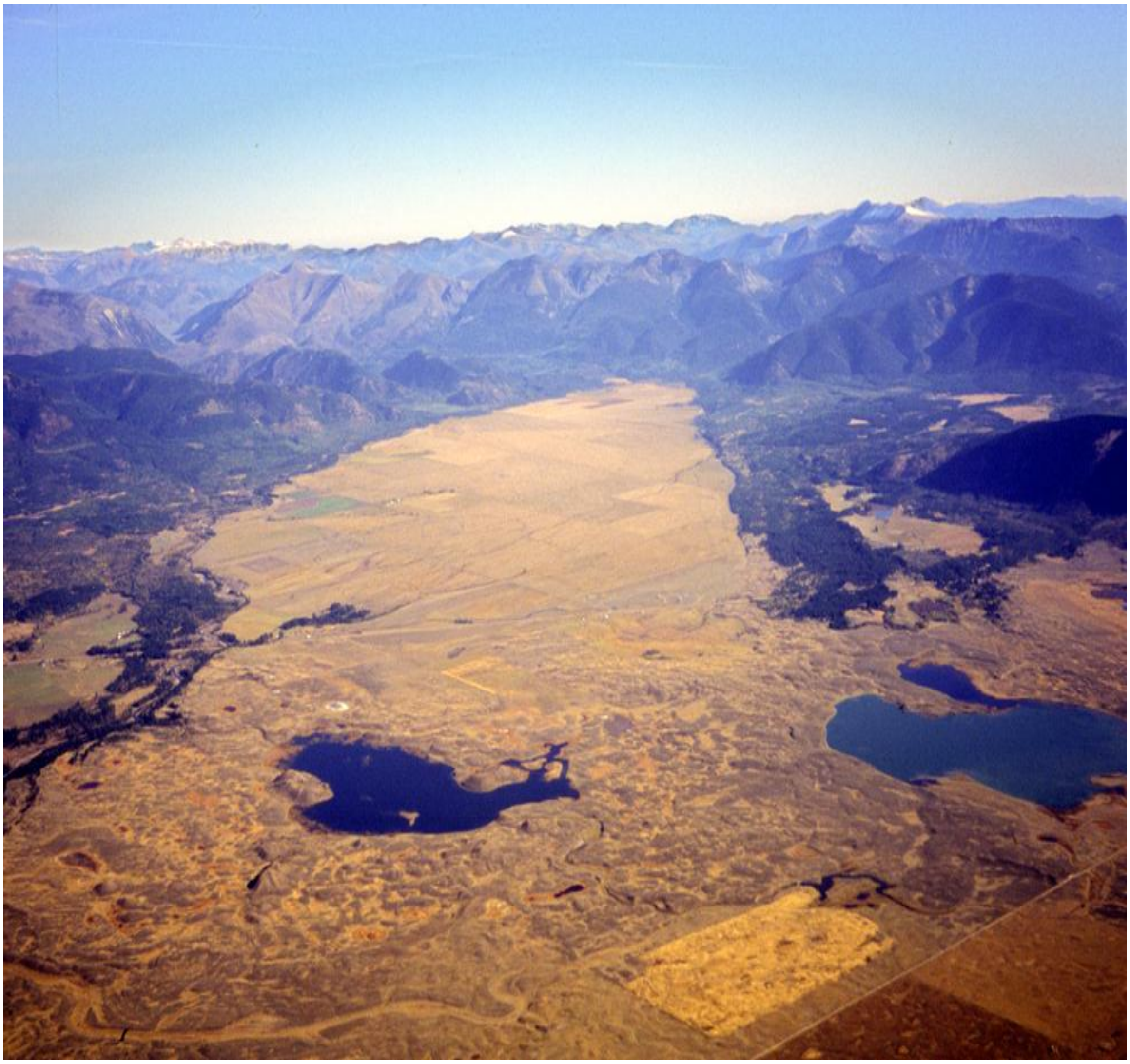
North Fork Blackfoot River Hydrologic Study



(photo by Janell Foley)

MONTANA DEPARTMENT OF NATURAL RESOURCES AND
CONSERVATION DNRC Report WR-3.C.2.NFB

Helena, Montana
March 2001

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By Mike Roberts and Kirk Waren

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INTRODUCTION

The North Fork Blackfoot River watershed, located in western Montana, is a significant contributor of the Blackfoot River providing between one-quarter and one-third of its annual flow. This contribution and the equally significant demand for this water make it imperative to have an understanding of the hydrology of the area and how it interacts with multiple land uses that are present.

The North Fork Blackfoot River watershed provides important habitat for native bull and westslope cutthroat trout. The bull trout is an endangered species and the westslope cutthroat is listed as a species of special concern the Montana Department of Fish, Wildlife, and Parks and a sensitive species with the USDA Forest Service. A citizen-led watershed management group, the Blackfoot Challenge, has initiated work to enhance native trout habitat in the North Fork Blackfoot River watershed. Reaches along the lower North Fork Blackfoot River and some of its tributaries experience seasonal water shortages which may impair native trout habitat. This study, conducted by the Montana Department of Natural Resources and Conservation (DNRC) and the United States Bureau of Reclamation (USBR), with assistance from the United States Geological Survey (USGS), assesses current hydrology of the North Fork Blackfoot River in its lower reaches. Of particular interest are natural and anthropogenic factors that may impact surface and groundwater interactions and ultimately instream flows of the North Fork Blackfoot River, Rock Creek, and Salmon Creek.

The goals of this study are:

1) To characterize surface and groundwater resources and their interactions in the study area.

2) Identify through monitoring, reaches of streams and ditches where measurable gains and losses in surface flow occur.

3) Characterize water use by presenting up-to-date water rights, irrigated acres, places of use, and methods used.

It is anticipated that information presented in this report will provide a scientific basis for making water management decisions that will not only increase water use efficiency among landowners, but enhance instream flows as well.

Project Area

The North Fork Blackfoot River is located approximately 80 miles northwest of Helena, Montana and 4.5 miles east of Ovando, Montana (Figure 1). The North Fork Blackfoot River joins the Blackfoot River 54 miles upstream from its confluence with the Clark

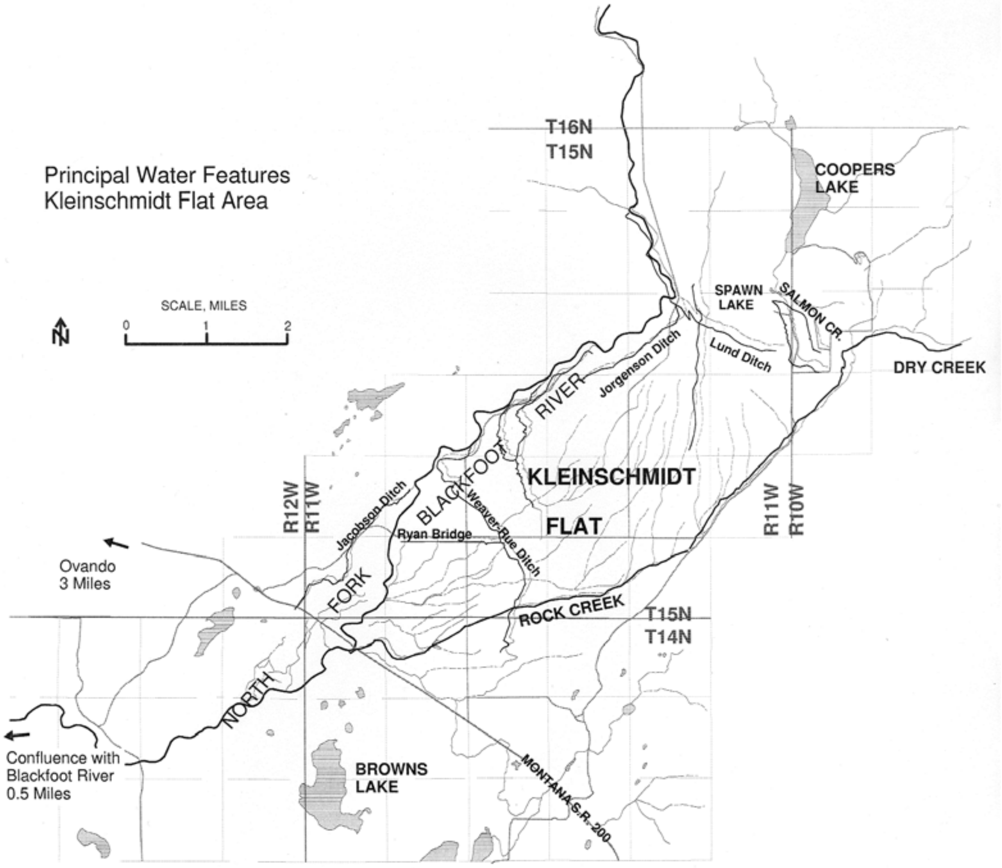


Figure 1. Principal water features: Kleinschmidt Flat area in the lower reaches of the North Fork Blackfoot River (See also Plate 1).

Fork River. The headwaters of the North Fork Blackfoot River lie in the Scapegoat Wilderness Area on the Lolo National Forest. This study focuses on a lower section of the watershed, between the forest boundary and Highway 200, approximately 5.5 miles upstream from the mouth. This area, known as Kleinschmidt Flat, is where most streamflow diversion and irrigation occurs in the watershed. A large map referencing principal water features, surface and groundwater measurement sites, irrigated acres, and legal features is included at the back of this report (Plate1).

The study area ranges in elevation from 4155 feet above mean sea level near Highway 200 to 4400 feet at the point the river enters the flat, and 4525 feet at the forest boundary. From the Highway 200 bridge, the North Fork Blackfoot River drains approximately 275 square miles or 176,000 acres. The average precipitation on Kleinschmidt Flat ranges from 18 inches near Highway 200 to 22 inches where the river exits onto the flat, to 45-50 inches in the headwaters (Parrett 1997).

Average runoff for the three years of record from the U. S. Geological Survey gaging station located 2.5 miles upstream from the mouth, is about 275,000 acre-feet per year. Based on this limited data, the North Fork Blackfoot River contributes approximately one-quarter to one-third of the total Blackfoot River annual discharge while occupying about 15% of its watershed area. This contribution becomes more prominent during the runoff months (April through July).

Rock Creek is the only mainstem perennial tributary of the North Fork Blackfoot River in the Kleinschmidt Flat area. Tributaries of Rock Creek include Kleinschmidt Creek, Salmon Creek and Dry Creek. Intermittent tributaries of the North Fork Blackfoot River include Spring Creek and Bear Creek.

Geology

Headwater areas of the North Fork Blackfoot River in the Scapegoat Wilderness are underlain by bedrock and surficial glacial deposits. The bedrock is composed mainly of Precambrian and Cambrian argillites, limestone, and dolomites. The argillites are red, green, maroon, tan, and purple metasedimentary rocks that generally have low primary porosity. These rocks are the source area for glacial sediments that dominate the geology of the Kleinschmidt Flat and surrounding area.

Previous geologic studies have revealed that glaciers once extended out of the North Fork Blackfoot River canyon and across Kleinschmidt Flat. At least two major episodes of glaciation occurred, the first about 100,000 years ago and the second from 70,000 to 10,000 years ago. During each major episode, the glaciers advanced and retreated numerous times due to minor climatic changes (Witkind and Weber, 1982). Sediments left behind by the ice now cover the valley bottoms and form low hills in the Kleinschmidt Flat area.

Figure 2 is a geologic map of the Kleinschmidt Flat area. Glacial till forms the hummocky land south of Highway 200, and the low, rugged hills that flank Kleinschmidt

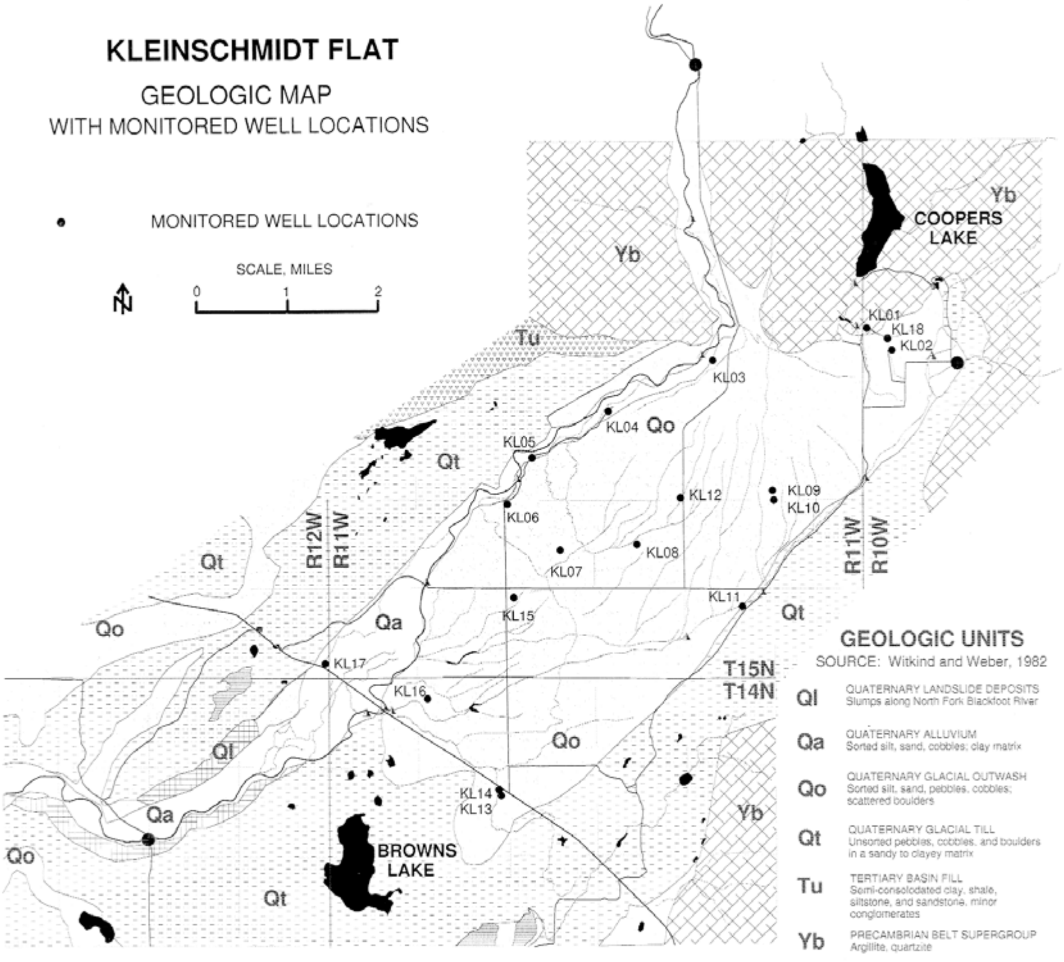


Figure 2. Geologic map of the Kleinschmidt Flat area.

Flat on each side. As described by Witkind and Weber (1982), the till is a heterogeneous mixture of unsorted sand, gravel and boulders in a clayey matrix. As the mass of ice melted, sediment-rich meltwater flowed across Kleinschmidt flat, depositing glacial outwash in the area previously occupied by ice. The flat appearance of the valley is a result of the deposition of glacial outwash. The outwash consists of generally sorted silt, sand, granules, pebbles, and cobbles. Large glacial erratics, as large as 5 to 8 feet on a side, are scattered irregularly through the deposit and across the surface. According to Witkind and Weber (1982), the upper few feet is fine to medium sand at some locales. Available well logs recorded by water well drillers in the area indicate that the outwash materials are hundreds of feet thick beneath the flat.

The surface of Kleinschmidt Flat slopes from the northeast to the southwest. Toward the upper northeast end of the flat, channels up to 40 feet deep fan outward across the flat, emanating from the mouth of the North Fork Blackfoot River canyon at the north end of the flat. These channels become shallower toward the central part of the flat.
Figure 1 shows principal features in the Kleinschmidt Flat area.

The North Fork Blackfoot River occupies a deeply incised channel along the northwest edge of Kleinschmidt Flat. The channel sides are poorly consolidated and unconsolidated materials, and form unstable, actively eroding cliffs that are 80 to 100 feet high at the upper end of the flat. The channel is deepest and narrowest near the mouth of the North Fork Blackfoot River canyon, and gradually widens and becomes shallower as the river approaches the southwest corner of Kleinschmidt Flat. At the mouth of the canyon, the channel is only a few hundred feet wide from the top of one side to the other. Near Highway 200, the channel valley is much wider and not nearly as steep. The terrace that separates the wide channel from Kleinschmidt Flat is perhaps 20 feet high. The west-side of the floodplain abuts glacial till that forms bumpy hills. South of the highway, the valley narrows as it enters an area blanketed by glacial till. The steep valley sides are prone to landslides, which have been mapped by Witkind and Weber (1982) and are visible on aerial photographs.

Water Use

The entire upper Clark Fork Basin (the Clark Fork River above Milltown Reservoir, the Blackfoot River, and all tributaries) is a closed basin, that is, closed to new appropriations of surface water. There are exceptions for stock use and groundwater development. The Blackfoot River drainage has not yet been adjudicated in the State of Montana’s general stream adjudication program. While some decrees do exist between competing water users, the project area streams have not been adjudicated on a broad scale.

The primary use of water on Kleinschmidt Flat is agriculture. Surface water is diverted for flood and sprinkler irrigation to provide water for alfalfa, timothy hay, clover, and pasture grasses. Many ditches provide the dual purpose of providing water for irrigation and livestock. Other water uses such as domestic and commercial play a minor role in the water budget of the North Fork Blackfoot River. The irrigation season lasts from mid-to-late April through September. Some ditches may stay open late in the year to water stock.

The Powell County Water Resources Survey (1959) delineates about 1500 irrigated acres on Kleinschmidt Flat. Approximately 4650 acres are claimed for irrigation. A full accounting of information pertaining to landowner water rights in the Kleinschmidt Flat area is provided by stream and priority date in Appendix I. Included in these tables are: water right owner name, type of use, rate, claimed acres, estimated acres, method of use, priority date, location, and where applicable, ditch used. These data were obtained from “Statements of Existing Water Right Claims” and “Provisional Permits to Appropriate Water” as displayed in water rights files on record with the DNRC. They do not, at this time, represent verified or adjudicated records. Many of the water rights listed in Appendix I are unverified claims and may not accurately reflect present or historic irrigation practices. Field observations indicate actual irrigated use is considerably less than claimed in some water rights. Based on the Powell County Water Resource Survey, the water rights database, and field observations, it appears irrigated acres have fluctuated over the years. The amount of acres historically irrigated on Kleinschmidt Flat most likely lies between the acreage claimed in the water right database and irrigated acres presently in use. Present irrigated acres were estimated through field observation, landowner interviews, and aerial photo analysis. Table 1 lists actual water right and permit claims and estimates made for present use, including a breakdown between methods of use.

Table 1. Kleinschmidt Flat Water Use	*water rights claims and permits**			*estimates based on use in 2000 (acres)*			
stream	acres	total appropriation** (cfs)	irrigation appropriation only (cfs)	acres	flood	center pivot	Other Sprinkler
North Fork Blackfoot R	3355	888	262	1849	764	715	370
Rock and Dry Creek (and Kleinschmidt Creek)	1031	146	113	110	70	0	40
Salmon Creek	355	86	52	10	10	0	0
Total	**4740**	1120	427	**1969**	844	715	410

** data obtained form DNRC records*

*** includes water appropriated for irrigation, stock, recreation, domestic, fish and wildlife, and commercial use*

The total estimated irrigated acreage on Kleinschmidt Flat for the year 2000 is approximately 1969 acres, or about 3.1 square miles. In contrast, the total of claimed irrigated acres as shown on Table 1 is 4740 acres, or approximately 7.4 square miles.

STUDY DESIGN

To assess current watershed hydrology, efforts focused on characterizing surface and groundwater resources. The surface water assessment focused on measuring stream and ditch flows synoptically in an effort to quantify seepage gains and losses. To assess the groundwater hydrology of this area, a well network was established and monitored to spatially characterize water levels. Well logs were examined to supplement known geologic conditions in the area.

Surface Water Study

The main focus of the surface water study evaluated stream seepage gains and losses and ditch conveyance efficiencies. Fluctuations in stream and ditch flow, not accounted for by normal rise and fall of inflows, can be attributed to two factors, diversion of surface water and interaction with groundwater. To assess flow conditions at a given time and ultimately determine gaining or losing reaches, synoptic flow measurements were taken concurrently (within 48 hours during constant discharge conditions) from the perennial streams in the study area: North Fork Blackfoot River, Rock Creek and Salmon Creek. Kleinschmidt Creek, a tributary of Rock Creek, was periodically measured but not synoptically. Eleven irrigation and stock watering ditches were measured as well. The idea behind synoptic flow measurements is to capture a “snapshot” of surface flow conditions in order to evaluate gains and losses. All surface inflows and outflows must be quantified during the run. Gains and losses were measured using the following equation:

$$\text{Gain/Loss} = (\Sigma\text{Basin Outflows} - \Sigma\text{Basin Inflows}) + \Sigma\text{Basin Diversions}$$

Surface water gains and losses determined in this calculation are assumed to result entirely from interaction with ground water. In other words, losses due to seepage of surface water to groundwater and gains due to returns of subsurface flow. Direct evaporative loss is assumed negligible.

Inflow to the study area was monitored using two continuous gaging stations:

- 12337900 – “North Fork Blackfoot River below Lake Creek near Ovando”
  (inflow station maintained by USFS)
  Period of Record: 1991 to present
  Located 16.1 miles upstream of the Blackfoot River confluence.

- 12338100 – “Rock Creek above Salmon Creek near Ovando”
  (inflow station maintained by USGS)
  Period of Record: May 1998 to October 1998
  Located 0.25 miles upstream of Salmon Creek confluence.

Outflows were monitored using gage data from a station located approximately 3 miles downstream from the highway 200.

- 12338300 – “North Fork Blackfoot River above Dry Gulch near Ovando”
  (outflow station maintained by USGS)
  Period of Record: October 1997 to September 1998
  Located 2.5 miles upstream of the Blackfoot River confluence.

Miscellaneous discharge measurements on streams and ditches were taken using a portable flow meter (Marsh-McBirney).

Three streams and 11 ditches were periodically measured over the past several field seasons (Table 2). Most ditch names refer to the primary users or the historical users of the ditch.

Table 2. Surface water locations monitored for study. Dates indicate years when some measurements occurred.

Streams Monitored	
North Fork Blackfoot River	1997-2000
Rock Creek	1997-2000
Salmon Creek	1997-1998
Ditches Monitored	
Lund-Jorgenson	1997-1998
Jorgenson	1997-1998
Lund	2000
Hoxworth-Williams	2000
Hoxworth (NFBF)	2000
O’Connell-Oehl	2000
Weaver-Rue	1999-2000
Weaver	2000
Jacobsen	2000
Spawn Lake Div.	1999-2000
Salmon Creek Diversion	2000

Streams

The only perennial mainstem tributary that directly contributes to the North Fork Blackfoot River within the study area is Rock Creek. Rock Creek has often been referred as Dry Creek. Some claimed water rights use the two names interchangeably. This report distinguishes the two based on the USGS Coopers Lake 7.5 minute quadrangle (1968) which delineates Dry Creek as a tributary of Rock Creek in the northeast corner of the study area on Forest Service land. Rock Creek flows southwest along the eastern margin of Kleinschmidt Flat for several miles before taking a more westerly course across the valley and joining the North Fork Blackfoot River near Highway 200. Rock Creek supports several diversions for irrigation and stock watering. The reach of Rock

Creek that flows along the east edge of Kleinschmidt Flat and partially out into the Flat is identified as intermittent on the Coopers Lake quadrangle.

Salmon Creek is a tributary of Rock Creek. Flowing out of Coopers Lake, Salmon Creek continues to the south and west through Spawn Lake and several ranches before entering Rock Creek in the northeast corner of Kleinschmidt Flat. Like Rock Creek, Salmon Creek supports diversions for irrigation and stock watering.

Ditches

- North Fork Blackfoot River

Six diversions from the North Fork Blackfoot River were monitored (Figure 3).

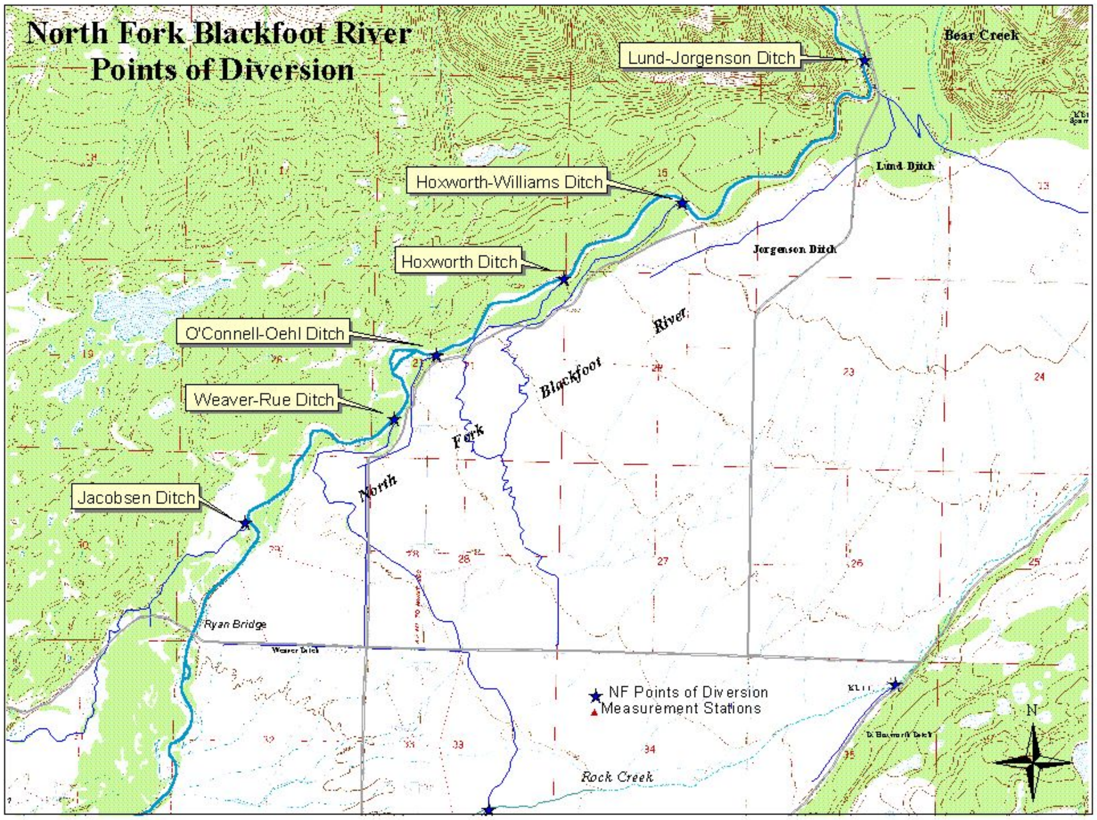


Figure 3. North Fork Blackfoot River points of diversion.

The Lund-Jorgenson Ditch is the furthest upstream diversion on the North Fork Blackfoot River. The ditch parallels the river for approximately 1.5 miles before splitting into two separate ditches, the Jorgenson and the Lund Ditch. The Jorgenson Ditch parallels the North Fork Blackfoot River for several miles while servicing flood and sprinkler irrigated lands in this area. The Lund Ditch conveys water eastward across the northern edge of Kleinschmidt Flat and provides water for some flood irrigation and stock.

The Hoxworth-Williams Ditch diverts water primarily to service center pivot and wheel-line systems.

The Hoxworth Ditch carries water parallel to the Hoxworth-Williams ditch for more than a mile before the two ditches join. It is only operable above a specific water level in the river and therefore is not always in use.

The next downstream diversion is the O’Connell-Oehl ditch. This ditch conveys water approximately 1.2 miles to a pump station that services a center pivot near the east-west road.

The Weaver-Rue Ditch, also referred to as the Ryan-Healy Ditch, has a headgate on the North Fork Blackfoot River located approximately four miles upstream from Highway 200. It diverts water to the southeast across Kleinschmidt Flat and provides water to several areas in the southern portion of the flat. Below the east-west road the ditch splits and the Weaver lateral diverts water to the west and the Rue ditch continues southeast towards Rock Creek.

The Jacobsen Ditch diverts water from the west-side of the river to several irrigated fields near Highway 200.

- Salmon Creek

Two diversions are located on Salmon Creek (Figure 4).

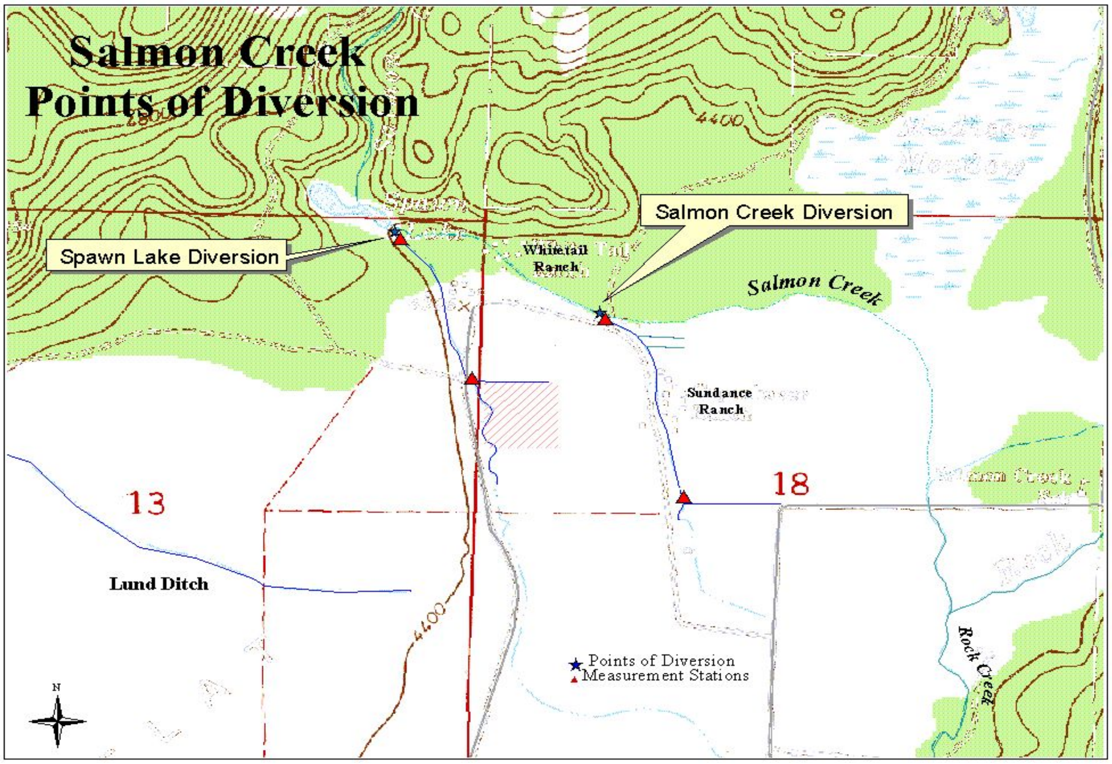


Figure 4. Salmon Creek points of diversion.

The Spawn Lake Diversion distributes water to a small flood irrigated parcel south of the Whitetail Ranch. Further downstream, the Salmon Creek Diversion waters stock on the Whitetail and Sundance Ranches.

- Rock Creek

Two diversions on Rock Creek, D. Hoxworth Ditch and Rue Ditch, were monitored at the point of diversion during synoptic runs on Rock Creek but only the Rue Ditch was measured beyond the headgate (Figure 5).

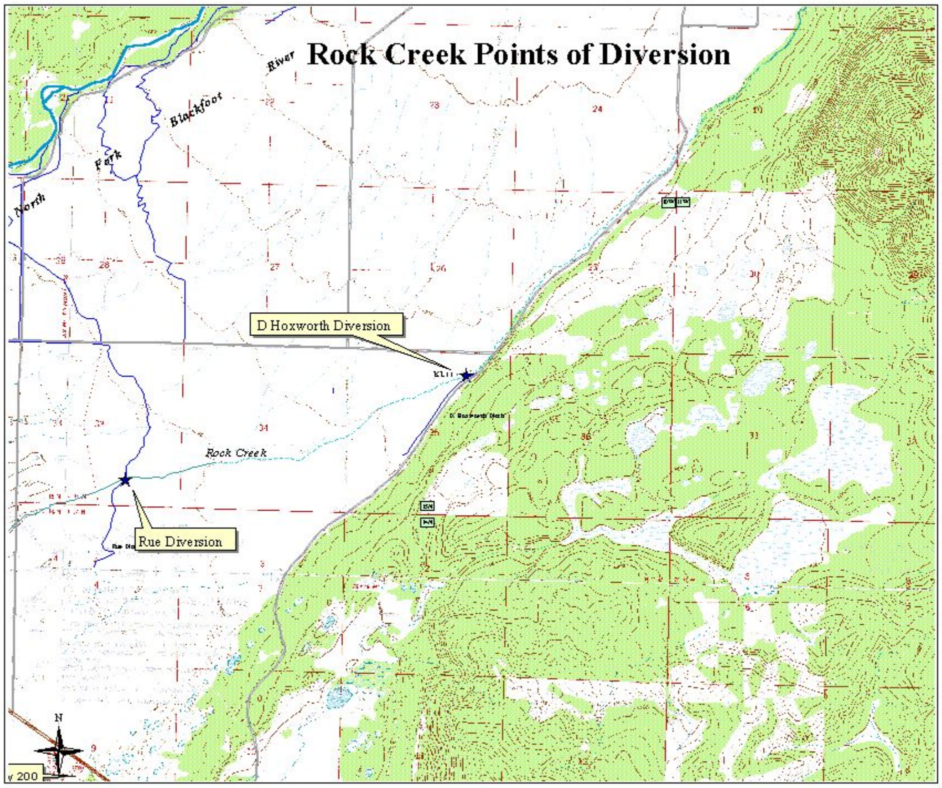


Figure 5. Rock Creek points of diversion.

Groundwater Study

Groundwater in the area was studied by compiling available geologic and groundwater information, and by measuring groundwater levels monthly in eighteen area wells for a year. Infrared aerial photographs and well logs from state records were also obtained for the study area. The information was evaluated to characterize the general groundwater setting and to investigate how it relates to surface water flows.

The locations of wells monitored during the study are shown on the geologic map (Figure 2). All of the wells are domestic and stock wells. Table 3 provides basic information about the monitored wells. Well KL07, located near the middle of Kleinschmidt Flat, was equipped with a water level and temperature recorder for about eight months. It recorded data every six hours. The well was equipped with a recorder because there was no pump in the well, so the site afforded an opportunity to collect continuous data to compare with monthly measurements.

Table 3. Water wells monitored during the study

Well ID	**Location**	**Name**	**Depth (ft.)**	**Map Elev. (ft.)**	**MBMG #**
KL01	15N10W18BBBC	White Tail Ranch	?	4395	?
KL02	15N10W18BDBD	Sundance Ranch	?	4390	?
KL03	15N11W14BDCD	Norman Jorgenson	244	4440	M:132918
KL04	15N11W22BBAB	John Roe	?	4360	M:71541 ?
KL05	15N11W21CABA	Gary Aitkin	120	4290	M:123212
KL06	15N11W28BBBB	Steve Ambrose	71	4260	M:71546
KL07	15N11W28DBAC	Ray Hoxworth	58	4260	none
KL08	15N11W27BDDD	Price Williams	75	4310	M:135524
KL09	15N11W23DDDA	David Mannix	150	4375	M:138596
KL10	15N11W25BBBB	WTR Outfitters	140	4370	M:164083
KL11	15N11W35ABDC	Duane Hoxworth	75	4300	none
KL12	15N11W22DDDD	John Roe	115	4350	M:152543
KL13	14N11W08ADAC	Terry Smith	17	4200	M:138585
KL14	14N11W08ADAB	Terry Smith	40	4200	M:71554
KL15	15N11W33BBBD	Ruby Geary	44	4220	?
KL16	14N11W05BBC	Jon Krutar	12	4170	none
KL17	15N12W36DDAD	Gary Jacobsen	?	4160	?
KL18	15N10W18BACC	White Tail Ranch	100	4390	?
KL19	15N11W34BDAA	White Tail Ranch	42	4270	M:71555

RESULTS

Surface Water

Data collected on the streams and ditches of Kleinschmidt Flat indicate consistent flow loss to groundwater in the northeastern three-fourths of the study area. Streams lose water as they flow out of the mountains across the flat until they intersect groundwater discharging in the southwestern quarter of the study area. At this point, dramatic increases in surface flow were measured in the North Fork Blackfoot River, Rock Creek and Kleinschmidt Creek. In other words, groundwater is recharged by surface flows in the upper three-quarters of the flat, and surface water is recharged by groundwater in the lower quarter of the flat. Another way of looking at groundwater influence on surface flows is shown by a simplified water balance shown as Table 4. All basin inflows, stream diversions, and basin outflow were measured. Large gains in surface flow occur for each sampling period, even during dry water years such as 2000. Based on this data, it appears that groundwater is discharging into the surface water system.

Table 4. Kleinschmidt Flat Water Budget

	inflow	diversions	outflow	gain/loss
08/27/1997	172	-35	223	86
09/09/1997	133	-30	179	76
07/22/1998	345	-37	326	18
08/14/1998	185	-40	191	47
09/24/1998	85	-15	126	56
09/07/2000	70	-22	88	40

Inflow and outflow data (continuous gages) are presented in Appendix II. The 2000 data set is provisional and subject to revision. Miscellaneous flow measurements taken on streams and ditches are presented in Appendix III. Results of synoptic flow measurement runs identifying natural gains and losses are presented below. Loss of surface flow is calculated as a percent of flow for each stream or ditch.

North Fork Blackfoot River

As mentioned, North Fork Blackfoot River flows were continuously monitored at two sites, the Forest Service boundary (inflows) and 2.5 miles upstream from its confluence with the Blackfoot River (outflows). Figure 6 shows the relationship between the two stations during the irrigation season of 2000. Outflow is consistently greater than inflow even during low flow periods due to other basin inflows (Rock Creek, Salmon Creek, and Spring Creek) and groundwater released from available storage in Kleinschmidt Flat.

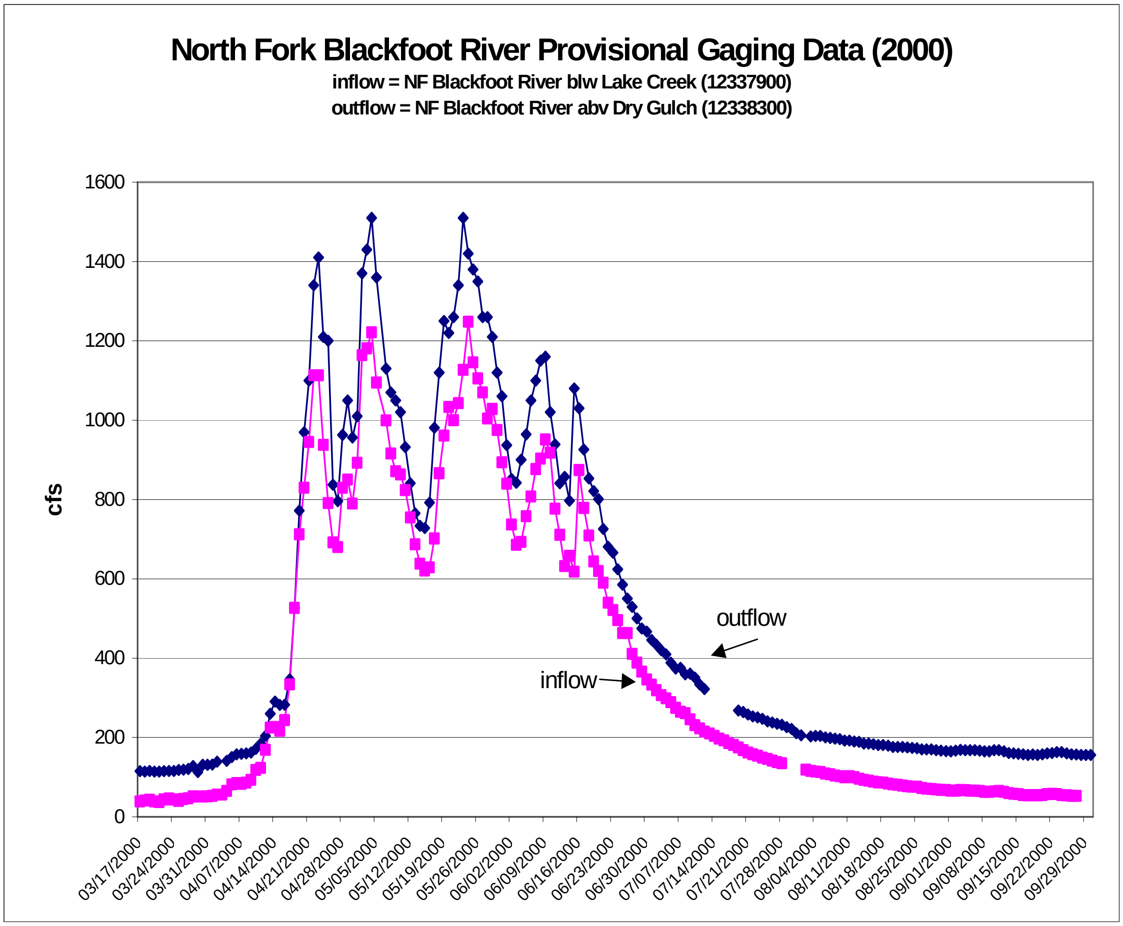


Figure 6. Inflows versus outflows on the North Fork Blackfoot River for the 2000 irrigation season.

Streamflow gains and losses were observed on the North Fork Blackfoot River during several synoptic runs in 1997, 1998, and 2000 (Figure 7). Streamflows measured between the Forest Service gage and Ryan Bridge (approximately 8.2 miles), decrease in the downstream direction due to diversions and seepage. Between Ryan Bridge and Highway 200, flows increase substantially.

A closer look at gains and losses is shown in Table 5. Here, the results of eight synoptic measurement runs taken on the North Fork Blackfoot River during irrigation season are listed. Streamflow diversions averaged about 25 cfs in the upper reach (above Ryan Bridge) while flow reductions due to seepage losses average nearly 42 cfs or 33% of the inflow. Conversely, an average of about 76 cfs returns to the river in the 1.8 miles between Ryan Bridge and Highway 200 (includes Rock Creek). Again, these gains and losses can be accounted for by the losses to or gains from groundwater.

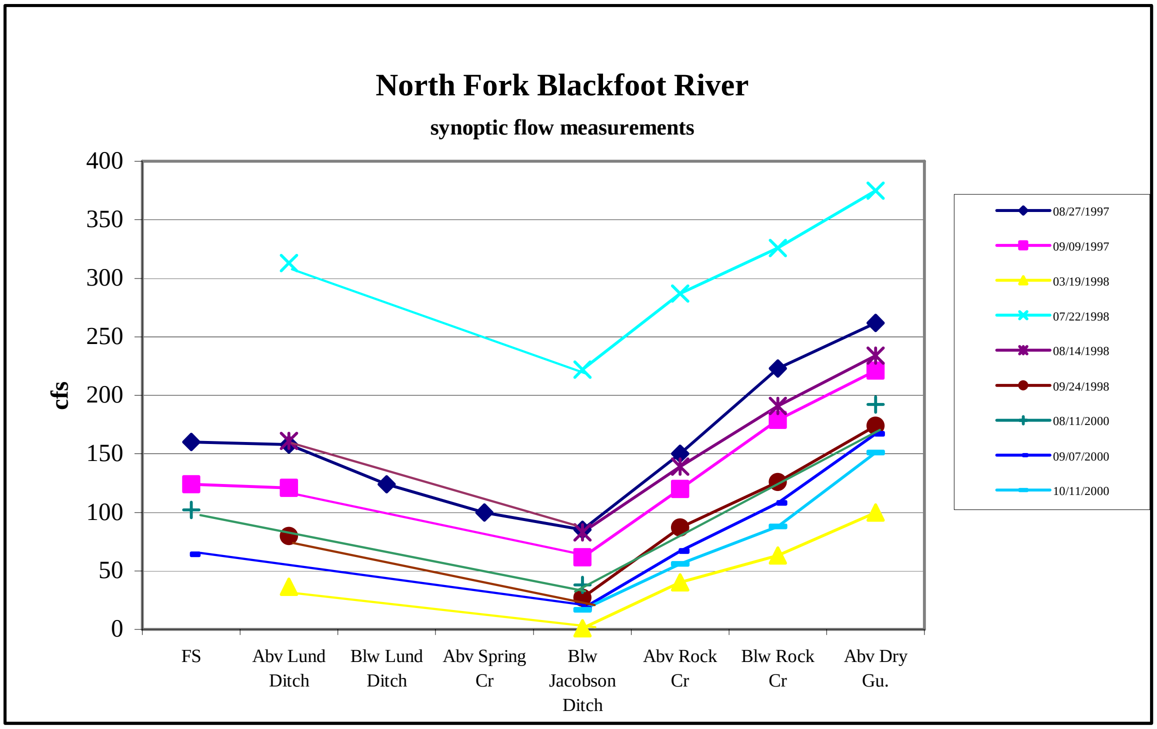


Figure 7. North Fork Blackfoot River synoptic measurement runs 1997-2000.

date	inflow (abv L-J Ditch)	total diversions	Ryan Bridge	natural loss	% natural loss	below Hwy 200	Ryan Bridge to Hwy 200 gain	% gain
	(cfs)	(cfs)	(cfs)	(cfs)		(cfs)	(cfs)	
08/27/1997	158	-28.6	85	-44.4	28.1	194	109	128
09/09/1997	121	-23	61.5	-36.5	30.2	158.5	97	158
07/22/1998	313	-26	222	-65	20.8	290	68	31
08/14/1998	161	-30.2	83	-47.8	29.7	166	83	100
09/24/1998	80	-13	27.1	-39.9	49.9	113.1	86	319
08/11/2000	102*	-31	37.9	-33.1	32.5	--	--	--
09/07/2000	65*	-22.1	17.7	-25.2	38.8	107.7	90	509
10/11/2000	--	--	16.5	--	--	88.5	72	436
*provisional	Average =	-24.8		-41.7	32.8		76	

Table 5. Numerical account of North Fork Blackfoot River synoptic measurement runs 1997-2000.

The distribution of flows in the North Fork Blackfoot River can be observed in a flow duration series for the 1998-2000 record at the North Fork above Dry Creek USGS gage (Figure 8). The flow duration curve gives a broad indication of overall movement of water through the basin. It compares mean daily discharge and the probability of exceeding that discharge. For example, for the three years represented, a flow of 190 cubic feet per second (cfs) is equaled or exceeded 40% of the time. Another interpretation indicates that 60% of the time, flows are less than 190 cfs. The flat slope of the lower end of the curve indicates low flows are sustained over much of the water year and is typical of a stream draining a basin of high ground-storage capacity (Leopold 1994).

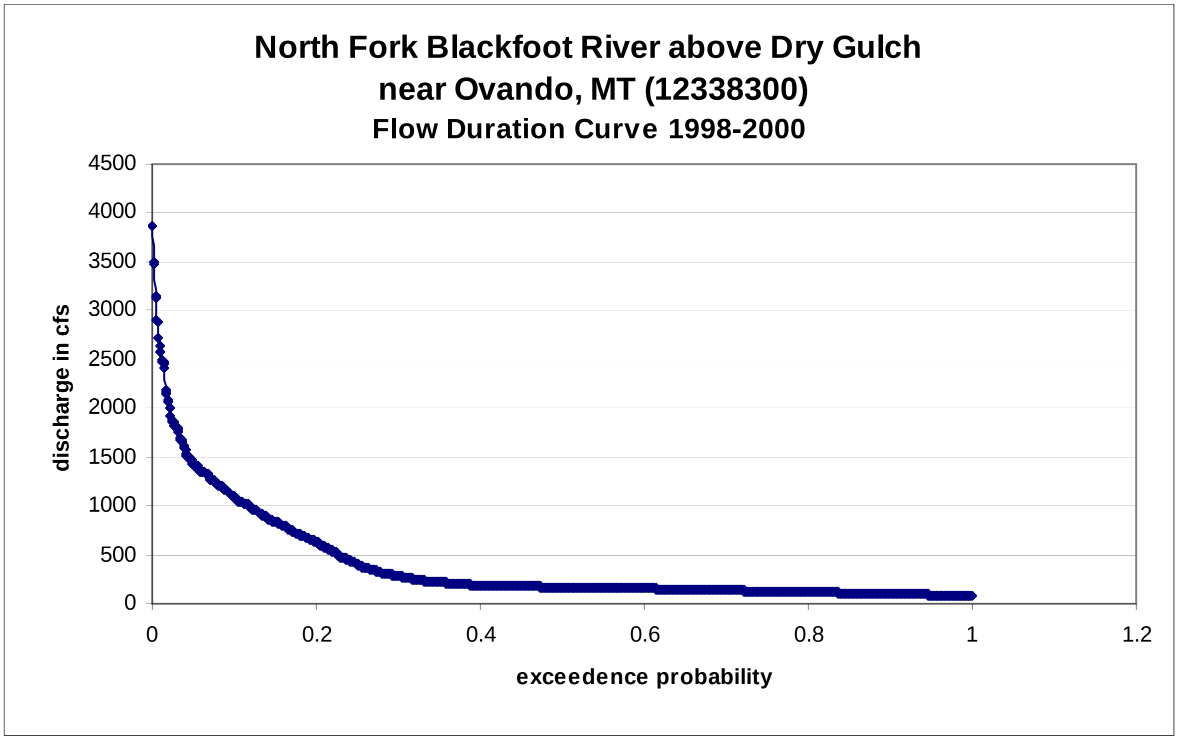


Figure 8. Flow Duration Series for North Fork Blackfoot River USGS gage, 1998-2000 (station number 12338300).

Rock Creek

Synoptic measurements taken on Rock Creek are shown in Figure 9. Surface flow losses were observed between the USGS gage above Salmon Creek and 6.5 miles downstream at the main Kleinschmidt Flat road (North-South Road). Large gains in surface flows are observed in the lower mile of Rock Creek above its confluence with the North Fork Blackfoot River. Measured streamflows increase between 500 and 1000% between the North-South road and the mouth of Rock Creek.

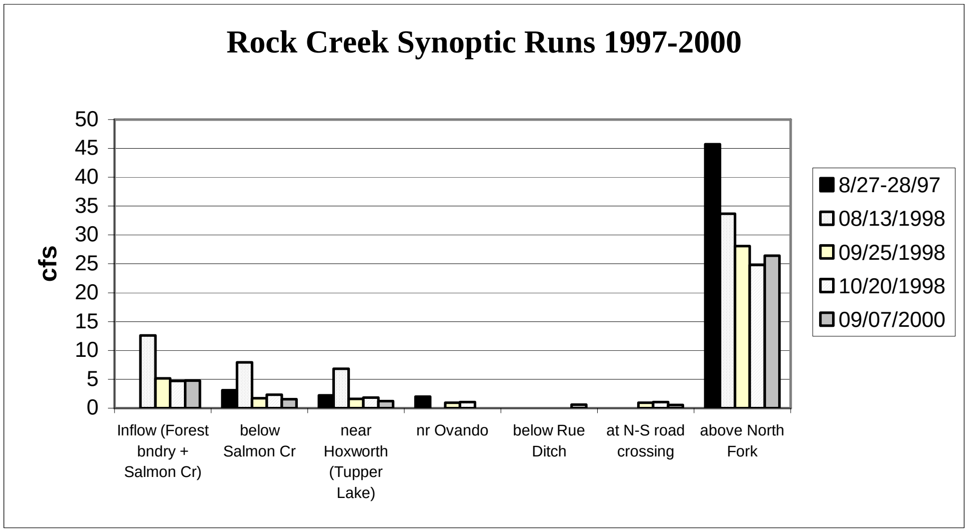
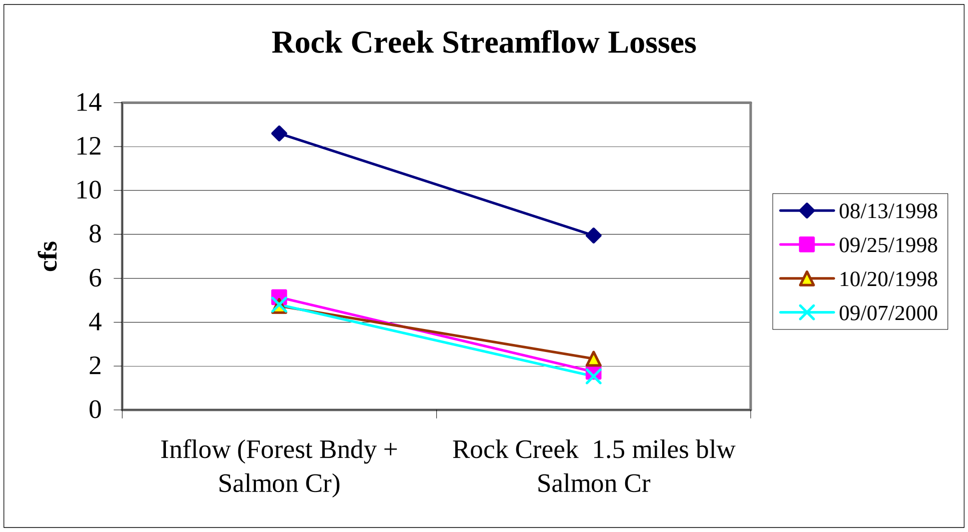


Figure 9. Rock Creek synoptic measurements.



Rock Creek Discharge (cfs)				
	08/13/1998	09/25/1998	10/20/1998	09/07/2000
Inflow (Forest Bndy + Salmon Cr)	12.6	5.14	4.74	4.8
Rock Creek 1.5 miles blw Salmon Cr	7.95	1.74	2.33	1.53
percent loss observed =	37	66	51	68
			Mean =	**56**

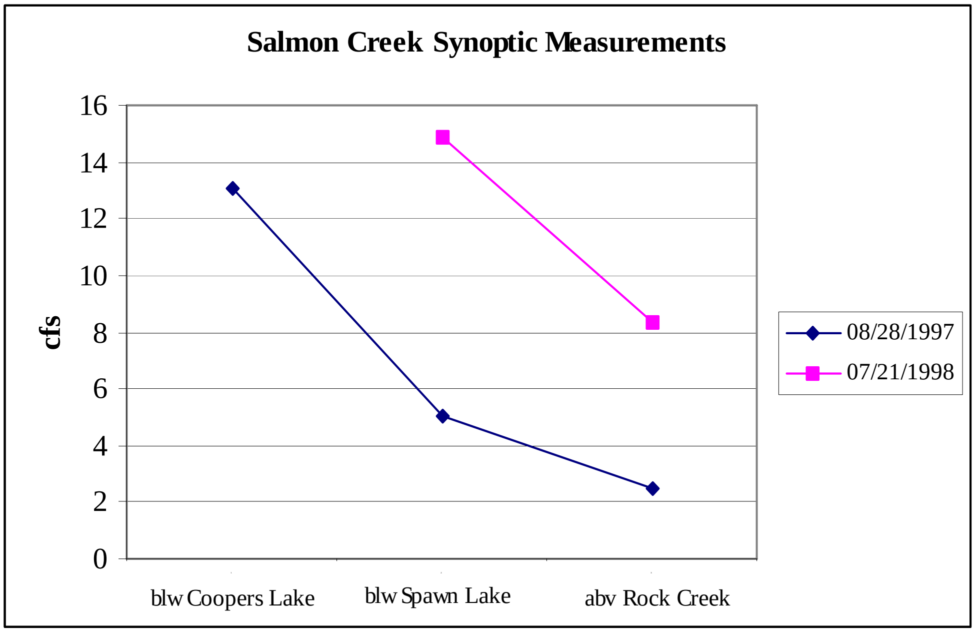
Figure 10. Streamflow losses in Rock Creek measured in the 1.5 miles below Salmon Creek.

The 1.5-mile reach below the Salmon Creek confluence exhibited particularly large seepage losses. These losses, shown in Figure 10, averaged 56% during the sampling episodes.

Rock Creek has undergone a substantial amount of stream restoration in its upper reaches near the Salmon Creek confluence as well as below the north-south road. However, large sections of the creek, particularly where the creek crosses the middle of the flat, remain in poor condition. That is, the channel is extremely shallow due to widening. Riparian vegetation is virtually non-existent and streambanks are unstable. These channel conditions do not enhance the carrying capacity of Rock Creek and conversely, may enable greater seepage losses in these reaches by exposing water to more surface area during transport.

Salmon Creek

Very few measurements were taken on Salmon Creek. Streamflow losses were observed in Salmon Creek between Coopers Lake and its confluence with Rock Creek (Figure 11).



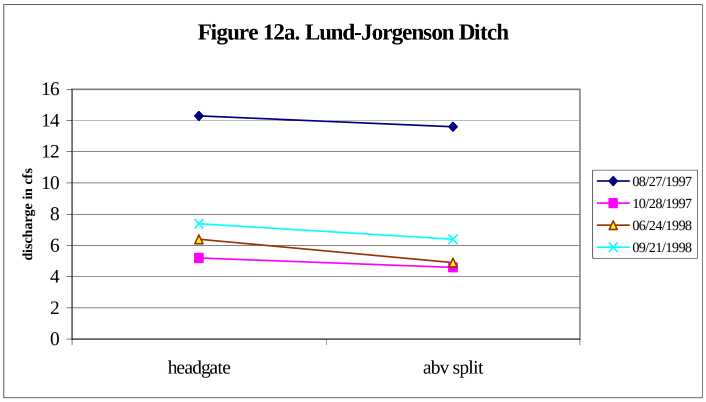
Date	blw Coopers Lake (cfs)	amount diverted	blw Spawn Lake (cfs)	% seepage loss	amount diverted	abv Rock Creek (cfs)	% seepage loss
8/28/97	13.1	5.2	5	22	0.3	2.5	44
7/21/98			14.9		6.1	8.35	3

Figure 11. Salmon Creek synoptic measurements.

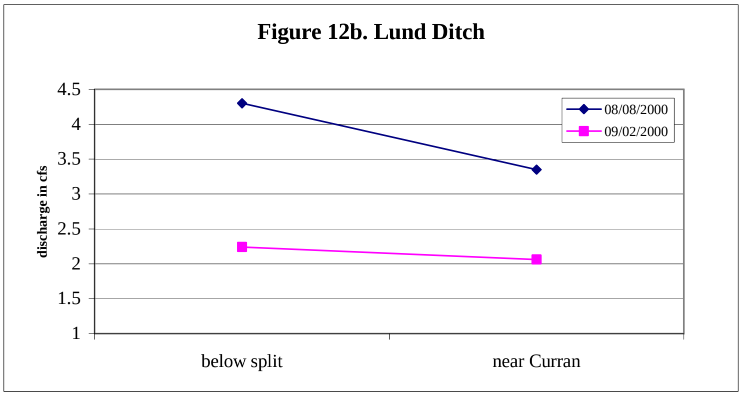
Ditches

Nearly all ditches measured lose water during conveyance. The Spawn Lake Diversion is an exception as no discernable loss was quantified on the short reach measured. Greatest overall loss (i.e. from headgate to place of use) was observed in the Weaver-Rue Ditch. Seepage loss for all ditches tends to be higher earlier in the irrigation season as dry soils initially soak up a lot of water. Results are based on three to five synoptic runs for most of the ditches. Although a greater sampling size would minimize variability it was not within the scope of this project. Three to five measurements is adequate for making generalizations on efficiency of the ditches on Kleinschmidt flat. Brief descriptions of measurement results are provided below for each ditch. Actual measurements and seepage loss calculations are presented in Appendix IV.

Four synoptic measurement runs were conducted on the Lund-Jorgenson Ditch between the headgate and the split approximately 1.5 miles down gradient (Figure 12a). Seepage loss during conveyance ranged between 4.9% on 8/27/97 to 23.4% on 6/24/98. Average loss for the four measurements was 13.3%. The average cubic feet per second loss per mile (cfs/mi) was 0.63. This ditch appears to be in use during most of the irrigation season. The Lund-Jorgenson split equally divides water into two ditches.



Two synoptic measurement runs were conducted on the Lund Ditch (Figure 12b). Losses on the August run were 22% while only 8% for the September run. This ditch was not consistently used during the irrigation season so it is likely the August measurements reflect conditions more recent to ditch turn-on. Per mile loss of surface flows was approximately 0.45 cfs.



Three sets of synoptic measurements were gathered on Jorgenson Ditch between the split and the Rowland House (Figure 12c). These runs were conducted during periods when very little diversion was taking place. Therefore, all losses observed were due to seepage. Ditch maintenance occurred between 1997 and 1998 and may have accounted for some efficiency improvements. Seepage losses between the split and lower Rowland crossing averaged 31% while losses between the lower Rowland crossing and the Rowland house were closer to 60%. Overall loss between the split and the Rowland house was closer to 70%.

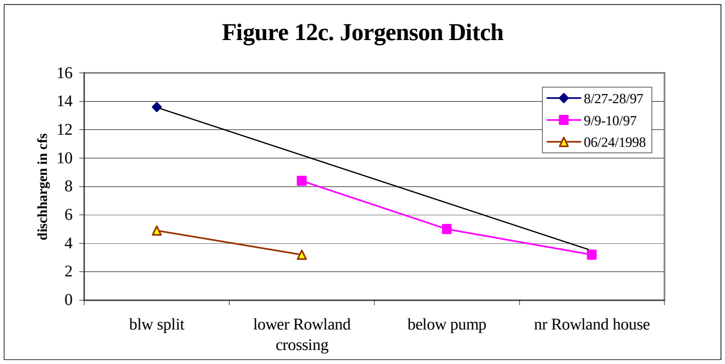


Figure 12c. Jorgenson Ditch

Five synoptic measurement runs were conducted on the Hoxworth-Williams ditch (Figure 12d). All measurements were done in 2000. Most measurements were done between the headgate and road crossing (appx. 1 mile). In this reach, seepage loss was greatest shortly after the ditch was turned on, 55% on 5/11. Losses continued to decline later into the season with 18% recorded on 8/11. Average per mile loss was 2.1 cfs. Two synoptic runs captured losses between the headgate and Williams fence (appx. 0.8 miles). Average loss for this reach equaled 36% or 0.9 cfs/mi.

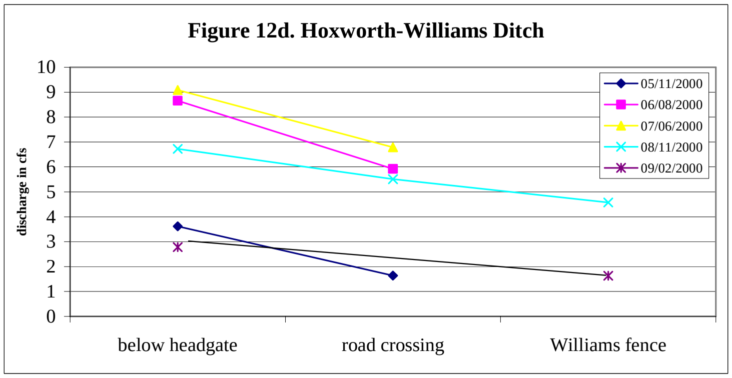


Figure 12d. Hoxworth-Williams Ditch

Hoxworth Ditch is not equipped with a regulating headgate and therefore only in use when the river is discharging above a certain level. The year 2000 was a low water year and therefore the ditch was seldom in use. One synoptic measurement run was conducted in June (Figure 12e) and revealed a 61% loss during conveyance between the headgate and a

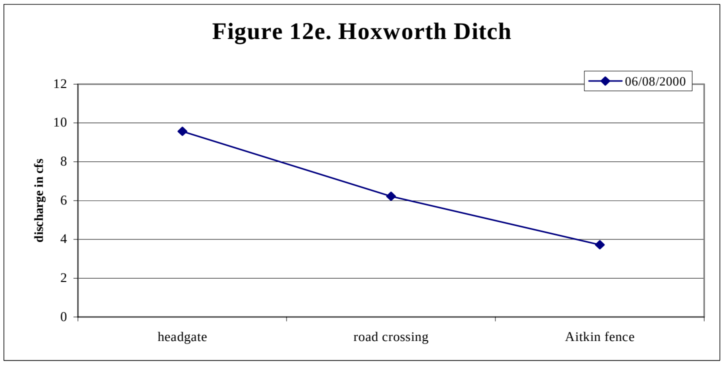


Figure 12e. Hoxworth Ditch

property boundary approximately 1.9 miles down gradient. This value may be misleading as the ditch had only been in use a short time when the measurements were taken and therefore losses may reflect the charging of dry bank soils.

Four synoptic measurements were taken on the O’Connell-Oehl Ditch between the headgate and split box located just below the North-South road (Figure 12f). Significant conveyance losses, measured over this distance of 0.8 miles, were observed early in the irrigation season, 84% on 5/11, and then tapered off to less than 10% in September.

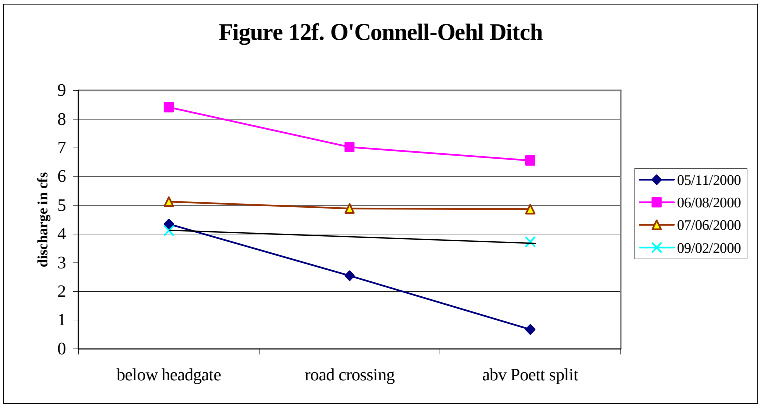


Figure 12f. O'Connell-Oehl Ditch

Surface losses were observed in Weaver-Rue Ditch between its headgate on the North Fork Blackfoot River and approximately 2.75 miles out onto Kleinschmidt Flat where the Rue portion of the ditch crosses Rock Creek. Observations on three synoptic runs indicate that surface losses on the ditch were much greater for the period immediately after the headgate was opened (mid May) than during measurement runs on successive months (Figure 12g). The overall loss of ditch flows in May was 90% while only 29% in July. Of particular note is the reach between Hoxworth and Rock Creek, where the Rue Ditch flows south across the flat. In this reach, conveyance losses were high during all three synoptic runs, averaging 33% and 1.5 cfs/mi. Where the Rue Ditch intersects Rock Creek, very little flowing water was observed during the synoptic runs. Just across Rock Creek—opposite of where Rue Ditch enters—water is diverted out of Rock Creek into a continuation of the Rue Ditch. The nature of surface and groundwater interaction in Rue Ditch below this area was not measured. However, it is suspected that excess water in Rue Ditch below Rock Creek may supplement flows in Kleinschmidt Creek.

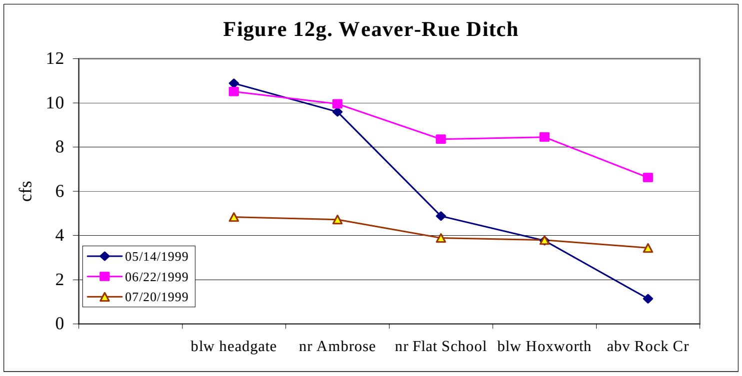


Figure 12g. Weaver-Rue Ditch

One synoptic run conducted on the Weaver portion of the Weaver-Rue Ditch showed over half of surface flows are lost through conveyance between the split junction and Weavers field (Figure 12h). The measurements were taken 8/11/00, after the ditch had been in use most of the irrigation season.

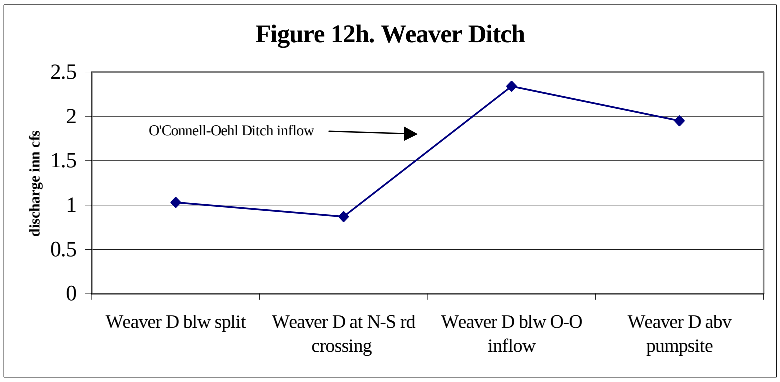


Figure 12h. Weaver Ditch

The three synoptic measurement runs conducted on Jacobsen Ditch between the headgate and road crossing show about a 25% reduction in surface flows occur over the one-mile distance. A seldom used turnout a few hundred yards above the road was in use on 8/8/00 and therefore large losses appear graphically in Figure 12i. In the fields directly below the road crossing, irrigation is frequently occurring and therefore only one measurement was extended to Highway 200. Surface losses were similar in this reach as above, approximately 25%.

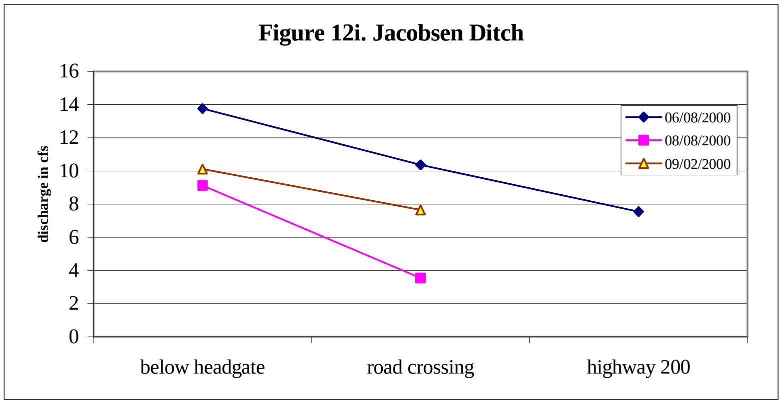


Figure 12i. Jacobsen Ditch

Results of the synoptic runs on the Spawn Lake Diversion show that ditch losses are not significant (Figure 12j). One of the three runs showed a slight loss in surface flows while the other two showed a slight gain. The distance between the point of diversion and place of use is relatively short (0.25 miles). Gains and losses measured, were around 5%.

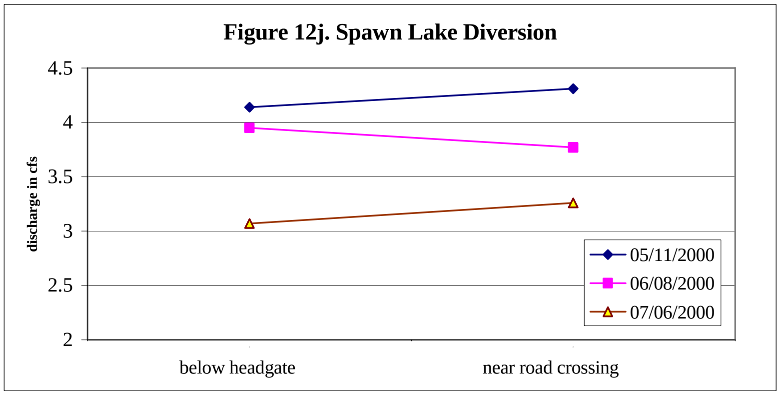


Figure 12j. Spawn Lake Diversion

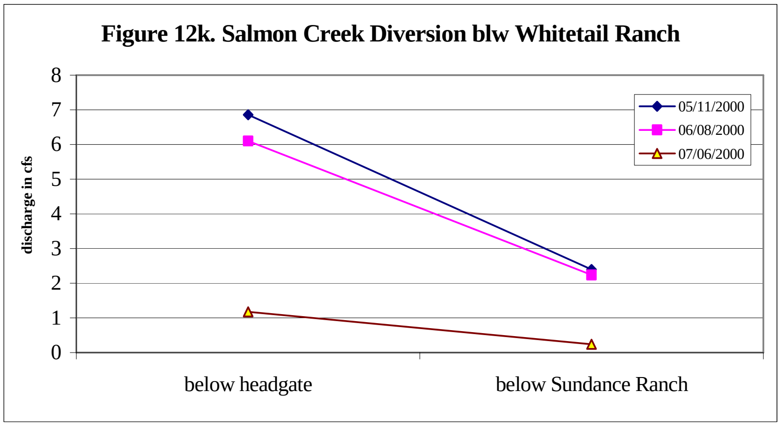


Figure 12k. Salmon Creek Diversion blw Whitetail Ranch

The Salmon Creek Diversion was synoptically measured three times (Figure 12k). Surface losses averaged 37% between the headgate and the driveway of the Sundance Ranch (0.3 miles).

A summary of ditch use by owner, distance to place of use, and average percent loss is summarized in Table 6. These distances and values are estimates based on field observations and field measurements.

Table 6. Ditch distance and efficiency

Ditch	Water User	Distance to Irrigation (miles)	Distance to Stock (miles)	average % loss
Lund	Hutton	2.5	1.9	15
	Curran	--	2.7	15
Jorgenson	Roe	1.8-2.2	1.7	--
Hoxworth-Williams	Williams	1.8	?	46
	Hoxworth	2.5	2	46
Hoxworth	Hoxworth	1.9	--	61
O'Connell-Oehl	Poett	0.8	0.8	30
	Pocha	1.3	--	
	Weaver	1.5-1.9	1.2	
Weaver-Rue	Weaver	2.7-3	2.4	
	Rue	3.6	--	52
	Hooker	--	1.9	
Jacobsen	Jacobsen	1.2-2.3	1.2	24 to 45
Spawn Lake Div.	Whitetail	0.25	0.25	negligible
	Meunier, Perelman	--	0.8	
Salmon Cr Div.				37
D. Hoxworth	Hoxworth	0.4	--	--

Groundwater

Hydrogeologic Setting

Generally, glacial outwash deposits are good aquifers because they consist largely of sorted sand and gravel materials that can store and move groundwater readily in the void spaces between individual grains of sand and gravel. In contrast, glacial till such as that south of Highway 200, and flanking Kleinschmidt Flat as low hills at the base of the mountains, acts as an aquitard, or a material through which groundwater does not readily move, in this case due to its high clay content.

Kleinschmidt Flat is underlain by a glacial outwash aquifer, and this aquifer is essentially isolated by till or bedrock on all sides. Like the ground surface of the flat, the aquifer is tilted to the southwest. At the upper, northeast end of the aquifer, groundwater levels are relatively deep, especially near the end of March and first part of April when groundwater levels are at their seasonal low. Groundwater levels get shallower toward the southwest, approaching and intersecting the ground surface in spring-fed coulees. Figure 13 is a map showing the depth to groundwater in July 1998.

Outwash Characteristics

At Kleinschmidt Flat, well logs and other observations suggest that the outwash is cemented in some areas, both near the surface and at depth. Figure 14 shows the locations of well logs retrieved from the Montana Bureau of Mines and Geology Ground Water Information Center database. The lithologic descriptions are presented in Appendix IV. The cementation is a mineral precipitate that partially fills voids between individual grains of sand and gravel, creating a consolidated rock, in this case sandstone or conglomerate. Also, clay lenses and clay-rich gravels are reported for some intervals on many of the well logs in the area. The cementation and high clay content may explain why reported well productivity is modest, at least in comparison to what we might expect if the outwash consisted of relatively pure, loosely consolidated or unconsolidated sand and gravel. Well yields of 50 to 70 gallons per minute are reported for some wells near the North Fork Blackfoot River, but yields of 10 to 18 gallons per minute are reported for the few well logs available from the central part of Kleinschmidt Flat. It is possible that greater yields of water could be encountered in parts of Kleinschmidt Flat, but exploratory drilling would be needed to determine the potential for water development. No data is available to determine water quality, but the water is used for domestic and stock purposes in the area.

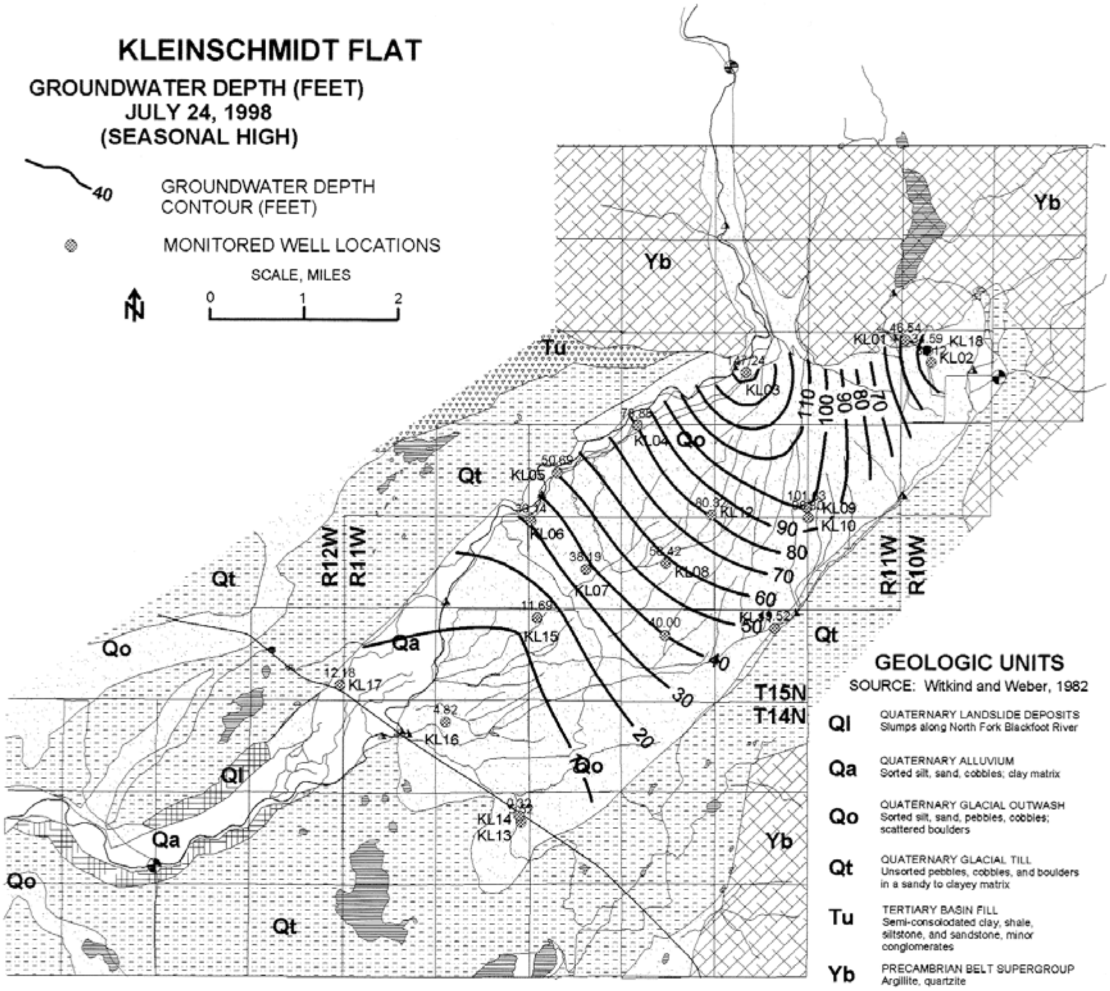


Figure 13. Groundwater depth at Kleinschmidt Flat, July 24, 1998.

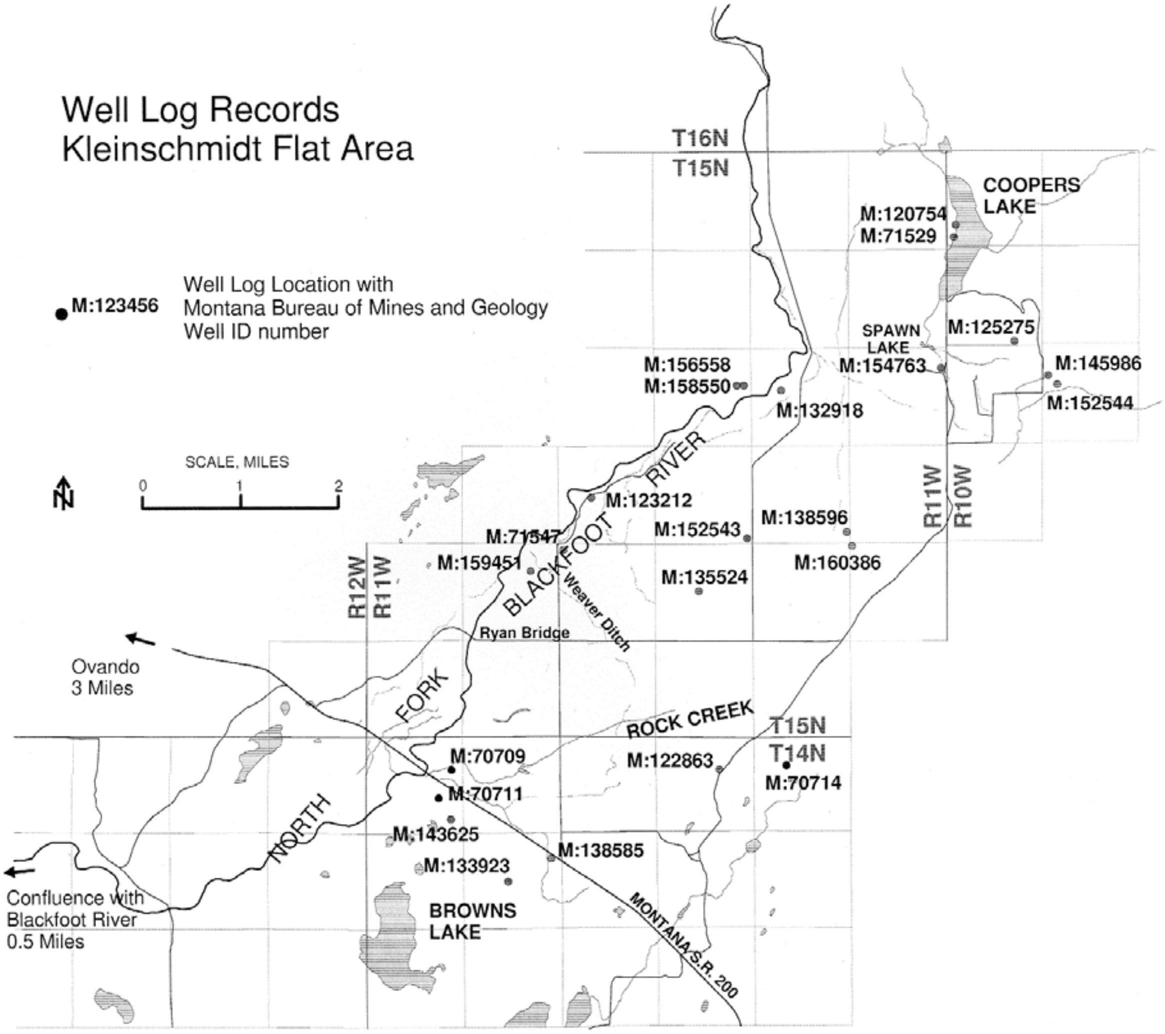


Figure 14. Well log record locations: Kleinschmidt Flat area.

Groundwater Occurrence and Fluctuations

The water table beneath the Kleinschmidt Flat, as mapped out using available data, generally mimics the landscape. Figure 15 shows the contoured groundwater surface for March and July, 1998, respectively. In the north part of the flat the groundwater surface slopes southwest. In the south part of the flat, closer to Highway 200, the groundwater table surface slopes west toward the North Fork Blackfoot River. Springs appear in the coulees at the southwest end of the flat, generally in the vicinity of the 4190 foot contour as shown for the March 1998 map. This is apparent on color infrared aerial photographs, in which the saturated coulee bottom areas stand out distinctly.

Groundwater levels fluctuate seasonally in response to recharge from snowmelt, streams, and irrigation diversions on the flat. Figure 16 is a graph showing the groundwater levels measured in seventeen wells over a period of about one year. Measurements are tabulated in Appendix V. Generally, groundwater levels rise during May, June, and July, and decline from sometime in August until they reach seasonal low levels in mid-Spring. Note that the shallowest wells, those having a depth to groundwater of less than 25 feet, are relatively stable year-round, while wells with deeper water levels tend to have larger fluctuations. Wells KL01 and KL02, located at the northeast end of the flat, have the greatest measured seasonal fluctuations, with groundwater levels nearly 50 feet higher in July than in March.

Groundwater levels recorded at well KL07 near the center of Kleinschmidt Flat are shown in Figure 17. The recorded data and measured data are both shown on the water depth graph. This data provides some verification that the monthly measurements taken in area wells reasonably and adequately describes the general trend of groundwater levels. In this well, the brunt of seasonal groundwater level rise occurred between March 22 and June 21. From June 21 to August 1, water levels stayed high, with minor perturbations. After August 1, water levels generally declined, except for a slight rise at the end of August.

Figure 18 is a graph showing the change in groundwater levels in wells between measurements. The measurements were made about a month apart. Positive values indicate rising groundwater levels. The tendency for water levels to rise during May, June, and July is apparent by the positive values shown for most wells during those months. Note also that groundwater levels declined most rapidly in the interval between mid-September and mid-October.

Figure 19 is a map showing the change in groundwater levels measured between December 4, 1997 and March 6, 1998. This map illustrates the spatial distribution of groundwater level declines during the winter, when recharge is expected to be minimal. Note the even distribution of contours specifying the decline in feet.

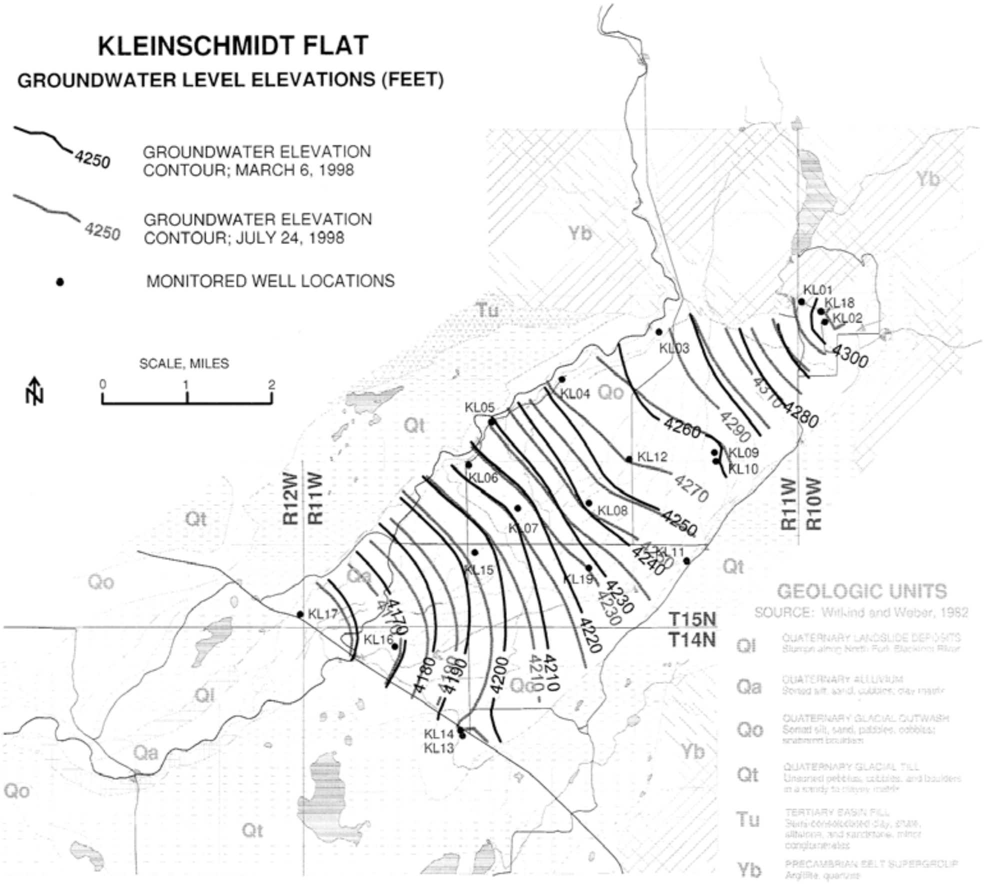


Figure 15. Groundwater elevations at Kleinschmidt Flat

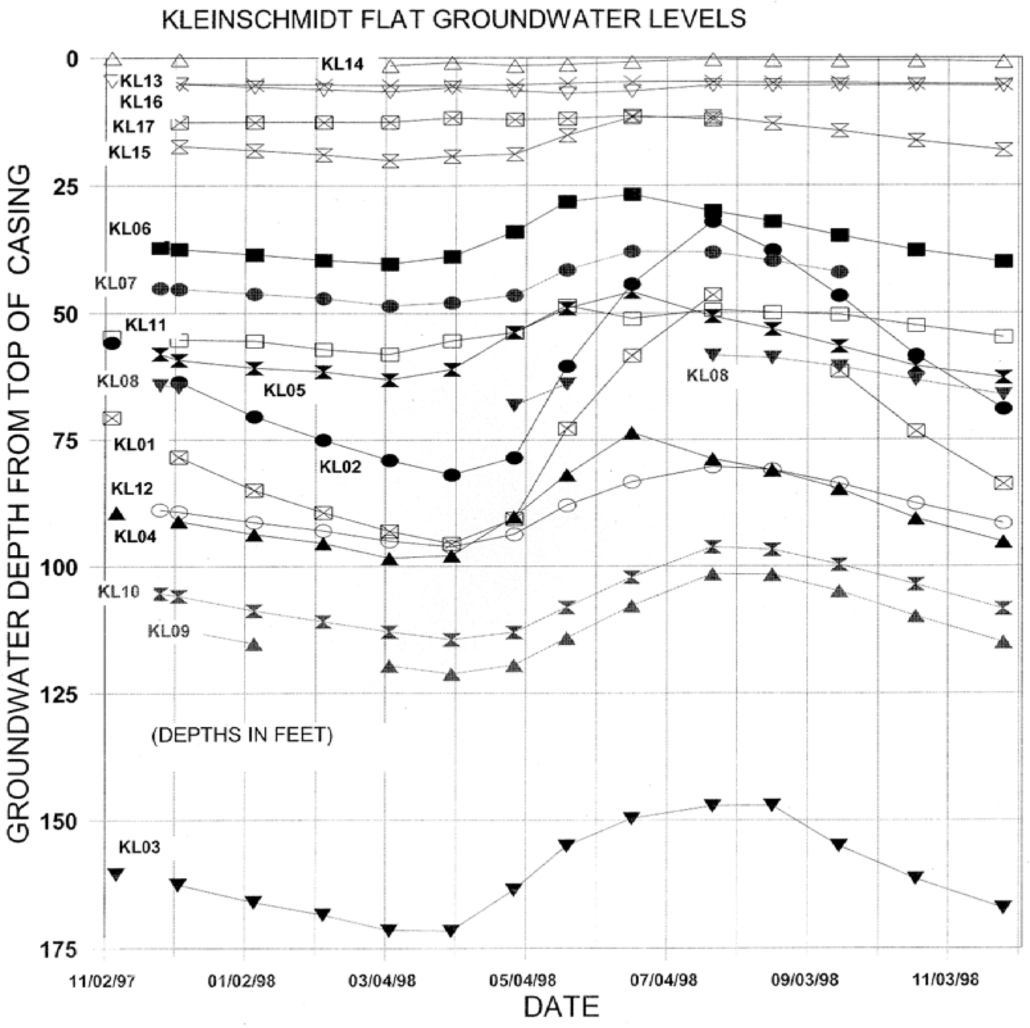


Figure 16. Graph of groundwater level measurements at Kleinschmidt

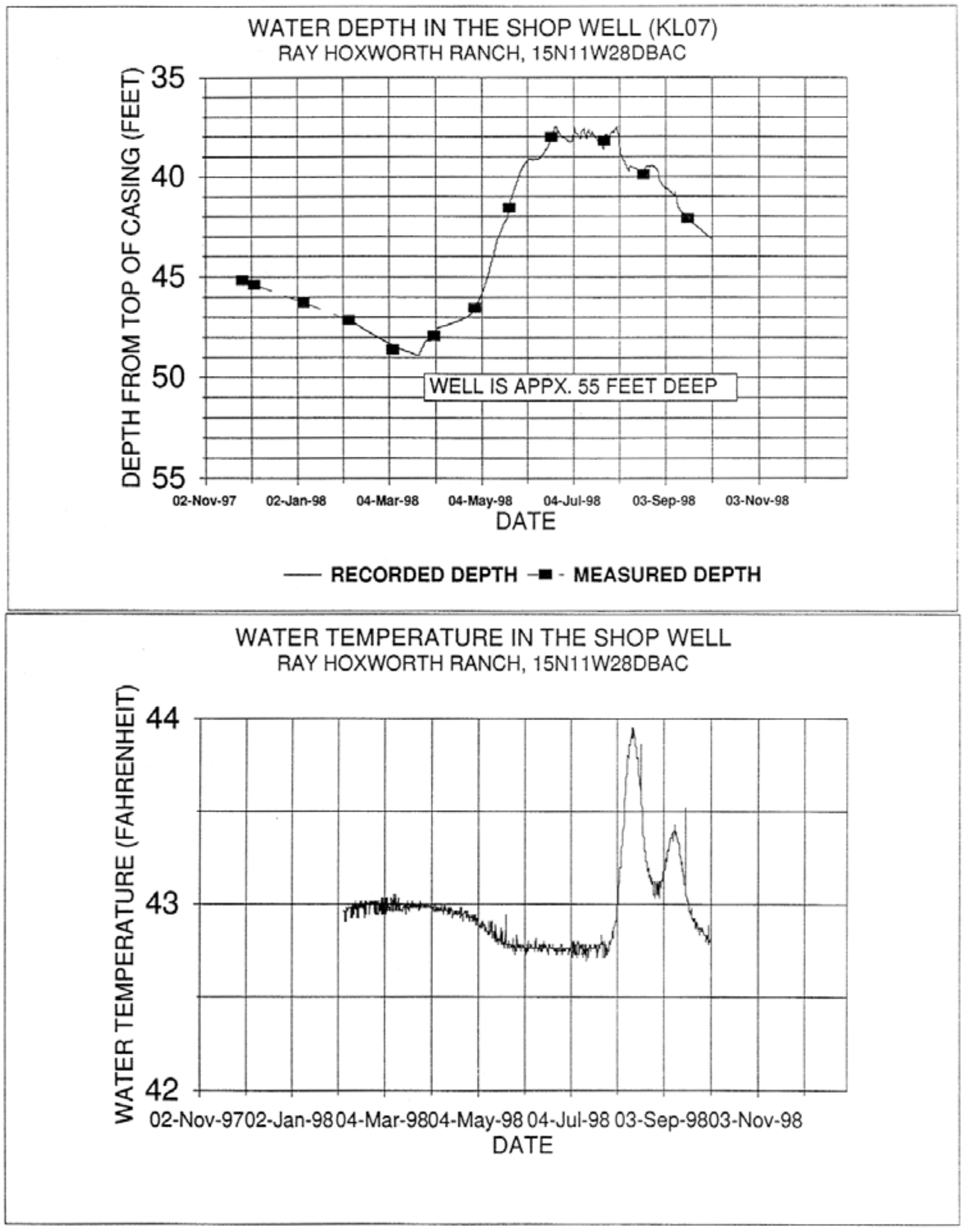


Figure 17. Measured and recorded groundwater levels and recorded groundwater temperatures at well KL07.

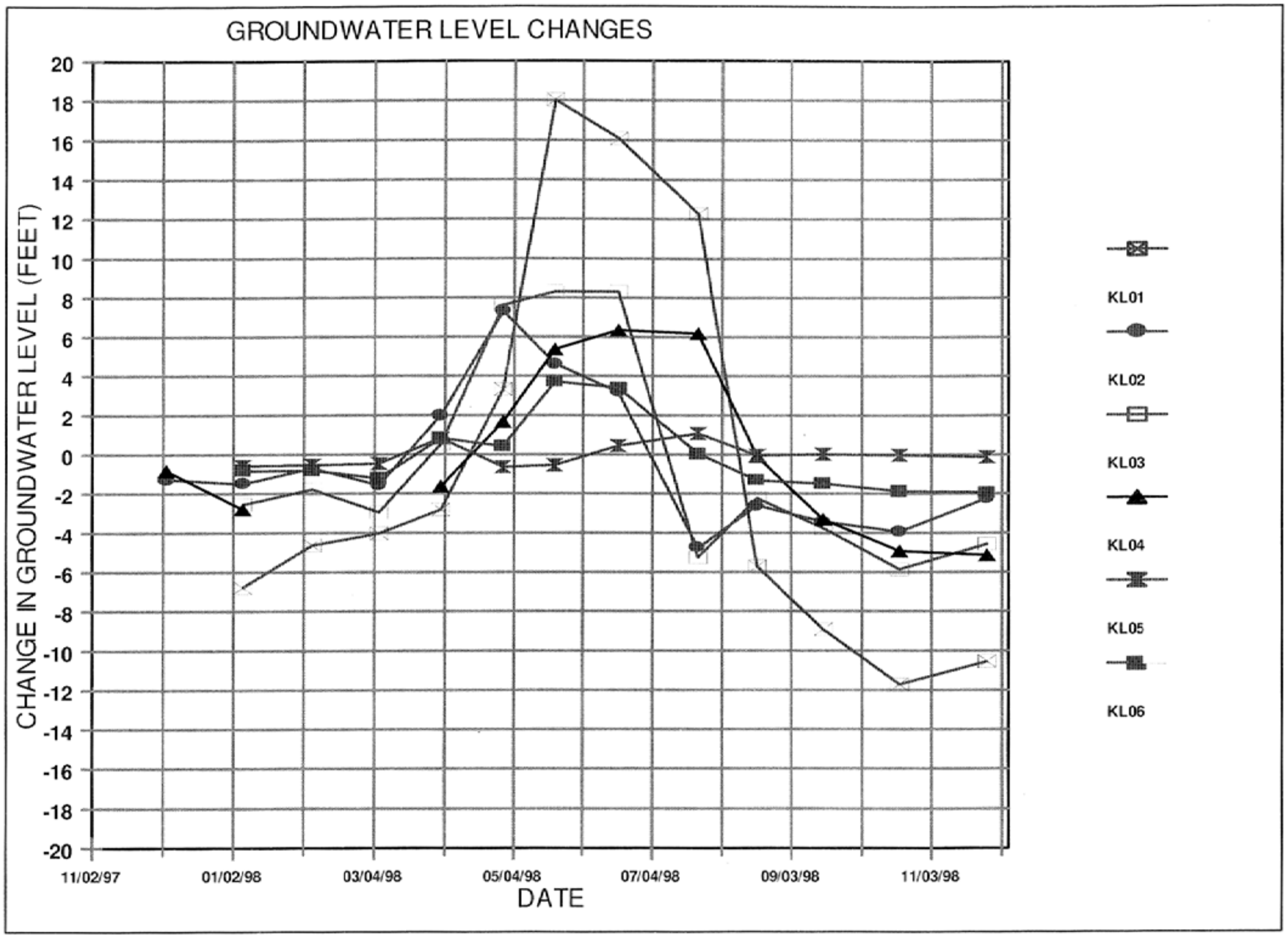


Figure 18. Graph of change in groundwater levels between measurements for selected wells at Kleinschmidt Flat.

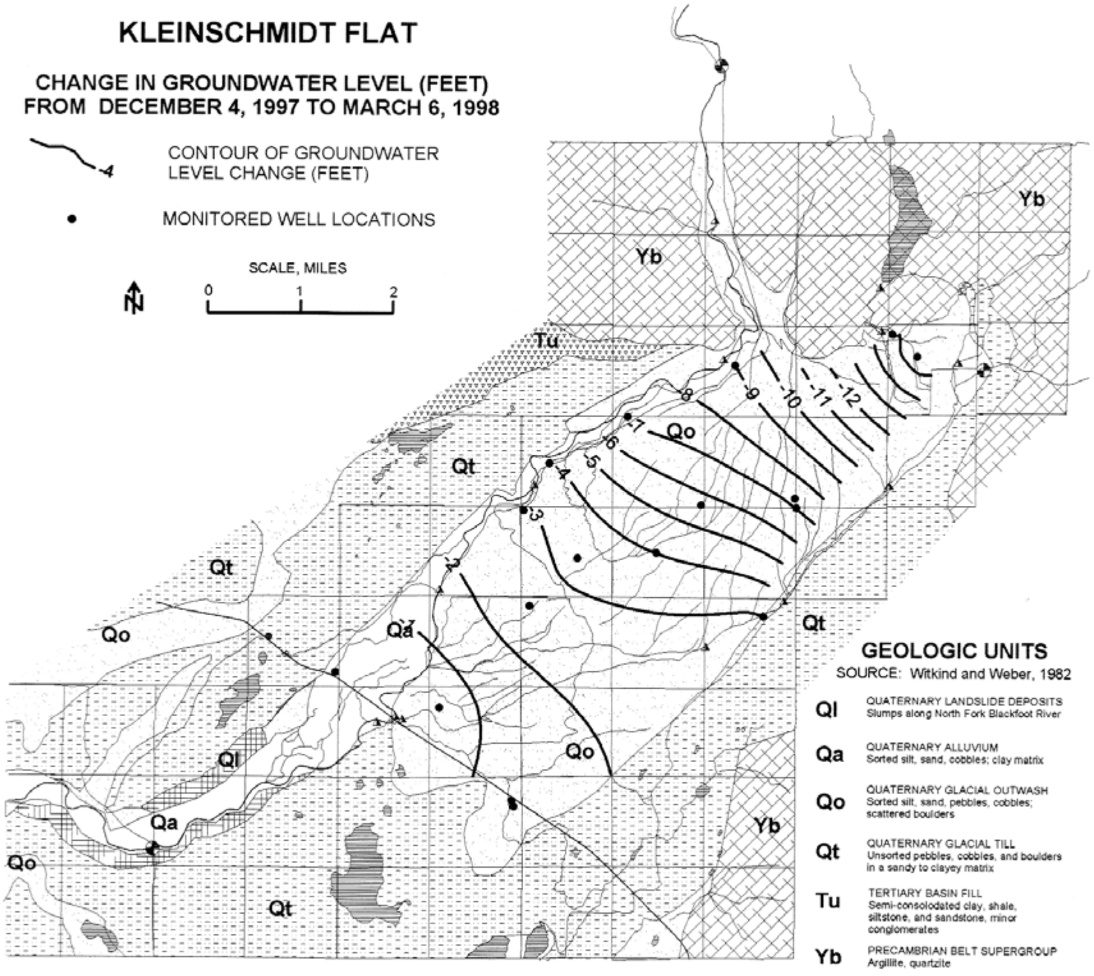


Figure 19. Change in groundwater level at Kleinschmidt Flat from December 4, 1997 to March 6, 1998.

Groundwater Budget

Using the measured groundwater level data, combined with measured streamflow gains and losses, estimates of the amount of groundwater that moves through the aquifer, and that is stored and released seasonally can be made. In fact, the containment of the Kleinschmidt Flat outwash aquifer provides an excellent opportunity to evaluate groundwater-surface water interactions.

Transmissivity can be grossly estimated by making the assumption that all gains observed in the North Fork Blackfoot River at measuring sites “above Rock Creek” and “below Rock Creek” represent groundwater that flows through the Kleinschmidt Flat outwash aquifer. Gains that come in below Rock Creek, generally south of Highway 200 and measured at site “above Dry Gulch” may be driven out of the alluvium within the floodplain of the North Fork Blackfoot River. In that area, the alluvial channel begins narrowing as it incises glacial till on both banks above Dry Gulch, in the area where landslide deposits flank the floodplain.

The August 27-28 1997 streamflow measurement data indicate a 92 cfs gain for North Fork Blackfoot River sites “above Rock Creek” and “below Rock Creek” combined. An additional 39 cfs gain is calculated in the reach south of Highway 200.

Assuming that the 92 cfs gains represent groundwater flow through the Kleinschmidt Flat outwash aquifer, transmissivity can be estimated using Darcy’s Law. The width of the aquifer and the hydraulic gradient are calculated using the July 1998 groundwater surface map (Figure 15). The aquifer width and hydraulic gradient in the vicinity of the 4200 to 4240 groundwater elevation contours were selected because they are just above the spring coulees, which mark the upper end of the aquifer discharge area.

Using this approach, the transmissivity of the aquifer is estimated to be about 800,000 gallons per day per foot (gpd/ft). The thickness of the aquifer is unknown, but available well logs suggest that it may vary from about 100 to 250 feet. Using these figures, average hydraulic conductivity is calculated to be in the range of about 400 to 1000 ft/day, within that expected for a clean sand as shown in Freeze and Cherry (1979). In actuality, it is likely that the aquifer is heterogeneous, and certain zones or areas transmit more water than others. The sparse well yield data available suggests that the aquifer may be much more permeable along the west side closer to the North Fork Blackfoot River than in the central and eastern areas. These calculations show that the observed streamflow gains could reasonably be attributed to groundwater flow through the Kleinschmidt Flat outwash aquifer.

An estimate of the amount groundwater stored and released seasonally can be made using the groundwater level change maps. For this analysis, it is assumed that groundwater is generally unconfined in the outwash aquifer, and the aquifer has a storage coefficient in the range of 0.15 to 0.20. While the validity of these assumptions is questionable, some assumptions must be made in order to evaluate the groundwater budget.

For the period December 4, 1997 through March 6, 1998, the earth volume difference between groundwater levels was approximately 47,000 acre-feet (AF). This is the volume of aquifer material assumed to be dewatered during this period of falling groundwater levels. Assuming a storage coefficient of 0.15 to 0.20, this would represent some 7100 to 9400 AF of water removed from aquifer storage, or an average of 40 to 53 cfs during the approximately 90-day period. From this exercise, we can conclude that during winter months, as much as 40 to 50 cfs gains appearing as spring flow and streamflow gains at the lower end of Kleinschmidt Flat can be accounted for by releases from groundwater storage alone.

This magnitude of groundwater discharge is consistent with observed surface water gains. The March 19, 1998 synoptic flow measurements indicate a 25 cfs loss in the North Fork Blackfoot River in the upper part of the reach (between above Lund Ditch and below Jacobson Ditch), and a 99 cfs gain in the lower reaches. This shows that there is some 74 cfs net gain even in late winter. The calculations above suggest that the outwash aquifer is the principal source of these gains, and the observed, steady groundwater level declines measured in wells on Kleinschmidt Flat throughout the winter support this hypothesis.

The earth volume difference between the groundwater levels observed on March 6, 1998 and July 24, 1998 (Figure 20) is about 135,000 acre-feet (AF). That is, 135,000 AF volume of the aquifer became saturated during the period. If a storage coefficient of 0.15 is assumed, this represents some 20,000 to 27000 AF of water stored as groundwater during the 140-day period, equivalent to an average inflow of 73 to 99 cfs for the period.

The July and August, 1998 synoptic flow data for the North Fork Blackfoot River indicate natural losses on the order of about 80 cfs, and diversions of about 20 cfs. At the same time, just over 100 cfs was appearing as gains in the lower reach above the below Rock Creek measurement site. From this information, it appears that by August the potential recharge to the outwash aquifer is similar to the amount discharging. This is consistent with the groundwater data, because by late July and August 1998, groundwater levels had already peaked and generally remained at high levels. Therefore, inflow and outflow would be expected to be of similar magnitude.

An analysis of the streamflow conditions in the North Fork Blackfoot River cannot be made for the early summer months with available data. The calculations above suggest that streamflow losses may be much greater during times of high water in the North Fork Blackfoot River than those observed in August.

While these estimates of groundwater stored and released are questionable, the figures nevertheless provide a basis to conclude that there are significant interactions between the outwash aquifer and surface water. Furthermore, the measured gains and losses observed in the surface water evaluation verify that interactions of the same magnitude are actually occurring in the North Fork Blackfoot River.

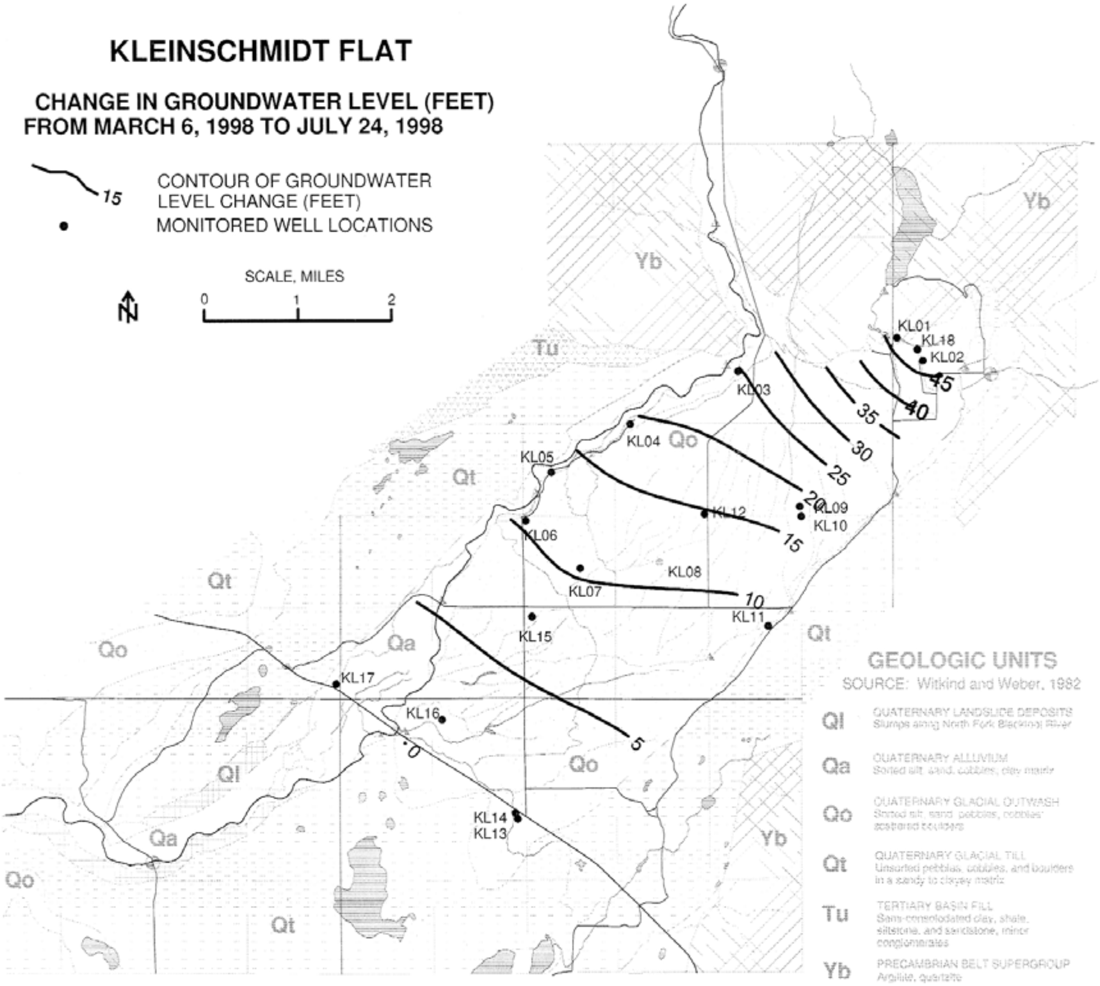


Figure 20. Change in groundwater level at Kleinschmidt Flat from March 6, 1998 to July 24, 1998.

CONCLUSIONS

Data collected for this study indicates that considerable interaction occurs between surface water and groundwater on Kleinschmidt Flat. These interactions affect the availability of surface water in the North Fork Blackfoot River, Rock Creek, Salmon Creek, and all diversion ditches. Dewatering is observed in all streams and most ditches in the upper three-quarters of the study area. Groundwater discharge and return flows supplement surface flows in the lower quarter of the study area.

The dewatering of streams on Kleinschmidt Flat occurs as a result of natural seepage loss and diversion of water for agricultural purposes. The combination of the two conditions is prevalent over much of the study area. For example, extremely low water conditions can occur in the North Fork Blackfoot River near the Ryan Bridge. Based on eight synoptic measurement runs over a three-year period, an average of 25 cubic feet per second was diverted for irrigation and 42 cfs was naturally lost through seepage in the four miles of river above the bridge. Another example shows all quantified surface flow loss on Rock Creek between the Lolo National Forest boundary and 1.5 miles below the Salmon Creek confluence, was solely the result of natural channel seepage.

Seepage losses are prevalent in ditches as well. Ten of the eleven ditches monitored consistently lose water during conveyance. Seepage losses tend to be greatest early in the irrigation season but have been shown to continue into September.

Water lost in streams and ditches during transport recharges groundwater. In the lower quarter of the study area, groundwater returns to surface flows in Rock Creek and the North Fork Blackfoot River. An estimated average of 76 cfs was observed returning to the river between Ryan Bridge and Highway 200. Additional gains occur south of Highway 200.

The available data suggests that water losses from streams, ditches, and the application of water on the porous soils of Kleinschmidt Flat greatly exceed the amount used by crops or other uses. If 1969 acres are an accurate estimate of full-season irrigation areas, the crops would be expected to consume approximately 3450 acre-feet of water, based on a crop-consumption estimate of 1.75 acre-feet per acre per year (Dalton 1988). An average flow of about 14.5 cfs would provide this amount of water in four months. An average of about 30 cfs is diverted from the North Fork Blackfoot River, Rock Creek, and Salmon Creek during the irrigation season to irrigate crops and water stock. It appears from this data the estimated water requirements of crops is much less than the amount diverted from the streams. At this study site, improvements in water conveyance and irrigation application methods on existing acres could result in additional water available for instream flow in dewatered sections of the river.

It is important to remember that seepage loss and some other losses related to irrigation inefficiencies do not equate to a depletion in the system. The large return flow quantified in this study suggests that water lost from streams and ditches as well as crop-applied water not consumptively used, is returned to Rock Creek, Kleinschmidt Creek, and the North Fork Blackfoot River near Highway 200. Because of this relationship, further depletions in the system could occur if water rights undergo a change of use application from flood to sprinkler irrigation methods and more land is put into production.

As possible, diversions should be maximized during early summer when water is abundant, and minimized during water-short periods. This would maximize groundwater recharge to the aquifer, which may be important in sustaining the perennial springs in the lower part of Rock Creek and other coulees in that area that serve as the primary source of gains in the North Fork Blackfoot River below Ryan Bridge.

OTHER STUDIES

In addition to this study, Janell Foley is building a groundwater model of the Kleinschmidt Flat aquifer system in fulfillment of a Masters Degree at Montana Tech. Her investigation, which will use Groundwater Modeling System (GMS) software, will attempt to quantify groundwater resources and movement and provide a tool to assess the success of water savings measures employed on the Flat. In conjunction with this work, a geophysical study of Kleinschmidt Flat was completed in the spring of 2000. The study provides a characterization of subsurface materials including thickness of outwash, glacial till, Tertiary sedimentary rocks, depth to bedrock and depth to water table. Floodplain mapping on the North Fork Blackfoot River, conducted by DNRC’s Floodplain Management Program is near completion.

ACKNOWLEDGEMENTS

This report presents findings based on data collected from 1997 through 2000. During this period, landowners on the Kleinschmidt Flat were most helpful by providing insight into their operations as well as access to their property. Their cooperation is greatly appreciated and continues to be instrumental and beneficial to maintaining instream flows and agricultural values in this area. Many individuals who contributed to the successful completion of this report include: Terry Voeller, Mike McLane, and Larry Dolan of DNRC, Jeff Peterson of USBR, Ron Shields of USGS, Greg Neudecker of USFWS, and Ron Pierce of MDFWP.

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APPENDIX I CLAIMED WATER RIGHTS AND PERMITS
(note: These data represent present database records at DNRC. Recent changes/updates may not be reflected in this list)

NORTH FORK BLACKFOOT RIVER

OWNER NAME	USE	RATE (cfs)	CLAIMED ACRES	DATE	QTR SEC SEC TWP RGE UT	DITCH
JACOBSEN RANCH CO	IR	9	170	05/24/1890	SESENW 29 15N 11W	Jacobsen
JACOBSEN, GARY D & SHARO	IR	10	173	05/24/1890	SESENW 29 15N 11W	Jacobsen
HOXWORTH RAYMOND,PAULINE	IR	18.75	160	05/11/1893	SWNWSE 15 15N 11W	Hoxworth, Hoxworth-Williams
HOXWORTH RAYMOND,PAULINE	ST	18.75		05/11/1893	SWNWSE 15 15N 11W	
SMITH STEVEN, MARKER ALAYNE	IR	25		05/11/1893	NENENE 21 15N 11W	Hoxworth
SMITH STEVEN, MARKER ALAYNE	ST	25		05/11/1893	NENENE 21 15N 11W	
WILLIAMS JUSTIN, LAURA,PRICE	IR	18.75	220	05/11/1893	SENWSE 15 15N 11W	Hoxworth-Williams
WILLIAMS JUSTIN, LAURA,PRICE	ST	18.75		05/11/1893	SENWSE 15 15N 11W	
OEHL,OCONNELL,POETT	IR	20	404	4/1/1901	SESENW 21 15N 11W	O'Connell-Oehl
HUTTON, CURRAN FAMILY TRUST	IR	12.5	360	6/12/1905	NENWNE 14 15N 11W	Lund
HUTTON, CURRAN FAMILY TRUST	ST	12.5		6/12/1905	NENWNE 14 15N 11W	
PERELMAN JILL, MEUNIER LOUIS	IR	6.25	160	6/12/1905	SWSWSW 2 15N 11W	Lund?
ROE, III JOHN SANDRA	IR	12.5	254	6/12/1905	SWSWSW 2 15N 11W	Jorgenson
ROE, III JOHN SANDRA	ST	0.13		6/12/1905	SWNE 14 15N 11W	
USA (DEPT OF AGRICULTURE	IR	80		6/1/1910	NESESW 29 17N 10W	
GEARY CHARLES	IR	3.38	90	11/29/1910	NESWSW 21 15N 11W	Weaver-Rue
GEARY CHARLES	ST	3		11/29/1910	NESWSW 21 15N 11W	
HOOKER KAREN	IR	3	80	11/29/1910	NESWSW 21 15N 11W	Weaver-Rue
HOOKER KAREN	ST	3		11/29/1910	NESWSW 21 15N 11W	
TALAN INC	IR	20	180	11/29/1910	N2SWSW 21 15N 11W	Weaver-Rue
WEAVER JOHN IRENE	IR	22.5	300	11/29/1910	SENWSW 21 15N 11W	Weaver-Rue, O'Connell-Oehl
WEAVER JOHN IRENE	ST	22.5		11/29/1910	SENWSW 21 15N 11W	
USA (DEPT OF AGRICULTURE	RC	80		6/1/1912	NENENE 27 16N 11W	
HAGGART HEIDI GEORGE	IR	5	594	10/21/1923	NESWSE 20 15N 11W	n/a
USA (DEPT OF AGRICULTURE	RC	100		6/1/1925		
USA (DEPT OF AGRICULTURE	RC	1		6/1/1926	SWSWNE 28 17N 10W X	
USA (DEPT OF AGRICULTURE	ST	80		6/1/1930	NENENE 31 17N 10W	
USA (DEPT OF AGRICULTURE	RC	100		6/1/1932	SESESE 34 16N 11W	
KRUTAR ROY JON	IR	11.14	100	06/00/1950	NWSESW 32 15N 11W X	
USA (DEPT OF AGRICULTURE	RC	80		9/1/1966	SWNESE 2 17N 10W	
PLUM CREEK TIMBER CO INC	ST	0.00		6/1/1969	SENENW 30 15N 11W X	

PLUM CREEK TIMBER CO INC	ST	0.00		7/1/1969	SENWNE 30 15N 11W X	
PLUM CREEK TIMBER CO INC	ST	0.00		7/1/1969	SENESW 30 15N 11W X	
PLUM CREEK TIMBER CO INC	ST	0.00		7/1/1969	NWNWSW 30 15N 11W X	
PLUM CREEK TIMBER CO INC	ST	0.00		7/1/1969	NENENW 30 15N 11W X	
PLUM CREEK TIMBER CO INC	ST	0.01		7/1/1969	NESWSW 30 15N 11W X	
PLUM CREEK TIMBER CO INC	ST	0.00		7/1/1969	SWNWNW 30 15N 11W X	
PLUM CREEK TIMBER CO INC	ST	0.00		7/1/1969	SESW 19 15N 11W X	
POETT CYNTHIA HENRY	ST	0.01		7/1/1969	SENESW 19 15N 11W X	O'Connel-Oehl
POETT CYNTHIA HENRY	ST	0.01		7/1/1969	SENWSE 19 15N 11W X	
POETT CYNTHIA HENRY	ST	0.01		7/1/1969	N2NESE 19 15N 11W X	
POETT CYNTHIA HENRY	ST	0.00		6/1/1970	E2W2NW 21 15N 11W X	
USA (DEPT OF AGRICULTURE	RC	2		6/1/1970	SWNWSW 35 16N 11W X	
USA (DEPT OF AGRICULTURE	RC	80		6/5/1970	SWNWSE 31 17N 10W	
AITKEN GARY, BENSON AMBER	IR	2.75	100	6/29/1993	SENWSE 15 15N 11W	pump
	Total =	**907.19**	**3345**			

ROCK (DRY) CREEK

OWNER NAME	USE	RATE (cfs)	CLAIMED ACRES	DATE	QTR SEC SEC TWP RGE U	SOURCE NAME
KRUTAR ROY JON	IR	1.78	45	11/14/1883	NWSWNW 5 14N 11W	ROCK CREEK
PERELMAN JILL	IR	2.81	80	8/6/1902	SWNESE 18 15N 10W	DRY CREEK
PERELMAN JILL, WIEDEMAN THEODORE	IR	6.13	172	6/15/1903	SENWNE 19 15N 10W	DRY CREEK
STRANAHAN MARY	IR	10.00	130	4/25/1903	SENWSW 34 15N 11W	DRY CREEK
STRANAHAN MARY	ST	10.00		4/25/1903	SENWSW 34 15N 11W	DRY CREEK
HOOKER KAREN	ST	15.00		8/24/1904	SWNESW 30 15N 10W X	ROCK CREEK
MCCORMICK MAE	IR	50.00	300	6/28/1904	NESWNE 35 15N 11W	DRY CREEK
BRUMIT PHILLIP CARLA & TALAN INC	ST	0.00		11/29/1910	NE 5 14N 11W	DRY CREEK
HOOKER KAREN	ST	4.00		5/26/1914	NENWNE 25 15N 11W	ROCK CREEK
USA (DEPT OF AGRICULTURE	RC	0.03		6/1/1918	NWNWSE 17 15N 10W	DRY CREEK
MCCORMICK MICHAEL	FW			7/16/1928	E2SW 25 15N 11W X	ROCK CREEK
CARPINO PAUL LORAINE	DM	0.07		9/26/1932	SWSWNW 17 15N 10W	DRY CREEK
CARPINO PAUL LORAINE	IR	2.50	4	9/26/1932	SESWNW 17 15N 10W	DRY CREEK
KRUTAR ROY JON	IR	15.00	60	6/26/1932	SWSWNW 5 14N 11W	ROCK CREEK
MC PHEE BETTY MAYNARD	IR	0.13	5	9/26/1932	SWSENW 17 15N 10W X	ROCK CREEK
PLUM CREEK TIMBER CO INC	ST	0.01		5/6/1935	E2SWSE 25 15N 11W X	ROCK CREEK
PLUM CREEK TIMBER CO INC	ST	0.01		5/6/1935	NWSENE 25 15N 11W X	ROCK CREEK

BRUMIT PHILLIP CARLA & TALAN INC	IR	2.50	60	6/1/1945	NESWSE 33 15N 11W	DRY CREEK
PLUM CREEK TIMBER CO INC	ST	0.01		06/00/1946	E2NESE 25 15N 11W X	ROCK CREEK
PLUM CREEK TIMBER CO INC	ST	0.00		6/3/1946	E2NENE 35 15N 11W X	ROCK CREEK
PLUM CREEK TIMBER CO INC	ST	0.01		6/3/1946	SESENE 35 15N 11W X	ROCK CREEK
PLUM CREEK TIMBER CO INC	ST	0.01		6/3/1946	NWNENE 25 15N 11W	ROCK CREEK
PLUM CREEK TIMBER CO INC	ST	0.00		6/3/1946	SWSESW 35 15N 11W X	ROCK CREEK
HOOKER KAREN	ST	0.00		2/2/1951	NWNE 25 15N 11W X	ROCK CREEK
HOXWORTH DUANE JEWELIE	IR	2.50	85	2/2/1951	NWNENE 35 15N 11W	DRY CREEK
MC PHEE BETTY MAYNARD	DM	0.09		8/1/1968	NESWNW 17 15N 10W X	ROCK CREEK
KRUTAR ROY	CM	19.00		4/19/1976	SESENW 5 14N 11W	ROCK CREEK
	Total=	**142**	**941**			

SALMON CREEK

OWNER NAME	**USE**	**RATE** (CFS)	**CLAIMED ACRES**	**DATE**	**QTR SEC SEC TWP RGE**	**SOURCE NAME**
MEUNIER LOUIS, PERELMAN JILL	IR	8.91	240	08/24/1891	NWNENE 13 15N 11W	SPAWN LAKE
MEUNIER LOUIS, PERELMAN JILL	ST	8.91		08/24/1891	NWNENE 13 15N 11W	SPAWN LAKE
PERELMAN JILL	IR	8.91		4/16/1900	NWNENE 13 15N 11W	SPAWN LAKE
MEUNIER LOUIS	IR	8.91		3/1/1938	NWNENE 13 15N 11W	SPAWN LAKE
WHITE TAIL RANCH LLC	ST	25		3/1/1938	NENENE 13 15N 11W	SALMON CREEK
WHITE TAIL RANCH LLC	IR	25	115	6/12/1938	NWNENE 13 15N 11W	SALMON CREEK
LEHNE GARY	DM	0.08		2/2/1994	NENENE 12 15N 11W	SALMON CREEK
	Total=	**86**	**355**			

KLEINSCHMIDT CREEK

OWNER NAME	**USE**	**RATE** (cfs)	**CLAIMED ACRES**	**DATE**	**QTR SEC SEC TWP RGE**	**SOURCE NAME**
MONTANA, STATE OF BOARD	ST	<.01		00/00/1880	NWNENW1014N11W	KLEINSCHMIDT CREEK
TALAN INC	ST	<.01		11/29/1910	NE814N11W	KLEINSCHMIDT CREEK
KRUTAR ROY JON	IR	0.56	20	9/15/1916	SWSENE614N11W	KLEINSCHMIDT CREEK
WEAVER JOHN IRENE	IR	2.5	65	6/28/1973	NENESE614N11W	KLEINSCHMIDT CREEK
WEAVER JOHN IRENE	ST	0.07		6/28/1973	NENESE614N11W	KLEINSCHMIDT CREEK
FRIEDE ROSS LACENE	ST	1.25		6/28/1973	NENESE614N11W	KLEINSCHMIDT CREEK
FRIEDE ROSS	IR	1.25	4.5	6/28/1973	NENESE614N11W	KLEINSCHMIDT CREEK
	Total=	**6**	**90**			

Appendix III. Miscellaneous Flow Measurements (CFS)

Station	7/26/97	08/27-28/97	09/9-10/97	09/21-23/98	10/16/97	10/28/97	3/19/98	6/24/98	07/21-23/98	08/13-14/98	9/21-24/98	10/20/98	5/10/99	6/22/99
NF Blackfoot River blw Lake Cr	292	160	124											
NF Blackfoot River abv Lund Ditch	324	158	121		88.1		36.5		313	161	79.6			
Lund-Jorgenson Ditch nr Ovando		14.3	11.6			5.2		6.4	10.5		7.4			
Lund-Jorgenson abv split				6.4										
Jorgenson Ditch blw split		13.6				4.6		4.9			4.6	4.2		
Jorgenson Ditch at Lower Crossing			8.4					3.2						
Jorgenson Ditch blw pump at fenceline			5											
Jorgenson Ditch at Rowland House		3.2	3.2											
Jorgenson Ditch at 2nd crossing				4.8										
North Fork Blackfoot River blw Lund D.		124												
North Fork Blackfoot River abv Sp. Cr		100												
North Fork Blackfoot River blw Jac. Di.		85	61.5		41.4		1.09		222	83	27.1			
North Fork Blackfoot River abv Rock Cr.		150	120		97.9		40.2		287	139	87			
Total Ditch withdrawel between L-J Ditch and Spring Creek		10.2												
Jacobsen Ditch blw headgate		4.1							2.4	16.6				
Hoxworth D blw O'Connell-Oehl		1.9							13.1	16.6	13			
Rock Cr abv Salmon Cr			0.76											
Salmon Cr blw Coopers Lake		13.1	11.6		9.1					17.8		7.1		
Spawn Lake diversion		5.2							5.1					4.83
Spawn Lake Div @ Rd Crossing														4.57
Salmon Cr blw Spawn Lake		5							14.9					
Salmon Cr diversion blw Whitetail		1.5							6.1					
Return Flow to Salmon Cr at school rd		1.2												
Salmon Cr abv Rock Cr		2.5							8.35	6.72	2.84	2.74		
Rock Cr blw Salmon Cr		3.1								7.95	1.74	2.33		
Rock Cr nr Tupper Lake		2.2	1.4						12.6	6.81	1.6	1.83	7.02	
Rock Creek nr Ovando		2	0.76								0.96	1.06		
Rock Creek abv Krutar		6.5											1.38	
Rock Cr at Healy Ditch									11.9					
Rock Cr abv NF Blackfoot R nr Ovando		45.7	40.2		33		13.8		36	33.7	28.1	24.8		

Station	5/14/99	6/22/99	7/20/99	05/11-12/2000	6/8-9/2000	7/6/00	8/8-9/2000	8/11/00	9/7/00	10/11/00	
NF Blackfoot River @ Forest Boundary											
NF Blackfoot River @ Ryan Bridge								37.92	17.74	16.54	
NF Blackfoot River near Ovando											
Spawn Lake Div blw HG				4.14	3.95	3.07		-	-	-	
Spawn Lake Div nr Rd Crossing				4.31	3.77	3.26		-	-	-	
Salmon Cr Div#2 blw HG				6.86	6.1	1.17	dry				
surface losses				-1.01	2.61	0.4	dry				
Salmon Cr Div#2 blw Sundance				2.39	2.24	0.239	dry				
Lund Ditch blw Split				-	-	-	4.3	4.66	2.24		
Bear Creek inflow				-	-	-	-0.33				
Lund Ditch nr Curran				-	-	-	3.68		2.06		
NF Div #1 blw HG (nr Roe)				3.61	8.66	9.09		6.72	2.78		
NF Div# 1 at Rd Crossing (blw Rowlands)				1.64	5.92	6.79		5.45			
NF Div#1 @ Aitkin fence				-	-						
NF Div#1 blw fenceline (Williams)				-	-	4.57			1.63		
NF Div#2 blw HG				dry	9.57	dry	dry				
NF Div#2 @ Rd Crossing (abv Aitkin)				dry	6.22	dry	dry				
NF Div#2 at Aitkin fence corner				dry	3.72	dry	dry				
NF Div#3 blw HG (abv Aitkin)				4.35	8.41	5.13		3.62	4.12		
NF Div#3 @ Rd Crossing (blw Aitkin)				2.55	7.03	4.89					
NF Div#3 @ Poett Split				0.68	6.56	4.872		4.89	3.73		
Jacobsen Ditch blw HG				-	13.76	dry	9.12		10.12		
Jacobsen Ditch @ Rd Crossing				-	10.36	dry	3.54		7.65		
Jacobsen Ditch @ Hwy 200				-	7.55	dry	irrigating				
Weaver-Rue blw HG	10.88	10.51						0.898	0.59		
Weaver-Rue nr Ambrose	9.59	9.95									
Weaver-Rue nr Flat School	4.88	8.36									
Weaver-Rue abv split	3.77	8.45						1.11			
Weaver Ditch blw split	0.1	5.46						1.03			
Weaver Ditch abv #3 inflow								0.87			

Station	5/14/99	6/22/99	7/20/99	05/11-12/2000	6/8-9/2000	7/6/00	8/8-9/2000	8/11/00	9/7/00	10/11/00
Weaver Ditch blw #3 inflow								2.34		
Weaver Ditch outflow								1.95		
Rock Creek blw Kleinscmidt Creek									40.78	32.4
Kleinschmidt Creek nr mouth									14.37	11.66
NFBF abv Rock Cr									66.77	55.96
Rock Cr @ Fst Bndy									2.07	
Salmon Cr abv Dry Cr confluence									2.19	
Rock Cr @ Rd Crossing									1.53	
Rock Cr nr Hoxworth									1.24	
Rock Creek @ Rue Ditch									0.608	
Rue Ditch blw Rock Cr									0.04	
Rock Cr @ N-S Road									0.557	

APPENDIX IV. Well Logs in the Kleinschmidt Flat Area

T14N R11W

MBMG WELL ID	**M:122863**
LOCATION	14N 11W 03 AC 01
SITE.NAME	BADEN TIM
TOTAL DEPTH	163.0

FROM (FT)	TO (FT)	DESC..
0.0	17.0	CLAY SAND GRAVEL AND BOULDERS
17.0	29.0	WET CLAY AND GRAVEL
29.0	138.0	CLAY GRAVEL BOULDERS AND BROKEN ROCK
138.0	140.0	CLAY GRAVEL AND WATER
140.0	156.0	CLAY GRAVEL AND BOULDERS
156.0	163.0	CLAY GRAVEL AND WATER

MBMG WELL ID	**M:70709**
LOCATION	14N 11W 06 AD 01
SITE.NAME	KRUTAR ROY
TOTAL DEPTH	42.0

FROM (FT)	TO (FT)	DESC
0.0	38.0	CLAY
38.0	42.0	SAND GRAVEL

MBMG WELL ID	**M:70711**
LOCATION	14N 11W 06 D 01
SITE.NAME	FLEMING ANNIE M
TOTAL DEPTH	86.0

FROM (FT)	TO (FT)	DESC
0.0	35.0	SURFACE DIRT AND ROCK
35.0	70.0	SANDY CLAY GRAYISH WHITE COLOR
70.0	83.0	HARD BLUE CLAY
83.0	89.0	SAND AND GRAVEL

MBMG WELL ID	**M:143625**
LOCATION	14N 11W 06 DD 01
SITE.NAME	BARD ALLEN & JULIA
TOTAL DEPTH	218.0

FROM (FT)	TO (FT)	DESC
0.0	4.0	TOPSOIL
4.0	118.0	CLAY AND GRAVEL
118.0	122.0	GREEN CLAY
122.0	126.0	BROWN CLAY
126.0	182.0	GREEN CLAY
182.0	216.0	BLUE CLAY
216.0	218.0	GRAVEL

MBMG WELL ID	**M:133923**
LOCATION	14N 11W 08 01
SITE.NAME	MCCORMICK EVA
TOTAL DEPTH	152.0

FROM (FT)	TO (FT)	DESC
0.0	1.0	TOPSOIL
1.0	9.0	CLAY
9.0	14.0	CLAY GRAVEL SOME WATER
14.0	20.0	CLAY AND GRAVEL
20.0	79.0	RED CLAY
79.0	83.0	SAND SOME GRAVEL AND WATER
83.0	94.0	SAND SILT AND CLAY
94.0	110.0	YELLOW CLAY
110.0	111.0	GRAVEL WITH CLAY WATER ABOUT 2 G.P.M.
111.0	118.0	YELLOW CLAY AND GRAVEL
118.0	122.0	SAND AND WATER
122.0	128.0	YELLOW CLAY AND GRAVEL
128.0	130.0	SAND AND WATER
130.0	144.0	BLUE CLAY AND SAND
144.0	147.0	SOFT BLUE CLAY
147.0	151.0	WHITE SHALE AND BENTONITE
151.0	155.0	GRAY SHALE AND WATER
155.0	168.0	BLUE SHALE (NO WATER)

MBMG WELL ID	**M:138585**
LOCATION	14N 11W 08 AD 01
SITE.NAME	SMITH TERRANCE J.
TOTAL DEPTH	26.0

FROM (FT)	TO (FT)	DESC
0.0	3.0	TOPSOIL
3.0	28.0	GRAVEL
28.0	40.0	HARD PAN

MBMG WELL ID	**M:70714**
LOCATION	14N 11W 10 BDA 01
SITE.NAME	BRADSHAW CLAIR
TOTAL DEPTH	340.0

FROM (FT)	TO (FT)	DESC
0.0	240.0	BOULDERS CLAY AND GRAVEL
240.0	245.0	BOULDERS CLAY GRAVEL AND WATER 3/4 GPM
245.0	290.0	BOULDERS CLAY AND GRAVEL
290.0	295.0	BOULDERS CLAY GRAVEL AND WATER 1 GPM
295.0	340.0	GRAY CLAY AND GRAVEL

T15N R10W

MBMG WELL ID	**M:120754**
LOCATION	15N 10W 06 C 01
SITE.NAME	EDWARDS CARSON P AND ELIZABETH J
TOTAL DEPTH	80.0

FROM (FT)	TO (FT)	DESC
0.0	3.0	FRACTURED ROCK (GREEN)
3.0	50.0	HARD GREEN BEDROCK
50.0	80.0	GREEN ROCK W/WATER

MBMG WELL ID	**M:71529**
LOCATION	15N 10W 06 CC 01
SITE.NAME	ANDERSON MARY EDITH
TOTAL DEPTH	80.0

FROM (FT)	TO (FT)	DESC
0.0	55.0	HARD PURPLE ROCK
55.0	80.0	HARD PURPLE ROCK

MBMG WELL ID	**M:125275**
LOCATION	15N 10W 07 DCD 01
SITE.NAME	CREMER KAREN
TOTAL DEPTH	50.0

FROM (FT)	TO (FT)	DESC
0.0	5.0	FILL
5.0	50.0	GRAVEL

MBMG WELL ID	**M:145986**
LOCATION	15N 10W 17 BCB 01
SITE.NAME	MCPHEE MAYNARD AND BETTY
TOTAL DEPTH	125.0

FROM (FT)	TO (FT)	DESC
0.0	12.0	GRAVEL
12.0	20.0	GRAVEL AND CLAY
20.0	40.0	SAND
40.0	45.0	CLAY
45.0	48.0	ROCK
48.0	85.0	GRAVEL
85.0	115.0	GREY CLAY
115.0	120.0	RED CLAY
120.0	125.0	GRAVEL

MBMG WELL ID	**M:152544**
LOCATION	15N 10W 17 BCD 01
SITE.NAME	MCPHEE MAYNARD & BETTY
TOTAL DEPTH	173.0

FROM (FT)	TO (FT)	DESC
0.0	0.5	TOPSOIL
0.5	26.0	GRAVEL
26.0	38.0	GRAVEL & CLAY
38.0	122.0	CEMENTED GRAVEL
122.0	126.0	CLAY
126.0	170.0	GRAY SHALE
170.0	173.0	GRAVEL

T15N R11W

MBMG WELL ID	**M:154763**
LOCATION	15N 11W 13 AAD 01
SITE.NAME	CURRAN PATRICK & KATHLEEN
TOTAL DEPTH	225.0

FROM (FT)	TO (FT)	DESC
0.0	1.0	TOPSOIL
1.0	55.0	GRAVEL
55.0	65.0	SAND
65.0	80.0	CLAY & GRAVEL
80.0	220.0	SAND
220.0	225.0	GRAVEL

MBMG WELL ID	**M:132918**
LOCATION	15N 11W 14 BDC 01
SITE.NAME	JORGENSEN NORMAN
TOTAL DEPTH	244.0

FROM (FT)	TO (FT)	DESC
0.0	197.0	CLAY- GRAVEL AND BOULDERS
197.0	240.0	CLAY- GRAVEL- BOULDERS AND WATER
240.0	244.0	CLAY

MBMG WELL ID	**M:156558**
LOCATION	15N 11W 15 AD 01
SITE.NAME	BILES JIM
TOTAL DEPTH	118.0

FROM (FT)	TO (FT)	DESC...
0.0	100.0	CLAY GRAVEL & BOULDERS
100.0	118.0	CLAY GRAVEL BOULDERS & WATER

MBMG WELL ID	**M:158550**
LOCATION	15N 11W 15 AD 01
SITE.NAME	ROE JOHN H
TOTAL DEPTH	178.0

FROM (FT)	TO (FT)	DESC
0.0	128.0	CLAY GRAVEL & BOULDERS
128.0	178.0	CLAY GRAVEL BOULDERS & WATER

MBMG WELL ID	**M:71538**
LOCATION	15N 11W 18 BB 01
SITE.NAME	EDWARD THOMAS A
TOTAL DEPTH	111.0

FROM (FT)	TO (FT)	DESC...
0.0	111.0	WASHED IN OR GLACIER DEPOSITED GRAVEL & EARTH MORE OR LESS UNIFORM UNTIL NEAR BOTTOM SAND WAS STRUCK.

MBMG WELL ID	**M:71539**
LOCATION	15N 11W 18 BB 02
SITE.NAME	EDWARDS THOMAS A
TOTAL DEPTH	111.0

FROM (FT)	TO (FT)	DESC...
0.0	111.0	WASHED IN OR GLACIER DEPOSITED GRAVEL & EARTH MORE OR LESS UNIFORM UNTIL NEAR BOTTOM SAND WAS STRUCK.

MBMG WELL ID	**M:147185**
LOCATION	15N 11W 19 BB 01
SITE.NAME	VALITON FRED
TOTAL DEPTH	57.0

FROM (FT)	TO (FT)	DESC
0.0	3.0	TOPSOIL
3.0	40.0	GRAVEL
40.0	56.0	CLAY AND GRAVEL
56.0	57.0	GRAVEL

MBMG WELL ID	**M:149170**
LOCATION	15N 11W 19 BBD 01
SITE.NAME	VALITION DON
TOTAL DEPTH.........	55.0

FROM (FT)	TO (FT)	DESC
0.0	6.0	TOPSOIL
6.0	20.0	GRAVEL
20.0	32.0	CLAY & GRAVEL
32.0	40.0	CLAY
40.0	52.0	GREEN CLAY
52.0	55.0	GRAVEL

MBMG WELL ID	**M:123212**
LOCATION	15N 11W 21 AD 01
SITE.NAME	AITKEN GARY/BENSON
TOTAL DEPTH.........	120.0

FROM (FT)	TO (FT)	DESC
0.0	58.0	CLAY- GRAVEL AND BOULDERS
58.0	65.0	CLAY- GRAVEL- BOULDERS AND WATER
65.0	73.0	GRAY CLAY AND GRAVEL
73.0	77.0	CLAY AND ROCK
77.0	81.0	HARD ROCK
81.0	120.0	SHALE

MBMG WELL ID	**M:152543**
LOCATION	15N 11W 22 DDD 01
SITE.NAME	ROE JOHN & SANDRA
TOTAL DEPTH	115.0

FROM (FT)	TO (FT)	DESC
0.0	1.0	TOPSOIL
1.0	71.0	GRAVEL
71.0	78.0	CLAY
78.0	115.0	GRAVEL

MBMG WELL ID	**M:138596**
LOCATION	15N 11W 23 DD 01
SITE.NAME	MANNIX BROTHERS INC
TOTAL DEPTH	150.0

FROM (FT)	TO (FT)	DESC
0.0	3.0	TOP SOIL
3.0	150.0	GRAVEL & BOULDERS

MBMG WELL ID	**M:164083**
LOCATION	15N 11W 25 BBB 01
SITE.NAME	HOOKER KAREN
TOTAL DEPTH	140.0

FROM (FT)	TO (FT)	DESC
0.0	140.0	SAND GRAVEL

MBMG WELL ID	**M:135524**
LOCATION	15N 11W 27 BD 01
SITE.NAME	WILLIAMS PRICE
TOTAL DEPTH	75.0

FROM (FT)	TO (FT)	DESC
0.0	2.0	TOP SOIL
2.0	40.0	BOULDERS AND GRAVEL
40.0	62.0	CEMENTED GRAVEL
62.0	70.0	GREY CLAY
70.0	75.0	GRAVEL

MBMG WELL ID	**M:71547**
LOCATION	15N 11W 28 BB 01
SITE.NAME	EDWARDS TOM
TOTAL DEPTH	185.0

FROM (FT)	TO (FT)	DESC
0.0	20.0	TOP SOIL AND BOULDERS
20.0	65.0	GRAVEL
65.0	70.0	SAND
70.0	87.0	GRAVEL AND SAND (FINE)
87.0	160.0	YELLOW SILT
160.0	161.0	SAND AND FINE GRAVEL
161.0	185.0	BLUE CLAY

MBMG WELL ID	**M:71546**
LOCATION	15N 11W 28 BBB 01
SITE.NAME	EDWARDS TOM
TOTAL DEPTH	71.0

FROM (FT)	TO (FT)	DESC...
0.0	5.0	TOP SOIL
5.0	15.0	GRAVEL
15.0	25.0	GRAVEL AND BOULDERS
25.0	65.0	BLUE CLAY
65.0	71.0	GRAVEL

MBMG WELL ID	**M:164404**
LOCATION	15N 11W 29 A 01
SITE.NAME	LIANE ANTHONY
TOTAL DEPTH.........	400.0

FROM (FT)	TO (FT)	DESC
0.0	26.0	CLAY & SAND & GRAVEL & BOULDERS
26.0	41.0	GRAY CLAY & GRAVEL
41.0	400.0	GRAY CLAY

MBMG WELL ID	**M:159451**
LOCATION	15N 11W 29 ABD
SITE.NAME	LIANE ANTHONY
TOTAL DEPTH	60.5

FROM (FT)	TO (FT)	DESC
0.0	14.0	CLAY GRAVEL AND BOULDERS
14.0	18.0	WET BLACK CLAY AND GRAVEL
18.0	30.0	TAN CLAY SAND AND GRAVEL
30.0	60.5	TAN CLAY SAND GRAVEL AND WATER