TABLE OF CONTENTS

ALL VOLUMES

R645-301-100 Through R645-301-800

Volume 1.....Chapter 1.....Legal, Financial, Compliance and Related Information

Chapter 2.....Soils

Volume 2.....Chapter 3.....Biology

Chapter 4.....Land Use and Air Quality

Volume 3.....Chapter 5.....Engineering

Chapter 6.....Geology

Volume 4.....Chapter 7.....Hydrology

Chapter 8.....Bonding and Insurance

Volume 5.....Confidential Files

TABLE OF CONTENTS

Chapter 7

R645-301-700

HYDROLOGY

711.	**GENERAL REQUIREMENTS**	7-1
711.100.	Existing Hydrologic Resources	7-1
711.200.	Proposed Operations and Potential Impacts to the Hydrologic Balance	7-1
711.300.	The methods and calculations utilized to achieve compliance with the hydrologic design criteria and plans	7-1
711.400.	Applicable Hydrologic Performance Standards	7-1
711.500.	Reclamation Activities	7-1
712.	**CERTIFICATION**	7-1
713.	**INSPECTION**	7-1
720.	**ENVIRONMENTAL DESCRIPTION**	7-1
721.	**GENERAL REQUIREMENTS**	7-1
722. 722.100-500.	**CROSS SECTIONS AND MAPS**	7-5
723	**SAMPLING AND ANALYSIS**	7-5
724	**BASELINE INFORMATION**	7-6
724.100.	Groundwater Information	7.6
724.200.	Surface Water Information	7-6
724.300.	Geologic Information	7-6
724.400.	Climatological Information	7-7
724.411.	Seasonal Precipitation	7-7
724.412.	Wind Direction and Velocity	7-8
724.413.	Seasonal Temperature Ranges	7-8
724.500.	Supplemental Information	7-8
724.600.	Renewable Resource Lands	7-8
724.700.	Alluvial Valley Floor Determination	7-8
725.	**BASELINE CUMULATIVE IMPACT AREA INFO.**	7-10
727.	**ALTERNATIVE WATER SOURCE INFO.**	7-10

728.	**PROBABLE HYDROLOGIC CONSEQUENCES**	7-10
728.310.	Potential Adverse Impacts to the Hydrologic Balance	7-10
728.320.	Presence of Acid-forming or Toxic-forming Materials	7-12
728.331.	Sediment Yield from the Disturbed Area	7-12
728.332.	Impacts to Important Water Quality Parameters	7-12
728.333.	Flooding of Streamflow Alteration	7-13
728.334.	Groundwater and Surface Water Availability	7-14
728.340.	Whether Mining and Reclamation Activity will Result in Contamination, Diminution or Interruption State-appropriated Water.	7-15
730.	**OPERATION PLANS**	7-15
731.	**GENERAL REQUIREMENTS**	7-15
731.200.	Water Monitoring	7-18
Table 7-4	Hydrologic Monitoring Protocols and Locations	7-20
Table 7-5	Hydrologic Monitoring Locations	7-21
Table 7-6	Surface Water Operational Water Quality Monitoring	7-22
Table 7-7	Groundwater Operational Water Quality Monitoring	7-23
731.600.	Stream Buffer Zones	7-24
731.700.	Cross-Sections and Maps	7-24
731.800.	Water Rights and Replacement	7-24
732.	**SEDIMENT CONTROL MEASURES**	7-25
732.100.	Siltation Structures	7-25
732.200.	Sedimentation Ponds	7-25
732.300.	Diversions	7-25
732-400-420.	Road Drainage	7-26
733.	**IMPOUNDMENTS**	7-26
733.100.	General Plans	7-26
733.200.	Permanent and Temporary Impoundments	7-26
734.	**DISCHARGE STRUCTURES**	7-27
735.	**DISPOSAL OF EXCESS SPOIL**	7-27
736.	**COAL MINE WASTE**	7-27
737.	**NONCOAL MINE WASTE**	7-27
738.	**TEMPORARY CASING AND SEALING OF WELLS**	7-27
740.	**DESIGN CRITERIA AND PLANS**	7-27
741.	**GENERAL REQUIREMENTS**	7-27

742.	**SEDIMENT CONTROL MEASURES**	7-27
742.100.	General Requirements	7-28
742.110.	Design	7-28
742.220-223.	Sedimentation Ponds	7-28
742.230.	Other Treatment Facilities	7-29
742.300.	Diversions	7-30
742-310-313.	General Requirements	7-30
742.320-324.	Diversion of Perennial and Intermittent Streams	7-30
742.330.	Diversion of Miscellaneous Flows	7-31
742.400.	Road Drainage	7-31
742.410.	All Roads	7-31
742.420.	Primary Roads	7-32
742.423.	Drainage Control	7-32
743.	**IMPOUNDMENTS**	7-32
743.100.	General Requirements	7-32
744.	**DISCHARGE STRUCTURES**	7-33
744.100.	General Requirements	7-33
745.200.	Valley Fills and Head of Hollow Fills	7-34
745.300.	Durable Rock Fills	7-34
745.400.	Preexisting Benches	7-34
746.	**COAL MINE WASTE**	7-34
746.100.	General Requirements	7-34
746.200.	Refuse Piles	7-34
746.220.	Surface Stabilization	7-35
746.300.	Impounding Structures	7-35
746.330.	Drainage Control	7-36
746.400.	Return of Coal Processing Waste to Abandoned Underground Workings	7-36
747.	**DISPOSAL OF NON-COAL WASTE**	7-36
747.100-300.		
748.	**CASING AND SEALING OF WELLS**	7-37
750.	**REFORMANCE STANDARDS**	7-37
751.	**WATER QUALITY STANDARDS**	7-37
752.	**SEDIMENT CONTROL MEASURES**	7-37
752.100		7-37
752.200.	Road Drainage	7-38

753.	**IMPOUNDMENTS AND DISCHARGE STRUCTURES**	7-38
754.	**DISPOSAL OF EXCESS SPOIL, COAL MINE WASTE AND NON-COAL MINE WASTE**	7-38
755.	**CASING AND SEALING OF WELLS**	7-38
760.	**RECLAMATION**	7-39
761.	**GENERAL REQUIREMENTS**	7-39
762.	**ROADS**	7-39
762.100-200.		7-39
763.	**SILTATION STRUCTURES**	7-39
763.100-200.		
764.	**STRUCTURE REMOVAL**	7-40
REFERENCES		7-41

PHOTOS

APPENDICES

DRAWINGS

R645-301-700 HYDROLOGY

711 GENERAL REQUIREMENTS

This chapter provides a description of hydrology and hydrogeology of the Coal Hollow permit area. Specifically, this permit application includes:

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

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

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

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

711.500 Reclamation activities according to R645-301-760.

R645-301-712 CERTIFICATION

All cross sections, maps, and plans have been prepared per R645-301-512.

713 INSPECTION

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

720 ENVIRONMENTAL DESCRIPTION

721 GENERAL REQUIREMENTS

The existing, pre-mining hydrologic resources within the permit and adjacent areas that may be affected by coal mining and reclamation operations are described herein. It should be noted that additional hydrogeologic field work and investigations are planned for the 2006 field season. Based on the findings of these and other investigations, a comprehensive report of groundwater and surface-water systems in the Coal Hollow Project and adjacent areas will be submitted to the division upon its completion.

Groundwater Resources

A spring and seep survey of the Coal Hollow Project and surrounding area was conducted by Petersen Hydrologic, LLC during 2005 and 2006. Additional hydrologic inventories and baseline monitoring activities were conducted previously by Utah International, Inc. The locations of springs and seeps in the project area are shown on Drawing 7-1. Seasonal discharge and field water quality measurements for springs and seeps in the Coal Hollow Project area are presented in Appendix 7-1. Baseline discharge and water quality data for groundwater resources in the Coal Hollow Project area are presented in Appendix 7-2. Locations of baseline monitoring locations are shown on Drawing 7-2. Locations of water rights in the Coal Hollow Project area are shown on Drawing 7-3. Water rights data from the project area are detailed in Appendix 7-3.

There are no domestic water supply springs or wells in the proposed permit area. However, wells and springs that provide limited quantities of water for domestic and livestock use are located adjacent to the proposed permit area (Drawing 7-2).

Natural groundwater discharge in the permit and adjacent area occurs primarily from alluvial sediments. Groundwater resources in the Tropic Shale and underlying Dakota Formation in the permit and adjacent area are not appreciable. No springs that discharge from either the Tropic Shale or the Dakota Formation have been identified in the proposed permit area or adjacent area (within ½ mile). It is noteworthy, however, that some seepage (<5 gpm) into the stream channel occurs in the lower reaches of Lower Robinson Creek overlying the Dakota Formation in the northwest quarter of Section 30, T39S, R5W. The seepage enters the stream channel near the base of the alluvial sediments in the deeply incised stream channel. This seepage likely originates from alluvial groundwater discharge at the topographic constriction in the Lower Robinson Creek drainage.

Groundwater discharge occurs from springs and seeps in the upland areas of the Paunsaugunt Plateau east of the permit area (Tilton, 2001). However, these springs discharge from rock strata that are topographically and stratigraphically up-gradient of and miles from the proposed permit area. Consequently, groundwater systems in these areas will not be impacted by mining activities and these are not considered further here.

Alluvial groundwater discharge in the Coal Hollow Project area occurs principally in two areas. These two groundwater discharge areas are described below and are shown on a map in Drawing 7-4.

Groundwater Discharge Area 1

Groundwater discharges from a number of springs and seeps, and groundwater flows from artesian wells completed in deep alluvial sediments in the northwest quarter of Section 29, T39S, R5W. Groundwater discharging from springs and wells in Area 1 is used for domestic water supply for two ranch houses and also for stock watering and limited irrigation. Groundwater in Area 1 is also used by wildlife in the area.

Groundwater Discharge Area 2

Diffuse seepage of alluvial groundwater from springs and seeps occurs at the topographic constriction of Sink Valley in the northwest quarter of Section 32, T39S, R5W. Groundwater from a developed spring in Area 2 is used for domestic water for two mountain cabins. Seepage of alluvial groundwater in Area 2 is also collected in a series of small ponds for stock watering use. Groundwater in Area 2 is also used by wildlife in the area.

It is noteworthy that groundwater discharging from both Area 1 and Area 2 typically infiltrates into the clayey soils and alluvial material below spring discharge points or is lost to evapotranspiration. Discharge of alluvial groundwater does not support perennial stream discharge locally in Sink Valley.

Groundwater and surface-water quality information from the Coal Hollow Project and adjacent area is summarized in Appendix 7-2. Solute chemical compositions of groundwaters and surface waters in the project area are also depicted graphically as Stiff (1951) diagrams in Drawing 7-5. Stiff diagrams are a useful tool to facilitate the presentation and analysis of solute chemical data. The shape of the Stiff diagram is a reflection of the chemical type of the water, while the size of the Stiff diagram is related to the total dissolved solids concentration.

It is apparent in Drawing 7-5 that appreciable spatial variability exists in groundwater and surface water quality in the Coal Hollow Project area. The mountain streams and upper Sink Valley groundwaters are of the moderate TDS, calcium-magnesium-bicarbonate chemical type. Alluvial groundwaters in lower Sink Valley have appreciably elevated TDS concentrations relative to the groundwaters in upper Sink Valley and are generally of the magnesium-bicarbonate-sulfate chemical type. The geochemical evolution by which the lower Sink Valley surface waters and alluvial groundwaters acquire their elevated solute compositions is likely characterized by interaction with soluble minerals in the Tropic Shale or Tropic Shale-derived alluvial sediments.

Total dissolved solids concentrations increase naturally in alluvial groundwater in the Coal Hollow Project area. The increase in TDS concentrations are particularly marked in the upper Sink Valley area. Water quality in the alluvial sediments in Sink Valley degrades markedly (TDS concentrations doubling) relative to Alluvial Groundwater Discharge Area 1, which is located on the eastern, up-thrown side of the Sink Valley Fault. There is also a marked change in the solute chemical composition of alluvial groundwater in Sink Valley. Groundwater from Alluvial Groundwater Discharge Area 1 is of the calcium-magnesium-bicarbonate chemical type, while alluvial groundwater in Sink Valley is of the magnesium-bicarbonate-sulfate chemical type. The water quality characteristics of alluvial groundwater in the Coal Hollow Project area are summarized in Appendix 7-2.

Surface Water Resources

Surface water in the Coal Hollow Project and adjacent area is tributary to the Kanab Creek drainage. Surface waters in the northern portion of the proposed permit and adjacent area drain into the Robinson Creek and Upper Kanab Creek drainages. Surface waters in the southern portion of the proposed permit and adjacent area drain into the Sink Valley Wash drainage which is tributary to Kanab Creek about 6 miles below the Coal Hollow Project area. Surface water drainage into Sink Valley Wash in the permit and adjacent area is via several small drainages that drain the western flanks of the Paunsaugunt Plateau. Surface water drainages in the permit and surrounding areas are shown on Drawing 7-6. Baseline surface-water discharge and water quality measurements in the Coal Hollow Project area are presented in Appendix 7-2. Surface water baseline monitoring locations are shown on Drawing 7-2.

Surface waters in Kanab Creek are used for crop irrigation and stock watering in the irrigable lands west of the Coal Hollow Project area. Discharge in the Kanab Creek near the town of Alton (SW-1) is highly seasonally dependent and typically ranges from 10 cfs or less during the springtime runoff period to 1 cfs or less during summertime baseflow conditions.

Discharge in Lower Robinson Creek in the Coal Hollow Project area is meager, with measurable flow typically occurring only during the springtime snowmelt and in direct response to torrential precipitation events. Irrigation diversions in the upper Robinson Creek drainage exist to facilitate irrigation and stock watering use.

Tributaries to the Sink Valley Wash drainage in the Coal Hollow Project and adjacent areas include (from north to south) Water Canyon, an unnamed drainage south of Water Canyon, Swapp Hollow, an unnamed drainage south of Swapp Hollow, and Broad Hollow (Drawing 7-6). Surface water discharges in these drainages are highly seasonally dependent (Appendix 7-2). Discharge in Water Canyon and Swapp Hollow is intermittent or perennial in nature.

The water quality and discharge characteristics of surface waters in the Coal Hollow Project area are presented in Appendix 7-1 and 7-2. Solute compositions of stream waters are also depicted graphically as Stiff diagrams in Drawing 7-6.

Considerable seasonal variability in the solute compositions of stream waters in Kanab Creek in the Coal Hollow Project area is also evident in Drawing 7-5 and in Appendix 7-2. During low-flow conditions, interactions of stream waters with Tropic Shale or Tropic Shale-derived alluvial sediments in the stream channel likely result in increased TDS concentrations. Return flow from irrigated fields with soils rich in soluble minerals also likely contributes to increased TDS concentrations in the summertime. During the spring runoff season, high surface water flows that originate from the adjacent upland areas dominate the flow in the channel. The TDS concentrations of Kanab Creek waters during high-flow conditions are thus lower than during the low-flow season. Much less seasonal variability in solute content in surface water flows from the mountain stream in Swapp Hollow (Drawing 7-5; Appendix 7-2). This condition is likely attributable to the fact that the stream in Swapp Hollow, which originates on geologic formations overlying the Tropic Shale, has considerable less contact with the Tropic Shale than does Kanab Creek, and that there are no irrigation returns above the stream monitoring point in Swapp Hollow.

722 CROSS SECTIONS AND MAPS

722.100 A map showing the locations of groundwater discharge to springs and seeps in the Coal Hollow Project area is presented in Drawing 7-1. A map showing the location of alluvial groundwater discharge is presented in Drawing 7-4. Also shown in Drawing 7-4 are the approximate contours of the top of the shallow water table surface in the proposed permit area during high-water conditions in May 2006. Additional characterization and mapping of groundwater resources will be performed during the 2006 field season. This additional information will be included in a subsequent submittal to the Division.

722.200 Location of surface water bodies
Within the Coal Hollow Project area, no natural ponds or lakes occur. The locations of springs and streams are shown in Drawing 7-1. The locations of ponds created for stock watering and limited irrigation use in the Coal Hollow Project and adjacent area is shown on Drawing 7-7. Several earthen ponds have been created to store surface runoff and spring discharge water for stock watering and irrigation use. The locations of these ponds as well as conveyance ditches are shown on Drawing 7-7.

722.300 Baseline monitoring stations
Baseline monitoring stations are shown on Drawing 7- 2. Monitoring station locations, elevations, and other details are presented in Table 7-1.

722.400 Location of water wells
Water well locations are shown in Drawing 7-2. Well construction details and locations are presented in Table 7-2

722.500 Contour map(s) of disturbed area(s)
Contours delineating the land surface of potentially disturbed areas are shown in Drawing 7-2. Additional information on natural land slopes and geomorphic differences will be provided to the Division in a subsequent submittal.

723 SAMPLING AND ANALYSIS

Water quality sampling and analyses have been and will be conducted according to the "Standard Methods for the Examination of Water and Wastewater" or EPA methods listed in 40 CFR Parts 136 and 434.

724 BASELINE INFORMATION

Baseline groundwater, surface water, geologic, and climatologic data are described below. Additional baseline data will be collected during the 2006 field season. A comprehensive report characterizing groundwater and surface-water systems in the Coal Hollow Project area will be submitted to the Division in a future submittal.

724.100 Groundwater Information

The location of wells and springs are shown on Drawings 7-1 and 7-2. Groundwater rights in and around the permit and adjacent areas are shown on Drawing 7-3 and tabulated in Appendix 7-3.

Seasonal quality and quantity of groundwater and usage is described in the Petersen Hydrologic, LLC 2005-2006 spring and seep survey report (Appendix 7-1). Baseline discharge and water quality data are presented in Appendix 7-2. Additional groundwater discharge data and water-quality data will be collected during the 2006 field season. These data will be fully analyzed and a comprehensive report will be prepared that will be submitted to the Division in a subsequent submittal.

724.200 Surface Water Information

The location of streams, stock watering ponds, and conveyance ditches in the proposed Coal Hollow permit and adjacent area are shown on Map 7-X. Surface water rights in and adjacent to the proposed Coal Hollow permit area are shown on Map 7-3 and tabulated in Appendix 7-6.

It is anticipated that as mining progresses, it will become necessary to discharge water from the mine. Mine water will likely be discharged to the ephemeral Lower Robinson Creek drainage. The location of the mine discharge point will be determined upon completion of the final mine design plan.

Surface water discharge rates and water quality data are presented in Appendix 7-2. Additional surface-water discharge and water quality data will be collected during the 2006 field season. A comprehensive report characterizing groundwater and surface-water systems in the Coal Hollow Project area will be submitted to the Division in a future submittal.

As described in R645-301-728.320, no acid drainage is expected from the proposed mining operation.

724.300 Geologic Information

Geologic information in sufficient detail to determine the probable hydrologic consequences of mining and determine whether reclamation as required by R645 can be accomplished is given in Chapter 6 of this permit application package.

724.400 Climatological Information

Climatological information, including temperature and precipitation data, have been routinely measured and compiled at the Alton, Utah weather station (420086) since 1928. The station is located in the town of Alton, approximately two miles north of the Coal Hollow Project area. Climatological data collected at the Alton station for the 77 year period from 1928 to 2005 are summarized in Table 7-3. Climatological data from the Alton station are plotted in Drawing 7-8.

An automated weather station was installed in the Coal Hollow Project area in December 2005. The station is configured to continuously monitor and record temperature, wind velocity, and wind direction data. The station is also configured to continuously measure and record precipitation, although the tipping rain-gauge is not operative during the cold, winter months. Climatological information from the Coal Hollow Project weather station will be submitted to the division in a subsequent submittal.

724.411 Seasonal precipitation

Precipitation data from the Alton, Utah weather station indicates average annual precipitation of 16.38 inches per year. Doelling (1972) reports average annual precipitation in the Alton Coal Field area ranging from 9 to 20 inches annually with slightly higher increments likely in the higher parts of the plateau (Doelling, 1972). There are generally two annual wet periods in the region. During the wintertime, cyclonic storm bring precipitation (mainly snowfall) to the region. During the summertime, storms originating from convection of air from the Gulf of Mexico or the Pacific Ocean bring rains to the region. Of the two annual wet cycles, the summer rainfall is most reliable. Average monthly precipitation at the Alton station ranges from a low of 0.57 inches in June to a maximum of 1.80 inches in February.

The Palmer Hydrologic Drought Index (PHDI; NCDC, 1997) indicates long-term climatic trends for the region. The PHDI is a monthly value generated by the National Climatic Data Center (NCDC) that indicates the severity of a wet or dry spell. The PHDI is computed from climatic and hydrologic parameters such as temperature, precipitation, evapotranspiration, soil water recharge, soil water loss, and runoff. Because the PHDI takes into account parameters that affect the balance between moisture supply and moisture demand, the index is a useful for evaluating the long-term relationship between climate and groundwater recharge and discharge. A plot of the PHDI for Utah Region 4 (which includes the Coal Hollow Project and surrounding area) is shown in Drawing 7-9. It is apparent in Drawing 7-9 that the region has experienced cyclical periods of drought and wetness since 1980. Baseline hydrologic monitoring performed by Utah International, Inc in 1987 and 1988 occurred during a period of near normal wetness. Recent baseline hydrologic monitoring conducted in 2005 and 2006 occurred during a period of moderate to severe wetness, with 2005 being wetter than 2006.

724.412 Wind direction and velocity

Wind data have been collected at the Coal Hollow Project weather station since December 2005. Wind data have also been collected historically at nearby locations by governmental and other entities. The predominant direction of winds in the region is southwest through west. Secondary peaks are from southeast and northwest. Surface winds in the area average approximately 8 miles per hour. Higher wind speeds are associated with fronts and storms and generally occur during the springtime.

724.413 Seasonal temperature ranges

Temperature data from the region is summarized in Table 7-3. Temperatures in the permit area vary greatly. Temperature data from the Alton station (1928-2005) indicate that monthly average low temperatures are below freezing for the 6-month period from November to April. Monthly average minimum temperatures range from a low of 15.1 °F during January to a high of 49.8 °F in July. Monthly average maximum temperatures range from a low of 39.5 °F in January to a high of 82.6 °F in July.

724.500 Supplemental Information

Adverse impacts to the hydrologic balance either on or off the permit area are not expected to occur based on the probable hydrologic consequences determination in R645-301-728. Acid- and toxic-forming materials present in mining materials will not cause contamination of groundwater or surface-water supplies. Consequently, information regarding remedial and reclamation activities has not been prepared.

724.600 Renewable resource lands

The existence and recharge of aquifers in the proposed permit and adjacent areas is discussed in section 301.721 of this report. A discussion of the potential for material damage or diminution of these aquifers and their recharge areas is provided in Section 301.728 of this report.

724.700 Alluvial Valley Floor Determination

An investigation regarding the presence or lack of an alluvial valley floor (AVF) in Sink Valley is currently being performed. The field work for this investigation will be completed during the 2006 field season. A report of the findings of this investigation will be submitted to the Division in a subsequent submittal.

Preliminary results of this investigation indicate that Sink Valley in the vicinity of the Coal Hollow Permit area is not an AVF as defined in R645-302-321.300. This conclusion is based on observations and field data collected in the project area, and on the findings of a previous

investigation performed by Water Engineering & Technology, Inc. entitled "Geomorphological and sedimentological characteristics of Sink Valley, Kane County, Utah." A copy of this report is included as Appendix 7-4. The Water Engineering & Technology investigation was comprehensive and included lateral and longitudinal land surveys, geological field investigations, backhoe pits, and a total of 37 measured stratigraphic sections, which were performed in the backhoe pits and incised stream channels.

The basis for the finding that Sink Valley in the vicinity of the proposed mine area is not an alluvial valley floor is summarized below.

To satisfy the criteria of R645-302-321.300 as an alluvial valley floor, it must be shown that

1) There are stream-laid deposits beneath the valley floor of a valley holding a stream,

2) There is sufficient water to support agricultural activities as evidenced by; The existence of flood irrigation in the area in question or its historical use; The capability of an area to be flood irrigated, based on the streamflow water yield, soils, water quality, or topography; or, Subirrigation of the lands in question, derived from the groundwater system of the valley floor.

Water Engineering & Technology found in their investigation the following:

"There are no stream-laid deposits within the sediments that were observed in the backhoe pits and exposed banks of lower Robinson Creek and Sink Valley Wash. The sediments were deposited by unconfined sheetfloods, debris flows and mudflows. Minor channel fill sediments were observed in the stratigraphic sections, but they are related to the presence of small ephemeral channels during sheetflood events and to topographic irregularities caused by the presence of mudflor and debris flow deposits."

"No continuous channel has traversaed the length of Sink Valley within the time interval that is represented by the valley fill that was observed in this investigation. The valley fan that prograded down-valley from the confluence of Dry Fork and Water Canyon is composed primarily of Wasatch- [Claron] derived sediments…"

"Further, the absence of any sedimentary evidence for channelized flow in the investigated stratigraphic fill indicates that surface modifications of the valley floor by man's activities has not obscured the presence of a continuous channel. This is further reinforced by the rapid down-valley fining of the size of the Wasatch-derived sediments, ands by the relative paucity of Wasatch-derived sediments in the stratigraphic sections down-valley from the toe of the valley fan."

It is noteworthy that 1) there is not a well defined stream channel running through the proposed permit area in Sink Valley, 2) terrace deposits are not evident, 3) there is only very rarely any surface flow in Sink Valley (which occurs during local, active snowmelt or torrential thunderstorm events). When surface flow was observed at SW-6 (below the proposed permit area) on 30 March 2006, the flow originated as diffuse sheet flow on the valley floor that was not concentrated in any particular portion of the valley bottom. The water was derived from active

local melting of snow and slush on the ground surface. It was apparent during the active snowmelt that infiltration into the subsurface was minimal as the melt water ponded on the ground surface.

725 BASELINE CUMULATIVE IMPACT AREA INFORMATION

Information that can be used to assess the probable hydrologic impacts associated with mining in the proposed Coal Hollow permit area is provided in Chapter 6 and Chapter 7. A comprehensive report of groundwater and surface-water systems in the Coal Hollow Project and adjacent area will be prepared and submitted to the Division in a subsequent submittal. This report will contain additional information to assess the probable cumulative hydrologic impacts of coal mining and reclamation operations as required by R645-301-729.

R645-301-726 Modeling

No numerical models have been created for the permit area nor are any planned.

727 ALTERNATIVE WATER SOURCE INFORMATION

The determination of the probable hydrologic consequences (R645-301-728) indicates that the proposed coal mining activities will likely not result in appreciable contamination, diminution, or interruption of groundwater or surface-water sources within the proposed or adjacent areas. Therefore, information regarding alternative water sources has not been prepared. If upon subsequent investigation it is determined that such impacts are likely, information on an alternative water source will be provided to the Division in a subsequent submittal.

728 PROBABLE HYDROLOGIC CONSEQUENCES (PHC) DETERMINATION

This section describes the probable hydrologic consequences of surface coal mining in the permit area. This determination is based on the data and information presented previously in this chapter. *A comprehensive investigation of groundwater and surface-water systems will be completed following the 2006 field season. A report of this investigation will be submitted to the Division in a subsequent submittal. The findings of this investigation may result in modifications or additions to the determination of probable hydrologic consequences presented here.*

728.310 Potential adverse impacts to the hydrologic balance

The most important groundwater systems in the proposed permit and adjacent area, in terms of both groundwater storage and transmission potential as well as productivity for use in supporting wildlife and vegetation. Alluvial groundwater systems are also the only systems that provide useful quantities of groundwater for domestic and limited agricultural use. Groundwater

discharge in the proposed mining and adjacent area occurs primarily in Alluvial Groundwater Area A and Area B (Drawing 7-4). These areas are located primarily outside the proposed Coal Hollow permit area (Drawing 7-4).

In order to ensure that groundwater systems in Alluvial Groundwater Discharge Area A are not impacted by mining operations, coal mining in that portion of the proposed lease area that occurs in Section 29, T39S, R5W has been excluded from mining. Consequently, because Area A is located outside the mining area, and will be generally up-gradient of mining activities, the potential for mining-related impacts to groundwater resources in Area A is minimal.

It should be noted that the role of the Sink Valley Fault on the precise mechanism whereby groundwater discharges in Alluvial Groundwater Discharge Zone A will be investigated during the 2006 field season.

Alluvial Groundwater Discharge Area B appears to discharge groundwater that has flowed through the alluvium in Sink Valley and is forced to the land surface where the geometry of the valley constricts. Based on drilling experience in Sink Valley, it is apparent that the alluvial groundwater in the valley occurs under perched conditions. The condition is created because the clayey alluvial sediments in the valley are underlain by Tropic Shale bedrock, which has very poor groundwater transmitting potential. The potentiometric surface on groundwater systems in a deeper system near the Smirl coal zone is appreciably lower than that of the overlying alluvial sediments in both Area A and Area B (See Appendix.7-2).

Groundwater systems in the other principal geologic formations present in the permit area, including the Tropic Shale and underlying Dakota Formation, do not support appreciable groundwater systems. Likewise, they do not support appreciable spring discharge or provide water to wells locally. During exploration drilling in the Coal Hollow permit area, while minor wetness was noted in the near-surface alluvial sediments, little or no groundwater inflow was encountered in the Tropic Shale overlying the coal seam, although the low-permeability shale was wet. Because of the lack of a significant groundwater resource in the Tropic Shale, the probable impacts to the hydrologic balance resulting from the temporary excavation of the Tropic Shale overlying the coal seam appears minor.

Because there is no appreciable groundwater-derived baseflow component in the stream drainages in the proposed permit area, the potential for detrimental impacts to base flow discharge rates in these drainages is minimal. Springs discharging from Area A and Area B do not appreciably contribute to baseflow discharge in creeks. This is evidenced by the fact that there generally is no surface flow in Sink Valley in the vicinity of the permit area. The Lower Robinson Creek stream channel is also usually dry during most of the year except during active snowmelt or immediately after torrential rainfall events. It should be noted that a meager discharge in lower Robinson Creek near the intersection of the coal seam in the bottom of the stream channel was observed during high-flow periods in 2005 and 2006, which were unusually wet years. The stream flow in the creek was apparently derived from the diffuse seepage of alluvial groundwater into the stream channel at the base of the alluvial deposits. It is not known whether this seepage will persist during drier years.

728.320 Presence of acid-forming or toxic-forming materials

Chemical information on the acid- and toxic-forming potential of earth materials in the proposed permit area are presented in Appendix 7-5.

Acid-forming materials in western coal mines generally consist of sulfide minerals, most commonly pyrite and marcasite, which, when exposed to air and water, are oxidized causing the production of H^+ ions (acid). Oxidation of sulfide minerals may occur in limited amounts in the mine. However, the acid produced by pyrite oxidation is quickly consumed by dissolution of abundant, naturally occurring carbonate minerals. Dissolved iron is readily precipitated as iron-hydroxide, and excess iron will be not observed in mine discharge water. Because of the low-permeability of the rock strata and sediments surrounding the mine workings, the potential for seepage of mine water into adjacent stratigraphic horizons is low.

No other acid-forming materials or any toxic-forming materials have been identified or are suspected to exist in materials to be disturbed by mining.

728.331 Sediment yield from the disturbed area.

Erosion from disturbed areas will be minimized through the use of silt fences and other sediment control divices. Surface runoff occurring on disturbed areas will be collected and treated as necessary to remove suspended matter. After mining in a area is completed, the pit area will be reclaimed to approximate original contour and revegetated to decrease erosion potential.

728.332 Impacts to important water quality parameters

As discussed previously, an important groundwater resource near the proposed mining area is associated with Alluvial Groundwater Discharge Area A. This area will not be disturbed or otherwise impacted by mining-related activities. Additionally, this area is up-gradient of proposed mining locations. Consequently, the potential for detrimental impacts to this water resource, in terms of water quality or discharge rates is considered low. As discussed previously, there is no appreciable component of groundwater-derived baseflow locally in streams. Consequently, the potential for impacts to water quality in local streams is low. Minor amounts of alluvial groundwater also discharge to springs and seeps in Alluvial Groundwater Discharge Area B. This area is situated near the lower end of Sink Valley, which is down-gradient of proposed mining activities. Water quality in alluvial groundwater flowing in Sink Valley naturally degrades as it flows over the Tropic Shale and Tropic Shale derived alluvial sediments. Because Area B is down-gradient of the proposed mine area, impacts to water quality are possible. However, through careful water handling procedures, it is likely that this potential can be minimized.

As discussed above, acid mine drainage is not anticipated at the Coal Hollow Project site. This is due primarily to the relatively low sulfur content of the coal and rock strata in the project area, and to the abundant presence of carbonate minerals in the soil and rock strata which neutralize the acidity of the water if it occurs. If sulfide mineral oxidation and subsequent acid neutralization via carbonate dissolution does occur, increases in TDS concentrations can be anticipated. The dissolution of carbonate minerals typically liberates calcium, magnesium, and bicarbonate.

Additionally, where water interacts with Tropic Shale or other earth materials containing soluble minerals, the dissolution of soluble minerals may result in increased TDS concentrations. This phenomenon occurs naturally and is evident in the increasing TDS concentrations observed in alluvial groundwater in Sink Valley as the groundwater flows through Tropic Shale derived alluvium. The potential for TDS increases associated with interaction of waters with the Tropic Shale can be minimized by avoiding contact where practical between water sources and earth materials containing soluble minerals.

Mine water will be discharged to the Lower Robinson Creek drainage. This discharge will be permitted and will be in compliance with a NPDES discharge permit.

Surface runoff that occurs on disturbed areas will be treated through sedimentation ponds or other sesdiment-control devices and particulate matter will be allowed to settle prior to the discharging of the water to the receiving water, thus controlling suspended solids concentrations. Mine discharge water will also be treated as necessary before discharge to the receiving water to ensure compliance with the requirements of the NPDES discharge permit.

There is the potential for contamination of soils, surface-water and groundwater resources resulting from the spillage of hydrocarbons. Diesel fuels, oils, greases, and other hydrocarbons products will be stored and used at the mine site for a variety of purposes. A spill Prevention Control and Countermeasure Plan will be implemented that will help minimize any potential detrimental impacts to the environments.

728.333 Flooding or streamflow alteration

As described above, the groundwater systems overlying proposed mining areas are not extensive. The thicknesses of the alluvial sediments in the region are not great. The potential for rapid movement of groundwater through the clayey alluvial sediments in the proposed mining area is low, and the likely groundwater flow rates through the bedrock overburden (Tropic Shale) is even lower. The size of the proposed mining operation in the Coal Hollow Project area is relatively small for a surface-mining operation. The volume of open mine pit at any given time will be modest. Consequently, the potential for the need to pump water from the mine at large volumes is not anticipated.

The channel morphology of the receiving water for the mine discharge (Lower Robinson Creek) is sufficiently large to contain the very large thunderstorm runoff events which occur periodically in the region. The discharge rate of mine discharge water is anticipated to be only a

small fraction of the peak thunderstorm discharge rate that occurs periodically in the drainage. Consequently, the potential for flooding in the drainage is considered minor. Lower Robinson Creek flows into Kanab Creek about ½ mile below the proposed permit area. Flooding of the Kanab Creek stream channel is also considered unlikely, as the size of the stream channel is considerable, and perennial stream flows are already present in the stream.

It should be noted that most alluvial stream channels in the vicinity of the Coal Hollow Project area, including Lower Robinson Creek and Kanab Creek, have undergone considerable erosion in the historic past. The discharge of modest amounts of mine discharge water into these drainages may marginally increase erosion in these stream channels. However, the anticipated small amounts of erosion associated with the modest mine discharge will likely be relatively inconsequential relative to that that occurs during naturally occurring high stream flow events in the drainage.

A small-scale exploration/demonstration pit in the Coal Hollow Project area is planed for construction during the 2006 field season. One of the primary purposes of this exploration/demonstration pit will be to determine the amount and rates of inflow of groundwater inflow into the mine pit. Information gained from this activity will allow a more accurate determination of the likely mine inflow rates. Information gained from this activity will be submitted to the Division upon its completion.

Sediment control facilities will be designed and constructed to be geotechnically stable. This will minimize the potential for breaches of sediment control structures, which if they occur could result in down-stream flooding and increases in stream erosion and sediment yield.

Following reclamation, stream channels will be returned to a stable state. Stream channels will be designed to withstand anticipated storm events, thus minimizing the potential of flooding in the reclaimed areas.

728.334 Groundwater and surface water availability

As discussed above, among the most important groundwater resources in the proposed Coal Hollow permit and adjacent area are those associated with Alluvial Groundwater Discharge Area 1 and Area 2 (Drawing 7-4). In order to ensure that groundwater systems in Alluvial Groundwater Discharge Area A are not impacted by mining operations, coal mining in that portion of the proposed lease area that occurs in Section 29, T39S, R5W has been excluded from mining. Consequently, because Area A is located outside the mining area, and will be generally up-gradient of mining activities, the potential for mining-related impacts to groundwater resources in Area A is minimal. Therefore, groundwater availability in Area A should not be adversely impacted.

Alluvial groundwater discharging from Area B appears to originate primarily from drainage of perched alluvial groundwater in Sink Valley. Mining will occur along the western margin of Sink Valley and some of the shallow groundwater will likely be intercepted. However, alluvial sediments in the center and eastern portions of Sink Valley, through which an appreciable

component of the alluvial flux through the valley likely migrates, will not be disturbed by mining activities. Additionally, the progression of the coal mining activities in the area will be incremental. Individual mining areas will be disturbed for a time, and then reclaimed shortly thereafter. Thus, although a temporary decrease in discharge rates from alluvial groundwater systems in Area B may occur during and for a time after mining in the southern portion of the proposed permit area is complete, the impact will likely be temporary.

As stated above, groundwater contributions to baseflow in streams in the region is generally not observed. Additionally, the information presented above suggests that the potential for significant impacts to groundwater systems in the region is low. Consequently, the potential for decreases in surface-water availability due to mining-related activities is considered low.

728.340 Whether mining and reclamation activity will result in contamination, diminution or interruption State-appropriated waters

It is anticipated that mining-related activities will likely not result in contamination, diminution or interruption of State-appropriated water in the proposed Coal Hollow Permit and adjacent area. Additional hydrogeologic investigations regarding the potential for contamination, diminution or interruption of State-appropriated water will be performed during the 2006 field season. The results of this investigation will be submitted to the Division in a subsequent submittal.

730 OPERATION PLAN

Coal mining in the Coal Hollow Project will occur using surface mining techniques. All coal mining and reclamation operations will be conducted to minimize disturbance to the hydrologic balance within the permit and adjacent areas, to prevent material damage to the hydrologic balance outside the permit area and support approved postmining land uses in accordance with the terms and conditions of the approved permit and the performance standards of R645-301 and R645-302. Operations will be conducted to assure the protection or replacement of water rights in accordance with the terms and conditions of the approved permit and the performance standards of R645-301 and R645-302.

731 GENERAL REQUIREMENTS

Operations will be conducted to assure protection or replacement of water rights in accordance with the terms and conditions of the approved permit and the performance standards of R645-301 and R645-302.

Groundwater Protection

To protect the hydrologic balance, coal mining and reclamation operations will be conducted to handle earth materials and runoff in a manner that minimizes acid, toxic, or other harmful infiltration to the groundwater system. Additionally, excavations, and disturbances will be managed to prevent or control discharges of pollutants to the groundwater. The mine will replace loss of any surface water identified for protection in this MRP that are impacted by mining operations.

Surface Water Protection

To protect the hydrologic balance, coal mining and reclamation operations will be conducted to handle earth materials and runoff in a manner that minimizes acidic or toxic drainage, prevents to the extent possible, additional contributions of suspended solids to streamflow outside the permit area and otherwise prevents water pollution. Additionally, the mine will maintain adequate runoff- and sediment-control facilities to protect local surface waters.

Discharges of water from areas disturbed by coal mining and reclamation operations will be made in compliance with all Utah and federal water quality laws and regulations and with effluent limitations for coal mining promulgated by the U.S. Environmental Protection Agency set forth in 40 CFR part 434.

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

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

Roads will be located, designed, constructed, reconstructed, used, maintained and reclaimed according to R645-301-732.400, R645-301-742.400 and R645-301-762 and to achieve the following:

Control or prevent additional contributions of suspended solids to stream flow or runoff outside the permit area; Neither cause nor contribute to, directly or indirectly, the violation of effluent standards given under R645-301-751; minimize the diminution to or degradation of the quality or quantity of surface- and ground-water systems; and refrain from significantly altering the normal flow of water in streambeds or drainage channels.

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

Disposal of excess spoil, coal mine waste and noncoal mine waste will be located, maintained, constructed and reclaimed to comply with R645-301-735, R645-301-736, R645-301-745, R645-301-746, R645-301-747 and R645-301-760.

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

Before abandoning a permit area or seeking bond release, the operator will ensure that all temporary structures are removed and reclaimed, and that all permanent sedimentation ponds, diversions, impoundments, and treatment facilities meet the requirements of R645-301 and R645-302 for permanent structures, have been maintained properly and meet the requirements of the approved reclamation plan for permanent structures and impoundments. The operator will renovate such structures if necessary to meet the requirements of R645-301 and R645-302 and to conform to the approved reclamation plan.

Roads not to be retained for use under an approved postmining land use will be reclaimed immediately after it is no longer needed for coal mining and reclamation operations, including: restoring the natural drainage patterns, reshaping all cut and fill slopes to be compatible with the postmining land use and to compliment the drainage pattern of the surrounding terrain.

Siltation structures will be maintained until removel is authorized by the Division and the disturbed area has been stabilized and revegetated. In no case will the structure be reoved sooner than two years after the last augmented seeding. When the siltation structure is removed, the land on which the siltation structure was located will be regarded and revegetated in accordance with the reclamation plan and R645-301-358, R645-301-356, and R645-301-357.

Wells no longer needed for monitoring or other use approved by the Division upon a finding of no adverse environmental or health and safety effects, or unless approved for a transfer as a water well under R645-301-731.100 through R645-301-731.522and R645-301-731.800, each well will be capped, sealed, backfilled, or otherwise properly managed, as required by the Division in accordance with R645-301-529.400, R645-301-631.100, and R645-301-748. Permanent closure measures will be designed to prevent access to the mine workings by people, livestock, fish and wildlife, ,machinery and to keep acid or other toxic drainage from entering ground or surface waters.

In order to protect water rights and restore approximate premining recharge capacity, mining in sensitive areas will be excluded. This includes that portion of the proposed permit area located in Section 29, T39S, R5W. If mining and reclamation activities result in the contamination, diminution, or interruption of State appropriated groundwater or surface-water sources, replacement water will be provided.

After the conclusion of mining in an area, excavated earth materials will be returned to the mine pit area in a manner that will approximate pre-mining conditions. The area will be reclaimed to approximate original contour and revegetated.

Efforts will be made to protect the quality of groundwater encountered during mining and reclamation activities by mimizing its contact with materials that could degrade water quality. Acid or toxic drainage is not anticipated. However, to minimize the potential of pyrite oxidation, where practical, attempts will be made to isolate oxygenated waters from earth materials containing sulfide minerals.

Diesel fuels, oils, greases, and other hydrocarbons products will be stored and used at the mine site for a variety of purposes. A spill Prevention Control and Countermeasure Plan will be implemented that will help minimize any potential detrimental impacts to the environments.

731.200 Water Monitoring

This section describes the hydrologic monitoring plan. Locations of surface-water and groundwater monitoring sites are indicated on Drawing 7-10. Hydrologic monitoring protocols, sampling frequencies, and sampling sites are described in Table 7-4. Groundwater and surface-water monitoring locations are listed in Table 7-5. Operational field and laboratory hydrologic monitoring parameters for surface water are listed in 7-6, and for groundwater in Table 7-7. The hydrologic monitoring parameters have been selected in consultation with the Division's directive Tech-006, *Water Monitoring Programs for Coal Mines.*

Each of the sampling locations and their hydrologic significance are described below.

Streams

Kanab Creek will be monitored at sites SW-3 (above the permit area), and SW-2 (below the permit area). Robinson Creek will be monitored at sites SW-4 (above the permit area), SW-101 (within the permit area), and SW-5 (below the permit area above the confluence with Kanab Creek. The irrigation water near SW-4 will also be monitored at site RID-1. Swapp Hollow Creek will be monitored above the permit area at site SW-8. Sink Valley Wash will be monitored at SW-6 (a small tributary to the wash immediately below the permit area) and at SW-9, located in the main drainage below the permit area. All of these locations will be monitored for discharge and operational water quality parameters quarterly, when reasonably accessible.

Springs

Springs from Alluvial Groundwater Area A will be monitored including SP-14, which is an undeveloped spring that discharges at the upper extent of Area A, and SP-8, which is a developed spring in Area A that provides culinary water for the Swapp Ranch house. SP-8 will be monitored for discharge and operational laboratory water quality measurements quarterly when reasonably accessible. SP-14 will be monitored for discharge and field water quality measurements quarterly when reasonably accessible.

Springs SP-4 and SP-6, and SP-33, which are located in Sink Valley below the proposed mining area, will also be monitored. SP-6 is an area of diffuse seepage above an impoundment in the wash immediately below the permit area. Spring SP-33 is a developed spring that discharges into a pond below the permit area and provides culinary water to two adjacent cabins. SP-4 discharges from the canyon margin in Sink Valley Wash below the permit area. Each of these springs will be monitored for discharge and operational laboratory water quality measurements quarterly when reasonably accessible. Spring SP-3 discharges from pediment alluvium in the upland area above Sink Valley Wash more than a mile from the permit area. It is extremely unlikely that discharge rates or water quality at this spring could be impacted as a result of mining-related activities in the mine permit area. However, this spring will be monitored for

discharge and field water quality measurements quarterly primarily to provide background data from springs in the region.

Wells

Wells Y-98 (Robinson Creek alluvium above the permit area), Y-45 (coal seam well in Swapp Hollow above permit area), Y-102 (flowing alluvial well in Alluvial Groundwater Discharge Area A), Y-36 (coal seam well in Sink Valley above the permit area), Y-38 (coal seam well in Sink Valley permit area), Y-59 (alluvial well at the Sorenson Ranch house), and Y-61 (alluvial well at the Sorenson Ranch) will be monitored quarterly when reasonable accessible. Wells Y-102, Y-59, and Y-61 will be monitored for operational laboratory water quality parameters to monitor groundwater quality in Alluvial Groundwater Discharge Area A. The other wells will be monitored for water level only.

A new well will also be constructed in lower Sink Valley for the purpose of monitoring for potential impacts to water quality or water level in Sink Valley below the proposed mining area. The well will be completed in the alluvial sediments and will be monitored quarterly for water level and operational laboratory water quality measurements.

Table 1 Baseline monitoring site locations and details in the Coal Hollow Project.

Site	Alternate name	UTM location, Z12, NAD 27		Elevation (approx)	Drainage basin	Geologic Formation
Springs						
SP-3		372028	4136009	6882	lower Sink Valley Wash	Pediment alluvium
SP-4		371531	4136427	6700	lower Sink Valley Wash	Alluvium/fault ?
SP-5				7215	Sink Valley	Pediment alluvium
SP-6		371717	4137977	6829	Sink Valley	Alluvium
SP-8		371861	4139231	6920	Sink Valley	Alluvium
SP-14		372023	4139790	6985	Sink Valley	alluvium
SP-15		371960	4139660	6980	Sink Valley	alluvium
SP-16	Teal Spring	372035	4139656	6980	Sink Valley	alluvium
SP-17		372236	4139559	6970	Sink Valley	alluvium
SP-18		372196	4139486	6965	Sink Valley	alluvium
SP-19	Sorenson Pond			6960	Sink Valley	alluvium
SP-20		372014	4139325	6940	Sink Valley	alluvium
SP-21		371980	4139289	6940	Sink Valley	alluvium
SP-22		371863	4139423	6940	Sink Valley	alluvium
SP-23		371838	4139382	6935	Sink Valley	alluvium
SP-24		371822	4139356	6920	Sink Valley	alluvium
SP-25		371798	4139322	6920	Sink Valley	alluvium
SP-26		371717	4139211	6920	Sink Valley	alluvium
SP-27	Clampett Spring	371645	4137416	6800	Sink Valley	coal ?
SP-28	Seep #1	371896	4137718	6790	Sink Valley	alluvium
SP-29	Seep #2	371885	4137853	6800	Sink Valley	alluvium
SP-30	Seep #3	371852	4137787	6800	Sink Valley	alluvium
SP-31	Seep #4	371830	4137764	6800	Sink Valley	alluvium
SP-32	Seep #5	371810	4137864	6800	Sink Valley	alluvium
SP-33	Johnson Spring	371788	4137543	6785	Sink Valley	alluvium
SP-34		371512	4135632	6660	lower Sink Valley Wash	alluvium/colluvium ?
SP-35		372051	4139747	6980	Sink Valley	alluvium
Streams						
SW-1				6961	Kanab Creek	---
SW-2				6644	Kanab Creek	---
SW-3				6797	Kanab Creek	---
SW-7				7228	Swapp Hollow (adjacent)	---
SW-8				7212	Swapp Hollow	---
SW-6				6834	Sink Valley Wash	---
SW-9				6624	Lower Sink Valley Wash	---
SW-4				7213	Robinson Creek	---
SW-5				6681	Robinson Creek	---
SW-101				7885	Robinson Creek	---
RID-1 (irrigation)				7220	Robinson Creek	---
SW-10				6553	Unnamed trip to Sink Valley	---
Lamb Canal				6751	Kanab Creek	---
Wells						
Y-102	A5				Sink Valley	Alluvium
Y-45					Swapp Hollow	Coal
Y-61					Sink Valley	Alluvium
Y-59					Sink Valley	Alluvium
Y-63					Sink Valley Wash	Alluvium
Y-36					Sink Valley	Coal
Y-38					Sink Valley	Coal
Y-98	A1				Robinson Creek	Alluvium
Y-99	A2				Robinson Creek	Coal
Alluvial trenches						
SVT-01				6835.85	Sink Valley	Allvuium
SVT-02				6844.21	Sink Valley	Allvuium
SVT-03				6856.33	Sink Valley	Allvuium
SVT-04				6869.11	Sink Valley	Allvuium
SVT-05				6882.28	Sink Valley	Allvuium
SVT-06				6881.45	Sink Valley	Allvuium

Table 7-4 Hydrologic monitoring protocols and locations.

Discharge and water level measurements

Protocol	Applies to	Parameter	Frequency
A	Streams	Discharge	Quarterly
B	Springs	Discharge	Quarterly
C	Monitoring wells	Water elevation	Quarterly

Water quality

Protocol	Applies to	Parameters	Table	Frequency
1	Streams	Operational field and laboratory water quality measurements	7-6	Quarterly
2	Streams	Field water quality measurements only	7-6	Quarterly
3	Springs	Operational field and laboratory water quality measurements	7-7	Quarterly
4	Springs	Field water quality measurements only	7-7	Quarterly
5	Monitoring wells	operational field and laboratory water quality measurements	7-7	Quarterly
6	Monitoring wells	Field water quality measurements only	7-7	Quarterly

Table 7-5 Hydrologic monitoring locations.

Site	Protocols	Comments
Streams		
SW-2	A,1	Kanab Creek below Robinson Creek
SW-3	A,1	Kanab Creek above permit area
SW-4	A,1	Lower Robinson Creek above permit area
RID-1	A,1	Irrigation ditch in Robinson Creek
SW-101	A,1	Lower Robinson Creek in permit area
SW-5	A,1	Lower Robinson Creek above Kanab Creek
SW-8	A,1	Swapp Hollow Creek above permit area
SW-6	A,1	Sink Valley Wash at permit boundary
SW-9	A,1	Sink Valley Wash below permit area
Springs		
SP-6	B,3	Seep in Sink Valley below permit area
SP-8	B,3	Developed spring in Sink Valley above permit area
SP-4	B,3	Developed spring in Sink Valley Wash 1 mile below permit area
SP-3	B,4	Spring in upland pediment alluvium south of permit area
SP-14	B,4	Spring in Sink Valley in permit area
SP-33	B,3	Developed spring in lower Sink Valley alluvium
Johnson spring		
Wells		
Y-98	C	Alluvial well in Robinson Creek above permit area
Y-45	C	Coal seam well in Swapp Hollow above permit area
Y-102	C,5	Alluvial well in upper Sink Valley in permit area
Y-36	C	Coal well in Sink Valley above permit area
Y-38	C	Coal well in Sink Valley in permit area
Y-59	C,5	Alluvial well in Sink Valley above permit area
Y-61	C,5	Alluvial well in Sink Valley above permit area
New Sink Valley Well	C,5	New alluvial well in Sink Valley below permit area

Table 7-6 Surface water operational water quality monitoring

FIELD MEASUREMENTS	REPORTED AS
pH	pH units
Specific Conductivity	µs/cm @ 25°C
Dissolved Oxygen	mg/L
Temperature	°C
LABORATORY MEASUREMENTS	
Total Dissolved Solids	mg/L
Total Suspended Solids	mg/L:
Bicarbonate	mg/L
Carbonate	mg/L
Calcium (dissolved)	mg/L
Chloride	mg/L
Iron (total)	mg/L
Iron (dissolved)	mg/L
Magnesium (dissolved)	mg/L
Manganese (total)	mg/L
Potassium (dissolved)	mg/L
Sodium (dissolved)	mg/L
Sulfate	mg/L
Oil and grease	mg/L
Cations	meq/l
Anions	meq/l
Cation/Anion Balance	%

Table 7-7 Groundwater operational water quality monitoring.

FIELD MEASUREMENTS	REPORTED AS
pH	pH units
Specific Conductivity	µs/cm @ 25°C
Temperature	°C
LABORATORY MEASUREMENTS	
Total Dissolved Solids	mg/L
Carbonate	mg/L
Bicarbonate	mg/L
Calcium (dissolved)	mg/L
Chloride	mg/L
Iron (total)	mg/L
Iron (dissolved)	mg/L
Magnesium (dissolved)	mg/L
Manganese (total)	mg/L
Potassium (dissolved)	mg/L
Sodium (dissolved)	mg/L
Sulfate	mg/L
Oil and grease	mg/L
Cations	meq/L
Anions	meq/L
Cation/Anion Balance	%

Groundwater and surface-water monitoring will continue through the post-mining periods until bond release. The monitoring requirements, including the analytical parameters and the sampling frequency may be modified in the future in consultation with the Division if the data demonstrate that such a modification is justified.

731.600 Stream Buffer Zones

Any perennial or intermittent streams in the mine area will be protected by 100 foot stream buffer zones on either side of these streams. Coal mining and reclamation operations should not cause or contribute to the violation o fapplicable Utah or federal water standards and should not adversely affect the water quality and quantity or other environmental resources of the stream.

Temporary or permanent stream channel diversion will comply with R645-301-742-300.

The areas surrounding the streams that are not to be disturbed will be designated as buffer zones, and will be marked as specified in R645-301-521.260

731.700 Cross sections and Maps

The locations of springs and seeps identified in the proposed Coal Hollow permit and adjacent area are shown in Drawing 7-1. The locations of baseline hydrologic monitoring locations are shown on Drawing 7-2. The locations of water rights in the proposed Coal Hollow permit and adjacent area are provided on Drawing 7-3.

Other Cross Sections and Maps
Other relevant cross sections and maps are presented and discussed in Chapter 5 of this MRP.

731.800 Water Rights and Replacement

The mine operator commits to replace the water supply of an owner of interest in real property who obtains all or part of his or her supply of water for domestic, agricultural, industrial, or other legitimate use from the underground or surface source, where the water supply has been adversely impacted by contamination, diminution, or interruption proximately resulting from the surface mining activities. Baseline hydrologic information required in R645-301-624.100 through R645-301-624.200, R645-301-625, R645-301-626, R645-301-723 through R645-301-724.300, R645-301-724.500, R645-301-725 through R645-301-731, and R645-301-731.210 through R645-301-731.223 will be used to determine the extent of the impact of mining upon ground water and surface water.

732 Sediment Control Measures

Sediment control measures will be designed, constructed and maintained to prevent additional contributions of sediment to streamflow or to runoff outside the permit area. The sediment control measures will also be designed to meet applicable effluent limitations, and minimize erosion to the extent possible. The structures to be used for the runoff-control plan for the permit area include disturbed and undisturbed area diversion channels, sediment ponds, containment berms, silt fences, and road diversions and culverts.

732.100 Siltation Structures

Siltation structures within the permit area are described in Section 732.200

732.200 Sedimentation Ponds

Sedimentation ponds, whether temporary or permanent, will be designed in compliance with the requirements of R645-301-356.300, R645-301-356.400, R645-301-513.200, R645-301-742.200 through R645-301-742.240, and R645-301-763. Any sedimentation pond or earther structure which will remain on the proposed permit area as a permanent water impoundment will also be constructed and maintained to comply with the requirements of R645-301-743, R645-301-533.100 through R645-301-533.600, R645-301-512.240, R645-301-514.310 through R645-301-514.321 and R645-301-515.200. Each plan will, at a minimum, comply with the MSHA requirements given under R645-301-513.100 and R645-301-513.200.

732.300 Diversions

The runoff control plan is designed to isolate, to the maximum degree possible, runoff from disturbed areas from that of undisturbed areas. Where possible, this will be accomplished by allowing up-stream runoff to bypass the disturbed area, and routing any runoff from undisturbed areas which enters the disturbed area into a sediment control system.

A map showing the locations of diversion ditches and culverts will be submitted upon final design of the mine facility.

Diversion ditches will be maintained with rip-rap or other suitable erosion prevention system.

732.400 Road Drainage

All roads will be constructed, maintained and reconstructed to comply with R645-301-742.400. Road drainage facilities include diversion ditches, culverts, containment berms, and/or water bars.

732.410

A description of measures to be taken to obtain division approval for alteration or relocation of a natural drainage way will be presented to the Division when necessary.

732.420

A description of measures to be taken to protect the inlet end of a ditch relief culvert will be submitted to the Division when necessary.

All road drainage diversions will be maintained and repaired to operational condition following the occurrence of a large storm event. Culvert inlets and outlets will be kept clear of sediment and other debris.

733 IMPOUNDMENTS

733.100 General Plans

Details for each proposed water impoundment within the proposed permit area will be submitted upon final facility design. Each general plan will be prepared and certified as described under R645-301-512, contain maps and cross sections, contain a narrative that describes the structure, contains the results of a survey as described under R645-301-531, contain the preliminary hydrologic and geologic information required to assess the hydrologic impact of the structure and contain a certification statement which includes a schedule setting forth the dates when any detailed design plans for structures that are not submitted with the general plan to the Division.

733.200 Permanent and Temporary Impoundments

All impoundments will be designed and constructed using current, prudent engineering practices and will be designed to comply with the requirements of R645-301-512.240, R645-301-514.300, R645-301-515.200, R645-301-533.100 through R645-301-533.600, R645-301-733.220 through R645-301-733.226, R645-301-743.240, and R645-301-743. Each plan for an impoundment meeting the size or other criteria of the Mine Safety and

Health Administration will comply with the requirements of 30 CFR 77.216-1 and 30 CFR 77.216-2. The plan required to be submitted to the District Manager of MSHA under 30 CFR 77.216 will be submitted to the Division as part of the permit application package.

734 Discharge Structures

Discharge structures will be constructed and maintained to comply with R645-301-744.

735 Disposal of Excess Spoil

Areas designated for the disposal of excess spoil and excess spoil structures will be constructed and maintained to comply with R645-301-745.

736 Coal Mine Waste

Areas designated for disposal of coal mine waste and coal mine waste structures will be constructed and maintained to comply with R645-301-746.

737 Noncoal Mine Waste

Noncoal mine waste will be stored and final disposal of noncoal mine waste will comply with R645-301-747.

738 Temporary Casing and Sealing of Wells

Each well that will be used to monitor ground water conditions will comply with R645-301-748 and be temporarily sealed before use and protected during use by barricades, or fences, or other protective devices approved by the Division. These devices will be periodically inspected and maintained in good operating conditions by the operator.

740 DESIGN CRITERIA AND PLANS

741 GENERAL REQUIREMENTS

742 SEDIMENT CONTROL MEASURES

742.100 General Requirements

742.110 Design

Appropriate sediment control measures will be designed, constructed and maintained using best technology currently available to prevent to the extent possible, contributions of sediment to stream flow or to runoff outside the permit area; meet the effluent limitations under R645-301-751; and minimize erosion to the extent possible.

742.120

Sediment control methods may include retaining sediment within disturbed areas, diverting runoff away from disturbed areas, diverting runoff using protected channels or pipes through disturbed areas so as not to cause additional erosion; using straw dikes, riprap, check dams, mulches, vegetative sediment filters, dugout ponds and other measures that reduce overland flow velocities, reduce runoff volumes or trap sediment; treating with chemicals.

742.200 Siltation Structures

Siltation structures will be designed in compliance with the requirements of R645-301-742.

742.210 General Requirements

Additional contributions of suspended solids and sediment to streamflow or runoff outside the permit area will be prevented to the extent possible using the best technology currently available. Additional contributions of suspended solids and sediment to streamflow or runoff outside the permit area will be prevented to the extent possible using the best technology currently available. Siltation structures for an area will be constructed before beginning any coal mining and reclamation operations in that area and, upon construction, will be certified by a qualified registered professional engineer to be constructed as designed and as approved in the reclamation plan. Any siltation structures which impounds water will be designed, constructed and maintained in accordance with R645-301-512.240, R645-301-514.300, R645-301-515.200, R645-301-533.100 through R645-301-533.600, R645-301-733.220 through R645-301-733.224, and R645-301-743.

742.220 Sedimentation Ponds.

742.221

Sedimentation ponds, when used will be used individually or in series; be located as near as possible to the disturbed area and out of perennial streams unless approved by the Division; and be designed, constructed, and maintained to provide adequate detention time to allow the effluent from the ponds to meet Utah and federal effluent limitations; Contain or treat the 10-year, 24-hour precipitation event unless a lesser design event is approved by the Division based on terrain, climate, or other site-specific conditions and on a demonstration that the effluent limitations of R645-301-751 will be met; provide a nonclogging dewatering device adequate to maintain the detention time required under R645-301-742.221.32. Minimize, to the extent possible, short circuiting; Provide periodic sediment removal sufficient to maintain adequate volume for the design event; Ensure against excessive settlement; Be free of sod, large roots, frozen soil, and acid- or toxic-forming coal processing waster and be compacted properly.

742.222

Sedimentation ponds meeting the size or other qualifying criteria of MSHA, 30 CFR 77.216(a) will comply with all the requirements of that section, and will have a single spillway or principal and emergency spillways that in combination will safely pass a 100-year, 6-hour precipitation event or greater event as demonstrated to be necessary by the Division.

742.223

Sedimentation ponds not meeting the size or other qualifying criteria of MSHA, 30 CFR 77.216(a) will provide a combination of principal and emergency spillways that will safely discharge a 25-year, 6 hour precipitation event or greater event as demonstrated to be needed by the Division. Such ponds may use a single open channel spillway if the spillway is: Of nonerodible construction and designed to carry sustained flows; or Earth- or grass-lined and designed to carry short-term infrequent flows at non-erosive velocities where sustained flows are not expected.

742.230 <u>Other Treatment Facilities</u>

Other treatment facilities will be designed to treat the 10-year, 24-hour precipitation event unless a lesser design event is approved by the Division based on terrain, climate, other site-specific conditions and a demonstrations by the operator that the effluent limitations of R645-301-751 will be met.

Other treatment facilities will be designed in accordance with the applicable requirements of 645-301-751.

742.300 Diversions

742-310 General Requirements

All diversions will be designed to minimize adverse impacts to the hydrologic balance within the permit and adjacent areas, to prevent material damage outside the permit area and to assure the safety of the public.

The diversion and its appurtenant structures will be designed, located, constructed, maintained and used to be stable; provide against flooding and resultant damage to life and property; prevent, to the extent possible using the best technology currently available, additional contributions of suspended solids to streamflow outside the permit area; and comply with all applicable local, Utah, and federal laws and regulations.

742.313

Temporary diversions will be removed when no longer needed to achieve the purpose for which they were authorized. The land disturbed by the removal process will be restored in accordance with R645-301 and R645-302. Before diversions are removed, downstream water-treatment facilities previously protected by the diversion will be modified or removed, as necessary, ,to prevente overtopping or failure of the facilities. A permanent diversion or a sstream channel reclaimed after the removal of a temporary diversion will be designed and constgructed so as to restore or approximate the premining characteristics of the original stream channel including the natural riparian vegetation to promote the recovery and enhancement of the aquatic habitat.

742.320 Diversion of Perennial and Intermittent Streams.

742.322

The design capacity of channels for temporary and permanent stream channel diversions will be at least equal to the capacity of the unmodified stream channel immediately upstream and downstream from the diversion.

742.323

The requirements of R645-301-742.312.2 will be met when the temporary and permanent diversion forperennial and intermittent streams are designed so that the combination of channel, bank and floodplain configuration is adequate to pass safely the peak runoff of a 10-year, 6-hour precipitation event for a temporary diversion and a 100-year, 6-hour precipitation event for a permanent diversion.

742.324

The design and construction of all stream channel diversions of perennial and intermittent streams will be certified by a qualified registered professional engineer as meeting the performance standards of R645-301 and R645-302 and any design criteria set by the division.

742.330 Diversion of Miscellaneous Flows.

Miscellaneous flows, which consist of all flows except for perennial and intermittent streams, may be diverted away from disturbed areas if required or approved by the Division. Miscellaneous flows will include ground-water discharges and ephemeral streams.

The design, location, construction, maintenance, and removal of miscellaneous flows will meet all of the performance standards set forth in R645-301-742.310.

The requirements of R645-301-742.312.2 will be met when the temporary and permanent diversions for miscellaneous flows are designed so that the combination of channel, bank and floodplain configuration is adequate to pass safely the peak runoff of a 2-year, 6-hour precipitation event for a temporary diversion and a 10-year, 6-hour precipitation event for a permanent Diversion.

742.400 Road Drainage

742.410 All Roads

The design and construction of reconstruction of roads will incorporate appropriate limits for surface drainage control, culvert placement, culvert size, and any necessary design criteria established by the Division.

No part of any road will be located in the channel of an intermittent or perennial stream unless specifically approved by the Division in accordance with applicable parts of R645-301-731 through R645-301-742.300.

Roads will be located to minimize downstream sedimentation and flooding.

742.420 Primary Roads

To minimize erosion, a primary road will be located, insofar as practical, on the most stable available surfaces.

Stream fords by primary roads will not be utilized unless they are specifically approved by the Division as temporary routes during periods of construction.

742.423 Drainage Control

Primary roads will be designed, constructed or reconstructed and maintained to have adequate drainage control, using structures such as bridges, ditches, cross drains, and ditch relief drains. The drainage control system will be designed to pass the peak runoff safely from a 10-year, 6-hour precipitation event, or an alternative event of greater size as demonstrated to be needed by the Division.

Drainage pipes and culverts will be constructed to avoid plugging or collapse and erosion at inlets and outlets.

Drainage ditches will be designed to prevent uncontrolled drainage over the road surface and embankment. Trash racks and debris basins will be installed in the drainage ditches where debris from the drainage area may impair the functions of drainage and sediment control structures.

Natural stream channels will not be altered or relocated without the prior approval of the Division in accordance with R645-301-731.100 through R645-301-731.522, R645-301-731.600, R645-301-731.800, R645-301-742.300, and R645-301-751.

Except as provided in R645-301-742.422, drainage structures will be used for stream channel crossings, made using bridges, culverts or other structures designed, constructed and maintained using current, prudent engineering practice.

743 **IMPOUNDMENTS**

743.100 General Requirements

Temporary and permanent impoundments meeting the Cloass B or C criteria for dams in the U.S. Department of Agriculture, Natural Resources Conservation Services Technical Release No. 60. Earth Dams and Reservoirs will comply with the Minimum Emergence Spillway Hydrologic Criteria, table in TR-60 and the requirements of this section.

Impoundments meeting the criteria of MSHA, 30 CFR 77.216(a) will comply with the requirements of 77.216 and R645-301-512.240, R645-301-514.300, R645-301-515.200, R645-301-533.100 through R645-301-533.600, R645-301-733.220 through R645-301-

733.224, and R645-301-743. The plan required to be submitted to the Division as part of the permit application.

The design of impoundments will be prepared and certified as described under R645-301-512. Impoundments will have adequate freeboard to resist overtopping by waves and by sudden increases in storage volume. Impoundments meeting the NRCS Class B or C critera for dams in TR-60 will comply with the freeboard hydrograph criteria in the "Minimum Emergency Spillway Hydrologic Criteria" table in TR-60.

Impoundments will include either a combination of principal and emergency spillways or a single spillway as specified in 743.131 which will be designed and constructed to safely pass the design precipitation event or greater event specified in R645-301-743.200 or R645-301-743.300

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

744 DISCHARGE STRUCTURES

Discharge from sedimentation ponds, permanent and temporary impoundments, coal processing waste dams and embankments, an diversion sill be controlled, by energy dissipators, riprap channels and other devices, where necessary to reduce erosion to prevent deepening or enlargement of stream channels, and to minimize disturbance of the hydrologic balance.

Discharge structures will be designed according to standard engineering design procedures.

744 Disposal of Excess Spoil

744.100 General Requirements

Excess spoil will be placed in designated disposal areas within the permit area, in a controlled manner to minimize the adverse effects of leachate and surface water runoff from the fill on surface and ground waters; ensure permanent impoundments are not located on the completed fill. Small depressions may be created if approved by the Division if they are needed to retain moisture or minimize erosion, create and enhance wildlife habitat or assist revegetation, and if they are not incompatible with the stability of the fill; and adequately cover or treat excess spoil that is acid- and toxic-forming with nonacid nontoxic mterial to control the impact on surface and ground water is accordance with R645-301-731.300 and to minimize adverses effects on plant growth and the approved postmining land use.

If the disposal area contains springs, natural or manmade water cources,l or wet weather seeps, the fill design will include diversions and underdrains as necessary to control erosion, prevent water infiltration into the fill and ensure stability.

745.200 Valley Fills and Head-of-Hollow Fills

Valley fills and head-of-hollow fills are not anticipated in the Coal Hollow Project area.

745.300. Durable Rock Fills.

Durable rock fills are not anticipated in the Coal Hollow Project area.

745.400. Preexisting Benches.

The disposal of excess spoil through placement on preexisting benches is not anticipated in the Coal Hollow Project area.

746. COAL MINE WASTE

746.100. General Requirements.

All coal mine waste will be placed in new or existing disposal areas within a permit area which are approved by the Division.
Coal mine waste will be placed in a controlled manner to minimize adverse effects of leachate and surface water runoff on surface and ground water quality and quantity.

746.200. Refuse Piles.

Refuse piles will meet the requirements of R645-301-512.230, R645-301-515.200, R645-301-528.320, R645-301-536 through R645-301-536.200, R645-301-536.500, R645-301-542.730, and R645-301-746.100 and the additional requirements of R645-301-210, R645-301-513.400, R645-301-514.200, R645-301-528.322, R645-301-536.900, R645-301-553.250, and R645-301-746.200 and the requirements of the MSHA, 30 CFR 77.214 and 77.215.

If the disposal area contains springs, natural or manmade water courses, or wet weather seeps, the design will include diversions and underdrains as necessary to control erosion, prevent water infiltration into the disposal facility and ensure stability.

Uncontrolled surface drainage will not be diverted over the outslope of the refuse pile. Runoff from areas above the refuse pile and runoff from the surface of the refuse pile will be diverted into stabilized diversion channels designed to meet the requirements of R645-301-742.300 to safely pass the runoff from a 100-year, 6-hour precipitation event. Runoff diverted from undisturbed areas need not be commingled with runoff from the surface of the refuse pile.

Underdrains will comply with the requirements of R645-301-745.122.

746.220. Surface Area Stabilization.

Slope protection will be provided to minimize surface erosion at the site. All disturbed areas, including diversion channels that are not riprapped or otherwise protected, will be revegetated upon completion of construction.

No permanent impoundments will be allowed on the completed refuse pile. Small depressions may be allowed by the Division if they are needed to retain moisture, minimize erosion, create and enhance wildlife habitat, or assist revegetation, and if they are not incompatible with stability of the refuse pile.

746.300. Impounding structures.

New and existing impounding structures constructed of coal mine waste or intended to impound coal mine waste will meet the requirements of R645-301-512.230, R645-301-515.200, R645-301-528.320, R645-301-536 through R645-301-536.200, R645-301-536.500, R645-301-542.730, and R645-301-746.100.

Coal mine waste will not be used for construction of impounding structures unless it has been demonstrated to the Division that the use of coal mine waste will not have a detrimental effect on downstream water quality or the environment due to acid seepage through the impounding structure. The potential impact of acid mine seepage through the impounding structure will be discussed in detail.

Each impounding structure constructed of coal mine waste or intended to impound coal mine waste will be designed, constructed and maintained in accordance with R645-301-512.240, R645-301-513.200, R645-301-514.310 through R645-301-514.330, R645-301-515.200, R645-301-533.100 through R645-301-533.500, R645-301-733.230, R645-301-733.240, R645-301-743.100, and R645-301-743.300. Such structures may not be retained permanently as part of the approved postmining land use.

Each impounding structure constructed of coal mine waste or intended to impound coal mine waste that meets the criteria of 30 CFR 77.216(a) will have sufficient spillway capacity to safely pass, adequate storage capacity to safely contain, or a combination of storage capacity and spillway capacity to safely control the probable maximum precipitation

of a 6-hour precipitation event, or greater event as demonstrated to be needed by the Division.

Spillways and outlet works will be designed to provide adequate protection against erosion and corrosion. Inlets will be protected against blockage.

746.330. Drainage control.

Runoff from areas above the disposal facility or runoff from the surface of the facility that may cause instability or erosion of the impounding structure will be diverted into stabilized diversion channels designed to meet the requirements of R645-301-742.300 and designed to safely pass the runoff from a 100-year, 6-hour design precipitation event.

Impounding structures constructed of or impounding coal mine waste will be designed and operated so that at least 90 percent of the water stored during the design precipitation event will be removed within a 10-day period following that event.

746.400. Return of Coal Processing Waste to Abandoned Underground Workings.

No underground mining is being permitted in the Coal Hollow Project area.

747. DISPOSAL OF NONCOAL WASTE.

747.100.

Noncoal mine waste, including but not limited to grease, lubricants, paints, flammable liquids, garbage, machinery, lumber and other combustible materials generated during coal mining and reclamation operations will be placed and stored in a controlled manner in a designated portion of the permit area or state-approved solid waste disposal area.

747.200.

Placement and storage of noncoal mine waste within the permit area will ensure that leachate and surface runoff do not degrade surface or ground water.

747.300.

Final disposal of noncoal mine waste within the permit area will ensure that leachate and drainage does not degrade surface or underground water.

748. Casing and Sealing of Wells.

Each water well will be cased, sealed, or otherwise managed, as approved by the Division, to prevent acid or other toxic drainage from entering ground or surface water, to minimize disturbance to the hydrologic balance, and to ensure the safety of people, livestock, fish and wildlife, and machinery in the permit and adjacent area. If a water well is exposed by coal mining and reclamation operations, it will be permanently closed unless otherwise managed in a manner approved by the Division. Use of a drilled hole or borehole or monitoring well as a water well must comply with the provision of R645-301-731.100 through R645-301-731.522 and R645-301-731.800.

750 RFORMANCE STANDARDS

All coal mining and reclamation operations will be conducted to minimize disturbance to the hydrologic balance within the permit and adjacent areas, to prevent material damage to the hydrologic balance outside the permit area and support approved postmining land uses in accordance with the terms and conditions of the approved permit and the performance standards of R645-301 and R645-302. Mining operations will be conducted to assure the protection or replacement of water rights in accordance with the terms and conditions of the approved permit and the performance standards of R645-301 and R645-302.

751. Water Quality Standards and Effluent Limitations.

Discharges of water from areas disturbed by coal mining and reclamation operations will be made in compliance with all Utah and federal water quality laws and regulations and with effluent limitations for coal mining promulgated by the U.S. Environmental Protection Agency set forth in 40 CFR Part 434.

752. Sediment Control Measures.

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

752.100.

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

752.200. Road Drainage

Roads will be located, designed, constructed, reconstructed, used, maintained and reclaimed according to R645-301-732.400, R645-301-742.400 and R645-301-762 and to achieve the following:

Control or prevent erosion, siltation and the air pollution attendant to erosion by vegetating or otherwise stabilizing all exposed surfaces in accordance with current, prudent engineering practices;

Control or prevent additional contributions of suspended solids to stream flow or runoff outside the permit area;

Neither cause nor contribute to, directly or indirectly, the violation of effluent standards given under R645-301-751;

Minimize the diminution to or degradation of the quality or quantity of surface- and ground-water systems; and

Refrain from significantly altering the normal flow of water in streambeds or drainage channels.

753. IMPOUNDMENTS AND DISCHARGE STRUCTURES

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

754. DISPOSAL OF EXCESS SPOIL, COAL MINE WASTE AND NONCOAL MINE WASTE

Disposal areas for excess spoil, coal mine waste and noncoal mine waste will be located, maintained, constructed and reclaimed to comply with R645-301-735, R645-301-736, R645-301-745, R645-301-746, R645-301-747 and R645-301-760.

755. CASING AND SEALING OF WELLSs.

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

760. RECLAMATION.

761. GENERAL REQUIREMENTS.

Before abandoning a permit area or seeking bond release, the mine will ensure that all temporary structures are removed and reclaimed, and that all permanent sedimentation ponds, diversions, impoundments and treatment facilities meet the requirements of R645-301 and R645-302 for permanent structures, have been maintained properly and meet the requirements of the approved reclamation plan for permanent structures and impoundments. The mine will renovate such structures if necessary to meet the requirements of R645-301 and R645-302 and to conform to the approved reclamation plan.

762. ROADS.

A road not to be retained for use under an approved postmining land use will be reclaimed immediately after it is no longer needed for coal mining and reclamation operations, including:

762.100

Restoring the natural drainage patterns;

762.200.

Reshaping all cut and fill slopes to be compatible with the postmining land use and to complement the drainage pattern of the surrounding terrain.

763. SILTATION STRUCTURES.

763.100.

Siltation structures will be maintained until removal is authorized by the Division and the disturbed area has been stabilized and revegetated. In no case will the structure be removed sooner than two years after the last augmented seeding.

763.200.

When the siltation structure is removed, the land on which the siltation structure was located will be regraded and revegetated in accordance with the reclamation plan and R645-301-

358, R645-301-356, and R645-301-357. Sedimentation ponds approved by the Division for retention as permanent impoundments may be exempted from this requirement.

764. STRUCTURE REMOVAL.

The application will include the timetable and plans to remove each structure, if appropriate.

765. PERMANENT CASING AND SEALING OF WELLS.

When no longer needed for monitoring or other use approved by the Division upon a finding of no adverse environmental or health and safety effects, or unless approved for transfer as a water well under R645-301-731.100 through R645-301-731.522 and R645-301-731.800, each well will be capped, sealed, backfilled, or otherwise properly managed, as required by the Division in accordance with R645-301-529.400, R645-301-631.100, and R645-301-748. Permanent closure measures will be designed to prevent access to the mine workings by people, livestock, fish and wildlife, machinery and to keep acid or other toxic drainage from entering ground or surface waters.

REFERENCES

Stiff, A.H., Jr., 1951, The interpretation of chemical water analyses by means of patterns: Journal of Petroleum Techniques, Technical Note 84, p. 15-17.

Water Engineering & Technology, Inc., 1988, Geomorphological and sedimentological characteristics of Sink Valley, Kane County, Utah, unpublished consulting report for Nevada Electric Investment Company, 86 p. and appendices.

APPENDIX 7-1

Coal Hollow Project

Spring and seep survey information

Table 1 Spring and Seep survey data, Coal Hollow Project

Spring	Alternate name	Date	UTM location, Z12, NAD 27		Discharge (gpm)	T (°C)	pH	Sp. Cond. (µS/cm)
SP-33	Johnson Spring	17-Jun-05	371788	4137543	13.2	9.1	7.87	1148
SP-33	Johnson Spring	24-Sep-05			4.37	11.2	7.79	1386
SP-33	Johnson Spring	3-Nov-05			4.36	10.6	7.86	1031
SP-33	Johnson Spring	30-Mar-06			9.43	7.6	7.96	1254
SP-33	Johnson Spring	21-Apr-06				8	7.97	1293
SP-33	Johnson Spring	29-May-06			8.98	9	7.96	1239
SP-3		18-Jun-05	372028	4136009	5.94	9.8	7.43	658
SP-3		24-Sep-05			7.23	9.5	7.58	777
SP-3		3-Nov-05			6.82	9.5	7.42	703
SP-3		30-Mar-06			7.37	9.9	7.48	703
SP-3		29-May-06			7.73	9.5	7.57	747
SP-4		18-Jun-05	371531	4136427	0.96			
SP-4		24-Sep-05			0.72	12.5	7.47	990
SP-4		3-Nov-05			0.76	10.6	7.61	984
SP-4		30-Mar-06			0.64	8.6	7.7	955
SP-4		29-May-06			0.85	11.3	7.76	972
SP-5		18-Jun-05			Dry			
SP-5		12-Aug-05			Damp			
SP-5		30-May-06			Dry			
SP-6		17-Jun-05	371717	4137977	Seep	19.2	8.5	804
SP-6		24-Sep-05			Seep	16.0	7.41	1310
SP-6		3-Nov-05			Seep	10.5	7.76	1602
SP-6		16-May-06			Seep	18.7	8.21	1918
SP-6		29-May-06			Seep	25.2	8.12	1475

SP-8		27-May-05			17.6	10.3	7.89	642
SP-8		18-Jun-05	371861	4139231		11.5	7.39	660
SP-8		24-Sep-05			9.1	9.6	7.27	704
SP-8		4-Nov-05			12.8	9.6	7.48	706
SP-8		31-Mar-06			20.3	9.3	7.5	716
SP-8		16-May-05			19.1	9.7	7.42	726
SP-8		29-May-06			14.0	10.5	7.75	701
SP-14		16-May-06	372023	4139790	6.3	12.7	7.83	734
		31-Mar-06			5.77	8.6	7.4	708
SP-15		10-Nov-05	371960	4139660	0.57	9.1	7.44	715
		16-May-06			0.9	11.1	7.71	733
SP-16	Teal Spring	4-Nov-05	372035	4139656	1.35	6.7	7.3	692
		25-Jan-06			1.00	4.3	7.59	695
		16-May-06			0.98	11.9	7.42	737
		29-May-06			0.86	10.5	7.68	712
SP-17		16-May-05	372236	4139559	Seep			
SP-18		16-May-05	372196	4139486	Seep	9.6	7.46	700
SP-19	Sorenson Pond	4-Nov-05			Seep	8.7	8.07	779
		31-Mar-06			0.33	8.9	7.58	699
		16-May-06			0.24	9.3	7.53	730
SP-20		31-Mar-06			5.95	9.3	7.66	696
		16-May-06	372014	4139325	6.76	9.5	7.39	704
SP-21		16-May-06	371980	4139289	0.98	9.6	7.43	709
		29-May-06			0.85	9.5	7.78	680
SP-22		10-Nov-05	371863	4139423	Seep	9.9	7.56	725
		16-May-06	371869	4139430	Seep	9.3	7.38	780

SP-23		10-Nov-05	371838	4139382	Seep	10	7.33	736
		16-May-06			0.84	9.2	7.38	735
SP-24		10-Nov-05	371822	4139356	Seep	8.6	7.45	1324
		16-May-06			Seep	12.5	7.42	1241
SP-25		10-Nov-05			Seep	9.4	7.47	911
		16-May-06	371798	4139322	0.21	12.2	7.49	1083
SP-26		10-Nov-05	371717	4139211	Seep	9.6	7.4	738
		16-May-06			1.5	9.6	7.44	742
SP-28	Seep #1	17-Jun-05	371896	4137718	Seep	23	7.99	2110
		12-Aug-05			Dry			
		3-Nov-05			Dry			
		16-May-06			Dry			
SP-29	Seep #2	17-Jun-05	371885	4137853	Seep	17.4	7.58	2570
		12-Aug-05			Dry			
		3-Nov-05			Dry			
		16-May-06			Seep	12.4	7.35	2740
SP-30	Seep #3	17-Jun-05	371852	4137787	Seep	20.9	7.98	2940
		12-Aug-05			Dry			
		3-Nov-05			Dry			
		16-May-05			Seep	15.8	8.45	3180
SP-31	Seep #4	17-Jun-05	371830	4137764	Seep	21.7	8.61	3080
		12-Aug-05			Dry			
		3-Nov-05			Dry			
		16-May-06			Seep	13.7	8.49	4150
SP-32	Seep #5	17-Jun-05	371810	4137864	Seep	22.2	9.1	2690

		12-Aug-05			Dry			
		3-Nov-05			Dry			
		16-May-06			0.2	17.8	8.34	2910
SP-34		16-May-06	371512	4135632	Seep	13	7.04	2470
SP-35		29-May-06	372051	4139747	0.21	9.5	7.62	706
SP-27	Clampett Spring	17-Jun-05	371645	4137416	0.5	16.6	8.94	4,580
SP-27		3-Nov-05			Seep	7.8	8.52	4,640
	Teal Spring	25-Jan-06						

APPENDIX 7-2

Coal Hollow Project

Baseline solute and discharge, and water level data for springs, stream, and wells

Appendix 7-2 Discharge and water-quality data for groundwaters and surface waters in the Coal Hollow Project area.

	Date	Data Source	Q	Cond	DO	T	Turb	pH	Bicarb	Carb	Alk	Al	Anions	As	Barium	Boron	Cd	Ca	Cations
Streams																			
Kenab Creek																			
SW-1	1-Jul-87	Utah International	45	1320	8.40	25.2		8.25											
SW-1	3-Aug-87	Utah International	117	1320	6.30	18.4		8.1											
SW-1	4-Sep-87	Utah International	144	1415	8.30	11.2		8.05	430	<5	430	<0.05		<0.001	0.04	0.09	<0.005	114	
SW-1	26-Oct-87	Utah International	206	1260	7.0	18.9		7.9											
SW-1	13-Nov-87	Utah International	390	1510	11.3	7.5		8											
SW-1	8-Dec-87	Utah International	449	950	13.8	2.0		6.7	376	<5	376	0.17		<0.001	0.15	0.03	0.007	89	
SW-1	15-Jan-88	Utah International	3460	735	10.3	0.0		7.9											
SW-1	20-Feb-88	Utah International	3190	770	8.4	3.9		7.8											
SW-1	17-Mar-88	Utah International	3280	920	9.8	1.5		7.8	343	<5	343	0.28		<0.001	0.15	<0.02	<0.005	78	
SW-1	27-May-05	Petersen	1630	813	7.21	21.9	57.9	8.20	290	<5	303	<0.03	9.7	<0.010	0.179	0.07	<0.001	72.4	10.9
SW-1	25-Sep-05	Petersen	161	1962	7.58	12.2	4.21	7.90	500	<5	500	<0.03	21.2	<0.010	0.073	0.09	<0.001	146	22.2
SW-1	3-Nov-05	Petersen	893	1551	8.09	8.4	25.1	8.24	460	<5	460	<0.03	19.0	<0.010	0.120	0.08	<0.001	124	18.7
SW-1	31-Mar-06	Petersen	2770	846	8.32	10.0	240	8.89	342	11	353	<0.03	10.5	<0.010	0.145	0.04	<0.001	77.2	10.1
SW-2	7-Jul-87	Utah International	36	2490	8.4	11.3		8.20											
SW-2	10-Aug-87	Utah International	45	2440	6.3	28.2		8.45											
SW-2	14-Sep-87	Utah International	54	1950	9.4	6.8		8.50	382	<5	382	<0.05		<0.001	0.020	0.17	<0.005	93	
SW-2	29-Oct-87	Utah International	139	1910	8.8	15.2		8.2											
SW-2	17-Nov-87	Utah International	—	1925	9.1	2.1		8.3	400	<5	400	1.47		0.002	0.050	0.13	<0.005	113	
SW-2	16-Dec-87	Utah International	99	1030	11.7	0.5		7.9	332	<5	332	0.35		<0.001	0.130	0.03	<0.005	86	
SW-2	13-Jan-88	Utah International	1975	1500	8.7	0.0		9.1	364	<5	364	0.14		<0.001	0.130	0.08	<0.005	112	
SW-2	11-Feb-88	Utah International	6283	1270	11.7	0.0		8.3	296	<5	296	3.81		0.001	0.150	0.07	<0.005	106	
SW-2	17-Mar-88	Utah International	3590	1215	9.5	7.0		8.0	318	<5	318	1.77		0.002	0.160	<0.02	<0.005	75	
SW-2	27-May-05	Petersen	934	1120	8.47	15.8	>1,000	8.4	360	<5	360	<0.03	14.9	<0.010	0.155	0.10	<0.001	87.5	15.8
SW-2	25-Sep-05	Petersen	32	1926	8.24	6.1	4.75	8.22	439	<5	439	<0.03	26.6	<0.010	0.037	0.22	<0.001	112	27.3
SW-2	3-Nov-05	Petersen	430	1814	7.82	5.9	7.18	8.09	415	<5	415	<0.03	25.8	<0.010	0.054	0.18	<0.001	127	24.1
SW-3	1-Jul-87	Utah International	206	1210	8.20	15.7		8.4											
SW-3	3-Aug-87	Utah International	184	1110	6.20	22.1		8.5											
SW-3	4-Sep-87	Utah International	126	1450	8.40	14.9		8.45	368	<5	368	<0.05		<0.001	0.03	0.08	<0.005	99	
SW-3	26-Oct-87	Utah International	233	1350	8.2	18.5		8.1											
SW-3	13-Nov-87	Utah International	350	1525	9.4	7.5		8.3											
SW-3	16-Dec-87	Utah International	54	860	11.0	0.2		7.9	300	<5	300	0.45		<0.001	0.16	<0.01	<0.005	63	
SW-3	9-Jan-88	Utah International	449	800	10.1	0.9		8.0											
SW-3	20-Feb-88	Utah International	3366	760	9.9	2.1		8.0											
SW-3	17-Mar-88	Utah International	3590	795	8.3	5.0		7.9	286	<5	286	3.05		0.004	0.30	<0.02	<0.005	63	
SW-3	27-May-05	Petersen	1854	874	9.2	12.1	19.6	8.26											
SW-3	25-Sep-05	Petersen	119	1665	836	9.8	7.91	8.12	392	<5	392	<0.03	20.4	<0.010	0.010	0.02	<0.001	110	20.8
SW-3	3-Nov-05	Petersen	320	1519	7.83	9.6	4.06	8.33	416	<5	416	<0.03	19.9	<0.010	0.096	0.08	<0.001	125	19.8
SW-3	31-Mar-06	Petersen	2690	878	7.44	9.5	144	8.94	348	<5	348	0.05	10.7	<0.010	0.143	0.04	<0.001	79.3	10.6
Swapp Hollow																			
SW-7	2-Jul-87	Utah International	Dry																
SW-7	4-Aug-87	Utah International	Dry																
SW-7	6-Sep-87	Utah International	Dry																
SW-7	27-Oct-87	Utah International	Dry																
SW-7	15-Nov-87	Utah International	Dry																
SW-7	4-Dec-87	Utah International	Dry																
SW-7	5-Jan-88	Utah International	Dry																
SW-7	16-Feb-88	Utah International	Dry																
SW-7	18-Mar-88	Utah International	Dry																
SW-8	6-Jul-87	Utah International	36	490	8.65	10.3		8.5	228	<5	228	0.07		<0.001	0.22	<0.01	<0.005	37	
SW-8	6-Aug-87	Utah International	22	490	7.4	14.1		8.4	241	<5	241	0.21		<0.001	0.21	<0.02	<0.005	44	
SW-8	17-Sep-87	Utah International	40	480	8.2	7.1		8.5	232	<5	232	<0.05		<0.001	0.21	<0.02	<0.005	51	
SW-8	28-Oct-87	Utah International	36	430	6.6	18.2		8.2	241	<5	241	0.11		<0.001	0.25	<0.02	<0.005	48	
SW-8	17-Nov-87	Utah International	40	525	9.3	9		8.2	243	<5	243	0.55		<0.001	0.22	<0.02	<0.005	49	
SW-8	15-Dec-87	Utah International	13	585	8	0.8		7.7*	300	<5	300	0.45		<0.001	0.24	<0.02	<0.005	57	
SW-8	13-Jan-88	Utah International	40	550	9.3	0.3		8.2	250	<5	250	0.32		<0.001	0.24	<0.02	<0.005	47	
SW-8	17-Feb-88	Utah International	49	565	9.1	-0.3		8.1	273	<5	273	2.01		<0.001	0.23	<0.02	<0.005	61	
SW-8	21-Mar-88	Utah International	49	610	8.6	1.5		8.2	263	<5	263	2.45		0.002	0.43	<0.02	<0.005	56	
SW-8	18-Jun-05	Petersen	290	566	6.78	17.5	208	8.38	302	<5	278	<0.03	6.9	<0.010	0.221	0.02	<0.001	59.2	6.9
SW-8	12-Aug-05	Petersen	130	493	7.35	17.8	12.9	8.41	243	<5	243	<0.03	5.8	<0.010	0.219	0.02	<0.001	51.4	6.0
SW-8	24-Sep-05	Petersen	69	536	6.71	14.0	63	8.36	250	<5	250	<0.03	5.8	<0.010	0.195	<0.02	<0.001	48.4	5.9
SW-8	4-Nov-05	Petersen	71	555	7.99	6.2	16.4	8.63	265	<5	265	<0.03	6.4	<0.010	0.206	0.01	<0.001	59.8	6.6
Sink Valley																			
SW-6	17-Sep-87	Utah International	0	860	5.8	11.0		8.70	292	40	332	0.45		0.004	0.05	0.21	<0.005	34	
SW-6	15-Dec-87	Utah International	0	1840	8.2	0.8		8.3	602	37	639	0.19		0.002	0.06	0.21	<0.005	51	
SW-6	11-Mar-88	Utah International	0	1600	6.9	1.5		8.4	590	<5	590	0.21		0.002	0.04	0.16	<0.005	45	
SW-6	30-Mar-06	Petersen	58	1352	5.98	13.8	3.13	8.91	436	47	483	<0.03	17.8	<0.010	0.089	0.17	<0.001	58.9	17.9
SW-9	29-Oct-87	Utah International	9	—	9.3	11.1		8.6	392	53	445	5.1		0.002	0.15	0.3	<0.005	20	
SW-9	17-Nov-87	Utah International	18	1390	9.2	2.1		8.4	563	37	600	0.57		<0.001	0.06	0.24	<0.005	23	
SW-9	16-Feb-88	Utah International	763	955	10.0	-0.2		8.1	354	<5	354	2.84		0.002	0.16	0.09	<0.005	38	
SW-9	24-Mar-88	Utah International	1.3	3820	7.7	14.2		8.5	798	50	848	1.62		0.003	0.11	0.55	<0.005	39	
SW-9	30-Mar-06	Petersen	Dry						448	50	498	<0.03	21.9	<0.010	0.097	0.30	<0.001	53.7	21.7
Robinson Creek																			
SW-4	2-Jul-87	Utah International	Dry																
SW-4	4-Aug-87	Utah International	Dry																
SW-4	6-Sep-87	Utah International	Dry																
SW-4	27-Oct-87	Utah International	Dry																
SW-4	15-Nov-87	Utah International	Dry																
SW-4	4-Dec-87	Utah International	Dry																
SW-4	5-Jan-88	Utah International	Dry																
SW-4	16-Feb-88	Utah International	Dry																
SW-4	18-Mar-88	Utah International	Dry																
SW-4	27-May-05	Petersen	539	453	7.25	19.1	>1,000												
SW-5	10-Aug-87	Utah International	13.5	1680	5.9	27.5		8.65	433	49	482	0.42		0.002	0.05	0.17	<0.005	39	
SW-5	14-Sep-87	Utah International	13.5	1480	8.4	9.0		8.65	444	12	456	<0.05		<0.001	0.03	0.11	<0.005	49	
SW-5	29-Oct-87	Utah International	58	1070	8.5	12.5		8.10	290	<5	290	3.83		0.002	0.06	0.08	<0.005	42	
SW-5	18-Nov-87	Utah International	Puddle	1305	9.2	1.2		8.00	402	16	418	1.55		<0.001	0.04	0.06	<0.005	54	
SW-5	11-Feb-88	Utah International	36	665	6.9	0.0		8.00	204	<5	204	0.44		0.001	0.04	0.02	<0.005	46	
SW-5	17-Mar-88	Utah International	4.5	1670	6.4	9.1		8.20	378	<5	378	1.3		0.002	0.06	0.06	<0.005	54	
SW-5	27-May-05	Petersen	410	721	7.23	16.0	>1,000	8.46											
SW-101	27-May-05	Petersen	734	495	8.03	17.7	>1000	8.41	345	8	353	<0.03	8.1	<0.010	0.182	0.02	<0.001	54.2	5.9
SW-101	31-Mar-06	Petersen	20.8	3120	7.77	8.6	25,000	8.62	820	<5	820	0.19	57.3	<0.010	0.061	0.19	<0.001	356	42.6
RID-1 (irrigation)	4-Nov-05	Petersen	64.7	376	9.29	1.0	13.1	8.73	238	<5	238	<0.03	5.1	<0.010	0.248	<0.01	<0.001	47.5	5.5
Other Drainage																			
SW-10	9-Jul-87	Utah International	4.5	—	8.1	13.8		8.4	264	<5	264	2.65		0.001	0.19	0.03	<0.005	59	
SW-10	10-Aug-87	Utah International	1.8	520	7.9	28.9		8.65	159	33	192	0.19		<0.001	0.04	0.05	<0.005	31	
SW-10	14-Sep-87	Utah International	4.5	525	7.7	14.9		8.65	218	<5	218	0.39		<0.001	0.05	0.03	<0.005	41	
SW-10	29-Oct-87	Utah International	18.0	450	10.2	10.1		8.2	171	8	179	2.35		<0.001	0.06	0.03	<0.005	34	
SW-10	17-Nov-87	Utah International	13.5	540	9.1	3.0		8.0	2	<5	2	<0.05		<0.001	0.01	<0.02	<0.005	<1	
SW-10	16-Dec-87	Utah International	9.0	735	10.4	0.1		7.6	270	<5	270	0.5		<0.001	0.08	0.03	<0.005	48	
SW-10	13-Jan-88	Utah International	frozen	—	—	—		—											
SW-10	11-Feb-88	Utah International	13.5	325	9.8	0.6		8.1											
SW-10	11-Mar-88	Utah International	3.6	760	10.0	1.0		8.4	327	<5	327	0.19		<0.001	0.06	0.04	<0.005	84	
Lamb Canal	27-May-05	Petersen	1560	966	8.91	17.6	16.0	8.29											
Springs																			
Solar Panel	24-Sep-05	Petersen	4.37	1386		11.2		7.79	505	<5	505	<0.03	15.8	<0.010	0.131	0.23	<0.001	47.2	17.6
Solar Panel	3-Nov-05	Petersen	4.36	1031		10.6		7.88	507	<5	507	0.09	16.4	<0.010	0.019	0.2	0.002	45.9	16.2
Solar Panel	30-Mar-06	Petersen							508	<5	508	<0.03	15.6	<0.010	0.018	0.19	<0.001	44.8	16.1

	Date	Cl	Cr	Cu	F	Hard	Fe t	Fe d	Pb t	Pb d	Mg	Mn t	Mn d	ug/l Hg t	ug/l Hg	Mo	Ni
SW-1	4-Sep-87	16	<0.01	<0.01	0.4	867	0.27			<0.02	142	0.03			<0.2	<0.05	<0.02
SW-1	8-Dec-87	8	0.02	<0.01	0.2	575	1.8			<0.02	86	0.06			<0.2	<0.05	<0.02
SW-1	17-Mar-88	7	<0.01	<0.01	0.2	470	2.89			<0.02	67	0.06			<0.2	<0.05	<0.02
SW-1	27-May-05	6	<0.001	<0.01	0.20	519	3.77	<0.03		<0.01	82.1	0.034	0.005		<0.2	<0.005	<0.001
SW-1	25-Sep-05	14	<0.001	0.01	0.21	1023	<0.05	<0.03		<0.01	160	<0.002	0.043		<0.2	<0.005	<0.001
SW-1	3-Nov-05	14	<0.001	<0.01	0.15	870		<0.03		<0.01	136		0.011		<0.2	<0.005	0.002
SW-1	31-Mar-06	7	<0.001	<0.01	0.20	482	4.63	<0.03		<0.01	70.2	0.071	0.007		<0.2	<0.005	0.001
SW-2	14-Sep-87	27	<0.01	<0.01	0.5	1098	0.13			<0.02	211	0.02			<0.2	<0.05	<0.02
SW-2	29-Oct-87														<0.2		
SW-2	17-Nov-87	22	<0.01	<0.01	0.3	1078	10.1			<0.02	194	0.18			<0.2	<0.05	0.02
SW-2	16-Dec-87	8	<0.01	<0.01	0.2	592	3.4			<0.02	92	0.06			<0.2	<0.05	<0.02
SW-2	13-Jan-88	16	<0.01	<0.01	0.2	813	2.08			<0.02	130	0.08			<0.2	<0.05	<0.02
SW-2	11-Feb-88	10	<0.01	0.01	0.3	691	16			<0.02	104	0.33			<0.2	<0.05	0.03
SW-2	17-Mar-88	8	0.01	0.01	0.2	487	35.5			<0.02	73	0.3			<0.2	<0.05	<0.02
SW-2	27-May-05	12	0.001	<0.01	0.22	696	16	<0.03		<0.01	116	0.28	0.018		<0.2	<0.005	0.001
SW-2	25-Sep-05	22	<0.001	<0.01	0.18	1153	<0.05	<0.03		<0.01	212	<0.002	0.049		<0.2	<0.005	<0.001
SW-2	3-Nov-05	16	<0.001	<0.01	0.17	1071		<0.03		<0.01	183		0.048		<0.2	<0.005	0.001
SW-3	4-Sep-87	17	<0.01	<0.01	0.4	850	0.2			<0.02	147	<0.01			<0.2	<0.05	<0.02
SW-3	16-Dec-87	6	<0.01	<0.01	0.2	440	5			<0.02	69	0.08			<0.2	<0.05	<0.02
SW-3	17-Mar-88	5	0.01	0.01	0.2	358	56.8			<0.02	49	0.71			<0.2	<0.05	0.02
SW-3	25-Sep-05	16	<0.001	<0.01	0.21	962	<0.05	<0.03		<0.01	167	<0.002	<0.002		<0.2	<0.005	<0.001
SW-3	3-Nov-05	14	<0.001	<0.01	0.07	917		<0.03		<0.01	147		0.008		<0.2	<0.005	0.001
SW-3	31-Mar-06	7	<0.001	<0.01	0.20	503	2.43	<0.03		<0.01	74.1	0.049	0.010		<0.2	<0.005	0.001
SW-8	6-Jul-87	10	<0.01	<0.01	0.3	248	0.19		<0.02		38	0.01		<0.2		<0.05	<0.02
SW-8	6-Aug-87	3	<0.01	<0.01	0.5	258	1.8		<0.02		36	0.04		<0.2		<0.05	<0.02
SW-8	17-Sep-87	3	<0.01	0.01	0.4	292	0.44		<0.02		40	0.01		<0.2		<0.05	<0.02
SW-8	28-Oct-87	4	<0.01	<0.01	0.7	276	0.38		<0.02		38	0.02		<0.2		<0.05	<0.02
SW-8	17-Nov-87	3	<0.01	<0.01	0.2	270	2.77		<0.02		36	0.05		<0.2		<0.05	<0.02
SW-8	15-Dec-87	7	<0.01	<0.01	0.2	307	3.8		<0.02		40	0.06		<0.2		<0.05	<0.02
SW-8	13-Jan-88	7	<0.01	<0.01	0.2	273	2.83		<0.02		38	0.06		<0.2		<0.05	<0.02
SW-8	17-Feb-88	3	<0.01	<0.01	0.2	317	4.95		<0.02		40	0.1		<0.2		<0.05	<0.02
SW-8	21-Mar-88	<1	0.01	<0.01	0.2	296	30.8		<0.02		38	0.46		<0.2		<0.05	<0.02
SW-8	18-Jun-05	5	0.001	<0.01	0.06	329		<0.03		<0.01	44.1		0.002		<0.2	<0.005	<0.001
SW-8	12-Aug-05	4	<0.001	<0.01	0.13	284	0.66	<0.03		<0.01	37.7	0.016	<0.002		<0.2	<0.005	<0.001
SW-8	24-Sep-05	4	<0.001	<0.01	0.20	281	0.06	<0.03		<0.01	38.9	0.002	<0.002		<0.2	<0.005	<0.001
SW-8	4-Nov-05	4	<0.001	<0.01	0.14	310		<0.03		<0.01	39		0.006		<0.2	<0.005	<0.001
SW-6	17-Sep-87	18	<0.01	0.01	0.8	487	0.71		<0.02		98	0.02			<0.2	<0.05	<0.02
SW-6	15-Dec-87	41	<0.01	<0.01	0.4	984	0.3		<0.02		209	0.01			<0.2	<0.05	<0.02
SW-6	11-Mar-88	34	<0.01	<0.01	0.4	859	0.34		<0.02		182	0.03			<0.2	<0.05	<0.02
SW-6	30-Mar-06	22	<0.001	<0.01	0.27	810	<0.05	<0.03		<0.01	161	0.002	<0.002		<0.2	<0.005	0.002
SW-9	29-Oct-87	33	<0.01	<0.01	2.2	575	23.8		<0.02		128	0.31		<0.2		<0.05	0.02
SW-9	17-Nov-87	30	<0.01	<0.01	0.4	726	7.97		<0.02		163	0.05		<0.2		<0.05	<0.02
SW-9	16-Feb-88	15	<0.01	<0.01	0.3	534	21.5		<0.02		107	0.46		<0.2		<0.05	<0.02
SW-9	24-Mar-88	52	<0.01	0.01	0.9	946	18.5		<0.02		207	0.22		<0.2		<0.05	<0.02
SW-9	30-Mar-06	41	<0.001	<0.01	0.48	809	0.36	<0.03		<0.01	164	0.034	0.010		<0.2	<0.005	0.001
SW-5	10-Aug-87	24	<0.01	<0.01	0.8	754	5.19			<0.02	160	0.07			<0.2	<0.05	<0.02
SW-5	14-Sep-87	3	<0.01	<0.01	0.6	787	0.06			<0.02	162	0.02			<0.2	<0.05	<0.02
SW-5	29-Oct-87	19	<0.01	0.01	1	536	12			<0.02	105	0.14			<0.2	<0.05	<0.02
SW-5	18-Nov-87	21	<0.01	<0.01	0.4	664	9.1			<0.02	129	0.17			<0.2	<0.05	0.02
SW-5	11-Feb-88	10	<0.01	0.01	0.3	357	1.97			<0.02	59	0.04			<0.2	<0.05	0.02
SW-5	17-Mar-88	21	0.01	<0.01	0.4	561	10.1			<0.02	104	0.14			<0.2	<0.05	<0.02
SW-101	27-May-05	4	<0.001	<0.01	0.17	284	52.7	<0.03		<0.01	36	0.882	<0.002		<0.2	<0.005	<0.001
SW-101	31-Mar-06	47	<0.001	<0.01	1.23	1498	332	0.06		<0.01	148	4.16	0.002		<0.2	0.005	0.003
RID-1 (irrigation)	4-Nov-05	2	<0.001	<0.01	0.09	270		<0.03		<0.01	38.8		<0.002		<0.2	<0.005	<0.001
SW-10	9-Jul-87	16	<0.01	0.01	0.6	332	26.3		<0.02		45	0.33		<0.2		<0.05	0.02
SW-10	10-Aug-87	14	<0.01	<0.01	0.6	229	0.21		<0.02		37	<0.01		<0.2		<0.05	<0.02
SW-10	14-Sep-87	19	<0.01	0.01	0.4	267	0.84		<0.02		40	0.01		<0.2		<0.05	<0.02
SW-10	29-Oct-87	13	<0.01	<0.01	0.9	220	2.71		<0.02		33	0.03		<0.2		<0.05	<0.02
SW-10	17-Nov-87	<1	<0.01	<0.01	<0.1	<7	<0.02		<0.02		<1	<0.01		<0.2		<0.05	<0.02
SW-10	16-Dec-87	17	<0.01	0.01	0.2	305	2.81		<0.02		45	0.05		<0.2		<0.05	<0.02
SW-10	11-Mar-88	17	<0.01	<0.01	0.2	415	0.82		<0.02		50	0.01		<0.2		<0.05	<0.02
Solar Panel	24-Sep-05	12	<0.001	<0.01	0.44	781	<0.05	<0.03		<0.01	161	<0.002	<0.002		<0.2	<0.005	<0.001
Solar Panel	3-Nov-05	15	0.002	<0.01	0.28	708		0.03		<0.01	144		<0.002		<0.2	0.012	<0.001
Solar Panel	30-Mar-06	18	<0.001	<0.01	0.42	709	<0.05	<0.03		<0.01	145	<0.002	<0.002		<0.2	<0.005	<0.001

	Date	Ammonia	no3/no2	NO3	NO2	O&G	T. Phos	O-PO4	K	Se	Na	Set Sol	TSS	TDS	SO4	Sulfide	Zn	balance
SW-1	4-Sep-87	0.04		0.58	0.01	<1		<0.1	5	<0.001	33	<0.1	4	1050	416	<0.2	<0.01	2.96
SW-1	8-Dec-87	0.04		0.20	<0.02	<1		<0.1	3	<0.002	9	<0.1	68	554	150	<0.2	<0.01	4.63
SW-1	17-Mar-88	0.07		0.20	<0.01	<1		<0.1	2	<0.001	9	0.1	118	600	161	<0.2	0.01	4.93
SW-1	27-May-05	<0.1				<2	<0.05		2.33	<0.02	10.4			578	170		0.005	5.8
SW-1	25-Sep-05	0.1	<0.05	<0.05	<0.05	<2	<0.05		3.78	<0.02	37.9	<0.1		1293	521		<0.004	2.2
SW-1	3-Nov-05	<0.1	0.04			<2	<0.05		5.46	<0.02	27.4	<0.1		1085	453		<0.004	-0.8
SW-1	31-Mar-06	<0.1	0.3	0.06	<0.05	<2		<0.05	2.65	<0.02	9.31	0.4		530	154		<0.004	-1.8
SW-2	14-Sep-87	<0.02		<0.02	<0.01	<1		<0.1	6	<0.001	81	<0.1	<2	1604	700	<0.2	<0.01	5.27
SW-2	17-Nov-87	0.04		0.22	0.02	<1		<0.1	7	<0.002	58	0.7	484	1474	796	<0.2	0.01	2.10
SW-2	16-Dec-87	0.02		0.22	<0.01	<1		<0.1	3	<0.001	24	<0.1	88	674	239	<0.2	<0.01	4.42
SW-2	13-Jan-88	0.05		0.13	<0.01	<1		<0.1	4	<0.001	41	<0.1	82	1046	482	<0.2	<0.01	0.89
SW-2	11-Feb-88	0.07		0.12	<0.01	<1		<0.1	5	<0.001	29	0.5	3272	876	428	0.5	0.01	0.13
SW-2	17-Mar-88	0.17		0.17	<0.01	<1		<0.1	2	<0.001	15	2.5	1168	624	226	0.3	0.02	4.04
SW-2	27-May-05	<0.1				<2	0.88		3.15	<0.02	42			853	353		<0.004	3.0
SW-2	25-Sep-05	0.2	<0.02	<0.05	<0.05	<2	<0.05		5.24	<0.02	94.2	<0.1		1625	<1		0.053	1.2
SW-2	3-Nov-05	<0.1	<0.03			<2	<0.05		7.04	<0.02	58.6	<0.1		1513	821		<0.004	-3.4
SW-3	4-Sep-87	0.02		0.30	0.01	<1		0	5	<0.001	32	<0.1	16	1014	438	<0.2	<0.01	4.25
SW-3	16-Dec-87	0.04		0.22	<0.01	<1		0	3	<0.001	9	<0.1	158	518	130	0.2	<0.01	2.09
SW-3	17-Mar-88	0.10		0.12	<0.01	<1		0	2	<0.001	7	13.8	2836	424	111	0.3	0.03	4.2
SW-3	25-Sep-05	0.2	<0.02	<0.05	<0.05	<2	<0.05		0.86	<0.02	35.7	<0.1		1281	<1		<0.004	0.9
SW-3	3-Nov-05	<0.1	0.03			<2	<0.05		5.22	<0.02	30.10	<0.1		1144	538		<0.004	-0.4
SW-3	31-Mar-06	0.1	0.3	0.06	<0.05	<2		<0.05	2.63	<0.02	9.94	0.2		554	170		0.008	-0.7
SW-8	6-Jul-87	<0.02		<0.02	<0.01	<1		0	1	0.001	7.00	<0.1	20	286	31	<0.2	<0.01	1.76
SW-8	6-Aug-87	0.02		<0.02	<0.02	<1		0	1	0.001	5.00	<0.1	170	262	14	<0.2	<0.01	1.89
SW-8	17-Sep-87	0.05		0.03	<0.01	<1		0	1	<0.001	4.00	<0.1	28	245	21	<0.2	<0.01	7.77
SW-8	28-Oct-87	<0.02		<0.02	<0.01	<1		0	1	<0.001	5.00	<0.2	22	256	27	<0.2	0.01	2.31
SW-8	17-Nov-87	<0.02		0.03	<0.01	<1		0	1	<0.002	4.00	<0.2	178	302	29	<0.2	<0.01	0.45
SW-8	15-Dec-87	0.04		0.1	<0.01	<1		0	1	<0.001	6.00	<0.1	116	338	33	0.2	0.04	3.68
SW-8	13-Jan-88	0.1		0.06	<0.01	<1		0	1	<0.001	4.00	0.2	148	306	33	<0.2	<0.01	1.9
SW-8	17-Feb-88	0.2		0.06	<0.01	1		0	1	0.001	4.00	0.1	238	324	31	0.2	0.01	2.67
SW-8	21-Mar-88	0.03		0.18	0.18	1		0	1	0.001	4.00	4	2940	290	29	<0.2	0.03	2.34
SW-8	18-Jun-05	<0.1		0.17			0.43		1.03	<0.02	6.75			366	34		<0.004	0.1
SW-8	12-Aug-05	<0.1		0.08	<0.05	<2	<0.05		1.03	<0.02	6.63			274	38		<0.004	1.9
SW-8	24-Sep-05	<0.1	0.03	<0.05	<0.05	—	<0.05		0.99	<0.02	6.09	<0.1		298	33		<0.004	0.9
SW-8	4-Nov-05	<0.1	0.07			<2	<0.05		1.04	<0.02	7.95	<0.1		321	49		<0.004	1.0
SW-6	17-Sep-87	0.07		0.02	<0.01	<1		0	11	<0.001	29.00	<0.1	28	556	140	0.5	<0.01	5.5
SW-6	15-Dec-87	0.02		<0.02	<0.01	<1		0	9	<0.001	73.00	<0.1	12	1212	418	0.2	<0.01	0.9
SW-6	11-Mar-88	0.04		0.04	<0.01	1		0	5	<0.001	63.00	<0.1	12	992	344	0.2	<0.01	0.3
SW-6	30-Mar-06	<0.1	0.2	<0.05	<0.05	<2		<0.05	12.5	<0.02	31.30	<0.1		1026	361		0.008	0.2
SW-9	29-Oct-87	0.03		0.03	0.01	<1		0.1	6	<0.001	106.00	12.5	1140	860	280	0.3	0.03	1.9
SW-9	17-Nov-87	0.02		0.04	<0.01	<1		0	4	<0.002	86	<0.2	110	888	274	0.2	<0.01	0.51
SW-9	16-Feb-88	0.04		0.02	0.01	1		0.2	7	<0.001	30	1.5	1006	584	165	<0.2	0.02	5.23
SW-9	24-Mar-88	<0.02		0.03	0.01	1		0	7	<0.001	232.00	2.7	784	1556	591	<0.2	0.04	2.5
SW-9	30-Mar-06	<0.1	0.3	<0.05	<0.05	<2		<0.05	9.88	<0.02	122.00	<0.1		1270	520		<0.004	-0.5
SW-5	10-Aug-87	0.02		<0.02	<0.02	<1		0	7	0.001	69	0.3	226	984	403	0.5	<0.01	1.32
SW-5	14-Sep-87	<0.02		0.02	<0.01	<1		0	5	<0.001	61	<0.1	<2	1008	368	<0.2	<0.01	4.57
SW-5	29-Oct-87	<0.02		0.02	<0.01	<1		0	4	<0.001	49	0.6	584	666	298	<0.2	0.03	1.49
SW-5	18-Nov-87	0.03		0.03	<0.01	<1		0	4	<0.002	58	0.3	466	886	350	<0.2	0.02	1.15
SW-5	11-Feb-88	0.03		0.06	<0.01	1		0.2	6	<0.001	23	<0.1	92	446	163	0.2	<0.01	3.29
SW-5	17-Mar-88	0.07		0.08	<0.01	<1		0	5	0.001	55	1.6	714	876	344	0.4	0.01	3.54
SW-101	27-May-05	<0.1				2	2.94		1.02	<0.02	4.67			309	45		<0.004	-15.4
SW-101	31-Mar-06	<0.1	2.0	1.85	<0.05	<2		<0.05	16.4	<0.02	262	82		3013	1699		0.01	-14.6
RID-1 (irrigation)	4-Nov-05	<0.1	<0.02			<2	<0.05		0.67	<0.02	1.76	<0.1		250	16		<0.004	3.3
SW-10	9-Jul-87	0.07		0.45	0.01	<1		0	4	0.004	25	5.6	1084	390	66	<0.2	0.03	4.6
SW-10	10-Aug-87	<0.02		<0.02	<0.01	<1		0	3	0.005	24	<0.1	8	270	56	<0.2	0.01	2.79
SW-10	14-Sep-87	<0.02		0.03	<0.01	<1		0	3	0.003	13	<0.1	30	316	60	<0.2	0.01	1.4
SW-10	29-Oct-87	<0.02		0.01	0.01	1		0	2	0.002	22	<0.2	114	266	60	<0.2	0.02	2.16
SW-10	17-Nov-87	0.02		0.07	<0.01	<1		0	<1	<0.002	<1	<0.2	2	10	<2	<0.2	<0.01	0
SW-10	16-Dec-87	0.02		0.4	<0.01	<1		0	3	0.003	30	<0.1	94	408	64	0.2	0.01	1.7
SW-10	11-Mar-88	0.04		0.56	<0.01	<1		0	3	0.003	31	<0.1	20	450	86	0.2	0.1	4.96
Solar Panel	24-Sep-05	<0.1	0.21	0.16	<0.05		<0.05		4.87	<0.02	47			859	5		0.004	5.8
Solar Panel	3-Nov-05	<0.1	0.22				<0.05		4.97	0.08	44			840	280		<0.004	-0.6
Solar Panel	30-Mar-06	<0.1	0.5	0.23	<0.05			0.07	4.72	<0.02	42.7			843	237		<0.004	1.7

SP-3	7-Jul-87	Utah International	1.6	605	14.2																																									
SP-3	7-Aug-87	Utah International	2.1	665	15.6																																									
SP-3	16-Sep-87	Utah International	1.7	700	12.5		7.55	290	<5		<0.05		<0.001	0.07	0.03	<0.005	71		12	<0.01	0.01	0.5	354		<0.02	<0.02	43		0.03	<0.2	<0.05	<0.02	<0.02		0.05	<0.01		<0.01	2	<0.001	18	360	49	0.2	<0.01	5.04
SP-3	31-Oct-87	Utah International	2.2	685	11.0																																									
SP-3	22-Nov-87	Utah International	2.1	630	5.0																																									
SP-3	16-Dec-87	Utah International	1.1	610	8.0		7.4	308	<5		0.08		0.002	0.08	0.02	<0.005	70		13	<0.01	<0.01	0.2	339		0.15	<0.02	40		0.04	<0.2	<0.05	<0.02	0.03		0.38	<0.01		<0.01	2	0.003	20	398	39	<0.2	0.01	2.46
SP-3	9-Jan-88	Utah International	1.2	690	4.0																																									
SP-3	15-Feb-88	Utah International	1.5	715	4.2																																									
SP-3	24-Mar-88	Utah International	1.8	840	11.5		6.6	329	<5		<0.05		<0.001	0.09	0.04	<0.005	81		13	<0.01	<0.01	0.2	371		<0.02	<0.02	41		0.01	<0.2	<0.05	<0.02	<0.02		0.45	<0.01		<0.01	2	0.005	25	418	54	<0.2	0.01	2.88
SP-3	18-Jun-05	Petersen						480	<5	480	<0.03	15.9	<0.010	0.017	0.18	<0.001	48.4	17.6	20	0.001	<0.01	0.26	776		<0.03	<0.01	159		<0.002	<0.2	<0.005	<0.001	<0.1	0.22			0.06		4.78	<0.02	45.5	882	276		<0.004	5.0
SP-3	24-Sep-05	Petersen	7.23	777	9.5		7.58	324	<5	324	<0.03	7.8	<0.010	1.08	0.05	<0.001	83.4	8.7	15	<0.001	<0.01	0.23	379	0.11	<0.03	<0.01	41.4	0.003	<0.002	<0.2	<0.005	<0.001	<0.1	1.10	0.98	<0.05	<0.05		2.24	<0.02	25.7	391	41		<0.004	6.0
SP-3	3-Nov-05	Petersen	6.82	703	9.5		7.42	322	<5	322	0.07	7.8	<0.010	0.083	0.04	0.001	77.5	7.8	17	0.001	<0.01	0.17	334		<0.03	<0.01	34.2		0.022	<0.2	<0.005	<0.001	<0.1	1.00			<0.05		2.29	<0.02	23.4	403	43		<0.004	-0.4
SP-3	30-Mar-06	Petersen						324	<5	324	<0.03	7.8	<0.010	0.081	0.05	<0.001	77.1	7.9	17	<0.001	<0.01	0.24	340	0.15	<0.03	<0.01	35.8	0.013	0.009	<0.2	<0.005	<0.001	<0.1	2.0	1.04	<0.05		<0.05	2.21	<0.02	23.1	394	40		0.004	0.4
SP-4	1-Jul-87	Utah International	0.74	1005	15.4																																									
SP-4	3-Aug-87	Utah International	0.57	975	15.0																																									
SP-4	4-Sep-87	Utah International	0.67	945	14.1			374	<5		<0.05		<0.001	0.02	0.15	<0.005	33		11	<0.01	0.01	0.6	230		<0.02	<0.02	36		0.06	<0.2	<0.05	<0.02	0.56		<0.03	0.01		<0.01	3	<0.001	147	564	123	<0.2	<0.01	3.62
SP-4	26-Oct-87	Utah International	0.63	900	13.9																																									
SP-4	13-Nov-87	Utah International	0.54	945	9.2																																									
SP-4	14-Dec-87	Utah International	0.86	990	5.1			390	<5		0.10		0.001	0.02	0.15	<0.005	52		14	<0.01	<0.01	0.5	286		0.48	<0.02	38		0.06	<0.2	<0.05	<0.02	0.57		0.02	<0.01		<0.01	3	<0.001	142	566	128	<0.2	0.01	5.06
SP-4	9-Jan-88	Utah International	0.72	915	7.9																																									
SP-4	15-Feb-88	Utah International	0.71	920	6.8																																									
SP-4	11-Mar-88	Utah International	0.70	945	6.5			402	<5		<0.01		<0.001	0.02	0.14	<0.005	49		13	<0.01	<0.01	0.5	266		0.4	<0.02	35		0.07	<0.2	<0.05	<0.02	0.59		0.03	<0.01		<0.01	3	<0.001	138	550	103	<0.2	<0.01	4.08
SP-4	18-Jun-05	Petersen						394	<5	394	<0.03	11.5	<0.010	0.030	0.17	<0.001	53.3	12.6	13	0.001	<0.01	0.39	306		<0.03	<0.01	42.1		0.06	<0.2	<0.005	<0.001	<0.1	0.04			<0.05		3.10	<0.02	148	692	158		<0.004	4.6
SP-4	24-Sep-05	Petersen	0.72	990	12.5		7.47	400	<5	400	<0.03	10.3	<0.010	0.187	0.17	<0.001	47.9	10.9	10	<0.001	<0.01	0.51	245	0.17	<0.03	<0.01	30.5	0.020	0.06	<0.2	<0.005	<0.001	0.2	<0.02	<0.05	<0.05	<0.05		3.64	<0.02	135	506	99		<0.004	2.4
SP-4	3-Nov-05	Petersen	0.76	984	10.6		7.61	395	<5	395	<0.03	11	<0.010	0.033	0.16	0.001	46.2	10.3	12	<0.001	<0.01	0.45	243		<0.03	<0.01	31.0		0.06	<0.2	<0.005	0.001	<0.1	0.04			<0.05		2.79	0.05	124	576	135		<0.004	-3.4
SP-4	30-Mar-06	Petersen						388	<5	388	<0.03	10.6	<0.010	0.029	0.16	<0.001	47.7	10.2	12	<0.001	<0.01	0.48	255	0.46	<0.03	<0.01	33.0	0.070	0.060	<0.2	<0.005	<0.001	0.4	0.1	<0.05	0.31		<0.05	3.03	<0.02	116	576	119		0.004	-1.7
SP-6	3-Jul-87	Utah International	Seep	3485	18.8																																									
SP-6	5-Aug-87	Utah International	Seep	2900	19.1																																									
SP-6	17-Sep-87	Utah International	Seep	3140	12.0			1268	<5		<0.05		<0.001	0.06	0.47	<0.005	32		56	<0.01	<0.01	0.9	1827		0.08	<0.02	426		0.05	<0.2	<0.05	<0.02	0.06		0.02	<0.01		0.02		<0.001	156	2280	798	0.6	0.02	0.1
SP-6	28-Oct-87	Utah International	Seep	2520	12.3																																									
SP-6	17-Nov-87	Utah International	Seep	2830	7.9																																									
SP-6	9-Dec-87	Utah International	Seep	2385	6.1			1069	<5		<0.05		<0.001	0.04	0.31	<0.005	19		44	<0.01	<0.01	0.4	1569		0.02	<0.02	371		0.01	<0.2	<0.05	<0.02	0.05		<0.02	<0.02		0.02		<0.002	95	1638	492	<0.2	<0.01	4.03
SP-6	15-Jan-88	Utah International	Seep	2350	5.6																																									
SP-6	15-Feb-88	Utah International	Frozen	—	—		—																																							
SP-6	11-Mar-88	Utah International	Seep	2265	3.0			913	<5		<0.05		<0.001	0.03	0.20	<0.005	14		45	<0.01	<0.01	0.4	1404		<0.02	<0.02	334		0.01	<0.2	<0.05	<0.02	0.02		0.06	<0.01		0.02		<0.001	72	1598	572	<0.2	0.74	0.27
SP-6	24-Sep-05	Petersen	Seep	1310	16.0		7.41	602	<5	602	<0.03	14.6	<0.010	0.069	0.10	<0.001	84.1	13.9	6	<0.001	<0.01	0.38	614	0.34	<0.03	<0.01	96.1	0.011	<0.002	<0.2	<0.005	0.001	<0.1	0.03	<0.05	<0.05	<0.05		7.87	0.03	33	707	112		<0.004	-2.6
SP-6	3-Nov-05	Petersen	Seep	1602	10.5		7.76	612	<5	612	<0.03	19.7	<0.010	0.087	0.14	<0.001	84.5	18.7	44	<0.001	<0.01	0.22	759		<0.03	<0.01	133		0.064	<0.2	<0.005	<0.001	<0.1	0.03			<0.05		18.8	<0.02	81.3	1083	301		<0.004	-2.7
SP-8	3-Jul-87	Utah International	10.0	785	10.9																																									
SP-8	5-Aug-87	Utah International	8.6	795	10.7																																									
SP-8	18-Sep-87	Utah International	10.0	725	11.2		7.25	308	<5		<0.05		<0.001	0.05	<0.02	<0.005	81		5	<0.01	<0.01	0.4	432		<0.02	<0.02	56		<0.01	<0.2	<0.05	<0.02	0.04		0.19	<0.01		<0.01	2	<0.001	6	386	76	0.5	0.11	6.29
SP-8	27-Oct-87	Utah International	10.7	750	10.8																																									
SP-8	15-Nov-87	Utah International	10.0	715	7.5																																									
SP-8	9-Dec-87	Utah International	10.0	765	10.0		6.8	329	<5		<0.05		<0.001	0.07	<0.02	0.007	88		5	<0.01	<0.01	0.2	466		<0.02	<0.02	60		<0.01	<0.2	<0.05	<0.02	0.03		0.20	<0.02		<0.01	2	<0.002	6	420	76	<0.2	0.02	7.35
SP-8	9-Jan-88	Utah International	15.9	685	12.0																																									
SP-8	18-Feb-88	Utah International	15.4	675	7.8																																									
SP-8	18-Mar-88	Utah International	12.2	725	10.1		7.4	324	<5		<0.05		<0.001	0.05	<0.02	<0.005	77		5	<0.01	<0.01	0.2	398		<0.02	<0.02	50		<0.01	<0.2	<0.05	<0.02	0.02		0.22	<0.01		<0.01	2	0.001	6	438	82	<0.2	0.02	0.42
SP-8	27-May-05	Petersen	17.6	642	10.3	1.52	7.80	328	<5	328	<0.03	8.3	<0.010	0.052	0.02	<0.001	73.6	8.5	4	<0.001	<0.01	0.17	408	<0.05	<0.03	<0.01	54.5	<0.002	<0.002	<0.2	<0.005	<0.001	<0.1				<0.05		1.37	<0.02	7.44	456	77		0.005	1.4
SP-8	24-Sep-05	Petersen	9.1	704	9.6		7.27	338	<5	338	<0.03	8.3	<0.010	0.300	0.02	<0.001	83.7	9	3	<0.001	<0.01	0.18	433	<0.05	<0.03	<0.01	54.5	<0.002	<0.002	<0.2	<0.005	<0.001	<0.1	0.07	<0.05	<0.05	<0.05		1.60	<0.02	6.87	426	71		<0.004	3.9
SP-8	4-Nov-05	Petersen	12.8	706	9.6		7.48	333	<5	333	0.05	8.1	<0.010	0.047	0.02	<0.001	80.1	8.2	2	<0.001	<0.01	<0.05	396		<0.03	<0.01	47.7		<0.002	<0.2	<0.005	<0.001	<0.1	0.46			<0.05		1.43	<0.02	6.47	413	65		<0.004	1.1
SP-8	31-Mar-06	Petersen						335	<5	335	<0.03	8.4	<0.010	0.048	0.02	<0.001	79.7	8.4	4	<0.001	<0.01	0.20	402	<0.05	<0.03	<0.01	49.4	<0.002	<0.002	<0.2	<0.005	<0.001	<0.1	0.3	0.05	<0.05		<0.05	1.47	<0.02	6.55	407	74		0.005	0.1
SP-14																																														
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Clampett Spring	18-Jun-05	Petersen	0.5	4,580	16.6		8.94	1627	179	1807	0.24	79.3	<0.010	0.053	4.60	<0.001	60.5	66.6	162	<0.001	0.02	1.95	513		0.94	<0.01	88.0	<0.002		<0.2	0.077	0.027	<0.1	2.50			1.71		1.33	0.07	1760	6550	1856		0.026	4.5
Teal Spring	25-Jan-06	Petersen						330	<5	330	<0.03	8.4	<0.010	0.041	0.02	<0.001	83.1	8.9	4	<0.001	<0.01	0.20	426	0.06	<0.03	<0.01	53.1	<0.005	<0.005	<0.2	<0.005	<0.001	<0.1		<0.05	<0.05		<0.05	1.60	0.02	6.79	443	82		0.007	2.5
Wells																																														
Y-102 (A5)	18-Sep-87	Utah International		850	10.5		7.2	314	<5		<0.05		<0.001	0.03	<0.02	<0.005	81		6	<0.01	<0.01	0.4	473		<0.02	<0.02	66		<0.01	<0.2	<0.05	<0.02	0.03		0.21	<0.01		<0.01	2	<0.001	9	488	138	0.2	0.01	2.64
Y-102 (A5)	9-Dec-87	Utah International		840	9.8		7.0	316	<5		<0.05		<0.001	0.03	0.02	0.009	84		7	<0.01	<0.01	0.2	485		<0.02	<0.02	67		<0.01	<0.2	<0.05	<0.02	<0.02		0.22	<0.02		<0.01	2	<0.002	8	498	142	<0.2	<0.01	3.06
Y-102 (A5)	18-Mar-88	Utah International		850	9.9		7.4	329	<5		<0.05		<0.001	0.04	<0.02	<0.005	86		8	<0.01	<0.01	0.2	453		<0.02	<0.02	58		<0.01	<0.2	<0.05	<0.02	0.04		0.23	<0.01		<0.01	2	<0.001	9	522	146	<0.2	0.02	1.91
Y-102 (A5)	27-May-05	Petersen	0.64	662	9.5	1.5	7.25	329	<5	329	<0.03	8.7	<0.010	0.039	0.03	<0.001	82.2	9.3	4	<0.001	0.04	0.18	439	<0.05	<0.03	<0.01	56.8	<0.002	<0.002	<0.2	<0.005	<0.001	<0.1				<0.05		1.60	<0.02	10.2	492	98		<0.004	2.9
Y-102 (A5)	24-Sep-05	Petersen	0.62	715	9.4		7.29	341	<5	341	<0.03	8.8	<0.010	0.413	0.03	<0.001	81.4	8.7	3	<0.001	<0.01	0.18	408	<0.05	<0.03	<0.01	49.8	<0.002	<0.002	<0.2	<0.005	<0.001	<0.1	0.08	0.06	<0.05	<0.05		2.14	<0.02	10.1	455	89		<0.004	-0.6
Y-102 (A5)	4-Nov-05	Petersen	0.78	739	9.5		7.45	329	<5	329	<0.03	8.6	<0.010	0.035	0.02	<0.001	81.8	8.6	4	<0.001	<0.01	0.06	409		<0.03	<0.01	49.8		<0.002	<0.2	<0.005	<0.001	<0.1	0.08			<0.05			<0.02	8.71	440	91		<0.004	0.1
Y-102 (A5)	26-Jan-06	Petersen						330	<5	330	<0.03	8.6	<0.010	0.043	0.02	<0.001	86.8	9.3	5	<0.001	<0.01	0.21	444	<0.05	<0.03	<0.01	55.2	<0.002	<0.002	<0.2	<0.005	<0.001	<0.1		0.07	<0.05		<0.05	1.67	0.03	9.09	441	91		0.011	3.6
Y-61	20-Sep-87	Utah International		775	10.1		7.3																																							
Y-61	13-Dec-87	Utah International		830	8.9		7.2																																							
Y-61	20-Mar-88	Utah International		790	11.0		6.8																																							
Y-61	12-Aug-05	Petersen	21.6	611	9.6		7.59	328	<5	328	<0.03	8.1	<0.010	0.046	0.03	<0.001	79.3	8.2	3	<0.001	<0.01	0.10	394	<0.05	<0.03	<0.01	47.7	0.005	<0.002	<0.2	<0.005	<0.001	<0.1		0.09	<0.05	<0.05		1.43	<0.02	6.47	400	69		<0.004	0.7
Y-61	4-Nov-05	Petersen	—	724			7.48	332	<5	332	<0.03	8.1	<0.010	0.046	0.02	<0.001	79.1	8.1	3	<0.001	<0.01	0.11	389		<0.03	<0.01	46.5		<0.002	<0.2	<0.005	<0.001	<0.1	0.08			<0.05		1.35	<0.02	6.21	397	68		<0.004	-0.4
Y-61	31-Mar-05	Petersen						330	<5	330	<0.03	8.0	<0.010	0.043	0.03	<0.001	78.9	8.3	4	<0.001	<0.01	0.20	396	0.06	<0.03	<0.01	48.4	0.003	0.003	<0.2	<0.005	<0.001	<0.1	0.3	0.06	<0.05		<0.05	1.49	<0.02	7.26	393	63		0.007	1.5
Y-59	18-Sep-87	Utah International		800	10.7		7.2	320	<5		<0.05		<0.001	0.04	0.02	<0.005	83		7	<0.01	<0.01	0.5	449		<0.02	<0.02	59		<0.01	<0.2	<0.05	<0.02	0.05		0.63	<0.01		0.01	2	<0.001	10	468	115	<0.2	0.01	2.54
Y-59	15-Dec-87	Utah International		850	9.0		7.0	329	<5		<0.05		<0.001	0.04	0.04	<0.005	72		8	<0.01	0.01	0.2	414		<0.02	0.02	57		<0.01	<0.2	<0.05	0.02	<0.02		0.58	<0.01		<0.01	1	0.002	11	482	123	<0.2	<0.01	3.46
Y-59	21-Mar-88	Utah International		870	10.2		7.4	333	<5		<0.05		<0.001	0.05	0.02	<0.005	93		6	<0.01	<0.01	0.2	474		<0.02	<0.02	59		<0.01	<0.2	<0.05	<0.02	<0.02		0.33	<0.01		0.01	1	<0.001	8	472	107	<0.2	<0.01	4.17
Y-59	12-Aug-05	Petersen	—	651	13.6		7.11	329	<5	329	<0.03	8.2	<0.010	0.045	0.03	<0.001	60.6	8.4	3	<0.001	<0.01	0.10	405	<0.05	<0.03	<0.01	49.4	<0.002	<0.002	<0.2	<0.005	<0.001	<0.1		0.09	<0.05	<0.05		1.57	<0.02	7.05	395	73		<0.004	1.5
Y-59	4-Nov-05	Petersen	0.061	681	9.4		7.43	326	<5	326	<0.03	8.1	<0.010	0.039	0.02	<0.001	79.2	8.3	3	<0.001	<0.01	0.11	297		<0.03	<0.01	48.5		<0.002	<0.2	<0.005	<0.001	<0.1	0.12			<0.05		1.39	<0.02	6.87	397	73		<0.004	0.9
Y-59	31-Mar-06	Petersen						329	<5	329	<0.03	8.1	<0.010	0.04	0.03	<0.001	79	8.3	4	<0.001	<0.01	0.18	399	<0.05	<0.03	<0.01	49.1	<0.002	<0.002	<0.2	<0.005	<0.001	<0.01	0.3	0.07	<0.05		<0.05	1.53	<0.02	7.19	381	66		0.009	1.6
Y-63	18-Sep-87	Utah International		740	10.2		8.05	362	<5		<0.05		<0.001	0.14	0.07	<0.005	41		12	0.01	<0.01	0.5	369		0.18	<0.02	65		0.16	<0.2	<0.05	<0.02	3.9		0.01	0.04		<0.01	3	<0.001	33	400	27	0.3	<0.01	4.52
Y-63	9-Dec-87	Utah International		740	9.1		7.8	361	<5		<0.05		<0.001	0.22	0.13	<0.005	44		12	<0.01	<0.01	0.2	385		0.05	<0.02	67		0.08	<0.2	<0.05	<0.02	4.14		<0.02	<0.02		<0.01	3	<0.002	33	368	25	2.1	<0.01	5.37
Y-63	31-Mar-88	Utah International		900	9.8		7.7	410	<5		<0.05		<0.001	0.27	0.07	<0.005	57		14	<0.01	<0.01	0.3	405		0.03	<0.02	64		0.15	<0.2	<0.05	<0.02	3.16		<0.02	<0.01		0.01	2	<0.001	31	454	51	2.2	<0.01	0.78
Y-36	17-Sep-87	Utah International		1320	10.2		7.2	630	<5		<0.05		<0.001	0.22	1.69	<0.005	4		50	<0.01	0.01	3.9	14		0.05	<0.02	1		0.02	<0.2	<0.05	<0.02	0.54		0.02	<0.01		0.03	2	<0.001	397	815	<2	0.3	0.02	5.58
Y-36	15-Dec-87	Utah International		1320	10.2		7.9	616	<5		0.08		<0.001	0.14	1.49	<0.005	3		54	<0.01	0.01	3.9	12		0.05	<0.02	1		0.01	<0.2	<0.05	<0.02	0.49		<0.02	<0.01		<0.01	2	<0.001	316	784	10	<0.2	0.01	0.21

Y-98 (A1)	16-Sep-87	Utah International	535	11.2	7.3	272	<5		<0.05		<0.001	0.08	0.06	0.005	56		6	<0.01	<0.01	0.9	388		<0.02	<0.02	60		0.02	<0.2	<0.05	<0.02	0.03		0.13	<0.01	<0.01	3	<0.001	12	346	70	0	0.03	8.11
Y-98 (A1)	9-Dec-87	Utah International	955	8.9	7.3	355	<5		<0.05		<0.001	0.26	0.1	<0.005	62		14	<0.01	<0.01	0.4	508		<0.02	<0.02	86		0.06	<0.2	<0.05	<0.02	<0.02		0.23	<0.2	<0.01	3	<0.002	27	548	159	0.7	0.01	2.65
Y-98 (A1)	18-Mar-88	Utah International	1000	6.9	7 0	337	<5		<0.05		<0.001	0.05	0.03	<0.005	79		8	<0.01	<0.01	0.2	497		0.03	<0.02	73		0.02	<0.2	<0.05	<0.02	<0.02		0.19	<0.01	0.01	3	<0.001	13	600	200	0.6	0.01	2.62
Alluvial tranches																																											
SVT-01	21-Apr-06	Petersen	2030	6.1	8.14	1040	<5	1040	<0.03	31.7	<0.010	0.062	0.2	<0.001	14	28.8	33	<0.001	<0.01	0.60	1316	1.22	<0.03	<0.01	311	0.012	<0.002	<0.2	<0.005	0.003	<0.1	<0.1	<0.05	<0.05	0.06	4.51	<0.02	54.2	1469	478		<0.004	-4.8
SVT-03	21-Apr-06	Petersen	3700	11.4	8.43	781	<5	781	<0.03	61.8	<0.010	0.089	0.15	<0.001	64.4	56.5	102	<0.001	<0.01	0.36	2582	6.88	<0.03	<0.01	588	0.149	0.006	<0.2	<0.005	0.001	<0.1	<0.1	<0.05	<0.05	<0.05	14.5	<0.02	104	3608	2080		<0.004	-4.5
SVT-04	21-Apr-06	Petersen	2090	7.2	8.12	490	<5	490	<0.03	26.6	<0.010	0.028	0.09	<0.001	54.6	26.5	47	<0.001	<0.01	0.33	1059	3.37	<0.03	<0.01	224	0.070	0.016	<0.2	<0.005	<0.001	<0.1	1.4	2.51	<0.05	<0.05	3.46	<0.02	122	1561	741		0.024	0.0
SVT-05	21-Apr-06	Petersen	1142	7.3	7.89	531	<5	531	<0.03	18.4	<0.010	0.047	0.08	<0.001	55.1	18.1	20	<0.001	<0.01	0.41	850	2.26	<0.03	<0.01	173	0.037	0.003	<0.2	<0.005	<0.001	<0.1	0.1	<0.05	<0.05	<0.05	1.93	<0.02	25.7	966	966		0.006	-0.6
SVT-06	21-Apr-06	Petersen	1288	9.1	8.16	440	<5	440	<0.03	16.6	<0.010	0.040	0.06	<0.001	62.4	16.6	18	<0.001	<0.01	0.44	761	1.29	<0.03	<0.01	147	0.028	0.002	<0.2	<0.005	<0.001	<0.1	0.2	<0.05	<0.05	<0.05	1.53	<0.02	30.3	903	349		0.009	0.0
SVT-01	21-Apr-06	Petersen	2030	6.1	8.14	1040	<5								14		33								311											4.51		54.2	1469	478			
SVT-03	21-Apr-06	Petersen	3700	11.4	8.43	781	<5								64.4		102								588											14.5		104	3608	2080			
SVT-04	21-Apr-06	Petersen	2090	7.2	8.12	490	<5								54.6		47								224											3.46		122	1561	741			
	21-Apr-06	Petersen	1142	7.3	7.89	531	<5								55.1		20								173											1.93		25.7	966	345			
SVT-06	21-Apr-06	Petersen	1288	9.1	8.16	440	<5								62.4		18								147											1.53		30.3	903	349			
Y-99	27-May-05	Dry																																									
Y-98	27-May-05	81.00																																									

APPENDIX 7-3

Coal Hollow Project

Water rights information

APPENDIX 7-3

EXHIBIT 7-1

Stream Reaches

STREAM REACHES

REF #	WR #	OWNER	SOURCE
1	85-162	Garn L. Swapp	Kanab Creek
2	85-303	Sharon C. & Lorene C. Lamb	Kanab Creek
3	85-608	Lloyd, Ross, Gail & Vard Heaton	Lower Robinson Creek
4	85-463	BLM	Lower Robinson Creek
5	85-209	C. Burton Pugh	Lower Robinson Creek
6	85-210	C. Burton Pugh	Lower Robinson Creek
7	85-458	BLM	Lower Robinson Creek
8	85-211	C. Diane & Greg Braund & C. Burton Pugh	Lower Robinson Creek
9	85-459	BLM	Lower Robinson Creek
10	85-393	Sharon C. & Lorene C. Lamb	Lower Robinson Creek
11	85-213	C. Burton Pugh	Right Hand Wash
12	85-387	Darlynn & Arlene Sorensen	Right Hand Wash
13	85-388	Darlynn & Arlene Sorensen	Sink Valley Wash

STATE OF UTAH -- DIVISION OF WATER RIGHTS -- DATA PRINT OUT for 85-162

SR 1

(WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/24/2006

WATER RIGHT: 85-162 APPLICATION/CLAIM NO.: CERT. NO.:

OWNERSHIP

NAME: Garn L. Swapp
ADDR: P.O. Box 354
Kanab UT 84741

DATES, ETC.

LAND OWNED BY APPLICANT?
FILED: 08/01/1969|PRIORITY: 00/00/1864|PUB BEGAN: |PUB ENDED: |NEWSPAPER:
ProtestEnd: |PROTESTED: [No]|HEARNG HLD: |SE ACTION: [ ]|ActionDate: |PROOF DUE:
EXTENSION: |ELEC/PROOF:[ ]|ELEC/PROOF: |CERT/WUC: 08/01/1969|LAP, ETC: |PROV LETTER:
RENOVATE: |RECON REQ: |TYPE: [ ]

PD Book No. 1 Map: 4a

Type of Right: Diligence Claim Source of Info: Proposed Determination Status:

LOCATION OF WATER RIGHT

FLOW: SOURCE: Kanab Creek

COUNTY: Kane COMMON DESCRIPTION:

POINT OF DIVERSION -- POINT TO POINT:
(1)Stockwatering directly on stream from a point in SW4NE4 Sec 24, T39S, R6W, SLBM,
to a point in NW4SE4 Sec 24, T39S, R6W, SLBM.
COMMENT: Administratively updated by State Engineer.

USES OF WATER RIGHT

SUPPLEMENTAL GROUP NO. 612239. Water Rights Appurtenant to the following use(s):
85-159,160,161,162,163

###STOCKWATER: Group Total: 400 Stock Units Diversion Limit: PERIOD OF USE: 04/01 TO 12/31
Sole Supply for Stockwatering for 85-162 in this Group has NOT YET been evaluated

PLACE OF USE for STOCKWATERING

	NORTH-WEST¼	NORTH-EAST¼	SOUTH-WEST¼	SOUTH-EAST¼
	NW NE SW SE	NW NE SW SE	NW NE SW SE	NW NE SW SE
Sec 24 T 39S R 6W SLBM	* : : : *	* : : X: *	* : : : *	* X: : : *

E N D O F D A T A

STATE OF UTAH -- DIVISION OF WATER RIGHTS -- DATA PRINT OUT for 85-303

SR 2

(WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/24/2006

WATER RIGHT: 85-303 APPLICATION/CLAIM NO.: CERT. NO.:

OWNERSHIP

NAME: Sharon E. and Lorene C. Lamb
ADDR: Orderville UT 84758

DATES, ETC.

LAND OWNED BY APPLICANT?
FILED: 09/03/1969 | PRIORITY: 00/00/1864 | PUB BEGAN: | PUB ENDED: | NEWSPAPER:
ProtestEnd: | PROTESTED: [No] | HEARNG HLD: | SE ACTION: [ ] | ActionDate: | PROOF DUE:
EXTENSION: | ELEC/PROOF: [ ] | ELEC/PROOF: | CERT/WUC: 09/03/1969 | LAP, ETC: | PROV LETTER:
RENOVATE: | RECON REQ: | TYPE: [ ]

PD Book No. 1 Map: 4a

Type of Right: Diligence Claim Source of Info: Proposed Determination Status:

LOCATION OF WATER RIGHT

FLOW: SOURCE: Kanab Creek

COUNTY: Kane COMMON DESCRIPTION:

POINT OF DIVERSION -- POINT TO POINT:
(1)Stockwatering directly on stream from a point in SW4SE4 Sec 24, T39S, R6W, SLBM,
to a point in SW4SE4 Sec 24, T39S, R6W, SLBM.
COMMENT: Administratively updated by State Engineer.

USES OF WATER RIGHT

SUPPLEMENTAL GROUP NO. 612336. Water Rights Appurtenant to the following use(s):
85-303,304,393

###STOCKWATER: Group Total: 60 Stock Units Diversion Limit: PERIOD OF USE: 04/01 TO 12/31
Sole Supply for Stockwatering for 85-303 in this Group has NOT YET been evaluated

PLACE OF USE for STOCKWATERING

	NORTH-WEST¼	NORTH-EAST¼	SOUTH-WEST¼	SOUTH-EAST¼
	NW NE SW SE	NW NE SW SE	NW NE SW SE	NW NE SW SE
Sec 24 T 39S R 6W SLBM	* : : : *	* : : : *	* : : : *	* : : X: *

E N D O F D A T A

STATE OF UTAH -- DIVISION OF WATER RIGHTS -- DATA PRINT OUT for 85-608

SR 3

(WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/24/2006

WATER RIGHT: 85-608 APPLICATION/CLAIM NO.: CERT. NO.:

OWNERSHIP

NAME: Lloyd W. & Ross E. & Gail P. & Vard H. Heaton
ADDR: Alton UT 84710

NAME: Ross E. Heaton
ADDR: Alton UT

NAME: Gail P. Heaton
ADDR: Alton UT

NAME: Vard H. Heaton
ADDR: Alton UT

DATES, ETC.

LAND OWNED BY APPLICANT?
FILED: 04/14/1970 | PRIORITY: 00/00/1864 | PUB BEGAN: | PUB ENDED: | NEWSPAPER:
ProtestEnd: | PROTESTED: [No] | HEARNG HLD: | SE ACTION: [ ] | ActionDate: | PROOF DUE:
EXTENSION: | ELEC/PROOF: [ ] | ELEC/PROOF: | CERT/WUC: 04/14/1970 | LAP, ETC: | PROV LETTER:
RENOVATE: | RECON REQ: | TYPE: [ ]

PD Book No. 1 Map: 5b

Type of Right: Diligence Claim Source of Info: Proposed Determination Status:

LOCATION OF WATER RIGHT

FLOW: SOURCE: Lower Robinson Creek

COUNTY: Kane COMMON DESCRIPTION:

POINT OF DIVERSION -- POINT TO POINT:
(1)Stockwatering directly on stream from a point in NE4NE4 Sec 20, T39S, R5W, SLBM,
to a point in NE4NE4 Sec 20, T39S, R5W, SLBM.
COMMENT: Administratively updated by State Engineer.

USES OF WATER RIGHT

SUPPLEMENTAL GROUP NO. 612401. Water Rights Appurtenant to the following use(s):
85-412,413,414,415,543,544,545,546,547,548,549,550,551,552,553,554,555,556,557,558,559,608,631,632,713,733

###STOCKWATER: Group Total: 1600 Stock Unit Diversion Limit: PERIOD OF USE: 04/01 TO 12/31
Sole Supply for Stockwatering for 85-608 in this Group has NOT YET been evaluated

SUPPLEMENTAL GROUP NO. 612515. Water Rights Appurtenant to the following use(s):
85-412,413,414,415,543,544,545,546,547,548,549,550,551,552,553,554,555,556,557,558,559,608,631,632,713,731,733

###STOCKWATER: Group Total: 1600 Stock Unit Diversion Limit: PERIOD OF USE: 04/01 TO 12/31
Sole Supply for Stockwatering for 85-608 in this Group has NOT YET been evaluated

PLACE OF USE for STOCKWATERING

	NORTH-WEST¼ NW NE SW SE	NORTH-EAST¼ NW NE SW SE	SOUTH-WEST¼ NW NE SW SE	SOUTH-EAST¼ NW NE SW SE
Sec 20 T 39S R 5W SLBM	* : : : *	* : X: : *	* : : : *	* : : : *

**********E N D O F D A T A**********

STATE OF UTAH – DIVISION OF WATER RIGHTS – DATA PRINT OUT for 85-463

SR 4

(WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/24/2006 Page 1

WATER RIGHT: 85-463 APPLICATION/CLAIM NO.: CERT. NO.:

OWNERSHIP

NAME: Kanab District USA Bureau of Land Management
ADDR: 320 North 1st East
Kanab UT 84741

DATES, ETC.

LAND OWNED BY APPLICANT?

FILED:	|PRIORITY: 00/00/1864	|PUB BEGAN:	|PUB ENDED:	|NEWSPAPER:
ProtestEnd:	|PROTESTED: [No]	|HEARNG HLD:	|SE ACTION: [ ]	|ActionDate: |PROOF DUE:
EXTENSION:	|ELEC/PROOF: [ ]	|ELEC/PROOF:	|CERT/WUC:	|LAP, ETC: |PROV LETTER:
RENOVATE:	|RECON REQ:	|TYPE: [ ]		

PD Book No. 1 Map: 5b

Type of Right: Diligence Claim Source of Info: Proposed Determination Status:

LOCATION OF WATER RIGHT

FLOW: SOURCE: Lower Robinson Creek

COUNTY: Kane COMMON DESCRIPTION:

POINT OF DIVERSION -- POINT TO POINT:
(1)Stockwatering directly on stream from a point in SW4NE4 Sec 20, T39S, R5W, SLBM,
to a point in SE4NW4 Sec 20, T39S, R5W, SLBM.
COMMENT: Administratively updated by State Engineer.

USES OF WATER RIGHT

SUPPLEMENTAL GROUP NO. 612417. Water Rights Appurtenant to the following use(s):
85-458,462,463,464

###STOCKWATER: Group Total: 13 Stock Units Diversion Limit: PERIOD OF USE: 04/01 TO 12/31
Sole Supply for Stockwatering for 85-463 in this Group has NOT YET been evaluated
Cecil Pugh Allotment No. 39

PLACE OF USE for STOCKWATERING

	NORTH-WEST¼	NORTH-EAST¼	SOUTH-WEST¼	SOUTH-EAST¼
	NW NE SW SE	NW NE SW SE	NW NE SW SE	NW NE SW SE
Sec 20 T 39S R 5W SLBM	* : : : X*	* : : X: *	* : : : : *	* : : : : *

E N D O F D A T A

STATE OF UTAH -- DIVISION OF WATER RIGHTS -- DATA PRINT OUT for 85-209

SR 5

(WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/24/2006 Page 1

WATER RIGHT: 85-209 APPLICATION/CLAIM NO.: CERT. NO.:

OWNERSHIP

NAME: C. Burton Pugh
ADDR: 533 North 650 East
Lindon, Utah 84042

DATES, ETC.

LAND OWNED BY APPLICANT?
FILED: 08/08/1969|PRIORITY: 00/00/1864|PUB BEGAN: |PUB ENDED: |NEWSPAPER:
ProtestEnd: |PROTESTED: [No]|HEARNG HLD: |SE ACTION: [ ]|ActionDate: |PROOF DUE:
EXTENSION: |ELEC/PROOF:[ ]|ELEC/PROOF: |CERT/WUC: 08/08/1969|LAP, ETC: |PROV LETTER:
RENOVATE: |RECON REQ: |TYPE: [ ]

PD Book No. 1 Map: 5b

Type of Right: Diligence Claim Source of Info: Proposed Determination Status:

LOCATION OF WATER RIGHT

FLOW: SOURCE: Lower Robinson Creek

COUNTY: Kane COMMON DESCRIPTION:

POINT OF DIVERSION -- POINT TO POINT:
(1)Stockwatering directly on stream from a point in SE4NE4 Sec 20, T39S, R5W, SLBM,
to a point in SE4NE4 Sec 20, T39S, R5W, SLBM.
COMMENT: Administratively updated by State Engineer.

USES OF WATER RIGHT

SUPPLEMENTAL GROUP NO. 612093. Water Rights Appurtenant to the following use(s):
85-100,199,200,201,202,203,204,205,206,207,208,209,210,211,213,214,215

###STOCKWATER: Group Total: 250 Stock Units Diversion Limit: PERIOD OF USE: 04/01 TO 12/31
Sole Supply for Stockwatering for 85-209 in this Group has NOT YET been evaluated

SUPPLEMENTAL GROUP NO. 612251. Water Rights Appurtenant to the following use(s):
85-94,95,96,97,98,183,184,185,186,187,188,208,209,210,211,212,213,221,222,227,228,229,256,282,284,614

###STOCKWATER: Group Total: 250 Stock Units Diversion Limit: PERIOD OF USE: 04/01 TO 12/31
Sole Supply for Stockwatering for 85-209 in this Group has NOT YET been evaluated

PLACE OF USE for STOCKWATERING

	NORTH-WEST¼ NW NE SW SE	NORTH-EAST¼ NW NE SW SE	SOUTH-WEST¼ NW NE SW SE	SOUTH-EAST¼ NW NE SW SE
Sec 20 T 39S R 5W SLBM	* : : : *	* : : : X*	* : : : *	* : : : *

**********E N D O F D A T A**********

STATE OF UTAH – DIVISION OF WATER RIGHTS – DATA PRINT OUT for 85-210

SR 6

(WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/24/2006 Page 1

WATER RIGHT: 85-210 APPLICATION/CLAIM NO.: CERT. NO.:

OWNERSHIP

NAME: C. Burton Pugh
ADDR: 533 North 650 East
Lindon, Utah 84042

DATES, ETC.

LAND OWNED BY APPLICANT?
FILED: 08/08/1969|PRIORITY: 00/00/1864|PUB BEGAN: |PUB ENDED: |NEWSPAPER:
ProtestEnd: |PROTESTED: [No]|HEARNG HLD: |SE ACTION: [ ]|ActionDate: |PROOF DUE:
EXTENSION: |ELEC/PROOF:[ ]|ELEC/PROOF: |CERT/WUC: 08/08/1969|LAP, ETC: |PROV LETTER:
RENOVATE: |RECON REQ: |TYPE: [ ]

PD Book No. 1 Map: 5b

Type of Right: Diligence Claim Source of Info: Proposed Determination Status:

LOCATION OF WATER RIGHT

FLOW: SOURCE: Lower Robinson Creek

COUNTY: Kane COMMON DESCRIPTION:

POINT OF DIVERSION -- POINT TO POINT:
(1)Stockwatering directly on stream from a point in NE4SW4 Sec 20, T39S, R5W, SLBM,
to a point in SW4SE4 Sec 19, T39S, R5W, SLBM.
COMMENT: Administratively updated by State Engineer.

USES OF WATER RIGHT

SUPPLEMENTAL GROUP NO. 612093. Water Rights Appurtenant to the following use(s):
85-100,199,200,201,202,203,204,205,206,207,208,209,210,211,213,214,215

###STOCKWATER: Group Total: 250 Stock Units Diversion Limit: PERIOD OF USE: 04/01 TO 12/31
Sole Supply for Stockwatering for 85-210 in this Group has NOT YET been evaluated

SUPPLEMENTAL GROUP NO. 612251. Water Rights Appurtenant to the following use(s):
85-94,95,96,97,98,183,184,185,186,187,188,208,209,210,211,212,213,221,222,227,228,229,256,282,284,614

###STOCKWATER: Group Total: 250 Stock Units Diversion Limit: PERIOD OF USE: 04/01 TO 12/31
Sole Supply for Stockwatering for 85-210 in this Group has NOT YET been evaluated

PLACE OF USE for STOCKWATERING

	NORTH-WEST¼	NORTH-EAST¼	SOUTH-WEST¼	SOUTH-EAST¼
	NW NE SW SE	NW NE SW SE	NW NE SW SE	NW NE SW SE
Sec 19 T 39S R 5W SLBM	* : : : *	* : : : *	* : : : *	* : : X: *
Sec 20 T 39S R 5W SLBM	* : : : *	* : : : *	* : X: : *	* : : : *

E N D O F D A T A

STATE OF UTAH -- DIVISION OF WATER RIGHTS -- DATA PRINT OUT for 85-458

SR 7

(WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/24/2006 Page 1

WATER RIGHT: 85-458 APPLICATION/CLAIM NO.: CERT. NO.:

OWNERSHIP**********

NAME: Kanab District USA Bureau of Land Management
ADDR: 320 North 1st East
Kanab UT 84741

DATES, ETC.**********

LAND OWNED BY APPLICANT?

FILED:	|PRIORITY: 00/00/1864	|PUB BEGAN:	|PUB ENDED:	|NEWSPAPER:
ProtestEnd:	|PROTESTED: [No]	|HEARNG HLD:	|SE ACTION: [ ]	|ActionDate: |PROOF DUE:
EXTENSION:	|ELEC/PROOF: [ ]	|ELEC/PROOF:	|CERT/WUC:	|LAP, ETC: |PROV LETTER:
RENOVATE:	|RECON REQ:	|TYPE: [ ]		

PD Book No. 1 Map: 4a

Type of Right: Diligence Claim Source of Info: Proposed Determination Status:

LOCATION OF WATER RIGHT**********

FLOW: SOURCE: Lower Robinson Creek

COUNTY: Kane COMMON DESCRIPTION:

POINT OF DIVERSION -- POINT TO POINT:
(1)Stockwatering directly on stream from a point in SE4SW4 Sec 19, T39S, R5W, SLBM,
to a point in SW4SW4 Sec 19, T39S, R5W, SLBM.
COMMENT: Administratively updated by State Engineer.

USES OF WATER RIGHT**********

SUPPLEMENTAL GROUP NO. 612417. Water Rights Appurtenant to the following use(s):
85-458,462,463,464

.....

###STOCKWATER: Group Total: 13 Stock Units Diversion Limit: PERIOD OF USE: 04/01 TO 12/31
Sole Supply for Stockwatering for 85-458 in this Group has NOT YET been evaluated
Cecil Pugh Allotment No. 39

PLACE OF USE for STOCKWATERING**********

	NORTH-WEST¼ NW NE SW SE	NORTH-EAST¼ NW NE SW SE	SOUTH-WEST¼ NW NE SW SE	SOUTH-EAST¼ NW NE SW SE
Sec 19 T 39S R 5W SLBM	* : : : *	* : : : *	* : : : X: X*	* : : : : *

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**********E N D O F D A T A**********

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STATE OF UTAH -- DIVISION OF WATER RIGHTS -- DATA PRINT OUT for 85-211

SR 8

(WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/24/2006

WATER RIGHT: 85-211 APPLICATION/CLAIM NO.: CERT. NO.:

OWNERSHIP

NAME: C. Diane and Greg Braund
ADDR: 5720 Hedgehaven Court
Las Vegas, NV 89120
REMARKS: 1.008 acft, 36 elu's supp/w other rights (joint tenants)

NAME: C. Burton Pugh
ADDR: 533 North 650 East
Lindon, Utah 84042
REMARKS: 214 elu's supp/w other rights

DATES, ETC.

LAND OWNED BY APPLICANT?
FILED: 08/08/1969|PRIORITY: 00/00/1864|PUB BEGAN: |PUB ENDED: |NEWSPAPER:
ProtestEnd: |PROTESTED: {No]|HEARNG HLD: |SE ACTION: [ ]|ActionDate: |PROOF DUE:
EXTENSION: |ELEC/PROOF:[ ]|ELEC/PROOF: |CERT/WUC: 08/08/1969|LAP, ETC: |PROV LETTER:
RENOVATE: |RECON REQ: |TYPE: [ ]

PD Book No. 1 Map: 4d

Type of Right: Diligence Claim Source of Info: Proposed Determination Status:

LOCATION OF WATER RIGHT

FLOW: SOURCE: Lower Robinson Creek

COUNTY: Kane COMMON DESCRIPTION:

POINT OF DIVERSION -- POINT TO POINT:
(1)Stockwatering directly on stream from a point in NW4NW4 Sec 30, T39S, R5W, SLBM,
to a point in NW4NW4 Sec 30, T39S, R5W, SLBM.
COMMENT: Administratively updated by State Engineer.

USES OF WATER RIGHT

SUPPLEMENTAL GROUP NO. 612093. Water Rights Appurtenant to the following use(s):
85-100,199,200,201,202,203,204,205,206,207,208,209,210,211,213,214,215

###STOCKWATER: Group Total: 250 Stock Units Diversion Limit: PERIOD OF USE: 04/01 TO 12/31
Sole Supply for Stockwatering for 85-211 in this Group has NOT YET been evaluated

SUPPLEMENTAL GROUP NO. 612251. Water Rights Appurtenant to the following use(s):
85-94,95,96,97,98,183,184,185,186,187,188,208,209,210,211,212,213,221,222,227,228,229,256,282,284,614

###STOCKWATER: Group Total: 250 Stock Units Diversion Limit: PERIOD OF USE: 04/01 TO 12/31
Sole Supply for Stockwatering for 85-211 in this Group has NOT YET been evaluated

PLACE OF USE for STOCKWATERING

	NORTH-WEST¼	NORTH-EAST¼	SOUTH-WEST¼	SOUTH-EAST¼
	NW NE SW SE	NW NE SW SE	NW NE SW SE	NW NE SW SE
Sec 30 T 39S R 5W SLBM	* X: : : *	* : : : *	* : : : *	* : : : *

E N D O F D A T A

STATE OF UTAH -- DIVISION OF WATER RIGHTS -- DATA PRINT OUT for 85-459

SR 9

(WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/24/2006 Page 1

WATER RIGHT: 85-459 APPLICATION/CLAIM NO.: CERT. NO.:

OWNERSHIP

NAME: Kanab District USA Bureau of Land Management
ADDR: 320 North 1st East
Kanab UT 84741

DATES, ETC.

LAND OWNED BY APPLICANT?

FILED:	PRIORITY: 00/00/1864	PUB BEGAN:	PUB ENDED:	NEWSPAPER:
ProtestEnd:	PROTESTED: [No]	HEARNG HLD:	SE ACTION: [ ]	ActionDate: / PROOF DUE:
EXTENSION:	ELEC/PROOF: [ ]	ELEC/PROOF:	CERT/WUC:	LAP, ETC: / PROV LETTER:
RENOVATE:	RECON REQ:	TYPE: [ ]		

PD Book No. 1 Map: 4d

Type of Right: Diligence Claim Source of Info: Proposed Determination Status:

LOCATION OF WATER RIGHT

FLOW: SOURCE: Lower Robinson Creek

COUNTY: Kane COMMON DESCRIPTION:

POINT OF DIVERSION -- POINT TO POINT:
(1)Stockwatering directly on stream from a point in NE4NE4 Sec 25, T39S, R6W, SLBM,
to a point in NE4NE4 Sec 25, T39S, R6W, SLBM.
COMMENT: Administratively updated by State Engineer.

USES OF WATER RIGHT

SUPPLEMENTAL GROUP NO. 612418.

###STOCKWATER: 18 Stock Units Diversion Limit: PERIOD OF USE: 05/01 TO 10/31
Sharon Lamb Allotment No. 38.

PLACE OF USE for STOCKWATERING

	NORTH-WEST¼	NORTH-EAST¼	SOUTH-WEST¼	SOUTH-EAST¼
	NW NE SW SE	NW NE SW SE	NW NE SW SE	NW NE SW SE
Sec 25 T 39S R 6W SLBM	* : : : *	* : X: : *	* : : : *	* : : : *

E N D O F D A T A

STATE OF UTAH -- DIVISION OF WATER RIGHTS -- DATA PRINT OUT for 85-393 SR 10

(WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/24/2006 Page 1

WATER RIGHT: 85-393 APPLICATION/CLAIM NO.: CERT. NO.:

OWNERSHIP

NAME: Sharon C. & Lorene C. Lamb
ADDR: Orderville UT 84741

DATES, ETC.

LAND OWNED BY APPLICANT?
FILED: 02/17/1970 | PRIORITY: 00/00/1864 | PUB BEGAN: | PUB ENDED: | NEWSPAPER:
ProtestEnd: | PROTESTED: [No] | HEARNG HLD: | SE ACTION: [ ] | ActionDate: | PROOF DUE:
EXTENSION: | ELEC/PROOF: [ ] | ELEC/PROOF: | CERT/WUC: 02/17/1970 | LAP, ETC: | PROV LETTER:
RENOVATE: | RECON REQ: | TYPE: [ ]

PD Book No. 1 Map: 4d

Type of Right: Diligence Claim Source of Info: Proposed Determination Status:

LOCATION OF WATER RIGHT

FLOW: SOURCE: Lower Robinson Creek

COUNTY: Kane COMMON DESCRIPTION:

POINT OF DIVERSION -- POINT TO POINT:
(1)Stockwatering directly on stream from a point in NW4NE4 Sec 25, T39S, R6W, SLBM,
to a point in NE4NW4 Sec 25, T39S, R6W, SLBM.
COMMENT: Administratively updated by State Engineer.

USES OF WATER RIGHT

SUPPLEMENTAL GROUP NO. 612336. Water Rights Appurtenant to the following use(s):
85-303,304,393

###STOCKWATER: Group Total: 60 Stock Units Diversion Limit: PERIOD OF USE: 04/01 TO 12/31
Sole Supply for Stockwatering for 85-393 in this Group has NOT YET been evaluated

PLACE OF USE for STOCKWATERING

	NORTH-WEST¼ NW NE SW SE	NORTH-EAST¼ NW NE SW SE	SOUTH-WEST¼ NW NE SW SE	SOUTH-EAST¼ NW NE SW SE
Sec 25 T 39S R 6W SLBM	* : X: : *	* X: : : *	* : : : *	* : : : *

E N D O F D A T A

STATE OF UTAH -- DIVISION OF WATER RIGHTS -- DATA PRINT OUT for 85-213 SR 11

(WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/24/2006 Page 1

WATER RIGHT: 85-213 APPLICATION/CLAIM NO.: CERT. NO.:

OWNERSHIP

NAME: C. Burton Pugh
ADDR: 533 North 650 East
Lindon, Utah 84042

DATES, ETC.

LAND OWNED BY APPLICANT?
FILED: 08/08/1969|PRIORITY: 00/00/1864|PUB BEGAN: |PUB ENDED: |NEWSPAPER:
ProtestEnd: |PROTESTED: [No]|HEARNG HLD: |SE ACTION: [ ]|ActionDate: |PROOF DUE:
EXTENSION: |ELEC/PROOF:[ ]|ELEC/PROOF: |CERT/WUC: 08/08/1969|LAP, ETC: |PROV LETTER:
RENOVATE: |RECON REQ: |TYPE: [ ]

PD Book No. 1 Map: 5b

Type of Right: Diligence Claim Source of Info: Proposed Determination Status:

LOCATION OF WATER RIGHT

FLOW: SOURCE: Right Hand Wash

COUNTY: Kane COMMON DESCRIPTION:

POINT OF DIVERSION -- POINT TO POINT:
(1)Stockwatering directly on stream from a point in SW4NW4 Sec 21, T39S, R5W, SLBM,
to a point in NW4SE4 Sec 21, T39S, R5W, SLBM.
COMMENT: Administratively updated by State Engineer.

USES OF WATER RIGHT

SUPPLEMENTAL GROUP NO. 612093. Water Rights Appurtenant to the following use(s):
85-100,199,200,201,202,203,204,205,206,207,208,209,210,211,213,214,215

###STOCKWATER: Group Total: 250 Stock Units Diversion Limit: PERIOD OF USE: 04/01 TO 12/31
Sole Supply for Stockwatering for 85-213 in this Group has NOT YET been evaluated

SUPPLEMENTAL GROUP NO. 612251. Water Rights Appurtenant to the following use(s):
85-94,95,96,97,98,183,184,185,186,187,188,208,209,210,211,212,213,221,222,227,228,229,256,282,284,614

###STOCKWATER: Group Total: 250 Stock Units Diversion Limit: PERIOD OF USE: 04/01 TO 12/31
Sole Supply for Stockwatering for 85-213 in this Group has NOT YET been evaluated

PLACE OF USE for STOCKWATERING

	NORTH-WEST¼	NORTH-EAST¼	SOUTH-WEST¼	SOUTH-EAST¼
	NW NE SW SE	NW NE SW SE	NW NE SW SE	NW NE SW SE
Sec 21 T 39S R 5W SLBM	* : : X: *	* : : : *	* : : : *	* X: : : *

**********E N D O F D A T A**********

STATE OF UTAH -- DIVISION OF WATER RIGHTS -- DATA PRINT OUT for 85-387

SR 12

(WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/24/2006

WATER RIGHT: 85-387 APPLICATION/CLAIM NO.: CERT. NO.:

OWNERSHIP

NAME: Darlynn and Arlene Sorensen
ADDR: P. O. Box 47
Orderville, UT 84758
INTEREST: 100% REMARKS: joint tenants

DATES, ETC.

LAND OWNED BY APPLICANT?
FILED: 01/29/1970 | PRIORITY: 00/00/1864 | PUB BEGAN: | PUB ENDED: | NEWSPAPER:
ProtestEnd: | PROTESTED: [No] | HEARNG HLD: | SE ACTION: [ ] | ActionDate: | PROOF DUE:
EXTENSION: | ELEC/PROOF: [ ] | ELEC/PROOF: | CERT/WUC: 01/29/1970 | LAP, ETC: | PROV LETTER:
RENOVATE: | RECON REQ: | TYPE: [ ]

PD Book No. 1 Map: 5b

Type of Right: Diligence Claim Source of Info: Proposed Determination Status:

LOCATION OF WATER RIGHT

FLOW: SOURCE: Right Hand Wash

COUNTY: Kane COMMON DESCRIPTION:

POINT OF DIVERSION -- POINT TO POINT:
(1)Stockwatering directly on stream from a point in SW4SE4 Sec 20, T39S, R5W, SLBM,
to a point in NW4SW4 Sec 29, T39S, R5W, SLBM.
COMMENT: Administratively updated by State Engineer.

USES OF WATER RIGHT

SUPPLEMENTAL GROUP NO. 612374. Water Rights Appurtenant to the following use(s):
85-362,363,364,365,366,367,368,369,370,371,372,373,374,375,377,378,379,380,381,382,383,384,385,386,387,388,389

###STOCKWATER: Group Total: 300 Stock Units Diversion Limit: PERIOD OF USE: 04/01 TO 12/31
Sole Supply for Stockwatering for 85-387 in this Group has NOT YET been evaluated

PLACE OF USE for STOCKWATERING

	NORTH-WEST¼	NORTH-EAST¼	SOUTH-WEST¼	SOUTH-EAST¼
	NW NE SW SE	NW NE SW SE	NW NE SW SE	NW NE SW SE
Sec 20 T 39S R 5W SLBM	* : : : *	* : : : *	* : : : *	* : : X: *
Sec 29 T 39S R 5W SLBM	* : : : *	* : : : *	* X: : : *	* : : : *

E N D O F D A T A

STATE OF UTAH -- DIVISION OF WATER RIGHTS -- DATA PRINT OUT for 85-388

SR 13

(WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/24/2006 Page 1

WATER RIGHT: 85-388 APPLICATION/CLAIM NO.: CERT. NO.:

OWNERSHIP

NAME: Darlynn and Arlene Sorensen
ADDR: P. O. Box 47
Orderville, UT 84758
INTEREST: 100% REMARKS: joint tenants

DATES, ETC.

LAND OWNED BY APPLICANT?
FILED: 01/29/1970|PRIORITY: 00/00/1864|PUB BEGAN: |PUB ENDED: |NEWSPAPER:
ProtestEnd: |PROTESTED: [No]|HEARNG HLD: |SE ACTION: [ ]|ActionDate: |PROOF DUE:
EXTENSION: |ELEC/PROOF:[ ]|ELEC/PROOF: |CERT/WUC: 01/29/1970|LAP, ETC: |PROV LETTER:
RENOVATE: |RECON REQ: |TYPE: [ ]

PD Book No. 1 Map: 5c

Type of Right: Diligence Claim Source of Info: Proposed Determination Status:

LOCATION OF WATER RIGHT

FLOW: SOURCE: Sink Valley Wash

COUNTY: Kane COMMON DESCRIPTION:

POINT OF DIVERSION -- POINT TO POINT:
(1)Stockwatering directly on stream from a point in NW4SW4 Sec 29, T39S, R5W, SLBM,
to a point at N500 ft. E580 ft. from W4 corner, Sec 32, T39S, R5W, SLBM.
COMMENT: Administratively updated by State Engineer.

USES OF WATER RIGHT

SUPPLEMENTAL GROUP NO. 612374. Water Rights Appurtenant to the following use(s):
85-362,363,364,365,366,367,368,369,370,371,372,373,374,375,377,378,379,380,381,382,383,384,385,386,387,388,389

###STOCKWATER: Group Total: 300 Stock Units Diversion Limit: PERIOD OF USE: 04/01 TO 12/31
Sole Supply for Stockwatering for 85-388 in this Group has NOT YET been evaluated

PLACE OF USE for STOCKWATERING

	NORTH-WEST¼ NW NE SW SE	NORTH-EAST¼ NW NE SW SE	SOUTH-WEST¼ NW NE SW SE	SOUTH-EAST¼ NW NE SW SE
Sec 29 T 39S R 5W SLBM	* : : : *	* : : : *	* X: : : *	* : : : *
Sec 32 T 39S R 5W SLBM	* : : X: *	* : : : *	* : : : *	* : : : *

END OF DATA

APPENDIX 7-3

EXHIBIT 7-2

Surface Diversions

SURFACE DIVERSIONS

REF #	WR #	OWNER	SOURCE
1	85-366	Darlynn & Arlene Sorensen	Right Hand Wash
2	85-367	Darlynn & Arlene Sorensen	Right Hand Wash
3	85-368	Darlynn & Arlene Sorensen	Right Hand Wash
4	85-365	Darlynn & Arlene Sorensen	Swapp Canyon Creek
5	85-369	Darlynn & Arlene Sorensen	Sink Valley Wash
6	85-370	Darlynn & Arlene Sorensen	Sink Valley Wash
7	85-371	Darlynn & Arlene Sorensen	Sink Valley Wash
8	85-372	Darlynn & Arlene Sorensen	Sink Valley Wash
9	85-356	James, Julie & Lloyd Johnson	Sink Valley Wash

STATE OF UTAH -- DIVISION OF WATER RIGHTS -- DATA PRINT OUT for 85-366

SD 1

(WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/24/2006 Page 1

WATER RIGHT: 85-366 APPLICATION/CLAIM NO.: CERT. NO.:

OWNERSHIP

NAME: Darlynn and Arlene Sorensen
ADDR: P. O. Box 47
Orderville, UT 84758
INTEREST: 100% REMARKS: joint tenants

DATES, ETC.

LAND OWNED BY APPLICANT?
FILED: 01/29/1970|PRIORITY: 00/00/1889|PUB BEGAN: |PUB ENDED: |NEWSPAPER:
ProtestEnd: |PROTESTED: [No]|HEARNG HLD: |SE ACTION: [ ]|ActionDate: |PROOF DUE:
EXTENSION: |ELEC/PROOF:[ ]|ELEC/PROOF: |CERT/WUC: 01/29/1970|LAP, ETC: |PROV LETTER:
RENOVATE: |RECON REQ: |TYPE: [ ]

PD Book No. 1 Map: 5c

Type of Right: Diligence Claim Source of Info: Proposed Determination Status:

LOCATION OF WATER RIGHT

FLOW: 10.0 cfs SOURCE: Right Hand Wash

COUNTY: Kane COMMON DESCRIPTION:

POINT OF DIVERSION -- SURFACE:
(1) S 1040 ft E 100 ft from N4 cor, Sec 29, T 39S, R 5W, SLBM
Diverting Works: Source:

Stream Alt Required?: No

USES OF WATER RIGHT

SUPPLEMENTAL GROUP NO. 612373. Water Rights Appurtenant to the following use(s):
85-362,366

###IRRIGATION: Group Total: 101.1 acres Diversion Limit: 0.0 acft. PERIOD OF USE: 04/01 TO 10/31
Sole Supply for Irrigation for 85-366 in this Group has NOT YET been evaluated

###PLACE OF USE:	NORTH WEST QUARTER				NORTH EAST QUARTER				SOUTH WEST QUARTER				SOUTH EAST QUARTER				Section
	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	Totals
Sec 29 T 39S R 5W SLBM		8.8000	10.0000	27.4000					14.3000	0.6000	29.8000						90.9000
Sec 32 T 39S R 5W SLBM	10.2000																10.2000

SUPPLEMENTAL GROUP NO. 612374. Water Rights Appurtenant to the following use(s):
85-362,363,364,365,366,367,368,369,370,371,372,373,374,375,377,378,379,380,381,382,383,384,385,386,387,388,389

###STOCKWATER: Group Total: 300 Stock Units Diversion Limit: PERIOD OF USE: 04/01 TO 12/31
Sole Supply for Stockwatering for 85-366 in this Group has NOT YET been evaluated

E N D O F D A T A

STATE OF UTAH -- DIVISION OF WATER RIGHTS -- DATA PRINT OUT for 85-367

SD 2

(WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/24/2006

WATER RIGHT: 85-367 APPLICATION/CLAIM NO.: CERT. NO.:

OWNERSHIP**********

NAME: Darlynn and Arlene Sorensen
ADDR: P. O. Box 47
Orderville, UT 84758
INTEREST: 100% REMARKS: joint tenants

DATES, ETC.**********

LAND OWNED BY APPLICANT?
FILED: 01/29/1970|PRIORITY: 00/00/1889|PUB BEGAN: |PUB ENDED: |NEWSPAPER:
ProtestEnd: |PROTESTED: [No]|HEARNG HLD: |SE ACTION: [ ]|ActionDate: |PROOF DUE:
EXTENSION: |ELEC/PROOF:[ ]|ELEC/PROOF: |CERT/WUC: 01/29/1970|LAP, ETC: |PROV LETTER:
RENOVATE: |RECON REQ: |TYPE: [ ]

PD Book No. 1 Map: 5c

Type of Right: Diligence Claim Source of Info: Proposed Determination Status:

LOCATION OF WATER RIGHT**********

FLOW: 10.0 cfs SOURCE: Right Hand Wash

COUNTY: Kane COMMON DESCRIPTION:

POINT OF DIVERSION -- SURFACE:
(1) S 200 ft E 1550 ft from W4 cor, Sec 29, T 39S, R 5W, SLBM
Diverting Works: Source:

Stream Alt Required?: No

USES OF WATER RIGHT**********

SUPPLEMENTAL GROUP NO. 612374. Water Rights Appurtenant to the following use(s):
85-362,363,364,365,366,367,368,369,370,371,372,373,374,375,377,378,379,380,381,382,383,384,385,386,387,388,389

###STOCKWATER: Group Total: 300 Stock Units Diversion Limit: PERIOD OF USE: 04/01 TO 12/31
Sole Supply for Stockwatering for 85-367 in this Group has NOT YET been evaluated

SUPPLEMENTAL GROUP NO. 612376. Water Rights Appurtenant to the following use(s):
85-363,367

###IRRIGATION: Group Total: 2.4 acres Diversion Limit: 0.0 acft. PERIOD OF USE: 04/01 TO 10/31
Sole Supply for Irrigation for 85-367 in this Group has NOT YET been evaluated

###PLACE OF USE:	NORTH WEST QUARTER				NORTH EAST QUARTER				SOUTH WEST QUARTER				SOUTH EAST QUARTER				Section
	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	Totals
Sec 29 T 39S R 5W SLBM										2.4000							2.4000

SUPPLEMENTAL GROUP NO. 612377. Water Rights Appurtenant to the following use(s):
85-363,367,368

###IRRIGATION: Group Total: 1.1 acres Diversion Limit: 0.0 acft. PERIOD OF USE: 04/01 TO 10/31
Sole Supply for Irrigation for 85-367 in this Group has NOT YET been evaluated

###PLACE OF USE:	NORTH WEST QUARTER				NORTH EAST QUARTER				SOUTH WEST QUARTER				SOUTH EAST QUARTER				Section Totals
	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	
Sec 29 T 39S R 5W SLBM									0.3000	0.8000							1.1000

This Right (85-367) has an evaluated sole-supply total for irrigation of 0.00 acres.

This Right (85-367) is a member of 3 supplemental water right groups with irrigated acreage totaling 0.00 acres.

**********E N D O F D A T A**********

STATE OF UTAH -- DIVISION OF WATER RIGHTS -- DATA PRINT OUT for 85-368

SD 3

(WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/24/2006 Page 1

WATER RIGHT: 85-368 APPLICATION/CLAIM NO.: CERT. NO.:

OWNERSHIP

NAME: Darlynn and Arlene Sorensen
ADDR: P. O. Box 47
Orderville, UT 84758
INTEREST: 100% REMARKS: joint tenants

DATES, ETC.

LAND OWNED BY APPLICANT?
FILED: 01/29/1970|PRIORITY: 00/00/1889|PUB BEGAN: |PUB ENDED: |NEWSPAPER:
ProtestEnd: |PROTESTED: [No]|HEARNG HLD: |SE ACTION: [ ]|ActionDate: |PROOF DUE:
EXTENSION: |ELEC/PROOF:[ ]|ELEC/PROOF: |CERT/WUC: 01/29/1970|LAP, ETC: |PROV LETTER:
RENOVATE: |RECON REQ: |TYPE: [ ]

PD Book No. 1 Map: 5c

Type of Right: Diligence Claim Source of Info: Proposed Determination Status:

LOCATION OF WATER RIGHT

FLOW: 10.0 cfs SOURCE: Right Hand Wash

COUNTY: Kane COMMON DESCRIPTION:

POINT OF DIVERSION -- SURFACE:
(1) S 390 ft E 1360 ft from W4 cor, Sec 29, T 39S, R 5W, SLBM
Diverting Works: Source:

Stream Alt Required?: No

USES OF WATER RIGHT

SUPPLEMENTAL GROUP NO. 612374. Water Rights Appurtenant to the following use(s):
85-362,363,364,365,366,367,368,369,370,371,372,373,374,375,377,378,379,380,381,382,383,384,385,386,387,388,389

###STOCKWATER: Group Total: 300 Stock Units Diversion Limit: PERIOD OF USE: 04/01 TO 12/31
Sole Supply for Stockwatering for 85-368 in this Group has NOT YET been evaluated

SUPPLEMENTAL GROUP NO. 612377. Water Rights Appurtenant to the following use(s):
85-363,367,368

###IRRIGATION: Group Total: 1.1 acres Diversion Limit: 0.0 acft. PERIOD OF USE: 04/01 TO 10/31
Sole Supply for Irrigation for 85-368 in this Group has NOT YET been evaluated

###PLACE OF USE:	NORTH WEST QUARTER				NORTH EAST QUARTER				SOUTH WEST QUARTER				SOUTH EAST QUARTER				Section Totals
	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	
Sec 29 T 39S R 5W SLBM									0.3000	0.8000							1.1000

**********END OF DATA**********

STATE OF UTAH -- DIVISION OF WATER RIGHTS -- DATA PRINT OUT for 85-365

SD 4

(WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/24/2006

WATER RIGHT: 85-365 APPLICATION/CLAIM NO.: CERT. NO.:

OWNERSHIP

NAME: Darlynn and Arlene Sorensen
ADDR: P. O. Box 47
Orderville, UT 84758
INTEREST: 100% REMARKS: joint tenants

DATES, ETC.

LAND OWNED BY APPLICANT?
FILED: 01/29/1970|PRIORITY: 00/00/1889|PUB BEGAN: |PUB ENDED: |NEWSPAPER:
ProtestEnd: |PROTESTED: [No]|HEARNG HLD: |SE ACTION: [ ]|ActionDate: |PROOF DUE:
EXTENSION: |ELEC/PROOF:[ ]|ELEC/PROOF: |CERT/WUC: 01/29/1970|LAP, ETC: |PROV LETTER:
RENOVATE: |RECON REQ: |TYPE: [ ]

PD Book No. 1 Map: 5c

Type of Right: Diligence Claim Source of Info: Proposed Determination Status:

LOCATION OF WATER RIGHT

FLOW: 10.0 cfs SOURCE: Swapp Canyon Creek

COUNTY: Kane COMMON DESCRIPTION:

POINT OF DIVERSION -- SURFACE:
(1) S 700 ft E 1375 ft from W4 cor, Sec 29, T 39S, R 5W, SLBM
Diverting Works: Source:

Stream Alt Required?: No

USES OF WATER RIGHT

SUPPLEMENTAL GROUP NO. 612374. Water Rights Appurtenant to the following use(s):
85-362,363,364,365,366,367,368,369,370,371,372,373,374,375,377,378,379,380,381,382,383,384,385,386,387,388,389

###STOCKWATER: Group Total: 300 Stock Units Diversion Limit: PERIOD OF USE: 04/01 TO 12/31
Sole Supply for Stockwatering for 85-365 in this Group has NOT YET been evaluated

SUPPLEMENTAL GROUP NO. 612379. Water Rights Appurtenant to the following use(s):
85-364,365

###IRRIGATION: Group Total: 1.4 acres Diversion Limit: 0.0 acft. PERIOD OF USE: 04/01 TO 10/31
Sole Supply for Irrigation for 85-365 in this Group has NOT YET been evaluated

###PLACE OF USE:	NORTH WEST QUARTER				NORTH EAST QUARTER				SOUTH WEST QUARTER				SOUTH EAST QUARTER				Section
	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	Totals
Sec 29 T 39S R 5W SLBM									0.2000	1.2000							1.4000

SUPPLEMENTAL GROUP NO. 612380. Water Rights Appurtenant to the following use(s):
85-364,365,369

###IRRIGATION: Group Total: 5.9 acres Diversion Limit: 0.0 acft. PERIOD OF USE: 04/01 TO 10/31
Sole Supply for Irrigation for 85-365 in this Group has NOT YET been evaluated

###PLACE OF USE:	NORTH WEST QUARTER				NORTH EAST QUARTER				SOUTH WEST QUARTER				SOUTH EAST QUARTER				Section
	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	Totals
Sec 29 T 39S R 5W SLBM										0.8000	5.1000						5.9000

SUPPLEMENTAL GROUP NO. 612381. Water Rights Appurtenant to the following use(s):
85-364,365,369,370

###IRRIGATION: Group Total: 9.2 acres Diversion Limit: 0.0 acft. PERIOD OF USE: 04/01 TO 10/31
Sole Supply for Irrigation for 85-365 in this Group has NOT YET been evaluated

###PLACE OF USE:	NORTH WEST QUARTER				NORTH EAST QUARTER				SOUTH WEST QUARTER				SOUTH EAST QUARTER				Section
	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	Totals
Sec 29 T 39S R 5W SLBM											0.9000	8.3000					9.2000

SUPPLEMENTAL GROUP NO. 612382. Water Rights Appurtenant to the following use(s):
85-364,365,369,370,371

###IRRIGATION: Group Total: 7.0 acres Diversion Limit: 0.0 acft. PERIOD OF USE: 04/01 TO 10/31
Sole Supply for Irrigation for 85-365 in this Group has NOT YET been evaluated

###PLACE OF USE:	NORTH WEST QUARTER				NORTH EAST QUARTER				SOUTH WEST QUARTER				SOUTH EAST QUARTER				Section
	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	Totals
Sec 29 T 39S R 5W SLBM											2.3000	1.0000					3.3000
Sec 32 T 39S R 5W SLBM	3.7000																3.7000

SUPPLEMENTAL GROUP NO. 612383. Water Rights Appurtenant to the following use(s):
85-364,365,369,370,371,372

###IRRIGATION: Group Total: 13.9 acres Diversion Limit: 0.0 acft. PERIOD OF USE: 04/01 TO 10/31
Sole Supply for Irrigation for 85-365 in this Group has NOT YET been evaluated

###PLACE OF USE:	NORTH WEST QUARTER				NORTH EAST QUARTER				SOUTH WEST QUARTER				SOUTH EAST QUARTER				Section
	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	Totals
Sec 32 T 39S R 5W SLBM	8.0000		5.9000														13.9000

This Right (85-365) has an evaluated sole-supply total for irrigation of 0.00 acres.

This Right (85-365) is a member of 6 supplemental water right groups with irrigated acreage totaling 0.00 acres.

**********E N D O F D A T A**********

STATE OF UTAH – DIVISION OF WATER RIGHTS – DATA PRINT OUT for 85-369

SD 5

(WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/24/2006

WATER RIGHT: 85-369 APPLICATION/CLAIM NO.: CERT. NO.:

OWNERSHIP

NAME: Darlynn and Arlene Sorensen
ADDR: P. O. Box 47
Orderville, UT 84758
INTEREST: 100% REMARKS: joint tenants

DATES, ETC.

LAND OWNED BY APPLICANT?
FILED: 01/29/1970|PRIORITY: 00/00/1889|PUB BEGAN: |PUB ENDED: |NEWSPAPER:
ProtestEnd: |PROTESTED: [No]|HEARNG HLD: |SE ACTION: [ ]|ActionDate: |PROOF DUE:
EXTENSION: |ELEC/PROOF:[ ]|ELEC/PROOF: |CERT/WUC: 01/29/1970|LAP, ETC: |PROV LETTER:
RENOVATE: |RECON REQ: |TYPE: [ ]

PD Book No. 1 Map: 5c

Type of Right: Diligence Claim Source of Info: Proposed Determination Status:

LOCATION OF WATER RIGHT

FLOW: 10.0 cfs SOURCE: Sink Valley Wash

COUNTY: Kane COMMON DESCRIPTION:

POINT OF DIVERSION -- SURFACE:
(1) S 1010 ft E 1290 ft from W4 cor, Sec 29, T 39S, R 5W, SLBM
Diverting Works: Source:

Stream Alt Required?: No

USES OF WATER RIGHT

SUPPLEMENTAL GROUP NO. 612374. Water Rights Appurtenant to the following use(s):
85-362,363,364,365,366,367,368,369,370,371,372,373,374,375,377,378,379,380,381,382,383,384,385,386,387,388,389

###STOCKWATER: Group Total: 300 Stock Units Diversion Limit: PERIOD OF USE: 04/01 TO 12/31
Sole Supply for Stockwatering for 85-369 in this Group has NOT YET been evaluated

SUPPLEMENTAL GROUP NO. 612380. Water Rights Appurtenant to the following use(s):
85-364,365,369

###IRRIGATION: Group Total: 5.9 acres Diversion Limit: 0.0 acft. PERIOD OF USE: 04/01 TO 10/31
Sole Supply for Irrigation for 85-369 in this Group has NOT YET been evaluated

###PLACE OF USE:	NORTH WEST QUARTER				NORTH EAST QUARTER				SOUTH WEST QUARTER				SOUTH EAST QUARTER				Section
	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	Totals
Sec 29 T 39S R 5W SLBM										0.8000	5.1000						5.9000

SUPPLEMENTAL GROUP NO. 612381. Water Rights Appurtenant to the following use(s):
85-364,365,369,370

###IRRIGATION: Group Total: 9.2 acres Diversion Limit: 0.0 acft. PERIOD OF USE: 04/01 TO 10/31
Sole Supply for Irrigation for 85-369 in this Group has NOT YET been evaluated

###PLACE OF USE:	NORTH WEST QUARTER				NORTH EAST QUARTER				SOUTH WEST QUARTER				SOUTH EAST QUARTER				Section
	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	Totals
Sec 29 T 39S R 5W SLBM											0.9000	8.3000					9.2000

SUPPLEMENTAL GROUP NO. 612382. Water Rights Appurtenant to the following use(s):
85-364,365,369,370,371

###IRRIGATION: Group Total: 7.0 acres Diversion Limit: 0.0 acft. PERIOD OF USE: 04/01 TO 10/31
Sole Supply for Irrigation for 85-369 in this Group has NOT YET been evaluated

###PLACE OF USE:	NORTH WEST QUARTER				NORTH EAST QUARTER				SOUTH WEST QUARTER				SOUTH EAST QUARTER				Section
	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	Totals
Sec 29 T 39S R 5W SLBM											2.3000	1.0000					3.3000
Sec 32 T 39S R 5W SLBM	3.7000																3.7000

SUPPLEMENTAL GROUP NO. 612383. Water Rights Appurtenant to the following use(s):
85-364,365,369,370,371,372

###IRRIGATION: Group Total: 13.9 acres Diversion Limit: 0.0 acft. PERIOD OF USE: 04/01 TO 10/31
Sole Supply for Irrigation for 85-369 in this Group has NOT YET been evaluated

###PLACE OF USE:	NORTH WEST QUARTER				NORTH EAST QUARTER				SOUTH WEST QUARTER				SOUTH EAST QUARTER				Section
	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	Totals
Sec 32 T 39S R 5W SLBM	8.0000		5.9000														13.9000

SUPPLEMENTAL GROUP NO. 612384.
85-369

###IRRIGATION: 5.0 acres Diversion Limit: 0.0 acft. PERIOD OF USE: 04/01 TO 10/31

###PLACE OF USE:	NORTH WEST QUARTER				NORTH EAST QUARTER				SOUTH WEST QUARTER				SOUTH EAST QUARTER				Section
	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	Totals
Sec 29 T 39S R 5W SLBM									1.2000		3.8000						5.0000

This Right (85-369) has an evaluated sole-supply total for irrigation of 0.00 acres.

This Right (85-369) is a member of 6 supplemental water right groups with irrigated acreage totaling 0.00 acres.

**********E N D O F D A T A**********

STATE OF UTAH – DIVISION OF WATER RIGHTS – DATA PRINT OUT for 85-370

SD 6

(WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/24/2006 Page 1

WATER RIGHT: 85-370 APPLICATION/CLAIM NO.: CERT. NO.:

OWNERSHIP

NAME: Darlynn and Arlene Sorensen
ADDR: P. O. Box 47
Orderville, UT 84758
INTEREST: 100% REMARKS: joint tenants

DATES, ETC.

LAND OWNED BY APPLICANT?
FILED: 01/29/1970 | PRIORITY: 00/00/1889 | PUB BEGAN: | PUB ENDED: | NEWSPAPER:
ProtestEnd: | PROTESTED: [No] | HEARNG HLD: | SE ACTION: [ ] | ActionDate: | PROOF DUE:
EXTENSION: | ELEC/PROOF: [ ] | ELEC/PROOF: | CERT/WUC: 01/29/1970 | LAP, ETC: | PROV LETTER:
RENOVATE: | RECON REQ: | TYPE: [ ]

PD Book No. 1 Map: 5c

Type of Right: Diligence Claim Source of Info: Proposed Determination Status:

LOCATION OF WATER RIGHT

FLOW: 10.0 cfs SOURCE: Sink Valley Wash

COUNTY: Kane COMMON DESCRIPTION:

POINT OF DIVERSION -- SURFACE:
(1) N 1050 ft E 1280 ft from SW cor, Sec 29, T 39S, R 5W, SLBM
Diverting Works: Source:

Stream Alt Required?: No

USES OF WATER RIGHT

SUPPLEMENTAL GROUP NO. 612374. Water Rights Appurtenant to the following use(s):
85-362,363,364,365,366,367,368,369,370,371,372,373,374,375,377,378,379,380,381,382,383,384,385,386,387,388,389

###STOCKWATER: Group Total: 300 Stock Units Diversion Limit: PERIOD OF USE: 04/01 TO 12/31
Sole Supply for Stockwatering for 85-370 in this Group has NOT YET been evaluated

SUPPLEMENTAL GROUP NO. 612381. Water Rights Appurtenant to the following use(s):
85-364,365,369,370

###IRRIGATION: Group Total: 9.2 acres Diversion Limit: 0.0 acft. PERIOD OF USE: 04/01 TO 10/31
Sole Supply for Irrigation for 85-370 in this Group has NOT YET been evaluated

###PLACE OF USE:	NORTH WEST QUARTER				NORTH EAST QUARTER				SOUTH WEST QUARTER				SOUTH EAST QUARTER				Section Totals
	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	
Sec 29 T 39S R 5W SLBM											0.9000	8.3000					9.2000

SUPPLEMENTAL GROUP NO. 612382. Water Rights Appurtenant to the following use(s):
85-364,365,369,370,371

###IRRIGATION: Group Total: 7.0 acres Diversion Limit: 0.0 acft. PERIOD OF USE: 04/01 TO 10/31
Sole Supply for Irrigation for 85-370 in this Group has NOT YET been evaluated

###PLACE OF USE:	NORTH WEST QUARTER				NORTH EAST QUARTER				SOUTH WEST QUARTER				SOUTH EAST QUARTER				Section
	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	Totals
Sec 29 T 39S R 5W SLBM											2.3000	1.0000					3.3000
Sec 32 T 39S R 5W SLBM	3.7000																3.7000

SUPPLEMENTAL GROUP NO. 612383. Water Rights Appurtenant to the following use(s):
85-364,365,369,370,371,372

###IRRIGATION: Group Total: 13.9 acres Diversion Limit: 0.0 acft. PERIOD OF USE: 04/01 TO 10/31

Sole Supply for Irrigation for 85-370 in this Group has NOT YET been evaluated

###PLACE OF USE:	NORTH WEST QUARTER				NORTH EAST QUARTER				SOUTH WEST QUARTER				SOUTH EAST QUARTER				Section
	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	Totals
Sec 32 T 39S R 5W SLBM	8.0000		5.9000														13.9000

This Right (85-370) has an evaluated sole-supply total for irrigation of 0.00 acres.

This Right (85-370) is a member of 4 supplemental water right groups with irrigated acreage totaling 0.00 acres.

**********E N D O F D A T A**********

STATE OF UTAH -- DIVISION OF WATER RIGHTS -- DATA PRINT OUT for 85-371

SD 7

(WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/24/2006

WATER RIGHT: 85-371 APPLICATION/CLAIM NO.: CERT. NO.:

OWNERSHIP

NAME: Darlynn and Arlene Sorensen
ADDR: P. O. Box 47
Orderville, UT 84758
INTEREST: 100% REMARKS: joint tenants

DATES, ETC.

LAND OWNED BY APPLICANT?
FILED: 01/29/1970 |PRIORITY: 00/00/1889 |PUB BEGAN: |PUB ENDED: |NEWSPAPER:
ProtestEnd: |PROTESTED: [No] |HEARNG HLD: |SE ACTION: [ ] |ActionDate: |PROOF DUE:
EXTENSION: |ELEC/PROOF: [ ] |ELEC/PROOF: |CERT/WUC: 01/29/1970 |LAP, ETC: |PROV LETTER:
RENOVATE: |RECON REQ: |TYPE: [ ]

PD Book No. 1 Map: 5c

Type of Right: Diligence Claim Source of Info: Proposed Determination Status:

LOCATION OF WATER RIGHT

FLOW: 10.0 cfs SOURCE: Sink Valley Wash

COUNTY: Kane COMMON DESCRIPTION:

POINT OF DIVERSION -- SURFACE:
(1) N 490 ft E 1200 ft from SW cor, Sec 29, T 39S, R 5W, SLBM
Diverting Works: Source:

Stream Alt Required?: No

USES OF WATER RIGHT

SUPPLEMENTAL GROUP NO. 612374. Water Rights Appurtenant to the following use(s):
85-362,363,364,365,366,367,368,369,370,371,372,373,374,375,377,378,379,380,381,382,383,384,385,386,387,388,389

###STOCKWATER: Group Total: 300 Stock Units Diversion Limit: PERIOD OF USE: 04/01 TO 12/31
Sole Supply for Stockwatering for 85-371 in this Group has NOT YET been evaluated

SUPPLEMENTAL GROUP NO. 612382. Water Rights Appurtenant to the following use(s):
85-364,365,369,370,371

###IRRIGATION: Group Total: 7.0 acres Diversion Limit: 0.0 acft. PERIOD OF USE: 04/01 TO 10/31
Sole Supply for Irrigation for 85-371 in this Group has NOT YET been evaluated

###PLACE OF USE:	NORTH WEST QUARTER				NORTH EAST QUARTER				SOUTH WEST QUARTER				SOUTH EAST QUARTER				Section Totals
	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	
Sec 29 T 39S R 5W SLBM											2.3000	1.0000					3.3000
Sec 32 T 39S R 5W SLBM	3.7000																3.7000

SUPPLEMENTAL GROUP NO. 612383. Water Rights Appurtenant to the following use(s):
85-364,365,369,370,371,372

###IRRIGATION: Group Total: 13.9 acres Diversion Limit: 0.0 acft. PERIOD OF USE: 04/01 TO 10/31
Sole Supply for Irrigation for 85-371 in this Group has NOT YET been evaluated

###PLACE OF USE:	NORTH WEST QUARTER				NORTH EAST QUARTER				SOUTH WEST QUARTER				SOUTH EAST QUARTER				Section Totals
	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	
Sec 32 T 39S R 5W SLBM	8.0000		5.9000														13.9000

This Right (85-371) has an evaluated sole-supply total for irrigation of 0.00 acres.

This Right (85-371) is a member of 3 supplemental water right groups with irrigated acreage totaling 0.00 acres.

**********E N D O F D A T A**********

STATE OF UTAH – DIVISION OF WATER RIGHTS – DATA PRINT OUT for 85-372

SD 8

(WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/24/2006 Page 1

WATER RIGHT: 85-372 APPLICATION/CLAIM NO.: CERT. NO.:

OWNERSHIP

NAME: Darlynn and Arlene Sorensen
ADDR: P. O. Box 47
Orderville, UT 84758
INTEREST: 100% REMARKS: joint tenants

DATES, ETC.

LAND OWNED BY APPLICANT?
FILED: 01/29/1970|PRIORITY: 00/00/1889|PUB BEGAN: |PUB ENDED: |NEWSPAPER:
ProtestEnd: |PROTESTED: [No]|HEARNG HLD: |SE ACTION: [ ]|ActionDate: |PROOF DUE:
EXTENSION: |ELEC/PROOF:[ ]|ELEC/PROOF: |CERT/WUC: 01/29/1970|LAP, ETC: |PROV LETTER:
RENOVATE: |RECON REQ: |TYPE: [ ]

PD Book No. 1 Map: 5c

Type of Right: Diligence Claim Source of Info: Proposed Determination Status:

LOCATION OF WATER RIGHT

FLOW: 10.0 cfs SOURCE: Sink Valley Wash

COUNTY: Kane COMMON DESCRIPTION:

POINT OF DIVERSION -- SURFACE:
(1) S 290 ft E 860 ft from NW cor, Sec 32, T 39S, R 5W, SLBM
Diverting Works: Source:

Stream Alt Required?: No

USES OF WATER RIGHT

SUPPLEMENTAL GROUP NO. 612374. Water Rights Appurtenant to the following use(s):
85-362,363,364,365,366,367,368,369,370,371,372,373,374,375,377,378,379,380,381,382,383,384,385,386,387,388,389

###STOCKWATER: Group Total: 300 Stock Units Diversion Limit: PERIOD OF USE: 04/01 TO 12/31
Sole Supply for Stockwatering for 85-372 in this Group has NOT YET been evaluated

SUPPLEMENTAL GROUP NO. 612383. Water Rights Appurtenant to the following use(s):
85-364,365,369,370,371,372

###IRRIGATION: Group Total: 13.9 acres Diversion Limit: 0.0 acft. PERIOD OF USE: 04/01 TO 10/31
Sole Supply for Irrigation for 85-372 in this Group has NOT YET been evaluated

###PLACE OF USE:	NORTH WEST QUARTER				NORTH EAST QUARTER				SOUTH WEST QUARTER				SOUTH EAST QUARTER				Section Totals
	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	
Sec 32 T 39S R 5W SLBM	8.0000		5.9000														13.9000

**********E N D O F D A T A**********

STATE OF UTAH -- DIVISION OF WATER RIGHTS -- DATA PRINT OUT for 85-356

SD 9

(WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/24/2006 Page 1

WATER RIGHT: 85-356 APPLICATION/CLAIM NO.: CERT. NO.:

OWNERSHIP**********

NAME: Julie Johnson
ADDR: PO Box 2063
Page AZ 86040

NAME: James Johnson
ADDR: PO Box 2063
Page AZ 86040

NAME: Lloyd Johnson
ADDR: PO Box 2063
Page AZ 86040

DATES, ETC.**********

LAND OWNED BY APPLICANT?
FILED: 04/27/1970|PRIORITY: 00/00/1889|PUB BEGAN: |PUB ENDED: |NEWSPAPER:
ProtestEnd: |PROTESTED: [No]|HEARNG HLD: |SE ACTION: [ ]|ActionDate: |PROOF DUE:
EXTENSION: |ELEC/PROOF:[ ]|ELEC/PROOF: |CERT/WUC: 04/27/1970|LAP, ETC: |PROV LETTER:
RENOVATE: |RECON REQ: |TYPE: [ ]

PD Book No. 1 Map: 5c

Type of Right: Diligence Claim Source of Info: Proposed Determination Status:

LOCATION OF WATER RIGHT**********

FLOW: 0.25 cfs SOURCE: Sink Valley Wash

COUNTY: Kane COMMON DESCRIPTION:

POINT OF DIVERSION -- SURFACE:
(1) N 240 ft E 590 ft from W4 cor, Sec 32, T 39S, R 5W, SLBM
Diverting Works: Source:

Stream Alt Required?: No

USES OF WATER RIGHT**********

SUPPLEMENTAL GROUP NO. 612367. Water Rights Appurtenant to the following use(s):
85-350,351,352,353,354,355,356,357,358,359

###STOCKWATER: Group Total: 125 Stock Units Diversion Limit: PERIOD OF USE: 04/01 TO 12/31
Sole Supply for Stockwatering for 85-356 in this Group has NOT YET been evaluated

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SUPPLEMENTAL GROUP NO. 612370.
85-356

###IRRIGATION: 9.0 acres Diversion Limit: 0.0 acft. PERIOD OF USE: 04/01 TO 10/31

###PLACE OF USE:	NORTH WEST QUARTER				NORTH EAST QUARTER				SOUTH WEST QUARTER				SOUTH EAST QUARTER				Section
	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	Totals
Sec 32 T 39S R 5W SLBM			1.0000						8.0000								9.0000

**********E N D O F D A T A**********

APPENDIX 7-3

EXHIBIT 7-3

Springs

SPRINGS

REF #	WR #	OWNER	SOURCE
1	85-214	C. Burton Pugh	Tater Patch Spring
2	85-350	Richard L. & Alecia S. Dame	Swapp Ranch Spring Area #1
3	85-373	Darlynn & Arlene Sorensen	Sorensen Ranch Spring #1
4	85-374	Darlynn & Arlene Sorensen	Sorensen Ranch Spring #2
5	85-351	Richard L. & Alecia S. Dame	Swapp Ranch Spring Area #2
6	85-352	Richard L. & Alecia S. Dame	Swapp Ranch Spring Area #3
7	85-215	C. Burton Pugh	Spring House Spring
8	85-353	Richard L. & Alecia S. Dame	Swapp Ranch Spring Area #4
9	85-375	Darlynn & Arlene Sorensen	Sorensen Ranch Spring #3
10A	85-355	James, Julie & Lloyd Johnson	Pulsifer Spring
10B	85-1011	James, Julie & Lloyd Johnson	Pulsifer Spring

STATE OF UTAH -- DIVISION OF WATER RIGHTS -- DATA PRINT OUT for 85-214

SPR 1

(WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/24/2006 Page 1

WATER RIGHT: 85-214 APPLICATION/CLAIM NO.: CERT. NO.:

OWNERSHIP

NAME: C. Burton Pugh
ADDR: 533 North 650 East
Lindon, Utah 84042

DATES, ETC.

LAND OWNED BY APPLICANT?

FILED: 08/08/1969	PRIORITY: 03/04/1889	PUB BEGAN:	PUB ENDED:	NEWSPAPER:	
ProtestEnd:	PROTESTED: [No	HEARNG HLD:	SE ACTION: [	ActionDate:	PROOF DUE:
EXTENSION:	ELEC/PROOF: [	ELEC/PROOF:	CERT/WUC: 08/08/1969	LAP, ETC:	PROV LETTER:
RENOVATE:	RECON REQ:	TYPE: [ ]			

PD Book No. 1 Map: 5c

Type of Right: Diligence Claim Source of Info: Proposed Determination Status:

LOCATION OF WATER RIGHT

FLOW: 0.033 cfs SOURCE: Tater Patch Spring

COUNTY: Kane COMMON DESCRIPTION:

POINT OF DIVERSION -- SURFACE:
(1) S 490 ft E 1040 ft from NW cor, Sec 29, T 39S, R 5W, SLBM
Diverting Works: Source:

Stream Alt Required?: No

USES OF WATER RIGHT

SUPPLEMENTAL GROUP NO. 612092. Water Rights Appurtenant to the following use(s):
85-100,214

###IRRIGATION: Group Total: 0.6 acres Diversion Limit: 0.0 acft. PERIOD OF USE: 04/01 TO 10/31
Sole Supply for Irrigation for 85-214 in this Group has NOT YET been evaluated

###PLACE OF USE:	NORTH WEST QUARTER				NORTH EAST QUARTER				SOUTH WEST QUARTER				SOUTH EAST QUARTER				Section Totals
	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	
Sec 29 T 39S R 5W SLBM	0.6000																0.6000

SUPPLEMENTAL GROUP NO. 612093. Water Rights Appurtenant to the following use(s):
85-100,199,200,201,202,203,204,205,206,207,208,209,210,211,213,214,215

###STOCKWATER: Group Total: 250 Stock Units Diversion Limit: PERIOD OF USE: 04/01 TO 12/31
Sole Supply for Stockwatering for 85-214 in this Group has NOT YET been evaluated

**********E N D O F D A T A**********

STATE OF UTAH -- DIVISION OF WATER RIGHTS -- DATA PRINT OUT for 85-350 SPR 2

(WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/24/2006 Page 1

WATER RIGHT: 85-350 APPLICATION/CLAIM NO.: CERT. NO.:

OWNERSHIP

NAME: Richard & Alecia S. Dame
ADDR: 1620 Georgia Ave.
Boulder City NV 89005-3643
INTEREST: 100% REMARKS: As Joint Tenants

DATES, ETC.

LAND OWNED BY APPLICANT?
FILED: 04/27/1970|PRIORITY: 00/00/1889|PUB BEGAN: |PUB ENDED: |NEWSPAPER:
ProtestEnd: |PROTESTED: [No]|HEARNG HLD: |SE ACTION: [ ]|ActionDate: |PROOF DUE:
EXTENSION: |ELEC/PROOF:[ ]|ELEC/PROOF: |CERT/WUC: 04/27/1970|LAP, ETC: |PROV LETTER:
RENOVATE: |RECON REQ: |TYPE: [ ]

PD Book No. 1 Map: 5c

Type of Right: Diligence Claim Source of Info: Proposed Determination Status:

LOCATION OF WATER RIGHT

FLOW: 1.0 cfs SOURCE: Swapp Ranch Spring Area No. 1

COUNTY: Kane COMMON DESCRIPTION:

POINT OF DIVERSION -- SURFACE:
(1) S 510 ft E 1090 ft from NW cor, Sec 29, T 39S, R 5W, SLBM
Diverting Works: Source:

Stream Alt Required?: No

USES OF WATER RIGHT

SUPPLEMENTAL GROUP NO. 612366. Water Rights Appurtenant to the following use(s):
85-350,351,352,353

###IRRIGATION: Group Total: 93.0 acres Diversion Limit: 0.0 acft. PERIOD OF USE: 04/01 TO 10/31
Sole Supply for Irrigation for 85-350 in this Group has NOT YET been evaluated

###PLACE OF USE:	NORTH WEST QUARTER				NORTH EAST QUARTER				SOUTH WEST QUARTER				SOUTH EAST QUARTER				Section
	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	Totals
Sec 29 T 39S R 5W SLBM	7.2000	0.2000	23.2000	0.3000					21.1000								52.0000
Sec 30 T 39S R 5W SLBM								1.0000						20.0000		20.0000	41.0000

SUPPLEMENTAL GROUP NO. 612367. Water Rights Appurtenant to the following use(s):
85-350,351,352,353,354,355,356,357,358,359

###STOCKWATER: Group Total: 125 Stock Units Diversion Limit: PERIOD OF USE: 04/01 TO 12/31
Sole Supply for Stockwatering for 85-350 in this Group has NOT YET been evaluated

**********E N D O F D A T A**********

STATE OF UTAH -- DIVISION OF WATER RIGHTS -- DATA PRINT OUT for 85-373

SPR 3

(WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/24/2006 Page 1

WATER RIGHT: 85-373 APPLICATION/CLAIM NO.: CERT. NO.:

OWNERSHIP

NAME: Darlynn and Arlene Sorensen
ADDR: P. O. Box 47
Orderville, UT 84758
INTEREST: 100% REMARKS: joint tenants

DATES, ETC.

LAND OWNED BY APPLICANT?
FILED: 01/29/1970|PRIORITY: 00/00/1864|PUB BEGAN: |PUB ENDED: |NEWSPAPER:
ProtestEnd: |PROTESTED: [No]|HEARNG HLD: |SE ACTION: [ ]|ActionDate: |PROOF DUE:
EXTENSION: |ELEC/PROOF:[ ]|ELEC/PROOF: |CERT/WUC: 01/29/1970|LAP, ETC: |PROV LETTER:
RENOVATE: |RECON REQ: |TYPE: [ ]

PD Book No. 1 Map: 5c

Type of Right: Diligence Claim Source of Info: Proposed Determination Status:

LOCATION OF WATER RIGHT

FLOW: 0.011 cfs SOURCE: Sorensen Ranch Spring No. 1

COUNTY: Kane COMMON DESCRIPTION:

POINT OF DIVERSION:
(1)Stockwatering directly on spring located in NE4NW4 Sec 29, T39S, R5W, SLBM.
COMMENT: Administratively updated by State Engineer.

USES OF WATER RIGHT

SUPPLEMENTAL GROUP NO. 612374. Water Rights Appurtenant to the following use(s):
85-362,363,364,365,366,367,368,369,370,371,372,373,374,375,377,378,379,380,381,382,383,384,385,386,387,388,389

###STOCKWATER: Group Total: 300 Stock Units Diversion Limit: PERIOD OF USE: 04/01 TO 12/31
Sole Supply for Stockwatering for 85-373 in this Group has NOT YET been evaluated

SUPPLEMENTAL GROUP NO. 612386.
85-373

###DOMESTIC: 1 Family Diversion Limit: PERIOD OF USE: 04/01 TO 12/31

###PLACE OF USE:	NORTH WEST QUARTER				NORTH EAST QUARTER				SOUTH WEST QUARTER				SOUTH EAST QUARTER				Section Totals
	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	
Sec 29 T 39S R 5W SLBM		X															0.0000

PLACE OF USE for STOCKWATERING

	NORTH-WEST¼				NORTH-EAST¼				SOUTH-WEST¼				SOUTH-EAST¼			
	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE
Sec 29 T 39S R 5W SLBM			X:													

**********END OF DATA**********

STATE OF UTAH – DIVISION OF WATER RIGHTS – DATA PRINT OUT for 85-374

SPR 4

(WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/24/2006 Page 1

WATER RIGHT: 85-374 APPLICATION/CLAIM NO.: CERT. NO.:

OWNERSHIP**********

NAME: Darlynn and Arlene Sorensen
ADDR: P. O. Box 47
Orderville, UT 84758
INTEREST: 100% REMARKS: joint tenants

DATES, ETC.**********

LAND OWNED BY APPLICANT?
FILED: 01/29/1970|PRIORITY: 00/00/1864|PUB BEGAN: |PUB ENDED: |NEWSPAPER:
ProtestEnd: |PROTESTED: [No]|HEARNG HLD: |SE ACTION: [ ]|ActionDate: |PROOF DUE:
EXTENSION: |ELEC/PROOF:[ ]|ELEC/PROOF: |CERT/WUC: 01/29/1970|LAP, ETC: |PROV LETTER:
RENOVATE: |RECON REQ: |TYPE: [ ]

PD Book No. 1 Map: 5c

Type of Right: Diligence Claim Source of Info: Proposed Determination Status:

LOCATION OF WATER RIGHT**********

FLOW: 0.011 cfs SOURCE: Sorensen Ranch Spring No. 2

COUNTY: Kane COMMON DESCRIPTION:

POINT OF DIVERSION:
(1)Stockwatering directly on spring located in SE4NW4 Sec 29, T39S, R5W, SLBM.
COMMENT: Administratively updated by State Engineer.

USES OF WATER RIGHT**********

SUPPLEMENTAL GROUP NO. 612374. Water Rights Appurtenant to the following use(s):
85-362,363,364,365,366,367,368,369,370,371,372,373,374,375,377,378,379,380,381,382,383,384,385,386,387,388,389

###STOCKWATER: Group Total: 300 Stock Units Diversion Limit: PERIOD OF USE: 04/01 TO 12/31
Sole Supply for Stockwatering for 85-374 in this Group has NOT YET been evaluated

PLACE OF USE for STOCKWATERING**********

	NORTH-WEST¼	NORTH-EAST¼	SOUTH-WEST¼	SOUTH-EAST¼
	NW NE SW SE	NW NE SW SE	NW NE SW SE	NW NE SW SE
Sec 29 T 39S R 5W SLBM	* : : : X*	* : : : *	* : : : *	* : : : *

**********E N D O F D A T A**********

STATE OF UTAH – DIVISION OF WATER RIGHTS – DATA PRINT OUT for 85-351

SPR 5

(WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/24/2006 Page 1

WATER RIGHT: 85-351 APPLICATION/CLAIM NO.: CERT. NO.:

OWNERSHIP

NAME: Richard L. & Alecia S. Dame
ADDR: 1620 Georgia Ave.
Boulder City NV 89005-3643
INTEREST: 100% REMARKS: As Joint Tenants

DATES, ETC.

LAND OWNED BY APPLICANT?
FILED: 04/27/1970|PRIORITY: 00/00/1889|PUB BEGAN: |PUB ENDED: |NEWSPAPER:
ProtestEnd: |PROTESTED: [No]|HEARNG HLD: |SE ACTION: [ ]|ActionDate: |PROOF DUE:
EXTENSION: |ELEC/PROOF:[ ]|ELEC/PROOF: |CERT/WUC: 04/27/1970|LAP, ETC: |PROV LETTER:
RENOVATE: |RECON REQ: |TYPE: [ ]

PD Book No. 1 Map: 5c

Type of Right: Diligence Claim Source of Info: Proposed Determination Status:

LOCATION OF WATER RIGHT

FLOW: 0.25 cfs SOURCE: Swapp Ranch Spring Area No. 2

COUNTY: Kane COMMON DESCRIPTION:

POINT OF DIVERSION -- SURFACE:
(1) S 1635 ft E 1100 ft from NW cor, Sec 29, T 39S, R 5W, SLBM
Diverting Works: Source:

Stream Alt Required?: No

POINT OF DIVERSION:
(1)Stockwatering directly on spring located in SW4NW4 Sec 29, T39S, R5W, SLBM.
COMMENT: Administratively updated by State Engineer.

USES OF WATER RIGHT

SUPPLEMENTAL GROUP NO. 612366. Water Rights Appurtenant to the following use(s):
85-350,351,352,353

###IRRIGATION: Group Total: 93.0 acres Diversion Limit: 0.0 acft. PERIOD OF USE: 04/01 TO 10/31
Sole Supply for Irrigation for 85-351 in this Group has NOT YET been evaluated

###PLACE OF USE:	NORTH WEST QUARTER				NORTH EAST QUARTER				SOUTH WEST QUARTER				SOUTH EAST QUARTER				Section
	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	Totals
Sec 29 T 39S R 5W SLBM	7.2000	0.2000	23.2000	0.3000					21.1000								52.0000
Sec 30 T 39S R 5W SLBM								1.0000						20.0000		20.0000	41.0000

SUPPLEMENTAL GROUP NO. 612367. Water Rights Appurtenant to the following use(s):
85-350,351,352,353,354,355,356,357,358,359

###STOCKWATER: Group Total: 125 Stock Units Diversion Limit: PERIOD OF USE: 04/01 TO 12/31
Sole Supply for Stockwatering for 85-351 in this Group has NOT YET been evaluated

PLACE OF USE for STOCKWATERING

	NORTH-WEST¼				NORTH-EAST¼				SOUTH-WEST¼				SOUTH-EAST¼			
	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE
Sec 29 T 39S R 5W SLBM			X													

****
**********E N D O F D A T A**********
****

STATE OF UTAH – DIVISION OF WATER RIGHTS – DATA PRINT OUT for 85-352

SPR 6

(WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/24/2006 Page 1

WATER RIGHT: 85-352 APPLICATION/CLAIM NO.: CERT. NO.:

OWNERSHIP

NAME: Richard L. & Alecia S. Dame
ADDR: 1620 Georgia Ave.
Boulder City NV 89005-3643
INTEREST: 100% REMARKS: As Joint Tenants

DATES, ETC.

LAND OWNED BY APPLICANT?
FILED: 04/27/1970|PRIORITY: 00/00/1889|PUB BEGAN: |PUB ENDED: |NEWSPAPER:
ProtestEnd: |PROTESTED: [No]|HEARNG HLD: |SE ACTION: [ ]|ActionDate: |PROOF DUE:
EXTENSION: |ELEC/PROOF:[ ]|ELEC/PROOF: |CERT/WUC: 04/27/1970|LAP, ETC: |PROV LETTER:
RENOVATE: |RECON REQ: |TYPE: [ ]

PD Book No. 1 Map: 5c

Type of Right: Diligence Claim Source of Info: Proposed Determination Status:

LOCATION OF WATER RIGHT

FLOW: 0.25 cfs SOURCE: Swapp Ranch spring Area No. 3

COUNTY: Kane COMMON DESCRIPTION:

POINT OF DIVERSION -- SURFACE:
(1) S 1475 ft E 530 ft from NW cor, Sec 29, T 39S, R 5W, SLBM
Diverting Works: Source:

Stream Alt Required?: No

USES OF WATER RIGHT

SUPPLEMENTAL GROUP NO. 612366. Water Rights Appurtenant to the following use(s):
85-350,351,352,353

###IRRIGATION: Group Total: 93.0 acres Diversion Limit: 0.0 acft. PERIOD OF USE: 04/01 TO 10/31
Sole Supply for Irrigation for 85-352 in this Group has NOT YET been evaluated

###PLACE OF USE:	NORTH WEST QUARTER				NORTH EAST QUARTER				SOUTH WEST QUARTER				SOUTH EAST QUARTER				Section
	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	Totals
Sec 29 T 39S R 5W SLBM	7.2000	0.2000	23.2000	0.3000					21.1000								52.0000
Sec 30 T 39S R 5W SLBM								1.0000					20.0000		20.0000		41.0000

SUPPLEMENTAL GROUP NO. 612367. Water Rights Appurtenant to the following use(s):
85-350,351,352,353,354,355,356,357,358,359

###STOCKWATER: Group Total: 125 Stock Units Diversion Limit: PERIOD OF USE: 04/01 TO 12/31
Sole Supply for Stockwatering for 85-352 in this Group has NOT YET been evaluated

END OF DATA

STATE OF UTAH – DIVISION OF WATER RIGHTS – DATA PRINT OUT for 85-215

SPR 7

(WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/24/2006 Page 1

WATER RIGHT: 85-215 APPLICATION/CLAIM NO.: CERT. NO.:

OWNERSHIP

NAME: C. Burton Pugh
ADDR: 533 North 650 East
Lindon, Utah 84042

DATES, ETC.

LAND OWNED BY APPLICANT?
FILED: 08/08/1969|PRIORITY: 00/00/1864|PUB BEGAN: |PUB ENDED: |NEWSPAPER:
ProtestEnd: |PROTESTED: |No]|HEARNG HLD: |SE ACTION: [ ]|ActionDate: |PROOF DUE:
EXTENSION: |ELEC/PROOF:[ ]|ELEC/PROOF: |CERT/WUC: 08/08/1969|LAP, ETC: |PROV LETTER:
RENOVATE: |RECON REQ: |TYPE: [ ]

PD Book No. 1 Map: 5c

Type of Right: Diligence Claim Source of Info: Proposed Determination Status:

LOCATION OF WATER RIGHT

FLOW: 0.007 cfs SOURCE: Spring House Spring

COUNTY: Kane COMMON DESCRIPTION:

POINT OF DIVERSION:
(1)Stockwatering directly on spring located in SW4NW4 Sec 29, T39S, R5W, SLBM.
COMMENT: Administratively updated by State Engineer.

USES OF WATER RIGHT

SUPPLEMENTAL GROUP NO. 612093. Water Rights Appurtenant to the following use(s):
85-100,199,200,201,202,203,204,205,206,207,208,209,210,211,213,214,215

###STOCKWATER: Group Total: 250 Stock Units Diversion Limit: PERIOD OF USE: 04/01 TO 12/31
Sole Supply for Stockwatering for 85-215 in this Group has NOT YET been evaluated

SUPPLEMENTAL GROUP NO. 612269.
85-215

###DOMESTIC: 1 Family Diversion Limit: PERIOD OF USE: 01/01 TO 12/31

###PLACE OF USE:	NORTH WEST QUARTER				NORTH EAST QUARTER				SOUTH WEST QUARTER				SOUTH EAST QUARTER				Section
	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	Totals
Sec 29 T 39S R 5W SLBM			X														0.0000

PLACE OF USE for STOCKWATERING

	NORTH-WEST¼				NORTH-EAST¼				SOUTH-WEST¼				SOUTH-EAST¼			
	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE
Sec 29 T 39S R 5W SLBM			X:													

E N D O F D A T A

STATE OF UTAH -- DIVISION OF WATER RIGHTS -- DATA PRINT OUT for 85-353 SPR 8

(WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/24/2006 Page 1

WATER RIGHT: 85-353 APPLICATION/CLAIM NO.: CERT. NO.:

OWNERSHIP

NAME: Richard L. & Alecia S. Dame
ADDR: 1620 Georgia Ave.
Boulder City NV 89005-3643
INTEREST: 100% REMARKS: As Joint tenants

DATES, ETC.

LAND OWNED BY APPLICANT?
FILED: 04/27/1970|PRIORITY: 00/00/1889|PUB BEGAN: |PUB ENDED: |NEWSPAPER:
ProtestEnd: |PROTESTED: [No]|HEARNG HLD: |SE ACTION: [ ]|ActionDate: |PROOF DUE:
EXTENSION: |ELEC/PROOF:[ ]|ELEC/PROOF: |CERT/WUC: 04/27/1970|LAP, ETC: |PROV LETTER:
RENOVATE: |RECON REQ: |TYPE: [ ]

PD Book No. 1 Map: 5c

Type of Right: Diligence Claim Source of Info: Proposed Determination Status:

LOCATION OF WATER RIGHT

FLOW: 1.0 cfs SOURCE: Swapp Ranch Spring Area No. 4

COUNTY: Kane COMMON DESCRIPTION:

POINT OF DIVERSION -- SURFACE:
(1) S 1930 ft E 570 ft from NW cor, Sec 29, T 39S, R 5W, SLBM
Diverting Works: Source:

Stream Alt Required?: No

USES OF WATER RIGHT

SUPPLEMENTAL GROUP NO. 612366. Water Rights Appurtenant to the following use(s):
85-350,351,352,353

###IRRIGATION: Group Total: 93.0 acres Diversion Limit: 0.0 acft. PERIOD OF USE: 04/01 TO 10/31
Sole Supply for Irrigation for 85-353 in this Group has NOT YET been evaluated

###PLACE OF USE:	NORTH WEST QUARTER				NORTH EAST QUARTER				SOUTH WEST QUARTER				SOUTH EAST QUARTER				Section
	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	Totals
Sec 29 T 39S R 5W SLBM	7.2000	0.2000	23.2000	0.3000					21.1000								52.0000
Sec 30 T 39S R 5W SLBM								1.0000						20.0000		20.0000	41.0000

SUPPLEMENTAL GROUP NO. 612367. Water Rights Appurtenant to the following use(s):
85-350,351,352,353,354,355,356,357,358,359

###STOCKWATER: Group Total: 125 Stock Units Diversion Limit: PERIOD OF USE: 04/01 TO 12/31
Sole Supply for Stockwatering for 85-353 in this Group has NOT YET been evaluated

END OF DATA

STATE OF UTAH -- DIVISION OF WATER RIGHTS -- DATA PRINT OUT for 85-375

SPR 9

(WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/24/2006 Page 1

WATER RIGHT: 85-375 APPLICATION/CLAIM NO.: CERT. NO.:

OWNERSHIP

NAME: Darlynn and Arlene Sorensen
ADDR: P. O. Box 47
Orderville, UT 84758
INTEREST: 100% REMARKS: joint tenants

DATES, ETC.

LAND OWNED BY APPLICANT?
FILED: 01/29/1970|PRIORITY: 00/00/1864|PUB BEGAN: |PUB ENDED: |NEWSPAPER:
ProtestEnd: |PROTESTED: [No]|HEARNG HLD: |SE ACTION: [ ]|ActionDate: |PROOF DUE:
EXTENSION: |ELEC/PROOF:[ ]|ELEC/PROOF: |CERT/WUC: 01/29/1970|LAP, ETC: |PROV LETTER:
RENOVATE: |RECON REQ: |TYPE: [ ]

PD Book No. 1 Map: 5c

Type of Right: Diligence Claim Source of Info: Proposed Determination Status:

LOCATION OF WATER RIGHT

FLOW: 0.022 cfs SOURCE: Sorensen Ranch Spring No. 3

COUNTY: Kane COMMON DESCRIPTION:

POINT OF DIVERSION:
(1)Stockwatering directly on spring located in NW4NW4 Sec 32, T39S, R5W, SLBM.
COMMENT: Administratively updated by State Engineer.

USES OF WATER RIGHT

SUPPLEMENTAL GROUP NO. 612374. Water Rights Appurtenant to the following use(s):
85-362,363,364,365,366,367,368,369,370,371,372,373,374,375,377,378,379,380,381,382,383,384,385,386,387,388,389

###STOCKWATER: Group Total: 300 Stock Units Diversion Limit: PERIOD OF USE: 04/01 TO 12/31
Sole Supply for Stockwatering for 85-375 in this Group has NOT YET been evaluated

PLACE OF USE for STOCKWATERING

	NORTH-WEST¼	NORTH-EAST¼	SOUTH-WEST¼	SOUTH-EAST¼
	NW NE SW SE	NW NE SW SE	NW NE SW SE	NW NE SW SE
Sec 32 T 39S R 5W SLBM	* X: : : *	* : : : *	* : : : *	* : : : *

E N D O F D A T A

STATE OF UTAH -- DIVISION OF WATER RIGHTS -- DATA PRINT OUT for 85-355 SPR 10A

(WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/24/2006 Page 1

WATER RIGHT: 85-355 APPLICATION/CLAIM NO.: CERT. NO.:

OWNERSHIP**********

NAME: Julie Johnson
ADDR: PO Box 2063
Page AZ

NAME: James Johnson
ADDR: PO Box 2063
Page AZ 86040

NAME: Lloyd Johnson
ADDR: PO Box2063
Page AZ 86040

DATES, ETC.**********

LAND OWNED BY APPLICANT?
FILED: 04/27/1970|PRIORITY: 00/00/1889|PUB BEGAN: |PUB ENDED: |NEWSPAPER:
ProtestEnd: |PROTESTED: [No]|HEARNG HLD: |SE ACTION: [ ]|ActionDate: |PROOF DUE:
EXTENSION: |ELEC/PROOF:[ ]|ELEC/PROOF: |CERT/WUC: 04/27/1970|LAP, ETC: |PROV LETTER:
RENOVATE: |RECON REQ: |TYPE: [ ]

PD Book No. 1 Map: 5c

Type of Right: Diligence Claim Source of Info: Proposed Determination Status:

LOCATION OF WATER RIGHT**********

FLOW: 31.725 acre-feet SOURCE: Pulsifer Spring

COUNTY: Kane COMMON DESCRIPTION:

POINT OF DIVERSION -- SURFACE:
(1) N 460 ft E 450 ft from W4 cor, Sec 32, T 39S, R 5W, SLBM
Diverting Works: Source:

Stream Alt Required?: No

USES OF WATER RIGHT**********

SUPPLEMENTAL GROUP NO. 612367. Water Rights Appurtenant to the following use(s):
85-350,351,352,353,354,355,356,357,358,359

###STOCKWATER: Group Total: 125 Stock Units Diversion Limit: PERIOD OF USE: 04/01 TO 12/31
Sole Supply for Stockwatering for 85-355 in this Group has NOT YET been evaluated

SUPPLEMENTAL GROUP NO. 612369.
85-355

###IRRIGATION: 4.82 acres Diversion Limit: 0.0 acft. PERIOD OF USE: 04/01 TO 10/31

###STOCKWATER: 125 Stock Units Diversion Limit: PERIOD OF USE: 04/01 TO 10/31

###PLACE OF USE:	NORTH WEST QUARTER				NORTH EAST QUARTER				SOUTH WEST QUARTER				SOUTH EAST QUARTER				Section
	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	Totals
Sec 32 T 39S R 5W SLBM			X						X								0.0000

PLACE OF USE for STOCKWATERING**********

```
                              NORTH-WEST¼       NORTH-EAST¼       SOUTH-WEST¼       SOUTH-EAST¼
                              NW NE SW SE       NW NE SW SE       NW NE SW SE       NW NE SW SE
Sec 32 T 39S R  5W SLBM      *  :  : X:  *     *  :  :  :  *     * X:  :  :  *     *  :  :  :  *
```

SEGREGATION HISTORY

This Right was Segregated from , with Appl#: , Approval Date: / / under which Proof is to be submitted.

This Right as originally filed:

FLOW IN CFS	QUANTITY IN ACRE-FEET	IRRIGATED ACREAGE	STOCK (ELUs)	DOMESTIC (FAM - PER)	MUNICIPAL	MINING	POWER	OTHER
	32.625	5.0000	125					

5 AF duty area/stockwater supplemental 350/359, based on 9 month period of use

The following Water Rights have been Segregated from 85-355:

(1) WRNUM: 85-1011 0.9 0.1800
APPL#:
NAME: Lloyd Swapp Johnson, et al
FILED: 01/03/1996 STATUS:
APPR:
segregated for change to be filed

	CFS	ACRE-FEET	IRRIGATED ACREAGE	STOCK (ELUs)	DOMESTIC (FAM - PER)	MUNICIPAL	MINING	POWER	OTHER
85-355 currently has: -		31.725	4.8200	125					

All IRRIGATION has been SEGREGATED OFF.
All STOCKWATERING has been SEGREGATED OFF.

E N D O F D A T A

STATE OF UTAH – DIVISION OF WATER RIGHTS – DATA PRINT OUT for 85-1011

SPR 10B

(WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/24/2006 Page 1

WATER RIGHT: 85-1011 APPLICATION/CLAIM NO.: CERT. NO.:

CHANGES: a19658 Cert.

OWNERSHIP**********

NAME: Lloyd Johnson
ADDR: PO Box 2063
Page AZ 86040

NAME: James Johnson
ADDR: c/o Lloyd Johnson
PO Box 2063
Page AZ 86040

NAME: Julie Johnson
ADDR: c/o Lloyd Johnson
PO Box 2063
Page AZ 86050

DATES, ETC.**********

LAND OWNED BY APPLICANT?
FILED: 04/27/1970|PRIORITY: 00/00/1889|PUB BEGAN: |PUB ENDED: |NEWSPAPER:
ProtestEnd: |PROTESTED: [No]|HEARNG HLD: |SE ACTION: [ ]|ActionDate: |PROOF DUE:
EXTENSION: |ELEC/PROOF:[ ]|ELEC/PROOF: |CERT/WUC: 01/17/2001|LAP, ETC: |PROV LETTER:
RENOVATE: |RECON REQ: |TYPE: [ ]

PD Book No. Map:

Type of Right: Diligence Claim Source of Info: Certificate Status: Certificate

LOCATION OF WATER RIGHT**********

FLOW: 0.9 acre-feet SOURCE: Pulsifer Spring

COUNTY: Kane COMMON DESCRIPTION: South of Sink Valley

POINT OF DIVERSION -- SURFACE:
(1) N 462 ft E 440 ft from W4 cor, Sec 32, T 39S, R 5W, SLBM
Diverting Works: Source:

Stream Alt Required?: No

USES OF WATER RIGHT**********

SUPPLEMENTAL GROUP NO. 612106.

###DOMESTIC: 2 Family Diversion Limit: 0.9 acft. PERIOD OF USE: 01/01 TO 12/31

###PLACE OF USE:	NORTH WEST QUARTER				NORTH EAST QUARTER				SOUTH WEST QUARTER				SOUTH EAST QUARTER				Section Totals
	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	
Sec 32 T 39S R 5W SLBM				X						X							0.0000

SEGREGATION HISTORY**********

This Right was Segregated from 85-355, with Appl#: , Approval Date: / / under which Proof is to be submitted.

This Right as originally filed:

FLOW IN CFS	QUANTITY IN ACRE-FEET	WATER USES: IRRIGATED ACREAGE	STOCK (ELUs)	DOMESTIC (FAM - PER)	MUNICIPAL	MINING	POWER	OTHER

0.9 0.1800

**********E N D O F D A T A**********

APPENDIX 7-4

Coal Hollow Project

Water Engineering & Technology, Inc
Report

Geomorphical and Sedimentological
Characteristics of Sink Valley, Kane County
Utah

1. INTRODUCTION

Sink Valley is located in west-central Kane County, Utah, in the West Block of the proposed Alton Coal Project. The hydrologic behavior of the valley has been significantly modified by the capture of the upper part of the drainage basin (Dry Fork and Water Canyon) by Lower Robinson Creek. The surficial discharges passing through Sink Valley are now derived primarily from the unnamed tributary in Section 21 and from Swapp Hollow drainage basin. Within Sink Valley there is no continuous channel, but a continuous and deeply incised channel (Sink Valley Wash) exists downstream of the culvert on County Road 136 (Alton-Skutumpah).

The incision of Sink Valley Wash downstream of the road culvert post-dates the General Land Office Survey (Burrill, 1876). At the time of the survey, Sink Creek (his term for Sink Valley Wash) was 5 links (~ 3 feet) wide and 6 inches deep. In contrast, the present channel is about 69 feet wide and 23 feet deep. The diminutive size of the pre-incision channel in the comparatively narrow valley, about 2 miles downstream of the County Road 136 culvert, suggests that sheetflow, rather than confined channel flow, was the primary discharge mode. This observation tends to be supported by Gregory (1935), who described the area within Sink Valley as being swampy, and this is corroborated by the accounts of early settlers (Carroll, 1960).

1.1. Alluvial Valley Floor Definition

The regulatory definition of an alluvial valley floor is outlined in the Office of Surface Mining's (OSM, 1983), Alluvial Valley Floor Identification Guidelines, in which are laid down two sets of criteria (1) Geologic and (2) Water Availability. The geologic criteria are:

(a) a topographic valley with a continuous perennial, intermittent, or ephemeral stream channel running through it; and

(b) within that valley, those surface landforms that are either flood plains or terraces if these landforms are underlain by unconsolidated deposits (streamlaid); and

(c) within that valley, those side-slope areas that can reasonably be shown to be underlain by alluvium and which are adjacent to flood plain or terrace landform areas.

Specifically excluded from the OSM definition of alluvial valley floors are upland areas, which are defined as those geomorphic features located outside the flood plain and terrace complex, such as isolated higher terraces, alluvial fans, pediment surfaces, landslide deposits, and surfaces covered with residuum, mud flows or debris flows, as well as highland areas underlain by bedrock and covered by residual weathered material or debris deposited by sheetwash, rillwash, or windblown material.

On the basis of the geologic criteria it is apparent, therefore, that the requirement for an Alluvial Valley Floor determination is the presence of a continuous channel within a topographic valley, the floor

of which contains floodplain and terrace features that are underlain by unconsolidated streamlaid deposits that were deposited by the continuous channel. The flow regime of the channel may be perennial, intermittent or discontinuous. By the same criteria alluvial fans, areas underlain by bedrock and covered by residuum or colluvial deposits and surfaces covered by mud flows, debris flows or sheetwash deposits are not considered to meet the geologic criteria for alluvial valley floors.

Current regulations of the Utah Division of Oil, Gas and Mining (UDOGM) state that unconsolidated streamlaid deposits holding streams means, with respect to alluvial valley floors, all floodplains and terraces located in the lower portions of topographic valleys which contain perennial or other streams with channels that are greater than 3 feet in bankfull width and greater than 0.5 feet in bankfull depth.

1.2. Background

The results of previous investigations of Sink Valley reported in July 1987 (C.D.M., 1987) concluded that Sink Valley did not meet the regulatory definition of an alluvial valley floor for two reasons. First, there is no continuous stream channel through the valley. Second, the valley fill in Sink Valley is not streamlaid but rather was deposited by various processes including mudflows, debris flows, and sheetfloods that formed alluvial fans.

This information was presented to Utah Division of Oil, Gas and Mining (UDOGM) for their consideration. UDOGM concluded that further information was necessary before Sink Valley could be determined not to

be an AVF. UDOGM proposed that man's activities may have eliminated the continuous stream through Sink Valley. They suggested that further work be performed to identify whether there are continuous streamlaid deposits through the valley.

Second, they suggested that, while streamlaid deposits did not appear to be present on the surface, exploration drill holes have indicated the possible presence of streamlaid deposits at depth. They suggested that further information be submitted to determine whether the surface expression of possible streamlaid deposits has been obscured by recent development of alluvial fans or man's activities. Under this scenario careful subsurface investigations would identify the presence of streamlaid deposits at a shallow depth that have been overlain by more recent deposits.

Therefore, the objectives of this investigation of Sink Valley, that was conducted for the Nevada Electric Investment Company, under the supervision of Mr. Dean Williams of BHP-Utah International were: (1) to determine whether there were streamlaid deposits beneath the surface of the valley floor, and (2) to determine whether the alluvial fans, or man's activities had obscured a previously existing continuous channel that traversed the length of Sink Valley.

1.3. Methods of Investigation

This field investigation of Sink Valley was conducted between July 7, 1988 and July 17, 1988. Nine topographic cross sections (I to IX) were surveyed across the valley and two tributaries with an EDM-coupled

theodolite such that they were oriented perpendicular to the depositional axis of the valleys. The cross sections were tied to a common datum and fiducial point (10,000, 10,000): the section corner between Sections 19, 20, 29 and 30, T. 39S. R. 5W, where there is a monumented brass cap (EL. 6914 feet). The up-valley cross section (No. I) is located in Section 21, T. 39S., R. 5W and the down-valley cross section (No. IX) is located in Sections 5 and 6, T. 40S., R. 5W. The cross sections were surveyed in order to characterize the valley floor topography, and to provide ground surface elevations for the stratigraphic investigation (Drawings No. 1 to 9).

Stratigraphic data for the valley floor were obtained from bank exposures in the incised channels of Lower Robinson Creek and Sink Valley Wash, and from 28 backhoe pits. A total of 37 stratigraphic sections were measured and described in the pits and incised-channel banks. All of the pit and channel bank exposures were photographed.

In addition to the above, a debris flow lobe on the valley floor was roughly surveyed with a hip chain and Brunton compass. The axes of coarse clastic sediments on one of the debris flow levees were measured and recorded. A field reconnaissance of the Sunset Cliffs in Water Canyon was conducted to document the up-valley sediment source. These deposits and the source rocks were photographed. During the field investigation previously mapped discontinuous channel segments within Sink Valley (Harvey and Schumm, 1987) were field checked to determine their origin and continuity.

1.4. Geology

Sedimentary rocks associated with the Pausaugunt Plateau range in age from Jurassic to Recent (Fig. 1.1). In the Sink Valley area, sandstones and coal seams of the Cretaceous Dakota Formation are overlain by the slope forming Tropic Shale. The Tropic Shale consists of grey to brown argillaceous shale, which commonly erodes into badlands topography (Gregory, 1951). The Tropic Shale is approximately 750 feet thick in central Kane County (Doelling, 1972). Overlying the Tropic Shale, the Upper Cretaceous Straight Cliffs, Wahweap, and Kaiparowits Formations are composed of weakly cemented sandstones and minor arenaceous shales which reach a cumulative thickness of 1700 feet in the study area.

The Upper Cretaceous Kaiparowits Formation is unconformably overlain by the Eocene Wasatch (Claron) Formation, a sequence of basal conglomerate and pink and white limestone which is approximately 500 feet thick in the Sunset Cliffs above Sink Valley. The basal portion of the Wasatch Formation consists of a conglomeratic unit which ranges in thickness from 20 to 100 feet (Gregory, 1951). The unit contains rounded quartzite, chert, limestone, and volcanic clasts in a calcareous matrix. Clasts reach 3 feet in diameter on the rim of the Paunsaugunt Plateau (Gregory, 1951). The Wasatch Formation becomes sandy upsection (Doelling, 1972). Quaternary basalt flows are present south of Sink Valley, in the Bald Knoll and Buck Knoll areas.

Pre-Quaternary sediments of the Sink Valley area dip gently northeastward. Along strike, the lateral continuity of these units is

System	Series	Stratigraphic Unit			Thickness (Feet)	Description
Tertiary	Eocene	Claron Formation (Wasatch)			1000-1300	Pink, white, and varicolored limestone, cliff former eroding into picturesque slopes and forms, basal conglomerate of exotic quartzite and limestone cobbles and pebbles.
						Unconformity
Cretaceous	Campanian	Kaiparowits Formation			265-700	Dark gray to gray-green arkosic sandstone, friable with weak calcareous cementation.
						Unconformity
	Santonian ? Coniacian ? Turonian	Wahweap Formation *Minor Coal*			500-1300	Alternating sandy shale and thin- to thick-bedded resistant sandstone, ledge and slope topography.
		Straight Cliffs Formation *Minor Coal*			80-500	Yellow-gray to brown, thick-bedded to massive cliff-forming sandstone with subordinate intervening gray shale, shaley sandstone, *coal* and carbonaceous shale.
		Tropic Shale			700-1000	Drab gray shale with subordinate thin brown fine-grained sandstone, slope former.
	Cenomanian	Dakota Formation *Major Coal Seams*			150-450	Yellow-gray to brown fine- to medium-grained sandstone alternating with gray shale, sandy shale, carbonaceous shale and *coal*, ledge and slope former creating Gray Cliffs; best *coal* near bottom and top of unit.
						Angular Unconformity
Jurassic	Upper	Entrada Sandstone		Cannonville Member	0-300	White and reddish banded fine-grained sandstone and siltstone, friable and earthy weathering, massive.
				Gunsight Butte Member	0-300	Red-brown and light green siltstone; also red cross-bedded sandstone of the "slickrock" type.
		Carmel Formation		Wiggler Wash Member	0-60	Limestone, red siltstone, white and greenish gypsum.
				Winsor Member	180-250	White, pink, brown sandstone alternating with thin red siltstone and mudstone.
				Paria River Member	55-200	Interbedded light gray and red sandstone, limestone, siltstone, shale, and gypsum.
			Judd Hollow Tongue of Carmel	Thousand Pockets Tongue of Navajo Sandstone	0-60	Yellowish cross-bedded friable but resistant sandstone.
				Crystal Peak Member	120-190	Dark reddish brown and white to light gray fine-grained sandstone, medium-bedded with minor thin gypsiferous or calcareous shales and conglomerate.
				Kolob Limestone	122-350	Gray and tan dense limestone with some thin sandy red shale near the base and thin gypsum near top.
						Unconformity
	Lower	Navajo Sandstone			1000+	Light gray to tan, locally red fine-grained sandstone, massive, exhibiting large-scale aeolian cross-bedding, calcareous and cliff forming.

Figure 1.1. Generalized Section of Rock Formations in the Alton Coal Field (Doelling and Graham, 1972).

disrupted by two major northeasterly trending faults which bound the Paunsaugunt Plateau (Fig. 1.2). The Paunsaugunt fault marks the eastern boundary of the plateau and is located approximately 13 miles east of Sink Valley. The fault is generally normal and downthrown to the west. Offset along the Paunsaugunt fault ranges from 100 to 500 feet (Doelling and Graham, 1972).

The Sevier fault lies 3 miles west of Sink Valley, marking the boundary of both the Pausaugunt Plateau and the Alton coal field. The fault extends approximately 300 miles from south of the Grand Canyon to central Utah. The fault is normal and downthrown to the west. Total displacement on the Sevier fault ranges from 1000 to 2000 feet (Doelling and Graham, 1972).

The Bald Knoll fault runs parallel to the Sevier and Paunsaugunt faults, passing approximately 1 mile east of Sink Valley. The fault is normal and downthrown to the east. Total offset on the Bald Knoll fault may be as much as 500 feet (Doelling and Graham, 1972).

A topographic gradient which averages 600 ft/mile extends from the head of Sink Valley, up Water Canyon, to the top of the Paunsaugunt Plateau. The edge of the plateau consists of a steep 400 feet escarpment of Eocene Wasatch Formation known as the Sunset Cliffs. The cliffs have weathered into a large amphitheatre as a result of mass wasting of the Wasatch Formation. Massive debris flow and landslide deposits are present at the base of the cliffs. As a result, a large amount of debris which has eroded from the Sunset Cliffs has concentrated at the head of Water Canyon in a large debris flow-

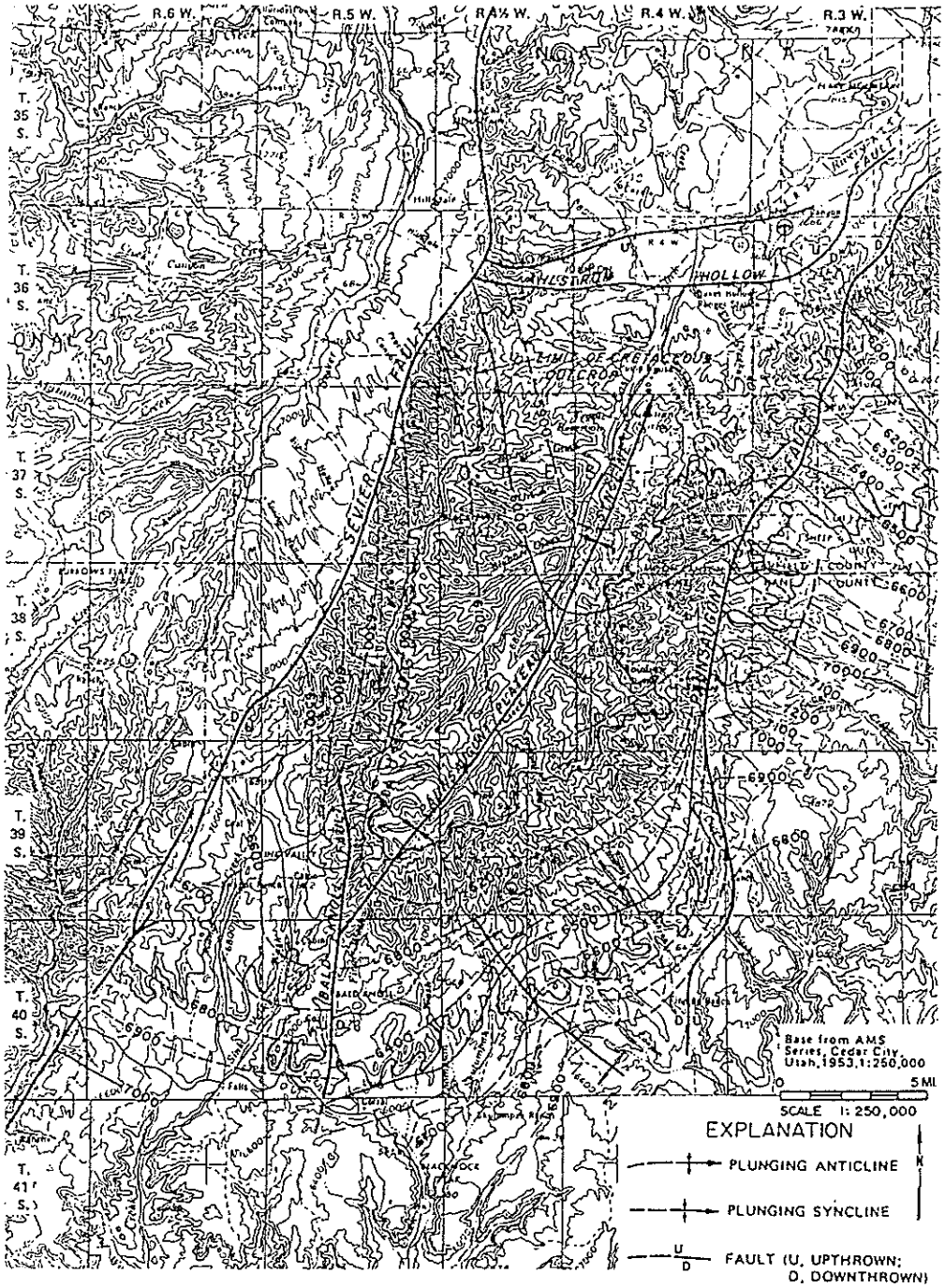

Figure 1.2. Generalized structure map, Alton coal field. (Doelling and Graham, 1972).

dominated fan. Subsequent events have remobilized and transported this material into Sink Valley, as evidenced by Sink Valley stratigraphic data presented in this report. Erosion as a result of mass wasting processes is characteristic of the Tropic Shale on the margins of Sink Valley.

Sink Valley lies on an erosional surface of Tropic Shale which, due to its lithologic character, has manifested itself into a relatively wide topographic depression in a region dominated physiographically by steep canyons in indurated sandstones. The margins of Sink Valley consist of laterally retreating Tropic Shale and a pediment. The pediment surface consists primarily of limestone, quartzite, and basalt clasts derived from the Wasatch Formation. Rounded clasts of quartzite and basalt on the pediments are derived from the basal conglomerate of the Wasatch Formation. The pediment gravels have provided a local source of coarse clastics during the most recent phase of Sink Valley deposition.

1.5. Alluvial Fan Literature Review

Previous studies of Sink Valley (Harvey and Schumm, 1987) indicated that the floor of Sink Valley was composed of alluvial fan sediments. Therefore, it is appropriate that a review of the alluvial fan literature be undertaken.

Numerous investigators have studied the sedimentology of alluvial fans. Although most research has been carried out on fans of arid regions, general controls on fan development may be extended to a range of climatic systems.

Reading (1978) described how alluvial fans develop in areas of high relief where an abundance of sediment exists. Deposition takes place when infrequent violent rainfall induces rapid erosion. Bull (1977) defines an alluvial fan as "a deposit whose surface forms a segment of a cone that radiates downslope from the point where the stream leaves the source area".

Climate plays a large role in alluvial fan development and sedimentation. Kochel and Johnson (1984) delineated four different fan types based on climate. Arid fans are characterized by periods of rapid deposition followed by long periods of inactivity. Humid-glacial fans consist of constantly shifting braided streams on an aggrading outwash plain. Humid-tropical fans reflect seasonal deposition by braided streams and debris flows, and humid-temperate fans are characterized by infrequent debris avalanching initiated by large rainstorms.

In general, alluvial fans form at the margins of steep basins due to a decreased confinement of streamflow (Bull, 1977). Deposition, is therefore, not due to a change in slope, but is the result of a rapid lateral expansion of sediment onto a fan surface (Reading, 1978). The reduction in lateral confinement which induces alluvial fan deposition is generally the result of base level lowering (Bull, 1977). An erosional base level reduction will generally produce a temporary thin fan, whereas tectonic base level lowering results in the development of a prolonged thick fan sequence (Bull, 1977).

High sediment supply is characteristic of alluvial fans. Therefore, the initiation of an alluvial fan may result from a climatic change

which increases rates of erosion. In addition, coarse unconsolidated materials on a fan surface will reduce downvalley surface discharges and promote deposition.

Three types of deposits are commonly found in small steep basins characteristic of alluvial fans: water floods, hyperconcentrated flows, and debris flows (Costa, 1988). Water floods behave as Newtonian fluids and, therefore, have no yield or shear strength. Waterflood deposits contain primary channels with width:depth ratios in excess of 12:1.

Sheetfloods are waterfloods on an alluvial fan surface. Sheetfloods are characterized by low viscosity flows which expand laterally at the downstream end of a confined channel onto a fan surface (Reading, 1978). They generally reflect upper flow regime conditions, and deteriorate into patterns of braided channels and bars which dissect the upper surface of the sediment sheet (Reading, 1978). Bull (1977) described sheetfloods as surges of sediment laden water which range in depth from 0.5 to 1.5 feet. The resultant deposit is a sheetlike unit of sand and gravel which may be traversed by shallow discontinuous channels which repeatedly divide and rejoin.

Hyperconcentrated flows are generally defined to begin at 40% sediment concentration by weight (Costa, 1988). Shear strength within hyperconcentrated flows is small but measurable (100-400 dynes/cm^2). The amount of fine material present in hyperconcentrated flows greatly affects fluid characteristics of the material, because shear stress is acquired very rapidly by clay rich deposits. Hyperconcentrated flows, also called noncohesive mudflows, mudfloods, and intermediate flows,

longitudinal profile found on many fans could be generated by both fluvial and mixed-mode (i.e., mudflow dominated) processes. Harvey (1984b) suggested that debris flow dominated fans are more likely to have numerous disconnected channel segments because of the greater irregularity of the fan surface. From the above discussion it is clear that fan sedimentology has important implications for understanding fan morphology, and this is especially true with respect to areas of local aggradation and degradation.

Experimental (Schumm et al., 1987) and field studies (Rust and Koster, 1984) of alluvial fans have shown that grain size generally diminishes in the down-fan direction such that the distal portion of the fan at any time is composed of the finest sediments (i.e., silts and clays). Schumm et al. (1987) suggested that a sharp break in the slope profile near the toe of the fan marks the point at which the silts and clays are deposited. Deposition of the fines forms a clay-rich basal layer over which the fan progrades through time. Progradation of the fan results in coarser sediments being deposited over the basal layer and therefore, at a given location on the fan the grain-size coarsens upwards. The net result of this type of sedimentation pattern would be confined or semi-confined flow within the fan. Because of the nature of depositional processes on alluvial fans, depositional units are more continuous longitudinally than they are laterally (Schumm et al., 1987) and, therefore, it is likely that subsurface flows will tend to follow the depositional axis of the fan. Galloway et al. (1979) showed that on alluvial fans groundwater recharge on the upper fan surface takes place

as a result of direct precipitation or infiltration of stream discharge. Groundwater discharge occurs in the lower fan region.

In contrast to laterally unconfined fans, the floors of valleys in the semi-arid regions of the western U.S. can be comprised of semi-confined valley alluvial fans that prograde down-valley (Patton, 1973; Patton and Schumm, 1975; Bergstrom and Schumm, 1981; Harvey, 1980; Schumm and Hadley, 1957; Laird and Harvey, 1986). In these valleys the flat-appearing alluvial-valley floors are irregular in the downstream direction. The processes that operate on the valley fans are very similar to those that have been described for the classical alluvial fans in semi-arid areas (Bull, 1964a, b; Denny, 1965; Hooke, 1967, 1968a; Lustig, 1965).

2. SINK VALLEY GEOMORPHOLOGY

The geomorphological characteristics of Sink Valley can be divided into three areas of concern: (1) the morphological characteristics of the valley itself, (2) the morphological characteristics of the valley floor, and (3) the spatial distribution and continuity of channels within Sink Valley.

2.1. Morphologic Characteristics of Sink Valley

The shape of Sink Valley is atypical of that of a valley formed in a uniform lithologic setting by fluvial processes. It is very evident that the resistance to erosion of the rock formations (Fig. 1.1) that comprise the margins of the valley has affected the shape of the valley. The rock formations bordering the valley margins are shown in Figure 2.1. From up-valley to down-valley the valley margins are composed of rock formations that get progressively older (Fig. 1.1). The upper reach of Sink Valley at the confluence of Dry Fork and Water Canyon (Fig. 2.1) is narrow and the valley margins at the elevation of the valley floor are composed of resistant sandstones of the Straight Cliffs Formation. Valley width is about 300 feet. Tropic shale forms the basin boundary for almost the remainder of Sink Valley in the down-valley direction. Valley width within the confines of the Tropic Shale, increases from 900 feet at cross section I (Fig. 3.1) to 3200 feet at cross section IV (Fig. 3.1) and then decreases to about 700 feet at cross section VIII (Fig. 3.1). The Dakota Fm. crops out down-valley from cross section VIII, and the valley width at cross section IX

(Fig. 3.1) is about 500 feet. The reduced valley width at this location is due to the resistance of Dakota Fm.

Field observation and aerial photograph analysis indicates that the shape of Sink Valley within the area whose margins are composed of Tropic Shale is strongly influenced by mass failure of the Tropic Shale. The distribution of mass failures in the Tropic Shale is shown in Figure 2.1. The mass failures are probably related to the distribution of faults (Fig. 1.2). The presence of mass failures on the perimeter of Sink Valley explains why the valley shape is atypical, but it also suggests that mass failure-derived deposits should make up a high proportion of the valley fill of Sink Valley.

The western margin of Sink Valley from where Lower Robinson Creek traverses the low relief outcrop of Tropic Shale to the area to the west of Swapp ranch (Fig. 2.1) is very subdued topographically. The Tropic Shale ridge and isolated remnants of Tropic Shale at the mouth of Swapp Hollow indicate that badland topography had formed on the Tropic Shale in Sink Valley and in the Lower Robinson Creek drainage basin. The eastern flank of the Tropic Shale ridge between Lower Robinson Creek and Swapp ranch has been buried by down-valley progradation of a valley fan. The western flank of this ridge, which is located in the Lower Robinson Creek drainage basin, forms a fairly steep and well defined escarpment. The southern extremity of the ridge is completely buried by sediments, and no Tropic Shale outcrop is visible at the ground surface. In fact at this location sheetfloods that are generated up-valley bifurcate into both lower Sink Valley and Lower Robinson Creek drainage basin. The

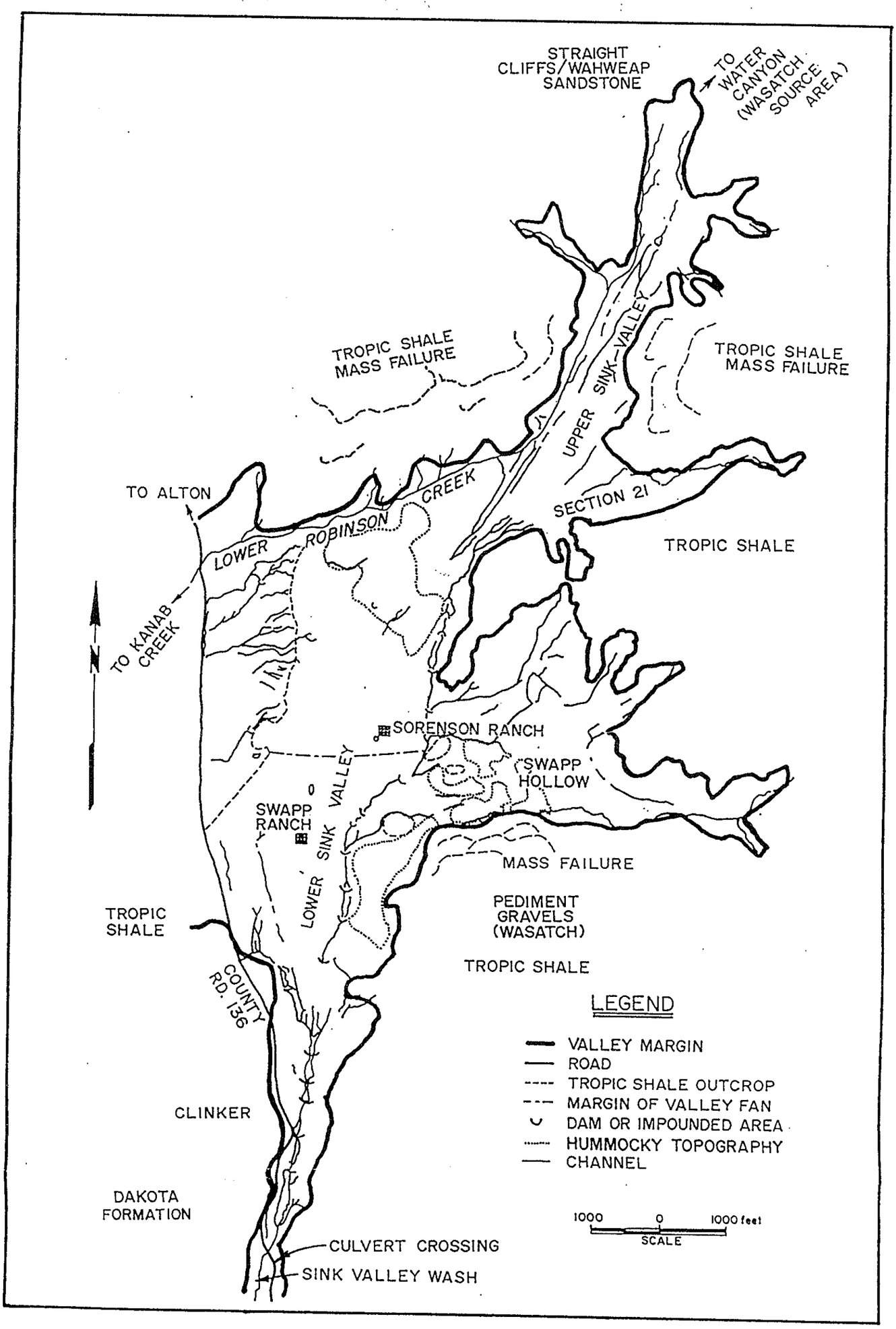

Figure 2.1. Map of significant features in Sink Valley.

western margin of Sink Valley has, therefore, been significantly modified by sedimentation in Sink Valley. The progradation of sediments onto the Tropic Shale outcrop has significantly affected the elevation of the water table within Sink Valley.

One further feature of the valley margin of Sink Valley has significant implications in terms of the valley fill sediments. A pediment surface is located on the south side of Swapp Hollow and it forms the eastern boundary of Sink Valley down-valley from the confluence with Swapp Hollow (Fig 2.1). The pediment was formed on Tropic Shale and it is capped by coarse-grained clasts that were originally derived from the Wasatch Formation. Mass failure of the Tropic Shale underlying the pediment and scarp retreat have introduced the coarse-grained Wasatch-derived clasts into Swapp Hollow and lower Sink Valley. Hillslope erosion processes and gullying of the valley walls are also introducing significant quantities of the coarse clasts to the floor of Sink Valley.

2.2. Valley Floor Morphology

The first indication that the floor of Sink Valley might be composed of a valley fan is seen on the Alton 7.5 min. Quadrangle (USGS, 1966). The 40-foot contour-interval map suggests that a fan-shaped body has prograded down valley from the confluence of Dry Fork and Water Canyon. Bull (1964) and Kochel and Johnson (1984) have demonstrated that there is a relationship between the size of the drainage basin and the surface area of the fan (Fig. 2.2). The fan area-drainage basin area

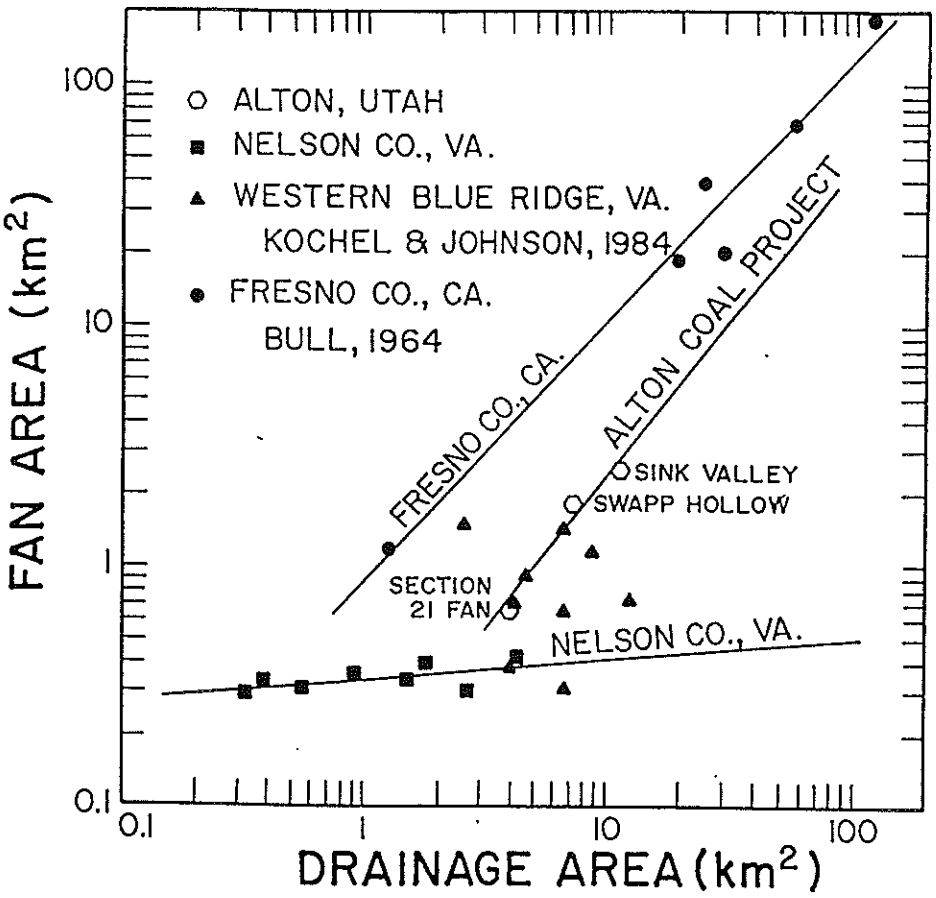

Figure 2.2. Plot of fan area versus drainage basin area for data sets from Fresno, CA, Nelson County, VA, and Sink Valley, Utah. (Figure modified from Kochel and Johnson, 1984).

relationships for three fans in the location of Sink Valley were determined from the USGS topographic map: (1) Sink Valley fan, (2) Section 21 fan, and (3) Swapp Hollow fan. These data were then plotted with the data from Bull (1964a) and Kochel and Johnson (1984) on Figure 2.2. The best-fit line for the Sink Valley data is sub-parallel to Bull's curve (Fresno, CA) and lies above the curve that fits the data for Nelson County, VA.

Two conclusions can be drawn from the data in Figure 2.2. First, there is a systematic relationship between fan and drainage basin areas in Sink Valley, which provides strong evidence that the floor of Sink Valley does contain a valley fan. The down-valley margin of the valley fan was determined from topographic and sedimentologic (Fig. 3.5) data (Fig. 2.1). It is evident that the valley fan is different morphologically from alluvial fans that were studied by previous investigators. The primary difference is one of shape. The conventional fan has a shape that is best described as a segment of a cone that radiates downslope from the point where the stream leaves the source area (Bull, 1977). The fan owes its existence to reduced confinement of the sediment and water discharges from the source area (Reading, 1978). However, the basic requirements for reduced confinement and a high supply of sediment are met in Sink Valley. Dry Fork and Water Canyon confluence in a reach of the valley whose width is narrow (~ 300 feet) and is controlled by outcrop of sandstones. Tropic Shale forms the valley margin down-valley from this location and the valley widens. The high sediment supply is derived primarily from the

Wasatch Formation in the Sunset Cliffs. The floor of Water Canyon is composed of numerous over-lapping debris flow deposits. Therefore, the confinement caused by the gradually widening valley has caused the fan to prograde down valley, but the fan area-drainage area relationship has been maintained. The rate of down-valley progradation of the fan must have been lower in the down-valley direction because the valley width increases significantly from about 300 feet at the head of the fan to about 3000 feet at the location of the fan toe at cross section V (Fig. 3.1).

The second conclusion that can be drawn from Figure 2.2 is that for a given drainage area the Sink Valley fans are larger than those in Nelson County, VA, but they are smaller than the ones in Fresno, CA. This may be due to differences in lithology of the source areas (Hadley and Schumm, 1961) but it may also be due to climatic differences. Mean annual precipitation at Alton, Utah is 16.56 ins. (CDM., 1987), which is intermediate between those in California and Virginia.

Longitudinal and cross-section profiles of Sink Valley were constructed from surveyed data to characterize the morphology of the valley floor. The longitudinal profile (Fig. 2.3) of the valley floor was constructed from the surveyed cross sections and the Alton Quadrangle. The profile extends from the base of the Sunset Cliffs in Water Canyon to cross section IX (Fig. 3.1). The irregular topography that is the result of the presence of over-lapping debris flow lobes in Water Canyon can be seen on the upper part of the profile. The profile of the valley floor shows clearly that the toe of the fan is located in

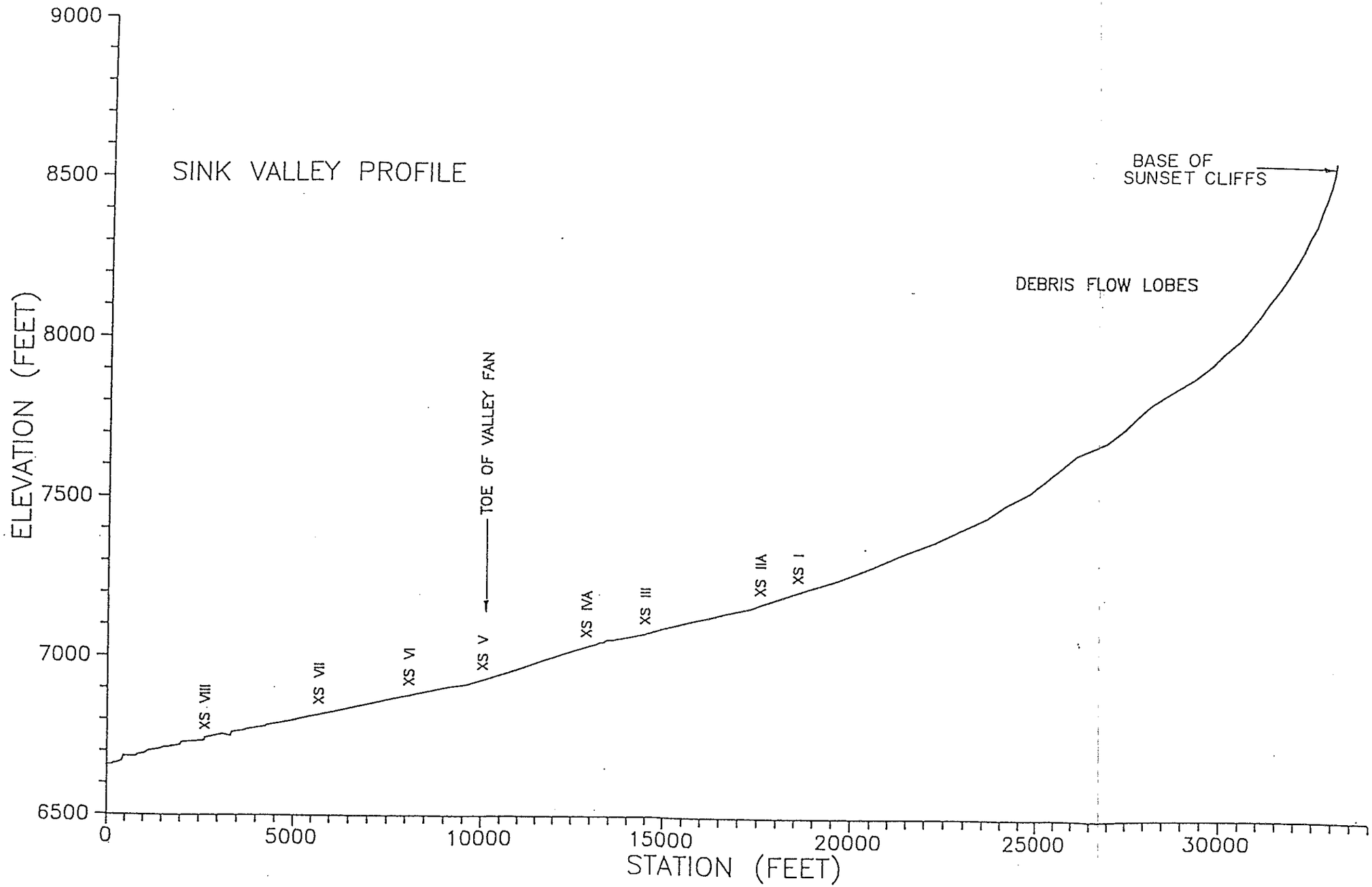

Figure 2.3. Longitudinal profile of Sink Valley showing the locations of surveyed cross sections.

the vicinity of cross section V, where there is a significant change in slope (Schumm et al., 1987). The crest of the fan is located between cross sections III and IVA.

The Sink Valley cross-section profiles (Fig. 2.4) further confirm the presence of a valley fan, and the effects on cross-section morphology of sediment contribution to the valley floor from valley margin hillslopes and tributary alluvial fans. The details of the cross-section morphology are more clearly seen on Drawings No. 1 to 9. Cross sections I and IIA show the irregularity of the valley floor in the upper fan region. Cross section III shows the cross-fan convexity very well, as does cross section IVA. Cross sections V and VI demonstrate that Swapp Hollow fan has prograded out onto the floor of Sink Valley. Valley wall contribution of sediment to the valley floor is clearly demonstrated in cross sections VII, VIII and IX.

2.3. Channels in Sink Valley

The locations of all the channels in Sink Valley are shown in Figure 2.1. With the exception of Lower Robinson Creek, Sink Valley Wash downstream of the culvert on County Road 136, and the incised former wagon road on the western margin of the lower reaches of the valley, the channels within Sink Valley are discontinuous. The majority of these channels have been either constructed, or modified, by local landowners. A number of the discontinuous channel segments are located on the eastern side of the valley between Section 21 tributary and the mouth of Swapp Hollow. These channel segments are located in areas that have

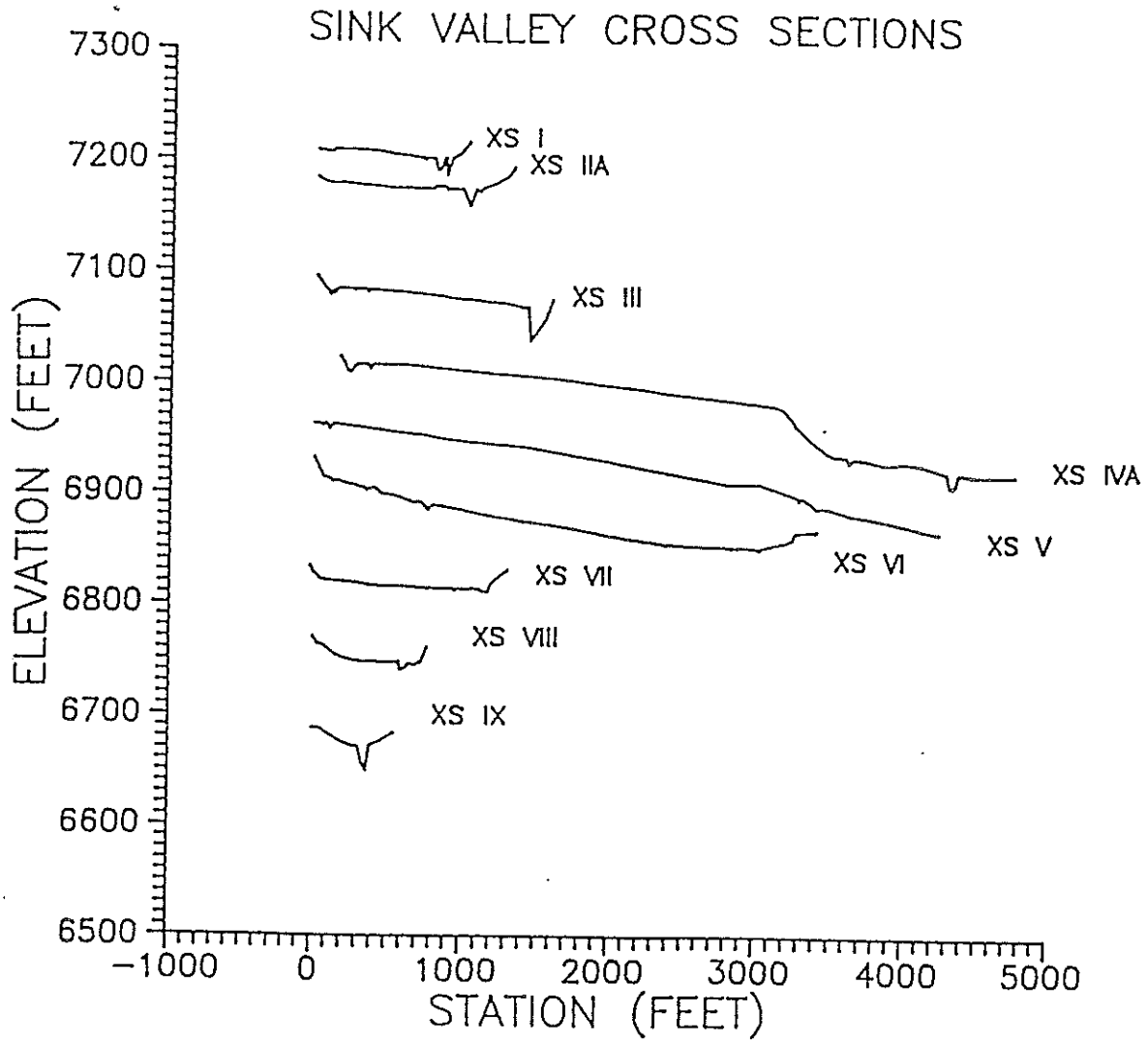

Figure 2.4. Cross-section profiles of Sink Valley.

been affected by localized sediment deposition on the medial part of the valley fan where aggradation and local oversteepening of the valley floor are to be expected (Harvey, 1987; Schumm et al., 1987). The presence of debris flow and mudflow deposits on the medial part of the fan can be expected to produce topographic irregularities on the valley floor which can lead to sheetflood concentration and, hence, the development of discontinuous gullies (Harvey 1984b). The absence of a continuous channel through Sink Valley is, therefore, further evidence that the valley floor is composed of a valley fan. The cross section profiles (Fig. 2.4: Drawings No. 1 to 9) show a strong cross-valley gradient to the west, and, therefore, if a channel was to be located through Sink Valley, it would be logical to find it towards the western part of the valley. Figure 2.1 shows that no such channel exists. Discontinuous channel segments are located on the valley floor south of the Swapp ranch where the valley narrows (Cross Section VI).

The incision of Kanab Creek (c. 1865) has significantly effected both Lower Robinson Creek and Sink Valley Wash by lowering their base levels which in turn has caused them to incise. The magnitude of the changes in these channels that was due to base level lowering can be seen by the changes that have taken place in Sink Valley Wash since 1876. Burrill (1876) states that Sink Creek, at a location that was down-valley from the culvert on County Road 136 (Fig. 2.1), was about 3 feet wide and 6 inches deep. In contrast the channel today is about 69 feet wide and 23 feet deep (see cross section IX, Fig. 2.4). There is little doubt that the culvert has prevented the bulk of the degradation

from migrating farther up-valley. However, the valley floor is being eroded by headcuts upstream of the culvert. Most of the headcut retreat appears to be related to sapping processes because of the high groundwater table. Undoubtedly when sheetfloods occur there is an element of surficial erosion of the gully headwalls.

The incision of Lower Robinson Creek has had a significant effect on both the sedimentology and morphology of Sink Valley, because Lower Robinson Creek has captured the headwaters of Sink Valley (Dry Fork and Water Canyon). Prior to capture the discharge from Sink Valley was delivered to Kanab Creek by Sink Valley Wash. Explicit evidence for the capture is provided by the sedimentological data.

There is no source of Wasatch-derived sediments in the pre-capture drainage basin of Lower Robinson Creek. Therefore, the Wasatch-derived sediments that were observed in the stratigraphic sections on the western end of cross section IVA (Figs. 2.4, 3.1) must have originated in Sink Valley. For these sediments to have been transported to Lower Robinson Creek drainage basin the divide between the two basins must have been overtopped. The intermittent presence of the Wasatch-derived sediments in the upper parts of the stratigraphic sections (measured sections #20, 14 , Fig. 3.1) indicates that this was not a continuous process, but rather it was related to discrete large magnitude events on the valley fan in Sink Valley. The fine-grained nature of the Wasatch-derived sediments indicates that they were fan margin sediments. Following incision of Lower Robinson Creek, and the burial of the eastern flank of the divide between the two basins by fan progradation,

floodflows that overtopped the divide would have been confined to the incised channel of Lower Robinson Creek. Flow confinement when coupled with the elevation difference between the top of the divide and the bed of the channel (approximately 60 feet; Fig. 2.4, cross section IVA) would have caused the channel to headcut through the divide, thereby initiating the capture of the Sink Valley headwaters.

The capture of the upper part of Sink Valley by Lower Robinson Creek has had significant effects on Sink Valley. First, following capture the discharge from the upper part of Sink Valley is now transported to Kanab Creek through Lower Robinson Creek which has reduced the discharge passing through Sink Valley. Second, the primary sediment source area for Sink Valley was Water Canyon. Capture has removed this source of sediments because the incised channel of Lower Robinson Creek at the confluence of Dry Fork and Water Canyon is now about 20 feet deep and 80 feet wide, and it is highly unlikely that there will be overbank discharge and sedimentation.

2.4. Summary of Geomorphological Characteristics of Sink Valley

The shape of Sink Valley and the valley widths are controlled by the resistance to erosion of the valley margin rock formations (Fig. 2.1). Where resistant formations (Straight Cliffs Fm., Dakota Fm.) crop out the valley is narrow (300 to 500 feet). Where the Tropic Shale crops out the valley is wide (700 to 3200 feet). Progradation of the valley fan has significantly modified the low relief western margin of Sink Valley. Mass failure of the Tropic Shale has contributed to the valley widening.

The presence of a valley fan within the floor of Sink Valley is confirmed by the valley floor topography. The longitudinal profile of the valley floor shows the presence of a fan-shaped body (Fig. 2.3), and the cross-sectional profiles show typical cross-fan shapes (Fig. 2.4). Confinement of the water and sediment discharges from upper Sink Valley has led to the down-valley progradation of a fan. The drainage area-fan area relationship developed by other investigators is supported by the Sink Valley data (Fig. 2.2).

No continuous channel that traverses the length of Sink Valley is present on the valley floor (Fig. 2.1). Discontinuous channel segments on the medial part of the fan are related to fan sedimentation. Base level lowering by the incision of Kanab Creek (c. 1865) has caused incision of both Sink Valley Wash and Lower Robinson Creek. Capture of the headwaters of Sink Valley by Lower Robinson Creek is attributable to both valley fan progradation in Sink Valley and incision of Lower Robinson Creek. The former eliminated the pre-existing drainage divide, and the latter caused sheetflood confinement into a single channel.

3. SINK VALLEY SEDIMENTOLOGY

In order to determine the sedimentologic characteristics of the valley fill deposits of Sink Valley, 9 cross sections (I to IX) were surveyed across the valley in orientations that are perpendicular to depositional strike (Fig. 3.1). Two cross sections (IIA, IVB) were surveyed across the mouths of tributary fans (Fig. 3.1). A total of 37 stratigraphic sections were measured and described along these cross sections; 5 on the banks of Lower Robinson Creek, 1 on the bank of Sink Valley Wash, and 31 in a total of 28 backhoe pits. The locations of the cross sections and measured stratigraphic sections are shown in Figure 3.1. Stratigraphic sections are compiled in Appendix I.

Measured stratigraphic sections are shown in relation to cross-sectional topography on the accompanying drawings, Nos. 1 to 9. All of the cross sections are oriented looking in a downvalley direction. Because the Cretaceous Tropic Formation weathers to dark brown silt and clay (10 YR 3/2 to 10 YR 4/4) whereas sediments derived from the Eocene Wasatch Formation are orange-red-brown in color (10 YR 5/4 to 10 YR 5/8) the two source areas were readily discernable in the valley fill stratigraphy. The Cretaceous sandstones are weakly cemented and hence do not resist chemical weathering as do the Wasatch sediments; as a result, the input of Cretaceous sandstone into Sink Valley generally consists of sands which are yellowish-grey in color (2.5Y 6/4).

The ability to delineate between Wasatch-derived, Tropic-derived, and Cretaceous sandstone-derived sediments is critical to the determination of sedimentation processes in Sink Valley. The Wasatch-

derived sediments in Sink Valley have been transported downvalley, whereas Tropic-derived sediments reflect a lateral component of deposition from the valley margins and tributary fans. The intermixing of the two types of sediment in a single depositional unit is indicative of surficial reworking of the valley fill. Cretaceous sandstone-derived sediments are primarily introduced to the valley floor of Sink Valley by the tributary fans and by hillslope processes.

3.1. Cross Section I (Drawing No. 1)

Cross section (XS) I is located in the upper portion of Sink Valley, where the valley is less than 1000 feet wide (Fig. 3.1). The two stratigraphic sections measured along Lower Robinson Creek are shown on the west side of the valley. Lower Robinson Creek consists of two channels along XS I. The bifurcation point of the channel is located approximately 100 feet upstream of the cross-section line. The thalweg of the east channel, at measured section (MS) #2, is located approximately 4 feet higher than the thalweg of the channel at MS #1. Where the main channel bifurcates upstream, the abandoned east channel contains a high concentration of boulders which consist of Wasatch-derived limestone, quartzite and conglomerate, which represent the leading edge of a debris flow. The boulders probably influenced the re-routing of the channel into the relatively erodible fine-grained deposits to the west. Subsequent incision of the west channel has perched the channel to the east.

Although several boulders present in the perched east channel are rounded, there is no evidence of reworking via conventional fluvial

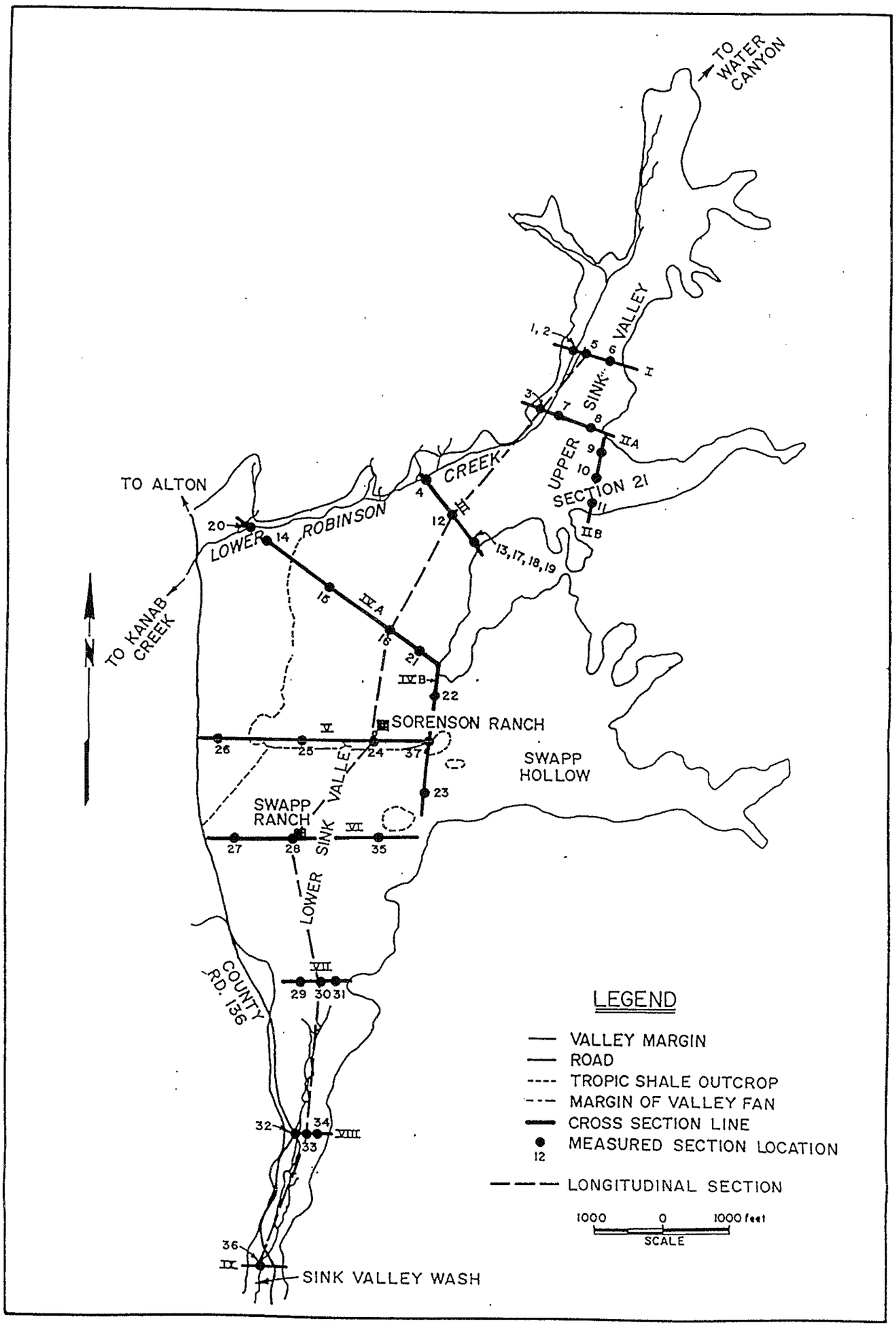

Figure 3.1. Locations of surveyed cross sections and measured stratigraphic sections in Sink Valley. Also shown is the longitudinal profile that was used to construct Figure 3.5.

transport. The rounded clasts are derived from the basal conglomerate of the Wasatch Formation, hence rounding occurred prior to this depositional cycle.

Measured section #1, on the west channel of Lower Robinson Creek, contains Wasatch-derived sand and minor gravel at its base which is overlain by a thick sequence of Tropic-derived silt and clay. Minor amounts of Wasatch-derived clasts are present within the Tropic sediments. The section is capped by Wasatch-derived silty sand. The thick sequence of Tropic-derived sediments is not present in MS #1, 78 feet to the east. The lateral thinning to the east of the unit as well as a high concentration of charcoal and dispersed pebbles suggests that the unit is a mudflow deposit from the western valley margin. Similar deposits exposed on the valley margins have been described by Harvey and Schumm (1987). The incorporation of Wasatch-derived pebbles reflects transport of the silt and clay over Wasatch-derived sediments. The valley margin is evident on the west side of XS I (Drawing No. 1); at station 9+00 the ground surface rises on Tropic Shale. The break in slope at station 9+50 probably represents a contact between intact Tropic shale to the west and mass wasted material to the east.

The lateral transport of sediment into Sink Valley from the valley walls is evident on the east end of XS I in MS #6. The base of the section is composed of both Tropic Shale and clasts of Cretaceous-age sandstone. The size of the sandstone boulder in MS #6 is striking (800 mm), because the poorly cemented nature of the sandstones generally favors chemical versus mechanical weathering (i.e., the sandstones break

down close to their source). Thus the association of Tropic-derived silt and clay with large clasts of Cretaceous age sandstone is indicative of rapid transport from a proximal source. The mass wasting of a sandstone block onto a Tropic Shale slope followed by transport of weathered shale by mudflow processes into the valley, provides a likely scenario for the observed deposit. Alternatively, the sequence represents two events; the deposition of a mudflow carrying sandstone boulders followed by a rockfall of Cretaceous age sandstone. The top of MS #6 contains thinly interbedded sands and clays of local derivation. These units represent lateral slopewash from the eastern bounding topographic high.

The mid-valley area of XS I consists primarily of Wasatch-derived sediments that reflect a transport direction oriented downvalley. MS #5 contains two Wasatch-derived coarse-grained horizons. The upper unit consists of a chaotic assemblage of matrix supported sand to boulder sized sediments which reach 170 mm in diameter. The unit pinches out to the west. Similar deposits are present in the lower portions of MS #1, #2, and #5. The matrix supported, chaotic nature of these units indicate downvalley deposition of Wasatch-derived sediments via debris flows. The absence of internal stratification, normally-graded bedding, and sorting indicates that deposition was not the result of fluvial processes.

The remainder of the sediments depicted on XS I consist of thinly bedded, structureless sands, horizontally laminated sands, and silt/clay drapes; these units are commonly separated by mud (silt/clay) drapes,

and the sand-mud couplets reflect deposition by shallow flow depth discrete events. The Wasatch-derived sands represent deposition during shallow sheetfloods on the fan surface, whereas the drapes document sediment deposition during recessional flows. Due to the narrowness of Sink Valley, a result of the presence of bounding Tropic Shale outcrops, distinct fan-margin facies were not present in the stratigraphic sections of XS I. The primary axis of deposition may be located generally at midvalley, where thick Wasatch-derived debris flow deposits are present (MS #5). This tends to be confirmed by the absence of Tropic-derived sediments in MS #5.

Cross section I (Fig. 3.1) effectively shows the complexity of Sink Valley sedimentation. Wasatch-derived sediments record downvalley transport directions, whereas deposits of Tropic Shale-derived sediments indicate mass wasting, and possibly sheetflow, from the valley margins. The sedimentary sequences described indicate deposition on an alluvial fan which, in the vicinity of XS I, is laterally confined by bounding topographic highs. Sedimentation at XS I has been dominated by down-valley transport of Wasatch-derived sediments by debris flow and sheetflood processes. The ubiquity of charcoal in the sediments indicates that fire has been a significant morphogenetic agent in this drainage basin. Fires followed by significant precipitation frequently result in the occurrence of debris and mud flows (Laird and Harvey, 1986).

3.2. Cross Section IIA (Drawing No. 2)

Cross section IIA (Fig. 3.1) is characterized by a predominance of Wasatch-derived sediments which range from thin clay/silt drapes to thick coarse gravels. The coarsest material observed in XS IIA is located on the west side of the valley in the left bank of Lower Robinson Creek. There, MS #3 contains 18 continuous feet of Wasatch-derived sediments. The section contains a basal gravel which consists of very poorly sorted gravel in a sandy silt matrix which displays faint inverse grading. The unit is overlain by interbedded gravels, sands, and silt drapes. Thirty-two individual events are distinguishable from the drapes in the section. The sand layers commonly contain trough crossbeds or coarse/fine couplets. These units are indicative of deposition by sheetflood; the sands containing coarse/fine couplets reflect shallow water flooding over the fan surface (Blair, 1986) and small-scale cross bedded sands are suggestive of deposition within an array of small braided channels on the fan surface during flood events. Silt drapes record the recession of discrete flow events. The distinctly bedded, cyclic nature of the sediments in MS #3, coupled with the presence of debris flow and sheetflood deposits reflect a typical vertical sequence of alluvial fan sediments.

The sediments of XS IIA fine eastward from Lower Robinson Creek, and at MS #8, only fine grained thinly bedded units are present. The eastward thinning and fining of individual units is coupled with an increase in Tropic-derived sediments. This relationship is due to the off-axis location of the section, where Tropic-derived sediments from

the valley slopes have been incorporated into the fan margin. A substantial portion of the units in MS #7 and MS #8 contain intermixed Wasatch- and Tropic-derived sediments, that reflect downfan reworking of the deposits on the fan margin.

The increase in Tropic-derived sediment on the east side of XS IIA is also due to the convergence of an alluvial fan from the east side of Sink Valley (Fig. 3.1), just downvalley from XS IIA in the vicinity of Section 21 (herewith referred to as the Section 21 fan). The Section 21 fan sediments are derived primarily from Tropic Shale and Cretaceous sandstones (see XS IIB), and deposition due to progradation of the fan has modified the depositional environment at XS IIA. The coalescence of the two fans has produced a topographically low area in the vicinity of MS #8 where slack-water sedimentation has produced the multiple-event deposits that are seen at the top of the section.

At MS #7, the upper 36 inches of the section document the presence of a mudflow deposit that was probably generated from the Tropic Shale outcrops on the margins of the valley. The mudflow travelled to at least the center of the valley.

The depositional axis of the Sink Valley fan in the vicinity of XS IIA is located on the west side of the valley, at the present location of Lower Robinson Creek. Displacement of the axis towards the west valley margin is due probably to the coalesence of the valley fan with the Section 21 fan. The convergence of the fans on the eastern side of the valley has produced a topographically low area on XS IIB that has resulted in considerable slack-water sedimentation. Mudflows generated

from the valley walls have the ability to travel a considerable distance into the valley (Costa, 1988).

3.3. Cross Section IIB (Drawing No. 3)

The absence of Wasatch-derived sediments is strikingly evident in XS IIB (Fig. 3.1), which traverses the distal margin of the Section 21 fan. As the drainage basin of the Section 21 fan does not include outcrop of Wasatch Formation, the deposits are relatively fine grained and are composed of Tropic Shale and Cretaceous age sandstone-derived sediment.

Small discontinuous channel segments are shown on XS IIA. They are located in the medial and distal parts of the fan, where discontinuous channels are to be expected (Harvey, 1984b; Schumm et al., 1987). The stratigraphic evidence in MS #9, 10, and 11, support the presence of the small scale discontinuous channels. One channel fill is present in MS #9, 3 are present in MS #10, and one is present in MS #11. The greater number of small-scale channel deposits in MS #10 tends to suggest that MS #10 is located along the depositional axis of Section 21 fan. Mudflow deposits are present in each of the measured sections, with higher frequency near the fan margins (MS #9, 11). Sheetflood deposits that consist of horizontally laminated and structureless sands that are separated by fine-grained silt/clay drapes are present in the three vertical sequences along XS IIB. The presence of ripup clasts and mudballs in all three sections argue for widespread reworking of surficial sediments that dry and crack between events.

3.4. Cross Section III (Drawing No. 3)

Cross section III (Fig. 3.1), located just downvalley from Section 21 fan, displays the effect of detrital input from Section 21 on Sink Valley sediments. The amount of Tropic-derived sediment increases markedly from XS IIA. In addition, coarse debris flow deposits are distinctly bimodal, with Wasatch-derived clasts included in a Tropic-derived silt/clay matrix (MS #12). The increased availability of silt and clay-sized sediments increases the viscosity of debris flows and thereby increases rates of sediment transport for a given event (Costa, 1988). The 4 measured sections on the east side of XS III represent 4 different localities in a single backhoe pit. In this pit, a paleotopographic surface that had formed on Tropic-derived mass wasted or sheetwash sediments is documented in the basal portions of MS #13 and MS #17. Sediments to the west of this surface are in tangential contact (i.e., lap onto) the Tropic-derived deposit. MS #17, MS #18, and MS #19 depict a convex paraconglomeratic unit which has eroded out a Tropic derived drape in MS #18. Sheetflood and minor channel features are common in the sand units in the four sections.

Measured sections #13, 17, 18 and 19 characterize the environment of deposition at this valley fan margin locality which is influenced by sediments that are derived from three sources; the valley wall, Section 21 fan and the valley fan. Sediments derived from the valley wall are characterized predominantly by fine-grained, Tropic-derived hillslope sheetwash and mudflow deposits. Mudflow and debris flow deposits that are derived from both the Wasatch source area and Section 21 fan make

up a significant portion of the sediments. Sheetflood deposits that include minor small-scale channel fills are generated by unconfined flood flows that are generated in the headwaters of both the valley fan and Section 21 fan drainage basins. Discontinuous channels are present on the eastern margin of XS III, and their presence is related to the relatively high rates of sedimentation at this locale, the result of sediment deposition from multiple source areas. The cross section demonstrates that the area around MS #13, 17, 18, 19, where the discontinuous channels are present, is a topographic high which indicates that the local valley slope is oversteepened and, it is, therefore, a logical location to find discontinuous gullies on a fan (Schumm, 1977; Schumm et al., 1987; Harvey, 1987).

The depositional axis of the valley fan at XS III is represented by MS #12. The stratigraphic column is dominated by debris flow and mudflow deposits that are separated by sheetflood deposits. The mudflow deposits can be subdivided on the basis of their sources. Where Wasatch-derived clasts are present, it is probable that the source area for the mudflow was Section 21 fan area, because the Wasatch-derived sediments were probably incorporated into the mudflow during the event. The source area for the Wasatch-derived clasts would have been the valley fan surface. In contrast, the mudflow deposits that do not contain appreciable quantities of Wasatch-derived clasts were probably generated on the eastern valley margin. Debris flow deposits contain sediments that were derived from both the Tropic Shale and the Wasatch Fm.

Both debris flows and mudflows produce irregular, hummocky terrain, and it is highly likely that this irregular terrain is responsible for producing some of the minor channel fills in the predominantly unconfined sheetflood deposits that cover the debris flow and mudflow deposits (Harvey, 1984b). Significant areas of hummocky terrain are located on the valley fan south of XS III. The spatial distribution of the coarser debris flow deposits is highlighted by the distribution of Gambol's oak (scrub oak) which has a preference for coarser grained deposits (Ed. Mogren, Forestry Department, Colorado State University, pers. comm).

During this field investigation one of the debris flow lobes that was located in the vicinity of XS III was mapped with a hip-chain and Brunton compass (Fig. 3.2). Raised ridges within the mapped lobe represent debris flow levees, and it was on the levees that very coarse grained cobble to boulder-size clasts were observed. Nineteen of the larger clasts were measured (Table 3.1), so that critical bottom velocity values (U.S.B.R., 1978) for initiation of motion under fluvial transport conditions could be calculated. For the range of clasts (b axis) in Table 3.1, the required bottom velocities ranged from 6.0 to 11.8 ft/sec. These velocities, which are conservative, are extreme for fluvial channels and therefore, it is unlikely that the clasts were deposited under fluvial conditions.

On the west side of XS III, the upper left bank of Lower Robinson Creek (MS #4) is characterized by thinly inter-bedded fine grained Wasatch- and Tropic-derived sediments which are indicative of a fan

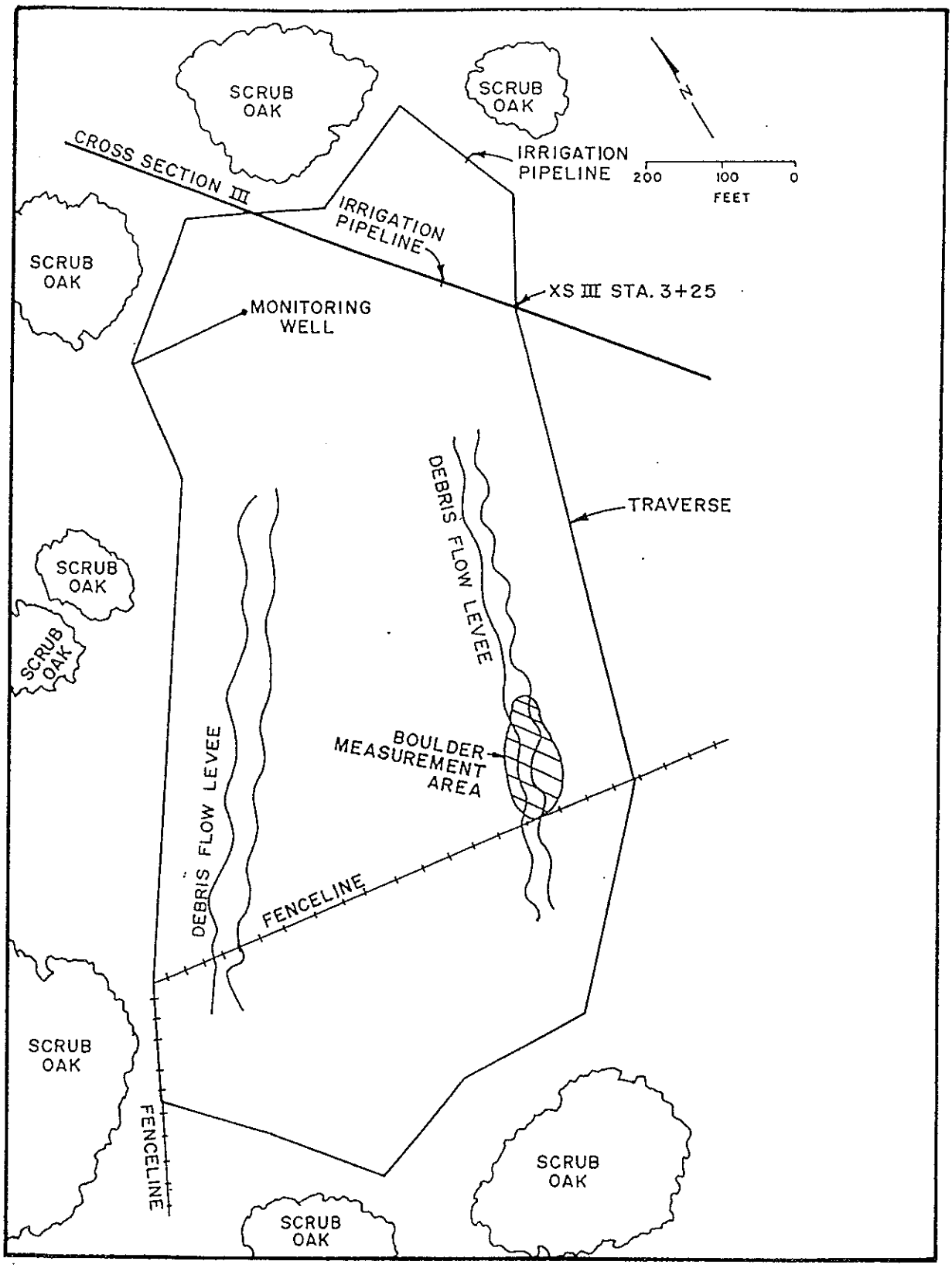

Figure 3.2. Map constructed from a Hip-Chain and Brunton compass survey of a debris flow lobe on the surface of Sink Valley.

Table 3.1. Boulder measurements on Sink Valley fan south of Cross Section III.

Sample No.	Clast Axes Dimensions (mm) A	B	C	Bottom[1] Velocity (ft/sec.)	Clast Lithology
1	320	160	90	6.7	sandstone
2	240	150	130	6.5	limestone
3	320	250	160	8.5	sandstone
4	230	190	150	7.3	sandstone
5	300	150	100	6.5	limestone
6	240	130	95	6.0	conglomerate
7	430	170	buried	7.0	sandstone
8	220	160	130	6.7	limestone
9	290	250	170	8.5	conglomerate
10	230	190	170	7.3	limestone
11	280	220	110	7.8	sandstone
12	290	170	130	7.0	conglomerate
13	330	190	130	7.3	limestone
14	400	260	200	8.6	sandstone
15	500	350	buried	9.8	sandstone
16	420	240	170	8.4	sandstone
17	330	210	180	7.6	limestone
18	480	310	260	9.4	conglomerate
19	700	500	240	11.8	sandstone

[1] Calculated from USBR (1978) using b axis diameter.

margin environment of deposition. A distinct cyclicity in the column reflects repeated relatively low energy deposition far off the axis of valley fan deposition (MS #12). The Wasatch-derived sediments of MS #4 are present only in the left bank of the channel; the right bank consists of only Tropic-derived sediments. Consequently, MS #4 is located at the extreme western margin of the Sink Valley Fan. This is supported by both topographic and sedimentologic evidence. Cross section III profile shows that the top of MS #4 represents the lowest elevation on the pre-incision cross section. This is consistent with a fan margin location because the cross profile of a fan in the medial location generally is convex (Bull, 1964b; Schumm et al., 1987). Sedimentologically, the evidence for a fan margin environment of deposition at MS #4 is fourfold. First, a comparison of grain size between MS #12 (depositional axis) and MS #4 shows that the sediments in MS #4 are much finer grained which can be expected in a fan margin environment (Rust and Koster, 1984). Second, a comparison of the grain sizes in MS #3 (XS II2A) and MS #4 also shows that the sediments in MS #4 are finer, which can be expected as one proceeds down-fan, (Blissenbach, 1954; Bull, 1964b; Rust and Koster, 1984). The third line of evidence for a fan margin environment of deposition at MS #4 is provided by the interbedding of Tropic Shale-derived and Wasatch-derived sediments. Sediments from both sources are fine grained and, therefore, it is unlikely that the Tropic-derived sediments originated from the eastern valley margin in the form of mudflows (c.f. MS #12).

The final piece of evidence that the sediments in MS #4 represent a valley margin environment of deposition is provided by the nature of the

contact between the Tropic-derived basal sediments and the overlying interbedded Tropic-derived and Wasatch-derived sediments that comprise the upper 6 feet of the section. Without doubt the Tropic Shale outcrop that forms the valley wall on the north side of Lower Robinson Creek is retreating today as a result of both mass wasting and sheet erosion processes, and there is no reason to believe that these processes were not active historically. Prior to the incision of Lower Robinson Creek, and progradation of the valley fan, channelized flow occurred from the Tropic Shale outcrop, across what is now Lower Robinson Creek, and southward into Sink Valley. Evidence for this is channel-shaped scour surfaces within the Tropic-derived basal sediments exposed in the banks of the left bank of Lower Robinson Creek (Fig. 3.3). The scour surfaces are oriented perpendicular to the present channel of lower Robinson Creek and prior to filling by the fan margin sediments it is likely that badland topography was present. The scoured channels have been filled by sediments derived from both the Tropic Shale and the Wasatch Formation. The interbedding of Tropic-derived and Wasatch-derived sediments in the upper part of MS #4 argues for discrete valley slope and valley fan events. On the slopes sheetwash was the transport mechanism whereas sheetfloods transported the sediments on the valley fan. Since there is no source of Wasatch Formation sediments on the north side of Lower Robinson Creek, the paleo-flow direction of the Wasatch-derived sediments must have been parallel or sub-parallel to the present course of Lower Robinson Creek, which makes the flow direction and, therefore, the direction of valley fan progradation sub-parallel to the depositional axis of the valley fan (MS #12).

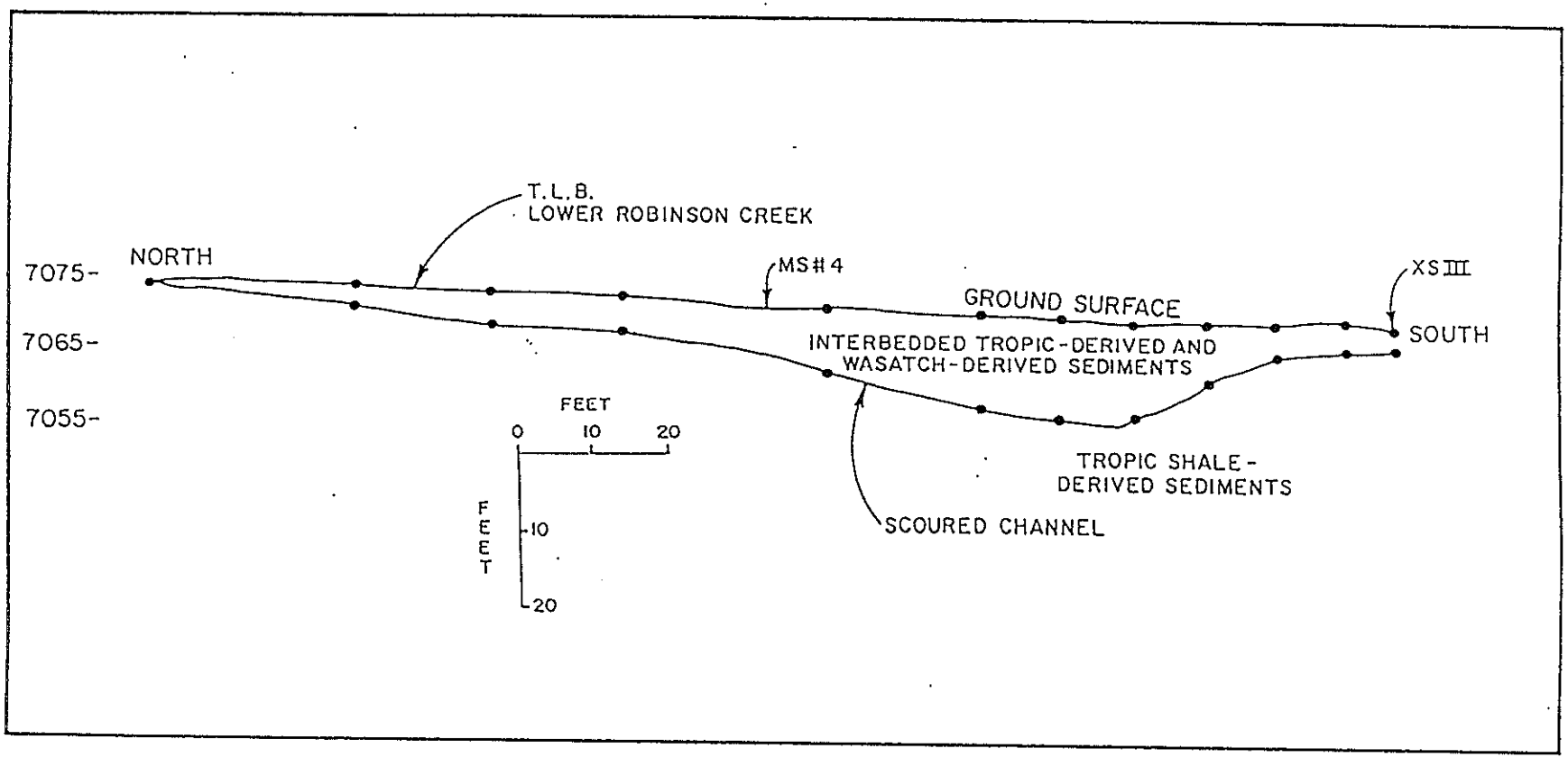

Figure 3.3. Cross section profile of a filled paleo-channel in the bank of Lower Robinson Creek in the vicinity of cross section III.

The measured sections along XS III provide very strong evidence to support the presence of a valley fan in Sink Valley. Sheetwash or mudflow deposits from the valley slopes contribute significantly to the valley fill on both the western (MS #4) and eastern (MS #13, 17, 18, 19) margins of the fan. The depositional axis of the valley fan contains significant mudflow and debris flow deposits which are characteristic of semi-arid fan sediments (Beaty, 1970). Sheetflood deposits and minor channel fills are deposited as a result of relatively shallow and unconfined flows. The absence of any laterally continuous channel deposits argues against the presence of a single major channel on the fan. Instead, it is highly likely that small discontinuous channels typical of the medial fan environment were present. The channels could originate as a result of local oversteepening of the valley floor due to high rates of local deposition (i.e., discontinuous gullies) or they could be the result of topographic irregularities caused by debris flow and mudflow deposits. The presence of a badland paleo-topography draining south into Sink Valley from the area to the north of the present location of the incised channel of Lower Robinson Creek is strong evidence that the valley fan prograded down valley and smoothed the topography. The presence on the fan surface of large cobble to boulder size clasts (Table 3.1) further argues for a non-fluvial transport mechanism.

3.5. Cross Section IVA (Drawing No. 4)

Cross Section IVA crosses the Tropic Shale ridge as shown in Figure 3.1. Due to the infilling of Sink Valley as a result of valley fan progradation, the ridge is characterized topographically by an escarpment which separates Sink Valley to the east and the lower Robinson Creek drainage to the west. The escarpment is approximately 50 feet high on XS IVA. The incision of Lower Robinson Creek through the north end of the ridge occurred just upvalley from XS IVA.

The two measured sections on the west side of XS IVA, MS #14 and MS #20, document the predominance of sheetwash transported, Tropic Shale-derived sediments in the Lower Robinson Creek drainage basin prior to capture of the upper drainage basin of Sink Valley. The presence of Wasatch-derived sediments records the overtopping by the Sink Valley fan of the Tropic ridge. Thus, two distinct sedimentologic phases are depicted within these sections. One is the initial overtopping of the Tropic ridge by the prograding valley fan, marked by the lowermost horizon of Wasatch-derived sand in MS #20. The second event recorded is the incision of Lower Robinson Creek and capture of a portion of the Sink Valley drainage basin. Following capture, the source of the Wasatch-derived sediments was removed from the valley fan as materials were transported down the new drainage. This event is stratigraphically located at the top of the section, because following capture by the incised channel of Lower Robinson Creek, it is highly unlikely that Wasatch-derived sediments could be deposited at the top of the section because of the depth of incision.

At the center of XS IVA, approximately 600 feet to the east of the Tropic ridge escarpment, the hydrologic complexity of Sink Valley becomes evident as the level of the water table is higher than the bottom of the backhoe pit. This emergence of groundwater is related to the impingement of the prograding valley fan sediments onto relatively impermeable Tropic Shale. In addition, the fine grained nature of the sediments overlying the water saturated horizon are indicative of both the down-fan fining of grain size and the fact that MS #15 is located off the major axis of fan deposition (MS #16) at the fan margin.

Measured Section #16 of XS IVA which is located towards the eastern side of the fan contains an excellent example of a debris flow deposit which was exposed in 3 dimensions in the backhoe pit. The coarse unit consists entirely of Wasatch-derived sediments which include boulders which reach 400 mm in diameter. The unit is matrix supported, very poorly sorted, and chaotic. The monolithologic nature of the unit suggests that it records a very large event which traversed a great deal of Sink Valley without being reworked and subsequently diluted by the inclusion of Tropic-derived silts and clays. The high frequency of debris flow and mudflow deposits in MS #16 indicates that the measured section represents the depositional axis of the valley fan. The vertical sequence is typical of a prograding fan in that it initially coarsens upwards and then fines upwards. The lowermost sediments probably represent fine grained fan toe deposits (Schumm et al., 1987). The debris flow and mudflow sediments represent progradation of a medial fan environment, and the upper sheetflood deposits represent deposition

on the back-slope of the fan crest. The mudflow deposits were probably generated from the Tropic Shale on the eastern valley margin. Minor channel fills within the section are located above and below debris flow deposits which tends to indicate that the debris flow deposits caused some channelization of the sheetfloods.

The east side of XS IVA consists of a section (MS #21) that contains laterally continuous, thinly bedded, fine grained deposits which are very similar to those of MS #8 on the east side of XS IIA. The two stratigraphic sections represent similar depositional sub-environments as they are both located up-valley of the point of coalescence between two alluvial fans. Both sections contain deposits indicative of low energy slackwater sedimentation. Consequently, each of the two alluvial fans which enter Sink Valley from the east (Section 21 and Swapp Hollow) must have produced sufficient sediment to prograde out onto the floor of Sink Valley, thereby creating a topographic depression which favored slackwater sedimentation.

The sedimentologic record preserved in the measured sections on XS IVA documents the down-valley progradation of the valley fan and it also highlights the role of the tributary fans. Progradation of the valley fan onto the Tropic Shale ridge, and the subsequent overtopping of the ridge are documented in MS #20 and MS #14. Both of these sections provide stratigraphic evidence that constrains the time of capture by Lower Robinson Creek of the upper drainage basin of Sink Valley, to within the period of time that Kanab Creek degraded (i.e., 1865). The fine grained and saturated sediments in MS #15 document the progradation

of the valley fan margin onto the Tropic Shale ridge and its effects on the elevation of the water table. MS #16 is located on the crest of the valley fan and it represents the axis of deposition which is characterized by a high frequency of debris flow and mudflow deposits. Progradation of Swapp Hollow fan onto the floor of Sink Valley created a topographically low area on the eastern margin of the valley fan that favored fine grained slackwater sedimentation (MS #21).

Cross section IVA (Fig. 3.1) shows an overall increase in the ratio of Tropic- to Wasatch-derived sediments relative to sections up-valley. Deposits are generally finer grained, although coarser horizons record large debris flow events. The combination of the down-valley transition towards the fan toe deposits with the onlapping of these fine sediments onto an impermeable bedrock ridge has induced the emergence of groundwater high in the stratigraphic section.

3.6. Cross Section IVB (Drawing No. 5)

Cross Section IVB (Fig. 3.1) traverses the mouth of Swapp Hollow fan from north (MS #22) to south (MS #23). Tropic-derived silts and clays constitute the majority of the sediments observed, however significant quantities of Wasatch-derived and Cretaceous sandstone-derived sediments are present as well. The Wasatch-derived sediments may have been emplaced from two sources. The finer grained sediments may represent sheetflood deposits formed as a result of large floods on the valley fan overtopping the toe of Swapp Hollow fan. The coarser grained sediments are derived from the pediment gravels that cap the Tropic Shale outcrop

to the east. Retreat of the Tropic Shale valley margins due to mass failure and gullying is delivering significant quantities of Wasatch-derived clasts to the valley floor.

An erosional remnant of Tropic Shale is present in the center of XS IVB. This outcrop is representative of the subsurface configuration of Sink Valley; the deposition of alluvial fan sediments has occurred on a surface of significant pre-existing relief. This shale is capped by pediment gravels which provide a local source of coarse rounded clasts, primarily limestone and quartzite of the Wasatch Formation.

In general the sediments exposed in the measured sections on XS IVB are fine grained and probably reflect the fine-grained nature of the proximal source rocks. Charcoal is abundantly distributed throughout the sections which indicates that fires have significantly affected fan sedimentation. The deposits in MS #22 reflect the predominance of local slope processes. The basal portion of MS #37 is composed of significant sheetflood deposits, but the upper portion contains significant mudflow deposits that include locally derived Wasatch clasts. MS #23 reflects mass failures of the Tropic Shale sediment on the south side of Swapp Hollow. The frequency of debris flow and mudflow deposits is higher in the upper portion of MS #37 and this probably correlates with the observed fairly recent mass failure deposits that are located up-fan from MS #23.

3.7. Cross Section V (Drawing No. 6)

Cross section V extends from the Lower Robinson Creek drainage basin in the west to the mouth of Swapp Hollow in the east (Fig. 3.1). The eastern end of the cross section is tied into MS #37 on XS IVB. This cross section provides further evidence for progradation of the valley fan and its effects on modifying pre-existing relief and drainage basin divides. Further, the effects of Swapp Hollow fan on the topography and sedimentologic characteristics of the valley floor are evident on this cross section. The sedimentologic evidence indicates that the toe of the valley fan is located in the vicinity of XS V, and this is supported by the valley slope and profile data (Fig. 2.3).

Measured section #26 documents the overtopping of the Tropic Shale ridge that formerly was the drainage divide between the Lower Robinson Creek drainage basin and Sink Valley drainage basin. The basal portion of MS #26 contains sediments that were primarily derived from the Lower Robinson Creek drainage basin prior to overtopping of the Tropic Shale divide. The coarser sandstone clasts were probably derived from local outcrops of the Dakota Formation. Wasatch-derived sediments document the down valley progradation of the valley fan. The upper portion of MS #26 is composed primarily of locally derived Tropic Shale sediments (sheetwash and mudflows), but the presence of Wasatch-derived sediments indicates that sheetfloods still transport valley fan sediments into this location. The sheetfloods that are generated up-valley split at a location between MS #26 and MS #27 because sedimentation has removed the divide between Sink Valley and Robinson Creek drainage basins. Part of

the flow and sediment travels down Sink Valley and the remainder enters the Lower Robinson Creek basin and is delivered to MS #26.

Measured section #25 is comprised mainly of finer-grained sediments that were deposited by sheetfloods in the distal portion of the valley fan (i.e., fan toe). The stratigraphic section shows an initial coarsening upwards trend followed by a fining upwards trend in the grain size. The sediments are dominantly Cretaceous sandstone-derived which suggests that Swapp Hollow was the source area. This tends to be supported by the cross section profile which dips fairly steeply to the west. The basal section of MS #25 is water saturated and this probably reflects the fact that sediments have prograded onto the Tropic Shale ridge at this location, a situation which is analogous to that at MS #15 (XS IVA).

Measured section #24 represents the depositional axis of the valley fan in a distal location. The sediments were transported down the valley fan and from Swapp Hollow fan. The basal portion of MS #24 contains mudflow deposits that appear to have originated from Swapp Hollow because they contain almost no Wasatch-derived sediments. Farther up section Cretaceous sandstone-derived sediments became more common and they consist of alternating horizontally laminated sand and drape units which are typical of discrete sheetflood events. The drapes tend to be composed of Wasatch-derived sediments. The interbedding of the sediments from the two source areas suggests that the mid section sediments represent events on both the valley fan and Swapp Hollow fan. The upper part of the section appears to be dominated by sheetflood and

mudflow sediments from Swapp Hollow, and this may be due to two causes. First, Swapp Hollow is proximally located with respect to the location of MS #24 and, therefore, it can be expected to exert considerable influence. Second, the relatively minor contribution of Wasatch-derived sediments may reflect the capture of the upper Sink Valley drainage basin by Lower Robinson Creek, thereby removing the source area.

The basal portion of MS #24 was water saturated. The reasons for the relatively high water table in MS #24 may be somewhat different from those responsible for the high water table in MS #25 and MS# 15. The high water table at the latter locations appear to be the result of fan margin sediments lapping onto impermeable Tropic Shale outcrop. The situation at MS #24 can probably be explained in terms of the fan dynamics and possibly by the geomorphic history of Sink Valley. The finest sediments on a prograding alluvial fan are located in the distal portion of the fan (Schumm et al., 1987). As the fan progrades coarser sediments are laid down over the silt-clay basal layer and, therefore, a perched water table can be formed. Groundwater tends to follow the depositional axis of the fan (Galloway et al., 1979) because depositional units are more continuous longitudinally than they are laterally (Schumm et al., 1987). Groundwater recharge takes place up-fan and discharge takes place in the lower fan region.

The high water table in MS #24 may also be related to the retreat of the valley margins. Isolated Tropic Shale remnants are located at the mouth of Swapp Hollow and there is little doubt that the Tropic Shale underlain pediment on the south side of Swapp Hollow is retreating

today. It is, therefore, conceivable that paleo-topography exists beneath the valley floor in the general location of MS # 24, and it is this relief that is causing the high water table. In this case the situations at MS #15, MS # 25 and MS #24 would be similar.

The eastern end of XS V is marked by MS #37 which has already been described (XS IVB). The basal part of the section is dominated by sheetflood deposits and the upper portion by mudflow deposits.

Cross section V (Fig. 3.1) is important as it documents the location of the toe of the valley fan and the progradation of the fan which resulted in elimination of the low-relief divide between Lower Robinson Creek drainage basin and Sink Valley drainage basin. The cross section profile, which dips to the west, indicates that significant cross-valley sediment transport has occurred from the Swapp Hollow drainage basin. All of the measured sections document the diminishing amount of Wasatch-derived sediments and the corresponding increase in the amount of Tropic-derived and Cretaceous sandstone-derived sediment. Further, the Wasatch-derived sediments are much finer than those encountered farther up-fan. The rather rapid dimunition of the size of the Wasatch-derived sediments and their reduced volumes in the stratigraphic sections argue very strongly for a non-channelized flow origin for the sediments along XS V. The coarse Wasatch-derived clasts in MS #37 were locally derived from pediment gravels that cap the Tropic Shale.

3.8. Cross Section VI (Drawing No. 7)

Cross section VI trends in an east-west direction across Swapp Ranch, and it is located where Sink Valley begins to narrow (Fig. 3.1). The western valley margin intersects outcrop of Tropic Shale, hence XS VI lies completely within the Sink Valley drainage basin. The narrowing of Sink Valley in the location of XS VI means that the valley slopes are contributing significant quantities of sediment to the valley floor and this is expressed in the stratigraphic sections.

Measured section #27 is located on the western margin of the cross section in the topographically lowest part of the cross section. Small discontinuous gullies are present on the valley floor and this probably reflects the confinement of the sheetfloods by the narrower valley. The sediments in MS #27 are fine grained and they reflect sheetwash deposition from the Tropic Shale outcrop to the west and sheetflood deposition from a down-valley direction. MS #27 is located south of the area where sheetfloods bifurcate into Lower Robinson Creek drainage basin and into Sink Valley. The interbedding of fine-grained Tropic-derived and predominantly Wasatch-derived sediments can probably be related to hillslope and valley events. Saturation of the basal part of MS #27 is probably due to the emergence of valley fan groundwater down valley from the toe of the fan and to the fact that sediments in MS #27 lap onto the Tropic Shale basin boundary.

Measured section #28 is located in the approximate center of the valley, and, therefore, it probably is representative of the depositional axis of the valley. Although it is located in the center

of the valley it is apparent that sediments derived from the eastern valley margin have significantly affected the sedimentological characteristics of the valley fill. The topographic cross section which dips to the west strongly confirms the observation. The basal part of the section is composed of horizontally laminated sands derived from Cretaceous sandstones in Swapp Hollow. The most noticeable depositional unit in MS #28 is the large, matrix supported debris flow deposit. The relatively coarse-grained Wasatch-derived sediments originated from the pediment gravels on the eastern valley margin. The generally coarser sediments in MS #28 probably can be attributed to the progradation of a lobe of Swapp Hollow fan onto the valley floor. This is supported by the cross section profile which shows a relatively steep (0.03) cross-valley gradient between MS #28 and MS #35. A relatively high water table was observed in MS #28, and it appeared to be perched on top of a mudflow deposit. Flow rates into the pit were very high.

Measured section #35 appears to be located on a former lobe of Swapp Hollow fan. Abandonment of this lobe may be related to the presence of the mass failure debris that is located up-fan on the southern margin of Swapp Hollow fan. The basal part of the section contains a mudflow deposit that is overlain by numerous sheetflood deposits that contain minor small-scale channel fills. Debris flow and mudflow deposits predominate in the upper part of the section. The coarse Wasatch-derived clasts must have been derived from the eroding hillslopes that form the eastern valley margin of this cross section. Field observation of the valley margin hillslopes showed that considerable quantities of

Wasatch-derived pediment gravels mantle the hillslope and they are also concentrated in hillslope gullies that are discharging to the valley floor.

Comparison of the size of the Wasatch-derived sediments across XS VI shows a marked fining in the westward direction. The coarsest sediments are located in MS #35 and the finest are found in MS #27. However, the ground surface elevation at MS #35 is 6903 feet, whereas that at MS #27 is 6851.9 feet, a difference of about 51 feet. It is highly unlikely that a channel, if one ever existed, would be located at the higher elevation on the valley cross profile. The cross-valley gradient would argue for a channel location in the lowest part of the valley where flows would be most confined. The fine grained nature of the Wasatch-derived sediments at MS #27 does not provide evidence of channelized flow, but rather it argues for unconfined sheetflows.

3.9. Cross Section VII (Drawing No. 8)

The valley width at XS VII (~ 1200 feet) is about half of that at XS VI, and the narrowing is an expression of the changing lithology at the basin margins (Fig. 3.1). The Dakota Fm, which is more erosion resistant than the Tropic Shale controls the width of the valley. Because of the topographic confinement, flow confinement occurs at this location and, therefore, the probability of having confined channel flow is high. However, only minor discontinuous channels are present on the valley floor. The larger channel on the western margin of the valley is at the location of the old Alton-Skutumpah wagon road which appears to

have incised relatively recently, probably as a result of flow concentration in the wagon wheel ruts.

Morphologically and stratigraphically XS VII is heavily influenced by valley margin contribution of sediments. On the eastern margin (MS #31), a detrital cone extends from the base of the hillslope for a distance of about 500 feet onto the valley floor. The basal sediments in MS #31 are sandy and they are water saturated. The absence of any sedimentary structures, other than horizontal laminations, in a relatively thick interval of well sorted sand indicates that these are sheetflood deposits. The remainder of MS #31 is comprised of hillslope derived sediments that encompass debris flow deposits, mudflow deposits and sheetwash deposits. The coarse Wasatch-derived sediments in the debris flow deposit are derived from the local pediment gravels.

MS #30 is located at the toe of the detrital cone. It reflects some valley margin sediment contribution, especially in the upper part of the section, which documents the progradation into the valley of the detrital cone. The lower part of the section appears to be composed of sheetflood deposits, as the sand units do not have structures other than horizontal laminations. The absence of cross-bedded structures in the relatively thick sand units argues for unchannelized flow conditions. The yellowish color of the sands in both MS #31 and MS #30 suggests that they were derived from the Cretaceous age sandstones that crop out in Swapp Hollow drainage basin rather than from an up-valley source such as the Wasatch Formation. The basal portion of MS #30 was water saturated.

Measured section #29 is located in the middle of the non-hillslope-modified part of the valley floor. The sediments in the base of the

section are similar to those in the basal portions of MS #31 and MS #30. The sands are water saturated. A mudflow deposit overlies the basal sand unit (Cretaceous Sandstone-derived). It could have been derived from either valley wall, but the presence of minor amounts of Wasatch-derived sediments in the mudflow deposit argues for an eastern source area. The remainder of the sediments in MS #29 are comprised primarily of fine grained Wasatch-derived silts and sands that are sheetflood deposits. The section appears to be capped by hillslope-sourced Tropic Shale-derived sheetwash deposits.

The stratigraphic data from XS VII indicate that the valley margins are significant source areas for the sediments. The relatively minor amounts of Wasatch-derived sediments and their fine grained nature in the stratigraphic sections further indicates that these sediments were not transported by channels that were continuously linked to their source area. The Wasatch-derived sediments were delivered to this lower valley location by periodic sheetflood events and their greater frequency in the upper parts of the stratigraphic sections provides evidence for valley fan progradation. The coarser Wasatch-derived clasts that are located in the eastern measured section (MS #31) were derived from a local source, the pediment. The yellow basal sands sections of the three measured sections indicate that Swapp Hollow drainage basin was probably the major source of sediments prior to valley fan progradation down Sink Valley, because the yellowish sands were derived from Cretaceous age sandstones. The absence of cross-bedding in the sands indicates strongly that the sands were transported by unconfined sheetfloods.

3.10. Cross Section VIII (Drawing No. 9)

The valley width at XS VIII (Fig. 3.1) is about 700 feet, but a detrital cone at the base of the hillslope on the eastern valley margin extends about 200 feet onto the valley floor. Sediments derived from the Dakota Formation on the western valley margin have been transported into the valley floor by slopewash processes. They include fragments of reddish colored clinker, the result of coal seam burns within the Dakota Formation.

Measured Section #34 is located at the toe of the detrial cone on the eastern side of the valley. MS #34 reflects considerable valley margin contribution of sediment in the form of both Tropic-derived and locally Wasatch-derived sediments. Coarse locally derived Wasatch clasts were observed on the surface of the detrital cone to the east of MS #34.

Measured section #33 is located in the middle of the valley. The basal part of the section contains numerous sheetflood deposits that contain clasts that were locally derived (i.e. Dakota SS and clinker chips) and those that may have been transported down valley (Wasatch), or from a local source such as the pediment (Wasatch). The base of the section was water saturated. The remainder of the section consists of interbedded sheetflood and locally derived sheetwash and mudflow deposits.

Measured section #32 is located to the east of a major incised channel on the western margin of the valley. The incised channel is in the former location of the Alton-Skutumpah wagon road, and it is

currently dammed. The basal portion of MS #32 contains a number of Wasatch-derived silt drapes which may reflect unusually large sheetfloods on the prograding valley fan. The remainder of the sediments in MS #32 are very fine grained and they contain abundant locally derived clinker and sandstone clasts. The coarser units were probably derived from the local hillslopes in the form of mudflows and debris flows. The base of the section was water saturated.

The small fraction of the total sediments that are exposed in the measured sections along XS VIII that were derived from Wasatch sources argues against channelized delivery of Wasatch-derived sediments to the lower valley region. Sediments in the valley fill appear to be strongly influenced by local sources.

3.11. Cross Section IX (Drawing No. 9)

The valley width at XS IX (Fig. 3.1) is about 500 feet. A small alluvial fan on the eastern valley margin has prograded out onto the valley floor for a distance of about 250 feet. Another small alluvial fan has prograded onto the valley floor from the western valley margin about 300 feet upstream of MS #36. Therefore, it is evident that sedimentation on the valley floor is very strongly influenced by valley margin sources. On the eastern valley margin coarse clastic sediments derived from the pediment gravels and outcrops of Dakota sandstone are being introduced to the valley floor. On the western valley margin the coarse clastics are derived from the Dakota sandstone.

Measured section #36 is located on the true right bank of the incised channel of Sink Valley Wash. The lowermost 14 feet of the

section is composed of shale-derived sediments, which include minor clinker chips. The frequency of occurrence of Wasatch-derived sediments increases up-section which suggests that the Wasatch-derived sediments were not available for deposition until late in the valley aggradation cycle which preceeded the incision of Sink Valley Wash, the result of base level lowering due to the incision of Kanab Creek. The upper part of MS #36 is dominated by interbedding of locally and down-valley-derived fine grained sediments.

There is no doubt that the bed of the currently incised channel of Sink Valley Wash contains significant quantities of coarse-grained clasts. It might be argued that they represent part of the valley fill. However, the field evidence indicates that the coarse clasts were locally derived and concentrated in the bed of the channel as a result of the processes of channel incision and incision-induced channel widening. The absence of coarse Wasatch-derived clasts in the measured sections up-valley (i.e., MS #32, MS #33, MS #27) indicates that the coarse clasts in the bed of the incised channel must have been locally derived. The majority of the coarser clasts were derived from the Dakota sandstone, but the quartzite, basalt and limestone clasts were derived from the pediment gravels on the eastern margin of the valley.

3.12. Summary of Sink Valley Sedimentology

The surveyed cross sections (9) and measured stratigraphic sections (37) in Sink Valley document a very complex valley fill. However, the very distinctive nature of the three principal sediment source

lithologies enable the sedimentology to be interpreted with a relatively high degree of confidence. Sedimentation in Sink Valley has significantly modified pre-existing relief in the basin and it has had a significant effect on flow distribution between Sink Valley drainage basin and the drainage basin of Lower Robinson Creek. A pre-existing drainage divide between Sink Valley and Lower Robinson Creek has been eliminated by stream capture and by burial of the divide. Sedimentation in the upper portion of Sink Valley has been the result of the down-valley progradation of a valley fan. This fan differs from more conventional alluvial fans in terms of its shape, but it has similar sedimentologic characteristics (Beaty, 1970; Costa, 1988).

The sedimentologic and morphologic characteristics of the valley fan have been in essence frozen by the capture of the Wasatch Formation source area by Lower Robinson Creek, which is deeply incised. Currently, sediments eroded from the Sunset Cliffs in Water Canyon are transported down-valley in this incised channel. An incised channel exists to the base of the Sunset Cliffs in Water Canyon, but the sediments eroded from the cliffs are being transported down Water Canyon principally as very coarse-grained debris flows. The debris flows, however, currently are unable to reach the valley fan in Sink Valley because of the presence of the incised channel. Channelized debris flow deposits were observed in the bed of the abandoned channel segment (east) of Lower Robinson Creek at XS I. It is reasonably certain that the capture by Lower Robinson Creek was related to the incision of Kanab Creek (c. 1865) and, therefore, it is likely that the morphologic and

sedimentologic characteristics of the valley fan represent events prior to the time of capture.

The dominant source rocks that contribute sediment to Sink Valley change along its length (Fig. 3.4). Cross section I (Fig. 3.1) sediments are predominantly Wasatch-derived and reasonably coarse grained. Sheetflood deposits with minor channel fills and debris flow deposits dominate the valley fill (MS #5). Valley margin influences are seen in MS #6 and MS #1 where sheetwash, mudflow and possibly gravity processes contribute sediment from the Tropic Shale and Cretaceous age sandstones. Cross Section II (Fig. 3.1) sediments are predominantly Wasatch-derived and consist of sheetflood and debris flow deposits (MS #3). Lateral contribution from the Tropic Shale is documented by a mudflow deposit in MS #7. The interbedded Wasatch-derived and Tropic-derived fine grained slackwater sediments at the top of MS #8 document the progradation of Section 21 fan onto the floor of Sink Valley and the displacement westward of the depositional axis of the valley fan (MS #3). Cross Section IIB (Fig. 3.1) across the mouth of Section 21 fan documents the delivery of both fine-grained (silt/clay) Tropic-derived sediments to the valley fan and yellowish-grey sands derived from the Cretaceous age sandstones.

Cross Section III (Fig. 3.1) documents the influence of Tropic-derived sediments on the character of the deposits along the depositional axis of the valley fan (MS #12). Mudflow and debris flow deposits dominate this cross section. Valley margin contribution of sediment to Sink Valley is evident in the eastern margin of the fan (MS

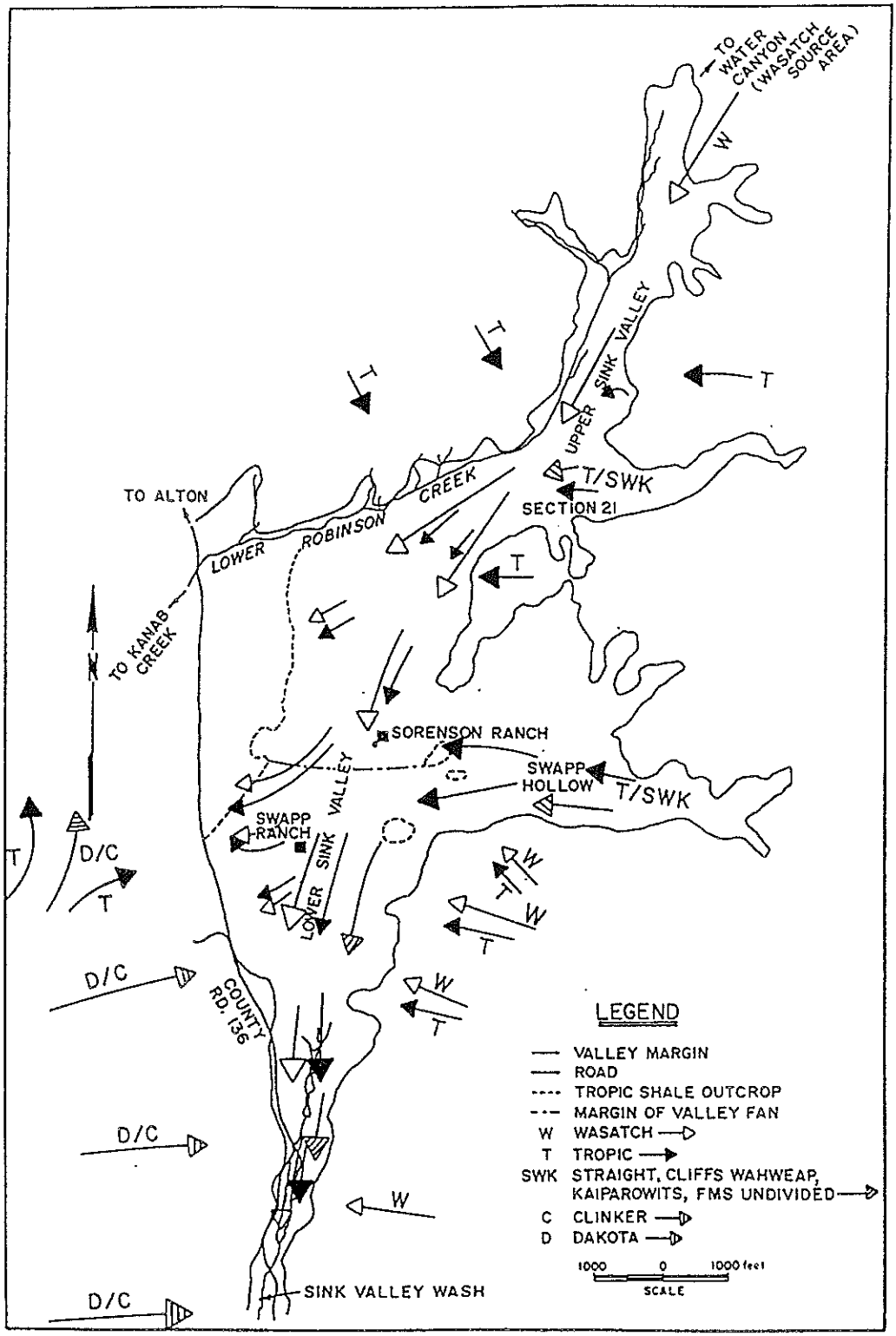

Figure 3.4. Source area lithologies for sediments in Sink Valley.

#13, 17, 18, 19). Localized deposition has created locally oversteepened topography and this has resulted in the formation of discontinuous gullies. Fan progradation towards the valley margin is documented in MS #4, where the Wasatch-derived sediments (sands and silts) have infilled a pre-existing badland topography (Fig. 3.3) that drained the area to the north of the presently incised channel of Lower Robinson Creek. The surveyed XS profile confirms that MS #4 is located on a fan margin.

Cross Section IVA extends from the drainage basin of Lower Robinson Creek on the west to the eastern margin of Sink Valley just up-valley from the junction with Swapp Hollow fan (Fig. 3.1). Progradation of the valley fan to the point where sheetfloods overtopped the Tropic Shale ridge which was the drainage divide between Lower Robinson Creek and Sink Valley is documented in MS #14 and MS #20. Since there is no outcrop of Wasatch Formation in the pre-capture drainage basin of lower Robinson Creek, then the Wasatch-derived sediments in MS #14 and MS #20 must have been derived from Sink Valley. The low frequency of the Wasatch-derived sediments in MS #14 and MS #20 and the fact that they are located in the upper portions of the stratigraphic sections indicates that the sediments were transported by extreme events on the valley fan. Deposition of the Wasatch-derived sediments must have pre-dated the incision of Lower Robinson Creek (c. 1865) and the capture of Upper Sink Valley because the Wasatch-derived sediments are interbedded with Tropic-derived sediments.

The on-lap of the valley fan onto the eastern side of the Tropic Shale ridge, and its effects on the water table are shown in MS #15,

which is composed of primarily fine grained fan-margin sediments. The depositional axis of the fan is located at MS #16 and it reflects the contribution of sediments from both the Wasatch Formation and the Tropic Shale. Progradation of Swapp Hollow fan into Sink Valley and its effects on slackwater sedimentation can be seen in MS #22 where fine-grained sediments from the Wasatch Formation and the Tropic Shale are interbedded. Cross Section IVA is located near the crest of the valley fan.

Cross Section IVB (Fig. 3.1) extends across the mouth of Swapp Hollow and it documents a number of important factors with respect to Sink Valley sedimentology. First, a considerable volume of Cretaceous age sandstone-derived sand-sized sediments are being introduced to Sink Valley (MS #37). Second, significant quantities of Tropic-derived sediment is also being introduced to Sink Valley. Finally, erosion of the pediment on the south side of Swapp Hollow is introducing coarse Wasatch-derived pediment gravels to Sink Valley.

Cross Section V extends from the Lower Robinson Creek drainage basin on the west to the mouth of Swapp Hollow on the east (Fig. 3.1). The cross section is located within Sink Valley at the approximate location of the down-valley terminus of the valley fan. The depositional axis of the valley fan is located at MS #24 and the sediments reflect different source lithologies; Wasatch Formation, Tropic Shale, and the Cretaceous age sandstones. The Wasatch-derived sediments have been diluted considerably in comparison to the sections that are located up-fan. MS #25 shows the effects on the water table of fan margin on-lap to the

impermeable Tropic Shale ridge. Sediment delivery from Swapp Hollow may have been responsible for displacing valley fan margin sedimentation towards the west, thereby eliminating the pre-existing drainage divide between Sink Valley and Lower Robinson Creek drainage basins. The coarse-grained basal sediments in MS #26 were derived from local Dakota Formation outcrops in the Lower Robinson Creek basin. Wasatch-derived sediments constitute a minor portion of MS #26. Elimination of the drainage divide as a result of sedimentation just south of XS V permits present day sheetfloods to bifurcate into both Sink Valley and Lower Robinson Creek. Groundwater discharge in the distal portion of the valley fan is confirmed in MS #24 and MS #25.

Cross Section VI lies completely within the margins of Sink Valley (Fig. 3.1). Pediment-derived Wasatch Formation clasts, Tropic-derived finer-grained sediments and Cretaceous age sandstone-derived sands were transported on a formerly active lobe of Swapp Hollow fan to the valley floor (MS #35, MS #28). This lobe formed a significant cross gradient across Sink Valley which must displace the sheetfloods to the west (MS #27). Very little Wasatch-derived sediment is present in MS #27, and the sediments in the section are dominated by sands derived from the Cretaceous age sandstones in Swapp Hollow and by local contributions of Tropic-derived sediments from the western valley margin. A shallow water table is present in both MS #28 and MS #27.

Cross Section VII (Fig. 3.1) demonstrates the importance to the valley fill of local sediment sources. A detrital cone has prograded from the eastern valley margin onto the valley floor. The coarse-

grained Wasatch-derived sediments in MS #31 and MS #30 originated from the pediment gravels. The basal portions of all the measured sections along XS VII are composed of yellowish-grey sands that were derived from Cretaceous age sandstones in Swapp Hollow. It is significant to note that Wasatch-derived finer grained sheetflood deposits are located in the upper part of MS #29. This tends to confirm that the delivery of Wasatch-derived sediments down-valley to this location was dependent on valley fan progradation rather than as the result of channelized flow.

The paucity of Wasatch-derived sediments other than silt/clay drapes in the measured sections (MS #32, 33, 34) along XS VIII (Fig. 3.1) indicates that it is highly unlikely that a continuous channel has been in existance through the length of Sink Valley during the time that the observed valley fill was deposited. The sediments in the measured sections are dominated by yellowish-grey sands that were derived from Swapp Hollow. Lateral contribution of sediments from the valley margins is documented by clasts of Dakota sandstone and clinker chips. Coarser-grained Wasatch-derived clasts and fine-grained Tropic-derived sediments are present in the detrital cone on the eastern valley margin (MS #34).

The absence of a continuous channel through Sink Valley in the time period represented by the valley fill is further confirmed by MS #36 on XS IX (Fig. 3.1). The coarse clasts in the bed of the incised channel of Sink Valley Wash have been derived from local sources. Dakota sandstone clasts were derived from both valley margins, and the Wasatch-derived clasts were transported by slope transport processes on the eastern valley margin.

The sedimentology of Sink Valley can be summarized in a longitudinal profile that follows the depositional axis (Fig 3.5). The measured sections that represent the depositional axis of the valley at each of the surveyed cross sections were arranged in a down-valley sequence (Fig. 3.1). The elevation of the top of each measured section was used to construct the longitudinal profile of the valley floor. The distances between the measured sections are to scale.

The valley fan extends from XS I (MS #5) to XS V (MS #24). The proximal (up-valley) part of the valley fan (MS #5, MS #3) is composed of predominantly Wasatch-derived, relatively coarse-grained sediments that were deposited by debris flows and sheetfloods. Minor channel fills are located within the horizontally laminated sheetflood deposits. The channels were probably small-scale and ephemeral, and they probably represent a braided pattern during sheetflood events (Reading, 1978; Bull, 1977; Blair, 1986). The coarse-fine couplets within the sheetflood deposits represent the down-fan passage of low relief sheets of sands and fine gravels (Bull, 1977; Blair, 1986).

The medial portion of the valley fan is represented by MS #12 (XS III) and MS #16 (XS IVA). The sediments were deposited by mudflows, debris flows and sheetfloods. However, there is a dilution of the Wasatch-derived sediments by Tropic-derived and Cretaceous sandstone-derived sediments. The Tropic-derived sediments probably originated from Section 21 tributary and the Tropic Shale eastern valley margin. Cross Section V marks the approximate location of the distal portion of the fan (MS #24). Both the volume and caliber of the Wasatch-derived

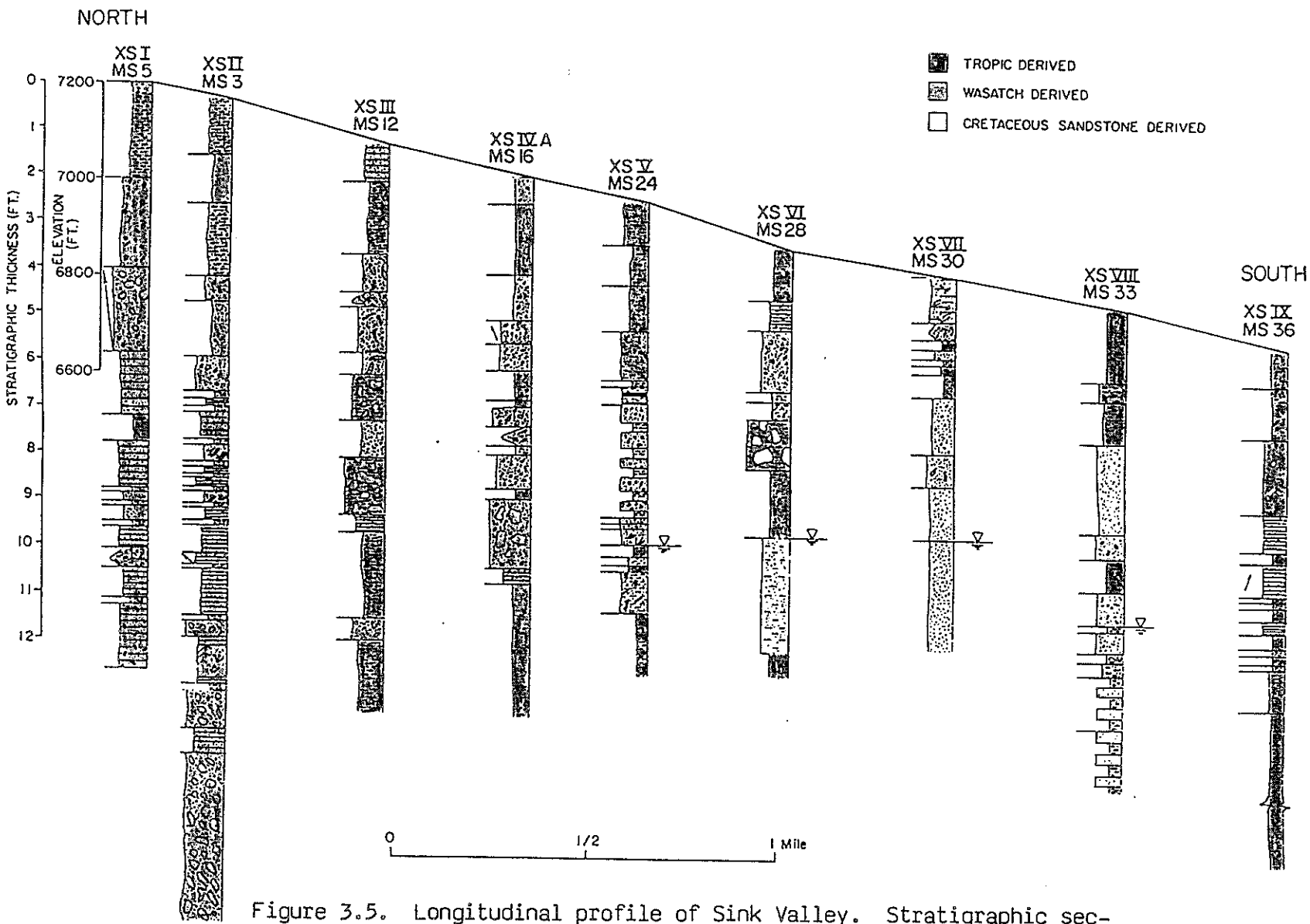

Figure 3.5. Longitudinal profile of Sink Valley. Stratigraphic sections represent the depositional axis of the valley.

sediments have declined significantly in MS #24 (XS V). The Wasatch-derived sediments are fine-grained and they represent drapes which document discrete down-valley flood events. The sediments in MS #24 also reflect a significant increase in the volume of sands that were derived from Cretaceous age sandstones in the Swapp Hollow drainage basin. The presence of groundwater at shallow depth in MS #24 also argues that this section represents the toe of the valley fan (Galloway et al., 1979).

Cross section VI is contained completely within Sink Valley, but the sediments in MS #28 are heavily influenced by Swapp Hollow fan, a lobe of which had prograded onto the floor of Sink Valley, thereby displacing the depositional axis to the west. The basal portion of MS #28 is dominated by Cretaceous sandstone-derived sands. Debris flow and mudflow deposits contain relatively coarse-grained Wasatch-derived sediments that originated from the pediment gravels on the south side of Swapp Hollow (Fig. 2.1).

Sink Valley narrows considerably at XS VII and the sediments in MS #30 are dominated by Cretaceous age sandstone-derived sands. The upper portion of MS #30 reflects progradation of a small detrital cone onto the valley floor. The sediments originated from the valley side slopes and they contain coarser clasts of both sandstone and the Wasatch-derived pediment gravels. The absence of fine-grained Wasatch-derived sediments (silt/clay drapes) in the basal parts of MS #30 and MS #28 may be the result of the relatively shallow depth of the pits. Very high rates of groundwater flow were encountered in the pits and wall caving

occurred rapidly and frequently. The Wasatch-derived fine-grained sediments (drapes) were prominent in the basal portion of MS #33 (XS VIII), which is a deeper section.

The bulk of the sediment in MS #33 were derived from the Cretaceous age sandstones in the Swapp Hollow drainage basin. The increasing dominance of these sands in MS #28, MS #30, and MS #33, and the concomittant reduction in the amount of Wasatch-derived sediments, may be related to the elimination of the Wasatch Formation source area due to its capture by Lower Robinson Creek. Conversely, the change in the character of the sediments may merely reflect the fact that the valley fan had not prograded far enough down-valley to deliver significant volumes of sediment to the lower valley. The presence of the multiple Wasatch-derived drapes in the basal portion of MS #33 indicates that sheetflood events that originated up-valley from XS VIII were more frequent in the earlier part of the valley fill cycle. It is also conceivable that the relative abundance of the sandstone-derived sediments is related to the dynamics of Swapp Hollow fan. Fan trenching (Schumm 1977; Schumm et al, 1987) may have delivered large quantities of fan sediments to the valley floor. The absence of sedimentary structures other than horizontal laminations in the sand units argues for unconfined flow conditions on the valley floor.

Minor amounts of fine-grained Wasatch-derived sediments are interbedded with Tropic-derived and Cretaceous age sandstone-derived sediments in MS #36 (XS IX). Coarser Wasatch-derived clasts interbedded with Tropic-derived sediments in the upper part of MS #36 were derived

from the pediment gravels on the eastern margin of the valley. Detrital cones and small scale fans at the base of both valley margins have significantly affected sedimentation in this narrow reach of the valley.

The morphological (Figs. 2.1, 2.3, 2.4) and sedimentological data (Fig. 3.5) strongly confirm that a valley fan exists in Sink Valley between XS I and XS V. Tributary fans (Section 21 and Swapp Hollow) have significantly affected the sedimentology and morphology of the valley floor (Fig. 3.3). Lateral inflow of sediments from the valley margins has introduced coarser grained sediments to the valley floor that interrupt the down-valley fining trends of the grain size (Fig. 3.4). The presence of a shallow groundwater table down-valley from XS V is consistent with the valley fan interpretation.

4. CONCLUSIONS

This investigation of Sink Valley was conducted to determine: (1) whether there were streamlaid deposits beneath the surface of the valley floor and (2) whether alluvial fans, or man's activities had obscurred a previously existing continuous channel that traversed the length of Sink Valley. Both of these factors are important with respect to determining whether Sink Valley meets the regulatory geologic criteria for an Alluvial Valley Floor (AVF). On the basis of these criteria, the requirement for an AVF determination is the presence of a continuous channel within a topographic valley, the floor of which contains floodplain and terrace features that are underlain by unconsolidated streamlaid deposits that were deposited by the continuous channel. Alluvial fans are specifically excluded from determination as AVF's

The results of this investigation have demonstrated that:

(1) there are no streamlaid deposits within the sediments that were observed in the backhoe pits and exposed banks of Lower Robinson Creek and Sink Valley Wash. The sediments were deposited by unconfined sheetfloods, debris flows and mudflows. Minor channel fill sediments were observed in the stratigraphic sections, but they are related to the presence of small ephemeral channels during sheetflood events and to topographic irregularities caused by the presence of mudflow and debris flow deposits.

(2) no continuous channel has traversed the length of Sink Valley within the time interval that is represented by the valley fill

that was observed in this investigation. The valley fan that prograded down-valley from the confluence of Dry Fork and Water Canyon is composed primarily of Wasatch-derived sediments. Capture of the upper part of the Sink Valley drainage basin by Lower Robinson Creek was due to base level lowering, the result of incision of Kanab Creek (c. 1865), and progradation of the valley fan that eliminated a pre-existing drainage divide between the basins. Capture of the source area for the Wasatch-derived sediments has in essence frozen the valley fan morphology into the pre-capture configuration, and therefore, the valley fan must pre-date the time of capture. Therefore, it cannot be argued that the valley fan is a recent feature that has obscurred the presence of a pre-existing continuous channel. Further, the absence of any sedimentary evidence for channelized flow in the investigated stratigraphic fill indicates that surface modifications of the valley floor by man's activities has not obscurred the presence of a continuous channel. This is further reinforced by the rapid down-valley fining of the size of the Wasatch-derived sediments, and by the relative paucity of Wasatch-derived sediments in the stratigraphic sections down-valley from the toe of the valley fan.

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APPENDIX I

SINK VALLEY STRATIGRAPHIC SECTIONS

LEGEND

- SILT/CLAY
- SAND
- GRAVEL
- CHARCOAL
- ROOT CASTS
- RIPUP CLASTS
- FINING UPWARD SEQUENCE
- COARSENING UPWARD SEQUENCE
- W — WASATCH DERIVED
- T — TROPIC DERIVED
- SW — SHEETWASH
- CH — CHANNEL FILL
- MF — MUDFLOW
- DF — DEBRIS FLOW
- HORIZONTAL STRATIFICATION
- RIPPLE CROSS STRATIFICATION
- TROUGH CROSS STRATIFICATION
- COARSE / FINE COUPLETS
- SILT/CLAY DRAPE
- PEDOGENIC STRUCTURE
- LENTICULAR BEDDING
- EROSIONAL CONTACT
- SWK — STRAIGHT CLIFFS/WAHWEAP DERIVED
- RF — ROCKFALL
- SF — SHEETFLOOD
- D — DRAPE
- WATER TABLE

MEASURED SECTION NO. 1
LOCALITY XS 1 WEST CHANNEL
SETTING TLB LOWER ROBINSON CREEK
STATION 8+56

DATE 7/11/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY MH/KF/JS/DW
ELEVATION 7202.4

DEPTH (FT.)	INCREMENT THICKNESS (IN.)	GRAIN SIZE (GRAV: 64 4; SAND: VC C M F VF; SILT CLAY)	SEDIMENTARY TEXTURES & STRUCTURES	SOURCE AREA (T=TROPIC; W=WASATCH; SWK=CRETACEOUS SANDSTONE)	DESCRIPTIONS
					TOP OF SECTION
1	22			W	WASATCH DERIVED SILT TO MEDIUM SAND LATERALLY CONTINUOUS SHARP LOWER CONTACT
2	13			T	TROPIC DERIVED SILT/CLAY DENSE
3	6			W/T	WASATCH/TROPIC DERIVED SILT TO MEDIUM SAND INCREASE IN WASATCH DERIVED MATERIAL UPSECTION LATERALLY CONTINUOUS
4 5 6 7 8 9	67			W/T	PRIMARILY TROPIC DERIVED SILT AND CLAY WITH MINOR WASATCH DERIVED SAND-PEBBLE SIZE CLASTS HIGH CHARCOAL CONTENT
10 11 12	35			T	TROPIC DERIVED SILT AND CLAY WITH MINOR ANGULAR GRIT HIGH CHARCOAL CONTENT
					CONTINUED

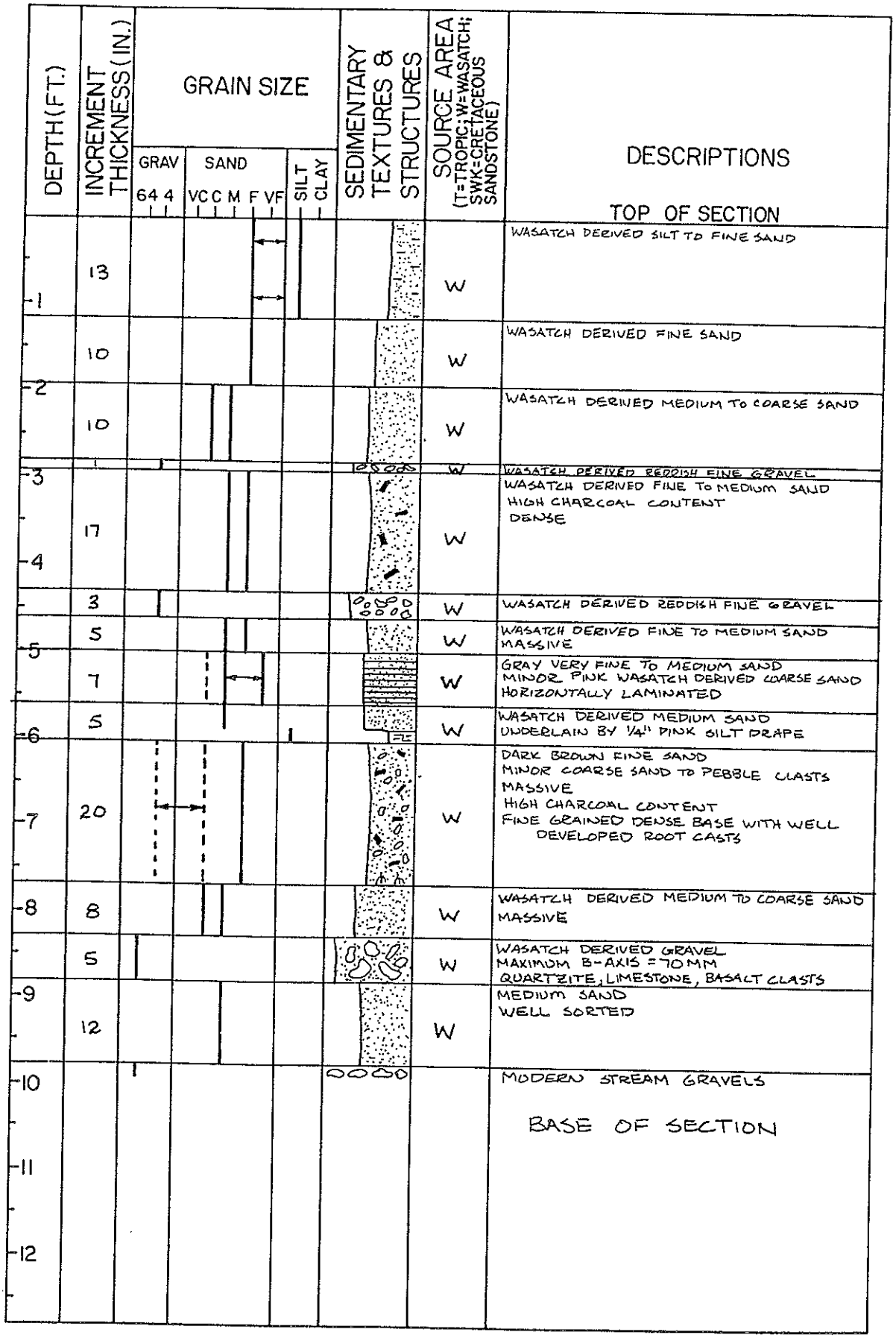
MEASURED SECTION NO. 1 (CONT.)
LOCALITY XS 1 WEST CHANNEL
SETTING TLB LOWER ROBINSON CREEK
STATION 8+56

DATE 7/11/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY MH/KF/JS/DW
ELEVATION 7202.4

DEPTH (FT.)	INCREMENT THICKNESS (IN.)	GRAIN SIZE (GRAV: 64 4; SAND: VC C M F VF; SILT CLAY)	SEDIMENTARY TEXTURES & STRUCTURES	SOURCE AREA (T=TROPIC; W=WASATCH; SWK=CRETACEOUS SANDSTONE)	DESCRIPTIONS CONTINUED SECTION
13	20			W/T	TROPIC DERIVED SILT AND CLAY WASATCH DERIVED FINE GRAVEL AND SAND MASSIVE
14	3			W	GRAVEL TO COBBLES; LIMESTONE/QUARTZITE/BASALT CLAST B-AXIS=55-100 MM MATRIX SUPPORTED CHAOTIC ⇒ DEBRI FLOW
	8			W/T	INTERBEDDED WASATCH DERIVED MEDIUM SAND AND TROPIC DERIVED SILT/CLAY DRAPES
	5			T	TROPIC DERIVED SILT TO FINE SAND
15	5			W	WASATCH DERIVED MEDIUM SAND
	4			W/T	TROPIC DERIVED SILT/CLAY DRAPE UNDERLAIN BY WASATCH DERIVED MEDIUM SAND
	1			W	SILT/CLAY DRAPE
16	6			W	WASATCH DERIVED MEDIUM SAND MASSIVE
					BASE OF SECTION

MEASURED SECTION NO 2
LOCALITY XS 1 EAST CHANNEL
SETTING TLB LOWER ROBINSON CREEK
STATION 7+78

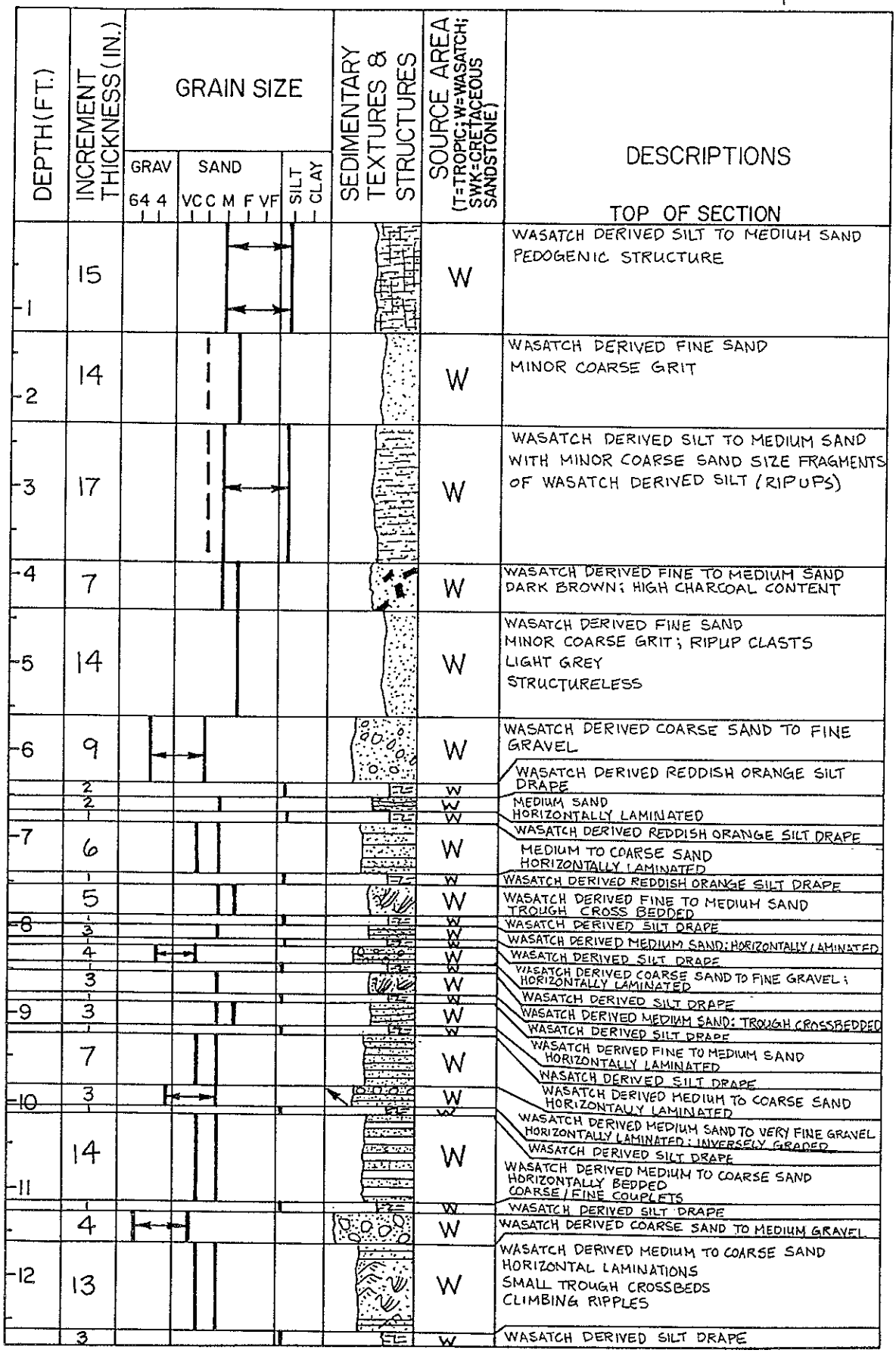
DATE 7/11/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY MH/KF/JS/DW
ELEVATION 7202.2



DEPTH (FT.)	INCREMENT THICKNESS (IN.)	SOURCE AREA (T=TROPIC; W=WASATCH; SWK=CRETACEOUS SANDSTONE)	DESCRIPTIONS
			TOP OF SECTION
1	13	W	WASATCH DERIVED SILT TO FINE SAND
	10	W	WASATCH DERIVED FINE SAND
2	10	W	WASATCH DERIVED MEDIUM TO COARSE SAND
	1	W	WASATCH DERIVED REDDISH FINE GRAVEL
3 4	17	W	WASATCH DERIVED FINE TO MEDIUM SAND HIGH CHARCOAL CONTENT DENSE
	3	W	WASATCH DERIVED REDDISH FINE GRAVEL
	5	W	WASATCH DERIVED FINE TO MEDIUM SAND MASSIVE
5	7	W	GRAY VERY FINE TO MEDIUM SAND MINOR PINK WASATCH DERIVED COARSE SAND HORIZONTALLY LAMINATED
6	5	W	WASATCH DERIVED MEDIUM SAND UNDERLAIN BY 1/4" PINK SILT DRAPE
7	20	W	DARK BROWN FINE SAND MINOR COARSE SAND TO PEBBLE CLASTS MASSIVE HIGH CHARCOAL CONTENT FINE GRAINED DENSE BASE WITH WELL DEVELOPED ROOT CASTS
8	8	W	WASATCH DERIVED MEDIUM TO COARSE SAND MASSIVE
	5	W	WASATCH DERIVED GRAVEL MAXIMUM B-AXIS = 70 MM QUARTZITE, LIMESTONE, BASALT CLASTS
9	12	W	MEDIUM SAND WELL SORTED
10 11 12			MODERN STREAM GRAVELS BASE OF SECTION

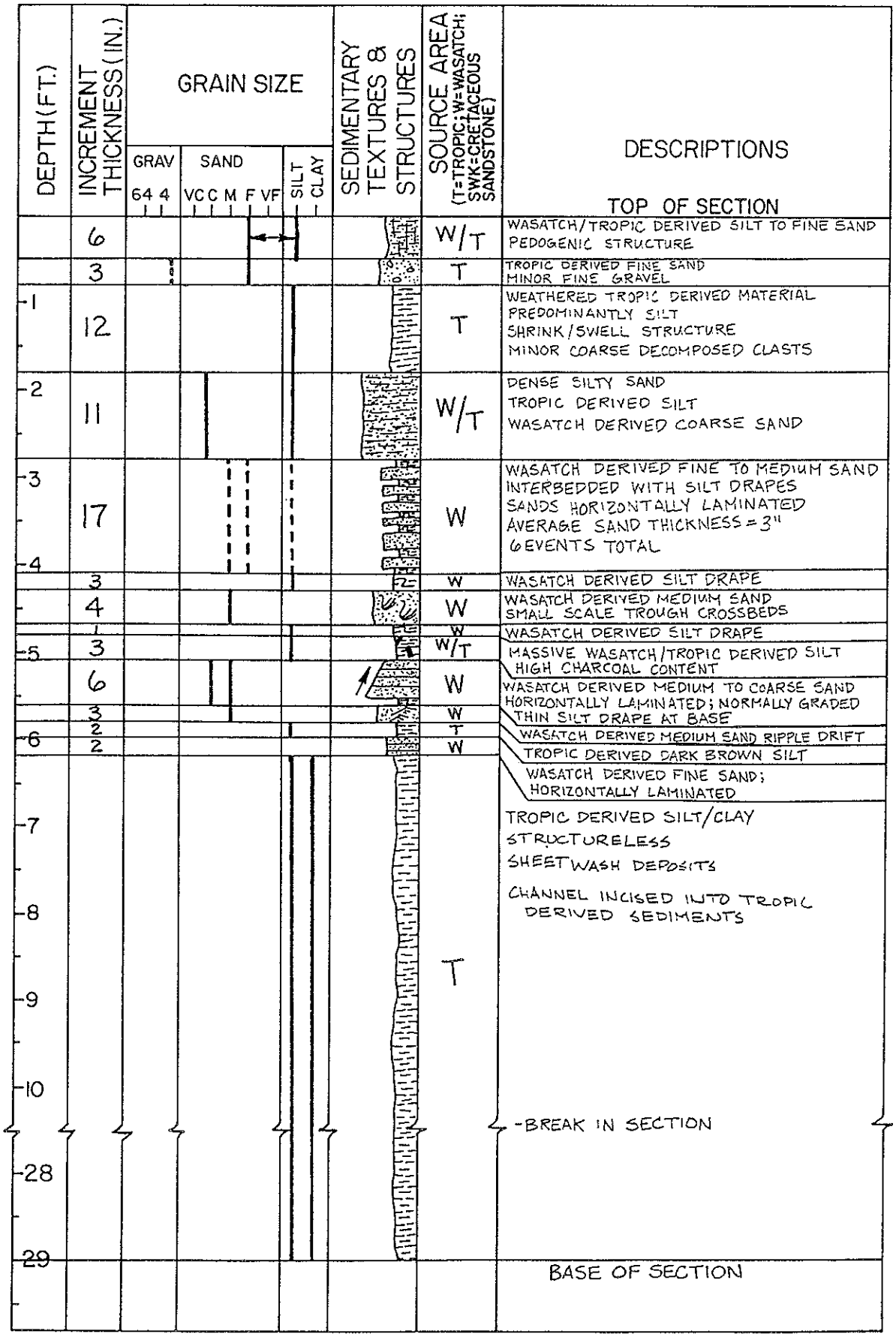
MEASURED SECTION NO. 3
LOCALITY XS 2 A
SETTING TLB LOWER ROBINSON CREEK
STATION 9+79

DATE 7/12/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY MH/KF/JS/DW
ELEVATION 7174.8



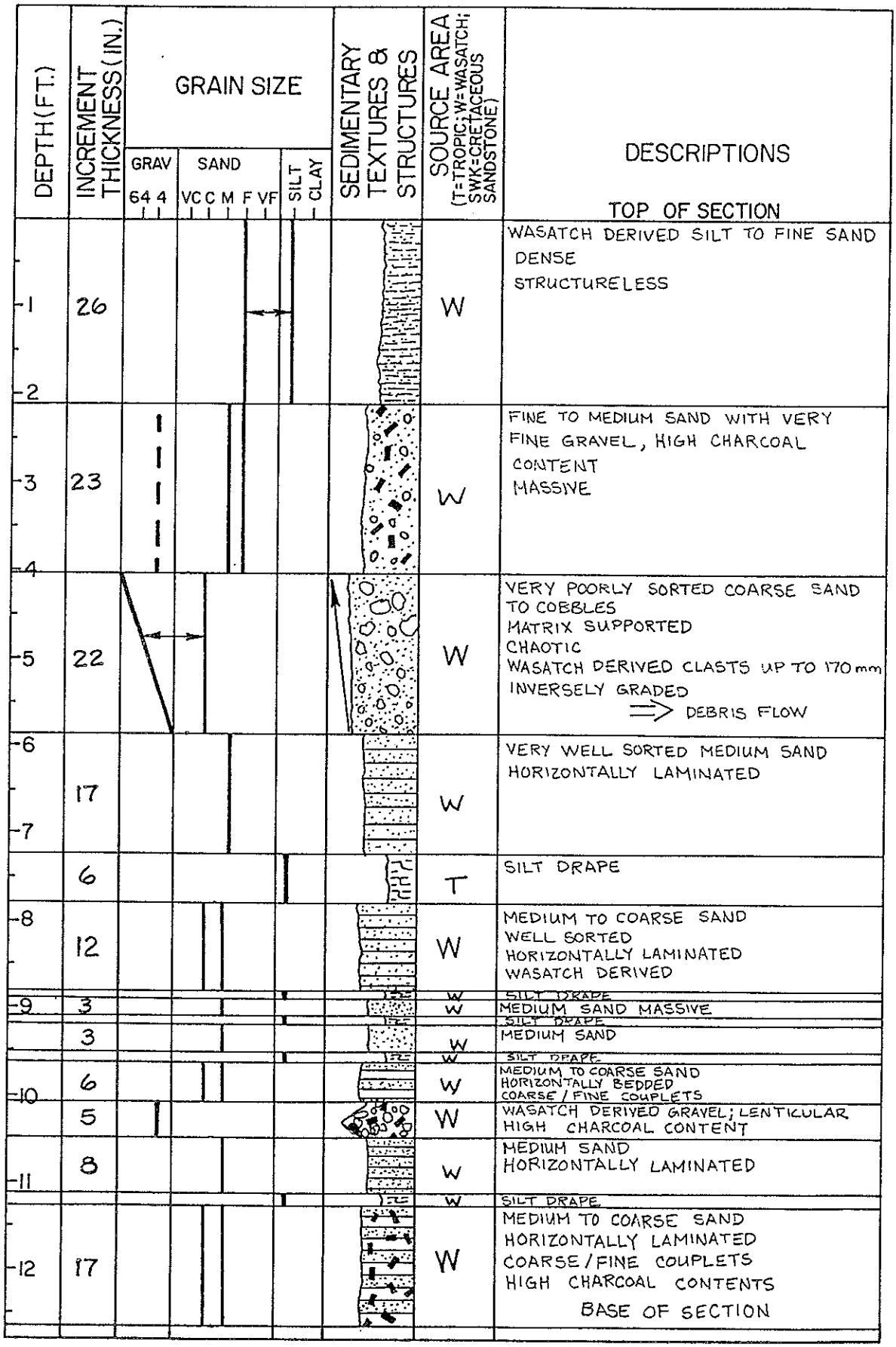
MEASURED SECTION NO. 4
LOCALITY XS 3
SETTING TLB LOWER ROBINSON CREEK
STATION 15+22

DATE 7/12/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY MH/KF/JS/DW
ELEVATION 7068.2



MEASURED SECTION NO. 5
LOCALITY XS 1
SETTING MIDVALLEY
STATION 5+14

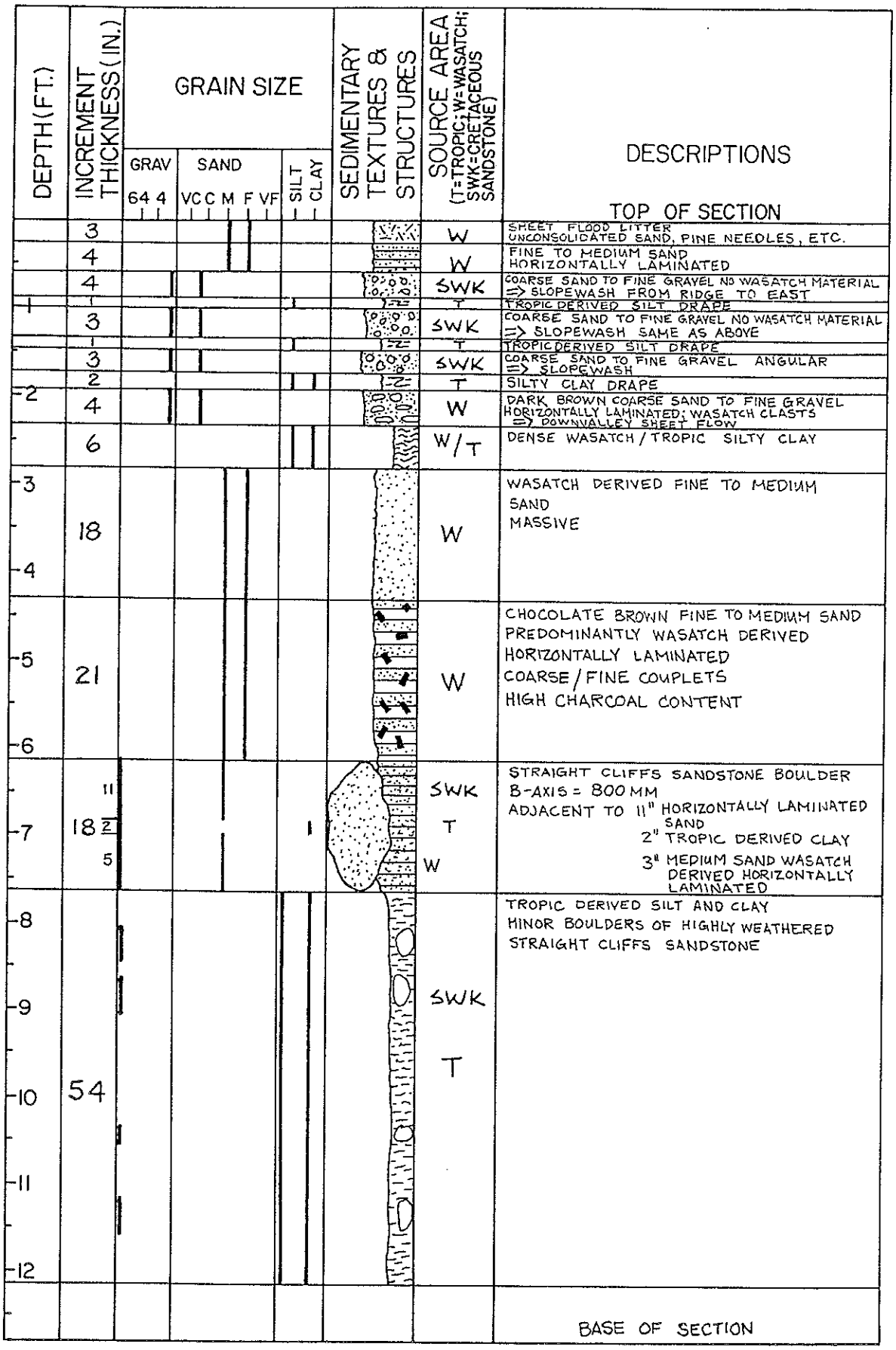
DATE 7/12/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY MH/KF/JS/DW
ELEVATION 7204.9



DEPTH (FT.)	INCREMENT THICKNESS (IN.)	SOURCE AREA (T=TROPIC; W=WASATCH; SWK=CRETACEOUS SANDSTONE)	DESCRIPTIONS
			TOP OF SECTION
1–2	26	W	WASATCH DERIVED SILT TO FINE SAND DENSE STRUCTURELESS
3–4	23	W	FINE TO MEDIUM SAND WITH VERY FINE GRAVEL, HIGH CHARCOAL CONTENT MASSIVE
5	22	W	VERY POORLY SORTED COARSE SAND TO COBBLES MATRIX SUPPORTED CHAOTIC WASATCH DERIVED CLASTS UP TO 170 mm INVERSELY GRADED ⟹ DEBRIS FLOW
6–7	17	W	VERY WELL SORTED MEDIUM SAND HORIZONTALLY LAMINATED
	6	T	SILT DRAPE
8	12	W	MEDIUM TO COARSE SAND WELL SORTED HORIZONTALLY LAMINATED WASATCH DERIVED
		W	SILT DRAPE
9	3	W	MEDIUM SAND MASSIVE
			SILT DRAPE
	3	W	MEDIUM SAND
		W	SILT DRAPE
10	6	W	MEDIUM TO COARSE SAND HORIZONTALLY BEDDED COARSE / FINE COUPLETS
	5	W	WASATCH DERIVED GRAVEL; LENTICULAR HIGH CHARCOAL CONTENT
11	8	W	MEDIUM SAND HORIZONTALLY LAMINATED
		W	SILT DRAPE
12	17	W	MEDIUM TO COARSE SAND HORIZONTALLY LAMINATED COARSE / FINE COUPLETS HIGH CHARCOAL CONTENTS
			BASE OF SECTION

MEASURED SECTION NO. 6
LOCALITY XS 1
SETTING EAST SIDE VALLEY
STATION 0+00

DATE 7/12/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY MH/KF
ELEVATION 7208.9



MEASURED SECTION NO. 7
LOCALITY XS 2A
SETTING MID VALLEY
STATION 7+14

DATE 7/12/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY MH/KF/JS/DW
ELEVATION 7174.5

DEPTH (FT.)	INCREMENT THICKNESS (IN.)	GRAIN SIZE (GRAV: 64 4; SAND: VC C M F VF; SILT CLAY)	SEDIMENTARY TEXTURES & STRUCTURES	SOURCE AREA (T=TROPIC; W=WASATCH; SWK=CRETACEOUS SANDSTONE)	DESCRIPTIONS
					TOP OF SECTION
1–2	36			W/T	VERY POORLY SORTED SILT, SAND, & FINE GRAVEL DENSE CHAOTIC U-SHAPED SOME TROPIC DERIVED CLASTS HIGH CHARCOAL CONTENT ⇒ MUDFLOW
3–4	17			W	MEDIUM SAND TO MEDIUM GRAVEL MASSIVE CONTAINS RIPUPS OF WASATCH DERIVED SILT DRAPES
	2			W	WASATCH DERIVED SILT DRAPE
	2			W	WASATCH DERIVED MEDIUM-COARSE SAND; RIPPLES
5	6			W/T	DARK BROWN TROPIC DERIVED SILT WITH MINOR WASATCH COMPONENT, DENSE HIGH CHARCOAL CONTENT
	6			W	PINK WASATCH DERIVED FINE TO MEDIUM SAND LATERALLY CONTINUOUS; COARSE/FINE COUPLETS HIGH CHARCOAL CONTENT
6	11			W/T	WASATCH/TROPIC DERIVED SILT TO FINE SAND DENSE RIPUPS OF WASATCH SILT
7	9			W	MEDIUM TO COARSE SAND COARSE/FINE COUPLETS RIPUPS ⇒ SHEETFLOW
	3			W	WASATCH DERIVED COARSE SAND LATERALLY CONTINUOUS ⇒ SHEETFLOW COARSE/FINE COUPLETS; COARSENS TO GRAVEL EASTWARD
8	10			W	WASATCH DERIVED MEDIUM SAND SMALL SCALE TROUGH CROSSBEDS LATERALLY CONTINUOUS HIGH CHARCOAL CONTENT
	3			T	TROPIC DERIVED SILT DRAPE LATERALLY CONTINUOUS
9	4			W	WASATCH DERIVED FINE TO MEDIUM SAND; SMALL SCALE TROUGH CROSSBEDS; CHANNEL FILL 18" WIDE X 14" DEEP
	1			T	TROPIC DERIVED SILT DRAPE
	9			W	WASATCH DERIVED COARSE SAND SMALL SCALE THROUGH CROSSBEDS
10	3			W/T	WASATCH/TROPIC DERIVED SILT DRAPE
	3			W	WASATCH DERIVED FINE SAND
	4			W	WASATCH DERIVED SILT DRAPE
11	6			W	WASATCH DERIVED MEDIUM TO COARSE SAND HORIZONTALLY LAMINATED OVERLYING SILT DRAPE
12					BASE OF SECTION

MEASURED SECTION NO 8
LOCALITY XS 2A
SETTING EAST SIDE VALLEY
STATION 1+58

DATE 7/12/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY MH/KF/JS/DW
ELEVATION 7108.0

DEPTH (FT.)	INCREMENT THICKNESS (IN.)	GRAIN SIZE (GRAV 64 4; SAND VC C M F VF; SILT CLAY)	SEDIMENTARY TEXTURES & STRUCTURES	SOURCE AREA (T=TROPIC; W=WASATCH; SWK=CRETACEOUS SANDSTONE)	DESCRIPTIONS
					TOP OF SECTION
1	16			T/W	COARSE SAND INTERBEDDED WITH SILT DRAPES. 11 DISTINGUISHABLE EVENTS ⇒ MULTIPLE SLACK WATER DEPOSITIONAL EVENTS ⇒ LOW TOPOGRAPHIC SPOT AT EASTERN SLOPE BREAK
2 3	22			T	BLACK-BROWN TROPIC DERIVED SILTY CLAY MINOR FINE SAND LATERALLY CONTINUOUS ⇒ SHEETWASH
4	18			W/T	WASATCH/TROPIC DERIVED SILT TO VERY FINE SAND DENSE NO STRUCTURE
5	6			W	WASATCH DERIVED MEDIUM SAND CONTAINS RIPUPS OF WASATCH DERIVED SILT
	3			W	WASATCH DERIVED SILT DRAPE; LATERALLY VERY CONTINUOUS
6	16			W	WASATCH DERIVED MEDIUM SAND INTERBEDDED WITH WASATCH DERIVED SILT DRAPES. 7 CYCLES DISTINGUISHABLE.
	2			W	WASATCH DERIVED VERY COARSE SAND; LATERALLY CONTINUOUS COARSE/FINE COUPLETS
7	4			T	TROPIC DERIVED SILT DRAPE
	3			W	WASATCH DERIVED FINE SAND; MASSIVE
	3			T	TROPIC DERIVED SILT DRAPE; LATERALLY CONTINUOUS
	2			W	WASATCH DERIVED COARSE SAND; HORIZONTALLY LAMINATED; COARSE/FINE COUPLETS
8				W	WASATCH DERIVED SILT DRAPE
	7			W/T	WASATCH DERIVED MEDIUM SAND RIPUP CLASTS OF TROPIC & WASATCH MATERIAL
	2			W/T	TROPIC/WASATCH DERIVED SILT DRAPE
9	4			T	TROPIC DERIVED MEDIUM SAND HORIZONTAL & TROUGH CROSS STRATIFICATION
	9			W/T	TROPIC DERIVED SILT DRAPE HIGH CHARCOAL CONTENT MINOR WASATCH COMPONENT
10	12			W/T	WASATCH DERIVED FINE TO MEDIUM SAND TROPIC RIPUPS
11 12					BASE OF SECTION

MEASURED SECTION NO. _____ DATE _____

LOCALITY XS 2B

SETTING NORTH SIDE VALLEY

STATION 1+59

STRATIGRAPHIC UNIT SEC. 21 V. FILL

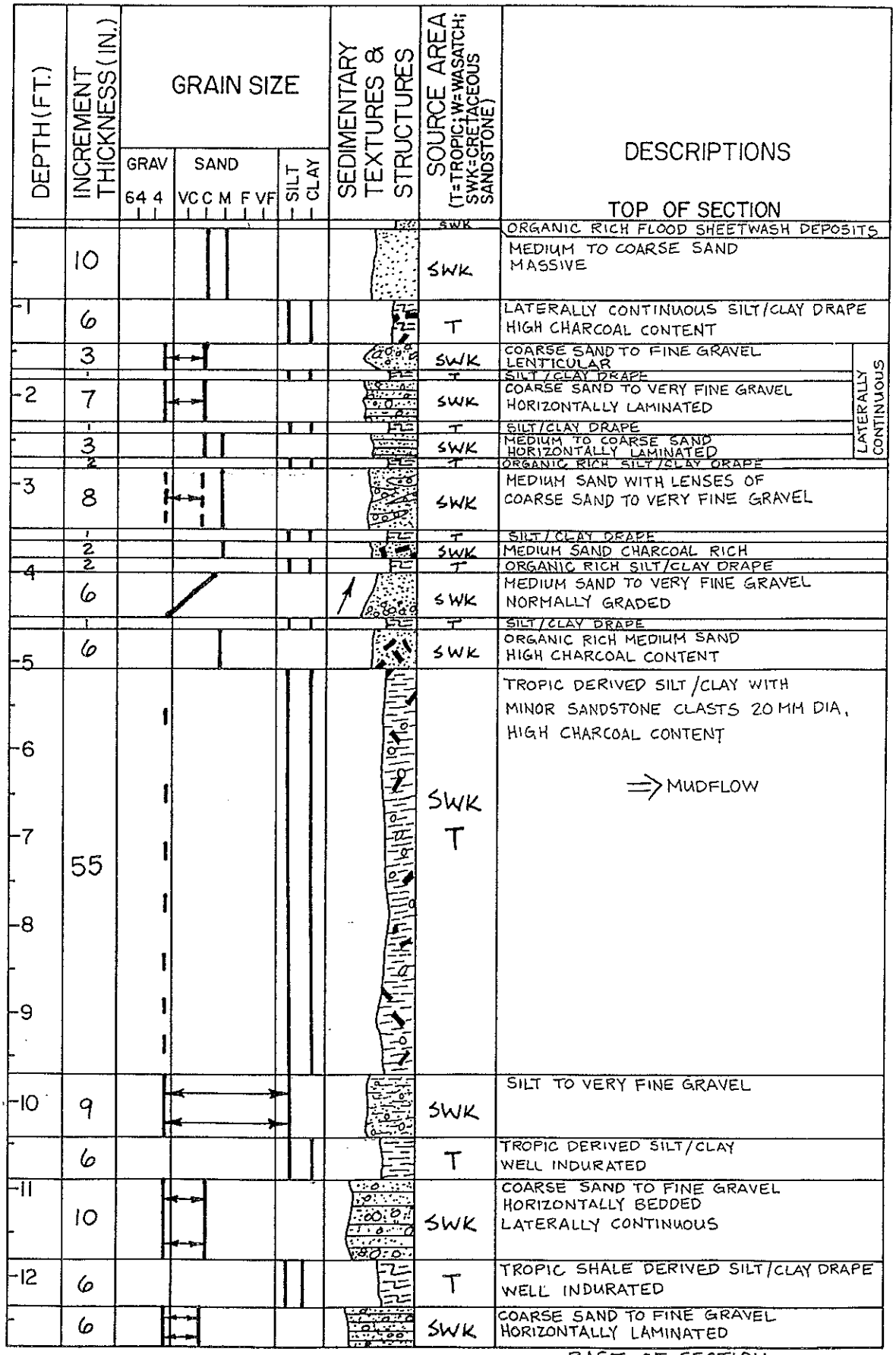
MEASURED BY MH/KF/JS/DW

ELEVATION 7174.0

DEPTH (FT.)	INCREMENT THICKNESS (IN.)	GRAIN SIZE (GRAV: 64 4; SAND: VC C M F VF; SILT CLAY)	SEDIMENTARY TEXTURES & STRUCTURES	SOURCE AREA (T=TROPIC; W=WASATCH; SWK=CRETACEOUS SANDSTONE)	DESCRIPTIONS	
					TOP OF SECTION	
	3			SWK	ORGANIC RICH SHEETFLOOD MATERIAL	
	5			SWK	STRAIGHT CLIFFS DERIVED VERY WELL SORTED MEDIUM SAND; GREYISH	LATERALLY CONTINUOUS DIP 5° WESTWARD (DOWNFAN)
				T	SILT DRAPE	
-1	10			SWK	MEDIUM SAND COARSE/FINE COUPLETS	
	4			T	ORGANIC RICH SILT DRAPE	
-2	3			SWK	MEDIUM SAND; HORIZONTALLY LAMINATED COARSE/FINE COUPLETS	
				T	SILT DRAPE	
	3			SWK	MEDIUM SAND; HORIZONTALLY LAMINATED COARSE/FINE COUPLETS	
				T	SILT DRAPE	
-3	7			SWK	COARSE SAND TO FINE GRAVEL	
				T	SILT DRAPE	
-4	9			SWK	MEDIUM SAND HIGH ORGANIC CONTENT	
	1			T	SILT/CLAY DRAPE	
-5	9			SWK	COARSE SAND TO FINE GRAVEL RIPUPS, MUDBALLS	
	4			SWK	FINE SAND HORIZONTALLY LAMINATED	
				T	ORGANIC RICH SILT/CLAY DRAPE	
	5			SWK	MEDIUM SAND MASSIVE	
-6	2			T	SILT/CLAY DRAPE	
	4			SWK	MEDIUM SAND MASSIVE	
				T	SILT/CLAY DRAPE	
-7	8			SWK	MEDIUM SAND COARSE/FINE COUPLETS	
				T	SILT/CLAY DRAPE	
	6			SWK	COARSE SAND ABUNDANT RIPUPS	
				T	SILT/CLAY DRAPE	
-8	5			SWK	MEDIUM SAND HORIZONTALLY LAMINATED COARSE/FINE COUPLETS	
	2			T	SILT/CLAY DRAPE	
	2			SWK	COARSE SAND HORIZONTALLY LAMINATED	
	2			T	ORGANIC RICH SILT/CLAY DRAPE	
	2			SWK	COARSE SAND	
-9	7			T	TROPIC DERIVED CLAY/SILT DARK BROWN TO BLACK; FRIABLE	
-10 -11	29			T	TROPIC DERIVED SILT/CLAY BLOCKY MASSIVE DENSE	
-12	5			SWK	COARSE SAND TO FINE GRAVEL IN BLOCKY MASSIVE TROPIC DERIVED SILT AND CLAY	

MEASURED SECTION NO. 10
LOCALITY XS 2B
SETTING MIDVALLEY
STATION 5+36

DATE 7/12/88
STRATIGRAPHIC UNIT SEC. 21 V. FILL
MEASURED BY MH/KF/JS/DW
ELEVATION 7168.2



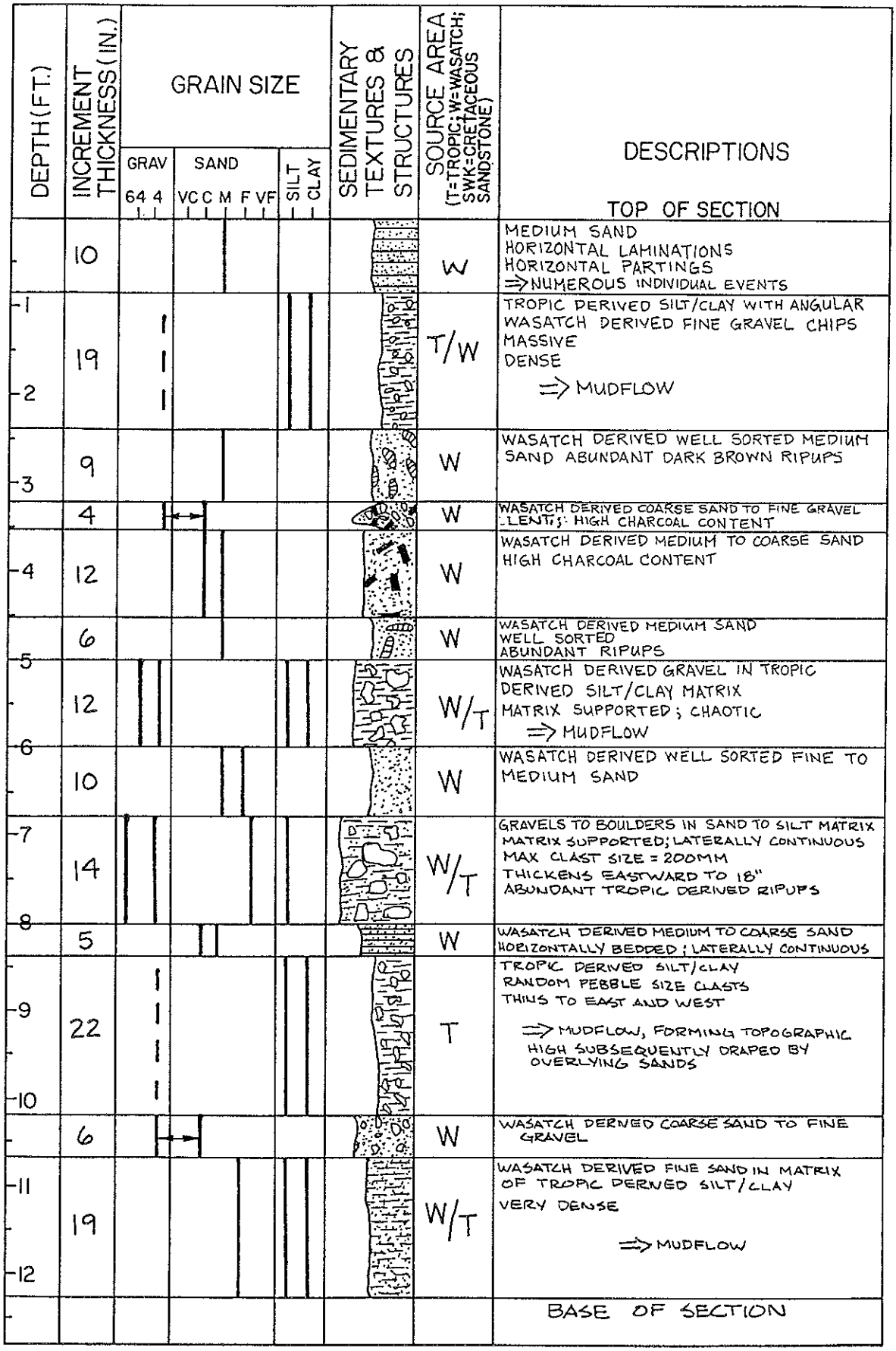
MEASURED SECTION NO. 11
LOCALITY XS 2B
SETTING SOUTH SIDE VALLEY
STATION 11+39

DATE 7/12/88
STRATIGRAPHIC UNIT SEC. 21 V. FILL
MEASURED BY MH/KF/JS/DW
ELEVATION 7159.5

DEPTH (FT.)	INCREMENT THICKNESS (IN.)	GRAIN SIZE (GRAV 64 4; SAND VC C M F VF; SILT CLAY)	SEDIMENTARY TEXTURES & STRUCTURES	SOURCE AREA (T=TROPIC; W=WASATCH; SWK=CRETACEOUS SANDSTONE)	DESCRIPTIONS
					TOP OF SECTION
1	19			T	TROPIC DERIVED SILT AND CLAY DARK BROWN TO BLACK BLOCKY ; DENSE
	3			T/SWK	GRAVEL IN MUD MATRIX ; CHAOTIC MAX GRAVEL = 20MM ⇒ MUDFLOW
2 3	22			T	TROPIC DERIVED DENSE SILT AND CLAY ⇒ LOWER PORTION OF OVERLYING MUDFLOW?
4	14			SWK T	FINE GRAVEL IN SANDY MUD MATRIX ⇒ MUDFLOW
5	8			SWK	WELL SORTED MEDIUM SAND HIGH CHARCOAL CONTENT
				T	SILT / CLAY DRAPE
6	10			SWK	MEDIUM SAND HORIZONTAL LAMINATIONS MUD RIPUPS
	3			SWK	COARSE SAND TO FINE GRAVEL LENTICULAR
7	9			SWK	VERY POORLY SORTED FINE TO MEDIUM SANDS ABUNDANT CHARCOAL, RIPUPS, ORGANICS CHAOTIC
	2			T	SILT / CLAY DRAPE
8	5			SWK	MEDIUM TO COARSE SAND HORIZONTAL LAMINATIONS COARSE / FINE COUPLETS
	5			T	SILT / CLAY DRAPE
9	9			SWK	MEDIUM TO COARSE SAND HORIZONTALLY BEDDED LENTICULAR TOTAL UNIT 33" WIDE x 9" THICK
	6			T	TROPIC DERIVED SILT/CLAY DRAPE HIGH CHARCOAL CONTENT
	3			SWK	MEDIUM SAND
10	9			T	TROPIC DERIVED SILT/CLAY
11	5			SWK	MEDIUM SAND HORIZONTAL LAMINATIONS
12					BASE OF SECTION

MEASURED SECTION NO. 12
LOCALITY XS 3
SETTING MIDVALLEY
STATION 8+59

DATE 7/13/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY MH/KF/JS/DW
ELEVATION 7078.1



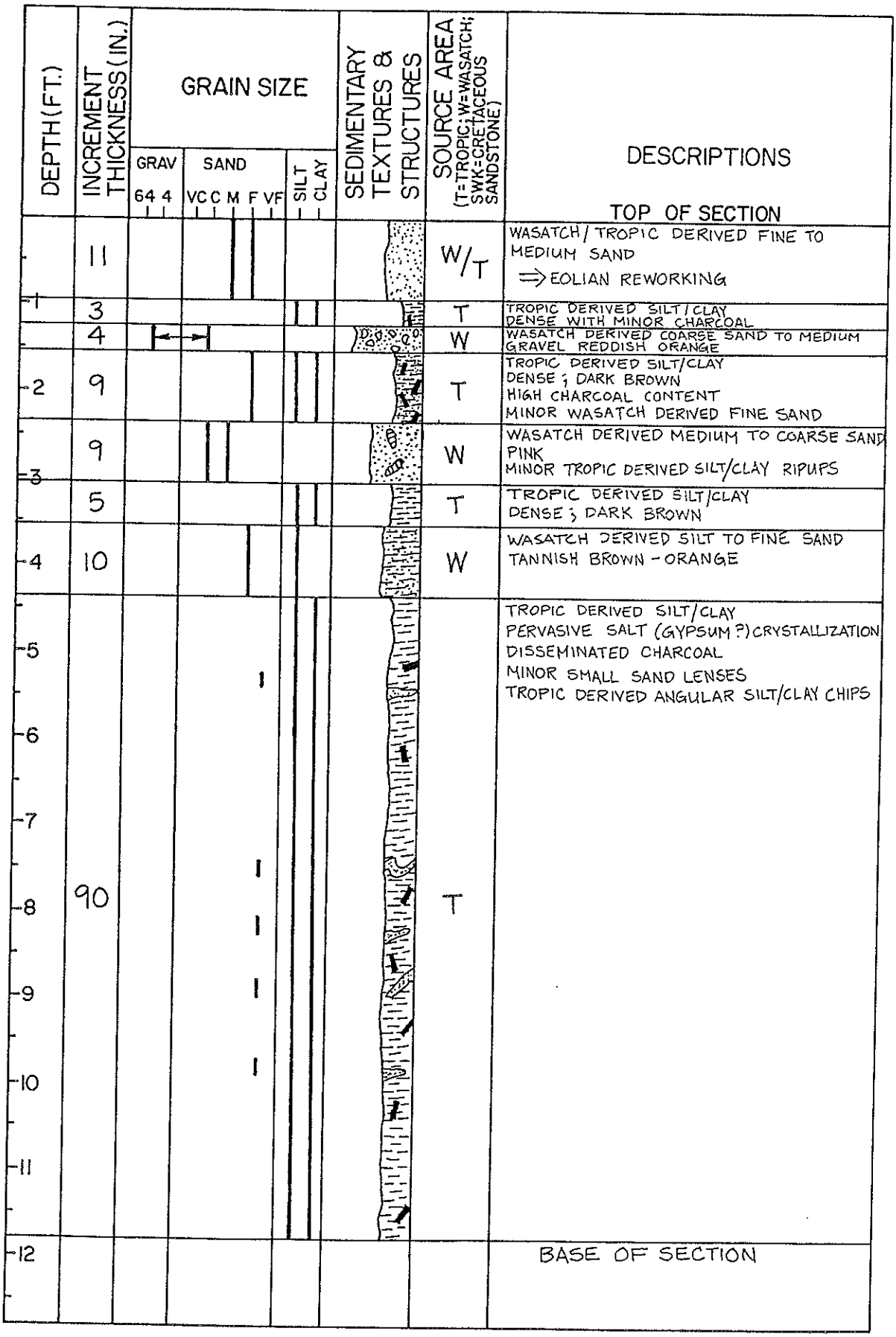
MEASURED SECTION NO. 13
LOCALITY XS 3
SETTING EAST SIDE VALLEY
STATION 1+79

DATE 7/13/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY MH/KF/JS/DW
ELEVATION 7084.0

DEPTH (FT.)	INCREMENT THICKNESS (IN.)	GRAIN SIZE (GRAV: 64 4; SAND: VC C M F VF; SILT CLAY)	SEDIMENTARY TEXTURES & STRUCTURES	SOURCE AREA (T=TROPIC; W=WASATCH; SWK=CRETACEOUS SANDSTONE)	DESCRIPTIONS
					TOP OF SECTION
1–2	30			W/T	WASATCH/TROPIC DERIVED VERY FINE SAND AND SILT WASATCH MATERIAL PRESERVED IN ROOT CASTS DOMINANTLY TROPIC DERIVED MATERIAL VERY DENSE ⇒ SLOPEWASH DEPOSITS OFF EASTERN TOPOGRAPHIC HIGH
3	10			W	WELL SORTED MEDIUM TO COARSE SAND HORIZONTAL LAMINATIONS MINOR CHARCOAL
	1			W	WASATCH DERIVED SILT DRAPE
	3			T	TROPIC DERIVED SILT/CLAY ⇒ SLOPEWASH DENSE
4	5			W	WASATCH DERIVED MEDIUM TO COARSE SAND HORIZONTAL LAMINATIONS COARSE/FINE COUPLETS
	7			W	FINE TO MEDIUM SAND SMALL SCALE TROUGH CROSSBEDS ABUNDANT RIPUPS
	1			T	TROPIC DERIVED SILT/CLAY DRAPE
5	2			SWK	MEDIUM TO COARSE SAND
	1			T	TROPIC DERIVED SILT/CLAY DRAPE
	5			W	MEDIUM TO COARSE SAND PLANAR LAMINATIONS RIPPLE CROSS STRATIFICATION
	3			T	TROPIC DERIVED SILT/CLAY DRAPE LATERALLY CONTINUOUS
6	3			W/T	WASATCH/TROPIC DERIVED SILT TO FINE SAND; GRAYISH BROWN; HIGH CHARCOAL CONTENT
	2			W	WASATCH DERIVED BRIGHT ORANGE MEDIUM TO COARSE SAND; LATERALLY CONTINUOUS
	6			SWK	GRAY MEDIUM TO COARSE SAND HORIZONTAL LAMINATIONS
7–12	70			T	TROPIC DERIVED SILT/CLAY WITH MINOR FINE SAND MASSIVE; DENSE HORIZONTAL PARTINGS UPPER CONTACT SHOWS EXTREME RELIEF HIGH CHARCOAL CONTENT ⇒ LOCALLY DERIVED MASS WASTING OR REPEATED SLOPEWASH DEPOSITS
					BASE OF SECTION

MEASURED SECTION NO. 14
LOCALITY XS 4A
SETTING WEST SIDE VALLEY
STATION 39+88

DATE 7/13/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY MH/KF
ELEVATION 6931.3



MEASURED SECTION NO 15
LOCALITY XS 4A
SETTING MIDVALLEY
STATION 26+00

DATE 7/13/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY MH/KF/JS/DW
ELEVATION 6988.2

DEPTH (FT.)	INCREMENT THICKNESS (IN.)	GRAIN SIZE (GRAV 64 4; SAND VC C M F VF; SILT CLAY)	SEDIMENTARY TEXTURES & STRUCTURES	SOURCE AREA (T=TROPIC; W=WASATCH; SWK=CRETACEOUS SANDSTONE)	DESCRIPTIONS
					TOP OF SECTION
1	20			T/W	DARK GRAY SILT TO FINE SAND MINOR WASATCH DERIVED PINK FINE PEBBLE CHIPS ROOTING ZONE
2	15			W	WASATCH DERIVED FINE SAND TO SILT WELL SORTED WELL INDURATED
3–4	16			T/W	CLAY TO MEDIUM SAND WASATCH DERIVED FINE PEBBLE CHIPS VERY DENSE
	6			T/W	ORGANIC RICH HORIZON (ROOTS) PEAT TYPE DEPOSIT => MAXIMUM DEPTH OF OPTIMUM ROOTING; SEASONALLY HIGH POINT OF WATER TABLE
5–6	23			T	GLEY HORIZON WATER SATURATED SILT =▽=
7–9	37				BASE OF SECTION-WATER LEVEL STANDING WATER
10–12					BASE OF HOLE

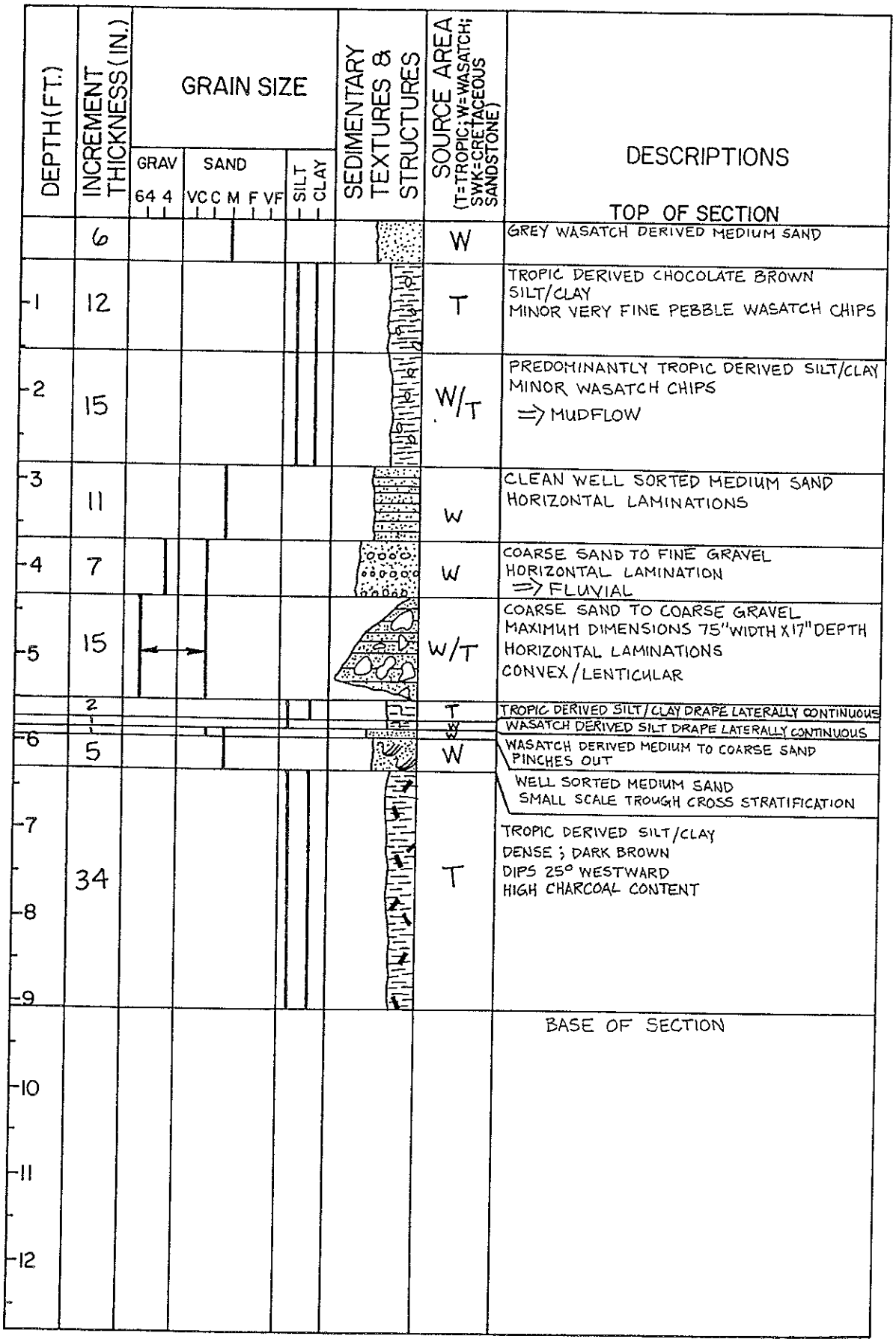
MEASURED SECTION NO. 16
LOCALITY XS 4A
SETTING MIDVALLEY
STATION 11+82

DATE 7/13/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY MH/KF
ELEVATION 7008.7

DEPTH (FT.)	INCREMENT THICKNESS (IN.)	GRAIN SIZE (GRAV: 64 4; SAND: VC C M F VF; SILT CLAY)	SEDIMENTARY TEXTURES & STRUCTURES	SOURCE AREA (T=TROPIC; W=WASATCH; SWK=CRETACEOUS SANDSTONE)	DESCRIPTIONS
					TOP OF SECTION
	8			W	VERY FINE SAND PINK WASATCH DERIVED VERY FINE PEBBLE CHIPS HORIZONTAL PARTINGS ⟹ SHEETFLOOD
1 2	17			W/T	SILT TO FINE SAND WASATCH DERIVED VERY FINE PEBBLE CHIPS CHOCOLATE BROWN BLOCKY STRUCTURE DENSE
3	12			W	PRIMARILY TROPIC DERIVED LIGHT BROWN TO FINE SAND MINOR WASATCH DERIVED CHIPS CHAOTIC DENSE ⟹ MUDFLOW
	6			W	GRAYISH-PINK COARSE SAND TO FINE GRAVEL COARSENS UPWARDS EROSIONAL BASAL CONTACT
4	7			W	WASATCH DERIVED PINK COARSE SAND TO FINE GRAVEL HIGHLY CEMENTED
	7			T	TROPIC DERIVED SILT/CLAY DENSE; INDURATED HIGH CHARCOAL CONTENT
5	8			T W	COARSE SAND TO MEDIUM GRAVEL LATERALLY CONTINUOUS; CHAOTIC TOP: ½" THICK TROPIC DERIVED SILT/CLAY DRAPE
	5			W	MEDIUM TO COARSE SAND SMALL SCALE RIPPLE CROSS STRATIFICATION LENTICULAR 16" WIDE X 5" DEEP ⟹ SMALL SCOUR CHANNEL
6	2			W	WASATCH DERIVED SILT DRAPE
	9			W	COARSE SAND TO FINE GRAVEL WELL SORTED
	2			T	CHOCOLATE BROWN TROPIC DERIVED SILT/CLAY DRAPE
7 8	18			W	VERY POORLY SORTED SAND TO BOULDERS MATRIX SUPPORTED; WASATCH DERIVED CHAOTIC; MAX BOULDER = 400 MM NUMEROUS CLASTS 150-250 MM ⟹ DEBRIS FLOW
	4			W	WELL SORTED MEDIUM SAND; HORIZONTAL LAMINATIONS; COARSE/FINE COUPLETS
9 10 11	35			T	TROPIC DERIVED CHOCOLATE BROWN SILT/CLAY MINOR PINK WASATCH DERIVED SILT IN UPPER 22" DENSE HIGH CHARCOAL CONTENT INCREASED INDURATION WITH DEPTH
12					BASE OF SECTION

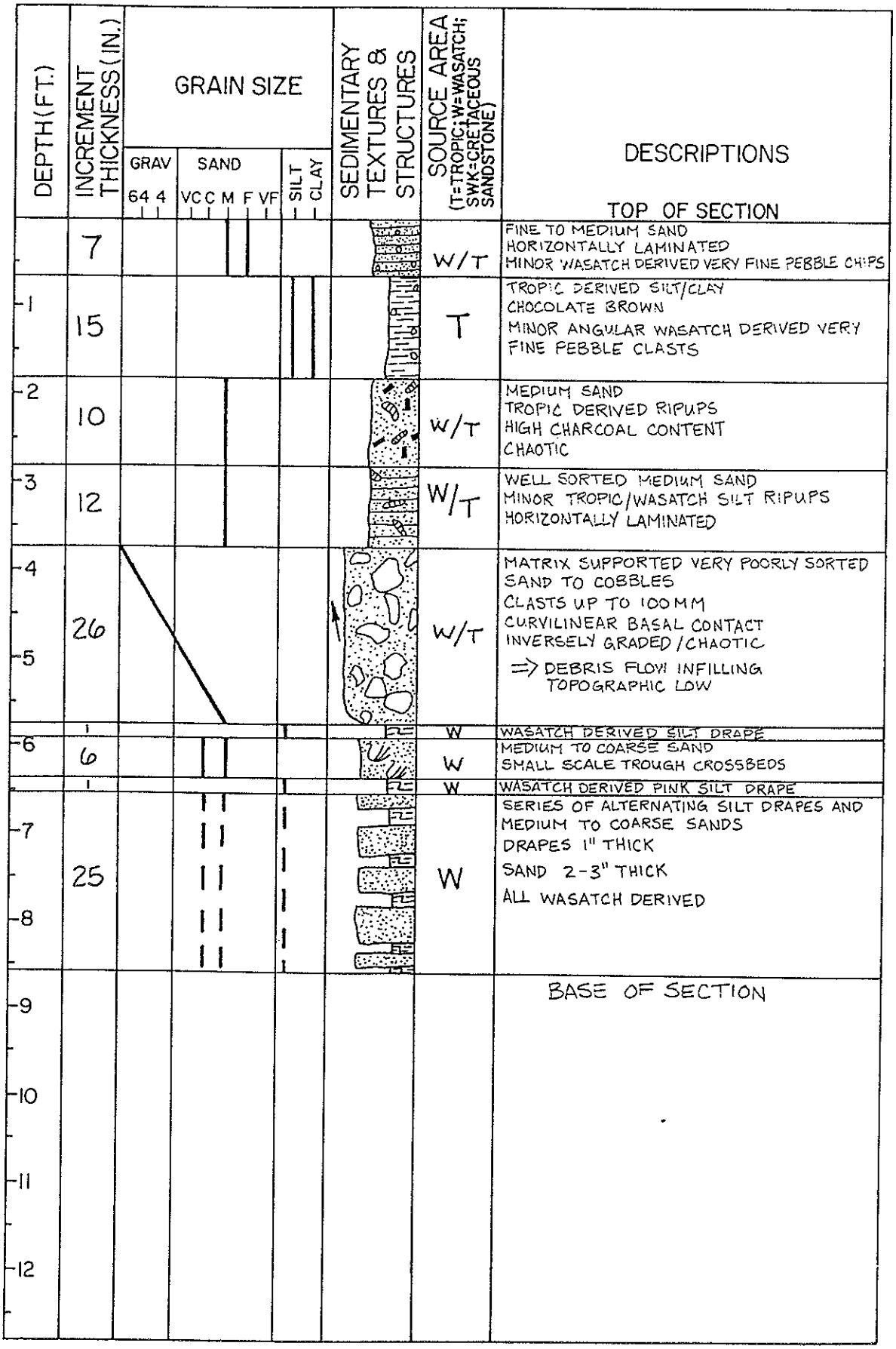
MEASURED SECTION NO. 17
LOCALITY XS 3
SETTING EAST SIDE; 9' WEST OF M.S. 13
STATION 1+79

DATE 7/13/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY MH/KF
ELEVATION 7084.0



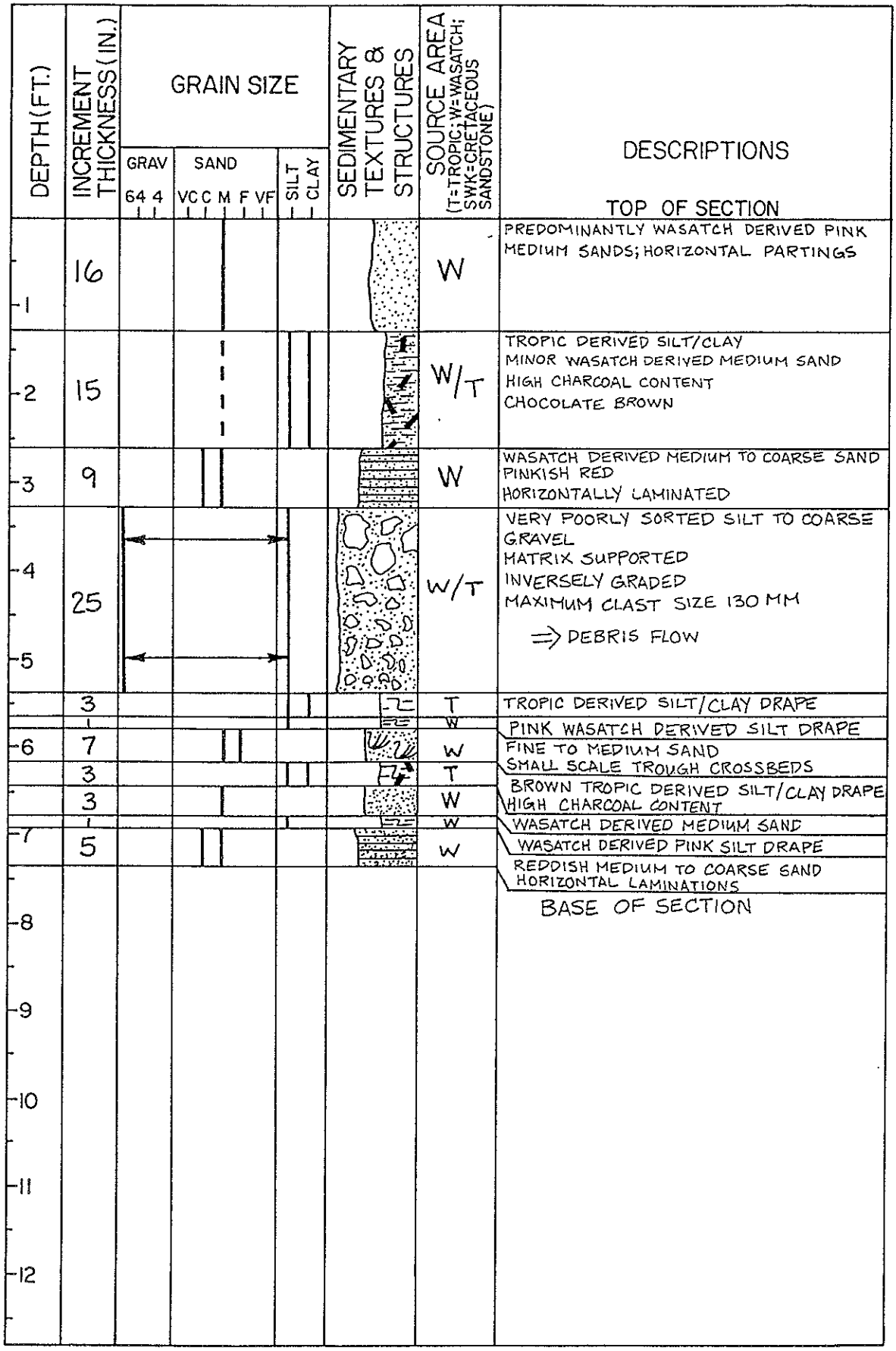
MEASURED SECTION NO. 18
LOCALITY XS 3
SETTING EAST SIDE; 16' WEST OF M.S. 13
STATION 1+79

DATE 7/13/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY MH/KF
ELEVATION 7048.0



MEASURED SECTION NO 19
LOCALITY XS 3
SETTING EAST SIDE; 25' WEST OF M.S. 13
STATION 1+79

DATE 7/13/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY MH/KF
ELEVATION 7084.0



MEASURED SECTION NO. 20
LOCALITY XS 4A
SETTING TLB LOWER ROBINSON CREEK
STATION 42+80

DATE 7/14/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY KF/JS
ELEVATION 6921.4

DEPTH (FT.)	INCREMENT THICKNESS (IN.)	GRAIN SIZE (GRAV 64 4; SAND VC C M F VF; SILT CLAY)	SEDIMENTARY TEXTURES & STRUCTURES	SOURCE AREA (T=TROPIC; W=WASATCH; SWK=CRETACEOUS SANDSTONE)	DESCRIPTIONS
					TOP OF SECTION
1	15			W/T	WASATCH/TROPIC DERIVED SILT TO FINE SAND MASSIVE; FRIABLE
2 3	31			T	TROPIC DERIVED SILT/CLAY DENSE; BLOCKY
4				W	WASATCH DERIVED SILT DRAPE DISCONTINUOUS
5 6	25			T	TROPIC DERIVED SILT/CLAY MASSIVE MINOR WASATCH DERIVED ROOT COATINGS
	3			W	WASATCH DERIVED FINE TO MEDIUM SAND MASSIVE; DISCONTINUOUS
7 8 9 10 11 12	71			T SWK	TROPIC DERIVED SILT/CLAY PERVASIVE SALT CRYSTALLIZATION 22" FROM TOP, MINOR STRAIGHT CLIFFS DERIVED PEBBLES, UP TO 20MM NO WASATCH MATERIAL
					BASE OF SECTION

MEASURED SECTION NO. 21
LOCALITY XS 4A
SETTING EAST SIDE VALLEY
STATION 4+42

DATE 7/14/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY KF/JS
ELEVATION 7017.6

DEPTH (FT.)	INCREMENT THICKNESS (IN.)	GRAIN SIZE (GRAV 64 4; SAND VC C M F VF; SILT CLAY)	SEDIMENTARY TEXTURES & STRUCTURES	SOURCE AREA (T=TROPIC; W=WASATCH; SWK=CRETACEOUS SANDSTONE)	DESCRIPTIONS
					TOP OF SECTION
	8			T	TROPIC DERIVED SILT TO FINE SAND DESSICATED; FRIABLE; MASSIVE MINOR WASATCH INPUT
1	12			W W T	TROPIC DERIVED SILT/CLAY DISCONTINUOUS LENSES OF WASATCH DERIVED SILTS
2	15			T	TROPIC DERIVED SILT/CLAY DENSE
3	6			T	TROPIC DERIVED SILT TO FINE SAND HORIZONTAL LAMINATION
	3			T	TROPIC DERIVED SILT, HIGH CHARCOAL CONTENT
	1			W	WASATCH DERIVED SILT DRAPE
4	2			T	TROPIC DERIVED SILT, SOME CHARCOAL, WASATCH CHIPS
	1			W	WASATCH DERIVED SILT DRAPE
	3			W/T	WASATCH/TROPIC DERIVED SILT TO MEDIUM SAND
	2			W	WASATCH DERIVED SILT DRAPE
	3			W/T	ALTERNATING T/W/T/W SILT DRAPE
	2			W	WASATCH DERIVED SILT TO FINE SAND
5	2			W/T	W/T MED. SAND TROUGH CROSSBEDS C/F COUPLETS
	1			W	WASATCH DERIVED SILT DRAPE
	1			W	WASATCH DERIVED SAND TROUGH CROSSBEDS
	2			W	WASATCH DERIVED SILT TO FINE SAND
	2			W/T	W/T DERIVED SILT TO MED. SAND; TROUGH CROSSBEDS
	1			W	WASATCH DERIVED SILT DRAPE
6	5			W/T	WASATCH/TROPIC DERIVED SILT TO MEDIUM SAND POORLY SORTED, MINOR TROUGH CROSS STRATIFICATION
	2			W/T	ALTERNATING W/T DERIVED SILT/CLAY DRAPES
	3			SWK	SILT TO MEDIUM SAND LIGHT BROWN MINOR TROUGH CROSSBEDS
	1			W	WASATCH DERIVED SILT DRAPE
	2			W	WASATCH DERIVED SILT TO FINE SAND
7	2			W/T	ALTERNATING W/T DERIVED SILT/CLAY DRAPES
	3			W	WASATCH DERIVED SILT TO MEDIUM SAND HORIZONTAL LAMINATIONS
	4			W/T	ALTERNATING W/T DERIVED SILT/CLAY DRAPES
	3			SWK	COARSE SAND TO FINE GRAVEL; INVERSELY GRADED EROSIONAL BASE
	2			T	TROPIC DERIVED SILT
8	4			SWK	FINE TO MEDIUM SAND COURSE / FINE COUPLETS
	1			W	WASATCH DERIVED SILT DRAPE
	5			SWK/W	SILT TO COARSE SAND TROUGH CROSSBEDS HIGH CHARCOAL CONTENT
9	7			T	TROPIC DERIVED CLAY TO FINE SAND; CHARCOAL MINOR WASATCH CHIPS
	1			W	WASATCH DERIVED SILT TO MEDIUM SAND
10	13			W/T	INTERBEDDED MEDIUM SAND AND SILT/CLAY DRAPES SAND 2-4", DRAPES 1" LIGHT TO DARK BROWN PRIMARILY TROPIC DERIVED, WITH SOME WASATCH MATERIAL IN DRAPES
11	6			W/T	ALTERNATING WASATCH/TROPIC DERIVED SILT/CLAY MINOR VF SAND
	5			W/T	WASATCH/TROPIC DERIVED SILT/CLAY
	2			W	WASATCH DERIVED SILT TO COARSE SAND LENTICULAR; HORIZONTAL LAMINATIONS
	4			W/T/SWK	ALTERNATING W/T DERIVED SILT/CLAY PINK-BROWN-GRAY HIGH CHARCOAL CONTENT
12	2			SWK	LIGHT BROWN FINE TO MEDIUM SAND; MASSIVE
	6			T/SWK	SILT TO FINE SAND LIGHT BROWN; MASSIVE
					BASE OF SECTION

MEASURED SECTION NO. 22
LOCALITY XS 4B
SETTING NORTH SWAPP HOLLOW
STATION 7+86

DATE 7/14/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY KF/JS
ELEVATION 6988.7

DEPTH (FT.)	INCREMENT THICKNESS (IN.)	GRAIN SIZE: GRAV (64 4)	SAND (VC C M F VF)	SILT	CLAY	SEDIMENTARY TEXTURES & STRUCTURES	SOURCE AREA (T=TROPIC; W=WASATCH; SWK=CRETACEOUS SANDSTONE)	DESCRIPTIONS
								TOP OF SECTION
1	23						T/W	DENSE PRIMARILY TROPIC DERIVED SILT/CLAY WITH MINOR WASATCH DERIVED COARSE SAND POORLY SORTED; BROWN HIGH CHARCOAL CONTENT
2, 3, 4	32						T/W	DENSE TROPIC DERIVED SILT/CLAY WITH MINOR FLOATING FRAGMENTS OF WASATCH DERIVED COARSE SAND TO FINE GRAVEL
	4						W	WASATCH DERIVED CLAY TO MEDIUM. SAND; DENSE; PINK LATERALLY CONTINUOUS; DIPS 4° SOUTHWARD
5, 6, 7, 8	43						T/W	TROPIC DERIVED SILT/CLAY VERY DENSE; HIGH CHARCOAL CONTENT DISCRETE POCKETS OF WASATCH DERIVED SILT TO FINE SAND- BRIGHT ORANGE IN DARK BROWN MATRIX => CRACK INFILLING? PERVASIVE SALT CRYSTALLIZATION
9, 10	25						T/W	TROPIC DERIVED SILT/CLAY SALT CRYSTALLIZATION MINOR WASATCH SILT TO FINE SAND
11, 12								BASE OF SECTION

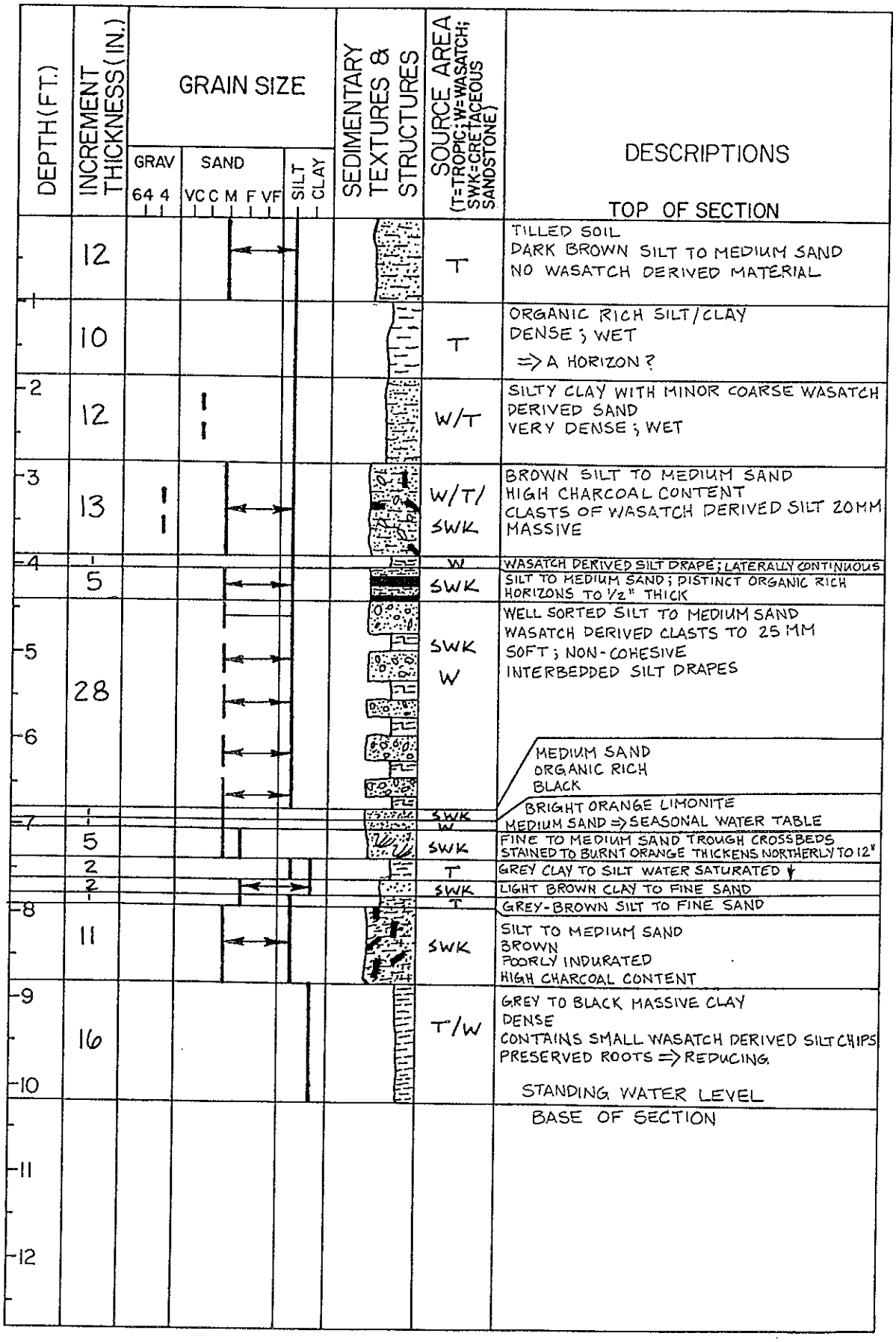
MEASURED SECTION NO 23
LOCALITY XS 4B
SETTING SOUTH SIDE SWAPP HOLLOW
STATION 23+67

DATE 7/14/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY KF/JS
ELEVATION 6952.3

DEPTH (FT.)	INCREMENT THICKNESS (IN.)	GRAIN SIZE (GRAV 64 4; SAND VC C M F VF; SILT CLAY)	SEDIMENTARY TEXTURES & STRUCTURES	SOURCE AREA (T=TROPIC; W=WASATCH; SWK=CRETACEOUS SANDSTONE)	DESCRIPTIONS
					TOP OF SECTION
1	15			W/T	TROPIC DERIVED SILT/CLAY MINOR WASATCH CLASTS UP TO 15 MM CHAOTIC
2 3 4	42			W/T	TROPIC DERIVED SILT/CLAY FRIABLE; VERY DENSE RANDOM WASATCH CLASTS UP TO 35MM CHAOTIC => MUDFLOW
5	9			T/W/SWK	MED. SAND TO COARSE GRAVEL UP TO 130MM CHAOTIC; CONVEX; LENTICULAR FAINT INVERSE GRADING; HIGH CHARCOAL CONTENT; MINOR WASATCH DERIVED MATERIAL
	2			W	WASATCH DERIVED PINK SILT DRAPE
6	4			W/T	TROPIC DERIVED SILT/CLAY W/ MINOR WASATCH DERIVED CHIPS UP TO 10MM
	1			W	WASATCH DERIVED PINK SILT DRAPE
	2			T	TROPIC DERIVED SILT/CLAY; CHARCOAL; MASSIVE
	1			W	WASATCH DERIVED PINK SILT DRAPE
7	10			T	TROPIC DERIVED SILT/CLAY BROWN RIPUPS OF WASATCH DERIVED SILT DRAPES
	2			T	SILT TO FINE SAND (TROPIC/STRAIGHT CLIFFS; CHARCOAL
8	9			W/T	TROPIC DERIVED SILT/CLAY WITH RANDOMLY ORIENTED WASATCH DERIVED FINE GRAVEL
	2			W	WASATCH DERIVED SILT/CLAY; PINK
9 10	25			SWK	SILT TO FINE SAND; MOTTLED; BROWN TROPIC/STRAIGHT CLIFFS DERIVED
11	6			T/W/SWK	TROPIC DERIVED CLAY TO FINE SAND HIGH CHARCOAL CONTENT MINOR WASATCH COARSE SAND
	5			SWK/W	SILT TO FINE SAND; GREY TO LIGHT BROWN; CHARCOAL; COARSE SAND SIZE WASATCH DERIVED FRAGMENTS
12					BASE OF SECTION

MEASURED SECTION NO. 24
LOCALITY XS 5
SETTING WEST EDGE SORENSON'S GARDEN
STATION 10+14

DATE 7/14/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY KF/JS
ELEVATION 6946.9



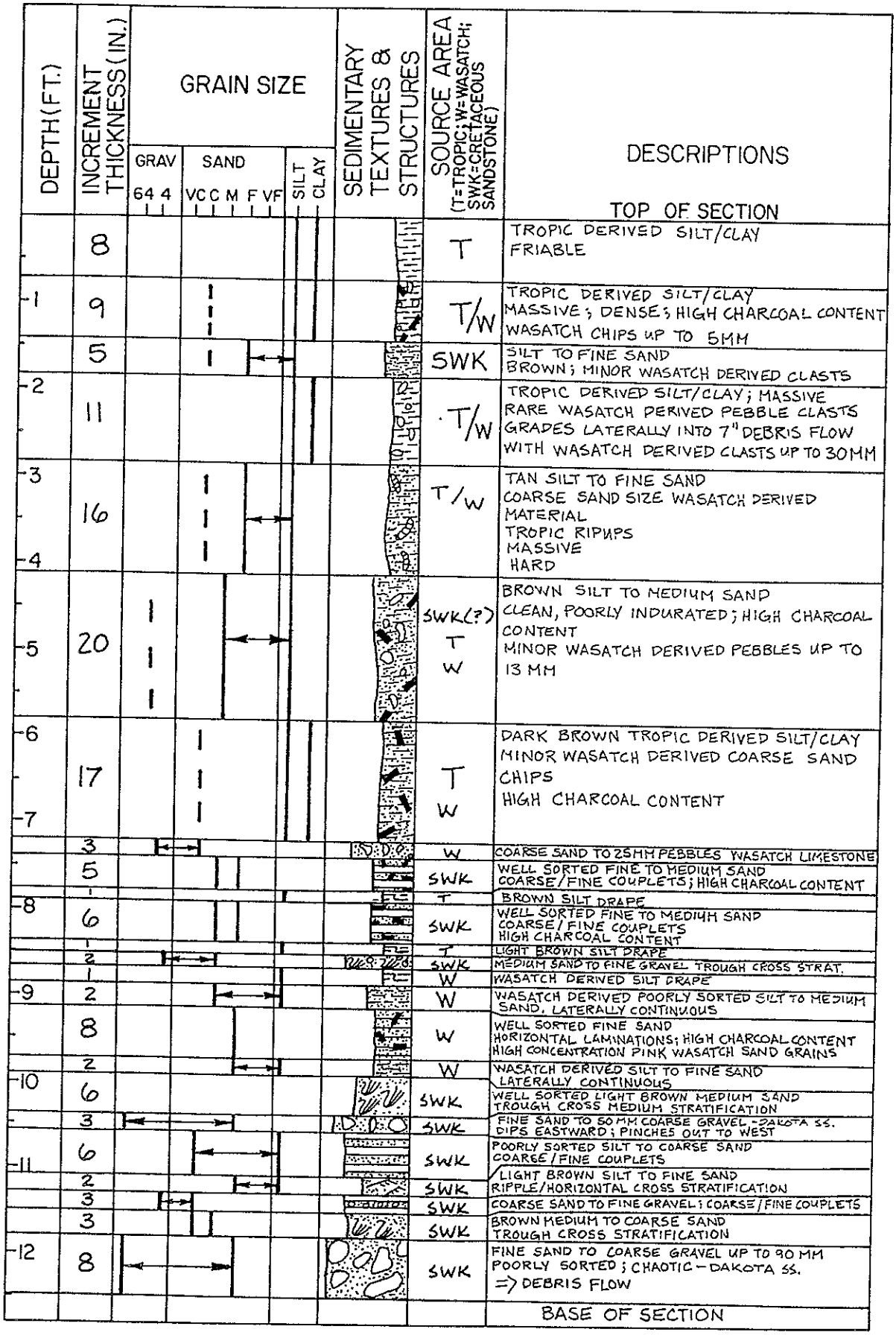
MEASURED SECTION NO. 25
LOCALITY XS 5
SETTING MIDVALLEY
STATION 24+29

DATE 7/14/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY KF/JS
ELEVATION 6917.5

DEPTH (FT.)	INCREMENT THICKNESS (IN.)	GRAIN SIZE (GRAV 64 4; SAND VC C M F VF; SILT CLAY)	SEDIMENTARY TEXTURES & STRUCTURES	SOURCE AREA (T=TROPIC; W=WASATCH; SWK=CRETACEOUS SANDSTONE)	DESCRIPTIONS
					TOP OF SECTION
	5			W/T	WASATCH / TROPIC DERIVED SILT TO FINE SAND COARSE / FINE COUPLETS
1	9			T	DARK GREY SILT TO FINE SAND PREDOMINANTLY TROPIC DERIVED
	3			W	PINK WASATCH DERIVED MASSIVE CLAY TO FINE SAND
	6			W/T	WASATCH / TROPIC DERIVED SILT TO MEDIUM SAND FRIABLE, MASSIVE; WASATCH DERIVED MEDIUM SAND SIZE SILT CHIPS
2	4			T	TROPIC DERIVED SILT/CLAY MASSIVE
	3			W/T	TROPIC/WASATCH DERIVED SILT TO MEDIUM SAND
3	14			T	TROPIC DERIVED SILT/CLAY MINOR WASATCH DERIVED CRACK INFILLING VERY DENSE
4	11			SWK W	GREY SILT MINOR AMOUNT OF WASATCH DERIVED SILT GIVES UNIT A MOTTLED GREY/PINK APPEARANCE
5	15			SWK W	SAME SILT AS ABOVE WITH A MUCH GREATER CONCENTRATION OF WASATCH DERIVED SILT TO FINE SAND VERY DENSE
	4			SWK	CLAY TO VERY FINE SAND GREY
6 7	28			T SWK	GREY, WATER SATURATED CLAY TO FINE SAND OCCASIONAL LIGHT MOTTLING BUT NO DISCRETE WASATCH DERIVED CLASTS WELL PRESERVED ROOTS ▽
8	12				BASE OF SECTION STANDING WATER
9 10 11 12					BASE OF PIT

MEASURED SECTION NO. 26
LOCALITY XS 5
SETTING WEST SIDE VALLEY
STATION 40+02

DATE 7/14/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY KF/JS
ELEVATION 6871.1



DEPTH (FT.)	INCREMENT THICKNESS (IN.)	GRAIN SIZE (GRAV 64 4; SAND VC C M F VF; SILT CLAY)	SEDIMENTARY TEXTURES & STRUCTURES	SOURCE AREA (T=TROPIC; W=WASATCH; SWK=CRETACEOUS SANDSTONE)	DESCRIPTIONS
					TOP OF SECTION
	8			T	TROPIC DERIVED SILT/CLAY FRIABLE
-1	9			T/W	TROPIC DERIVED SILT/CLAY MASSIVE; DENSE; HIGH CHARCOAL CONTENT WASATCH CHIPS UP TO 5MM
	5			SWK	SILT TO FINE SAND BROWN; MINOR WASATCH DERIVED CLASTS
-2	11			T/W	TROPIC DERIVED SILT/CLAY; MASSIVE RARE WASATCH DERIVED PEBBLE CLASTS GRADES LATERALLY INTO 7" DEBRIS FLOW WITH WASATCH DERIVED CLASTS UP TO 30MM
-3 -4	16			T/W	TAN SILT TO FINE SAND COARSE SAND SIZE WASATCH DERIVED MATERIAL TROPIC RIPUPS MASSIVE HARD
-5	20			SWK(?) T W	BROWN SILT TO MEDIUM SAND CLEAN, POORLY INDURATED; HIGH CHARCOAL CONTENT MINOR WASATCH DERIVED PEBBLES UP TO 13 MM
-6 -7	17			T W	DARK BROWN TROPIC DERIVED SILT/CLAY MINOR WASATCH DERIVED COARSE SAND CHIPS HIGH CHARCOAL CONTENT
	3			W	COARSE SAND TO 25MM PEBBLES WASATCH LIMESTONE
	5			SWK	WELL SORTED FINE TO MEDIUM SAND COARSE/FINE COUPLETS; HIGH CHARCOAL CONTENT
				T	BROWN SILT DRAPE
-8	6			SWK	WELL SORTED FINE TO MEDIUM SAND COARSE/FINE COUPLETS HIGH CHARCOAL CONTENT
				T	LIGHT BROWN SILT DRAPE
	2			SWK	MEDIUM SAND TO FINE GRAVEL TROUGH CROSS STRAT.
				W	WASATCH DERIVED SILT DRAPE
-9	2			W	WASATCH DERIVED POORLY SORTED SILT TO MEDIUM SAND, LATERALLY CONTINUOUS
	8			W	WELL SORTED FINE SAND HORIZONTAL LAMINATIONS; HIGH CHARCOAL CONTENT HIGH CONCENTRATION PINK WASATCH SAND GRAINS
	2			W	WASATCH DERIVED SILT TO FINE SAND LATERALLY CONTINUOUS
-10	6			SWK	WELL SORTED LIGHT BROWN MEDIUM SAND TROUGH CROSS MEDIUM STRATIFICATION
	3			SWK	FINE SAND TO 50 MM COARSE GRAVEL - DAKOTA SS. DIPS EASTWARD; PINCHES OUT TO WEST
-11	6			SWK	POORLY SORTED SILT TO COARSE SAND COARSE/FINE COUPLETS
	2			SWK	LIGHT BROWN SILT TO FINE SAND RIPPLE/HORIZONTAL CROSS STRATIFICATION
	3			SWK	COARSE SAND TO FINE GRAVEL; COARSE/FINE COUPLETS
	3			SWK	BROWN MEDIUM TO COARSE SAND TROUGH CROSS STRATIFICATION
-12	8			SWK	FINE SAND TO COARSE GRAVEL UP TO 90 MM POORLY SORTED; CHAOTIC - DAKOTA SS. => DEBRIS FLOW
					BASE OF SECTION

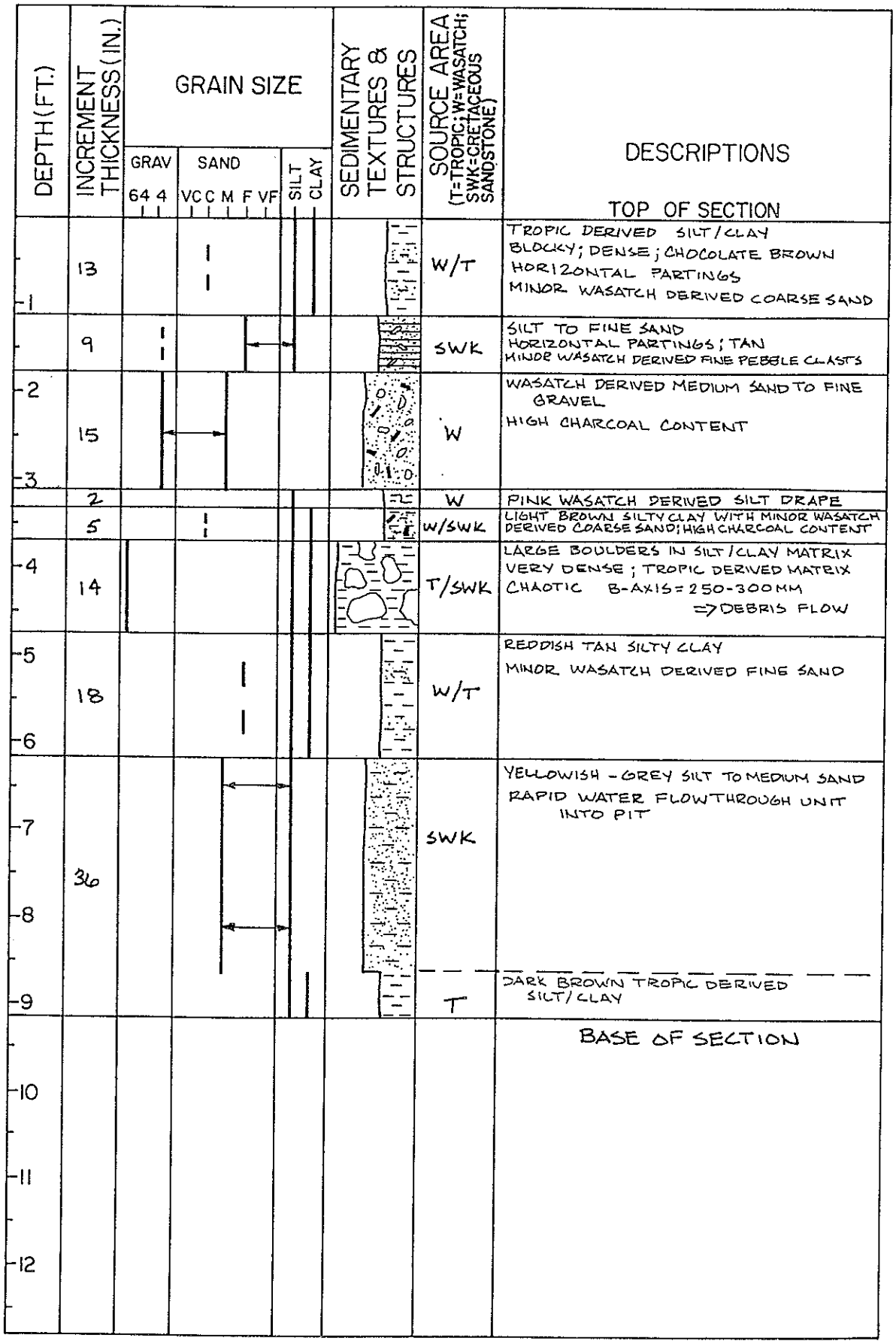
MEASURED SECTION NO. 27
LOCALITY XS 6
SETTING WEST SIDE VALLEY
STATION 29+92

DATE 7/14/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY KF/JS
ELEVATION 6851.9

DEPTH (FT.)	INCREMENT THICKNESS (IN.)	GRAIN SIZE (GRAV 64 4; SAND VC C M F VF; SILT CLAY)	SEDIMENTARY TEXTURES & STRUCTURES	SOURCE AREA (T=TROPIC; W=WASATCH; SWK=CRETACEOUS SANDSTONE)	DESCRIPTIONS
					TOP OF SECTION
	11			W	WASATCH DERIVED SILT TO FINE SAND HORIZONTAL PARTINGS ⇒ SHEETFLOW
1	2			T	TROPIC DERIVED SILT/CLAY; MASSIVE; HIGH CHARCOAL CONTENT
	7			W/T	WASATCH/TROPIC DERIVED SILT
2 3	20			T	TROPIC DERIVED SILT/CLAY HIGH CHARCOAL CONTENT MASSIVE
	5			SWK	SILT TO MED. SAND LIGHT BROWN HIGH CHARCOAL CONTENT
4 5	16			W/T	TROPIC DERIVED SILT/CLAY WITH WASATCH DERIVED FINE SAND
6 7	31			T	GREY CLAY WATER SATURATED ORANGE MOTTLING ▽
8 9					BASE OF SECTION STANDING WATER
10 11 12					BASE OF PIT

MEASURED SECTION NO: 28
LOCALITY XS 6
SETTING SWAPP RANCH
STATION 18+91

DATE 7/15/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY MH/KF
ELEVATION 6866.8



DEPTH (FT.)	INCREMENT THICKNESS (IN.)	SOURCE AREA (T=TROPIC; W=WASATCH; SWK=CRETACEOUS SANDSTONE)	DESCRIPTIONS
			TOP OF SECTION
1	13	W/T	TROPIC DERIVED SILT/CLAY BLOCKY; DENSE; CHOCOLATE BROWN HORIZONTAL PARTINGS MINOR WASATCH DERIVED COARSE SAND
	9	SWK	SILT TO FINE SAND HORIZONTAL PARTINGS; TAN MINOR WASATCH DERIVED FINE PEBBLE CLASTS
2–3	15	W	WASATCH DERIVED MEDIUM SAND TO FINE GRAVEL HIGH CHARCOAL CONTENT
	2	W	PINK WASATCH DERIVED SILT DRAPE
	5	W/SWK	LIGHT BROWN SILTY CLAY WITH MINOR WASATCH DERIVED COARSE SAND; HIGH CHARCOAL CONTENT
4	14	T/SWK	LARGE BOULDERS IN SILT/CLAY MATRIX VERY DENSE; TROPIC DERIVED MATRIX CHAOTIC B-AXIS = 250-300 MM ⇒ DEBRIS FLOW
5–6	18	W/T	REDDISH TAN SILTY CLAY MINOR WASATCH DERIVED FINE SAND
7–8	36	SWK	YELLOWISH-GREY SILT TO MEDIUM SAND RAPID WATER FLOW THROUGH UNIT INTO PIT
9		T	DARK BROWN TROPIC DERIVED SILT/CLAY
10–12			BASE OF SECTION

MEASURED SECTION NO. 29
LOCALITY XS 7
SETTING WEST SIDE VALLEY
STATION 8+99

DATE 7/15/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY MH/KF/JS
ELEVATION 6814.2

DEPTH (FT.)	INCREMENT THICKNESS (IN.)	GRAIN SIZE (GRAV 64 4; SAND VC C M F VF; SILT; CLAY)	SEDIMENTARY TEXTURES & STRUCTURES	SOURCE AREA (T=TROPIC; W=WASATCH; SWK=CRETACEOUS SANDSTONE)	DESCRIPTIONS
					TOP OF SECTION
	8			T	DARK BROWN TROPIC DERIVED SILT/CLAY PEDOGENIC STRUCTURE
1	9			W	PREDDOMINANTLY WASATCH DERIVED SILT TO FINE SAND MINOR SMALL PEBBLE SIZE WASATCH SILT FRAGMENTS
2	8			T	DARK BROWN TROPIC DERIVED SILT/CLAY HIGH CHARCOAL CONTENT
3	14			W/T	PINK-TAN WASATCH DERIVED SILT TO FINE SAND TROPIC SHALE RIPUPS
	1			W	PINK WASATCH DERIVED SILT DRAPE
4	10			SWK	VERY WELL SORTED MEDIUM SAND TANNISH, WITH MINOR PINK WASATCH DERIVED SILT FRAGMENTS
5	15			T/W	DARK BROWN TROPIC DERIVED SILT/CLAY VERY DENSE MINOR WASATCH DERIVED PINK SILT FRAGMENTS
6 7 8 9	42			SWK	YELLOWISH-GREY VERY WELL SORTED FINE TO MEDIUM SAND WATER SATURATED; CONSTANT SEEPAGE INTO PIT FROM UNIT
10 11 12					BASE OF SECTION

MEASURED SECTION NO. 30
LOCALITY XS 7
SETTING MIDVALLEY
STATION 5+17

DATE 7/15/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY MH/JS/KF
ELEVATION 6815.6

DEPTH (FT.)	INCREMENT THICKNESS (IN.)	GRAIN SIZE (GRAV: 64 4; SAND: VC C M F VF; SILT CLAY)	SEDIMENTARY TEXTURES & STRUCTURES	SOURCE AREA (T=TROPIC; W=WASATCH; SWK=CRETACEOUS SANDSTONE)	DESCRIPTIONS
					TOP OF SECTION
	12			SWK	FINE TO MEDIUM SAND WITH MINOR MEDIUM GRAVEL CLASTS HORIZONTAL PARTINGS
	5			W	WASATCH DERIVED COARSE SAND TO FINE GRAVEL; EROSIONAL BASE; LENTICULAR
	2			T	TROPIC DERIVED SILT/CLAY DRAPE
	3			SWK	VERY WELL SORTED MEDIUM SAND
	1			W	WASATCH DERIVED SILT/CLAY DRAPE
-2	2			T	LIGHT BROWN SILT TO FINE SAND; PREDOMINANTLY TROPIC DERIVED
	6			T	TROPIC DERIVED DARK BROWN TO BLACK SILTY CLAY
-3	15			SWK	GREYISH YELLOW WELL SORTED MEDIUM SAND MINOR VERY FINE GRAVEL
-4	8			SWK	MEDIUM TO COARSE SAND BROWN IRON STAINING TROPIC RIPUPS MASSIVE
-5	15			SWK	FINE TO MEDIUM SAND GREYISH - YELLOW IRON STAINING DENSE
-6 -7 -8	27			SWK	WELL SORTED MEDIUM SAND GREYISH -YELLOW WATER SATURATED
-9 -10 -11 -12					BASE OF SECTION

MEASURED SECTION NO. 31
LOCALITY XS 7
SETTING EAST SIDE VALLEY
STATION 1+72

DATE 7/15/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY MH/JS/KF
ELEVATION 6820.3

DEPTH (FT.)	INCREMENT THICKNESS (IN.)	GRAIN SIZE (GRAV: 64 4; SAND: VC C M F VF; SILT CLAY)	SEDIMENTARY TEXTURES & STRUCTURES	SOURCE AREA (T=TROPIC; W=WASATCH; SWK=CRETACEOUS SANDSTONE)	DESCRIPTIONS
					TOP OF SECTION
	9			SWK	MEDIUM TO COARSE SAND ⟹ SHEETFLOW
1	10			T	TROPIC DERIVED DARK BROWN TO BLACK SILT/CLAY WITH ABUNDANT FINE GRAVEL BLOCKY; CHAOTIC ⟹ MUDFLOW
2	8			SWK	MEDIUM SAND TO FINE GRAVEL WASATCH COLORATION
3 4	28			T/W	WASATCH DERIVED BOULDERS IN SAND/MUD MATRIX CHAOTIC; MATRIX SUPPORTED BOULDERS REACH 200MM LENTICULAR; PINCHES OUT WESTWARD ⟹ DEBRIS FLOW FROM EAST
5 6 7	36			SWK	VERY WELL SORTED MEDIUM SAND GREYISH-YELLOW IRON STAINING SATURATED-HEAVY WATER FLOW
8 9 10 11 12					BASE OF SECTION

MEASURED SECTION NO. 32
LOCALITY XS 8
SETTING WEST SIDE VALLEY
STATION 5+50

DATE 7/15/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY MH/KF/JS
ELEVATION 6747.7

DEPTH (FT.)	INCREMENT THICKNESS (IN.)	GRAIN SIZE (GRAV: 64 4; SAND: VC C M F VF; SILT CLAY)	SEDIMENTARY TEXTURES & STRUCTURES	SOURCE AREA (T=TROPIC; W=WASATCH; SWK=CRETACEOUS SANDSTONE)	DESCRIPTIONS
					TOP OF SECTION
1	13			SWK	FINE TO MEDIUM SAND HORIZONTAL LAMINATION, PARTINGS GREY MINOR CLINKER CHIPS
2	15			T	TROPIC DERIVED SILT/CLAY DARK BROWN BLOCKY DENSE
3	9			SWK	LIGHT BROWN TO GREY SILT TO FINE SAND MINOR CLINKER CHIPS MASSIVE DENSE
4	11			SWK/W	SILT TO VERY FINE SAND VERY WELL SORTED MINOR WASATCH DERIVED SILT CHIPS
	1			T	TROPIC DERIVED CHOCOLATE BROWN SILT/CLAY DRAPE
5	13			SWK	VERY WELL SORTED FINE SAND MASSIVE MINOR CLINKER CHIPS
	7			SWK	MEDIUM SAND TO FINE GRAVEL GRAVEL IS REDDISH-ORANGE AND CONTAINS CLINKER MATERIAL
6	4			SWK	SILT TO FINE SAND GREYISH BROWN; MASSIVE; DENSE
	1			W	WASATCH DERIVED PINK SILT DRAPE
	3			SWK	WELL SORTED FINE SAND; HIGH CHARCOAL CONTENT
	1			W	WASATCH DERIVED SILT DRAPE
7	6			SWK	SILT TO VERY FINE SAND TAN; ABUNDANT CLINKER CHIPS
	1			W	WASATCH DERIVED SILT DRAPE
	5			T	BROWN SILT/CLAY ABUNDANT WASATCH DERIVED CHIPS; CHARCOAL
	2			W	TANNISH PINK SILT TO VERY FINE SAND CLINKER CHIPS
	1			W	PINK SILT DRAPE
8	8			T/W	ORANGE-BROWN SILT/CLAY ABUNDANT CLINKER CHIPS
	6			SWK	VERY FINE SAND WATER SATURATED ▽
9	13				BASE OF SECTION STANDING WATER
10					BASE OF PIT
11					
12					

MEASURED SECTION NO 33
LOCALITY XS 8
SETTING MIDVALLEY
STATION 3+82

DATE 7/15/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY MH/KF/JS
ELEVATION 6747.8

DEPTH (FT.)	INCREMENT THICKNESS (IN.)	GRAIN SIZE (GRAV 64 4; SAND VC C M F VF; SILT CLAY)	SEDIMENTARY TEXTURES & STRUCTURES	SOURCE AREA (T=TROPIC; W=WASATCH; SWK=CRETACEOUS SANDSTONE)	DESCRIPTIONS
					TOP OF SECTION
1	19			T	TROPIC DERIVED SILT/CLAY HEAVILY ROOTED THIN SAND STRINGERS TOP 12" PEDOGENIC
2	5			W/T	WASATCH DERIVED ORANGE FINE TO MEDIUM SAND WITH TROPIC DERIVED SILT/CLAY; DENSE; BLOCKY
	11			T	TROPIC DERIVED CLAY TO VERY FINE SAND DARK BROWN MINOR CLINKER CHIPS
3 4	23			SWK	TAN FINE TO MEDIUM SAND ABUNDANT ORGANICS, TROPIC CHIPS, CLINKER CHIPS IRON STAINING PRODUCES YELLOW MOTTLING
5	5			SWK	MEDIUM SAND TO VERY FINE GRAVEL GRAVEL CONSISTS OF SANDSTONE, CLINKER CHIPS ⇒ LOCAL SOURCE
6	9			T	CHOCOLATE BROWN TROPIC DERIVED SILT/CLAY DENSE HIGH CHARCOAL CONTENT
	8			SWK	WELL SORTED MEDIUM SAND MINOR AMOUNT OF FINE CLINKER, SANDSTONE CLASTS HIGH CHARCOAL CONTENT MASSIVE
	2			W	TANNISH-YELLOW SILT/CLAY DRAPE
7	5			SWK	WELL SORTED MEDIUM VERY WET; HIGH WATER FLOW
	3			W	PINKISH-ORANGE SILT DRAPE; HIGH CHARCOAL CONTENT
	3			W	BROWNISH-ORANGE SILT TO FINE SAND; DENSE ABUNDANT CLINKER OR WASATCH DERIVED CLASTS
8 9	15			W/SWK	ALTERNATING PINKISH ORANGE SILT AND GREY MEDIUM SAND. SAND - 2" SILT - 1". CONTINUES BELOW WATER LEVEL TO T.D. =▽=
10	16			W/SWK	STANDING WATER LEVEL
11 12					BASE OF SECTION

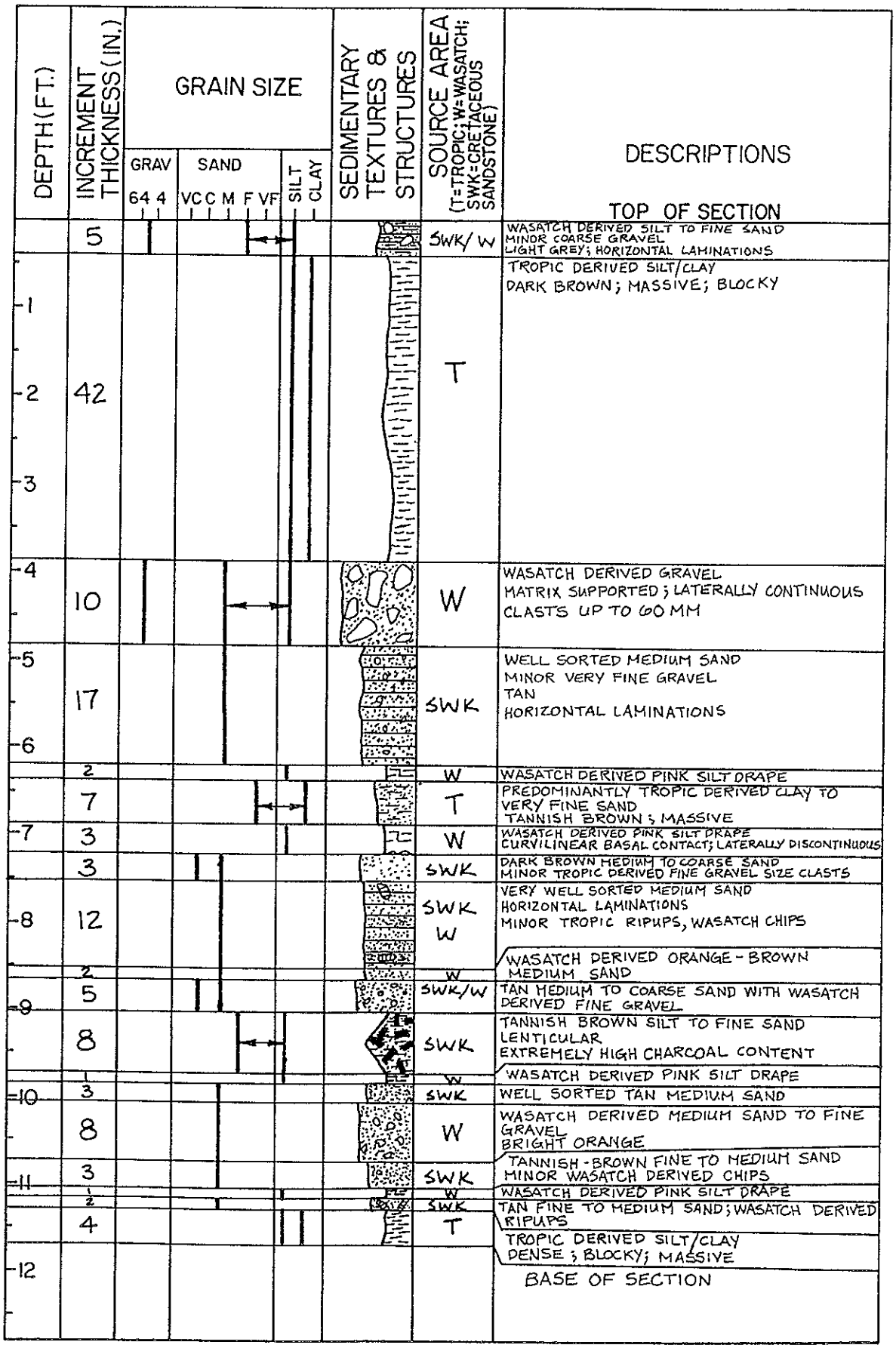
MEASURED SECTION NO 34
LOCALITY XS 8
SETTING EAST SIDE VALLEY
STATION 2+33

DATE 7/15/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY MH/KF/JS
ELEVATION 6750.0

DEPTH (FT.)	INCREMENT THICKNESS (IN.)	GRAIN SIZE (GRAV 64 4; SAND VC C M F VF; SILT CLAY)	SEDIMENTARY TEXTURES & STRUCTURES	SOURCE AREA (T=TROPIC; W=WASATCH; SWK=CRETACEOUS SANDSTONE)	DESCRIPTIONS
					TOP OF SECTION
	7			T	TROPIC DERIVED SILT/CLAY BLOCKY PEDOGENIC STRUCTURE MINOR PINK FINE CLASTS
1 2 3	32			W/T	DARK BROWN TROPIC DERIVED SILT/CLAY BLOCKY; DENSE; MASSIVE SOME WASATCH DERIVED FINE TO MEDIUM GRAVEL
4 5	23			SWK W/T	TAN MEDIUM SAND MINOR WASATCH DERIVED FINE GRAVEL LARGE TROPIC DERIVED RIPUPS MASSIVE; DENSE; WET
	6			SWK	WELL SORTED LENTICULAR MEDIUM SAND
6	7			W	WASATCH DERIVED MEDIUM TO COARSE SAND VERY WELL SORTED; PINK DIPS WESTWARD 4°
	1			W	SILT DRAPE
	4			SWK	WELL SORTED MEDIUM SAND MINOR WASATCH DERIVED RIPUPS
7 8	18			T W	TROPIC DERIVED SILT/CLAY HIGH CHARCOAL CONTENT DIP WESTWARD 4° LARGE RIPUP CLASTS OF WEATHERED WASATCH DERIVED MATERIAL
	2			W	PINK-GRAY WASATCH DERIVED SILT DRAPE; LATERALLY CONTINUOUS
	5			T	BROWN SILT/CLAY DENSE
	1			W	PINK WASATCH DERIVED SILT DRAPE
9	12			W SWK	WELL SORTED MEDIUM TO COARSE SAND HORIZONTAL LAMINATIONS; COARSE/FINE COUPLETS PEBBLES AT TOP: WASATCH DERIVED LIMESTONE, QUARTZITE BASAL SURFACE - HIGH WATER FLOW
10	4			W/T	WASATCH DERIVED SILT THINLY INTERBEDDED WITH TROPIC DERIVED SILT/CLAY
	6			T	TROPIC DERIVED SILT/CLAY - CONTINUES TO BASE OF SECTION
11	6			T	STANDING WATER LEVEL
12					BASE OF SECTION

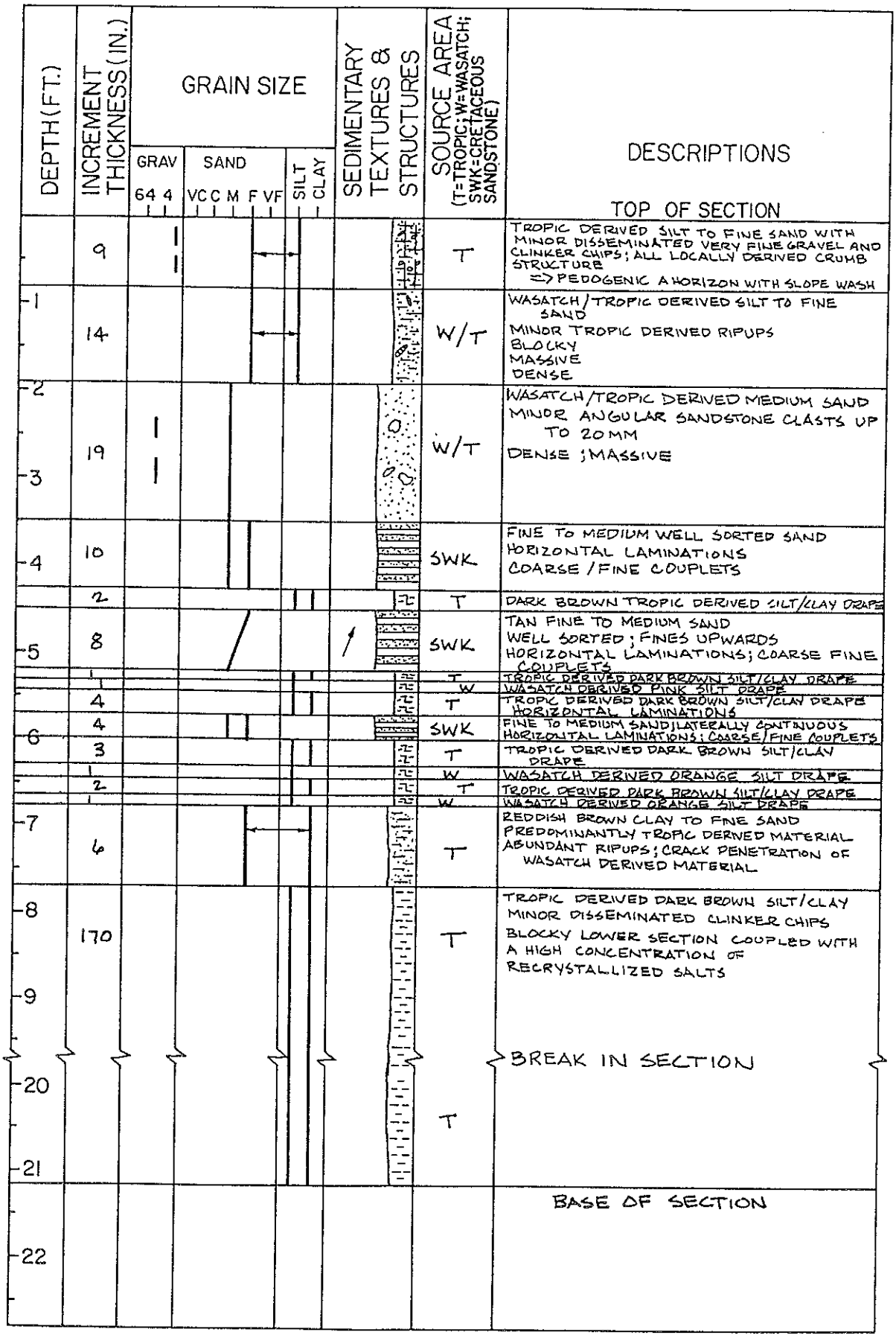
MEASURED SECTION NO. 35
LOCALITY XS 6
SETTING EAST SIDE VALLEY
STATION 3+84

DATE 7/15/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY MH/KF/JS
ELEVATION 6903.0

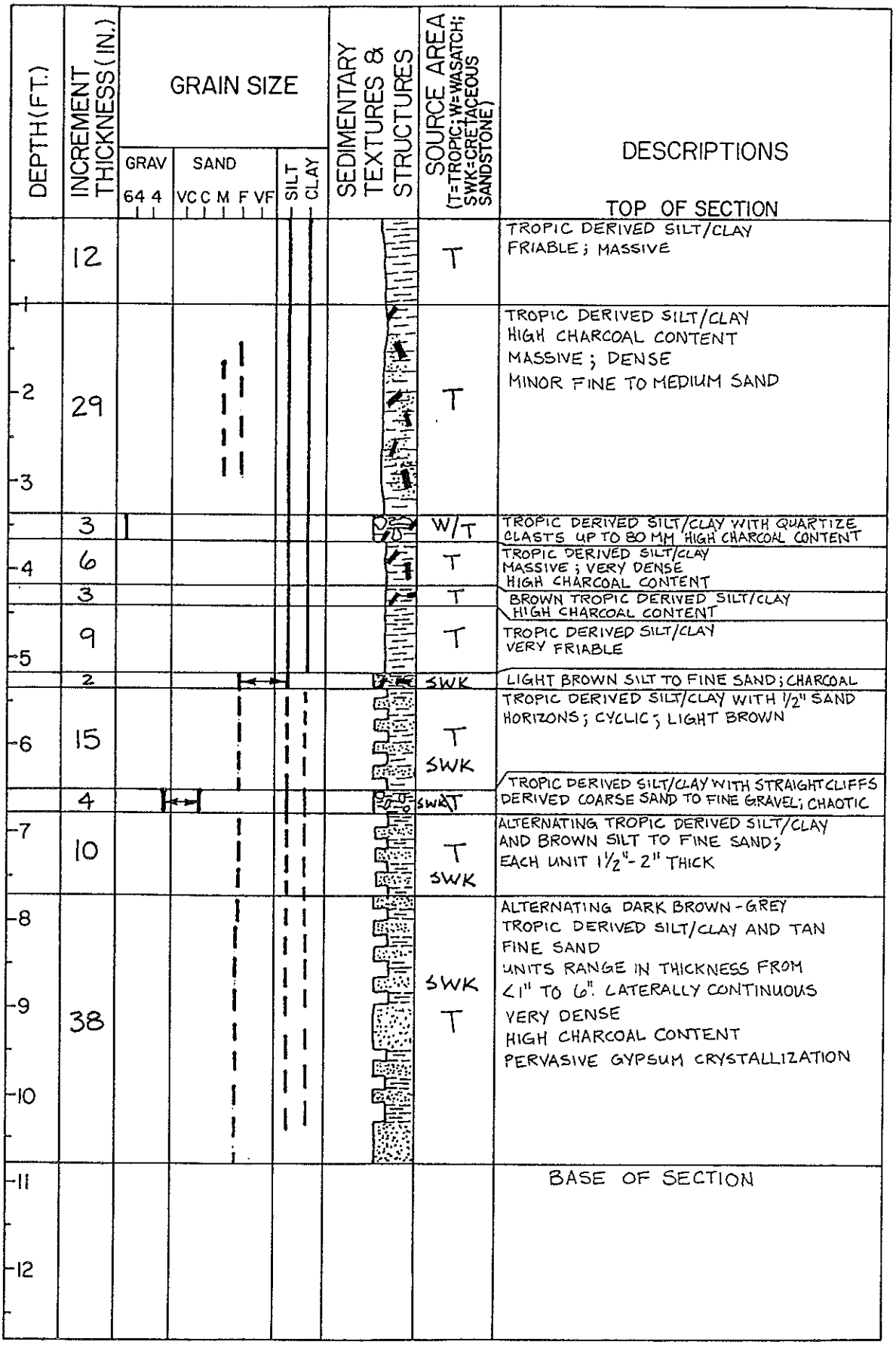


MEASURED SECTION NO 36
LOCALITY XS 9
SETTING TRB SINK VALLEY WASH
STATION 3+13

DATE 7/16/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY MH/JS/KF
ELEVATION 6670.4



MEASURED SECTION NO. 37 | DATE 7/14/88
LOCALITY XS 4B; XS 5 | STRATIGRAPHIC UNIT VALLEY FILL
SETTING CENTER SWAPP HOLLOW | MEASURED BY KF/MH/JS
STATION 14+59(4B); 0+00(5) | ELEVATION 6963.3



APPENDIX 7-5

Coal Hollow Project

Overburden and underburden chemical information

APPENDIX 7-6

Coal Hollow Project

Climatological Data

TABLE OF CONTENTS

Chapter 8

R645-301-800

Bonding and Insurance

SECTION	DESCRIPTION	PAGE
820.	Requirement to File a Bond	8-1
820.100	Operator Agrees to File a Bond	8-1
820.110.111	Area to be Covered	8-1
820.112.114	Incremental bonding	8-1
820.120	Acceptance of Bond	8-1
820.130	Coverage of Bond	8-1
820.200	Form of the Performance Bond	8-1
820.223	Surety bond	8-1
830.	Determination of Bond Amount	8-1
830.100	Bond Determination	8-1
830.140	Detailed Estimated Costs	8-2
840.	General Terms and Conditions	8-2
850.	Bond Requirements for Underground Coal Mining and Reclamation Activities	8-2
860	Form of Bond	8-2
860.100	Surety Bond	8-2
870.	Replacement of Bonds	8-2
880.	Requirement to Release Performance Bonds	8-2
890.	Terms and Conditions for Liability Insurance	8-2
890.100	Certificate of Liability Insurance	

TABLE OF CONTENTS

Chapter 8

R645-301-800

Bonding and Insurance

PHOTOGRAPHS	DESCRIPTION
None	

APPENDICES No.	DESCRIPTION
8-1	Detailed cost Estimates and Calculations

DRAWING No.	DESCRIPTION
None	

CHAPTER 8

BONDING AND INSURANCE

R645-301-800

CHAPTER 8

R645-301-800. BONDING AND INSURANCE

820. REQUIREMENT TO FILE A BOND

820.100 The Operator Agrees to File a Bond.

After the permit application is approved, but before the permit is issued, the applicant will file with the Division, on a form prescribed and furnished by the Division, a bond or bonds conditioned upon performance of all requirements of the State Program, the permit and the reclamation bond.

820.110-111 Area to be Covered by the Performance Bond

The disturbed area at the Coal Hollow Project will be bonded. The disturbed areas are identified on Drawing 5-1. The area to be mined is also identified on Drawing 5-1.

820.112-114 Incremental Bonding

Not applicable at this time.

820.120 Acceptance of Bond

The applicant agrees not to commence operations until the Division approves a performance bond for the Coal Hollow Project.

820.130 Coverage of Bond

The applicant will provide a performance bond for the disturbed area within the permit.

820.200 Form of the Performance Bond

820.223 Surety Bond

Alton Coal Development, LLC is proposing to submit a surety bond consistent with the requirements of R645-301-860.100 and any additional requirements in the State Program.

830. DETERMINATION OF BOND AMOUNT

830.100 Determined by the Division

The amount of the bond required will be determined by the Division.

830.140 Detailed Estimated Costs

The detailed estimated cost for final reclamation is listed at Appendix 8-1. The cost calculations are for the disturbed area boundaries. Total cost for final reclamation has been estimated at $4,363,548 as shown in Appendix 8-1.

840. GENERAL TERMS AND CONDITIONS OF THE BOND

General terms and conditions of the bond as stated at R645-301-840 through R645-301-840.520 will be met by Alton Coal Development, LLC

850. BOND REQUIREMENTS FOR UNDERGROUND COAL MINING

Not Applicable

860. FORM OF BOND

860.100 Surety Bond

The applicant will submit a surety bond as defined under R645-100-200 and meet all the requirements under R645-301-860.110 to .120.

870. REPLACEMENT OF BONDS

Equivalent bond coverage will be provided if Alton Coal Development, LLC replaces the surety bond.

880. REQUIREMENT TO RELEASE PERFORMANCE BONDS

Upon completion of reclamation operations, the applicant will apply for bond release and meet the requirements of R645-301-880.

890. TERMS AND CONDITIONS FOR LIABILITY INSURANCE

890.100 Certificate of Liability Insurance

A copy of the Certificate of Liability Insurance is provided in Appendix 1-3. Alton Coal Development, LLC will meet the requirements of R645-301-890 prior to commencing any mining operations.

APPENDIX 8-1

DETAIL COST ESTIMATE
And CALCULATIONS
COAL HOLLOW MINE

By: John T. Boyd Company

BONDING

Introduction

The purpose of this section is to provide a reclamation cost estimate in satisfaction of the requirements of R645-301-800, section 830.140 which requires estimated reclamation costs and supporting information to be submitted by the permit applicant.

The calculation of reclamation costs is intended to conform to "Handbook for Calculation of Reclamation Bond Amounts" published by the US Office of Surface Mining. That handbook provides a series of Worksheets used to perform the calculation. This calculation follows that same worksheet format and numbering system. Attached to this introduction are the following worksheets:

Worksheet 1 - Description of the Worst Case Reclamation Scenario
Worksheet 2 - Structure Demolition and Disposal Costs
Worksheet 3 - Material Handling Plan Summary
Worksheet 4 - Earthwork Quantity
Worksheet 5A - Equipment Productivity - Doze Spoil to Backfill Ramp Void
Worksheet 5B - Equipment Productivity - D10R - Backfill Pit and Ramps
Worksheet 5C - Equipment Productivity - Remove Ponds
Worksheet 5D - Equipment Productivity - D10R - Remove Ponds
Worksheet 9A - Equipment Productivity - Backfill Pit from Stockpile
Worksheet 9B - Equipment Productivity - End Dump Truck Travel Time
Worksheet 9C - Equipment Productivity - Loader/Truck Backfill Pit from Stockpile
Worksheet 9D - Equipment Productivity - Topsoil Replacement from E & W Stockpiles
Worksheet 9E - Equipment Productivity - Loader/Truck Topsoil Replacement - E&W
Worksheet 9F - Equipment Productivity - Topsoil Replacement from Central Stockpile
Worksheet 9G - Equipment Productivity - Loader/Truck Topsoil Replacement - Central
Worksheet 12A - Grading Requirements Haulroads, Facilities, Spoil, Topsoil
Worksheet 12B - Equipment Productivity - Grading & Ripping
Worksheet 13 - Summary Calculation of Earthmoving Costs
Worksheet 14 - Revegetation Costs
Worksheet 15 - Reclamation Bond Summary Sheet

Worksheet 1
Description of the Worst Case Reclamation Scenario

The "Worst Case" reclamation scenario occurs at the point during the permit term when the reclamation liabilities would be the highest. The determination of that point is based on the mining plans and material movement requirements, as well as the status of infrastructure and facilities. As with most truck/shovel mines, the major reclamation cost is pit backfilling and reclamation, and the "Worst Case" reclamation scenario occurs at the time when the largest pit void exists creating the largest backfilling requirements. At the Coal Hollow Mine, this will occur late in the life of the mine when the longest pit (in the NE ¼ NE ¼ of Section 30) is fully open and part of the overburden from next pit has been removed. During the same time period, an idle ramp will exist in the southern part of the property (SE ¼ SE ¼ of Section 30) that will require backfilling.

Structure Demolition:

The office, shop, the coal handling facilities will be located at the north end of the permit area in the E ½ SE ¼ of Section 19. The facilities area, including the explosives storage area, covers about 45 acres parts of which will not be disturbed. When returning the site to the post-mining land use, all structures not required for the post-mining land use will be removed. The office will be modular and will be hauled away after mining and reclamation is complete. The shop and coal handling facilities will be constructed of concrete and steel and will be demolished and the demolition debris disposed of in the pit. The coal stockpile pad will be excavated and the material buried in the open pit.

Earthmoving Activities:

Mining operations are conducted such that most of the spoil from the active pit is hauled to the previous mined-out pit which is backfilled and reclaimed. Thus, at any one time some portions of the planned mining area will have been mined and backfilled, some portions will have not been disturbed as yet, and some portion will be open and active. The worst-case reclamation scenario occurs when the active pit is at it's greatest extent. At Coal Hollow this occurs when the longest pit in the mine plan (Pit 20) is fully opened with the coal removed, and the upper lifts of subsequent pit have also been removed. At that time, the volume of material contained in the spoil stockpile, material stacked next to ramps, and the volume of the haulroad surfacing is sufficient to fill that "worst case" void to the planned post mining contour.

The main haulroad is located on the east side of the mining area and covers about 20 acres. The haulroad will be constructed with overburden material and surfaced with crushed rock. Since the slope along the haulroad from north to south is gradual, no significant cuts or fills are required. Road material will be removed and disposed of in the open pits or ramps using the truck and shovel fleet.

The "worst case" mining pit void will be about 180 feet deep (measured from the planned post-mining surface). The void volume was determined by superimposing the pit design

including spoil slopes, sidewalls and pit advance wall slopes, over the planned post mining contours using Carlson Software's SurvCADD software. (This is illustrated on the drawing at the end of this section).

Reclamation of the office, shop, and coal pad will require the removal of contaminated material where applicable. The material will be disposed of and buried in the open pit. All sediment ponds, diversion ditches, and berms will be removed when they are no longer needed to control erosion and runoff.

Topsoil Replacement:

Twelve inches of topsoil will be removed from the areas to be disturbed prior to that disturbance. Initially the topsoil will be placed in stockpiles, however as mining progresses, the topsoil removed from ahead of the pit will be placed on mined over areas as part of normal reclamation. At the time of the "worst case" reclamation scenario, sufficient topsoil will exist in stockpiles in the permit area to reclaim the pit area, roads facilities area and other disturbed zones. The stockpiled topsoil will be used to cover all areas where topsoil has been removed but not replaced. All topsoil will be graded in preparation for seeding.

Revegetation:

The worst-case reclamation situation occurs during the third year of mining in the late fall. By the spring seeding season, some of the southern portion of the mine area may be ready for seedbed preparation. The remaining areas will not be ready until the following fall and spring of the next year. The sediment ponds and diversion ditches will not be reclaimed until they are no longer needed for sediment control.

No prime farmland has been identified in the mining area.

Project: Coal Hollow Mine
Date: May 1, 2006
Prepared by:

Worksheet 2
Structure Demolition and Disposal Costs

Structures to be demolished

Item	Construction Material	Volume (cuft)	Unit Cost Basis ($)	Demolition Cost ($)
Office (footers only)	Concrete	80	14.60	$ 1,168
Shop	Concrete	14,525	6.30	$ 91,508
Fuel Storage	Concrete	420	6.30	$ 2,646
Oil Storage	Concrete	288	6.30	$ 1,814
Coal Hopper	Concrete	12,160	6.30	$ 76,608
Coal Crusher (footers only)	Concrete	64	14.60	$ 934
Coal Conveyors and Tower	Concrete	280	14.60	$ 4,088
Reclaim Tunnel	Concrete	15,224	6.30	$ 95,911
Coal Loadout	Concrete	1,272	6.30	$ 8,014
Subtotal				$ 282,691
Item	Construction Material	Volume (cuft)	Unit Cost Basis ($)	Demolition Cost ($)
Shop	Steel	50,400	0.26	$ 13,104
Fuel Storage (2 tanks)	Steel	1,206	0.26	$ 314
Oil Storage (5 tanks)	Steel	628	0.26	$ 163
Coal Hopper	Steel	3,400	0.26	$ 884
Coal Crusher	Steel	16,000	0.26	$ 4,160
Reclaim Tunnel	Steel	4,768	0.26	$ 1,240
Coal Loadout	Steel	10,400	0.26	$ 2,704
Subtotal				$ 22,569
Item	Construction Material	Volume (feet)	Unit Cost Basis ($)	Demolition Cost ($)
Coal Conveyors and Tower	Steel	1,380	44.25	$ 61,065
Subtotal				$ 61,065
Total				$ 366,325

Reference: 2006 RSMeans Heavy Construction Cost Data

Project: Coal Hollow Mine
Date: May 1, 2006
Prepared by:

Worksheet 3
Material Handling Plan Summary

Earthmoving Activity	Volume (LCY)	Origin	Destination	Haul Distance (Feet)	Grade* (%)	Equipment To Be Used
Doze Spoil	935,000	In-Pit Stockpile	South end of mining area	500	-20	Cat D10R
Haul spoil	7,100,000	Spoil Stockpile	NE corner of mining area	2,300	-6	Cat 777 trucks
Haul topsoil	187,000	West Topsoil Stockpile	NE corner of mining area	4,500	1	Cat 777 trucks
Haul topsoil	1,044,000	Center Topsoil Stockpile	NE corner of mining area	1,900	-2	Cat 777 trucks
Haul topsoil	280,000	East Topsoil Stockpile	South end of mining area	4,500	-2	Cat 777 trucks

* Includes grade resistance (% grade)

Project: Coal Hollow Mine
Date: May 1, 2006
Prepared by:

Worksheet 4
Earthwork Quantity

Backfill Active Pits and South Ramp

Active Pit volume	=	7,100,000	cuyd	
South Ramp volume	=	935,000	cuyd	

(Volumes derived from pit design and Carlson Software's SurvCADD)

Replace topsoil	=	80 acres X 1 foot	=	129,067	cuyd

Haulroad Material

Total haulroad volume	=	20 acres X 1 foot	=	32,267	cuyd

Haulroad material will be windrowed with a motorgrader and picked up by a front end loader. It will be hauled by truck to the south ramp area or placed in the backfill of Pit 20 or 21.

Replace topsoil	=	20 acres X 1 foot	=	32,267	cuyd

Facilities Area Cleanup

Facilities area volume	=	45 acres X .25 ft	=	18,150	cuyd
Replace topsoil	=	45 acres X 1 foot	=	72,600	cuyd

Any contaminated material will be picked up and hauled to the pit for disposal before topsoil is replaced.

Temporary Spoil Stockpile

Replace topsoil	=	95 acres X 1 foot	=	153,267	cuyd

Sediment Ponds

Four sediment ponds			=	90,000	cuyd
Replace topsoil	=	6 acres X 1 foot	=	9,680	cuyd

Project: Coal Hollow Mine
Date: May 1, 2006
Prepared by:

Worksheet 13
Summary Calculation of Earthmoving Costs

Equipment	Ownership & Operation Cost ($/hr)	Labor Cost ($/hr)	Total Hours Required	Total Cost
992G Wheel Loader	104.74	12.86	6,081	$ 715,126
777D Rear Dump Trucks	67.28	11.02	6,081	$ 476,142
D10R Dozer	79.08	14.70	2,180	$ 204,440
16H Motorgrader	43.09	14.27	6,081	$ 348,806
Water Truck (7000 gal.)	42.48	11.02	6,081	$ 325,334
Subtotal				$ 2,069,848

Reference: US Department of Labor website, Labor Cost Data for Kane County, Utah
Reference: Western Mine Engineering, Inc., Mine and Mill Equipment Costs

Project: Coal Hollow Mine
Date: May 1, 2006
Prepared by:

Worksheet 14
Revegetation Costs

Description of Area to be Revegetated:
Northeast corner and south end of mining area, haulroads, as well as area under spoil and topsoil stockpiles

Description of Revegetation Activities:
Seedbed preparation, seeding, fertilizing, mulching, tree planting and spraying

Cost calculation for Individual Revegetation Activities:

Initial Seeding

246.0	X	117	+	609	=	$ 178,596
Area to be seeded (acres)		Seedbed preparation ($/acre)		Seeding, fertilizing, & mulching ($/acre)		

Planting Trees and Shrubs

49.2	X	315	+	50	=	$ 17,958
Area to be planted (acres)		Planting ($/acre)		Herbicide Treatment ($/acre)		

Reseeding

246.0	X	0.25	X	45	+	609	=	$ 40,221
Area to be seeded & unreleased disturbed areas (acres)		Failure rate		Seedbed preparation ($/acre)		Seeding, fertilizing, & mulching ($/acre)		

Replanting Trees and Shrubs

49.2	X	0.50	X	315	+	50	=	$ 8,979
Area to be planted & unreleased disturbed areas (acres)		Failure rate		Planting ($/acre)		Herbicide Treatment ($/acre)		

Total revegetation cost for this area = $ 245,754

Project: Coal Hollow Mine
Date: May 1, 2006
Prepared by:

Worksheet 16
Reclamation Bond Summary Sheet

1	Total Facility and Structure Removal Costs	$ 366,325
2	Total Earthmoving Costs	$ 2,069,848
3	Total Revegetation Costs	$ 245,754
4	Total Other Reclamation Activities Costs	$ -
5	Total Direct Costs (sum of 1 through 4)	$ 2,681,927
6	Inflated Total Direct Costs	$ 3,161,992
7	Mobilization/Demobilization 5% of line 6	$ 158,100
8	Contingencies 5% of line 6	$ 158,100
9	Engineering Redesign Fee 3% of line 6	$ 94,860
10	Contractor Profit/Overhead 20% of line 6	$ 632,398
11	Project Management Fee 5% of line 6	$ 158,100
12	Total Indirect Costs (sum of 7 through 11)	$ 1,201,557
13	Grand Total Bond Amount	$ 4,363,548

Inflation factor for prior 4.25 years = 17.90%

Source: U.S. Department of Labor, Producer Price Index, Bituminous coal & lignite surface mining
(Only available from December 2001 through March 2006)

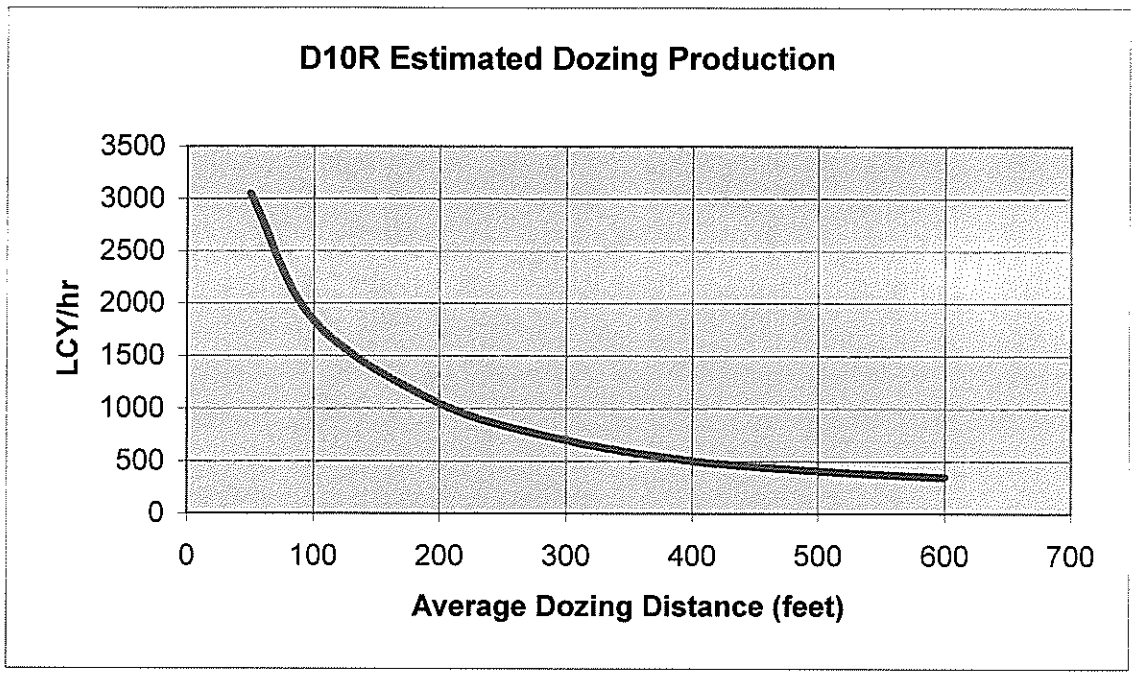
Worksheet 5A

Project: Coal Hollow Mine
Date: May 1, 2006
Prepared by:

Earthmoving Activity:
Doze Spoil to Backfill Ramp Void in Southern Portion of Permit Area

Characterization of Dozer Used (type, size, etc.):		
D10R, U-blade, ripper		
Power shift transmission	1.00	yes
Description of Dozer Use:		
Average dozing distance (feet)	500	
Hourly production (LCY/hr from chart)	410	
Grade (in percent)	-20	
Grade Correction	1.40	
Material Unit Weight (lb/LCY)	2,673	
Density Correction	0.86	
Production Adjustment Factors		
Operator Factor		
Is operator excellent	1.00	no
Is operator average	0.75	yes
Is operator poor	0.60	no
Material Factor		
Loose stockpile	1.20	yes
Hard to cut, frozen with tilt cylinder	0.80	no
Hard to cut, frozen without tilt cylinder	0.70	no
Normal material	1.00	no
Hard to drift	0.80	no
Rock, ripped or blasted	0.75	no
Production Method/Blade Factor		
Slot dozing	1.20	yes
Side by side dozing	1.20	no
Normal dozing	1.00	no
Visibility		
Dust, rain, snow, fog, or darkness	0.80	no
Normal weather	1.00	yes
Job Efficiency		
50 min/hr	0.83	yes
40 min/hr	0.67	no
Elevation Factor		
<7,500 feet	1.00	yes
Quantity of Material to be Moved (LCY)	935,000	

Worksheet 5B
Backfill Pit and Ramps



Operating Adjustment Factor	=	0.75 Operator Factor	X	1.20 Material Factor	X	0.83 Job Efficiency Factor	X	1.40 Grade Factor	X	0.86 Weight Correction Factor		
	X	1.20 Production Method	X	1.00 Visibility Factor	X	1.00 Elevation Factor	=	1.08				
Net Hourly Production	=	410 Normal Hourly Production (see graph)	X	1.08 Operating Adjustment Factor	=	444	LCY/hr					
Hours Required	=	935,000 Volume to be Moved (LCY)	/	444 Net Hourly Production (LCY/hr)	=	2,104	Hours					

Data Source: Caterpillar Performance Handbook, Edition 34

Worksheet 5C

Project: Coal Hollow Mine
Date: May 1, 2006
Prepared by:

Earthmoving Activity:
Remove Ponds

Characterization of Dozer Used (type, size, etc.):

D10R, U-blade, ripper		
Power shift transmission	1.00	yes

Description of Dozer Use:

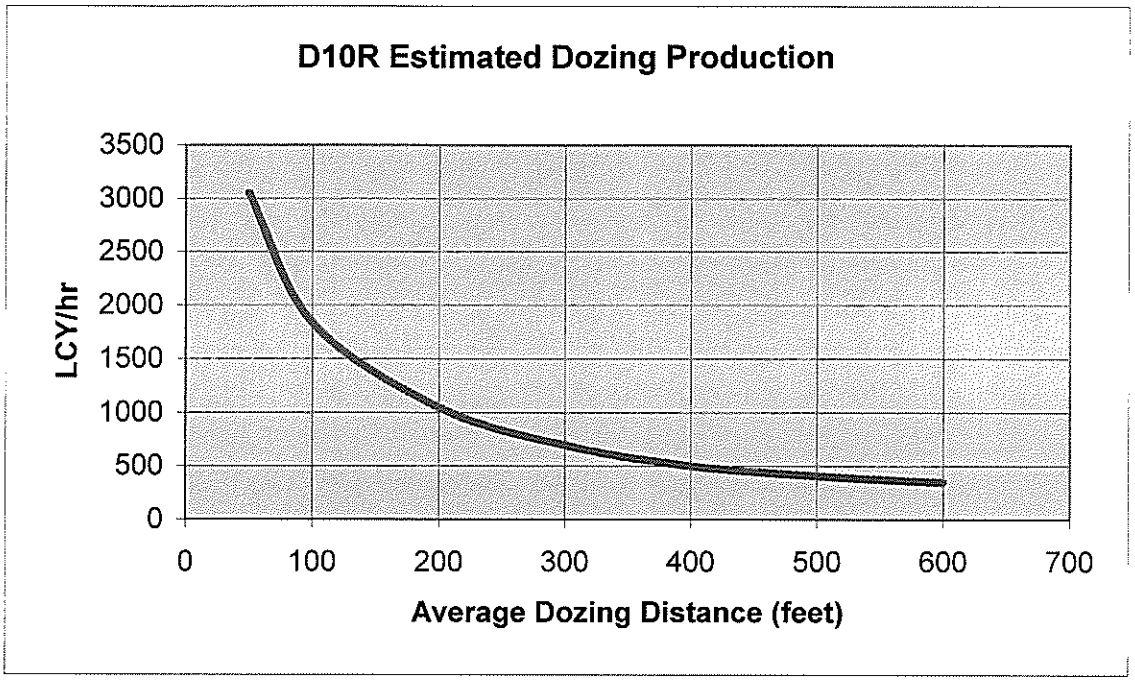
Average dozing distance (feet)	200	
Hourly production (LCY/hr from chart)	1050	
Grade (in percent)	-10	
Grade Correction	1.20	
Material Unit Weight (lb/LCY)	1,826	
Density Correction	1.26	

Production Adjustment Factors

Operator Factor		
Is operator excellent	1.00	no
Is operator average	0.75	yes
Is operator poor	0.60	no
Material Factor		
Loose stockpile	1.20	yes
Hard to cut, frozen with tilt cylinder	0.80	no
Hard to cut, frozen without tilt cylinder	0.70	no
Normal material	1.00	no
Hard to drift	0.80	no
Rock, ripped or blasted	0.75	no
Production Method/Blade Factor		
Slot dozing	1.20	no
Side by side dozing	1.20	no
Normal dozing	1.00	yes
Visibility		
Dust, rain, snow, fog, or darkness	0.80	no
Normal weather	1.00	yes
Job Efficiency		
50 min/hr	0.83	yes
40 min/hr	0.67	no
Elevation Factor		
<7,500 feet	1.00	yes

Quantity of Material to be Moved (LCY) 90,000

Worksheet 5D
Remove Ponds



Operating Adjustment Factor	=	0.75 Operator Factor	X	1.20 Material Factor	X	0.83 Job Efficiency Factor	X	1.20 Grade Factor	X	1.26 Weight Correction Factor			
	X	1.00 Production Method	X	1.00 Visibility Factor	X	1.00 Elevation Factor	=	1.13					
Net Hourly Production	=	1,050 Normal Hourly Production (see graph)	X	1.13 Operating Adjustment Factor	=	1190	LCY/hr						
Hours Required	=	90,000 Volume to be Moved (LCY)	/	1,190 Net Hourly Production (LCY/hr)	=	76	Hours						

Data Source: Caterpillar Performance Handbook, Edition 34

Worksheet 9A

Project: Coal Hollow Mine
Date: May 1, 2006
Prepared by:

Earthmoving Activity:
Backfill Pit From Stockpile

Characterization of Loader Used (type, size, etc.):

992G Wheel Loader	15 cy
777D Rear Dump Trucks	67 cy

Loading and Haulage

Productivity Factors

Basic Loader Cycle (min)	0.60
Bulky Material (min)	0.03
Dumped Pile (min)	0.02
Common Loader/Truck Ownership (min)	-0.04
Work Hour Factor (50 min/hr)	0.83
Bucket Fill Factor	0.85
Truck Loaded Volume - 5 passes	67
Haulage Distance (feet)	2,500
Effective Grade (%)	5.0

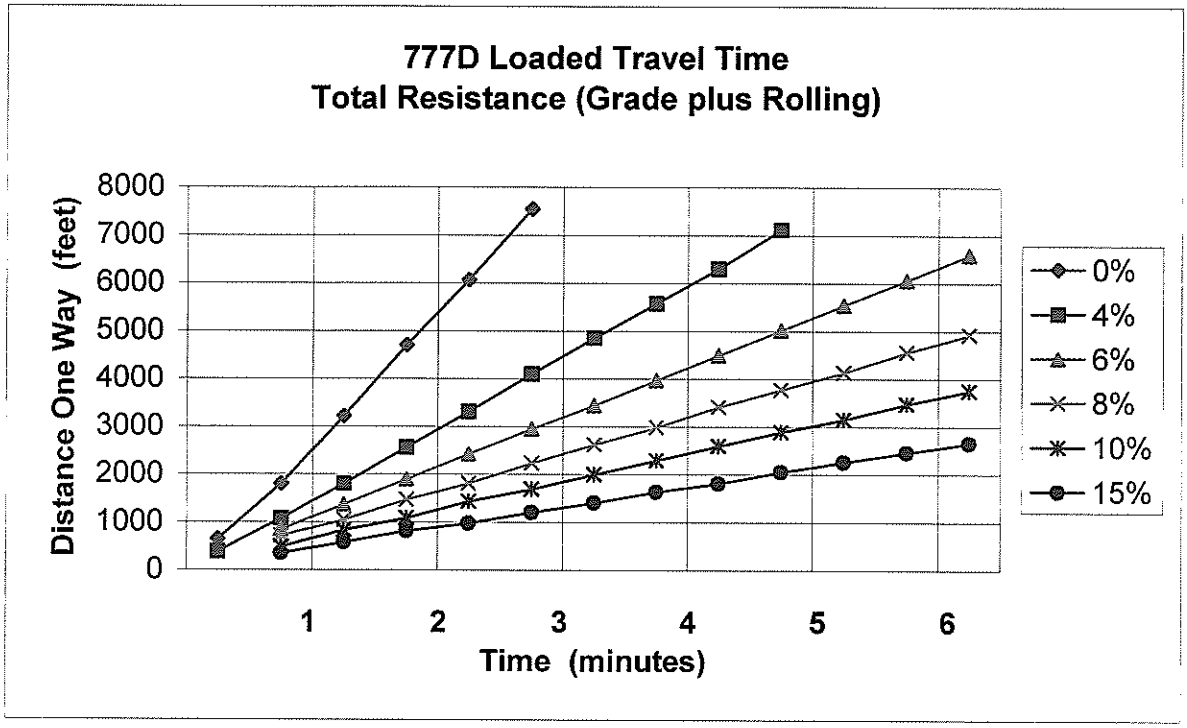
Production Times

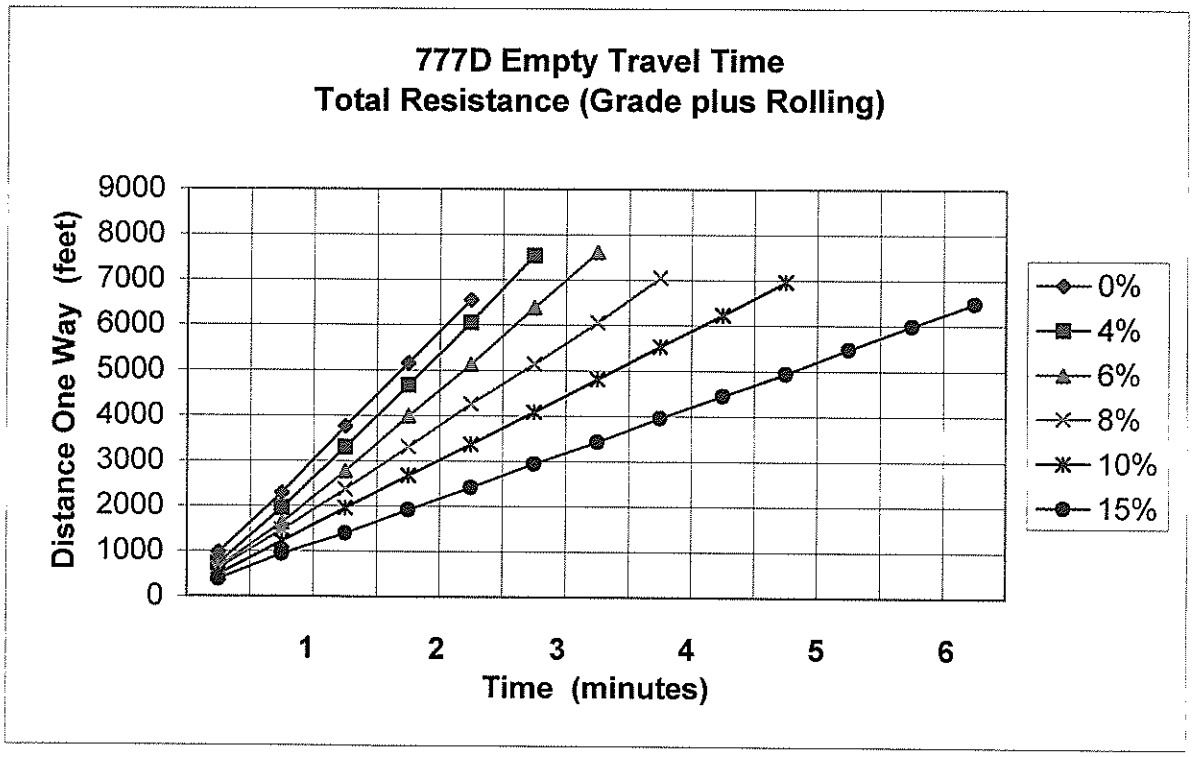
Haul Time (min)	1.6
Dump Time (min)	1.1
Return Time (min)	1.2

Truck / Loader Match (trucks per loader)	3
Quantity of Material to be Moved (LCY)	7,100,000

(Using Carlson Software's SurvCADD)

Worksheet 9B





Data Source: Caterpillar Performance Handbook, Edition 34

Worksheet 9C

Backfill Pit from Stockpile
Loader Summary

Loader Cycle Time	=	0.60 Basic Loader Cycle Time	+	0.03 Bulky Material	+	0.02 Dumped Pile	+	(0.04) Common Owner	=	0.61 minutes

Loader Volume per Cycle	=	15 Bucket Capacity	X	0.85 Bucket Fill Factor	=	12.75 cubic yards

Loader Cycle Time per Truck	=	0.61 Loader Cycle Time	X	5.0 Passes per Truck	=	3.05 minutes

Truck Summary

Truck Cycle Time	=	3.05 Load Time	+	1.60 Haul Time	+	1.10 Dump Time	+	1.20 Return Time	=	6.95 minutes

Production Rate	=	67 Truck Capacity (LCY)	X	3 Number of Trucks	/	6.95 Truck Cycle Time	=	28.92	LCY/min

Hourly Production	=	28.92 Production Rate	X	60 Minutes per Hour	X	0.83 Efficiency Factor	=	1,445	LCY/hour

Hours Required	=	7,100,000 Volume to be moved	/	1,445 Hourly Production	=	4,912 hours

Worksheet 9D

Project: Coal Hollow Mine
Date: May 1, 2006
Prepared by:

Earthmoving Activity:
Topsoil Replacement From East and West Stockpiles

Characterization of Loader Used (type, size, etc.):

992G Wheel Loader	15 cy
777D Rear Dump Trucks	67 cy

Loading and Haulage

Productivity Factors

Basic Loader Cycle (min)	0.60
Bulky Material (min)	0.03
Dumped Pile (min)	0.02
Common Loader/Truck Ownership (min)	-0.04
Work Hour Factor (50 min/hr)	0.83
Bucket Fill Factor	0.85
Truck Loaded Volume - 5 passes	67
Haulage Distance (feet)	4,500
Effective Grade (%)	5.0

Production Times

Haul Time (min)	2.7
Dump Time (min)	1.1
Return Time (min)	2.0

Truck / Loader Match (trucks per loader)	3
Quantity of Material to be Moved (LCY)	467,000

Worksheet 9E

Topsoil Replacement from East and West Stockpiles
Loader Summary

Loader Cycle Time	=	0.60 Basic Loader Cycle Time	+	0.03 Bulky Material	+	0.02 Dumped Pile	+	(0.04) Common Owner	=	0.61 minutes

Loader Volume per Cycle	=	15 Bucket Capacity	X	0.85 Bucket Fill Factor	=	12.75 cubic yards

Loader Cycle Time per Truck	=	0.61 Loader Cycle Time	X	5.0 Passes per Truck	=	3.05 minutes

Truck Summary

Truck Cycle Time	=	3.05 Load Time	+	2.70 Haul Time	+	1.10 Dump Time	+	2.00 Return Time	=	8.85 minutes

Production Rate	=	67 Truck Capacity (LCY)	X	3 Number of Trucks	/	8.85 Truck Cycle Time	=	22.71	LCY/min

Hourly Production	=	22.71 Production Rate	X	60 Minutes per Hour	X	0.83 Efficiency Factor	=	1,135	LCY/hour

Hours Required	=	467,000 Volume to be moved	/	1,135 Hourly Production	=	411 hours

Worksheet 9F

Project: Coal Hollow Mine
Date: May 1, 2006
Prepared by:

Earthmoving Activity:
Topsoil Replacement from Central Stockpile

Characterization of Loader Used (type, size, etc.):

992G Wheel Loader	15 cy
777D Rear Dump Trucks	67 cy

Loading and Haulage

Productivity Factors

Basic Loader Cycle (min)	0.60
Bulky Material (min)	0.03
Dumped Pile (min)	0.02
Common Loader/Truck Ownership (min)	-0.04
Work Hour Factor (50 min/hr)	0.83
Bucket Fill Factor	0.85
Truck Loaded Volume - 5 passes	67
Haulage Distance (feet)	1,900
Effective Grade (%)	5.0

Production Times

Haul Time (min)	1.1
Dump Time (min)	1.1
Return Time (min)	2.0

Truck / Loader Match (trucks per loader)	3
Quantity of Material to be Moved (LCY)	1,044,000

Worksheet 9G

Topsoil Replacement from Central Stockpile
Loader Summary

Loader Cycle Time	=	0.60 Basic Loader Cycle Time	+	0.03 Bulky Material	+	0.02 Dumped Pile	+	(0.04) Common Owner	=	0.61	minutes

Loader Volume per Cycle	=	15 Bucket Capacity	X	0.85 Bucket Fill Factor	=	12.75	cubic yards

Loader Cycle Time per Truck	=	0.61 Loader Cycle Time	X	5.0 Passes per Truck	=	3.05	minutes

Truck Summary

Truck Cycle Time	=	3.05 Load Time	+	1.14 Haul Time	+	1.10 Dump Time	+	2.00 Return Time	=	7.29	minutes

Production Rate	=	67 Truck Capacity (LCY)	X	3 Number of Trucks	/	7.29 Truck Cycle Time	=	27.57	LCY/min

Hourly Production	=	27.57 Production Rate	X	60 Minutes per Hour	X	0.83 Efficiency Factor	=	1,378	LCY/hour

Hours Required	=	1,044,000 Volume to be moved	/	1,378 Hourly Production	=	758	hours

Worksheet 9E

Topsoil Replacement from East and West Stockpiles
Loader Summary

Loader Cycle Time	=	0.60 Basic Loader Cycle Time	+	0.03 Bulky Material	+	0.02 Dumped Pile	+	(0.04) Common Owner	=	0.61 minutes

Loader Volume per Cycle	=	15 Bucket Capacity	X	0.85 Bucket Fill Factor	=	12.75	cubic yards

Loader Cycle Time per Truck	=	0.61 Loader Cycle Time	X	5.0 Passes per Truck	=	3.05	minutes

Truck Summary

Truck Cycle Time	=	3.05 Load Time	+	2.70 Haul Time	+	1.10 Dump Time	+	2.00 Return Time	=	8.85 minutes

Production Rate	=	67 Truck Capacity (LCY)	X	3 Number of Trucks	/	8.85 Truck Cycle Time	=	22.71	LCY/min

Hourly Production	=	22.71 Production Rate	X	60 Minutes per Hour	X	0.83 Efficiency Factor	=	1,135	LCY/hour

Hours Required	=	467,000 Volume to be moved	/	1,135 Hourly Production	=	411	hours

Worksheet 12A

Project: Coal Hollow Mine
Date: May 1, 2006
Prepared by:

Earthmoving Activity:
Grading of haulroads, facilities, final grading of spoil, and grading of topsoil

Characterization of Motorgrader Used (type, size, etc.):

16H Motorgrader with ripper	16	ft blade

Productivity Factors:

Average speed	3	mph
Effective blade width	13.9	ft
Work hour factor (50 min/hr)	0.83	

Work Activities:

Grade haulroads	17	acres
Grade spoil	80	acres
Grade topsoil	200	acres
Grade stockpile areas	120	acres
Facilities areas	45	acres
Sediment ponds	6	acres
Diversion ditches	30	acres
Total	498	acres

Worksheet 12B
Motorgrader Productivity Calculation - Final Preparation and Grading of Disturbed Areas

Grading

Hourly Production	=	3.0 Average Speed	X	13.9 Effective Blade Width	X	5,280 Feet per Mile	/	43,560 Square feet per acre	X	0.83 Efficiency Factor	=	4.21	acres/hr

Hours Required	=	498 Acres Graded	/	4.21 Hourly Production	=	118 hours

Ripping

Hourly Production	=	3.0 Average Speed	X	9.0 Ripper Width	X	5,280 Feet per Mile	/	43,560 Square feet per acre	X	0.83 Efficiency Factor	=	2.73	acres/hr

Hours Required	=	142 Acres Graded	/	2.73 Hourly Production	=	52 hours

Motorgrader is assumed to be onsite during total project.

Data Souce: Caterpillar Performance Handbook, Edition 34