A Technical Report
Project C-7651

GROUND WATER FLOW SYSTEMS
IN THE PHOSPHATE SEQUENCE
CARIBOU COUNTY, IDAHO

by
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GROUND WATER FLOW SYSTEMS IN THE PHOSPHATE SEQUENCE
CARIBOU COUNTY, IDAHO

A Thesis
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GERRY VERNON WINTER
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Section line	———
Perennial stream	——➤——
Intermittent stream	——··——··——
Spring	•
Pond	▨
Formation contact	———
Fault U indicates upthrown side D indicates downthrown side Arrows indicate relative movement	— — U/D — ⇌
Anticline	- - - ↕ - - -
Syncline	- - - ⤈ - - -
Overturned anticline	- - - ⩚ - - -
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ABSTRACT

Phosphate has been mined in southeastern Idaho since 1945 but additional demands for the ore will require that new areas be mined. A comprehensive understanding of the hydrogeology and hydrology of the area is required to assess the potential impact of this mining on those respective systems.

The formations constituting the phosphate sequence exhibited similar hydrogeologic properties during previous research efforts in Little Long Valley, lower Diamond Creek valley (Upper Valley), lower Dry Valley and Schmid Ridge. The phosphate sequence consists of the upper and lower members of the Dinwoody Formation, the cherty shale, Rex Chert and Meade Peak Phosphatic Shale Members of the Phosphoria Formation and the upper and lower members of the Wells Formation. It was concluded from these studies that the Phosphoria Formation does not support any major ground water flow system. The Dinwoody and Wells Formations were found to support ground water flow systems. This study analyzed stream gain-loss measurements and spring locations in other areas of the Caribou National Forest to verify that these hydrogeologic properties are valid over a much greater area.

Stream gain-loss measurements consistently indicated that ground water flow systems exist in both members of the Dinwoody Formation and the upper member of the Wells Formation. No ground water flow systems exist in the Meade Peak Phosphatic Shale Member of the Phosphoria Formation but the cherty shale and Rex Chert Members do support such systems at certain locations. Stream flow mainly increased across the lower member of the Dinwoody Formation but stream flow always decreased across the

upper member of the Wells Formation. There were no changes in stream flow across the Meade Peak Phosphatic Shale Member of the Phosphoria Formation.

More springs discharge from the lower member of the Dinwoody Formation than any other formation member. One-third of the springs with a measurable discharge were found to discharge from this member. At least one spring was found to discharge from each member of the phosphate sequence.

It is concluded from this study that the platy siltstone and black limestone members of the Thaynes Formation, the upper and lower members of the Dinwoody Formation and the Wells Formation all have sufficient hydraulic conductivity to allow these formations to support ground water flow systems. The Rex Chert Member of the Phosphoria Formation also has the potential to support a ground water flow system but it does not exhibit a uniform hydraulic conductivity through out the area. It may or may not support such a flow system. Neither the cherty shale nor the Meade Peak Phosphatic Shale Members of the Phosphoria Formation exhibit sufficient hydraulic conductivity to permit the existence of a significant ground water flow system. The ground water flow system characteristics of the phosphate sequence are consistent throughout the study area except for the Rex Chert Member of the Phosphoria Formation.

Ground water flow systems are separated into one of two groups by their location with respect to the Meade Peak Phosphatic Shale Member of the Phosphoria Formation. Those formations that occur above this member support short ground water flow systems while those formations below it support regional type ground water flow systems.

INTRODUCTION

Phosphate has been surface mined in southeastern Idaho since 1945. Approximately six million short tons of phosphate rock were mined in 1975 while a recently revised estimate by the mining companies places the anticipated 2000 A.D. production level at about 15 million tons per year (U.S. Department of the Interior, 1977, p. P-1). This increased mining of phosphate ore will result in the expansion of currently mined areas into previously unmined areas as demands and mining policies dictate.

Past hydrogeologic research efforts have been site specific but the results of these studies are similar. Ground water flow systems exist in the Thaynes and Dinwoody Formations that usually occur stratigraphically above the Phosphoria Formation which contains the phosphatic ore beds (Ralston and others, 1977). The Phosphoria Formation does not support any major ground water flow systems but the Wells Formation that underlies it was found to support such a system (Ralston and others, 1977). These similarities were found even though the region has been extensively folded and faulted. This study will examine the ground water flow systems of the phosphate sequence in Caribou County, Idaho over a larger area than any previous hydrogeologic research effort.

The low precipitation received in this research area prior to the summer of 1977 was particularly advantageous to the type of study undertaken. Ground water flow systems receive their principle recharge from the spring snow melt. So the low volume of recharge available in 1977 would be rapidly discharged from those ground water flow systems with a short flow path or a low storage capability. Only those ground water flow systems of significant length or storage capability would continue to discharge during this period. This extended discharge exists due to the capability of the ground water flow system to store and discharge water that was recharged over more than one recharge period.

Purpose

Extensive areas exist in the Western Phosphate Field of Idaho where mining has not occurred but minable phosphate ore does exist. Little information is available on the capability of the formations in the area to support ground water flow systems. The potential impact of phosphate mining on the hydrogeology and hydrology of the area can only be evaluated if the capability of the formations to support ground water flow systems is understood. The purpose of this study is to evaluate the capability of the formations to support ground water flow systems.

General Objective

The general objective of this study is to test the hypothesis that similar ground water flow systems exist within the phosphate sequence of geologic units throughout a large area of the Western Phosphate Field of Caribou County, Idaho. These geologic units include the Dinwoody, Phosphoria and Wells Formations.

Specific Objectives

The specific objectives of this study are:

1. Test the hypothesis that a major ground water flow system exists in the upper member of the Dinwoody Formation.
2. Test the hypothesis that a major ground water flow system exists in the lower member of the Dinwoody Formation.

3. Test the hypothesis that the cherty shale member of the Phosphoria Formation does not support a major ground water flow system.
4. Test the hypothesis that the Rex Chert Member of the Phosphoria Formation does not support a major ground water flow system.
5. Test the hypothesis that the Meade Peak Phosphatic Shale Member of the Phosphoria Formation does not support a major ground water flow system.
6. Test the hypothesis that a major ground water flow system exists in the upper member of the Wells Formation.
7. Test the hypothesis that a major ground water flow system exists in the lower member of the Wells Formation.

Acknowledgements

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GEOGRAPHY AND HYDROLOGY

The study area is located in southeastern Idaho and is a part of the Western Phosphate Field. Research was conducted in the area that lies between Soda Springs, Idaho, and the Wyoming state line as shown on figure 1. Areas that should be noted include the Aspen Range, Slug Creek valley, Schmid Ridge, Dry Valley, Dry Ridge, Webster Range, Wooley Range, and Rasmussen Ridge. Elevations in the valleys and ridges range from about 6,500 feet (1,980 meters) above mean sea level (M.S.L.) to nearly 10,000 feet (3,050 meters) above M.S.L. with the ridges and valleys having a predominantly northwest to southeast trend. The major drainages are the Salt River to the east of the Webster Range, the Blackfoot River between the Webster and Aspen Ranges, and the Bear River to the west of the Aspen Range.

Precipitation occurs principally as snow in the study area. The prevailing westerly wind causes the greatest snow accumulation on the east sides of the ridges while decreasing significantly on the west slopes and valley floors (Ralston and Trihey, 1975). Since snow melt forms the greatest source of ground water recharge in this area, the east slopes of the ridges have the greatest potential for significant recharge.

The summer of 1977 was of particular importance for a ground water flow system study because of the preceding recharge period in which little precipitation occurred. Annual precipitation for Conda, Idaho is plotted on figure 2 as is the annual streamflow of the Blackfoot River above the Blackfoot Reservoir. The magnitude of the low precipitation runoff is more accurately shown by the streamflow graph. Precipitation for the 1977 water year was lower than any preceding water year after 1966 while

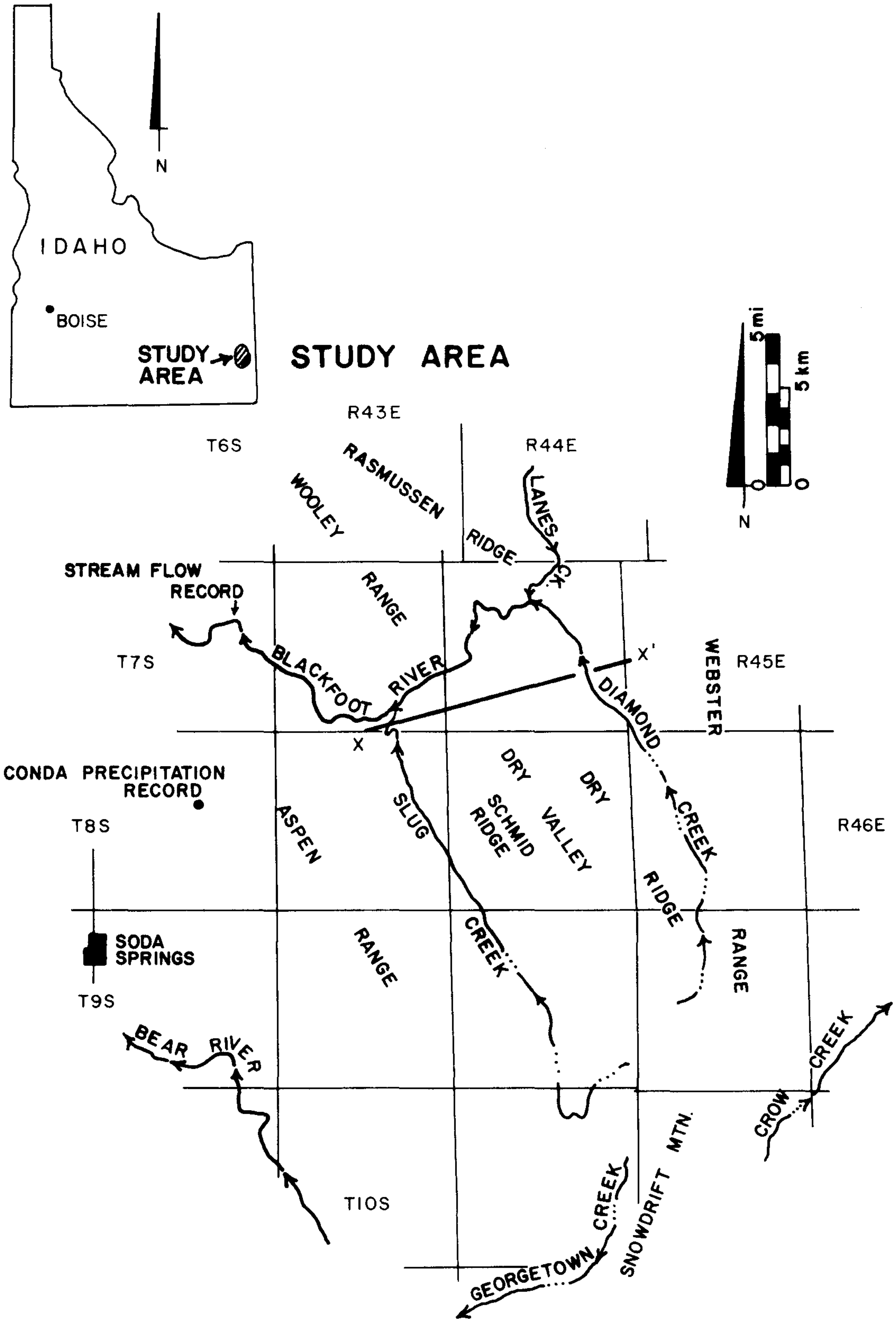
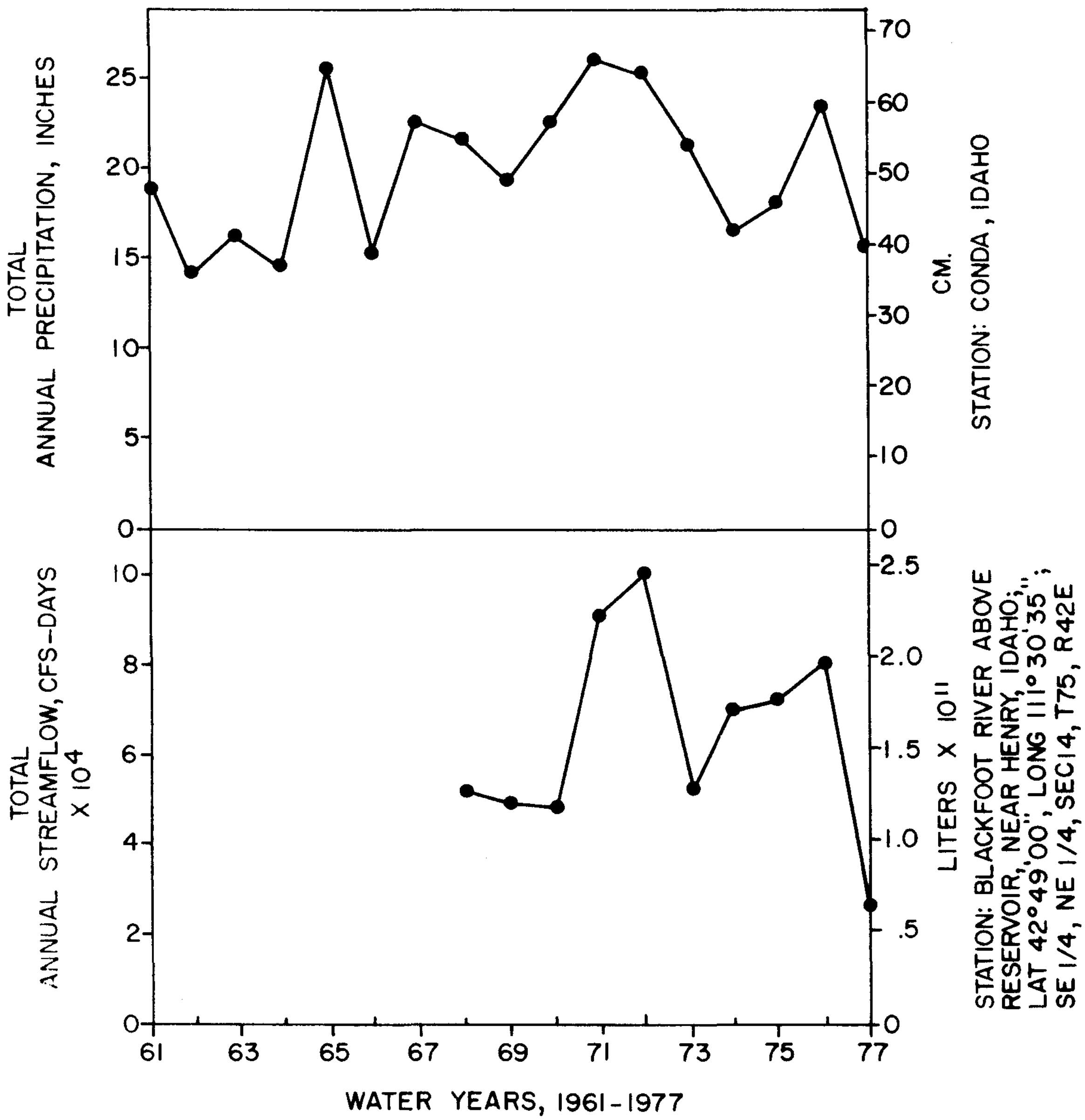


Figure 1. Location map of study area.



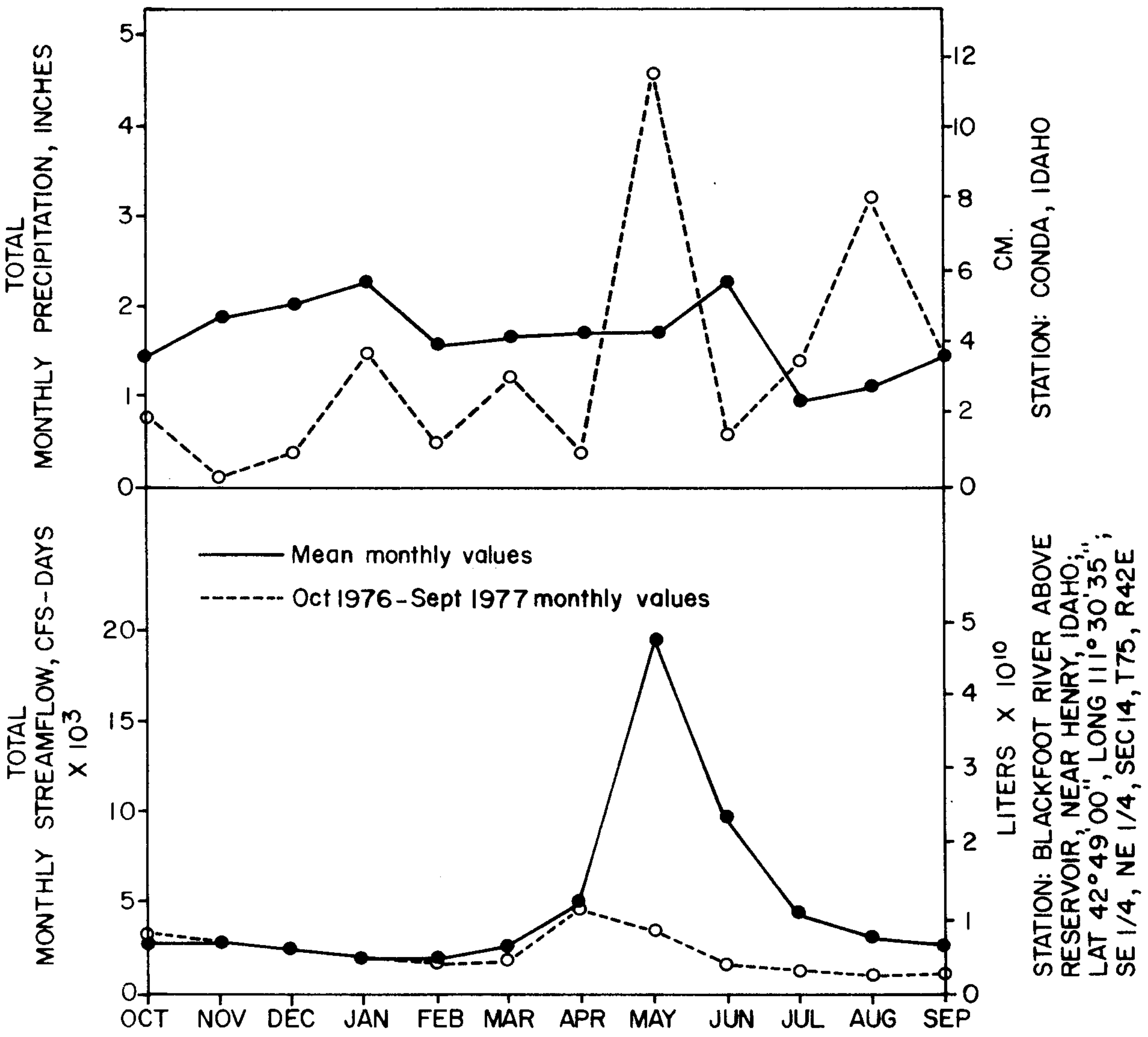
PRECIPITATION DATA SOURCE: U.S. DEPT. OF COMMERCE, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

STREAM FLOW DATA SOURCE: U.S. DEPT. OF INTERIOR, GEOLOGIC SURVEY

Figure 2. Annual precipitation and streamflow.

streamflow in the Blackfoot River was the lowest on record. Monthly precipitation and stream flow for the same stations are plotted on figure 3 with the mean values for the same time periods. Precipitation was below the mean except for May, July and August while flow in the Blackfoot River was near the mean through April. Normally the stream flow would continue to increase through May due to the spring snow melt but this did not occur during the study period. Stream flow began to recede after April without achieving even one-fourth of the long term mean peak flow normally existing. The stream flow during May was slightly greater than would be anticipated if a recession curve was drawn from the mean peak flow in April. This could be attributed to the above normal precipitation received during that month. The lack of any significant effect on the stream flow from the above normal precipitation in May, July, and August could be due to two main factors. One of the most significant being the deficit in precipitation that accrued during the winter. Figure 4 is a plot of the cumulative departure from the mean for the precipitation in the 1977 water year. The above normal precipitation during the last part of the water year does not balance the total annual figure to the mean. Evapotranspiration is usually at its greatest during the summer and early fall months (Walton, 1970, p. 360). The combination of cumulative deficient precipitation and a high rate of evapotranspiration result in the May, July, and August precipitation having a negligible effect on stream flow in the Blackfoot River.

The significance of the low precipitation period is best illustrated by examining the basis for stream flow. Stream flow consists of three basic components as illustrated by figure 5. Direct runoff and interflow are those components of streamflow first depleted after precipitation or snow melt while base flow is the longer term discharge of ground water (Meyboom,

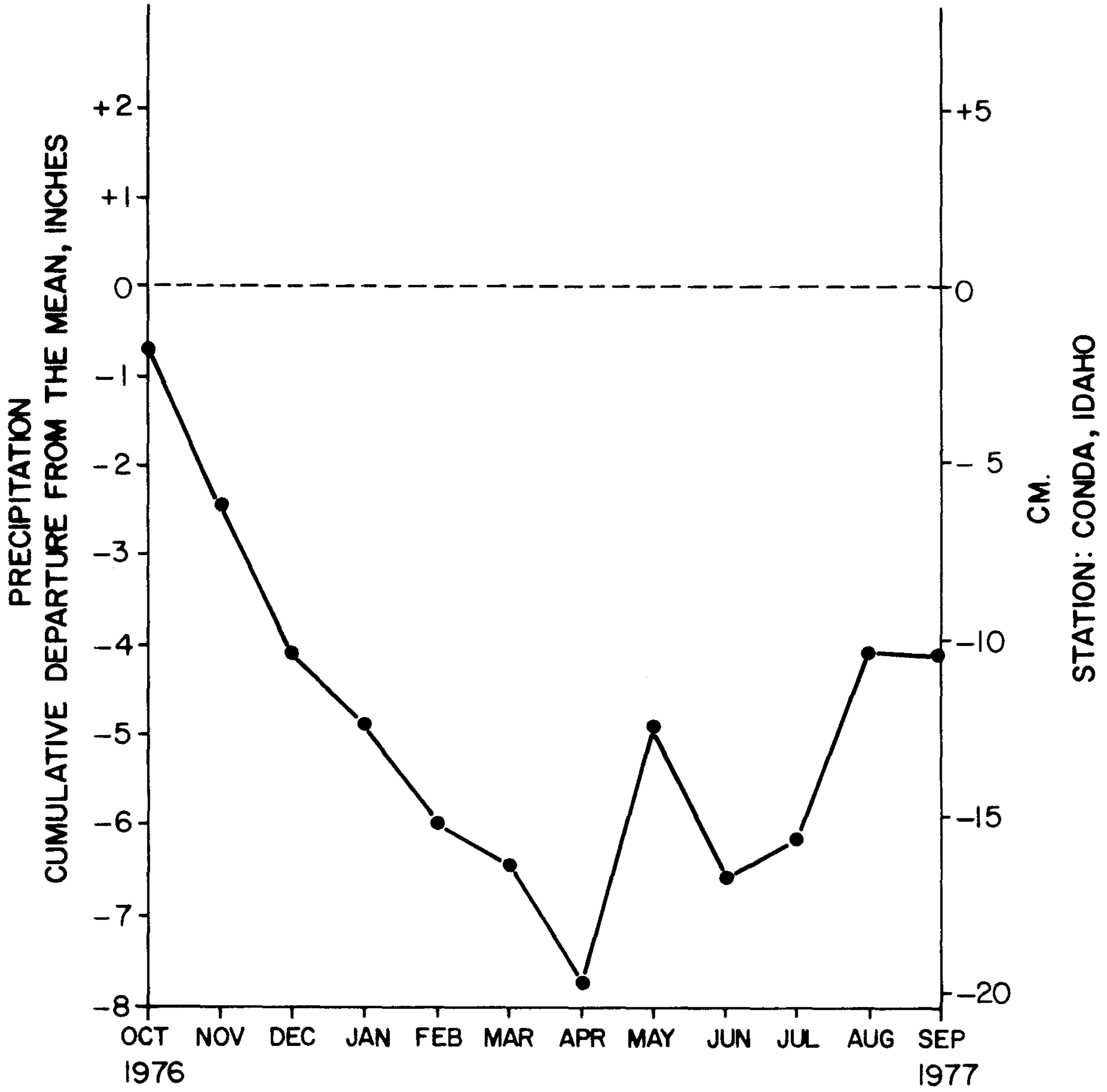


PRECIPITATION DATA SOURCE: U.S. DEPT. OF COMMERCE, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

STREAM FLOW DATA SOURCE: U.S. DEPT. OF INTERIOR, GEOLOGIC SURVEY

MEAN VALUES, PERIOD OF RECORD; PRECIPITATION = 1-1960 TO 12-1976
STREAMFLOW = 4-1914 TO 9-1925 & 8-1967 TO 9-1976

Figure 3. Monthly precipitation and streamflow, October, 1976, through September, 1977.



PRECIPITATION DATA SOURCE: NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

MEAN VALUES, PERIOD OF RECORD: 1-1960 TO 12-1976

Figure 4. Precipitation, cumulative departure from the mean.

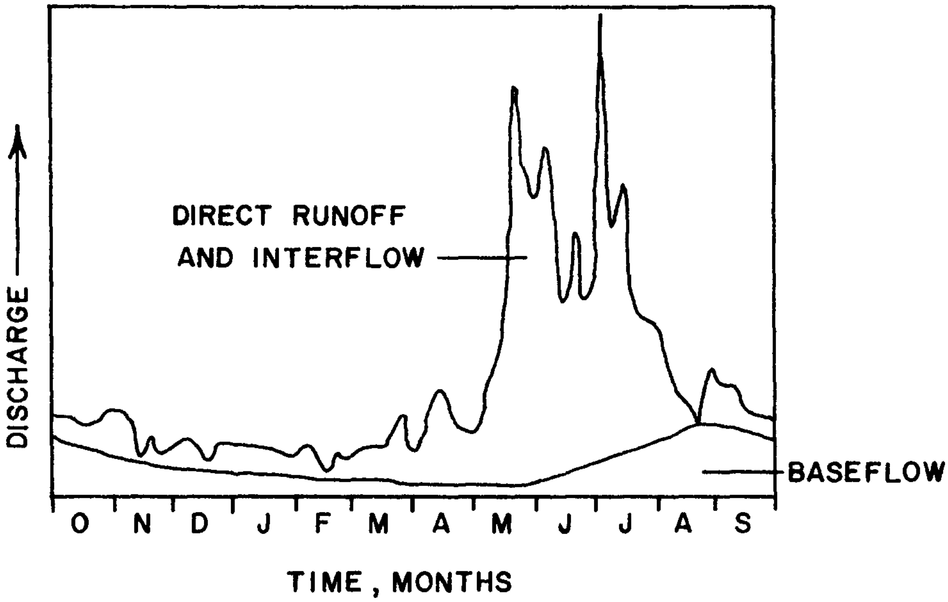


Figure 5. Components of streamflow (Modified after Domenico, 1972, p. 49).

1961, p. 1203). Ground water discharge or baseflow is controlled by the size, topography, permeability (hydraulic conductivity), ground water storage characteristics of the drainage basin and variations in the evapotranspiration rate (Butler, 1957, p. 215). The baseflow component of streamflow is due to the discharge of ground water from storage. Spring discharge is also baseflow since direct runoff and interflow are not part of the ground water system so the ground water discharged from springs is also derived from storage. Ground water discharge from storage is dependent upon annual or relatively frequent recharge events that replenish the dischargeable storage capability of a ground water flow system. The lack of recharge would dictate that spring discharge or the baseflow component of streamflow cease if the dischargeable storage is depleted. Ground water discharges occur at a declining rate following an exponential decay law (Domenico, 1972, p. 48).

Ground water storage when recharged can be slow to yield its accretion at a discharge site since ground water has low flow velocities (Linsley and others, 1975, p. 224-225). The length of a ground water flow system is therefore of importance since short ground water flow systems rapidly reflect low recharge. Conversely, a long ground water flow system might not reflect the period of low recharge experienced in the study area until after the field work was completed.

Discharge from ground water flow systems is also controlled by the size of the dischargeable storage. A system with a small dischargeable storage has a rapidly decreasing rate of discharge after recharge was completed. A large dischargeable storage capacity fosters more stable discharge rates with a slowly declining rate of discharge after recharge is completed. Low recharge causes those systems with a low dischargeable storage capacity to have rapidly declining rates of discharge that are depleted shortly after recharge ceases. Systems with a large dischargeable storage capacity are affected by low recharge but discharge continues at lower rates since storage is not depleted as rapidly.

HYDROGEOLOGY

The formations comprising the ground water flow systems that were encountered in this study are sedimentary in origin (table 1). The Phosphoria Formation is mined in the area for the phosphatic ore beds it contains. Mining operations would therefore affect any ground water flow systems that it might support. The potential impact of mining on other formations is significantly less due to the thickness of the stratigraphic section represented by the Dinwoody and Wells Formations. The formations of primary interest are the Dinwoody, Phosphoria, and Wells. These formations comprise the phosphate sequence.

The Dinwoody Formation consists of an upper and lower member that are in some areas separated by a distinct tongue of the Woodside Shale. The distinction between the formations is not always evident and hence not mapped.

The Phosphoria Formation consists of three members. Frequently the cherty shale member and the Rex Chert Member are mapped as one unit although where possible the distinction between the members was maintained for this study. The third member is the Meade Peak Phosphatic Shale Member which contains the phosphatic ore beds of economic interest in the area.

For the purpose of this study, the Grandeur Tongue of the Park City Formation is considered to be a part of the upper member of the Wells Formation. The lower member is also considered as a separate unit in this study.

Geologic structure viewed today is the result of major overthrusting associated with the Bannock Thrust Zone. This thrusting resulted in synclinal-anticlinal folds and some faulting during the Upper Cretaceous and

Table 1. Geologic section.

Age	Formation Name	Unit Name	Symbol	Thickness		Description
				(ft)	(m)	
Quaternary			Qal			Alluvium or colluvium
Quaternary or Tertiary	Basalt		Qtb	Varies		Olivine basalt
Tertiary	Salt Lake		Tsl			Light-gray fine-grained pebble conglomerate mostly chert and limestone
Upper Triassic	Higham Grit[*1]		Trh		200 to 250	Sandstone-conglomeratic, light-gray, pink, buff and pale green, medium to coarse grained
Lower Triassic	Thaynes	Timothy Sandstone Member	Trtt		200 to 250	Buff to gray and maroon sandstone
		Upper Part of Portneuf Limestone Member	Trtpv		250 to 300	Dark-gray and gray limestone, thin to thick bedded with yellowish-gray to yellowish-brown sandstone
Lower Triassic	Ankareh[*1]	Lanes Tongue	Tral		500	Red to reddish brown, very fine grained to fine grained, thin bedded sandstone
Lower Triassic	Thaynes	Lower Part Portneuf Limestone Member	Trtpl	300 to 400		Gray, finely crystalline, massive limestone and gray to yellowish-gray and fine grained sandstone
		Nodular Siltstone Member	Trtn	400		Olive to brownish-gray siltstone and shale, contains small dark-gray limestone nodules; interbedded with sandstone and limestone
		Black Shale Member	Trtb	300		Gray to black, fissile, hard platy shale; interbedded with thin dark-gray limestone and brownish-gray siltstone in lower part; a few thin bedded shaly and silty black limestone beds in upper part
		Platy Siltstone Member	Trts	650 to 750		Yellowish-brown to olive-gray, calcareous, thin bedded, platy siltstone; a few thin beds of shale and limestone
		Black Limestone Member	Trtl	550 to 800		Dark-gray to black shale and siltstone interbedded with dark-gray to black limestone over dark-gray

Table 1. cont'd

Age	Formation Name	Unit Name	Symbol	Thickness (ft)	Thickness (m)	Description
Lower Triassic (cont'd)	Thaynes (cont'd)	Black Limestone Member (cont'd)	Trtl (cont'd)	550 (cont'd)		to black limestone with a few thin beds of dark-gray shale over dark-gray to black shale and siltstone over gray limestone with Meekoceras ammonite zone at base
	Dinwoody*2	Upper Member	Trdu	700		Gray fossiliferous limestone interbedded with soft olive-brown calcareous siltstone, contains tongues of Woodside Formation as red siltstone or green and maroon shale
	Woodside		Trw	150		
	Dinwoody	Lower Member	Trdl	500 to 900		Olive-brown calcareous siltstone and shale with thin bedded limestone
Permian	Phosphoria	Cherty Shale Member*3	Ppc	170		Thin-bedded dark brown to black cherty mudstone, siliceous shale and argillaceous chert
		Rex Chert Member*3	Ppr	80		Thick-bedded black to white chert with some mudstone, some limestone lenses near top and bottom
		Meade Peak Phosphatic Shale Member	Ppm	100 to 200		Dark-brown to black mudstone, limestone, and phosphorite
	Park City	Grandeur Tongue*4	Ppg	100		Light-gray dolomite and cherty dolomite and minor amounts of sandstone
Permian and Pennsylvanian	Wells	Upper Member	PPwu	1000 to 1400		Light-gray to reddish-brown sandstone, some interbedded gray limestone and dolomite
Pennsylvanian		Lower Member	Pwl	500 to 950		Medium bedded gray cherty limestone, some interbedded sandstone
Mississippian	Monroe Canyon Limestone (also referred to as Brazer Limestone)		Mb	800 to 1600		Light-gray limestone with interbedded sandstone, occasionally with gray and green shale
	Madison Limestone (or Lodgepole Limestone)		Mn	1000		Dark-gray to black finely crystalline to aphanitic limestone in thin beds

Table 1. cont'd

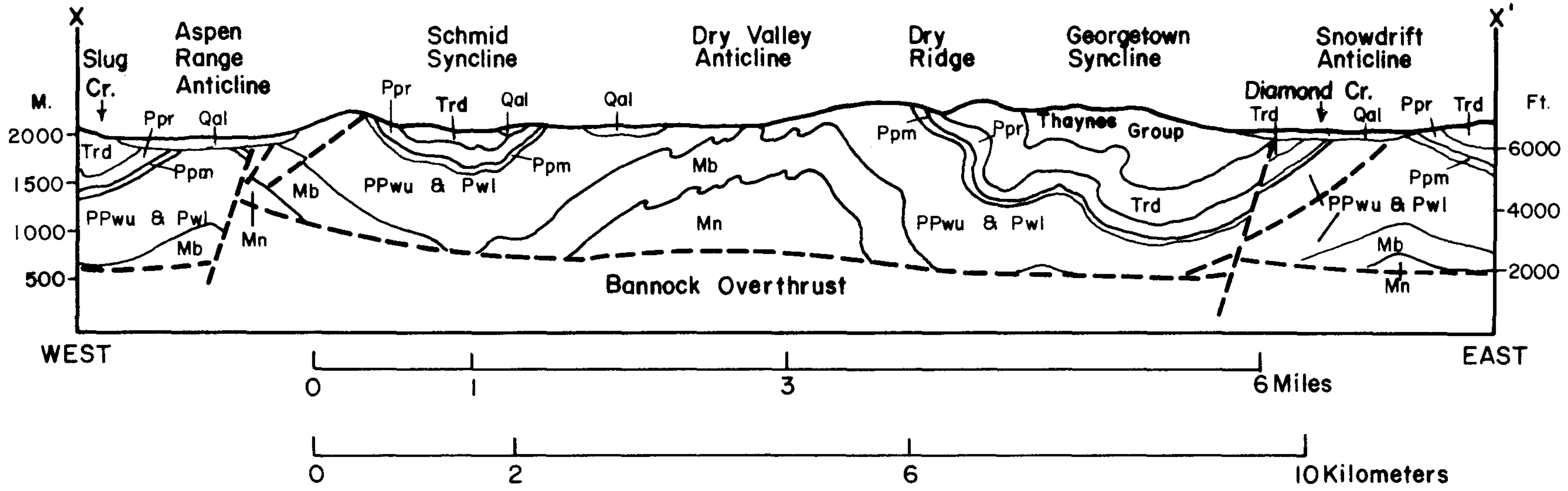
Note: *1 = Appear on geologic maps, not of importance to study.
*2 = Occasionally mapped as one unit (Trd).
*3 = Occasionally mapped as one unit.
*4 = Usually mapped as part of upper Wells.

(Armstrong, F., 1969, 2 plates; Cressman, E., 1964, 105 p.; Cressman, E. and Gulbrandsen, R., 1955, 18 p.; Gulbrandsen, R., and others, 1956, 23 p.; Lowell, W., 1952, 53 p.; Montgomery, K. and Cheney, T., 1967, 63 p.; Rioux, R., and others, 1975, 6 p.)

Paleocene periods. The plane of the overthrusting, at least in the Georgetown Canyon-Snowdrift Mountain area, is thought to be the base of the Madison Limestone which lies below those formations of primary interest in this study. Additional faulting has occurred since the Oligocene with differential subsidence and uplift occurring mostly with normal faulting; these faulting and erosional processes have resulted in the current major valleys and ridges (Cressman, 1964, p. 62-91). The northward trending graben valleys seen today were produced at this time from extensive block faulting (Armstrong and Cressman, 1963, p. J20). The complex structure and formation sequence of the area are illustrated by the geologic section view of figure 6.

The competency of the formations of interest in this area varies as illustrated by table 2. The folding that occurred in the area results in the convex side of the fold being placed in tension while the concave side is placed in compression. Competent formations under this stress might rupture with tension fractures or small gravity faults on the convex side and small thrust faults on the concave side while incompetent formations will yield plastically (Billings, 1954, p. 89 and 90). Field investigations of the hydrogeologic properties of the phosphate sequence will therefore indicate the combined effects of both the primary hydraulic conductivity of the unaltered formations and the secondary hydraulic conductivity created by the stress induced fracturing and faulting.

Previous researchers found that the hydrogeologic characteristics of the phosphate sequence are very similar even though their studies were conducted in different areas. Table 3 summarizes the hydraulic conductivities determined by previous investigators. These values, besides indicating specific site values indicate that anisotropic conditions exist in at least



Note: Figure 1 shows the location of X–X' in plan view

Figure 6. Geologic section view, Lower Diamond Creek valley to Slug Creek valley (Modified after Mansfield, 1927, Plates 4 and 11).

Table 2. Formation competency.

Formation	Unit	Symbol	Competent	Intermediate Competency	Incompetent
Thaynes	Black Limestone Member[1]	Trtl			X
Dinwoody	Upper Member	Trdu	X		
	Lower Member	Trdl			X
Phosphoria	Rex Chert Member[2]	Ppr	X		
	Meade Peak Phosphatic Shale Member	Ppm			X
Wells	Upper Member	PPwu		X	
	Lower Member	Pwl	X		
Monroe Canyon Limestone		Mb	X		
Madison Limestone		Mn		X	

[1] Referred to as Lower Black Shale Member by Cressman (after Cressman, 1964, p. 62).

[2] Member not differentiated into cherty shale and Rex Chert Members.

Table 3. Summary of hydraulic conductivity data for the phosphate area (modified after Ralston and others, 1977, p. 112 and Vandell, 1978, p. 38, 59, 64, 89 and 94).

Formation	Unit	Symbol	Study Area	Test Procedure	Transmissivity T ft^2/day	Transmissivity T M^2/day	Hydraulic Conductivity K ft/day	Hydraulic Conductivity K M/day	Storage S
Dinwoody	Middle of Formation	Trd	Little Long Valley	Field-Slug Test	83	7.7	--	--	--
Phosphoria	Rex Chert Member (fractured)	Ppr	Lower Dry Valley	Field-Pump Test	12,000	1,100	75	23	0.0003
					2,300	210	28	8.5	0.001
	Rex Chert Member	Ppr	Lower Dry Valley	Field-Pump Test	450	42	2.2	0.67	--
			Diamond Creek	Field-Pump Test	750	70	2.5	0.76	0.007
	Meade Peak Phosphatic Shale Member (fractured)	Ppm	Lower Dry Valley	Field-Pump Test	2,000	190	25	7.6	0.0005
	Meade Peak Phosphatic Shale Member (unfractured)	Ppm	Lower Dry Valley	Field-Slug Test	8.0	0.74	0.3	0.09	--
					64	5.9	1.6	0.49	--
					23	2.1	0.4	0.1	--
					16	1.5	0.14	0.043	--
					63	5.9	0.44	0.13	--
					6.0	0.56	0.07	0.02	--
	Meade Peak Phosphatic Shale Member (middle waste)	Ppm	Lower Dry Valley	Field-Pump Test	300	28	4.0	1.2	0.0013
	Meade Peak Phosphatic Shale Member (ore)	Ppm	Little Long Valley	Field-Slug Test	11	1.0	2.2	0.67	--
	Meade Peak Phosphatic Shale Member (middle waste with bedding)	Ppm	Little Long Valley	Lab	--	--	5.2	1.6	--
	Meade Peak Phosphatic Shale Member (middle waste across bedding)	Ppm	Little Long Valley	Lab	--	--	0.4	0.12	--
Alluvium	Alluvium	Qal	Diamond Creek	Field-Pump Test	3,200	300	55	17	--

the Meade Peak Phosphatic Shale Member of the Phosphoria Formation.

Spring discharges were measured and analyzed by Robinette (1977) in the lower Dry Valley-Schmid Ridge complex based on the following equation (Butler, 1957, p. 214-218).

$$Q_T = \frac{Q_o}{10^{T/K}}$$

where: K = time increment corresponding to a log cycle change in Q,

Q_o = the discharge at any given time, and

Q_T = the discharge T time units after Q_o.

Discharge data plotted on semi-logarithmic graph paper will plot as a straight line during periods of no recharge. The size and topography of the drainage basin, hydraulic conductivity and ground water storage characteristics of the water bearing formation and the season of the year determine the slope of this line (Butler, 1957, p. 214-218). This technique is also applicable to streamflow in the absence of overland flow. Robinette (1977) found spring discharges as large as 3,600 gallons per minute (gpm) (230 liter/sec.) while recession constants (K) in the consolidated formations ranged from 120 days to 1000 days. Those springs evaluated by Robinette for recession constants are summarized in table 4.

Previous investigators concluded from this analysis of geology, ground water levels, spring discharges, stream gain-loss measurements, and pump tests that the formations comprising the phosphate sequence have distinct ground water flow system characteristics. The results of these analyses are summarized in table 5. No major ground water flow system

Table 4. Summary of spring characteristics in Lower Dry Valley and Schmid Ridge (after Robinette, 1977, p. 27-30, 83).

Robinette Spring No.	This Study Spring No.	Location	Formation*1	Unit*1	Symbol*1	Discharge (gpm)	Discharge (liter/sec)	Date	Recession Constant K (days)	Electrical Conductivity (micromhos/cm^2)
1	56	SW¼, NE¼, Sec 28, T8S, R44E	Thaynes	Platy Siltstone Member	Trts	126 61.4	7.95 3.87	6/ 8/75 9/19/75	330	470
2	44	SE¼, NE¼, Sec 7, T8S, R44E*2	Thaynes	Platy Siltstone Member	Trts	176.4 57.0	11.1 3.60	6/11/75 9/19/75	180 200*3	410
3	50	SW¼, SE¼, Sec 17, T8S, R44E	Thaynes	Platy Siltstone Member	Trts	103.9 103.9 15.8	6.55 6.55 1.00	6/16/75 6/19/75 9/19/75	120 110*3	440
4	51	SW¼, SE¼, Sec 17, T8S, R44E	Thaynes	Platy Siltstone Member	Trts	31 25	1.00 1.58	6/16/75 9/19/75	1000	400
5	57	SE¼, NE¼, Sec 28, T8S, R44E	Thaynes	Platy Siltstone Member	Trts	73 40	4.6 2.5	6/ 8/75 9/19/75	440 400*3	---
16	36	SW¼, SE¼, Sec 5, T8S, R44E	Alluvium	--	Q	9.2	0.58	6/26/75	23	---
24	22	NW¼, SE¼, Sec 30, T8S, R44E*2	Dinwoody	Lower Member	Trdl	1736 1583 1000	110 100 63.1	6/12/75 6/19/75 10/23/75	735 630*3	380

*1 Formations, units, and symbols correlated to correspond with Table 1.
*2 Mislocated in Robinette, 1977; correct location given this table.
*3 K value calculated for this study from 1975 data.

Table 5. Flow system summary of previous studies.

Formation	Member	Vandell's Conclusions	Robinette's Conclusions	Edwards' Conclusions	Mohammad's Conclusions
Thaynes	Upper	--	--	--	Aquifer
	Middle	--	Intermediate flow system	--	Aquifer
	Lower	--	Intermediate flow system	--	Aquifer
Dinwoody	Upper	--	Intermediate flow system	--	Aquifer
	Lower	--	Intermediate flow system	Intermediate flow system	Aquitard
Phosphoria	Rex Chert	Aquifer - localized high transmissivity	Moderate hydraulic conductivity with confining beds	Intermediate flow system	Aquifer
	Meade Peak	Aquiclude	Moderate hydraulic conductivity with confining beds	Intermediate flow system	Aquiclude
Wells		Regional ground water flow system	Regional ground water flow system	Postulated regional ground water flow system	Aquifer (all members)
Monroe Canyon Limestone (Brazer Limestone)	--	--	--	--	Aquifer (all members)

(Vandell, 1978, IX, 93-95, 111-112; Robinette, 1977, p. 26-39, 43, 64, 67, 90; Edwards, 1977, p. 93-94; Mohammad, 1976, p. 31) was found in the Phosphoria Formation in any of the study areas (Ralston and others, 1977, p. 109).

The results of these investigators can be illustrated by the diagrammatical section view of figure 7. Snow occurs mainly along the ridge tops and the eastern flanks of the ridges. Ground water recharge will also occur in these areas if the underlying formations have sufficient hydraulic conductivity. Some of the recharge will cross formation contacts while the rest follows the bedding plane of the formation to discharge at a lower elevation. The presence of a low hydraulic conductivity layer prevents any significant interchange of ground water flow between those formations above and below the layer. Two major divisions of ground water flow can exist though faults may provide a means for such a ground water interchange via formation displacement.

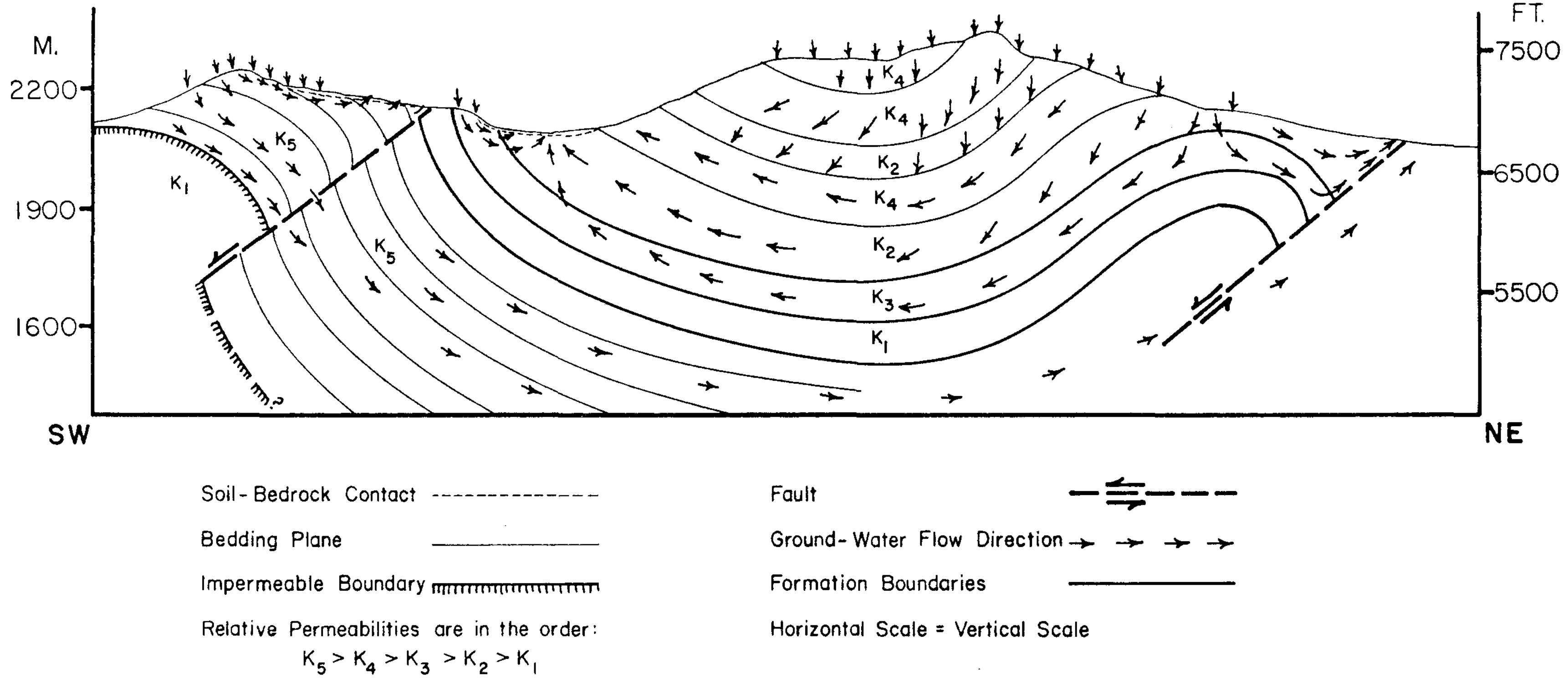


Figure 7. Diagrammatical section view of the hydrogeologic characteristics of Little Long Valley.

PAST AND PRESENT HYDROGEOLOGIC RESEARCH

Previous hydrogeologic studies in Caribou County were directed mainly toward specific sites. Vandell's (1978) study of lower Dry Valley and Slug Creek valley concentrated on the ground water flow systems in the Phosphoria and Wells Formations. This area was also studied for the determination of ground water flow systems by Robinette (1977). Edwards (1977) investigated the relationships between the surface flow of Diamond Creek and its tributaries and the ground water flow systems in the southern part of Upper Valley. A dissertation by Mohammad (1976) reviewed several mine sites in the area for an evaluation of the impacts of open pit mining on the ground water systems. Mohammad also conducted a detailed study of the hydrogeology of Little Long Valley. Sylvester (1975) conducted a preliminary evaluation of the ground water in Upper Dry Valley and Little Long Valley. These studies were all conducted under the same general research effort of the University of Idaho. Ralston and others (1977) summarized the research efforts of Mohammad (1976), Robinette (1977), and Edwards (1977). Additional hydrologic research has been conducted by the U.S. Department of the Interior and the Department of Agriculture (1977), Ralston and Trihey (1975), Pederson and others (1977) and several consultants.

Concurrent hydrogeologic studies include a detailed analysis of the hydrology and hydrogeology associated with the North Henry mine in the vicinity of the Little Blackfoot River. Brooks (1979) is working with Monsanto Corporation on this ongoing study in which data collection began the summer of 1977. Corbet (1979) is collecting and analyzing data at this time on the J. R. Simplot mine located on the Fort Hall Indian Reservation. Data collection began during the summer of 1978. Cannon (1979) initiated a review of existing literature and existing mine sites during the summer of 1978. Concurrent research will also be reviewed by Cannon for an overall evaluation of potential mining impacts on the hydrology and hydrogeology of the area. These studies are continuing research efforts through the University of Idaho.

METHOD OF STUDY

Introduction

The hypothesis that the Dinwoody, Phosphoria and Wells Formations exhibit similar hydrogeologic characteristics over a broad area is examined in this study. The method of study is based on basic principles of hydrogeology.

A ground water flow system consists of a recharge area and discharge area connected by a continuous flow path. Several factors are necessary for the formation of a ground water flow system. First, the formation must have sufficient hydraulic conductivity to permit the significant movement of water. Second, the formation must be exposed to an area where recharge can occur and water must be available in that area. Third, a discharge area must exist or there can not be any ground water movement. Fourth, there must be hydraulic continuity between the recharge area and the discharge area. Recharge or discharge can also occur via ground water movement to or from adjacent formations respectively. This can be due to the general hydrogeologic characteristics of the formation or to conditions found only at specific sites.

The existence of ground water flow systems in the Dinwoody, Phosphoria or Wells Formations would be indicated by the gain or loss of stream flow and by the existence of springs. The hydrologic properties of the streams and springs were measured in order to determine the hydrogeologic properties of these three formations. A gain or loss of stream flow across a formation indicates that the formation supports a ground water flow system. Spring discharge indicates that the formation from which it issues also supports a ground water flow system. A lack of change in stream flow or the absence of springs does not necessarily indicate that the formation does not have significant hydraulic conductivity. A formation with a high hydraulic conductivity may not support a ground water flow system if the formation is structurally isolated. Stream flow and spring data were therefore analyzed in conjunction with local geologic conditions. This constitutes the bulk of the field data studied.

Additional information can be obtained such as the specific conductivity of the water which indicates the amount of total dissolved solids occurring in the water (Hem, 1970, p. 99). A fundamental principle of chemical hydrogeology is that the concentration of dissolved minerals in ground water is directly proportional to the length of the flow path and to the residence time of the water in the formation (Domenico, 1972, p. 283). Relative ground water flow lengths can, therefore, be determined from a comparison of specific conductivities. Multiple discharge measurements allow the calculation of the recession characteristics for a spring and the ground water flow system it represents. Recession characteristics also indicate the size of the flow system.

The field work for this study was conducted in June, July, and August of 1977. It consisted of stream gain-loss measurements at formation contacts and spring reconnaissance.

Site Selection

Stream gain-loss measurement sites were selected based on several criteria. The primary requirement was that there be stream flow across at least part of the phosphate sequence consisting of the Dinwoody, Phosphoria, and Wells Formations. It was desired that the stream channels be underlain by a minimum amount of alluvium and colluvium so that flow measurements would reflect as nearly as possible any flow change due to the exposed formation. Fault areas were avoided where possible so that the ground water flow system characteristics would represent the regional hydraulic properties of the given formations. These prerequisites combined with the desire to expand the current hydrogeologic knowledge outside the previously studied areas dictated that the eastern flank of the Webster Range be the primary study area. One main site was also selected in the Aspen Range to further extend the areal extent of this study. Information was also desired on the hydrogeologic characteristics of the members of the Thaynes Formation which lie above the Dinwoody Formation in the normal geologic sequence but only one site was possible, Sheep Creek on Rasmussen Ridge. Here the Dinwoody Formation lies above the Thaynes Formation. It was also required that all the selected sites have some means of reasonable access.

Areas were selected for spring reconnaissance based mainly on the desire to expand the areal extent of the study where stream gain-loss measurements were not possible. Particular emphasis was placed on the Sulphur Canyon area since no previous hydrogeologic research had been conducted there. The southern portions of Slug Creek valley and Schmid Ridge were also of interest since previous studies had only covered their northern portions. Those springs previously studied by Robinette (1977) were of interest due to the low precipitation received as snow prior to the summer of 1977. Spring reconnaissance along the base of the east flank of the Webster Range was desired since it was anticipated that large spring areas might exist there. This concept was based on the existence of a synclinal structure along that flank (Cressman, 1964, plate 1). Such a structure might allow the formation of long ground water flow systems from high on the range to Crow Creek valley where the formations are again exposed.

Data Collection

Stream gain-loss measurements were initially selected by locating the contacts between members of a formation or between formations using existing geologic maps and topographic maps. Formations were field verified where possible. A stream section suitable for a flow measurement was located or rebuilt at or near a contact and the flow was measured.

Stream flow was measured by one of three different methods. The primary method utilized a single, sixty degree, V-notch flume constructed of fiberglass with a sidewall head scale. Flume discharges were determined from a rating curve that shows a flow range from 0.05 to about 37 gpm (0.003 to 2.33 liter/sec.). Twin flumes were also used in parallel to extend the range of these highly portable tools.

A second type of flume was also used but only to a limited extent due to its much greater size and weight. This was a forty-five degree trapezoidal flume with a two-inch throat constructed of fiberglass with a sidewall head scale. A thin metal scale was used to measure vertical heads since the installed scale lacked divisions of a hundreth of a foot. The flow range of this flume is from 10.3 to 1,895 gpm (.65 to 119.5 liter/sec.) based upon its rating chart. Field use was limited to locations close to a jeep trail since the flume was awkward to handle. Two trips were required to carry all the necessary gear for installing the flume and making a flow measurement. In addition, the flume was frequently difficult to install due to irregular channel shapes, sizes, and flow rates encountered. Upon several occasions the pygmy current meter was used for flow rates well within the range of this flume because of these difficulties.

A pygmy current meter and topsetting rod were frequently used for measuring stream flow. The basic gear consisted of a converted flashlight for a power source and an earphone although a digital counter was also available but seldom used due to malfunctions. Several days of field time were lost when the counter ceased to function at inopportune times. The meter was used when the flow rate was too high for the flume or when channel or access conditions ruled out the use of a flume. All flow measurements are rounded off to two significant figures.

Comparison of measurements for determining gain-loss characteristics must be done with descretion as a number of variables affect the surface-ground water flow ratio. The primary variables are the width and depth of the valley alluvium and the hydraulic conductivity of the alluvium. An increase in the width or depth of the valley alluvium could cause more of the total down valley flow to occur as ground water flow resulting in a decreased surface water flow. The same result would occur if the hydraulic conductivity of the alluvium increased. A decrease in the width, depth or hydraulic conductivity of the valley alluvium could cause an increase in the surface flow with a concurrent decrease in the ground water flow. These factors were recognized prior to conducting the field work and consequently comments were noted while making the flow measurements so that a value judgement could be made during the data evaluation. The error of the methods used for measuring the rate of flow is estimated to be plus or minus ten percent.

Springs were located by either finding previously mapped springs or by hiking an area of interest and visually locating them. The latter method was basically used in the area between Wood Canyon and Swan Lake Gulch in the Aspen Range since Robert V. Kimball, Senior Staff Geologist - J. R. Simplot Company, had indicated that the previously mapped geology was inaccurate (personal communication, 1977). Once a spring was found, the site was located on a seven and one-half or fifteen minute quadrangle map. Locations were determined by a combination of techniques: pacing, compass bearings, vehicle odometer, topographic map orientation, and comparison with known geology. Once the spring was located, a site was selected where there was no apparent change in stream flow. The site was flagged and a flow measurement was made by one of the previously described methods. The specific conductivity of the water was then measured after determining the water temperature. Unfortunately the conductivity meter ceased functioning properly and a replacement was not available so subsequent springs were only checked for discharge.

Analysis Techniques

The techniques developed for analyzing the data are based upon Darcy's Law which is commonly expressed as

$$Q = - \frac{K(h_2 - h_1)A}{L}$$

where Q is the flow rate, K is the coefficient of permeability (hydraulic conductivity), $h_2 - h_1$ is the head loss over a distance of L, and A represents the cross sectional area of the porous medium across which the flow occurs (Hubbert, 1940, p. 791 and 819). This equation can also be expressed as:

$$Q = -K A \frac{1}{g} \frac{d\phi}{dL}$$

in terms of the fluid potential (ϕ) indicating that the direction of fluid flow is from the higher to lower potential. The acceleration due to gravity is g (Hubbert, 1940, p. 791-819). Ground water flow will therefore occur if the medium has some degree of hydraulic conductivity and flow path continuity. There must also be an inlet for the formation to be recharged and an outlet for discharge.

For the purposes of this study, hydraulic conductivity will be defined to have one of two values, low or high. A low hydraulic conductivity indicates that a formation or geologic unit will transmit such a small volume of water under prevailing conditions that the volume can not be measured by the field measurement techniques used. Any measurable volume of stream gain or loss or spring discharge indicates that the formation has a high hydraulic conductivity.

A stream will gain flow as it crosses a formation if: 1) the formation has a high hydraulic conductivity and 2) there is a continuous flow path from a recharge area at a higher elevation to the formation exposure in the stream at a lower elevation. Figure 8 illustrates the characteristics of gaining, losing, and no gain or loss sections of a stream.

The characteristics necessary for a stream to lose flow across a formation are basically the same as for a gaining stream. The formation must have a high hydraulic conductivity and a continuous flow path from the formation exposure at the stream to a formation exposure at a lower

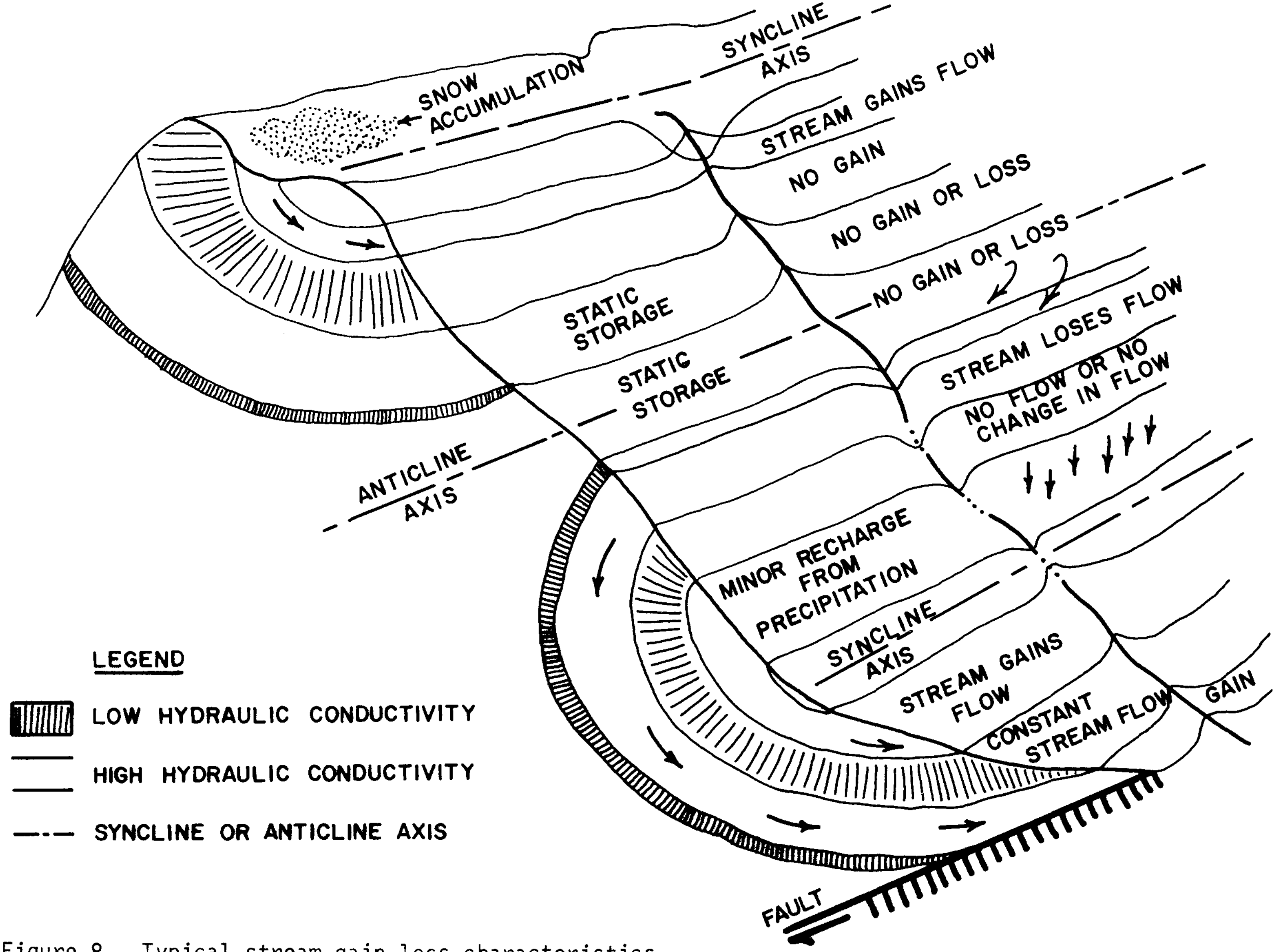
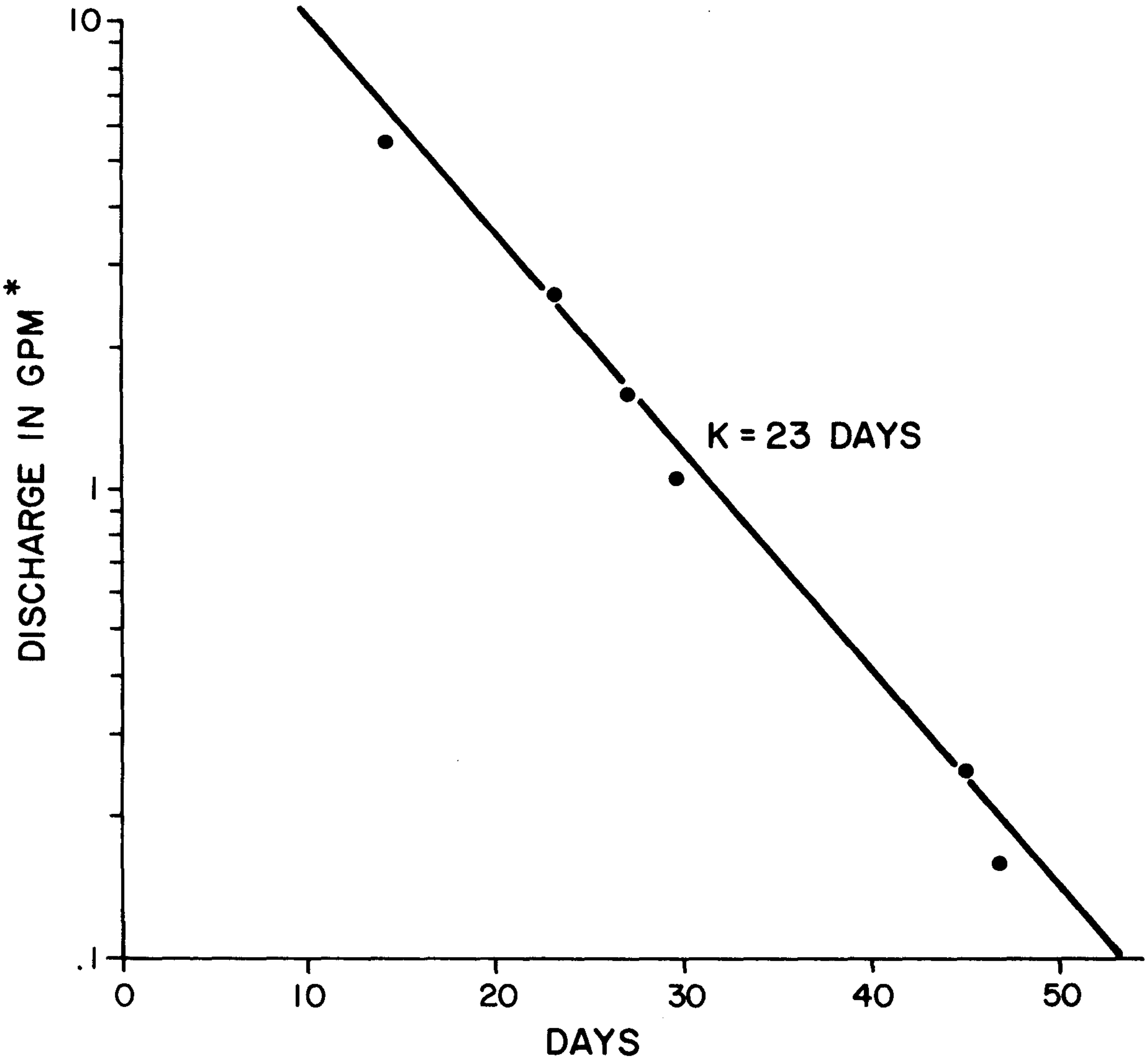


Figure 8. Typical stream gain-loss characteristics.

elevation. These characteristics are illustrated in figure 8.

A stream can have a constant flow across an exposed formation for several reasons. The stream will not gain or lose flow if the formation has a low hydraulic conductivity, regardless of any other factors. Constant stream flow can also result if the formation has a high hydraulic conductivity and there is no difference between the elevation of the stream surface and the potentiometric surface of the ground water at that point. This can occur where there is no recharge at a higher elevation or where there is a flow path discontinuity between the recharge area and the formation exposure at the stream. The same result is achieved if the formation does not have an exposure at a lower elevation where discharge could occur. A flow path discontinuity could separate the formation exposure at the stream from an exposure at a lower elevation and prevent any ground water flow. The lack of a discharge site creates a static storage condition. Figure 8 illustrates the basic no gain or no loss conditions that could exist.

A spring can exist only if the formation from which it issues has a high hydraulic conductivity. Recharge to the formation must occur at an elevation that is higher than the spring and there has to be flow path continuity from the recharge area to the spring. Spring discharge can only occur if the formation is capable of accepting recharge and yielding discharge from ground water storage. This discharge is determined by a number of factors as previously discussed in the hydrogeology section. A plot of discharge versus time approaches a straight line on semi-logarithmic paper during periods of no recharge (figure 9). The K value is the recession constant as defined by the following equation (Butler, 1957, p 214-218):



*1 GALLON PER MINUTE = 0.0631 LITER PER SECOND

ROBINETTE SPRING #16 = THIS STUDY SPRING # 36

Figure 9. Spring recession hydrograph (from Robinette, 1977, p. 47 & 49).

$$Q_T = \frac{Q_o}{10^{T/K}}$$

where: K = time increment corresponding to a log cycle change in Q,

Q_o = the discharge at any given time, and

Q_T = the discharge T time units after Q_o.

The recession characteristic provides a means of evaluating the ground water flow system sustaining a spring.

Spring discharge and the baseflow component of stream flow are controlled by several hydrogeologic factors. Rorabaugh (1964) determined that the baseflow contribution to stream flow can be evaluated from the following equation:

$$Q = 2T\ (h_{o/a})\ e^{-\pi^2 Tt/4a^2 S}$$

where Q is the ground water discharge per unit length of the stream (one side) at some time t after an instantaneous water table rise of h_o. The transmissivity of the formation is represented by T and the storage coefficient by S. The distance from the stream to a ground water divide is represented by a (Rorabaugh, 1964, p. 432-441). Ground water discharge (Q or Q_T) and the recession constant (K) are directly proportional to the transmissivity of the formation and inversely proportional to the length of the flow system.

The significance of the low precipitation, October, 1976, through May, 1977, prior to the period of study is evident in figure 9. This spring had a low recession constant (K) of 23 days during Robinette's

(1977, p. 47 and 49) study. Spring discharge declined rapidly with time indicating a rapid depletion of ground water storage. Low precipitation creates a low volume of water that can recharge a ground water flow system; therefore, the initial spring discharge after recharge is completed will be lower than the normal. Spring discharge will decrease to a very low rate at an earlier time after recharge ceases, assuming that the recession constant (K) is still valid. This spring was not flowing when visited during the summer of 1977.

STREAM GAIN-LOSS CHARACTERISTICS

The study area was broken up into subareas based upon topographic features shown in figure 1. Each of these subareas was then broken into smaller units referred to by their site name such as Wood Canyon in the Aspen Range subarea. Information on the sites investigated in the study are presented in table 6. These data include the formations exposed, the means of access and the maximum flow rate measured. Details of the stream gain-loss measurements are shown in appendix 1.

Aspen Range Subarea

Wood Canyon

Stream flow in Wood Canyon began at spring #19 in section 32 in the black limestone member (Trtl) of the Thaynes Formation and proceeded downstream across the sequence of formations until surface flow ceased in the upper member (PPwu) of the Wells Formation at point I (figure 10). Flow measurements for gain-loss characteristics began at the syncline axis in the Thaynes Formation since any flow changes between the spring and the axis of the syncline would be difficult to interpret due to the fault. Stream gain-loss measurements are shown on table 7.

The black limestone member (Trtl) of the Thaynes Formation between the synclinal axis at point A on figure 10 and the contact with the upper member (Trdu) of the Dinwoody Formation at point B does not appear to significantly affect the stream flow. An analysis of the geologic structure indicates that this lack of change in flow could be due to the synclinal structure creating a bathtub effect where the formation cannot accept any more water into storage. No categorization can be made as to

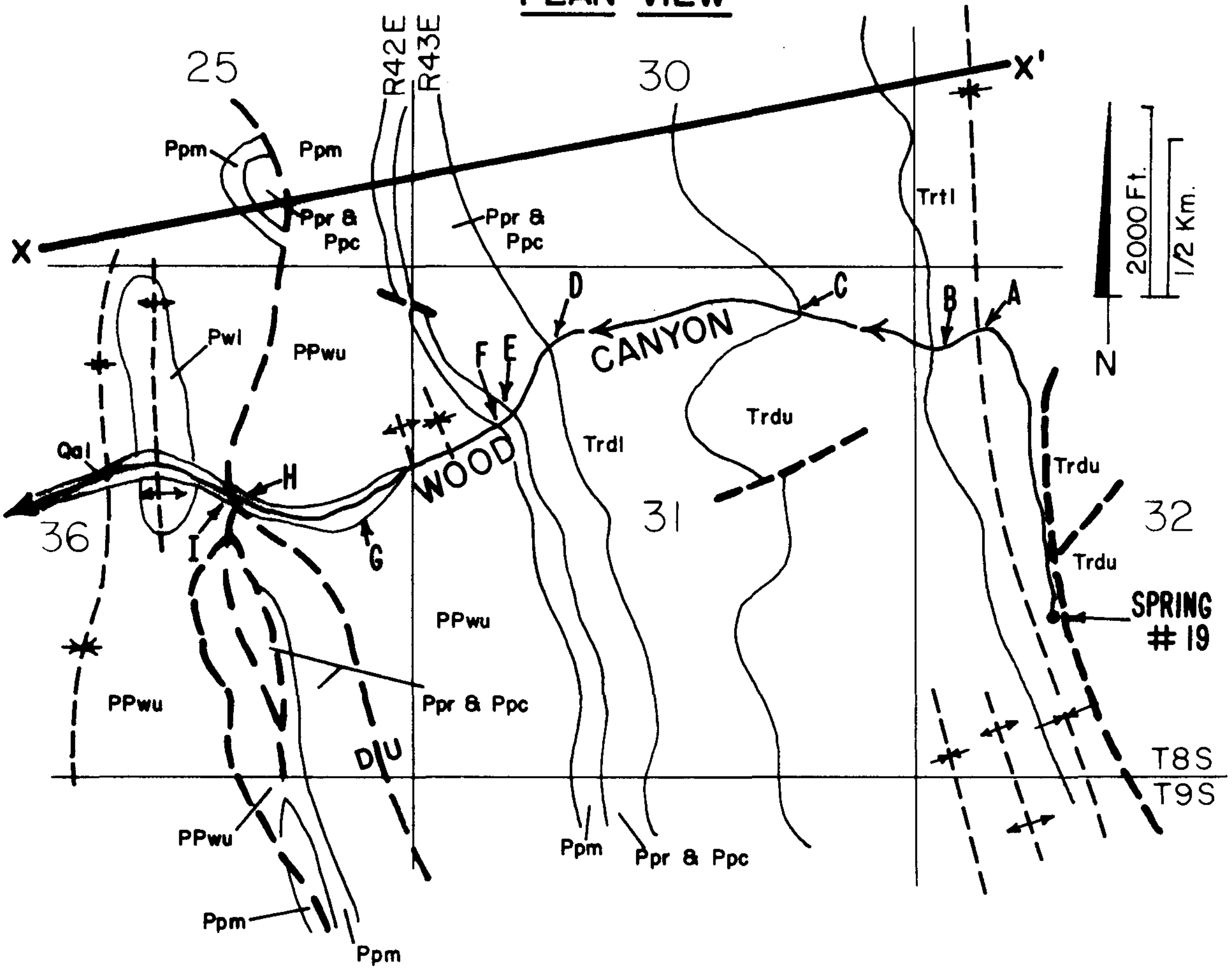
Table 6. Stream gain-loss site selection.

Subarea	Site	Formation Exposed	Access	Maximum Flow	
				GPM	Liter/sec
Aspen Range	Wood Canyon T8S, R42 & 43E	Trtl, Trdu, Trdl, Ppc & Ppr, Ppm, PPwu, & Pwl	Jeep and Hiking	99	6.2
	Unnamed Tributary to Johnson Creek T9S, R43E	Trdu, Trdl & Ppc	Hiking	17	1.1
Wooley Range	Sheep Creek T6S, R44E	Trdu, Trtl, Trts, Trtb, Trtn, Trtpl, & Tral	Jeep and Hiking	620	39
Webster Range	Smoky Canyon T8S, R45 & 46E	Trdu, Trw, Trdl, Ppc, Ppr, & Ppm	Jeep	22	1.4
	Sage Creek T9S, R45 & 46E	Trdu, Trw, Trdl, Ppc, Ppr, Ppm, & PPwu	Hiking	1260	80
	Unnamed Tributary to Deer Creek T9S, R45E	Trdu, Trdl, Ppc, Ppr, & Ppm	Hiking	200	13
	South Fork Deer Creek T9 & 10S, R45E	Ppc, Ppr, Ppm, PPwu, Pwl, & Mb	Jeep and Hiking	68	4.3
	Well Canyon T10S, R45E	Ppr, Ppm, PPwu, & Pwl	Jeep	110	6.9

Note: Refer to figure 1 for locations.

WOOD CANYON

PLAN VIEW



SECTION VIEW

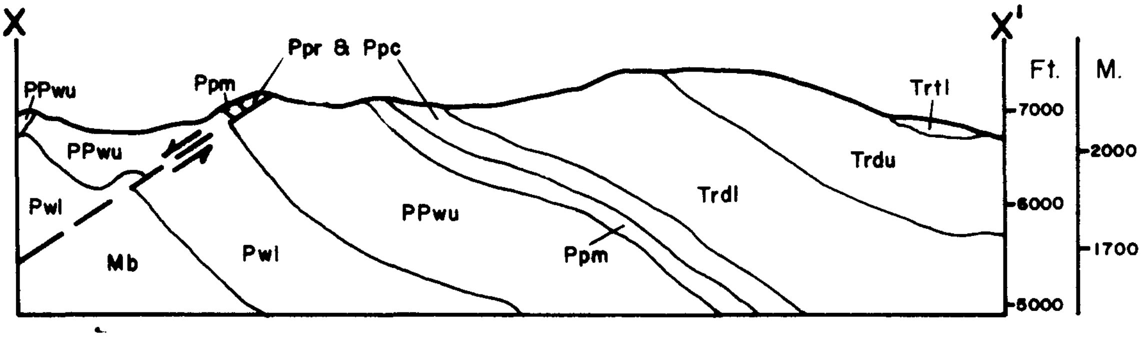


Figure 10. Geologic plan and section views of Wood Canyon showing stream measurement sites and spring locations (Modified after Gulbrandsen and others, 1956 Plate 1).

Table 7. Wood Canyon, stream gain-loss measurements.

Measuring Point	Flow Measurement	
	GPM	Liter/sec.
A	12	0.76
B	10	0.63
C	1.6	0.10
D	95	6.0
E	99	6.2
F	95	6.0
G	88	5.6
H	4.2	0.26
I	0	0

the relative hydraulic conductivity of the formation or its potential as a ground water flow system.

The stream loses flow as it crosses the upper member (Trdu) of the Dinwoody Formation between points B and C on figure 10. Stream flow gains as the stream crosses the lower member (Trdl) of the Dinwoody Formation between points C and D on figure 10. Both members (Trdu and Trdl) have a high hydraulic conductivity as previously defined. Stream flow lost to the upper member (Trdu) probably enters a ground water flow path that connects the upper and lower members (Trdu and Trdl) through vertical leakage and possibly fault displacement. The upper member (Trdu) is a competent formation so the stresses induced by folding could be anticipated to create fracturing and faulting.

A distinction was not made between the two upper members (Ppc and Ppr) of the Phosphoria Formation in Wood Canyon so these members will be referred to as the Rex Chert Member (Ppr). There was no significant change in stream flow across the Rex Chert Member (Ppr) or the Meade Peak Phosphatic Shale Member (Ppm) between points D, E, and F on figure 10. Cross bedding leakage from the lower member (Trdl) of the Dinwoody Formation could have occurred or the formation could have been recharged directly by precipitation but neither process is apparent. Ground water flow in the Rex Chert Member was not evident even though the formation is competent and would be expected to fracture and fault under strain. The incompetency of the Meade Peak Phosphatic Shale Member (Ppm) would preclude the development of secondary hydraulic conductivity. The Phosphoria Formation as a unit exhibits potential flow path continuity and a low hydraulic conductivity. This formation thus does not include a ground water flow system in this area.

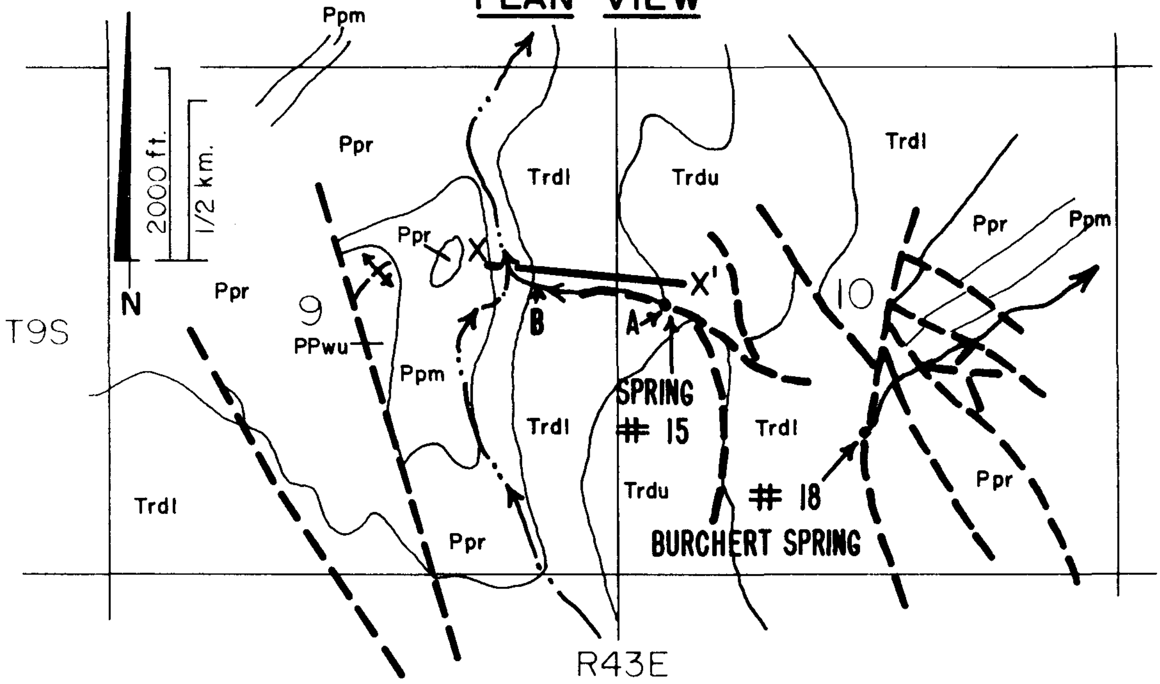
Stream flow across the upper member (PPwu) of the Wells Formation does not change significantly between the contact with the Phosphoria Formation at point F and point G on figure 10. All the stream flow is lost, however, between point G and points H and I. A major fault near points H and I is the apparent cause for the lost stream flow. Water movement is probably along zones of increased secondary hydraulic conductivity associated with the fault. The discharge point for this flow system is unknown.

Unnamed Tributary to Johnson Creek

This tributary was found while conducting a spring reconnaissance (figure 11). Neither the spring nor the stream are shown on the 7½ minute Johnson Creek quadrangle but their presence in the summer of 1977 should rank the stream as a perennial water supply. Stream flow was measured at two points so only the lower member (Trdl) of the Dinwoody Formation can be evaluated. The spring discharges from the upper member (Trdu) of the Dinwoody Formation at point A on figure 11. Stream flow more than doubles

UNNAMED TRIBUTARY TO JOHNSON CREEK

PLAN VIEW



A = 8.4 gpm (0.5 liters/sec) Spring # 15

B = 17 gpm (1.1 liters/sec)

SECTION VIEW

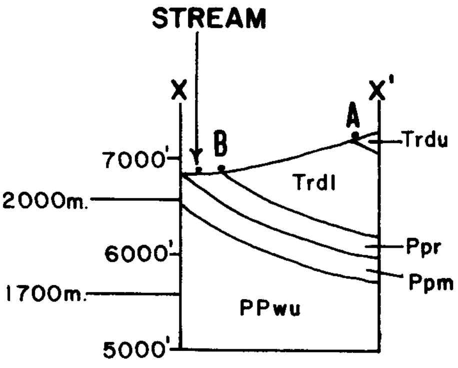


Figure 11. Geologic plan and section views of unnamed tributary to Johnson Creek showing stream measurement sites and spring locations (Modified after Gulbrandsen and others, 1956, Plate 1).

by the time it reaches the contact between the lower member (Trdl) of the Dinwoody Formation and the Rex Chert Member (Ppr) of the Phosphoria Formation at point B in figure 11. Here, as in Wood Canyon, the two upper members (Ppc and Ppr) of the Phosphoria Formation are not separated and are mapped as the Rex Chert Member (Ppr). The gain in stream flow across the lower member (Trdl) of the Dinwoody Formation indicates that this formation has a high hydraulic conductivity. The formation supports a ground water flow system with the recharge coming from the higher formation exposures to the north and south.

Wooley Range Subarea

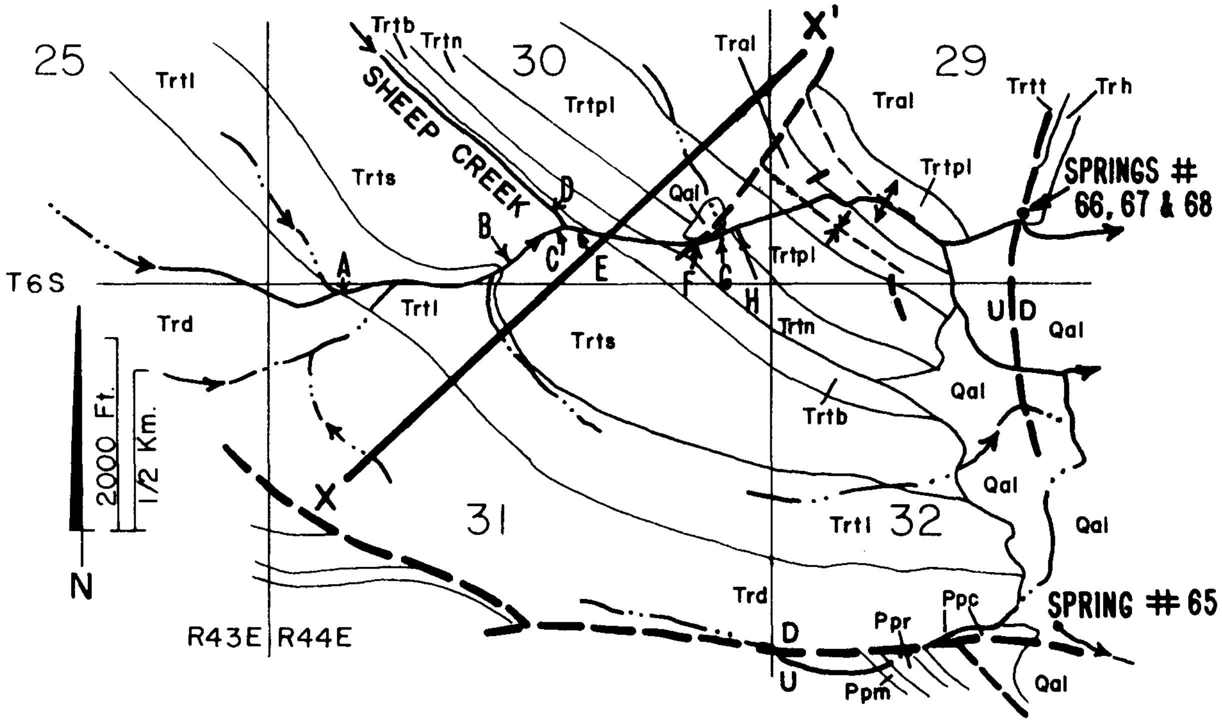
Sheep Creek

Stream flow was continuous across the reversed sequence of formations at this location (figure 12). Flow occurred in the stream channel from the upper member (Trdu) of the Dinwoody Formation through the Lower Part of the Portneuf Limestone Member (Trtpl) of the Thaynes Formation. Flow measurements were only possible though from the upper member (Trdu) of the Dinwoody Formation to the contact between the nodular siltstone member (Trtn) and the Lower Part of the Portneuf Limestone Member (Trtpl) of the Thaynes Formation.

Stream flow begins in the stream channel where the Dinwoody Formation is exposed. Rioux (1975) did not map the separate members of the Dinwoody Formation but flow begins within 200 feet upstream of the contact between the Dinwoody Formation (Trd) and the black limestone member (Trtl) of the Thaynes Formation at point A on figure 12. This corresponds to the upper member (Trdu) of the Dinwoody Formation. The unit therefore has a high

SHEEP CREEK

PLAN VIEW



A = 23 gpm (1.5 liter/sec)
B = 1.9 gpm (0.12 liter/sec)
C = 15 gpm (0.95 liter/sec)
D = 470gpm (30 liter/sec)
E = 500 gpm (32 liter/sec)
F = 450 gpm (28 liter/sec)
G = North side stream, 70gpm (4.4 liter/sec)
H = 620 gpm (39 liter/sec)

SECTION VIEW

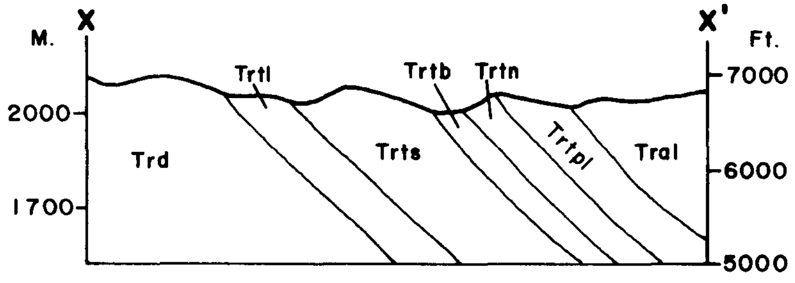


Figure 12. Geologic plan and section views of Sheep Creek showing stream measurement sites and spring locations (Modified after Rioux and others, 1975).

hydraulic conductivity. There is flow path continuity with the probable recharge area being to the northwest and southeast where the formation is exposed at higher elevations.

Stream flow appears to decrease as the stream crosses the black limestone member (Trtl) of the Thaynes Formation from point A to point B on figure 12. The accuracy of the flow measurement at the contact, point G, between the black limestone member (Trtl) and the platy siltstone member (Trts) is questionable though due to an excessive amount of valley filling alluvium. An increase in the amount of alluvium would affect the ratio of surface flow to down valley ground water flow by decreasing the surface component. A potential ground water flow path exists from the stream to the Lanes Creek valley (Upper Valley). The flow properties of this unit may not be determined because of the questionable accuracy of the flow measurements.

Since the flow measurement at point B on figure 12 is questionable, the measured gain in stream flow across the platy siltstone member (Trts) of the Thaynes Formation is also questionable. A gain in flow is indicated between the black limestone member (Trtl) and the platy siltstone member (Trts) contact at point B and the measuring site at point C. Point C is approximately 100 feet upstream of the fork in Sheep Creek. Only tentative values can be applied but it appears that the platy siltstone member (Trts) may have a high hydraulic conductivity. This member may support a ground water flow system based upon a potential flow path continuity to a recharge area at a higher exposure.

The remainder of the flow measurements were made on the main fork of Sheep Creek. Measurements ranged from 450 to 620 gpm (28 to 39 liters/

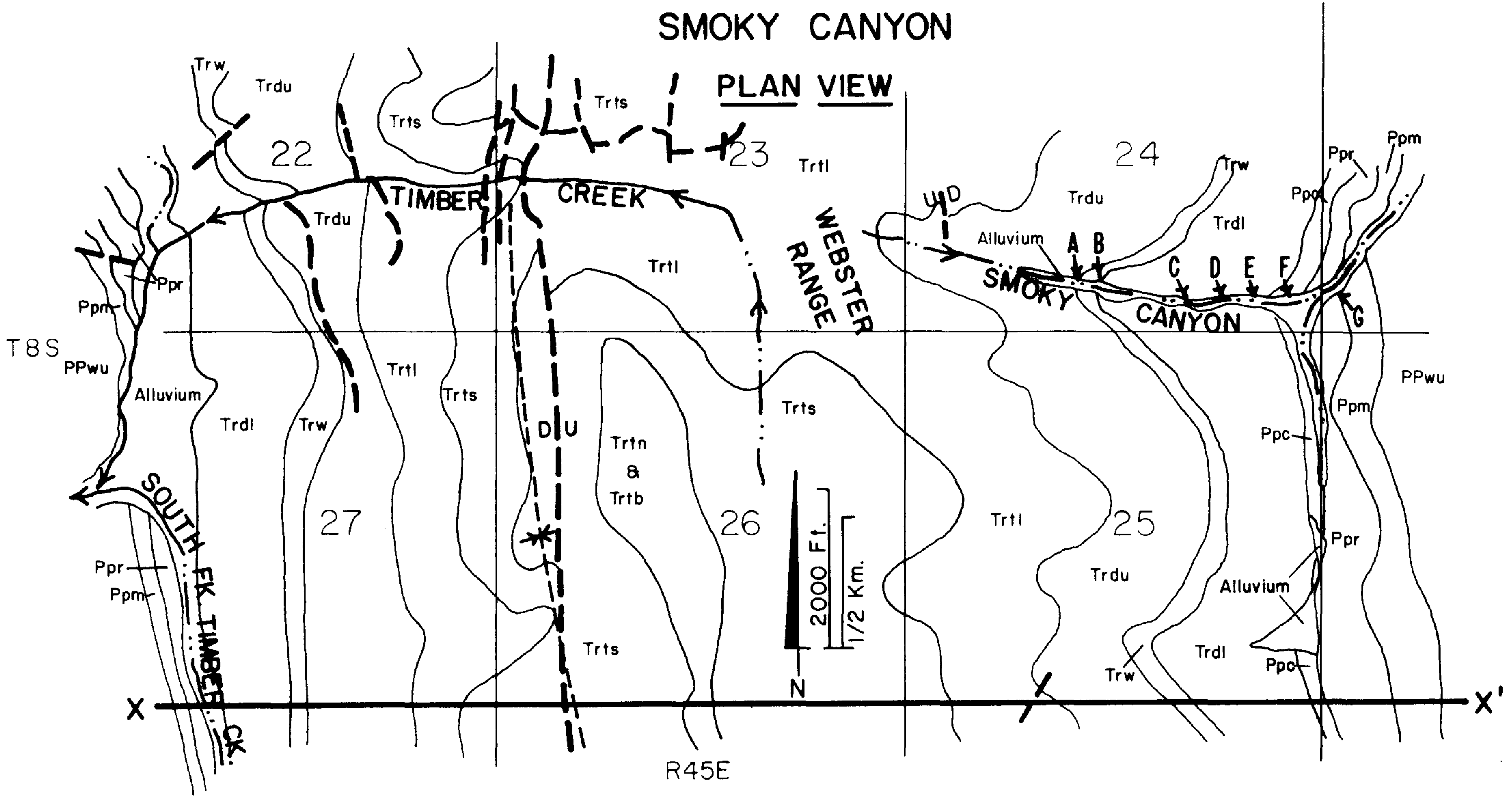
sec.). Small increases or decreases in the flow would not have been noticeable because of the large stream discharge. No significant change in stream flow occurred across the black shale member (Trtb) of the Thaynes Formation from point E to point F on figure 12. This could be due to the magnitude of the change required in order to be measured or it could be due to the low hydraulic conductivity of this unit. A continuous ground water flow path appears to exist from the stream to Lanes Creek valley (Upper Valley). The head or water elevation at the stream is higher than Lanes Creek valley so the potential exists to drive water through this member. It is concluded that the relatively constant streamflow across this member (Trtb) is due to the member having a low hydraulic conductivity.

Stream flow increases as the stream crosses the nodular siltstone member (Trtn) of the Thaynes Formation. Flow increases significantly from point F to point H (figure 12) even when the side stream flow at point G is subtracted. This member has a high hydraulic conductivity which is probably due to the fault intersecting the stream and this formation. A flow path either exists along the plane of the fault or to an exposure of the formation at a higher elevation to the north or northwest. The nodular siltstone member (Trtn) supports a ground water flow system at this location.

Webster Range Subarea

Smoky Canyon

Stream flow in Smoky Canyon was intermittent from the initial flow in the upper member (Trdu) of the Dinwoody Formation to the Meade Peak Phosphatic Shale Member (Ppm) of the Phosphoria Formation (figure 13a and



A =.47 gpm (0.03 liters/sec)
B = 0
C = 8.9 " (0.56 ")
D = 0
E = 11 gpm (0.70 liters/sec)
F = 8.4 " (0.53 ")
G = 0

Figure 13a. Geologic plan view of Smoky Canyon showing stream measurement sites and spring locations (Modified after Montgomery and others, 1967, Plate 2).

SMOKY CANYON

SECTION VIEW

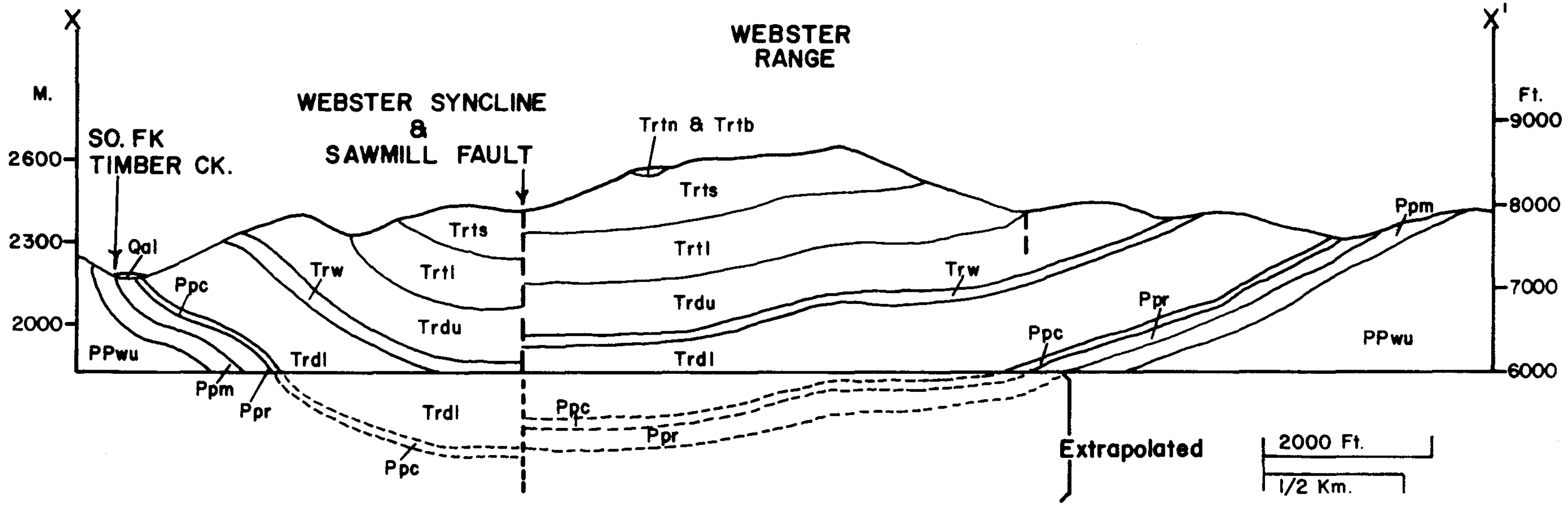


Figure 13b. Geologic section view of Smoky Canyon (Modified after Montgomery and others, 1967, Plate 2).

13b). The normal sequence of formations is exposed in Smoky Canyon.

The initial stream flow began in the stream channel at point A on figure 13a which corresponds to the contact between the upper member (Trdu) of the Dinwoody Formation and the Woodside Formation (Trw). This shows that the upper member (Trdu) of the Dinwoody Formation has a high hydraulic conductivity and a continuous flow path to a higher elevation where recharge occurs.

The stream flow measured at point A was totally lost to the ground water system before the downstream contact of the Woodside Formation (Trw) and the lower member (Trdl) of the Dinwoody Formation was reached at point B. The loss of flow would normally indicate that the Woodside Formation (Trw) has a high hydraulic conductivity but due to the very low flow rate measured (0.47 gpm or 0.03 liter/sec.) this conclusion is not adequately justified. No determination of the formation characteristics can be made.

Stream flow began again from an area approximately in the middle of the lower member (Trdl) of the Dinwoody Formation at point C. This flow was also lost to a ground water flow system, point D, but stream flow again appeared upstream of the contact between this member (Trdl) and the cherty shale member (Ppc) of the Phosphoria Formation at point E. These gain-loss characteristics indicate that the lower member (Trdl) of the Dinwoody Formation has a high hydraulic conductivity and that this member has individual units within it that have different hydrogeologic characteristics. Recharge for this member is on the east side of the Webster Range at a higher elevation while the main ground water discharge area is in the vicinity of Timber Creek west of the Webster Range. The lower member (Trdl) of the Dinwoody Formation is exposed at a lower elevation, 7,040 feet to 7,100 feet (2,150 M. to 2,160 M.), on the west side of the range than on the east side, 7,240 feet to 7,440 feet (2,210 M. to 2,270 M.).

A decrease in the stream flow was measured as the stream crossed the cherty shale member (Ppc) of the Phosphoria Formation from point E to point F. A greater thickness of alluvium is present at the measurement site which affects the ratio of surface flow to down valley ground water flow by decreasing the surface component. The flow measurement was probably low so the flow characteristic will be analyzed as if there had not been a change in flow. A ground water flow path appears to exist from the cherty shale member (Ppc) exposure in Smoky Canyon to the lower member (Trdl) of the Dinwoody Formation exposure near Timber Creek. The continuity of this flow path assumes that the formational alignment can be extrapolated to a depth as illustrated on figure 13b. If it can, these two different members (Ppc and Trdl) can constitute a continuous flow path since the lower member (Trdl) of the Dinwoody Formation was previously shown to support a ground water flow system. The fault is not thought to act as a barrier to ground water flow. Ground water flow would be from Smoky Canyon at an elevation of about 7,240 feet (2,210 M.) to Timber Creek at an elevation of about 7,040 feet (2,150 M.). The requirements necessary for a ground water flow system to exist are present except for the hydraulic conductivity. Stream flow did not decrease because the cherty shale member (Ppc) has a low hydraulic conductivity. This supports the hypothesis that this member does not support a major ground water flow system.

All stream flow was lost between the cherty shale member (Ppc)-Rex Chert Member (Ppr) contact at point F and the Rex Chert Member (Ppr)-Meade

Peak Phosphatic Shale Member (Ppm) contact at point G. The Rex Chert Member (Ppr) has a high hydraulic conductivity. A continuous ground water flow path can be extrapolated from Smoky Canyon to Timber Creek (figure 13b). Sawmill Fault displaces the lower member (Trdl) of the Dinwoody Formation so that it is aligned with the Rex Chert Member (Ppr) of the Phosphoria Formation. A continuous ground water flow path exists since the lower member (Trdl) of the Dinwoody Formation was previously shown to support a ground water flow system.

Sage Creek

Stream flow in Sage Creek was continuous from the initial measuring point at the Woodside Formation (Trw) contact with the upper member (Trdu) of the Dinwoody Formation to the final measuring point approximately 1,600 feet (488 meters) downstream of the contact between the Phosphoria Formation and the Wells Formation (figure 14). The normal stratigraphic sequence of formations occurs at this site. Table 8 lists the stream gain-loss measurements for this site.

Table 8. Sage Creek, stream gain-loss measurements.

Measuring Point	Flow Measurement GPM	Flow Measurement Liter/sec	Comments
A	75	4.7	
B	340	21	
C	17	1.1	
D	950	60	
E			Not measurable
F	1200	76	
G	1200	76	
H	1100	69	
I	1100	69	
J	800	50	

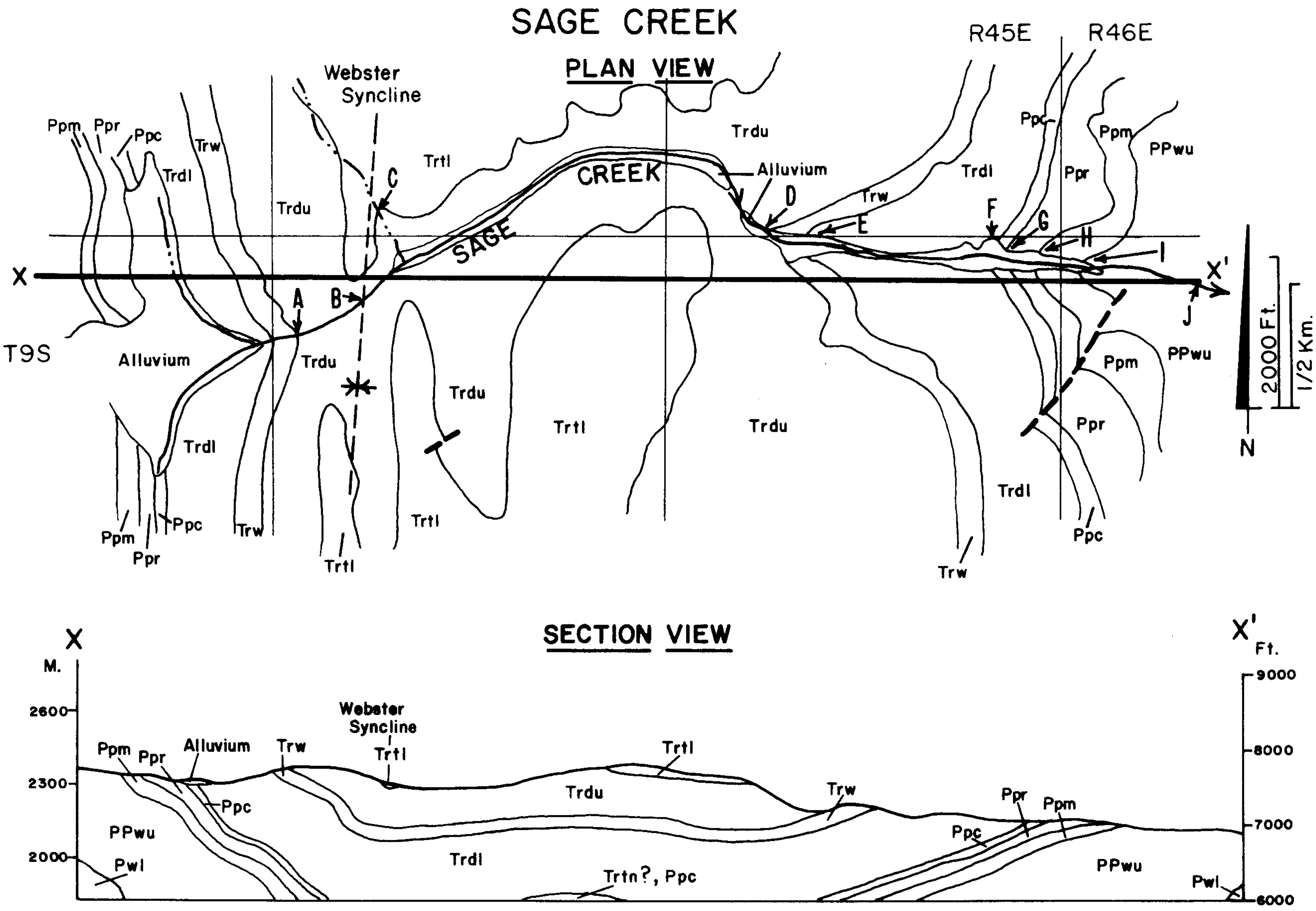


Figure 14. Geologic plan and section views of Sage Creek showing stream measurement sites and spring locations (Modified after Montgomery and others, 1967, Plate 2).

Stream flow increased across the entire exposure of the upper member (Trdu) of the Dinwoody Formation from point A to point D. This member has a high hydraulic conductivity. A continuous ground water flow path exists from the stream to higher elevations north and south of the stream where recharge occurs.

The Woodside Formation (Trw) could not be checked for stream gain or loss since beaver dams at the contact, point E, with the lower member (Trdl) of the Dinwoody Formation precluded measuring stream flow. Stream flow significantly increased across the combined Woodside Formation (Trw) and the lower member (Trdl) of the Dinwoody Formation. This increase is attributed primarily to the Dinwoody Formation since it is much thicker. The Woodside Formation (Trw) is about 150 feet (46 meters) thick whereas the lower member (Trdl) of the Dinwoody Formation is about 900 feet (274 meters) thick in this area. This member (Trdl) of the Dinwoody Formation has high hydraulic conductivity. A continuous flow path exists from the lower reach of the stream to higher elevations west of the Webster Syncline where recharge occurs.

There is no significant change in the stream flow across the three members (Ppc, Ppr, and Ppm) of the Phosphoria Formation from point F to point I. A continuous ground water flow path exists from their exposure in the stream channel to their outcrop west of the Webster Syncline where recharge could occur at a higher elevation. These members (Ppc, Ppr, and Ppm) must have a low hydraulic conductivity since stream flow did not increase.

Stream flow decreased as Sage Creek flowed across the upper member (PPwu) of the Wells Formation from point I at the contact with the Phosphoria

Formation to a point 1,600 feet (488 meters) downstream at point J. The upper member (PPwu) of the Wells Formation has a high hydraulic conductivity. A continuous flow path must exist to some unknown discharge area.

Unnamed Tributary to Deer Creek

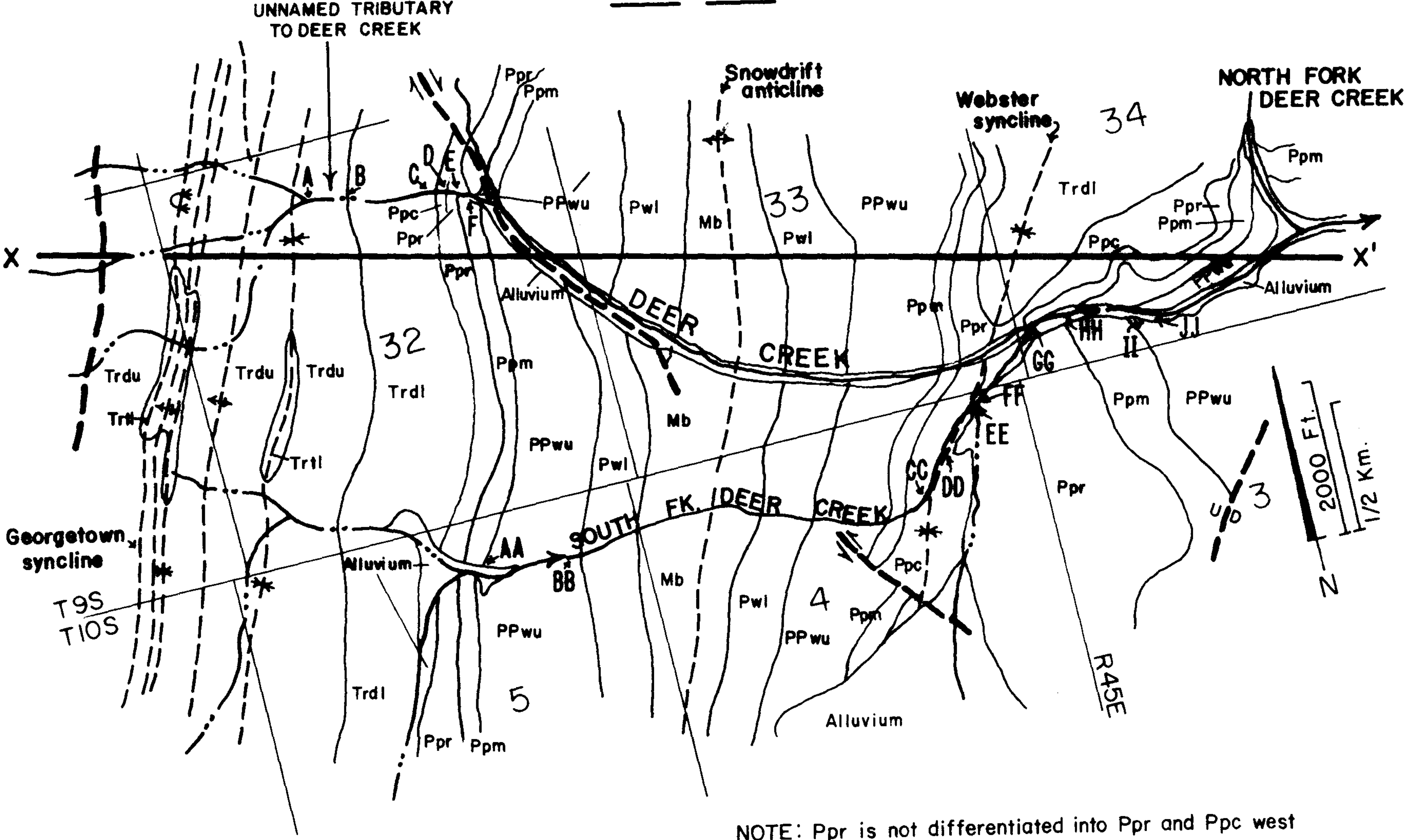
This stream lies in the northern half of section 32 in township 9 south, range 45 east as shown on figure 15a. A geologic section view is shown on figure 15b while the stream gain-loss measurements are included as table 9. Stream flow was continuous from the upper member (Trdu) of the Dinwoody Formation to a point approximately halfway through the Meade Peak Phosphatic Shale Member (Ppm) of the Phosphoria Formation. The Woodside Formation was not mapped as a separate unit in this area but was included in the upper member (Trdu) of the Dinwoody Formation. No differentiation was made of the two upper members (Ppc and Ppr) of the Phosphoria Formation west of the Webster Syncline by Cressman (1964) but the contact was discernible in the field. A flow measurement was made at that point (D).

There is a large increase in the stream flow as the stream crosses the upper member (Trdu) of the Dinwoody Formation between point A and the contact with the lower member (Trdl) of the Dinwoody Formation at point B. Stream flow also increases across the lower member (Trdl) between points B and C so both members have a high hydraulic conductivity. Both must have a continuous ground water flow path from the stream to a higher elevation where recharge can occur. Recharge can occur in a northeast-southwest area along the east side of Dry Ridge.

Stream flow does not increase as the stream crosses the cherty shale member (Ppc), Rex Chert Member (Ppr), or the upper half of the Meade Peak

UNNAMED TRIBUTARY TO DEER CREEK AND SOUTH FORK DEER CREEK

PLAN VIEW



NOTE: Ppr is not differentiated into Ppr and Ppc west of Webster syncline axis

Figure 15a. Geologic plan view of unnamed tributary to Deer Creek and South Fork of Deer Creek showing stream measurement sites and spring locations (Modified after Cressman, 1964, Plate 1).

UNNAMED TRIBUTARY TO DEER CREEK AND SOUTH FORK DEER CREEK

SECTION VIEW

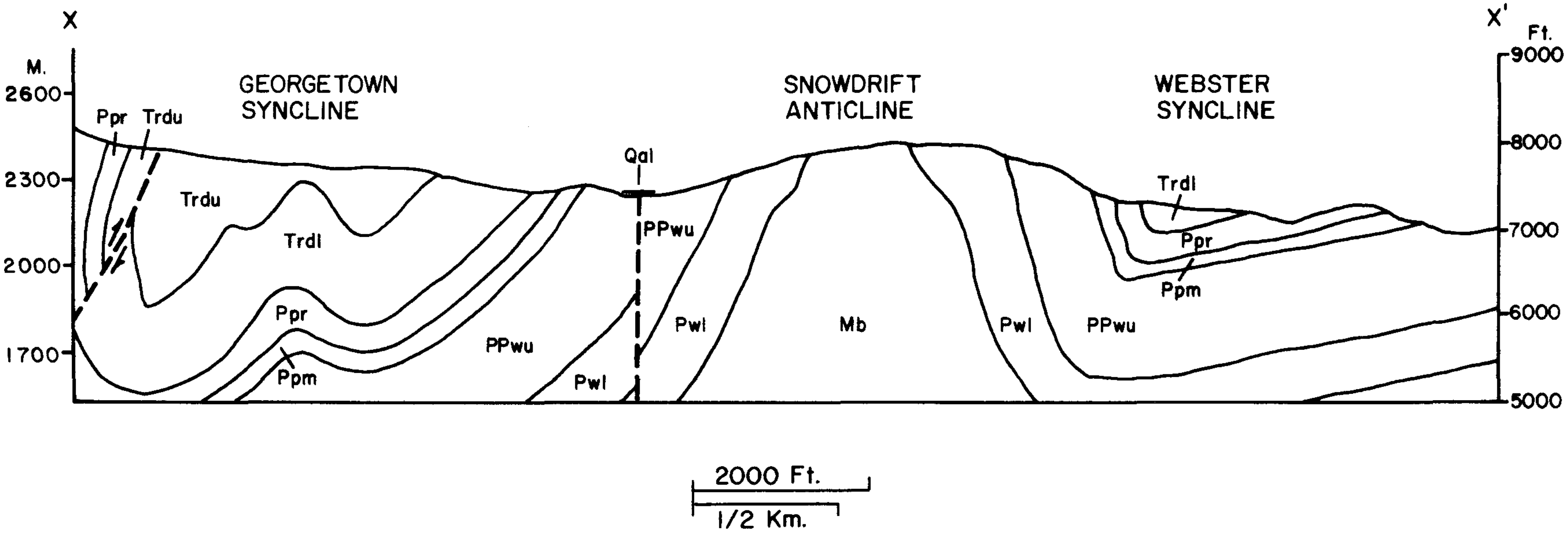


Figure 15b. Geologic section view of unnamed tributary to Deer Creek and South Fork of Deer Creek (Modified after Cressman, 1964, Plate 2).

Table 9. Unnamed tributary to Deer Creek and South Fork of Deer Creek, stream gain-loss measurements.

Measuring Point	Flow Measurement		Comments
	GPM	Liter/sec	
	Unnamed Tributary to Deer Creek		
A	29	1.8	
B	160	10	
C	190	11	
D	200	12	Ppc-Ppr contact was field determined
E	200	12	
F	200	12	Measuring point was approximately half way through Ppm
	South Fork of Deer Creek		
AA	66	4.2	
BB	0	0	No surface flow
CC	11	0.69	Spring about 50 feet upstream of syncline axis
DD	0	0	Surface flow converts to ground water flow about 700 feet (213 meters) downstream of spring CC
EE	3.1	0.20	Side stream flow
FF	0	0	Side stream flow converts to ground water flow within 20 feet (6.1 meters) after entering main channel
GG	0	0	Both channels dry
HH	56	3.5	Spring in Rex Chert Member within 50 feet (15 meters) of contact with Meade Peak Member
II	68	4.3	
JJ	0	0	Stream flow converts to ground water flow within 300 feet (91 meters) downstream of contact between the Phosphoria Formation and the Wells Formation

Phosphatic Shale Member (Ppm) of the Phosphoria Formation between points C and F. A possible ground water flow path extends from the Phosphoria Formation at the stream into the upper member (PPwu) of the Wells Formation via fault displacement. This member (PPwu) of the Wells Formation is exposed along the east side of Dry Ridge where recharge could occur. This member (PPwu) was shown to have a high hydraulic conductivity at Sage Creek. The Phosphoria Formation must have a low hydraulic conductivity since there is no increase in stream flow across it even though the other requirements for a ground water flow system appear to be present.

South Fork Deer Creek

This stream had intermittent flow from the initial measuring site in the NE¼ of section 5 to the SW½ of section 34 (figure 15a). Flow measurements were made of the stream as it crossed the upper member (PPwu) of the Wells Formation and the Phosphoria Formation. The stream channel crosses the east limb of the Georgetown Syncline, the Snowdrift Anticline, and the Webster Syncline (figure 15b). Stream flow measurements are shown on table 9.

The initial stream flow measurement was made at the contact between the Meade Peak Phosphatic Shale Member (Ppm) of the Phosphoria Formation and the upper member (PPwu) of the Wells Formation (point AA on figure 16a). All stream flow was lost as the stream crossed the upper member (PPwu) of the Wells Formation. There was no stream flow at point BB which is the contact between the members (PPwu and Pwl) of the Wells Formation. The upper member (PPwu) has a high hydraulic conductivity that could be due to any fracturing and faulting that occurred from the folding. A continuous ground water flow path must exist but the discharge area is unknown. Flow could be toward the east if the lower member (Pwl) of the Wells Formation and the Monroe Canyon Limestone (Mb) are highly fractured and faulted. This possibility exists since both formations are competent and would therefore be prone to such alterations in the vicinity of folding. If fracturing and faulting did not occur or if the fracturing healed in the limestone the ground water flow path would have to be parallel to the bedding plane and within the upper member (PPwu) of the Wells Formation. Potential ground water flow paths in the upper member (PPwu) of the Wells Formation could be to the north or the south where this member (PPwu) is exposed at lower elevations.

There was no further flow in the stream channel until the cherty shale member (Ppc) of the Phosphoria Formation was encountered on the west limb of the Webster Syncline at point CC. This cherty shale member (Ppc) was field identified but the contact between this member and the Rex Chert Member (Ppr) was indistinct so member assignment for the initiation of surface flow is not positive. All surface flow was lost before the stream reached the contact between the cherty shale member (Ppc) and the Rex Chert Member (Ppr) at point DD on figure 15a. The cherty shale member (Ppc) has high hydraulic conductivity which is probably induced by fracturing and faulting of this member due to the stress created by the synclinal folding. This ground water flow system is probably recharged to the south along the axis of the Webster Syncline. Discharge is created by the interception of the stream channel and the syncline axis along which ground water flow would be directed. Stream flow is lost across this member (Ppc) as the member thins near the contact with the Rex Chert Member (Ppr). The ground water flow path is from the cherty shale member (Ppc) into the Rex Chert Member (Ppr).

A side stream enters the main channel of the South Fork of Deer Creek at point EE but the surface flow was lost within about 20 feet (point FF). There was no stream flow between points FF and HH even though the South Fork of Deer Creek was tributary to Deer Creek. The stream gains flow from the Rex Chert Member (Ppr) of the Phosphoria Formation upstream of point HH. Point HH is the contact between the Rex Chert Member (Ppr) and the Meade Peak Phosphatic Shale Member (Ppm). The Rex Chert Member (Ppr) has a high hydraulic conductivity which is probably due to fracturing and faulting induced by the folding near the Webster Syncline. This formation contains a ground water flow system that is probably recharged principally within its outcrop limits on either side of the Webster Syncline where the elevations are higher than at the stream.

There was no significant change in the stream flow across the Meade Peak Phosphatic Shale Member (Ppm) of the Phosphoria Formation between points HH and II (figure 15a). There is a large amount of valley alluvium in this reach of the stream channel. A continuous ground water flow path exists from this point to higher elevations both south and west where recharge could occur. The lack of a significant change in the stream flow indicates that the member (Ppm) has a low hydraulic conductivity.

All stream flow was lost between point II, Meade Peak Phosphatic Shale Member (Ppm) contact with the upper member (PPwu) of the Wells Formation, and point JJ (figure 16a). Point JJ is 300 feet downstream of point II and within the upper member of the Wells Formation. The upper member (PPwu) has a high hydraulic conductivity. The discharge area for the ground water flow path is unknown.

Wells Canyon

Stream flow began in the Rex Chert Member (Ppr) of the Phosphoria Formation in the NW¼ of the NE¼ of section 9 (figure 16). All surface flow was lost across the upper member (PPwu) of the Wells Formation also in section 9. Stream gain-loss measurements are shown on table 10.

Table 10. Wells Canyon, stream gain-loss measurements.

Measuring Point	Flow Measurement GPM	Flow Measurement Liter/sec	Comments
A (Spring #82)	3.1	0.20	
B	1.6	0.10	May be low due to site conditions
C	1.3	0.08	
D	6.0	0.38	
E	0	0	500 feet (150 meters) downstream of Fork
F (Spring #83)	110	6.9	

The initial stream flow measured in Wells Canyon was derived from a spring in the Rex Chert Member (Ppr) of the Phosphoria Formation at point A (figure 16). This member has a high hydraulic conductivity with recharge occurring at a higher elevation. A potential flow path exists between the spring and the exposed member flanking the Webster Syncline.

Stream flow did not significantly change across the Meade Peak Phosphatic Shale Member (Ppm) from point A to point B (figure 16). Stream flow may have been low at point B due to the presence of a considerable amount of alluvium at the site. A potential ground water flow path exists to higher exposures where recharge could occur on the east side of Snowdrift Mountain but stream flow did not increase. The member (Ppm) therefore

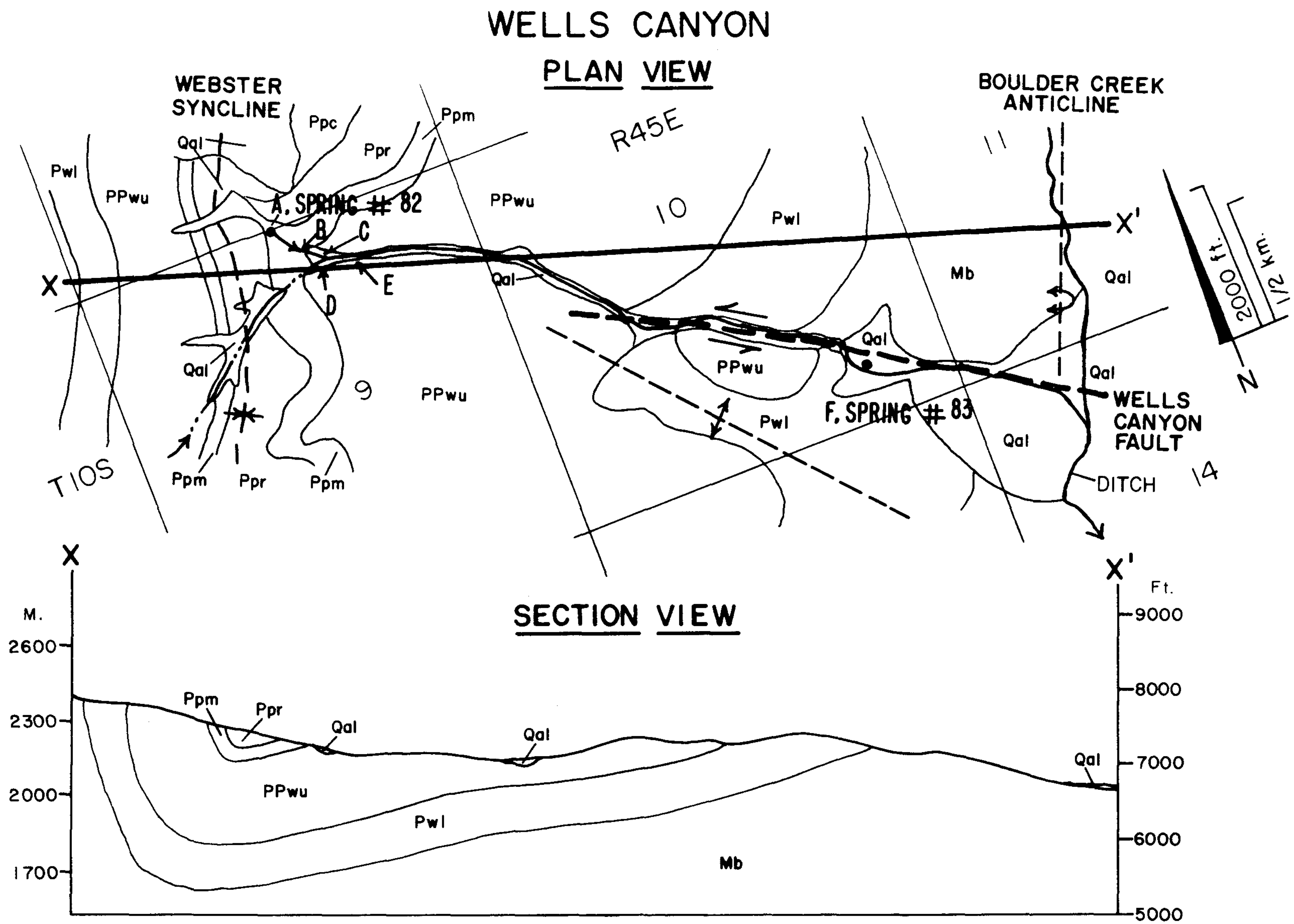


Figure 16. Geologic plan and section views of Wells Canyon showing stream measurement sites and spring locations (Modified after Cressman, 1964, Plates 1 and 2).

has a low hydraulic conductivity.

All stream flow passing point B and from a side stream in the NW¼ of section 9 is lost to the upper member (PPwu) of the Wells Formation. There was no stream flow at point E (figure 16). The upper member (PPwu) of the Wells Formation has a high hydraulic conductivity. A continuous ground water flow path must exist to a discharge area but the location is not known. Point F is the location of a large spring (110 gpm or 6.9 liter/sec) near the mouth of Wells Canyon which is a possible discharge area for recharge along the top of the ridge west of the Webster Syncline.

SUMMARY OF STREAM GAIN-LOSS CHARACTERISTICS

A summary of the stream gain-loss characteristics is presented as table 11. The hydrogeologic characteristics of the Thaynes Formation are not well documented due to their limited exposure in stream channels. Both the black limestone member (Trtl) and the platy siltstone member (Trts) may support ground water flow systems. The black shale member (Trtb) does not appear to be capable of supporting a flow system although the nodular siltstone member (Trtn) will, if intercepted by a fault.

Both members (Trdu and Trdl) of the Dinwoody Formation support flow systems throughout the area. The cherty shale member (Ppc) and the Rex Chert Member (Ppr) of the Phosphoria Formation generally do not support ground water flow systems. The Meade Peak Phosphatic Shale Member (Ppm) did not support a flow system in any of the areas. The upper member (PPwu) of the Wells Formation supports flow systems throughout the area.

Table 12 summarizes the gain-loss characteristics of these formations. The Dinwoody Formation usually discharges ground water from its flow systems forming the perennial flow of those streams crossing this formation. Stream flow is usually lost to the upper member (PPwu) of the Wells Formation to be discharged at some unknown location. The low hydraulic conductivity of the Meade Peak Phosphatic Shale Member (Ppm) and of the Phosphoria Formation in general at least partially restricts vertical flow from the Dinwoody Formation to the Wells Formation. Two major ground water flow systems are formed. One ground water flow system exists in the formations that stratigraphically lie above the Phosphoria Formation, mainly the Dinwoody Formation. The second ground water flow system consists of the formations that lie stratigraphically below the Phosphoria Formation. The downward

Table 11. Stream gain-loss characteristics.

Subarea	Site	Formation Evaluated	Unit Evaluated	Stream Gain-Loss Characteristics	Comments
Aspen Range	Wood Canyon T8S, R42 & 43E	Thaynes	Black Limestone Member - Trtl	Indeterminate	
		Dinwoody	Upper Member - Trdu	Losing	
		Dinwoody	Lower Member - Trdl	Gaining	
		Phosphoria	Cherty Shale & Rex Chert Members - Ppc & Ppr	No gain or loss	
		Phosphoria	Meade Peak Phosphatic Shale Member - Ppm	No gain or loss	
		Wells	Upper Member - Ppwu	Losing	Lost all surface flow in the vicinity of a fault
	Unnamed Tributary to Johnson Creek T9S, R43E	Dinwoody	Lower Member - Trdl	Gaining	Fault intercepts part of stream channel
Wooley Range	Sheep Creek T6S, R44E	Dinwoody	Upper Member - Trdu	Gaining	
		Thaynes	Black Limestone Member - Trtl	Losing	Validity of measurement questionable at Trtl-Trts contact
			Platy Siltstone Member - Trts	Gaining	Validity of measurement questionable at Trtl-Trts contact
			Black Shale Member - Trtb	No gain or loss	
			Nodular Siltstone Member - Trtn	Gaining	Fault intercepts Stream
Webster Range	Smoky Canyon T8S, R45 & 46E	Dinwoody	Upper Member - Trdu	Gaining	
		Woodside -Trw		Indeterminate	Magnitude of change in flow insignificant
		Dinwoody	Lower Member - Trdl	Gaining and losing	
		Phosphoria	Cherty Shale Member - Ppc	No gain or loss	
		Phosphoria	Rex Chert Member - Ppr	Losing	
	Sage Creek T9S, R45 & 46E	Dinwoody	Upper Member - Trdu	Gaining	
		Woodside -Trw		Unknown	Unable to measure flow at Trw-Trdl contact

Table 11. cont'd

Subarea	Site	Formation Evaluated	Unit Evaluated	Stream Gain-Loss Characteristics	Comments
Webster Range (cont'd)	Sage Creek (cont'd)	Dinwoody	Lower Member Trdl	Gaining	
		Phosphoria	Cherty Shale Member - Ppc	No gain or loss	
		Phosphoria	Rex Chert Member - Ppr	No gain or loss	
		Phosphoria	Meade Peak Phosphatic Shale Member - Ppm	No gain or loss	
		Wells	Upper Member - PPwu	Losing	
	Unnamed Tributary to Deer Creek T9S, R45E	Dinwoody	Upper Member - Trdu	Gaining	
			Lower Member - Trdl	Gaining	
		Phosphoria	Cherty Shale Member - Ppc	No gain or loss	
		Phosphoria	Rex Chert Member - Ppr	No gain or loss	
		Phosphoria	Meade Peak Phosphatic Shale Member - Ppm	No gain or loss	Flow measurement made approximately midway through member
	South Fork Deer Creek T9 & 10S, R45E	Wells	Upper Member - PPwu	Losing	Lost all surface flow crossing this member
			Lower Member - Pwl	Unknown	No stream flow
		Monroe Canyon Limestone -Mb		Unknown	No stream flow
		Wells	Lower Member - Pwl	Unknown	No stream flow
		Wells	Upper Member - PPwu	Unknown	No stream flow
		Phosphoria	Cherty Shale Member - Ppc	Gaining -and- Losing	Contact between Ppr and Ppc was estimated in field, member assignment not definite Thin (?) exposure
		Phosphoria	Rex Chert Member - Ppr	Losing and gaining	
		Phosphoria	Meade Peak Phosphatic Shale Member - Ppm	No gain or loss	
		Wells	Upper Member - PPwu	Losing	

Table 11. cont'd

Subarea	Site	Formation Evaluated	Unit Evaluated	Stream Gain-Loss Characteristics	Comments
Webster Range (cont'd)	Wells Canyon T10S, R45E	Phosphoria	Rex Chert Member - Ppr	Gaining	
		Phosphoria	Meade Peak Phosphatic Shale Member - Ppm	No gain or loss	Alluvium at site may have created low surface flow
		Wells	Upper Member - PPwu	Losing	All surface flow lost approximately 1,100 feet downstream of Ppm-PPwu contact

Note: Formations listed in sequence proceeding downstream.

Table 12. Summary of geologic control of stream flow.

Formation	Unit Name	Unit Symbol	Number of Sites With Given Stream Flow Characteristics			Comments
			Gaining	Losing	No Change	
Thaynes	Nodular Siltstone Member	Trtn	1			Fault intercepts stream and formation
	Black Shale Member	Trtb			1	
	Platy Siltstone Member	Trts	1			Validity of flow measurement questionable
	Black Limestone Member	Trtl		1		Validity of flow measurement questionable
Dinwoody	Upper Member	Trdu	4	1		
Woodside		Trw	No definitive data			
Dinwoody	Lower Member	Trdl	4[*a]	1[*a]		
Phosphoria	Cherty Shale Member	Ppc	1[*a]	1[*a]	4	
	Rex Chert Member	Ppr	2[*a]	2[*a]	3	One gaining site is also noted as a spring
	Meade Peak Phosphatic Shale Member	Ppm			5	
Wells	Upper Member	PPwu		5		

[*a] There was both a gain and loss across a single exposure

distribution of hydrologic potential indicates that this area is in the recharge portion of a regional ground water flow system.

Stream flow gains totalled 1,560 gpm (98.4 liter/sec) from the Thaynes and Dinwoody Formations. Only 100 gpm (6.3 liter/sec) of that total came from the Thaynes Formation because few streams cross the formation. Stream flow gained across the Phosphoria Formation at only one site, the South Fork of Deer Creek. Gains totalled 70 gpm (4.4 liter/sec) with 67 gpm (412 liter/sec) coming from the Rex Chert Member and the balance coming from the cherty shale member. Stream flow did not gain across the Wells Formation.

SPRING CHARACTERISTICS

A total of 88 springs were located in the field during this study. Some of the springs had been located by previous investigators while many of them were measured and located, possibly for the first time. Not all of the springs that were located had flow but their location was noted as a potential spring area that might exist during a normal precipitation period. A judgement factor was frequently required in order to make a distinction between a spring and a gaining reach of a stream.

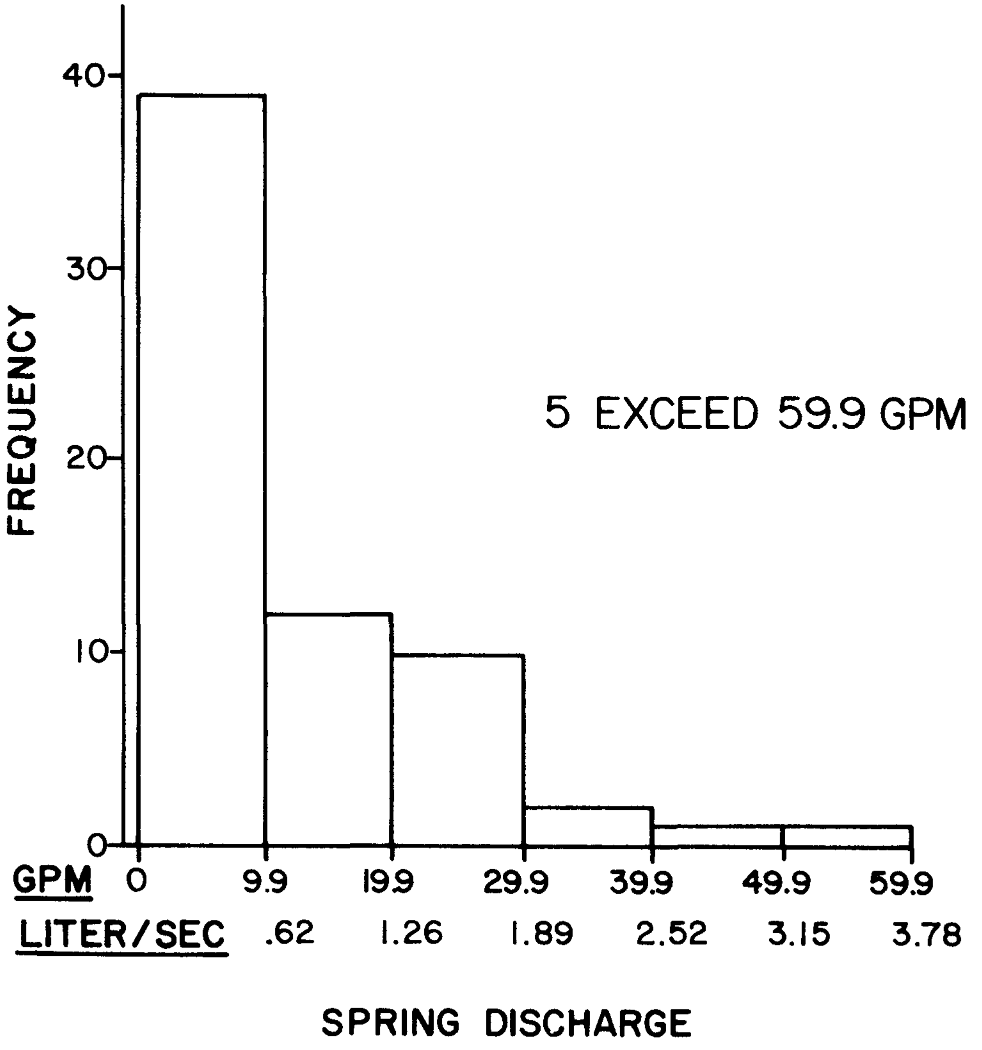
All the springs visited during this study are noted in appendix II along with the location of the spring, discharge, specific conductivity, discharge measuring device, and the formation from which discharge is thought to occur. Appendix III is a cross reference that can be used to locate the figures on which the springs are mapped. All springs are located on geologic maps either in the text or in appendix IV.

The principle information derived from an analysis of springs is the formation that supports the ground water flow system discharging at the spring. Table 13 summarizes those formations. The Phosphoria Formation supports very few springs while those formations that normally occur above the Phosphoria support the greatest number of springs. The largest concentration occurs from the lower member (Trdl) of the Dinwoody Formation. This indicates that the Phosphoria Formation acts as a barrier to ground water flow between those formations above the Phosphoria Formation and those below it.

Figure 17 is a histogram of spring discharges. Most springs had a discharge of less than 10 gpm (0.63 liters/sec) although one spring (no. 22) had a measured discharge of 500 gpm (32 liter/sec). Spring

Table 13. Summary of formations that discharge ground water at springs.

Formation	Unit	Symbol	Number of Springs	Comments
Salt Lake	----	Tsl	1	
Ankareh	----	Tral	3	
Thaynes	Black Shale Member	Trtb	1	
	Platy Siltstone Member	Trts	9	
	Black Limestone Member	Trtl	9	
Dinwoody	Upper Member	Trdu	4	
	Lower Member	Trdl	19	
Phosphoria	Cherty Shale Member	Ppc		Ppc and Ppr as one unit had 1 spring
	Rex Chert Member	Ppr	2	
	Meade Peak Phosphatic Shale Member	Ppm	1	Complex structure
Wells	Upper Member	PPwu	4	
	Lower Member	Pwl	4	
Monroe Canyon Limestone	----	Mb	1	



NOTE: ONLY THOSE SPRINGS WITH A MEASURABLE DISCHARGE AT THE FINAL MEASUREMENT TIME WERE COUNTED

Figure 17. Spring discharge histogram.

discharges are further illustrated by figure 18. The majority of the springs discharged from the Thaynes and Dinwoody Formations but the discharges were small. The mean discharge was 25 gpm (1.6 liter/sec). The Phosphoria Formation contains few ground water flow systems as only three springs were found discharging from this formation. Their mean discharge was only 2.0 gpm (0.12 liter/sec). Eight springs were found that discharge from the Wells Formation with a mean discharge of 130 gpm (8.0 liter/sec). Several of these springs, such as spring numbers 87 and 88 in appendix II, can be considered as local oddities. Their occurrence is not indicative of the long ground water flow systems and large spring discharges anticipated from this formation.

The maximum number of discharge measurements at any spring is two. This is of limited value since more than two measurements are required to determine the peak discharge period. A significant period of time can exist between the recharge period and the peak discharge. Calculation of a recession constant for a spring requires that the peak discharge period be over. Several of the springs with multiple discharge measurements had not reached their peak discharge while the discharge remained constant at a few others. Those springs with declining discharges were analyzed for a recession constant based on the following equation (Butler, 1957, p. 214-218) as previously discussed.

$$Q_T = \frac{Q_o}{10^{T/K}}$$

Recession constants are summarized in table 14. Only one spring has a recession constant (K) from a previous study and this study. This spring is located in Slug Creek valley at what was the Knudsen Ranch. The recession

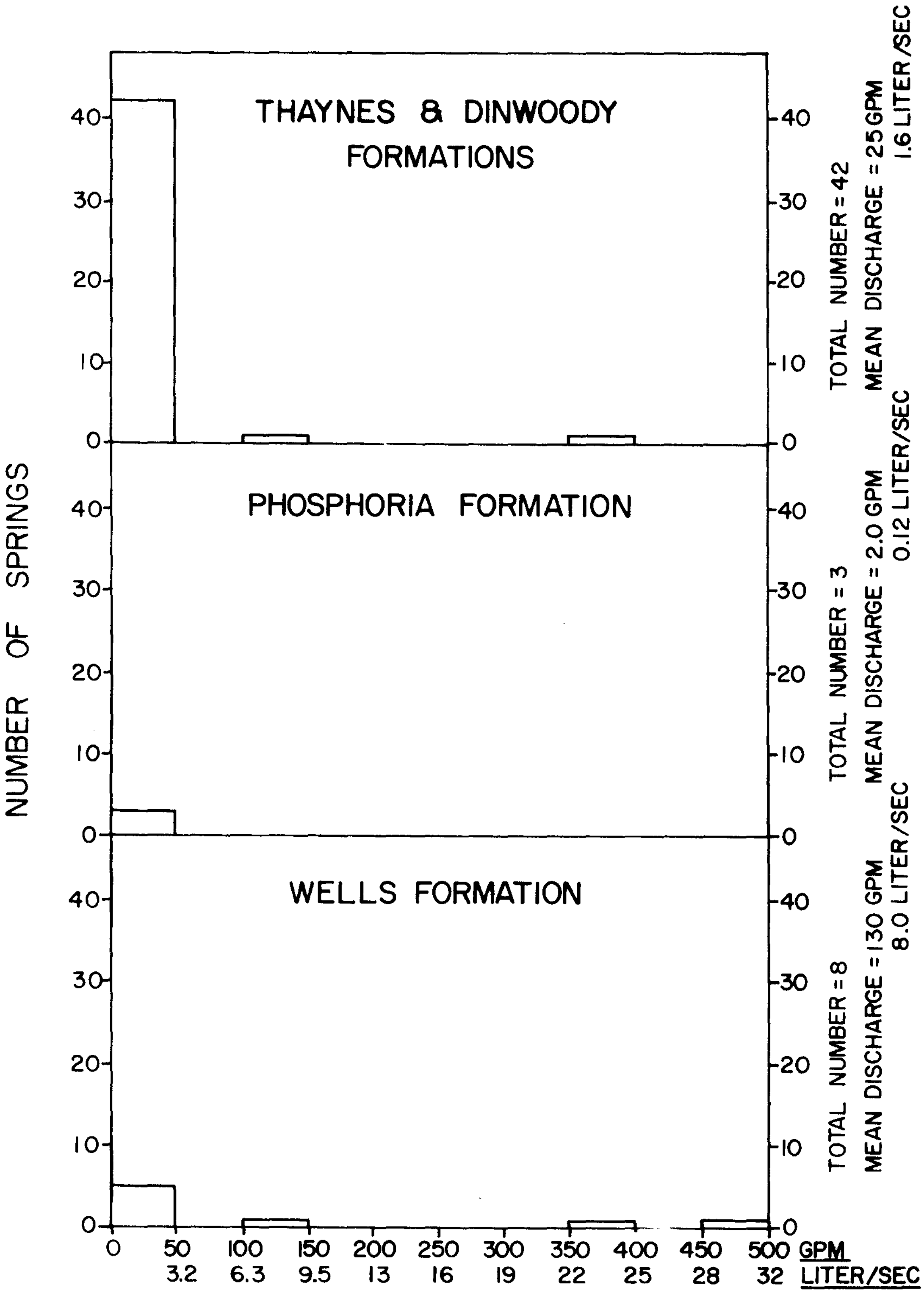


Figure 18. Spring Discharge histograms by formation.

Table 14. Spring recession and quality characteristics.

Formation	Unit	Symbol	Spring No.	Spring Discharge (gpm)	Spring Discharge (liter/sec)	Recession Constant K (days)	Specific Conductivity (micromhos/cm^2)	Comments
Thaynes	Black Limestone Member	Trtl	19	22 20	1.4 1.3	846	320	Wood Canyon near syncline axis
Dinwoody	Lower Member	Trdl	3	5.4 3.1	0.34 0.20	124	380	Middle Sulphur Canyon
			6	3.1 1.9	0.20 0.12	99	370	Side canyon off South Sulphur Canyon
			8	3.1 2.6	0.20 0.16	275	330	South Sulphur Canyon
			13	26 23	1.6 1.5	188	---	Head of Johnson Creek
			18	5.4 4.2	0.34 0.26	229	340	Burchertt Canyon
			20	7.6 5.4	0.48 0.34	236	380	Junction Spring
			22	500 390	32 25	250	---	K=630, Summer, 1975*
Phosphoria	Cherty Shale or Rex Chert	Ppc or Ppr	2	0.80 0.05	0.05 0.003	21	530	North Sulphur Canyon
			11	22 1.9	1.4 0.12	32	---	Swan Lake Gulch
	Meade Peak Phosphatic Shale Member	Ppm	1	1.9 1.6	0.12 0.10	335	900	North Sulphur Canyon
Wells	Upper Member	PPwu	5	1.0 0.23	0.06 0.01	45	340	Near pond in side canyon off Middle Sulphur Canyon
			21	8.4 0.09	0.53 0.006	14	---	Slug Creek valley
			88	0.47 0.23	0.03 0.01	81	440	Specific conductivity probably high due to manure in discharge area, on low ridge off Dry Fork
Alluvium	---	Qal	23	1.9 0.80	0.12 0.05	72	---	Slug Creek valley, referred to as Square Pond

* Robinette, 1977, p. 82, reported K = 735 days for spring #24.

constant has dropped from 630 days to 250 days indicating a change in the ground water flow system discharging at this point.

Recession constants are generally the same for those springs issuing from the lower member (Trdl) of the Dinwoody Formation. This indicates that similar hydrogeologic characteristics exist where these springs are located. Springs 3 and 6 are evidently part of smaller ground water flow systems than the other springs issuing from this member.

Spring #21 discharges from the upper member (PPwu) of the Wells Formation in Slug Creek valley. The discharge increased for each successive measurement made by Robinette (1977) but there was no measurable flow at his weir when discharges were measured for this study. Discharge was measured across the road in a pasture. A short flow system is indicated by the recession constant.

Short ground water flow systems are also indicated for springs 2, 11, 5, 88, and 23 based upon their recession constants. The flow system associated with spring #5 may be more related to a nearby fault than to the upper member (PPwu) of the Wells Formation. Spring #88 is a small spring located off Dry Fork on the flank of a low ridge of the Wells Formation where a short flow system would be expected. Multiple discharge measurements were not obtained for any of the large, major springs in the Wells Formation.

Discharge from spring #1 is controlled by a syncline but in this case the syncline is overturned. The ground water flow mechanism for this spring is unknown but the high recession constant is probably caused by a low storage coefficient since the Meade Peak Phosphatic Shale Member (Ppm) of the Phosphoria Formation is characterized by a low hydraulic conductivity.

The black limestone member (Trtl) of the Thaynes Formation is exposed along the top of the ridge at spring number 19. It is improbable that the formation would behave as an artesian aquifer with a low storage coefficient so the high recession constant must be caused by a high hydraulic conductivity.

Recession constants and specific conductivities should be highest for the longest flow systems. These values should therefore be largest for the Dinwoody Formation for those formations above the Phosphoria Formation. The Wells Formation should have the largest values of the entire phosphate sequence but the data does not illustrate this fact. A larger sample with multiple discharge measurements should confirm this fact.

The specific conductivity data in table 15 indicate that the ground water quality in the area is relatively consistent with respect to total dissolved solids. The only exceptions are those springs discharging from the Phosphoria Formation. Only one spring was found to discharge from the Meade Peak Phosphatic Shale Member (Ppm) of the Phosphoria Formation but this spring had the highest specific conductivity of any spring measured. This high specific conductivity is probably caused by the ground water having a high residence time in the formation and by the formation being more soluble than the others.

DISCUSSION OF RESULTS

Stream flow data and spring data indicate that the formations constituting the phosphate sequence exhibit similar hydrogeologic characteristics throughout the study area. These characteristics are essentially identifiable by formation. Ground water flow systems can be delineated from this data.

Spring data indicate that the Salt Lake (Tsl) and Ankareh (Tral) Formations can support ground water flow systems in the study area. There are no stream flow data to support this.

The black shale member (Trtb), the platy siltstone member (Trts), and the black limestone member (Trtl) of the Thaynes Formation have ground water flow systems supporting spring discharges. Stream flow data, though questionable, do support the spring data except for the black shale member (Trtb). Stream flow did not change across this member although the accuracy range of the measurement technique used may have prevented the detection of a flow change. The nodular siltstone member (Trtn) of the Thaynes Formation can support a ground water flow system if faulted as noted at Sheep Creek.

Ground water flow systems exist within the upper and lower members (Trdu and Trdl) of the Dinwoody Formation at every site measured for their stream flow characteristics. Numerous springs occur in these members especially the lower member (Trdl). Stream flow data in Smoky Canyon indicate that the lower member (Trdl) has more than one ground water flow system characteristic. Reference to the member acting as a single hydrogeologic unit is only justified with that restriction in mind. Other formations may have similar complexities but the data are not of great enough detail to analyze that aspect.

The Phosphoria Formation supports very few ground water flow systems as indicated by both stream flow and spring data. Stream flow changed across the cherty shale member (Ppc) in one location, the South Fork of Deer Creek. Here, the member (Ppc) discharges ground water to the stream while this stream flow is lost across the same exposure a short distance farther downstream. All this occurs on or near the axis of the Webster Syncline where fracturing and faulting might have increased the hydraulic conductivity of this unit.

At least two springs were found to discharge from the Rex Chert Member (Ppr) of the Phosphoria Formation. A third spring may also discharge from this member (Ppr) but the specific member could not be identified in the field. Stream flow data indicate that this member (Ppr) may or may not support a ground water flow system. The South Fork of Deer Creek site had both a stream gain and loss across the same exposure. This occurred near the axis of the Webster Syncline where folding may have induced fracturing and faulting within this member (Ppr). The loss of stream flow to this member (Ppr) in Smoky Canyon can not be directly attributed to major secondary hydraulic conductivity. The formations are not folded to as great a degree at this location as they were in the area of the South Fork of Deer Creek.

The Meade Peak Phosphatic Shale Member (Ppm) of the Phosphoria Formation does not support any significant ground water flow systems at any of the sites studied. One spring discharges from this member (Ppm) from a complex geologic structure in North Sulphur Canyon. The primary hydraulic conductivity of this member (Ppm) is low. Secondary hydraulic conductivity is also low due, no doubt, to the incompetency of the member. The stresses imposed by folding generally do not cause extensive fracturing and faulting in an incompetent formation.

Stream flow was always lost to some degree if not entirely when the stream crossed the upper member (PPwu) of the Wells Formation. A few springs were located that discharged from either the upper or lower (PPwu or Pwl) members of the Wells Formation. One spring also appears to discharge from the Monroe Canyon Limestone (Mb).

Ground water flow systems in the study area may be separated into two general categories by their relative position to the Meade Peak Phosphatic Shale Member (Ppm) of the Phosphoria Formation. Recharge to the Thaynes and Dinwoody Formations from precipitation moves downward to discharge at sites stratigraphically above the Phosphoria Formation. Cross bedding flow from the Dinwoody Formation through the Phosphoria Formation is virtually prevented by the low hydraulic conductivity of this unit. Numerous springs and areas where streams gain flow are thus located in the Thaynes and Dinwoody Formations. Approximately 71% of the total stream gain and spring discharge occurred from the Thaynes and Dinwoody Formations. The Wells Formation supplied 27% of the total while the Phosphoria Formation supplied about 2% of the total stream gain and spring discharge.

The upper member (PPwu) of the Wells Formation is recharged by precipitation where exposed but also through the vertical movement of ground water from those formations above the Phosphoria Formation. This movement can only occur where the Phosphoria Formation has been displaced or removed and a continuous flow path exists. The Wells Formation and the Monroe Canyon Limestone (Mb) normally occur, stratigraphically, below the rest of the formations exposed in the area. Their position and the recharge of the Wells Formation by stream flow indicates that these formations form long ground water flow systems of regional extent. Discharge areas for these long flow systems were not located as a part of this study.

CONCLUSIONS

1. This study indicates that the formations comprising the phosphate sequence exhibit similar hydrogeologic characteristics throughout the study area.
2. The platy siltstone member (Trts) and the black limestone member (Trtl) of the Thaynes Formation support ground water flow systems in the area.
3. Both the upper member (Trdu) and the lower member (Trdl) of the Dinwoody Formation support major ground water flow systems.
4. The cherty shale member (Ppc), the Rex Chert Member (Ppr) and the Meade Peak Phosphatic Shale Member (Ppm) of the Phosphoria Formation do not support any major ground water flow systems in the study area.
5. A major ground water flow system exists in the upper member (PPwu) of the Wells Formation.
6. The flow system in the upper member (PPwu) of the Wells Formation is separated from the flow systems in the Thaynes and Dinwoody Formations by the low hydraulic conductivity of the Phosphoria Formation and in particular the Meade Peak Phosphatic Shale Member (Ppm).
7. A major ground water flow system exists in the lower member (Pwl) of the Wells Formation.
8. Ground water flow systems above the Phosphoria Formation are separated from those below the Phosphoria Formation. This causes the upper flow systems to be local in extent while the lower flow system is regional in extent.
9. The ground water information derived from this study should be transferable to other areas where this phosphate sequence is present. Minor variations in the ground water flow system characteristics of the

sequence may occur if the physical composition of the formations varies. Separation of the two flow systems by the Meade Peak Phosphatic Shale Member (Ppm) of the Phosphoria Formation should be consistent though.

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APPENDICES

Appendix I . . . . Stream gain-loss measurements

Appendix II . . . . Spring reconnaissance

Appendix III . . . . Spring cross reference; from II to figure number

Appendix Iv . . . . Spring locations on geologic maps

Appendix V . . . . Miscellaneous stream flow data

Appendix I. Stream gain-loss measurements

Subarea	Site	Location	Date	Formation	Flow		Measuring Device	Comments
					(gpm)	(liter/sec)		
Aspen Range	Wood Canyon	NW¼, NW¼, Sec 32, T8S, R43E	8-12-77	Trtl	12	0.76	1	Syncline axis
		NW¼, NW¼, Sec 32, T8S, R43E	8-12-77	Trtl-Trdu Contact	10	0.63	1	
		NE¼, NE¼, Sec 31, T8S, R43E	8-12-77	Trdu-Trdl Contact	1.6	0.10	1	
		NE¼, NW¼, Sec 31, T8S, R43E	8-12-77	Trdl-Ppc Contact	95	6.0	2	
		SW¼, NW¼, Sec 31, T8S, R43E	8-12-77	Ppr-Ppm Contact	99	6.2	2	
		SW¼, NW¼, Sec 31, T8S, R43E	8-12-77	Ppm-PPwu Contact	95	6.0	2	
		SE¼, NE¼, Sec 36, T8S, R42E	8-12-77	PPwu	88	5.6	2	1,300 ft. upstream of fault
		SW¼, NE¼, Sec 36, T8S, R42E	8-12-77	PPwu	4.2	0.26	1	Near fault
		SW¼, NE¼, Sec 36, T8S, R42E	8-12-77	PPwu	0	0	-	No surface flow about 95 feet downstream of fault
	Unnamed Tributary to Johnson Creek	SW¼, NW¼, Sec 10, T9S, R43E	7-30-77	Trdu-Trdl Contact	8.4	0.53	1	
		NE¼, NE¼, Sec 9, T9S, R43E	7-30-77	Trdl-Ppc Contact	17	1.1	1	
Wooley Range	Sheep Creek	SE¼, SE¼, Sec 30, T6S, R44E	8-14-77	Trtn-Trtpl Contact	620	39	3	
		SE¼, SE¼, Sec 30, T6S, R44E	8-14-77	Trtn	70	4.4	2	Side stream flow from north
		SE¼, SE¼, Sec 30, T6S, R44E	8-14-77	Trtb-Trtn Contact	450	28	3	Upstream of fault
		SW¼, SE¼, Sec 30, T6S, R44E	8-14-77	Trts-Trtb Contact	500	32	3	
		SW¼, SE¼, Sec 30, T6S, R44E	8-14-77	Trts	470	30	3	Main channel flow upstream of fork about 250 feet
		SW¼, SW¼, Sec 30, T6S, R44E	8-14-77	Trts	15	0.95	1	Left fork flow about 100 feet above fork
		SE¼, SW¼, Sec 30, T6S, R44E	8-14-77	Trtl-Trts Contact	1.9	0.12	1	Numerous old beaver ponds in this stretch
		NW¼, NW¼, Sec 31, T6S, R44E	8-14-77	Trdu-Trtl Contact	23	1.5	1	This is a spring area with no surface flow 100 feet upstream

Appendix I. cont'd

Subarea	Site	Location	Date	Formation	Flow (gpm)	Flow (liter/sec)	Measuring Device	Comments
Webster Range	Smoky Canyon	SE¼, SW¼, Sec 24, T8S, R45E	7-29-77	Trdu-Trw Contact	.47	0.03	1	Small spring in Trdu in channel above Trw
		SE¼, SW¼, Sec 24, T8S, R45E	7-29-77	Trw	.47 to 0	0.03 to 0	-	Magnitude of flow change insignificant
		SW¼, SE¼, Sec 24, T8S, R45E	7-29-77	Trdl	8.9	0.56	1	Spring
		SW¼, SE¼, Sec 24, T8S, R45E	7-29-77	Trdl	0	0	-	No surface flow
		SE¼, SE¼, Sec 24, T8S, R45E	7-29-77	Trdl-Ppc Contact	11	0.69	1	
		SE¼, SE¼, Sec 24, T8S, R45E	7-29-77	Ppc-Ppr Contact	8.4	0.53	1	Suspect fair amount of seepage through gravel at this point
		SW¼, SW¼, Sec 19, T8S, R46E	7-29-77	Ppr	0	0	-	No surface flow before Ppr-Ppm contact
		SW¼, Sec 17, T8S, R46E	8-10-77	Trdl	22	1.4	3	Channel shape precluded measuring by flume
	Sage Creek	NE¼, NW¼, Sec 7, T9S, R46E	8-6-77	PPwu	800	50	3	About 1800 feet down stream of section line
		NW¼, NW¼, Sec 7, T9S, R46E	8-6-77	Ppm-PPwu Contact	1100	69	3	
		NE¼, NE¼, Sec 12, T9S, R45E	8-6-77	Ppr-Ppm Contact	1130	71.3	3	
		NE¼, NE¼, Sec 12, T9S, R45E	8-6-77	Ppc-Ppr Contact	1220	77.0	3	
		NE¼, NE¼, Sec 12, T9S, R45E	8-6-77	Trdl-Ppc Contact	1260	79.5	3	
		NE¼, NW¼, Sec 12, T9S, R45E	8-6-77	Trw-Trdl Contact	--	--	-	Not measurable
		NE¼, NW¼, Sec 12, T9S, R45E	8-6-77	Trdu-Trw Contact	950	60	3	
		SE¼, SW¼, Sec 2, T9S, R45E	8-7-77	Trtl-Trdu Contact	17	1.1	1	No precipitation over night; flow is of side stream
		NW¼, NW¼, Sec 11, T9S, R45E	8-7-77	Trdu	340	21	3	
		NW¼, NW¼, Sec 11, T9S, R45E	8-7-77	Trw-Trdu Contact	75	4.7	3	

Appendix I. cont'd

Subarea	Site	Location	Date	Formation	Flow		Measuring Device	Comment
					(gpm)	(liter/sec)		
Webster Range cont'd	Unnamed Tributary to Deer Creek	NE¼, NE¼, Sec 32, T9S, R45E	8-4-77	Ppm	200	13	2	
		NW¼, NE¼, Sec 32, T9S, R45E	8-4-77	Ppr-Ppm Contact	200	13	2	
		NW¼, NE¼, Sec 32, T9S, R45E	8-4-77	Ppc-Ppr Contact	200	13	2	
		NW¼, NE¼, Sec 32, T9S, R45E	8-4-77	Trdl-Ppc Contact	190	12	2	
		NE¼, NW¼, Sec 32, T9S, R45E	8-4-77	Trdu-Trdl Contact	160	10	3	
		NE¼, NW¼, Sec 32, T9S, R45E	8-4-77	Trdu	29	1.8	1	Syncline axis
	South Fork Deer Creek	NW¼, NE¼, Sec 5, T10S, R45E	7-27-77	Ppm-PPwu Contact	66	4.2	1	Twin flumes in parallel
		NE¼, NE¼, Sec 5, T10S, R45E	7-27-77	PPwu	0	0	-	No surface flow 1300 feet downstream of road crossing
		NW¼, NE¼, Sec 4, T10S, R45E	7-27-77	Ppc ?	11	0.69	1	Near Syncline axis
		NE¼, NE¼, Sec 4, T10S, R45E	7-27-77	Ppc	0	0	-	No surface flow near Ppc-Ppr contact
		NE¼, NE¼, Sec 4, T10S, R45E	7-27-77	Ppr	3.1	0.20	1	Side stream flow from southwest
		NE¼, NE¼, Sec 4, T10S, R45E	7-27-77	Ppr	0	0	-	No surface flow in main channel within 20 feet of side stream entrance
		SW¼, SW¼, Sec 34, T9S, R45E	7-27-77	Ppr	0	0	-	Both the south fork and main branch of Deer Creek have no surface flow
		SW¼, SW¼, Sec 34, T9S, R45E	7-27-77	Ppr-Ppm Contact	56	3.5	1	Twin flumes in parallel; spring in channel upstream of contact, thick alluvium
		SE¼, SW¼, Sec 34, T9S, R45E	7-27-77	PPwu-Ppm Contact	68	4.3	1	Twin flumes in parallel, thick alluvium
		SE¼, SW¼, Sec 34, T9S, R45E	7-27-77	PPwu	0	0	-	No surface flow about 300 feet downstream of contact, thick alluvium

Appendix I. cont'd

Subarea	Site	Location	Date	Formation	Flow (gpm)	Flow (liter/sec)	Measuring Device	Comment
Webster Range cont'd	Wells Canyon	NW¼, NE¼, Sec 9, T10S, R45E	7-28-77	Ppr-Ppm Contact	3.1	0.20	1	Spring upstream of contact; no surface flow above spring
		NW¼, NE¼, Sec 9, T10S, R45E	7-28-77	Ppm-PPwu Contact	1.6	0.10	1	Significant amount of alluvium here
		NW¼, NE¼, Sec 9, T10S, R45E	7-28-77	PPwu	1.3	0.08	1	Right fork flow above fork
		NW¼, NE¼, Sec 9, T10S, R45E	7-28-77	PPwu	6.0	0.38	1	Left fork flow above fork
		NE¼, NE¼, Sec 9, T10S, R45E	7-28-77	PPwu	0	0	-	No surface flow about 500 feet downstream of fork
		SE¼, SE¼, Sec 10, T10S, R45E	8-7-77	Pwl and Alluvium	110	6.9	2	

Note: Measuring devices key

1 = 60°, V-notch flume
2 = 2-inch, 45°, trapezoidal flume
3 = Pygmy current meter with topsetting rod

Appendix II. Spring reconnaissance.

Spring No.	Name	Location	Formation	Discharge (gpm)	Discharge (liter/sec)	Date	Measuring Device	Temp F°	Temp C°	Electrical Conductivity (micromhos/cm^2)	Miscellaneous
North Sulphur Canyon											
1	--	SW¼, NE¼, Sec 12, T9S, R42E	Ppm	1.9 1.6	0.12 0.10	7-6-77 7-31-77	1 1	52	11.1	900	From old exploration trench
2	--	NW¼, NW¼, Sec 7, T9S, R43E	Ppr or Ppc	.80 .05	0.05 0.003	7-6-77 7-31-77	1 1	65	18.3	530	
Middle Sulphur Canyon											
3	--	SE¼, SE¼, Sec 6, T9S, R43E	Trdl	5.4 3.1	0.34 0.20	7-1-77 7-31-77	1 1	42	5.56	380	Upper spring
4	--	SE¼, SE¼, Sec 6, T9S, R43E	Trdl ? Alluvium	11 6.8	0.69 0.43	7-1-77 7-31-77	1 1	46	7.78	370	Lower spring
5	--	NW¼, NW¼, Sec 17, T9S, R43E	PPwu ?	1.0 .23	0.06 0.01	7-2-77 7-31-77	1 4	47	8.33	340	@ Simplot pond, near fault
South Sulphur Canyon											
6	--	SE¼, NE¼, Sec 17, T9S, R43E	Trdl	3.1 1.9	0.20 0.12	7-10-77 7-31-77	1 1	45	7.22	370	
7	--	NE¼, SE¼, Sec 17, T9S, R43E	Trdl	2.3	0.15	7-31-77	1				Opposite Sheep Camp above stream
8	--	NW¼, SW¼, Sec 16, T9S, R43E	Trdl	3.1 2.6	0.20 0.16	7-10-77 7-31-77	1 1	43	6.11	330	Above stream
9	--	NE¼, SW¼, Sec 16 T9S, R43E	Trdu	12 12	0.76 0.76	7-9-77 7-31-77	1 1	40	4.44	310	In stream channel, right fork
10	--	SW¼, NW¼, Sec 16, T9S, R43E	Trdu	42 49	2.65 3.09	7-9-77 7-31-77	1* 1*	40	4.44	280	Combined flow of emerging channel and bank flow

Appendix II. cont'd

Spring No.	Name	Location	Formation	Discharge (gpm)	Discharge (liter/sec)	Date	Device	Temp F°	Temp C°	Electrical Conductivity (micromhos/cm^2)	Miscellaneous
Swan Lake Gulch											
11	--	NE¼, NW¼, Sec 22, T9S, R43E	Ppr	22 1.9 Dry	1.39 0.12	6-9-77 7-13-77 7-31-77	1 1 -	52	11.1	Too low to measure?	Meter?
12	--	NE¼, NE¼, Sec 21, T9S, R43E	Trdl	1.1 1.1	0.07 0.07	7-16-77 7-31-77	1* 1*	54 69	12.2 20.6	380 380	Combined flow of 2 seeps
Johnson Creek Canyon											
13	--	SW¼, NE¼, Sec 8, T9S, R43E	Trdl	26 23	1.64 1.45	7-20-77 7-30-77	1* 1*	--	--	---	
14	--	NE¼, SE¼, Sec 8, T9S, R43E	Trdl?	10 10	0.63 0.63	7-20-77 7-30-77	1 1	--	--	---	By fault
15	--	SW¼, NW¼ Sec 10, T9S, R43E	Trdu	8.4	0.53	7-30-77	1	--	--	---	
16	--	SE¼, SE¼, Sec 9, T9S, R43E	Trdl	.62	0.04	7-30-77	1	--	--	---	Almost on Sec. line 9-16
17	--	NE¼, SE¼, Sec 9, T9S, R43E	Trdl	15	0.95	7-30-77	1	--	--	---	
Burchertt Canyon											
18	Burchertt Spring	NW¼, SE¼, Sec 10, T9S, R43E	Trdl	5.4 4.2	0.34 0.26	7-19-77 8-13-77	1 1	50	10.0	340	By fault
Wood Canyon											
19	--	NE¼, SW¼, Sec 32, T8S, R43E	Trtl	22 20	1.39 1.26	7-8-77 8-12-77	1* 1	42		320	

Appendix II. cont'd

Spring No.	Name	Location	Formation	Discharge		Date	Measuring Device	Temp		Electrical Conductivity (micromhos/cm^2)	Miscellaneous
				(gpm)	(liter/sec)			F°	C°		
Unnamed Canyon East of and Opposite Wood Canyon											
20	Junction Spring	SE¼, SW¼, Sec 27, T8S, R43E	Trdl	7.6 5.4	0.48 0.34	7-8-77 8-12-77	1 1	50	10.0	380	
Slug Creek Valley											
21	--	NE¼, NE¼, Sec 11, T8S, R43E	PPwu	8.4 .09	0.53 0.006	7-24-77 8-20-77	1	--	--	---	Robinette #11, measured west of road
22	--	NW¼, SE¼, Sec 30, T8S, R44E	Trdl	500 390	32 25	7-24-77 8-20-77	3 3	--	--	---	Robinette #24, velocities very low
23	--	SW¼, NE¼, Sec 5, T9S, R44E	Alluvium	1.9 .80	0.12 0.05	7-24-77 8-20-77	1	--	--	---	Robinette #25
24	Horseshoe Spring	NE¼, NW¼, Sec 3, T10S, R44E	Basalt or Alluvium	14	0.88	8-13-77	1	--	--	---	
25	Cold Spring	SE¼, SE¼, Sec 3, T10S, R44E	Pwl ?	14	0.88	8-13-77	1	--	--	---	
26	Pritchert Spring	SW¼, NW¼, Sec 10, T10S, R44E	?	1.9	0.12	8-13-77	1	--	--	---	Surface flow lost over Monroe Canyon Limestone
Schmid Ridge											
27	--	SW¼, SE¼, Sec 25, T7S, R43E	?	11	0.69	7-26-77	1	--	--	---	
28	--	SW¼, NE¼, Sec 36, T7S, R43E	Trd ?	1.5	0.09	7-26-77	4	--	--	---	Robinette #21
29	--	NE¼, SE¼, Sec 36, T7S, R43E	Alluvium	Wet no Flow		7-26-77	-	--	--	---	

Appendix II. cont'd

Spring No.	Name	Location	Formation	Discharge		Date	Measuring Device	Temp		Electrical Conductivity$_2$ (micromhos/cm^2)	Miscellaneous
				(gpm)	(liter/sec)			F°	C°		
Schmid Ridge - cont'd											
30	--	SE¼, SE¼, Sec 36, T7S, R43E	--	Could not find		7-26-77	-	--	--	---	Robinette #19
31	--	NW¼, NE¼, Sec 36, T7S, R43E	Trd ?	11	0.69	7-26-77	1	--	---	---	Robinette #20
32	--	NW¼, NW¼, Sec 36, T7S, R43E	--	Could not find		7-26-77	-	--	--	---	Robinette #17
33	--	SE¼, NE¼, Sec 1, T8S, R43E	Trdl	7.6	0.48	7-23-77	1	--	--	---	Robinette #26
34	--	SE¼, SW¼, Sec 5 T8S, R44E	Alluvium	No flow but standing water		7-23-77	-	--	--	---	Northwest of Robinette #16
35	--	NW¼, SW¼, Sec 5, T8S, R44E	Trdl ? (Alluvium)	.34	0.02	7-23-77	1	--	--	---	Robinette #15
36	--	SW¼, SE¼, Sec 5, T8S, R44E	Alluvium	No flow		7-23-77	-	--	--	---	Robinette #16
37	--	SE¼, NW¼, Sec 6, T8S, R44E	Trtl Robinette has Rex?	3.6	0.23	7-23-77	1	--	--	---	Robinette #13
38	--	SW¼, NE¼, Sec 6 T8S, R44E	Trdu	No flow		7-23-77	-	--	--	---	Robinette #14
39	--	NW¼, NW¼, Sec 6, T8S, R44E	Trtl Robinette has Din.?	27	1.70	7-23-77	1	--	--	---	Robinette #12
40	--	NE¼, NW¼, Sec 6, T8S, R44E	Trdu	1.6	0.10	7-23-77	1	--	--	---	

Appendix II. cont'd

Spring No.	Name	Location	Formation	Discharge (gpm)	Discharge (liter/sec)	Date	Measuring Device	Temp F°	Temp C°	Electrical Conductivity (micromhos/cm^2)	Miscellaneous
Schmid Ridge - cont'd											
41	--	NW¼, SW¼, Sec 7, T8S, R44E	Trdl Robinette has Trdu ?	No flow		7-26-77	-	--	--	---	Robinette #27
42	--	NW¼, SW¼, Sec 7, T8S, R44E	Trdl	No flow		7-26-77	-	--	--	---	
43	--	NW¼, SE¼, Sec 7 T8S, R44E	Trtl	6.8	0.43	7-23-77	1	--	--	---	
44	--	SE¼, NE¼, Sec 7, T8S, R44E	Trts	14	0.88	7-22-77	1	--	--	---	Robinette #2
45	--	SE¼, SE¼, Sec 7, T8S, R44E	Trtl	1.6	0.10	7-22-77	1	--	--	---	Robinette #8
46	--	SW¼, SW¼, Sec 8, T8S, R44E	Trtl	19	1.20	7-23-77	1	--	--	---	Robinette #29
47	--	SE¼, SE¼, Sec 8, T8S, R44E	Trdl	23	1.45	7-22-77	1	--	--	---	Robinette #22
48	--	NW¼, NW¼, Sec 16, T8S, R44E	Trdl	12	0.76	7-22-77	1	--	--	---	Robinette #23
49	--	SW¼, SW¼, Sec 16, T8S, R44E	?	Could not find		7-22-77	-	--	--	---	Robinette #10
50	--	SW¼, SE¼, Sec 17, T8S, R44E	Trts	7.3	0.46	7-22-77	1	--	--	---	Robinette #3
51	--	SW¼, SE¼, Sec 17, T8S, R44E	Trts	1.3	0.08	7-22-77	1	62	16.7	---	Robinette #4

Appendix II. cont'd

Spring No.	Name	Location	Formation	Discharge (gpm)	Discharge (liter/sec)	Date	Measuring Device	Temp F°	Temp C°	Electrical Conductivity (micromhos/cm^2)	Miscellaneous
Schmid Ridge - cont'd											
52	--	SE¼, NW¼, Sec 18, T8S, R44E	Trdl	.15	0.01	7-23-77	1	--	--	---	Robinette #18
53	--	NE¼, NW¼, Sec 20, T8S, R44E	Trts	6.0	0.38	7-22-77	1	52	11.1	---	Robinette #6
54	--	SW¼, NW¼, Sec 20, T8S, R44E	Trtl	3.1	0.20	7-22-77	1	64	17.8	---	Robinette #7
55	--	NW¼, NW¼, Sec 21, T8S, R44E	Trtl	4.8	0.30	7-22-77	1	48	8.89	---	Robinette #9
56	Lonetree Spring (upper)	SW¼, NE¼, Sec 28, T8S, R44E	Trts	23	1.45	7-21-77	1	54	12.2	---	Robinette #1
57	Lonetree Spring (lower)	SE¼, NE¼, Sec 28 T8S, R44E	Trts	21	1.32	7-21-77	1* (less upstream flow)	--	--	---	Robinette #5
58	--	NW¼, SW¼, Sec 34, T9S, R44E	Trtl	12	0.76	7-21-77	1	49	9.44	---	Downstream of Goodheart Spring
59	Goodheart Spring	SE¼, NW¼, Sec 34, T9S, R44E	Trts	19	1.20	7-21-77	1	49	9.44	---	
60	--	NE¼, SW¼, Sec 34, T8S, R44E	Trts	30	1.89	7-21-77	1*	44	6.67	---	
61	--	NW¼, NE¼, Sec 15, T9S, R44E	PPwu or Alluvium	Dry		8-17-77	-	--	--	---	Apparent spring area in Dry Basin
62	--	SE¼, NW¼, Sec 2, T10S, R44E	Tsl	.35	0.02	8-13-77	4	--	--	---	

Appendix II. cont'd

Spring No.	Name	Location	Formation	Discharge (gpm)	Discharge (liter/sec)	Date	Measuring Device	Temp F°	Temp C°	Electrical Conductivity (micromhos/cm^2)	Miscellaneous
Dry Valley											
63	Bell Spring	SW¼, NE¼, Sec 18, T9S, R45E	Alluvium ?	No flow		8-20-77	-	--	--	---	Mislocated on 7½ min. quad.
64	--	NW¼, NW¼, Sec 18, T9S, R45E	Alluvium ?	Dry		8-17-77	-	--	--	---	Doubtful existence
Rasmussen Ridge											
65	--	NW¼, SE¼, Sec 32, T6S, R44E	Trd Lower ?	130	8.2	8-18-77	3	--	--	---	South of Sheep Creek
66	--	SW¼, SE¼, Sec 29, T6S, R44E	Tral (fault)	25	1.6	8-10-77	1	--	--	---	Right spring by road to Sheep Creek
67	--	SW¼, SE¼, Sec 29, T6S, R44E	Tral (fault)	1.9	0.12	8-17-77	1	--	--	---	Middle Spring by road to Sheep Creek
68	--	SW¼, SE¼, Sec 29, T6S, R44E	Tral (fault)	5.4	0.34	8-17-77	1	--	--	---	Left spring by road to Sheep Creek
69	--	SW¼, NE¼, Sec 18 and NW¼, NE¼ Sec 18, T7S, R44E	Alluvium	No discernible flow		8-18-77	-	--	--	---	Apparent spring area
Wooley Range											
70	--	SW¼, SW¼, Sec 18, T7S, R44E	Ppg	22	1.39	7-5-77	1	51	10.6	490	Left fork aggregate
71	--	NW¼, SW¼, Sec 18, T7S, R44E	Trd (lower ?)	50	3.2	7-5-77	1*	46	7.78	340	Right fork aggregate

Appendix II. cont'd

Spring No.	Name	Location	Formation	Discharge (gpm)	Discharge (liter/sec)	Date	Measuring Device	Temp F°	Temp C°	Electrical Conductivity (micromhos/cm^2)	Miscellaneous
Dry Ridge											
72	Hess Spring	SE¼, NW¼, Sec 36, T9S, R44E	Mb	Dry		8-13-77	-	--	--	---	Catch box has no flow
73	--	SW¼, SE¼, Sec 22, T7S, R44E	Trts	35	2.2	8-18-77	3	--	--	---	Upper spring Mosquito Creek
74	--	SW¼, SE¼, Sec 22, T7S, R44E	Trtb	27	1.7	8-18-77	1	--	--	---	Lower spring Mosquito Creek
Diamond Creek Valley											
75	Lonepine Spring	SW¼, SE¼, Sec 35, T8S, R45E	Trdl Alluvium	Dry		8-19-77	-	--	--	---	
Webster Range - Freeman Range											
76	--	SW¼, Sec 17, T8S, R46E	Trdl	22	1.4	8-10-77	3	--	--	---	Near mouth of Smoky Canyon
77	Hill Spring	NE¼, SE¼, Sec 15, T9S, R45E	Trdl	1.6	0.10	8-19-77	1	--	--	---	Sum of flows from trough
78	--	NW¼, SE¼, Sec 22, T9S, R45E	Alluvium	1.0	0.06	8-19-77	1	--	--	---	Aggregate of two springs west and south of South Fork Sage Creek
79	--	NW¼, SE¼, Sec 22, T9S, R45E	Alluvium	.34	0.02	8-19-77	1	--	--	---	Spring east and south of South Fork Sage Creek
80	--	SW¼, NE¼, Sec 22, T9S, R45E	Alluvium	.15	0.01	8-19-77	1	--	--	---	West spring north of South Fork Sage Creek, East spring flows only 20 feet
81	--	SE¼, Sec 7 and NE¼, Sec 18, T9S, R46E	Alluvium ?	Potential spring area		8-19-77	-	--	--	---	Access not possible

Appendix II. cont'd

Spring No.	Name	Location	Formation	Discharge (gpm)	Discharge (liter/sec)	Date	Measuring Device	Temp F°	Temp C°	Electrical Conductivity (micromhos/cm^2)	Miscellaneous
Webster Range - Freeman Range											
82	--	NW¼, NE¼, Sec 9, T10S, R45E	Ppr	3.1 4.2	0.20 0.26	7-28-77 8-19-77	1	--	--	---	Upper Wells Canyon
83	--	SE¼, SE¼ Sec 10, T10S, R45E	Pwl	110	6.9	8-7-77	2	--	--	---	Near mouth of Wells Canyon
84	Books Spring	NE¼, SW¼, Sec 1, T10S, R45E	Pwl	500	32	8-19-77	Estimated	--	--	---	Manmade pond on spring, no access
85	--	NW¼, NW¼, Sec 35, T10S, R45E	Alluvium	Not measurable		8-19-77	-	--	--	---	By road crossing of Crow Creek
86	--	SE¼, NE¼, Sec 27, T10S, R45E	Pwl	380	24	8-19-77	3	--	--	---	Stream gains from springs 1400 feet and 1600 feet upstream of road (measuring point)
Dry Fork											
87	Meadow Spring	NE¼, SW¼, Sec 13, T9S, R43E	PPwu	1.3 1.6	0.08 0.10	7-19-77 8-13-77	1	58	14.4	530	Conductivity could be high due to manure
88	Saddle Spring	NW¼, NE¼, Sec 24, T9S, R43E	PPwu	.47 .23	0.03 0.01	7-19-77 8-13-77	1 1	69	20.6	440	Conductivity could be high due to manure

NOTE: Measuring Devices Key

1 = 60°, V-notch flume
1* = 2-60°, V-notch flume
2 = 2-inch, 45°, trapezoidal flume
3 = Pygmy current meter with topsetting rod
4 = Timed filling of 1 quart canteen

Appendix III. Spring cross reference.

Spring No.	Figure No.	Spring No.	Figure No.
1	19	45	30
2	19	46	30
3	20	47	32
4	20	48	30
5	21	49	--
6	21	50	30
7	21	51	30
8	21	52	30
9	21	53	30
10	21	54	30
11	22	55	30
12	22	56	31
13	21	57	31
14	21	58	32
15	11,21	59	32
16	21	60	32
17	21	61	33
18	21	62	27
19	10	63	34
20	23	64	34
21	24	65	12
22	25	66	12
23	26	67	12
24	27	68	12
25	27	69	35
26	27	70	35
27	28	71	35
28	28	72	27
29	28	73	36
30	--	74	36
31	28	75	37
32	--	76	38
33	29	77	39
34	29	78	40
35	29	79	40
36	29	80	40
37	29	81	41
38	29	82	16
39	29	83	16
40	29	84	42
41	30	85	43
42	30	86	44
43	30	87	45
44	30	88	45

Appendix IV. Spring locations on geologic maps.

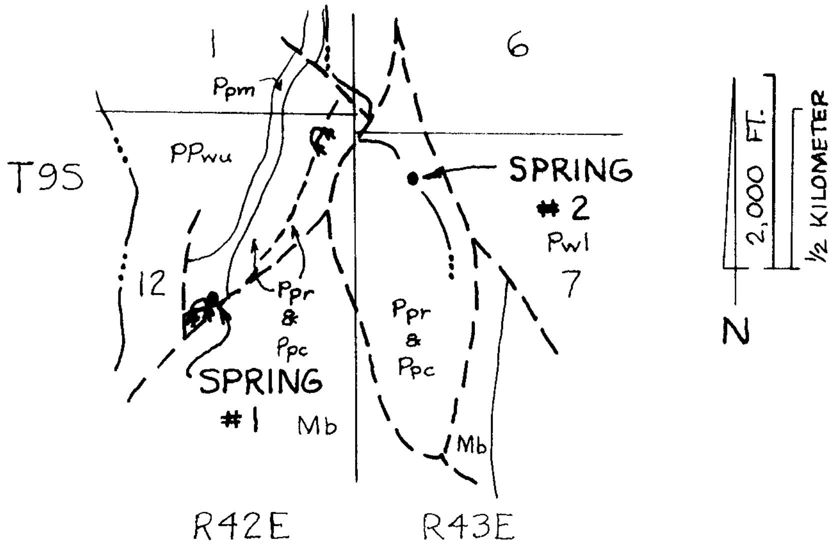

Figure 19. Springs, North Sulphur Canyon (Modified after Gulbrandsen and others, 1956, Plate 1).

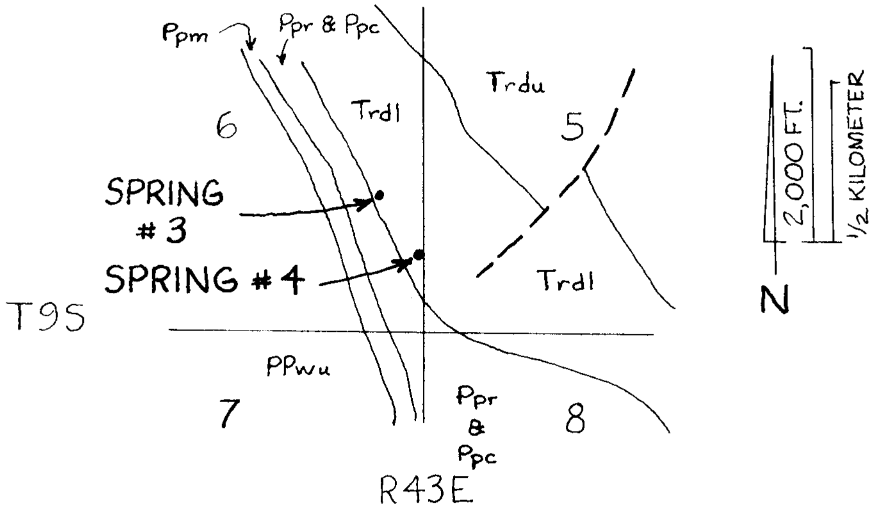

Figure 20. Springs, Middle Sulphur Canyon (Modified after Gulbrandsen and others, 1956, Plate 1).

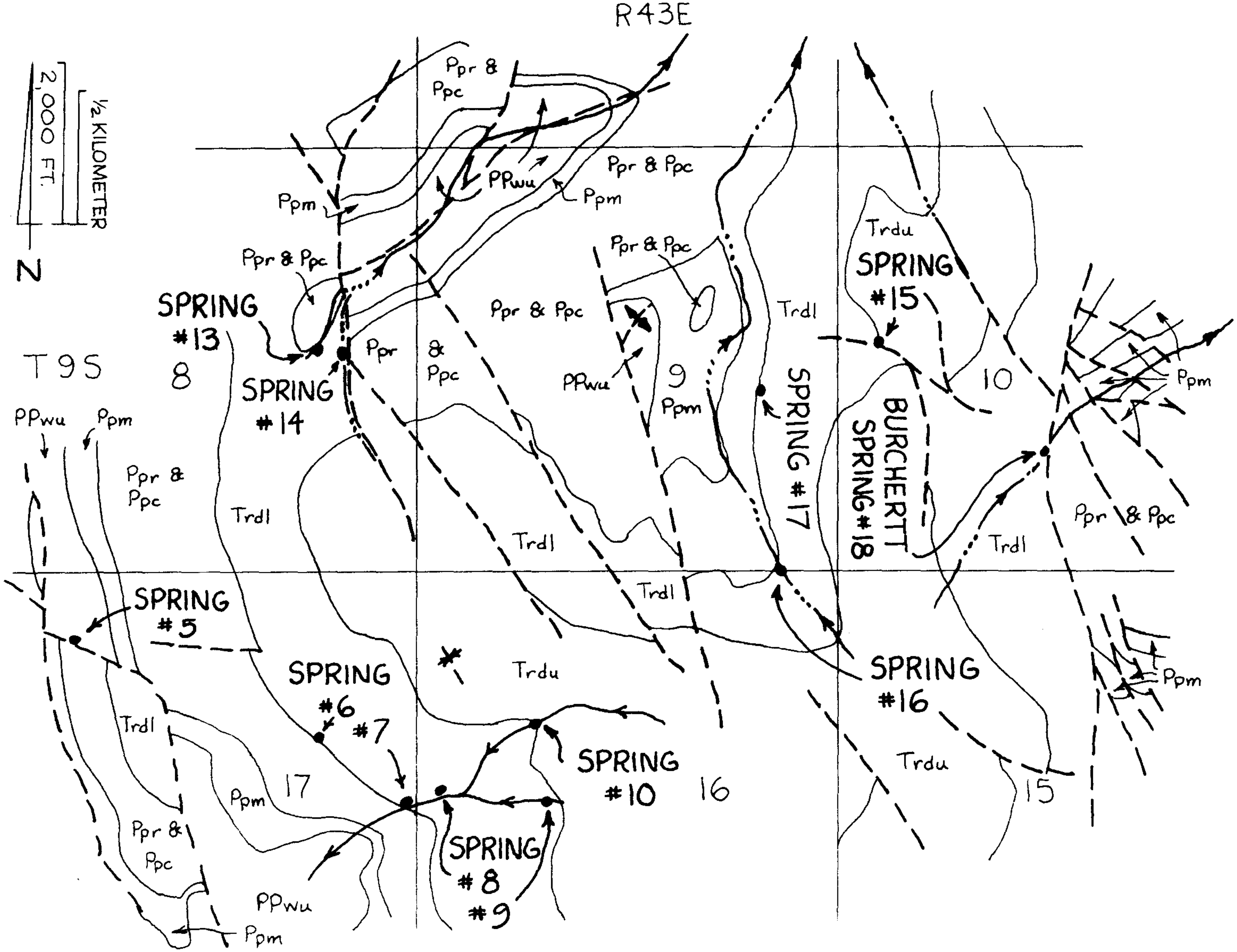

Figure 21. Springs, Middle and South Sulphur Canyons, Johnson Creek, and Burchertt Canyon (Modified after Gulbrandsen and others, 1956, Plate 1).

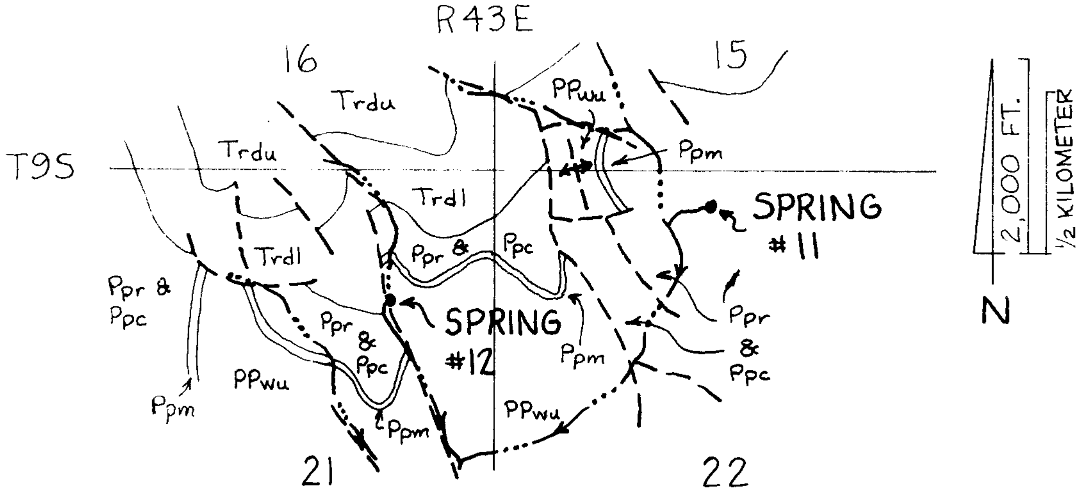

Figure 22 Springs, Swan Lake Gulch (Modified after Gulbrandsen and others, 1956, Plate 1).

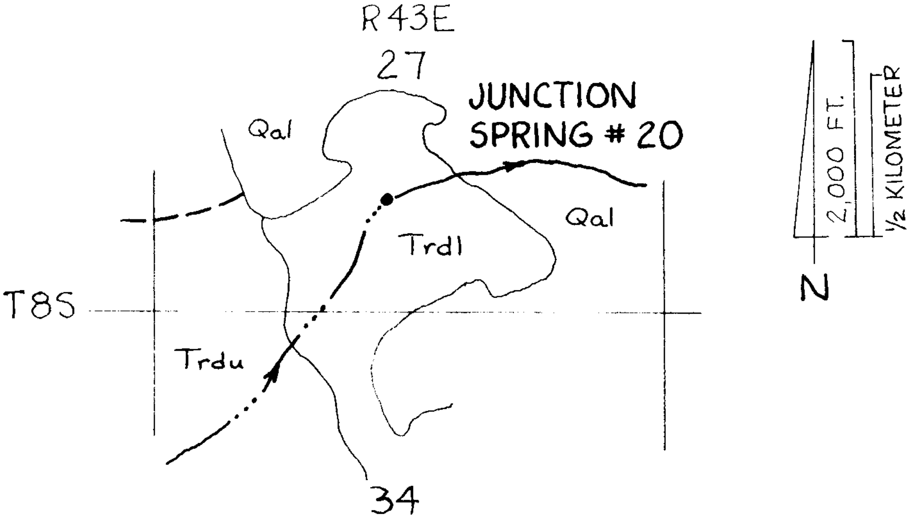

Figure 23. Spring, Johnson Creek (Modified after Gulbrandsen and others, 1956, Plate 1)

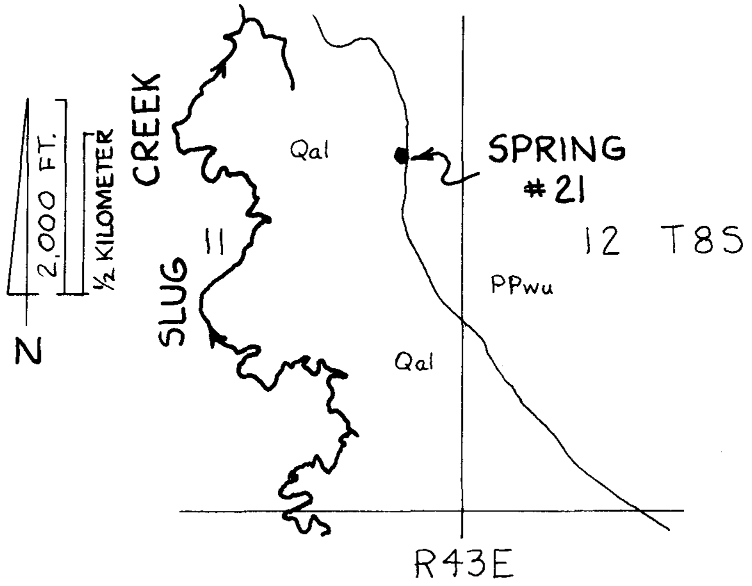

Figure 24. Spring, Slug Creek (Modified after Gulbrandsen and others, 1956, Plate 1).

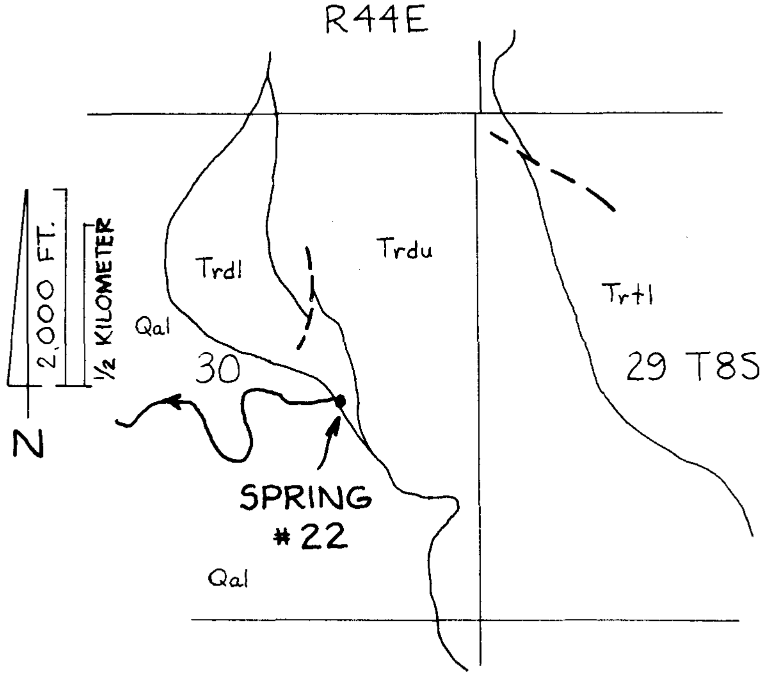

Figure 25. Spring, Slug Creek (Modified after Cressman and others, 1955, Plate 27).

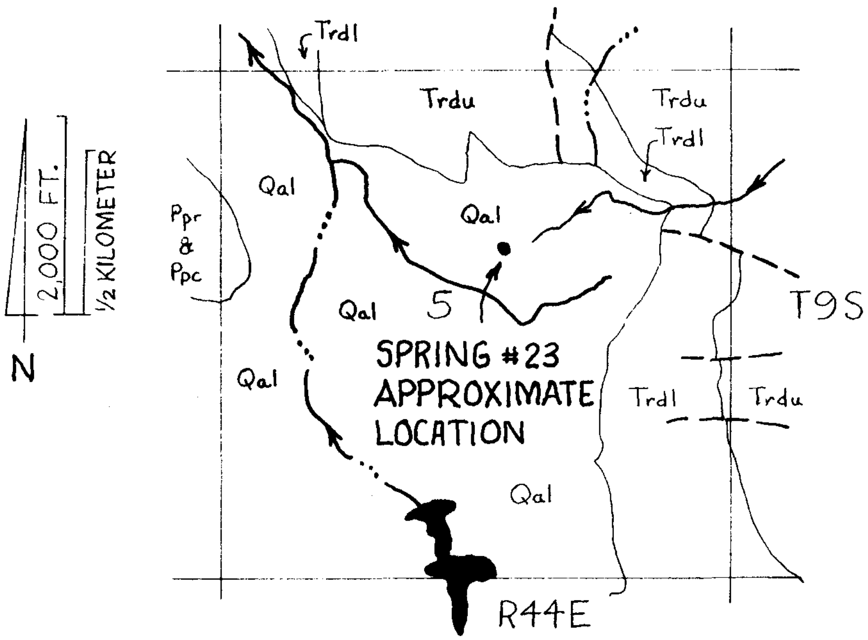

Figure 26. Springs, Slug Creek (Modified after Cressman and others, 1955, Plate 27).

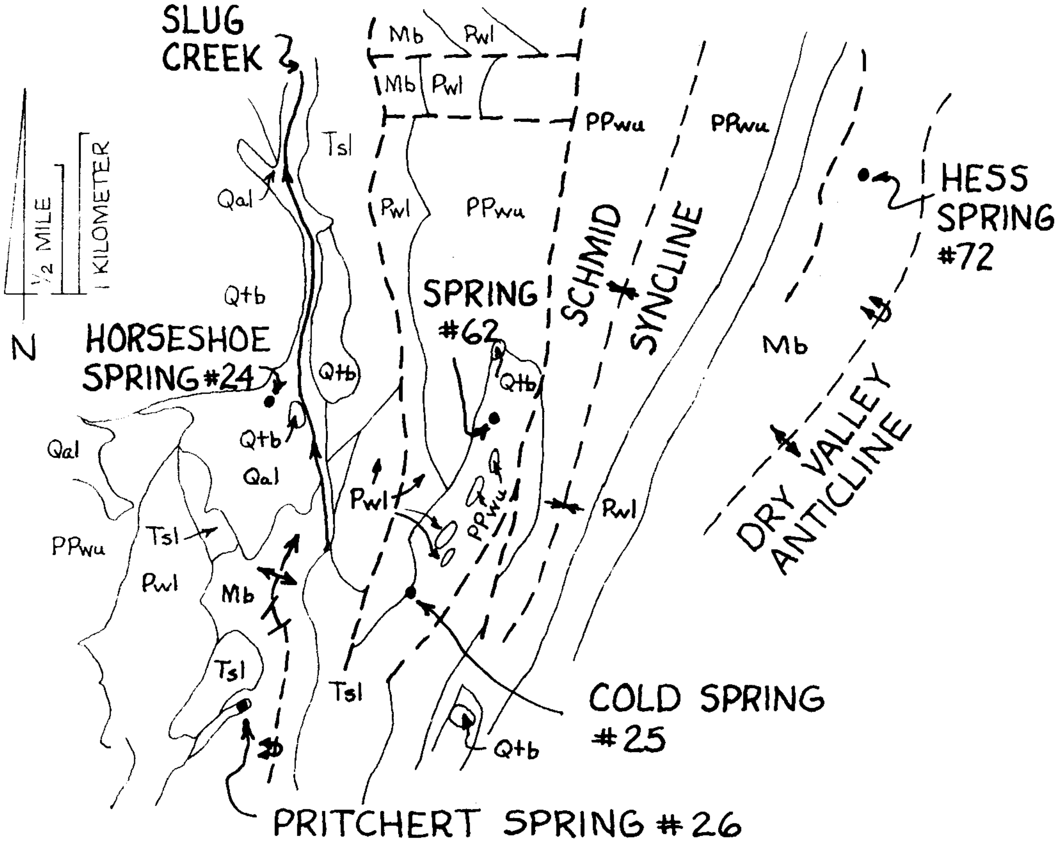

Figure 27 Springs, Slug Creek, Schmid and Dry Ridges (Modified after Cressman, 1964, Plate 3).

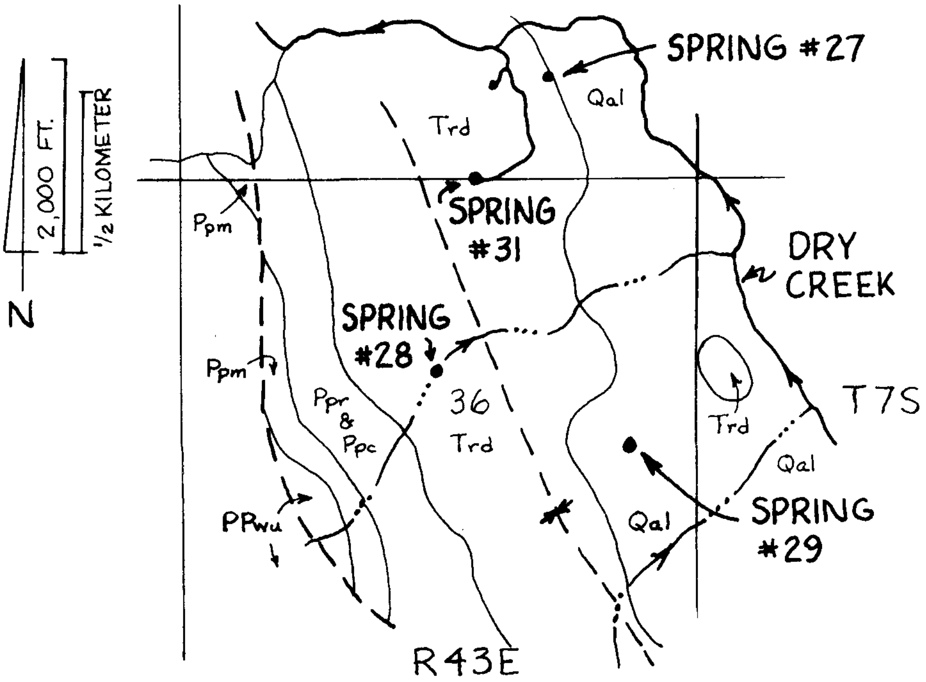

Figure 28. Springs, Schmid Ridge (Modified after Rioux and others, 1975; Mansfield, 1927, Plate 4; and Mabey, 1970 Plate 1).

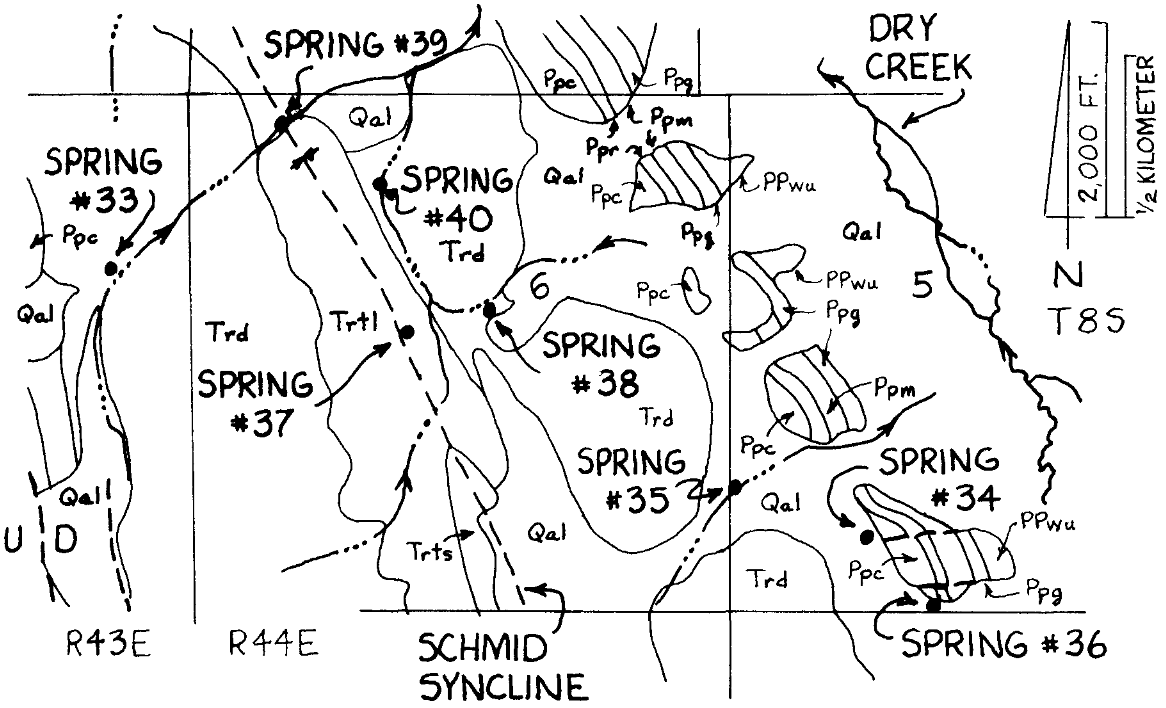

Figure 29. Springs, Schmid Ridge (Modified after Rioux and others, 1975).

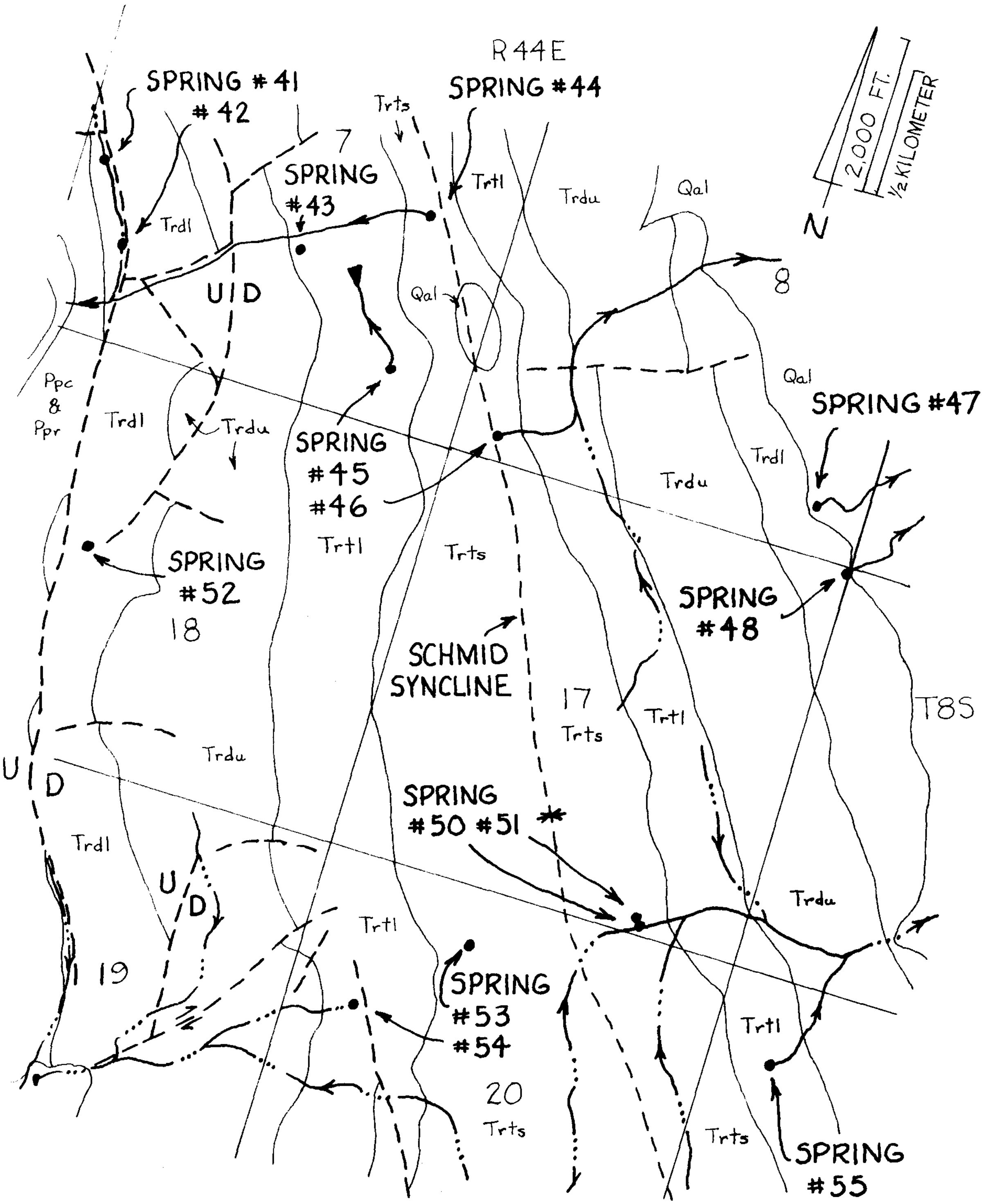

Figure 30. Springs, Schmid Ridge (Modified after Cressman and others, 1955, Plate 27).

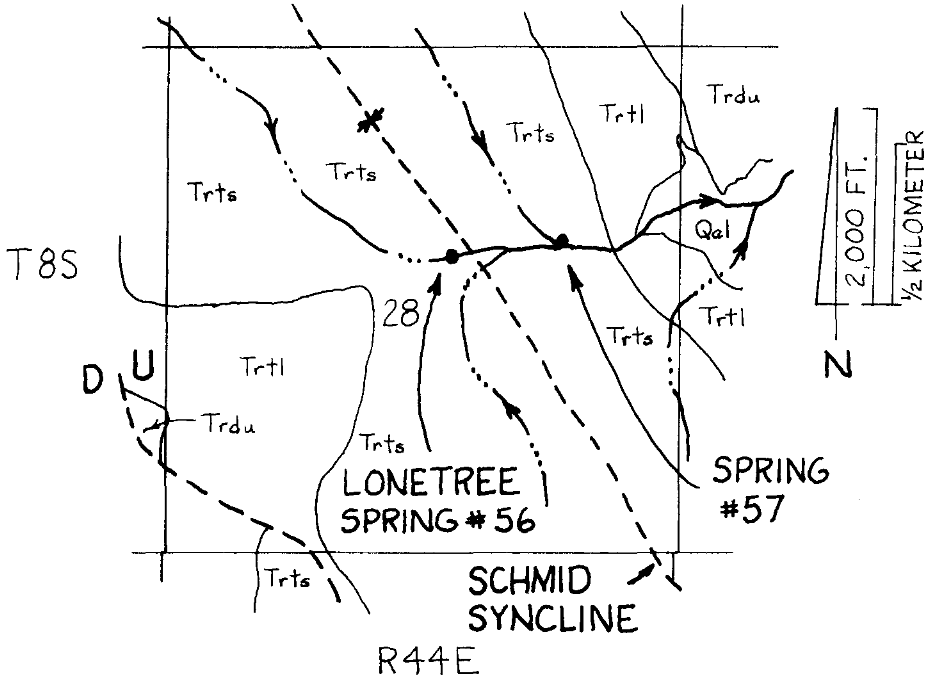

Figure 31. Springs, Schmid Ridge (Modified after Cressman and others, 1955, Plate 27).

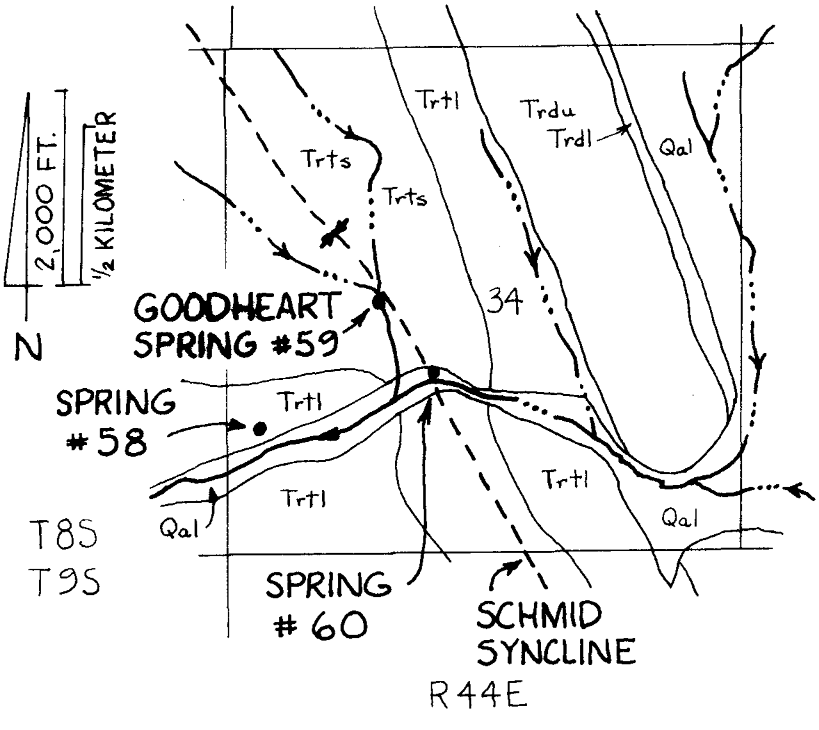

Figure 32. Springs, Schmid Ridge (Modified after Cressman and others, 1955, Plate 27).

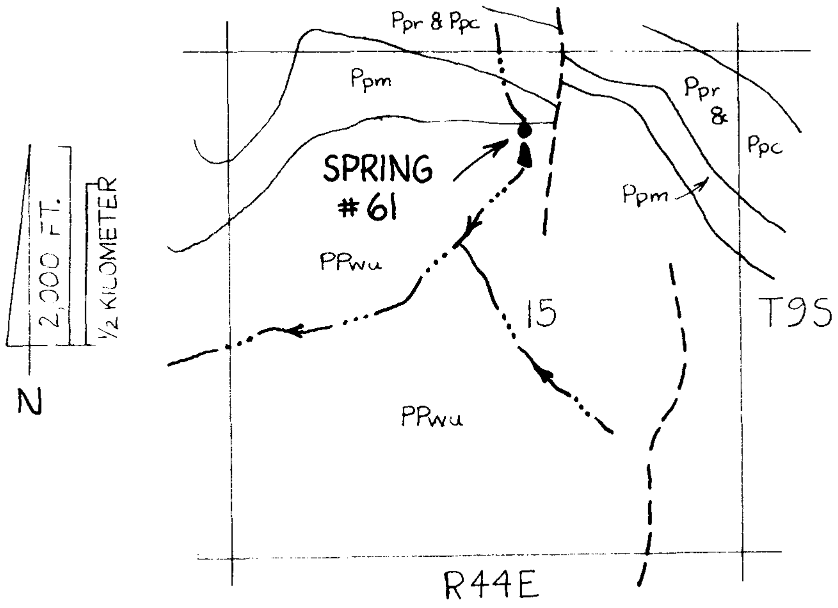

Figure 33. Springs, Schmid Ridge (Modified after Cressman and others, 1955, Plate 27).

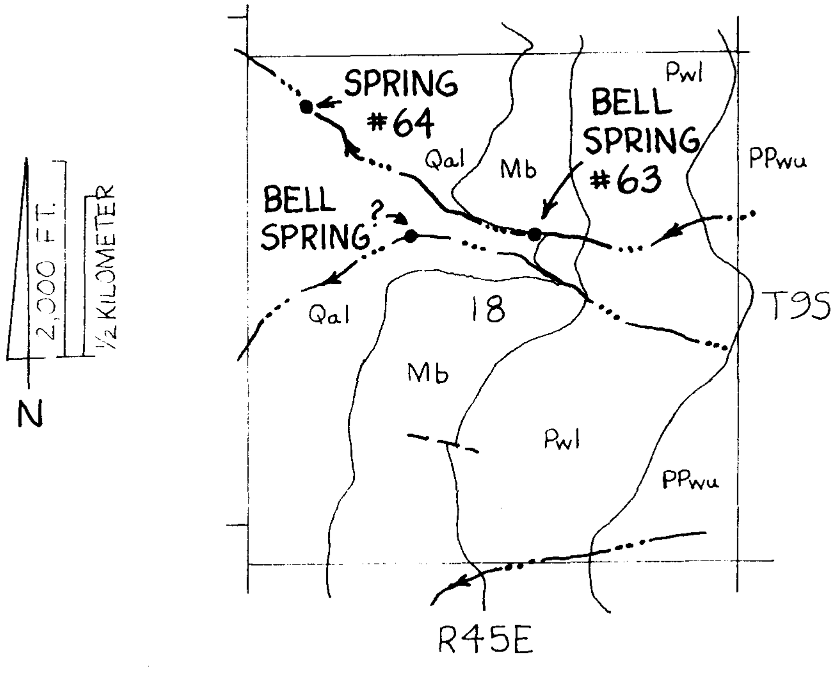

Figure 34. Springs, Dry Ridge (Modified after Montgomery and others, 1967, Plate 2).

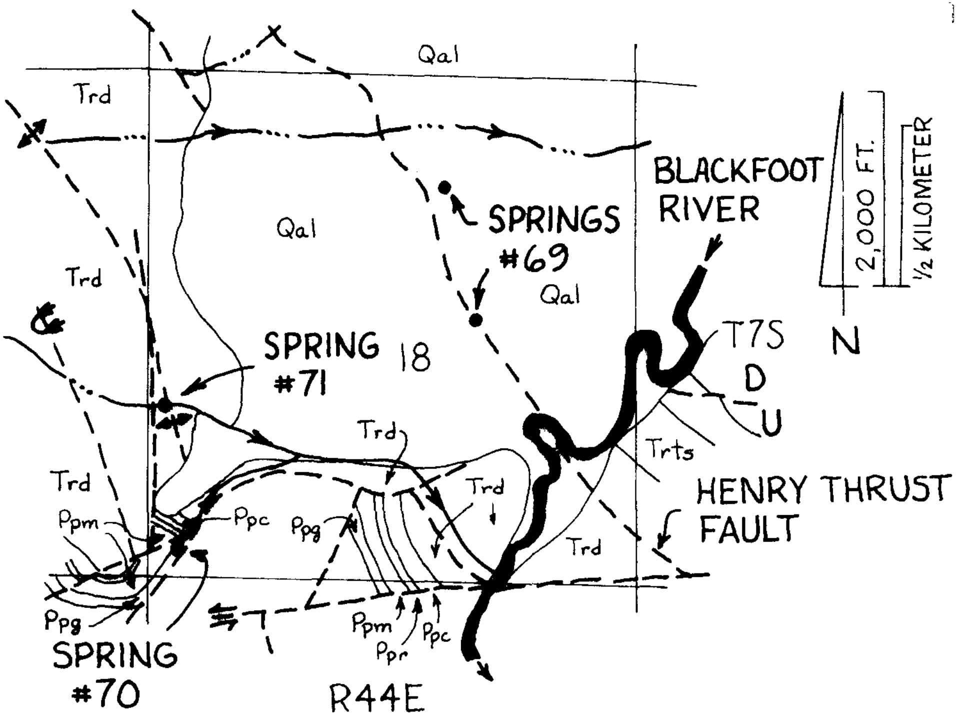

Figure 35. Springs, Rasmussen Ridge (Modified after Rioux and others, 1975).

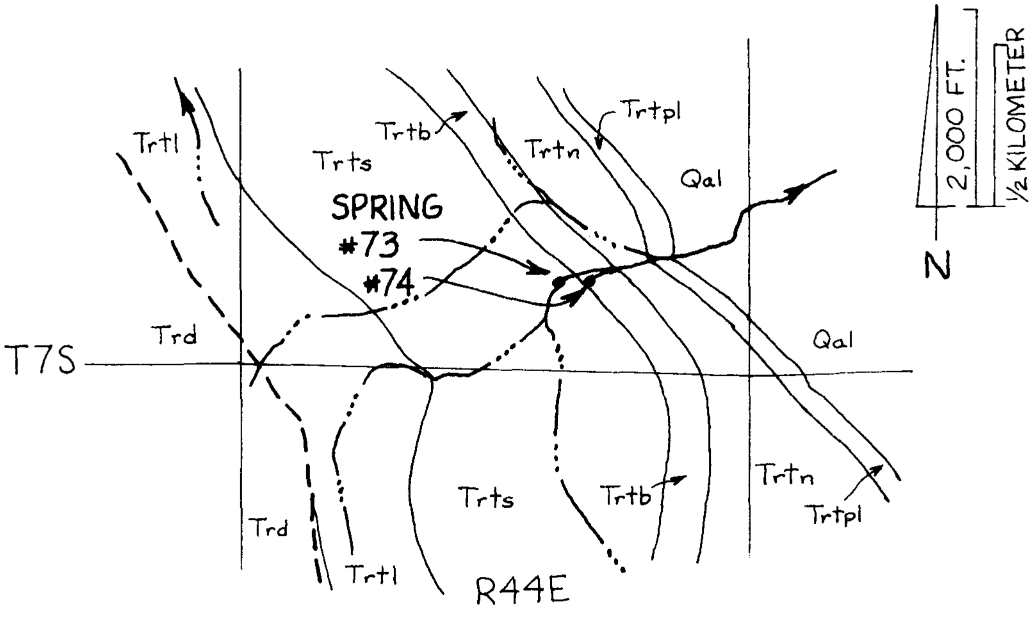

Figure 36. Springs, Dry Ridge (Modified after Rioux and others, 1975).

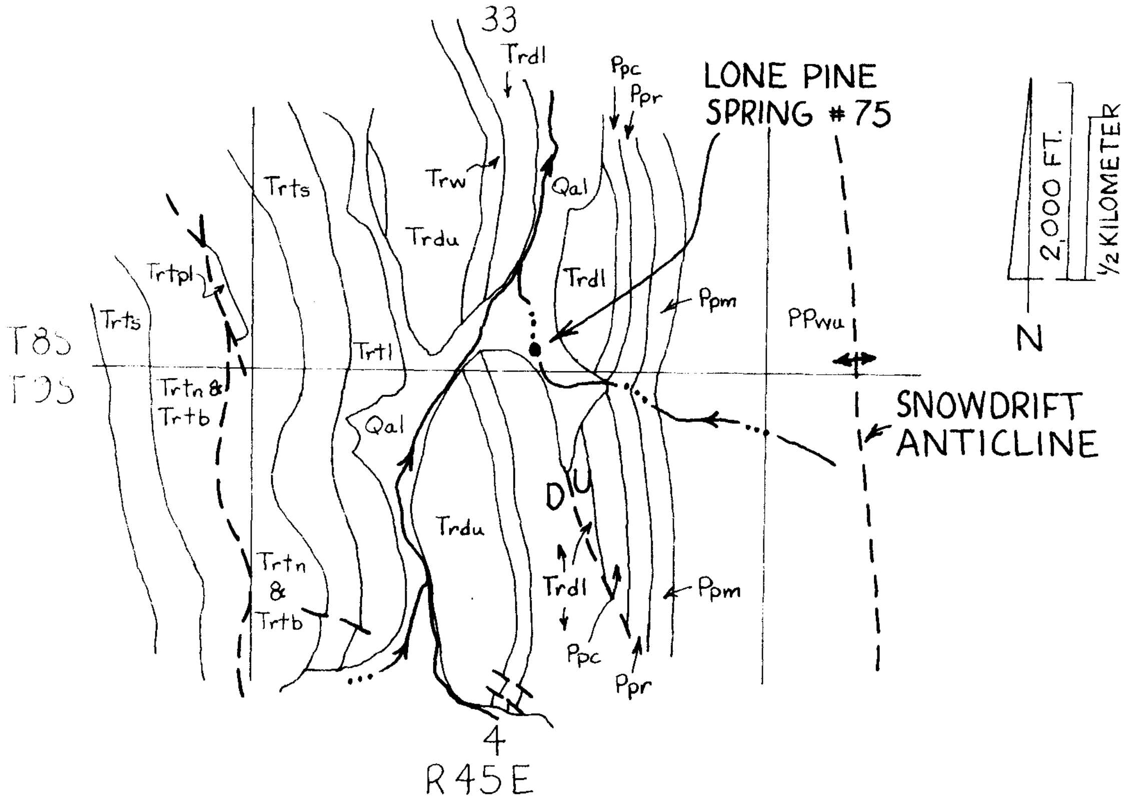

Figure 37. Springs, Diamond Creek (Modified after Montgomery and others, 1967, Plate 2).

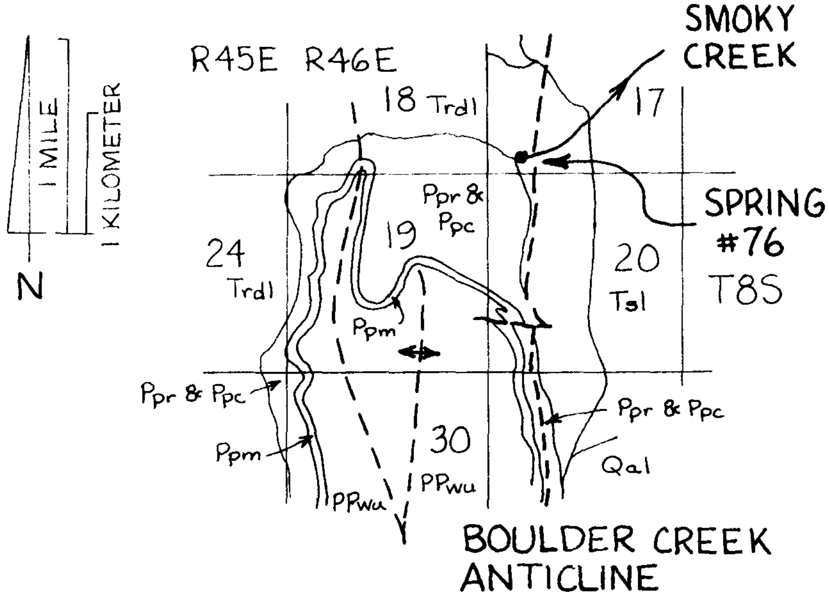

Figure 38. Springs, Smoky Canyon (Modified after Mansfield, 1927, Plate 7 and Montgomery and others, 1967, Plate 2).

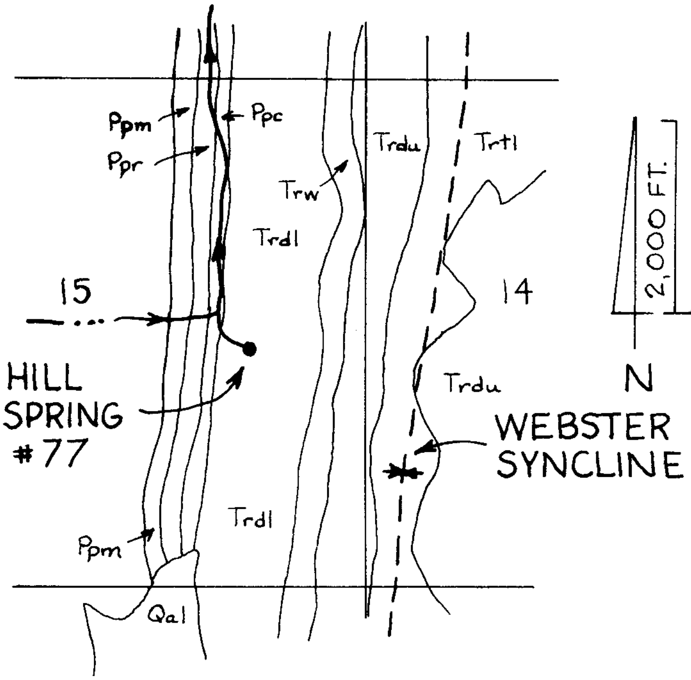

Figure 39. Springs, Webster Range (Modified after Montgomery and others, 1967, Plate 2).

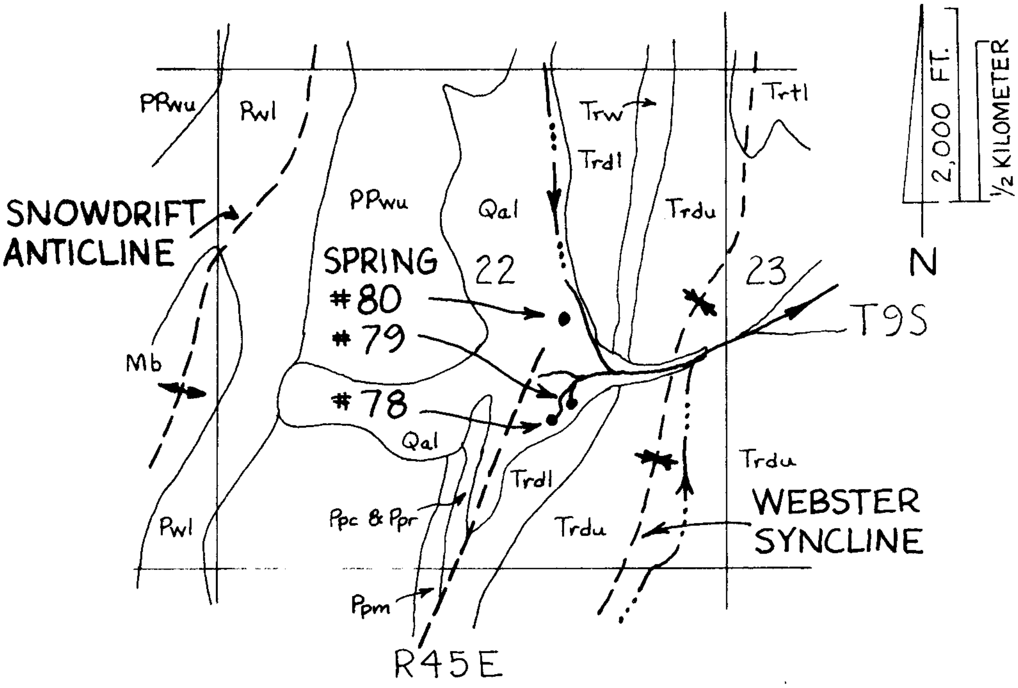

Figure 40. Springs, Webster Range (Modified after Montgomery and others, 1967, Plate 2 and Cressman, 1964, Plate 1).

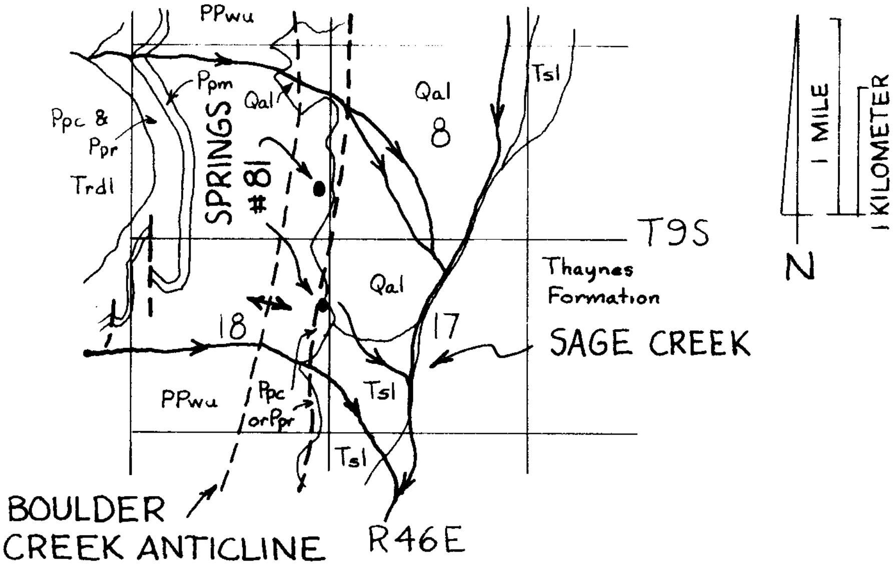

Figure 41   Springs, Webster Range (Modified after Mansfield, 1927, Plate 7).

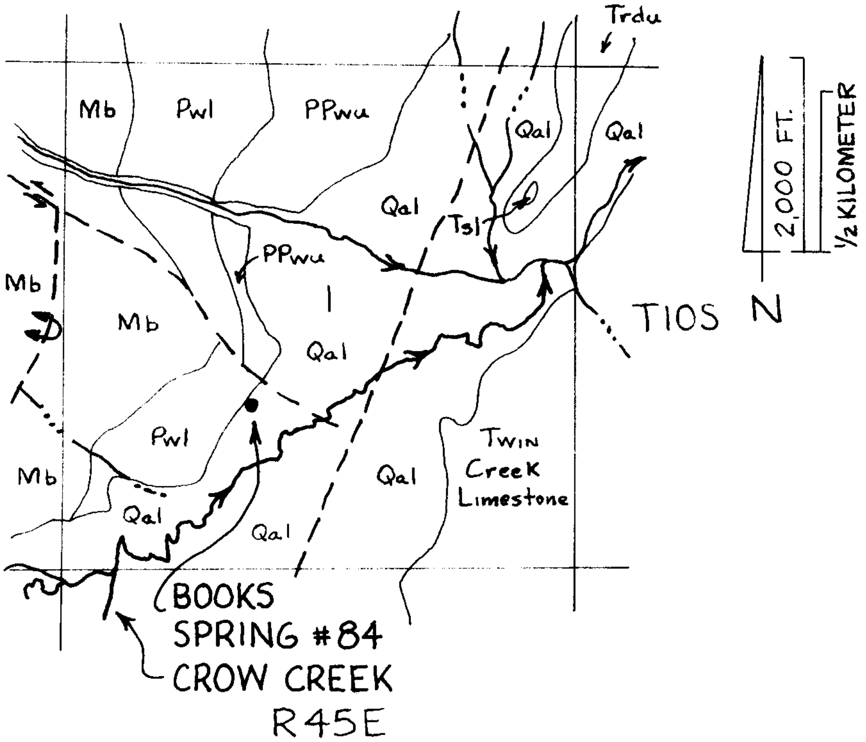

Figure 42. Springs, Webster Range (Modified after Cressman, 1964, Plate 1).

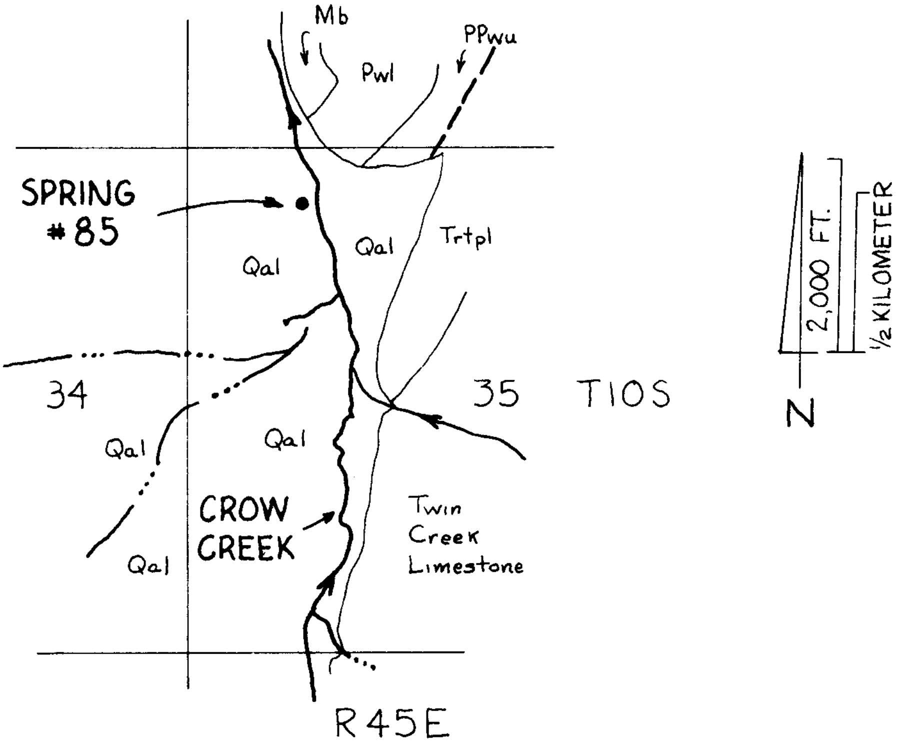

Figure 43. Springs, Webster Range (Modified after Cressman, 1964, Plate 1).

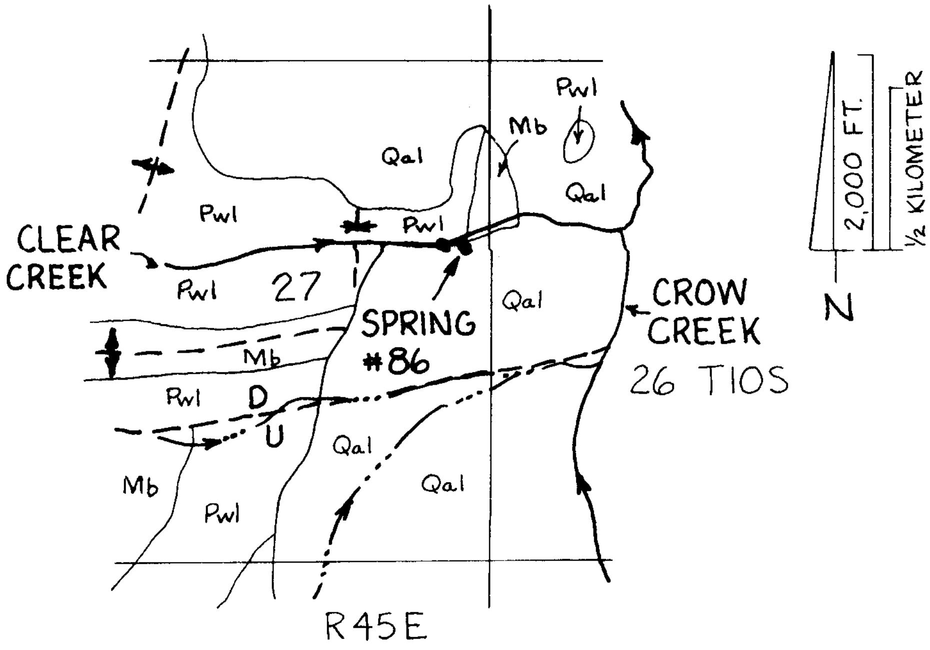

Figure 44. Springs, Webster Range (Modified after Cressman, 1946, Plate 1).

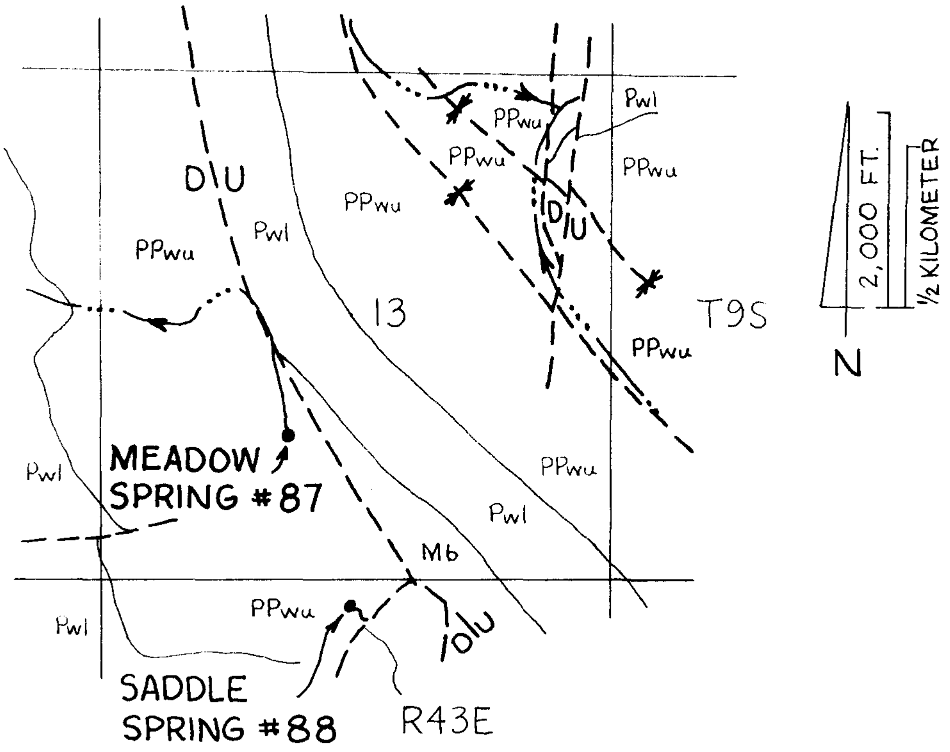

Figure 45 Springs, Dry Fork (Modified after Cressman and others, 1955, Plate 27 and Gulbrandsen and others, 1956, Plate 1).

Appendix V. Miscellaneous stream flow data.

Stream or River	Location	Date	Flow (gpm)	Flow (liter/sec)	Measuring Device	Comments
Slug Creek	SW¼, SW¼, Sec 19, T8S, R44E	6-12-77	1050	66.2	3	Water was 66°F (18.9°C) with specific conductivity of 380 micromhos/cm^2; measuring point is upstream of road culverts
		6-28-77				Water was 52°F (11.1°C) and 370 micromhos/cm^2
		6-29-77	480	30	3	
		8-20-77	550	35	3	
Johnson Creek	½ section line between NE¼ and SE¼ of Sec 26, T8S, R43E	6-28-77				Water was 54°F (12.2°C) and 370 micromhos/cm^2
		6-29-77	52	3.3	1*	
		8-12-77	59	3.7	1*	
Left Fork Trail Creek	NW¼, NE¼, Sec 28, T8S, R43E by road culvert	6-29-77	20	1.3	1	Water was 56°F (13.3°C) and 320 micromhos/cm^2
		8-12-77	14	0.88	1	
Middle Fork Trail Creek	NE¼, NW¼, Sec 28, T8S, R43E by road culvert	6-29-77				Water was 56°F (13.3°C) and 330 micromhos/cm^2
		7-2-77	450	28	3	
		8-20-77	470	30	3	
Right Fork Trail Creek	SE¼, SE¼, Sec 20, T8S, R43E by road culvert	7-2-77				Water was 56°F (13.3°C) and 400 micromhos/cm^2
		7-3-77	120	7.6	2	
		8-12-77	65	4.1	2	
Little Blackfoot River	SW¼, SW¼, Sec 10, T6S, R42E under bridge	6-15-77	4400	280	3	Water was 63°F (17.2°C and 900 micromhos/cm^2
		7-7-77	4800	300	3	
		8-11-77	4500	280	3	
	SE¼, SW¼, Sec 14, T6S, R42E	7-7-77				Water was 68°F (20.0°C) and 820 micromhos/cm^2
		8-11-77	700	44	3	Wells Formation-Basalt contact
	NE¼, SE¼, Sec 14, T6S, R42E	6-10-77	790	50	3	Rex Chert-Meade Peak contact in Phosphoria Formation
		6-15-77	1350	85	3	Water was 75°F (23.9°C) and 770 micromhos/cm^2
		7-7-77	960	61	3	
		8-11-77	910	57	3	

Appendix V. cont'd

Stream or River	Location	Date	Flow (gpm)	Flow (liter/sec)	Measuring Device	Comments
Little Blackfoot River cont'd	SE¼, NE¼, Sec 14, T6S, R42E (350 feet upstream of access road culvert)	6-10-77	580	37	3	
		6-15-77	1490	94	3	Water was 67°F (19.4°C) and 800 micromhos/cm^2
		7-7-77	970	61	3	Probably low
		8-11-77	850	54	3	Probably low
	Collapse structure upstream of previous location	6-25-77	14.5	0.91	1	
		6-28-77	27	1.7	1	
		6-29-77	30	1.9	1	
		7-7-77	133	8.4	2	
		8-2-77	102	6.4	2	
		8-11-77	4.8	0.30	1	
	NE¼, NE¼, Sec 14, T6S, R42E (about 2550 feet upstream of road culvert)	6-15-77	1500	95	3	Water was 57°F (13.9°C) and 820 micromhos/cm^2
		8-11-77	1200	76	3	

NOTE: Measuring Device Key

1 = 60°, V-notch flume
1* = 2-60°, V-notch flumes in parallel
2 = 2-inch, 45°, trapezoidal flume
3 = Pygmy current meter with topsetting rod

SELECTED WATER
RESOURCES ABSTRACTS
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5. Report Date

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Technical Report

15. Supplementary Notes

16. Abstract Phosphate has been mined in southeastern Idaho since 1945 but additional demands for the ore will require that new areas be mined. A comprehensive understanding of the hydrogeology and hydrology of the area is required to assess the potential impact of this mining on those respective systems.

It was concluded from previous studies that the Phosphoria Formation does not support any major ground water flow system. The Dinwoody and Wells Formations were found to support ground water flow systems. The present study analyzed stream gain-loss measurements and spring locations in other areas of the Caribou National Forest to verify that these hydrogeologic properties are valid over a much greater area.

Stream gain-loss measurements consistently indicated that ground water flow systems exist in both members of the Dinwoody Formation and the upper member of the Wells Formation. No ground water flow systems exist in the Meade Peak Phosphatic Shale Member of the Phosphoria Formation but the cherty shale and Rex Chert Members do support such systems at certain locations. Stream flow mainly increased across the lower member of the Dinwoody Formation but stream flow always decreased across the upper member of the Wells Formation. There were no changes in stream flow across the Meade Peak Phosphatic Shale Member of the Phosphoria Formation.

Ground water flow systems are separated into one of two groups by their location with respect to the Meade Peak Phosphatic Shale Member of the Phosphoria Formation. Those formations that occur above this member support short ground water flow systems while those formations below it support regional type ground water flow systems.

17a. Descriptors Ground water flow

17b. Identifiers Southeastern Idaho

17c. COWRR Field & Group 08 D, 08 E

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