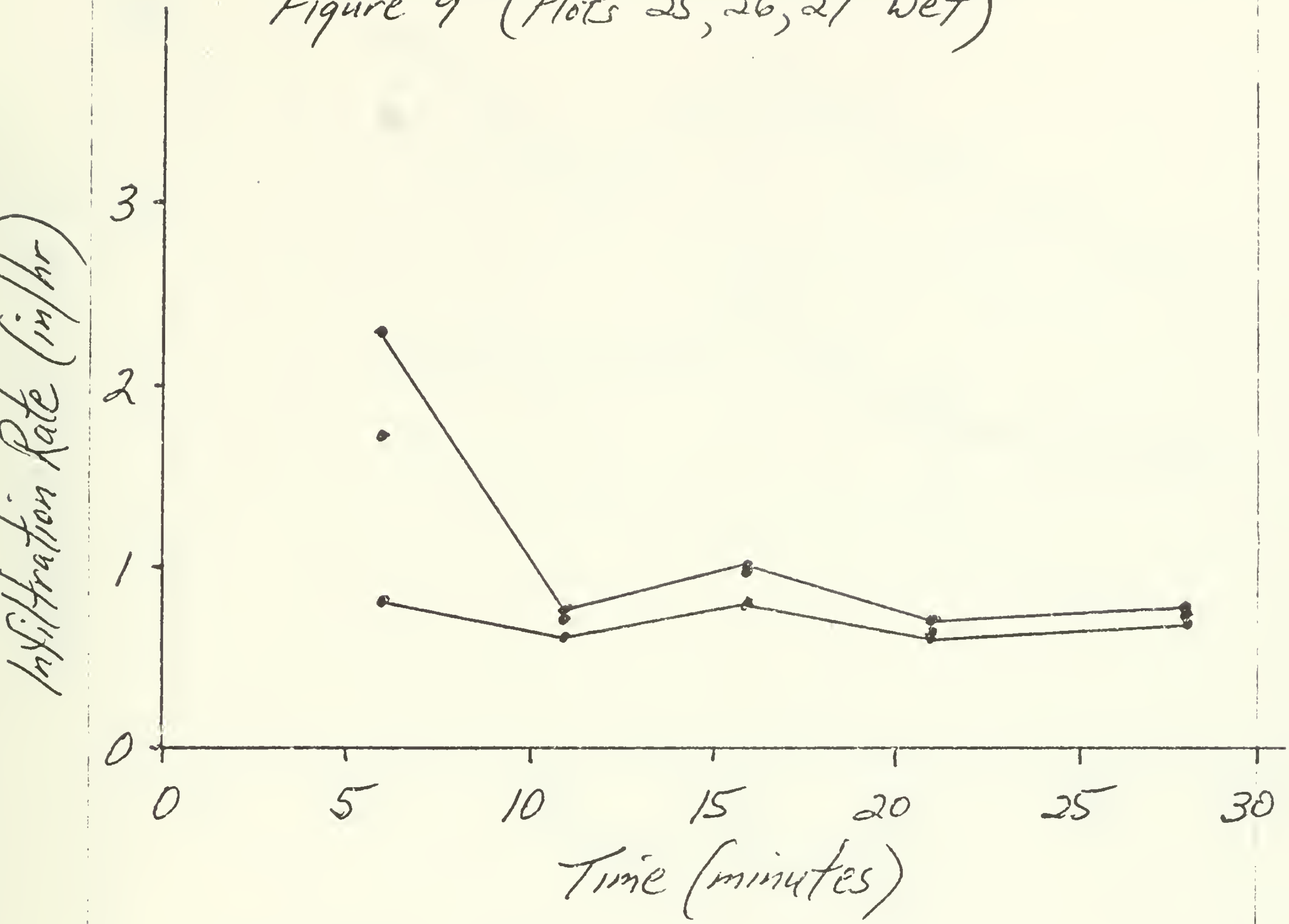
Vegetation: Juniper
Black Sage
Shadscale

Antecedent Moisture (Wet)

Average Percent Bare Soil: 60%

Sediment Yield: Wet $\bar{x}$ = 0.56 tons/acre

Figure 9 (Plots 25, 26, 27 wet)



30% Slope

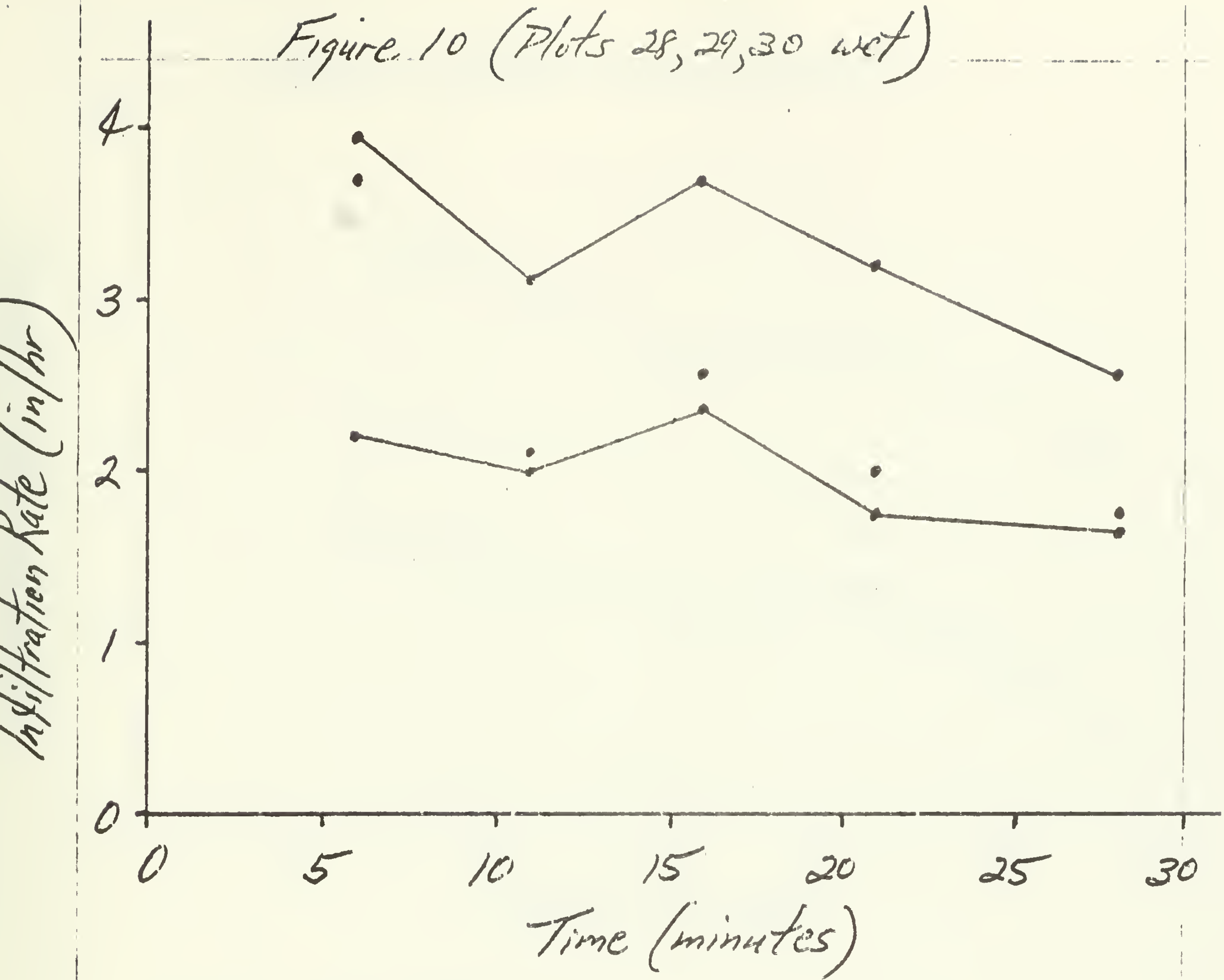
Vegetation: Juniper
Rabbitbrush
Shadscale

Antecedent Moisture (Wet)

Average Percent Bare Soil: 39%

Sediment Yield: Wet $\bar{x}$ = 0.69 tons/acre

Figure 10 (Plots 28, 29, 30 wet)



80-90% Slope

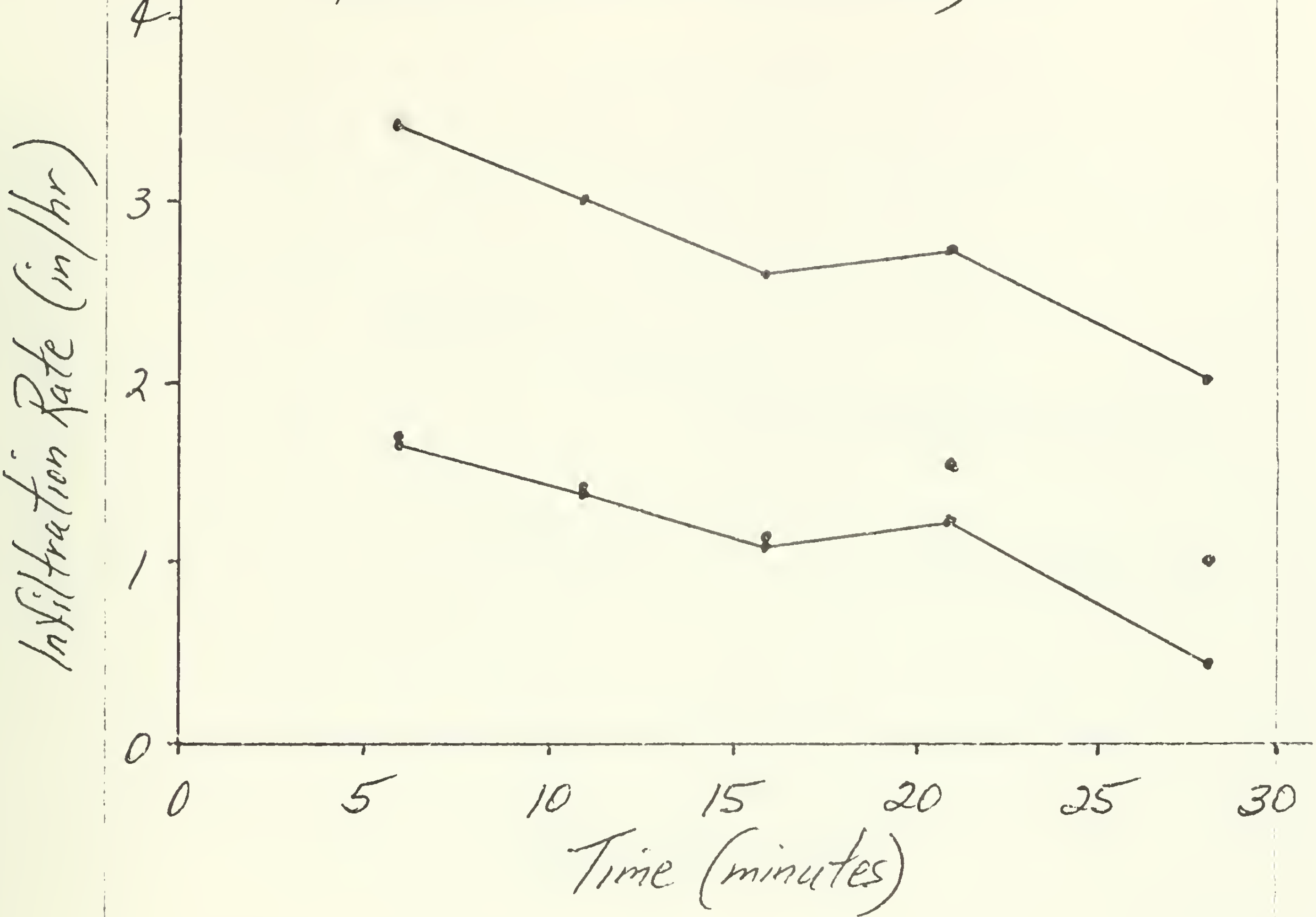
Vegetation: Blacksage, Shadscale, Scattered Juniper

Antecedent Moisture (Wet)

Average Percent Bare Soil: 43%

Sediment Yield: Wet $\bar{x} = 2.44$ tons/acre

Figure 11 (Plots 31, 32, 33 wet)



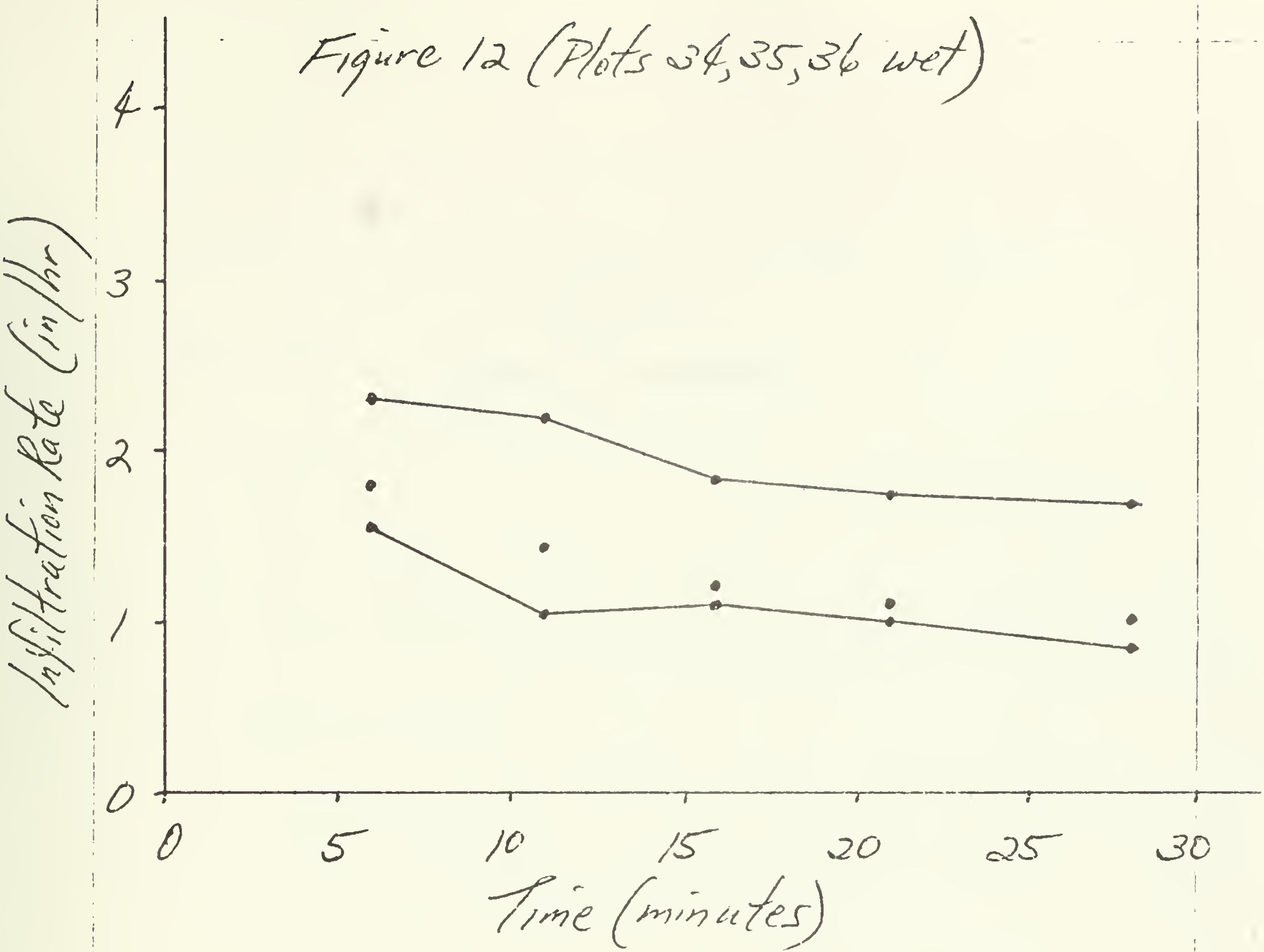
40% Slope (Rocky)

Vegetation: Shadscale
Blacksage
Tetradymia
Cheatgrass

Antecedent Moisture (Wet)

Average Percent Bare Soil: 29%

Sediment Yield: Wet $\bar{x}$ = 0.24 tons/acre



30% Slope (Rocky)
Vegetation: Blacksage
Shadscale
Tetradymia
Cheatgrass

Antecedent Moisture (Wet)
Average Percent Bare Soil: 9%
Sediment Yield: Wet $\bar{x}$ = 0.61 tons/acre

APPENDIX D

GEOLOGIC EXPLORATION

APPENDIX

GEOLOGIC EXPLORATION DRILLING AND CORING PROGRAM

A. SCOPE OF WORK

I. VTN will perform the following tasks:

1. Prepare and execute drilling contract(s).

2. Provide manpower to coordinate drilling operation. This function will include but not be limited to the following responsibilities:

   a. Site Preparation
   b. Road Maintenance and Improvement
   c. Equipment Acquisition
   d. Agency Coordination
   e. Site Reclamation

3. Prepare, compile, coordinate, and distribute all status reports to the White River Shale Project Mining Supervisor, BLM, and other pertinent agencies.

4. Prepare interpretive and final reports as required by the mining supervisor.

5. Present data and program status as required by the White River Shale Project.

II. Cleveland Cliff Iron Company will perform the following tasks:

1. Supervise collection and disposition of drill cuttings and cores.

2. Supervise geophysical logging operation.

3. Monitor well effluents as required for flow rate, temperature and conductivity.

4. Arrange for auxiliary services as may be required to expedite the implementation of the drilling operation.

5. Select and prepare drill cuttings for analysis.

6. Select and prepare core samples for analysis and rock mechanics testing.

7. Select laboratories to perform the analysis and core testing as required or outlined in the Geologic Exploration Plan and accompanying Conditions of Approval.

8. Perform data analysis and compilation as required by the mining supervisor to fulfill the commitments as imposed by the Geologic Exploration Plan and the corresponding Conditions of Approval.

9. Prepare and present data as may be required by the White River Shale Project.

III. 1. Contracts and payments to subcontractors and vendors will be processed and executed by VTN Colorado, Inc.

2. Commitments to vendors and/or subcontractors may be executed by Cleveland Cliff Iron Company in amounts up to $500.00 without prior processing by VTN Colorado, Inc.

In such cases, the invoice shall be approved by Cleveland Cliffs and then sent to VTN for payment.

B. SCHEDULE OF COMPLETION

Phase I Drilling and Coring

Start November 15, 1974

Complete February 1, 1975

Phase II Core Sample Preparation

Start December 1, 1974

Complete June 1, 1975

Phase III Core and Drill Cuttings Analysis and Evaluation

Start December 15, 1974

Complete August 15, 1975

APPENDIX E

REVEGETATION PROGRAM

A PROPOSAL
TO DEVELOP A REVEGETATION PROGRAM
FOR SPENT OIL SHALE DEPOSITS AND OTHER DISTURBED AREAS
WITH EMPHASIS ON REDUCING LEACHATE SALINITY

FEDERAL OIL SHALE PROTOTYPE

LEASING PROGRAM, TRACTS U-a and U-b

SUBMITTED AS A JOINT-VENTURE PROPOSAL BY

ENVIRONMENT AND MAN PROGRAM

UTAH STATE UNIVERSITY

LOGAN, UTAH

and

VTN

DENVER, COLORADO

November 7, 1974

Proposal To: Sun Oil Company, Phillips Petroleum Company and White River Oil Shale Company.

Mr. Earl Ramsey, Program Director

Title: A Proposal to Develop a Revegetation Program for Spent Oil Shale Deposits and other Disturbed Areas with an Emphasis on Reducing Leachate Salinity.

Principal Investigator: C. M. McKell, Professor of Range Science and Director, Environment and Man Program, Utah State University, Logan, Utah

Associate Investigator: Gordon Van Epps, Associate Professor of Plant Science, USU Snow Field Station, Ephriam, Utah

Hayden Phillips, Ground Water Hydrologist, VTN, Denver, Colorado

Research Assistant: Kent A. Crofts, Range Science Department, Utah State University

Research Assistant: To be assigned

Consultants: A. Perry Plummer, Range Scientist, Intermountain Forest and Range Experiment Station, Ephriam, Utah

B. L. Kay, Range Improvement Specialist, Agronomy and Range Science Department, University of California, Davis, California

Don Dwyer, Professor of Range Science and Head, Department of Range Science, Utah State University, Logan, Utah

Duration: 36 months

Location of Work: Bonanza, Utah
Snow Field Station, Ephriam, Utah
Utah State University, Logan, Utah

ABSTRACT

One of the more significant and visible impacts resulting from the mining and retorting of oil shale in Utah, Colorado, and Wyoming will be the disposal areas of spent shale. A commercial oil shale development may result in a requirement for disposal of a large portion of the spent shale in canyons and dry washes in the general vicinity of the processing facilities. Because of its physical and chemical characteristics, the spent shale is not a favorable medium for plant growth, but after leaching, fertilization, irrigation and seed-bed preparation some plant species have been grown on it. Still unanswered are the greater problems of the duration of successful plant growth under normal environmental conditions, escape of leached salts into the hydrologic system, and whether the plants will sufficiently stabilize the surface of spent shale to induce subsequent growth of understory vegetation.

A program of research is proposed that would evaluate various techniques of propagating native shrubs and perennial forbs, develop methods of transplanting rooted cuttings, seedlings or plants directly into spent oil shale in tubes or columns of soil, develop and evaluate soil surface treatments to tie down loose particles and concentrate naturally occurring precipitation around native plants that would eliminate or reduce the need for irrigation and its threat of leaching salts from deposits of spent oil shale, and evaluate the persistence of transplanted species under various intensities of care.

Concurrent research would establish soil permeability, the subsurface movement of the leachate, and the impact of any accumulated leachate upon

local ground and surface water hydrology. The chemistry of the leachate will be continuously monitored in an effort to measure any changes during its vertical and lateral migration. This information may eventually lead to methods of leachate treatment to lessen its impact upon the environment.

Besides aiding the immediate shale oil operation, information from the study would have widespread application for rehabilitating areas disturbed by mining, strip mining, and road construction in arid and semi-arid regions.

I. JUSTIFICATION

One of the major mitigating practices required to ameliorate the environmental effects that will be created by the development of an oil shale extractive and retorting industry in Utah, Colorado, and Wyoming is revegetation. Many areas of land surface may be disturbed by test drilling, exploration and activities relative to oil shale extraction. Spent shale disposal areas will present even more difficult problems for plant establishment because of the unfavorable physical and chemical characteristics of the processed shale.

According to the lease conditions specified in the Federal register,[1/] the lessee of an oil shale tract shall demonstrate at the time of the submission of a detailed development plan that revegetation technology is available to enable him to provide the revegetation that is required under said lease. Failure to demonstrate the required technology would result in the lessee having to submit for approval a study program designed to obtain the required technology. Even though the lessee has a period of ten years to demonstrate the necessary technology (otherwise he would be forced to cease all operations) it would appear to be good judgment to begin a program of revegetation research as soon as possible for the following reasons:

1. Results of preliminary studies could help guide the preparation of the detailed development plan.

[1/] Federal Register, Vol. 38, No. 230, November 30, 1973, Section 11, This page describes

2. Revegetation of arid lands is very difficult at best and new approaches must be tried in order to rehabilitate spent shale and disturbed areas of low rainfall. These studies will require time to work out problems and obtain results that can be translated into management practices. An early start will assure that answers will be ready when needed.
3. A sufficient period of observation following plant establishment is necessary to assure that the vegetation will persist under natural conditions and uses as required in Section 11 (6) (1). Thus, a research program should be initiated as soon as possible.
4. Inasmuch as water is a scarce resource and limitations on its use for oil shale development may be placed for economic or political-social reasons, a program of studies on revegetation that minimizes the use of water would help provide data for planning the operation of facilities and allocation of resources.
5. Considerable public attention has been stimulated by the publicity surrounding the issuance of the oil shale leases. A good faith effort for supporting revegetation research would be helpful to maintain a public image of responsible resources development by the lessee.

Research conducted or supported by other oil shale developers indicates that it is possible to grow plants on spent shale if sufficient attention is exercised in leaching, seed-bed preparation, fertilization, mulching and irrigation (Block and Kilburn, 1973). However, there is no information at

the present time as to the continuing requirement and resulting costs for such expensive cultural treatments to maintain the planted species. Many of the plant species tried in the revegetation studies by Baker and Duffield (1973) are normally used for range seedlings such as various wheat-grasses. In addition, a number of other species were studied including some shrubs and forbs native to the Parachute Creek, Colorado area. Some of the species studied are adapted to harsh environments and might continue to grow in spent shale but no evidence exists for such knowledge. Any information developed in other revegetation studies would be utilized in guiding the research proposed here. Conversely, results from these studies would be freely exchanged with other study programs in so far as practicable.

Greater emphasis should be given to plant species which are adapted to the drought and salinity of shale areas. Field observations of oil shale areas in Utah by the principal investigator indicate that the plant species existing on soil parent materials derived from mahogany zone oil shales tend to be salt tolerant and drought resistant. Thus, plants which would offer the greatest potential for persistence on deposit areas of processed shale may be those of the immediate area.

One of the difficulties of working intensively with most of the plant species of the oil shale region is that very little is known about their ecology, particularly the relation of reproduction or propagation under stress environmental conditions. Establishment obviously takes place infrequently under natural conditions but little is known about the nature of such conditions. The work of Plummer and his associates (1968) provides a wealth of useful information that is helpful in estab-

lishing plants under rangeland conditions. Information on the biology of wildland shrubs is summarized in a proceedings edited by McKell, Blaisdell, and Goodin (1971) and provides some general principles to follow in establishing shrubs in harsh environments.

One of the most critical problems posed by the cultural practices employed in the studies conducted in Colorado is the abundant use of irrigation water. In the three-state oil shale area, water is a scarce resource and may be a limiting factor in the development of an oil shale industry with its support population. Heavy use of water, suggested by Wymore (1973) to be 15 inches annually for irrigating revegetated areas similar to Davis Gulch, would aggravate the salinity problems of the Colorado River by reducing the volume of water in the river. Initial leaching of the spent shale by 40 inches of water (Wymore, 1973) would create a potential hazard by the addition of leached salts from spent shale into the Colorado River drainage system. Any increase in the salinity of the Colorado River would receive critical attention and public disfavor.

A better means of revegetation is needed that would establish plant species that have little or no irrigation requirement, thus reducing the chance for flows of high salinity leachate. Some possible alternatives to be used to obtain establishment might include drip-irrigation, irrigation limited to critical drought periods with gradual phasing-out, or more effective use of natural rainfall. Use of surface treatments as described by Kay (1973) to stabilize and partially seal the soil surface in basins around plants and thus concentrate the limited amount of natural precipitation for use by transplanting native species offers a further, but untried, alternative. The principal investigator initiated some preliminary studies

of this nature in 1969 but was unable to complete them.

Another potential problem associated with the development of a shale oil industry is the resulting dust pollution of the air created by soil disturbance and possibly from the surface of spent shale disposal areas. One of the purposes of revegetation is to stabilize the soil surface and retard or prevent wind-blown dust from the disturbed areas. Vegetation seeded or transplanted on disturbed surfaces should be sufficiently adapted and established in such a manner as to "persist and progress towards a potential plant community resembling that on an alkaline and saline soil, or perhaps developing a new community uniquely adapted to weathered oil shale."[2/] Shrubs are important components of the existing vegetation in the general oil shale area and should serve as microcenters for the subsequent development of perennial and annual understory plant species which would further hold the soil in place and prevent wind erosion, reduce blowing dust, and improve the visual appearance of formerly disturbed areas.

In addition to these problems there is need to determine to what extent leachate salinity might be reduced so as to lessen its impact upon native water resources, and how any resulting leachate percolates downward and through the spent shale deposit. There is also a need to identify the responses of the native hydrology and leachate to seasonal changes in the climatological regime. These would provide valuable data for future management of spent shale disposal areas with regard to salinity problems in underground acquifers.

[2/] Quoted from Vol. 19 1-72. Final Environmental Statement for the Prototype Oil Shale Leasing Program. U.S. Department of Interior, 1973.

In summation, establishment of adapted native plant species for revegetating disturbed areas and spent shale disposal sites is a necessary componenet of a prototype oil shale development program and would respond to the requirements mentioned in the stipulations of the Federal leases. There is a need for improved techniques for propagation and transplanting native shrubs that will require less water than those practices reported by other oil shale developments. Plant species selected for revegetation would be adapted to or tolerant of the soils and processed shale they would stabilize in order that they could persist under the harsh environment of the oil shale region. Stabilization of the soil surface to hold wind erosion and dust pollution to a minimum while at the same time collecting precipitation for use by transplanted species is worthy of investigation. Careful monitoring of ground water quality, leachate and soil moisture in the root zone would provide important data for management of spent shale disposal areas with regard to salinity problems.

II. PROGRAM OBJECTIVES

The general objective is to develop techniques for establishing native plants in disturbed areas of oil shale development while at the same time reducing irrigation and leaching requirements (and thus avoiding an impact on water quality) and increasing soil surface stability. Specific objectives are to:

A. Develop propagation and transplanting techniques for adapted native plant species. One promising concept that would be tried is the use of tall containers or paper cylinders to permit root growth of seedlings and/or rooted cuttings in favorable medium prior to their extention into spent shale. Other methods would also be studied in addition to the container idea.

B. Investigate the suitability, rates of application, and surface effectiveness of selected materials for soil surface stability and concentration of precipitation to transplanted native plants.

C. Study the ecology of selected native species as to their suitability for rehabilitating disturbed areas including: salinity and drought tolerance, root and top growth, reproduction, associated species compatibility, longevity, and palatability to animals.

D. Study leaching relationships and chemistry with regard to soil moisture, soil salinity and soil permeability to determine the potential for reducing leachate salinity and thus reducing its impact on the native hydrologic regime.

One promising avenue of research would be to develop methods for transplanting native shrubs and forbs in intact soil columns with a stabilized surface collecting basin around the plant to collect moisture which would irrigate the plant and gradually leach salts out of the immediate vicinity of the root zone (see Figure 1). The idea of using a soil column is partly adapted from the highway planting studies of Hodder and Sindelar (1971) in Montana.

Each phase of research and investigation would be developed according to a specific study plan written in response to information obtained from the site area, the detailed oil shale development plan, and new information derived from on-going studies by this project and others.

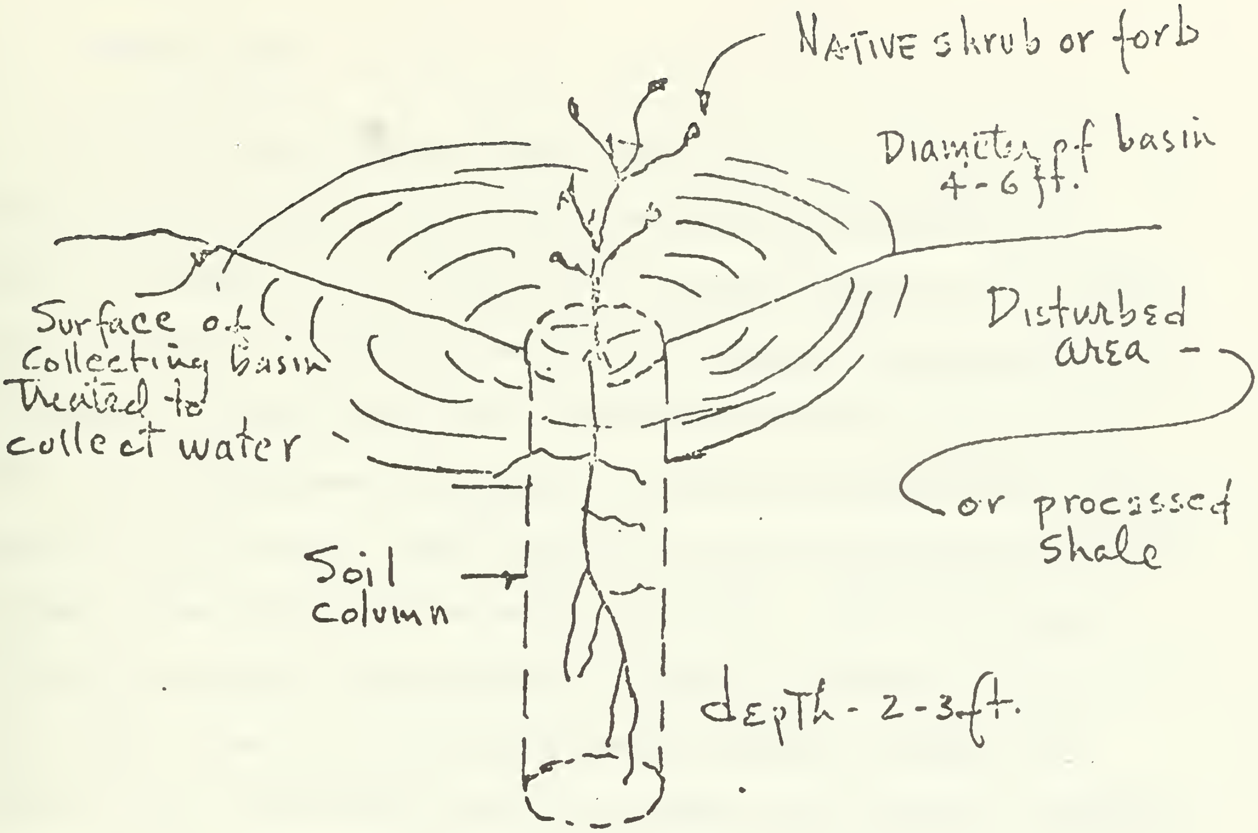


Figure 1. Diagram of Transplanted Shrub, Soil Column and Surface Moisture Collecting Basin.

III. RESEARCH PLAN

Prior to initial studies in the field, collection of seeds and cuttings must be obtained from plants growing on shale-derived soils. Particular emphasis will be given to salt tolerant species such as greasewood (*Sarcobatus vermiculatus*) and shadscale (*Atriplex confertifolia*) and to drought resistant shrubs such as sagebrush (*Artemisia tridentata*) and rabbitbrush (*Chrysothamnus nauseosus*). No promising native shrub or forb species will be ignored. Seed collections for the four shrub species must be done in the late fall at the point of maturity. Seed will be hand-collected and taken to the laboratory in Logan for cleaning, analysis, and storage. Seed viability and treatments necessary to ensure the highest level of germination must be determined, using chemical treatments if necessary to break the dormancy of the seeds. Fungicide treatments may also be needed to prevent possible seed decay be bacteria that are commonly present in the soil. Root hormones would be used to promote root formation on cuttings of native shrubs.

Preliminary Studies

The first year of investigation will allow gathering and evaluation of as much data on the natural plant habitat as is available. Measurement of soil - physical and chemical characteristics, temperature regimes, and other habitat factors - will help to determine what range of conditions must be provided for transplant. Much of this environmental information would be available from the Environmental Baseline Data Collection Program now in progress.

Various methods of vegetative propagation will be attempted using plant material collected in the local area. Rooting of stem cuttings will be attempted on the four shrub species and other plants. Since very little artificial propagation of these species has been reported, attempts must be made to determine what proportions of the roots or stems are required at what period of time, and under what stage of plant growth and development would also be studied.

The major effort of the establishment trials, however, would be aimed at the development of optimum methods to foster good plant development (particularly of the roots) and suitable techniques for transplanting the developed seedlings or cuttings. Particular emphasis would be placed on developing the optimum size of soil column and a bio-degradable container that would serve as a "refuge" against the high levels of salts likely to be found in the spent shale. Such a volume of soil will tend to protect roots from the levels of toxicity associated with the shale that will surround the soil column when planted, thus providing a more favorable environment for plant growth.

Field Trials

A suitable area for field studies has been selected, after field inspection and consultation with Mr. Reese Madsen and VTN personnel, in Section 6, T 105, R 25 E. on land owned by Skyline Oil Company. An area of about 50 acres should be fenced to assure protection to research sites and prevent livestock trespass. This amount of area would allow for a choice in selecting plot locations for slope, exposure, soil depth, etc.

The field phase of study would involve several field experiments in the spring of 1975 to test planting methods, soil surface treatments,

plant responses to transplanting, soil moisture levels and leaching. A schedule of work is shown in Appendix I. The initial series of studies would involve transplanting the prepared plant materials to field test plots which would receive various soil surface treatments and irrigation levels. These trials would involve root and stem cuttings, seedlings and direct transplants. These tests would be developed in conjunction with various types of soil surface treatments for rainfall collection basins using chemical emulsions, vinyl particle binders and other surface sealers to determine the optimum method of surface treatment that most effectively collects runoff, influences water infiltration, and increases moisture storage in the rooting area of the transplants.

As soon as a sufficient quantity of spent shale is available, possibly in the fall of 1975, an experiment would be conducted on a deposit of spent shale. As a preliminary estimate, the area of the spent shale deposit would be 40 x 50 feet and from 10 to 15 feet deep, thus requiring haulage of about 1000 cubic years of spent shale. This study would compare planting methods in relation to the survival of different plant species on the spent shale. Particular emphasis will be placed on those methods that will provide maximum plant density and cover for the shale deposit area. Rooting depth and lateral spread of roots into the shale will also be studied to determine any beneficial effects which occur from various planting techniques and surface treatments.

Soil moisture will be monitored closely throughout the growing season to determine the effectiveness of differing treatments in maintaining levels of soil moisture that are necessary for plant growth. Associated with the

moisture monitoring, analysis will be conducted to determine the extent of natural leaching that occurs from the collection basins and deposits of spent shale and to what degree periodic applications of water through the use of a drip-irrigation system could improve plant and root growth.

Further, deep leaching and resultant leachate chemistry would be monitored together with that of naturally occurring ground and surface water. The data would be combined to investigate the inter-relationship of leachate and naturally occurring waters to determine potential methods of ameliorating that impact.

Construction of the facilities to monitor the movement and quality of leachate as it passes through the spent shale deposits is of paramount importance to this project. A system of subsurface collection pans will be installed at suitable depth intervals beneath the test plots. These pans will be automatically drained into a central chamber to receiving bottles. Periodically these receiving bottles would be collected by field personnel for laboratory analyses. In addition to this network of pans to collect vertically percolating leachates, a series of shallow observation wells should be constructed around the test plots at various distances to enable monitoring of the leachate as it either joins the existing ground water regime or forms a new subsurface water body which will utlimately migrate away from the test area. These shallow wells should be constructed so that they can be pumped for water quality sampling and be measured for water table fluctuations.

The overall comparison of these varied techniques of planting, the differing methods of surface manipulation, the observation of changes in soil salinity and moisture content accompanied by data on plant growth

rates and cover undoubtedly will provide data as to plant requirements and serve as a quide for obtaining effective vegetative stabilization on a large scale.

Development Materials for Broader Use

After reliable methods and materials have been developed, further study should involve implementation of the most proven methods of native plant establishment on a more expanded scale. Large scale propagation of planting materials of the best performing shrub species should be undertaken. A suitable location near the lease site (possibly on existing fee lands) or the Snow Field Station in Ephriam could be employed to propagate materials and plant them in suitable containers or tubes. Information from such an effort could be made available to commercial nurseries or an oil company unit designated for routine rehabilitation plantings. This effort is not covered in the present proposal, however.

IV. ORGANIZATION AND MANAGEMENT PLAN

The project would be jointly administered by the Utah State University Agricultural Experiment Station, and VTN, Denver, Colorado. Direct cooperation with Utah Agricultural Experiment Station Project 742 would occur since the principal and one associate investigator are project leaders on that project and would have available the resources of the Agricultural Experiment Station at Logan, Utah, the Snow Field Station in Ephriam, Utah and facilities at an Agricultural Experiment Station in Vernal, Utah. Hydrological monitoring and leaching studies would be conducted by VTN personnel. Routine collection of water quality data can be performed by VTN personnel now based in Vernal, Utah.

Actual research activities would be under the supervision of the principal investigator who would organize and direct the research work.

The field study area should be fenced with water, electricity, and shelter available. In lieu of direct water availability, an on-site storage tank and tank truck would be suitable. USU has a 500-gallon tank truck that could be available for use on the project. (Costs of site development are not included in the budget for the proposal.)

LEGEND

TYPE 1 . . . . . . SAGEBRUSH - GREASEWOOD

TYPE 2 . . . . . . JUNIPER - SAGEBRUSH

TYPE 3 . . . . . . SHAD SCALE - BLACK SAGEBRUSH

TYPE 4 . . . . . . RIPARIAN

VEGETATION MAP

LEGEND

TYPE 1 . . . . . SAGEBRUSH - GREASEWOOD

TYPE 2 . . . . . . JUNIPER - SAGEBRUSH

TYPE 3 . . . . . . SHAD SCALE - BLACK SAGEBRUSH

TYPE 4 . . . . . . RIPARIAN

VEGETATION MAP

SHEET 2 of 2

DAT LOANED	BORROWER