Hydrology of the Big Hole Basin and an Assessment of the Effects of Irrigation on the Hydrologic Budget

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ABSTRACT

A hydrologic investigation was conducted in the Big Hole River basin of southwest Montana during 1997 and 1998 to document the effects of irrigation on the basin's water budget and to better understand the interactions of ground water, surface water, plants, and the atmosphere. Two sections of the basin were studied intensively: the Francis Creek drainage south of the town of Wisdom, and the irrigated portion of river basin near Melrose and Glen. Limited work also was conducted in the overall upper basin and in the middle basin in the vicinity of Wise River and Divide.

In the areas of intensive study, streamflows were monitored so that total surface-water inflow and outflow could be estimated. Networks of wells were used to collect aquifer-characteristic data and to track changes in ground-water storage. Weather stations were used to gather temperature, precipitation, solar radiation, and other meteorological data.

In the Francis Creek area, a 6,300 acre-ft increase in ground-water storage occurred in the spring and early summer 1998 due to recharge from snowmelt, rainfall, and excess irrigation water. When most irrigation in this area ended at the beginning of July, ground-water storage began to decrease rapidly. Surprisingly, surface-water outflow exceeded inflow for only 4 days. After this brief gaining period, net surface-water losses were observed for the remainder of the summer and early fall. Evapotranspiration (ET) likely accounted for the loss of the irrigation returns.

In the lower basin study area around Melrose and Glen, seasonal water-table fluctuations beneath irrigated pastures generally ranged from 5 to 15 ft. In several areas, the fluctuations were more than 20 ft. The total increase in ground-water storage in the late spring/early summer was estimated to be 33,000 acre-ft. About 60 percent of this storage gain occurred in May with the onset of irrigation; the other 40 percent occurred in June. Natural recharge from precipitation was not quantified but is believed to be relatively small compared to recharge contributed by irrigation. By July, ground-water storage was near its maximum and was relatively stable due to a dynamic equilibrium in which irrigation recharge to the aquifer system was about equal to ground-water discharge to the surface-water system. During August and September, ground-water storage began to decline, but hydrologic balances indicate that this water was lost to ET rather than discharging to the surface-water system. Although the storage declines did not benefit the surface-water system directly, some indirect benefit was realized because less water had to be diverted from streams in order to meet crop-water needs. After the growing season ended and irrigation ceased, ground-water storage continued to decline, resulting in an average 90 cfs gain in streamflow directly attributable to irrigation returns during October and November. A smaller gain in flow is believed to persist through December and perhaps into January and February.

In conclusion, although irrigation water contributes significantly to ground-water recharge in the Big Hole basin, the timing and amount of ground-water returns to the surface-water system are strongly influenced by evapotranspiration. Declines in ground-water storage during the growing season are attributed to little, if any, to streamflow. Instead, most of the water is consumed by ET. However, as demonstrated in the lower basin, once the growing season ends and plant water-uptake ceases, river flow increases for a 2- to 4-month period due to irrigation returns. It is speculated that the post growing-season return-flow process in the upper basin is similar.

ACKNOWLEDGMENTS

This report is the culmination of a 4-year effort to characterize the effects of agricultural water use on the hydrology of the Big Hole basin. The study would not have been possible without the support of the Big Hole Watershed Committee, the Beaverhead County Board of Commissioners, the Big Hole River Foundation, the George Grant Chapter of Trout Unlimited, and the Beaverhead Conservation District. The authors also wish to thank the many landowners who willingly provided access to their property and wells and shared information about their land management. In particular, Jim Hagenbarth, Clayton Huntley, Liz Jones, Jay Lyndes, T.J. Pendergast, and Harold Peterson were instrumental in moving the project forward. Their insight and concern about past, present, and future land and water use is commendable.

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INTRODUCTION

Water availability in the Big Hole River basin is a critical concern for agricultural, recreational, municipal, and industrial water users in southwest Montana. Ranchers use the river and its tributaries to irrigate more than a 130,000 acres of alfalfa and hay. The city of Butte (pop. 35,000) depends on the river to meet approximately a quarter of its water needs. Outfitters, boaters, and fishing and hunting enthusiasts are drawn to the river because of its pristine waters, abundant wildlife, and rural beauty.

Not surprisingly, droughts in the late 1980s and early 1990s led to heated disputes over water allocation for irrigation and municipal use versus instream flow. To address this issue, a group of ranchers, conservationists, and local government officials banded together to form the Big Hole Watershed Committee (BHWC). According to the BHWC's ground rules, "the purpose of the committee is to seek understanding of the river and agreement among individuals and groups with diverse viewpoints on water use and management in the Big Hole watershed." To fulfill this purpose, the BHWC recognized the need for a more comprehensive understanding of the basin's hydrology and the dynamics between irrigation and the ground-water and surface-water systems.

At the BHWC's request, the Beaverhead County Board of Commissioners submitted a proposal to the DNRC's Renewable Resource Grant Program to study the Big Hole basin's water budget and the effects of irrigation on the hydrologic budget. Agencies that joined in preparing the proposal included the Montana Bureau of Mines and Geology (MBMG), the Montana Department of Natural Resources and Conservation (DNRC), the U.S. Geological Survey (USGS), and the U.S. Bureau of Reclamation (USBR).

In April 1997, the Montana State Legislature approved funding for the "Big Hole Return Flow and Water Budget Study", and fieldwork began in September of that year. This report summarizes and interprets the data collected during the project and documents the conclusions drawn from the study.

LOCATION

The Big Hole River drains a 2,800-square mile intermontane basin in southwestern Montana (figure 1). The river's headwater is located in the Beaverhead Mountains southwest of Jackson. From there, it flows northward through the broad upper basin that earned the river its name from trappers in the mid-1800s who referred to valleys as "holes". About 20 miles north of Wisdom, the river bends southeastward and enters a relatively narrow valley that loops around the north end of the Pioneer Mountains. At Divide the river turns southward, flowing first through Maiden Rock Canyon, and then through the Melrose and Glen valleys. Downstream of Glen, it runs eastward, passes through a short canyon known as Notch Bottom and then skirts the southeast flank of McCartney Mountain before joining the Beaverhead River at Twin Bridges to form the Jefferson River. From headwater to mouth, the river is about 130 miles long.

Throughout the report, the Big Hole basin will be discussed in terms of three hydrologic units: the upper, middle, and lower basins (figure 1). The upper basin encompasses the valley surrounding Wisdom and Jackson; the Highway 43 bridge that crosses the Big Hole below Mudd Creek is designated as the downstream terminus of this section. The middle basin refers to the section between the Highway 43 bridge and the Maiden Rock bridge between Divide and Melrose. The lower basin refers to the broad valleys between Maiden Rock and Notch Bottom. The portion of basin below Notch Bottom is not discussed in this report. The boundaries were selected to reflect changes in valley geomorphology and to minimize uncertainty in the measurement of sub-basin inflow and outflow. Most of the water exiting each of the sub-basins can be accounted for by measuring streamflow alone; the ground-water outflow component is small because of natural valley constrictions.

Most of the basin's mountainous uplands lie within the Beaverhead-Deerlodge National Forest which is managed by U.S. Forest Service (USFS) district offices in Wisdom, Wise River, Butte, and Dillon (table 1). The areal extent of the National Forest land within the basin exceeds 1,600 mi^2, almost 60 percent of the watershed. The Bureau of Land Management (BLM) administers about 260 mi^2 of land, the majority of which is dry rangeland in the lower basin. Irrigable valley-bottom lands generally are privately owned and cover about 810 mi^2 (29 percent) of the basin. Most of the remaining land is held by the State of Montana as school trust lands.

As the land-ownership distribution suggests, the basin is a rural area with a small population. Of the 7 small communities along the river (Jackson, Wisdom, Wise River, Dewey, Divide, Melrose, and Glen), none has more than 200 residents. By the account of local humorists, and in fact, cattle outnumber full-time residents by at least 10 to 1.

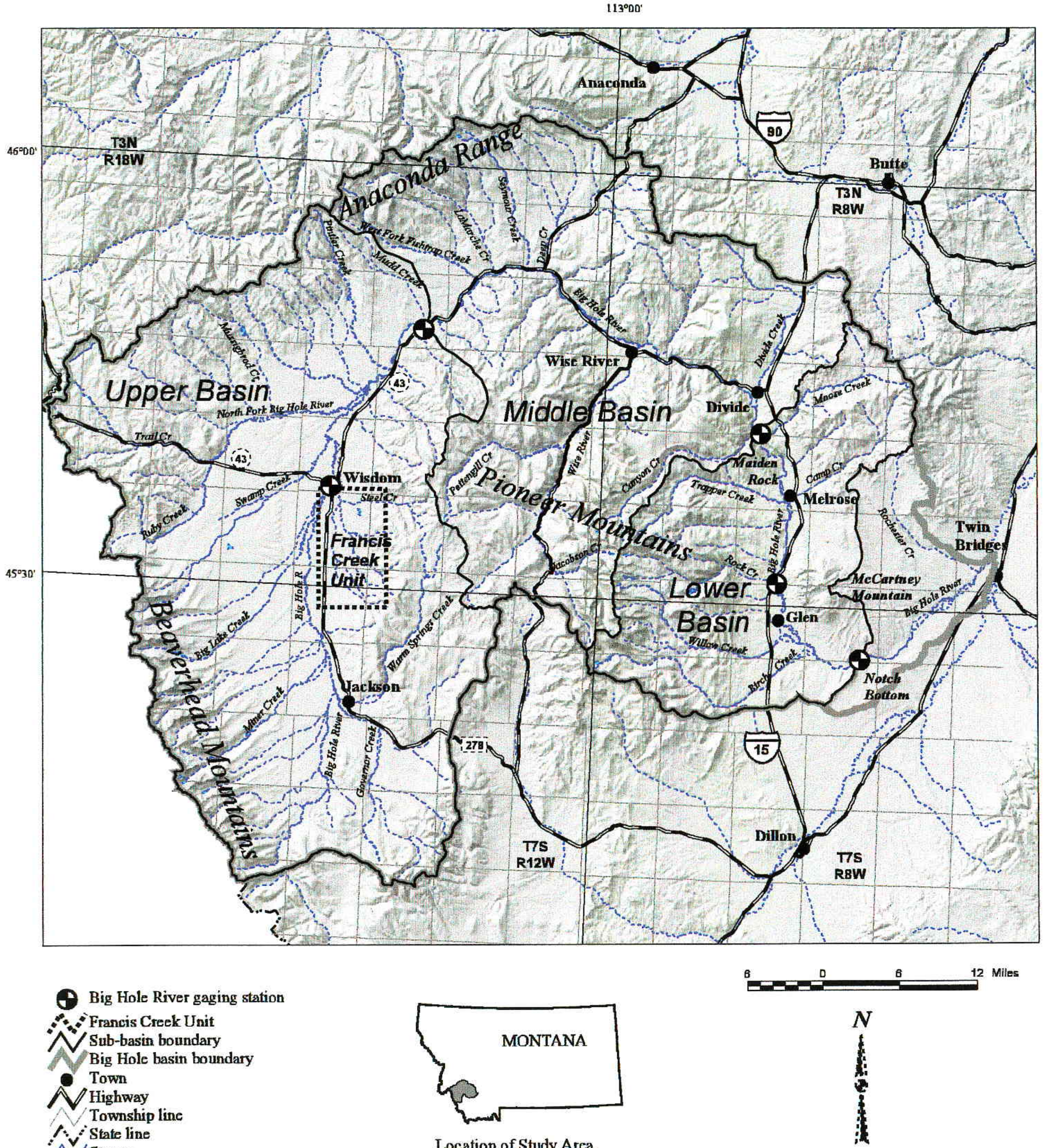

Figure 1. Map of the Big Hole basin.

Table 1. Land ownership in the Big Hole basin

Ownership	Area (acres)	Area (mi²)	Portion of Basin (%)
Federal			
Forest Service	1,045,166	1,633	58.3
Bureau of Land Management	168,188	263	9.4
National Park Service	665	1	<0.1
Private	517,581	809	28.9
State	60,351	94	3.4
Total	1,791,951	2,800	100.

CLIMATE

The basin typically experiences long cold winters, mild summers, and low annual precipitation. Wisdom, at an elevation of 6,060 ft above sea level, received an average of 11.9 inches of precipitation annually during the 51-year period from 1948-98 (WRCC, 1999). Glen (elev. 4,990 ft) received an annual average of slightly more than 9 inches over the 41-year period from 1958-98. In the mountains surrounding the basin, precipitation generally ranges from 30-50 inches annually (WRCC, 1999).

Because of its high elevation and dry climate, the Big Hole basin is subject to extreme cold in the winter. Sub-zero temperatures are common during January and February. Summers are generally mild, with monthly average temperatures ranging from 50-60° F in Wisdom and from 60-65 °F in Glen (WRCC, 1999).

GEOLOGY

The Big Hole basin lies within the thrust belt of the Northern Rocky Mountain physiographic province, which is characterized by numerous mountain ranges and intermontane valleys. The mountains surrounding the Big Hole are predominantly uplifted Proterozoic and Cretaceous sedimentary and igneous rocks (figure 2). In the broad valleys surrounding Jackson, Wisdom, Melrose, and Glen, thin (<150 ft) deposits of Quaternary glacial till, outwash, and alluvium overlie Tertiary sandstone and siltstone. The thickness of the Tertiary fill in the upper basin between Wisdom and Jackson is estimated at more than 16,000 ft (Hanneman and Nichols, 1981) The rocks exposed in the narrow middle basin near Wise River, Dewey, and Divide are Mississippian to Permian sandstone, shale, and limestone. Thin alluvial and glacial deposits also are found in this area.

GROUND-WATER OCCURRENCE AND USE

Tertiary and Quaternary sedimentary deposits are the most important hydrogeologic units within the basin and provide the most reliable supply of ground water. They primarily occupy bottom lands in the upper and lower basins (figures 1 and 2). The Tertiary rocks typically are exposed along the mountain flanks and consist of sandstone and sandy siltstone. Subordinate cross-bedded channel deposits of pebble and cobble conglomerate with a sand matrix also are found (Hanneman and Nichols, 1981). Wells completed in the Tertiary deposits are usually less than 150 ft deep. Levings (1986) measured the specific capacities of 31 wells completed in Tertiary deposits in the upper basin near Wisdom and Jackson. Values ranged from 0.2 to 83 gal/min/ft of drawdown, with a median of 1.4 gal/min/ft which, under certain assumptions, corresponds to a transmissivity of about 450 ft^2/day.

Quaternary deposits in the basin include glacial tills, glacial outwash, and alluvium. Most of the till deposits occur along the eastern flank of the Beaverhead Mountains and the

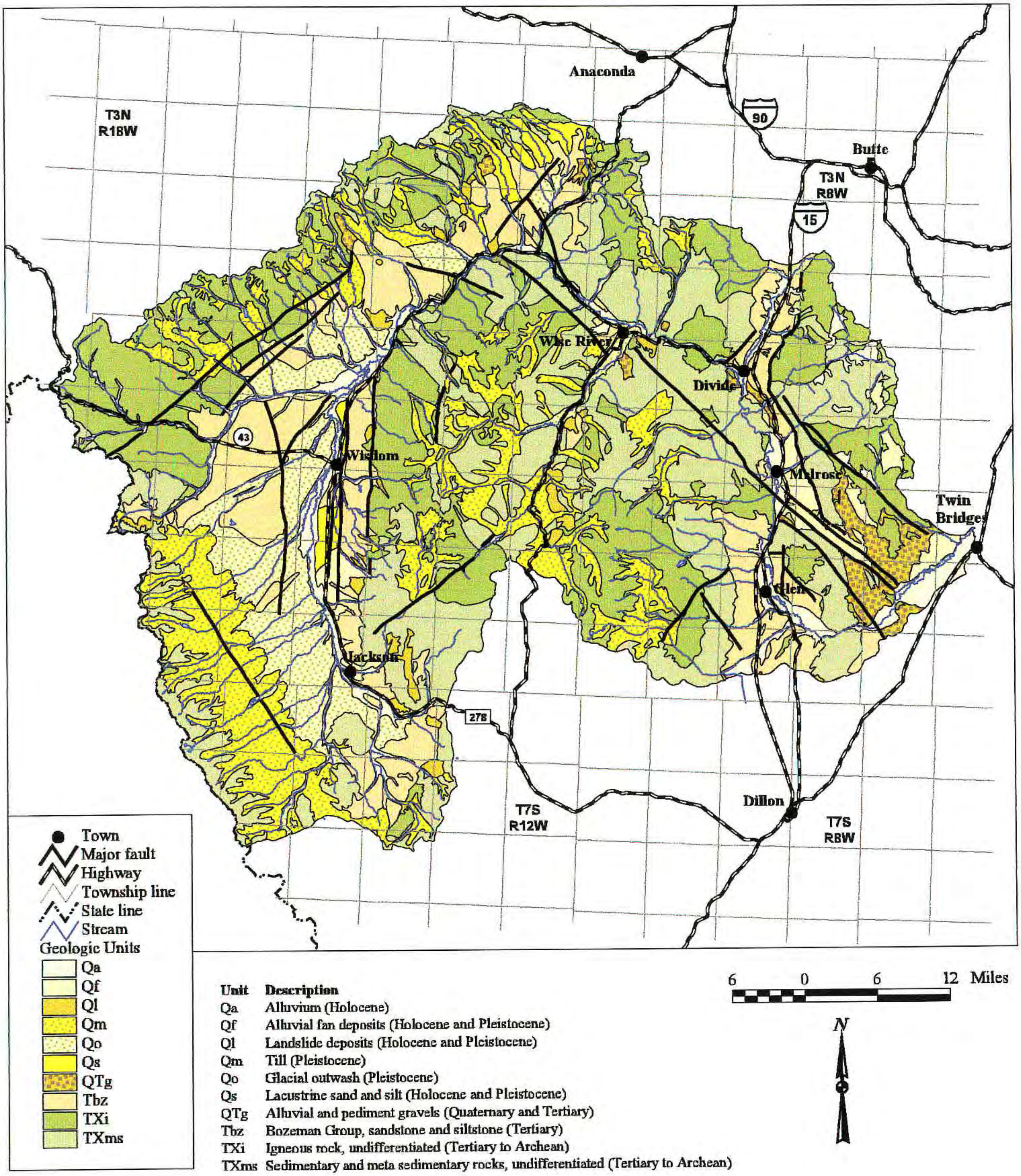

Figure 2. Geologic map of the Big Hole basin, modified from Ruppel and others (1993).

southeastern flank of the Anaconda Range. The deposits consist of ice-transported, locally-derived, angular boulders and cobbles, sand, silt, and clay. Levings (1986) reported specific capacities ranging from 0.2 to 3.8 gal/min/ft of drawdown for 6 wells completed in this material in the upper basin, suggesting theoretical transmissivities ranging from about 30 to 700 ft^2/day. Glacial outwash, deposited by melt water, is present in the central portion of the upper basin and along the Wise River valley near the town of Wise River. The outwash deposits consist of well-sorted lenses of cobbles, gravel, and sand with a small fraction of silt and clay. Specific capacities of 7 wells completed in the outwash of the upper basin ranged from 1.0-14.5 gal/min/ft, with a median value of 2.5 gal/min/ft; a corresponding theoretical median transmissivity would be about 550 ft^2/day (Levings, 1986). Quaternary alluvium consisting of cobbles, gravel, sand, silt, and clay is associated with active stream channels and flood plains throughout the basin. Specific capacities for 7 wells completed in upper basin alluvium ranged from 1.1 to 5.3 gal/min/ft, with a median value of 2.5 gal/min/ft. Thus, the transmissivity of the alluvium is probably similar to that of the glacial outwash (Levings, 1986).

Ground water occurs under both water-table and artesian conditions in the basin. Artesian conditions generally occur where an overlying confining layer results in a hydrostatic pressure buildup in the underlying aquifer. Artesian conditions also may occur in ground-water discharge areas where deeper hydraulic pressures exceed those at the water table.

Most existing wells are less than 300 ft deep, so the vertical extent of the aquifer system beyond this depth is not well documented. Geophysical logs from a 16,000-ft AMOCO exploration hole drilled between Wisdom and Jackson in 1980 suggest that the potential of finding potable water in the Tertiary material of the upper basin decreases substantially at a depth beyond 1,000 ft (Levings 1986). An exploration hole drilled near Glen encountered highly saline water at a depth of 2,000 ft (Jim Hagenbarth, personal communication, 1999), which places a depth limit on potable water potential in the lower basin as well.

Of the more than 1,100 water wells in the basin, most are used for domestic (65 percent) and stock (21 percent) needs (GWIC, 2000). Typically, the wells are completed in Tertiary or Quaternary sand and gravel deposits and have reported yields of 5-20 gallons per minute. A few wells are completed in igneous or metamorphic bedrock, but they generally have lower yields. In recent years, several test wells have been drilled with the hope of locating areas in the lower basin aquifer system that would produce sufficient yields (several hundred to several thousand gallons per minute) to supply irrigation systems; none of these exploratory efforts has been fruitful (Jim Hagenbarth, personal commun., 1997; Clint Speirs, personal commun., 1997).

SURFACE-WATER OCCURRENCE AND USE

The mean discharge for the Big Hole at the USGS gaging station near Melrose (period of record 1924-1999) is about 1,140 cubic feet per second (cfs), or 825,000 acre-feet per year (Shields and others, 2000). Average monthly flow hydrographs (figure 3) for this station and one at Wisdom (period of record 1988-1999) show that spring runoff typically begins in April and peaks in June. Discharge declines rapidly in July and August when precipitation is minimal and most of the seasonal snow pack has melted. During the fall and winter, stable base-flow conditions prevail as ground water slowly but steadily discharges to the surface-water system.

The largest tributary to the Big Hole is the Wise River, which drains the north-central portion of the Pioneer Mountains. For the period of record 1973-1985, mean discharge of the Wise River was 183 cfs, or 132,500 acre-feet per year, accounting for 15 percent of the flow measured in the Big Hole near Melrose (period of record 1973-1985). Other important tributaries to the Big Hole include Governor, Miner, Mussigbrod, Steel, Trail, and Warm Springs Creeks in the upper basin, Divide, Deep, and LaMarche Creeks in the middle basin, and Birch, Camp, Moose, Rock, Trapper, and Willow Creeks in the lower basin.

Water rights and permits on the Big Hole and its tributaries are summarized in table 2. Water-right claims total nearly 2.1 million acre-ft; however, the mean annual discharge of the Big Hole near Melrose is only 826,000 acre-ft (period of record 1924-1998). Nonetheless, the water-rights data are useful for demonstrating that the primary use of surface water is for irrigation of the basin's 134,000 acres (DNRC, 1981) of cropland and pasture.

Grass hay is the primary irrigated crop in the upper and middle basins, whereas alfalfa and alfalfa-grass hay are common in the lower basin. Diverted water typically is distributed via unlined ditches and canals and is used for flood irrigation. However, in the lower basin, sprinkler systems are used to irrigate about half the land. The peak irrigation period in the upper basin begins in May and ends by mid-July. Because of the short growing season, only one cutting of hay is possible. After July, many ditches and canals are left flowing to supply stock water and to encourage forage growth in pastures used for summer grazing. In the lower basin, the milder climate allows for 2 cuttings of hay, and therefore the irrigation season is longer, running from May through September. Although the amount of water diverted for irrigation has never been measured in the Big Hole basin, monthly estimates have been made by the DNRC (1981). However, many agricultural users in the area feel that these estimates are incorrect (DNRC, 1995).

Flows for fisheries and recreation are another source of water demand in the basin. The Montana Department of Fish, Wildlife and Parks estimates that 40 cfs are needed in the river near Wisdom during the summer and early fall to maintain sufficient habitat for the rare fluvial Arctic grayling fishery; about 250 cfs are needed in the Melrose and Glen area to maintain the blue-ribbon trout fishery (BHWC, 1999). In the summer 1999, a drought-management plan was implemented to encourage voluntary water conservation and reduce fishing pressure on the mainstem when flows drop below these values (BHWC, 1999).

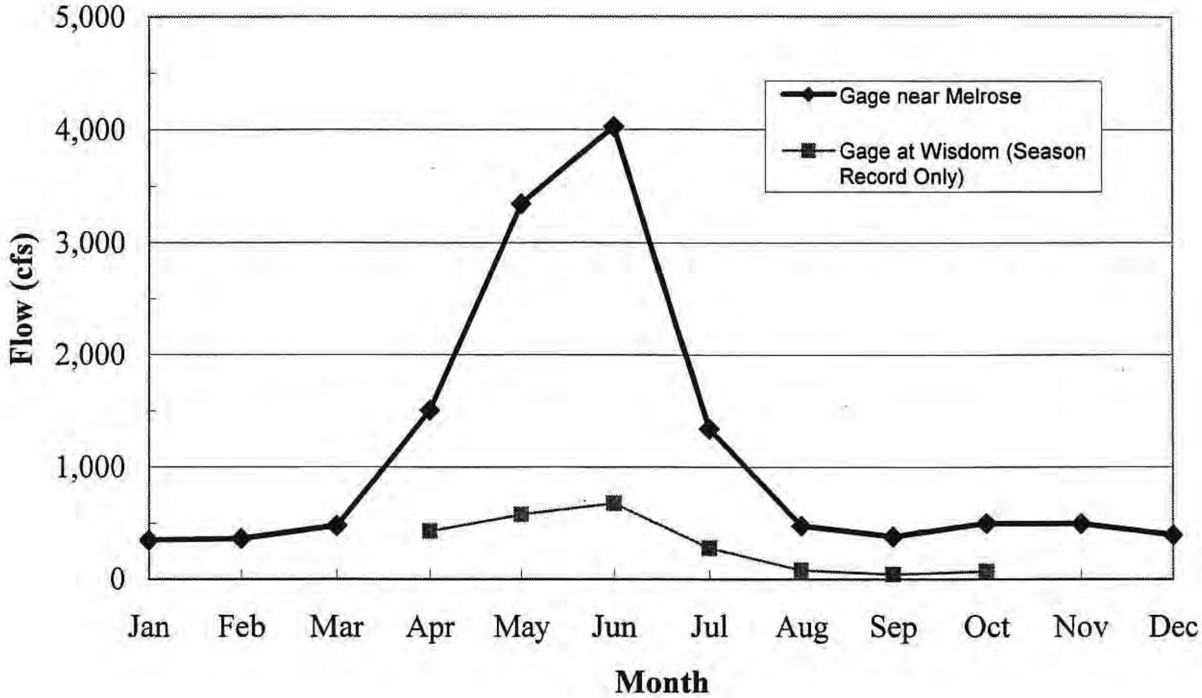

Figure 3. Average monthly flow hydrograph for the Big Hole River between Melrose and Glen (USGS Station 06025500), period of record 1924-1998. (Data from Shields and others, 1999)

Table 2. Summary of water rights and permits for the Big Hole basin. Data from DNRC Water Management Bureau (1998)

Big Hole Main Stem

Purpose	Number	Total Rate (cfs)	Volume (acre-ft)
Municipal and Domestic	3	21	15,427
Irrigation	326	5,013	94,274
Stock	90	306	132
Fish and Wildlife	2	13	1,825
Power Generation	2	1,250	912,500
Other	3	648	1,075
Total	426	7,251	1,025,233

Tributaries

Purpose	Number	Total Rate (cfs)	Volume (acre-ft)
Municipal and Domestic	42	23	4,796
Irrigation	1,328	15,865	676,673
Stock	793	85	6,943
Fish and Wildlife	6	2	1,671
Power Generation	1	111	47,876
Other	83	625	299,858
Total	2,253	16,711	1,037,817

A third demand on surface water in the basin is for municipal use. The City of Butte, the largest municipal user, diverts water from the river upstream of Divide and from the South Fork Reservoir on Divide Creek and pumps it across the Continental Divide. Butte has a water right for 21.26 cfs from the Big Hole River and 12.5 cfs from the South Fork Reservoir on Divide Creek. The water company's monthly water-use statistics for the Big Hole River and the reservoir for the period from January 1996 through December 1999 are summarized in table 3. Withdrawal rates from the river generally are highest during July and August; for the reservoir, rates are highest in May and June. The highest withdrawal rate from the river during the 1996-99 period was 19.2 cfs on July 13, 1999. An average of 4.2 cfs is pumped from the river annually; the average annual withdrawal from the reservoir is 2.5 cfs.

Despite over-allocation, the surface-water supply in the basin during most years is adequate to meet user needs. However, in some years with early runoff and/or below normal snow pack and precipitation, water shortages do occur. The lowest flow recorded at the USGS gaging station south of Melrose was 49 cfs on August 17, 1931 (Shields and others, 2000); no flow was recorded on the mainstem near Wisdom from August 28 through September 20, 1988 (Shields and others, 1989).

RELATED RESEARCH AND TECHNICAL REPORTS

Levings (1986) investigated the occurrence, quantity, and quality of surface water and ground water in the upper basin near Wisdom and Jackson. During the one-year study, about 90 wells and springs were inventoried, and monthly stream-discharge measurements were collected at 15 tributary and mainstem locations. Total mean annual precipitation in the upper basin was calculated to be 22.8 inches over the 1,267 mi^2 drainage area. Of this amount, 6.1 inches (27 percent) was estimated to discharge from the basin via the river. The remaining 16.7 inches (73 percent) was presumably lost to evapotranspiration. Although Levings (1986) observed that flood irrigation contributes recharge to the basin's near-surface aquifer, the amount of recharge was not quantified because it was outside the scope of the study.

Marvin (1997) collected additional aquifer characteristic data in the upper basin and measured water leakage along 18 diversions. Losses averaged 0.6 cfs/mile of ditch and were as high as 5.1 cfs/mile. Much of the water was lost to infiltration and therefore contributed to aquifer recharge.

Phillip (1999) compared the water quality of diverted water to irrigation return water at 4 locations in the basin. She found minor changes in water chemistry, but concluded that there were no acute water-quality problems associated with irrigation.

Additional hydrologic investigations include Perry (1934), Bahls (1978), Marvin and Abdo (2000), Marvin (1999), Marvin and others (1998), DNRC (1981), and DNRC

Table 3. Summary of water withdrawals from the Big Hole basin by the Butte-Silver Bow Water Company, period of record 1996-1999. Data provided by Marty Hoven of the Butte-Silver Bow Water Company

Month	Big Hole Pump Station Average (cfs)	Big Hole Pump Station Maximum (cfs)	S Fk Reservoir Average (cfs)	S Fk Reservoir Maximum (cfs)	Total Average Water Use (cfs)
January	3.5	5.5	1.6	2.4	5.1
February	4.2	10.1	1.4	2.5	5.6
March	3.0	5.6	1.4	5.0	4.4
April	2.4	6.4	2.1	6.3	4.5
May	1.2	7.2	4.0	9.9	5.2
June	0.7	10.7	5.6	11.1	6.3
July	8.8	19.2	3.9	9.8	12.7
August	8.4	19.1	2.3	5.1	10.7
September	6.2	18.5	1.7	3.2	7.9
October	3.5	7.8	1.6	5.7	5.1
November	3.6	6.4	1.7	3.6	5.3
December	3.4	6.0	1.5	3.7	4.9
Average	4.2	10.2	2.5	5.7	6.7
Maximum	9.1	19.2	5.6	11.1	12.7

(1995). Perry (1934) provided an overview of the physiography, geology, and hydrology of the upper basin. Bahls (1978) discussed the effects of dewatering on water quality and biological diversity along the lower Big Hole during the summer of 1977. Bahls (1978) referenced unpublished return-flow data collected by the USBR (Field Planning Branch, Billings) that show that average specific conductance of diverted water was about 170 µmhos/cm in 1974 and 1975, whereas the average conductance of return water was about 320 µmhos/cm for the same 2 years. The increase in specific conductivity was not considered a water-quality problem. Marvin and Abdo (2000) presented a source-water protection plan for the Divide Public School that contains a discussion on the hydrogeology of the alluvial aquifer near Divide. Marvin (1999) evaluated the hydrogeology of a defunct tungsten mill site near Glen. Marvin and others (1997) and Marvin and others (1998) discussed the impacts of mining on Forest Service and Bureau of Land Management land in the Big Hole basin. DNRC (1981) evaluated the basin's water resources and recommended the development of a reservoir on Pettengill Creek (referred to as Pattengail Creek in the report) to alleviate water shortages. DNRC (1995) reviewed the water-shortage issue and recommended that measurement devices be installed on all diversions of water from the river's main stem in order to improve water management.

Previous investigations on the effect of irrigation on basin-scale hydrology in western Montana include Hackett and others (1960), Voeller and Waren (1997), and Uthman and Beck (1998). Hackett and others (1960) conducted a detailed study on the hydrology of the Gallatin River basin near Bozeman and constructed a water budget that included irrigation returns. Voeller and Waren (1997) quantified irrigation return flows along the Flint Creek drainage, a tributary to the Clark Fork River. The timing and magnitude of irrigation returns were found to vary across the basin, ranging from 80 to 100 cfs during October and November. Uthman and Beck (1998) evaluated the effects of irrigation on the ground-water and surface-water resources of the upper Beaverhead River basin near Dillon.

STUDY DESIGN

A primary objective of the project was to gain a better understanding of the Big Hole basin's overall hydrology so that water users can develop strategies to deal with current and future irrigation, fisheries, recreational, residential, and municipal water-use concerns. A second, more specific objective was to evaluate the effect of irrigation on the surface- and ground-water systems in the upper and lower basins.

To accomplish these objectives, a network of streamflow-gaging stations, wells, and weather stations was monitored over about a 16-month period from August 1997 through November 1998. The data gathered from the network were used to construct hydrologic budgets for irrigated portions of the upper and lower basins. A hydrologic budget accounts for how water enters, is stored, and leaves a drainage area over a period of time.

Typical components of a hydrologic budget include surface-water inflows and outflows, ground-water inflows and outflows, precipitation, and evapotranspirative (ET) loss.

Another important water-budget component, especially when evaluating irrigation returns, is the change in ground-water storage. When a field is irrigated, commonly a portion of the water percolates into the ground and recharges the underlying aquifer. Later, the water either discharges to the surface-water system or is released to the atmosphere by ET. One of the most challenging tasks of the project was to determine changes in ground-water storage produced by irrigation and to evaluate the relative importance of ET versus surface-water discharge in the eventual fate of the stored ground water.

For the purposes of this study, the basin was divided into 3 study areas: the upper, middle, and lower basins (figure 1). The upper basin encompasses the broad valley surrounding Jackson and Wisdom and extended downstream to the State Highway 43 bridge that crosses the river below Mudd Creek. Because of the hydrologic complexity of this region, a sub-area south of Wisdom, referred to as the Francis Creek unit, was selected for intensive study. The middle basin study area extends from the Highway 43 bridge to the Maiden Rock bridge between Divide and Melrose. The lower basin study area extends from the Maiden Rock bridge, through the Melrose and Glen valleys, to Notch Bottom. No work was conducted downstream of Notch Bottom because flat terrain and numerous diversions mask the hydrologic boundary between the Big Hole and Beaverhead river drainages.

UPPER BASIN

Characterization of the hydrology of the 1,267 mi^2 upper basin was relatively limited. River flow data were compiled from USGS gaging stations at Wisdom (USGS ID 06024450) and at the Highway 43 bridge below Mudd Creek (USGS ID 06024540). The Hwy 43 bridge gage was installed especially for this study in order to monitor total surface-water outflow from the upper basin. Forty-three wells were monitored on a quarterly basis to provide an indication of the magnitude and timing of annual changes in ground-water storage. In addition, historical ground-water data were reviewed to determine if longer-term aquifer storage trends exist. To characterize weather conditions, temperature and precipitation data were obtained from National Weather Service (NWS) stations in Wisdom and Jackson; also, snowfall data were compiled from Natural Resource Conservation Service (NRCS) snow course and snow telemetry (SNOTEL) stations in the nearby mountains.

In August and September 1998, synoptic streamflow measurements were made on 20 of the more than 40 tributaries in the upper basin for comparisons of surface-water inflow and outflow. These measurements were used to estimate the contribution of irrigation returns to river flow during the late summer. Additional streamflow data were collected by the DNRC-Water Management Bureau in the summer 2000 for a more detailed analysis of the upper basin flows.

The locations of the gaged and ungaged streamflow sites and the monitoring wells in the upper basin are shown in figure 4.

FRANCIS CREEK UNIT

The Francis Creek unit south of Wisdom (inset, figure 4) covers a 27 mi^2 area within the Stanley, Sheep, and Francis creek watersheds. This area was selected for intensive study because it has relatively well-defined hydrologic boundaries and has 11 mi^2 of flood-irrigated pasture that are managed similarly to most other ranch lands in the upper basin.

During the 1998 field season, numerous synoptic streamflow measurements were made at ungaged sites on the streams and irrigation diversions that flow across the unit. In addition, continuous discharge measurements were collected at streamflow-gaging stations on the lower end of Francis Creek and on the Huntley Ditch, the site's largest diversion, just downstream of where it crosses beneath Highway 278. The streamflow data were used to construct a surface-water flow balance for the site.

To characterize the ground-water system, water levels were measured in 23 wells and 2 piezometers at the site. Nine of the wells were installed specifically for this project; the remainder were pre-existing stock and domestic wells. During the winter 1997-98, water-level measurements were made monthly; from May through September 1998, the monitoring frequency increased to every 2 weeks. Aquifer tests were performed on many of the wells to obtain hydraulic-conductivity (K) estimates. Ground water from most wells was sampled quarterly for specific conductance (SC), which is an indirect measure of the dissolved solids (salts) present in the water. The SC measurements provided insight into how water moves through the aquifer system.

Two rain gages were established at the site to determine the timing and variability of precipitation across the area. A weather station was placed near one of the gages in order to monitor air and soil temperatures, wind speed, relative humidity, incident solar radiation, net radiation, and barometric pressure. The gathered data were used to compute crop water-use rates.

MIDDLE BASIN

In the middle basin (drainage area 930 mi^2), the river and its tributaries have carved relatively narrow valleys through bedrock and loosely consolidated Tertiary sand and gravel deposits; the broad alluvial plains characteristic of the upper and lower basins generally do not occur. Consequently, only a small portion of the middle basin is irrigated. Streamflow-gaging stations at the Highway 43 bridge below Mudd Creek (USGS ID 06024540) and at Maiden Rock bridge (USGS ID 06025250) were used to

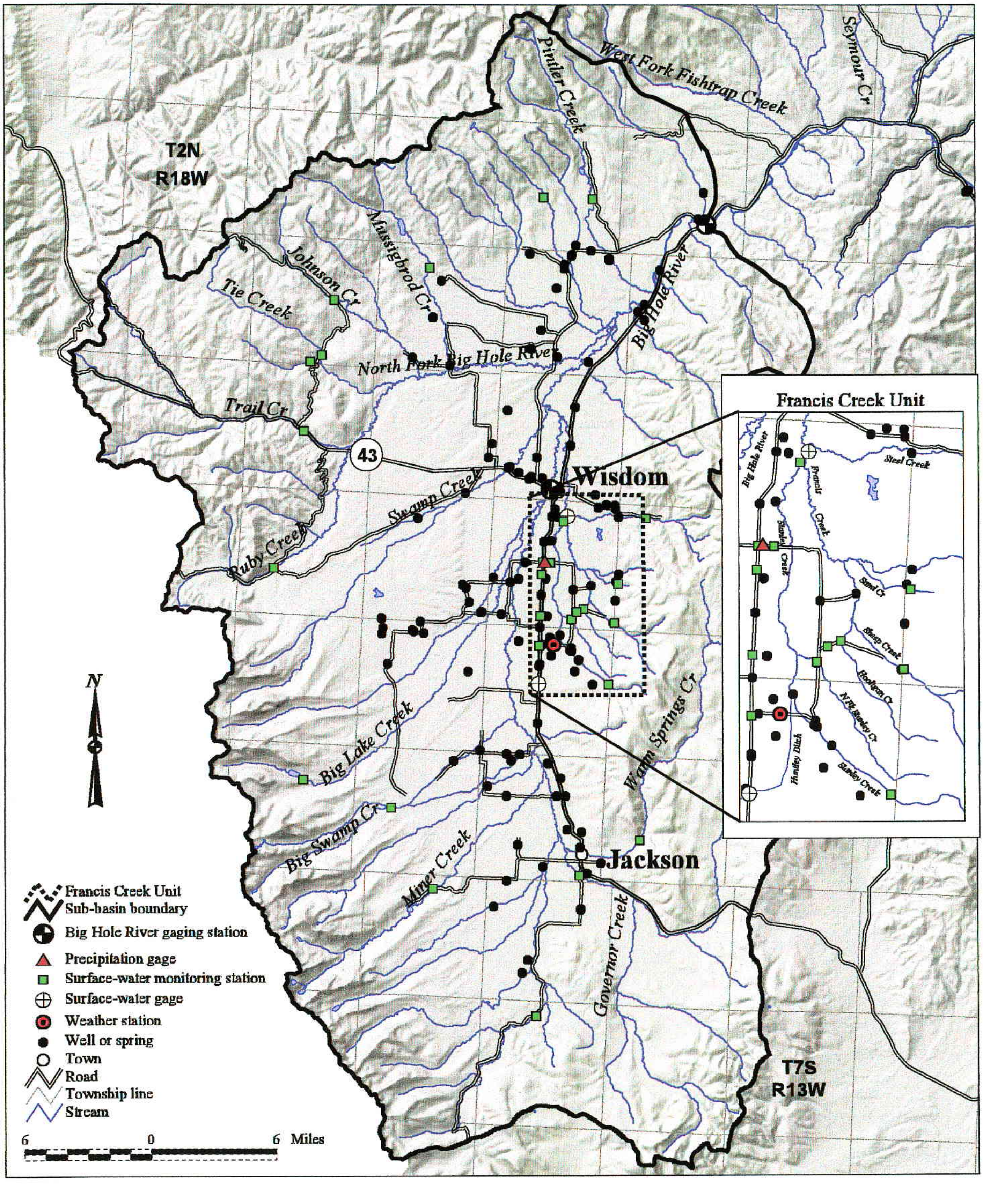

Figure 4. Locations of monitoring sites in the upper Big Hole basin.

assess surface-water inflow and outflow (figure 5). The Butte-Silver Bow Water Company's withdrawals from the Big Hole River and the South Fork Reservoir were accounted for in the inflow/outflow balance as well. A set of water-level measurements collected at 67 wells in the spring 1998 was used to construct a potentiometric contour map of the near-surface aquifer for the region from Wise River to Divide. Slug tests were performed on several wells to measure aquifer hydraulic conductivity. A Wise River resident collected daily precipitation, average wind speed, and maximum and minimum air temperature data during the spring, summer, and early fall 1998. These data were used to estimate the water use of the grass hay and alfalfa grown on the irrigated land in the area.

LOWER BASIN

The 45-square-mile irrigated portion of the lower basin was studied intensively so that a detailed hydrologic budget could be developed. Monitoring locations in the area are shown on figure 6. Surface-water flow into the valley was recorded at the Maiden Rock bridge gage north of Melrose (USGS ID 06025250) and at tributary gaging stations on Birch, Moose (USGS ID 06025270), Rock (USGS ID 06025480), Trapper, and Willow (USGS ID 06025800) Creeks. In addition, flow measurements were made periodically on Cherry and Camp Creeks and a diversion that carries water from Canyon Creek into the Trapper Creek drainage. Outflow from the study area was recorded at the Notch Bottom gage (USGS ID 0602610) on the Big Hole River and by two gages on diversions that bypass the river gage. A diversion on Birch Creek that carries water across the basin divide into the Beaverhead River drainage also was measured periodically. Measurements at a pre-existing USGS gaging station near the frontage road bridge between Melrose and Glen (USGS ID 06025500) allowed for separation of the study area into two sub-units referred to as the Melrose and Glen valleys. Two diversions bypass this gage, but only one was monitored at a streamflow gaging station. The other diversion was estimated to carry about 12 cfs during the irrigation season and was assumed to carry no flow during the remainder of the year.

Ground-water levels in the lower basin were monitored using a network of about 90 domestic wells, stock wells, and springs. Water levels in about 60 of the wells were measured every 2 weeks during the irrigation season (May-September) and monthly at other times of the year. When conditions permitted, slug tests and/or short-duration aquifer tests were performed on the wells to obtain estimates of aquifer hydraulic conductivity. Also, SC was measured at many locations to provide insight into how ground water moves through the basin's aquifer system.

Precipitation gages were installed at 12 locations in the lower basin to supplement data collected by the NWS observer near Glen. Typically the gages were checked during the ground-water monitoring rounds, but several were monitored more frequently, thanks to assistance from interested landowners. In addition to precipitation data collected in the Glen and Melrose valleys, precipitation and snowpack data were compiled from six NRCS

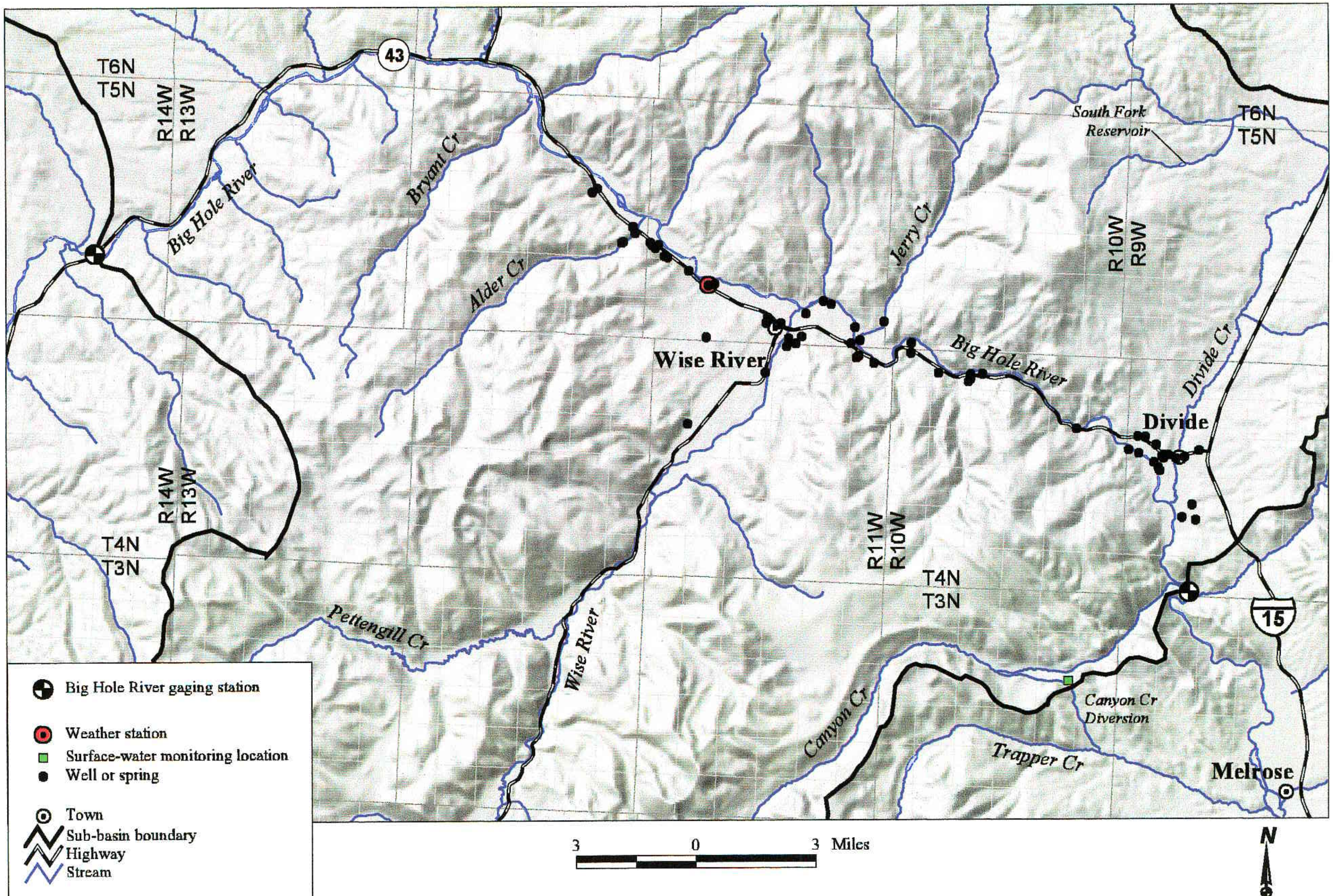

Figure 5. Locations of monitoring sites in the middle Big Hole basin.

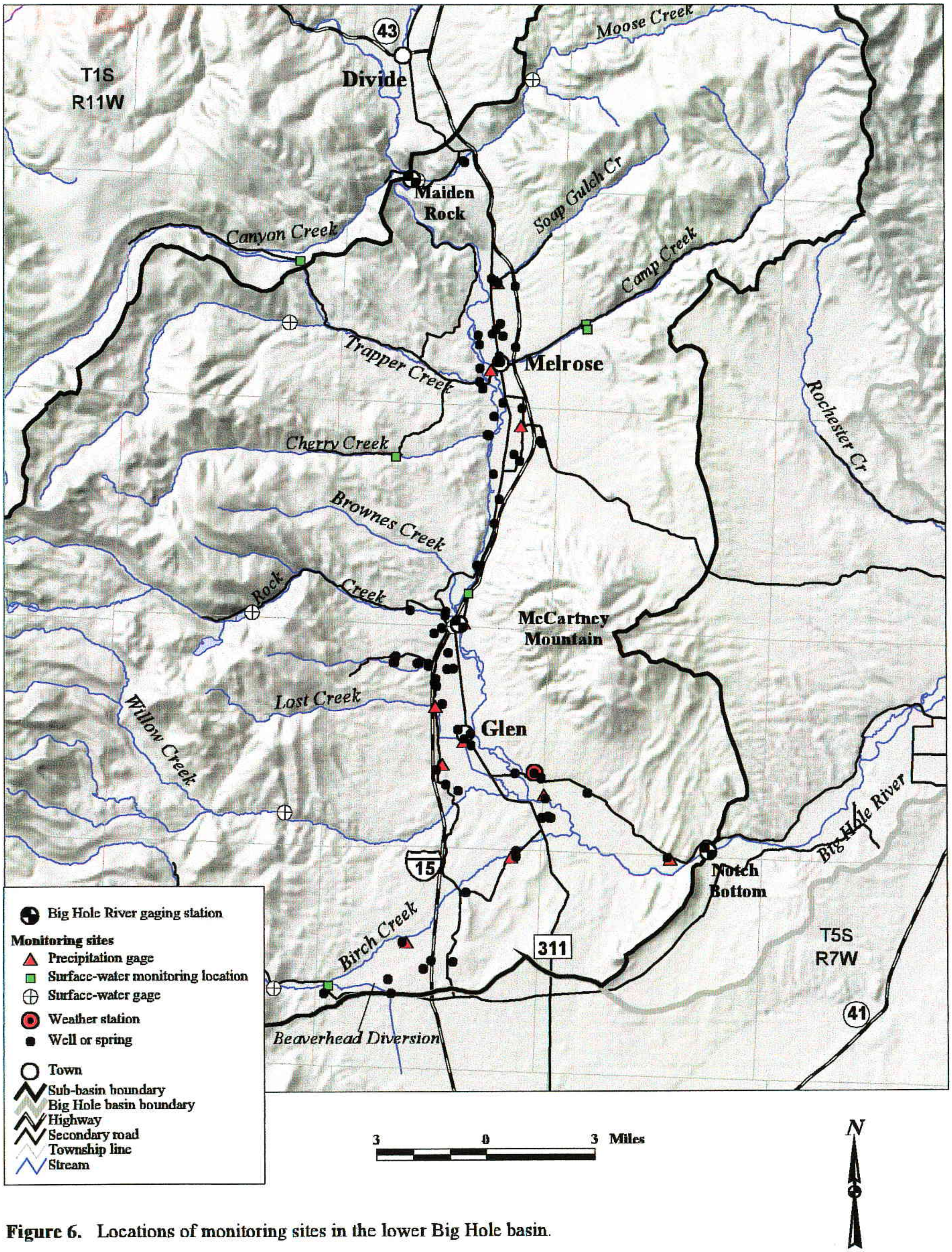

Figure 6. Locations of monitoring sites in the lower Big Hole basin.

SNOTEL and snow course sites located in the surrounding mountains. Also, hourly air-temperature data were collected with a datalogger placed in the NWS enclosure near Glen. These temperature data supplemented the daily high and low temperature readings that were recorded by the NWS observer. Finally, solar radiation, wind speed and other data were compiled from the U.S. Bureau of Reclamation Agrimet station near Dillon. Although this station is located outside the Big Hole basin, the weather conditions that it records are similar to those of the Glen and Melrose valleys and therefore were used to calculate lower-basin grass and alfalfa ET rates.

RESULTS AND DISCUSSION

Climate, ground-water, and surface-water data collected for the study are presented and discussed in the following sections. Each of the three major river segments, the upper, middle, and lower basins, are discussed separately. The Francis Creek unit, which is a drainage within the upper basin, is discussed in a fourth section. Appendices A, B, C, and D contain summaries of the climate, ground-water, surface-water, and ET data, respectively.

UPPER BASIN

Climate

Mean air temperatures in the upper basin were near normal during the September 1997 through September 1998 study period (table 4). The winter months, especially December, were somewhat cooler than normal, but a warm spring and summer followed.

Total precipitation in the Wisdom area during the study was 16.3 inches, approximately 25 percent more than normal (table 5). In contrast, the total precipitation in Jackson was 10.2 inches, which is approximately 21 percent below normal. The difference in precipitation at the two stations reflects the tendency of storms to be localized in the upper basin. Levings (1986) noted that rainfall recorded during a single cloudburst over only one of the stations could be responsible for an increase of as much as 10 percent in the total annual precipitation at the station.

Precipitation and snowpack in the mountains surrounding the upper basin was generally below normal during the study. Table 6 lists monthly precipitation at 5 NRCS SNOTEL stations in the Beaverhead Mountains and the Pintler Range from September 1997 through September 1998. At the Bloody Dick station, total precipitation was almost 20 percent below normal. Table 7 lists first-of-the-month snowpack data for 11 NRCS snow course sites. Snowpack was consistently 15 to 25 percent less than the 30-year averages (1961-90) for the stations. If not for above average precipitation during the late spring and early summer, the 1997-98 water year would have been relatively dry.

Table 4. Monthly mean temperatures at Jackson and Wisdom, Montana, September 1997-September 1998. Data from WRCC (1999)

	Jackson				Wisdom			
	Monthly Mean Temperature (°F)		Departure from Normal	Percent of Normal	Monthly Mean Temperature (°F)		Departure from Normal	Percent of Normal
Month	Observed	30-yr avg*	(°F)	(%)	Observed	30-yr avg*	(°F)	(%)
Sep-97	51.0	47.8	3.2	107	49.6	47.0	2.7	106
Oct-97	--	38.5	--	--	36.9	37.5	-0.6	98
Nov-97	25.2	26.0	-0.7	97	25.8	24.9	0.9	104
Dec-97	13.7	18.0	-4.3	76	9.9	15.6	-5.7	64
Jan-98	20.7	17.3	3.4	119	16.4	14.0	2.4	117
Feb-98	19.1	20.3	-1.2	94	13.9	17.7	-3.8	79
Mar-98	27.6	25.6	2.0	108	25.7	24.2	1.5	106
Apr-98	35.5	33.9	1.6	105	36.2	34.5	1.7	105
May-98	44.8	43.8	1.0	102	46.0	44.0	2.0	105
Jun-98	46.0	51.0	-5.0	90	49.2	52.0	-2.8	95
Jul-98	61.3	57.4	4.0	107	62.1	57.8	4.4	108
Aug-98	59.5	57.1	2.4	104	57.5	55.7	1.9	103
Sep-98	52.8	47.8	5.0	111	52.9	47.0	6.0	113
Average	38.1	37.2 **	0.9	103	37.1	36.3	0.8	102

* Years 1961-1990

** Average excludes October mean temperature

Table 5. Monthly precipitation at Jackson and Wisdom, Montana, September 1997-September 1998. Data from WRCC (1999)

	Jackson				Wisdom			
	Precipitation (in)		Departure from Normal	Percent of Normal	Precipitation (in)		Departure from Normal	Percent of Normal
Month	Observed	30-yr avg*	(in)	(%)	Observed	30-yr avg*	(in)	(%)
Sep-97	0.15	1.10	-0.95	14	1.42	0.99	0.43	143
Oct-97	--	0.85	--	--	1.66	0.76	0.90	218
Nov-97	0.17	0.78	-0.61	22	0.36	0.77	-0.41	47
Dec-97	1.03	0.65	0.38	158	0.26	0.76	-0.50	34
Jan-98	1.42	0.71	0.71	200	0.78	0.66	0.12	118
Feb-98	0.18	0.56	-0.38	32	0.37	0.52	-0.15	71
Mar-98	0.14	0.83	-0.69	17	0.47	0.68	-0.21	69
Apr-98	1.68	1.09	0.59	154	1.75	0.90	0.85	194
May-98	0.43	1.83	-1.40	23	3.02	1.66	1.36	182
Jun-98	3.22	2.13	1.09	151	2.58	1.95	0.63	132
Jul-98	1.40	1.01	0.39	139	1.80	1.13	0.67	159
Aug-98	0.02	1.07	-1.05	2	0.47	1.08	-0.61	44
Sep-98	0.38	1.10	-0.72	35	1.38	0.99	0.39	139
Total	10.22	12.86 **	-2.64	--	16.32	12.85	3.47	--

* Years 1961-1990
** Total excludes October precipitation

Table 6. Monthly precipitation data from SNOTEL stations around the upper Big Hole basin, September 1997 - September 1998. Data from NRCS (1999)

Site Name	Bloody Dick				Calvert Creek				Darkhorse Lake				Moose Creek				Saddle Mountain				
NRCS Site ID	13D10S				13D26S				13D19S				13D16S				13D22S				
Latitude/Longitude	45°10'N/113°30'W				45°53'N/113°20'W				45°10'N/113°35'W				45°40'N/113°57'W				45°42'N/113°58'W				
Section, Township, Range	12 08S 16W				34 02N 14W				04 08S 16W				14 27N 21E				05 02S 19W				
Elevation (ft)	7,600				6,430				8,600				6,200				7,940				
Month	Precip (in)	30-yr Average (in)	Departure from Normal (in)	Percent of Normal	Precip (in)	30-yr Average (in)	Departure from Normal (in)	Percent of Normal	Precip (in)	30-yr Average (in)	Departure from Normal (in)	Percent of Normal	Precip (in)	30-yr Average (in)	Departure from Normal (in)	Percent of Normal	Precip (in)	30-yr Average (in)	Departure from Normal (in)	Percent of Normal	Average Percent of Normal (%)
Sep-97	1.5	1.8	-0.3	83	2.0	1.4	0.6	143	1.6	3.1	-1.5	52	1.3	1.9	-0.6	68	1.7	1.7	0.0	100	89
Oct-97	3.3	1.5	1.8	220	2.2	1.1	1.1	200	3.7	2.7	1.0	137	3.7	2.1	1.6	176	4.0	2.4	1.6	167	180
Nov-97	2.0	2.6	-0.6	77	1.8	1.5	0.3	120	3.5	4.9	-1.4	71	2.6	3.7	-1.1	70	3.0	4.3	-1.3	70	82
Dec-97	0.9	2.8	-1.9	32	0.5	2.3	-1.8	22	2.7	5.3	-2.6	51	1.8	4.0	-2.2	45	1.9	5.6	-3.7	34	37
Jan-98	3.4	3.1	0.3	110	2.0	2.0	0.0	100	7.0	5.0	2.0	140	4.7	4.1	0.6	115	5.4	6.6	-1.2	82	109
Feb-98	0.9	2.6	-1.7	35	0.8	1.9	-1.1	42	2.0	4.9	-2.9	41	1.4	3.0	-1.6	47	1.6	4.9	-3.3	33	39
Mar-98	1.4	2.5	-1.1	56	1.4	1.6	-0.2	88	3.5	5.0	-1.5	70	2.3	3.0	-0.7	77	2.7	4.4	-1.7	61	70
Apr-98	2.6	2.7	-0.1	96	1.7	1.5	0.2	113	5.9	4.5	1.4	131	3.8	2.4	1.4	158	5.3	3.6	1.7	147	129
May-98	2.9	4.0	-1.1	73	3.1	1.9	1.2	163	6.1	6.4	-0.3	95	3.6	2.6	1.0	138	3.8	3.7	0.1	103	114
Jun-98	3.4	2.2	1.2	155	2.1	1.4	0.7	150	7.0	3.1	3.9	226	4.1	2.7	1.4	152	4.0	2.5	1.5	160	168
Jul-98	1.1	1.7	-0.6	65	1.5	1.1	0.4	136	3.0	1.9	1.1	158	2.0	1.1	0.9	182	2.4	1.5	0.9	160	140
Aug-98	0.3	1.6	-1.3	19	0.3	1.4	-1.1	21	1.5	2.6	-1.1	58	0.3	1.3	-1.0	23	0.5	1.4	-0.9	36	31
Sep-98	1.2	1.8	-0.6	67	1.3	1.4	-0.1	93	1.8	3.1	-1.3	58	1.9	1.9	0.0	100	1.5	1.7	-0.2	88	81
Total	24.9	30.9	-6.0	--	20.7	20.5	0.2	--	49.3	52.5	-3.2	--	33.5	33.8	-0.3	--	37.8	44.3	-6.5	--	--

Table 7. First-of-the-month snow-water equivalent (SWE) snowpack data from NRCS SNOTEL and Snow Course stations around the upper Big Hole basin, January-July 1998. Data from NRCS (1999)

		Jan-98			Feb-98			Mar-98			Apr-98		
Site Name	NRCS Site ID	Measured SWE (in)	Normal SWE (in)	Percent of Normal	Measured SWE (in)	Normal SWE (in)	Percent of Normal	Measured SWE (in)	Normal SWE (in)	Percent of Normal	Measured SWE (in)	Normal SWE (in)	Percent of Normal
Bloody Dick	13D10S	4.8	5.1	94	8.3	8.2	101	9.4	10.7	88	10.2	12.6	81
Calvert Creek	13D26S	2.0	4.1	49	4.1	6.1	67	5.0	8.0	63	6.1	8.9	69
Darkhorse Lake	13D19S	10.0	15.5	65	17.9	22.0	81	20.3	27.9	73	24.2	33.7	72
Gibbons Pass	13D02	--	9.1	--	--	15.4	--	--	19.8	--	17.0	23.2	73
Gold Stone	13D09	--	--	--	--	--	--	--	14.4	--	14.3	17.4	82
Jahnke Lake Trail	13D27	--	--	--	--	--	--	--	8.5	--	8.6	10.0	86
Moose Creek	13D16S	5.4	7.1	76	10.1	11.6	87	11.5	14.5	79	13.2	18.0	73
Mudd Lake	13D25	--	--	--	--	--	--	--	17.0	--	15.2	20.0	76
Palisade Creek	13D23	--	--	--	--	--	--	--	20.4	--	26.4	29.9	88
Saddle Mountain	13D22S	9.5	11.1	86	15.7	17.0	92	17.8	21.9	81	20.4	26.1	78
Slag-A-Melt Lake	13D24	--	--	--	--	--	--	--	21.6	--	19.9	25.9	77
Average Percent of Normal				74			86			77			78

		May-98			Jun-98			Jul-98		
Site Name	Site No.	Measured SWE (in)	Normal SWE (in)	Percent of Normal	Measured SWE (in)	Normal SWE (in)	Percent of Normal	Measured SWE (in)	Normal SWE (in)	Percent of Normal
Bloody Dick	13D10S	10.1	10.5	96	0.0	1.7	--	0.0	0.0	100
Calvert Creek	13D26S	1.2	3.4	35	0.0	0.0	100	0.0	0.0	100
Darkhorse Lake	13D19S	**28.6**	35.3	81	26.6	28.5	93	16.9	4.0	423
Gibbons Pass	13D02	--	22.2	--	--	8.4	--	--	--	--
Gold Stone	13D09	18.2	17.8	102	--	--	--	--	--	--
Jahnke Lake Trail	13D27	--	8.7	--	--	--	--	--	--	--
Moose Creek	13D16S	10.5	14.6	72	0.0	0.0	100	0.0	0.0	100
Mudd Lake	13D25	--	18.8	--	--	--	--	--	--	--
Palisade Creek	13D23	--	32.1	--	--	--	--	--	--	--
Saddle Mountain	13D22S	22.6	27.6	82	12.3	17.5	70	0.0	1.2	--
Slag-A-Melt Lake	13D24	--	28.6	--	--	--	--	--	--	--
Average Percent of Normal				78			91			181

Ground Water

Occurrence and Flow

Plate 1 is a composite potentiometric-surface map for the shallow ground-water system in the Tertiary and Quaternary sediments of the upper basin. Contours were developed from water-level measurements made during the 1997 and 1998 field seasons and from historical data obtained from the MBMG's Ground-Water Information Center (GWIC) database. Elevations of perennial surface-water features also were used. The map represents a composite potentiometric surface because water levels were observed in many wells screened or perforated at various intervals within the aquifer system. In general, the potentiometric surface is a subdued expression of the topography of the land surface, with gentle horizontal gradients across the broad valley bottom and steeper gradients along the valley margin. Ground-water movement in the western and southwestern portion of the basin is to the northeast. East of the river, ground-water movement is west-northwestward. At the north end of the basin where the valley constricts, ground-water flow converges on the river from both sides of the basin.

The upper basin ground-water system also has vertical components of flow. Upwelling often occurs along the river and its tributaries, at the valley margin, and along fault and fracture systems as evidenced by springs and/or artesian wells (table 8). On the basis of geothermometry tests (Mariner and others, 1976) and geothermal gradient in the Tertiary valley fill, Levings (1986) speculates that water in the Jardine hot spring near Jackson rises from a depth greater than 10,000 ft along a vertically extensive fault-and-fracture system. Downward gradients ranging from 0.06 to 0.18 ft/ft (Marvin, 1997) also are observed in the valley, most often on benches and terraces away from the river and its tributaries. Rates of ground-water flow and production by wells are in large part functions of an aquifer's hydraulic conductivity (K), a value computed from the testing of wells.

Table 9 summarizes aquifer-test results for 25 wells in the upper basin. Hydraulic-conductivity estimates range from 0.6 to 390 ft/day, with a median of 5.5 ft/day. This range of values is typical for a silty sand and gravel aquifer (Freeze and Cherry, 1979). More than half of the tested wells are completed in Tertiary Bozeman Group sediments which were found to have a median K of 24 ft/day (n=15). Most wells completed in this formation yield 10-100 gpm. Pumping rates in this range are more than adequate to meet domestic- and stock-water needs but are too low for most irrigation purposes.

Water-Levels and Storage

Hydrographs for eight upper basin wells with periods of record from 1982 to 1998 are presented in figure 7. Most wells have some data from 1982-83 and were measured sporadically until 1992 when they were measured on a quarterly basis for 6 years. Each well has a stable annual cycle: a water level from a given month in 1 year generally differs by less than 1 foot from the same month in any other year. This pattern suggests that no substantial changes have occurred in the annual ground-water recharge/discharge cycle over this period.

Table 8. Artesian wells and noteworthy springs in the upper Big Hole basin

GWIC Site ID		Location (Township, Range, Section, Tract)	Land Surface Elevation (ft)	Well Depth (ft)	Water-Level Elevation (ft)	Comments
Artesian Wells						
M:107208	*	01S16W22CDAB	6,160	153	--	Flows
M:107684		03S15W20CDAC	6,138	33	6,139	WL above ground surface
M:108581	*	05S14W31BCAC	6,565	509	--	Reportedly flows
M:108583		05S15W03BDCB	6,319	66	6,319	Flows
M:109114	*	06S16W09CBDD	7,000	85	--	Flows
M:145343	*	02S15W34CBBC	6,050	320	--	Flows
M:145348		04S15W05DBCD	6,195	26	6,196	WL above ground surface
M:145355	*	05S15W03BDBC	6,320	114	--	Flows
M:145357	*	06S15W02ADAD	6,508	84	--	Flow rate <1 gpm
M:145359	*	06S15W30DBBC	6,934	50	--	Flow rate <1 gpm
M:145360	*	06S16W09CBDC	7,010	63	--	Flows
M:151289		01N14W27ABDD	5,910	200	5,910	Flowed 1 gpm, but grouted after inventory
M:156194		01S16W21ADCC01	6,180	6	6,180	Flow rate is several gpm
M:156220		04S16W04ACCC	6,340	--	6,342	Flow rate is 5-10 gpm
M:156224		04S16W17BABA	6,515	--	6,516	Flows seasonally, <1 gpm
M:156227		05S15W34BCAD	6,500	--	6,503	WL above ground surface
M:156230		06S15W06ADAA	6,625	--	6,625	Flow rate is several gpm
M:158564		03S15W33ADCD01	6,180	80	6,182	Flows seasonally, <1 gpm
M:158565		04S15W09DCBD01	6,228	90	6,230	Flows seasonally, <1 gpm
Springs						
--		03S14W19BCBA	6,190	--	6,190	Spring with buoyant vegetative mat near S Fk Francis Creek
--		04S16W02ABBB	6,215	--	6,215	Large spring near Rock Creek
--		05S15W25CABB	6,480	--	6,480	Jardine hot spring at Jackson, 135-140 °F
--		05S15W33BCCA	6,570	--	6,570	Large spring near Mulkey Lake, buoyant vegetative mat

* Data from Levings (1986)

Table 9. Hydraulic conductivity estimates for the upper Big Hole basin aquifer system

GWIC M:Number	Location (Township, Range, Tract, Section)	Test Date	Test Type	Number of Tests	Aquifer	Well Depth (ft)	Depth to Water (ft)	Screen/ Perf Length (ft)	Well Diameter (ft)	Screen Diameter (ft)	Pumping Rate (gpm)	Pumping Duration (hr)	Maximum Observed Drawdown (ft)	Hydraulic Conductivity (ft/day)	Trans-missivity (ft²/day)	Storativity	Analytical Method
165818	02S15W29AAAA	05/12/98	Slug	4	112GCLO	44	10.20	20	.5	.5	--	--	--	2.9	--	--	Bouwer and Rice (1976)
158563	02S15W29DCDC	11/26/96	Slug	2	120BZMN	121	21.20	2	.5	.5	--	--	--	390	--	--	Bouwer and Rice (1976)
129151	02S15W34BCCD01	01/30/98	Pump	1	120BZMN	125	14.35	10 *	.5	.5	21.	.5	5.7	35.	350	--	Cooper and Jacob (1946)
153312	02S16W07CDAC	10/20/95	Slug	3	120BZMN	115	38.10	39	.5	.33	--	--	--	52.	--	--	Bouwer and Rice (1976)
153310	02S16W24ADBC	09/28/98	Pump	1	120BZMN	85	24.90	3	.5	.33	5.8	.5	2.5	64.	192	--	Cooper and Jacob (1946)
153310	02S16W24ADBC	10/16/95	Slug	3	120BZMN	85	24.70	3	.5	.33	--	--	--	29.	--	--	Bouwer and Rice (1976)
153311	02S16W25ABAB	10/20/95	Slug	1	120BZMN	203	32.84	0.1	.5	.33	--	--	--	.6	--	--	Kipp (1985)
162499	03S15W03CCBA	07/20/98 **	Slug	2	120BZMN	55	35.60	10 *	.5	.5 *	--	--	--	72.	--	--	Bouwer and Rice (1976)
107679	03S15W04DDBA	07/20/98	Slug	1	120BZMN	36	4.52	6	.5	.5 *	--	--	--	75.	--	--	Bouwer and Rice (1976)
163243	03S15W09DDCA01	05/01/98	Slug	4	110GLCC	45	30.45	10	.17	.17	--	--	--	14.	--	--	Bouwer and Rice (1976)
163242	03S15W16BAAA	07/20/98 **	Slug	2	110GLCC	29	9.56	10	.17	.17	--	--	--	2.9	--	--	Bouwer and Rice (1976)
107681	03S15W16DCCD	02/25/98	Pump	1	120BZMN	205	28.20	5	.5	.5	11.5	12.	40.6	5.9	29	--	Cooper and Jacob (1946)
107689	03S15W21DCAB01	01/29/98	Pump	1	120BZMN	40	12.50	4	.5	.5	15.	12.	18.8	24.	98	--	Cooper and Jacob (1946)
107688	03S15W21DCAB02	03/30/98	Pump	1	120BZMN	81	19.24	10 *	.5	.5	10.	12.	51.3	1.8	19	--	Cooper and Jacob (1946)
163247	03S15W28ACCC01	07/20/98 **	Pump	1	110GLCC	25	6.48	10	.17	.17	1.7	5.	6.2	3.3	33	0.14	Cooper and Jacob (1946)
163247	03S15W28ACCC01	05/01/98	Slug	4	110GLCC	25	4.11	10	.17	.17	--	--	--	4.4	--	--	Bouwer and Rice (1976)
158564	03S15W33ADCD	09/29/98	Pump	1	120BZMN	80	0.00	22	.5	.5	6.1	.5	29.8	.3	20	--	Cooper and Jacob (1946)
158564	03S15W33ADCD	10/10/97	Slug	1	120BZMN	80	0.08	22	.5	.5	--	--	--	1.1	--	--	Bouwer and Rice (1976)
156215	04S15W03BCCC01	07/26/98	Pump	2	120BZMN	70	5.00	10 *	.5	.5 *	14.9	1.4	51.0	1.9	19	0.04	Theis (1935)
156215	04S15W03BCCC01	07/26/98	Pump	2	120BZMN	70	5.00	10 *	.5	.5 *	14.9	1.4	51.0	1.8	18	--	Cooper and Jacob (1946)
163249	04S15W04ABBB01	05/01/98	Slug	4	110GLCC	15	2.71	5	.17	.17	--	--	--	38.	--	--	Bouwer and Rice (1976)
163250	04S15W04DCAD01	05/01/98	Slug	2	110GLCC	15	2.91	10	.17	.17	--	--	--	3.2	--	--	Bouwer and Rice (1976)
163252	04S15W09CBCD01	05/01/98	Slug	2	110GLCC	15	2.06	5	.17	.17	--	--	--	3.	--	--	Bouwer and Rice (1976)
158565	04S15W09DCBD01	09/29/98	Pump	1	120BZMN	90	1.59	11	.5	.5	6.3	.5	13.0	2.3	55	--	Cooper and Jacob (1946)
158565	04S15W09DCBD01	10/10/97	Slug	2	120BZMN	90	1.37	11	.5	.5	--	--	--	5.	--	--	Bouwer and Rice (1976)
163251	04S15W10BCBD	05/01/98	Slug	3	110ALVF	15	3.50	10	.17	.17	--	--	--	2.5	--	--	Bouwer and Rice (1976)
165830	05S15W23DAAD01	07/29/98	Pump	2	120BZMN	48	12.83	15	.5	.5	15.2	.67	15.3	3.2	48	0.23	Hantush (1961)
165830	05S15W23DAAD01	07/29/98	Pump	2	120BZMN	48	12.83	15	.5	.5	15.2	.67	15.3	4.9	74	--	Cooper and Jacob (1946)
165830	05S15W23DAAD01	07/29/98	Slug	4	120BZMN	48	12.83	15	.5	.5	--	--	--	7.2	--	--	Bouwer and Rice (1976)
108610	05S15W36CABD	08/29/95	Slug	2	120BZMN	36	23.11	6	.5	.33	--	--	--	42.	--	--	Bouwer and Rice (1976)
165827	06S15W11ACCC	07/29/98	Slug	6	112GCLO	36	8.10	6	.5	.5	--	--	--	27.	--	--	Bouwer and Rice (1976)
165828	06S15W11DBBB	07/29/98	Slug	6	112GCLO	38	5.41	6	.5	.5	--	--	--	19.	--	--	Bouwer and Rice (1976)
													Average:	34.			
													Median:	5.5			
													Maximum:	390			
													Minimum:	.6			
													n:	25 wells			

Aquifer Codes: 110GLCC, Quaternary lacustrine sand and silt; 111ALVM, Holocene alluvium; 112GCLO, Pleistocene glacial outwash; 120BZMN, Tertiary Bozeman Group sediments

Depth to Water Code: F, flowing

* Estimated

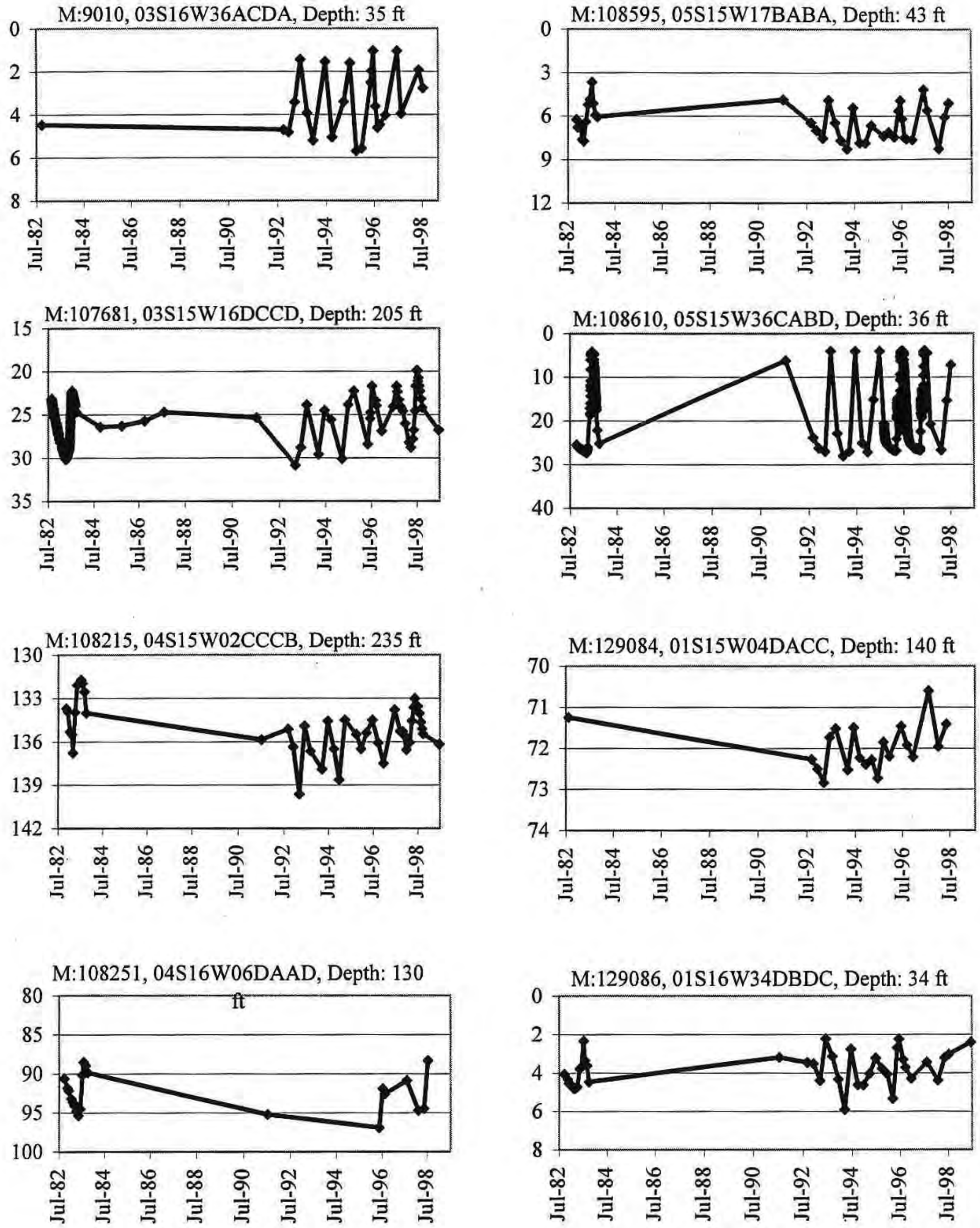

Figure 7. Long-term hydrographs for eight wells in the upper Big Hole basin. Note the differences in vertical scales.

The hydrographs show a consistent seasonal pattern. Water levels generally start to rise in March or April when the valley snow pack begins to melt. Levels may drop for a brief period following the melt of the valley snow but then rise again from May to the beginning of July as the mountain snow pack melts and water is spread for irrigation. After mid-July, water levels generally decline until the following spring. Fluctuations within the annual cycles result from short-term precipitation conditions and, more dramatically, from irrigation withdrawals and return flows.

The hydrograph for M:108610 for the period March 1996 to March 1997 (figure 8) demonstrates the annual cycle and the impact of irrigation on the shallow ground-water system particularly well. The 36-foot deep well is located on a Tertiary gravel terrace about 60 ft above the flood plain of Governor Creek near Jackson. A large ditch and the edge of a flood-irrigated pasture are located about 110 ft to the east. Following a period of recharge as the snow pack around the well melted, the water level in the well gradually declined. On May 12, flood irrigation began, and the water level rose 16.7 ft in 6 days. For the next 7 weeks, the water level remained relatively stable due to recharge from irrigation water. When irrigation ended on or about July 9, the water level in the well began declining by 0.33 ft/day. By the end of September, the water level again stabilized but at a position about 20 ft lower then the mid-summer peak.

Although the M:108610 hydrograph serves as an instructive example, the seasonal water-level change at the well is unusually large for the upper basin. Only five other wells (M:107688, M:107689, M:108590, M:156226, and M:163242) were found to have seasonal water-level changes greater than 10 ft, and all are completed in elevated terrace deposits with surface-water diversions or irrigated pasture nearby.

More commonly, ground-water levels in the upper basin vary by only a few feet annually. Data from 75 wells (appendix B) show that the annual average water-level change is typically about 5 ft (standard deviation = 4.7 ft; median = 3.5 ft). Although the estimate is somewhat biased by areas with greater well densities, such as near Wisdom, it nonetheless serves as a useful “yardstick” against which other water-level variations can be compared. The water levels reflect the amount of water that is stored in the aquifer, and their fluctuations are useful in calculating the changes in storage that result from natural and induced conditions.

By assuming that the average seasonal water-level change is representative of the upper basin aquifer system, an estimate of the annual change in aquifer storage was obtained with the equation

$$S_{gw} = WL * S * A$$

where, S_{gw} is change in annual ground-water storage (acre-ft), WL is annual average water-level fluctuation (ft), S is aquifer specific yield (unitless), and A is aquifer areal extent (acres). Specific yield is defined as the volume of water that an unconfined aquifer

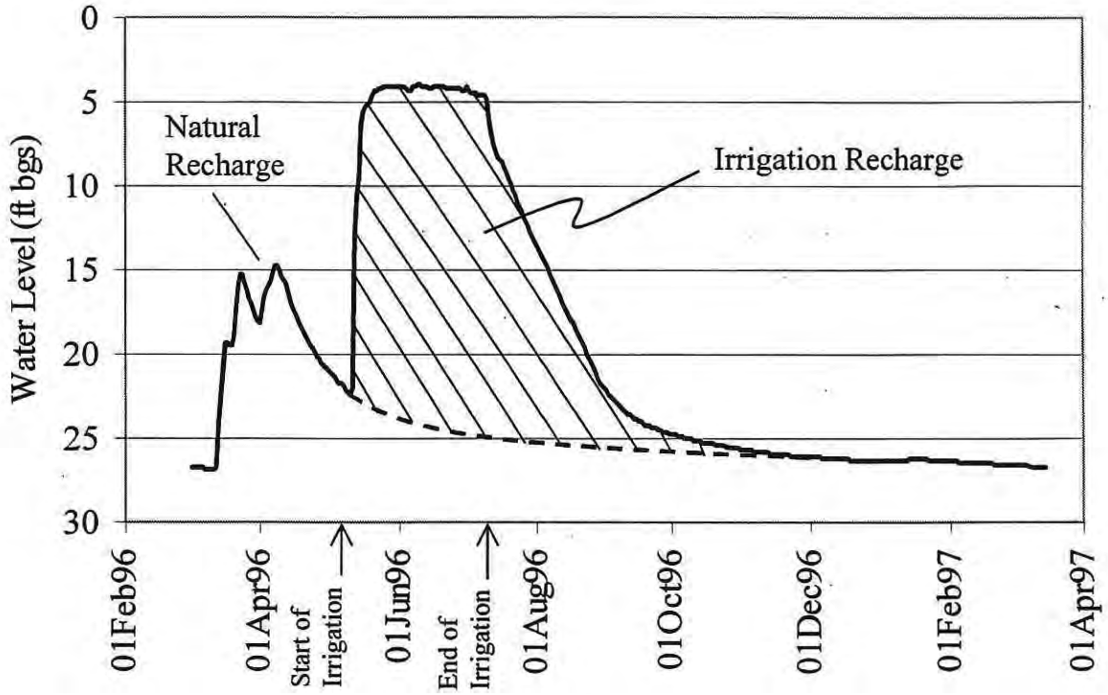

Figure 8. The hydrograph for well M:108610, March 1996-March 1997, shows the annual water-level cycle and the effect of irrigation recharge on the shallow ground-water system. Water level is in feet below ground surface (ft bgs).

releases from storage per unit surface area of aquifer per unit decline in the water table. Assuming that the average annual water-level change is 5 ft, and that the upper basin valley aquifer has a specific yield of 0.1 ft/ft and covers an area of about 540 mi^2 (345,600 acres), the annual change in ground-water storage is approximately 170,000 acre-ft. This is a conservative estimate of the volume of water added to aquifer storage in April, May, June, and early July and released over the remainder of the annual cycle. The water represents recharge from natural sources (rainfall, snowmelt, and stream infiltration), as well as from irrigation. However, as will be shown for the Francis Creek unit, most recharge appears to be associated with irrigation.

Surface Water

Flow Conditions

Table 10 is a monthly summary of the flow data collected at the Big Hole River gages at Wisdom (USGS ID 06024450) and at the Hwy 43 bridge below Mudd Creek (USGS ID 06024540) for the period October 1997 through October 1998. No data are available for the period from November 1997 through March 1998 because the gages were not maintained over the winter. Flows measured at Wisdom were well above the historical average (period of record 1988-98). No historical data are available for the Hwy 43 bridge gage because the 1997-98 season was the first year of operation.

Daily mean flow hydrographs (figure 9) provide a comparison of the flow data between April and October 1998. The hydrographs show that a small peak in flow occurred in early April that is associated with runoff from low-elevation snowmelt. Flow repeatedly rose and fell between the end of April and the end of June as mountain snow pack melted and spring storms moved across the area. The maximum mean daily flow measured at the Wisdom gage was 1,550 cfs on May 24; the maximum at the Hwy 43 bridge gage was 3,090 cfs on the same day. During the first half of July, two smaller peaks were measured that probably were caused by the shutdown of irrigation diversions. After mid-July, flows decreased rapidly, with only minor increases at the end of July and in mid-September due to rainfall events. The lowest daily mean flow measured at the Wisdom gage was 45 cfs on September 5; the lowest flow at the Hwy 43 gage was 100 cfs on September 5 and 6. The rise and fall in flow observed at both locations around the second week of September was due to a rainfall event. After that, flow remained slightly higher than before as ET decreased and baseflow conditions prevailed.

On the average, flow at Wisdom represented 44 percent of flow measured at the Highway 43 bridge. This value agrees well with the relative drainage-area distribution: the Wisdom gage measures flow from a 570 mi^2 watershed, which is 45 percent of the upper basin's 1,270 mi^2 drainage area. The greatest deviation from this relationship occurred in June when flow at the Wisdom gage was only 36 percent of the flow measured at the Hwy 43 bridge gage. The deviation likely was due to irrigation withdrawals upstream of Wisdom that diverted water around the Wisdom gage.

Table 10. Monthly flow statistics for the Big Hole River at Wisdom and at the Hwy 43 bridge below Mudd Creek, October 1997-October 1998. Data from Shields and others (1999)

Description: Wisdom
USGS Name: Big Hole River below Big Lake Creek, at Wisdom, MT
USGS ID: 06024450
Drainage Area: 575 mi^2

Date	Mean (cfs)	Percent of Normal* (%)	Median (cfs)	Max (cfs)	Min (cfs)	Total Discharge (acre-ft)
Oct-97	139	199	140	270	72	8,570
Nov-97	--	--	--	--	--	--
Dec-97	--	--	--	--	--	--
Jan-98	--	--	--	--	--	--
Feb-98	--	--	--	--	--	--
Mar-98	--	--	--	--	--	--
Apr-98	560	128	400	1,340	250	33,300
May-98	1,035	180	1,070	1,550	516	63,620
Jun-98	763	113	715	1,320	453	45,380
Jul-98	486	165	492	922	211	29,890
Aug-98	106	127	72	287	50	6,500
Sep-98	64	149	65	100	45	3,810
Oct-98	83	119	85	90	67	5,100

Description: Hwy 43 Bridge below Mudd Cr
USGS Name: Big Hole River below Mudd Creek, near Wisdom, MT
USGS ID: 06024540
Drainage Area: 1,267 mi^2

Date	Mean (cfs)	Percent of Normal** (%)	Median (cfs)	Max (cfs)	Min (cfs)	Total Discharge (acre-ft)
Oct-97	258	--	262	398	172	15,890
Nov-97	--	--	--	--	--	--
Dec-97	--	--	--	--	--	--
Jan-98	--	--	--	--	--	--
Feb-98	--	--	--	--	--	--
Mar-98	--	--	--	--	--	--
Apr-98	1,076	--	842	2,720	600	64,000
May-98	2,306	--	2,230	3,090	1,390	141,800
Jun-98	2,135	--	2,050	2,850	1,470	127,100
Jul-98	961	--	840	1,680	455	59,080
Aug-98	244	--	195	565	114	14,990
Sep-98	151	--	155	232	100	8,990
Oct-98	187	--	189	202	159	11,530

* Period of record 1988-1998
** No historical data available for comparison

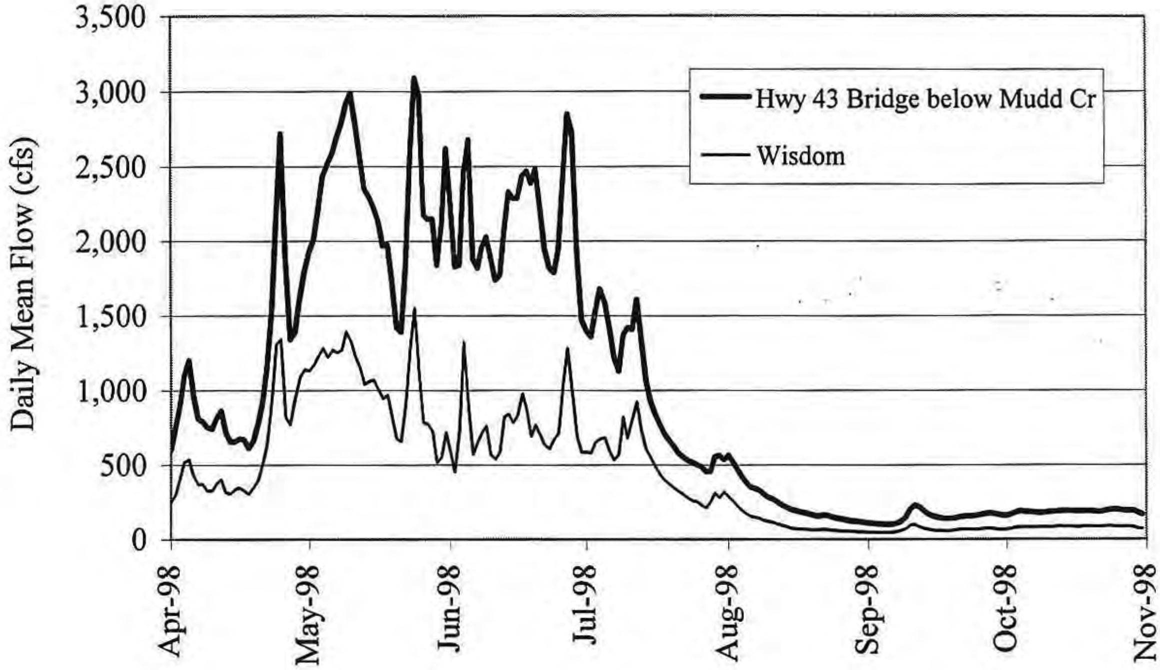

Figure 9. Mean daily flow hydrographs for the Big Hole River at Wisdom (USGS Station 06024450) and at Highway 43 bridge below Mudd Creek (USGS Station 06024540). Data from Shields and others (1999).

Effects of Irrigation Return Flows

The water-level data suggested that large declines in ground-water storage occurred in July, August, and September, so two rounds of synoptic streamflow measurements were made to determine if the water was entering the surface-water system. Outflow from the basin as measured at the Big Hole River gage at the Highway 43 bridge was compared to total inflow from mountain watersheds. The premise was that if ground-water returns to the surface-water system were substantial, outflow would exceed inflow during this period.

Low flows were measured on 20 of the river's tributaries on August 11 and 12 and on September 1 and 2, and flows for the remainder of the tributaries were estimated using linear regressions relating drainage area to discharge (table 11). Tributaries highlighted with bold-faced type are those for which the estimated flows are most uncertain. These creeks drain relatively low-elevation watersheds whereas most of the measured tributaries drain high-elevation mountain areas. The regression equations did not take into consideration orographic effects on precipitation and snowpack and therefore probably yielded flow estimates that were too high for the lower elevation watersheds.

The inflow and outflow determined from the August round of measurements were nearly equal: inflow estimates ranged from 249 to 272 cfs, and outflow was 261 cfs. This suggests that evapotranspiration and seepage losses were approximately balanced by ground-water discharge to the river system at this time. By September, however, a definite imbalance existed. Results from the September event showed a net surface-water loss of 32 ± 6 cfs (table 11), suggesting that inflow from the ground-water system was not great enough to offset surface-water losses. It can be argued, however, that without ground-water returns, the surface-water losses would have been even greater.

Evapotranspiration and Water Balance

Mean annual ET loss (1.2 million acre-ft, or 18.3 inches) was obtained by comparing precipitation to surface-water and ground-water discharge. Mean annual precipitation (P) for the period 1961-90 was found to be 25.1 inches based on an analysis of a GIS precipitation-distribution coverage of the area (Daly and others, 1994; Daly and others, 1997; Daly and Taylor, 1998). In terms of volume, this is equivalent to about 1.7 million acre-ft of water. Mean annual surface-water discharge of the watershed was estimated to be about 456,000 acre-ft (6.8 in), which is 27 percent of the precipitation total. Because the Highway 43 gage had only the 1997-98 period of record, the long-term discharge estimate was obtained by multiplying the mean annual flow (1961-90) measured at the USGS gage below Melrose by the ratio of river discharge at the Highway 43 bridge to the flow at the Melrose gage (period 1997-98). This analysis therefore assumed that the ratio of flows for the two gages in 1997-98 was typical for the period 1961-90 as well.

Table 11. Surface-water flow balance for the upper Big Hole basin, mid-August and early September, 1998.

Drainage Name	Discharge Measurement Location for Drainage (township, range, section, tract)	Drainage Area (mi²)	August 11 and 12		September 1 and 2	
			Date	Flow (cfs)	Date	Flow (cfs)
Inflow						
Bender Cr	01S17W13	9.9	--	6.1 est	--	3.5 est
Berry Cr	06S15W31	14.4	--	7.6 est	--	4.4 est
Big Hole River, Upper	07S15W04DBDB	44.4	8/11/98	29.3	9/2/98	17.6
Big Lake Cr	05S17W10DBCD	6.3	--	2.0 est	9/2/98	2.6
Big Lake Cr, S Fk	05S17W15	6.4	--	2.0 est	--	1.2 est
Big Swamp Cr	05S16W17DDBC	16.7	8/11/98	6.5	9/2/98	2.7
Butler Cr*	03S17W03	10.3	--	4.7 est	--	2.2 est
Doolittle Cr	01S14W29	17.1	--	7.6 est	--	5.6 est
Dry Cr*	04S16W30	6.0	--	1.8 est	--	1.0 est
Englejard Cr	06S16W14	5.1	--	1.2 est	--	0.7 est
Francis Cr	03S15W24ADAA	2.1	--	0.3 est	--	0.0 est
Governor Cr	05S15W35DADA	127.1	8/11/98	10.1	9/2/98	5.8
Hamby Cr	06S16W23	8.9	--	3.8 est	--	2.2 est
Hooligan Cr	03S15W35ABBB	3.6	8/12/98	0.1	9/2/98	0.0
Howell Cr	01N15W21CABB	7.3	8/11/98	4.9	9/1/98	2.9
Johnson Cr	01S17W15DDDB	16.0	8/11/98	8.8	9/1/98	4.9
Little Lake Cr	05S16W28	12.0	--	5.9 est	--	3.4 est
Little Moosehorn Cr*	03S17W33	2.6	--	2.3 est	--	0.5 est
McCormick Cr*	01N15W22	4.5	--	4.5 est	--	3.1 est
McVey Cr	02S14W17	5.1	--	1.7 est	--	0.9 est
Miner Cr	06S16W03CDAC	18.7	8/11/98	17.8	9/2/98	9.7
Moose Cr and Holland Cr	03S17W35	13.3	--	5.6 est	--	2.9 est
Mudd Cr	01N14W05	9.2	--	5.9 est	--	3.4 est
Mussigbrod Cr	01S16W09BAAD	18.6	8/11/98	15.4	9/1/98	3.7
Nickel Bar Cr and Wenger Cr*	03S17W16 and 03S17W21	8.3	--	4.1 est	--	1.8 est
Pintlar Cr	01N15W23DBBA	23.2	8/11/98	9.4	9/1/98	3.8
Plimpton Cr	01S15W03	8.0	--	5.5 est	--	3.4 est
Rock Cr	04S16W19	9.4	--	4.1 est	--	2.4 est
Ruby Cr	03S17W20DCAA	24.2	8/11/98	8.9	9/1/98	4.7
Sand Cr	03S15W25DAAA	2.9	8/12/98	0.0	9/2/98	0.0
Sand Cr, N Fk	03S15W24DADA	1.3	8/12/98	1.0	9/2/98	0.4
Sawmill Cr*	05S16W18	3.0	--	0.0 est	--	0.0 est
Sheep Cr	03S15W36DAAD	5.1	8/12/98	2.7	9/2/98	1.3
Squaw Cr	01N14W35	19.2	--	8.4 est	--	5.1 est
Stanley Cr	04S15W13DABA	3.0	8/12/98	1.1	9/2/98	0.6
Stanley Cr, N Fk	03S15W34DAAD	3.3	8/12/98	0.0	9/2/98	0.0
Steel Cr	03S14W05CABA	14.0	8/12/98	5.7	9/2/98	2.2
Steel Cr, S Fk	03S14W08	2.9	--	0.7 est	--	0.3 est
Thompson Cr and Thompson Cr, E Fk	01N15W19 and 01N15W31	13.4	--	7.1 est	--	3.7 est
Tie Cr	01S17W34CAAA	17.8	8/11/98	5.8	9/1/98	2.6
Tie Cr, S Fk	01S17W33DDAD	5.2	8/11/98	2.3	9/1/98	1.4
Trail Cr	02S17W21AACB	77.3	8/11/98	25.8	9/1/98	17.1
Warm Springs Cr	05S14W20DDCC	81.1	8/11/98	17.9	9/2/98	8.6
York Gulch*	01N14W21	8.6	--	5.7 est	--	3.4 est
Total Inflow				272 est		148 est
Total Inflow w/o **bold-faced type** tributary estimates				249 est		136 est
Ouflow						
Big Hole Below Mudd Cr.	01N14W26BCDC		8/11/98	261	9/1/98	110
Balance						
Outflow-Inflow (all tributaries)				-11		-38
Outflow-Inflow (excluding **bold-faced type tributaries**)				12		-26

* Flow estimates for bold-faced type tributaries are highly uncertain and are probably overestimated. These creeks drain low-elevation watersheds that are not similar to the measured tributaries.

Despite possible problems with these assumptions, the percentage of precipitation lost to ET (73 percent) in the upper basin is the same as that estimated by Levings (1986) for the entire Big Hole basin.

FRANCIS CREEK UNIT

Efforts to characterize ground-water/surface-water interactions and ET were focused on the Francis Creek drainage, a relatively small watershed that drains about 5 percent of the irrigated land in the upper basin (figure 4).

Climate

Monthly mean air temperatures at the MBMG weather station at the Francis Creek unit (PG-1) ranged from a low of 11.9° F in December 1997 to a high of about 60° F in July 1998 (table 12). Temperatures at the station were slightly warmer than those recorded by the NWS at Wisdom during the winter (table 4), most likely due to inversion conditions. During the spring, summer, and early fall, temperatures at the MBMG station were slightly cooler than those at Wisdom.

During the winter, the soil temperature 2 feet below the ground surface never dropped below 33° F (figure 10), suggesting that frost did not penetrate deeply in this area, perhaps due to the accumulation of an insulating snow pack in October and November. Shallow soil temperature data (z = -0.2 ft) indicate that the frost melted in the middle of April, about the same time that daily mean air temperatures began to rise consistently above freezing (figure 10). Because grasses emerge from dormancy shortly after the ground frost melts, the end of April was assumed to be the start of the growing season in the area.

Precipitation data collected at the weather station, PG-1 (figure 4), and at a location several miles to the north, PG-2, are summarized in figure 11. Peak monthly precipitation at both locations occurred in May when 2-3 inches of precipitation fell; the driest months were February and August with less than half an inch. Cumulative precipitation at the two stations was nearly equal from November 1997 through April 1998 (figure 12). However, heavier rainfall at PG-1 in April, May, June, July, and September resulted in cumulative precipitation being 2.4 inches greater than at PG-2 during the study period. These data along with those from the NWS stations at Jackson and Wisdom (table 5) underscore the variability of precipitation across the upper basin.

Ground Water

Occurrence and Flow

The relatively high density of wells with lithologic logs within the Francis Creek unit made it possible to distinguish between a shallow water-table aquifer and a deeper

Table 12. Climatological data summary for weather station PG-1, Francis Creek unit south of Wisdom, Montana, November 1997 - September 1998

Month-Yr	Avg Air Temp z = 6.5 ft (°F)	Avg Max Air Temp (°F)	Avg Min Air Temp (°F)	Avg Subsurface Soil Temp z = -2.0 ft (°F)	Avg Surface Soil Temp z = -0.2 ft (°F)	Avg Wind Speed (m/sec)	Precip (in)
Nov-97	23.9	37.1	12.4	38.2	29.6	1.5	0.7
Dec-97	11.9	22.0	1.0	34.8	27.0	1.6	0.1
Jan-98	19.8	28.3	10.1	33.9	29.7	2.6	0.1
Feb-98	14.7	26.5	3.4	33.5	29.4	1.6	0.8
Mar-98	25.2	36.0	15.6	33.6	31.2	1.9	0.0
Apr-98	34.7	46.2	24.0	34.7	34.8	2.0	0.0
May-98	44.3	57.1	31.2	41.8	45.7	2.5	3.6 *
Jun-98	46.9	57.2	37.1	46.6	50.0	2.1	1.5
Jul-98	59.7	77.2	41.8	51.2	56.8	1.6	1.8
Aug-98	56.3	78.0	33.9	51.3	53.6	1.7	0.3
Sep-98**	50.2	69.7	33.7	50.1	50.0	1.5	2.4

* Heaviest day of rain during study period: May 30, almost 1 inch

** Data for last 3 days of Sep-98 not included because weather station was decommissioned

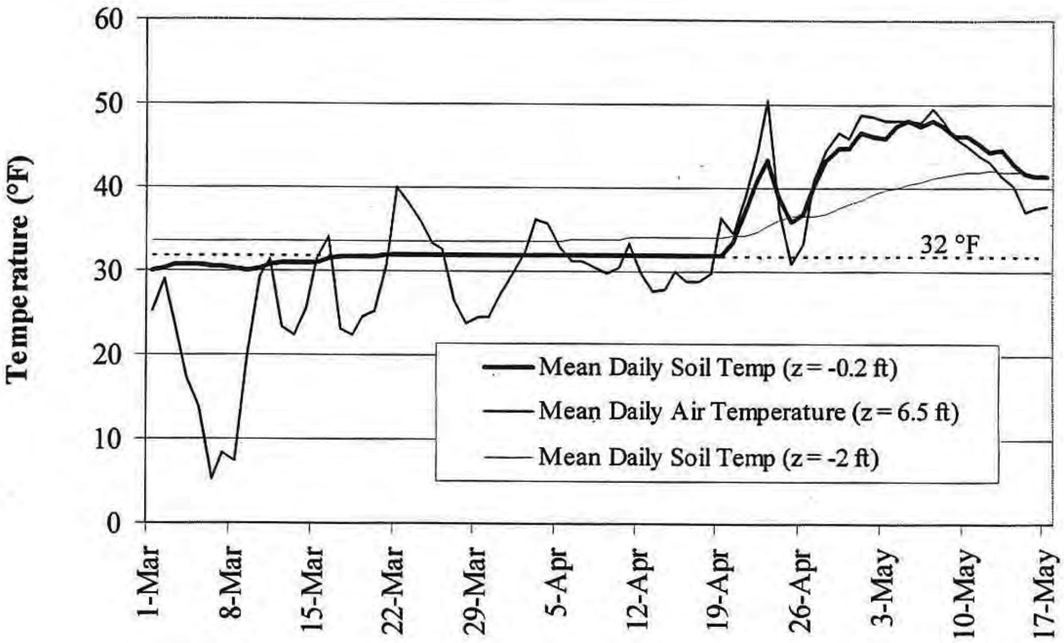

Figure 10. Soil and air temperatures at weather station PG-1, Francis Creek unit, March-May 1998.

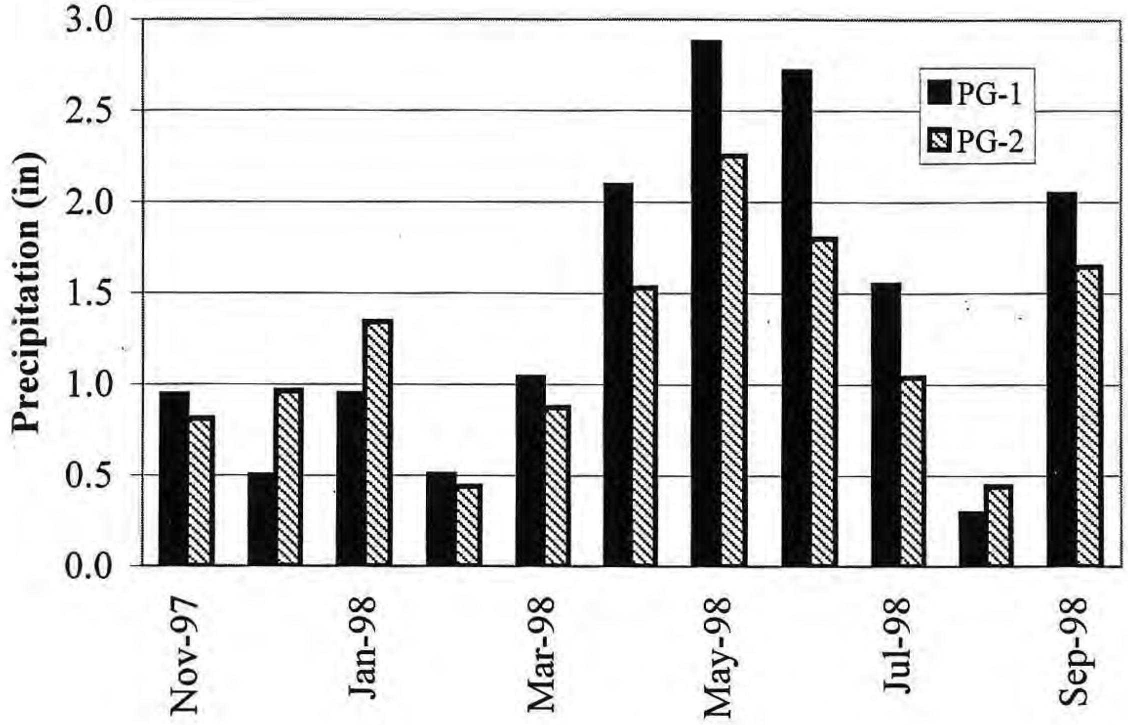

Figure 11. Monthly precipitation at rain gages PG-1 and PG-2 (figure 4), Francis Creek unit, November 1997-September 1998.

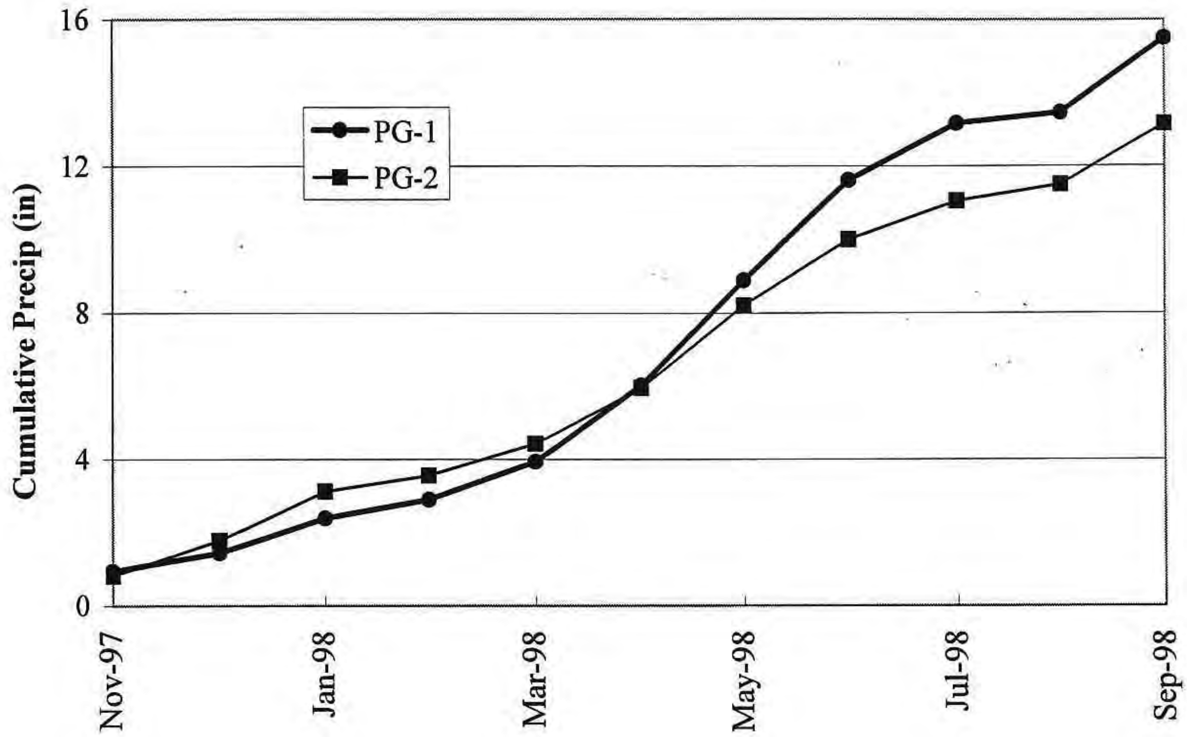

Figure 12. Cumulative precipitation at rain gages PG-1 and PG-2 (figure 4), Francis Creek unit, November 1997-September 1998.

semi-confined aquifer in this part of the upper basin. Figures 13 and 14 are N–S and E–W stratigraphic cross sections of the area. The locations of the cross sections are shown on plates 2 and 3, which are potentiometric contour maps for the water-table and semi-confined aquifers, respectively. The cross sections show the water- table aquifer is in Tertiary and Quaternary sand and gravel deposits. A clay unit (10-20 ft thick) underlies the sand and gravel and acts as a semi-confining bed for the deeper aquifer. This deeper aquifer is located in Tertiary sand, sandstone, and fractured siltstone. North-striking normal faults depicted in the E–W cross section (figure 14) vertically displace the stratigraphic units; thus, the deeper aquifer is only semi-confined by the overlying clay bed.

As shown in plate 2, shallow ground water flows northwestward through the Stanley, Sheep, Sand, and Francis creek alluvial deposits that border the West Pioneer Mountains. In these areas, springs and boggy ground are common. As the topography flattens and the ground water enters the thicker, more permeable Bozeman Group sand and gravel deposits, the hydraulic gradient decreases markedly. At the southern end of the study area, the water-table aquifer appears to discharge to the Big Hole River; ground water from the central and northern portion of the study area discharges to lower Francis and Stanley creeks.

The potentiometric contour map for the semi-confined aquifer (plate 3) shows that ground water generally flows northward, parallel to the Big Hole River, and that the hydraulic gradient is fairly uniform. Water levels measured at two deeper wells at the south end of the Francis Creek unit (M:158564, depth = 80 ft; M:158565, depth = 90 ft) are above the ground surface, which suggests that upwelling of water into the overlying water-table aquifer is possible, especially along the normal faults that disturb the Tertiary clay bed. At the north end of the study area, the vertical gradient is reversed as evidenced by deeper water levels measured at M:107688 (depth = 93 ft) versus M:107689 (depth = 40 ft), two wells that are within 30 ft of each other.

Water Levels and Storage

Hydrographs for several wells and one of the piezometers in the Francis Creek unit are presented in figure 15. Monitoring occurred from September 1997 to September 1998. The hydrographs for M:163247, M:163249, and M:163252 are typical of wells completed in the water-table aquifer close to flood-irrigated pastures. Water levels were stable or declined only slightly during the winter and then rose in the spring as the valley snow pack melted and recharged the aquifer. Levels started to decline after the spring thaw but rose again when irrigation began. After the irrigation season ended in early July, levels declined rapidly.

M:163242 also is completed in the water-table aquifer close to an irrigated pasture. The 31-ft water-level change at this well between April and July 1998 was the largest

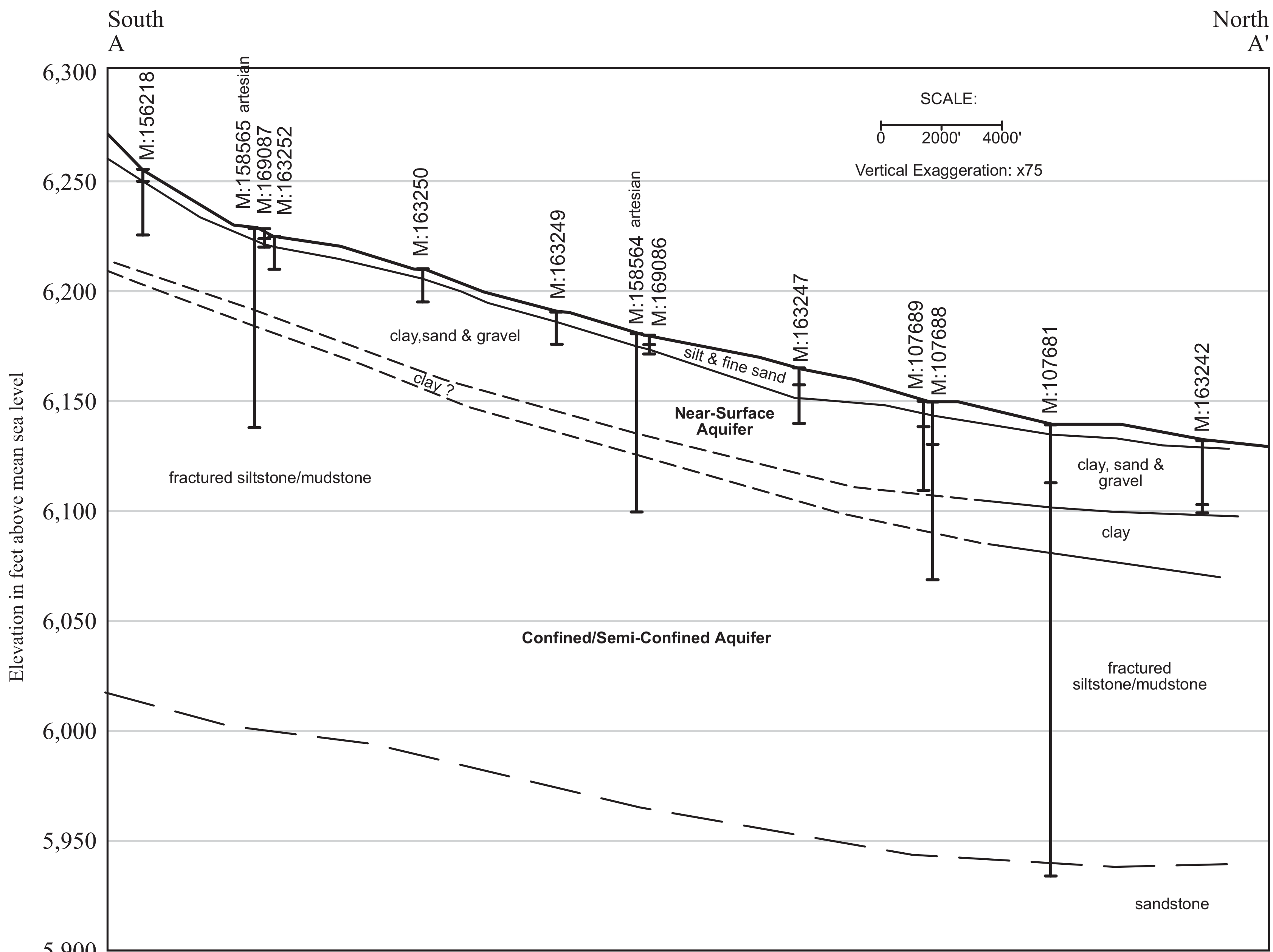

Figure 13. N-S geologic cross section of the Francis Creek unit. The location of the cross section is shown in plates 2 and 3.

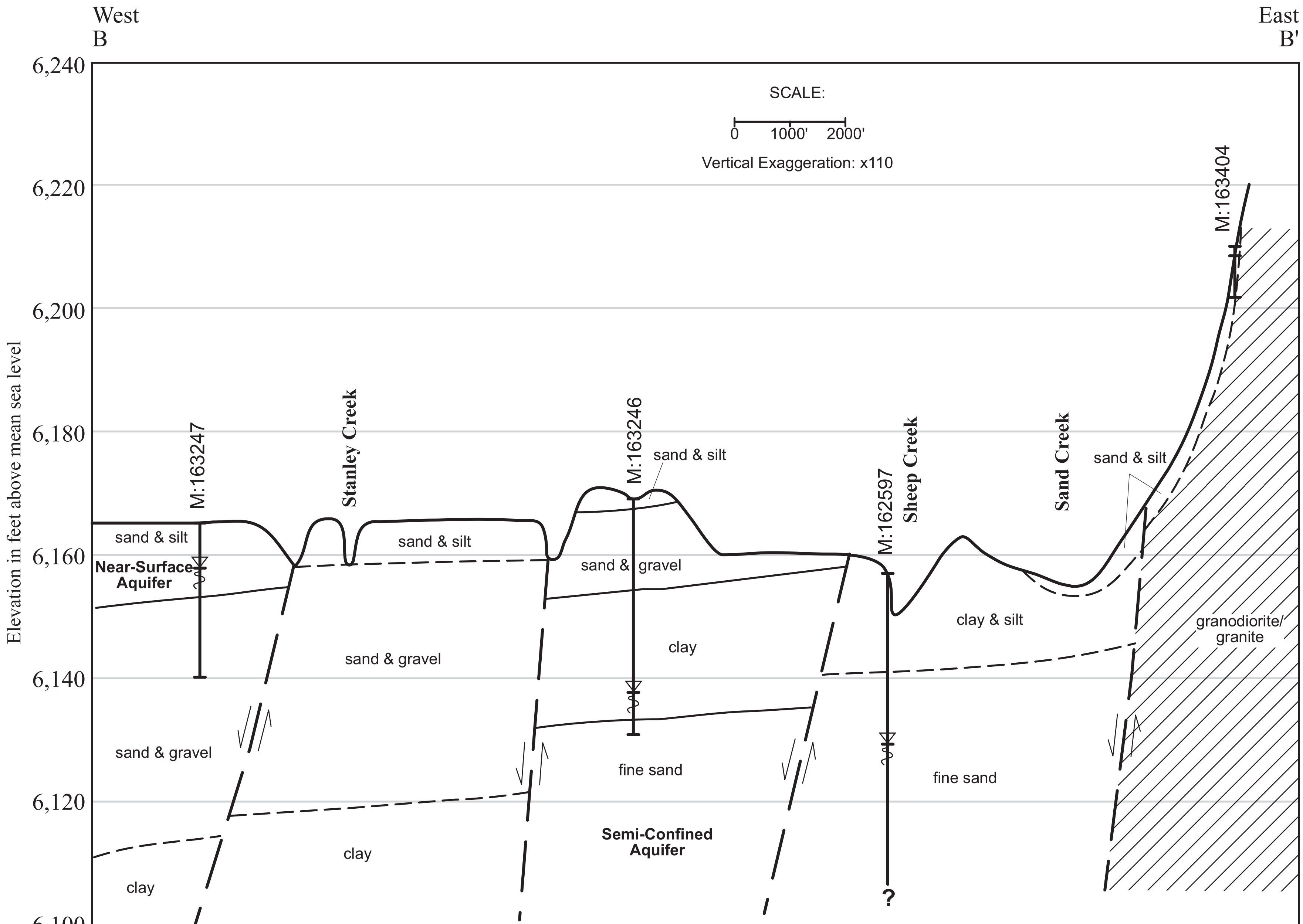

Figure 14. E–W geologic cross section of the Francis Creek unit. The location of the cross section is shown in plates 2 and 3.

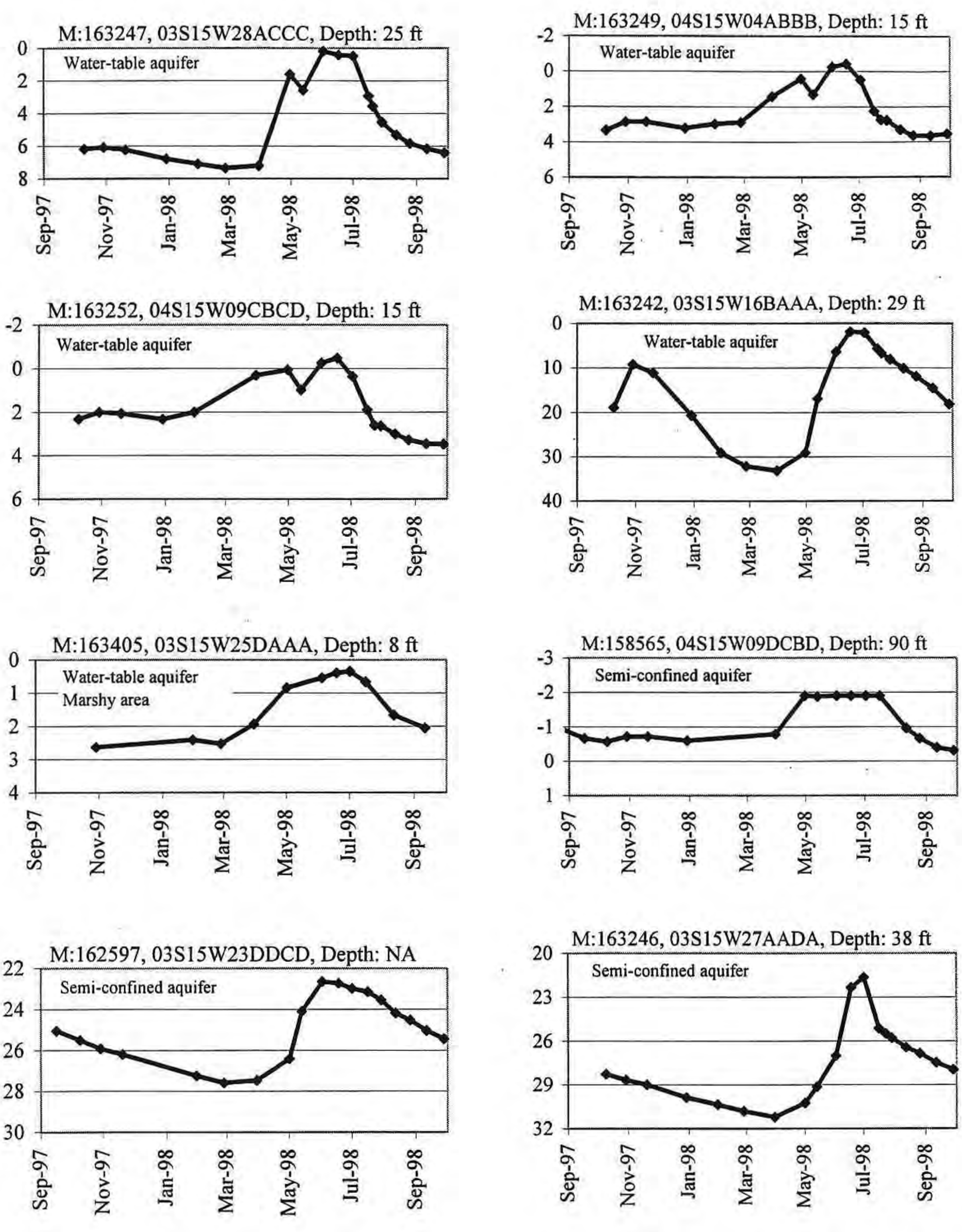

Figure 15. Hydrographs for seven wells and a piezometer at the Francis Creek unit. Note the differe in vertical scales.

observed in the entire Big Hole basin during the study. Water levels for January, February, March, and April were estimated using a regression equation because the water table dropped below the bottom of the well. Flooding of a nearby ditch at the end of October 1997 produced a sharp water-level rise in the fall. If this event had not occurred, the water level at the well probably would have been projected to drop several additional feet during the winter 1997 and early spring 1998.

M:163405 is a piezometer completed in a marshy area along the ephemeral Sand Creek drainage. The water table is shallow in this area (<2 ft) and the seasonal water-level fluctuation is accordingly small. No interruption is evident in the water-level rise during the spring, perhaps because no measurement was made in mid-May or because melt of the snow pack further up the watershed continued to recharge the aquifer.

Wells M:158565, M:162597, and M:163246 are completed in the deeper, semi-confined aquifer. The water level at M:158565, a stock well near flood-irrigated pasture at the south end of the study area, was above the ground surface throughout the study period, indicating an upward gradient at this location. Efforts to document the magnitude of the seasonal water-level change at the well were hampered by ice in the casing during the winter and flow over the top of the casing in April, June, and July. M:162597 and M:163246 are in the central portion of the study area where the vertical gradient appeared to be downward. M:163246 is about a quarter mile from any irrigated land; M:162597 is west of the Sheep Creek alluvial fan which is irrigated continually during the summer. The seasonal water-level changes observed at these wells were similar in timing and magnitude to those observed in the water-table wells. The most noteworthy difference is that water levels in the deeper wells declined steadily throughout the fall, winter and spring, with no indication of leveling off until recharge began in March and April.

Estimates of monthly changes in ground-water storage in the study area were calculated using area-weighted averages of water-level change and an aquifer specific-yield (S) estimate of 0.1 ft/ft, which is typical of an unconfined aquifer composed of silty fine sand and gravel. The contribution of irrigation water to the change in storage was estimated by hydrograph separation as demonstrated in figure 16. The water-level drop observed at the shallow wells between late April and mid-May was generally assumed to mark the beginning of the normal seasonal water-level decline. Rainfall in May and June also probably contributed to natural recharge, but the quantity could not be easily deduced because irrigation had started by that time. Ignoring this addition natural contribution, the difference between the observed and the projected April-May water-level trends was assumed to represent the irrigation water stored in the aquifer. The results of the storage analysis are summarized in table 13 and figure 17.

Reductions in ground-water storage during the fall and winter were fairly stable, averaging 400 acre-ft/month. From March through June, storage increased by about 6,300 acre-ft. Of this amount, about 2,100 acre-ft are attributed to natural recharge that occurred during March and April as the valley snow pack melted; the remainder is attributed to recharge from irrigation in May and June. During July, August, and

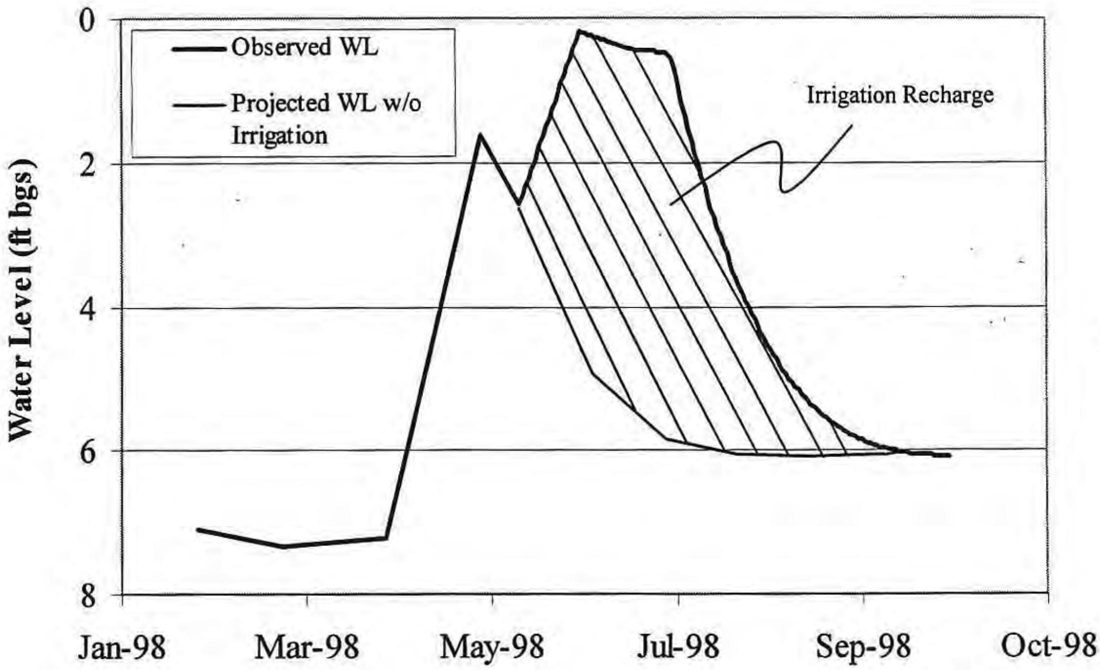

Figure 16. Hydrograph showing separation of irrigation recharge from natural recharge at well M:163247. Water level is in feet below ground surface (ft bgs).

Table 13. Monthly changes in ground-water storage within the Francis Creek unit, October 1997 - September 1998. Aquifer specific yield is assumed to be 0.1.

Month	Observed Change in Storage		Estimated Change in Storage Related to Irrigation		Estimated Change in Storage w/o Irrigation	
	(acre-ft)	(cfs)	(acre-ft)	(cfs)	(acre-ft)	(cfs)
Oct-97	-356	-5.8	-132	-2.1	-224	-3.6
Nov-97	-473	-7.9	-259	-4.4	-214	-3.6
Dec-97	-547	-8.9	-255	-4.2	-292	-4.7
Jan-98	-337	-5.5	-133	-2.2	-204	-3.3
Feb-98	-279	-5.0	-87	-1.6	-192	-3.5
Mar-98	387	6.3	-27	-0.4	413	6.7
Apr-98	1680	28.2	-4	-0.1	1684	28.3
May-98	3140	51.1	2379	38.7	761	12.4
Jun-98	1084	18.2	1918	32.2	-834	-14.0
Jul-98	-2504	-40.7	-2012	-32.7	-492	-8.0
Aug-98	-1188	-19.3	-732	-11.9	-457	-7.4
Sep-98	-789	-13.3	-367	-6.2	-422	-7.1

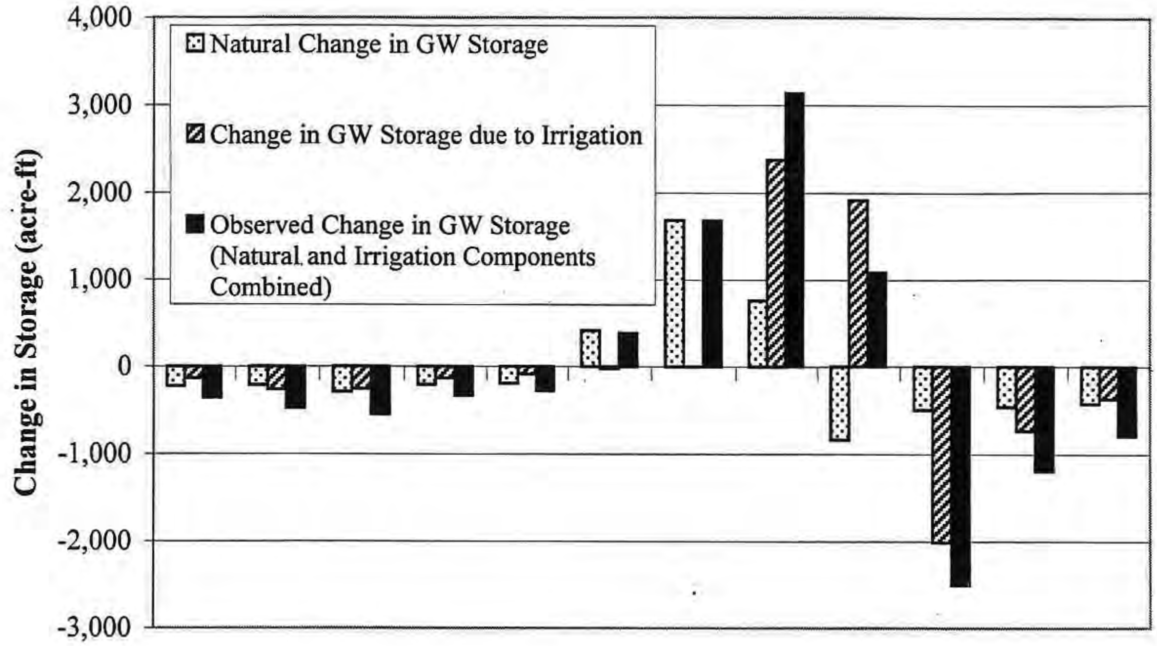

Figure 17. Monthly changes in ground-water storage for the Francis Creek unit, October 1997-September 1998. Positive values indicate gains in storage; negative values indicate decreases in storage.

September, ground-water storage was reduced by 4,500 acre-ft, which represents about 70 percent of the water that was previously gained. Stored irrigation water was found to account for 3,100 acre-ft (70 percent) of the total release.

Clearly, the amount of ground water released from storage during the late summer and fall would be significantly reduced if irrigation did not occur. However, the data do not reveal the portion of water that is lost to the surface-water system versus ET. This question will be addressed in the following sections.

Specific Conductance

Specific conductance (SC) was measured quarterly at many of the wells (table 14) and was found to range from about 60 to 600 µS/cm across the study area. A map of the SC distribution for September 1998 (figure 18) does not reveal any obvious spatial patterns, and a scatter plot of SC versus well depth (figure 19) likewise is unrevealing. The lack of a discernable pattern hints at the complexity of the aquifer system in the area.

SC was plotted versus time for the 12 wells with the most complete records in order to determine if any seasonal trends were evident (figure 20). At many locations, the SC rose slightly between the spring and mid-July 1998 measurements. Mid-July is the time when most of the pastures were drying, and evapotranspiration was at its peak. Salts were therefore probably concentrated in the shallow ground-water system by evapotranspiration. The cause of the large decrease in SC at well M:163252 between November 1997 and January 1998 is unclear. Saline seepage occurs in the poorly drained area surrounding this 15-ft deep, 2-inch diameter monitoring well. Perhaps snowmelt flushed the salt from the area, or the well seal had not swelled sufficiently to prevent migration of water down outside of the casing.

Surface Water

Flow Conditions

To characterize the surface-water flow balance for the Francis Creek unit, 10 rounds of synoptic flow measurements were made during the spring, summer, and fall 1998. Flows were measured on all streams and irrigation ditches that carried significant volumes of water into or out of the unit. In addition to the synoptic measurements, flows were gaged continuously on the Huntley Ditch and on Francis Creek. The Huntley Ditch gage was at the south (upstream) end of the study area, where the ditch crosses under Highway 278; the Francis Creek gage was at the downstream end of the study area and measured the total surface-water outflow from the unit. Hydrographs for the Francis Creek and the Huntley Ditch gaging locations are presented in figure 21.

Following a large runoff event in April, the flow in Francis Creek stabilized at about 30 cfs for the next month. On May 22, the Huntley ditch was flooded, and shortly thereafter flow in Francis Creek began to rise. Several other irrigation ditches were flooded at about

Table 14. Specific conductance (SC) of ground water at the Francis Creek unit, November 1997 - September 1998. (All SC values are temperature corrected to 25 °C)

GWIC	Location	Depth	Fall 1997			Winter 1998			Spring 1998			Summer 1998			Fall 1998		
M:Number	(TRST)	(ft)	Date	SC (µS/cm)	Temp (°C)	Date	SC (µS/cm)	Temp (°C)	Date	SC (µS/cm)	Temp (°C)	Date	SC (µS/cm)	Temp (°C)	Date	SC (µS/cm)	Temp (°C)
107679	03S15W04DDBA	36	--	--	--	--	--	--	--	--	--	07/20/98	226	8.0	09/29/98	203	8.0
163243	03S15W09DDCA01	45	--	--	--	01/30/98	271	6.4	04/30/98	244	9.1	07/20/98	257	11.8	09/29/98	248	9.7
163242	03S15W16BAAA	29	10/09/97	515	8.9	--	--	--	04/30/98	--	--	07/20/98	617	8.8	09/29/98	377	8.8
107681	03S15W16DCCD	87	--	--	--	01/29/98	158	7.5	04/30/98	138	8.2	07/20/98	153	7.4	09/29/98	148	11.3
107689	03S15W21DBDC01	33	--	--	--	01/29/98	594	4.5	04/30/98			07/23/98	497	5.4	09/29/98	551	5.7
107688	03S15W21DBDC02	81	--	--	--	01/29/98	477	5.7	04/30/98	440	6.0	07/23/98	620	4.2	09/29/98	473	6.0
163246	03S15W27AADA	38	10/09/97	418	7.8	01/30/98	417	5.6	05/01/98	379	8.9	07/23/98	337	9.6	09/29/98	381	7.3
163247	03S15W28ACCC01	24	10/10/97	515	7.1	01/29/98	517	2.5	04/30/98	476	5.3	07/20/98	476	12.0	09/29/98	326	8.0
158564	03S15W33ADCD01	80	--	--	--	--	--	--	--	--	--	07/23/98	128	12.0	09/29/98	111	7.8
163248	03S15W34DAAD	37	10/09/97	388	8.1	01/30/98	319	5.2	05/01/98	373	9.4	07/23/98	436	7.4	09/29/98	409	7.5
108215	04S15W02CCCB01	235	--	--	--	--	--	--	--	--	--	--	--	--	09/29/98	580	10.0
156215	04S15W03BCCC01	70	11/19/97	131	6.8	01/30/98	127	5.8	04/30/98	116	8.4	07/23/98	139	6.4	09/29/98	117	6.4
141232	04S15W03BDAD	45	--	--	--	--	--	--	05/01/98	495	6.8	--	--	--	--	--	--
163249	04S15W04ABBB01	15	10/10/97	167	8.8	01/29/98	141	2.2	04/30/98	168	6.3	07/23/98	185	9.4	09/29/98	148	10.6
163250	04S15W04DCAD01	15	10/09/97	428	8.9	01/29/98	421	2.0	04/30/98	464	4.5	07/23/98	526	11.5	09/29/98	462	10.9
163252	04S15W09CBCD01	15	10/09/97	564	9.1	01/29/98	229	2.5	04/30/98	223	5.2	07/23/98	280	9.1	09/29/98	205	10.7
158565	04S15W09DCBD01	90	--	--	--	--	--	--	--	--	--	--	--	--	09/29/98	112	7.5
163251	04S15W10BCBD	13	10/09/97	250	7.2	--	--	--	05/01/98	202	3.8	07/23/98	226	8.8	09/29/98	201	9.2
169083	04S15W11BDDC	0	--	--	--	--	--	--	--	--	--	--	--	--	09/29/98	63	8.7
156218	04S15W16CAAA	29	--	--	--	01/29/98	407	4	04/30/98	356	5.1	07/23/98	391	6.1	09/29/98	348	5.9
			Average:	375	8.1		340	4.5		313	6.7		343	8.6		288	8.4
			St Dev:	157	0.9		156	1.8		137	1.9		168	2.4		160	1.8
			Maximum:	564	9.1		594	7.5		495	9.4		620	12.0		580	11.3
			Minimum:	131	6.8		127	2.0		116	3.8		128	4.2		63	5.7

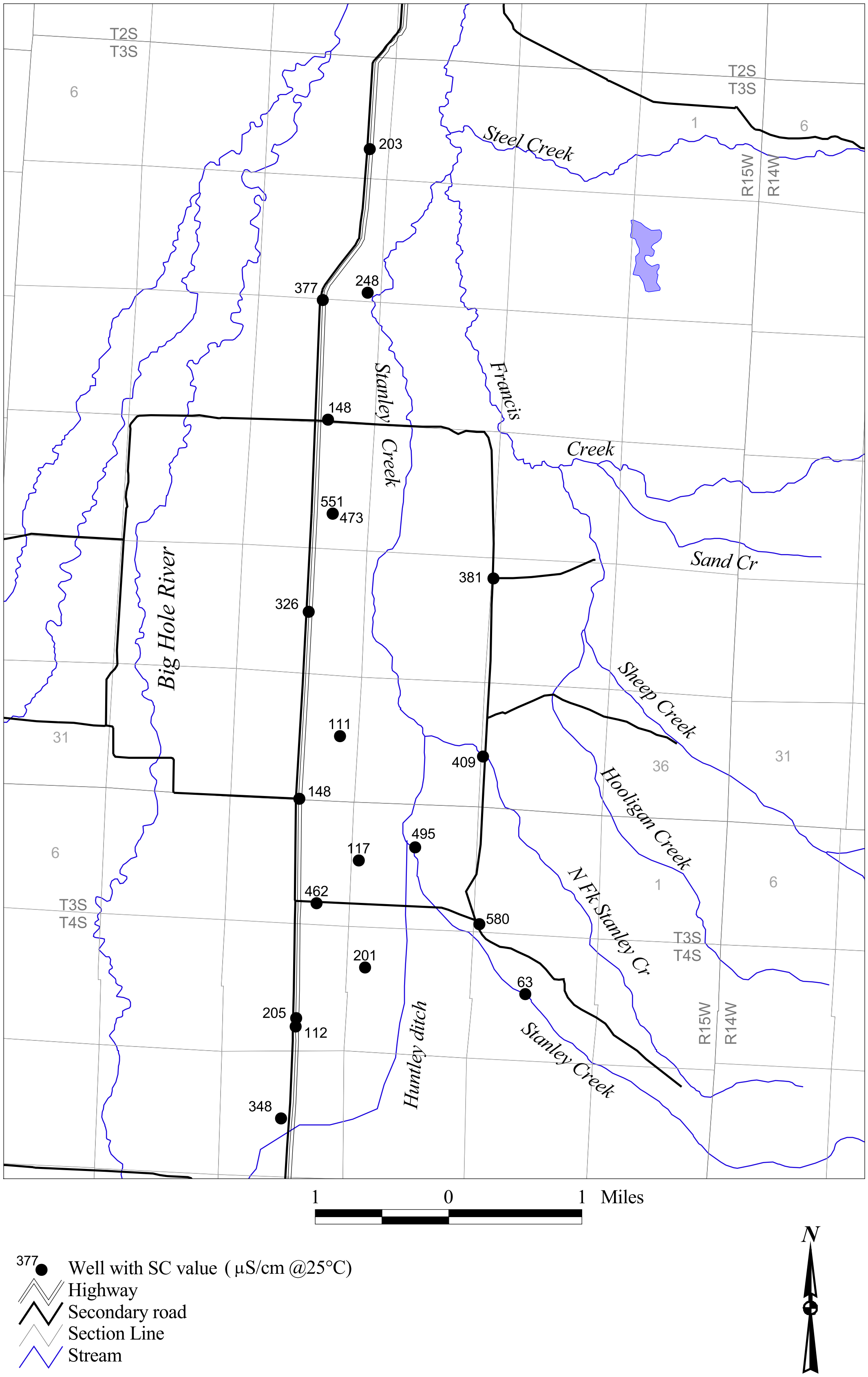

Figure 18. Map showing distribution of ground-water specific conductance (SC) in the Francis Creek unit, September 1998.

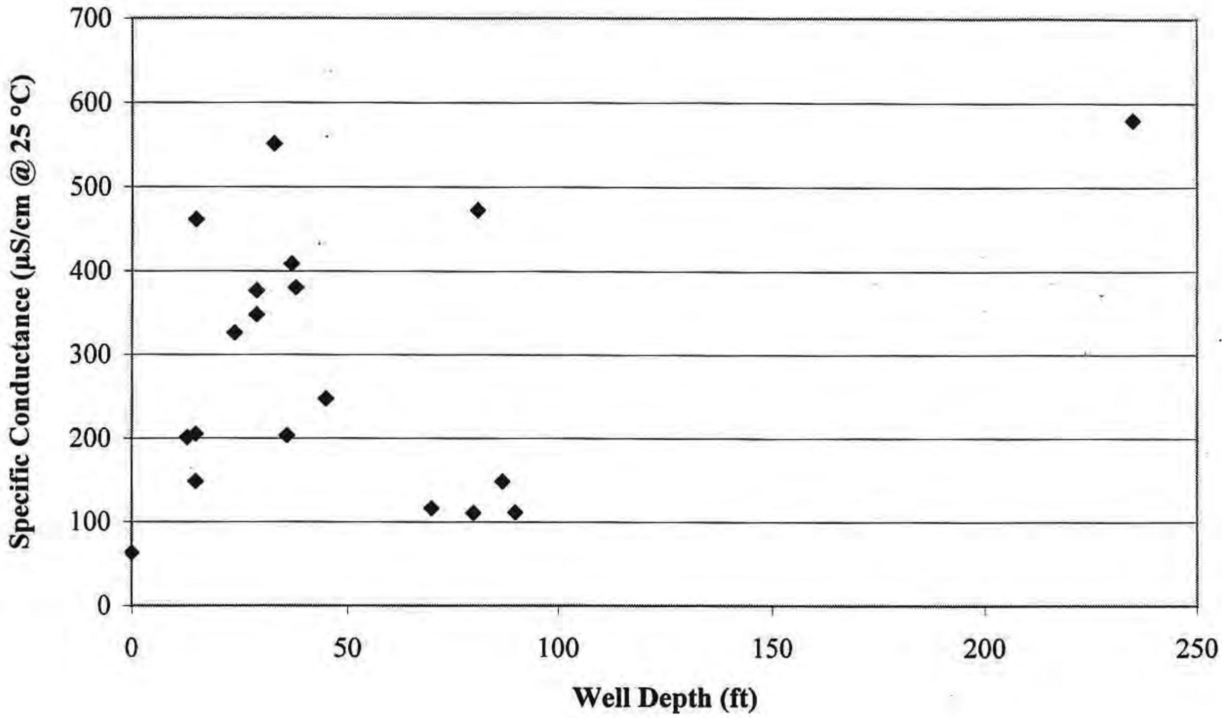

Figure 19. Scatter plot of specific conductance versus well depth, Francis Creek unit, September 1998.

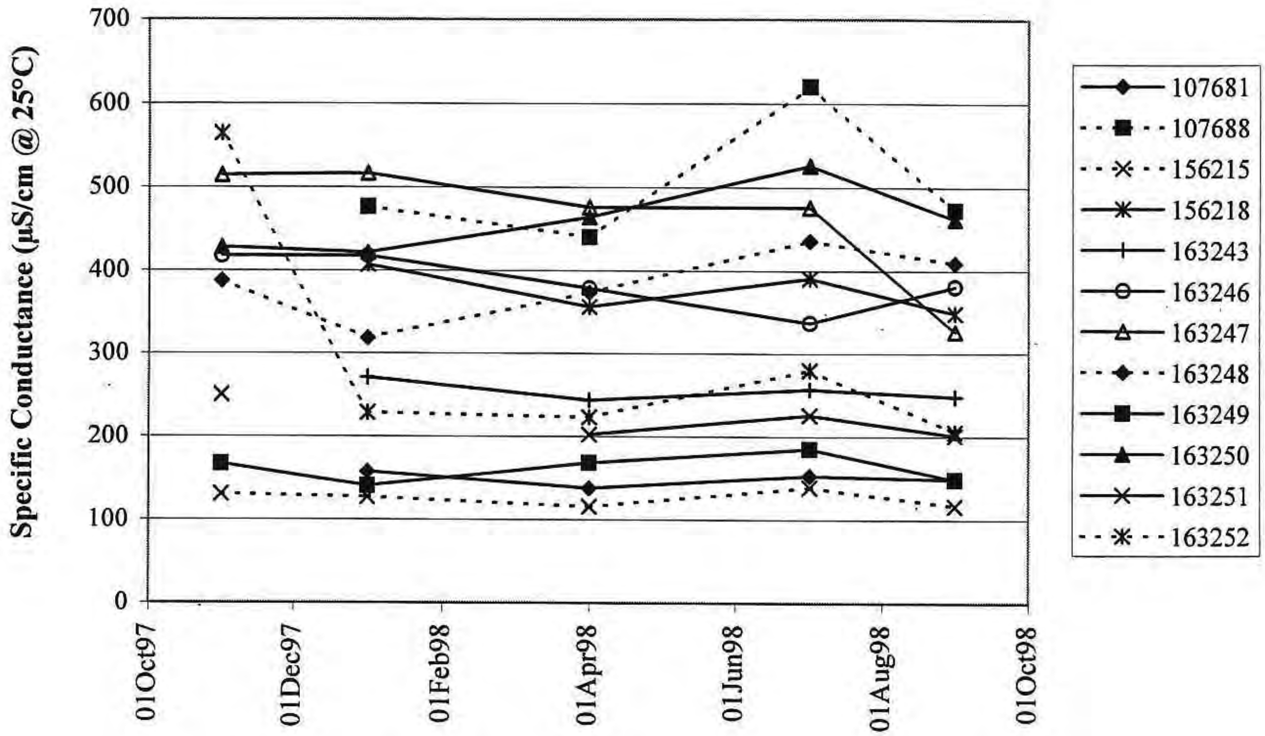

Figure 20. Plots of specific conductance versus time for ground water at twelve locations, Francis Creek unit, November 1997-September 1998.

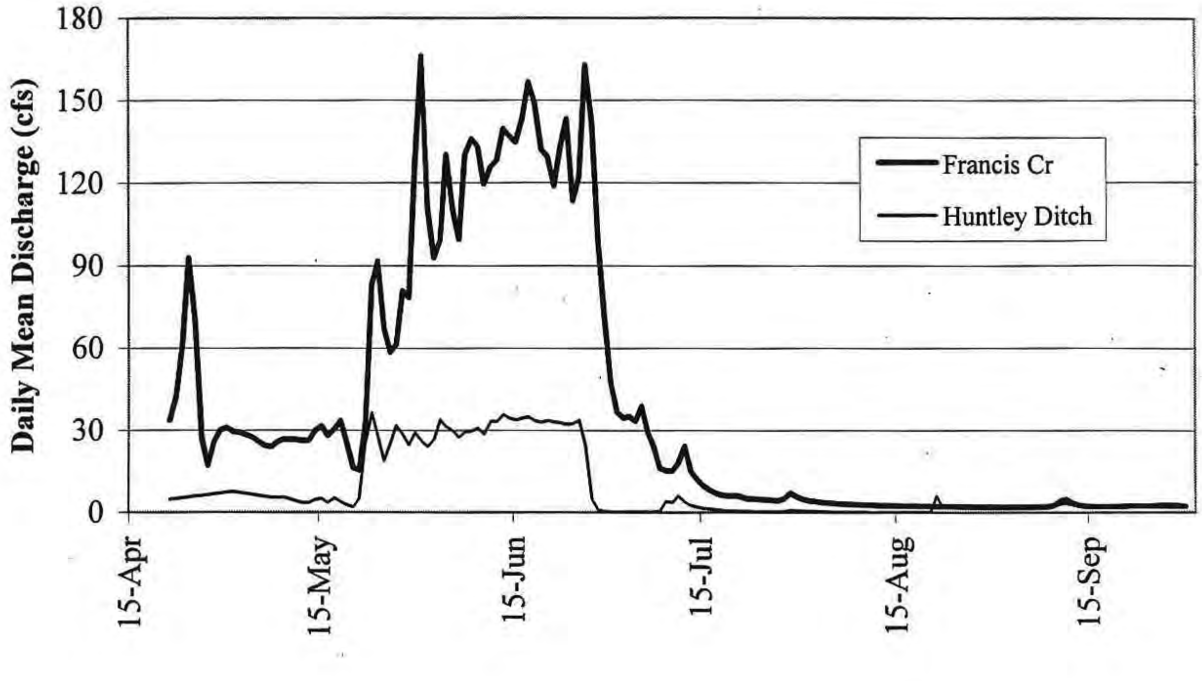

Figure 21. Hydrographs for Francis Creek and the Huntley Ditch, April-September 1998.

the same time, which explains why the increase in creek flow is much greater then the flow measured in the Huntley Ditch. Flows in the creek and ditches remained high until the end of June. On June 26, flow in the irrigation ditches was shutoff, and within 4 days, the flow rate dropped to 0.1 cfs. The flow in Francis Creek also declined sharply, dropping from about 160 cfs to about 45 cfs over the same time interval. During the next few weeks, flow in Francis Creek continued to decline but not as rapidly. From mid-August until the end of the field season, flows averaged less than 2.5 cfs.

Figure 22 is a hydrograph of the estimated daily mean inflow and outflow of the Francis Creek unit. Figure 23 is a plot of the difference between the outflow and inflow. The figures show that surface-water flow into the Francis Creek unit was greater than outflow throughout most of the study period. The deficit presumably was caused by loss of surface water to the ground-water system and to ET.

The brief gain in surface-water discharge on May 30 and 31 is probably due to underestimation of inflow from the mountain tributaries (Sheep Creek, Stanley Creek, N. Fk. Sand Creek, Hooligan Creek). Almost 1 inch of rain was recorded at the Francis Creek weather station on May 30, and due to orographic effects, it is likely that precipitation in the mountains to the east was even greater. None of the tributaries were monitored continuously, so flows were estimated based on the flow of Big Hole River at Wisdom. The regression models probably did not work well because the tributary watersheds are much smaller and differ markedly in character from the majority of the upper Big Hole watershed.

The 4-day gaining period at the end of June is attributed to irrigation returns. During this time, outflow exceeded inflow by up to 45 cfs. The period was surprisingly brief, however, considering the amount of ground water stored in the aquifer during the spring and early summer.

One possible explanation for the brevity of the irrigation-return period is that much of the ground water lost from storage moved off the site as subsurface flow. The potentiometric contour map for the water-table aquifer (plate 2) indicates that this could be especially true at the southern end of the site. However, estimates of subsurface flow made with a ground-water flow net and Darcy's law (figure 24) suggest that much less than 2 cfs is lost via this path. Based on the calculation, it therefore appears that ET accounts for most ground water lost from storage during July, August and September.

Ground-Water Contribution to Streamflow, Based on SC Balance

During the study, it was noted that the SC of Francis Creek at the downstream end of the study area was significantly higher than that of any surface water flowing into the unit. A reasonable explanation for this increase is the mixing of higher SC ground water with the surface water. Using SC and flow data collected in the second half of July 1998, it was estimated that 33 percent of the surface water leaving the Francis Creek unit originated as ground water (appendix E). This estimate is based on the assumption that the average SC

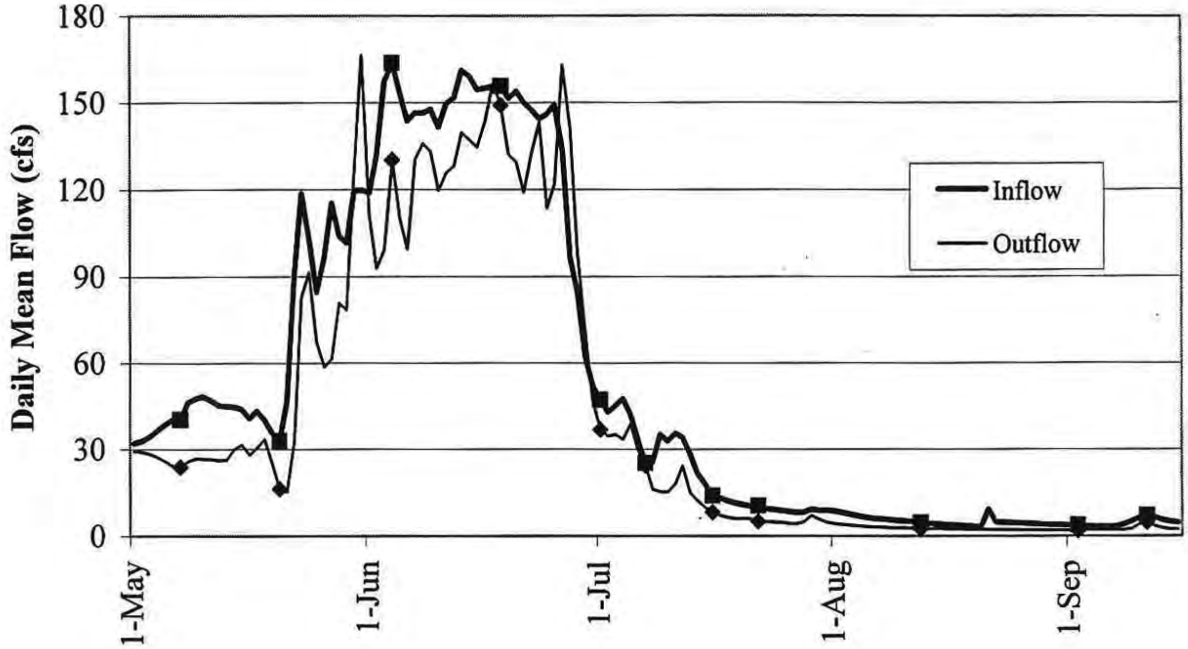

Figure 22. Francis Creek unit inflow and outflow hydrographs, May-September 1998. Tie marks indicate synoptic measurement events.

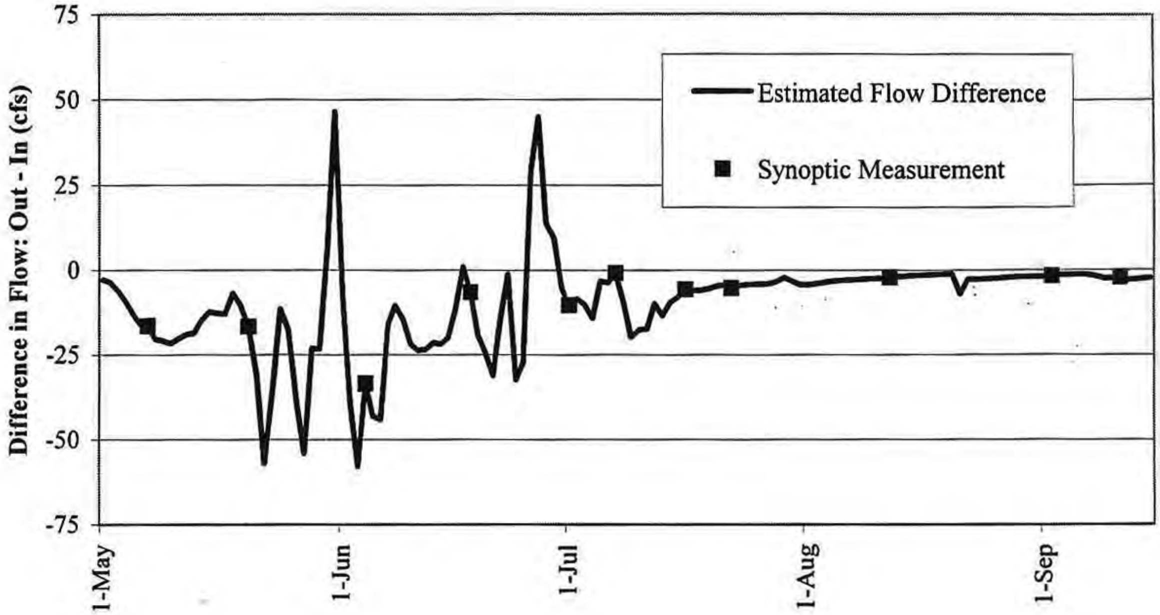

Figure 23. Hydrograph of the difference between inflow and outflow for the Francis Creek unit, May-September 1998.

Darcy Equation: Q = KIA/86,400

where, Q = Flow (cfs)
K = Hydraulic Conductivity (ft/day)
I = Hydraulic Gradient (ft/ft)
A = Flow Tube Area (ft^2):
Tube Width x Aquifer Thickness

Flow Tube	1	2	3	4
Hydraulic Gradient (ft/ft)	0.0059	0.0075	0.0095	0.0070
Flow Tube Width (ft)	3,400	3,200	3,000	2,500
Aquifer Thickness (ft)	40	40	40	40

If K = 3 ft/day, Q = 0.1 cfs

If K = 50 ft/day, Q = 2.1 cfs

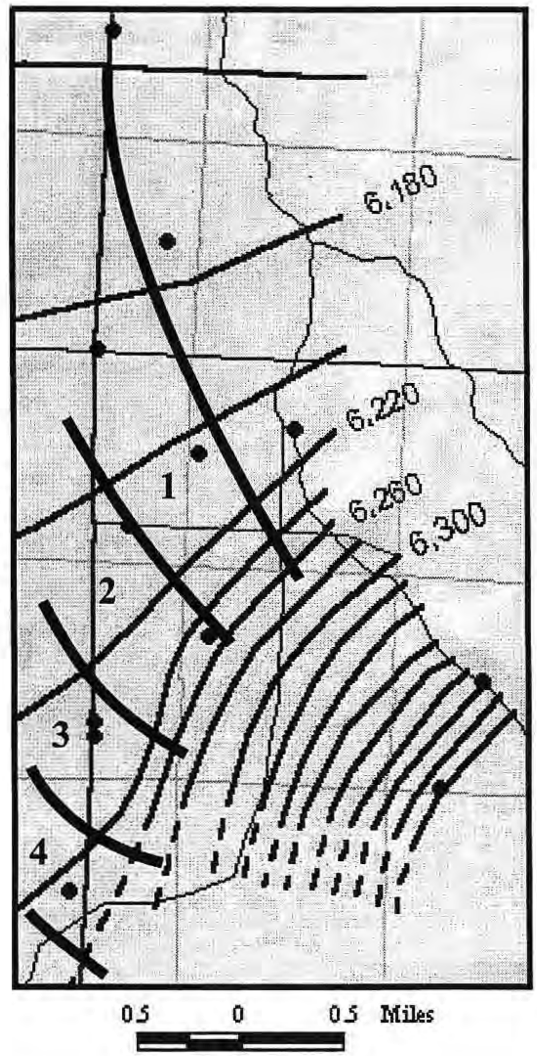

Figure 24. Estimate of ground-water flow loss for the Francis Creek Unit using a flownet and Darcy's Law.

of the ground water entering the stream was similar to the average measured at the wells at this time. This result might seem to contradict the conclusions drawn from the inflow/outflow- balance discussion in the preceding paragraphs, but it does not. The flow balance was strictly an accounting of surface-water entering versus leaving the unit; the balance did not define the flow paths followed by the water as it traveled through the study area. The ground-water contribution estimate reflects that some of the water entering the unit, especially along the Sheep and Francis Creek drainages, was diverted to irrigate pasture. Much of this water was lost to ET, but a portion of it percolated into the ground-water system and subsequently discharged back to the streams. This return water had a greater SC than the original stream water, and thus the SC of the outflow from the study area was higher.

Evapotranspiration

Monthly ET estimates for the Francis Creek unit were determined for the period from May to September 1998 using two approaches. In one case, ET was determined as the residual of the study area's water balance. In the other case, ET was estimated using the 1982 Kimberly-Penman equation and estimates of the irrigated and non-irrigated acreage at the site.

The water balance approach assumes that, with the exception of ET losses, all water that enters or leaves a watershed can be accounted for by measuring streamflows, precipitation, ground-water flow, and changes in surface- and ground-water storage. The imbalance between these components then represents ET losses. Expressed as an equation,

$$ET = P + SW_{in} + GW_{in} - SW_{out} - GW_{out} - S_{gw} - S_{sw}$$

where, ET is evapotranspiration,
P is precipitation,
SW_{in} is surface-water inflow,
GW_{in} is ground-water inflow,
SW_{out} is surface-water outflow,
GW_{out} is ground-water outflow,
S_{gw} is ground-water storage change, and
S_{sw} is surface-water storage change.

GW_{in}, GW_{out}, and S_{sw} were assumed to be negligible for the study area, and therefore the equation reduced to

$$ET = P + SW_{in} - SW_{out} - S_{gw}$$

Monthly estimates of P, SW_{in}, SW_{out}, and S_{gw} were then used to obtain monthly ET estimates. The peak monthly ET loss determined using this method was approximately 4,800 acre-ft in July (table 15). Intuitively, the September estimate (3,500 acre-ft) seems

Table 15. Monthly ET estimates determined using the water balance at the Francis Creek unit, May - September 1998

Water-Balance Method

$ET_{total} = Precip + SW_{in} - SW_{out} - \Delta S_{gw}$

Month	Precipitation		SW_{in}		SW_{out}		ΔS_{gw}		ET_{total}	
	(in)	(acre-ft)	(in)	(acre-ft)	(in)	(acre-ft)	(in)	(acre-ft)	(in)	(acre-ft)
May-98	2.6	3,632	2.7	3,802	2.0	2,786	2.2	3,140	1.1	1,508
Jun-98	2.3	3,198	5.8	8,262	5.2	7,323	0.8	1,084	2.1	3,053
Jul-98	1.3	1,832	0.9	1,342	0.6	893	-1.8	-2,504	3.4	4,785
Aug-98	0.4	520	0.2	314	0.1	160	-0.8	-1,188	1.3	1,862
Sep-98	1.8	2,612	0.2	272 **	0.1	152 **	-0.6	-789	2.5	3,521
								Total:	10.4	14,728

* ET_{other} for May 1998 assumed to be half of precipitation on non-irrigated land

** Monthly estimate based on data from Sept 1 - Sept 15.

too high, but the value is largely a function of the amount of precipitation that fell that month and the lack of significant surface-water runoff.

For the 1982 Kimberly-Penman method, estimates of crop-water use are based on meteorological parameters and crop water-use curves. The method was developed by the USDA Agricultural Research Service in Kimberly, Idaho and yields accurate estimates of ET in arid regions (Wright, 1982). It is known as a "combination method" because it estimates ET based on a combination of net radiation (the heat function) and advective energy transfer (the wind function). The governing equation is:

$$\lambda ET_r = (\Delta/\Delta + \gamma)(R_n - G) + (\gamma / \Delta + \gamma) 6.43 W_f (e_s - e_a)$$

where, λ is the latent heat of vaporization of water (MJ/kg),
ET_r is the daily potential evapotranspiration rate of alfalfa (mm/day),
Δ is the slope of the saturation vapor pressure-temperature curve (kPa/°C),
γ is the psychometric constant (kPa/°C),
R_n is the net radiation (MJ/m²/day),
G is the soil heat flux (MJ/m²/day),
6.43 is the constant of proportionality (MJ/m²/day/kPa),
W_f is the wind function (dimensionless),
e_s is the average saturation vapor pressure (kPa), and
e_a is the actual vapor pressure.

The sum of the terms $(\Delta/\Delta + \gamma)$ and $(\gamma / \Delta + \gamma)$ is equal to one. These terms are weighting factors that assess the relative effects of the heat and wind functions on evapotranspiration. For more detailed explanations of the 1982 Kimberly-Penman equation, refer to Dockter (1994), Jensen and others (1990), and Wright (1982).

Daily meteorological data from the weather station at the Huntley ranch (appendix A) were used in the 1982 Kimberly-Penman equation to obtain daily ET_r values. To convert ET_r to the ET rate of the grass hay (ET_{grass}) grown at the study site, it was multiplied by a crop coefficient (K_{grass}). Expressed as an equation,

$$ET_{grass} = K_{grass} * ET_r$$

K_{grass} varies with the growth stage of the grass hay (figure 25), and therefore a graph was developed to show the change of K_{grass} with time at the study site (figure 26). For the 1998 growing season, grass hay was assumed to emerge from dormancy on April 19, the first day that the shallow soil temperature (2 inches below the surface) at the weather station was above 32° F and to reach full canopy by the first of July. The reduction of K_{grass} at the end of July was incorporated to reflect the reduction in water consumption following the cutting of the grass hay. As the grass hay began to regenerate during August, K_{grass} was inferred to gradually increase again, but then was assumed to decline when cool fall temperatures arrived. The first killing frost ($T_{min} < 24°$ F) of the fall occurred on September 22 and marked the end of the grass-hay growing season.

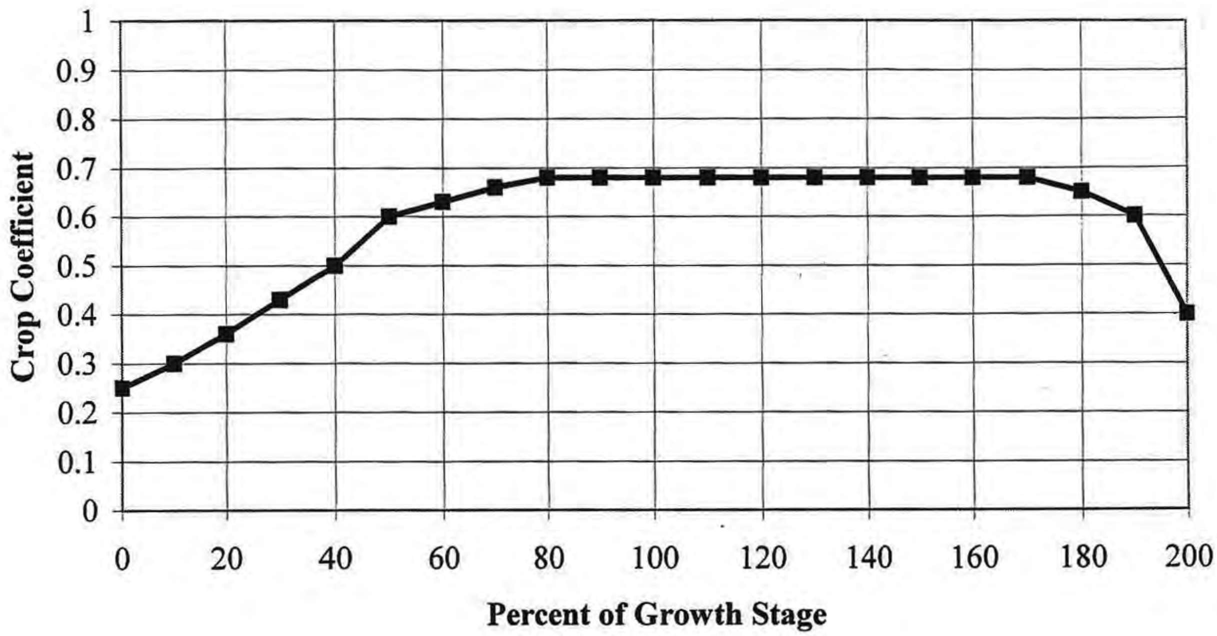

Figure 25. Crop curve for estimating the evapotransiration rate of grass hay. Crop reaches maturity at 100%. (Data from U.S. Bureau of Reclamation, 1994)

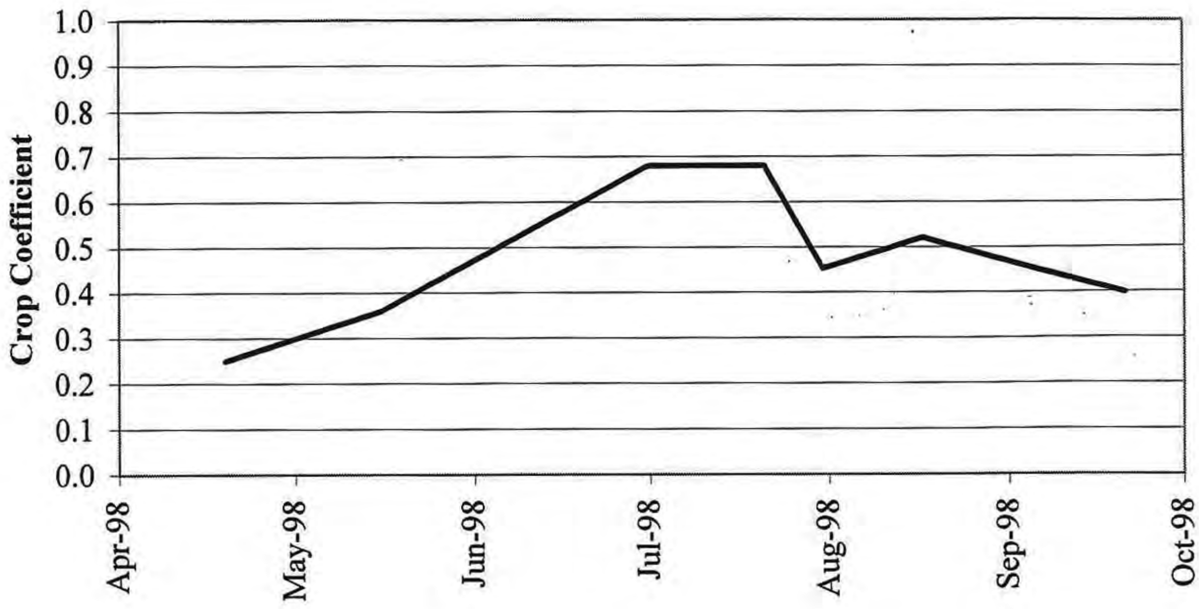

Figure 26. Variation of the grass-hay crop coefficient with time, Francis Creek unit, May-September 1998.

Monthly estimates of the amount of water lost to grass-hay ET (table 16) were obtained by summing the daily ET_{grass} values for a given month and multiplying by the irrigated acreage (figure 27). The irrigated acreage at the site was estimated to be 7,000 acres based on field observations and a Landsat infrared false-color imagery map (U.S. Geological Survey, 1985).

The non-irrigated portion of the study area encompassed about 10,000 acres that was vegetated with rangeland plants such as sage brush and bunch grasses. These plants contributed to ET losses (ET_{other}, table 16), but the amount could not be quantified using 1982 Kimberly-Penman method. Instead, it was assumed that during the summer and early fall (mid-June—September), all precipitation that fell on the non-irrigated land was lost to ET_{other}. This seems reasonable given that rangeland plants are adapted to scavenging water in an arid environment and most summer storms did not produce significant runoff. For May and the first half of June, ET_{other} was assumed to be equal to half of the precipitation because conditions were generally cooler and wetter.

The monthly ET_{grass} and ET_{other} estimates were added together to obtain the total monthly ET loss at the site. For the 1998-growing season, the ET loss was estimated to be 14,000 acre-ft, with water consumption by grass hay accounting for 64 percent of the total. ET_{grass} rose from about half an inch (270 acre-ft) in April to 5.2 inches (3,035 acre-ft) in July and then steadily declined until the end of the growing season. Total water consumption by grass hay was estimated to be 15.3 inches. This value agrees well with the mean 16.1 inches of water (period of record unknown) consumed by pasture grasses in Lima (elevation 6,275 ft), south of Dillon (SCS, 1986).

A comparison of the ET values determined using the water-balance method versus the 1982 Kimberly-Penman approach reveals that the methods produced similar results (figure 28). Monthly values differed by about 670 acre-ft on the average, but neither method yielded values consistently higher than the other. The total ET estimate (May-September 1998) obtained using the water budget method was about 1,000 acre-ft (7 percent) greater than that obtained using the Kimberly-Penman method.

Water Balance and Irrigation Return Flows

Monthly water balances for the period from May through September 1998 are presented in figure 29. The left bar of each monthly pair represents the inputs, or gains, of water; the right bar represents the sinks, or losses. Ideally, if all water-balance components were measured accurately, the left and right bars for each month would represent equal volumes of water. However, each component has some errors and uncertainties associated with it, and therefore, the balances are not perfect.

In May and June, the water balance was expressed as

$$P + SW(\text{Inflow-Outflow}) = ET + S_{gw}$$

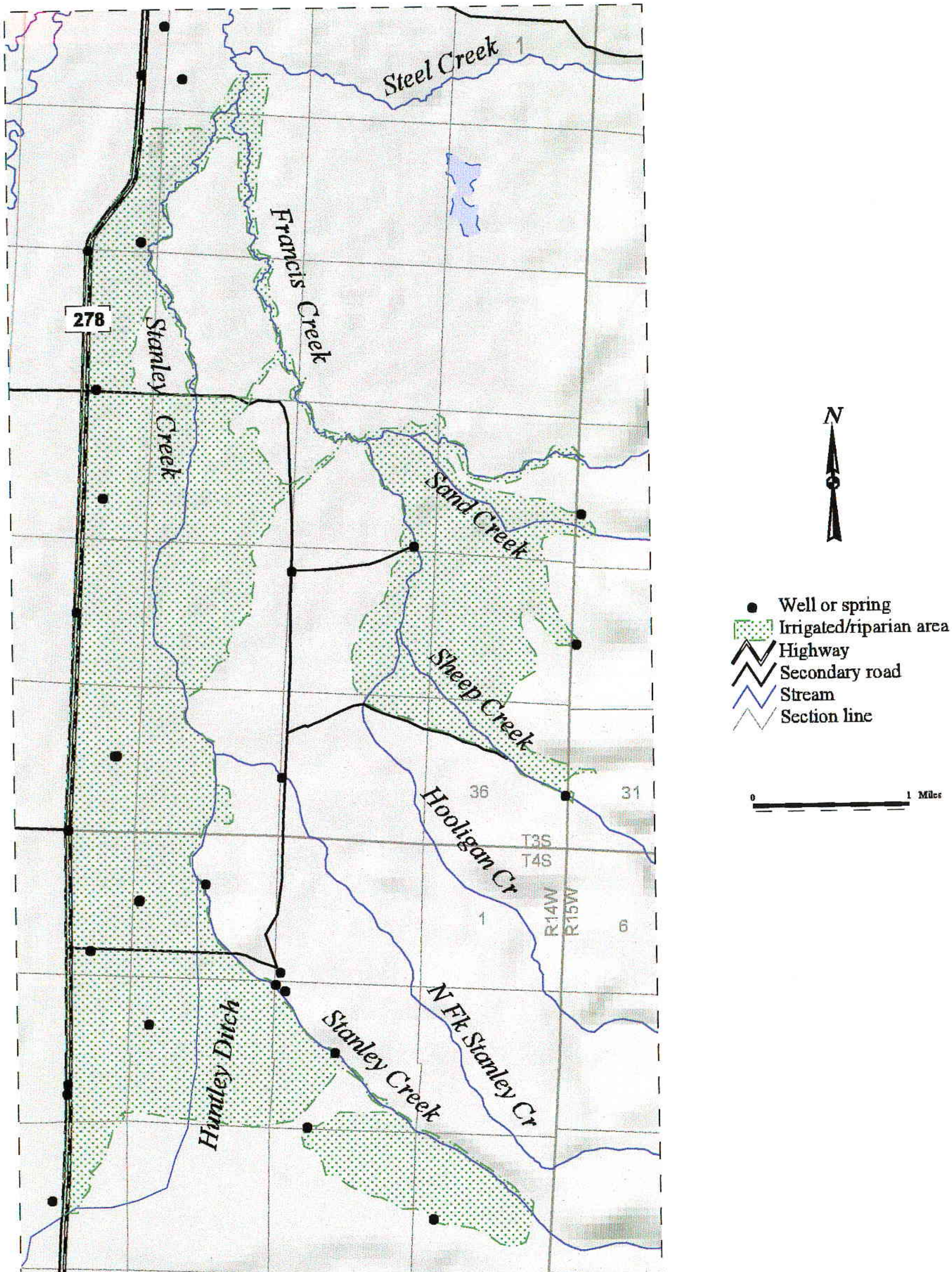

Figure 27. Map of irrigated and riparian areas in the Francis Creek unit, which is east of Highway 278 based on Landsat infrared false-color imagery, 1:250,000 (U.S. Geological Survey, 1985).

Table 16. Monthly ET estimates for the Francis Creek unit using the 1982 Kimberly-Penman method. About 7,000 acres of the study area were covered by irrigated crops or riparian vegetation; about 10,000 acres were dry-land range. ET_r is the potential evapotranspiration of alfalfa; ET_{grass} is actual evapotranspiration of grass hay; ET_{other} is the actual evapotranspiration of the dryland range plants; ET_{total} is the area-weighted actual evapotranspiration for the study area.

Date	ET_r	ET_{grass}		ET_{other}		ET_{total}	
	(in)	(in)	(acre-ft)	(in)	(acre-ft)	(in)	(acre-ft)
Apr-98 *	0.0	0.0	0	0.0	0	0.0	0
May-98	0.0	0.0	0	1.3	1,068	0.8	1,068
Jun-98	0.0	0.0	0	1.3	1,066	0.8	1,066
Jul-98	0.0	0.0	0	1.3	1,078	0.8	1,078
Aug-98	0.0	0.0	0	0.4	306	0.2	306
Sep-98 **	0.0	0.0	0	1.8	1,536	1.1	1,536
Total:	0.0	0.0	0	6.1	5,054	3.6	14,000

* April 19, 1998 was selected as beginning of growing season
** September 22, 1998 was selected as end of growing season

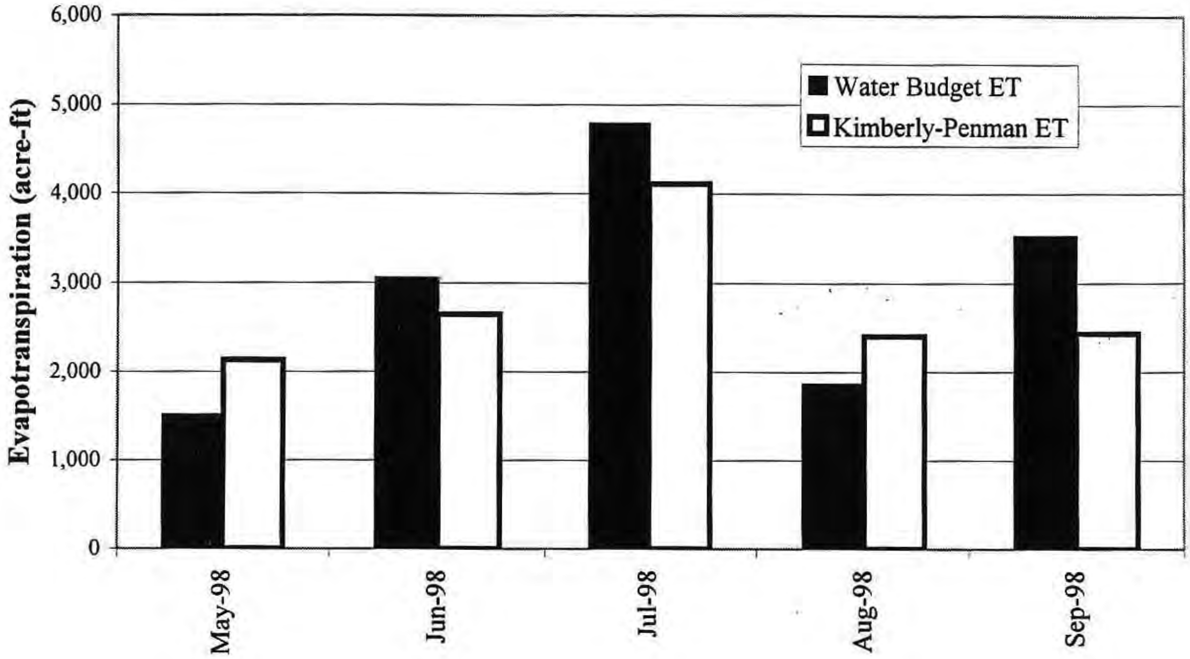

Figure 28. Comparison of evapotranspiration losses estimated with the water-balance method versus the 1982 Kimberly-Penman method, Francis Creek unit.

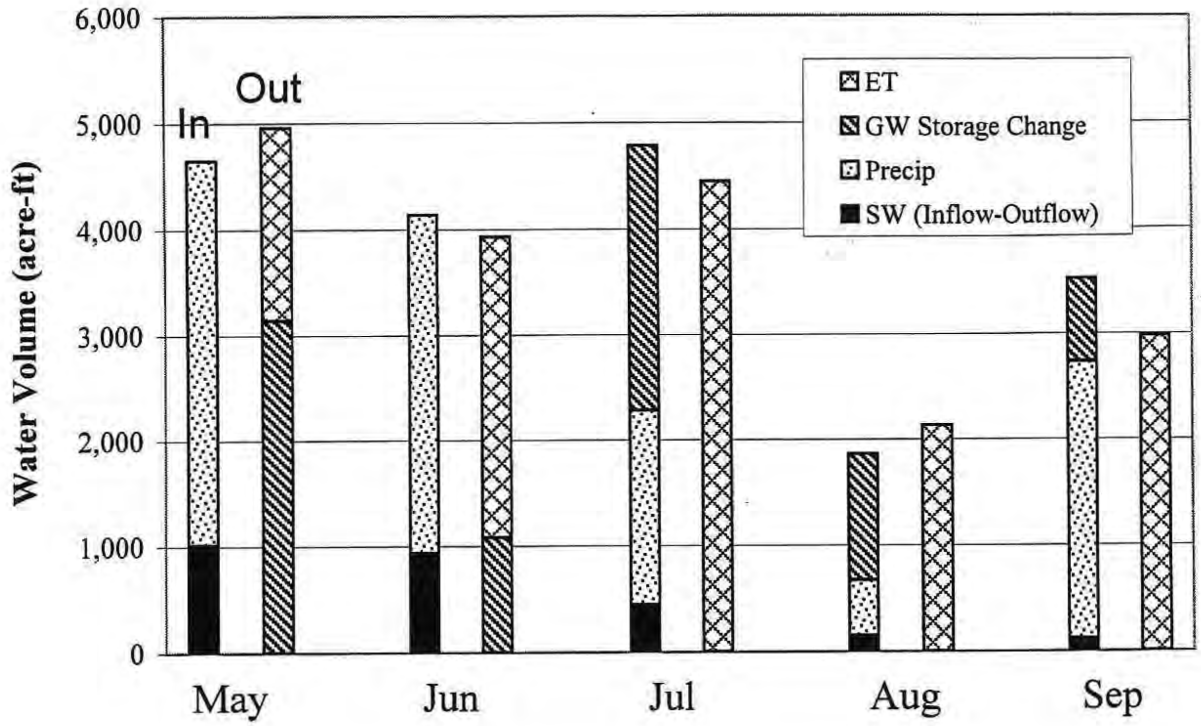

Figure 29. Monthly water bablances for the Francis Creek unit, May-September 1998. The left bar of each monthly pair represents the volume of precipitation input, ground-water storage loss, and/or surface-water flow loss for the study area. The right bar represents the volume of water removed from or temporarily stored in the study area as a result of ET and/or ground-water storage gains. The estimated ET for September was greater than that for August largely due to a substantial rainfall event in early September that did not generate significant runoff from the study area.

where, P is precipitation
SW(Inflow-Outflow) is the difference between the surface-water inflow and outflow,
ET is evapotranspiration loss (average of water balance and 1982 Kimberly-Penman methods), and
S_{gw} is the change in ground-water storage.

During these months, water input from precipitation and flood irrigation was either lost to ET or added to ground-water storage. The gain in ground-water storage in June was only about a third of that in May because less unsaturated material was available, and the shallow ground-water system was closer to reaching a balance between recharge and discharge.

In July, August, and September, the balance equation was rearranged to

$$P + SW(\text{Inflow-Outflow}) + S_{gw} = ET$$

to reflect that ground water was released from storage following the irrigation season. For these months, precipitation input as well as ground-water storage and surface-water losses were about equal to ET. The balances show that although 4,200 acre-ft of water were added to ground-water storage during May and June (the irrigation season), a roughly equal amount of water was lost to ET in July, August, and September. The implication of this observation is that ground water lost from storage from July through September did not directly help increase surface-water flow. However, it should be noted that without the contribution of the ground-water storage, it might have been necessary to divert additional surface water to meet plant needs.

Although irrigation returns appear to have a negligible effect on streamflow during the summer and early fall, it is possible that returns help improve surface flows after the growing season ends. The ground-water storage data collected at the site (see table 13) suggest that irrigation water accounted for about 40 percent of the water that was released from ground-water storage from October 1997 through February 1998. Assuming ET losses were minimal, it seems reasonable to conclude that ground-water discharge to the surface-water system was enhanced by irrigation returns during this period.

MIDDLE BASIN

Climate

Temperatures in the middle basin were near normal during the study period, September 1997 - October 1998 (table 17). December and June were cool, but several other months were slightly warmer than normal.

Table 17. Monthly mean temperatures measured west of Wise River, at Wise River, and at Divide, Montana, September 1997-October 1998. National Weather Service station data from WRCC (1999)

	PG-3, West of Wise River				NWS Station at Wise River				NWS Station at Divide			
	Monthly Mean Temperature (°F)		Departure from Normal	Percent of Normal	Monthly Mean Temperature (°F)		Departure from Normal	Percent of Normal	Monthly Mean Temperature (°F)		Departure from Normal	Percent of Normal
	Observed	30-yr avg*	(°F)	(%)	Observed	30-yr avg*	(°F)	(%)	Observed	30-yr avg*	(°F)	(%)
Sep-97	--	--	--	--	51.8	51.7	0.1	100	53.6	52.5	1.2	102
Oct-97	--	--	--	--	39.9	39.1	0.8	102	41.2	42.7	-1.5	97
Nov-97	--	--	--	--	27.3	29.9	-2.6	91	29.8	29.8	0.0	100
Dec-97	--	--	--	--	16.7	19.7	-3.0	85	19.6	21.4	-1.8	92
Jan-98	--	--	--	--	20.3	21.4	-1.1	95	20.5	19.6	0.8	104
Feb-98	--	--	--	--	20.5	20.0	0.4	102	22.5	24.7	-2.3	91
Mar-98	--	--	--	--	29.4	29.2	0.2	101	29.6	30.3	-0.7	98
Apr-98	40 **	--	--	--	37.8	36.3	1.6	104	39.6	39.4	0.2	101
May-98	48 **	--	--	--	45.0	44.5	0.6	101	49.8	48.3	1.5	103
Jun-98	51 **	--	--	--	48.8	52.0	-3.2	94	42.6	55.9	-13.3	76
Jul-98	--	--	--	--	61.7	59.8	2.0	103	66.3	62.9	3.4	105
Aug-98	61 **	--	--	--	59.2	57.9	1.3	102	63.2	61.6	1.6	103
Sep-98	54 **	--	--	--	53.0	51.7	1.3	102	56.6	52.5	4.1	108
Oct-98	38 **				38.9	39.1	-0.3	99	39.9	42.7	-2.8	93
Average	--	--	--	--	39.3	39.4	-0.1	99	41.1	41.7	-0.7	98

* Years 1961-1990
** Missing 1-7 days of data

As in the upper basin, precipitation in the middle basin was quite variable, in part due to the small storm systems that tracked across the area. Precipitation was about 10 percent above average in Wise River but was about 10 percent below average at Divide (table 18). The limited precipitation data from weather station PG-3, located several miles west of Wise River, agreed well with the data collected at the NWS station at Wise River. The greatest deviation occurred in April and May.

Based on data from NRCS SNOTEL and snow course sites, precipitation and snowpack in the mountains surrounding the middle basin were below normal (tables 19 and 20). The Barkers Lake SNOTEL data suggest that without the above-normal precipitation in June and July, the summer of 1998 would have been very dry.

Ground Water

Potentiometric-surface maps for the aquifers in the Wise River and Divide areas are presented in plate 4. Most water-level data used for the maps were collected in late March and early April 1998. Data for several wells in the Divide valley were obtained from Marvin and Abdo (2000). The maps indicate that ground-water movement is generally toward the river, suggesting that the river is gaining from ground-water discharge along these reaches and accounting for the numerous springs along the south side of the river valley in the Wise River area. As topography suggests, ground-water gradients are steep along the valley margin and decrease as the water flows into the alluvium and outwash deposits nearer to the river.

Slug tests conducted on 3 of the inventoried wells yielded hydraulic conductivity estimates ranging from 74 to 790 ft/day (table 21). Two of the wells are completed in Quaternary alluvium; the third is completed in coarse alluvial fan deposits.

No seasonal water-level data were collected in the middle basin for this study. However, historical data from well M:131967 near Divide Creek were obtained from the MBMG's GWIC database and are presented in figure 30. The well is 55 feet deep and is completed in Tertiary Bozeman Group sediment. For the period of record, the water level fluctuated 1 to 2 ft annually, typically peaking in June or July and reaching its lowest point in March. This trend is similar to that generally observed in the upper basin.

Because no other seasonal water-level data exist for the middle basin, changes in ground-water storage were not evaluated.

Surface Water

Surface-water flow in the middle basin was monitored only to determine the net increase in flow along this reach of the river; irrigation returns were not characterized. As such, inflow was measured only at the Big Hole River gage below Mudd Creek (USGS ID 06024540); inflow contributions from the numerous tributaries along this reach were not measured. Basin outflow was recorded at the Big Hole River gage at Maiden Rock

Table 18. Monthly precipitation measured west of Wise River, at Wise River, and at Divide, Montana, September 1997-October 1998. National Weather Service station data from WRCC (1999).

	PG-3, West of Wise River				NWS Station at Wise River				NWS Station at Divide			
	Precipitation (in)		Departure from Normal	Percent of Normal	Precipitation (in)		Departure from Normal	Percent of Normal	Precipitation (in)		Departure from Normal	Percent of Normal
	Observed	30-yr average	(in)	(%)	Observed	30-yr avg*	(in)	(%)	Observed	30-yr avg*	(in)	(%)
Sep-97	--	--	--	--	1.04	1.06	-0.02	98	1.23	1.15	0.08	107
Oct-97	--	--	--	--	1.97	0.80	1.17	246	1.74	0.72	1.02	242
Nov-97	--	--	--	--	0.90	0.76	0.14	118	0.32	0.58	-0.26	55
Dec-97	--	--	--	--	0.12	0.70	-0.58	17	0.00	0.58	-0.58	0
Jan-98	1.8 inches	--	--	--	0.90	0.51	0.39	176	0.12	0.52	-0.40	23
Feb-98	from Jan	--	--	--	0.52	0.39	0.13	133	0.00	0.42	-0.42	0
Mar-98	through Mar	--	--	--	0.51	0.50	0.01	102	0.81	0.75	0.06	108
Apr-98	1.19 **	--	--	--	0.92	0.82	0.10	112	0.71	1.01	-0.30	70
May-98	1.75 **	--	--	--	2.00	1.65	0.35	121	2.14	1.80	0.34	119
Jun-98	1.98 **	--	--	--	2.04	2.10	-0.06	97	3.77	2.34	1.43	161
Jul-98	--	--	--	--	2.38	1.36	1.02	175	0.15	1.22	-1.07	12
Aug-98	0.74 **	--	--	--	0.62	1.16	-0.54	53	0.80	1.30	-0.50	62
Sep-98	1.03 **	--	--	--	1.03	1.06	-0.03	97	1.05	1.15	-0.10	91
Oct-98	0.15 **				0.14	0.80	-0.66	18	0.10	0.72	-0.62	14
Total	--	--	--	--	15.09	13.67	1.42	--	12.94	14.26	-1.32	--

* Years 1961-1990
** Missing 1-7 days of data

Table 19. Monthly precipitation data for the Barker Lakes SNOTEL station near the middle Big Hole basin, September 1997-September 1998. Data from NRCS (1999).

Site Name	Barker Lakes			
NRCS Site ID	13C44S			
Latitude/Longitude	46°06'N/113°08'W			
Section, Township, Range	17 04N 12W			
Elevation (ft)	8,250			
Month	Precip (in)	30-yr Average (in)	Departure from Normal (in)	Percent of Normal
Sep-97	2.2	2.7	-0.5	81
Oct-97	3.2	2.5	0.7	128
Nov-97	1.6	2.2	-0.6	73
Dec-97	0.9	2.7	-1.8	33
Jan-98	3.1	2.6	0.5	119
Feb-98	1.1	2.8	-1.7	39
Mar-98	3.0	3.7	-0.7	81
Apr-98	3.8	3.8	0.0	100
May-98	4.6	5.2	-0.6	88
Jun-98	5.9	3.8	2.1	155
Jul-98	4.6	2.6	2.0	177
Aug-98	0.6	2.4	-1.8	25
Sep-98	1.6	2.7	-1.1	59
Total	36.2	39.7	-3.5	--

Table 20. First-of-the-month snow-water equivalent (SWE) snowpack data from NRCS SNOTEL and Snow Course stations in or near the middle Big Hole basin, January-June 1998. Data from NRCS (1999)

		Jan-98			Feb-98			Mar-98		
Site Name	NRCS Site ID	Measured SWE (in)	Normal SWE (in)	Percent of Normal	Measured SWE (in)	Normal SWE (in)	Percent of Normal	Measured SWE (in)	Normal SWE (in)	Percent of Normal
Barker Lakes	13C44S	5.0	6.8	74	7.9	9.4	84	9.0	12.2	74
Bull Mountain	12D08	--	2.1	--	--	4.0	--	3.2	5.0	64
Elk Horn Springs	13D15	--	--	--	--	--	--	7.0	7.8	90
Fleecer Ridge	12D07	--	4.2	--	--	6.8	--	6.0	8.9	67
Foolhen	13D21	--	--	--	--	--	--	12.0	13.9	86
Storm Lake	13C07	5.4	5.4	100	8.4	8.7	97	9.1	10.8	84
Average Percent of Normal				87			90			78

		Apr-98			May-98			Jun-98		
Site Name	Site No.	Measured SWE (in)	Normal SWE (in)	Percent of Normal	Measured SWE (in)	Normal SWE (in)	Percent of Normal	Measured SWE (in)	Normal SWE (in)	Percent of Normal
Barker Lakes	13C44S	12.1	15.4	79	12.7	16.0	79	5.4	10	54
Bull Mountain	12D08	2.9	6.4	45	0.0	2.7	--	--	--	--
Elk Horn Springs	13D15	7.5	9.3	81	8.1	7.7	105	--	--	--
Fleecer Ridge	12D07	7.3	11.3	65	6.2	7.8	79	--	--	--
Foolhen	13D21	15.2	17.1	89	17.8	18.3	97	--	--	--
Storm Lake	13C07	12.7	14.0	91	15.0	15.0	100	--	--	--
Average Percent of Normal				75			92			54

Table 21. Hydraulic conductivity estimates for aquifers in the middle Big Hole basin.

M:Number	Location (Township, Range, Tract, Section)	Test Date	Test Type	Number of Tests	Aquifer	Well Depth (ft)	Depth to Water (ft)	Screen/ Perf Length (ft)	Well Diameter (ft)	Screen Diameter (ft)	Hydraulic Conductivity (ft/day)	Analytical Method
M:163674	01S10W05DADD	07/15/98	Slug	6	111ALVM	26	8.50	6	0.5	0.5	87	Bouwer and Rice (1976)
M:165030	01N12W24ABCC	07/15/98	Slug	4	110ALVF	80	30.16	1	0.5	0.5	74	Bouwer and Rice (1976)
M:168611	01N11W36CDAB	07/15/98	Slug	6	111ALVM	41	28.79	1	0.5	0.5	790	Bouwer and Rice (1976)
										Average:	317	
										Median:	87	

Notes:
Aquifer Codes: 110ALVF, Quaternary alluvial fan deposits; 111ALVM, Holocene alluvium
* Estimated

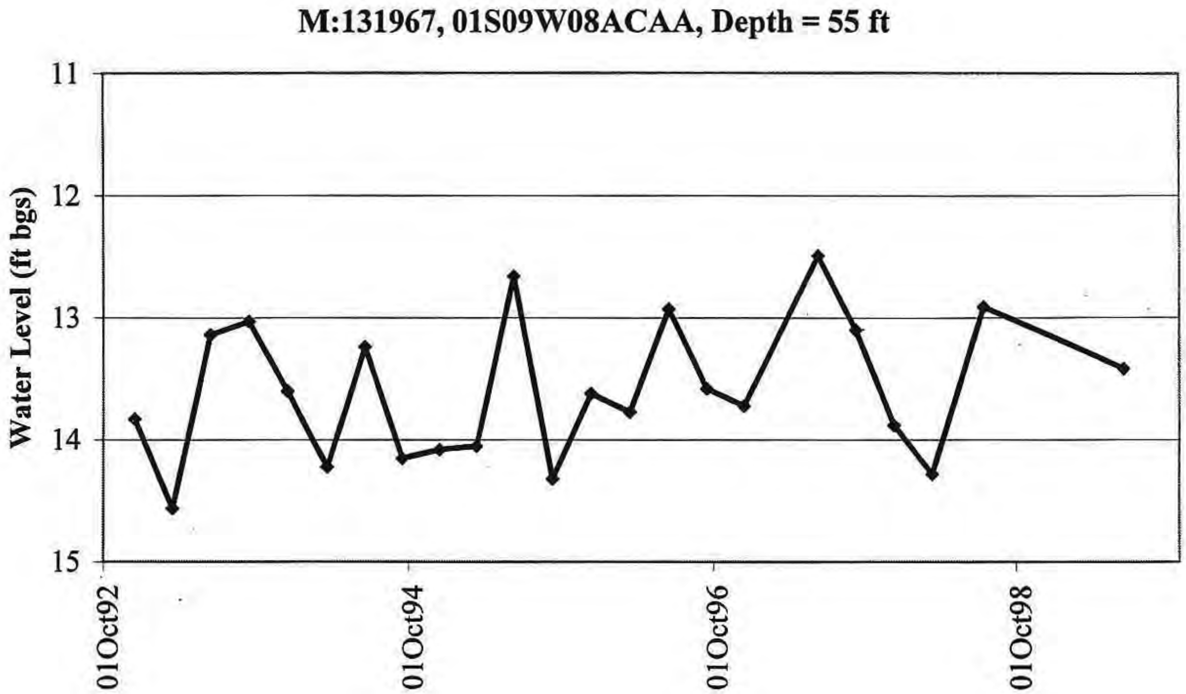

Figure 30. Hydrograph for well M:131967 near Divide, montana, October 1992-October 1998. Data from GWIC (2000).

(USGS ID 06025250), south of Divide. Also, water withdrawn from the middle basin by the Butte-Silver Bow Water Company was tracked. This water is pumped from the Big Hole River upstream of Divide and from the South Fork Reservoir on Divide Creek. Tables 22 and 23 summarize the inflow and outflow data from the above locations. No river-flow data are available from the period from November 1997 through March 1998 because the gages were not maintained during the winter; the data reported for the Maiden Rock gage from November 1998 through February 1999 are provisional.

For the months in which both inflow and outflow data were available, outflow exceeded inflow by about a factor of two. The greatest deviation from this relationship occurred in April 1998 when about 70 percent of the flow exiting the middle basin originated from the upper basin. The difference was probably due to the relatively large volume of runoff from the low-elevation snowpack in the upper basin at this time.

As shown in figure 31, the amount of water withdrawn from the middle basin by the Butte-Silver Bow Water Company averaged about 7 cfs during the period April through October 1998. Figure 32 presents the data in terms of percentage of total outflow from the middle basin. Typically, the water company's withdrawals represented less than 2 percent of the outflow; however, as river flow dropped and withdrawals increased over the summer 1998, a peak of 4.9 percent was reached.

Figure 33 is a hydrograph of the difference between the mean daily inflow and outflow of the middle basin for the period April 1 through October 31, 1998. With the exception of potential irrigation returns, this difference represents the water that originated as precipitation within the middle basin. Similar to the upper basin, peak discharges from the middle basin occurred in May, June and early July as the mountain snowpack melted. The maximum discharge was about 2,100 cfs on May 27. During the period from July through mid-August, discharge declined rapidly from over 1,900 cfs to about 300 cfs. In September and October, discharge stabilized at about 200 cfs as baseflow conditions prevailed.

Evapotranspiration

An estimate of the mean annual ET loss for the overall middle basin (930,000 acre-ft, or 18.8 inches) was obtained by comparing precipitation to surface-water discharge. Mean annual precipitation (period 1961-90) was taken to be 26.1 inches based on an analysis of a GIS precipitation-distribution coverage of the middle basin area (Daly and others, 1994; Daly and others, 1997; Daly and Taylor, 1998). In terms of volume, this is equivalent to about 1.3 million acre-ft of water. The mean annual surface-water discharge of the middle basin was estimated to be about 360,000 acre-ft (7.3 in), which is 28 percent of the precipitation total. Because the USGS river gages at the Highway 43 and Maiden Rock had only the 1997-98 periods of record, long-term discharge estimates were obtained by multiplying the mean annual flow (1961-90) measured at the USGS gage below Melrose by the ratio of river discharges at the Highway 43 and Maiden Rock gages to the flow at the Melrose gage (period 1997-98). This analysis therefore assumed that the ratio of

Table 22. Monthly flow statistics for the Big Hole River at the Hwy 43 bridge below Mudd Creek and at the Maiden Rock bridge, October 1997-October 1998. Data from Shields and others (1999) and USGS unpublished files

Description: Hwy 43 Bridge below Mudd Cr
USGS Name: Big Hole River below Mudd Creek, near Wisdom, MT
USGS ID: 06024540
Drainage Area: 1,267 mi²

Date	Mean (cfs)	Percent of Normal* (%)	Median (cfs)	Max (cfs)	Min (cfs)	Total Discharge (acre-ft)
Oct-97	258	--	262	398	172	15,890
Nov-97	--	--	--	--	--	--
Dec-97	--	--	--	--	--	--
Jan-98	--	--	--	--	--	--
Feb-98	--	--	--	--	--	--
Mar-98	--	--	--	--	--	--
Apr-98	1,076	--	842	2,720	600	64,000
May-98	2,306	--	2,230	3,090	1,390	141,800
Jun-98	2,135	--	2,050	2,850	1,470	127,100
Jul-98	961	--	840	1,680	455	59,080
Aug-98	244	--	195	565	114	14,990
Sep-98	151	--	155	232	100	8,990
Oct-98	187	--	189	202	159	11,530

Description: Maiden Rock Bridge
USGS Name: Big Hole River at Maiden Rock, near Divide, MT
USGS ID: 06025250
Drainage Area: 2,199 mi²

Date	Mean (cfs)	Percent of Normal* (%)	Median (cfs)	Max (cfs)	Min (cfs)	Total Discharge (acre-ft)
Oct-97	573	--	580	855	442	35,260
Nov-97	--	--	--	--	--	--
Dec-97	--	--	--	--	--	--
Jan-98	--	--	--	--	--	--
Feb-98	--	--	--	--	--	--
Mar-98	--	--	--	--	--	--
Apr-98	1,497	--	1,150	3,300	795	89,090
May-98	3,871	--	3,940	4,740	2,610	238,000
Jun-98	3,829	--	3,775	4,550	3,040	227,800
Jul-98	1,999	--	1,770	3,570	925	122,900
Aug-98	563	--	498	1,070	340	34,590
Sep-98	362	--	358	490	299	21,550
Oct-98	390	--	392	402	366	23,970
Nov-98 **	450	--	459	530	360	26,700
Dec-98 ***	354	--	327	503	196	21,800
Jan-99 **	354	--	357	411	281	21,800
Feb-99	362	--	362	403	342	20,100

* No historical data available for comparison
** 2 days of data missing
*** 5 days of data missing

Table 23. Summary of the Butte-Silver Bow Water Company's monthly water withdrawals from the Big Hole basin, July 1997 - October 1998. Data provided by Marty Hoven of the Butte-Silver Bow Water Company.

	Big Hole Pump Station				S. Fk. Reservoir				Combined Total	
Date	Mean (cfs)	Median (cfs)	Max (cfs)	Total Volume (acre-ft)	Mean (cfs)	Median (cfs)	Max (cfs)	Total Volume (acre-ft)	Mean (cfs)	Total Volume (acre-ft)
Jul-97	5.5	4.6	12.8	336	4.9	5.4	7.4	299	10.4	635
Aug-97	7.8	6.9	14.5	480	3.3	3.2	5.1	201	11.1	681
Sep-97	3.9	4.2	12.0	233	2.1	2.2	3.2	126	6.0	359
Oct-97 *	4.7	4.7	7.8	291	2.3	2.0	5.1	141	7.0	432
Nov-97	5.1	5.2	6.4	301	2.0	2.0	3.6	119	7.1	420
Dec-97 *	3.5	3.6	5.9	213	1.8	1.9	3.7	108	5.3	321
Jan-98	3.4	3.7	5.3	207	1.7	1.8	2.2	102	5.1	309
Feb-98	4.1	4.0	10.1	227	1.6	1.7	2.4	87	5.7	314
Mar-98	2.8	3.4	4.3	174	1.4	1.7	2.6	87	4.2	260
Apr-98	3.3	3.2	6.4	195	2.3	2.3	3.9	135	5.6	330
May-98	2.1	1.6	7.2	130	4.4	5.0	7.2	268	6.5	398
Jun-98	0.1	0.0	0.2	3	4.9	5.6	7.9	291	5.0	294
Jul-98	8.6	8.3	17.9	532	4.1	3.9	7.2	253	12.7	785
Aug-98	8.9	9.9	13.5	547	2.0	2.0	4.7	121	10.9	668
Sep-98	5.1	3.7	14.2	303	1.6	1.6	2.9	95	6.7	398
Oct-98	2.2	1.8	5.3	137	1.3	0.8	5.7	78	3.5	215
								Average:	7.0	426

* 1 day of data missing

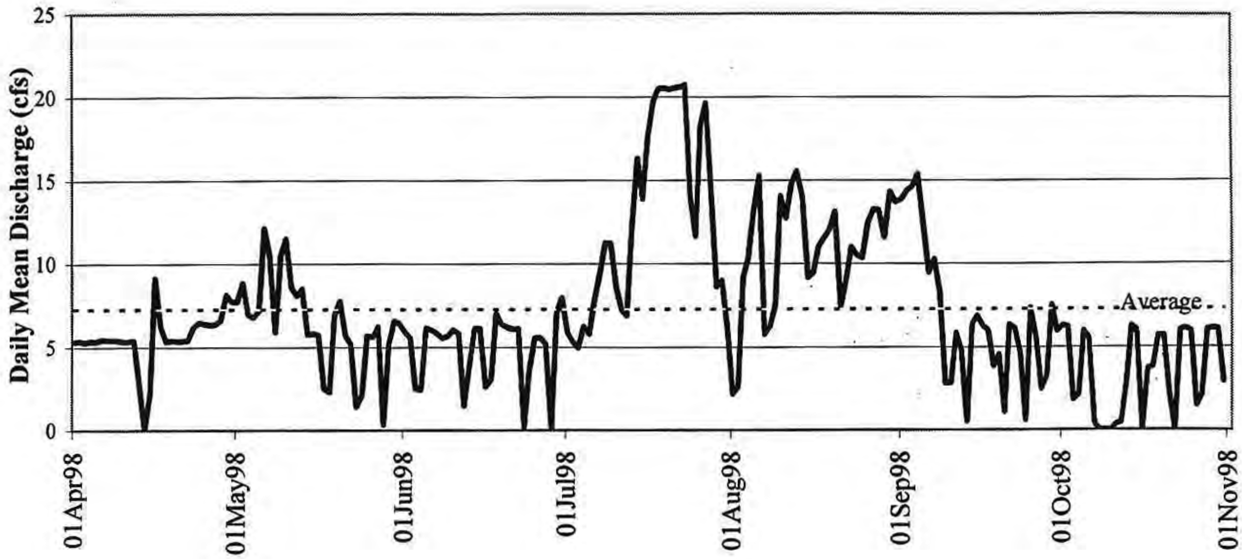

Figure 31. Hydrograph of water withdrawn from the middle Big Hole basin by the Butte-Silver Bow Water Company, April-November 1998.

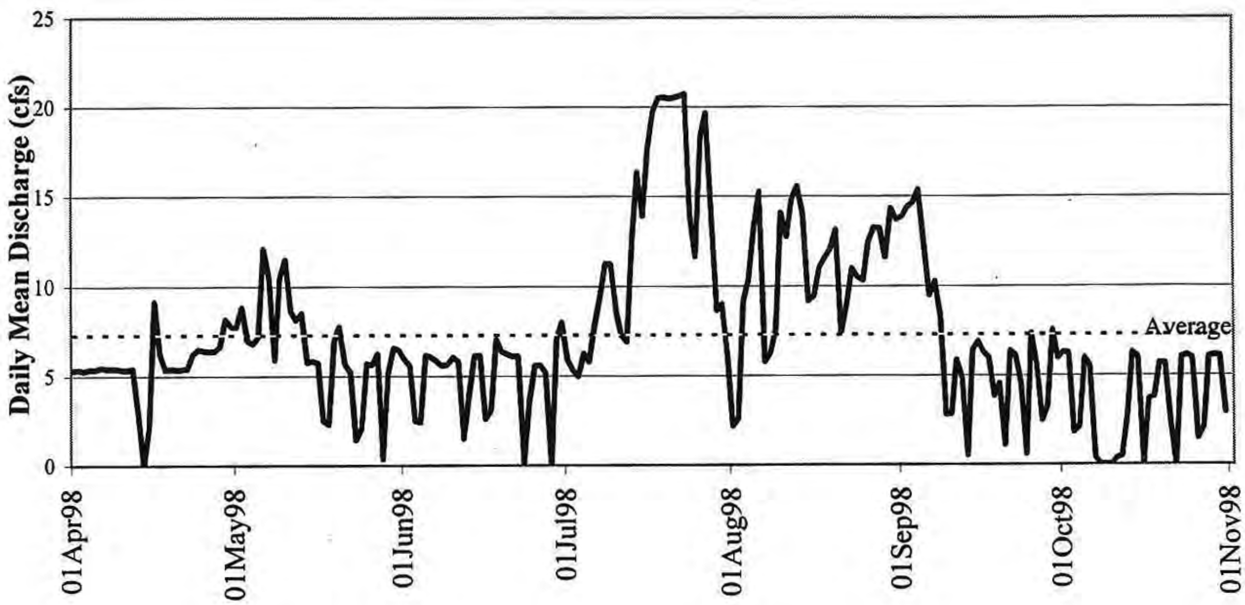

Figure 32. Water withdrawn from the middle Big Hole basin by Butte-Silver Bow Water Company as a percentage of total outflow, April-November 1998.

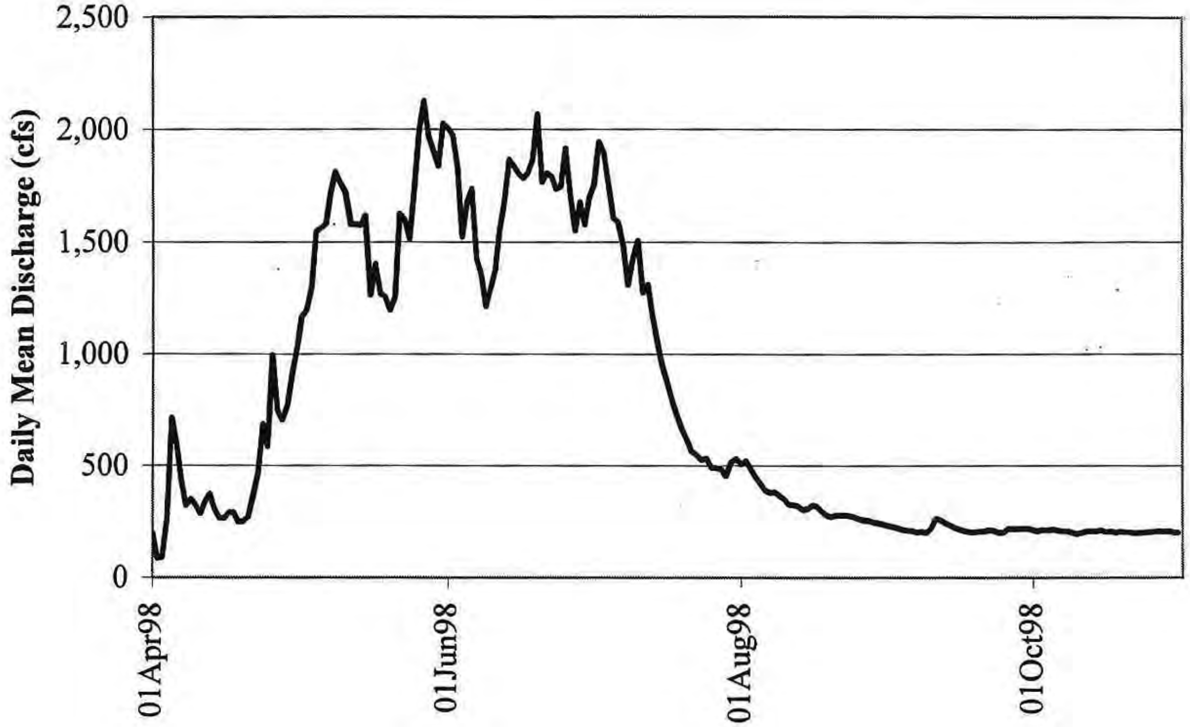

Figure 33. Hydrograph of surface-water runoff that originated from the middle Big Hole basin, April-October 1998.

flows for the gages in 1997-98 was typical for the period 1961-90 as well. Flows transferred out of the middle basin by the Canyon Creek diversion and by the Butte-Silver Bow Water Company were also factored into the analysis. The percentage of precipitation lost to ET in the middle basin (72 percent) is nearly identical to the percentage in the upper basin (73 percent).

Crop Water Use

Estimates of water use by grass hay and alfalfa, the most common crops in the middle basin, were obtained using the Jensen-Haise method (table 24). The method uses air temperature and solar radiation to calculate daily ET_r as follows:

$$\lambda ET_r = C_T(T_{mean} - T_x)R_s$$

where, λ is the latent heat of water (cal/g)
ET_r is the daily potential evapotranspiration rate of alfalfa (cm/day)
C_T is a site-specific temperature coefficient
T_{mean} is the daily mean temperature (°F)
T_x is the intercept of the temperature axis as calculated for the weather station at the Francis unit
R_s is the measured global solar radiation (cal/cm²/day)

This equation has no wind function and is simpler to use then the 1982 Kimberly-Penman equation; however, it is less accurate (Jensen and others, 1990). Refer to Docker (1994), Jensen and others (1990), and Jensen and Haise (1963) for more detailed discussions about the method.

Temperature data for the computations were collected at weather station PG-3 northwest of Wise River. No global solar radiation was available for the middle basin, so R_s was taken as the average of the values measured at the Francis Creek unit weather station (PG-1) and at the AgriMet station near Dillon. The temperature and R_s data are contained in appendix A.

To determine crop-water use, ET_r values were multiplied by crop coefficients for grass hay (K_{grass}) and alfalfa (K_{alf}). As noted previously, crop coefficients change according to the growth stage of the crop. The relationship between the growth stage of alfalfa and K_{alf} is shown in figure 34; a similar curve for grass hay was previously presented as figure 25. Because alfalfa is the reference crop for the Jensen-Haise equation, K_{alf} would be expected to equal 1.0 when the crop reaches full canopy. However, the curve in figure 34 shows K_{alf} never exceeding 0.85. This is because the curve was developed to reflect mean water use of alfalfa that is cut multiple times during the growing season.

Figures 35 is a graph of the estimated values of K_{grass} and K_{alf} over the course of the 1998-growing season. The grass hay was assumed to emerge from dormancy on May 1; alfalfa was assumed to emerge 2 weeks later. The grass hay was assumed to reach full

Table 24. Monthly evapotranspiration estimates for the middle Big Hole basin, May-October 1998. ET_r is the potential evapotranspiration of alfalfa; ET_{grass} is actual evapotranspiration of grass hay; ETalf is the actual evapotranspiration of alfalfa.

Date	ET_r (in)	ET_{grass} (in)	ET_{alf} (in)
May-98	5.4	1.9 *	0.7 **
Jun-98	5.5	3.6	3.6
Jul-98	10.3	6.7	8.7
Aug-98	8.1	4.1	5.2 ***
Sep-98	4.7	2.2	0.0
Oct-98	0.3	0.1 ****	0.0
Total:	34.2	18.6	18.2

* May 1 was selected as beginning of growing season for grass hay
** May 15 was selected as end of growing season for alfalfa
***August 23 was selected as end of growing season for alfalfa
**** October 4 was selected as end of growing season for grass hay

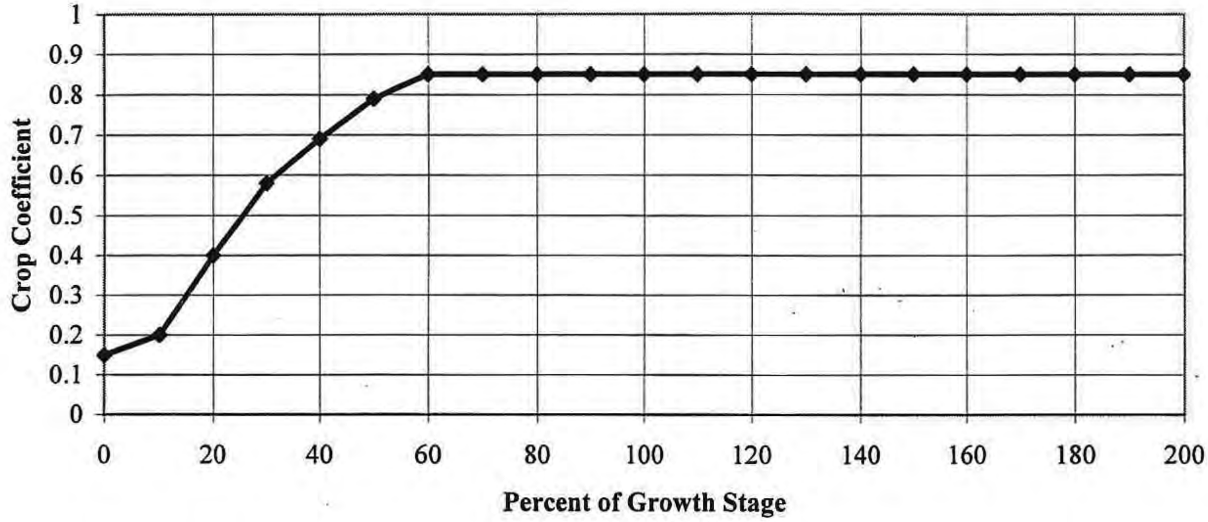

Figure 34. Crop curve for estimating the evapotranspiration rate of alfalfa. Data from U.S. Bureau of Reclamation (1994).

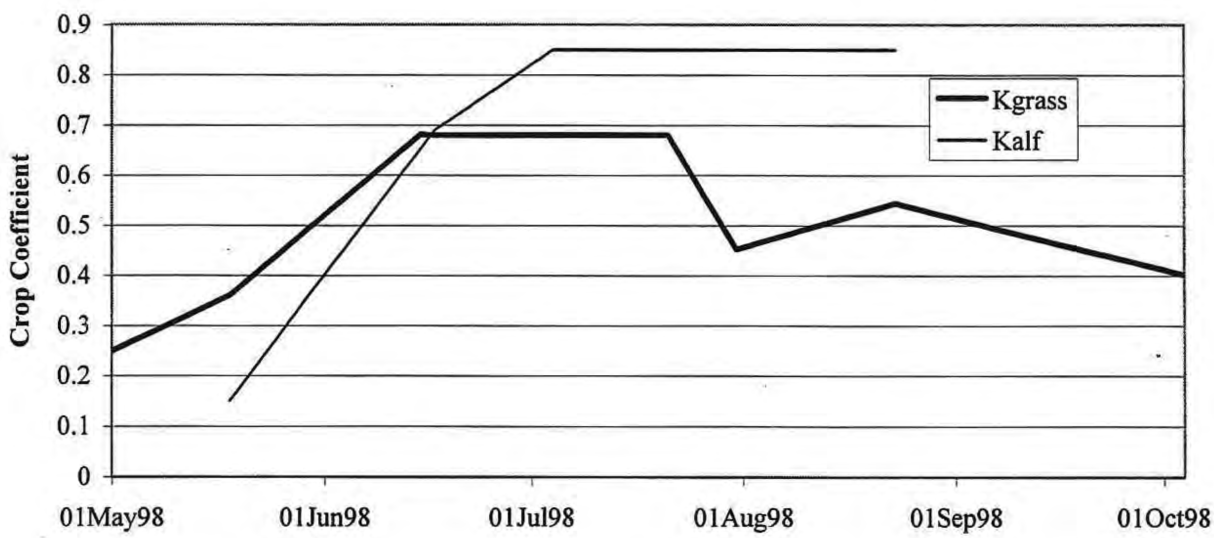

Figure 35. Plot of alfalfa crop coefficient versus time, middle Big Hole basin, May-October 1998.

canopy by mid-June; alfalfa was assumed to reach full canopy in early-July. The decline of K_{grass} starting in mid-July was to reflect the cutting of the grass hay at that time. Two cuttings of hay occurred in the Divide area, but one cutting is believed to be more typical for the middle basin as a whole. No reduction in K_{alf} was necessary because the mean alfalfa water-use curve already takes cutting into consideration. The first frost occurred on August 23 and was assumed to mark the end of the alfalfa growing season. The growing season of the grass hay was assumed to end on October 24, the first day that the minimum temperature (T_{min}) was less than 24° F.

As shown in table 24, ET_{grass} and ET_{alf} were estimated to peak in July at 6.7 and 8.7 inches, respectively. Total water use of the grass hay was found to be about 18.5 inches, several inches greater than the estimate obtained at the Francis Creek unit in the upper basin.

Irrigation Return Flows

Characterization of irrigation returns to river flow in the middle basin was outside the scope of this study. However, it is speculated that the timing of returns is transitional between that observed at the Francis Creek unit in the upper basin and that of the lower basin. Because irrigated land represents a relatively small percentage of the middle basin, the volume of irrigation returns is probably minor compared to the runoff from the surrounding mountains.

LOWER BASIN

Climate

Air temperatures in the lower basin were generally close to normal during the study period (table 25). Monthly mean temperatures at Glen for December 1997 and June 1998 were several degrees cooler than normal but were balanced by warm temperatures in September and November 1998. Summary data for a temperature datalogger placed at the Glen NWS station also are reported in table 25. The monthly mean temperatures calculated from hourly datalogger readings agree well with NWS estimates, which are based on maximum and minimum daily temperatures.

Cumulative precipitation across the lower basin averaged 10 inches during the study (tables 26 and 27), with about 4 inches (40 percent) falling during May and June 1998. Data from the NWS station near Glen indicate that conditions were wetter than normal largely due to greater than average precipitation in October 1997 and June 1998. From July through October 1998, precipitation was below normal.

Based on data from NRCS SNOTEL and snow course sites, precipitation and snow pack in the mountains surrounding the lower basin were close to or above normal (tables 28 and 29). Data from the Basin Creek and Mule Creek SNOTEL sites suggest 30-40

Table 25. Mean monthly temperatures at Glen, Montana, September 1997-November 1998. National Weather Service (NWS) station data from WRCC (1999).

	Glen NWS Station				MBMG Temperature Datalogger at Glen NWS Station	
	Monthly Mean Temperature (°F)		Departure from Normal	Percent of Normal	Monthly Mean	Deviation from NWS Observation
	Observed*	30-yr avg**	(°F)	(%)	Temperature (°F)***	(°F)
Sep-97	56.7	53.6	3.1	106	--	--
Oct-97	42.7	44.0	-1.3	97	--	--
Nov-97	31.3	31.0	0.3	101	--	--
Dec-97	18.0	22.3	-4.3	81	--	--
Jan-98	22.3	21.7	0.6	103	--	--
Feb-98	26.3	26.5	-0.2	99	--	--
Mar-98	32.7	33.4	-0.7	98	--	--
Apr-98	41.8	41.7	0.1	100	41.5	-0.3
May-98	51.1	50.6	0.5	101	52.0	0.9
Jun-98	53.1	58.4	-5.3	91	53.6	0.5
Jul-98	67.9	65.5	2.5	104	69.0	1.1
Aug-98	64.7	63.3	1.4	102	66.2	1.5
Sep-98	58.3	53.6	4.7	109	59.2	0.9
Oct-98	41.8	44.0	-2.2	95	42.5	0.7
Nov-98	34.8	31.0	3.8	112	--	--
Average	43.5	43.5	-0.1	99	--	--

* Calculated with daily maximum and minimum measurements
** Years 1961-1990
*** Calculated with hourly measurements

Table 26. Monthly precipitation at the NWS station near Glen, Montana, September 1997-November 1998. Data from WRCC (1999).

	Precipitation (in)		Departure from Normal	Percent of Normal
	Observed	30-yr avg*	(in)	(%)
Sep-97	0.54	0.93	-0.39	58
Oct-97	1.36	0.39	0.97	349
Nov-97	0.58	0.33	0.25	176
Dec-97	0.15	0.18	-0.03	83
Jan-98	0.59	0.21	0.38	281
Feb-98	0.24	0.17	0.07	141
Mar-98	0.54	0.38	0.16	142
Apr-98	1.15	0.66	0.49	174
May-98	2.13	1.63	0.50	131
Jun-98	2.94	2.06	0.88	143
Jul-98	0.81	1.06	-0.25	76
Aug-98	0.36	1.11	-0.75	32
Sep-98	0.69	0.93	-0.24	74
Oct-98	0.21	0.39	-0.18	54
Nov-98	0.62	0.33	0.29	188
Total	12.91	10.76	2.15	--

* Years 1961-1990

Table 27. Monthly precipitation estimates from MBMG precipitation gages in the Melrose and Glen valleys, November 1997-October 1998. Locations of gages are shown on figure 6 and described in appendix A.

	Precipitation (in)						
Station ID	PG-4	PG-5	PG-6	PG-7	PG-8	PG-9	PG-10
Property Owner	Pendergast	Lattin	Speirs	Kalsta	R Smith	Hagenbarth	M Smith
Location	N of Melrose	Melrose	S of Melrose	N of Glen	Glen	NW of Glen	W of Glen
Nov-97	0.28	0.23	--	0.77	--	0.52	0.55
Dec-97	0.12	0.27	0.41	0.12	--	0.31	0.45
Jan-98	0.95	0.77	0.71	0.66	0.67	0.81	0.37
Feb-98	0.36	0.46	0.34	0.72	0.13	0.30	0.13
Mar-98	0.80	0.42	0.73	0.52	0.57	0.75	0.70
Apr-98	1.26	1.37	1.28	1.13	1.51	1.31	1.55
May-98	2.18	2.43	2.10	--	1.79	1.90	1.79
Jun-98	1.65	1.51	1.72	--	1.89	1.45	2.40
Jul-98	0.70	0.65	0.54	--	0.45	0.87	0.75
Aug-98	2.02	2.19	0.59	--	0.32	0.12	0.19
Sep-98	1.42	0.59	0.93	--	0.72	1.01	0.80
Oct-98	0.00	0.00	0.14	--	0.06	0.14	0.12
Total	11.75	10.89	--	--	--	--	9.80

	Precipitation (in)					
Station ID	PG-11	PG-12	PG-13	PG-14	PG-15	Average Precip
Property Owner	Kalsta	Garrison	Raffety	Hagenbarth	J Marchessault	in Lower Basin
Location	E of Glen	E of Glen	E of Glen	SE of Glen	SW of Glen	(in)
Nov-97	0.58 *	0.38	0.90	0.71	--	0.55
Dec-97	0.14	0.67	0.00	0.21	0.07	0.25
Jan-98	0.68	0.36	0.78	0.66	0.94	0.70
Feb-98	0.28	0.20	0.21	0.17	0.18	0.29
Mar-98	0.70	0.65	0.70	0.76	0.94	0.69
Apr-98	0.94	0.90	1.17	1.00	1.80	1.27
May-98	2.13 *	1.77	2.31	1.39	1.56	1.94
Jun-98	2.94 *	2.32	1.31	2.11	2.85	2.01
Jul-98	0.81 *	0.64	0.76	0.76	0.73	0.70
Aug-98	0.36 *	0.79	1.15	0.62	0.80	0.83
Sep-98	0.69 *	0.58	0.49	0.51	0.57	0.76
Oct-98	0.21 *	0.14	0.33	0.21	0.13	0.14
Total	10.46	9.39	10.13	9.10	--	10.11

* NWS data

Table 28. Monthly precipitation data from SNOTEL stations surrounding the lower Big Hole basin, September 1997-November 1998. Data from NRCS (1999).

Site Name	Basin Creek				Mule Creek			
NRCS Site ID	12D09S				12D11S			
Latitude/Longitude	45°48'N/112°31'W				45°24'N/112°58'W			
Section, Township, Range	31 01N 07W				09 05S 11W			
Elevation (ft)	7,180				8,300			
Month	Precip (in)	30-yr Average (in)	Departure from Normal (in)	Percent of Normal	Precip (in)	30-yr Average (in)	Departure from Normal (in)	Percent of Normal
Sep-97	1.0	2.4	-1.4	42	1.4	1.9	-0.5	74
Oct-97	3.6	1.4	2.2	257	3.9	1.9	2.0	205
Nov-97	1.3	1.5	-0.2	87	1.7	2.8	-1.1	61
Dec-97	0.9	1.2	-0.3	75	1.1	3.0	-1.9	37
Jan-98	1.8	1.1	0.7	164	3.9	3.4	0.5	115
Feb-98	1.0	1.2	-0.2	83	1.5	3.0	-1.5	50
Mar-98	2.6	2.6	0.0	100	2.2	2.8	-0.6	79
Apr-98	4.2	2.7	1.5	156	4.1	2.6	1.5	158
May-98	3.0	4.7	-1.7	64	4.5	3.5	1.0	129
Jun-98	5.0	2.7	2.3	185	3.9	2.8	1.1	139
Jul-98	1.3	1.7	-0.4	76	1.4	1.5	-0.1	93
Aug-98	0.5	1.9	-1.4	26	0.0	1.7	-1.7	--
Sep-98	1.6	2.4	-0.8	67	2.1	1.9	0.2	111
Oct-98	1.3	1.4	-0.1	93	0.5	1.9	-1.4	26
Nov-98	1.7	1.5	0.2	113	4.5	2.8	1.7	161
Total	30.8	30.4	0.4	--	36.7	37.5	-0.8	--

Table 29. First-of-the-month snow-water equivalent (SWE) snowpack data from NRCS SNOTEL and Snow Course stations in or near the lower Big Hole basin, January 1998-June 1998. Data from NRCS (1999).

		Jan-98			Feb-98			Mar-98		
Site Name	Site No.	Measured SWE (in)	Normal SWE (in)	Percent of Normal	Measured SWE (in)	Normal SWE (in)	Percent of Normal	Measured SWE (in)	Normal SWE (in)	Percent of Normal
Abundance Lake	13D20	--	--	--	--	--	--	15.1	16.8	90
Basin Creek	12D09	--	3.2	--	7.6	4.5	169	8.6	6.2	139
Fish Creek	12D10	--	3.6	--	8.0	5.1	157	8.2	7.1	115
Mule Creek	12D11S	5.8	6.8	85	9.6	10.2	94	11.1	13.2	84
Mule Creek	12D11	--	--	--	--	--	--	--	11.0	--
Average Percent of Normal				85			140			107

		Apr-98			May-98			Jun-98		
Site Name	NRCS Site ID	Measured SWE (in)	Normal SWE (in)	Percent of Normal	Measured SWE (in)	Normal SWE (in)	Percent of Normal	Measured SWE (in)	Normal SWE (in)	Percent of Normal
Abundance Lake	13D20	16.4	20.8	79	21.8	22.6	96	--	--	--
Basin Creek	12D09	9.3	8.7	107	13.8	7.3	189	--	5.0	--
Fish Creek	12D10	9.8	9.9	99	14.7	9.8	150	--	6.7	--
Mule Creek	12D11S	13.5	16.2	83	16.4	17.0	96	11.6	9.0	129
Mule Creek	12D11	13.0	13.9	94	--	13.5	--	--	--	--
Average Percent of Normal				92			133			129

percent of the total precipitation during the 15-month study period occurred in April, May, and June 1998.

Ground Water

Occurrence and Flow

Plates 5 and 6 are composite potentiometric-surface maps for the valley aquifers in the Melrose and Glen areas, respectively. As observed in the upper and middle basins, ground-water flow converges on the Big Hole River from both sides of the valley. Hydraulic gradients are as high as 0.08 ft/ft along the valley margin but decrease markedly in the coarse, highly permeable Tertiary and Quaternary alluvial deposits that fill the valley bottom. Several tributary watersheds, most notably Birch Creek, have shallow ground-water systems that drain into the main valley aquifer. The Birch Creek drainage is extensively irrigated, and as will be discussed, irrigation water is believed to be a major source of recharge in this area.

Figures 36 through 39 are hydrogeologic cross sections of the river valley. The locations of the cross sections are shown on the potentiometric-surface maps. The figures show that many wells in the lower basin are completed in Tertiary and Quaternary sand, gravel, and cobble deposits. The aquifer in these sediments typically is unconfined, and the water table is less than 20 ft below the ground surface. Wells along the valley margin often are completed in deeper semi-confined or confined aquifers within Tertiary Bozeman Group or Cretaceous sedimentary rocks. As the water levels in wells M:163241 (depth: 39 ft) and M:163401 (depth: 156 ft) demonstrate (figure 39), an upward gradient exists between the deep and shallow aquifer systems south of Glen.

To obtain estimates of hydraulic conductivity (K), slug and/or pump tests were performed on 14 wells in the lower basin (table 30). K was found to range from 0.4 to 1,200 ft/day, with a median value of 34 ft/day. Interestingly, the wells with the highest and lowest K estimates, M:166506 and M:108187, respectively, are located less than 2 hundred feet apart. M:108187 is about 50 ft deeper than M:166506, and probably is completed in a less permeable horizon within the Bozeman group sediments.

Water Levels and Storage

Water levels were monitored in about 60 wells in the lower basin from August 1997 to the end of October 1998. Hydrographs for eight of the wells are presented in figure 40. The hydrographs for M:107660, M:108188, M:127990, M:131113, M:162072, and M:162164 are typical for wells located close to irrigated pastures. Water levels declined during the fall and winter and began to rise in March or April due to recharge from snow melt. Levels continued to rise in May and part of June due to recharge from irrigation. The water levels then stabilized in mid- to late-summer once recharge was balanced by discharge. Usually 2 crops of hay are grown each summer; therefore, some wells experienced a mid-summer water-level decline when the fields were dried and the first

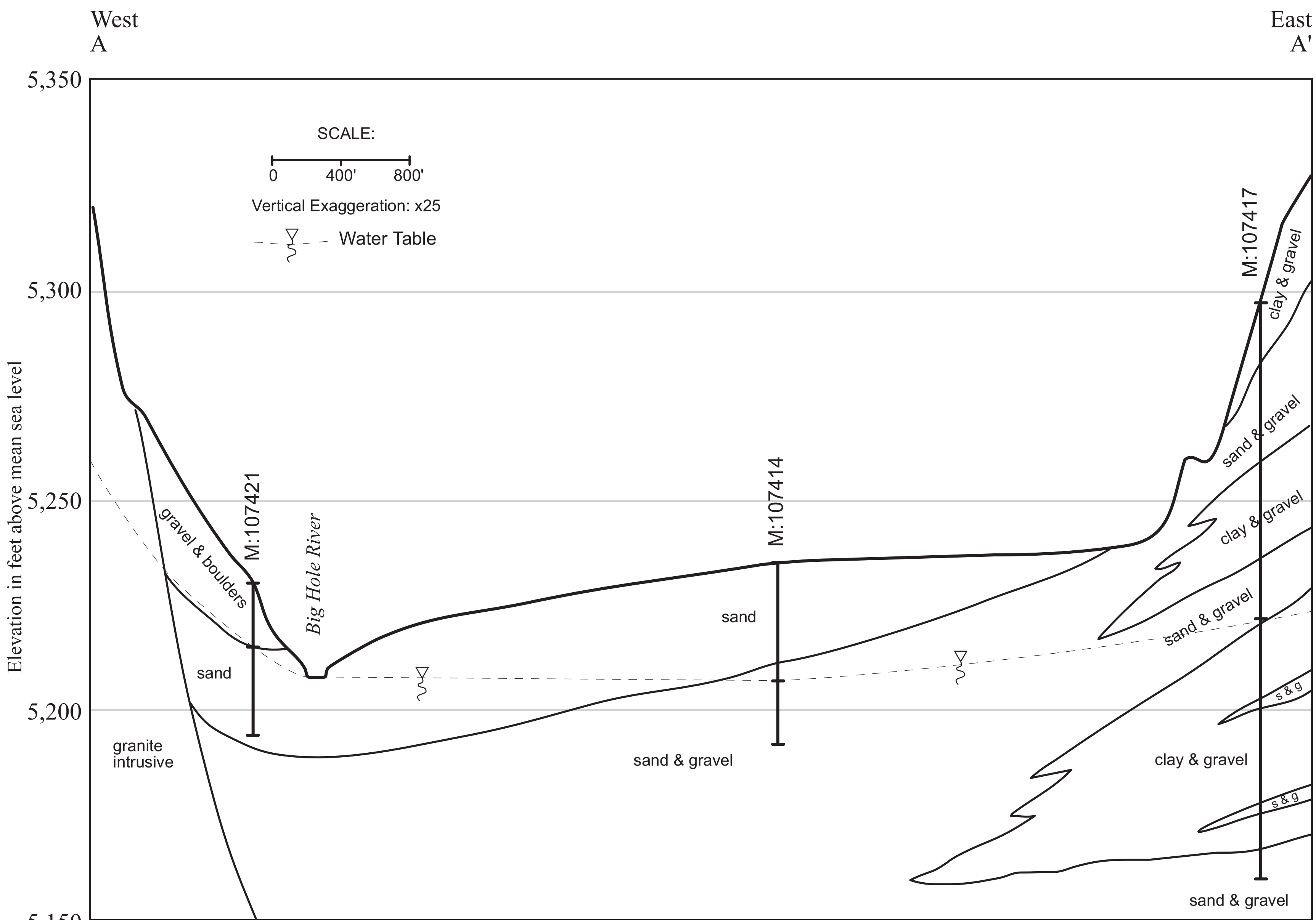

Figure 36. Hydrogeologic cross section of the Big Hole valley north of Melrose, Montana. The location of the cross section is shown in plate 5. Water levels in wells are indicated by middle bars. All geologic contacts are inferred based on field observations, well logs, and/or the Dillon 1°x2° geologic map (Ruppel and others, 1993).

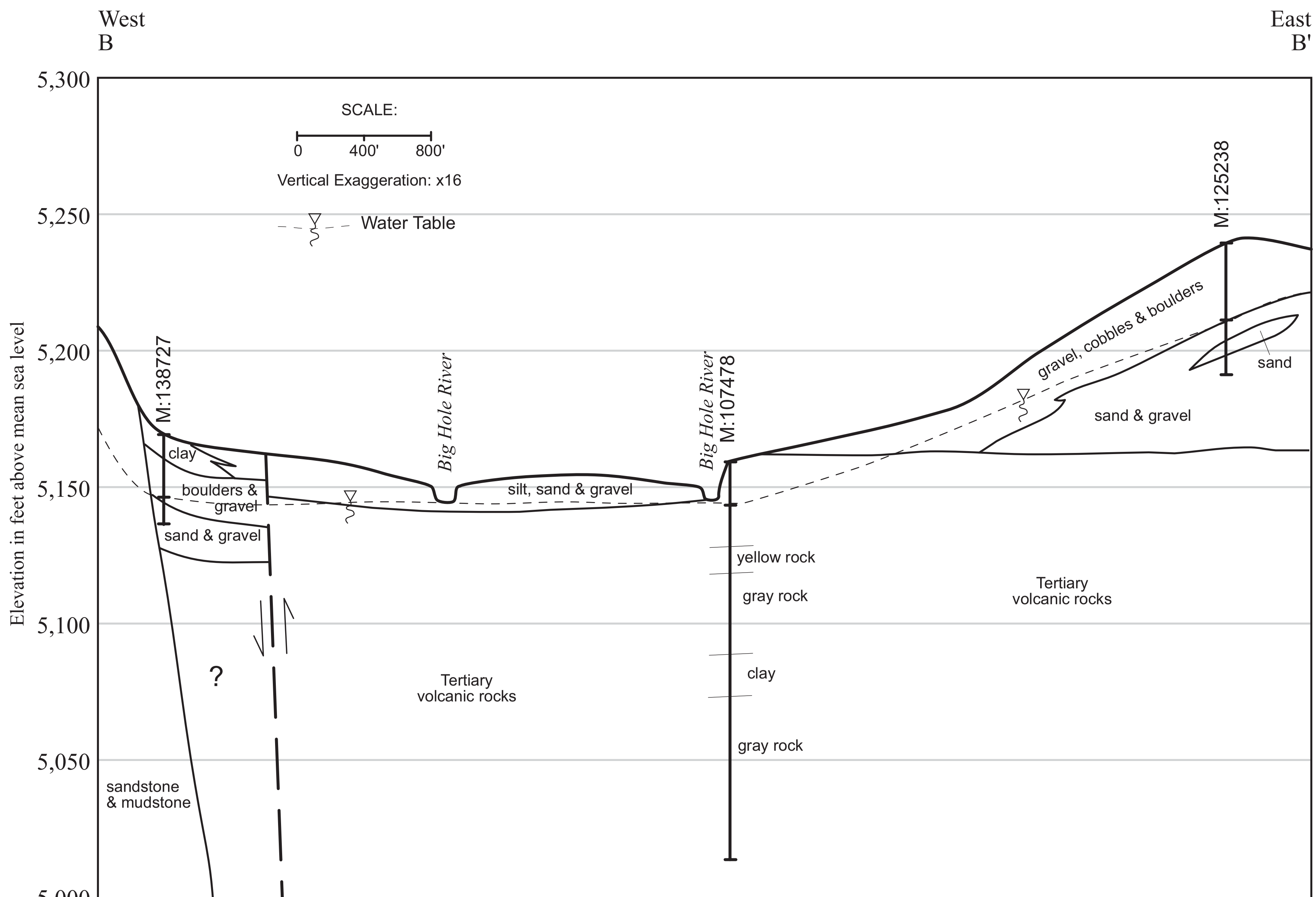

Figure 37. Hydrogeologic cross section of the Big Hole valley south of Melrose, Montana. The location of the cross section is shown in plate 5. Water levels in wells are indicated by middle bars. All geologic contacts are inferred based on field observations, well logs, and/or the Dillon 1°x2° geologic map (Ruppel and others, 1993).

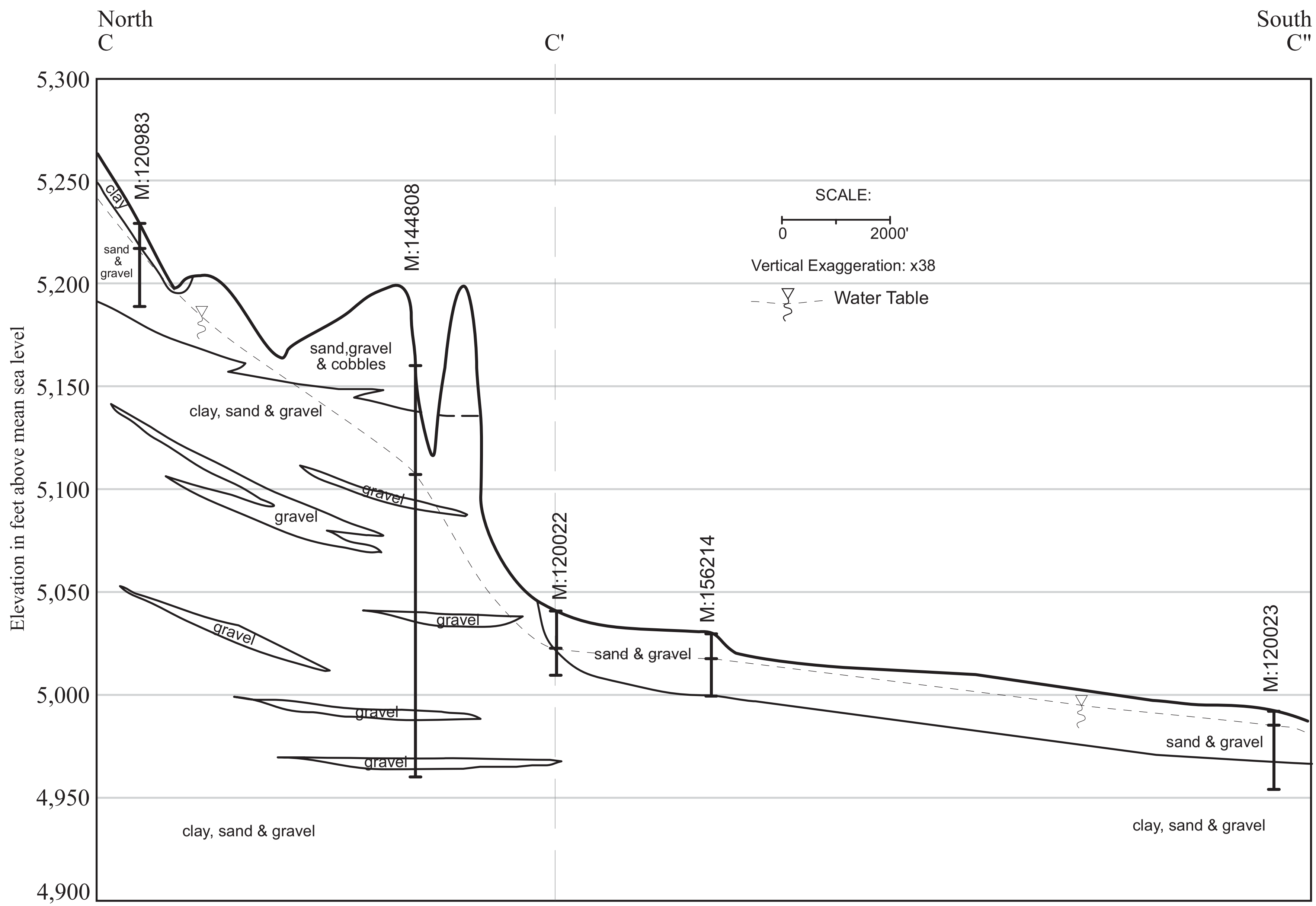

Figure 38. Hydrogeologic cross section of the Big Hole valley north of Glen, Montana. The location of the cross section is shown in plate 6. Water levels in wells are indicated by middle bars. All geologic contacts are inferred based on field observations, well logs, and/or the Dillon 1°x2° geologic map (Ruppel and others, 1993).

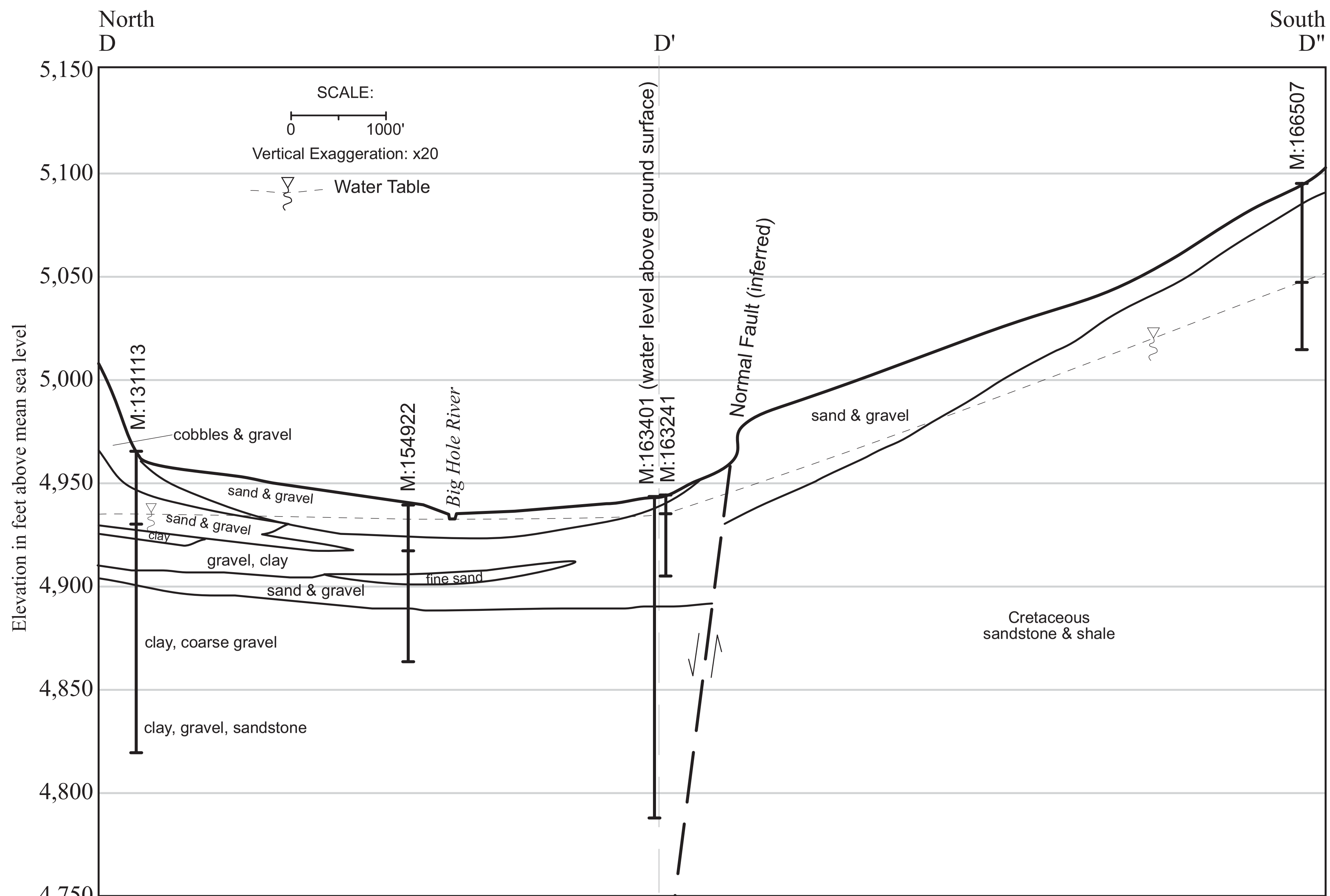

Figure 39. Hydrogeologic cross section of the Big Hole valley southeast of Glen, Montana. The location of the cross section is shown in plate 6. Water levels in wells are indicated by middle bars. All geologic contacts are inferred based on field observations, well logs, and/or the Dillon 1°x2° geologic map (Ruppel and others, 1993).

Table 30. Hydraulic conductivity estimates for the valley aquifer of the lower Big Hole basin

GWIC M:Number	Location (Township, Range, Tract, Section)	Test Date	Test Type	Number of Tests	Aquifer	Well Depth (ft)	Depth to Water (ft)	Screen/ Perf Length (ft)	Well Diameter (ft)	Screen Diameter (ft)	Pumping Rate (gpm)	Pumping Duration (hr)	Maximum Observed Drawdown (ft)	Hydraulic Conductivity (ft/day)	Transmissivity (ft²/day)	Storativity	Analytical Method
M:107656	03S09W01CDDD	02/25/98	Pump	1	110ALVF	65	43.20	10	.5	.5	13.6	12.	4.8	41.	410	--	Cooper and Jacob (1946)
M:108186	04S09W09ABAA	11/17/98	Pump	1	120BZMN	85	29.84	9	.5	.5	10.	.5	9.2	8.2	74	--	Cooper and Jacob (1946)
M:108187	04S09W09DDAA	11/25/97	Pump	1	120BZMN	97	19.50	20	.5	.33	9.4	.5	41.	.4	8	--	Cooper and Jacob (1946)
M:120022	04S09W03CCCC	11/25/97	Pump	1	111ALVM	30	11.60	1	.5	.5	9.4	.5	3.6	230.	230	--	Cooper and Jacob (1946)
M:144809	04S09W09ADDB	10/28/98	Pump	1	120BZMN	88	20.11	22	.5	.5	14.	.25	21.7	3.2	70	0.02	Theis (1935)
M:144809	04S09W09ADDB	10/28/98	Pump	1	120BZMN	88	20.11	22	.5	.5	14.	.25	21.7	1.4	30	--	Cooper and Jacob (1946)
M:162131	03S09W02CCBA02	10/30/97	Slug	3	111ALVM	43	8.16	10 *	.5	.5 *	--	--	--	280.	--	--	Bouwer and Rice (1976)
M:162163	02S09W26BAAB	10/08/97	Slug	3	111ALVM	31	6.26	10 *	.5	.5 *	--	--	--	290.	--	--	Bouwer and Rice (1976)
M:162628	03S09W34CBBC	10/30/97	Slug	3	111ALVM	43	31.37	6	.5	.5 *	--	--	--	83.	--	--	Bouwer and Rice (1976)
M:163239	03S09W02AAAA	04/27/98	Pump	1	110ALVF	46	30.53	10 *	.5	.5	2.	.5	10.	2.	20	--	Cooper and Jacob (1946)
M:163241	04S08W31BBBC01	10/30/98	Slug	1	120BZMN	39	9.62	10 *	.5	.5 *	--	--	--	.4	--	--	Bouwer and Rice (1976)
M:163401	04S08W31BBBC02	10/30/98	Slug	1	120BZMN	156	0.31	10 *	.5	.5 *	--	--	--	5.	--	--	Bouwer and Rice (1976)
M:166502	03S09W01DCCA	04/27/98	Slug	2	110ALVF	100	54.08	1 *	.5	.5	--	--	--	260.	--	--	Bouwer and Rice (1976)
M:166506	04S09W09DAAC	04/29/98	Slug	4	120BZMN	48	32.82	2	.5	.5	--	--	--	1200.	--	--	Bouwer and Rice (1976)
M:166507	05S09W01BACA	04/29/98	Slug	4	120BZMN	80	49.36	42	.5	.33	--	--	--	27.	--	--	Bouwer and Rice (1976)

Average:	173.
Median:	34.
Maximum:	1200.
Minimum:	.4
n:	14 wells

Aquifer Codes: 110ALVF, Quaternary alluvial fan deposits; 111ALVM, Holocene alluvium; 120BZMN, Tertiary Bozeman Group sediments

* Estimated

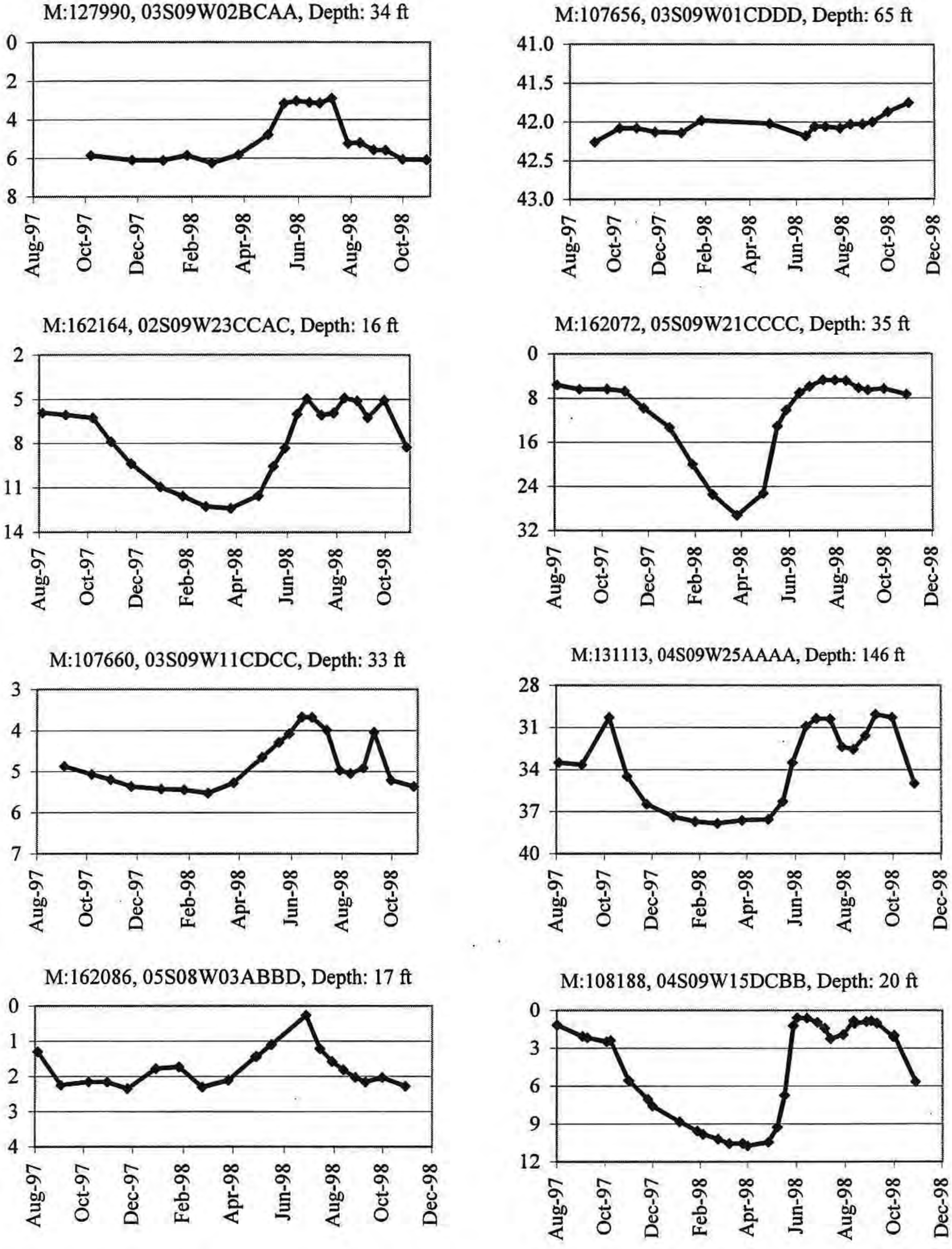

Figure 40. Hydrographs for eight wells in the lower Big Hole basin. Note the differences in vertical scales.

crop was harvested. When irrigation ended in late September to early October, water levels started the annual fall and winter decline again. Two of the wells had water level trends that deviated from this general pattern. Well M:127990 is close to an irrigation diversion that was only used during the first half of the summer; therefore, the water table did not rise again later in the summer. The fall/winter water-level decline at well M:162072 did not begin until November because the well is located close to an inter-basin diversion that carries water until the end of October.

The hydrograph for well M:162086 demonstrates the interaction between the river and the shallow alluvial aquifer system when irrigation has a lesser influence on the aquifer. The well is located about a quarter mile north of the river, near Notch Bottom, and is close to a slough and some wetlands. The water table at this location is near the ground surface year round. When river discharge was high during the spring and early summer, the water level in the well steadily rose. After peak flows had passed, the water level at the well gradually declined during the mid-summer and fall. No sustained period of high water levels occurred.

The hydrograph for M:107656 is unusual for the lower basin. The water level varied less than a foot during the course of the study, and no seasonal cycle was evident. The well is located southeast of Melrose and is probably completed in a confined or semi-confined aquifer within alluvial fan deposits; however, no driller's log was available to verify this supposition. The lack of an obvious seasonal water-level cycle suggests that the well is located far from any sources of recharge.

Longer-term hydrographs for 4 wells in the lower basin are shown in figure 41. Data for M:107478 were collected by the MBMG's Ground-Water Assessment and Monitoring Program. The data for the other wells were collected by Robert Reichle and Jim Hagenbarth, residents of the Big Hole basin. Regardless of depth of completion, the wells have stable annual water-level cycles that vary only slightly from one year to the next. No long-term rising or falling trends are apparent, which suggests that no substantial change has occurred in the annual recharge/discharge cycle and in ground-water storage in the lower basin during the periods of record for the wells.

Plate 7 is a map of the maximum observed change in ground-water level in the lower basin. It was constructed using the difference between the highest and lowest water levels observed at the wells during the study. In areas where no wells existed, water-level changes were estimated based on land use (irrigated vs. non-irrigated), topography, and geologic/aquifer setting. Much of the map is speculative, but nonetheless it is useful for identifying the approximate extent of areas with large seasonal changes in ground-water storage. Several locations near Glen had changes greater than 20 ft. Near Melrose the maximum observed change was slightly less than 15 ft. Typically, the greatest fluctuations occurred in irrigated terrace areas, away from surface-water drainages. The terraces are generally composed of thick sequences of permeable alluvial sediments that can store and transmit the irrigation water as it percolates down from the surface. If

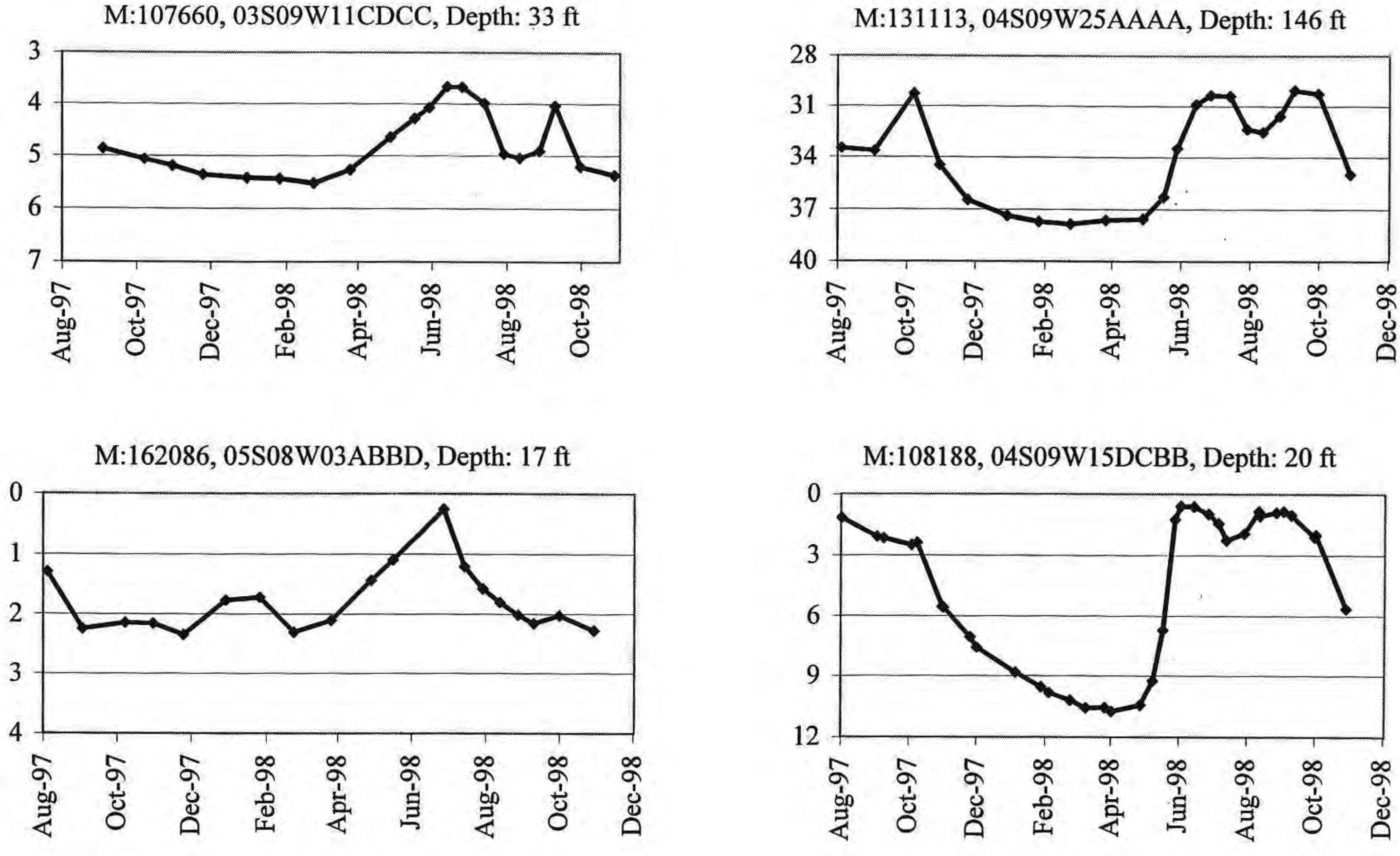

Figure 41. Long-term hydrographs for four wells in the lower Big Hole basin. Note the differences in vertical scales.

recharge from irrigation did not occur in the lower basin, it is likely that water-table fluctuations in most areas would be less than 5 ft, with 2 ft being more typical. To obtain estimates of monthly ground-water storage changes, the lower basin study area was divided into numerous polygons (figure 42). Each polygon had a well within it, and the water-level changes measured at the well were assumed to represent the changes within the polygon as a whole. Storage changes within each polygon were calculated by multiplying the monthly change in water level in the well by the polygon area and by an assumed aquifer specific yield of 0.15 ft/ft. Overall basin-storage changes were then determined by summing the storage changes obtained for the polygons (table 31 and figure 43).

As shown in figure 43, the largest gains in aquifer storage occurred in May and June when more than 30,000 acre-ft of water were added. This gain is equivalent to about 250 cfs entering storage throughout these months. Based on the timing and quantity of water, it appears that much of this recharge was due to irrigation. During most other months of the year, ground water was released from storage, where “release” refers to both losses to the surface-water system and to evapotranspiration (ET). When ET losses were minimal i.e. late fall, winter, and spring, most of the storage release probably contributed to streamflow. During July, August, and September, however, much of the water must have been released to ET, but it is not clear what proportion. This problem will be addressed in the following sections.

Specific Conductance

Ground-water specific conductance (SC) and temperature were measured at several locations and times during the study to assess their spatial and temporal variability (table 32). Adjacent to the river and its tributaries, ground water tended to have SC values of 200 to 300 µS/cm (figure 44). Ground water in the Tertiary and Cretaceous formations along the valley margin typically had values greater than 600 µS/cm. The highest SC (2,880 µS/cm) was measured at well M:168864, which is completed in Tertiary silty fine sand down gradient of a reclaimed tungsten-mill site northwest of Glen (see Marvin, 1999). At several locations where SC was measured quarterly, it appeared to follow a cyclical trend, reaching a minimum during the summer and a maximum in the winter (figure 45). The locations at which this trend was observed (wells M:107474, M:108188, and M:120022) were close to irrigated pastures, and it is likely that the cycle reflects the percolation of relatively low SC irrigation water into the ground-water system.

Ground-water temperatures in the lower basin were consistently in the range of 8 to 11° C. However, the temperatures at well M:162176 and spring M:169096 were about 5-10° C warmer than the average. Both monitoring locations are on the margin of a hogback northeast of the Apex exit of I-15. The warm temperatures probably reflect upwelling of deeply circulated geothermal water along a N-S trending fault or fracture system.

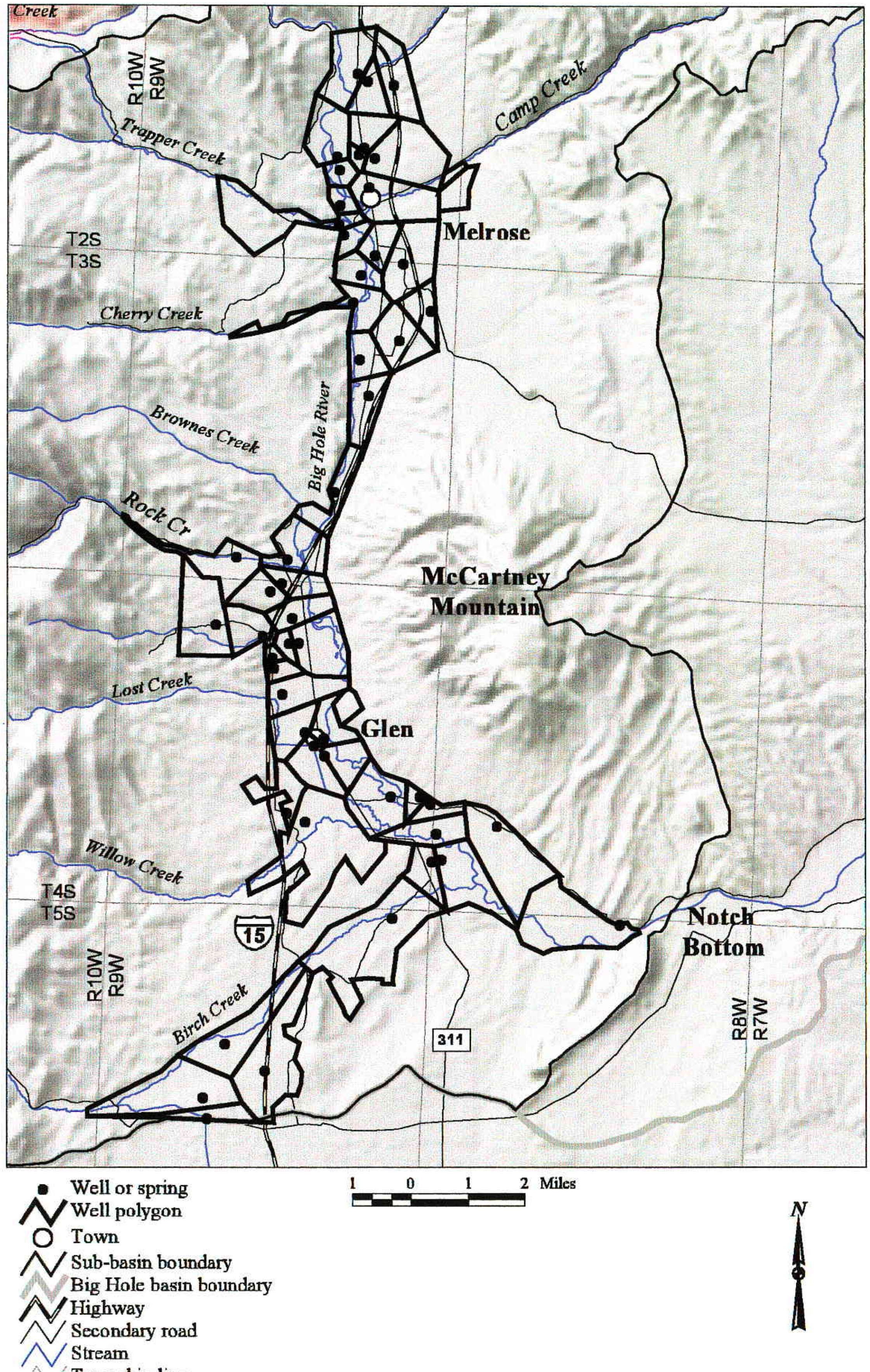

Figure 42. Map of the polygonal areas assigned to wells in the lower Big Hole basin.

Table 31. Monthly changes in ground-water storage in the lower Big Hole basin, September 1997-October 1998. Aquifer specific yield is assumed to be 0.15

Month	Lower Basin Area-Weighted Average WL Change (ft)	Estimated Change in Storage (acre-ft): Melrose Valley (acre-ft/mon)	Melrose Valley (cfs)	Glen Valley (acre-ft/mon)	Glen Valley (cfs)	Overall Lower Basin (acre-ft/mon)	Overall Lower Basin (cfs)
Sep-97	-0.08	-382	-6	44	1	-338	-6
Oct-97	-0.89	-1,663	-27	-2,202	-36	-3,865	-63
Nov-97	-1.55	-1,790	-30	-4,972	-84	-6,762	-114
Dec-97	-1.22	-1,123	-18	-4,193	-68	-5,317	-86
Jan-98	-1.11	-400	-7	-4,419	-72	-4,819	-78
Feb-98	-0.62	-481	-9	-2,215	-40	-2,695	-49
Mar-98	-0.35	353	6	-1,890	-31	-1,536	-25
Apr-98	0.68	1,501	25	1,455	24	2,956	50
May-98	4.38	3,407	55	15,664	255	19,071	310
Jun-98	2.59	1,936	33	9,315	157	11,250	189
Jul-98	-0.07	-270	-4	-44	-1	-314	-5
Aug-98	-0.92	-693	-11	-3,298	-54	-3,991	-65
Sep-98	-0.66	-663	-11	-2,188	-37	-2,851	-48
Oct-98	-1.50	-1,727	-28	-4,808	-78	-6,535	-106

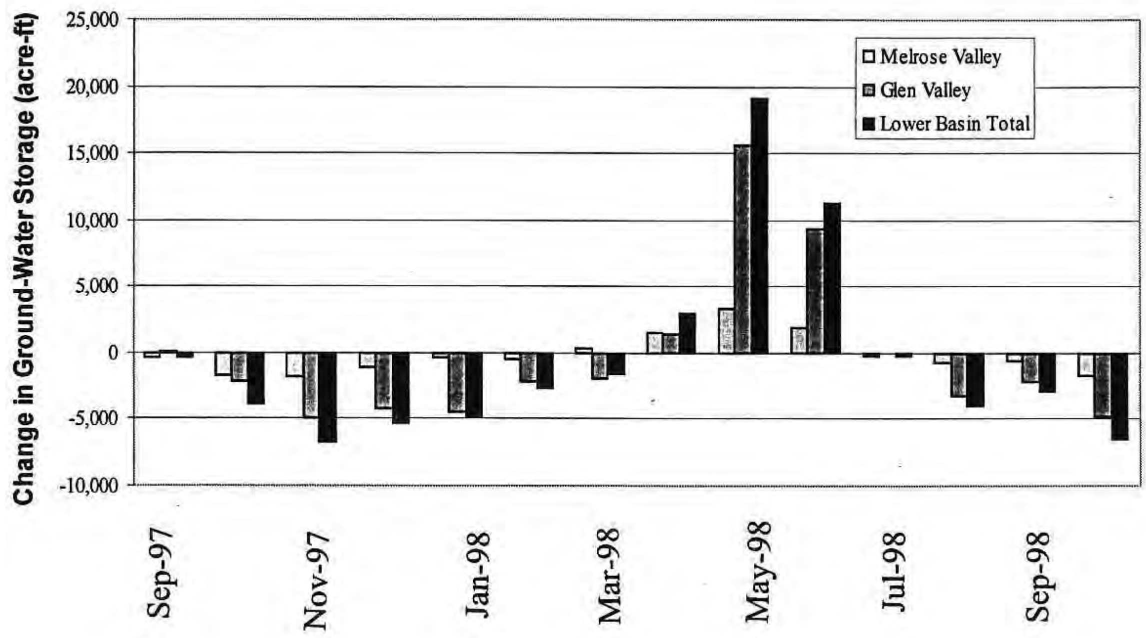

Figure 43. Monthly changes in ground-water storage for the lower Big Hole basin, September 1997-October 1998. Positive values indicate gains in storage; negative values indicate decreases in storage.

Table 32. Specific conductance (SC) data for ground water in the lower Big Hole basin, fall 1997 - fall 1998. SC values are temperature corrected to 25 °C

GWIC	Location	Depth	Fall 1997			Winter 1998			Spring 1998			Summer 1998			Fall 1998		
M:Number	(TRST)	(ft)	Date	SC (µS/cm)	Temp (°C)	Date	SC (µS/cm)	Temp (°C)	Date	SC (µS/cm)	Temp (°C)	Date	SC (µS/cm)	Temp (°C)	Date	SC (µS/cm)	Temp (°C)
107417	02S09W14DBDA	140	--	--	--	--	--	--	4/27/98	639	10.7	--	--	--	--	--	--
107474	02S09W27ADBB	40	10/30/97	289	9.7	1/26/98	292	6.5	4/27/98	271	7.3	7/13/98	251	9.4	10/28/98	266	9.7
107656	03S09W01CDDD	65	--	--	--	2/23/98	451	10.5	4/27/98	406	10.9	--	--	--	--	--	--
107663	03S09W14CAAA	50	10/08/97	650	10.3	1/26/98	657	9.7	4/27/98	700	10.3	7/13/98	644	10.9	10/28/98	582	10.5
107666	03S09W27ADAB	95	--	--	--	--	--	--	--	--	--	--	--	--	10/28/98	205	9.0
108178	04S08W29DBDC	54	--	--	--	--	--	--	--	--	--	7/13/98	296	14.4	--	--	--
108185	04S09W05DCAD	25	--	--	--	1/28/98	403	2.5	--	--	--	--	--	--	--	--	--
108186	04S09W09ABAA	85	09/18/97	645	10.6	1/28/98	634	8.5	4/29/98	556	9.4	7/13/98	539	10.6	10/29/98	619	11.2
108187	04S09W09DDDB	97	11/25/97	648	9.8	1/28/98	653	9.1	--	--	--	--	--	--	10/28/98	559	10.3
108188	04S09W15DCBB	20	11/25/97	450	9.0	1/28/98	458	9.2	4/27/98	449	9.7	7/13/98	388	10.9	10/28/98	423	10.6
108190	04S09W15BBAD	50	--	--	--	1/28/98	535	9.8	--	--	--	--	--	--	--	--	--
108198	04S09W22ABAA	38	--	--	--	--	--	--	4/28/98	469	9.8	--	--	--	--	--	--
120022	04S09W03CCCC	30	10/31/97	705	10.0	1/28/98	720	7.7	4/27/98	490	7.9	7/13/98	304	11.1	10/28/98	655	10.0
120983	03S09W33CBBA	40	--	--	--	1/28/98	214	9.0	--	--	--	--	--	--	--	--	--
131113	04S09W25AAAA	146	--	--	--	--	--	--	--	--	--	--	--	--	10/28/98	342	9.4
144809	04S09W09ADDB	88	--	--	--	--	--	--	--	--	--	--	--	--	10/28/98	811	9.7
156213	04S09W10BABD	36	--	--	--	--	--	--	5/2/98	476	9.4	--	--	--	--	--	--
156214	04S09W10BBDA	30	--	--	--	--	--	--	5/2/98	370	8.1	--	--	--	--	--	--
162083	04S09W24CCDB	25	10/30/97	194	10.1	--	--	--	--	--	--	--	--	--	--	--	--
162086	05S08W03ABBD	17	--	--	--	1/26/98	265	6.8	--	--	--	7/13/98	242	9.6	10/29/98	240	9.6
162135	02S09W23CCCD	10	10/30/97	306	11.5	1/26/98	284	7.4	4/27/98	220	7.1	7/13/98	257	9.5	10/28/98	285	10.7
162176	05S09W22ABAB	270	10/08/97	609	17.5	1/28/98	563	16.0	4/29/98	593	18.2	7/13/98	694	17.9	10/29/98	599	17.5
162454	05S09W34CABD	8	10/08/97	254	11.7	1/28/98	230	3.0	--	--	--	7/13/98	345	13.0	10/29/98	218	10.4
162627	03S09W34CBCC	118	10/30/97	200	8.7	1/28/98	224	7.3	4/29/98	206	8.9	7/13/98	220	8.5	10/29/98	191	8.1
163239	03S09W02AAAA	45	--	--	--	--	--	--	4/27/98	472	10.5	--	--	--	--	--	--
165462	04S09W04AAAA	92	--	--	--	1/28/98	883	9.5	--	--	--	--	--	--	--	--	--
168862	04S09W05DDCC	36	--	--	--	--	--	--	--	--	--	--	--	--	11/17/98	406	8.5
168864	04S09W04CDDD	30	--	--	--	--	--	--	--	--	--	--	--	--	11/17/98	2880	8.3
168865	04S09W04CDDC	35	--	--	--	--	--	--	--	--	--	--	--	--	11/17/98	701	8.7
169094	04S09W22CCCB	Spring	--	--	--	1/28/98	202	13.2	--	--	--	--	--	--	--	--	--
169095	04S08W31BBAD	Spring	--	--	--	1/28/98	705	4.5	--	--	--	--	--	--	--	--	--
169096	05S09W10AADA	Spring	--	--	--	--	--	--	3/26/98	548	24.3	--	--	--	--	--	--

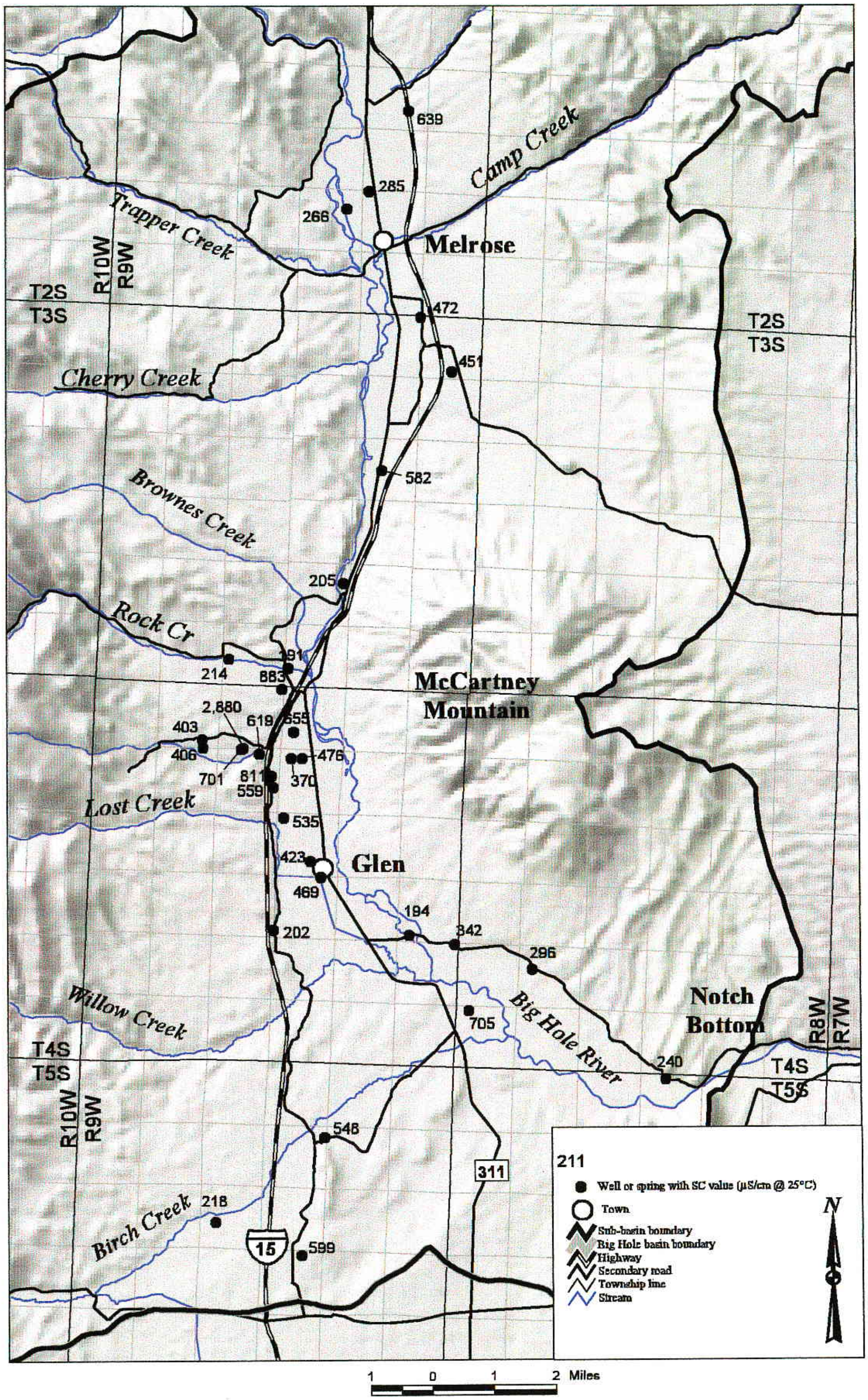

Figure 44. Map showing distribution of ground-water specific conductance (SC) in the lower Big Hole basin.

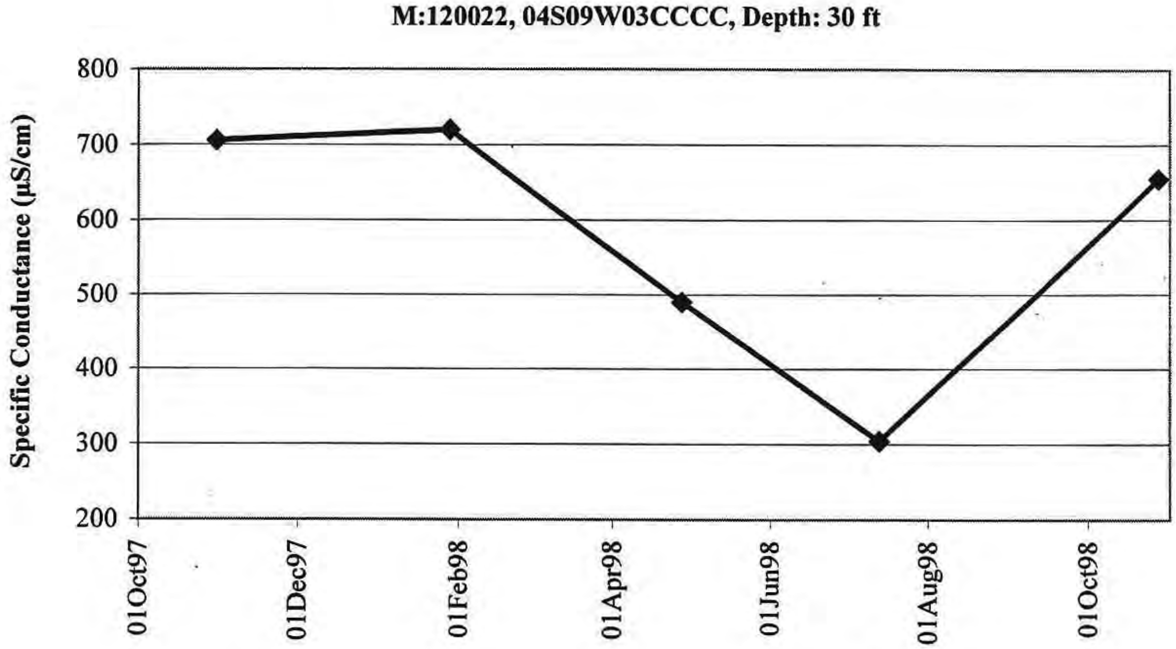

Figure 45. Variation of specific conductance of ground water at well M:120022, lower Big Hole basin.

Surface Water

Flow Conditions

Table 33 is a monthly summary of the flow data collected for the Big Hole River gage between Melrose and Glen (USGS ID 06025500) for the period October 1997 through February 1999. Departure-from-normal values are provided for the entire period of record of the gage (1923-1998) as well as for the eleven-year period 1988 to 1998, which corresponds to the period of record available for the Big Hole River gage at Wisdom. Flows in May and July 1998 were well above normal compared to both periods of record. Most of the high discharge in May can be attributed to the greater than average discharge from the upper basin at this time. The elevated flows in July were caused by greater than average basin-wide mountain runoff from snowmelt after the relatively cool June. During the remainder of the study, flows were generally near or slightly above normal.

Hydrographs of total surface-water inflow to and outflow from the lower basin from April through December 1998 are presented in figure 46. Inflow was calculated by adding the streamflow measured at the Big Hole River gage at Maiden Rock (USGS ID 06025250) to the flow of the Canyon Creek diversion. Outflow was calculated by adding the flow measured at the Big Hole River gage at Notch Bottom (USGS ID 06026210) to the flow diverted from Birch Creek into the Beaverhead River drainage. The hydrographs are presented to demonstrate the relatively minor differences between inflow and outflow with time.

To directly quantify the surface-water discharge that was gained or lost in the lower basin during this time, the inflow and outflow hydrographs were subtracted from one another. The resulting hydrograph (figure 47) shows that the peak gain in flow within the lower basin watershed was about 640 cfs on June 28 and 29. The periods in April, May, June, and August when the change in discharge was negative indicate that inflow was greater than outflow at those times. In other words, the flow declined between the inflow and outflow monitoring points. The negative periods in May, June, and August are attributed to loss of surface water to ground-water storage and to evapotranspiration. The water loss in August was not as great as that in the spring and early summer because the near-surface aquifer was already near capacity and therefore the net loss to ground-water storage was small.

The negative values in April may be due to measurement error at the gaging stations. At this time, large changes in discharge (400-800 cfs) were occurring daily due to snowmelt runoff from the mountains. Indeed, much of the rapid fluctuation observed from April through June may be “noise” due to discharge-measurement error.

Using the flow data from the Big Hole River gage between Melrose and Glen (USGS ID 06025500), the flow that originated in the Melrose portion of the lower basin (figure 48) was separated from that which originated in the Glen portion (figure 49). A comparison of the hydrographs shows that most of the peak discharge from the lower basin at the end of June came from the Melrose area. This is probably because the tributaries in the Melrose

Table 33. Monthly flow statistics for the Big Hole River near Melrose, Montana, October 1997-February 1999. Data from Shield and others (1999) and Shield and others (2000).

Site Name Big Hole River near Melrose, MT
USGS ID 06025500
Drainage Area 2,476 mi²

Date	Mean (cfs)	Departure from Normal 1923-1998 (cfs)	Departure from Normal 1988-1998 (cfs)	Median (cfs)	Max (cfs)	Min (cfs)	Total Discharge (acre-ft)
Oct-97	662	161	269	675	876	515	40,740
Nov-97	615	117	177	570	998	360	36,570
Dec-97	463	67	104	460	582	370	28,470
Jan-98	462	113	145	480	500	340	28,420
Feb-98	450	87	119	460	460	421	24,960
Mar-98	565	88	18	480	983	422	34,710
Apr-98	1,535	26	145	1,200	3,310	824	91,360
May-98	3,883	531	1,112	4,020	4,900	2,530	238,700
Jun-98	3,911	-108	323	3,970	4,980	3,150	232,700
Jul-98	2,045	700	801	1,790	3,870	866	125,800
Aug-98	503	25	65	417	1,020	299	30,910
Sep-98	354	-26	29	365	441	265	21,080
Oct-98	432	-69	39	432	450	405	26,570
Nov-98	350	-9	51	488	565	412	29,120
Dec-98	382	-14	23	348	546	150	21,510
Jan-99	380	31	63	390	410	320	23,500
Feb-99	479	116	148	380	413	360	21,110

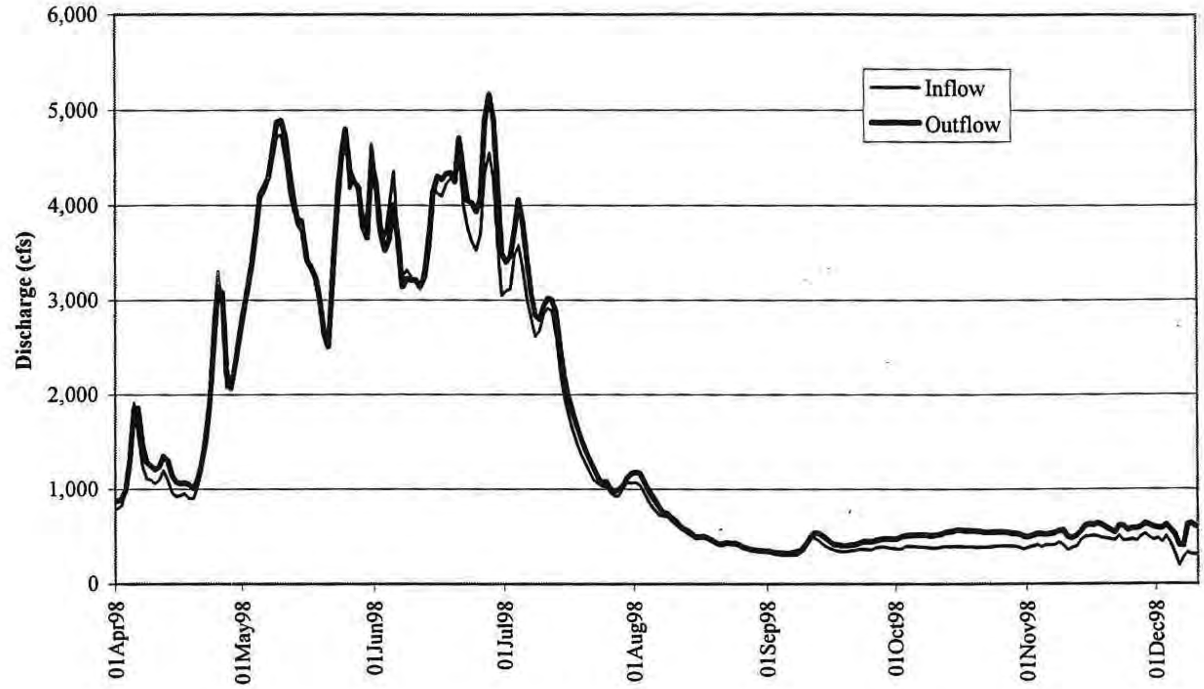

Figure 46. Hydrographs of the surface-water inflow to and outflow from the overall lower Big Hole basin, April-December 1998.

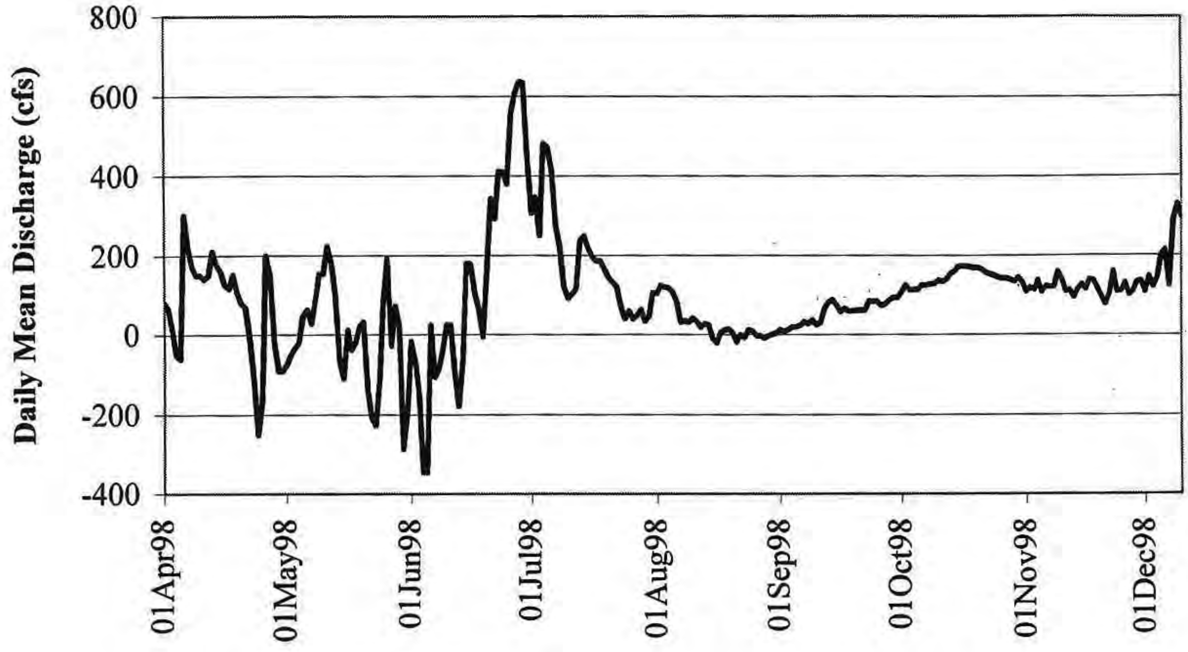

Figure 47. Hydrograph of the difference between inflow and outflow for the overall lower basin, April–December 1998. Inflow was measured at the Big Hole River at Maiden Rock (USGS ID 06025250) and at the Canyon Creek diversion; outflow was measured at the Big Hole River at Notch Bottom (USGS ID 06026210) and at the inter-basin diversion near Birch Creek. The USGS gaging-station data for November and December 1998 were provisional. Periods of negative discharge indicate that the flow leaving the basin at that time was less than the inflow, which reflects losses to ground-water storage and to evapotranspiration.

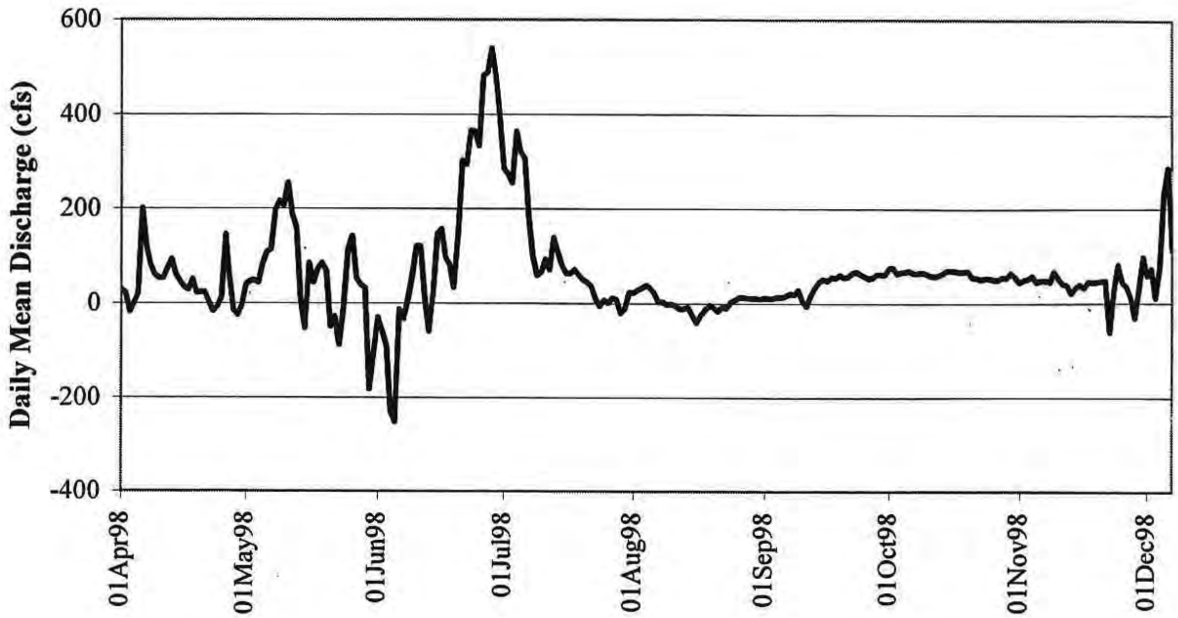

Figure 48. Hydrograph of the difference between inflow to and outflow from the Melrose portion of the lower Big Hole basin, April-Decmber 1998.

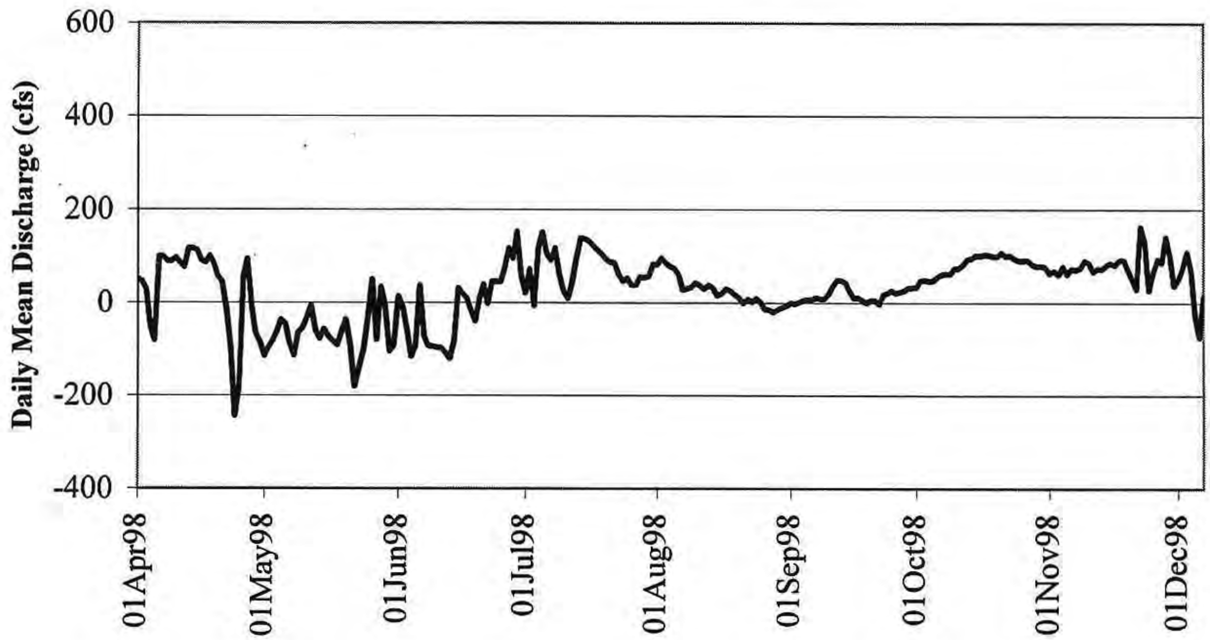

Figure 49. Hydrograph of the difference between inflow to and outflow from the Glen portion of the lower Big Hole basin, April-Decmber 1998.

section of the watershed drain a larger high-elevation area. The hydrographs also reveal that most of the surface-water loss in April and May (real or imaginary) occurred in the Glen area. The higher loss in this area may be indicative of the larger amount of irrigated land and/or the greater storage capacity of the sediments underlying the irrigated portion of this basin.

Effects of Irrigation on Return Flows

To quantify the effects of irrigation on surface-water flow in the lower basin, inflow to and outflow from the irrigated portions of the Melrose and Glen valleys were estimated for October 1997 and for April to November 1998 (table 34). Table 35 is a list of the measurement locations for the streams and diversions that were considered in making the inflow/outflow determinations and identifies whether flow was measured continuously or periodically or was estimated based on a drainage-area regression model. Flow-measurement data are presented in appendix C.

Figure 50 shows the differences between outflow and inflow during the 1998-field season using 7-day moving average trend lines. The moving-average technique is a statistical method that averages the data for a fixed period around a given date. For example, the 7-day average for July 10 is the average of the values for July 7 through July 13. The technique reduces the amplitude of peaks and troughs in a data set, making it easier to identify longer-term trends. The hydrographs show that there was a net gain in surface-water discharge from the Melrose and Glen valleys in the first half of April 1998. The gains probably were due to runoff from low-elevation snowmelt. Between mid-April and mid-September, flow generally was lost throughout the lower basin because water diverted for irrigation was lost to ET and to ground-water storage.

The flow surplus observed in the Melrose valley between late June and early July presumably was caused by irrigation returns. Flow in most irrigation diversions in the area was reduced or shutoff during this period to allow fields to dry prior to the first cutting of hay. After the hay had been harvested, irrigation resumed and the flow deficit was re-established. Mid-season return flows were not observed for the Glen valley perhaps because irrigated lands are spread over a larger area and the ranchers did not irrigate and harvest their hay crops on as closely a synchronized schedule.

From mid-September until surface-water monitoring ended in mid-November, outflow exceeded inflow in both sections of the lower basin. The average surplus for the Melrose valley was about 25 cfs; the surplus for the Glen valley was about 55 cfs. Similar surpluses also were observed for the October 1997 data set. The additional surface water likely represents irrigation returns released from ground-water storage. Natural ground-water baseflow also is included in the additional flow but probably is a relatively small fraction.

Table 34. Inflow and outflow data summary for the irrigated portion of the lower Big Hole basin, October 1997 and April to November 1998

Period		Melrose Section				Glen Section				Lower Basin Total			
		Mean Inflow	Mean Outflow	Difference between Outflow and Inflow		Mean Inflow	Mean Outflow	Difference between Outflow and Inflow		Mean Inflow	Mean Outflow	Difference between Outflow and Inflow	
From	To	(cfs)	(cfs)	(cfs)	(acre-ft)	(cfs)	(cfs)	(cfs)	(acre-ft)	(cfs)	(cfs)	(cfs)	(acre-ft)
1-Oct-97	15-Oct-97	584	638	54	1,609	667	686	19	572	613	686	73	2,181
16-Oct-97	31-Oct-97	638	701	63	2,003	731	751	20	646	668	751	83	2,649
1-Apr-98	15-Apr-98	1,187	1,208	21	626	1,225	1,273	48	1,428	1,204	1,273	69	2,054
16-Apr-98	30-Apr-98	1,921	1,868	-53	-1,563	1,897	1,863	-34	-1,008	1,950	1,863	-87	-2,571
1-May-98	15-May-98	4,127	4,099	-28	-830	4,214	4,043	-170	-5,067	4,241	4,043	-198	-5,897
16-May-98	31-May-98	3,898	3,766	-131	-4,169	3,890	3,709	-181	-5,751	4,021	3,709	-312	-9,920
1-Jun-98	15-Jun-98	3,819	3,652	-167	-4,966	3,788	3,599	-189	-5,623	3,955	3,599	-356	-10,589
16-Jun-98	30-Jun-98	4,176	4,283	107	3,191	4,460	4,337	-123	-3,652	4,353	4,337	-16	-461
1-Jul-98	15-Jul-98	3,067	3,050	-17	-511	3,266	3,139	-127	-3,786	3,283	3,139	-144	-4,297
16-Jul-98	31-Jul-98	1,276	1,197	-79	-2,498	1,296	1,284	-12	-383	1,375	1,284	-91	-2,881
1-Aug-98	15-Aug-98	788	724	-64	-1,906	788	786	-2	-71	852	786	-66	-1,977
16-Aug-98	31-Aug-98	464	403	-61	-1,930	442	416	-26	-820	503	416	-87	-2,750
1-Sep-98	15-Sep-98	406	373	-33	-982	404	401	-3	-92	437	401	-36	-1,074
16-Sep-98	30-Sep-98	395	413	18	533	441	439	-2	-68	423	439	16	465
1-Oct-98	15-Oct-98	416	445	29	851	468	521	52	1,559	440	521	81	2,410
16-Oct-98	31-Oct-98	417	447	30	947	468	544	76	2,423	438	544	106	3,370
1-Nov-98	15-Nov-98	444	465	21	629	484	539	55	1,638	463	539	76	2,267

Table 35. Measurement locations for inflow to and outflow from the irrigated portion of the lower Big Hole basin

Station Name	USGS Station ID, if applicable	Township, Range Section, Tract	Drainage Area (mi^2)	Record Type (continuous, periodic, estimated)	Melrose Section (In/Out)*	Glen Section (In/Out)*	Lower Basin Total (In/Out)*
Big Hole River at Maiden Rock	06025250	01S09W32DDCA	2,199	Continuous	In	--	In
Moose Creek above MacLean Creek	06025270	01S09W14DDDD	32	Continuous	In	--	In
MacLean Creek	--	01S09W23AAAA	4	Estimated	In	--	In
Soap Gulch	--	02S08W06AABD	5	Estimated	In	--	In
Camp Creek	--	02S08W19DBDA	16	Periodic	In	--	In
Camp Creek Diversion	--	02S08W19DDBB	--	Periodic	In	--	In
Trapper Creek	--	02S10W23DCCA	26	Continuous	In	--	In
Canyon Creek Diversion	--	02S10W14AACC	--	Periodic	In	--	In
Cherry Creek	--	03S10W11BDCA	16	Periodic	In	--	In
McCartney Creek/Earls Gulch Creek	--	03S09W36 (Approx.)	6	Estimated	In	--	In
Brownes Creek	--	03S09W20CACB	5	Estimated	In	--	In
Rock Creek below Brownes Lake	06025480	03S10W34DDBD	23	Continuous	In	--	In
Big Hole River near Melrose	06025500	03S09W34CDDA	2,476	Continuous	Out	In	--
Glen Ranch Diversion	--	03S09W34CDCD	--	Continuous	Out	In	--
Lost Creek	--	04S10W13AACA	6	Estimated	--	In	In
Willow Creek	06025800	04S10W34AACC	36	Continuous	--	In	In
Birch Creek**	06026000	05S10W23DDCA	36	Continuous	--	In	In
Beaverhead Diversion	--	05S09W19CDBA01	--	Periodic	--	Out	Out
Big Hole River near Glen	06026210	04S08W35DCBC	2,655	Continuous	--	Out	Out

* In/Out: Inflow/Outflow

** Maintained by MBMG and DNRC during the study

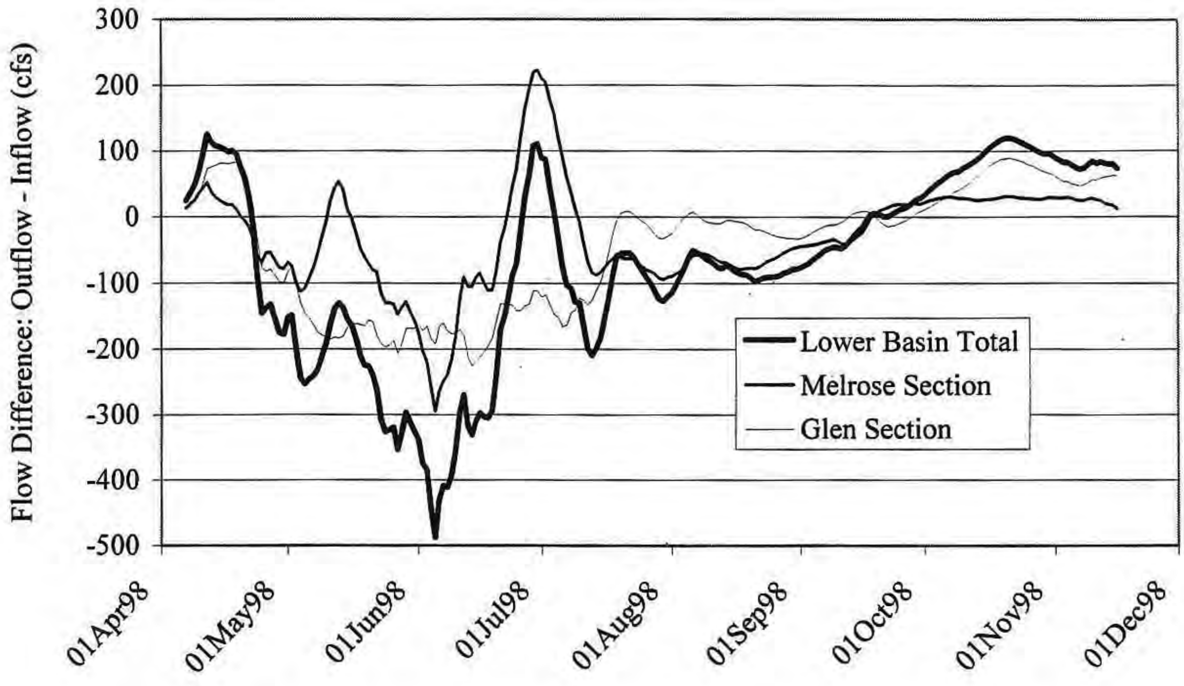

Figure 50. Hydrographs of the difference between surface-water outflow and inflow for the irrigated portion of the lower Big Hole basin, April–November 1998. Data have been smoothed using 7-day moving averages. Positive values indicate that flow increased from upstream to downstream due to runoff and/or irrigation returns. Negative values indicate that surface-water flow decreased due to losses to ground-water storage and/or evapotranspiration.

Because surface-water monitoring did not occur during the winter months, it is uncertain how long return flows significantly contribute to flow in the Big Hole River. A conservative estimate of mid-December was obtained by linearly projecting the lower basin return-flow trend observed in October/November 1998. However, the ground-water storage data suggest that the return-flow period may well extend into the early spring.

Evapotranspiration

Overall Lower Basin

An estimate of the mean annual ET loss (413,000 acre-ft, or 17.0 inches) was obtained by comparing precipitation to surface-water discharge in the lower basin. Mean annual precipitation (period 1961-90) was 18.8 inches based on an analysis of a GIS precipitation-distribution coverage of the lower basin area (Daly and others, 1994; Daly and others, 1997; Daly and Taylor, 1998). In terms of volume, this is equivalent to about 460,000 acre-ft of water. The mean annual surface-water discharge of the lower basin was estimated to be about 43,000 acre-ft (1.8 in), which is about 10 percent of the precipitation total. Because the USGS river gages at Maiden Rock and Notch Bottom had only the 1997-98 periods of record, long-term discharge estimates were obtained by multiplying the mean annual flow (1961-90) measured at the USGS gage below Melrose by the ratio of river discharges at the Maiden Rock and Notch Bottom gages to the flow at the Melrose gage (period 1997-98). This analysis therefore assumed that the ratio of flows for the gages in 1997-98 was typical for the period 1961-90 as well. Flows transferred into or out of the lower basin by diversions were also factored into the analysis. The percentage of precipitation lost to ET in the lower basin (90 percent) is markedly greater than the 73 percent estimates for the upper and middle basins.

Irrigated Portion of Lower Basin

Monthly ET estimates for the irrigated portion of the lower basin were determined for the 1998-growing season using the water balance and 1982 Kimberly-Penman methods that were introduced previously in the discussion of the Francis Creek unit. Refer to that section for additional background information.

The water balance method indicated that monthly ET losses increased steadily from May through July, peaked at 10,700 acre-ft in August, and then rapidly declined (table 36). The ET estimates were based on the monthly precipitation, surface-water inflow and outflow, and change in ground-water storage discussed previously. Ground-water inflow and outflow and changes in surface-water storage were considered negligible. ET losses in April were not determined using this method due to complications arising from the melt of low-elevation snow pack.

Estimates of ET obtained using the Kimberly-Penman method are based on meteorological parameters and crop water-use curves. Daily potential ET rates for alfalfa (ET_r) were calculated using air temperatures measured at the National Weather Service

Table 36. Monthly evapotranspiration estimates for the lower Big Hole basin (May-October 1998) based on the water-balance method

Water-Balance Method

$ET_{total} = Precip + SW_{in} - SW_{out} - \Delta S_{gw}$

Month	Precipitation		SW_{in}		SW_{out}		ΔS_{gw}		ET_{total}	
	(in)	(acre-ft)	(in)	(acre-ft)	(in)	(acre-ft)	(in)	(acre-ft)	(in)	(acre-ft)
May-98	1.9	4,689	105.0	253,806	98.5	237,989	7.9	19,071	0.5	1,435
Jun-98	2.0	4,869	102.3	247,186	97.7	236,112	4.7	11,250	1.9	4,693
Jul-98	0.7	1,684	58.5	141,333	55.5	134,156	-0.1	-314	3.8	9,175
Aug-98	0.8	2,009	17.1	41,309	15.1	36,582	-1.7	-3,991	4.5	10,728
Sep-98	0.8	1,827	10.6	25,579	10.3	24,988	-1.2	-2,851	2.3	5,269
Oct-98	0.1	328	11.2	26,987	13.6	32,766	-2.7	-6,535	0.4	1,083
								Total:	13.4	32,383

(NWS) station near Glen and other meteorological data (solar radiation, wind speed, etc.) from the U.S. Bureau of Reclamation AgriMet station near Dillon. Although the Agrimet station is located in the Beaverhead River drainage, meteorological conditions there are believed to be similar to those of the lower Big Hole basin (Tim Grove, personal communication, 1999). Data from the NWS and Agrimet stations are contained in appendix D. Daily ET_r values were multiplied by crop coefficients for grass hay (K_{grass}) and alfalfa (K_{alf}) to obtain estimates of crop-water use (ET_{grass} and ET_{alf}). Figure 51 shows the estimates of K_{grass} and K_{alf} over the course of the 1998-growing season. Grass hay was assumed to emerge from dormancy on April 1, and alfalfa was assumed to emerge 2 weeks later. Both crops were estimated to reach full canopy by the beginning of June. Because the grass hay was cut twice, first in mid- to late-June and again in early- to mid-September, K_{grass} was reduced at these times to reflect the reduction in ET_{grass}. The crop-curve for alfalfa already takes periodic cuttings into consideration, and therefore K_{alf} was held constant after reaching full canopy. The growing season for alfalfa was assumed to end on September 22, the first day on which the air minimum temperature was less than 32° F; the end of the grass hay growing season was October 5, the first day on which a hard frost occurred ($T_{min} < 24°$ F).

To obtain monthly estimates of the combined water loss due to crop uptake ($ET_{gr/alf}$), daily ET_{grass} and ET_{alf} values were summed for a given month, multiplied by weighting factors, 0.4 and 0.6, respectively and then added together (table 37). The weighting factors represent estimates of the proportion of irrigated land that is used for growing alfalfa versus grass hay (Chris Berg, NRCS, personal communication, 1999). $ET_{gr/alf}$ then was converted to a volume by multiplying by 21,000 acres. This estimate of the irrigated acreage was determined from a GIS map (figure 52) that was compiled based on field observations, aerial photographs, and Landsat-5 infrared false-color imagery (U.S. Geological Survey, 1985).

Total monthly ET losses for the lower basin were obtained by combining the monthly $ET_{gr/alf}$ estimates with the ET losses of the non-irrigated portion of the study area (ET_{other}). The non-irrigated area encompasses about 8,000 acres and is vegetated with rangeland plants such as sagebrush and bunch grasses. ET_{other} could not be quantified using the Kimberly-Penman method, so instead it was assumed that all precipitation that fell on the non-irrigated land from mid-June through the first week in October was lost to ET_{other}. This seems reasonable given that the plants are adapted to an arid environment, and most valley precipitation during this period did not produce significant runoff. For April, ET_{other} was assumed to be negligible because conditions were relatively cool and wet; for May through mid-June, ET_{other} was assumed to be equal to half of the precipitation.

The cumulative ET-water loss determined by the above method was about 18 inches (44,000 acre-ft) for the 1998-growing season, with water consumption by grass hay and alfalfa accounting for about 90 percent of the total. $ET_{gr/alf}$ rose from about 1 inch (1,800 acre-ft) in April to a peak of 5.8 inches (10,200 acre-ft) in August. Total water-use estimates for grass and alfalfa were 20.5 and 27.5 inches, respectively, which agree well with the 1998 crop-water use estimates determined for the Dillon area (USBR, 1999).

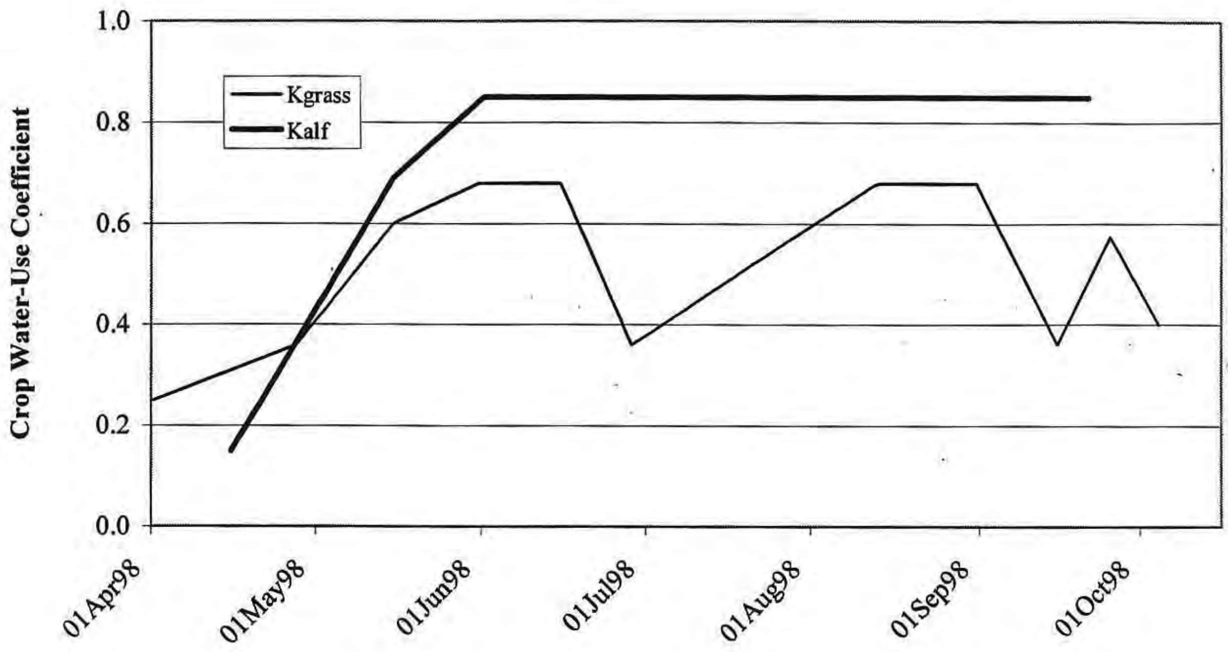

Figure 51. Plots of the variation of grass-hay (Kgrass) and alfalfa (Kalf) crop coefficients with time, lower Big Hole basin, April–September 1998.

Table 37. Monthly evapotranspiration estimates for the lower Big Hole basin (April-October 1998) based on the 1982 Kimberly-Penman approach

Date	ET_r (in)	ET_{grass} (in)	ET_{alf} (in)	$ET_{gr/alf}$ (in)	$ET_{gr/alf}$ (acre-ft)	ET_{other} (in)	ET_{other} (acre-ft)	ET_{total} (in)	ET_{total} (acre-ft)
Apr-98	3.8	1.2 *	0.8 **	1.0	1,829	0	0	0.8	1,829
May-98	6.6	3.8	4.4	4.0	6,991	1.0	647	3.2	7,638
Jun-98	5.7	3.2	4.8	3.9	6,751	1.5	1,020	3.2	7,771
Jul-98	9.0	4.3	7.6	5.6	9,885	0.7	464	4.3	10,349
Aug-98	7.9	5.2	6.7	5.8	10,208	0.8	554	4.5	10,762
Sep-98	5.0	2.5	3.2 ***	2.8	4,898	0.8	504	2.2	5,402
Oct-98	0.5	0.2 ****	0.0	0.1	224	0.1	90	0.1	315
Total:	38.4	20.5	27.5	23.3	40,786	4.9	3,280	18.3	44,066

$ET_{gr/alf} = 0.4*ET_{grass} + 0.6*ET_{alf}$
* April 1, 1998 selected as start of growing season for grass, and
** April 15, 1998 selected as start of growing season for alfalfa
***September 22, 1998 selected as end of growing season for alfalfa
**** October 5, 1998 selected as end of growing season for grass hay

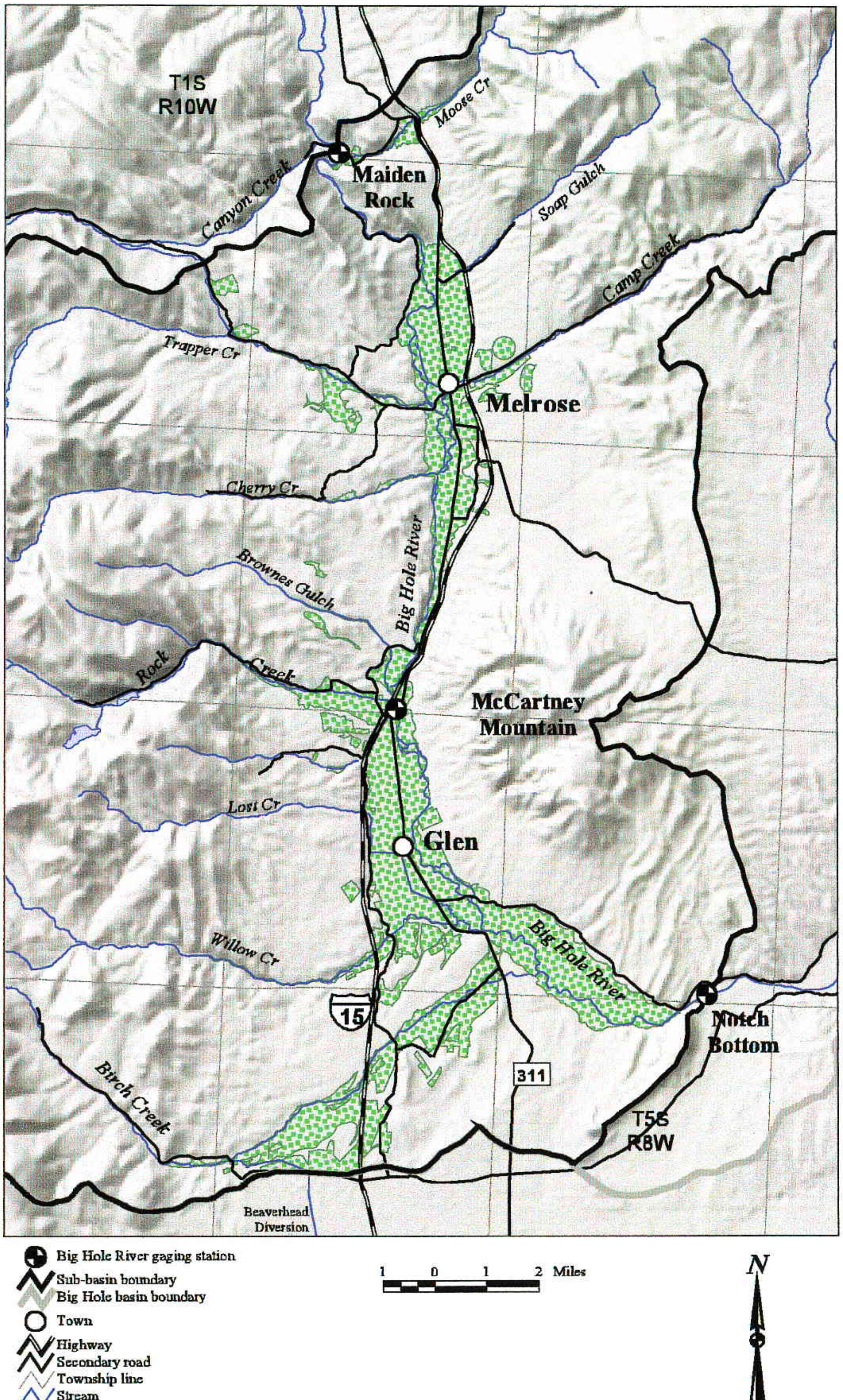

Figure 52. Map of irrigated and riparian land in the lower Big Hole basin study area, based on Landsat infrared false-color imagery, 1:250,000 (U.S. Geological Survey, 1985).

The ET results from the water balance and the Kimberly-Penman methods are compared in figure 53. The data from May and June do not agree well, possibly because of large errors associated with the surface-water inflow versus outflow component of the water balance. However, the ET data for the remainder of the growing season are similar and thus provide some confidence in the results.

Water Balance and Irrigation Return Flows

Monthly water balances for the period from May through October 1998 are presented in figure 54. The left bar of each monthly pair represents the inflows, or gains, of water; the right bar represents the losses, or sinks. Ideally, if all water-balance components were measured accurately, the left and right bars for each month would represent equal volumes of water. However, each component has some errors and uncertainties associated with it, and therefore, the balances are not perfect.

In May and June, the water balance was expressed as

$$P + SW(\text{Inflow-Outflow}) = ET + S_{gw}$$

where, P is precipitation,

SW(Inflow-Outflow) is the difference between the surface-water inflow and outflow,

ET is evapotranspiration loss,

S_{gw} is increase in ground-water storage

During these months, water input from precipitation and flood irrigation accounted for ET losses and large increases in ground-water storage. The gain in ground-water storage was approximately 3 times greater than the estimated losses to ET. This reflects that much of the water applied for irrigation was lost to deep percolation and thus helped recharge the valley aquifer.

In July, August and September, ground-water storage began to decline slowly, and therefore the balance equation was rearranged to

$$P + SW(\text{Inflow-Outflow}) + S_{gw} = ET$$

The ground-water storage loss in July was only slight, suggesting that recharge to and discharge from the aquifer were nearly equal. In August and September, the percent contribution of ground-water storage lost to evapotranspiration increased steadily while the percent contribution from surface-water declined. This suggests that without the contribution of ground water, irrigators would need to use more water from the surface-water system in order to maintain adequate soil moisture for their crops.

In October, surface-water outflow from the lower basin was found to exceed inflow, and therefore, the water balance equation was rearranged in a third way:

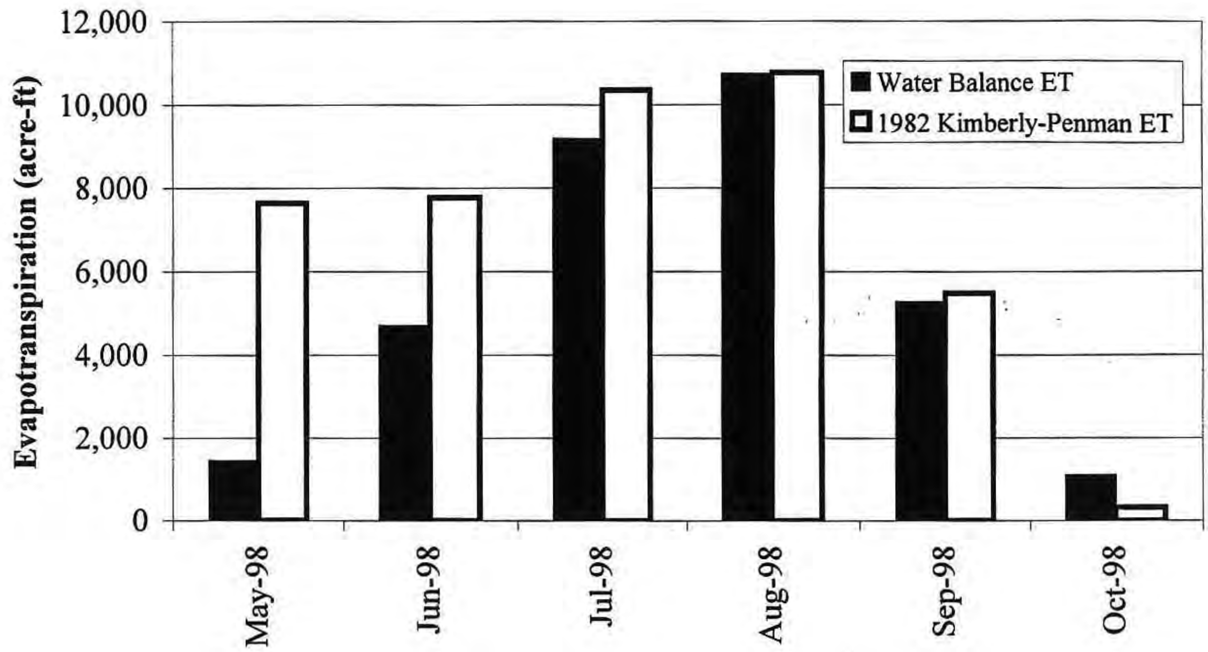

Figure 53. Comparison of evapotranspiration losses estimated with the water-balance method versus the 1982 Kimberly-Penman method, lower Big Hole basin, May–October 1998.

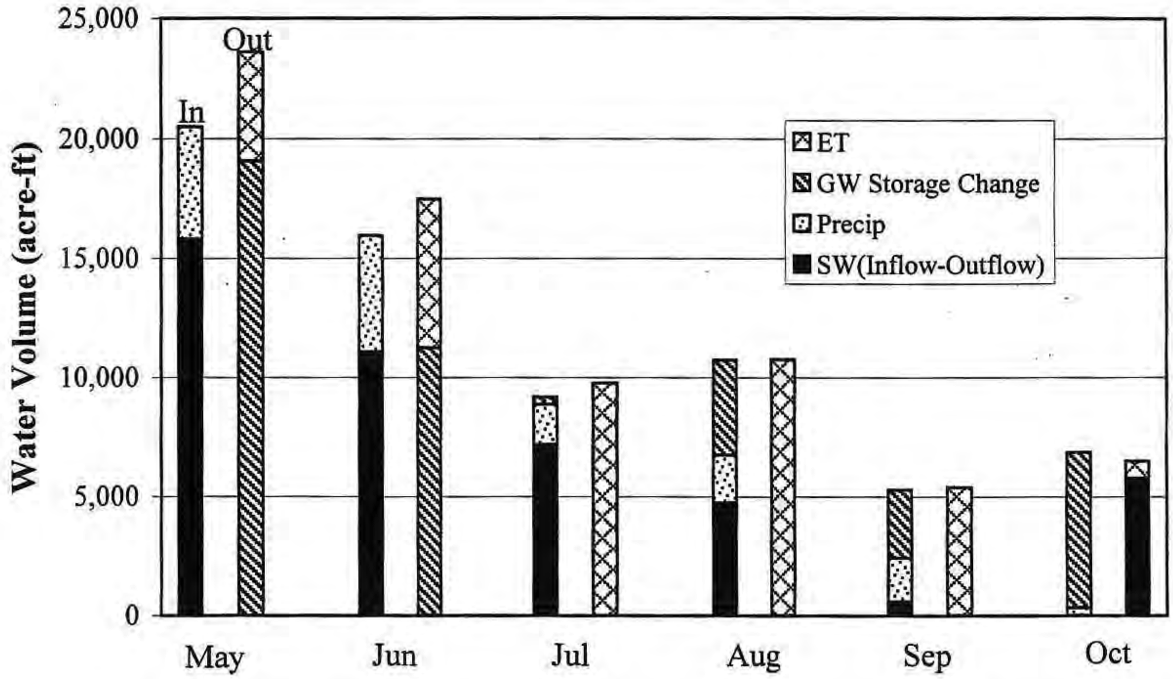

Figure 54. Monthly water balances for the lower Big Hole basin, May–October 1998. The left bar of each monthly pair represents the volume of precipitation input, ground-water storage loss, and/or surface-water flow loss for the study area. The right bar represents the volume of water removed from or temporarily stored in the study area as a result of ET and/or ground-water storage gains.

$$P + S_{gw} = ET + SW(\text{Inflow-Outflow})$$

ET, which was a large water-loss component during the growing season, became a relatively minor component because the growing season ended. The ground-water storage loss that had been supporting ET now appeared in the surface-water system as return flows. As noted previously, it is uncertain how long the returns significantly enhanced surface-water flow, but it is likely that it was until at least December and perhaps into the early spring.

SUMMARY AND CONCLUSIONS

Irrigation has altered the hydrology of the Big Hole basin in several critical ways. Large quantities of surface water are diverted from the river and its tributaries each spring and summer in order to supply water to the more than 130,000 acres of grass hay and alfalfa that are grown here. Some of this irrigation water is released to the atmosphere by evapotranspiration; some percolates into the ground and recharges the valley aquifers; and some flows back into the streams as surface runoff. In areas where irrigated pastures are underlain by thick, unsaturated deposits, increases in ground-water storage in the spring and early-summer can be substantial. The water table rises by more 20 ft at several locations in the upper basin around Wisdom and Jackson and in the lower basin around Glen. Without irrigation, it is estimated that water levels would generally rise by less than 5 ft.

The length of time that high ground-water levels are sustained is also controlled by irrigation. In the lower basin, high water levels persist through June, July, August, and September, once recharge reaches a dynamic equilibrium with discharge. The greatest annual declines in ground-water storage occur in October and November, after irrigation recharge has ceased. In the upper basin, the period in which artificially high water levels are maintained is much more brief, typically about a month, because the irrigation season is shorter. Without irrigation, water levels in most parts of the Big Hole basin would peak in April or May and then would rapidly decline.

Ground water, including the recharge augmented by irrigation, contributes to streamflow during the growing season, partly by direct discharge to watercourses, but mostly by supporting evapotranspiration demands that otherwise would be met by surface water. In fact, water balances for the Francis Creek unit in the upper basin and for the lower basin show that evapotranspiration is so great from July through September that it consumes all water accountable to precipitation, surface-water flow loss, and ground-water storage loss combined.

At the Francis Creek unit, the release from aquifer storage in July and August amounted to 4,500 acre-ft of water, all of which was lost to ET. If this water had not been released, an average of 30 cfs would have had to have been supplied from another source, presumably a stream or the river, in order to meet plant water needs. In the lower basin, a similar situation was observed. The water released from aquifer storage helped offset part of the loss to evapotranspiration. If this stored water had not been available for release, about an additional 55 cfs of water would have had to have been diverted from a surface-water source or pumped from the ground-water system in order to meet plant water needs.

After evapotranspiration becomes minimal following the end of the grow season, increases in streamflow finally are evident due to the release of water from aquifer storage. In the lower basin, the gain in flow averaged 90 cfs in October and November 1998. If not for irrigation-supported ground-water returns at this time, much of this gain would probably not have occurred. It is speculated that irrigation-supported returns also occur in the upper basin at about the same time.

Recommendations

Diversion of water from the Big Hole and its tributaries during the late summer contributes to dewatering of the stream system, especially during dry years. Use of more efficient irrigation and stock-watering practices can potentially reduce the amount of water withdrawn from the streams and thus help alleviate shortages.

Diversion canals used for watering stock lose much of their flow to the ground-water system and to evapotranspiration. Ranchers should continue to be encouraged to develop off-stream water sources such as wells and springs to replace surface-water diversions. Generally, off-stream water sources can supply livestock needs using only a small fraction of the water that is diverted from a stream.

Efforts to improve irrigation efficiency should also be encouraged. Irrigation costs and crop yield rise in parallel to a point, but then crop yield begins to level off. In fact, crop yield will decline if a crop is over irrigated. Soil moisture measurements can assist the agricultural community make informed decisions about the amount and timing of irrigation and potentially maximize crop production. The U.S. Bureau of Reclamation (Agrimet Program), the National Center for Appropriate Technology, the NRCS, and the DNRC can provide guidance on how to implement this strategy.

In the lower basin, another management practice that could potentially improve stream flows would be to switch from flood to sprinkler irrigation during the course of the summer. Flood irrigation in early summer would help increase aquifer storage when surface water is plentiful, and then some of the water would be available to discharge back to the river as return flows. In the second half of the summer, sprinkler irrigation would be used because it is more efficient (i.e. reduced loses to ground-water system) and therefore, less water would have to be diverted. Many ranchers have purchased sprinkler-irrigation equipment just recently to replace flood irrigation, so it is possible that such a strategy could be adopted at a relatively low cost.

Finally, it is recommended that computer modeling be used to evaluate how possible changes in land use, irrigation and agricultural practices, natural processes, and ground- and surface-water use are likely to affect the hydrologic budget of the basin and flow in the river. Simulating such changes will provide the information necessary to better manage the limited water resources of the basin and potentially improve river flows.

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Appendix A

Climate Data

A - 1 Francis Creek Unit

A - 2 Middle Big Hole basin

A - 3 Lower Big Hole basin

A - 1

Francis Creek Unit

Station Name: Weather Station at Francis Creek Unit
Station ID: PG-1
Location Description: In SE corner of fenced enclosure, 7.2 mi south of Wisdom, 0.7 mi east of Hwy 278
Township, Range, Section, Tract: 04S15W03CCAC
Latitude: N45°30'38" Longitude: W113°26'41"
Elevation: 6,238 ft
Equipment: 8" diameter PVC pipe, non-toxic anti-freeze mixed with liquid catch to inhibit ice formation, light oil at liquid-air interface to reduce evaporative loss
Comments: Located 5 ft west of weather station tripod

Date	Precipitation Between Measurements (in)	Cumulative Total (in)	Comments
08/27/97	--	0.00	Initial set-up
09/25/97	0.96	0.96	
10/09/97	0.96	1.92	
10/14/97	0.48	2.40	
10/29/97	0.12	2.52	
11/19/97	0.90	3.42	Ice present. May have evap/sublimation loss
12/29/97	0.58	4.00	Ice present. May have evap/sublimation loss
01/29/98	1.00	4.99	Ice present. May have evap/sublimation loss
02/25/98	0.43	5.42	Ice present. May have evap/sublimation loss
03/30/98	1.00	6.42	Ice present. May have evap/sublimation loss
04/21/98	1.75	8.17	Ice no longer present
04/30/98	0.50	8.67	
05/07/98	0.00	8.67	
05/13/98	0.19	8.86	
05/20/98	0.44	9.30	
06/02/98	2.44	11.74	
06/17/98	1.25	12.99	
06/18/98	0.00	12.99	
07/02/98	1.38	14.36	
07/07/98	0.19	14.55	
07/16/98	0.31	14.86	
07/20/98	0.00	14.86	
07/28/98	0.50	15.36	Heavy thundershowers on afternoon of 7/28
07/29/98	0.44	15.80	
08/12/98	0.06	15.86	
08/25/98	0.24	16.10	
09/02/98	0.00	16.10	Slight evaporative loss
09/11/98	1.63	17.73	Rained on 9/7, 9/8, 9/9
09/29/98	0.38	18.10	End of record

Station Name: Precipitation Gage at North End of Francis Creek Unit
Station ID: PG-2
Location Description: In fenced enclosure 30 ft east of storage shed, 3.3 mi south of Wisdom, 0.15 mi east of Hwy 278
Township, Range, Section, Tract: 03S15W16DCCD
Latitude: N45°34'04" Longitude: W113°27'25"
Elevation: 6,147 ft
Equipment: 8" diameter PVC pipe, non-toxic anti-freeze mixed with liquid catch to inhibit ice formation, vegetable oil at liquid-air interface to reduce evaporative loss
Comments: Surrounded by 3 ft tall grass during growing season

Date	Precipitation Between Measurements (in)	Cumulative Total (in)	Comments
10/29/97	--	0.00	Initial set-up
10/30/97	0.09	0.09	
11/19/97	0.51	0.60	
12/29/97	1.18	1.78	
01/29/98	1.44	3.22	
02/25/98	0.37	3.59	
03/30/98	0.87	4.47	
04/30/98	1.63	6.09	
05/13/98	0.13	6.22	
06/02/98	2.25	8.47	
06/17/98	1.06	9.53	
07/01/98	0.63	10.15	Sticky goop on surface of liquid
07/07/98	0.17	10.32	
07/16/98	0.38	10.70	
07/20/98	0.00	10.70	
07/28/98	0.31	11.01	
07/29/98	0.13	11.13	
08/12/98	0.31	11.45	
08/25/98	0.19	11.63	
09/02/98	0.00	11.63	
09/11/98	1.44	13.07	
09/29/98	0.19	13.26	End of record

Station Name: Weather Station at Francis Creek Unit
Station ID: PG-1
Location Description: In SE corner of fenced enclosure, 7.2 mi south of Wisdom, 0.7 mi east of Hwy 278
Township, Range, Section, Tract: 04S15W03CCAC
Latitude: N45°30'38" Longitude: W113°26'41"
Elevation: 6238 ft
Equipment: Campbell Scientific CR10 Datalogger, CM10 Tripod, Campbell Scientific 207 Air Temperature and Relative Humidity Probe,
2 Campbell Scientific 107B Soil Temperature Probes, R.M. Young 05103 Wind Monitor, LI-COR LI-200SZ Pyranometer,
Campbell Scientific CS105 Barometric Pressure Sensor, Texas Electronics TRP-525 Rainfall Sensor, REBS Q*6.7.1 Net Radiometer
Comments: Averages are based on hourly readings

Date	Avg Air Temp z = 6.5 ft (°C)	Max Air Temp (°C)	Min Air Temp (°C)	Avg Subsurface Soil Temp z = -2.0 ft (°C)	Avg Surface Soil Temp z = 0.2 ft (°C)	Avg Relative Humidity (%)	Avg Wind Speed (m/sec)	Avg Daytime Wind Spd 7 am - 7 pm (m/sec)	Day/Night Wind Speed Ratio	Avg Solar Radiation (cal/cm²/day)	Net Radiation (MJ/m²/day)	Wind Corrected Net Radiation (MJ/m²/day)	Precip (in/day)	Barometric Pressure (mm Hg)
10/30/97	4.2	8.4	0.7	4.8	2.9	87.6	3.57	5.14	2.58	106	2.05	2.18	0.21	608.9
10/31/97	1.7	4.6	-0.4	4.9	1.6	74.1	3.20	3.54	1.24	203	1.58	1.68	0.08	609.0
11/01/97	-0.3	3.9	-6.8	5.0	0.8	69.5	1.98	2.93	2.84	153	1.24	1.31	0.00	608.6
11/02/97	-3.6	6.9	-10.4	4.9	-0.2	78.4	1.17	1.06	0.83	258	2.23	2.34	0.00	608.6
11/03/97	1.5	12.5	-7.1	4.7	-0.1	69.5	1.66	2.12	1.78	173	1.70	1.79	0.00	609.5
11/04/97	4.3	10.0	-4.7	4.6	1.1	62.0	1.92	2.47	1.79	244	1.86	1.97	0.00	609.2
11/05/97	0.1	15.0	-8.3	4.5	0.0	71.4	1.05	1.09	1.08	241	0.42	0.45	0.00	608.9
11/06/97	0.8	14.4	-8.6	4.5	-0.1	73.6	1.19	1.24	1.09	259	1.60	1.68	0.00	608.9
11/07/97	2.3	11.8	-3.7	4.4	0.7	79.0	1.06	1.25	1.42	176	2.13	2.24	0.08	609.0
11/08/97	-2.0	-0.6	-3.7	4.3	0.9	99.8	1.49	1.39	0.87	82	0.96	1.01	0.01	605.0
11/09/97	-2.8	1.5	-8.7	4.3	0.7	90.6	1.98	2.57	1.87	157	0.40	0.42	0.03	607.1
11/10/97	-6.7	-4.2	-11.1	4.3	-0.2	95.9	0.82	0.94	1.37	89	1.26	1.32	0.00	607.2
11/11/97	-8.3	-1.8	-13.0	4.2	-0.6	93.5	1.26	1.42	1.28	165	0.00	0.00	0.00	607.5
11/12/97	-8.6	4.0	-16.6	4.1	-2.1	76.9	1.17	0.91	0.64	236	0.56	0.59	0.02	607.9
11/13/97	-7.7	3.8	-15.2	3.9	-3.1	75.0	1.24	1.16	0.87	240	0.43	0.46	0.00	608.3
11/14/97	-11.1	-0.2	-18.5	3.7	-4.5	72.6	1.26	0.88	0.54	239	-0.61	-0.61	0.00	607.8
11/15/97	-11.1	3.7	-19.5	3.4	-5.2	68.7	0.87	0.84	0.95	234	0.21	0.22	0.00	607.9
11/16/97	-7.8	4.5	-17.2	3.1	-4.5	69.2	1.04	0.76	0.57	212	0.61	0.64	0.00	608.2
11/17/97	-3.3	2.8	-8.9	2.9	-2.3	79.6	2.04	2.49	1.57	113	0.84	0.89	0.00	608.2
11/18/97	-2.7	2.4	-7.6	2.8	-1.5	81.0	1.77	1.99	1.29	102	-0.62	-0.62	0.03	607.9
11/19/97	-3.7	1.8	-8.1	2.7	-1.8	90.9	1.28	1.46	1.33	71	-1.47	-1.47	0.14	607.7
11/20/97	-1.2	1.2	-6.0	2.6	-1.1	80.6	2.44	3.10	1.74	100	-0.24	-0.24	0.00	608.8
11/21/97	-3.3	-0.2	-9.7	2.6	-1.4	80.7	2.26	2.84	1.70	129	-0.69	-0.69	0.00	607.8
11/22/97	-7.7	2.0	-14.6	2.5	-2.9	78.5	1.35	1.43	1.12	206	-1.33	-1.32	0.00	607.8
11/23/97	-3.8	4.8	-13.5	2.5	-2.4	83.7	1.44	1.47	1.05	116	0.26	0.27	0.00	608.0
11/24/97	1.8	4.7	-0.3	2.4	-0.7	82.0	2.33	2.45	1.11	53	-0.17	-0.18	0.00	607.3
11/25/97	-4.4	-0.4	-15.0	2.3	-0.5	96.5	2.22	2.21	0.99	79	-1.82	-1.83	0.35	605.1
11/26/97	-13.2	-7.5	-19.5	2.3	-1.9	91.1	0.88	1.00	1.31	122	-0.05	-0.05	0.00	604.4
11/27/97	-5.2	-0.4	-10.1	2.3	-1.5	90.1	1.73	1.78	1.06	198	-1.21	-1.21	0.00	606.8
11/28/97	-7.4	-0.9	-12.9	2.3	-1.8	86.1	1.56	1.60	1.06	193	-1.64	-1.64	0.00	607.9
11/29/97	-12.3	-6.6	-16.4	2.3	-2.4	91.9	0.63	0.51	0.68	133	-0.21	-0.21	0.00	607.0

Date	Avg Air Temp z = 6.5 ft (°C)	Max Air Temp (°C)	Min Air Temp (°C)	Avg Subsurface Soil Temp z = -2.0 ft (°C)	Avg Surface Soil Temp z = 0.2 ft (°C)	Avg Relative Humidity (%)	Avg Wind Speed (m/sec)	Avg Daytime Wind Spd 7 am - 7 pm (m/sec)	Day/Night Wind Speed Ratio	Avg Solar Radiation (cal/cm²/day)	Net Radiation (MJ/m²/day)	Wind Corrected Net Radiation (MJ/m²/day)	Precip (in/day)	Barometric Pressure (mm Hg)
11/30/97	-7.5	-2.8	-11.7	2.2	-1.9	93.1	0.69	0.86	1.67	120	0.60	0.63	0.00	607.7
12/01/97	-4.5	-2.2	-10.1	2.2	-1.2	86.5	1.26	0.89	0.55	113	-0.98	-0.98	0.00	607.6
12/02/97	-16.6	-9.9	-23.8	2.2	-3.5	85.4	1.33	1.45	1.20	169	0.11	0.11	0.00	606.9
12/03/97	-22.3	-13.5	-28.1	2.2	-4.6	78.8	0.42	0.33	0.64	148	-0.68	-0.67	0.00	606.7
12/04/97	-18.8	-11.5	-24.5	2.1	-4.2	81.2	0.74	0.88	1.46	162	-0.65	-0.65	0.00	606.8
12/05/97	-19.1	-11.1	-23.8	2.0	-4.9	80.4	1.17	1.00	0.75	186	-0.10	-0.10	0.00	607.1
12/06/97	-17.8	-12.2	-23.6	1.9	-4.5	83.5	0.87	0.71	0.69	111	-0.33	-0.33	0.00	606.9
12/07/97	-12.9	-7.1	-19.5	1.8	-3.7	85.3	0.78	0.89	1.34	140	0.02	0.02	0.00	607.4
12/08/97	-8.7	-3.5	-16.1	1.8	-3.0	95.7	1.18	1.35	1.33	44	-0.75	-0.75	0.02	604.7
12/09/97	-8.3	-6.0	-12.1	1.7	-2.0	86.2	1.95	2.36	1.53	68	-0.43	-0.43	0.00	605.9
12/10/97	-12.2	-6.9	-21.2	1.7	-3.4	79.8	1.35	1.80	2.03	181	-0.42	-0.42	0.00	607.0
12/11/97	-13.6	-7.2	-19.7	1.7	-4.5	83.5	1.75	1.92	1.22	173	-1.24	-1.24	0.00	607.3
12/12/97	-14.4	-4.5	-20.6	1.6	-4.8	81.9	1.20	1.13	0.89	163	-0.24	-0.24	0.00	607.0
12/13/97	-14.5	-6.8	-20.6	1.5	-4.5	79.8	1.27	1.35	1.13	178	-0.98	-0.98	0.00	607.2
12/14/97	-11.6	-3.6	-17.0	1.5	-4.0	79.7	1.35	1.66	1.61	137	-0.02	-0.02	0.00	607.5
12/15/97	-3.6	-1.1	-9.8	1.4	-2.8	75.2	3.19	2.66	0.71	128	-1.27	-1.28	0.00	607.8
12/16/97	0.0	2.9	-3.1	1.4	-2.2	73.3	5.08	5.24	1.07	124	-0.05	-0.05	0.00	608.5
12/17/97	-0.3	3.1	-4.4	1.4	-1.1	88.1	3.30	3.13	0.91	78	0.12	0.12	0.00	608.1
12/18/97	-7.4	-4.8	-16.6	1.4	-1.1	87.3	1.59	2.09	1.91	130	-0.52	-0.52	0.00	607.2
12/19/97	-19.0	-13.6	-26.0	1.4	-1.9	83.5	1.45	1.43	0.98	166	-0.27	-0.27	0.00	606.9
12/20/97	-13.5	-8.9	-19.4	1.4	-2.1	84.1	0.92	0.81	0.79	102	0.39	0.41	0.00	607.0
12/21/97	-11.4	-6.2	-17.4	1.4	-1.9	83.1	1.47	1.51	1.04	111	-0.54	-0.54	0.00	607.1
12/22/97	-14.4	-7.9	-19.1	1.4	-2.1	76.3	1.40	1.39	0.99	176	-1.44	-1.44	0.00	607.2
12/23/97	-11.0	-7.1	-19.8	1.3	-2.2	79.6	1.41	1.71	1.55	87	0.12	0.13	0.00	607.5
12/24/97	-11.6	-6.2	-21.5	1.3	-1.9	81.1	1.25	1.29	1.06	141	-1.45	-1.45	0.00	607.2
12/25/97	-21.5	-15.6	-26.6	1.3	-2.6	81.1	1.22	1.34	1.22	162	-0.49	-0.49	0.00	606.8
12/26/97	-17.9	-8.6	-25.0	1.2	-3.0	81.3	0.98	1.11	1.32	167	-0.71	-0.71	0.00	607.1
12/27/97	-7.6	-4.7	-10.6	1.2	-2.6	79.3	3.23	3.80	1.43	111	-1.14	-1.15	0.00	607.5
12/28/97	-3.8	1.9	-9.2	1.1	-2.0	82.2	2.21	2.95	2.01	90	0.17	0.18	0.00	608.2
12/29/97	2.5	4.5	-0.2	1.1	-1.0	81.8	1.73	2.03	1.42	109	-0.53	-0.53	0.04	608.9
12/30/97	-2.3	3.9	-10.6	1.1	-0.7	63.3	1.61	1.98	1.60	171	-1.10	-1.10	0.00	608.2
12/31/97	-7.9	2.9	-14.0	1.1	-1.7	75.9	1.42	1.46	1.05	119	-1.75	-1.75	0.00	607.7
01/01/98	1.4	5.0	-5.9	1.1	-1.5	65.0	4.81	5.91	1.60	68	-1.19	-1.20	0.00	608.5
01/02/98	-0.6	2.5	-7.8	1.1	-0.5	90.2	3.79	4.34	1.34	82	-0.33	-0.33	0.02	607.9
01/03/98	-3.6	0.9	-8.8	1.1	-0.9	85.2	3.72	5.21	2.32	115	-0.31	-0.31	0.00	607.7
01/04/98	-2.5	0.3	-6.1	1.1	-1.2	75.7	5.47	6.89	1.70	143	-1.24	-1.25	0.00	608.4
01/05/98	-11.1	-7.2	-15.0	1.1	-1.6	76.9	2.57	2.81	1.20	186	-2.47	-2.48	0.00	607.4
01/06/98	-10.3	-6.0	-15.6	1.1	-2.0	68.5	3.09	2.80	0.83	158	-1.53	-1.54	0.00	607.6
01/07/98	-5.4	-1.5	-10.4	1.1	-1.8	75.4	3.71	4.23	1.32	107	-0.45	-0.45	0.00	607.9
01/08/98	-10.3	-6.9	-13.3	1.1	-1.8	77.8	2.87	3.41	1.46	169	-1.04	-1.04	0.00	607.1
01/09/98	-20.3	-14.5	-26.3	1.1	-2.3	80.1	1.19	0.95	0.66	166	-0.78	-0.78	0.00	606.6
01/10/98	-16.0	-4.5	-25.9	1.1	-2.8	84.1	1.23	1.38	1.29	99	-0.04	-0.04	0.00	606.9

Date	Avg Air Temp z = 6.5 ft (°C)	Max Air Temp (°C)	Min Air Temp (°C)	Avg Subsurface Soil Temp z = -2.0 ft (°C)	Avg Surface Soil Temp z = 0.2 ft (°C)	Avg Relative Humidity (%)	Avg Wind Speed (m/sec)	Avg Daytime Wind Spd 7 am - 7 pm (m/sec)	Day/Night Wind Speed Ratio	Avg Solar Radiation (cal/cm²/day)	Net Radiation (MJ/m²/day)	Wind Corrected Net Radiation (MJ/m²/day)	Precip (in/day)	Barometric Pressure (mm Hg)
01/11/98	-6.8	-3.3	-10.6	1.0	-2.1	89.5	2.96	1.96	0.49	86	0.15	0.16	0.00	606.3
01/12/98	-5.7	-1.1	-9.7	1.0	-1.6	84.1	3.33	3.32	0.99	147	0.31	0.33	0.01	607.7
01/13/98	-3.3	0.3	-6.4	1.0	-1.2	83.3	2.17	2.63	1.53	129	-0.59	-0.60	0.01	608.4
01/14/98	-4.3	-0.5	-11.2	1.0	-1.3	74.9	5.54	6.19	1.27	143	-0.48	-0.49	0.00	608.5
01/15/98	-4.1	-1.0	-8.1	1.0	-1.0	82.9	2.34	1.95	0.71	185	-0.30	-0.30	0.00	608.2
01/16/98	-8.7	-4.3	-16.4	1.0	-1.2	79.7	2.07	1.84	0.80	123	-1.01	-1.01	0.00	607.6
01/17/98	-1.9	0.4	-4.6	1.0	-1.1	90.0	3.31	3.29	0.99	159	-1.14	-1.14	0.03	608.2
01/18/98	-6.8	-2.4	-12.2	1.0	-0.9	83.5	2.15	2.29	1.14	173	-1.67	-1.67	0.00	607.9
01/19/98	-6.7	-2.0	-11.8	1.0	-1.1	97.1	1.00	1.09	1.19	87	0.53	0.56	0.00	607.9
01/20/98	-5.4	-2.4	-9.9	1.0	-1.0	86.9	1.33	1.59	1.51	93	-0.36	-0.36	0.00	607.4
01/21/98	-9.9	-3.1	-13.5	1.0	-1.0	80.2	2.24	2.22	0.98	140	-0.89	-0.89	0.00	607.4
01/22/98	-7.8	-0.7	-14.1	1.0	-1.1	77.7	1.96	1.42	0.57	208	-1.64	-1.64	0.00	607.6
01/23/98	-12.1	-3.6	-19.3	1.0	-1.4	88.1	1.10	1.18	1.15	127	0.06	0.06	0.00	607.7
01/24/98	-1.9	1.0	-5.5	1.0	-1.3	78.5	3.84	3.96	1.06	184	-0.47	-0.47	0.01	608.9
01/25/98	-3.9	-0.5	-7.5	1.0	-1.0	75.5	2.26	2.35	1.08	212	-1.43	-1.43	0.00	608.5
01/26/98	-2.0	2.9	-9.8	1.0	-0.9	79.3	2.45	2.87	1.41	152	-0.23	-0.23	0.00	608.6
01/27/98	-1.7	1.9	-4.8	1.0	-0.8	90.5	2.30	3.21	2.29	159	0.48	0.51	0.00	608.9
01/28/98	-6.5	-2.0	-13.4	1.0	-0.7	86.1	1.69	2.23	1.94	240	-2.04	-2.04	0.00	608.2
01/29/98	-13.3	-6.6	-19.2	1.0	-1.1	90.4	0.99	0.86	0.78	167	-0.10	-0.10	0.00	607.7
01/30/98	-4.4	1.8	-12.3	1.1	-1.1	88.8	1.24	1.26	1.03	171	0.30	0.32	0.01	607.9
01/31/98	-14.0	-6.7	-21.4	1.1	-1.2	90.0	1.20	1.29	1.16	207	-1.23	-1.22	0.00	607.4
02/01/98	-18.2	-10.6	-24.0	1.1	-1.7	84.6	0.64	0.50	0.65	192	-0.87	-0.87	0.00	607.2
02/02/98	-13.8	-7.4	-17.8	1.0	-2.0	86.0	1.22	1.49	1.56	246	-0.59	-0.59	0.00	607.7
02/03/98	-10.0	0.9	-17.8	1.0	-2.0	89.7	1.35	1.13	0.72	176	-0.18	-0.18	0.00	608.6
02/04/98	-8.5	-0.7	-14.5	1.0	-1.7	93.2	1.00	0.72	0.56	243	-0.30	-0.30	0.01	608.1
02/05/98	-8.8	-2.0	-13.7	1.0	-1.6	89.4	1.25	1.30	1.09	242	-0.18	-0.18	0.01	608.3
02/06/98	-12.4	-8.0	-17.8	0.9	-1.8	92.9	0.84	0.75	0.81	132	0.23	0.24	0.00	607.4
02/07/98	-5.8	0.9	-12.4	0.9	-1.6	96.0	1.06	1.17	1.24	183	0.16	0.16	0.01	607.6
02/08/98	-7.0	-1.8	-13.9	0.9	-1.4	95.1	1.51	2.01	2.00	186	0.04	0.04	0.02	608.0
02/09/98	-4.3	-1.8	-6.7	0.9	-1.1	89.1	2.02	2.35	1.38	179	0.80	0.85	0.00	608.2
02/10/98	-13.1	-6.5	-21.1	0.9	-1.3	82.8	1.59	1.46	0.85	270	-0.46	-0.46	0.00	607.9
02/11/98	-6.0	1.3	-10.4	0.9	-1.5	88.5	1.10	1.10	0.99	210	0.94	0.99	0.15	607.8
02/12/98	-8.5	-1.4	-14.9	0.9	-1.4	86.8	1.45	0.99	0.52	241	0.74	0.78	0.03	608.6
02/13/98	-5.5	0.1	-13.5	0.9	-1.3	86.9	2.02	2.16	1.15	198	-0.44	-0.44	0.06	608.2
02/14/98	-14.4	-9.0	-22.4	0.9	-1.5	88.6	1.36	1.08	0.65	184	-0.16	-0.16	0.00	607.8
02/15/98	-5.6	-0.2	-12.0	0.8	-1.6	87.1	1.03	0.92	0.82	268	0.81	0.85	0.14	608.5
02/16/98	-7.1	-1.8	-13.9	0.8	-1.3	88.4	1.47	1.58	1.17	293	0.11	0.12	0.09	607.9
02/17/98	-13.9	-6.8	-20.6	0.8	-1.6	89.2	0.75	0.91	1.52	244	0.13	0.14	0.00	607.5
02/18/98	-7.9	0.7	-12.8	0.8	-1.6	81.1	1.66	1.97	1.45	285	0.27	0.28	0.09	608.2
02/19/98	-12.8	-4.4	-19.0	0.8	-1.8	83.0	1.10	0.91	0.70	331	-0.04	-0.04	0.01	608.0
02/20/98	-9.7	-0.7	-16.4	0.8	-1.9	81.9	1.62	1.31	0.68	332	0.41	0.43	0.04	608.6
02/21/98	-0.3	3.1	-3.2	0.8	-1.5	78.6	6.82	8.24	1.53	253	0.86	0.92	0.06	609.2

Date	Avg Air Temp z = 6.5 ft (°C)	Max Air Temp (°C)	Min Air Temp (°C)	Avg Subsurface Soil Temp z = -2.0 ft (°C)	Avg Surface Soil Temp z = 0.2 ft (°C)	Avg Relative Humidity (%)	Avg Wind Speed (m/sec)	Avg Daytime Wind Spd 7 am - 7 pm (m/sec)	Day/Night Wind Speed Ratio	Avg Solar Radiation (cal/cm²/day)	Net Radiation (MJ/m²/day)	Wind Corrected Net Radiation (MJ/m²/day)	Precip (in/day)	Barometric Pressure (mm Hg)
02/22/98	-5.7	-2.4	-12.9	0.7	-1.0	91.1	2.17	2.70	1.66	290	-0.86	-0.86	0.03	607.9
02/23/98	-12.8	-4.6	-18.4	0.7	-0.9	80.9	1.26	1.04	0.70	360	-0.28	-0.28	0.00	608.1
02/24/98	-8.8	-3.0	-17.7	0.8	-1.0	89.7	1.16	1.16	1.01	220	-0.37	-0.37	0.00	607.9
02/25/98	-9.2	-4.2	-15.1	0.8	-1.0	74.6	1.48	1.56	1.11	343	0.80	0.84	0.00	608.2
02/26/98	-10.8	-4.1	-18.2	0.8	-1.0	85.0	1.94	1.80	0.86	285	0.35	0.37	0.00	607.7
02/27/98	-11.1	-4.5	-18.6	0.8	-1.0	73.5	2.01	2.20	1.21	333	0.63	0.67	0.00	608.0
02/28/98	-16.1	-6.6	-26.0	0.8	-1.1	80.5	1.19	1.31	1.23	335	0.76	0.80	0.00	608.3
03/01/98	-3.7	2.1	-9.0	0.8	-1.1	85.5	1.75	2.23	1.76	288	1.93	2.04	0.00	609.0
03/02/98	-1.6	6.5	-6.7	0.8	-1.0	84.4	1.91	1.15	0.43	322	1.57	1.66	0.00	609.1
03/03/98	-4.5	-1.6	-7.7	0.8	-0.7	88.3	2.44	3.08	1.71	266	1.01	1.07	0.00	608.6
03/04/98	-8.2	-3.7	-11.1	0.8	-0.7	88.7	1.52	1.59	1.10	323	0.96	1.01	0.00	607.9
03/05/98	-10.1	-0.7	-18.4	0.8	-0.7	78.0	1.37	1.27	0.86	354	0.99	1.04	0.00	607.7
03/06/98	-14.9	-8.3	-20.7	0.8	-0.8	80.5	1.19	1.15	0.94	382	1.02	1.07	0.00	608.0
03/07/98	-13.1	-4.3	-17.7	0.8	-0.9	74.4	1.60	2.34	2.72	414	0.21	0.22	0.00	608.1
03/08/98	-13.7	-8.1	-21.0	0.8	-1.0	82.3	0.93	1.04	1.27	284	1.29	1.35	0.00	608.2
03/09/98	-6.8	0.1	-13.5	0.8	-1.1	80.8	1.98	1.96	0.98	354	1.90	2.01	0.00	608.4
03/10/98	-1.5	2.3	-4.1	0.8	-1.0	84.2	2.78	2.36	0.74	362	2.15	2.27	0.00	609.3
03/11/98	-0.3	6.5	-5.1	0.8	-0.7	74.2	1.86	2.19	1.43	387	2.11	2.23	0.00	609.0
03/12/98	-4.8	3.7	-11.2	0.8	-0.6	80.6	1.25	1.39	1.23	443	1.01	1.06	0.00	609.1
03/13/98	-5.4	5.0	-13.8	0.8	-0.6	78.2	1.22	1.08	0.79	415	1.28	1.35	0.00	609.1
03/14/98	-3.6	5.3	-12.6	0.9	-0.6	80.7	1.37	1.31	0.90	391	1.64	1.73	0.00	609.3
03/15/98	-0.3	5.2	-6.4	0.9	-0.6	83.3	1.31	1.37	1.09	354	3.23	3.40	0.00	609.3
03/16/98	1.1	4.7	-5.0	0.9	-0.3	89.6	2.09	2.40	1.35	339	3.30	3.49	0.00	609.2
03/17/98	-4.9	-1.7	-9.5	0.9	-0.2	84.5	1.94	2.30	1.46	332	1.18	1.25	0.00	608.9
03/18/98	-5.4	0.5	-14.1	0.9	-0.2	82.8	0.87	0.93	1.13	351	1.93	2.02	0.00	608.7
03/19/98	-4.2	2.6	-10.4	0.9	-0.2	79.1	1.34	1.79	2.00	482	0.32	0.33	0.00	609.0
03/20/98	-3.8	6.7	-12.2	0.9	-0.2	78.5	1.47	1.52	1.07	450	2.22	2.34	0.00	609.3
03/21/98	-0.7	5.1	-8.3	0.9	-0.1	82.8	1.61	1.61	1.00	393	2.77	2.92	0.00	609.5
03/22/98	4.4	7.5	2.9	0.9	-0.1	83.0	2.82	2.94	1.09	308	3.78	4.01	0.00	610.2
03/23/98	3.4	5.9	1.5	0.9	-0.1	87.8	3.09	3.40	1.23	231	2.69	2.85	0.00	610.1
03/24/98	2.2	6.8	-1.1	0.9	-0.1	90.5	1.68	1.71	1.04	329	2.60	2.74	0.00	610.1
03/25/98	0.7	5.6	-2.5	0.9	-0.1	91.7	1.07	1.04	0.95	319	1.87	1.97	0.00	609.7
03/26/98	0.4	3.9	-2.3	0.9	-0.1	90.3	2.39	3.10	1.86	323	3.33	3.52	0.00	609.6
03/27/98	-3.1	0.2	-5.8	0.9	-0.1	84.3	2.17	2.43	1.27	440	3.83	4.06	0.00	609.2
03/28/98	-4.5	-0.7	-8.0	0.9	-0.1	87.2	2.96	2.75	0.87	400	2.66	2.82	0.00	608.9
03/29/98	-4.2	-1.4	-6.2	0.9	-0.1	86.4	5.58	6.69	1.50	365	2.84	3.02	0.00	609.3
03/30/98	-4.2	6.7	-11.8	0.9	-0.1	70.3	1.94	2.14	1.23	542	4.19	4.43	0.00	609.1
03/31/98	-2.5	6.3	-10.0	0.9	-0.1	69.2	1.66	1.42	0.75	513	4.40	4.64	0.00	609.6
04/01/98	-1.2	6.8	-7.7	0.9	-0.1	75.4	1.42	1.36	0.92	465	4.44	4.67	0.00	609.4
04/02/98	0.2	8.8	-7.0	0.9	-0.1	79.4	1.53	1.59	1.09	507	6.65	7.01	0.00	609.5
04/03/98	2.3	6.0	0.2	0.9	-0.1	87.2	2.17	2.63	1.53	408	6.61	6.99	0.00	610.1
04/04/98	2.1	7.2	-0.6	0.9	-0.1	85.7	1.17	1.31	1.28	419	6.65	6.98	0.00	609.8

Date	Avg Air Temp z = 6.5 ft (°C)	Max Air Temp (°C)	Min Air Temp (°C)	Avg Subsurface Soil Temp z = -2.0 ft (°C)	Avg Surface Soil Temp z = 0.2 ft (°C)	Avg Relative Humidity (%)	Avg Wind Speed (m/sec)	Avg Daytime Wind Spd 7 am - 7 pm (m/sec)	Day/Night Wind Speed Ratio	Avg Solar Radiation (cal/cm²/day)	Net Radiation (MJ/m²/day)	Wind Corrected Net Radiation (MJ/m²/day)	Precip (in/day)	Barometric Pressure (mm Hg)
04/05/98	0.5	2.4	-1.2	0.9	-0.1	95.7	1.00	1.03	1.07	249	2.40	2.51	0.00	609.4
04/06/98	-0.5	3.1	-3.1	1.0	-0.1	92.8	1.66	1.81	1.19	401	3.01	3.17	0.00	609.7
04/07/98	-0.4	4.6	-3.8	1.0	-0.1	86.0	1.47	1.88	1.77	486	7.27	7.66	0.00	609.8
04/08/98	-0.8	2.7	-4.6	1.0	-0.1	84.0	1.70	1.99	1.41	403	5.25	5.54	0.00	609.6
04/09/98	-1.2	4.9	-7.0	1.0	-0.1	84.7	2.00	2.56	1.77	415	6.00	6.34	0.00	609.7
04/10/98	-0.8	4.9	-5.7	1.1	-0.1	94.0	1.52	2.07	2.12	318	5.26	5.54	0.00	609.9
04/11/98	0.8	5.7	-4.3	1.1	-0.1	88.1	1.75	2.03	1.38	381	5.57	5.88	0.00	609.7
04/12/98	-1.2	1.3	-4.7	1.1	-0.1	77.0	3.07	4.69	3.23	379	5.26	5.58	0.00	609.9
04/13/98	-2.4	4.0	-9.7	1.1	-0.1	69.2	2.42	3.01	1.64	535	8.47	8.97	0.00	609.5
04/14/98	-2.3	1.7	-7.8	1.1	-0.1	95.8	1.48	1.62	1.22	397	2.95	3.11	0.00	609.3
04/15/98	-1.1	4.4	-3.5	1.2	-0.1	94.8	1.75	2.41	2.22	398	1.92	2.02	0.00	609.1
04/16/98	-1.8	2.3	-7.9	1.2	-0.1	88.1	2.08	2.64	1.73	458	4.88	5.16	0.00	609.6
04/17/98	-1.8	1.7	-5.3	1.2	-0.1	87.9	2.37	3.00	1.72	534	7.14	7.56	0.00	609.7
04/18/98	-1.3	6.8	-10.1	1.2	-0.1	74.9	1.94	2.26	1.40	581	9.51	10.04	0.00	610.0
04/19/98	2.5	6.5	-1.3	1.2	0.0	77.0	1.62	2.25	2.27	398	7.01	7.39	0.00	610.0
04/20/98	1.4	11.4	-7.1	1.2	0.9	68.8	1.86	1.76	0.89	630	10.86	11.47	0.00	609.9
04/21/98	3.8	15.3	-6.2	1.3	2.9	61.7	1.50	1.33	0.79	577	10.21	10.76	0.00	610.1
04/22/98	6.8	18.9	-4.0	1.5	5.0	59.7	2.04	1.74	0.74	616	12.19	12.89	0.00	610.6
04/23/98	10.3	16.9	2.7	1.9	6.3	54.1	4.10	4.64	1.30	520	11.68	12.41	0.00	611.2
04/24/98	3.0	6.6	-0.1	2.4	3.8	84.8	2.92	3.24	1.24	313	5.50	5.84	0.00	609.5
04/25/98	-0.6	2.7	-3.9	2.6	2.2	70.4	3.50	4.64	1.96	382	7.96	8.45	0.00	609.4
04/26/98	0.8	8.6	-7.2	2.6	2.7	69.1	2.01	2.46	1.59	602	12.60	13.32	0.00	609.9
04/27/98	5.0	14.8	-4.6	2.6	4.6	67.8	2.30	2.75	1.48	637	13.76	14.57	0.00	610.2
04/28/98	6.9	17.6	-3.0	2.8	6.3	65.0	1.57	1.29	0.70	634	13.88	14.62	0.00	610.6
04/29/98	8.1	18.6	-1.4	3.1	7.1	56.3	1.86	2.30	1.64	646	13.85	14.62	0.01	610.4
04/30/98	7.8	19.5	-3.4	3.4	7.1	54.9	1.35	1.41	1.09	660	13.59	14.29	0.00	610.4
05/01/98	9.4	19.8	-1.4	3.7	8.2	56.2	1.84	1.27	0.53	654	13.73	14.49	0.00	610.4
05/02/98	9.2	18.8	-2.5	4.0	7.9	60.6	2.32	2.85	1.59	550	12.39	13.11	0.00	610.6
05/03/98	9.0	18.9	0.0	4.3	7.7	69.2	2.60	3.26	1.69	448	9.64	10.22	0.00	610.7
05/04/98	8.9	17.9	0.1	4.5	8.6	69.0	2.20	2.27	1.07	596	13.90	14.70	0.00	610.9
05/05/98	9.0	18.4	-1.4	4.7	9.0	69.9	2.51	3.16	1.69	677	15.98	16.93	0.00	610.8
05/06/98	8.8	17.6	-0.8	4.9	8.6	68.2	2.27	2.69	1.44	577	12.79	13.53	0.01	610.8
05/07/98	9.7	17.6	1.5	5.1	9.0	73.1	2.49	3.29	1.95	537	12.62	13.37	0.08	611.1
05/08/98	9.0	15.7	2.2	5.3	8.6	75.4	2.48	3.21	1.85	492	11.16	11.82	0.01	611.2
05/09/98	7.8	16.8	-3.9	5.4	7.9	60.4	1.94	1.86	0.92	606	13.35	14.10	0.00	610.7
05/10/98	7.2	14.4	-1.2	5.5	7.9	64.6	3.01	3.71	1.60	659	14.33	15.21	0.00	610.6
05/11/98	6.6	12.4	0.0	5.6	7.4	72.7	1.88	2.15	1.33	432	9.34	9.86	0.00	610.5
05/12/98	6.1	12.9	-1.9	5.6	6.8	73.3	3.21	4.50	2.34	455	10.31	10.94	0.00	610.5
05/13/98	5.2	9.1	1.9	5.6	6.9	86.0	2.32	3.21	2.26	299	6.59	6.98	0.04	610.6
05/14/98	4.6	8.1	1.9	5.5	6.0	87.6	3.30	4.68	2.43	284	7.22	7.66	0.19	610.5
05/15/98	2.8	7.7	-1.8	5.5	5.4	77.4	2.16	2.90	2.04	461	10.63	11.24	0.01	610.2
05/16/98	3.1	11.4	-4.4	5.4	5.2	85.0	2.61	4.22	4.28	440	11.04	11.70	0.17	610.2

Date	Avg Air Temp z = 6.5 ft (°C)	Max Air Temp (°C)	Min Air Temp (°C)	Avg Subsurface Soil Temp z = -2.0 ft (°C)	Avg Surface Soil Temp z = 0.2 ft (°C)	Avg Relative Humidity (%)	Avg Wind Speed (m/sec)	Avg Daytime Wind Spd 7 am - 7 pm (m/sec)	Day/Night Wind Speed Ratio	Avg Solar Radiation (cal/cm²/day)	Net Radiation (MJ/m²/day)	Wind Corrected Net Radiation (MJ/m²/day)	Precip (in/day)	Barometric Pressure (mm Hg)
05/17/98	3.3	7.9	0.0	5.3	5.3	82.9	3.16	4.68	2.86	397	10.07	10.68	0.20	610.5
05/18/98	4.2	11.1	-1.2	5.3	6.1	66.3	1.75	1.79	1.05	437	9.56	10.09	0.01	610.4
05/19/98	6.0	16.4	-5.3	5.2	6.0	67.6	2.54	3.62	2.49	563	12.55	13.29	0.01	610.4
05/20/98	9.1	18.3	-2.5	5.3	7.4	64.6	3.22	4.65	2.61	600	14.16	15.03	0.03	610.8
05/21/98	6.6	10.6	4.4	5.4	7.4	89.6	1.75	2.08	1.45	191	4.34	4.58	0.43	609.9
05/22/98	3.7	5.7	1.2	5.5	6.1	92.6	1.61	1.92	1.46	176	4.09	4.31	0.85	610.1
05/23/98	4.5	8.8	0.8	5.5	6.8	87.8	1.52	2.16	2.44	345	8.56	9.02	0.38	610.2
05/24/98	7.3	15.1	-0.1	5.5	9.2	76.3	1.82	1.63	0.81	524	12.63	13.33	0.00	610.8
05/25/98	10.3	16.9	3.2	5.8	9.0	74.2	3.46	5.23	3.09	517	12.18	12.93	0.00	611.0
05/26/98	9.5	18.3	2.4	6.1	9.0	74.4	4.52	6.33	2.34	563	14.43	15.33	0.01	611.0
05/27/98	4.1	9.2	-0.7	6.3	7.3	73.2	3.34	4.72	2.41	610	15.07	16.00	0.17	610.4
05/28/98	6.9	17.2	-3.5	6.5	8.8	63.8	1.36	1.37	1.02	738	18.28	19.23	0.00	610.8
05/29/98	8.3	16.2	-0.2	6.6	9.2	71.1	3.17	4.76	3.03	596	13.66	14.50	0.00	610.8
05/30/98	5.0	9.3	0.5	6.8	8.2	86.9	1.73	2.25	1.87	455	10.75	11.34	0.96	610.5
05/31/98	7.0	14.1	-1.1	6.9	9.3	74.3	1.98	2.72	2.18	677	16.64	17.58	0.01	610.7
06/01/98	10.5	17.0	3.8	7.1	9.9	63.6	2.76	4.02	2.68	535	12.33	13.07	0.01	611.0
06/02/98	7.3	12.6	3.3	7.2	9.9	87.6	1.98	2.36	1.49	342	8.55	9.04	0.21	610.9
06/03/98	4.3	7.4	1.2	7.4	8.2	86.3	2.53	3.01	1.47	304	7.23	7.66	0.20	610.6
06/04/98	5.1	11.0	-1.5	7.4	8.4	64.4	2.66	3.54	1.98	667	15.56	16.49	0.00	610.7
06/05/98	5.6	11.9	-1.8	7.4	8.5	72.6	2.23	2.71	1.53	598	13.92	14.73	0.08	610.4
06/06/98	5.3	11.2	0.7	7.4	8.5	87.1	2.24	3.18	2.44	465	11.60	12.28	0.18	610.5
06/07/98	6.2	11.1	2.3	7.5	9.2	87.4	1.83	2.53	2.24	498	13.03	13.76	0.13	610.6
06/08/98	6.5	11.9	3.2	7.5	9.5	82.6	1.64	2.15	1.91	455	11.59	12.22	0.11	611.3
06/09/98	8.4	15.5	2.5	7.6	10.8	72.6	1.54	1.88	1.56	687	17.34	18.26	0.01	610.9
06/10/98	7.7	12.3	2.3	7.8	9.7	86.1	1.31	1.34	1.06	234	4.60	4.84	0.06	610.7
06/11/98	10.2	14.6	6.8	7.9	10.6	86.7	1.47	1.91	1.86	333	8.12	8.55	0.00	610.6
06/12/98	10.6	15.2	7.3	8.0	11.2	85.3	1.58	2.09	1.95	326	8.09	8.52	0.11	610.8
06/13/98	9.7	14.4	5.2	8.2	10.7	82.5	2.42	3.04	1.68	440	10.85	11.49	0.06	610.8
06/14/98	7.5	13.2	3.3	8.3	10.1	80.9	2.35	3.27	2.30	447	10.59	11.21	0.04	611.1
06/15/98	6.4	10.7	1.5	8.3	9.0	85.4	2.34	3.15	2.05	227	4.83	5.12	0.09	610.7
06/16/98	4.1	6.8	1.1	8.3	7.5	88.9	3.05	4.15	2.12	248	5.88	6.24	0.12	610.7
06/17/98	7.0	12.2	3.6	8.2	8.7	83.8	1.85	2.38	1.79	355	8.50	8.98	0.08	611.2
06/18/98	10.2	16.7	4.1	8.2	10.4	77.6	2.34	3.41	2.72	565	14.26	15.10	0.00	611.2
06/19/98	6.7	8.9	3.5	8.3	9.6	88.0	2.91	4.22	2.64	341	8.61	9.13	0.00	610.7
06/20/98	8.3	14.4	4.2	8.3	10.4	80.0	1.20	1.44	1.48	516	12.46	13.09	0.00	611.5
06/21/98	9.6	19.0	0.2	8.4	10.5	73.7	1.50	1.38	0.84	714	18.64	19.63	0.00	611.0
06/22/98	10.3	18.3	2.8	8.5	10.7	77.5	1.78	2.04	1.33	523	13.19	13.92	0.00	611.2
06/23/98	10.6	14.9	5.6	8.6	11.5	79.6	1.83	2.57	2.37	497	11.96	12.62	0.00	611.2
06/24/98	9.4	14.8	1.4	8.7	10.5	82.1	2.12	3.29	3.45	446	11.37	12.03	0.00	610.9
06/25/98	9.8	13.4	7.4	8.8	10.6	85.3	1.95	2.01	1.06	318	7.78	8.22	0.00	610.7
06/26/98	6.0	9.1	2.7	8.9	9.7	83.4	2.97	4.16	2.35	461	10.80	11.45	0.00	610.1
06/27/98	7.5	15.4	2.2	8.9	9.9	73.5	2.04	2.97	2.69	548	12.78	13.51	0.00	610.8

Date	Avg Air Temp z = 6.5 ft (°C)	Max Air Temp (°C)	Min Air Temp (°C)	Avg Subsurface Soil Temp z = -2.0 ft (°C)	Avg Surface Soil Temp z = 0.2 ft (°C)	Avg Relative Humidity (%)	Avg Wind Speed (m/sec)	Avg Daytime Wind Spd 7 am - 7 pm (m/sec)	Day/Night Wind Speed Ratio	Avg Solar Radiation (cal/cm²/day)	Net Radiation (MJ/m²/day)	Wind Corrected Net Radiation (MJ/m²/day)	Precip (in/day)	Barometric Pressure (mm Hg)
06/28/98	10.2	19.0	-0.4	8.9	10.9	66.7	1.83	2.40	1.89	733	18.13	19.14	0.00	610.8
06/29/98	12.7	23.0	1.8	9.0	12.2	66.6	1.34	1.28	0.90	761	18.86	19.83	0.00	610.9
06/30/98	15.4	24.1	5.4	9.2	13.5	64.5	1.92	1.48	0.63	693	17.51	18.50	0.00	610.8
07/01/98	14.1	20.7	6.6	9.5	13.6	74.0	1.71	2.13	1.65	600	15.11	15.94	0.00	611.2
07/02/98	13.8	24.1	4.3	9.7	13.6	77.9	1.72	2.08	1.54	610	15.96	16.84	0.05	610.8
07/03/98	14.1	21.5	7.4	9.9	14.2	83.4	1.84	2.23	1.54	551	14.11	14.89	0.11	611.5
07/04/98	13.7	22.2	6.6	10.1	13.6	77.1	1.63	1.94	1.46	570	14.55	15.33	0.04	611.3
07/05/98	14.4	22.6	5.0	10.2	13.8	70.7	1.42	1.75	1.60	711	18.15	19.10	0.01	611.0
07/06/98	14.4	23.0	4.5	10.3	13.8	70.6	1.35	1.58	1.41	704	17.87	18.79	0.00	610.9
07/07/98	14.7	24.7	4.5	10.3	13.9	72.8	1.53	1.45	0.89	690	18.04	19.00	0.04	610.6
07/08/98	13.6	24.7	4.9	10.4	13.2	75.4	1.42	1.86	1.89	555	13.87	14.59	0.01	610.6
07/09/98	14.3	26.3	3.3	10.4	12.9	72.0	1.66	1.61	0.95	629	16.81	17.72	0.00	610.8
07/10/98	15.9	24.6	8.6	10.4	14.1	75.6	1.80	2.23	1.63	534	13.54	14.29	0.11	611.3
07/11/98	14.8	20.4	7.2	10.5	13.9	72.5	2.57	2.50	0.95	625	15.16	16.07	0.17	611.5
07/12/98	14.7	24.3	3.9	10.6	13.3	65.3	2.02	2.76	2.14	706	17.95	18.97	0.00	611.0
07/13/98	15.5	25.4	2.5	10.6	13.5	64.5	2.03	2.84	2.32	710	17.97	19.00	0.00	610.6
07/14/98	15.6	25.4	4.0	10.6	13.5	65.0	1.32	1.56	1.44	695	17.50	18.40	0.00	610.7
07/15/98	16.3	27.4	4.3	10.7	13.8	65.2	1.09	0.88	0.67	730	18.31	19.21	0.00	610.7
07/16/98	16.6	28.5	5.3	10.7	14.0	66.1	1.03	0.93	0.82	730	18.26	19.15	0.00	610.6
07/17/98	17.4	29.8	3.9	10.8	14.3	66.2	1.09	0.93	0.75	715	17.86	18.73	0.00	610.7
07/18/98	18.4	29.2	6.5	10.8	14.9	65.3	1.24	1.31	1.12	710	18.04	18.95	0.00	611.0
07/19/98	18.4	29.9	5.1	10.9	14.6	60.6	1.16	1.20	1.07	722	18.17	19.07	0.00	610.8
07/20/98	17.1	27.5	5.1	11.0	14.3	57.6	1.52	1.82	1.49	723	18.02	18.97	0.00	610.8
07/21/98	14.0	27.3	0.6	11.0	12.4	55.6	1.28	1.32	1.06	731	17.66	18.56	0.00	610.3
07/22/98	15.3	27.5	3.1	10.9	13.3	65.4	1.67	1.79	1.15	712	17.83	18.80	0.00	610.6
07/23/98	16.6	28.2	5.2	10.9	13.9	62.5	1.65	1.80	1.20	708	18.11	19.09	0.00	611.0
07/24/98	16.8	24.2	11.3	10.9	14.9	73.5	1.54	1.46	0.90	455	12.12	12.77	0.04	610.6
07/25/98	16.8	26.7	6.3	11.0	14.3	65.3	1.75	2.12	1.53	701	18.43	19.45	0.00	611.1
07/26/98	17.2	29.0	6.0	11.0	14.5	64.4	1.61	1.72	1.14	684	17.81	18.78	0.00	611.0
07/27/98	18.3	28.5	7.9	11.1	14.9	66.4	2.32	2.25	0.94	635	17.28	18.30	0.33	611.0
07/28/98	14.9	19.2	11.0	11.2	14.4	85.5	2.01	2.32	1.36	244	5.96	6.30	0.81	610.6
07/29/98	14.0	24.1	5.0	11.2	13.3	77.8	1.47	1.65	1.28	541	14.54	15.31	0.00	610.7
07/30/98	12.3	21.8	5.3	11.2	12.7	84.1	1.68	1.96	1.41	277	6.59	6.95	0.06	609.7
07/31/98	12.3	20.0	3.9	11.1	12.4	75.8	2.15	3.06	2.47	475	12.31	13.02	0.01	610.9
08/01/98	12.7	18.7	6.1	11.0	12.4	79.6	1.32	1.66	1.70	348	9.02	9.48	0.00	610.9
08/02/98	15.1	21.2	7.7	11.0	13.5	75.6	1.28	1.98	3.38	377	9.99	10.50	0.00	611.4
08/03/98	13.9	24.4	2.1	11.0	12.5	70.1	1.50	1.76	1.43	674	18.15	19.11	0.00	610.4
08/04/98	15.9	29.5	2.8	11.0	13.0	61.0	1.37	1.17	0.75	686	17.60	18.52	0.00	610.6
08/05/98	16.5	30.5	1.8	11.0	12.9	56.6	1.26	1.13	0.81	669	16.81	17.66	0.00	610.6
08/06/98	17.0	29.6	5.4	11.0	13.5	58.2	2.37	2.96	1.66	524	12.98	13.74	0.05	610.9
08/07/98	16.3	25.8	7.9	11.0	14.1	70.3	2.24	2.82	1.69	534	14.00	14.82	0.04	611.0
08/08/98	14.3	26.0	2.6	11.0	12.7	60.5	1.44	1.47	1.04	655	16.59	17.46	0.00	610.2

Date	Avg Air Temp z = 6.5 ft (°C)	Max Air Temp (°C)	Min Air Temp (°C)	Avg Subsurface Soil Temp z = -2.0 ft (°C)	Avg Surface Soil Temp z = 0.2 ft (°C)	Avg Relative Humidity (%)	Avg Wind Speed (m/sec)	Avg Daytime Wind Spd 7 am - 7 pm (m/sec)	Day/Night Wind Speed Ratio	Avg Solar Radiation (cal/cm²/day)	Net Radiation (MJ/m²/day)	Wind Corrected Net Radiation (MJ/m²/day)	Precip (in/day)	Barometric Pressure (mm Hg)
08/09/98	14.5	27.0	0.9	11.0	12.2	57.7	2.24	2.30	1.06	527	13.16	13.92	0.00	610.4
08/10/98	15.7	26.9	2.2	10.9	13.2	58.0	1.39	1.26	0.83	643	16.17	17.02	0.00	610.5
08/11/98	15.3	27.5	1.1	10.9	12.6	57.5	1.43	1.54	1.16	604	15.09	15.88	0.00	610.4
08/12/98	16.8	27.9	4.0	10.9	13.8	58.2	1.63	1.13	0.53	636	15.87	16.73	0.00	611.0
08/13/98	16.1	29.9	3.1	11.0	13.4	62.0	1.43	1.50	1.11	625	15.80	16.63	0.00	610.7
08/14/98	16.8	28.2	2.6	11.0	14.0	53.9	1.92	2.38	1.63	630	15.85	16.75	0.00	610.6
08/15/98	14.2	26.0	1.9	11.0	12.6	58.7	1.55	1.81	1.41	502	11.96	12.60	0.07	610.4
08/16/98	13.7	25.2	2.2	11.0	12.4	62.8	2.78	4.02	2.62	514	12.64	13.40	0.01	610.4
08/17/98	10.6	21.3	-0.9	10.9	10.9	66.2	1.46	1.66	1.30	426	10.36	10.90	0.00	610.5
08/18/98	10.9	22.1	-1.5	10.8	11.0	60.3	1.71	2.21	1.83	561	13.95	14.72	0.00	610.3
08/19/98	11.6	24.6	-3.0	10.7	10.7	55.4	1.52	1.53	1.02	618	15.25	16.06	0.00	610.5
08/20/98	15.0	24.6	1.8	10.6	12.3	51.9	2.94	3.01	1.05	406	9.17	9.73	0.00	610.9
08/21/98	11.5	20.7	0.9	10.6	11.2	69.1	1.81	2.20	1.55	306	6.63	7.00	0.11	610.2
08/22/98	11.1	22.6	-1.0	10.6	10.8	64.1	1.82	2.12	1.40	543	13.58	14.33	0.01	610.5
08/23/98	9.6	23.1	-2.0	10.5	9.7	63.1	1.99	2.81	2.37	504	12.25	12.94	0.00	610.5
08/24/98	8.9	21.6	-3.0	10.4	9.7	64.4	1.35	1.50	1.24	590	14.75	15.51	0.00	610.4
08/25/98	10.3	25.5	-3.0	10.2	10.1	59.8	1.55	1.61	1.08	578	14.05	14.80	0.00	610.2
08/26/98	11.1	23.2	-1.2	10.2	10.2	55.6	1.76	2.06	1.41	492	11.29	11.91	0.00	610.3
08/27/98	11.2	24.9	-3.1	10.1	10.5	54.9	1.48	1.43	0.93	571	13.28	13.98	0.00	610.3
08/28/98	12.0	27.7	-2.0	10.1	10.9	52.5	1.23	1.14	0.86	571	13.01	13.66	0.00	610.2
08/29/98	12.7	29.7	-2.6	10.1	10.8	50.0	1.32	1.33	1.02	475	10.81	11.36	0.00	610.1
08/30/98	13.6	27.3	1.8	10.1	12.1	49.6	1.57	1.66	1.13	569	13.12	13.83	0.00	610.4
08/31/98	13.0	28.7	-2.4	10.2	11.6	48.7	1.29	0.98	0.61	559	12.61	13.26	0.00	610.3
09/01/98	13.7	29.3	-0.8	10.2	12.0	51.1	1.48	1.53	1.07	532	12.32	12.97	0.00	610.1
09/02/98	14.7	29.2	0.5	10.2	12.4	45.0	2.00	2.35	1.43	520	11.76	12.42	0.00	610.1
09/03/98	13.7	29.5	-1.1	10.3	11.8	45.0	1.43	1.28	0.81	529	11.71	12.32	0.00	610.4
09/04/98	14.4	30.2	0.6	10.3	12.4	49.6	1.40	1.24	0.79	520	11.52	12.13	0.00	610.2
09/05/98	15.1	29.4	2.1	10.4	12.5	48.1	1.29	1.44	1.27	391	9.10	9.56	0.00	610.2
09/06/98	16.8	25.5	10.6	10.4	14.8	72.5	1.89	2.23	1.44	352	9.07	9.58	0.16	610.2
09/07/98	14.4	26.4	4.9	10.6	13.0	74.3	1.59	2.05	1.82	375	9.02	9.50	0.11	610.4
09/08/98	11.6	18.8	6.2	10.7	12.2	87.1	1.75	2.17	1.63	192	4.80	5.06	0.42	610.2
09/09/98	12.1	20.3	5.6	10.6	12.0	84.7	1.70	1.93	1.30	298	8.26	8.71	0.59	610.5
09/10/98	11.8	17.7	7.9	10.6	11.9	81.8	1.40	1.64	1.41	265	6.96	7.32	0.66	610.0
09/11/98	10.8	20.9	3.9	10.6	11.5	80.1	1.33	1.48	1.26	322	8.32	8.75	0.00	610.0
09/12/98	11.8	20.6	5.4	10.6	11.9	76.3	1.22	1.42	1.40	357	8.63	9.06	0.00	610.3
09/13/98	10.4	22.5	-0.3	10.6	10.5	67.3	1.28	1.46	1.33	501	11.72	12.31	0.01	610.4
09/14/98	11.2	25.3	-0.9	10.5	10.1	64.5	1.26	1.04	0.70	498	10.85	11.40	0.00	610.4
09/15/98	12.6	26.7	1.5	10.4	10.5	62.3	1.22	1.16	0.91	495	11.31	11.88	0.00	610.2
09/16/98	12.5	25.9	1.5	10.3	10.5	65.8	1.62	1.81	1.25	342	7.46	7.87	0.00	610.5
09/17/98	12.3	23.7	2.6	10.3	10.7	64.4	2.08	2.48	1.48	304	7.03	7.43	0.00	610.1
09/18/98	11.6	19.5	4.5	10.3	10.9	55.5	2.87	4.02	2.32	452	10.52	11.15	0.00	610.8
09/19/98	5.9	11.4	2.3	10.3	8.8	77.7	1.48	2.14	2.59	284	6.77	7.13	0.14	609.6

Date	Avg Air Temp z = 6.5 ft (°C)	Max Air Temp (°C)	Min Air Temp (°C)	Avg Subsurface Soil Temp z = -2.0 ft (°C)	Avg Surface Soil Temp z = 0.2 ft (°C)	Avg Relative Humidity (%)	Avg Wind Speed (m/sec)	Avg Daytime Wind Spd 7 am - 7 pm (m/sec)	Day/Night Wind Speed Ratio	Avg Solar Radiation (cal/cm²/day)	Net Radiation (MJ/m²/day)	Wind Corrected Net Radiation (MJ/m²/day)	Precip (in/day)	Barometric Pressure (mm Hg)
09/20/98	4.2	9.5	-0.6	10.1	7.4	87.5	1.17	1.25	1.14	182	4.21	4.42	0.08	609.9
09/21/98	3.8	14.9	-4.1	9.9	7.1	77.4	1.21	1.06	0.79	377	9.04	9.50	0.01	609.6
09/22/98	4.2	14.4	-6.3	9.6	5.8	71.6	1.12	0.87	0.64	281	6.09	6.39	0.00	610.0
09/23/98	5.5	17.8	-5.3	9.4	6.4	68.3	1.15	1.22	1.13	451	10.33	10.84	0.00	610.2
09/24/98	6.6	18.9	-3.0	9.2	6.8	65.6	1.90	1.85	0.94	447	9.45	9.98	0.01	610.3
09/25/98	4.4	9.0	0.3	9.1	6.5	87.0	1.69	2.13	1.71	108	2.12	2.23	0.16	609.1
09/26/98	5.5	12.3	-1.1	9.0	7.1	81.1	1.20	1.50	1.66	245	5.83	6.12	0.00	609.7
09/27/98	4.9	18.9	-6.0	8.9	5.6	74.0	1.27	1.30	1.05	424	10.29	10.81	0.01	610.1
09/28/98	7.2	18.7	-3.8	8.8	6.6	70.0	1.35	1.51	1.28	363	8.02	8.44	0.01	610.4

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Middle Big Hole Basin

Station Name: Weather Station at Troutfitters Shop, northwest of Wise River
Station ID: PG-3
Location Description: On porch of west house, 2.1 mi northwest of Wise River, Montana, 0.1 mi north of Hwy 43
Township, Range, Section, Tract: 01N11W29DBBC
Latitude: N45°48'22" Longitude: W112°59'36"
Elevation: 5,635 ft
Equipment: Davis Weather Monitoring System with Anemometer, Air Temperature Sensor, and 4"-Dia. Rain Collector
Comments: Mounted on porch railing, about 8 ft above ground surface

Date	Daily High Air Temp (°F)	Daily Low Air Temp (°F)	Daily Average Wind Velocity (mph)	Daily Precipitation (in)	Comments
4/1/98	57	23	11	0.03	
4/2/98	56	28	17	--	
4/3/98	--	--	--	--	No data
4/4/98	--	--	--	--	No data
4/5/98	55	29	18	0.45	
4/6/98	43	29	12	0.09	
4/7/98	46	27	16	--	
4/8/98	50	23	20	--	
4/9/98	48	24	16	0.03	
4/10/98	47	33	19	0.23	
4/11/98	49	30	19	--	
4/12/98	45	20	23	0.02	
4/13/98	43	21	18	--	
4/14/98	42	29	27	--	
4/15/98	44	21	19	0.04	
4/16/98	47	26	22	0.01	
4/17/98	45	21	22	0.01	
4/18/98	52	29	22	--	
4/19/98	48	20	18	--	
4/20/98	66	23	13	0.01	
4/21/98	70	25	16	--	
4/22/98	78	32	17	--	
4/23/98	79	10	21	0.09	
4/24/98	47	29	30	0.18	
4/25/98	43	18	22	--	
4/26/98	60	22	18	--	
4/27/98	71	26	19	--	
4/28/98	73	27	9	--	
4/29/98	73	25	22	--	
4/30/98	79	23	21	--	
5/1/98	78	27	13	--	
5/2/98	78	27	29	--	
5/3/98	72	36	21	--	
5/4/98	74	31	16	--	
5/5/98	72	29	17	0.01	
5/6/98	71	33	20	--	

Date	Daily High Air Temp (°F)	Daily Low Air Temp (°F)	Daily Average Wind Velocity (mph)	Daily Precipitation (in)	Comments
5/7/98	69	35	25	0.01	
5/8/98	74	25	21	--	
5/9/98	--	--	--	--	No data
5/10/98	64	27	24	--	
5/11/98	63	23	15	--	
5/12/98	67	31	21	0.04	
5/13/98	57	32	17	0.12	
5/14/98	56	34	24	0.04	
5/15/98	53	22	23	--	
5/16/98	61	34	22	0.24	
5/17/98	53	33	32	0.01	
5/18/98	55	22	17	--	
5/19/98	69	28	20	0.01	
5/20/98	72	35	27	--	
5/21/98	56	38	17	0.32	
5/22/98	46	34	14	0.48	
5/23/98	55	31	17	0.04	
5/24/98	65	32	13	0.01	
5/25/98	70	38	23	--	
5/26/98	72	35	25	0.03	
5/27/98	56	28	27	--	
5/28/98	68	29	13	--	
5/29/98	71	35	24	0.18	
5/30/98	58	32	18	0.21	
5/31/98	65	38	32	--	
6/1/98	69	43	25	--	
6/2/98	69	35	25	0.07	
6/3/98	50	32	18	--	
6/4/98	65	25	21	--	
6/5/98	62	30	24	0.01	
6/6/98	63	37	20	0.07	
6/7/98	57	40	15	--	
6/8/98	--	--	--	--	No data
6/9/98	69	35	25	--	
6/10/98	56	43	12	0.07	
6/11/98	69	40	13	0.11	
6/12/98	69	40	18	0.03	
6/13/98	67	42	26	0.06	
6/14/98	63	37	21	0.01	
6/15/98	60	37	27	0.06	
6/16/98	50	37	27	0.19	
6/17/98	61	36	12	0.01	
6/18/98	66	43	24	0.15	
6/19/98	66	42	24	0.25	
6/20/98	--	--	--	--	No data
6/21/98	73	34	25	0.41	

Date	Daily High Air Temp (°F)	Daily Low Air Temp (°F)	Daily Average Wind Velocity (mph)	Daily Precipitation (in)	Comments
6/22/98	--	--	--	0.11	
6/23/98	66	36	29	0.05	
6/24/98	--	--	--	0.01	
6/25/98	67	44	31	0.31	
6/26/98	--	--	--	--	No data
6/27/98	--	--	--	--	No data
6/28/98	--	--	--	--	No data
6/29/98	--	--	--	--	No data
6/30/98	--	--	--	--	No data
7/1/98	--	--	--	--	No data
7/2/98	--	--	--	--	No data
7/3/98	--	--	--	--	No data
7/4/98	--	--	--	--	No data
7/5/98	--	--	--	--	No data
7/6/98	--	--	--	--	No data
7/7/98	--	--	--	--	No data
7/8/98	--	--	--	--	No data
7/9/98	--	--	--	--	No data
7/10/98	--	--	--	--	No data
7/11/98	--	--	--	--	No data
7/12/98	--	--	--	--	No data
7/13/98	--	--	--	--	No data
7/14/98	89	50	42	0.00	
7/15/98	92	--	--	--	
7/16/98	94	44	14	0.00	Cumulative Precip to 7/16/98 was 7.82 inches
7/17/98	96	46	20	0.00	
7/18/98	94	47	19	0.00	
7/19/98	95	44	22	0.00	
7/20/98	89	36	21	0.00	
7/21/98	94	37	20	0.00	
7/22/98	--	--	--	--	No data
7/23/98	98	44	12	0.08	
7/24/98	82	45	13	0.04	
7/25/98	89	45	14	0.00	
7/26/98	96	53	11	0.00	
7/27/98	86	52	20	0.01	
7/28/98	79	45	18	0.01	
7/29/98	84	51	23	0.11	
7/30/98	72	43	17	0.02	
7/31/98	74	41	20	0.15	
8/1/98	73	51	17	0.02	
8/2/98	76	42	17	0.00	
8/3/98	80	40	12	0.00	
8/4/98	94	40	12	0.00	
8/5/98	93	41	16	0.00	

Date	Daily High Air Temp (°F)	Daily Low Air Temp (°F)	Daily Average Wind Velocity (mph)	Daily Precipitation (in)	Comments
8/6/98	90	48	43	0.04	
8/7/98	85	42	17	0.14	
8/8/98	--	--	--	--	No data
8/9/98	89	40	23	0.00	
8/10/98	--	--	--	--	No data
8/11/98	88	40	19	0.00	
8/12/98	91	42	15	0.00	
8/13/98	91	44	18	0.00	
8/14/98	--	--	--	0.00 est	No data
8/15/98	89	39	28	0.13	
8/16/98	89	36	18	0.00	
8/17/98	75	35	18	0.00	
8/18/98	80	33	23	0.00	
8/19/98	77	36	12	0.13	
8/20/98	81	36	18	0.01	
8/21/98	78	37	37	0.27	
8/22/98	78	33	22	0.00	
8/23/98	79	31	32	0.00	
8/24/98	--	--	--	0.00 est	No data
8/25/98	84	31	32	0.00	
8/26/98	79	33	21	0.00	
8/27/98	82	33	23	0.00	
8/28/98	87	33	11	0.00	
8/29/98	87	33	15	0.00	
8/30/98	88	34	12	0.00	
8/31/98	88	35	19	0.00	
9/1/98	92	35	19	0.00	
9/2/98	88	35	24	0.00	
9/3/98	89	35	24	0.00	
9/4/98	92	38	12	0.00	
9/5/98	87	41	12	0.00	
9/6/98	82	44	17	0.01	
9/7/98	82	44	9	0.03	
9/8/98	68	43	21	0.01	
9/9/98	69	48	34	0.62	
9/10/98	66	43	13	0.14	
9/11/98	73	42	14	0.01	
9/12/98	72	36	12	0.00	
9/13/98	75	35	20	0.00	
9/14/98	78	35	13	0.00	
9/15/98	80	38	10	0.00	
9/16/98	78	37	25	0.00	
9/17/98	83	39	17	0.00	
9/18/98	70	41	31	0.11	
9/19/98	55	36	21	0.06	
9/20/98	54	30	21	0.01	

Date	Daily High Air Temp (°F)	Daily Low Air Temp (°F)	Daily Average Wind Velocity (mph)	Daily Precipitation (in)	Comments
9/21/98	61	25	11	0.00	
9/22/98	59	25	11	0.00	
9/23/98	66	28	12	0.00	
9/24/98	67	34	17	0.00	
9/25/98	53	40	13	0.02	
9/26/98	61	28	12	0.00	
9/27/98	67	30	17	0.01	
9/28/98	69	31	15	0.00	
9/29/98	71	31	15	0.00	
9/30/98	--	--	--	--	No data
10/1/98	68	26	16	0.00	
10/2/98	53	27	22	0.07	
10/3/98	51	27	16	0.00	
10/4/98	47	16	19	0.00	
10/5/98	55	16	27	0.00	
10/6/98	70	23	16	0.00	
10/7/98	--	--	--	--	No data
10/8/98	63	21	23	0.00	
10/9/98	63	21	23	0.00	
10/10/98	63	21	23	0.00	
10/11/98	--	--	--	--	No data
10/12/98	--	--	--	--	No data
10/13/98	--	--	--	--	No data
10/14/98	64	23	24	0.06	
10/15/98	--	--	--	--	No data
10/16/98	43	16	13	0.02	
10/17/98	51	19	19	0.00	
10/18/98	52	19	19	0.00	
10/19/98	53	16	12	0.00	
10/20/98	57	16	12	0.00	
10/21/98	62	17	15	0.00	
10/22/98	53	27	10	0.00	
10/23/98	55	22	16	0.00	
10/24/98	59	28	10	0.00	
10/25/98	60	22	11	0.00	
10/26/98	58	21	15	0.00	
10/27/98	60	21	15	0.00	
10/28/98	50	15	20	0.00	
10/29/98	50	11	20	0.00	
10/30/98	50	11	20	0.00	
10/31/98	50	21	8	0.00	

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Lower Big Hole Basin

Station Name: Precipitation Gage at Pendergast Ranch, north of Melrose
Station ID: PG-4
Location Description: In yard between easternmost houses, 2.0 mi north of Melrose, 0.2 mi east of frontage road
Township, Range, Section, Tract: 02S09W14CBAC
Latitude: N45°39'44" Longitude: W112°41'11"
Elevation: 5,230 ft
Equipment: 8" diameter PVC pipe, non-toxic anti-freeze mixed with liquid catch to inhibit ice formation, vegetable oil at liquid-air interface to reduce evaporative loss
Comments: Surrounded by grass lawn

Date	Precipitation Between Measurements (in)	Cumulative Precipitation (in)	Comments
11/5/97	--	0.00	Initial set-up
11/24/97	0.19	0.19	
1/5/98	0.31	0.50	
1/26/98	0.75	1.25	
2/1/98	0.06	1.31	
2/13/98	0.06	1.38	
2/23/98	0.25	1.63	
2/28/98	0.00	1.63	
3/6/98	0.25	1.88	
3/25/98	0.25	2.13	
3/27/98	0.00	2.13	
4/7/98	0.75	2.88	
4/13/98	0.50	3.38	
4/27/98	0.31	3.69	
5/15/98	0.19	3.88	
5/29/98	1.69	5.57	
5/30/98	0.31	5.88	
6/14/98	0.25	6.13	
6/20/98	0.88	7.01	
6/22/98	0.25	7.26	
6/25/98	0.13	7.38	
7/9/98	0.44	7.82	
8/11/98	0.64	8.46	Sprinkler affected gage. Precip estimated
8/27/98	1.25	9.71	
9/9/98	0.75	11.21	Sprinkler affected gage. Precip estimated
9/30/98	0.50	11.71	
10/28/98	0.00	11.71	End of record

Station Name: Precipitation Gage at Lattin home, west of Melrose
Station ID: PG-5
Location Description: About 10 ft northeast of hedge corner north of house, 0.2 mi west of Melrose
Township, Range, Section, Tract: 02S09W26CCCD
Latitude: N45°37'39" Longitude: W112°41'17"
Elevation: 5,165 ft
Equipment: 8" diameter PVC pipe, non-toxic anti-freeze mixed with liquid catch to inhibit ice formation, vegetable oil at liquid-air interface to reduce evaporative loss
Comments: Surrounded by grass lawn

Date	Precipitation Between Measurements (in)	Cumulative Precipitation (in)	Comments
11/5/97	--	0.00	Initial set-up
11/24/97	0.13	0.13	
12/17/97	0.25	0.38	
12/31/97	0.06	0.44	
1/14/98	0.56	1.00	
1/21/98	0.25	1.25	
1/26/98	0.00	1.25	
2/3/98	0.00	1.25	
2/18/98	0.13	1.38	
2/23/98	0.19	1.56	
2/27/98	0.06	1.63	
3/5/98	0.25	1.88	
3/12/98	0.00	1.88	
3/25/98	0.25	2.13	
4/1/98	0.00	2.13	
4/8/98	0.88	3.00	
4/15/98	0.25	3.25	
4/21/98	0.13	3.38	
4/27/98	0.13	3.50	
5/6/98	0.00	3.50	
5/29/98	1.90	5.40	Gage knocked over. Precip estimated
6/3/98	0.88	6.28	
6/13/98	0.25	6.53	
6/17/98	0.50	7.03	
6/25/98	0.25	7.28	
7/9/98	0.38	7.65	
7/22/98	0.38	8.03	
7/28/98	0.00	8.03	
8/5/98	0.13	8.15	
8/11/98	0.13	8.28	
8/27/98	1.13	9.40	
9/9/98	0.75	10.15	
9/30/98	0.13	10.28	
10/28/98	0.00	10.28	End of record

Station Name: Precipitation Gage at Shoestring Ranch, south of Melrose
Station ID: PG-6
Location Description: Between coral fence and fueling area, 1.7 mi southeast of Melrose, 0.35 mi east of frontage road
Township, Range, Section, Tract: 03S09W02DAAA
Latitude: N45°36'20" Longitude: W112°40'11"
Elevation: 5,190 ft
Equipment: 8" diameter PVC pipe, non-toxic anti-freeze mixed with liquid catch to inhibit ice formation, vegetable oil at liquid-air interface to reduce evaporative loss
Comments: Surrounded by 1-2 ft tall grassl

Date	Precipitation Between Measurements (in)	Cumulative Precipitation (in)	Comments
11/24/97	--	0.00	Initial set-up
12/30/97	0.44	0.44	
1/26/98	0.69	1.13	
2/23/98	0.31	1.44	
3/25/98	0.50	1.94	
4/27/98	1.56	3.50	
5/15/98	0.25	3.75	
5/29/98	1.69	5.44	
6/13/98	1.06	6.50	
6/25/98	0.69	7.19	
7/13/98	0.56	7.75	
7/28/98	0.06	7.82	
8/11/98	0.38	8.19	
8/27/98	0.25	8.44	
9/9/98	0.19	8.63	
9/30/98	0.81	9.44	
10/28/98	0.13	9.57	End of record

Station Name: Precipitation Gage at Kalsta Ranch, north of Glen
Station ID: PG-7
Location Description: In parking area south of ranch house, 3.4 mi north of Glen, 0.1 mi east of Big Hole River
Township, Range, Section, Tract: 03S09W34DCCA
Latitude: N45°31'36" Longitude: W112°41'54"
Elevation: 5,060 ft
Equipment: 8" diameter PVC pipe, non-toxic anti-freeze mixed with liquid catch to inhibit ice formation, vegetable oil at liquid-air interface to reduce evaporative loss
Comments: Located on edge of gravel park area

Date	Precipitation Between Measurements (in)	Cumulative Precipitation (in)	Comments
11/5/97	--	0.00	
11/19/97	0.06	0.06	
11/24/97	0.13	0.19	
11/25/97	0.44	0.63	
12/1/97	0.13	0.75	
1/5/98	0.13	0.88	
1/19/98	0.63	1.5	
1/26/98	0	1.5	
2/21/98	0.13	1.63	
2/23/98	0.13	1.75	
2/25/98	0	1.75	Snow and little rain
3/1/98	0.5	2.25	
3/11/98	0	2.25	
3/18/98	0	2.25	Snowed on the 17th and 18th
3/25/98	0.13	2.38	
4/5/98	0.63	3	Rain/snow
4/6/98	0.25	3.25	Rain/snow
4/11/98	0.38	3.63	Rain
4/12/98	0.13	3.75	Rain/snow
4/15/98	0.06	3.81	Rain/snow
4/27/98	0	3.81	
5/16/98	0.44	4.25	End of record

Station Name: Precipitation Gage at Smith Ranch near Glen
Station ID: PG-8
Location Description: On lawn east of ranch house, 0.2 mi northwest of Glen, 0.85 mi east of I-15
Township, Range, Section, Tract: 04S09W22AABB
Latitude: N45°28'51" Longitude: W112°41'42"
Elevation: 4,990 ft
Equipment: 8" diameter PVC pipe, non-toxic anti-freeze mixed with liquid catch to inhibit ice formation, vegetable oil at liquid-air interface to reduce evaporative loss
Comments: Surrounded by grass lawn

Date	Precipitation Between Measurements (in)	Cumulative Precipitation (in)	Comments
1/5/98	--	0.00	Initial set-up
1/11/98	0.25	0.25	
1/19/98	0.13	0.38	
1/26/98	0.13	0.50	
2/16/98	0.00	0.50	
2/23/98	0.13	0.63	
3/2/98	0.00	0.63	
3/9/98	0.25	0.88	
3/16/98	0.00	0.88	
3/24/98	0.25	1.13	
3/26/98	0.00	1.13	
3/30/98	0.00	1.13	
4/6/98	0.25	1.38	
4/15/98	1.31	2.69	
4/21/98	0.00	2.69	
4/27/98	0.00	2.69	
4/28/98	0.00	2.69	
5/5/98	0.06	2.75	
5/16/98	0.13	2.88	
5/18/98	0.12	3.00	
5/25/98	1.00	4.00	
5/28/98	0.13	4.13	
6/1/98	0.38	4.51	
6/8/98	0.50	5.00	
6/14/98	0.19	5.19	
6/16/98	0.19	5.38	
6/22/98	0.38	5.76	
6/27/98	0.63	6.38	
7/14/98	0.06	6.44	
7/20/98	0.00	6.44	
7/27/98	0.00	6.44	
7/29/98	0.25	6.69	
8/3/98	0.25	6.94	
8/10/98	0.13	7.07	
8/11/98	0.00	7.07	
8/18/98	0.00	7.07	
8/17/98	0.00	7.07	
8/18/98	0.00	7.07	
8/24/98	0.00	7.07	
8/27/98	0.00	7.07	
9/9/98	0.25	7.32	
9/11/98	0.50	7.82	
9/21/98	0.00	7.82	
9/30/98	0.06	7.88	
10/28/98	0.06	7.94	End of record

Station Name: Precipitation Gage at South End of Kalsta Ranch
Station ID: PG-9
Location Description: 10 ft south of National Weather Service's Glen station, 1.8 mi southeast of Glen, 0.14 mi north of Burma Road
Township, Range, Section, Tract: 04S09W24DCAD
Latitude: N45°28'07" Longitude: W112°39'16"
Elevation: 4,960 ft
Equipment: 8" diameter PVC pipe, non-toxic anti-freeze mixed with liquid catch to inhibit ice formation, vegetable oil at liquid-air interface to reduce evaporative loss
Comments: Surrounded by dry grass lawn

Date	Precipitation Between Measurements (in)	Cumulative Precipitation (in)	Comments
11/24/97	--	0.00	Initial set-up
11/25/97	0.50	0.50	
12/9/97	0.13	0.63	
12/29/97	0.00	0.63	
1/15/98	0.38	1.00	
1/17/98	0.13	1.13	
1/22/98	0.13	1.25	
1/26/98	0.13	1.38	
2/5/98	0.00	1.38	
2/23/98	0.13	1.50	
3/14/98	0.50	2.00	
3/23/98	0.00	2.00	
3/26/98	0.06	2.06	
4/9/98	0.69	2.75	
4/21/98	0.50	3.25	
4/28/98	0.00	3.25	
5/16/98	0.25	3.50	End of record

Station Name: Temperature Datalogger at South End of Kalsta Ranch
Station ID: PG-9
Location Description: National Weather Service's Glen station, 1.8 mi southeast of Glen, 0.14 mi north of Burma Road
Township, Range, Section, Tract: 04S09W24DCAD
Latitude: N45°28'07" Longitude: W112°39'16"
Elevation: 4,960 ft
Equipment: Hobo Temperature Datalogger
Comments: Datalogger placed inside white NWS shelter. Estimated values are based on regressions relating temperatures recorded at this station to those recorded at the Dillon AgriMet Station (DLNM)

Date	Daily Maximum Temperature (°F)	Daily Maximum Temperature (°C)	Daily Minimum Temperature (°F)	Daily Minimum Temperature (°C)	Daily Average Temperature (°F)	Daily Average Temperature (°C)	Comments
04/01/98	55	13.0	23	-5.3	39	3.9	
04/02/98	58	14.5	26	-3.3	42	5.6	
04/03/98	55	12.6	35	1.5	45	7.1	
04/04/98	57	14.1	29	-1.4	43	6.3	
04/05/98	40	4.4	32	0.1	36	2.2	
04/06/98	39	4.0	32	-0.2	35	1.9	
04/07/98	47	8.4	29	-1.9	38	3.2	
04/08/98	46	7.6	26	-3.3	36	2.2	
04/09/98	53	11.4	29	-1.4	41	5.0	
04/10/98	53	11.4	26	-3.3	39	4.1	
04/11/98	49	9.2	36	2.3	42	5.7	
04/12/98	38	3.2	30	-1.0	34	1.1	
04/13/98	44	6.4	24	-4.3	34	1.1	
04/14/98	44	6.4	25	-3.8	34	1.3	
04/15/98	40	4.4	31	-0.6	35	1.9	
04/16/98	49	9.2	29	-1.9	39	3.6	
04/17/98	46	8.0	27	-2.8	37	2.6	
04/18/98	55	13.0	21	-6.3	38	3.4	
04/19/98	53	11.4	32	-0.2	42	5.6	
04/20/98	59	15.3	24	-4.3	42	5.5	
04/21/98	68	19.8	24	-4.3	46	7.8	
04/22/98	72	22.0	29	-1.9	50	10.0	
04/23/98	71	21.7	36	2.3	54	12.0	
04/24/98	52	11.0	36	2.3	44	6.7	
04/25/98	50	10.0	34	1.0	42	5.5	
04/26/98	55	12.6	21	-6.3	38	3.2	
04/27/98	65	18.2	24	-4.3	45	7.0	
04/28/98	69	20.5	30	-1.0	49	9.7	
04/29/98	77	24.9	30	-1.1	53	11.9	
04/30/98	74	23.3	31	-0.3	53	11.5	
05/01/98	72	22.2	37	2.7	54	12.4	
05/02/98	77	24.9	32	0.2	55	12.5	
05/03/98	76	24.5	39	3.9	58	14.2	
05/04/98	73	22.9	45	7.2	59	15.1	
05/05/98	76	24.5	33	0.5	54	12.5	

Date	Daily Maximum Temperature (°F)	Daily Maximum Temperature (°C)	Daily Minimum Temperature (°F)	Daily Minimum Temperature (°C)	Daily Average Temperature (°F)	Daily Average Temperature (°C)	Comments
05/06/98	73	22.5	40	4.3	56	13.4	
05/07/98	75	24.1	38	3.6	57	13.8	
05/08/98	71	21.4	37	3.1	54	12.2	
05/09/98	69	20.3	33	0.5	51	10.4	
05/10/98	65	18.3	45	7.2	55	12.8	
05/11/98	66	19.1	39	3.9	53	11.5	
05/12/98	64	17.9	31	-0.7	48	8.6	
05/13/98	60	15.4	41	4.7	50	10.1	
05/14/98	60	15.8	41	5.1	51	10.5	
05/15/98	59	15.0	37	2.7	48	8.8	
05/16/98	61	16.1	29	-1.6	45	7.2	
05/17/98	55	12.7	36	2.3	45	7.5	
05/18/98	60	15.8	36	2.3	48	9.0	
05/19/98	71	21.4	29	-1.6	50	9.9	
05/20/98	75	24.1	41	5.1	58	14.6	
05/21/98	57	13.9	44	6.8	51	10.4	
05/22/98	46	8.0	40	4.3	43	6.2	
05/23/98	58	14.3	39	3.9	48	9.1	
05/24/98	65	18.3	35	1.9	50	10.1	
05/25/98	73	22.5	37	2.7	55	12.6	
05/26/98	75	24.1	44	6.8	60	15.5	
05/27/98	60	15.4	36	2.3	48	8.8	
05/28/98	73	22.5	28	-2.1	50	10.2	
05/29/98	72	22.2	35	1.9	54	12.0	
05/30/98	62	16.5	41	5.1	51	10.8	
05/31/98	69	20.6	35	1.9	52	11.2	
06/01/98	73	22.5	41	4.7	57	13.6	
06/02/98	58	14.3	44	6.4	51	10.4	
06/03/98	47	8.4	37	3.1	42	5.7	
06/04/98	58	14.3	38	3.6	48	8.9	
06/05/98	60	15.3	30	-1.1	45	7.1	Estimated
06/06/98	61	15.9	36	2.1	48	9.0	Estimated
06/07/98	58	14.2	42	5.7	50	10.0	Estimated
06/08/98	62	16.4	40	4.5	51	10.5	Estimated
06/09/98	67	19.5	41	5.0	54	12.3	Estimated
06/10/98	64	17.6	43	6.3	53	11.9	Estimated
06/11/98	71	21.8	51	10.8	61	16.3	
06/12/98	69	20.3	48	8.8	58	14.6	
06/13/98	71	21.4	46	7.6	58	14.5	
06/14/98	64	17.9	43	6.0	54	12.0	
06/15/98	64	17.6	41	5.1	52	11.3	
06/16/98	53	11.5	38	3.6	46	7.5	
06/17/98	61	16.1	41	5.1	51	10.6	
06/18/98	69	20.3	38	3.6	53	11.9	
06/19/98	58	14.6	46	7.6	52	11.1	
06/20/98	66	18.7	44	6.8	55	12.8	

Date	Daily Maximum Temperature (°F)	Daily Maximum Temperature (°C)	Daily Minimum Temperature (°F)	Daily Minimum Temperature (°C)	Daily Average Temperature (°F)	Daily Average Temperature (°C)	Comments
06/21/98	73	22.9	37	3.1	55	13.0	
06/22/98	74	23.3	43	6.0	58	14.7	
06/23/98	66	19.1	45	7.2	56	13.2	
06/24/98	70	21.0	40	4.3	55	12.7	
06/25/98	64	17.9	49	9.2	56	13.6	
06/26/98	60	15.4	42	5.5	51	10.5	
06/27/98	69	20.3	40	4.3	54	12.3	
06/28/98	77	24.9	36	2.3	56	13.6	
06/29/98	79	26.4	41	5.1	60	15.8	
06/30/98	81	27.2	51	10.4	66	18.8	
07/01/98	83	28.4	52	11.1	68	19.7	
07/02/98	84	28.8	47	8.4	65	18.6	
07/03/98	84	29.2	58	14.3	71	21.7	
07/04/98	81	27.2	51	10.4	66	18.8	
07/05/98	87	30.4	47	8.4	67	19.4	
07/06/98	87	30.4	49	9.6	68	20.0	
07/07/98	86	29.9	49	9.6	68	19.7	
07/08/98	90	32.3	47	8.4	69	20.4	
07/09/98	90	32.0	46	7.9	68	20.0	Estimated
07/10/98	85	29.6	50	10.3	68	19.9	Estimated
07/11/98	80	26.8	53	11.9	67	19.3	
07/12/98	86	29.9	44	6.8	65	18.3	
07/13/98	90	31.9	46	8.0	68	20.0	
07/14/98	89	31.4	48	8.8	68	20.1	
07/15/98	89	31.4	52	11.1	70	21.3	
07/16/98	94	34.4	49	9.2	71	21.8	
07/17/98	98	36.6	51	10.4	74	23.5	
07/18/98	98	36.9	52	11.1	75	24.0	
07/19/98	97	36.1	55	12.7	76	24.4	
07/20/98	95	35.2	53	11.5	74	23.4	
07/21/98	87	30.8	46	7.6	67	19.2	
07/22/98	85	29.5	49	9.6	67	19.5	
07/23/98	91	32.7	51	10.4	71	21.6	
07/24/98	82	27.6	61	16.1	71	21.8	
07/25/98	90	32.3	52	11.1	71	21.7	
07/26/98	92	33.1	51	10.8	72	22.0	
07/27/98	90	32.3	56	13.5	73	22.9	
07/28/98	73	22.9	56	13.5	65	18.2	
07/29/98	79	26.4	48	8.8	64	17.6	
07/30/98	84	28.8	51	10.4	67	19.6	
07/31/98	83	28.4	51	10.4	67	19.4	
08/01/98	73	22.5	51	10.4	62	16.5	
08/02/98	77	24.9	53	11.5	65	18.2	
08/03/98	80	26.8	52	11.1	66	18.9	
08/04/98	87	30.4	47	8.4	67	19.4	

Date	Daily Maximum Temperature (°F)	(°C)	Daily Minimum Temperature (°F)	(°C)	Daily Average Temperature (°F)	(°C)	Comments
08/05/98	93	33.6	44	6.8	68	20.2	
08/06/98	95	34.8	48	8.8	71	21.8	
08/07/98	90	31.9	56	13.5	73	22.7	
08/08/98	87	30.8	49	9.6	68	20.2	
08/09/98	92	33.1	46	8.0	69	20.6	
08/10/98	87	30.4	51	10.4	69	20.4	
08/11/98	93	33.6	46	7.6	69	20.6	
08/12/98	91	32.7	54	12.3	73	22.5	
08/13/98	94	34.4	49	9.6	72	22.0	
08/14/98	90	31.9	54	12.3	72	22.1	
08/15/98	83	28.4	46	8.0	65	18.2	
08/16/98	86	29.9	46	8.0	66	18.9	
08/17/98	83	28.4	46	8.0	65	18.2	
08/18/98	83	28.4	45	7.2	64	17.8	
08/19/98	82	27.6	44	6.4	63	17.0	
08/20/98	87	30.4	46	8.0	67	19.2	
08/21/98	80	26.8	46	7.6	63	17.2	
08/22/98	82	28.0	42	5.5	62	16.8	
08/23/98	86	29.9	41	4.7	63	17.3	
08/24/98	83	28.4	37	3.1	60	15.7	
08/25/98	87	30.4	38	3.6	63	17.0	
08/26/98	84	29.2	40	4.3	62	16.8	
08/27/98	88	31.2	37	2.7	62	16.9	
08/28/98	90	31.9	38	3.6	64	17.7	
08/29/98	92	33.1	40	4.3	66	18.7	
08/30/98	90	32.3	46	8.0	68	20.2	
08/31/98	92	33.1	42	5.5	67	19.3	
09/01/98	93	33.6	41	5.1	67	19.4	
09/02/98	96	35.7	44	6.4	70	21.1	
09/03/98	93	33.6	41	4.7	67	19.2	
09/04/98	95	34.8	44	6.4	69	20.6	
09/05/98	87	30.8	47	8.4	67	19.6	
09/06/98	88	31.2	58	14.3	73	22.7	
09/07/98	86	29.9	49	9.2	67	19.5	
09/08/98	79	26.0	51	10.8	65	18.4	
09/09/98	76	24.5	49	9.6	63	17.1	
09/10/98	66	19.1	51	10.4	59	14.8	
09/11/98	77	24.9	47	8.4	62	16.7	
09/12/98	66	18.7	48	8.8	57	13.8	
09/13/98	79	26.4	42	5.5	61	16.0	
09/14/98	82	28.0	41	5.1	62	16.6	
09/15/98	86	29.9	42	5.5	64	17.7	

Date	Daily Maximum Temperature (°F)	(°C)	Daily Minimum Temperature (°F)	(°C)	Daily Average Temperature (°F)	(°C)	Comments
09/16/98	86	29.9	43	6.0	64	17.9	
09/17/98	85	29.5	43	6.0	64	17.7	
09/18/98	78	25.7	44	6.8	61	16.3	
09/19/98	65	18.3	45	7.2	55	12.8	
09/20/98	60	15.8	45	7.2	53	11.5	
09/21/98	63	17.3	32	0.2	48	8.7	
09/22/98	64	17.9	31	-0.7	48	8.6	
09/23/98	71	21.4	30	-1.1	50	10.2	
09/24/98	75	24.1	30	-1.1	53	11.5	
09/25/98	61	16.1	36	2.3	48	9.2	
09/26/98	62	16.9	34	1.4	48	9.1	
09/27/98	73	22.5	28	-2.1	50	10.2	
09/28/98	76	24.5	33	0.5	54	12.5	
09/29/98	78	25.3	34	1.4	56	13.3	
09/30/98	69	20.3	33	0.5	51	10.4	
10/01/98	75	23.7	33	0.5	54	12.1	
10/02/98	57	13.9	37	2.7	47	8.3	
10/03/98	51	10.4	33	0.5	42	5.4	
10/04/98	53	11.9	29	-1.6	41	5.1	
10/05/98	59	15.0	20	-6.5	40	4.2	
10/06/98	70	21.0	27	-3.0	48	9.0	
10/07/98	73	22.9	27	-2.5	50	10.2	
10/08/98	71	21.8	29	-1.6	50	10.1	
10/09/98	65	18.3	24	-4.5	44	6.9	
10/10/98	50	10.0	33	0.5	41	5.2	
10/11/98	53	11.9	24	-4.5	39	3.7	
10/12/98	69	20.6	24	-4.5	47	8.1	
10/13/98	70	21.0	36	2.3	53	11.6	
10/14/98	57	13.9	27	-3.0	42	5.4	
10/15/98	41	4.7	35	1.9	38	3.3	
10/16/98	47	8.4	31	-0.7	39	3.8	
10/17/98	53	11.9	20	-6.5	37	2.7	
10/18/98	62	16.5	27	-2.5	45	7.0	
10/19/98	58	14.3	20	-6.5	39	3.9	
10/20/98	61	16.1	18	-8.0	39	4.0	
10/21/98	65	18.3	19	-7.5	42	5.4	
10/22/98	56	13.1	19	-7.0	37	3.1	
10/23/98	56	13.5	29	-1.6	43	5.9	
10/24/98	63	17.3	27	-3.0	45	7.1	
10/25/98	68	19.9	30	-1.1	49	9.4	
10/26/98	64	17.6	24	-4.5	44	6.5	
10/27/98	60	15.8	23	-5.0	42	5.4	
10/28/98	62	16.5	31	-0.4	46	8.0	Estimated
10/29/98	50	9.9	16	-9.1	33	0.4	Estimated
10/30/98	47	8.4	12	-10.9	30	-1.2	Estimated
10/31/98	54	12.5	13	-10.3	34	1.1	Estimated

Station Name: Precipitation Gage at Garrison Ranch, southeast of Glen
Station ID: PG-10
Location Description: 200 ft west of trailer home, 2.4 mi southeast of Glen, 0.45 mi south of Burma Road
Township, Range, Section, Tract: 04S08W30BCCC
Latitude: N45°27'36" Longitude: W112°38'55"
Elevation: 4,940 ft
Equipment: 8" diameter PVC pipe, non-toxic anti-freeze mixed with liquid catch to inhibit ice formation, vegetable oil at liquid-air interface to reduce evaporative loss
Comments: Surrounded by dry grass and sage brush

Date	Precipitation Between Measurements (in)	Cumulative Precipitation (in)	Comments
11/05/97	--	0.00	Initial set-up
11/24/97	0.00	0.00	
12/08/97	0.75	0.75	
01/18/98	0.50	1.25	
01/26/98	0.13	1.38	
02/23/98	0.13	1.50	
03/26/98	0.56	2.06	
04/28/98	1.06	3.13	
05/16/98	0.13	3.25	
05/28/98	1.38	4.63	
06/14/98	1.25	5.88	
06/27/98	1.25	7.13	
07/14/98	0.50	7.63	
07/29/98	0.13	7.75	
08/12/98	0.63	8.38	
08/27/98	0.25	8.63	
09/09/98	0.13	8.75	
09/30/98	0.50	9.25	
10/28/98	0.13	9.38	End of record

Station Name: Precipitation Gage at Old Raffety Ranch, near Notch Bottom
Station ID: PG-11
Location Description: 150 ft southwest of home, 0.4 mi west of Notch Bottom, 0.04 mi south of Burma Road
Township, Range, Section, Tract: 05S08W03ABBD
Latitude: N45°26'09" Longitude: W112°34'31"
Elevation: 4,858 ft
Equipment: 8" diameter PVC pipe, non-toxic anti-freeze mixed with liquid catch to inhibit ice formation, vegetable oil at liquid-air interface to reduce evaporative loss
Comments: Surrounded by grass lawn

Date	Precipitation Between Measurements (in)	Cumulative Precipitation (in)	Comments
11/05/97	--	0.00	Initial set-up
11/23/97	0.12	0.12	
12/1/97	0.75	0.87	
1/5/98	0.00	0.87	
1/8/98	0.25	1.12	
1/12/98	0.25	1.37	
1/20/98	0.25	1.62	
1/26/98	0.00	1.62	
2/23/98	0.13	1.75	
3/26/98	0.56	2.31	
4/28/98	1.38	3.69	
5/16/98	0.25	3.94	
5/28/98	1.81	5.75	
6/14/98	1.25	7.00	Sprinkler affected rain gage. Precip estimated.
6/27/98	1.51	7.26	
7/14/98	0.44	7.69	
7/29/98	0.19	7.88	
8/12/98	1.13	9.01	
8/27/98	0.13	9.13	
9/9/98	0.38	9.51	
9/30/98	0.25	9.76	
10/29/98	0.31	10.07	End of record

Station Name: Precipitation Gage at Mantle Ranch, southeast of Glen
Station ID: PG-12
Location Description: At north end of fenced hay enclosure, 3.0 mi southeast of Glen, 1.9 mi east of I-15
Township, Range, Section, Tract: 05S09W01BBDA
Latitude: N45°26'05" Longitude: W112°39'59"
Elevation: 5,100 ft
Equipment: 8" diameter PVC pipe, non-toxic anti-freeze mixed with liquid catch to inhibit ice formation, vegetable oil at liquid-air interface to reduce evaporative loss
Comments: Surrounded by 2-3 ft tall grass

Date	Precipitation Between Measurements (in)	Cumulative Precipitation (in)	Comments
11/05/97	--	0.00	Initial set-up
11/24/97	0.50	0.50	
12/16/97	0.25	0.75	
12/23/97	0.00	0.75	
1/5/98	0.06	0.81	
1/28/98	0.63	1.44	
2/23/98	0.06	1.50	
3/26/98	0.63	2.13	
4/7/98	0.50	2.63	
4/13/98	0.38	3.00	
4/26/98	0.38	3.38	
4/27/98	0.00	3.38	
5/16/98	0.00	3.38	
5/18/98	0.00	3.38	
5/28/98	1.19	4.57	
6/8/98	0.56	5.13	
6/14/98	0.56	5.69	
6/22/98	0.44	6.13	
6/27/98	0.75	6.88	
7/6/98	0.00	6.88	
7/14/98	0.38	7.26	
7/29/98	0.25	7.51	
8/12/98	0.63	8.13	
8/28/98	0.06	8.19	
9/9/98	0.19	8.38	
9/30/98	0.38	8.76	
10/28/98	0.19	8.94	End of record

Station Name: Precipitation Gage at Marchessault Ranch, near Apex
Station ID: PG-13
Location Description: Northeast of house and east of workshops, 1.65 mi northwest of Apex Exit on I-15, 5.6 mi southwest of Glen
Township, Range, Section, Tract: 05S09W16CABD
Latitude: N45°23'58" Longitude: W112°43'30"
Elevation: 5,450 ft
Equipment: 8" diameter PVC pipe, non-toxic anti-freeze mixed with liquid catch to inhibit ice formation, vegetable oil at liquid-air interface to reduce evaporative loss
Comments: Surrounded by grass lawn

Date	Precipitation Between Measurements (in)	Cumulative Precipitation (in)	Comments
11/24/97	--	0.00	Initial set-up
12/30/97	0.00	0.00	
1/28/98	1.00	1.00	
2/23/98	0.06	1.06	
3/26/98	0.69	1.75	
4/28/98	2.13	3.88	
5/17/98	0.38	4.26	
5/28/98	0.88	5.13	
6/14/98	1.56	6.69	
6/27/98	1.56	8.26	
7/14/98	0.38	8.63	
7/29/98	0.31	8.94	
8/12/98	0.63	9.57	
8/28/98	0.31	9.88	
9/9/98	0.00	9.88	
9/30/98	0.56	10.44	
10/29/98	0.13	10.57	End of record

Station Name: Precipitation Gage at Maynard Smith Ranch, west of Glen
Station ID: PG-14
Location Description: In yard west of house, 1.0 mi southwest of Glen, 0.2 mi east of I-15
Township, Range, Section, Tract: 04S09W22CBDC
Latitude: N45°28'14" Longitude: W112°42'28"
Elevation: 5,030 ft
Equipment: 8" diameter PVC pipe, non-toxic anti-freeze mixed with liquid catch to inhibit ice formation, vegetable oil at liquid-air interface to reduce evaporative loss
Comments: Surrounded by grass lawn

Date	Precipitation Between Measurements (in)	Cumulative Precipitation (in)	Comments
11/05/97	--	0.00	Initial set-up
11/12/97	0.00	0.00	
11/20/97	0.12	0.12	
11/24/97	0.38	0.50	
11/28/97	0.00	0.50	
12/6/97	0.12	0.62	
12/13/97	0.00	0.62	
12/20/97	0.00	0.62	
12/28/97	0.00	0.62	
12/30/97	0.38	1.00	
1/4/98	0.00	1.00	
1/11/98	0.00	1.00	
1/18/98	0.00	1.00	
1/25/98	0.25	1.25	
1/28/98	0.12	1.37	
1/31/98	0.00	1.37	
2/7/98	0.00	1.37	
2/14/98	0.00	1.37	
2/21/98	0.00	1.37	
2/23/98	0.13	1.50	
2/28/98	0.00	1.50	
3/8/98	0.00	1.50	
3/14/98	0.00	1.50	
3/21/98	0.50	2.00	
3/26/98	0.12	2.12	
3/28/98	0.00	2.13	
4/4/98	0.13	2.25	
4/11/98	0.38	2.63	
4/18/98	0.88	3.50	
4/25/98	0.13	3.63	
4/29/98	0.13	3.75	
5/2/98	0.00	3.75	
5/9/98	0.00	3.75	
5/16/98	0.00	3.75	
5/17/98	0.31	4.06	
5/23/98	0.57	4.63	
5/28/98	0.69	5.31	
5/30/98	0.19	5.50	
6/6/98	0.13	5.63	
6/13/98	0.63	6.25	
6/14/98	0.25	6.50	
6/20/98	0.50	7.00	
6/27/98	0.94	7.94	
6/29/98	0.00	7.94	
7/4/98	0.00	7.94	
7/13/98	0.25	8.19	Affected by sprinkler. Precip estimated
7/21/98	0.00	8.19	
7/28/98	0.06	8.25	
7/29/98	0.00	8.25	
8/1/98	0.44	8.69	
8/8/98	0.00	8.69	
8/12/98	0.00	8.69	
8/15/98	0.00	8.69	
8/22/98	0.00	8.69	
8/25/98	0.00	8.69	
8/28/98	0.19	8.88	
9/5/98	0.00	8.88	Affected by sprinkler. Precip estimated
9/9/98	0.30	9.18	Affected by sprinkler. Precip estimated
9/12/98	0.13	9.30	
9/19/98	0.13	9.43	
9/26/98	0.00	9.43	
9/30/98	0.25	9.68	
10/3/98	0.00	9.68	
10/10/98	0.00	9.68	
10/17/98	0.13	9.80	
10/28/98	0.00	9.80	End of record

Station Name: Precipitation Gage at Glen Ranch, northwest of Glen
Station ID: PG-15
Location Description: In hay storage area west of old house, 1.5 mi northwest of Glen, 0.05 mi east of I-15
Township, Range, Section, Tract: 04S09W16AADB
Latitude: N45°29'36" Longitude: W112°42'46"
Elevation: 5,045 ft
Equipment: 8" diameter PVC pipe, non-toxic anti-freeze mixed with liquid catch to inhibit ice formation, vegetable oil at liquid-air interface to reduce evaporative loss
Comments: Surrounded by 2-3 ft tall grass

Date	Precipitation Between Measurements (in)	Cumulative Precipitation (in)	Comments
11/05/97	--	0.00	Initial set-up
11/24/97	0.38	0.38	
12/29/97	0.25	0.63	
01/05/98	0.25	0.88	
01/12/98	0.25	1.13	
01/19/98	0.25	1.38	
01/28/98	0.13	1.50	
02/09/98	0.13	1.63	1" snow prior to reading
02/25/98	0.06	1.69	
03/05/98	0.31	2.00	2" snow prior to reading
03/23/98	0.19	2.19	1" snow plus rain prior to reading
03/26/98	0.00	2.19	
03/27/98	0.13	2.31	
04/06/98	0.56	2.88	
04/13/98	0.75	3.63	
04/16/98	0.13	3.75	
04/29/98	0.13	3.88	
05/17/98	0.25	4.12	
05/21/98	0.50	4.63	
05/25/98	0.50	5.13	
05/27/98	0.25	5.38	
05/28/98	0.00	5.38	
05/30/98	0.38	5.75	
06/03/98	0.12	5.87	
06/07/98	0.50	6.38	
06/14/98	0.06	6.44	
06/17/98	0.31	6.75	
06/27/98	0.44	7.19	
07/11/98	0.25	7.44	
07/13/98	0.00	7.44	
07/28/98	0.06	7.50	
07/29/98	0.13	7.63	
07/31/98	0.25	7.88	
08/01/98	0.25	8.13	
08/12/98	0.00	8.13	
08/27/98	0.00	8.13	
09/09/98	0.31	8.44	
09/09/98	0.31	8.75	
09/10/98	0.13	8.88	
09/18/98	0.38	9.25	
09/30/98	0.00	9.25	
10/28/98	0.13	9.38	End of record

Appendix B

Ground-Water Level Measurements

B - 1 Upper Big Hole basin (including Francis Creek unit)

B - 2 Middle Big Hole basin

B - 3 Lower Big Hole basin

B - 1

Upper Big Hole Basin, including Francis Creek Unit

Ground-Water Level Data: Upper Big Hole Basin including Francis Creek Unit

GWIC ID:	**8977**
1:24k Quad:	PROPOSAL ROCK
TRST:	01S14W18ACDD
Ground Elevation (ft):	5920
MP from Land Surface (ft):	0.0
Total Depth from MP (ft):	53

Date	Depth to Water from MP (ft)
5/9/96	13.00
5/20/96	9.97
7/19/96	13.04
8/21/96	13.76
8/12/97	13.60
7/28/98	13.47

GWIC ID:	**9010**
1:24k Quad:	HIGHLAND RANCH
TRST:	03S16W36ACDA
Ground Elevation (ft):	6176
MP from Land Surface (ft):	0.0
Total Depth from MP (ft):	35

Date	Depth to Water from MP (ft)
9/22/82	4.47
9/23/92	4.70
12/3/92	4.81
3/9/93	3.42
6/4/93	1.44
9/10/93	3.92
12/10/93	5.20
6/15/94	1.54
9/26/94	5.05
3/22/95	3.40
6/26/95	1.61
9/27/95	5.69
12/18/95	5.57
5/9/96	2.50
5/22/96	1.98

GWIC ID: **9010**
(continued)

Date	Depth to Water from MP (ft)
06/17/96	1.04
07/19/96	3.62
08/21/96	4.60
09/23/96	4.46
12/18/96	4.03
06/16/97	1.04
08/12/97	3.95
08/12/97	3.95
05/12/98	1.92
07/15/98	2.76

GWIC ID:	**48852**
1:24k Quad:	PINTLER LAKE
TRST:	01N15W34DDAA
Ground Elevation (ft):	6130
MP from Land Surface (ft):	0.6
Total Depth from MP (ft):	49

Date	Depth to Water from MP (ft)
08/12/97	31.87
01/29/98	32.81
05/12/98	32.85
07/15/98	31.86

GWIC ID: **107203**
1:24k Quad: PINTLER LAKE
TRST: 01S15W09CDDA01
Ground Elevation (ft): 6013
MP from Land Surface (ft): 0.4
Total Depth from MP (ft): 39

Date	Depth to Water from MP (ft)
5/21/96	10.16
8/19/96	10.10
8/12/97	8.53
1/29/98	11.57
5/12/98	10.56
7/15/98	7.61

GWIC ID: **107496**
1:24k Quad: MUD LAKE
TRST: 02S15W32AABB
Ground Elevation (ft): 6051
MP from Land Surface (ft): 1.0
Total Depth from MP (ft): 58

Date	Depth to Water from MP (ft)
5/8/96	16.06
6/21/96	12.98
7/19/96	13.87
8/19/96	16.39
9/12/96	16.53
10/9/96	16.91
8/12/97	16.12
1/29/98	18.24
5/12/98	15.72
7/15/98	13.53

GWIC ID: **107678**
1:24k Quad: WISDOM
TRST: 03S15W04ADDA
Ground Elevation (ft): 6062
MP from Land Surface (ft): 2.4
Total Depth from MP (ft): 42

Date	Depth to Water from MP (ft)
07/19/96	6.13
08/19/96	7.10
08/12/97	6.48
08/27/97	6.80
09/16/97	6.87
10/09/97	6.96
10/30/97	6.92
11/19/97	7.07
12/29/97	7.29
01/29/98	7.25
02/25/98	7.29
03/30/98	6.57
04/30/98	6.03
05/13/98	6.48
06/02/98	5.44
06/17/98	4.56
07/01/98	4.79
07/16/98	5.45
07/29/98	5.98
08/12/98	6.76
08/25/98	7.11
09/11/98	7.17
09/28/98	7.30

GWIC ID:	**107679**
1:24k Quad:	WISDOM
TRST:	03S15W04DDBA
Ground Elevation (ft):	6070
MP from Land Surface (ft):	1.8
Total Depth from MP (ft):	36

Date	Depth to Water from MP (ft)
05/08/96	5.56
06/21/96	4.91
08/19/96	6.01
08/12/97	5.12
08/27/97	5.49
09/16/97	5.75
10/09/97	5.97
10/29/97	5.97
11/19/97	6.08
12/29/97	6.36
01/29/98	6.4
02/25/98	6.48
03/30/98	5.93
04/30/98	5.26
05/13/98	5.46
06/02/98	4.83
06/17/98	4.13
07/01/98	3.94
07/16/98	4.28
07/20/98	4.52
07/29/98	4.84
08/12/98	5.40
08/25/98	5.78
09/11/98	6.05
09/28/98	6.17

GWIC ID:	**107681**
1:24k Quad:	WISDOM
TRST:	03S15W16DCCD
Ground Elevation (ft):	6140
MP from Land Surface (ft):	1.9
Total Depth from MP (ft):	205

Date	Depth to Water from MP (ft)
09/13/83	24.05
10/04/83	24.67
10/16/84	26.43
10/01/85	26.30
09/30/86	25.72
08/04/87	24.72
07/16/91	25.34
03/09/93	30.83
06/04/93	28.78
09/10/93	23.87
03/14/94	29.58
06/15/94	24.53
09/26/94	25.60
03/22/95	30.11
06/26/95	23.86
09/27/95	22.27
05/08/96	28.40
05/08/96	28.40
06/17/96	25.44
06/21/96	24.78
06/21/96	24.78
07/18/96	21.70
07/18/96	21.70
09/12/96	23.37
09/23/96	23.94
12/18/96	26.89
06/16/97	24.07
08/12/97	21.72
08/27/97	22.36
08/27/97	22.36
09/16/97	23.26
10/09/97	24.01
10/29/97	24.26
11/19/97	24.60
12/29/97	26.03
02/25/98	28.20

GWIC ID: **107681**
(continued)

Date	Depth to Water from MP (ft)
03/30/98	28.78
04/30/98	27.79
05/13/98	26.75
06/02/98	24.56
06/17/98	21.68
07/01/98	19.86
07/16/98	19.91
07/20/98	21.14
07/29/98	20.72
08/12/98	21.67
08/25/98	22.28
09/11/98	23.19
09/28/98	24.18
06/17/99	26.77

GWIC ID: **107688**
1:24k Quad: WISDOM
TRST: 03S15W21DBDC02
Ground Elevation (ft): 6150
MP from Land Surface (ft): 0.3
Total Depth from MP (ft): 81

Date	Depth to Water from MP (ft)
06/21/96	8.31
07/19/96	7.57
08/20/96	9.69
08/12/97	9.01
08/27/97	9.77
09/16/97	10.69
10/10/97	11.49
10/29/97	11.80
03/30/98	19.24
04/30/98	17.70
05/13/98	16.19
06/02/98	10.73
06/17/98	8.15
07/02/98	6.70

GWIC ID: **107688**
(continued)

Date	Depth to Water from MP (ft)
07/16/98	6.92
07/29/98	8.34
08/12/98	9.39
08/25/98	10.02
09/11/98	10.79
09/28/98	11.53

GWIC ID: **107689**
1:24k Quad: WISDOM
TRST: 03S15W21DBDC01
Ground Elevation (ft): 6150
MP from Land Surface (ft): 1.9
Total Depth from MP (ft): 40

Date	Depth to Water from MP (ft)
05/08/96	10.88
06/21/96	2.65
07/19/96	3.63
08/20/96	6.00
08/12/97	5.50
08/27/97	6.18
09/16/97	7.34
10/10/97	8.05
10/29/97	8.34
02/25/98	12.68
03/30/98	13.20
04/30/98	9.01
05/13/98	8.30
06/02/98	4.71
06/17/98	2.42
07/02/98	2.39
07/16/98	3.62
07/29/98	5.13
08/12/98	6.10
09/11/98	7.39
09/28/98	7.86

GWIC ID:	**108215**
1:24k Quad:	WISDOM
TRST:	04S15W02CCCB01
Ground Elevation (ft):	6350
MP from Land Surface (ft):	1.0
Total Depth from MP (ft):	235

Date	Depth to Water from MP (ft)
11/09/82	133.69
12/01/82	133.90
01/12/83	135.29
02/09/83	135.49
03/01/83	136.77
04/05/83	133.96
05/09/83	132.07
07/11/83	131.73
08/01/83	131.95
09/02/83	132.54
10/04/83	134.00
07/16/91	135.87
09/08/92	135.13
12/03/92	136.35
03/09/93	139.63
06/04/93	134.91
09/10/93	136.66
03/14/94	137.90
06/15/94	134.57
09/26/94	136.51
12/19/94	138.64
03/22/95	134.50
09/27/95	135.50
12/18/95	136.51
03/13/96	135.38
06/17/96	134.50
09/23/96	136.09
12/18/96	137.49
06/16/97	133.78
09/16/97	135.28
10/09/97	135.37
10/29/97	135.29
11/19/97	135.55
12/29/97	136.56
01/29/98	136.03
02/25/98	136.04

GWIC ID:	**108215**
(continued)	

Date	Depth to Water from MP (ft)
03/30/98	134.55
04/30/98	133.62
05/13/98	133.02
06/02/98	133.44
07/02/98	133.54
07/16/98	133.98
07/29/98	134.05
08/26/98	134.67
09/11/98	135.11
09/28/98	135.46
06/17/99	136.17

GWIC ID:	**108246**
1:24k Quad:	FOX GULCH
TRST:	04S15W32DDCD
Ground Elevation (ft):	6325
MP from Land Surface (ft):	2.1
Total Depth from MP (ft):	46

Date	Depth to Water from MP (ft)
05/22/96	7.60
06/20/96	5.54
07/18/96	5.56
08/20/96	7.70
08/12/97	7.26
02/10/98	10.24
05/12/98	7.44
07/15/98	5.72

GWIC ID:	**108247**
1:24k Quad:	HIGHLAND RANCH
TRST:	04S16W03BCCC
Ground Elevation (ft):	6362
MP from Land Surface (ft):	1.2
Total Depth from MP (ft):	110

Date	Depth to Water from MP (ft)
05/22/96	48.95
06/20/96	48.82
07/19/96	48.56
08/21/96	48.22
05/12/98	47.53
07/15/98	46.94

GWIC ID:	**108251**
1:24k Quad:	HIGHLAND RANCH
TRST:	04S16W06DAAD
Ground Elevation (ft):	6525
MP from Land Surface (ft):	1.4
Total Depth from MP (ft):	110

Date	Depth to Water from MP (ft)
09/22/82	91.97
11/10/82	93.19
12/01/82	93.54
01/13/83	94.55
02/09/83	95.03
03/01/83	95.46
04/04/83	96.20
05/09/83	96.73
06/06/83	95.88
07/11/83	91.55
08/01/83	89.92
09/02/83	90.35
10/04/83	91.22
07/17/91	96.59
05/22/96	98.32
07/19/96	93.30
08/21/96	93.99

GWIC ID: **108251**
(continued)

Date	Depth to Water from MP (ft)
08/12/97	92.24
02/10/98	96.09
02/11/98	96.09
05/12/98	95.87
07/15/98	89.75

GWIC ID:	**108254**
1:24k Quad:	AJAX RANCH
TRST:	04S16W36DDDA
Ground Elevation (ft):	6425
MP from Land Surface (ft):	1.6
Total Depth from MP (ft):	58

Date	Depth to Water from MP (ft)
05/22/96	3.48
06/20/96	3.34
07/18/96	4.76
08/20/96	5.18
08/12/97	4.97
05/12/98	3.60
07/15/98	3.47

GWIC ID:	**108585**
1:24k Quad:	FOX GULCH
TRST:	05S15W05BDAD
Ground Elevation (ft):	6365
MP from Land Surface (ft):	1.3
Total Depth from MP (ft):	110

Date	Depth to Water from MP (ft)
08/12/97	27.47
02/10/98	30.27
05/12/98	27.95
07/15/98	28.46

GWIC ID: **108590**
1:24k Quad: FOX GULCH
TRST: 05S15W10DCDA
Ground Elevation (ft): 6400
MP from Land Surface (ft): 1.0
Total Depth from MP (ft): 75

Date	Depth to Water from MP (ft)
05/23/96	18.85
06/20/96	7.50
07/18/96	6.43
08/20/96	9.33
08/13/97	8.28
02/10/98	18.36
05/12/98	14.91
07/15/98	4.53

GWIC ID: **108595**
1:24k Quad: FOX GULCH
TRST: 05S15W17BABA
Ground Elevation (ft): 6428
MP from Land Surface (ft): 1.0
Total Depth from MP (ft): 41

Date	Depth to Water from MP (ft)
11/09/82	7.93
11/30/82	8.46
01/12/83	8.45
02/08/83	9.31
03/01/83	9.42
04/05/83	8.08
05/10/83	6.91
06/06/83	6.56
07/11/83	5.36
08/01/83	6.83
09/02/83	7.62
10/04/83	7.74
07/16/91	6.56
09/10/92	8.15
12/03/92	8.66
03/09/93	9.21
06/04/93	6.58

GWIC ID: **108595**
(continued)

Date	Depth to Water from MP (ft)
09/10/93	8.14
12/10/93	9.37
03/14/94	9.96
06/15/94	7.13
09/26/94	9.55
12/19/94	9.56
03/22/95	8.35
09/27/95	9.08
12/18/95	8.81
03/13/96	9.15
05/22/96	7.34
06/17/96	6.63
07/18/96	7.90
08/20/96	9.20
09/23/96	9.28
12/18/96	9.34
06/16/97	5.87
08/12/97	7.31
02/10/98	9.98
05/12/98	7.78
07/15/98	6.82

GWIC ID: **108607**
1:24k Quad: JACKSON
TRST: 05S15W29ADAD
Ground Elevation (ft): 6520
MP from Land Surface (ft): 1.0
Total Depth from MP (ft): 51

Date	Depth to Water from MP (ft)
05/23/96	7.89
06/20/96	8.51
08/20/96	10.24
09/10/96	10.62
08/12/97	9.20
05/12/98	8.17
07/15/98	7.95

GWIC ID:	**108610**
1:24k Quad:	JACKSON
TRST:	05S15W36CABD
Ground Elevation (ft):	6565
MP from Land Surface (ft):	0.0
Total Depth from MP (ft):	36

Date	Depth to Water from MP (ft)
08/18/83	20.26
09/02/83	24.79
10/04/83	27.82
07/19/91	8.90
09/10/92	26.53
12/03/92	28.88
03/09/93	29.64
06/04/93	6.72
09/10/93	25.52
12/10/93	30.68
03/14/94	29.62
06/15/94	6.78
09/26/94	27.74
12/19/94	29.77
03/22/95	17.87
06/26/95	6.77
08/29/95	23.20
07/09/97	7.22
08/27/97	23.41
02/10/98	29.36
02/11/98	29.36
05/12/98	18.11
07/15/98	9.93

GWIC ID:	**129084**
1:24k Quad:	PINTLER LAKE
TRST:	01S15W04DACC
Ground Elevation (ft):	6100
MP from Land Surface (ft):	0.0
Total Depth from MP (ft):	140

Date	Depth to Water from MP (ft)
08/26/82	71.83
09/04/92	72.85
12/03/92	73.08

GWIC ID:	**129084**
(continued)	

Date	Depth to Water from MP (ft)
03/09/93	73.42
06/04/93	72.31
09/10/93	72.10
03/14/94	73.10
06/15/94	72.07
09/26/94	72.81
12/19/94	72.97
03/22/95	72.86
06/26/95	73.31
09/27/95	72.43
12/18/95	72.78
06/17/96	72.04
09/23/96	72.50
12/18/96	72.79
08/12/97	71.18
01/29/98	72.54
05/12/98	71.99

GWIC ID:	**129086**
1:24k Quad:	GIBBONS SCHOOL
TRST:	01S16W34DBDC
Ground Elevation (ft):	6070
MP from Land Surface (ft):	1.5
Total Depth from MP (ft):	36

Date	Depth to Water from MP (ft)
09/21/82	6.16
11/10/82	6.43
12/02/82	6.63
01/13/83	6.76
02/09/83	6.89
03/02/83	6.90
04/06/83	6.82
05/10/83	5.88
06/06/83	5.79
07/11/83	4.43
08/01/83	5.44
09/02/83	5.72

GWIC ID: **129086**
(continued)

Date	Depth to Water from MP (ft)
10/04/83	6.56
07/17/91	5.29
09/04/92	5.56
12/03/92	5.62
03/09/93	6.49
06/04/93	4.33
09/10/93	5.23
12/10/93	6.42
03/14/94	8.00
06/15/94	4.86
09/26/94	6.71
12/19/94	6.73
03/22/95	6.14
06/26/95	5.34
09/27/95	5.87
12/18/95	6.16
03/13/96	7.44
05/21/96	4.80
06/17/96	4.34
08/19/96	5.40
09/23/96	5.82
12/18/96	6.39
08/12/97	5.54
01/29/98	6.48
05/12/98	5.32
07/15/98	5.14
06/17/99	4.51

GWIC ID: **129151**
1:24k Quad: WISDOM
TRST: 02S15W34BCCD
Ground Elevation (ft): 6045
MP from Land Surface (ft): 1.0
Total Depth from MP (ft): 125

Date	Depth to Water from MP (ft)
11/10/82	14.07
12/01/82	13.97
03/01/83	14.39

GWIC ID: **129151**
(continued)

Date	Depth to Water from MP (ft)
04/05/83	14.49
05/10/83	13.51
06/06/83	13.08
07/11/83	11.85
08/01/83	13.79
09/02/83	14.00
10/04/83	13.89
07/17/91	12.40
10/22/92	14.09
12/03/92	14.29
03/09/93	14.40
06/04/93	12.42
09/10/93	13.93
12/10/93	14.51
03/14/94	14.61
06/15/94	12.49
09/26/94	14.56
12/19/94	14.68
03/22/95	14.25
06/26/95	12.35
09/27/95	14.01
12/18/95	14.00
03/13/96	13.99
06/17/96	12.20
09/23/96	14.13
12/18/96	14.40
06/16/97	11.63
09/04/97	13.57
10/29/97	13.90
01/30/98	14.35
07/15/98	12.62
06/17/99	12.56

GWIC ID: **133218**
1:24k Quad: WISDOM
TRST: 03S15W01AACC
Ground Elevation (ft): 6185
MP from Land Surface (ft): 2.2
Total Depth from MP (ft): 122

Date	Depth to Water from MP (ft)
05/08/96	57.08
06/21/96	55.76
07/19/96	56.34
08/19/96	56.98
10/09/96	57.50
08/12/97	56.90
02/10/98	56.92
07/28/98	56.08

GWIC ID: **141232**
1:24k Quad: WISDOM
TRST: 04S15W03BDAD
Ground Elevation (ft): 6215
MP from Land Surface (ft): 1.8
Total Depth from MP (ft): 45

Date	Depth to Water from MP (ft)
05/22/96	18.94
06/20/96	18.84
07/19/96	20.48
08/20/96	21.26
08/13/97	21.12
08/27/97	21.35
09/16/97	21.75
10/09/97	21.86
10/29/97	21.47
11/19/97	21.52
12/29/97	22.02
01/30/98	22.12
02/26/98	22.13
03/30/98	21.60
04/30/98	18.92
05/13/98	18.93
06/02/98	18.31

GWIC ID: **141232**
(continued)

Date	Depth to Water from MP (ft)
06/17/98	18.21
07/02/98	18.78
07/16/98	19.87
07/23/98	20.31
07/29/98	20.61
08/12/98	21.16
08/25/98	21.27
09/11/98	21.67
09/28/98	21.81

GWIC ID: **143321**
1:24k Quad: PINE HILL
TRST: 01S14W05CADC
Ground Elevation (ft): 5920
MP from Land Surface (ft): 0.3
Total Depth from MP (ft): 25

Date	Depth to Water from MP (ft)
08/12/97	7.21
02/26/98	8.03
07/28/98	7.02

GWIC ID: **145334**
1:24k Quad: PINTLER LAKE
TRST: 01S15W03BCBA01
Ground Elevation (ft): 6122
MP from Land Surface (ft): 0.5
Total Depth from MP (ft): 105

Date	Depth to Water from MP (ft)
08/12/97	41.93
01/29/98	44.28
05/12/98	43.76
07/15/98	41.09

GWIC ID:	**145340**
1:24k Quad:	MUD LAKE
TRST:	02S15W29CCAB
Ground Elevation (ft):	6050
MP from Land Surface (ft):	1.1
Total Depth from MP (ft):	60

Date	Depth to Water from MP (ft)
05/08/96	10.94
06/21/96	9.14
07/19/96	9.71
08/19/96	11.48
08/12/97	10.99
01/29/98	13.45
05/12/98	11.84
07/15/98	9.27

GWIC ID:	**145341**
1:24k Quad:	WISDOM
TRST:	02S15W32ABAB
Ground Elevation (ft):	6055
MP from Land Surface (ft):	0.0
Total Depth from MP (ft):	23

Date	Depth to Water from MP (ft)
05/08/96	5.44
05/20/96	5.33
06/21/96	0.84
07/19/96	1.81
08/21/96	6.36
08/19/96	6.24
09/12/96	2.05
10/09/96	4.80
08/12/97	6.37
05/12/98	2.37
07/15/98	1.71

GWIC ID:	**147061**
1:24k Quad:	HIGHLAND RANCH
TRST:	02S16W35DCAA
Ground Elevation (ft):	6115
MP from Land Surface (ft):	1.6
Total Depth from MP (ft):	32

Date	Depth to Water from MP (ft)
05/08/96	5.02
09/12/96	6.21
08/12/97	6.39
01/29/98	6.43
05/12/98	6.13
07/15/98	6.63

GWIC ID:	**147065**
1:24k Quad:	AJAX RANCH
TRST:	05S15W07CAAC
Ground Elevation (ft):	6460
MP from Land Surface (ft):	1.5
Total Depth from MP (ft):	64

Date	Depth to Water from MP (ft)
05/22/96	5.82
06/20/96	4.94
07/18/96	5.02
08/20/96	5.90
08/12/97	5.52
05/12/98	10.72
07/15/98	4.84

GWIC ID:	**152571**
1:24k Quad:	HIGHLAND RANCH
TRST:	03S16W26AACA01
Ground Elevation (ft):	6195
MP from Land Surface (ft):	2.3
Total Depth from MP (ft):	36

Date	Depth to Water from MP (ft)
06/20/96	22.42
07/19/96	23.66
08/21/96	26.80
09/12/96	28.45
08/12/97	24.83
02/10/98	31.20
07/15/98	23.54

GWIC ID:	**153310**
1:24k Quad:	GIBBONS SCHOOL
TRST:	02S16W24ADBC
Ground Elevation (ft):	6076
MP from Land Surface (ft):	2.1
Total Depth from MP (ft):	85

Date	Depth to Water from MP (ft)
05/08/96	29.34
09/21/96	27.05
10/09/96	27.95
08/12/97	24.23
08/27/97	24.94

GWIC ID:	**153311**
1:24k Quad:	GIBBONS SCHOOL
TRST:	02S16W25ABAB
Ground Elevation (ft):	6077
MP from Land Surface (ft):	1.6
Total Depth from MP (ft):	201

Date	Depth to Water from MP (ft)
05/08/96	33.48
05/21/96	33.21
06/19/96	32.02
06/21/96	31.87
07/17/96	31.24
08/19/96	32.08
09/12/96	32.54
10/09/96	33.23
08/12/97	31.35
01/29/98	34.67
05/12/98	33.90
07/15/98	31.17

GWIC ID:	**153312**
1:24k Quad:	GIBBONS SCHOOL
TRST:	02S16W07CDAC
Ground Elevation (ft):	6060
MP from Land Surface (ft):	2.5
Total Depth from MP (ft):	115

Date	Depth to Water from MP (ft)
05/21/96	38.87
07/17/96	37.32
08/19/96	37.01
10/09/96	37.41
08/12/97	37.32
05/12/98	39.81
07/15/98	38.11

GWIC ID:	**153412**
1:24k Quad:	MUD LAKE
TRST:	02S15W10DBAB
Ground Elevation (ft):	6020
MP from Land Surface (ft):	2.3
Total Depth from MP (ft):	74

Date	Depth to Water from MP (ft)
05/09/96	42.52
05/20/96	42.58
08/21/96	43.27
08/12/97	41.89
02/26/98	44.70
07/28/98	41.88

GWIC ID:	**156191**
1:24k Quad:	WISDOM
TRST:	03S15W19DDDD
Ground Elevation (ft):	6137
MP from Land Surface (ft):	2.0
Total Depth from MP (ft):	37

Date	Depth to Water from MP (ft)
05/22/96	4.97
06/20/96	4.21
08/21/96	6.77
08/12/97	6.61
02/10/98	7.72
07/15/98	5.35

GWIC ID:	**156193**
1:24k Quad:	MUD LAKE
TRST:	01S15W29CDAC
Ground Elevation (ft):	6000
MP from Land Surface (ft):	0.6
Total Depth from MP (ft):	38

Date	Depth to Water from MP (ft)
05/21/96	15.08
08/19/96	15.79
08/12/97	15.17
01/29/98	17.80
05/12/98	16.06
07/15/98	15.64

GWIC ID:	**156197**
1:24k Quad:	GIBBONS SCHOOL
TRST:	01S16W32ADCA
Ground Elevation (ft):	6125
MP from Land Surface (ft):	1.6
Total Depth from MP (ft):	28

Date	Depth to Water from MP (ft)
08/12/97	9.75
01/29/98	10.63
05/12/98	7.47
07/15/98	8.54

GWIC ID: **156203**
1:24k Quad: MUD LAKE
TRST: 02S15W30DBAC01
Ground Elevation (ft): 6050
MP from Land Surface (ft): 1.2
Total Depth from MP (ft): 31

Date	Depth to Water from MP (ft)
05/08/96	7.98
06/21/96	6.69
07/19/96	6.95
08/19/96	8.03
10/09/96	9.15
08/12/97	6.75
01/29/98	11.11
05/12/98	9.43
07/15/98	6.35

GWIC ID: **156205**
1:24k Quad: WISDOM
TRST: 02S15W34BCBA
Ground Elevation (ft): 6050
MP from Land Surface (ft): 1.3
Total Depth from MP (ft): 53

Date	Depth to Water from MP (ft)
05/09/96	18.40
06/21/96	17.14
08/12/97	18.31
02/10/98	19.31

GWIC ID: **156206**
1:24k Quad: WISDOM
TRST: 02S15W35DACB
Ground Elevation (ft): 6165
MP from Land Surface (ft): 1.5
Total Depth from MP (ft): 125

Date	Depth to Water from MP (ft)
06/21/96	96.21
07/19/96	96.24
08/19/96	96.29
10/09/96	96.65
08/12/97	94.71
07/28/98	95.10

GWIC ID: **156210**
1:24k Quad: WISDOM
TRST: 03S15W01DADA
Ground Elevation (ft): 6165
MP from Land Surface (ft): 1.3
Total Depth from MP (ft): 60

Date	Depth to Water from MP (ft)
05/08/96	24.90
06/21/96	22.60
07/19/96	23.15
08/19/96	23.89
10/09/96	24.36
08/12/97	23.80
02/10/98	24.35
07/28/98	22.92

GWIC ID:	**156211**
1:24k Quad:	WISDOM
TRST:	03S15W20ABAB
Ground Elevation (ft):	6140
MP from Land Surface (ft):	1.5
Total Depth from MP (ft):	123

Date	Depth to Water from MP (ft)
05/12/98	21.98
07/16/98	14.65
09/28/98	19.46

GWIC ID:	**156215**
1:24k Quad:	WISDOM
TRST:	04S15W03BCCC01
Ground Elevation (ft):	6209
MP from Land Surface (ft):	3.3
Total Depth from MP (ft):	70

Date	Depth to Water from MP (ft)
08/27/97	5.92
09/16/97	6.45
10/09/97	6.93
03/30/98	6.57
04/30/98	4.20
05/13/98	4.30
06/02/98	3.75
06/17/98	3.51
07/02/98	3.73
07/16/98	4.66
07/23/98	5.00
08/26/98	6.01
09/11/98	6.45
09/28/98	6.36

GWIC ID:	**156216**
1:24k Quad:	WISDOM
TRST:	04S15W10AAAA
Ground Elevation (ft):	6320
MP from Land Surface (ft):	3.2
Total Depth from MP (ft):	162

Date	Depth to Water from MP (ft)
05/22/96	98.27
08/20/96	98.41
09/16/97	100.36
10/09/97	98.56

GWIC ID:	**156217**
1:24k Quad:	WISDOM
TRST:	04S15W11BBBC
Ground Elevation (ft):	6340
MP from Land Surface (ft):	1.5
Total Depth from MP (ft):	158

Date	Depth to Water from MP (ft)
05/22/96	107.24
08/20/96	107.32
08/27/97	108.70
09/16/97	108.51
10/09/97	107.45
10/29/97	107.26
11/19/97	107.28
12/29/97	107.53
01/29/98	107.27
02/25/98	107.17
03/30/98	107.13
04/30/98	107.60
05/13/98	106.95
06/02/98	107.15
06/17/98	106.71
07/02/98	107.17
07/16/98	107.32
07/29/98	107.11
08/12/98	107.19
09/11/98	107.18
09/28/98	107.13

GWIC ID:	**156218**
1:24k Quad:	FOX GULCH
TRST:	04S15W16CAAA
Ground Elevation (ft):	6255
MP from Land Surface (ft):	2.6
Total Depth from MP (ft):	29

Date	Depth to Water from MP (ft)
08/12/97	6.35
08/27/97	6.73
09/16/97	6.00
10/09/97	7.21
10/29/97	7.14
11/19/97	7.17
12/29/97	9.00
02/25/98	9.65
03/30/98	7.93
04/30/98	5.03
05/13/98	5.35
06/02/98	3.57
06/17/98	3.42
07/02/98	3.99
07/16/98	5.75
07/29/98	6.53
08/12/98	7.03
08/25/98	7.35
09/11/98	7.76
09/28/98	7.88

GWIC ID:	**156219**
1:24k Quad:	HIGHLAND RANCH
TRST:	04S16W04AABA
Ground Elevation (ft):	6385
MP from Land Surface (ft):	0.7
Total Depth from MP (ft):	77

Date	Depth to Water from MP (ft)
05/22/96	27.57
06/20/96	27.65
07/19/96	27.75
08/21/96	27.83
08/12/97	28.47
05/12/98	28.31
07/15/98	28.20

GWIC ID:	**156226**
1:24k Quad:	FOX GULCH
TRST:	05S15W10AAAB
Ground Elevation (ft):	6420
MP from Land Surface (ft):	-8.0
Total Depth from MP (ft):	69

Date	Depth to Water from MP (ft)
05/22/96	50.95
06/20/96	39.93
07/18/96	39.39
08/20/96	44.36

GWIC ID:	**156228**
1:24k Quad:	JACKSON
TRST:	05S15W36AAAA
Ground Elevation (ft):	6534
MP from Land Surface (ft):	1.3
Total Depth from MP (ft):	38

Date	Depth to Water from MP (ft)
05/23/96	6.20
06/20/96	4.88
07/18/96	6.02
08/20/96	7.81
09/10/96	9.90
08/12/97	8.30
02/10/98	11.70
05/12/98	7.29
07/15/98	4.75

GWIC ID:	**156238**
1:24k Quad:	HIGHLAND RANCH
TRST:	03S16W26ADAA
Ground Elevation (ft):	6170
MP from Land Surface (ft):	0.0
Total Depth from MP (ft):	33

Date	Depth to Water from MP (ft)
05/22/96	7.82
06/20/96	6.13
07/19/96	8.60
08/21/96	10.99
09/12/96	11.95
08/12/97	8.34
07/15/98	6.70

GWIC ID:	**156865**
1:24k Quad:	PINTLER LAKE
TRST:	01N15W35DCDD
Ground Elevation (ft):	6127
MP from Land Surface (ft):	1.0
Total Depth from MP (ft):	63

Date	Depth to Water from MP (ft)
05/12/98	31.05

GWIC ID:	**158564**
1:24k Quad:	WISDOM
TRST:	03S15W33ADCD01
Ground Elevation (ft):	6180
MP from Land Surface (ft):	2.0
Total Depth from MP (ft):	80

Date	Depth to Water from MP (ft)
08/27/97	0.00
09/16/97	0.00
10/10/97	0.08
12/29/97	1.09
03/30/98	1.25
04/30/98	0.00
05/13/98	0.00
06/02/98	0.00
06/17/98	0.00
07/02/98	0.00
07/16/98	0.00
09/11/98	0.20
09/28/98	0.18

GWIC ID: **163246**
(continued)

Date	Depth to Water from MP (ft)
03/30/98	33.62
05/01/98	32.65
05/13/98	31.53
06/02/98	29.41
06/18/98	24.75
07/01/98	24.04
07/16/98	27.53
07/23/98	27.89
07/29/98	28.19
08/12/98	28.84
08/26/98	29.25
09/11/98	29.88
09/28/98	30.35

GWIC ID: **163247**
1:24k Quad: WISDOM
TRST: 03S15W28ACCC01
Ground Elevation (ft): 6165
MP from Land Surface (ft): 2.5
Total Depth from MP (ft): 25

Date	Depth to Water from MP (ft)
10/10/97	8.68
10/29/97	8.58
11/19/97	8.73
12/29/97	9.29
01/29/98	9.60
02/25/98	9.85
03/30/98	9.71
04/30/98	4.11
05/13/98	5.08
06/02/98	2.69
06/17/98	2.92
07/01/98	2.98
07/16/98	5.42
07/20/98	6.05
07/29/98	7.01
08/12/98	7.80
08/25/98	8.33
09/11/98	8.66
09/28/98	8.91

GWIC ID: **163248**
1:24k Quad: WISDOM
TRST: 03S15W34DAAD
Ground Elevation (ft): 6210
MP from Land Surface (ft): 2.6
Total Depth from MP (ft): 37

Date	Depth to Water from MP (ft)
10/09/97	31.73
10/29/97	32.06
11/19/97	32.21
12/29/97	32.44
01/30/98	32.42
02/26/98	32.42
03/30/98	32.38
05/01/98	30.75
05/13/98	30.83
06/02/98	27.31
06/18/98	26.38
07/01/98	26.26
07/16/98	28.90
07/23/98	30.75
07/29/98	31.16
08/12/98	31.53
08/26/98	31.46
09/11/98	31.78
09/28/98	31.86

GWIC ID: **163249**
1:24k Quad: WISDOM
TRST: 04S15W04ABBB01
Ground Elevation (ft): 6191
MP from Land Surface (ft): 2.3
Total Depth from MP (ft): 15

Date	Depth to Water from MP (ft)
10/09/97	5.63
10/29/97	5.16
11/19/97	5.15
12/29/97	5.51
01/29/98	5.28
02/25/98	5.18
03/30/98	3.73
04/30/98	2.71

GWIC ID: **163249**
(continued)

Date	Depth to Water from MP (ft)
05/13/98	3.61
06/02/98	2.05
06/17/98	1.87
07/02/98	2.77
07/16/98	4.55
07/23/98	5.03
07/29/98	5.07
08/12/98	5.61
08/25/98	5.95
09/11/98	5.96
09/28/98	5.85

GWIC ID: **163250**
1:24k Quad: WISDOM
TRST: 04S15W04DCAD01
Ground Elevation (ft): 6210
MP from Land Surface (ft): 2.0
Total Depth from MP (ft): 15

Date	Depth to Water from MP (ft)
10/09/97	4.04
10/29/97	4.08
11/19/97	5.14
12/29/97	6.00
01/29/98	5.86
02/25/98	5.90
03/30/98	2.68
04/30/98	2.91
05/13/98	3.89
06/02/98	2.13
06/17/98	1.67
07/02/98	2.60
07/16/98	4.80
07/23/98	5.74
07/29/98	5.47
08/12/98	6.55
08/25/98	7.00
09/11/98	7.13
09/28/98	7.25

GWIC ID: **163251**
1:24k Quad: WISDOM
TRST: 04S15W10BCBD
Ground Elevation (ft): 6257
MP from Land Surface (ft): 2.9
Total Depth from MP (ft): 13

Date	Depth to Water from MP (ft)
10/09/97	3.45
10/29/97	3.63
11/19/97	3.85
12/29/97	3.60
04/30/98	3.50
05/13/98	3.48
06/02/98	3.15
07/02/98	3.60
07/16/98	4.38
07/23/98	4.61
07/29/98	3.91
08/12/98	4.79
08/25/98	4.86
09/11/98	4.06
09/28/98	4.26

GWIC ID: **163252**
1:24k Quad: WISDOM
TRST: 04S15W09CBCD01
Ground Elevation (ft): 6225
MP from Land Surface (ft): 2.0
Total Depth from MP (ft): 15

Date	Depth to Water from MP (ft)
10/09/97	4.32
10/29/97	4.01
11/19/97	4.07
12/29/97	4.33
01/29/98	4.00
03/30/98	2.32
04/30/98	2.06
05/13/98	2.99
06/02/98	1.75
06/17/98	1.52
07/02/98	2.36
07/16/98	3.90

GWIC ID: 163252
(continued)

Date	Depth to Water from MP (ft)
07/23/98	4.61
07/29/98	4.63
08/12/98	5.00
08/25/98	5.28
09/11/98	5.46
09/28/98	5.48

GWIC ID: 163404
1:24k Quad: WISDOM
TRST: 03S15W24DADA
Ground Elevation (ft): 6210
MP from Land Surface (ft): 2.5
Total Depth from MP (ft): 8

Date	Depth to Water from MP (ft)
10/29/97	4.41
01/30/98	4.60
02/26/98	4.64
03/30/98	3.79
05/01/98	3.17
06/04/98	2.45
06/18/98	2.13
07/01/98	2.10
07/16/98	2.78
08/12/98	3.62
09/11/98	3.98

GWIC ID: 163405
1:24k Quad: WISDOM
TRST: 03S15W25DAAA
Ground Elevation (ft): 6215
MP from Land Surface (ft): 2.4
Total Depth from MP (ft): 8

Date	Depth to Water from MP (ft)
10/29/97	5.03
01/30/98	4.81

GWIC ID: 163405
(continued)

Date	Depth to Water from MP (ft)
02/26/98	4.93
03/30/98	4.34
05/01/98	3.24
06/04/98	2.94
06/18/98	2.79
07/01/98	2.75
07/16/98	3.06
08/12/98	4.06
09/11/98	4.45

GWIC ID: 165818
1:24k Quad: MUD LAKE
TRST: 02S15W29AAAA
Ground Elevation (ft): 6042
MP from Land Surface (ft): 2.5
Total Depth from MP (ft): 44

Date	Depth to Water from MP (ft)
05/12/98	10.20

GWIC ID: 165827
1:24k Quad: JACKSON
TRST: 06S15W11ACCC
Ground Elevation (ft): 6579
MP from Land Surface (ft):
Total Depth from MP (ft): 36

Date	Depth to Water from MP (ft)
07/29/98	8.10

GWIC ID:	**165828**
1:24k Quad:	JACKSON
TRST:	06S15W11DBBB
Ground Elevation (ft):	6581
MP from Land Surface (ft):	
Total Depth from MP (ft):	38

Date	Depth to Water from MP (ft)
07/29/98	5.41

GWIC ID:	**165830**
1:24k Quad:	JACKSON
TRST:	05S15W23DAAD
Ground Elevation (ft):	6535
MP from Land Surface (ft):	
Total Depth from MP (ft):	48

Date	Depth to Water from MP (ft)
07/29/98	12.83

GWIC ID:	**169086**
1:24k Quad:	WISDOM
TRST:	03S15W33ADCD03
Ground Elevation (ft):	6180
MP from Land Surface (ft):	2.0
Total Depth from MP (ft):	8

Date	Depth to Water from MP (ft)
09/11/98	6.15
09/29/98	5.75

GWIC ID:	**169087**
1:24k Quad:	FOX GULCH
TRST:	04S15W09DCBD02
Ground Elevation (ft):	6228
MP from Land Surface (ft):	2.6
Total Depth from MP (ft):	8

Date	Depth to Water from MP (ft)
09/11/98	6.75
09/29/98	6.58

B - 2

Middle Big Hole Basin

Ground-Water Level Data: Middle Big Hole Basin

GWIC ID:	**8974**
1:24k Quad:	DEWEY
TRST:	01S09W18BCBD
Ground Elevation (ft):	5,395
MP from Land Surface (ft):	1.5
Total Depth from MP (ft):	32

Date	Depth to Water from MP (ft)
7/16/97	4.10

GWIC ID:	8975
1:24k Quad:	WISE RIVER
TRST:	01S11W01BCAB
Ground Elevation (ft):	5,630
MP from Land Surface (ft):	1.5
Total Depth from MP (ft):	337

Date	Depth to Water from MP (ft)
7/17/97	58.15

GWIC ID:	48796
1:24k Quad:	DICKIE HILLS
TRST:	01N11W19CBCA
Ground Elevation (ft):	5,780
MP from Land Surface (ft):	1
Total Depth from MP (ft):	120

Date	Depth to Water from MP (ft)
3/31/98	90.00e

GWIC ID:	**48800**
1:24k Quad:	DICKIE HILLS
TRST:	01N11W29BCBB
Ground Elevation (ft):	5,650
MP from Land Surface (ft):	0.8
Total Depth from MP (ft):	25

Date	Depth to Water from MP (ft)
3/31/98	4.00

GWIC ID:	48802
1:24k Quad:	WISE RIVER
TRST:	01N11W29DBBC
Ground Elevation (ft):	5,638
MP from Land Surface (ft):	1.5
Total Depth from MP (ft):	33

Date	Depth to Water from MP (ft)
7/17/97	4.20
3/31/98	6.11

GWIC ID:	48807
1:24k Quad:	WISE RIVER
TRST:	01N11W34BCCC
Ground Elevation (ft):	5,710
MP from Land Surface (ft):	0.6
Total Depth from MP (ft):	120

Date	Depth to Water from MP (ft)
3/31/98	43.90

GWIC ID:	48821
1:24k Quad:	WISE RIVER
TRST:	01N11W34DDCC
Ground Elevation (ft):	5,685
MP from Land Surface (ft):	1.6
Total Depth from MP (ft):	NA

Date	Depth to Water from MP (ft)
4/1/98	43.56

GWIC ID:	48837
1:24k Quad:	DICKIE HILLS
TRST:	01N12W24ACAC01
Ground Elevation (ft):	5,755
MP from Land Surface (ft):	1
Total Depth from MP (ft):	59

Date	Depth to Water from MP (ft)
3/31/98	38.92

GWIC ID:	75551
1:24k Quad:	WISE RIVER
TRST:	01N11W36BDCC
Ground Elevation (ft):	5,590
MP from Land Surface (ft):	2.1
Total Depth from MP (ft):	40

Date	Depth to Water from MP (ft)
4/1/98	12.86

GWIC ID:	107114
1:24k Quad:	DEWEY
TRST:	01S09W17BCCD
Ground Elevation (ft):	5,399
MP from Land Surface (ft):	-7.3
Total Depth from MP (ft):	NA

Date	Depth to Water from MP (ft)
9/1/96	13.54
3/25/98	17.69

GWIC ID:	107119
1:24k Quad:	TUCKER CREEK
TRST:	01S09W17BDDD
Ground Elevation (ft):	5,410
MP from Land Surface (ft):	1.5
Total Depth from MP (ft):	69

Date	Depth to Water from MP (ft)
9/1/96	13.15
7/16/97	8.48

GWIC ID:	107120
1:24k Quad:	DEWEY
TRST:	01S09W18AACC
Ground Elevation (ft):	5,430
MP from Land Surface (ft):	1.5
Total Depth from MP (ft):	120

Date	Depth to Water from MP (ft)
9/1/96	42.93

GWIC ID:	107125
1:24k Quad:	DEWEY
TRST:	01S09W18DAAA
Ground Elevation (ft):	5,395
MP from Land Surface (ft):	0.6
Total Depth from MP (ft):	44

Date	Depth to Water from MP (ft)
9/1/96	17.52
5/13/97	17.50
7/16/97	13.61
3/25/98	22.76

GWIC ID:	107126
1:24k Quad:	CATTLE GULCH
TRST:	01S09W18DDBA
Ground Elevation (ft):	5,380
MP from Land Surface (ft):	2.5
Total Depth from MP (ft):	40

Date	Depth to Water from MP (ft)
9/1/96	11.35

GWIC ID:	107127
1:24k Quad:	DEWEY
TRST:	01S09W18ADDD
Ground Elevation (ft):	5,405
MP from Land Surface (ft):	-6.6
Total Depth from MP (ft):	38

Date	Depth to Water from MP (ft)
7/15/97	22.80
7/16/97	22.8

GWIC ID:	107132
1:24k Quad:	MELROSE
TRST:	01S09W29BAAA
Ground Elevation (ft):	5,375
MP from Land Surface (ft):	0.85
Total Depth from MP (ft):	32

Date	Depth to Water from MP (ft)
3/26/98	12.25

GWIC ID:	107148
1:24k Quad:	DEWEY
TRST:	01S10W05CBAC
Ground Elevation (ft):	5,550
MP from Land Surface (ft):	0.4
Total Depth from MP (ft):	77

Date	Depth to Water from MP (ft)
4/1/98	43.64

GWIC ID:	107156
1:24k Quad:	WISE RIVER
TRST:	01S10W06BACD
Ground Elevation (ft):	5,540
MP from Land Surface (ft):	1.1
Total Depth from MP (ft):	43

Date	Depth to Water from MP (ft)
3/31/98	21.86

GWIC ID:	107159
1:24k Quad:	DEWEY
TRST:	01S10W11DCAD
Ground Elevation (ft):	5,470
MP from Land Surface (ft):	2.7
Total Depth from MP (ft):	60

Date	Depth to Water from MP (ft)
7/17/97	31.54

GWIC ID:	107178
1:24k Quad:	WISE RIVER
TRST:	01S11W01BCBD
Ground Elevation (ft):	5,600
MP from Land Surface (ft):	1.5
Total Depth from MP (ft):	NA

Date	Depth to Water from MP (ft)
4/1/98	19.91

GWIC ID:	107180
1:24k Quad:	WISE RIVER
TRST:	01S11W03BABD
Ground Elevation (ft):	5,685
MP from Land Surface (ft):	1.6
Total Depth from MP (ft):	57

Date	Depth to Water from MP (ft)
4/1/98	42.70

GWIC ID:	107183
1:24k Quad:	DICKIE HILLS
TRST:	01S11W18AADB
Ground Elevation (ft):	5,890
MP from Land Surface (ft):	1
Total Depth from MP (ft):	76

Date	Depth to Water from MP (ft)
7/17/97	39.41
3/31/98	57.64

GWIC ID:	107185
1:24k Quad:	STINE MOUNTAIN
TRST:	01S11W18CCBB
Ground Elevation (ft):	5,900
MP from Land Surface (ft):	2.1
Total Depth from MP (ft):	157

Date	Depth to Water from MP (ft)
7/17/97	112.99

GWIC ID:	131967
1:24k Quad:	TUCKER CREEK
TRST:	01S09W08ACAA
Ground Elevation (ft):	5,450
MP from Land Surface (ft):	2.0
Total Depth from MP (ft):	55

Date	Depth to Water from MP (ft)
12/03/92	13.83
03/09/93	14.56
06/04/93	13.14
09/10/93	13.03
12/10/93	13.6
03/14/94	14.22
06/15/94	13.24

GWIC ID:	131967
(continued)	

Date	Depth to Water from MP (ft)
09/26/94	14.15
12/19/94	14.08
03/22/95	14.05
06/26/95	12.66
09/27/95	14.32
12/18/95	13.62
03/13/96	13.77
06/17/96	12.93
09/23/96	13.58
12/18/96	13.72
06/16/97	12.49
09/04/97	13.1
12/29/97	13.88
03/06/98	14.28
07/16/98	12.91
06/16/99	13.42

GWIC ID:	135202
1:24k Quad:	DEWEY
TRST:	01S10W04CABC
Ground Elevation (ft):	5,490
MP from Land Surface (ft):	0.9
Total Depth from MP (ft):	26

Date	Depth to Water from MP (ft)
7/16/97	6.37
4/1/98	8.29

GWIC ID:	140949
1:24k Quad:	WISE RIVER
TRST:	01S11W04DDBA
Ground Elevation (ft):	5,740
MP from Land Surface (ft):	1.3
Total Depth from MP (ft):	51

Date	Depth to Water from MP (ft)
7/16/97	19.04
3/31/98	33.50

GWIC ID:	143501
1:24k Quad:	WISE RIVER
TRST:	01N11W34DDAB
Ground Elevation (ft):	5,710
MP from Land Surface (ft):	1.8
Total Depth from MP (ft):	108

Date	Depth to Water from MP (ft)
4/1/98	76.41

GWIC ID:	158244
1:24k Quad:	DEWEY
TRST:	01S09W18BAAA
Ground Elevation (ft):	5,485
MP from Land Surface (ft):	1.4
Total Depth from MP (ft):	98

Date	Depth to Water from MP (ft)
4/1/98	68.86

GWIC ID:	**158740**
1:24k Quad:	WISE RIVER
TRST:	01N11W19CBDC
Ground Elevation (ft):	5,730
MP from Land Surface (ft):	1.5
Total Depth from MP (ft):	64

Date	Depth to Water from MP (ft)
3/31/98	38.04

GWIC ID:	**161774**
1:24k Quad:	WISE RIVER
TRST:	01S11W01ACCB
Ground Elevation (ft):	5,560
MP from Land Surface (ft):	1.5
Total Depth from MP (ft):	34

Date	Depth to Water from MP (ft)
7/17/97	19.09
4/1/98	18.58

GWIC ID:	**161777**
1:24k Quad:	WISE RIVER
TRST:	01N11W34DCBD
Ground Elevation (ft):	5,675
MP from Land Surface (ft):	2.7
Total Depth from MP (ft):	NA

Date	Depth to Water from MP (ft)
7/17/97	21.15
4/1/98	34.01

GWIC ID:	**161778**
1:24k Quad:	WISE RIVER
TRST:	01N11W34CABB
Ground Elevation (ft):	5,665
MP from Land Surface (ft):	2
Total Depth from MP (ft):	30

Date	Depth to Water from MP (ft)
7/16/97	8.00
3/31/98	22.47

GWIC ID:	**161779**
1:24k Quad:	TUCKER CREEK
TRST:	01S09W17ADBA
Ground Elevation (ft):	5,570
MP from Land Surface (ft):	1.3
Total Depth from MP (ft):	32

Date	Depth to Water from MP (ft)
7/16/97	161.49

GWIC ID:	**163572**
1:24k Quad:	WISE RIVER
TRST:	01N10W31DCAD
Ground Elevation (ft):	5,535
MP from Land Surface (ft):	1.4
Total Depth from MP (ft):	NA

Date	Depth to Water from MP (ft)
4/1/98	19.28

GWIC ID:	**163674**
1:24k Quad:	DEWEY
TRST:	01S10W05DADD
Ground Elevation (ft):	5,501
MP from Land Surface (ft):	1.9
Total Depth from MP (ft):	26

Date	Depth to Water from MP (ft)
4/1/98	10.01

GWIC ID:	**163952**
1:24k Quad:	WISE RIVER
TRST:	01N11W26CDAC
Ground Elevation (ft):	5,596
MP from Land Surface (ft):	3.6
Total Depth from MP (ft):	44

Date	Depth to Water from MP (ft)
4/1/98	12.31

GWIC ID:	**165030**
1:24k Quad:	DICKIE HILLS
TRST:	01N12W24ABCC
Ground Elevation (ft):	5,735
MP from Land Surface (ft):	2.4
Total Depth from MP (ft):	80

Date	Depth to Water from MP (ft)
3/31/98	52.69

GWIC ID:	**166639**
1:24k Quad:	DICKIE HILLS
TRST:	01N12W14ACAB
Ground Elevation (ft):	5,715
MP from Land Surface (ft):	2
Total Depth from MP (ft):	32.3

Date	Depth to Water from MP (ft)
7/15/98	7.67

GWIC ID:	**168611**
1:24k Quad:	WISE RIVER
TRST:	01N11W36CDAB
Ground Elevation (ft):	5,580
MP from Land Surface (ft):	1.4
Total Depth from MP (ft):	40.6

Date	Depth to Water from MP (ft)
7/15/98	28.79

GWIC ID:	**169059**
1:24k Quad:	DICKIE HILLS
TRST:	01N12W14ACCB01
Ground Elevation (ft):	5,780
MP from Land Surface (ft):	0.4
Total Depth from MP (ft):	100

Date	Depth to Water from MP (ft)
3/31/98	50.02

GWIC ID:	**169060**
1:24k Quad:	DICKIE HILLS
TRST:	01N12W24CACB
Ground Elevation (ft):	5,860
MP from Land Surface (ft):	0.8
Total Depth from MP (ft):	30

Date	Depth to Water from MP (ft)
3/31/98	15.50

GWIC ID:	**169061**
1:24k Quad:	DICKIE HILLS
TRST:	01N12W24CABD
Ground Elevation (ft):	5,840
MP from Land Surface (ft):	1.5
Total Depth from MP (ft):	34

Date	Depth to Water from MP (ft)
3/31/98	15.57

GWIC ID:	**169062**
1:24k Quad:	DICKIE HILLS
TRST:	01N12W24ABCB
Ground Elevation (ft):	5,730
MP from Land Surface (ft):	1.6
Total Depth from MP (ft):	57

Date	Depth to Water from MP (ft)
3/31/98	46.17

GWIC ID:	**169064**
1:24k Quad:	DICKIE HILLS
TRST:	01N11W19CBBC
Ground Elevation (ft):	5,730
MP from Land Surface (ft):	1.5
Total Depth from MP (ft):	NA

Date	Depth to Water from MP (ft)
3/31/98	66.40

GWIC ID:	**169065**
1:24k Quad:	DICKIE HILLS
TRST:	01N11W19CBDA
Ground Elevation (ft):	5,675
MP from Land Surface (ft):	1.8
Total Depth from MP (ft):	51

Date	Depth to Water from MP (ft)
3/31/98	9.64

GWIC ID:	**169067**
1:24k Quad:	DICKIE HILLS
TRST:	01N11W19CDDD
Ground Elevation (ft):	5,680
MP from Land Surface (ft):	2.1
Total Depth from MP (ft):	40

Date	Depth to Water from MP (ft)
3/31/98	19.94

GWIC ID:	**169069**
1:24k Quad:	WISE RIVER
TRST:	01N11W29DBAC
Ground Elevation (ft):	5,636
MP from Land Surface (ft):	2.4
Total Depth from MP (ft):	26

Date	Depth to Water from MP (ft)
3/31/98	5.01

GWIC ID:	**169070**
1:24k Quad:	WISE RIVER
TRST:	01N11W29DCBD
Ground Elevation (ft):	5,655
MP from Land Surface (ft):	-5
Total Depth from MP (ft):	40

Date	Depth to Water from MP (ft)
3/31/98	30.00e

GWIC ID:	**169071**
1:24k Quad:	WISE RIVER
TRST:	01N11W32DCCB
Ground Elevation (ft):	5,810
MP from Land Surface (ft):	0
Total Depth from MP (ft):	33

Date	Depth to Water from MP (ft)
3/31/98	17.50

GWIC ID:	**169072**
1:24k Quad:	WISE RIVER
TRST:	01N11W34BCBC
Ground Elevation (ft):	5,710
MP from Land Surface (ft):	0
Total Depth from MP (ft):	63

Date	Depth to Water from MP (ft)
3/31/98	54.90

GWIC ID:	**169073**
1:24k Quad:	WISE RIVER
TRST:	01N11W34BDDC
Ground Elevation (ft):	5,660
MP from Land Surface (ft):	1.8
Total Depth from MP (ft):	29

Date	Depth to Water from MP (ft)
3/31/98	18.86

GWIC ID:	**169074**
1:24k Quad:	DEWEY
TRST:	01S09W18BABB
Ground Elevation (ft):	5,420
MP from Land Surface (ft):	1.7
Total Depth from MP (ft):	NA

Date	Depth to Water from MP (ft)
3/30/98	62.70

GWIC ID:	**169075**
1:24k Quad:	DEWEY
TRST:	01S09W18BDCA
Ground Elevation (ft):	5,395
MP from Land Surface (ft):	0
Total Depth from MP (ft):	50

Date	Depth to Water from MP (ft)
3/30/98	13.33

GWIC ID:	**169076**
1:24k Quad:	DEWEY
TRST:	01S10W05DDAA
Ground Elevation (ft):	5,530
MP from Land Surface (ft):	-6
Total Depth from MP (ft):	50

Date	Depth to Water from MP (ft)
4/1/98	33.00

GWIC ID:	**169077**
1:24k Quad:	DEWEY
TRST:	01S10W05DAAD
Ground Elevation (ft):	5,500
MP from Land Surface (ft):	-4.8
Total Depth from MP (ft):	28

Date	Depth to Water from MP (ft)
4/1/98	7.41

GWIC ID:	**169078**
1:24k Quad:	WISE RIVER
TRST:	01N11W36CCDB
Ground Elevation (ft):	5,565
MP from Land Surface (ft):	1
Total Depth from MP (ft):	NA

Date	Depth to Water from MP (ft)
7/16/97	7.12
4/1/98	9.41

GWIC ID:	**169079**
1:24k Quad:	WISE RIVER
TRST:	01N11W26DCCD
Ground Elevation (ft):	5,590
MP from Land Surface (ft):	1.1
Total Depth from MP (ft):	37.5

Date	Depth to Water from MP (ft)
4/1/98	10.35

GWIC ID:	**169080**
1:24k Quad:	WISE RIVER
TRST:	01N11W35CADB
Ground Elevation (ft):	5,630
MP from Land Surface (ft):	-4
Total Depth from MP (ft):	NA

Date	Depth to Water from MP (ft)
4/1/98	51.23

GWIC ID: **169081**
1:24k Quad: WISE RIVER
TRST: 01N11W34AADD
Ground Elevation (ft): 5,625
MP from Land Surface (ft): 0
Total Depth from MP (ft): NA

Date	Depth to Water from MP (ft)
4/1/98	0.00

GWIC ID: **169082**
1:24k Quad: WISE RIVER
TRST: 01N11W36ADAD
Ground Elevation (ft): 5,660
MP from Land Surface (ft): 1
Total Depth from MP (ft): 140

Date	Depth to Water from MP (ft)
4/1/98	82.46

GWIC ID: **169088**
1:24k Quad: CATTLE GULCH
TRST: 01S09W18DBDA
Ground Elevation (ft): 5,386
MP from Land Surface (ft): 0
Total Depth from MP (ft): NA

Date	Depth to Water from MP (ft)
9/1/96	12.34

GWIC ID: **169089**
1:24k Quad: CATTLE GULCH
TRST: 01S09W18DDBD
Ground Elevation (ft): 5,381
MP from Land Surface (ft): 0.2
Total Depth from MP (ft): NA

Date	Depth to Water from MP (ft)
9/1/96	8.79
3/25/98	12.22

GWIC ID: **169090**
1:24k Quad: DEWEY
TRST: 01S09W18ADDD
Ground Elevation (ft): 5,395
MP from Land Surface (ft): 1.5
Total Depth from MP (ft): NA

Date	Depth to Water from MP (ft)
9/1/96	17.50
3/25/98	22.97

GWIC ID: **169091**
1:24k Quad: TUCKER CREEK
TRST: 01S09W17CABB
Ground Elevation (ft): 5,390
MP from Land Surface (ft): 0.9
Total Depth from MP (ft): 38

Date	Depth to Water from MP (ft)
3/26/98	16.43

GWIC ID:	**169092**
1:24k Quad:	MELROSE
TRST:	01S09W20DDCC
Ground Elevation (ft):	5,395
MP from Land Surface (ft):	-3.5
Total Depth from MP (ft):	40

Date	Depth to Water from MP (ft)
3/26/98	24.10

GWIC ID:	**169093**
1:24k Quad:	MELROSE
TRST:	01S09W20DBDA
Ground Elevation (ft):	5,420
MP from Land Surface (ft):	-6.3
Total Depth from MP (ft):	70

Date	Depth to Water from MP (ft)
3/26/98	37.70

B - 3

Lower Big Hole Basin

Ground-Water Level Data: Lower Big Hole Basin

GWIC ID:	**107414**
1:24k Quad:	MELROSE
TRST:	02S09W14CBAD
Ground Elevation (ft):	5,235
MP from Land Surface (ft):	1.45
Total Depth from MP (ft):	43

Date	Depth to Water from MP (ft)
9/3/97	14.93
10/7/97	17.32
10/30/97	20.80
11/24/97	24.08
12/30/97	27.07
1/26/98	28.26
2/23/98	29.14
3/25/98	29.34
4/27/98	28.51
5/15/98	26.55
5/29/98	24.68
6/14/98	18.34
6/25/98	14.82
7/9/98	14.87
7/28/98	14.71
8/11/98	16.20
8/27/98	15.89
9/9/98	16.12
9/30/98	15.99
10/28/98	19.74

GWIC ID:	**107415**
1:24k Quad:	MELROSE
TRST:	02S09W14BCCC
Ground Elevation (ft):	5,230
MP from Land Surface (ft):	1.70
Total Depth from MP (ft):	40

Date	Depth to Water from MP (ft)
8/5/97	16.49
9/3/97	15.78
10/7/97	17.22
10/30/97	20.24
11/24/97	22.82
12/30/97	25.15
1/26/98	25.93
2/23/98	26.77
3/25/98	26.54
4/27/98	25.05
5/15/98	23.10
5/29/98	21.92
6/14/98	18.06
6/25/98	14.55
7/9/98	14.74
7/28/98	14.44
8/11/98	16.30
8/27/98	16.35
9/9/98	17.04
9/30/98	15.94
10/28/98	19.53

GWIC ID: **107417**
1:24k Quad: MELROSE
TRST: 02S09W14DBDA
Ground Elevation (ft): 5,380
MP from Land Surface (ft): 1.20
Total Depth from MP (ft): 140

Date	Depth to Water from MP (ft)
9/3/97	67.78
10/7/97	66.75
10/30/97	70.10
11/24/97	72.85
12/30/97	75.85
1/26/98	75.70
2/23/98	76.32
3/25/98	79.13
6/14/98	73.20
6/25/98	71.99
7/9/98	69.78
7/28/98	69.00
8/11/98	65.18
8/27/98	70.85
9/9/98	71.10
9/30/98	67.82
10/28/98	67.55

GWIC ID: **107432**
1:24k Quad: MELROSE
TRST: 02S09W23CACD
Ground Elevation (ft): 5,195
MP from Land Surface (ft): 0.00
Total Depth from MP (ft): 22

Date	Depth to Water from MP (ft)
8/5/97	7.80
9/3/97	7.58
10/7/97	7.22

GWIC ID: **107448**
1:24k Quad: MELROSE
TRST: 02S09W26ADBC
Ground Elevation (ft): 5,190
MP from Land Surface (ft): 0.00
Total Depth from MP (ft): 40

Date	Depth to Water from MP (ft)
3/25/98	15.0e

GWIC ID: **107474**
1:24k Quad: MELROSE
TRST: 02S09W27ADBB
Ground Elevation (ft): 5,180
MP from Land Surface (ft): 1.45
Total Depth from MP (ft): 40

Date	Depth to Water from MP (ft)
8/5/97	6.82
9/3/97	7.27
10/7/97	7.65
10/30/97	7.84
11/24/97	8.24
12/30/97	8.57
1/26/98	8.52
2/23/98	8.74
3/25/98	8.36
4/27/98	7.19
5/15/98	5.65
5/29/98	5.08
6/13/98	4.26
6/25/98	4.91
7/28/98	7.00
9/9/98	7.98
9/30/98	7.81
10/28/98	8.03

GWIC ID:	**107475**
1:24k Quad:	MELROSE
TRST:	02S09W27ABAA
Ground Elevation (ft):	5,180
MP from Land Surface (ft):	1.35
Total Depth from MP (ft):	30

Date	Depth to Water from MP (ft)
9/3/97	7.68
10/7/97	7.72
10/30/97	7.77
11/24/97	8.17
12/30/97	8.51
1/26/98	8.51
2/23/98	8.77
3/25/98	8.26
4/27/98	6.97
5/15/98	5.72
5/29/98	5.44
6/13/98	5.38
6/25/98	5.35
7/28/98	6.89
8/11/98	7.42
8/27/98	7.82
9/9/98	7.96
9/30/98	7.76
10/28/98	7.94

GWIC ID:	**107478**
1:24k Quad:	EARLS GULCH
TRST:	02S09W35CDDB
Ground Elevation (ft):	5,160
MP from Land Surface (ft):	1.50
Total Depth from MP (ft):	145

Date	Depth to Water from MP (ft)
10/22/92	17.76
12/23/92	18.08
3/24/93	18.47

GWIC ID: **107478**
(continued)

Date	Depth to Water from MP (ft)
6/24/93	10.85
9/17/93	16.65
12/15/93	18.30
3/16/94	18.23
6/28/94	12.54
9/13/94	12.29
12/2/94	17.61
2/24/95	17.98
6/21/95	12.55
9/12/95	14.02
12/12/95	18.01
3/8/96	17.48
6/14/96	10.73
9/17/96	14.30
12/17/96	18.10
5/29/97	13.24
8/27/97	16.38
10/7/97	15.15
10/30/97	17.36
11/24/97	17.55
12/5/97	17.86
1/26/98	18.21
2/23/98	18.18
3/25/98	17.80
4/27/98	17.06
5/15/98	16.10
5/29/98	14.83
6/13/98	12.28
6/25/98	13.66
7/28/98	12.96
8/11/98	13.17
8/27/98	13.63
9/10/98	15.13
9/30/98	17.11
10/28/98	17.87

GWIC ID:	107656
1:24k Quad:	EARLS GULCH
TRST:	03S09W01CDDD
Ground Elevation (ft):	5,290
MP from Land Surface (ft):	1.20
Total Depth from MP (ft):	65

Date	Depth to Water from MP (ft)
8/5/97	44.92
9/3/97	43.46
10/7/97	43.28
10/30/97	43.28
11/24/97	43.33
12/30/97	43.34
1/26/98	43.18
2/23/98	48.00p
4/27/98	43.22
6/13/98	43.38
6/25/98	43.26
7/9/98	43.26
7/28/98	43.28
8/11/98	43.23
8/27/98	43.23
9/9/98	43.20
9/30/98	43.07
10/28/98	42.95

GWIC ID:	107660
1:24k Quad:	EARLS GULCH
TRST:	03S09W11CDCC
Ground Elevation (ft):	5,110
MP from Land Surface (ft):	1.60
Total Depth from MP (ft):	33

Date	Depth to Water from MP (ft)
9/3/97	6.47
10/7/97	6.67
10/30/97	6.80
11/24/97	6.97

GWIC ID: **107660**
(continued)

Date	Depth to Water from MP (ft)
12/30/97	7.03
1/26/98	7.05
2/23/98	7.13
3/25/98	6.88
4/27/98	6.25
5/17/98	5.89
5/29/98	5.68
6/13/98	5.27
6/25/98	5.28
7/13/98	5.59
7/29/98	6.57
8/11/98	6.65
8/27/98	6.51
9/9/98	5.64
9/30/98	6.81
10/28/98	6.97

GWIC ID:	107661
1:24k Quad:	EARLS GULCH
TRST:	03S09W11ADBB
Ground Elevation (ft):	5,150
MP from Land Surface (ft):	2.50
Total Depth from MP (ft):	NA

Date	Depth to Water from MP (ft)
9/30/98	5.40

GWIC ID: **107662**
1:24k Quad: EARLS GULCH
TRST: 03S09W14ADDD
Ground Elevation (ft): 5,185
MP from Land Surface (ft): 1.15
Total Depth from MP (ft): 53

Date	Depth to Water from MP (ft)
9/3/97	29.97
10/7/97	30.78
10/30/97	31.89
11/24/97	32.62
12/30/97	33.45
1/26/98	33.94
2/23/98	33.95
3/25/98	33.36
4/27/98	31.85
5/15/98	31.54
5/29/98	31.47
6/13/98	28.89
6/25/98	28.00
7/13/98	28.18
7/29/98	29.64
8/11/98	30.02
8/27/98	30.23
9/9/98	30.18
9/30/98	30.78
10/28/98	32.43

GWIC ID: **107663**
1:24k Quad: EARLS GULCH
TRST: 03S09W14CAAA
Ground Elevation (ft): 5,120
MP from Land Surface (ft): 2.20
Total Depth from MP (ft): 50

Date	Depth to Water from MP (ft)
9/3/97	18.87
10/7/97	19.70

GWIC ID: **107663**
(continued)

Date	Depth to Water from MP (ft)
10/30/97	21.48
11/24/97	22.80
12/30/97	23.55
3/25/98	22.92
4/27/98	22.23
5/29/98	21.18
6/13/98	16.16
6/25/98	14.90
7/13/98	19.15
7/29/98	20.50
8/11/98	18.93
8/27/98	17.55
9/9/98	17.27
9/30/98	20.68

GWIC ID: **107666**
1:24k Quad: EARLS GULCH
TRST: 03S09W27ADAB
Ground Elevation (ft): 5,070
MP from Land Surface (ft): 1.30
Total Depth from MP (ft): 95

Date	Depth to Water from MP (ft)
9/3/97	6.68
10/7/97	6.60
10/30/97	6.52
11/24/97	6.75
12/30/97	6.75
1/26/98	6.19
2/23/98	6.82
3/25/98	6.51
4/27/98	5.70
5/16/98	5.08
5/28/98	4.89
6/13/98	5.05

GWIC ID: (continued)	**107666**
Date	Depth to Water from MP (ft)
6/25/98	4.91
7/13/98	5.43
7/29/98	6.43
8/11/98	6.76
8/27/98	7.06
9/9/98	7.10
9/30/98	6.91
10/28/98	6.80

GWIC ID: **107666**
1:24k Quad: EARLS GULCH
TRST: 03S09W27ADAB
Ground Elevation (ft): 5,070
MP from Land Surface (ft): 1.30
Total Depth from MP (ft): 95

Date	Depth to Water from MP (ft)
9/3/97	6.68
10/7/97	6.60
10/30/97	6.52
11/24/97	6.75
12/30/97	6.75
1/26/98	6.19
2/23/98	6.82
3/25/98	6.51
4/27/98	5.70
5/16/98	5.08
5/28/98	4.89
6/13/98	5.05
6/25/98	4.91
7/13/98	5.43
7/29/98	6.43
8/11/98	6.76
8/27/98	7.06
9/9/98	7.10

GWIC ID: (continued)	**107666**
Date	Depth to Water from MP (ft)
9/30/98	6.91
10/28/98	6.80

GWIC ID: **108178**
1:24k Quad: BLOCK MOUNTAIN
TRST: 04S08W29BCDA
Ground Elevation (ft): 4,950
MP from Land Surface (ft): 1.35
Total Depth from MP (ft): 54

Date	Depth to Water from MP (ft)
9/2/97	23.50
10/7/97	20.95
10/30/97	23.37
11/24/97	25.99
12/29/97	28.33
1/26/98	29.69
2/23/98	30.51
3/26/98	31.06
4/28/98	30.74
5/16/98	34.6r
5/28/98	30.08
6/14/98	20.85
6/27/98	19.86
7/14/98	21.48
7/29/98	23.17
8/12/98	24.02
8/27/98	21.47
9/9/98	21.42
9/30/98	20.66
10/29/98	23.60

GWIC ID:	**108185**
1:24k Quad:	EARLS GULCH
TRST:	04S09W05DCAD
Ground Elevation (ft):	5,392
MP from Land Surface (ft):	0.00
Total Depth from MP (ft):	25

Date	Depth to Water from MP (ft)
10/7/97	6.62
10/30/97	6.59
11/24/97	6.60
12/30/97	6.63
1/28/98	6.69
2/25/98	6.75
3/26/98	6.70
4/29/98	6.94
5/16/98	7.66
5/29/98	7.12
6/13/98	7.22
6/25/98	5.75
7/13/98	6.04
7/28/98	5.15
8/11/98	5.27
8/27/98	5.44
9/10/98	5.45
9/30/98	5.58
10/29/98	6.71

GWIC ID:	**108186**
1:24k Quad:	EARLS GULCH
TRST:	04S09W09ABAA
Ground Elevation (ft):	5,110
MP from Land Surface (ft):	0.85
Total Depth from MP (ft):	85

Date	Depth to Water from MP (ft)
9/3/97	30.79
10/7/97	32.00
10/30/97	31.78

GWIC ID: **108186**
(continued)

Date	Depth to Water from MP (ft)
11/24/97	31.37
12/30/97	31.18
1/28/98	31.61
2/25/98	31.77
3/26/98	30.62
4/29/98	27.89
5/16/98	27.20
5/29/98	27.42
6/13/98	27.39
6/25/98	27.67
7/13/98	28.68
7/28/98	30.12
8/11/98	31.29
8/27/98	32.43
9/10/98	33.03
9/30/98	32.50
10/29/98	30.77
11/17/98	29.84
3/18/99	28.04

GWIC ID:	**108187**
1:24k Quad:	EARLS GULCH
TRST:	04S09W09DDDB
Ground Elevation (ft):	5,040
MP from Land Surface (ft):	1.50
Total Depth from MP (ft):	97

Date	Depth to Water from MP (ft)
4/1/95	29.92
5/3/95	28.17
5/30/95	26.75
7/8/95	13.33
8/8/95	7.67
9/1/95	9.75
10/1/95	13.33

GWIC ID: (continued)	108187
Date	Depth to Water from MP (ft)
11/11/95	18.92
12/28/95	24.42
2/5/96	26.75
3/2/96	27.67
4/8/96	28.42
5/7/96	27.50
6/9/96	22.42
6/29/96	9.50
7/30/96	9.59
9/5/96	12.42
10/3/96	15.08
1/3/97	25.92
5/4/97	26.67
6/6/97	22.00
7/10/97	15.00
8/1/97	10.17
9/8/97	14.67
10/3/97	16.33
10/8/97	16.48
10/31/97	19.57
11/1/97	19.50
11/25/97	20.91
1/28/98	25.30
2/23/98	27.38
3/26/98	28.47
4/1/98	28.67
4/27/98	28.29
5/8/98	23.42
5/17/98	25.67
5/28/98	15.12
6/2/98	12.92
6/14/98	10.49
6/27/98	10.35
7/6/98	8.92
7/13/98	8.52
7/29/98	8.56
8/11/98	9.17
8/12/98	9.13

GWIC ID: (continued)	108187
Date	Depth to Water from MP (ft)
8/27/98	10.21
9/2/98	9.42
9/9/98	8.41
9/30/98	12.68
10/1/98	11.58
12/1/98	23.33

GWIC ID:	108188
1:24k Quad:	GLEN
TRST:	04S09W15DCBB
Ground Elevation (ft):	5,002
MP from Land Surface (ft):	0.50
Total Depth from MP (ft):	20

Date	Depth to Water from MP (ft)
4/1/95	11.92
5/3/95	12.17
5/30/95	9.17
7/8/95	3.33
8/9/95	1.67
9/1/95	2.83
10/1/95	2.08
11/1/95	4.42
12/2/95	7.50
12/28/95	8.67
12/29/95	7.58
2/5/96	9.67
3/2/96	10.25
4/8/96	9.83
5/7/96	9.90
6/9/96	3.50
6/29/96	1.75
7/30/96	1.42
9/5/96	1.33
10/3/96	1.75

GWIC ID: **108188**
(continued)

Date	Depth to Water from MP (ft)
11/5/96	5.92
12/9/96	7.92
1/3/97	9.08
2/5/97	9.25
3/4/97	10.42
3/31/97	10.33
5/4/97	5.75
6/6/97	3.08
7/10/97	1.42
8/1/97	1.67
9/2/97	2.58
9/8/97	2.67
10/3/97	3.00
10/8/97	2.89
10/31/97	6.06
11/1/97	6.08
11/25/97	7.56
12/1/97	8.08
12/29/97	13.63
1/5/98	9.33
1/28/98	10.05
2/4/98	10.33
2/23/98	10.72
3/9/98	11.08
3/26/98	11.06
4/1/98	11.25
4/27/98	10.95
5/8/98	9.75
5/17/98	7.23
5/28/98	1.73
6/2/98	1.08
6/14/98	1.11
6/27/98	1.46
7/6/98	1.92
7/13/98	2.76
7/29/98	2.44
8/11/98	1.33
8/12/98	1.55

GWIC ID: **108188**
(continued)

Date	Depth to Water from MP (ft)
8/27/98	1.39
9/2/98	1.33
9/9/98	1.51
9/30/98	2.61
10/1/98	2.50
10/28/98	6.15
11/1/98	6.25
12/1/98	8.00
1/4/99	9.42
2/2/99	10.33

GWIC ID: **108190**
1:24k Quad: GLEN
TRST: 04S09W15BBAD
Ground Elevation (ft): 5,030
MP from Land Surface (ft): 2.00
Total Depth from MP (ft): 50

Date	Depth to Water from MP (ft)
5/7/96	25.60
7/30/96	9.00
9/15/96	14.50
10/3/96	17.33
11/5/96	21.25
12/9/96	26.00
1/3/97	27.17
2/5/97	26.50
3/4/97	29.42
3/30/97	29.08
5/4/97	11.50
6/6/97	12.00
7/10/97	16.67
8/1/97	11.67
9/2/97	13.29
9/8/97	16.25

GWIC ID: **108190**
(continued)

Date	Depth to Water from MP (ft)
10/3/97	17.67
10/8/97	17.64
10/31/97	21.76
11/1/97	21.83
11/25/97	24.42
12/1/97	25.00
12/29/97	26.91
1/28/98	28.24
2/4/98	28.50
2/23/98	29.08
3/9/98	29.42
3/26/98	29.56
4/1/98	29.33
4/27/98	28.92
5/8/98	11.75
5/17/98	22.75
5/28/98	15.65
6/2/98	14.50
6/14/98	7.80
6/27/98	8.64
7/6/98	10.50
7/13/98	11.42
7/29/98	8.12
8/11/98	9.67
8/12/98	9.97
8/27/98	9.69
9/2/98	11.33
9/9/98	11.62
9/30/98	13.98
10/1/98	13.83
10/28/98	20.85
11/1/98	20.17
12/1/98	25.00
1/4/99	27.33
2/2/99	28.67

GWIC ID: **108193**
1:24k Quad: GLEN
TRST: 04S09W22AADA
Ground Elevation (ft): 4,992
MP from Land Surface (ft): 1.55
Total Depth from MP (ft): 30

Date	Depth to Water from MP (ft)
9/2/97	8.57
10/7/97	8.04
10/30/97	9.15
11/24/97	9.60
12/29/97	9.78
1/26/98	9.90
2/23/98	9.94
3/26/98	10.06
4/28/98	9.83
5/16/98	7.51
5/28/98	6.01
6/14/98	6.99
6/27/98	7.37
7/14/98	8.00
7/29/98	8.36
8/11/98	7.99
8/27/98	7.30
9/9/98	7.47
9/30/98	8.33
10/28/98	9.09

GWIC ID: **108198**
1:24k Quad: GLEN
TRST: 04S09W22ABAA
Ground Elevation (ft): 4,993
MP from Land Surface (ft): 1.35
Total Depth from MP (ft): 38

Date	Depth to Water from MP (ft)
9/2/97	5.97
10/7/97	5.66

GWIC ID: **108198**
(continued)

Date	Depth to Water from MP (ft)
10/30/97	7.06
11/24/97	7.47
12/29/97	7.90
1/26/98	8.19
2/23/98	8.36
3/26/98	8.56
4/29/98	8.36
5/16/98	4.77
5/28/98	3.56
6/14/98	4.69
6/27/98	5.66
7/14/98	6.32
7/29/98	5.98
8/11/98	5.74
8/27/98	4.68
9/9/98	5.09
9/30/98	6.11
10/28/98	7.17

GWIC ID: **120022**
1:24k Quad: EARLS GULCH
TRST: 04S09W03CCCC
Ground Elevation (ft): 5,030
MP from Land Surface (ft): 1.60
Total Depth from MP (ft): 30

Date	Depth to Water from MP (ft)
9/2/97	10.71
10/8/97	11.64
10/31/97	13.97
11/25/97	17.14
12/29/97	18.80
1/28/98	19.71
2/23/98	18.08
3/26/98	18.62

GWIC ID: **120022**
(continued)

Date	Depth to Water from MP (ft)
4/27/98	19.08
5/17/98	11.07
5/28/98	11.31
6/14/98	11.83
6/25/98	7.60
7/13/98	11.57
7/29/98	6.99
8/12/98	8.21
8/27/98	10.71
9/9/98	11.61
9/30/98	12.65
10/28/98	14.59

GWIC ID: **120983**
1:24k Quad: EARLS GULCH
TRST: 03S09W33CBBA
Ground Elevation (ft): 5,342
MP from Land Surface (ft): 1.40
Total Depth from MP (ft): 40

Date	Depth to Water from MP (ft)
8/5/97	8.69
9/3/97	8.97
10/7/97	7.95
10/30/97	8.61
11/24/97	10.96
12/30/97	12.30
1/28/98	13.15
2/25/98	13.55
3/26/98	13.55
4/29/98	13.50
5/16/98	11.12
5/29/98	10.13
6/13/98	10.22
6/25/98	10.22

GWIC ID: **120983**
(continued)

Date	Depth to Water from MP (ft)
7/13/98	8.60
7/28/98	8.08
8/11/98	5.95
8/27/98	9.03
9/10/98	8.07
9/30/98	10.28
10/29/98	11.68

GWIC ID:	**127990**
1:24k Quad:	EARLS GULCH
TRST:	03S09W02BCAA
Ground Elevation (ft):	5,150
MP from Land Surface (ft):	0.40
Total Depth from MP (ft):	34

Date	Depth to Water from MP (ft)
10/7/97	6.25
11/24/97	6.50
12/30/97	6.50
1/26/98	6.25
2/23/98	6.65
3/25/98	6.22
4/27/98	5.17
5/15/98	3.56
5/29/98	3.43
6/13/98	3.51
6/25/98	3.55
7/9/98	3.29
7/28/98	5.63
8/11/98	5.59
8/27/98	5.96
9/10/98	5.97
9/30/98	6.45
10/28/98	6.48

GWIC ID:	**131113**
1:24k Quad:	GLEN
TRST:	04S09W25AAAA
Ground Elevation (ft):	4,965
MP from Land Surface (ft):	1.90
Total Depth from MP (ft):	146

Date	Depth to Water from MP (ft)
8/4/97	35.39
9/2/97	35.56
10/7/97	32.18
10/30/97	36.38
11/24/97	38.37
12/29/97	39.27
1/26/98	39.61
2/23/98	39.75
3/26/98	39.52
4/28/98	39.46
5/16/98	38.18
5/28/98	35.40
6/14/98	32.80
6/27/98	32.26
7/14/98	32.30
7/29/98	34.26
8/12/98	34.44
8/27/98	33.48
9/9/98	31.96
9/30/98	32.18
10/28/98	36.90

GWIC ID:	**138727**
1:24k Quad:	EARLS GULCH
TRST:	02S09W34DAAB
Ground Elevation (ft):	5,170
MP from Land Surface (ft):	1.80
Total Depth from MP (ft):	33

Date	Depth to Water from MP (ft)
8/5/97	22.51
9/3/97	24.02
10/7/97	24.16
10/30/97	24.26
11/24/97	24.41
12/30/97	24.25
1/26/98	24.24
2/23/98	24.81
3/25/98	24.63
4/27/98	23.66
5/15/98	21.00
5/29/98	21.99
6/13/98	21.06
6/25/98	21.84
7/9/98	22.31
7/28/98	20.49
8/11/98	23.66
8/27/98	21.71
9/10/98	23.70
9/30/98	24.34
10/28/98	24.53

GWIC ID:	**138728**
1:24k Quad:	EARLS GULCH
TRST:	02S09W34ADBA
Ground Elevation (ft):	5,170
MP from Land Surface (ft):	1.60
Total Depth from MP (ft):	34

Date	Depth to Water from MP (ft)
8/5/97	10.35
9/3/97	16.01
10/7/97	16.56
10/30/97	16.77
11/24/97	16.51
12/30/97	16.30
1/26/98	16.78
2/23/98	17.02
3/25/98	16.96
4/27/98	16.72
5/15/98	13.64
6/13/98	13.92
6/25/98	15.27
7/9/98	15.53
7/28/98	10.21
8/11/98	16.13
8/27/98	10.64
9/10/98	15.98
9/30/98	16.57
10/28/98	17.04

GWIC ID:	142992
1:24k Quad:	MELROSE
TRST:	02S09W27DDCC
Ground Elevation (ft):	5,190
MP from Land Surface (ft):	2.85
Total Depth from MP (ft):	41

Date	Depth to Water from MP (ft)
8/5/97	6.41
9/3/97	7.03
10/7/97	6.93
10/30/97	6.74
11/24/97	6.89
12/30/97	6.59
1/26/98	6.30
2/23/98	7.04
3/25/98	6.72
4/27/98	5.97
5/15/98	5.28
5/29/98	5.28
6/13/98	5.44
6/25/98	5.27
7/9/98	5.91
7/28/98	6.65
8/11/98	6.95
8/27/98	7.18
9/10/98	7.02
9/30/98	6.94
10/28/98	6.79

GWIC ID:	144808
1:24k Quad:	EARLS GULCH
TRST:	04S09W04AACC
Ground Elevation (ft):	5,160
MP from Land Surface (ft):	1.80
Total Depth from MP (ft):	200+

Date	Depth to Water from MP (ft)
10/7/97	8.54
10/30/97	9.91
11/24/97	9.25
1/5/98	9.96
1/28/98	10.94
2/25/98	12.44
3/26/98	12.17
5/16/98	10.22
5/29/98	10.85
6/13/98	8.83
6/25/98	10.73
7/13/98	8.28
7/28/98	8.10
8/11/98	10.10
8/27/98	9.89
9/10/98	7.73
9/30/98	12.26
10/29/98	11.75

GWIC ID:	144809
1:24k Quad:	EARLS GULCH
TRST:	04S09W09ADDB
Ground Elevation (ft):	5,040
MP from Land Surface (ft):	1.55
Total Depth from MP (ft):	88

Date	Depth to Water from MP (ft)
9/2/97	16.98
10/8/97	17.62
10/31/97	20.29
11/25/97	22.88

GWIC ID: **144809**
(continued)

Date	Depth to Water from MP (ft)
12/29/97	25.19
1/28/98	26.45
2/23/98	27.14
3/26/98	27.62
4/27/98	27.56
5/17/98	24.25
5/28/98	17.44
6/14/98	16.11
6/25/98	16.48
7/13/98	17.04
7/29/98	16.38
8/12/98	15.83
8/27/98	17.18
9/9/98	16.62
9/30/98	17.61
10/28/98	20.11

GWIC ID: **154922**
1:24k Quad: GLEN
TRST: 04S08W30CBBA
Ground Elevation (ft): 4,940
MP from Land Surface (ft): 1.90
Total Depth from MP (ft): 49

Date	Depth to Water from MP (ft)
9/2/97	8.04
10/7/97	6.00
10/30/97	7.64
11/24/97	8.25
12/29/97	8.57
1/26/98	8.57
2/23/98	9.01
3/26/98	8.01
4/28/98	6.88
5/16/98	6.03

GWIC ID: **154922**
(continued)

Date	Depth to Water from MP (ft)
5/28/98	5.62
6/14/98	4.56
6/27/98	4.20
7/14/98	5.26
7/29/98	7.20
8/12/98	7.55
8/27/98	7.58
9/9/98	5.97
9/30/98	6.08
10/28/98	7.71

GWIC ID: **156213**
1:24k Quad: EARLS GULCH
TRST: 04S09W10BABD
Ground Elevation (ft): 5,022
MP from Land Surface (ft): 1.00
Total Depth from MP (ft): 36

Date	Depth to Water from MP (ft)
4/1/95	6.58
5/3/95	5.33
5/30/95	3.25
7/8/95	3.75
8/9/95	3.67
9/1/95	3.08
10/1/95	3.17
11/11/95	3.92
12/2/95	4.42
12/28/95	5.00
2/1/96	5.25
3/2/96	5.25
4/8/96	5.17
5/7/96	4.61
6/9/96	3.67
6/29/96	3.50

GWIC ID: **156213**
(continued)

Date	Depth to Water from MP (ft)
7/30/96	3.16
9/5/96	3.16
10/3/96	3.16
11/5/96	4.16
12/9/96	4.50
1/3/97	5.00
2/5/97	5.25
3/5/97	5.67
3/30/97	5.67
5/4/97	3.42
6/6/97	5.16
7/10/97	2.92
8/1/97	2.17
9/8/97	2.67
10/3/97	3.42
11/1/97	4.08
12/1/97	4.75
1/5/98	5.08
1/28/98	5.15
2/4/98	5.50
3/9/98	5.75
4/1/98	5.67
5/8/98	4.75
6/2/98	3.58
7/6/98	3.17
8/11/98	3.00
9/2/98	3.00
10/1/98	3.50
11/1/98	4.33
12/1/98	4.75
1/4/99	5.25
2/2/99	5.83

GWIC ID: **156214**
1:24k Quad: EARLS GULCH
TRST: 04S09W10BBDA
Ground Elevation (ft): 5,030
MP from Land Surface (ft): 0.00
Total Depth from MP (ft): 30

Date	Depth to Water from MP (ft)
4/1/95	13.00
5/3/95	9.42
5/30/95	0.00
7/8/95	5.83
8/9/95	2.92
9/1/95	2.92
10/1/95	5.25
11/11/95	7.50
12/2/95	9.42
12/27/95	10.50
2/5/96	11.25
3/2/96	11.58
4/8/96	11.17
5/7/96	9.22
6/9/96	5.16
6/29/96	3.58
7/30/96	3.50
9/5/96	4.25
10/3/96	4.00
11/5/96	7.09
12/9/96	10.08
1/3/97	10.92
2/5/97	10.50
3/4/97	7.08
3/30/97	10.83
5/4/97	9.25
6/6/97	5.08
7/10/97	5.67
8/1/97	2.17
9/8/97	5.67
10/3/97	4.17
11/1/97	8.17
12/1/97	9.75
1/5/98	10.83

GWIC ID: **156214**
(continued)

Date	Depth to Water from MP (ft)
1/28/98	11.25
2/4/98	11.42
3/9/98	12.00
4/1/98	10.83
5/8/98	9.25
6/2/98	2.42
7/6/98	3.33
8/11/98	0.00
9/2/98	5.00
10/1/98	4.00
11/1/98	8.42
12/1/98	9.83
1/4/99	10.92
2/2/99	11.58

GWIC ID: **156231**
1:24k Quad: GLEN
TRST: 04S09W15DDAC
Ground Elevation (ft): 4,995
MP from Land Surface (ft): 1.00
Total Depth from MP (ft): 25

Date	Depth to Water from MP (ft)
4/1/95	6.50
5/3/95	6.17
5/30/95	5.25
7/8/95	5.25
8/9/95	5.92
9/1/95	6.00
10/1/95	5.75
11/11/95	5.92
12/2/95	5.92
12/28/95	5.42
2/5/96	5.42
3/2/96	5.42

GWIC ID: **156231**
(continued)

Date	Depth to Water from MP (ft)
4/8/96	5.50
5/7/96	5.89
6/9/96	5.58
6/29/96	5.25
7/30/96	5.75
9/5/96	5.92
10/3/96	5.92
11/5/96	5.99
12/9/96	6.33
1/3/97	5.50
2/5/97	5.75
3/4/97	5.92
3/31/97	6.42
5/4/97	5.57
6/6/97	5.16
7/15/97	5.10
8/1/97	5.75
9/2/97	5.96
9/8/97	5.00
10/3/97	5.75
10/7/97	5.79
10/30/97	6.12
11/1/97	6.25
11/24/97	6.31
12/1/97	6.92
12/29/97	5.78
1/5/98	6.00
1/28/98	5.91
2/4/98	5.92
2/23/98	6.22
3/9/98	6.67
3/26/98	6.49
4/1/98	6.50
4/28/98	6.07
5/8/98	5.67
5/17/98	5.35
5/28/98	5.15
6/2/98	5.08

GWIC ID: **156231**
(continued)

Date	Depth to Water from MP (ft)
6/14/98	5.19
6/27/98	5.09
7/6/98	5.42
7/14/98	5.53
7/29/98	5.93
8/11/98	5.95
8/27/98	5.89
9/9/98	5.98
9/30/98	5.94
10/1/98	5.92
11/1/98	6.17
12/1/98	6.42
1/4/99	6.08
2/2/99	6.17

GWIC ID: **158248**
1:24k Quad: MELROSE
TRST: 02S09W26CDBA
Ground Elevation (ft): 5,180
MP from Land Surface (ft): 1.35
Total Depth from MP (ft): 53

Date	Depth to Water from MP (ft)
9/3/97	7.53
10/7/97	9.20
10/30/97	9.92
11/24/97	10.5
12/30/97	10.97
1/26/98	11.13
2/23/98	11.28
3/25/98	11.15
4/27/98	10.18
5/15/98	9.28
5/29/98	7.44
6/13/98	7.57

GWIC ID: **158248**
(continued)

Date	Depth to Water from MP (ft)
6/25/98	6.42
7/13/98	7.06
7/28/98	8.30
8/11/98	8.63
8/27/98	7.74
9/9/98	7.62
9/30/98	7.94
10/28/98	8.77

GWIC ID: **161775**
1:24k Quad: MELROSE
TRST: 02S09W26CCAA
Ground Elevation (ft): 5,180
MP from Land Surface (ft): 0.90
Total Depth from MP (ft): 32

Date	Depth to Water from MP (ft)
9/3/97	9.40
10/7/97	10.29
10/30/97	10.74
11/24/97	11.21
12/30/97	11.60
1/26/98	11.73
2/23/98	11.90
3/25/98	11.75
4/27/98	10.87
5/15/98	10.09
5/29/98	8.86
6/13/98	8.79
6/25/98	8.15
7/13/98	8.60
7/28/98	9.63
8/11/98	9.84
8/27/98	9.50
9/9/98	9.51

GWIC ID: **161775**
(continued)

Date	Depth to Water from MP (ft)
9/30/98	9.56
10/28/98	10.24

GWIC ID: **162067**
1:24k Quad: GLEN
TRST: 05S09W20DAAD
Ground Elevation (ft): 5,600
MP from Land Surface (ft): 1.40
Total Depth from MP (ft): 170

Date	Depth to Water from MP (ft)
8/4/97	31.18
9/2/97	34.67
10/8/97	33.14
10/31/97	36.95
11/25/97	40.00
12/29/97	43.67
1/28/98	47.23
2/23/98	50.56
3/26/98	54.20
4/29/98	50.85
5/17/98	43.34
5/28/98	35.43
6/14/98	26.70
7/14/98	24.96
7/29/98	28.49
9/9/98	32.97
9/30/98	32.75
10/29/98	38.00

GWIC ID: **162072**
1:24k Quad: GLEN
TRST: 05S09W21CCCC
Ground Elevation (ft): 5,598
MP from Land Surface (ft): 2.50
Total Depth from MP (ft): 35

Date	Depth to Water from MP (ft)
8/4/97	8.10
9/2/97	8.90
10/8/97	8.86
10/31/97	9.24
11/25/97	12.29
12/29/97	15.81
1/28/98	22.50
2/23/98	27.97
3/26/98	31.70
4/29/98	27.76
5/17/98	15.58
5/28/98	12.67
6/14/98	9.54
6/27/98	8.38
7/14/98	7.24
7/29/98	7.26
8/12/98	7.39
8/28/98	8.65
9/9/98	9.06
9/30/98	8.79
10/29/98	9.85

GWIC ID:	**162077**
1:24k Quad:	GLEN
TRST:	05S09W22BBBA
Ground Elevation (ft):	5,440
MP from Land Surface (ft):	0.80
Total Depth from MP (ft):	22

Date	Depth to Water from MP (ft)
8/4/97	6.00
9/2/97	4.55
10/8/97	7.48
10/31/97	8.07
11/25/97	9.75
12/29/97	11.95
1/28/98	13.76
2/23/98	14.98
3/26/98	15.35
4/27/98	13.40
5/17/98	7.44
5/28/98	7.14
6/14/98	5.22
6/27/98	4.09
7/14/98	3.67
7/29/98	4.44
8/12/98	5.56
8/28/98	8.32
9/9/98	9.97
9/30/98	11.97
10/29/98	13.29

GWIC ID:	**162078**
1:24k Quad:	GLEN
TRST:	05S09W21ADAB
Ground Elevation (ft):	5,460
MP from Land Surface (ft):	2.20
Total Depth from MP (ft):	145

Date	Depth to Water from MP (ft)
8/4/97	5.88
9/2/97	6.54
10/8/97	6.81
12/29/97	8.72

GWIC ID:	**162079**
1:24k Quad:	GLEN
TRST:	04S09W27BDBC
Ground Elevation (ft):	5,090
MP from Land Surface (ft):	1.50
Total Depth from MP (ft):	91

Date	Depth to Water from MP (ft)
8/4/97	10.99
9/2/97	11.43
10/8/97	13.73
10/31/97	13.39
11/25/97	14.81
12/29/97	16.30
1/28/98	21.00
2/23/98	18.02
3/26/98	18.83
4/27/98	19.03
5/17/98	18.11
5/28/98	17.14
6/14/98	14.17
6/27/98	12.78
7/13/98	11.57
7/29/98	10.91
8/12/98	11.08
8/28/98	49.0r

GWIC ID: **162079**
(continued)

Date	Depth to Water from MP (ft)
9/9/98	12.81
9/30/98	12.28
10/28/98	18.95

GWIC ID: **162081**
1:24k Quad: GLEN
TRST: 04S09W27ACDA
Ground Elevation (ft): 5,020
MP from Land Surface (ft): 0.00
Total Depth from MP (ft): 32

Date	Depth to Water from MP (ft)
8/4/97	5.70
9/2/97	12.69
10/8/97	9.20
10/31/97	7.26
11/25/97	13.31
1/28/98	27.83
2/23/98	28.70
3/26/98	28.86
4/27/98	27.56
5/17/98	27.60
5/28/98	7.37
6/14/98	5.25
6/27/98	5.70
7/13/98	6.55
7/29/98	6.20
8/12/98	5.82
8/28/98	8.60
9/9/98	8.75
9/30/98	7.97
10/28/98	10.45

GWIC ID: **162083**
1:24k Quad: GLEN
TRST: 04S09W24CCDB
Ground Elevation (ft): 4,959
MP from Land Surface (ft): 1.30
Total Depth from MP (ft): 25

Date	Depth to Water from MP (ft)
8/4/97	7.77
9/2/97	8.53
10/7/97	8.55
10/30/97	8.44
11/24/97	8.64
12/29/97	7.29
1/26/98	7.45
2/23/98	8.29
3/26/98	8.26
4/28/98	7.07
5/16/98	6.06
5/28/98	5.64
6/14/98	5.69
6/27/98	5.15
7/14/98	6.71
7/29/98	7.96
8/12/98	8.45
8/27/98	8.93
9/9/98	8.98
9/30/98	8.84
10/28/98	8.82

GWIC ID: **162084**
1:24k Quad: GLEN
TRST: 04S09W24DCDA
Ground Elevation (ft): 4,965
MP from Land Surface (ft): 2.10
Total Depth from MP (ft): 52

Date	Depth to Water from MP (ft)
9/2/97	9.52
10/7/97	10.57
10/30/97	11.80
11/24/97	11.99
12/29/97	12.26
1/26/98	12.76
2/23/98	12.96
3/26/98	11.86
4/28/98	11.41
5/16/98	10.05
6/14/98	8.15
6/27/98	9.93
7/14/98	9.96
7/29/98	10.85
8/12/98	9.90
8/27/98	8.61
9/9/98	9.73
9/30/98	10.42
10/28/98	11.54

GWIC ID: **162085**
1:24k Quad: GLEN
TRST: 04S09W24DDDD
Ground Elevation (ft): 4,980
MP from Land Surface (ft): 2.60
Total Depth from MP (ft): 120

Date	Depth to Water from MP (ft)
8/4/97	48.12
9/2/97	48.28
10/7/97	44.08

GWIC ID: **162085**
(continued)

Date	Depth to Water from MP (ft)
10/30/97	48.30
12/29/97	50.89

GWIC ID: **162086**
1:24k Quad: BLOCK MOUNTAIN
TRST: 05S08W03ABBD
Ground Elevation (ft): 4,855
MP from Land Surface (ft): 0.00
Total Depth from MP (ft): 17

Date	Depth to Water from MP (ft)
8/4/97	1.30
9/2/97	2.25
10/7/97	2.15
10/30/97	2.16
11/24/97	2.35
12/29/97	1.78
1/26/98	1.73
2/23/98	2.31
3/26/98	2.11
4/28/98	1.44
5/16/98	1.10
6/27/98	0.26
7/14/98	1.21
7/29/98	1.58
8/12/98	1.81
8/27/98	2.02
9/9/98	2.16
9/30/98	2.03
10/29/98	2.28

GWIC ID:	**162110**
1:24k Quad:	GLEN
TRST:	05S09W01BABB
Ground Elevation (ft):	5,070
MP from Land Surface (ft):	0.00
Total Depth from MP (ft):	6

Date	Depth to Water from MP (ft)
8/5/97	6.05
9/2/97	5.15
10/7/97	5.05
10/31/97	5.07
11/25/97	5.07
12/29/97	5.18
3/26/98	4.82
4/27/98	4.81
5/16/98	4.79
5/28/98	4.80
6/14/98	4.75
6/27/98	4.73
7/14/98	5.03
7/29/98	4.59
8/12/98	4.07
8/28/98	3.42
9/9/98	3.26
9/30/98	3.23

GWIC ID:	**162116**
1:24k Quad:	GLEN
TRST:	04S08W31BABC
Ground Elevation (ft):	4,930
MP from Land Surface (ft):	0.00
Total Depth from MP (ft):	15

Date	Depth to Water from MP (ft)
8/5/97	4.60
9/2/97	5.40
10/8/97	5.48
10/31/97	5.22

GWIC ID: **162116**
(continued)

Date	Depth to Water from MP (ft)
11/25/97	5.22
12/29/97	5.20
1/28/98	5.32
2/23/98	5.34
3/26/98	5.20

GWIC ID:	**162131**
1:24k Quad:	EARLS GULCH
TRST:	03S09W02CCBA02
Ground Elevation (ft):	5,150
MP from Land Surface (ft):	1.00
Total Depth from MP (ft):	43

Date	Depth to Water from MP (ft)
9/3/97	10.93
10/30/97	8.16
11/24/97	11.37
12/30/97	12.83
1/26/98	13.13
2/23/98	13.69
3/25/98	12.15
4/27/98	7.72
5/15/98	7.57
5/29/98	7.90
6/13/98	8.11
6/25/98	8.39
7/28/98	10.68
8/11/98	10.26
9/10/98	10.25
10/28/98	11.00

GWIC ID: **162133**
1:24k Quad: EARLS GULCH
TRST: 03S09W02CCBA01
Ground Elevation (ft): 5,150
MP from Land Surface (ft): 1.65
Total Depth from MP (ft): 85

Date	Depth to Water from MP (ft)
8/5/97	22.70
9/3/97	21.80
10/7/97	21.15
10/30/97	21.31
11/24/97	22.03
12/30/97	22.40
1/26/98	22.45
2/23/98	22.68
3/25/98	21.97
4/27/98	20.21
5/15/98	19.36
5/29/98	19.02
6/13/98	19.50
6/25/98	21.30
7/9/98	20.42
7/28/98	21.39
8/11/98	21.79
9/10/98	21.87
9/30/98	21.71
10/28/98	22.02

GWIC ID: **162135**
1:24k Quad: MELROSE
TRST: 02S09W23CCCD
Ground Elevation (ft): 5,190
MP from Land Surface (ft): 1.00
Total Depth from MP (ft): 10

Date	Depth to Water from MP (ft)
8/5/97	5.77
9/3/97	7.24

GWIC ID: **162135**
(continued)

Date	Depth to Water from MP (ft)
10/7/97	7.63
10/30/97	8.74
11/24/97	10.05
12/30/97	11.20
1/26/98	11.91
2/23/98	12.56
3/25/98	12.59
4/27/98	11.65
5/15/98	9.19
5/29/98	8.29
6/13/98	6.50
6/25/98	6.12
7/13/98	7.03
7/28/98	7.27
8/11/98	6.66
8/27/98	6.97
9/9/98	7.69
9/30/98	7.03
10/28/98	9.04

GWIC ID: **162160**
1:24k Quad: MELROSE
TRST: 02S09W23CACD
Ground Elevation (ft): 5,195
MP from Land Surface (ft): 0.00
Total Depth from MP (ft): 38

Date	Depth to Water from MP (ft)
8/5/97	21.5
9/3/97	9.00
10/7/97	7.57

GWIC ID:	162163
1:24k Quad:	MELROSE
TRST:	02S09W26BAAB
Ground Elevation (ft):	5,195
MP from Land Surface (ft):	2.10
Total Depth from MP (ft):	31

Date	Depth to Water from MP (ft)
8/5/97	6.31
9/3/97	6.31
10/7/97	6.75
10/30/97	7.34
11/24/97	8.12
12/30/97	9.51
1/26/98	9.82
2/23/98	10.41
3/25/98	10.62
4/27/98	10.04
5/15/98	8.85
5/29/98	8.11
6/13/98	6.65
6/25/98	6.19
7/9/98	6.67
7/28/98	6.30
8/11/98	6.18
8/27/98	5.97
9/9/98	6.35
9/30/98	6.04
10/28/98	7.46

GWIC ID:	162164
1:24k Quad:	MELROSE
TRST:	02S09W23CCAC
Ground Elevation (ft):	5,195
MP from Land Surface (ft):	1.40
Total Depth from MP (ft):	16

Date	Depth to Water from MP (ft)
8/5/97	7.30
9/3/97	7.45
10/7/97	7.67
10/30/97	9.28
11/24/97	10.77
12/30/97	12.34
1/26/98	12.97
2/23/98	13.67
3/25/98	13.79
4/27/98	12.94
5/15/98	10.95
5/29/98	9.71
6/13/98	7.40
6/25/98	6.37
7/13/98	7.47
7/28/98	7.33
8/11/98	6.31
8/27/98	6.50
9/9/98	7.64
9/30/98	6.47
10/28/98	9.65

GWIC ID:	162170
1:24k Quad:	MELROSE
TRST:	01S09W34BCAC
Ground Elevation (ft):	5,410
MP from Land Surface (ft):	1.15
Total Depth from MP (ft):	53

Date	Depth to Water from MP (ft)
8/5/97	23.72
9/3/97	23.03
10/7/97	22.87
10/30/97	22.59
11/24/97	22.79
1/5/98	23.39
1/26/98	23.49
2/23/98	23.55
3/26/98	23.54
4/27/98	23.56
5/15/98	24.00
5/29/98	22.69
6/14/98	23.46
7/13/98	23.90
7/29/98	23.86
8/14/98	24.35
8/26/98	23.77

GWIC ID:	162176
1:24k Quad:	GLEN
TRST:	05S09W22ABAB
Ground Elevation (ft):	5,420
MP from Land Surface (ft):	1.55
Total Depth from MP (ft):	270

Date	Depth to Water from MP (ft)
8/4/97	192.45
9/2/97	199.14r
10/8/97	192.46
10/31/97	192.52
11/25/97	192.50

GWIC ID: 162176
(continued)

Date	Depth to Water from MP (ft)
12/29/97	193.29
1/28/98	194.51
2/23/98	192.89
3/26/98	192.53
4/27/98	192.72
5/17/98	192.71
5/28/98	192.66
6/14/98	192.53
7/14/98	192.08
9/9/98	192.45
10/29/98	192.70

GWIC ID:	162454
1:24k Quad:	GLEN
TRST:	05S09W34CABD
Ground Elevation (ft):	5,455
MP from Land Surface (ft):	0.00
Total Depth from MP (ft):	8

Date	Depth to Water from MP (ft)
9/2/97	4.50
10/8/97	5.15
10/31/97	4.73
11/25/97	4.72
12/29/97	5.02
1/28/98	4.75
2/23/98	4.59
3/26/98	4.11
4/28/98	4.44
5/17/98	2.92
5/28/98	2.78
6/14/98	4.32
7/14/98	4.19
7/29/98	5.40
8/28/98	5.53

GWIC ID: **162454**
(continued)

Date	Depth to Water from MP (ft)
9/9/98	6.10
9/30/98	5.77
10/29/98	4.95

GWIC ID: **162627**
1:24k Quad: EARLS GULCH
TRST: 03S09W34CBCC
Ground Elevation (ft): 5,100
MP from Land Surface (ft): 1.65
Total Depth from MP (ft): 118

Date	Depth to Water from MP (ft)
9/3/97	14.60
10/7/97	11.26
10/30/97	11.94
11/24/97	13.92
12/30/97	14.25
1/28/98	14.47
2/25/98	14.54
3/26/98	14.30
4/29/98	14.35
5/16/98	9.87
5/29/98	8.55
6/13/98	8.47
6/25/98	15.20r
7/13/98	11.34
7/28/98	9.40
9/10/98	9.80
9/30/98	8.27
10/29/98	9.57

GWIC ID: **162628**
1:24k Quad: EARLS GULCH
TRST: 03S09W34CBBC
Ground Elevation (ft): 5,110
MP from Land Surface (ft): 2.20
Total Depth from MP (ft): 43

Date	Depth to Water from MP (ft)
9/3/97	28.00
10/7/97	29.65
10/30/97	31.37
11/24/97	32.35
12/30/97	33.12
1/28/98	33.58
2/25/98	33.79
3/26/98	33.53
4/29/98	33.77
5/29/98	25.63
6/13/98	24.07
6/25/98	26.30
7/13/98	26.85
7/28/98	24.57
8/11/98	24.48
8/27/98	26.00
9/10/98	26.54
9/30/98	25.65
10/29/98	26.86

GWIC ID: **163239**
1:24k Quad: EARLS GULCH
TRST: 03S09W02AAAA
Ground Elevation (ft): 5,240
MP from Land Surface (ft): 1.80
Total Depth from MP (ft): 46

Date	Depth to Water from MP (ft)
10/7/97	30.11
10/30/97	29.97
11/24/97	29.89

GWIC ID: **163239**
(continued)

Date	Depth to Water from MP (ft)
12/30/97	29.84
1/26/98	29.78
2/23/98	29.73
3/25/98	29.67
4/27/98	30.53
5/15/98	30.45
5/29/98	29.89
6/13/98	29.80
6/25/98	29.75
7/9/98	29.83
7/28/98	29.96
8/11/98	29.83
8/27/98	29.90
9/9/98	29.86
9/30/98	29.66
10/28/98	29.36

GWIC ID: **163240**
1:24k Quad: GLEN
TRST: 04S08W31BBAD
Ground Elevation (ft): 4,930
MP from Land Surface (ft): 0.50
Total Depth from MP (ft): NA

Date	Depth to Water from MP (ft)
10/8/97	5.16
10/31/97	4.97
11/25/97	4.97
1/5/98	5.00
1/28/98	5.08
2/23/98	5.10
3/26/98	4.89
4/27/98	4.95
5/17/98	5.00
5/28/98	2.75

GWIC ID: **163240**
(continued)

Date	Depth to Water from MP (ft)
6/14/98	2.58
6/27/98	1.41
7/14/98	2.55
7/29/98	3.88
8/12/98	4.15
8/28/98	4.41
9/9/98	4.48
9/30/98	4.87
10/28/98	5.02

GWIC ID: **163241**
1:24k Quad: GLEN
TRST: 04S08W31BBBC01
Ground Elevation (ft): 4,940
MP from Land Surface (ft): 1.50
Total Depth from MP (ft): 39

Date	Depth to Water from MP (ft)
10/7/97	10.61
10/31/97	9.62
11/25/97	10.25
1/28/98	10.52
2/23/98	10.63
3/26/98	10.56
4/27/98	10.77
5/17/98	10.85
5/28/98	10.08
6/14/98	10.57
6/27/98	7.24
7/14/98	9.48
7/29/98	10.52
8/12/98	10.64
8/28/98	10.71
9/9/98	10.72
9/30/98	10.77
10/28/98	10.73

GWIC ID:	163401
1:24k Quad:	GLEN
TRST:	04S08W31BBBC02
Ground Elevation (ft):	4,940
MP from Land Surface (ft):	1.30
Total Depth from MP (ft):	156

Date	Depth to Water from MP (ft)
10/31/97	0.31
11/25/97	0.82
1/28/98	1.50
2/23/98	1.71
3/26/98	1.87
4/27/98	1.88
5/17/98	1.79
5/28/98	1.66
6/14/98	1.23
7/14/98	0.37
7/29/98	0.50
8/12/98	0.54
8/28/98	0.94
9/9/98	1.03
9/30/98	1.21
10/28/98	1.38

GWIC ID:	163402
1:24k Quad:	MELROSE
TRST:	01S09W34BCBA
Ground Elevation (ft):	5,395
MP from Land Surface (ft):	2.40
Total Depth from MP (ft):	124

Date	Depth to Water from MP (ft)
10/30/97	8.04
1/5/98	32.20
1/26/98	38.20

GWIC ID:	163403
1:24k Quad:	EARLS GULCH
TRST:	03S09W02CCBD
Ground Elevation (ft):	5,155
MP from Land Surface (ft):	0.40
Total Depth from MP (ft):	58

Date	Depth to Water from MP (ft)
10/30/97	8.70
11/24/97	11.41
1/5/98	12.92
1/26/98	13.16
2/23/98	13.62
3/25/98	12.10
4/27/98	9.17
5/29/98	7.76
6/13/98	8.24
6/25/98	8.27
7/9/98	8.84
7/28/98	9.95
8/27/98	10.09
9/10/98	9.70
10/28/98	10.38

GWIC ID:	164355
1:24k Quad:	EARLS GULCH
TRST:	04S09W09ABAB
Ground Elevation (ft):	5,100
MP from Land Surface (ft):	3.80
Total Depth from MP (ft):	48.2

Date	Depth to Water from MP (ft)
11/24/97	41.85
12/30/97	41.65
1/28/98	41.93
2/25/98	42.06
3/26/98	41.56
4/29/98	40.13
5/16/98	15.84

GWIC ID: **164355**
(continued)

Date	Depth to Water from MP (ft)
5/29/98	15.72
6/13/98	15.65
6/25/98	15.63
7/13/98	40.32
7/28/98	15.67
8/11/98	15.70
8/27/98	15.79
9/10/98	42.67
9/30/98	42.49
10/29/98	41.41

GWIC ID:	**165462**
1:24k Quad:	EARLS GULCH
TRST:	04S09W04AAAA
Ground Elevation (ft):	5,120
MP from Land Surface (ft):	1.10
Total Depth from MP (ft):	92

Date	Depth to Water from MP (ft)
1/5/98	53.66
1/28/98	57.90
2/25/98	55.20
5/16/98	60.05
5/29/98	57.55
6/13/98	65.06
7/13/98	47.85
7/28/98	49.55
8/11/98	45.65
8/27/98	44.13
9/10/98	44.97
10/29/98	43.14

GWIC ID:	**166502**
1:24k Quad:	EARLS GULCH
TRST:	03S09W01DCCA
Ground Elevation (ft):	5,295
MP from Land Surface (ft):	2.8
Total Depth from MP (ft):	100

Date	Depth to Water from MP (ft)
4/29/98	54.08
5/29/98	54.12
6/13/98	54.15
6/25/98	54.18
7/9/98	54.13
7/28/98	53.63
8/11/98	53.90
8/27/98	54.10
9/9/98	54.08
9/30/98	53.95
10/28/98	53.80

GWIC ID:	**166503**
1:24k Quad:	MELROSE
TRST:	02S09W26CABC
Ground Elevation (ft):	5,182
MP from Land Surface (ft):	1.5
Total Depth from MP (ft):	35

Date	Depth to Water from MP (ft)
4/27/98	10.16

GWIC ID:	**166504**
1:24k Quad:	EARLS GULCH
TRST:	04S09W05DDBC
Ground Elevation (ft):	5,405
MP from Land Surface (ft):	2.0
Total Depth from MP (ft):	NA

Date	Depth to Water from MP (ft)
4/29/98	5.21

GWIC ID:	**166505**
1:24k Quad:	EARLS GULCH
TRST:	04S09W09DAAB
Ground Elevation (ft):	5,070
MP from Land Surface (ft):	2.3
Total Depth from MP (ft):	220

Date	Depth to Water from MP (ft)
4/29/98	49.39

GWIC ID:	**166506**
1:24k Quad:	EARLS GULCH
TRST:	04S09W09DAAC
Ground Elevation (ft):	5,045
MP from Land Surface (ft):	
Total Depth from MP (ft):	47

Date	Depth to Water from MP (ft)
6/2/98	17.08
7/6/98	13.33
8/11/98	13.00
9/1/98	13.67
10/1/98	15.83
11/1/98	22.50
12/1/98	27.33
1/4/99	30.50
2/2/99	31.83

GWIC ID:	**166507**
1:24k Quad:	GLEN
TRST:	05S09W01BACA
Ground Elevation (ft):	5,095
MP from Land Surface (ft):	2.5
Total Depth from MP (ft):	82

Date	Depth to Water from MP (ft)
4/29/98	49.36
5/16/98	49.85
5/28/98	50.09
6/27/98	35.00
7/14/98	24.75
8/12/98	27.07
8/28/98	30.51
9/9/98	31.54
9/30/98	34.47
10/28/98	37.73

GWIC ID:	**168860**
1:24k Quad:	EARLS GULCH
TRST:	04S09W05DCDD
Ground Elevation (ft):	5,404
MP from Land Surface (ft):	2.5
Total Depth from MP (ft):	79

Date	Depth to Water from MP (ft)
11/17/98	17.69
3/18/99	17.95

GWIC ID:	**168862**
1:24k Quad:	EARLS GULCH
TRST:	04S09W05DDCC
Ground Elevation (ft):	5,377
MP from Land Surface (ft):	1.2
Total Depth from MP (ft):	36

Date	Depth to Water from MP (ft)
11/17/98	1.94
3/18/99	2.10

GWIC ID:	**169097**
1:24k Quad:	EARLS GULCH
TRST:	03S09W23BACA
Ground Elevation (ft):	5,110
MP from Land Surface (ft):	-6
Total Depth from MP (ft):	--

Date	Depth to Water from MP (ft)
3/25/98	25e

GWIC ID:	**168864**
1:24k Quad:	EARLS GULCH
TRST:	04S09W04CDDD
Ground Elevation (ft):	5,180
MP from Land Surface (ft):	0.4
Total Depth from MP (ft):	30

Date	Depth to Water from MP (ft)
11/17/98	23.00
3/18/99	22.85

GWIC ID:	**168865**
1:24k Quad:	EARLS GULCH
TRST:	04S09W04CDDC
Ground Elevation (ft):	5,200
MP from Land Surface (ft):	0.0
Total Depth from MP (ft):	35

Date	Depth to Water from MP (ft)
11/17/98	33.30
3/18/99	32.70

Appendix C

Surface-Water Measurements

C-1 Upper Big Hole basin (DNRC data)

C - 2 Francis Creek unit

C - 3 Lower Big Hole basin

C - 1

Upper Big Hole basin (DNRC data)

Upper Big Hole basin
Data collected by the DNRC July and September 2000

Drainage Name	Discharge Measurement Location for Drainage (township, range, section, tract)	Surface Flow (cfs) July 12-13, 2000	Surface Flow (cfs) September 18, 2000
Big Hole River, Upper	07S15W04DBDB	31.56	11.31
Big Lake Cr	05S17W10DBCD	11.84	3.75
Big Swamp Cr	05S16W17DDBC	23.45	5.5
Doolittle Cr	01S14W29	4.92	1.69
Governor Cr	05S15W35DADA	3.47	5.39
Howell Cr	01N15W21CABB	3.2	0.79
Johnson Cr	01S17W15DDDB	5.41	
Moosehorn Cr Diversion	03S17W33	4.09	
McCormick Cr	01N15W22	0.97	
Miner Cr	06S16W03CDAC	30.63	
Mussigbrod Cr	01S16W09BAAD	14.99	
Nickel Bar Cr	03S17W16	0.396	
Pintlar Cr	01N15W23DBBA	15.73	2.73
Ruby Cr	03S17W20DCAA	7.28	3.47
Steel Cr	03S14W05CABA	4.59	
Tie Cr	01S17W34CAAA	1.69	
Trail Cr	02S17W21AACB	6.68	12.58
Warm Springs Cr	05S14W20DDCC	13.17	

C - 2

Francis Creek unit

Surface-Water Flow Data, Francis Creek Unit

Streams: Arranged from upstream to downstream

Station Name: North Fork Sand Creek at National Forest boundary
Station ID:
Township, Range, Section, Tract: 03SR14W19CBCD
Latitude: N45°33'18" Longitude: W113°23'03"
Elevation: 6,210 ft
Drainage Area: 2.1 mi²
Description: At National Forest boundary, 3.5 mi east of Hwy 278, 4.7 mi southeast of Wisdom, MT
Remarks:

Date	Time	Flow (cfs)	Comments
5/1/98	15:00	5.4	
5/7/98	15:20	8.4	
5/20/98	13:20	5.7	
6/4/98	12:45	10.0	
6/18/98	12:45	8.2	
7/1/98	10:00	6.0	
7/7/98	--	4.5	
7/16/98	10:15	2.6	
7/22/98	16:30	2.2	
8/12/98	11:00	0.8	
9/2/98	--	0.4	

Station Name: Sheep Creek at National Forest boundary
Station ID:
Township, Range, Section, Tract: 03S14W31CBCB
Latitude: N45°31'40" Longitude: W113°23'09"
Elevation: 6,470 ft
Drainage Area: 5.1 mi²
Description: At Parshall flume near National Forest boundary, 3.5 mi east of Hwy 278, 6.7 mi southeast of Wisdom, Montana
Remarks: Stage-discharge relationship for flume was good.

Date	Time	Flow (cfs)	Comments
5/1/98	13:45	3.0	Ice shelf on right edge of water
5/7/98	12:15	7.3	
5/9/98	11:30	10.9	
5/13/98	15:00	14.0	
5/20/98	13:00	10.6	
6/4/98	11:30	21.3	

Sheep Creek (continued)

Date	Time	Flow (cfs)	Comments
6/18/98	11:45	19.4	
7/1/98	9:00	16.1	
7/16/98	9:40	6.7	
7/22/98	11:45	5.3	
8/12/98	12:45	2.4	
9/2/98	--	1.3	

Station Name: Hooligan Creek
Station ID:
Township, Range, Section, Tract: 03S15W35ABBB
Latitude: N45°32'11" Longitude: W113°25'02"
Elevation: 6,242 ft
Drainage Area: 3.6 mi^2
Description: Near dirt road crossing, 2 mi east of Hwy 278, 5.6 mi southeast of Wisdom, Montana
Remarks:

Date	Time	Flow (cfs)	Comments
5/1/98	16:00	1.5	Visual estimate
5/20/98	14:15	2.6	
6/4/98	14:10	4.6	Estimate
6/18/98	14:15	3.6	
7/1/98	11:30	2.0	Estimate
7/7/98	--	1.3	
7/16/98	9:00	0.9	
7/22/98	10:05	0.5	
8/12/98	13:45	0.1	

Station Name: Stanley Creek above Huntley Ranch
Station ID:
Township, Range, Section, Tract: 04S15W13DABA
Latitude: N45°29'06" Longitude: W113°23'21"
Elevation: 6,840 ft
Drainage Area: 3.0 mi²
Description: Near Parshall flume, 0.15 mi west of National Forest boundary, 3.3 mi east of Hwy 278, 8 mi north of Jackson, Montana
Remarks: Parshall flume has 5 ft throat; cannot be used to measure typical summer flows. Measurments include flow from a small irrigation diversion near National Forest boundary. Quality of measurements is generally poor

Date	Time	Flow (cfs)	Comments
5/7/98	16:45	12.9	
5/20/98	15:00	8.1	
6/4/98	16:45	13.1	
6/18/98	16:00	10.8	
7/1/98	13:00	6.1	
7/16/98	10:15	2.2	
7/22/98	13:45	2.4	
8/12/98	15:00	1.1	
9/2/98	--	0.6	
9/11/98	14:00	0.5	Estimate

Station Name: North Fork of Stanley Creek
Station ID:
Township, Range, Section, Tract: 03SR15W34DAAD
Latitude: N45°31'44" Longitude: W113°25'42"
Elevation: 6,205 ft
Drainage Area: 3.3 mi²
Description: At dirt road crossing, 1.5 mi east of Hwy 278, 6.0 mi south of Wisdom
Remarks:

Date	Time	Flow (cfs)	Comments
5/1/98	16:00	3.0	Visual estimate
6/4/98	15:15	2.0	
6/18/98	15:00	0.5	Visual estimate
7/1/98	12:00	0.5	Visual estimate
7/16/98	--	0.0	No flow
7/22/98	--	0.0	No flow
7/29/28	--	0.0	No flow
8/12/98	--	0.0	No flow

Station Name: Stanley Creek near confluence with Francis Creek
Station ID:
Township, Range, Section, Tract: 03S15W03CDCD
Latitude: N45°35'47" Longitude: W113°26'28"
Elevation: 6,061 ft
Drainage Area:
Description: 0.15 mi upstream of confluence with Francis Creek, 0.6 mi east of Hwy 278, 1.3 mi south of Wisdom, Montana
Remarks:

Date	Time	Flow (cfs)	Comments
9/26/97	--	1.0	
10/29/97	11:15	1.9	
4/22/98	12:10	10.8	
5/1/98	16:55	5.9	
5/7/98	--	2.1	
5/9/98	16:45	2.3	
5/13/98	10:00	3.9	
5/20/98	10:00	3.9	
6/2/98	10:30	64.0	
6/4/98	19:30	95.0	
6/5/98	8:15	82.1	
6/18/98	17:00	107.2	
6/30/98	20:15	20.6	
7/1/98	12:00	17.1	
7/1/98	16:10	15.6	
7/2/98	11:35	14.7	
7/7/98	14:45	6.6	
7/16/98	15:30	1.8	Estimated flow. Lots of algae
7/20/98	14:50	1.4	
7/21/98	12:45	1.4	Estimated flow
7/28/98	17:45	1.1	
8/12/98	18:55	0.8	
9/2/98	19:30	1.0	
9/3/98	9:30	1.0	
9/11/98	9:20	1.4	
9/30/98	19:30	1.2	

Station Name: Francis Creek near confluence with Stanley Creek
Station ID:
Township, Range, Section, Tract: 03S15W03DBCC
Latitude: N45°36'01" Longitude: W113°26'14"
Elevation: 6,058 ft
Drainage Area:
Description: 0.2 mi downstream of confluence with Stanley Creek, 0.75 mi east of Hwy 278, 1.2 mi southeast of Wisdom, Montana
Remarks:

Date	Time	Flow (cfs)	Comments
9/26/97	--	1.8	
4/22/98	11:30	35.5	
5/7/98	16:10	22.7	
6/4/98	19:00	137.0	
7/1/98	12:00	34.6	
7/7/98	13:45	17.3	
7/16/98	14:45	8.8	Lots of algae in channel
7/21/98	11:15	5.7	Estimate
8/12/98	18:50	2.4	
9/3/98	8:45	2.0	

Irrigation Ditches: Arranged from south to north along Hwy 278

Station Name: Huntley Ditch at Hwy 278
Station ID:
Township, Range, Section, Tract: 04S15W16DBCB
Latitude: N45°28'59" Longitude: W113°27'28"
Elevation: 6,263 ft
Drainage Area: NA
Description: On east side of Hwy 278, 8.1 mi northwest of Jackson, Montana
Remarks: Continuous recorder installed during study

Date	Time	Flow (cfs)	Comments
4/21/98	14:00	5.0	Headgate is closed, but lots of snow melt.
5/7/98	--	5.6	
5/20/98	15:10	1.8	
6/4/98	15:45	32.0	
6/18/98	15:30	32.3	
7/1/98	10:00	0.1	Close to zero flow. Headgate closed on 6/24 or 6/25
7/7/98	11:50	0.1	Visual estimate
7/16/98	18:00	0.8	Lots of algae on control.
7/21/98	15:15	0.5	Estimated flow. Even more algae on control.
9/2/98	17:30	1.5	Still some algae, but better.

Station Name: Diversion south of intersection of Huntley Ranch Lane and Hwy 278
Station ID:
Township, Range, Section, Tract: 04S15W04DCCB
Latitude: N45°30'35" Longitude: W113°27'31"
Elevation: 6,210 ft
Drainage Area: NA
Description: At Hwy 278, 0.05 mi south of Huntley Ranch lane, 7.3 mi south of Wisdom, Montana
Remarks:

Date	Time	Flow (cfs)	Comments
6/5/98	--	0.5	Estimate
6/18/98	--	0.0	Estimate
7/1/98	--	0.4	Estimate
7/7/98	12:00	0.3	
7/16/98	--	0.0	Dry

Station Name: First Ditch north of Huntley lane
Station ID:
Township, Range, Section, Tract: 04S15W04DBCC
Latitude: N45°30'44" Longitude: W113°27'36"
Elevation: 6,205 ft
Drainage Area: NA
Description: At Hwy 278, 0.1 mi north of Huntley lane, 7.1 mi south of Wisdom, Montana
Remarks:

Date	Time	Flow (cfs)	Comments
6/4/98	15:15	16.5	
6/18/98	--	16.0	
7/1/98	--	1.0	Visual estimate
7/7/98	12:20	0.0	No flow
7/16/98	--	0.0	No flow

Station Name: First Ditch South of Twin Lakes Road
Station ID:
Township, Range, Section, Tract: 04S15W04ACBB
Latitude: N45°31'08" Longitude: W113°27'36"
Elevation: 6,195 ft
Drainage Area: NA
Description: At Hwy 278, 0.25 mi south of Twin Lakes Road, 6.6 mi south of Wisdom, Montana
Remarks:

Date	Time	Flow (cfs)	Comments
6/5/98	9:00	3.0	
6/18/98	--	4.5	
7/1/98	--	<0.5	Visual estimate
7/7/98	--	0.0	No flow
7/16/98	--	0.0	No flow

Station Name: Ditch at Twin Lakes Road
Station ID:
Township, Range, Section, Tract: 03S15W33CDDD
Latitude: N45°31'22" Longitude: W113°27'37"
Elevation: 6,190 ft
Drainage Area: NA
Description: At intersection of Hwy 278 and Twin Lakes Road, 6.3 mi south of Wisdom, Montana
Remarks:

Date	Time	Flow (cfs)	Comments
6/4/98	14:45	4.8	
6/18/98	--	4.0	
7/1/98	--	<0.5	Visual estimate
7/7/98	--	0.0	1-2 gpm
7/16/98	--	0.0	

Station Name: Diversion 1/2 mi north of Twin Lakes Road
Station ID:
Township, Range, Section, Tract: 03S15W33ACCC
Latitude: N45°31'49" Longitude: W113°27'34"
Elevation: 6,183 ft
Drainage Area: NA
Description: At Hwy 278, 0.5 mi north of Twin Lakes Road, 5.8 mi south of Wisdom, Montana
Remarks:

Date	Time	Flow (cfs)	Comments
6/4/98	--	8.8	
6/18/98	--	14.0	
7/1/98	--	<1.0	Visual estimate
7/7/98	--	0.0	No flow
7/16/98	--	0.0	No flow

Station Name: Third Ditch South of Rock Creek Road
Station ID:
Township, Range, Section, Tract: 03S15W28DBBB
Latitude: N45°32'40"   Longitude: W113°27'35"
Elevation: 6,165 ft
Drainage Area: NA
Description: At Hwy 278, 1.55 mi south of Rock Creek Road, 4.9 mi south of Wisdom, Montana
Remarks:

Date	Time	Flow (cfs)	Comments
6/4/98		11.3	
6/18/98		10.5	
7/1/98		1.0	Estimate
7/7/98		0.2	Estimate
7/16/98		0.0	No flow

Station Name: Diversion 1/2 mi south of Rock Creek Road
Station ID:
Township, Range, Section, Tract: 03S15W21CAAA
Latitude: N45°33'33"   Longitude: W113°27'34"
Elevation: 6,151 ft
Drainage Area: NA
Description: At Hwy 278, 0.5 mi south of Rock Creek Road, 3.8 mi south of Wisdom, Montana
Remarks:

Date	Time	Flow (cfs)	Comments
6/4/98	--	7.2	
6/18/98	--	5.0	
7/1/98	--	1.0	Estimated
7/7/98	12:37	0.0	No flow
7/16/98	--	0.0	No flow

Station Name: First Ditch South of Rock Creek Road
Station ID:
Township, Range, Section, Tract: 03S15W21BADD
Latitude: N45°27'35" Longitude: W113°33'49"
Elevation: 6,145 ft
Drainage Area: NA
Description: At Hwy 278, 0.25 mi south of Rock Creek Road, 3.6 mi south of Wisdom, Montana
Remarks:

Date	Time	Flow (cfs)	Comments
6/4/98	12:05	10.5	
6/18/98	--	8.5	
7/1/98	--	5.0	
7/7/98	12:45	0.3	
7/16/98	--	0.0	No flow

Station Name: Diversion at Rock Creek Road
Station ID:
Township, Range, Section, Tract: 03SR15W16CDDD
Latitude: N45°34'03" Longitude: W113°27'33"
Elevation: 6,145 ft
Drainage Area: NA
Description: At intersection of Hwy 278 and Rock Creek Road, 3.2 mi south of Wisdom
Remarks:

Date	Time	Flow (cfs)	Comments
5/1/98	16:45	0.0	No flow
5/13/98	11:30	1.8	
6/2/98	11:00		
6/4/98	11:30	17.7	
6/18/98	11:30	15.4	Headgate closed on 6/30/98
7/7/98	13:00	1.9	
7/16/98	--	0.0	No flow
7/21/98	--	0.0	No flow

Station Name: Huntley Ditch at Hwy 278
Station ID:
Township, Range, Section, Tract: 04S15W16DBCB
Latitude: N45°28'59"
Longitude W113°27'28"
Elevation: 6,263 ft
Drainage Area: NA
Description: On east side of Hwy 278, 8.1 mi northwest of Jackson, Montana
Remarks: Water is diverted from Big Hole River

	1998 Daily Mean Flow (cubic feet per second)					
Day	May	June	July	August	September	October
1	--	24.0	0.1	0.5	1.4	1.9
2	--	26.6	0.1	0.4	1.4	1.9
3	--	33.9	0.1	0.3	1.4	1.9
4	--	31.4	0.1	0.2	1.4	1.9
5	--	29.9	0.1	0.2	1.4	1.9
6	--	27.5	0.1	0.1	1.4	1.9
7	--	29.5	0.1	0.1	1.5	1.9
8	--	29.7	0.5	0.1	1.9	1.9
9	--	31.0	4.0	0.1	2.3	1.9
10	--	28.7	3.7	0.1	3.1	1.9
11	--	33.3	6.0	0.1	3.3	1.9
12	3.4	33.3	4.0	0.0	2.8	1.9
13	3.6	35.8	2.6	0.0	2.4	1.9
14	4.6	34.5	2.0	0.0	2.2	1.9
15	5.1	33.8	1.6	0.0	2.1	1.9
16	3.5	34.4	1.3	0.0	1.9	--
17	5.3	35.0	1.1	0.0	1.9	--
18	3.9	33.5	0.9	0.0	1.9	--
19	2.7	33.0	0.6	0.0	1.9	--
20	1.9	33.7	0.5	0.0	1.9	--
21	5.1	33.0	0.5	6.0	1.9	--
22	25.3	32.9	0.4	1.6	1.9	--
23	36.4	32.1	0.3	1.6	1.9	--
24	28.1	32.5	0.3	1.6	1.9	--
25	18.8	33.8	0.3	1.6	1.9	--
26	25.1	24.7	0.3	1.6	1.9	--
27	31.8	4.7	0.2	1.6	1.9	--
28	28.5	0.9	0.3	1.4	1.9	--
29	24.8	0.3	0.8	1.4	1.9	--
30	29.1	0.1	0.6	1.4	1.9	--
31	26.2		0.6	1.4		--
Mean:	15.7	27.6	1.1	0.8	2.0	1.9
Max:	36.4	35.8	6.0	6.0	3.3	1.9
Min:	1.9	0.1	0.1	0.0	1.4	1.9

Station Name: Francis Creek below Stanley Creek
Station ID:
Township, Range, Section, Tract: 03S15W03DBCC
Latitude: N45°36'01"
Longitude: W113°26'14"
Elevation: 6,058 ft
Drainage Area:
Description: 0.2 mi downstream of confluence with Stanley Creek, 0.75 mi east of Hwy 278, 1.2 mi southeast of Wisdom, Montana
Remarks:

	1998 Daily Mean Flow (cubic feet per second)			
Day	April	May	June	July
1	--	29.5	111.4	36.8
2	--	29.3	92.9	34.5
3	--	28.4	99.3	35.1
4	--	27.5	130.2	33.4
5	--	26.0	110.4	38.9
6	--	24.4	99.6	29.7
7	--	23.9	130.6	24.4
8	--	25.9	135.9	16.2
9	--	26.8	133.3	15.3
10	--	26.6	119.7	15.2
11	--	26.6 Est	125.9	18.2
12	--	26.2 Est	128.2	24.3
13	--	26.4 Est	139.7	15.0 Est
14	--	30.0	137.1	12.2 Est
15	--	31.6	134.7	9.9 Est
16	--	28.1	143.4	8.3 Est
17	--	30.5	156.7	7.1 Est
18	--	33.5	149.1	6.4 Est
19	--	25.5	132.1	6.0 Est
20	--	16.3	129.6	6.1 Est
21	33.7	15.4	119.0	5.9
22	42.2	32.6	132.9	5.1
23	61.5	83.0	143.2	5.0
24	92.8	91.6	113.6	4.9
25	70.4	67.1	122.0	4.8
26	27.1	58.6	162.9	4.5
27	17.2	61.4	141.5	4.2
28	26.0	80.9	98.7	5.0
29	30.1	78.4	71.6	7.2
30	31.0	126.6	47.0	--
31		166.3		--
Mean:	43.2	45.3	123.1	15.2
Max:	92.8	166.3	162.9	38.9
Min:	17.2	15.4	47.0	4.2

C -3

Lower Big Hole basin

Surface-Water Flow Data, Lower Big Hole Basin

Station Name: Lower Moose Creek
Station ID:
Township, Range, Section, Tract: 01S09W33CDCB
Latitude: N45°42'05" Longitude: W112°43'32"
Elevation: 5,330 ft
Drainage Area: mi^2
Description: Near bridge, 1.4 mi southwest of I-15 Moose Creek exit, 5.2 mi northwest of Melrose, Montana
Remarks: Several irrigation diversions located upstream

Day	Time	Flow (cfs)	Comments
10/21/97	10:15	8.94	
4/6/98	18:00	19.7	
4/21/98	16:00	15.1	
5/15/98	13:00	27.0	
6/5/98	12:00	19.0	

Station Name: Trapper Creek
Station ID:
Township, Range, Section, Tract: 02S10W23DCCA
Latitude: N45°38'36" Longitude: W112°48'09"
Elevation: 5,810 ft
Drainage Area: 25.5 mi^2
Description: At stock pen, 1.0 mi west of Glendale, 5.8 mi west of Melrose, MT
Remarks: Continuous recorder at site from 4/13/98 - 11/16/98

Date	Time	Flow (cfs)	Comments
8/7/97	16:45	18.1	
8/25/97	11:20	12.2	
10/21/97	13:30	7.7	
10/28/97	9:00	7.6	Estimate
4/6/98	12:30	5.0	
4/21/98	18:15	5.4	
4/28/98	15:00	8.2	Estimate
5/2/98	14:30	10.5	Estimate
5/4/98	19:00	12.0	Estimate

Trapper Creek (continued)

Date	Time	Flow (cfs)	Comments
5/8/98	13:15	16.3	Estimate
5/15/98	9:00	13.1	Estimate
6/5/98	13:30	28.7	
6/11/98	10:25	19.4	Estimate
6/30/98	16:10	38.8	
7/13/98	11:30	35.3	Estimate
8/18/98	11:45	11.5	
9/10/98	9:45	9.6	
10/7/98	--	7.8	
11/4/98	9:00	5.0	

Station Name: Canyon Creek Diversion
Station ID:
Township, Range, Section, Tract: 02S10W14AACC
Latitude: N45°40'04" Longitude: W112°47'53"
Elevation: 6,270 ft
Drainage Area: NA
Description: At Picketts Pasture, 1.8 mi northwest of Glendale, 6.0 mi northwest of Melrose, Montana
Remarks:

Date	Time	Flow (cfs)	Comments
8/7/97	14:20	5.6	
8/25/97	12:10	5.1	
10/21/97	12:50	2.0	
4/6/98	13:30	0.0	No flow
4/21/98	16:30	0.0	No flow
4/29/98	19:00	0.0	No flow
5/8/98	13:45	1.3	Estimate
5/15/98	9:30	4.1	
6/5/98	14:10	4.9	Estimate
6/30/98	15:50	6.7	Estimate
7/13/98	11:40	3.4	Estimate
8/18/98	12:25	3.7	Estimate
9/10/98	11:00	2.4	Estimate
10/7/98	--	0.0	No flow
11/4/98	--	0.0	No flow

Station Name: Camp Creek
Station ID:
Township, Range, Section, Tract: 02S08W19DBDA
Latitude: N45°38'05" Longitude: W112°38'05"
Elevation: 5,420 ft
Drainage Area: 35.4 mi²
Description: At dirt road crossing, 0.5 mi downstream of reservoir, 2.6 mi northeast of Melrose, Montana
Remarks: Flow regulated by reservoir

Date	Time	Flow (cfs)	Comments
8/6/97	15:20	3.6	
8/25/97	15:05	3.4	
9/3/97	11:30	3.5	Estimate
10/21/97	12:00	3.9	
4/6/98	15:00	8.2	
4/22/98	8:15	12.5	
4/29/98	19:15	19.2	
5/15/98	8:10	15.6	Estimate
6/11/98	10:00	14.4	Estimate
6/30/98	14:35	25.2	
7/14/98	8:45	19.5	Estimate
8/18/98	13:45	4.2	Lots of algae
9/3/98	13:15	3.3	Algae still present
9/10/98	9:15	3.1	Estimate
10/7/98	--	3.8	
11/4/98	10:50	4.0	Estimate. Still lots of algae in channel

Station Name: Camp Creek Diversion
Station ID:
Township, Range, Section, Tract: 02S08W19DDBB
Latitude: N45°38'43" Longitude: W112°38'02"
Elevation: 5,460 ft
Drainage Area: NA
Description: At road crossing 0.15 mi south of Camp Creek, 0.6 mi downstream of reservoir, 2.6 mi northeast of Melrose, Montana
Remarks:

Date	Time	Flow (cfs)	Comments
8/6/97	16:05	4.0	
8/25/97	15:05	0.0	No flow
10/21/97	--	0.0	No flow
4/6/98	15:00	0.0	No flow
4/22/98	8:00	0.0	No flow
5/15/98	8:15	4.0	Estimate
6/11/98	9:30	4.5	
6/30/98	14:20	2.4	
7/14/98	8:55	0.2	Visually estimate
8/18/98	13:20	3.0	Estimate
9/3/98	13:00	3.3	Estimate
9/10/98	9:10	3.3	Estimate
10/7/98	--	0.0	No flow
11/4/98	--	0.0	No flow

Station Name: Cherry Creek
Station ID:
Township, Range, Section, Tract: 03S09W08ACCA
Latitude: N45°35'30" Longitude: W112°44'25"
Elevation: 5,590 ft
Drainage Area: 15.7 mi^2
Description: 0.9 mi upstream of Schuetz Ranch, 3.5 mi southwest of Melrose, MT
Remarks:

Date	Time	Flow (cfs)	Comments
08/07/97	12:15	8.9	
08/25/97	13:30	7.1	
10/21/97	15:00	5.0	
4/6/98	14:00	3.3	

Cherry Creek (continued)

Date	Time	Flow (cfs)	Comments
4/21/98	19:00	4.4	
5/15/98	10:30	7.8	
6/5/98	15:00	10.9	
6/30/98	17:15	13.9	
8/18/98	10:30	6.4	
10/7/98	--	4.9	
11/4/98	10:00	4.8	

Station Name: Hagenbarth Diversion
Station ID:
Township, Range, Section, Tract: 03S09W34CDCD
Latitude: N45°31'32" Longitude: W112°42'14"
Elevation: 5,050 ft
Drainage Area: NA
Description: At confluence of Rock Creek and Big Hole River, 3.5 mi north of Glen, Montana
Remarks: Continuous recorder at site from 4/14/98 - 11/16/98

Date	Time	Flow (cfs)	Comments
10/21/97	11:00	8.5	
10/28/97	9:45	8.2	Estimate
4/6/98	11:00	1.3	
4/22/98	9:30	3.4	
4/28/98	16:30	5.7	Estimate
5/2/98	9:00	17.1	Estimate
5/14/98	17:45	52.4	
6/10/98	15:45	56.3	Estimate
6/30/98	13:40	61.1	Estimate
7/13/98	15:20	33.3	
8/18/98	14:40	43.4	Estimate
9/3/98	14:20	37.8	Estimate
9/10/98	12:40	41.5	Estimate
10/7/98	13:15	18.3	Estimate
11/4/98	11:20	7.5	Estimate

Station Name: Birch Creek
Station ID:
Township, Range, Section, Tract: 05S10W23DDCA
Latitude: N45°22'46" Longitude: W112°47'49"
Elevation: 5,862 ft
Drainage Area: 35.8 mi^2
Description: At concrete structure, 2.3 mi downstream from Sheep Creek, 8.5 mi southwest of Glen, Montana
Remarks: Continuous recorder at site from 4/14/98 - 11/16/98. Some flow regulation at lakes in headwaters. Some water originates from Willow Creek drainage

Date	Time	Flow (cfs)	Comments
8/6/97	12:50	53.4	Estimate
8/26/97	14:30	28.2	
10/21/97	15:00	13.8	
10/28/97	10:35	12.3	Estimate
4/7/98	12:30	8.6	
4/22/98	12:00	12.3	
5/8/98	10:45	71.8	
5/14/98	13:30	58.3	Estimate
6/10/98	14:20	68.6	Estimate
6/30/98	13:15	123.9	Estimate
7/14/98	17:05	95.4	Estimate
8/18/98	16:10	16.7	Estimate
9/9/98	15:50	19.4	Estimate
10/7/98	13:45	12.3	Estimate
11/4/98	11:50	9.2	

Station Name: Beaverhead Diversion at Birch Creek
Station ID:
Township, Range, Section, Tract: 05S09W19CDBA01
Latitude: N45°22'53" Longitude: W112°45'59"
Elevation: 5,700 ft
Drainage Area: mi^2
Description: Near Parshall flume downstream of headgate, 2.8 mi west of I-15 Apex exit
Remarks: Discharge estimates derived from Parshall flume are not reliable.

Date	Time	Flow (cfs)	Comments
8/6/97	12:50	51.1	Estimate
8/26/97	15:10	27.2	Estimate
10/22/97	15:45	12.2	
10/31/97	--	0.0	No flow
4/7/98	13:00	0.0	No flow
4/22/98	11:15	0.0	No flow
5/8/98	11:20	45.0	Estimate
5/14/98	15:40	45.8	
6/10/98	15:00	50.1	
6/30/98	12:40	30.5	
7/14/98	17:00	51.9	Estimate
8/18/98	15:55	25.8	Estimate
9/9/98	15:30	27.1	Estimate
10/7/98	13:40	26.0	Estimate
11/4/98	13:00	0.0	No flow

Station Name: Trapper Creek
Station ID:
Township, Range, Section, Tract: 02S10W23DCCA
Latitude: N45°38'36"
Longitude: W112°48'09"
Elevation: 5,810 ft
Drainage Area: 25.5 mi²
Description: At stock pen, 1.0 mi west of Glendale, 5.8 mi west of Melrose, MT
Remarks:

1998 Daily Mean Flow (cubic feet per second)

Day	April	May	June	July	August	September	October	November
1	--	10.0	26.9	45.5	26.5	9.3	6.9	5.5
2	--	10.5	32.1	46.6	21.6	9.0	7.1	5.3
3	--	11.0	32.0	51.2	19.9	8.8	7.0	5.1
4	--	12.0	26.8	51.7	18.7	8.7	6.9	4.6
5	--	13.6	22.7	46.6	18.1	8.4	6.8	5.4
6	--	14.7	20.0	43.7	17.6	8.2	6.9	5.1
7	--	15.3	19.2	41.4	17.6	8.2	6.8	4.9
8	--	16.3	18.3	39.7	17.2	8.1	6.4	5.0
9	--	16.3	17.6	39.2	16.8	8.8	6.4	3.9
10	--	16.5	18.2	38.0	16.5	8.8	6.4	4.3
11	--	15.7	19.4	39.2	15.8	9.1	6.4	5.5
12	--	14.1	24.4	36.5	15.8	9.0	6.4	5.3
13	5.9	14.7	32.1	35.3	15.7	8.6	6.4	5.2
14	5.5	14.0	34.9	33.4	15.3	8.2	6.4	5.5
15	5.5	13.1	29.4	31.2	15.3	7.9	6.4	5.3
16	5.5	12.2	27.7	28.6	14.9	7.6	6.2	5.1
17	5.4	13.9	25.4	26.8	14.9	7.5	5.9	--
18	5.2	12.2	23.3	26.0	15.1	7.3	6.6	--
19	5.7	11.0	25.3	24.9	14.8	7.3	6.0	--
20	5.5	11.7	23.9	23.8	14.7	7.4	5.6	--
21	6.0	17.3	23.1	23.2	14.5	7.4	5.9	--
22	7.0	18.6	29.7	22.4	14.4	7.4	5.7	--
23	8.3	17.8	33.3	21.4	14.0	7.4	5.9	--
24	9.2	17.6	33.9	21.0	14.0	7.2	5.8	--
25	7.7	19.7	48.1	20.6	12.5	7.2	5.5	--
26	7.2	26.7	50.6	20.0	10.6	7.4	5.5	--
27	7.5	36.1	36.7	22.0	10.3	7.3	5.5	--
28	8.2	27.3	32.2	22.0	10.0	7.1	5.5	--
29	8.7	28.8	34.3	20.3	9.8	6.9	5.2	--
30	9.4	32.9	38.7	23.3	9.4	6.9	4.6	--
31		27.3		26.3	9.4		4.6	
Mean:	6.9	17.4	28.7	32.0	15.2	8.0	6.1	5.1
Max:	9.4	36.1	50.6	51.7	26.5	9.3	7.1	5.5
Min:	5.2	10.0	17.6	20.0	9.4	6.9	4.6	3.9

Station Name: Hagenbarth Diversion
Station ID:
Township, Range, Section, Tract: 03S09W34CDCD
Latitude: N45°31'32"
Longitude: W112°42'14"
Elevation: 5,050 ft
Drainage Area: NA
Description: At confluence of Rock Creek and Big Hole River, 3.5 mi north of Glen, Montana
Remarks:

	1998 Daily Mean Flow (cubic feet per second)							
Day	April	May	June	July	August	September	October	November
1	--	9.9	54.7	61.0	66.1	41.5	25.8	7.7
2	--	17.1	55.8	60.6	65.6	40.0	25.8	7.5
3	--	8.8	56.3	61.3	64.3	37.8	25.5	7.5
4	--	24.0	54.8	59.4	64.0	39.4	25.3	7.5
5	--	24.5	53.6	56.2	64.3	38.9	25.3	7.5
6	--	28.5	52.3	53.1	62.9	38.3	20.3	4.7
7	--	35.6	52.1	48.8	62.2	39.2	18.3	4.6
8	--	38.5	52.5	44.3	62.4	41.5	18.1	4.4
9	--	38.6	54.1	43.8	59.5	42.2	16.0	4.3
10	--	38.7	56.3	39.6	58.6	41.5	13.9	1.3
11	--	47.0	56.4	37.7	59.2	42.5	11.5	1.2
12	--	50.9	56.2	34.8	58.3	42.5	10.8	1.2
13	--	53.2	56.7	32.9	56.4	42.8	16.0	1.1
14	3.4	53.1	57.5	32.5	52.0	42.8	16.0	1.1
15	3.2	51.9	53.5	33.5	47.6	41.5	16.0	1.1
16	3.1	49.2	53.0	37.6	46.3	39.5	15.4	1.0
17	3.1	48.1	53.3	36.8	45.8	46.8	14.7	--
18	3.1	47.5	58.3	34.8	43.4	46.8	13.4	--
19	3.1	49.3	59.8	33.4	41.1	46.8	11.0	--
20	3.1	52.3	60.3	33.9	49.0	47.2	10.2	--
21	3.1	54.9	59.2	38.3	58.6	47.5	9.7	--
22	3.0	57.3	60.0	40.0	59.6	47.5	9.4	--
23	3.0	56.8	61.5	44.5	59.8	33.2	7.8	--
24	3.0	57.4	61.1	54.7	59.6	29.3	7.7	--
25	3.8	57.9	60.0	63.8	58.6	29.3	4.7	--
26	5.7	57.4	58.3	63.7	58.0	29.3	2.8	--
27	5.7	57.3	55.5	64.1	57.4	29.4	2.4	--
28	5.7	54.0	56.6	64.5	53.6	29.6	7.9	--
29	5.7	57.1	58.4	64.6	48.4	26.6	7.7	--
30	5.7	52.9	61.1	65.8	48.2	26.6	7.7	--
31		51.3		67.1	43.8		7.7	
Mean:	3.9	44.6	56.6	48.6	56.0	38.9	13.7	4.0
Max:	5.7	57.9	61.5	67.1	66.1	47.5	25.8	7.7
Min:	3.0	8.8	52.1	32.5	41.1	26.6	2.4	1.0

Station Name: Birch Creek
Station ID:
Township, Range, Section, Tract: 05S10W23DDCA
Latitude: N45°22'46"
Longitude: W112°47'49"
Elevation: 5,862 ft
Drainage Area: 35.8 mi²
Description: At concrete structure, 2.3 mi downstream from Sheep Creek, 8.5 mi southwest of Glen, Montana
Remarks: Some flow regulation at lakes in headwaters. Some water originates from Willow Creek drainage

	1998 Daily Mean Flow (cubic feet per second)							
Day	April	May	June	July	August	September	October	November
1	--	36.5	87.1	150.9	51.5	15.0	13.6	11.7
2	--	43.4	98.0	154.8	49.4	14.7	13.4	11.6
3	--	50.0	100.1	179.8	52.4	14.4	14.2	10.8
4	--	55.7	83.1	182.1	53.7	13.9	13.8	10.4
5	--	68.8	73.1	160.2	52.7	13.8	13.1	11.7
6	--	75.6	67.1	144.1	51.0	13.9	12.8	11.8
7	--	84.4	75.8	138.2	49.1	14.0	12.8	11.4
8	--	84.5	69.6	129.6	44.6	14.5	12.4	11.7
9	--	77.6	62.5	128.2	33.4	20.1	12.0	10.8
10	--	84.9	62.6	123.7	26.1	20.3	12.0	8.6
11	--	85.1	73.6	129.6	23.8	21.1	12.0	7.6
12	--	82.3	96.3	121.3	22.4	19.9	12.0	6.0
13	--	81.6	115.6	112.2	24.5	19.8	12.0	6.8
14	10.4	74.8	125.3	101.8	27.6	17.7	12.0	12.5
15	10.9	68.9	122.7	87.5	30.0	16.8	12.1	12.0
16	10.3	63.0	111.2	76.6	25.9	16.1	12.2	11.4
17	10.4	68.0	95.5	78.1	17.9	15.6	11.9	--
18	10.4	57.5	83.3	69.9	19.9	15.0	12.6	--
19	11.0	53.5	91.6	63.6	27.3	14.8	11.8	--
20	11.1	56.6	83.8	58.0	28.1	15.9	11.6	--
21	13.0	79.9	79.3	54.0	26.7	16.9	11.8	--
22	15.3	86.1	97.7	52.7	26.4	16.2	11.8	--
23	19.3	81.3	114.3	54.7	25.3	16.0	12.0	--
24	23.4	79.6	124.1	54.0	20.7	15.4	11.8	--
25	19.1	84.0	151.1	50.7	17.8	14.8	11.6	--
26	17.1	95.4	169.7	47.8	17.2	15.5	11.6	--
27	17.3	116.3	131.1	55.5	16.5	15.1	11.4	--
28	20.4	92.4	109.8	80.2	16.1	14.6	11.3	--
29	24.8	92.8	112.5	63.4	16.1	13.8	10.9	--
30	31.3	96.9	133.2	57.2	15.8	13.6	9.5	--
31		86.3		62.1	15.3		9.5	
Mean:	16.2	75.6	100.0	97.5	29.9	16.0	12.0	10.4
Max:	31.3	116.3	169.7	182.1	53.7	21.1	14.2	12.5
Min:	10.3	36.5	62.5	47.8	15.3	13.6	9.5	6.0

Appendix D

Daily Evapotranspiration Estimates

D - 1 Francis Creek unit

D - 2 Middle Big Hole basin

D - 3 Lower Big Hole basin

D - 1

Francis Creek Unit

Daily evapotranspiration estimates for grass hay, Francis Creek Unit, 1998 growing season

Date	1982 Kimberly-Penman Potential Evapotranspiration (in/day)	Grass Hay Water-Use Coefficient	Grass Hay Evapotranpiration (in/day)	Date	1982 Kimberly-Penman Potential Evapotranspiration (in/day)	Grass Hay Water-Use Coefficient	Grass Hay Evapotranpiration (in/day)
04/19/98	0.064	0.25	0.016	06/03/98	0.097	0.49	0.047
04/20/98	0.122	0.25	0.031	06/04/98	0.206	0.49	0.102
04/21/98	0.127	0.26	0.033	06/05/98	0.171	0.50	0.086
04/22/98	0.167	0.26	0.044	06/06/98	0.135	0.51	0.069
04/23/98	0.182	0.27	0.049	06/07/98	0.144	0.51	0.074
04/24/98	0.078	0.27	0.021	06/08/98	0.141	0.52	0.073
04/25/98	0.110	0.27	0.030	06/09/98	0.213	0.53	0.113
04/26/98	0.142	0.28	0.039	06/10/98	0.061	0.54	0.033
04/27/98	0.162	0.28	0.046	06/11/98	0.100	0.54	0.054
04/28/98	0.164	0.29	0.047	06/12/98	0.108	0.55	0.059
04/29/98	0.187	0.29	0.054	06/13/98	0.147	0.56	0.082
04/30/98	0.188	0.29	0.056	06/14/98	0.156	0.56	0.088
				06/15/98	0.080	0.57	0.046
05/01/98	0.197	0.30	0.059	06/16/98	0.081	0.58	0.047
05/02/98	0.184	0.30	0.056	06/17/98	0.113	0.58	0.066
05/03/98	0.161	0.31	0.049	06/18/98	0.184	0.59	0.109
05/04/98	0.194	0.31	0.060	06/19/98	0.100	0.60	0.060
05/05/98	0.218	0.32	0.069	06/20/98	0.160	0.61	0.097
05/06/98	0.182	0.32	0.058	06/21/98	0.245	0.61	0.150
05/07/98	0.175	0.32	0.057	06/22/98	0.183	0.62	0.113
05/08/98	0.154	0.33	0.051	06/23/98	0.154	0.63	0.096
05/09/98	0.189	0.33	0.063	06/24/98	0.146	0.63	0.093
05/10/98	0.201	0.34	0.068	06/25/98	0.112	0.64	0.072
05/11/98	0.126	0.34	0.043	06/26/98	0.144	0.65	0.093
05/12/98	0.146	0.34	0.050	06/27/98	0.192	0.65	0.126
05/13/98	0.086	0.35	0.030	06/28/98	0.247	0.66	0.164
05/14/98	0.092	0.35	0.032	06/29/98	0.262	0.67	0.175
05/15/98	0.126	0.36	0.045	06/30/98	0.265	0.68	0.179
05/16/98	0.133	0.36	0.048				
05/17/98	0.119	0.37	0.044	07/01/98	0.218	0.68	0.148
05/18/98	0.127	0.37	0.047	07/02/98	0.251	0.68	0.171
05/19/98	0.176	0.38	0.067	07/03/98	0.208	0.68	0.142
05/20/98	0.204	0.39	0.079	07/04/98	0.226	0.68	0.154
05/21/98	0.060	0.40	0.024	07/05/98	0.263	0.68	0.179
05/22/98	0.053	0.40	0.021	07/06/98	0.261	0.68	0.177
05/23/98	0.099	0.41	0.041	07/07/98	0.275	0.68	0.187
05/24/98	0.156	0.42	0.065	07/08/98	0.236	0.68	0.160
05/25/98	0.168	0.42	0.071	07/09/98	0.282	0.68	0.192
05/26/98	0.233	0.43	0.100	07/10/98	0.221	0.68	0.150
05/27/98	0.196	0.44	0.086	07/11/98	0.230	0.68	0.157
05/28/98	0.238	0.44	0.106	07/12/98	0.294	0.68	0.200
05/29/98	0.197	0.45	0.089	07/13/98	0.295	0.68	0.200
05/30/98	0.120	0.46	0.055	07/14/98	0.274	0.68	0.186
05/31/98	0.200	0.47	0.093	07/15/98	0.288	0.68	0.196
				07/16/98	0.294	0.68	0.200
06/01/98	0.189	0.47	0.089	07/17/98	0.292	0.68	0.199
06/02/98	0.110	0.48	0.053	07/18/98	0.294	0.68	0.200

Date	1982 Kimberly-Penman Potential Evapotranspiration (in/day)	Grass Hay Water-Use Coefficient	Grass Hay Evapotranpiration (in/day)
07/19/98	0.305	0.68	0.208
07/20/98	0.314	0.68	0.213
07/21/98	0.320	0.68	0.217
07/22/98	0.308	0.66	0.203
07/23/98	0.309	0.63	0.196
07/24/98	0.200	0.61	0.123
07/25/98	0.301	0.59	0.177
07/26/98	0.309	0.57	0.175
07/27/98	0.308	0.54	0.167
07/28/98	0.110	0.52	0.057
07/29/98	0.233	0.50	0.116
07/30/98	0.139	0.48	0.066
07/31/98	0.194	0.45	0.088
08/01/98	0.131	0.46	0.060
08/02/98	0.140	0.46	0.065
08/03/98	0.266	0.46	0.123
08/04/98	0.296	0.47	0.139
08/05/98	0.294	0.47	0.139
08/06/98	0.284	0.48	0.135
08/07/98	0.250	0.48	0.120
08/08/98	0.280	0.48	0.136
08/09/98	0.272	0.49	0.133
08/10/98	0.265	0.49	0.130
08/11/98	0.258	0.50	0.128
08/12/98	0.268	0.50	0.134
08/13/98	0.280	0.50	0.141
08/14/98	0.287	0.51	0.146
08/15/98	0.229	0.51	0.118
08/16/98	0.264	0.52	0.136
08/17/98	0.184	0.52	0.096
08/18/98	0.229	0.52	0.119
08/19/98	0.249	0.51	0.128
08/20/98	0.205	0.51	0.104
08/21/98	0.130	0.51	0.066
08/22/98	0.225	0.50	0.113
08/23/98	0.231	0.50	0.116
08/24/98	0.220	0.50	0.109
08/25/98	0.238	0.49	0.118
08/26/98	0.200	0.49	0.098
08/27/98	0.222	0.49	0.108
08/28/98	0.229	0.48	0.110
08/29/98	0.223	0.48	0.107
08/30/98	0.241	0.48	0.115
08/31/98	0.235	0.47	0.111
09/01/98	0.241	0.47	0.113
09/02/98	0.260	0.46	0.121
09/03/98	0.241	0.46	0.111
09/04/98	0.235	0.46	0.107

Date	1982 Kimberly-Penman Potential Evapotranspiration (in/day)	Grass Hay Water-Use Coefficient	Grass Hay Evapotranpiration (in/day)
09/05/98	0.193	0.45	0.088
09/06/98	0.161	0.45	0.072
09/07/98	0.169	0.45	0.076
09/08/98	0.095	0.44	0.042
09/09/98	0.132	0.44	0.058
09/10/98	0.106	0.44	0.046
09/11/98	0.131	0.43	0.057
09/12/98	0.127	0.43	0.055
09/13/98	0.178	0.43	0.076
09/14/98	0.179	0.42	0.076
09/15/98	0.186	0.42	0.078
09/16/98	0.152	0.42	0.063
09/17/98	0.154	0.41	0.063
09/18/98	0.205	0.41	0.084
09/19/98	0.108	0.41	0.044
09/20/98	0.067	0.40	0.027
09/21/98	0.123	0.40	0.049
09/22/98	0.084	0.40	0.034

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Middle Big Hole Basin

Daily evapotranspiration estimates for grass hay and alfalfa, middle Big Hole basin, 1998 growing seas

Date	Jensen-Haise Potential Evapotranspiration (in/day)	Grass Hay Water-Use Coefficient	Alfalfa Water-Use Coefficient	Grass Hay Evapotranpiration (in/day)	Alfalfa Evapotranpiration (in/day)
05/01/98	0.240	0.25	0.00	0.060	0.000
05/02/98	0.204	0.26	0.00	0.052	0.000
05/03/98	0.184	0.26	0.00	0.048	0.000
05/04/98	0.224	0.27	0.00	0.060	0.000
05/05/98	0.229	0.28	0.00	0.063	0.000
05/06/98	0.208	0.28	0.00	0.059	0.000
05/07/98	0.188	0.29	0.00	0.054	0.000
05/08/98	0.193	0.30	0.00	0.057	0.000
05/09/98	0.227	0.30	0.00	0.069	0.000
05/10/98	0.201	0.31	0.00	0.062	0.000
05/11/98	0.143	0.31	0.00	0.045	0.000
05/12/98	0.148	0.32	0.00	0.048	0.000
05/13/98	0.095	0.33	0.00	0.031	0.000
05/14/98	0.091	0.33	0.00	0.030	0.000
05/15/98	0.105	0.34	0.00	0.036	0.000
05/16/98	0.142	0.35	0.00	0.049	0.000
05/17/98	0.111	0.35	0.00	0.039	0.000
05/18/98	0.128	0.36	0.15	0.046	0.019
05/19/98	0.200	0.37	0.17	0.074	0.034
05/20/98	0.224	0.38	0.19	0.086	0.042
05/21/98	0.089	0.39	0.20	0.035	0.018
05/22/98	0.042	0.41	0.22	0.017	0.009
05/23/98	0.131	0.42	0.24	0.055	0.031
05/24/98	0.193	0.43	0.26	0.083	0.050
05/25/98	0.217	0.44	0.28	0.096	0.060
05/26/98	0.191	0.45	0.29	0.086	0.056
05/27/98	0.159	0.46	0.31	0.074	0.050
05/28/98	0.243	0.48	0.33	0.115	0.080
05/29/98	0.233	0.49	0.35	0.113	0.081
05/30/98	0.143	0.50	0.37	0.071	0.052
05/31/98	0.235	0.51	0.38	0.120	0.090
06/01/98	0.247	0.52	0.40	0.129	0.099
06/02/98	0.122	0.53	0.42	0.065	0.051
06/03/98	0.083	0.54	0.44	0.045	0.036
06/04/98	0.198	0.56	0.46	0.110	0.090

Date	Potential Evapotranspiration (in/day)	Grass Hay Water-Use Coefficient	Alfalfa Water-Use Coefficient	Grass Hay Evapotranpiration (in/day)	Alfalfa Evapotranpiration (in/day)
06/05/98	0.182	0.57	0.47	0.103	0.086
06/06/98	0.144	0.58	0.49	0.083	0.071
06/07/98	0.151	0.59	0.51	0.089	0.077
06/08/98	0.144	0.60	0.53	0.087	0.076
06/09/98	0.257	0.61	0.55	0.157	0.140
06/10/98	0.097	0.62	0.56	0.060	0.054
06/11/98	0.182	0.64	0.58	0.116	0.106
06/12/98	0.137	0.65	0.60	0.089	0.082
06/13/98	0.184	0.66	0.62	0.121	0.114
06/14/98	0.175	0.67	0.64	0.117	0.111
06/15/98	0.084	0.68	0.65	0.057	0.055
06/16/98	0.070	0.68	0.67	0.048	0.047
06/17/98	0.114	0.68	0.69	0.077	0.078
06/18/98	0.206	0.68	0.70	0.140	0.144
06/19/98	0.127	0.68	0.71	0.086	0.090
06/20/98	0.210	0.68	0.72	0.143	0.151
06/21/98	0.279	0.68	0.73	0.190	0.203
06/22/98	0.221	0.68	0.74	0.150	0.163
06/23/98	0.164	0.68	0.75	0.112	0.122
06/24/98	0.187	0.68	0.76	0.127	0.141
06/25/98	0.143	0.68	0.77	0.097	0.110
06/26/98	0.172	0.68	0.77	0.117	0.133
06/27/98	0.226	0.68	0.78	0.154	0.177
06/28/98	0.306	0.68	0.79	0.208	0.243
06/29/98	0.347	0.68	0.80	0.236	0.278
06/30/98	0.351	0.68	0.81	0.238	0.285
07/01/98	0.314	0.68	0.82	0.213	0.258
07/02/98	0.280	0.68	0.83	0.191	0.233
07/03/98	0.308	0.68	0.84	0.210	0.259
07/04/98	0.253	0.68	0.85	0.172	0.215
07/05/98	0.342	0.68	0.85	0.232	0.291
07/06/98	0.343	0.68	0.85	0.233	0.292
07/07/98	0.326	0.68	0.85	0.222	0.277
07/08/98	0.284	0.68	0.85	0.193	0.241
07/09/98	0.324	0.68	0.85	0.220	0.276
07/10/98	0.264	0.68	0.85	0.179	0.224
07/11/98	0.274	0.68	0.85	0.186	0.233
07/12/98	0.356	0.68	0.85	0.242	0.302

Date	Potential Evapotranspiration (in/day)	Grass Hay Water-Use Coefficient	Alfalfa Water-Use Coefficient	Grass Hay Evapotranpiration (in/day)	Alfalfa Evapotranpiration (in/day)
07/13/98	0.372	0.68	0.85	0.253	0.316
07/14/98	0.401	0.68	0.85	0.272	0.341
07/15/98	0.587	0.68	0.85	0.399	0.499
07/16/98	0.405	0.68	0.85	0.276	0.344
07/17/98	0.414	0.68	0.85	0.281	0.352
07/18/98	0.405	0.68	0.85	0.275	0.344
07/19/98	0.403	0.68	0.85	0.274	0.342
07/20/98	0.351	0.68	0.85	0.239	0.298
07/21/98	0.376	0.68	0.85	0.256	0.320
07/22/98	0.359	0.66	0.85	0.236	0.305
07/23/98	0.404	0.63	0.85	0.257	0.344
07/24/98	0.218	0.61	0.85	0.134	0.186
07/25/98	0.371	0.59	0.85	0.218	0.315
07/26/98	0.418	0.57	0.85	0.237	0.355
07/27/98	0.318	0.54	0.85	0.173	0.271
07/28/98	0.118	0.52	0.85	0.062	0.101
07/29/98	0.300	0.50	0.85	0.149	0.255
07/30/98	0.166	0.48	0.85	0.079	0.141
07/31/98	0.209	0.45	0.85	0.094	0.177
08/01/98	0.188	0.46	0.85	0.086	0.159
08/02/98	0.172	0.46	0.85	0.079	0.147
08/03/98	0.307	0.46	0.85	0.143	0.261
08/04/98	0.365	0.47	0.85	0.171	0.310
08/05/98	0.358	0.47	0.85	0.169	0.305
08/06/98	0.288	0.48	0.85	0.137	0.245
08/07/98	0.249	0.48	0.85	0.120	0.212
08/08/98	0.319	0.48	0.85	0.155	0.271
08/09/98	0.261	0.49	0.85	0.128	0.222
08/10/98	0.329	0.49	0.85	0.162	0.279
08/11/98	0.310	0.50	0.85	0.154	0.264
08/12/98	0.332	0.50	0.85	0.166	0.282
08/13/98	0.335	0.50	0.85	0.169	0.284
08/14/98	0.324	0.51	0.85	0.165	0.275
08/15/98	0.244	0.51	0.85	0.125	0.207
08/16/98	0.262	0.52	0.85	0.135	0.223
08/17/98	0.174	0.52	0.85	0.090	0.148
08/18/98	0.218	0.52	0.85	0.114	0.185
08/19/98	0.252	0.53	0.85	0.133	0.214

Date	Potential Evapotranspiration (in/day)	Grass Hay Water-Use Coefficient	Alfalfa Water-Use Coefficient	Grass Hay Evapotranpiration (in/day)	Alfalfa Evapotranpiration (in/day)
08/20/98	0.219	0.53	0.85	0.117	0.186
08/21/98	0.149	0.54	0.85	0.080	0.127
08/22/98	0.234	0.54	0.85	0.127	0.199
08/23/98	0.223	0.54	0.85	0.121	0.190
08/24/98	0.229	0.54	0.00	0.124	0.000
08/25/98	0.252	0.54	0.00	0.136	0.000
08/26/98	0.211	0.53	0.00	0.113	0.000
08/27/98	0.246	0.53	0.00	0.131	0.000
08/28/98	0.264	0.53	0.00	0.139	0.000
08/29/98	0.234	0.52	0.00	0.123	0.000
08/30/98	0.252	0.52	0.00	0.131	0.000
08/31/98	0.266	0.52	0.00	0.137	0.000
09/01/98	0.267	0.51	0.00	0.137	0.000
09/02/98	0.249	0.51	0.00	0.127	0.000
09/03/98	0.253	0.51	0.00	0.129	0.000
09/04/98	0.266	0.50	0.00	0.134	0.000
09/05/98	0.189	0.50	0.00	0.095	0.000
09/06/98	0.188	0.50	0.00	0.094	0.000
09/07/98	0.187	0.49	0.00	0.092	0.000
09/08/98	0.087	0.49	0.00	0.042	0.000
09/09/98	0.145	0.49	0.00	0.071	0.000
09/10/98	0.106	0.48	0.00	0.051	0.000
09/11/98	0.161	0.48	0.00	0.077	0.000
09/12/98	0.106	0.48	0.00	0.050	0.000
09/13/98	0.204	0.47	0.00	0.097	0.000
09/14/98	0.210	0.47	0.00	0.099	0.000
09/15/98	0.221	0.47	0.00	0.103	0.000
09/16/98	0.164	0.46	0.00	0.076	0.000
09/17/98	0.151	0.46	0.00	0.069	0.000
09/18/98	0.177	0.46	0.00	0.081	0.000
09/19/98	0.104	0.45	0.00	0.047	0.000
09/20/98	0.075	0.45	0.00	0.034	0.000
09/21/98	0.110	0.45	0.00	0.049	0.000
09/22/98	0.091	0.44	0.00	0.040	0.000
09/23/98	0.147	0.44	0.00	0.065	0.000
09/24/98	0.162	0.44	0.00	0.071	0.000
09/25/98	0.033	0.43	0.00	0.014	0.000
09/26/98	0.089	0.43	0.00	0.038	0.000

Date	Potential Evapotranspiration (in/day)	Grass Hay Water-Use Coefficient	Alfalfa Water-Use Coefficient	Grass Hay Evapotranpiration (in/day)	Alfalfa Evapotranpiration (in/day)
09/27/98	0.146	0.43	0.00	0.062	0.000
09/28/98	0.141	0.42	0.00	0.060	0.000
09/29/98	0.154	0.42	0.00	0.065	0.000
09/30/98	0.138	0.42	0.00	0.057	0.000
10/01/98	0.108	0.41	0.00	0.044	0.000
10/02/98	0.036	0.41	0.00	0.015	0.000
10/03/98	0.062	0.41	0.00	0.025	0.000
10/04/98	0.056	0.40	0.00	0.022	0.000

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Lower Big Hole Basin

Daily evapotranspiration estimates for grass hay and alfalfa, lower Big Hole basin, 1998 growing season

Date	1982 Kimberly-Penman Potential Evapotranspiration (in/day)	Grass Hay Water-Use Coefficient	Alfalfa Water-Use Coefficient	Grass Hay Evapotranpiration (in/day)	Alfalfa Evapotranpiration (in/day)
04/01/98	0.098	0.25	0.00	0.025	0.000
04/02/98	0.106	0.25	0.00	0.027	0.000
04/03/98	0.108	0.26	0.00	0.028	0.000
04/04/98	0.118	0.26	0.00	0.031	0.000
04/05/98	0.041	0.27	0.00	0.011	0.000
04/06/98	0.070	0.27	0.00	0.019	0.000
04/07/98	0.083	0.28	0.00	0.023	0.000
04/08/98	0.085	0.28	0.00	0.024	0.000
04/09/98	0.106	0.28	0.00	0.030	0.000
04/10/98	0.082	0.29	0.00	0.024	0.000
04/11/98	0.062	0.29	0.00	0.018	0.000
04/12/98	0.051	0.30	0.00	0.015	0.000
04/13/98	0.115	0.30	0.00	0.034	0.000
04/14/98	0.095	0.30	0.00	0.029	0.000
04/15/98	0.081	0.31	0.15	0.025	0.012
04/16/98	0.115	0.31	0.17	0.036	0.019
04/17/98	0.103	0.32	0.19	0.033	0.019
04/18/98	0.144	0.32	0.20	0.046	0.029
04/19/98	0.086	0.33	0.22	0.028	0.019
04/20/98	0.155	0.33	0.24	0.051	0.037
04/21/98	0.188	0.33	0.26	0.063	0.049
04/22/98	0.211	0.34	0.28	0.072	0.058
04/23/98	0.209	0.34	0.29	0.072	0.061
04/24/98	0.115	0.35	0.31	0.040	0.036
04/25/98	0.153	0.35	0.33	0.054	0.051
04/26/98	0.172	0.36	0.35	0.061	0.060
04/27/98	0.181	0.36	0.37	0.065	0.066
04/28/98	0.182	0.37	0.38	0.068	0.070
04/29/98	0.219	0.39	0.40	0.085	0.088
04/30/98	0.230	0.40	0.42	0.092	0.097
05/01/98	0.226	0.41	0.44	0.093	0.099
05/02/98	0.226	0.43	0.46	0.096	0.103
05/03/98	0.229	0.44	0.47	0.101	0.109
05/04/98	0.287	0.45	0.49	0.130	0.141
05/05/98	0.250	0.47	0.51	0.117	0.127
05/06/98	0.214	0.48	0.53	0.103	0.113
05/07/98	0.207	0.49	0.55	0.102	0.113
05/08/98	0.265	0.51	0.56	0.134	0.150
05/09/98	0.261	0.52	0.58	0.136	0.152

Date	1982 Kimberly-Penman Potential Evapotranspiration (in/day)	Grass Hay Water-Use Coefficient	Alfalfa Water-Use Coefficient	Grass Hay Evapotranpiration (in/day)	Alfalfa Evapotranpiration (in/day)
05/10/98	0.306	0.53	0.60	0.163	0.183
05/11/98	0.213	0.55	0.62	0.117	0.132
05/12/98	0.163	0.56	0.64	0.091	0.104
05/13/98	0.137	0.57	0.65	0.079	0.090
05/14/98	0.161	0.59	0.67	0.094	0.108
05/15/98	0.204	0.60	0.69	0.122	0.141
05/16/98	0.148	0.61	0.70	0.090	0.104
05/17/98	0.157	0.61	0.71	0.096	0.111
05/18/98	0.238	0.62	0.72	0.147	0.171
05/19/98	0.217	0.62	0.73	0.134	0.158
05/20/98	0.229	0.63	0.74	0.143	0.169
05/21/98	0.145	0.63	0.75	0.091	0.108
05/22/98	0.065	0.64	0.76	0.041	0.049
05/23/98	0.172	0.64	0.77	0.110	0.131
05/24/98	0.181	0.65	0.77	0.117	0.140
05/25/98	0.196	0.65	0.78	0.127	0.154
05/26/98	0.221	0.66	0.79	0.145	0.175
05/27/98	0.298	0.66	0.80	0.197	0.239
05/28/98	0.273	0.67	0.81	0.182	0.222
05/29/98	0.280	0.67	0.82	0.187	0.230
05/30/98	0.179	0.68	0.83	0.121	0.149
05/31/98	0.220	0.68	0.84	0.149	0.185
06/01/98	0.300	0.68	0.85	0.204	0.255
06/02/98	0.169	0.68	0.85	0.115	0.144
06/03/98	0.130	0.68	0.85	0.088	0.111
06/04/98	0.230	0.68	0.85	0.157	0.196
06/05/98	0.188	0.68	0.85	0.128	0.160
06/06/98	0.132	0.68	0.85	0.090	0.112
06/07/98	0.155	0.68	0.85	0.106	0.132
06/08/98	0.168	0.68	0.85	0.114	0.143
06/09/98	0.214	0.68	0.85	0.146	0.182
06/10/98	0.127	0.68	0.85	0.086	0.108
06/11/98	0.191	0.68	0.85	0.130	0.162
06/12/98	0.134	0.68	0.85	0.091	0.114
06/13/98	0.190	0.68	0.85	0.129	0.161
06/14/98	0.191	0.68	0.85	0.130	0.163
06/15/98	0.156	0.68	0.85	0.106	0.133
06/16/98	0.091	0.66	0.85	0.060	0.077
06/17/98	0.114	0.63	0.85	0.072	0.097
06/18/98	0.167	0.61	0.85	0.101	0.142
06/19/98	0.103	0.58	0.85	0.060	0.087
06/20/98	0.190	0.56	0.85	0.106	0.162

Date	1982 Kimberly-Penman Potential Evapotranspiration (in/day)	Grass Hay Water-Use Coefficient	Alfalfa Water-Use Coefficient	Grass Hay Evapotranpiration (in/day)	Alfalfa Evapotranpiration (in/day)
06/21/98	0.244	0.53	0.85	0.130	0.207
06/22/98	0.209	0.51	0.85	0.106	0.178
06/23/98	0.156	0.48	0.85	0.075	0.133
06/24/98	0.209	0.46	0.85	0.096	0.178
06/25/98	0.150	0.43	0.85	0.065	0.127
06/26/98	0.226	0.41	0.85	0.092	0.192
06/27/98	0.306	0.38	0.85	0.118	0.260
06/28/98	0.302	0.36	0.85	0.109	0.257
06/29/98	0.275	0.37	0.85	0.101	0.234
06/30/98	0.262	0.37	0.85	0.098	0.223
07/01/98	0.284	0.38	0.85	0.108	0.241
07/02/98	0.272	0.39	0.85	0.105	0.231
07/03/98	0.307	0.40	0.85	0.121	0.261
07/04/98	0.237	0.40	0.85	0.095	0.201
07/05/98	0.305	0.41	0.85	0.125	0.259
07/06/98	0.308	0.42	0.85	0.128	0.262
07/07/98	0.274	0.42	0.85	0.116	0.233
07/08/98	0.323	0.43	0.85	0.139	0.275
07/09/98	0.303	0.44	0.85	0.133	0.258
07/10/98	0.246	0.44	0.85	0.109	0.209
07/11/98	0.238	0.45	0.85	0.107	0.203
07/12/98	0.361	0.46	0.85	0.165	0.307
07/13/98	0.341	0.47	0.85	0.158	0.289
07/14/98	0.337	0.47	0.85	0.159	0.287
07/15/98	0.313	0.48	0.85	0.150	0.266
07/16/98	0.327	0.49	0.85	0.159	0.278
07/17/98	0.342	0.49	0.85	0.169	0.291
07/18/98	0.336	0.50	0.85	0.168	0.286
07/19/98	0.354	0.51	0.85	0.179	0.301
07/20/98	0.368	0.51	0.85	0.189	0.313
07/21/98	0.338	0.52	0.85	0.176	0.288
07/22/98	0.316	0.53	0.85	0.167	0.268
07/23/98	0.298	0.54	0.85	0.160	0.254
07/24/98	0.200	0.54	0.85	0.108	0.170
07/25/98	0.284	0.55	0.85	0.156	0.241
07/26/98	0.292	0.56	0.85	0.162	0.248
07/27/98	0.253	0.56	0.85	0.142	0.215
07/28/98	0.133	0.57	0.85	0.076	0.113
07/29/98	0.230	0.58	0.85	0.133	0.195
07/30/98	0.225	0.58	0.85	0.131	0.191
07/31/98	0.226	0.59	0.85	0.134	0.192

Date	1982 Kimberly-Penman Potential Evapotranspiration (in/day)	Grass Hay Water-Use Coefficient	Alfalfa Water-Use Coefficient	Grass Hay Evapotranpiration (in/day)	Alfalfa Evapotranpiration (in/day)
08/01/98	0.168	0.60	0.85	0.100	0.143
08/02/98	0.159	0.61	0.85	0.096	0.135
08/03/98	0.243	0.61	0.85	0.149	0.207
08/04/98	0.258	0.62	0.85	0.160	0.219
08/05/98	0.278	0.63	0.85	0.174	0.236
08/06/98	0.257	0.63	0.85	0.163	0.219
08/07/98	0.244	0.64	0.85	0.156	0.207
08/08/98	0.280	0.65	0.85	0.181	0.238
08/09/98	0.283	0.65	0.85	0.185	0.240
08/10/98	0.276	0.66	0.85	0.182	0.235
08/11/98	0.289	0.67	0.85	0.193	0.246
08/12/98	0.282	0.68	0.85	0.191	0.240
08/13/98	0.282	0.68	0.85	0.192	0.240
08/14/98	0.278	0.68	0.85	0.189	0.236
08/15/98	0.248	0.68	0.85	0.169	0.211
08/16/98	0.265	0.68	0.85	0.180	0.225
08/17/98	0.214	0.68	0.85	0.145	0.182
08/18/98	0.225	0.68	0.85	0.153	0.192
08/19/98	0.245	0.68	0.85	0.167	0.209
08/20/98	0.277	0.68	0.85	0.188	0.236
08/21/98	0.189	0.68	0.85	0.128	0.161
08/22/98	0.250	0.68	0.85	0.170	0.213
08/23/98	0.282	0.68	0.85	0.192	0.240
08/24/98	0.264	0.68	0.85	0.179	0.224
08/25/98	0.272	0.68	0.85	0.185	0.231
08/26/98	0.258	0.68	0.85	0.175	0.219
08/27/98	0.304	0.68	0.85	0.207	0.259
08/28/98	0.257	0.68	0.85	0.175	0.218
08/29/98	0.245	0.68	0.85	0.166	0.208
08/30/98	0.241	0.68	0.85	0.164	0.205
08/31/98	0.282	0.68	0.85	0.192	0.240
09/01/98	0.255	0.66	0.85	0.168	0.217
09/02/98	0.259	0.64	0.85	0.165	0.220
09/03/98	0.242	0.62	0.85	0.149	0.206
09/04/98	0.244	0.59	0.85	0.145	0.208
09/05/98	0.196	0.57	0.85	0.112	0.167
09/06/98	0.197	0.55	0.85	0.109	0.168
09/07/98	0.188	0.53	0.85	0.100	0.159
09/08/98	0.129	0.51	0.85	0.066	0.110
09/09/98	0.170	0.49	0.85	0.083	0.145
09/10/98	0.103	0.47	0.85	0.048	0.088
09/11/98	0.148	0.45	0.85	0.066	0.126

Date	1982 Kimberly-Penman Potential Evapotranspiration (in/day)	Grass Hay Water-Use Coefficient	Alfalfa Water-Use Coefficient	Grass Hay Evapotranpiration (in/day)	Alfalfa Evapotranpiration (in/day)
09/12/98	0.071	0.42	0.85	0.030	0.060
09/13/98	0.169	0.40	0.85	0.068	0.143
09/14/98	0.193	0.38	0.85	0.074	0.164
09/15/98	0.181	0.36	0.85	0.065	0.154
09/16/98	0.185	0.38	0.85	0.071	0.157
09/17/98	0.182	0.40	0.85	0.073	0.155
09/18/98	0.216	0.42	0.85	0.092	0.184
09/19/98	0.156	0.45	0.85	0.069	0.132
09/20/98	0.162	0.47	0.85	0.076	0.138
09/21/98	0.129	0.49	0.85	0.063	0.110
09/22/98	0.119	0.51	0.00	0.061	0.000
09/23/98	0.147	0.53	0.00	0.078	0.000
09/24/98	0.193	0.55	0.00	0.107	0.000
09/25/98	0.064	0.57	0.00	0.037	0.000
09/26/98	0.114	0.55	0.00	0.063	0.000
09/27/98	0.140	0.53	0.00	0.075	0.000
09/28/98	0.141	0.52	0.00	0.073	0.000
09/29/98	0.143	0.50	0.00	0.071	0.000
09/30/98	0.147	0.48	0.00	0.070	0.000
10/01/98	0.143	0.46	0.00	0.066	0.000
10/02/98	0.072	0.44	0.00	0.032	0.000
10/03/98	0.080	0.42	0.00	0.034	0.000
10/04/98	0.106	0.40	0.00	0.042	0.000

Appendix E

Calculation of Ground-Water Contribution to Surface-Water Flow for Francis Creek Unit

Calculation of ground-water contribution to surface-water outflow from the Francis Creek Unit, July 20-23, 1998.

Outflow (Q) from the Francis Creek Unit can be expressed as:

$$Q = Q_{sw} + Q_{gw}$$

where Q_{sw} is the flow that originates as surface water
Q_{gw} is the flow component that origates as ground water

The "mass balance" for SC can be expressed as:

$$Q * SC = Q_{sw} * SC_{sw} + Q_{gw} * SC_{gw}$$

where SC is the specific conductance of the outflow from Francis Creek
SC_{sw} is the specific conductance of the flow that originates as surface water
SC_{gw} is the specific conductance of the flow that originates as ground water

Summary of flow and SC measurements for July 20-23, 1998:

Q = 5.1 cfs
SC = 151 µS/cm
SC_{gw} = 380 µS/cm (average for samples from 15 wells)
SC_{sw} = 40 µS/cm (weighted average for streams flowing into Francis Creek Unit

Substituting these values into the equations yields two equation with two unknowns.

Solving the equations, Q_{gw} equals 1.7 cfs and Q_{sw} equals 3.4 cfs.

$$Q_{gw}/Q * 100\% = 33\%$$

Therefore, ground water contributes one-third of the flow in Francis Creek at this time.