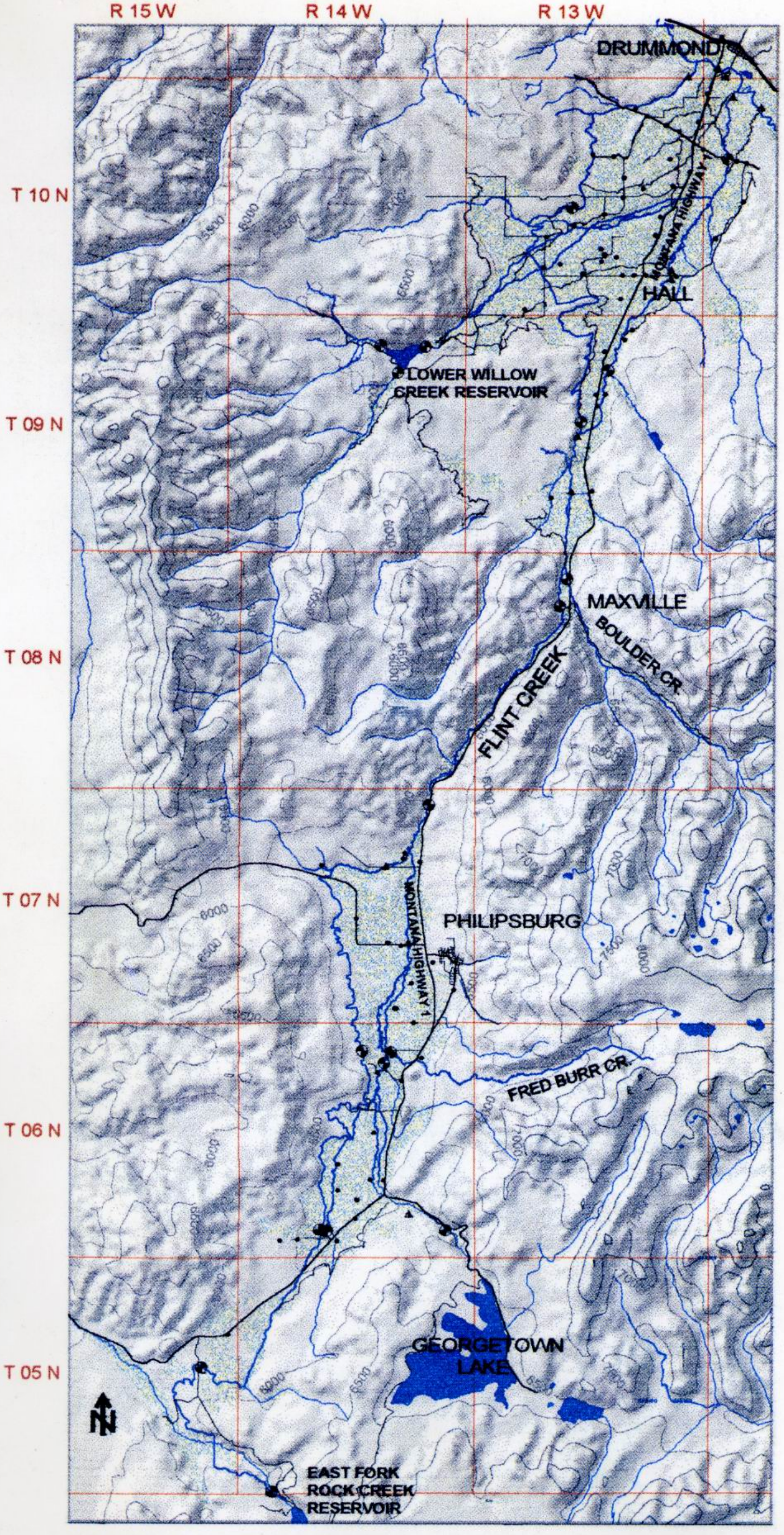

FLINT CREEK RETURN FLOW STUDY

DECEMBER, 1997

MONTANA DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION

MONTANA BUREAU OF MINES AND GEOLOGY OPEN-FILE REPORT 364

Flint Creek Return Flow Study

By Terry Voeller and Kirk Waren
MONTANA DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION

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Abstract

The Montana Department of Natural Resources and Conservation, in cooperation with the U.S. Geological Survey, conducted a hydrologic investigation to document and better understand the role of irrigation return flows in the Flint Creek basin of southwestern Montana. The study was part of a larger effort to develop a water-use model to measure the effects of future changes in irrigation and reservoir management in the basin. Field work for this study was done from 1994 through 1996.

Study Area and Methods

The study focused on irrigated lands in two intermontane basins, the Philipsburg valley and the Drummond valley. The Philipsburg valley is in the upper reaches of Flint Creek and includes about 8,200 acres of irrigated land, at elevations between 5,000 and 6,000 feet. The Drummond valley contains about 17,000 acres of irrigated land, at elevations ranging from about 4,000 feet to 4,600 feet. The two valleys are separated by a narrow canyon. Three major reservoirs, with a combined active storage of about 52,000 acre-feet, play an important role in the Flint Creek basin. One of these, the East Fork Rock Creek Reservoir, is located in the adjacent Rock Creek basin and contributes flows to Flint Creek by a canal.

For the purposes of this study, we divided the basin into four separate hydrologic units, placing boundaries so that all surface water flowing from one unit to the next could be measured at streamflow-gaging stations. Most unit boundaries were also placed where groundwater flow is limited by natural constrictions. For each hydrologic unit, we measured inflows from reservoirs, major tributaries, and mainstem streams. Inflows of numerous smaller tributaries were estimated based on data from gaged tributaries. We measured outflow from each unit with gages, except for outflows from the Hall unit, the lowermost unit where Flint Creek joins the Clark Fork River. Here, a more extensive evaluation of surface and groundwater discharge was required.

To quantify irrigation return flows, we compared daily average hydrographs of inflows and outflows (a more practical method than attempting to measure every irrigation diversion). As irrigation ceased in the fall, the amount by which outflow exceeded inflow in each unit was the return flow. This method quantifies return flows from aquifers charged by excess irrigation water. During summer, when unmeasured diversions and return flows occur simultaneously, only the net loss or gain from each hydrologic unit could be determined using this method.

We also studied groundwater in the basin to supplement the surface-water analyses and to determine how irrigation return flows are stored and released in the subsurface. We evaluated the geologic conditions within the upper few hundred feet of the valley fill by referring to existing well log data and logs from wells drilled during the study. Groundwater levels were monitored at an extensive network of wells throughout the basin. We also relied on geologic cross sections, groundwater maps, and groundwater-level hydrographs, combined with the surface-water analyses, to further interpret groundwater return flows in each hydrologic unit. Sediments in the upper few hundred feet of both the Philipsburg and Drummond valleys are predominately clay and shale. For the most part, appreciable thicknesses of coarse sediments are found only at shallow depths as alluvial deposits or gravelly caps on benches.

Consumptive use by irrigated crops in the Philipsburg valley averages approximately 0.75 acre-feet per acre irrigated; in the Drummond valley the average is between 1.5 and 1.75 acre-feet per acre irrigated. During dry periods, summer inflow into the Flint Creek basin is almost doubled by the water transferred from East Fork Rock Creek Reservoir.

Results

For the years studied, irrigation return flows from the Flint Creek basin averaged between 80 and 100 cubic feet per second (cfs) during October and November. This rate decreased through fall and winter, reaching a lower but still measurable rate by the start of the next irrigation season. The timing and magnitude of groundwater return

flows contributed by each of the four hydrologic units was variable. Areas where unsaturated zones are thick and composed of coarse sediments displayed a higher capacity to store excess irrigation water than areas with naturally shallow groundwater levels or less permeable near-surface sediments. A variety of information suggests that irrigation return flows occurred in the shallow, coarse alluvium and gravelly caps, even though groundwater levels in deeper, confined aquifers responded to changes in head in the shallow sediments.

Irrigated lands on higher ground in the upper part of the Philipsburg valley and west of Flint Creek in the Drummond valley are underlain by coarse, gravelly sediments. Groundwater can accumulate in these sediments throughout the irrigation season. Groundwater levels rose continuously during summer in some areas. Return flows from these areas were greatest during fall but continued throughout winter.

Floodplain aquifers tended to fill rapidly at the onset of irrigation. In most places, groundwater was maintained at high levels during summer. Once irrigation ceased, however, groundwater drained out of the upper part of floodplain sediments, and groundwater levels reached low winter levels within about two to three months. Near Philipsburg, groundwater levels are naturally shallow, limiting the amount of unsaturated sediments available to store groundwater. Return flows in this area were especially rapid in the fall, and modest surface-water gains diminished by the end of November. In the Drummond valley, the alluvium that remained unsaturated varied in thickness from 5 to 25 feet during winter. Naturally, there is more storage potential where groundwater levels are deeper. The vast alluvial floodplain aquifer in the Drummond valley, which can store considerable amounts of water where the natural water table is deeper, contributed an estimated 20 to 25 percent of fall return flows in the basin.

Conclusions

For downstream irrigators, the more immediate return flows from floodplain aquifers with shallow water tables may be more valuable than return flows from aquifers that store more water. Once the aquifers with shallow water tables are full, excess irrigation water is forced to return directly to streams and ditches. This return flow is available for immediate use downstream.

Aquifers with more storage potential absorb much of the water diverted during spring, and water diverted during summer continues to charge these aquifers. The benefit to streamflows is not fully realized until fall. Clearly, to maintain streamflows through summer and fall, it is critical during spring runoff to fill aquifers that have high storage potential. Flood irrigation in such areas during July and August, without the spring recharge, would seriously deplete the water supply of Flint Creek.

Modifying water rights from flood irrigation to sprinkler systems would reduce water availability in the Flint Creek basin if more land were put into irrigation. Conversion from flood to sprinkler irrigation on existing irrigated lands would have minimal effect on ranchers who rely on water stored in East fork Rock Creek Reservoir and Lower Willow Creek Reservoir. But the effect on decreed water right users, who have benefited from return flows generated by water from both reservoirs, would likely be significant during drought years.

Allowing increased flood irrigation (and to a lesser extent sprinkler irrigation) on new lands--only during spring runoff--would increase water availability during summer. The actual benefits would be dependent on aquifer characteristics and other physical properties associated with such irrigation. The model being completed by the U.S. Bureau of Reclamation will provide greater detail on these issues.

CHAPTER 1 - INTRODUCTION

The desire to store spring runoff for later use in the summer has long been a goal in Montana where water resources are limited. The number of reservoirs built throughout the state exclusively for irrigation storage indicates the importance placed on retaining water for agriculture use rather than permitting a large portion to leave the basins unused. Over the last 20 years, very few reservoirs have been built in Montana. The reasons for this lack of activity are many, including lack of funding, unavailability of good remaining reservoir sites, and increased awareness of the environmental implications associated with many reservoirs. This lack of activity, whether good or bad, has been a reality for many years and has forced us to more closely examine alternative storage solutions.

Irrigators have long been aware of the importance of groundwater storage derived from applied water to ditches and fields. This water eventually reenters streams as return flows. Although high spring streamflows have always recharged aquifers linked to the stream, the addition of flood irrigation in many basins has considerably increased groundwater storage. In many basins irrigation has altered the natural hydrologic cycle to a regime of lower streamflows during the irrigation season and increased streamflows during fall and early winter. The amount and timing of return flows in each basin is dependent on geology, the various water rights within a basin, and the location and pattern of irrigation. For example, if most irrigation takes place along the alluvial valley of a stream, the return flows are often almost immediate and storage potential is limited. On the other hand, if irrigation occurs along benches or tributaries distant from the stream, geologic conditions can enable storage for several months after irrigation water is applied, and return flows may continue through winter.

Hydrologists and other water resources professionals have been aware of return flows for many years. Unfortunately, little work has been done to quantify the amount and timing of return flows due to the high cost and time needed to complete a thorough analysis. Study results are often highly dependent on an accurate accounting of return flows, but because of the cost, time, and resources required, return flows are usually the study component that are simplified with assumptions and not measured. An exception is the publication of the "Geology and Ground-Water Resources of the Gallatin Valley, Gallatin County, Montana," by the U.S. Geological Survey (USGS) in 1960. If resources were unlimited, this incomparable report would be the standard for hydrologic investigations throughout Montana. It includes the extensive data collection for both groundwater and surface water necessary to complete a thorough water balance of the basin. Although in large part the Gallatin Valley study was completed to determine the feasibility of groundwater development in the basin, a detailed analysis of aquifer recharge through irrigation was quantified using both groundwater and surface-water techniques. Many of the methods discussed in the Gallatin Valley report were applied to this study.

At the request of the ranchers in the Flint Creek valley, the United States Bureau of Reclamation (USBR), United States Natural Resources and Conservation Service (NRCS), Granite County Conservation District, and Montana Department of Natural Resources and Conservation (DNRC) were asked to assist in development of a water-use model that could measure the effects of various irrigation and reservoir management changes in the basin. Issues of concern were water rights held downstream by power companies, conversions from flood to sprinkler irrigation, and project water made available to decreed water right holders. Obviously, any modifications of water use have the potential to affect return flows and the hydrology of the basin. USBR was established as the lead agency in this effort and is developing the computer model that will be used to assess various irrigation and reservoir changes. NRCS and Granite County Conservation District both contributed technical advice and local expertise. DNRC was responsible for collecting surface-water and groundwater data that could be used in the model. The purpose of this report is to document this collected data and to present the conclusions drawn from it.

Cooperation and assistance from many individuals and groups was required to successfully complete this study. Ron Shields, Norm Midtlyng, Lee Chambers, and Fred Bailey from USGS gathered a large portion of the field data for this report. USBR supplied much of the equipment for the field investigation. Onni Perala and Jeff Peterson of USBR, Ron Shields of USGS, and Joe Van Mullem of NRCS all contributed greatly to the study design. Finally, and most important, the cooperation from the Granite County Watershed Resources Committee as well as all ranchers in the Flint Creek basin is greatly appreciated. Their input and assistance were the most important contributions to this report. Two committee members in particular, Eugene Manley and Pat McDonald, dedicated a tremendous amount of their time and resources to this effort.

CHAPTER 2 - FLINT CREEK BASIN

Flint Creek, a tributary to the Clark Fork River in western Montana, is in the Upper Columbia River basin. The confluence of Flint Creek with the Clark Fork is near the town of Drummond, approximately 60 miles northwest of Butte and 40 miles southeast of Missoula. Upstream of Flint Creek, the Clark Fork averages 384,000 acre-feet of runoff each year (Shields et. al, 1997). The Flint Creek basin on average adds 125,000 acre-feet each year. By the time the Clark Fork reaches Milltown Dam upstream of Missoula, downstream from the confluence with the Blackfoot River, the average annual runoff is 2.1 million acre-feet (Shields et. al, 1997).

A map showing the general features of the Flint Creek study area is shown in Figure 2.1. The creek flows in a northerly direction and has a drainage area of approximately 500 square miles. The elevation of the basin ranges from more than 9,000 feet above Georgetown Reservoir to near 3,950 feet at the confluence of Flint Creek with the Clark Fork. The basin is surrounded by mountainous terrain, and the creek runs through two flat, wide valleys separated by a narrow canyon. Philipsburg is located in the valley at the south end of the basin, known as the Philipsburg valley. The valley in the north end of the basin is referred to as the Drummond valley.

Flint Creek lies within Granite County, which has one of the lowest populations in Montana. The 1990 census reported the population of the county to be 2,548. Philipsburg (the county seat), Maxville, Hall, and Drummond are the only towns within the Flint Creek basin.

The average annual precipitation is 14.5 inches in Philipsburg and 12 inches in Drummond. Average annual precipitation in the mountains can exceed 40 inches (NRCS, 1996). The county has a modified "continental" type climate, with low night temperatures. The heaviest precipitation in the valleys typically occurs during spring and summer. In the mountainous headwaters, where most runoff originates, the precipitation is highest in winter and spring. The average temperature is 41.2° F in Philipsburg and 42.9°F in Drummond (NRCS, 1996). During January, the average daily minimum temperature in the valleys is 12°F and the average daily maximum temperature is 32°F. In July, the average daily maximum temperature in the valleys is 82°F and the average daily minimum temperature is 43°F. The freeze-free period in Drummond typically extends from early June through early September, while in Philipsburg it extends from early July to mid-August (NRCS, 1996). The growing season for irrigated crops in the Philipsburg valley is significantly shorter than in the Drummond valley.

Fred Burr Creek, Boulder Creek, and Lower Willow Creek are three major tributaries to Flint Creek. Boulder Creek is an unregulated stream that enters Flint Creek near the town of Maxville. Lower Willow Creek, which is controlled by an irrigation reservoir, flows into Flint Creek two miles northeast of Hall. The only large tributary in the Philipsburg valley below Georgetown Lake is Fred Burr Creek. Other smaller tributaries to Flint Creek include Trout Creek, Spring Creek, Marshall Creek, Smart Creek, Douglas Creek, and Barnes Creek.

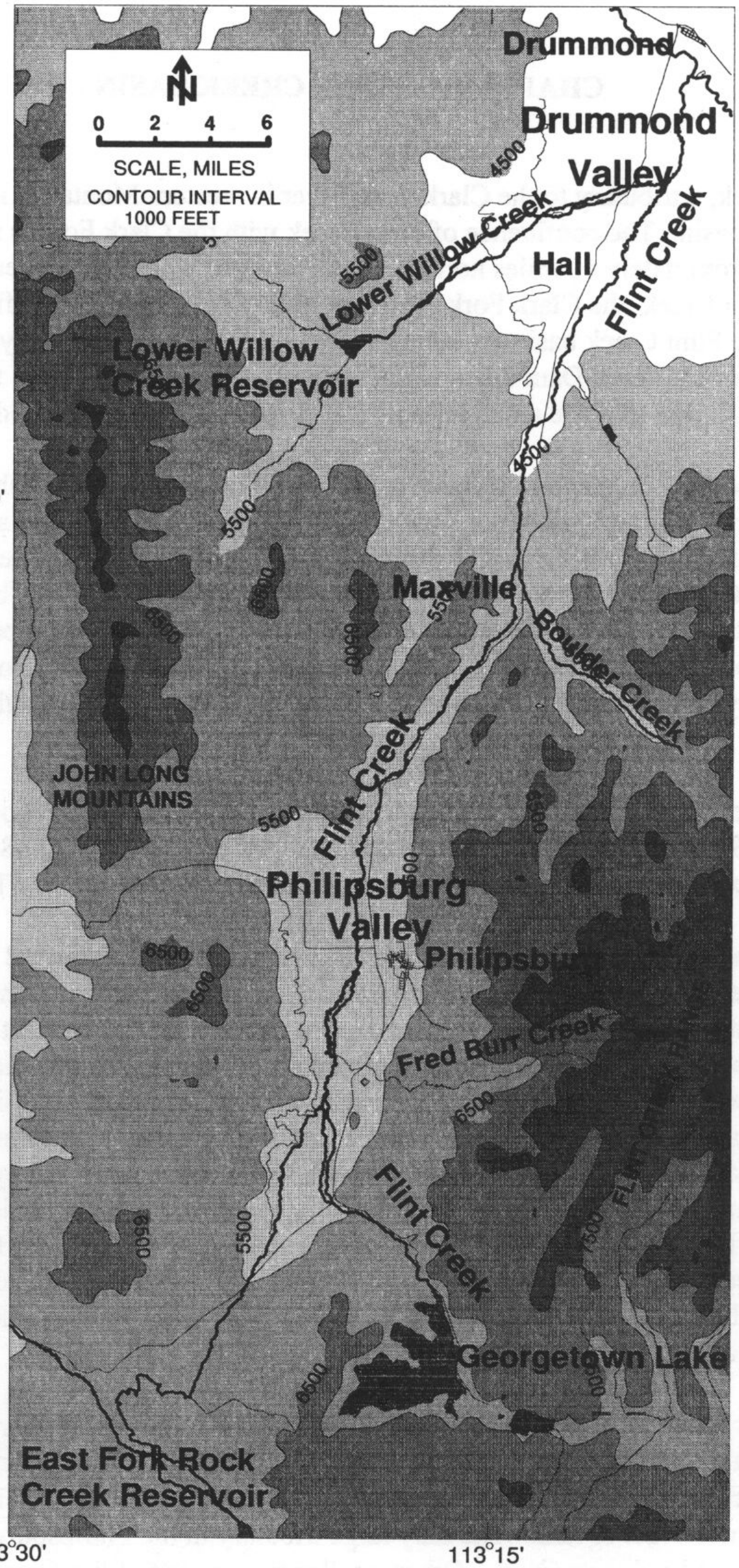


Figure 2.1 Flint Creek Study Area

Three major reservoir projects also play an important role in the Flint Creek basin hydrology. Georgetown Lake, a popular recreational area in Montana, is located in the headwaters of Flint Creek eight miles south of Philipsburg and has an active storage of 31,000 acre-feet. East Fork Rock Creek Reservoir, located in the neighboring Rock Creek drainage with an active storage of 16,000 acre-feet, stores water for agricultural use in Flint Creek via an inter-basin transfer. Lower Willow Creek Reservoir, in the Drummond valley, with an active storage of 4,800 acre-feet, impounds a significant portion of spring runoff for agricultural use in the summer.

Geology of the Flint Creek Basin

The Flint Creek basin includes two separate valleys, or intermontane basins, surrounded by mountains composed of a variety of sedimentary and igneous rock. This study focuses on the sediments that fill the two basins and form the valley floors where almost all irrigated lands are located. This section provides a description of the prevalent rock types and overall geology of the basin. More detailed discussions of the geology of the shallow groundwater systems are presented for each subbasin in Chapter 6.

Figure 2.2 is a geologic map of the basin, modified from Wallace (1987). The mountainous areas include Precambrian and lower Paleozoic metasedimentary rocks (ЄYs), upper Paleozoic and Mesozoic sedimentary rocks (KDs), Cretaceous intrusive igneous rocks (Kgd), and Tertiary volcanic rocks (Tv). The valleys are filled with Tertiary basin fill (T) and Quaternary glacial (Qg) and alluvial (Qa) deposits. Table 2.1 is a geologic time scale provided for reference.

Table 2.1 Geologic Time Scale

ERA	PERIOD	EPOCH	APPROXIMATE AGE (MILLIONS OF YEARS)	ERA	PERIOD	APPROXIMATE AGE (MILLIONS OF YEARS)
Cenozoic	Quaternary	Holocene	0 - .01	Mesozoic	Triassic	200 - 225
		Pleistocene	.01 - 2	Paleozoic	Permian	225 - 280
	Tertiary	Pliocene	2 - 5		Pennsylvanian	280 - 330
		Miocene	5 - 24		Mississippian	330 - 360
		Oligocene	24 - 36		Devonian	360 - 410
		Eocene	36 - 55		Silurian	410 - 435
		Paleocene	55 - 65		Ordovician	435 - 500
Mesozoic	Cretaceous		65 - 135		Cambrian	500 - 600
	Jurassic		135 - 200	Precambrian		>600

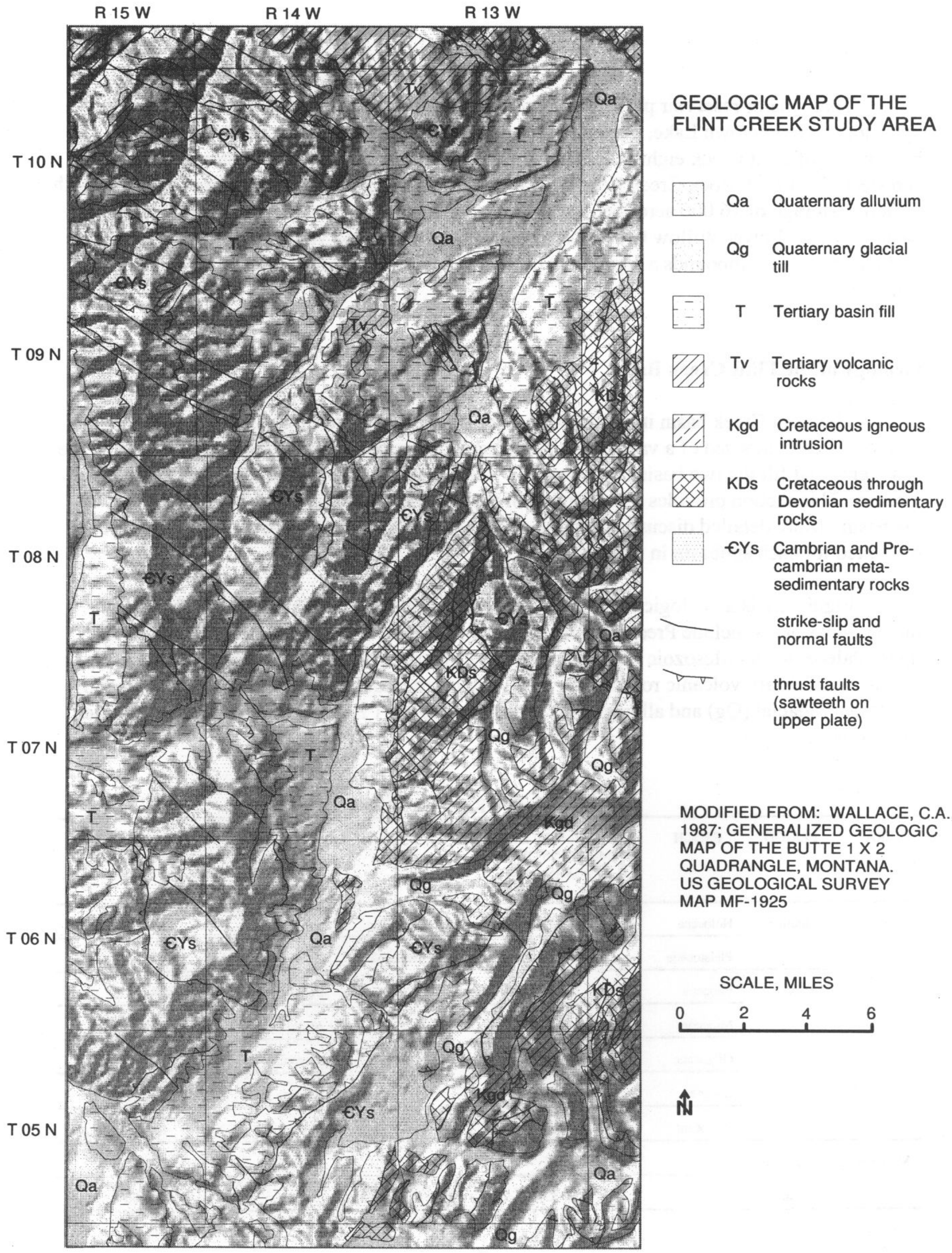


Figure 2.2 Geologic Map of the Flint Creek Study Area

The Precambrian and lower Paleozoic metasedimentary rocks (map unit ЄYs) include Cambrian carbonate, shale, and quartzite formations, the Precambrian Missoula Group, and the Precambrian Newland Limestone. These formations were mapped as one unit because they are composed of highly consolidated, slightly metamorphosed rock that probably has little primary porosity and limited fracture porosity. In much of the basin, this unit consists mainly of Missoula Group argillites and, to a lesser extent, quartzites (Maxwell, 1965; Dobell, 1965). Throughout the basin, the rocks in this map unit are thrust over each other or over younger rocks along thrust faults.

The upper Paleozoic and Mesozoic sedimentary rocks (map unit KDs) includes Devonian through Cretaceous formations. This map unit represents bedrock formations more likely to have both primary and secondary porosity. As summarized by Kendy and Tresch (1996), the Paleozoic rocks are mainly limestone, but include dolomite, phosphatic sandstone, quartzite, siltstone, mudstone, and shale. The Mesozoic rocks are principally marine shale interbedded with non-marine mudstone, siltstone, sandstone, conglomerate and minor amounts of limestone. These rocks are tightly folded and thrust faulted.

The Cretateous igneous intrusive rocks (map unit Kgd) are part of the Philipsburg batholith, a large pluton of granodiorite in the Flint Creek Range. Tertiary volcanic rocks (map unit Tv) are mainly rhyolite with some basalt, andesite, and latite (Wallace, 1987).

Tertiary deposits (map unit T) on both sides of Flint Creek in the Drummond valley have exposures of Cabbage Patch beds (Rasmussen, 1980), which have been dated by fossils to early Miocene age (Rasmussen, 1969). These are the oldest Tertiary sedimentary deposits mapped in the Drummond valley. It follows that the Drummond valley, which may have unconsolidated deposits more than 6,000 feet thick (Noble et. al, 1982), is filled predominately with early Miocene and older sediments, since early Miocene deposits are present at the surface. The Cabbage Patch beds, as described by Gwinn (1961), consist of tuffaceous mudstones and siltstones, crystal and vitric tuffs, argillaceous limestones, and micaceous conglomerates. Only two middle Miocene units, the Flint Creek beds and the Barnes Creek beds mapped by Gwinn (1961) on the benches east of Hall and New Chicago, are known in the Drummond valley. The Flint Creek beds consist of thin-bedded, light-colored tuffs, mudstones, and siltstones. Sandstones and siltstones are much less common than in the underlying Cabbage Patch beds, and conglomerates are absent. The Barnes Creek gravel has an unusual pink, sandy matrix and unconformably overlies the Flint Creek beds (Gwinn, 1961).

Gravelly deposits cap the Tertiary benches on both sides of Flint Creek in the Drummond valley. On the east bench, Gwinn (1961) mapped both the Barnes Creek gravel described above and an unnamed surficial gravel of possibly Quaternary age. Silty gravel and cobble deposits form a cap some 40 to 60 feet thick on much the benchland west of Flint Creek. The age of the deposits west of Flint Creek have not been determined. Gwinn (1961) describes the unnamed gravel on the east benches as thin veneers of gravel on several bench levels. The gravelly deposits on the west benches consist of pinkish-brown to brown silty sand, gravel, and cobbles, with interbeds of red-brown clay at some locations. It is covered with about five feet of silt (loess) in some areas. Erosion has removed variable amounts of Tertiary materials, especially in the channels carved out by the rivers where Quaternary alluvium has been deposited.

Mountain glaciation in the Flint Creek Range deposited glacial till along several valleys extending in every direction from the mass of Cretateous granodiorite (Kgd) shown in the southeast area of Figure 2.2. These include, for example, Fred Burr Creek, North Fork Flint Creek, southern headwater tributaries of Boulder Creek, and Racetrack Creek. An outwash plain extends from the terminal moraine at the mouth of the Fred Burr Creek canyon northwestward to meet Flint Creek southwest of Philipsburg.

Quaternary alluvium is present in the generally flat valley bottoms. Alluvium appears to be about 25 to 50 feet thick in most of the study area. A bouldery, probably post-glacial debris flow is present at the head of the Drummond valley (Beaty, 1965).

Hydrologic Separation of the Flint Creek Basin and Pre-existing Gaging Stations

For this study, the Flint Creek basin was divided into four hydrologic units, as shown in Figure 2.3. Through extensive field data collection, the water balance for all units will be shown later in this report. The boundaries were delineated so that essentially all of the surface water flowing from one unit to the next could be quantified. Furthermore, most of the boundaries are placed in areas where groundwater flow is limited by natural constrictions.

Following is a brief description of hydrologic features and pre-existing gaging stations in each unit. Estimates of average annual flow volumes for ungaged streams are determined by using the variables of average annual precipitation (Soil Conservation Service, 1977) and drainage area with regression equations presented by Potts (1983) and Parrett and Hull (1985). These estimated volumes were adjusted based on data from miscellaneous streamflow measurements taken by DNRC and USGS from 1994 through 1996.

Headwater Unit

The Headwater unit extends from the southern headwaters of the basin to immediately upstream of the mouth of Fred Burr Creek. As shown in Figure 2.3, the unit is located in the southern portion of the Philipsburg valley and includes Georgetown Lake, the inlet from East Fork Rock Creek Reservoir, and the Marshall Canal diversion. A more detailed map of this area is presented in Figure 2.4.

The Headwater unit is separated from the next downstream unit by a narrow constriction in the valley formed by bedrock outcrops. This constriction is evident in the north-central part of

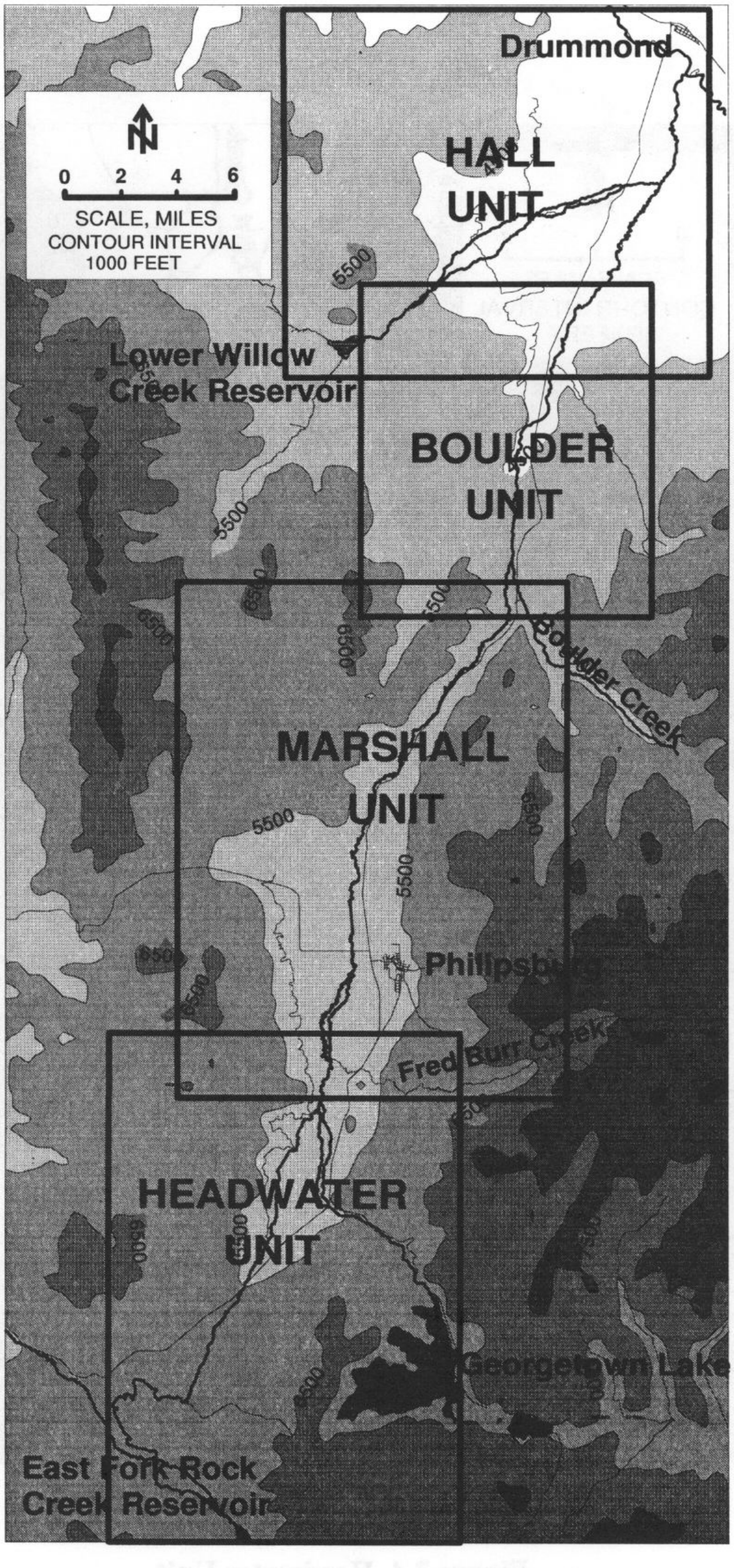


Figure 2.3 Hydrologic Separation of the Flint Creek Basin

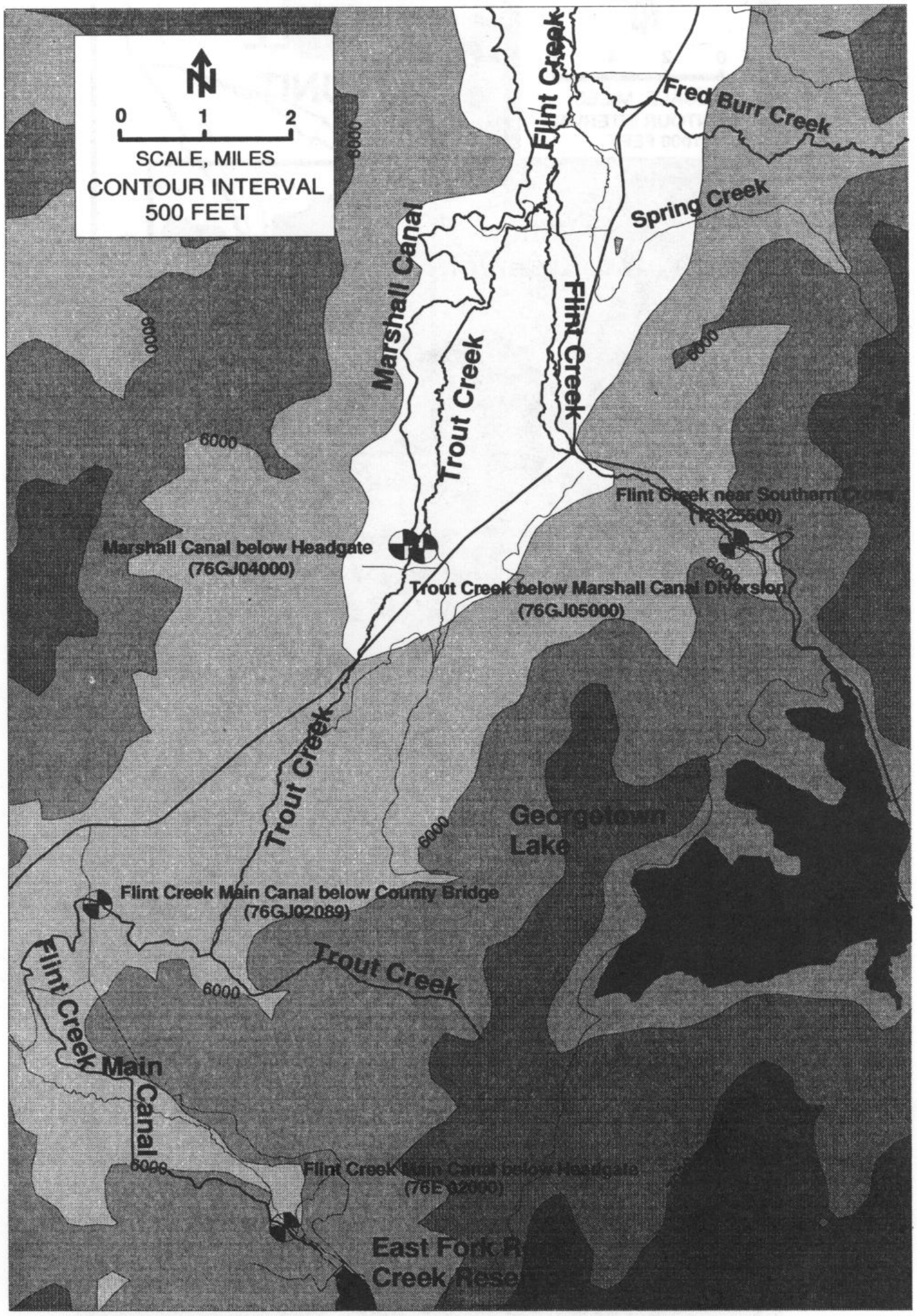


Figure 2.4 Headwater Unit

Figure 2.4 where Marshall Canal and Flint Creek are about 1,000 feet apart. The bedrock knoll that forms the east side of the constriction is evident as a mass of rock that is surrounded by Quaternary sediments in the northeast part of Township 6 North, Range 14 West on the geologic map shown in Figure 2.2. East of this bedrock mass, the Quaternary sediments are formed by the terminal moraine of the glacier that extended down the Fred Burr Creek valley. This moraine forms a hummocky, wooded bench about 300 feet above the Philipsburg valley. This feature has blocked any opportunity for surface water from the Headwater unit to flow around the east side of the bedrock mass.

The upper portion of the Headwater unit, generally above the Marshall Canal diversion, is about twice as steep as the lower portion of the unit. Trout Creek drops 520 feet over a distance of four miles between the drainage basin divide to the Marshall Canal diversion, whereas it drops only about 220 feet over a similar distance between the diversion and the outflow area. The steeper, upper portion of the unit is underlain predominately by Tertiary sediments. In contrast, the lower portion of the unit has extensive areas of alluvial deposits in a well-developed valley floor.

Tributaries within this unit include Spring Creek and Trout Creek. Spring Creek on average contributes about 2,500 acre-feet per year. Trout Creek, with a natural average annual runoff of approximately 3,000 acre-feet, has undergone a dramatic increase in water conveyance since the East Fork Rock Creek Reservoir project was built in 1938. Irrigation water from East Fork Rock Creek is transported into the Flint Creek basin via the Flint Creek Main Canal. Most of this water empties into Trout Creek, and from there either flows into Flint Creek or is diverted into Marshall Canal and several other small irrigation diversions.

Although Georgetown Dam, which existed in some form prior to 1900, has a great deal of storage potential, it has never been operated principally for irrigation. The dam was originally built for power production, and although hydroelectric facilities still exist at the dam, the reservoir is now one of the most popular recreational areas in Montana. In the early 1900s, many irrigators feared that because the dam was not operated for irrigation, its existence could interfere with their water rights. In 1901, the Montana Water, Electric Power and Mining Company, the owners of Georgetown Dam, brought suit against the water users to clarify all rights to Flint Creek water. The federal court of appeals in 1906 gave Montana Water, Electric Power and Mining Company the right to store water between October 15 and April 15 but to release a minimum of 30 cubic feet per second (cfs) into Flint Creek between April 15 and October 15. This 30 cfs requirement was established as the base flow that would occur naturally from Flint Creek downstream from the dam.

For several years, within the Headwater unit, USGS has operated one streamflow-gaging station downstream from Georgetown Lake, and DNRC has operated four streamflow-gaging stations to account for water use from the East Fork Rock Creek Reservoir project. The locations of these gages are shown in Figure 2.4, and a brief description of each gage follows.

12325500 - "Flint Creek near Southern Cross"
Period of record: 1940-Current
Drainage area = 53 square miles

At the "Flint Creek near Southern Cross" gage, which is funded by the Montana Power Company and operated by USGS, total releases from Georgetown Dam are recorded. The average annual outflow is 21,300 acre-feet (Shields et. al, 1997).

76E 02000 - "Flint Creek Main Canal below Headgate"
Period of record: 1961-1980, 1982-Current

This station, which is located in the Rock Creek drainage, is 0.25 mile below the East Fork Rock Creek Dam. The diversions into the Flint Creek Main Canal from East Fork Rock Creek are recorded at this site.

76GJ02089 - "Flint Creek Main Canal below County Bridge"
Period of record: 1961-1980, 1982-Current

Although flows are recorded here less than 1,000 feet downstream from the point where the Flint Creek Main Canal crosses into the Flint Creek basin, several diversions are taken out for irrigation between the basin divide and this gage.

76GJ04000 - "Marshall Canal below Headgate"
Period of record: 1961-1980, 1982-Current

Water taken from the East Fork Rock Creek Reservoir project for diversion into the Marshall Canal is recorded at this site.

76GJ05000 - "Trout Creek below Marshall Canal Diversion"
Period of record: 1961-1980, 1982-Current

Measured at this site is East Fork Rock Creek Reservoir water available downstream from the Marshall Canal diversion and to a much smaller extent the undiverted natural streamflow from Trout Creek.

Marshall Unit

The Marshall unit extends from the confluence of Fred Burr Creek and Flint Creek to the town of Maxville, nine miles north of Philipsburg. As shown in Figure 2.5, the area is located in the northern portion of the Philipsburg valley and includes the narrow canyon area that separates the Philipsburg and Drummond valleys. This canyon forms a bottleneck condition through which essentially all outflow from the Philipsburg valley can be measured as surface-water flow.

A portion of the Marshall unit, within the Philipsburg valley, includes a flat alluvial flood plain that is less than a mile wide in the upper portion, but is more than a mile wide in the lower reaches northwest of Philipsburg. A sloping bench underlain by Tertiary sediments extends along the west side of the unit below Marshall Canal, and much of this bench is irrigated. Southwest of Philipsburg, a gently sloping plain extends from the base of the terminal moraine of Fred Burr Creek to Flint Creek. This area is also irrigated. North of Philipsburg, the more rugged foothills formed by Tertiary deposits east of the valley floor are not irrigated.

Tributaries within this unit include Fred Burr Creek and Marshall Creek. Fred Burr Creek adds about 7,000 acre-feet on average into Flint Creek each year. Marshall Creek contributes an approximate average annual amount of 3,000 acre-feet each year and in addition serves as a wasteway for the Marshall Canal diversion.

Only one streamflow-gaging station, operated by USGS and partially funded by DNRC, exists within the Marshall unit.

12329500 - "Flint Creek at Maxville"
Period of record: 1942-Current
Drainage area = 208 square miles

At this point, the total outflow of the Philipsburg valley is measured. This outflow, which averages 70,800 acre-feet annually (Shields et. al, 1997), includes Flint Creek flow not used for irrigation, supplemental water from the East Fork Rock Creek Reservoir project, and return flows resulting from irrigation in the Philipsburg valley.

Boulder Unit

The Boulder unit extends from Maxville to downstream of the confluence of Douglas Creek and Flint Creek. As shown in Figure 2.6, this unit is located in the southern portion of the Drummond valley and includes the diversion for the Allendale Canal. Tributaries in the area include Boulder Creek, with an average annual runoff of 32,900 acre-feet (Shields, et. al, 1997); Smart Creek, which contributes an average of about 3,500 acre-feet per year; and Douglas Creek, with an approximate average annual runoff of 4,500 acre-feet.

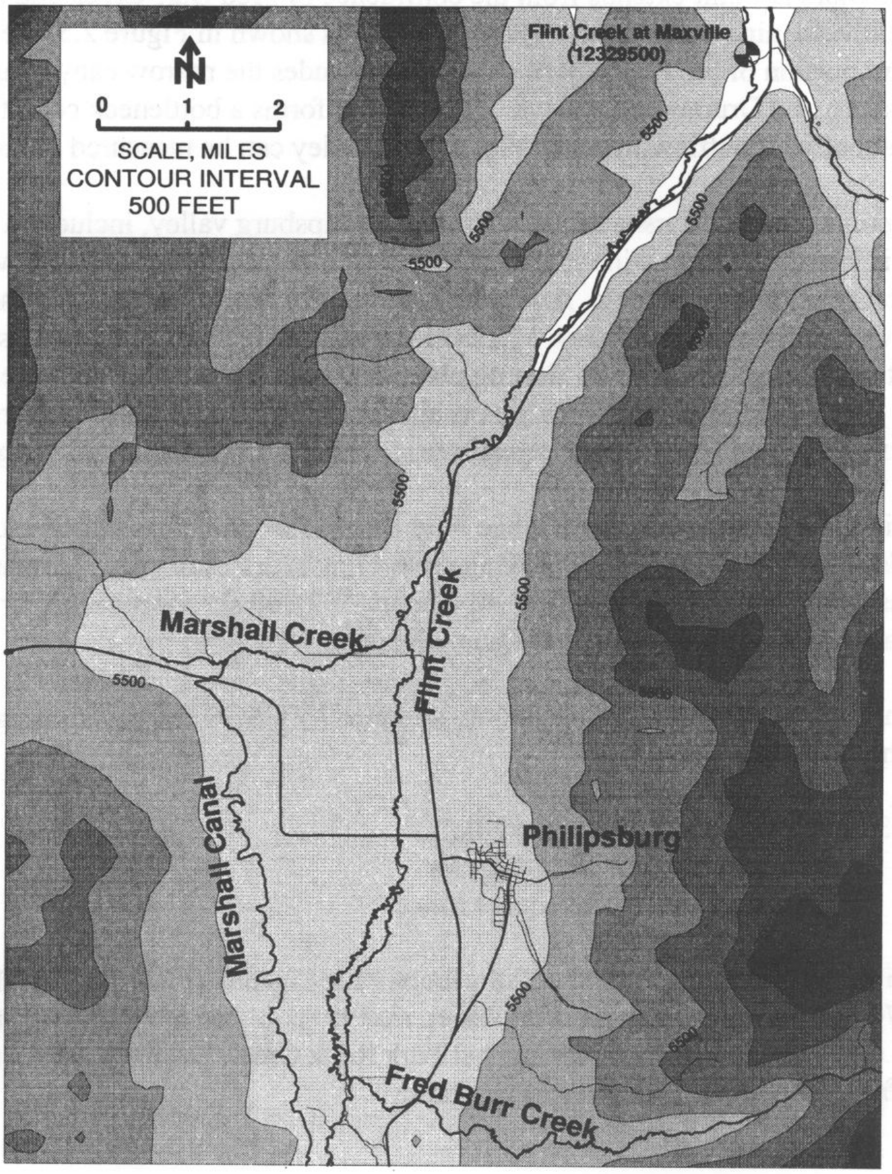


Figure 2.5 Marshall Unit

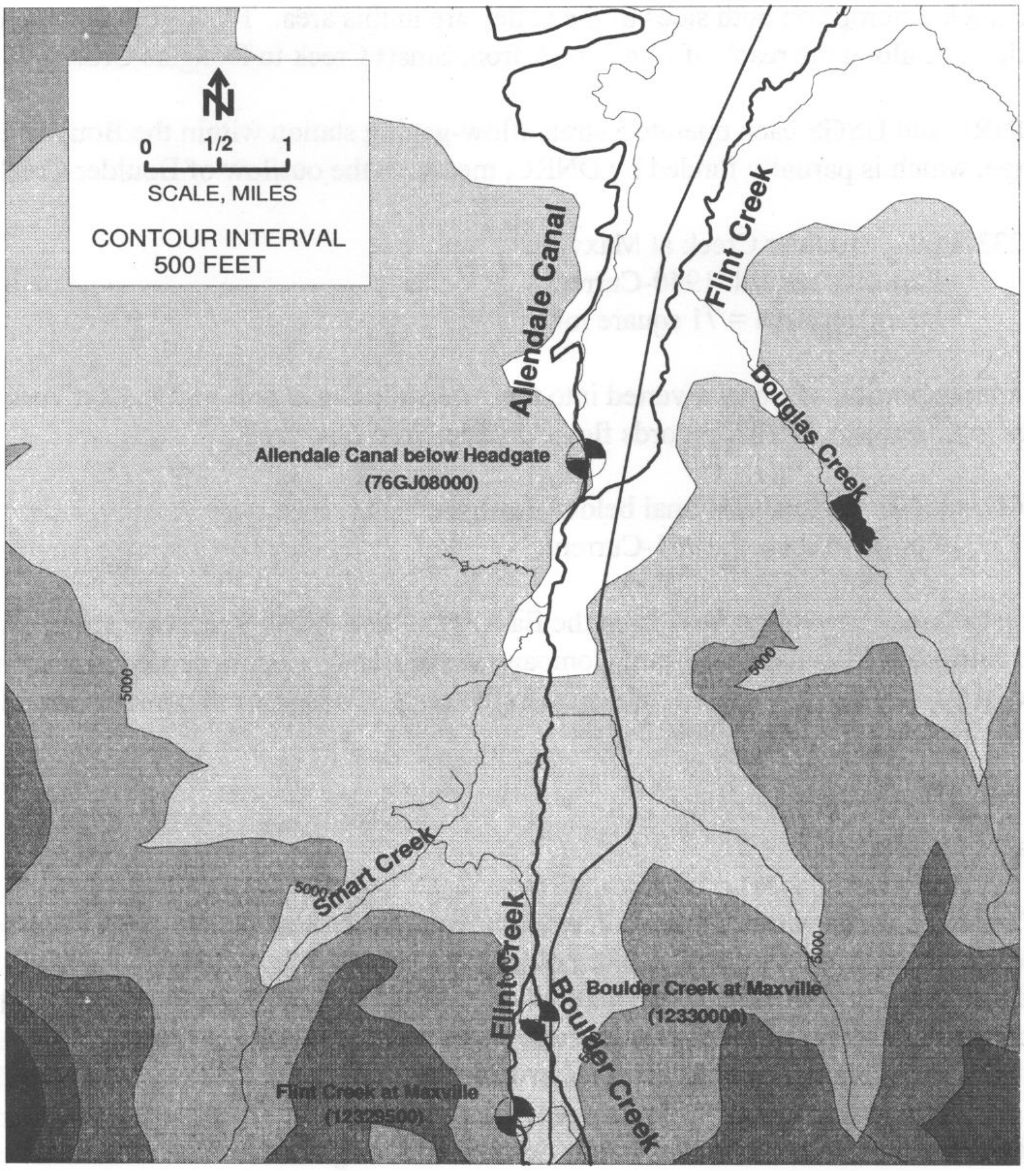


Figure 2.6 Boulder Unit

Most of the irrigated acreage within the Boulder unit is located on alluvial deposits of the Flint Creek valley floor. The valley floor is over a mile wide just north of the canyon but narrows considerably near the confluence with Smart Creek where the valley is about 2,000 feet wide. Bedrock outcrops on both sides of the valley are in this area. The valley floor remains less than a mile wide along the reach of Flint Creek from Smart Creek to Douglas Creek.

DNRC and USGS each operate a streamflow-gaging station within the Boulder unit. The USGS gage, which is partially funded by DNRC, measures the outflow of Boulder Creek.

12330000 - "Boulder Creek at Maxville"
Period of record: 1940-Current
Drainage Area = 71 square miles

Because a large portion of water diverted into the Allendale Canal is from the East Fork Rock Creek Reservoir project, DNRC records flows diverted into this canal.

76GJ08000 - "Allendale Canal below Headgate"
Period of record: 1961-Current

In addition to measuring streamflow from the East Fork Rock Creek Reservoir project, water needed to fulfill the Allendale Irrigation Company water rights is also recorded at this site. The Allendale Irrigation Company was established in the early 1900s prior to construction of East Fork Rock Creek Reservoir in 1938.

Hall Unit

The Hall unit, shown in Figure 2.7, extends from downstream of Douglas Creek to where Flint Creek joins the Clark Fork. This unit holds the largest amount of irrigated acreage in the basin and is also the most hydrologically complex. Lower Willow Creek Reservoir, with an active storage of 4,800 acre-feet, is used to store spring runoff for later irrigation use in the summer. The reservoir and over 3,000 acres irrigated from the project are located entirely within this area. A large portion of irrigated acreage within this unit is also supplied with water from East Fork Rock Creek Reservoir. Numerous decreed water rights also exist within this unit.

In addition to Lower Willow Creek, Barnes Creek also flows into Flint Creek and contributes an average of about 3,500 acre-feet per year. Lorranson Creek, which flows into the Clark Fork directly, would be dry almost year-round, but because it serves as one of the principal waste ways for the Allendale Canal and also conveys a significant amount of irrigation return flows, it is now a significant conveyor of Flint Creek water. Rodeo Grounds Spring, which also flows directly into the Clark Fork, exists primarily because of Flint Creek return flows.

The irrigated lands within this unit are located on alluvial deposits of Flint Creek and

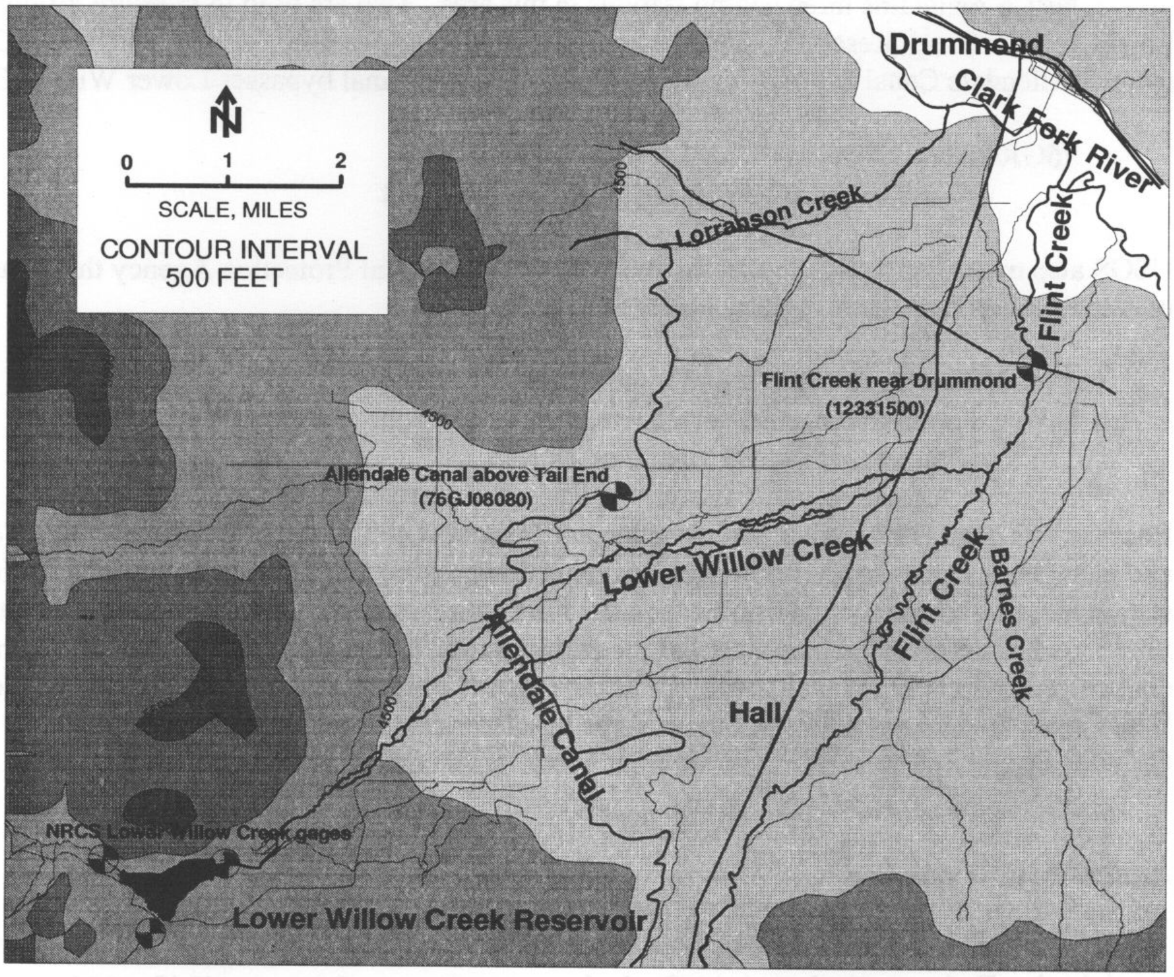


Figure 2.7 Hall Unit

Lower Willow Creek and on older deposits that form elevated benches west of Flint Creek. The alluvial deposits flanking Flint Creek between Hall and the Clark Fork River form a valley floor about 1.5 miles wide. Alluvium deposited by Lower Willow Creek includes deposits along the present course of the stream, and those in an abandoned channel that extends from the area where the Allendale Canal crosses Lower Willow Creek directly east to Hall.

NRCS maintains three gaging stations in this area. Two are used to measure inflows into Lower Willow Creek Reservoir; the other one measures outflow from the reservoir. DNRC also records Allendale Canal flows downstream from where the canal bypasses Lower Willow Creek.

76GJ08080 - "Allendale Canal above Tail End"
Period of record: 1961-1985 and 1987-Current

USGS also maintains a gage funded by the U.S. Environmental Protection Agency that is useful in determining Flint Creek outflow into the Clark Fork.

12331500 - "Flint Creek near Drummond"
Period of record: 1991-Current
Drainage area = 490 square miles

Because this gage is located two miles upstream from where Flint Creek enters the Clark Fork and there are approximately 1,000 acres irrigated downstream from this gage, the data from this station must be adjusted to determine the total Flint Creek outflow. Also, a significant portion of Flint Creek water bypasses this streamflow-gaging station through both irrigation and return flow ditches. Another concern is that not all Flint Creek water goes into the Clark Fork by way of the Flint Creek channel as explained earlier in the descriptions of Lorranson Creek and Rodeo Grounds Spring. Determination of the Flint Creek basin outflow is discussed in Chapter 4.

Agricultural Water Use

Water rights were established for both mining and agriculture prior to 1900 in the Flint Creek basin. Today, agriculture is by far the largest consumer of water. Alfalfa, alfalfa grass hay, and wild hay are the primary irrigated crops. Approximately 8,200 acres are irrigated in the Philipsburg valley and 17,000 acres in the Drummond valley. The best source for determining irrigated acreage, as well as diversion points within the basin, is still the *Water Resources Survey* completed in 1959 by the State's Engineer's Office (now DNRC). Within this publication are mapped ditch locations, irrigated acreage, and water right types. Because this information is dated pre-1960, much has changed since this survey, but it still remains the most detailed survey ever completed quantifying irrigated acreage in Granite County. In addition, DNRC has a computerized data base containing all water right claims and permits. The data base can be organized by priority date, claim numbers, owner names, or land descriptions.

Irrigation in the Flint Creek basin changed dramatically in 1938 with the completion of

East Fork Rock Creek Reservoir by the State's Engineer's Office. Unlike Georgetown Lake and Lower Willow Creek Reservoir, this water, administered by the Flint Creek Water Users Association, is additional water that would not have entered the basin at all without the project. As will be shown later, during a drought this water can almost equal the total natural runoff of Flint Creek in summer.

Several canals were built for this system in addition to the dam. The Flint Creek Main Canal was built for a capacity of 200 cfs. Although this canal was built primarily to convey water from East Fork Rock Creek to the Flint Creek basin, some water is used locally to irrigate and to supplement water rights for previously existing irrigated lands. The Marshall Canal, which follows a northerly direction for 16.8 miles until it spills into Marshall Creek, was built to carry 57 cfs. The water is used to irrigate additional lands and to supplement water rights for previously existing irrigated lands throughout the western side of the Philipsburg valley.

The Allendale Canal was built in the early 1900s by the Allendale Irrigation Company. During construction of East Fork Rock Creek Reservoir, the ditch capacity was enlarged by the State Water Conservation Board to 125 cfs. An agreement between the State Water Conservation Board and Allendale Irrigation Company allowed the State to use the ditch in exchange for which, the State, over the years, would provide the company water in the amount of 2,400 acre-feet from May 1 to June 30; 1,200 acre-feet from July 1 to July 15; and 1,200 acre-feet after September 15. From July 15 to September 15, the Allendale Irrigation Company would purchase 2,000 acre-feet of water annually from the East Fork Rock Creek Reservoir project. Therefore, water diverted in the Allendale Canal is administered by the Flint Creek Water Users Association to fulfill Allendale Irrigation Company water rights, Allendale Irrigation Company water rights supplemented with East Fork Rock Creek Reservoir water rights, and additional water rights for lands irrigated with East Fork Rock Creek Reservoir water that did not have water rights prior to construction of the reservoir. This mingled combination of water rights is extremely difficult to separate out.

The amount of water allocated to the Allendale Irrigation Company was agreed upon by the State Water Conservation Board and Allendale Irrigation Company following the Montana Supreme Court decision of June 27, 1942, "Allendale Irrigation Co., Appellant vs. State Water Conservation Board et al., Respondents." The Supreme Court ruling found that the State Water Conservation Board or Flint Creek Water Users Association could not interfere with the natural flow rights of the Allendale Irrigation Company.

In preparation for the above court case, the State Conservation Board and USGS collected a large amount of discharge data along tributaries and ditches within the Philipsburg valley. The State Water Conservation Board found that during July, 1939, the flow volume into the Philipsburg valley from natural sources was 3,800 acre-feet. The additional water from East Fork Rock Creek Reservoir amounted to 3,840 acre-feet, for a combined total inflow of 7,640 acre-feet. The diversion total was 8,640 acre-feet and the measured flow leaving the Philipsburg valley was 3,500 acre-feet. Therefore, the total amount of return flow during July, 1939, was

4,500 acre-feet, which was 37 percent of the sum of the water available for irrigation within the Philipsburg valley and the water leaving the valley.

CHAPTER 3 - STUDY DESIGN

Quantifying irrigation return flows requires an evaluation of the water budget within the Philipsburg and Drummond valleys. For this analysis, it is assumed that the largest loss within the study area is attributed to evapotranspiration and that losses such as direct evaporation are insignificant. Since surface-water inflow into the study areas is downstream of all reservoirs, this assumption is appropriate because evaporation from ditches and streams is usually minor. Precipitation, another component of inflow, is considered indirectly using streamflow measurements as well as observing changes in groundwater levels. Uses of water other than agriculture, such as municipal consumption, play an insignificant role in the hydrology of Flint Creek.

If all diversion volumes within the basin were measured below headgates, and inflow and outflow volumes were also measured, return flow volume could be quantified using the following:

$$ReturnFlow = \Sigma BasinOutflows - \Sigma BasinInflows + \Sigma BasinDiversions$$

Unfortunately, it was beyond the scope of this study to measure all diversions. Instead, the average daily discharge hydrographs of both inflows and outflows were compared. Once irrigation is "shut off," return flow, as a discharge, was determined by the amount that outflow exceeds inflow. Return flows are highest immediately after irrigation and diminish as time goes on. In a sense, this method is an estimation of groundwater storage of return flows and not total return flow amounts. In other words, excess irrigation water that returns immediately could not be accounted for using this method. Although groundwater storage of high spring runoff can also contribute to outflow, it was found by observing groundwater levels that by the time irrigation is completed in September or October, this source of water is negligible.

Return flow estimates for Flint Creek are desired not only for the basin as a whole, but also for individual reaches of the stream. Therefore, as explained in the previous chapter, the basin was divided into four hydrologic units: Headwater, Marshall, Boulder, and Hall. These units were chosen from analysis of geologic conditions where a large portion of agricultural water returns as surface water within the same unit. For example, most return flows resulting from agriculture in the Marshall unit would return to the stream before entering the Boulder unit. In this study, the water balance hydrographs for these units are determined for the years 1994 through 1996.

Several components had to be considered to determine return flow storage potential. Unit inflows and outflows were determined from continuous streamflow-gaging stations within each hydrologic unit. Geologic conditions, within most units, allowed for the outflow to be determined using either one or two gages. Limited resources, however, prevented measurement of all but the largest inflows. Therefore, several streamflow measurements were taken on ungaged streams to assist in determining total inflows.

In order to measure gains and losses of surface-water flow in areas where continuous recorders were not installed, near constant discharge conditions are needed. Therefore, streamflow measurements were taken on Flint Creek along several reaches without streamflow-gaging stations after the spring runoff in the summer and fall of 1994 through 1996. Tributaries to Flint Creek were also measured in the spring, enabling a more accurate estimate of inflows from these streams.

As part of the hydrologic evaluation of each unit, groundwater levels were measured in 87 wells throughout the Flint Creek basin. Well logs from these and other wells in the basin were compiled and analyzed. Sixteen project wells were drilled to provide detailed information for some areas.

Wells that were part of the monitoring well network are identified in this study with a prefix of "FC" followed by a number or letter identification. All of these wells were inventoried and located accurately during the study. Appendix A includes a listing of basic information for monitored wells. To help characterize the groundwater system, 129 well logs were entered into a groundwater data base. Most of the well log data were obtained from the Montana Bureau of Mines and Geology (MBMG) Ground Water Information Center or from DNRC water rights records. Many of these wells were not inventoried, so the locations for well log data shown on maps in this chapter are approximate. Well log data for inventoried wells were assigned a prefix of "WL" followed by an identification number. Appendix B contains a listing of the sources of these well log data and other basic well information.

Headwater Unit

Data from existing streamflow-gaging stations are used to determine a large portion of the inflow to the Headwater unit. These stations are shown in Figure 3.1. Reservoir releases from Georgetown Dam are recorded at the "Flint Creek near Southern Cross" (station 12325500) gage. Water taken from East Fork Rock Creek for use in the Flint Creek basin is recorded at the "Flint Creek Main Canal below Headgate" (station 76E 02000) gage. However, several drainages are not accounted for, with two of the largest being Trout Creek and Spring Creek. Several streamflow measurements were made at Spring Creek, and the baseflow is approximately 2 cfs, with the highest measurement taken being 7 cfs. Measuring natural Trout Creek flow was not possible because much of the diverted water from East Fork Rock Creek is routed through Trout Creek.

Streamflow data from the "Flint Creek Main Canal below Headgate" gage cannot be used, without adjustment, to determine the inflow from the East Fork Rock Creek diversion that makes its way into the Flint Creek basin. Once the water is diverted into the Flint Creek Main Canal from the East Fork Rock Creek, it flows for more than five miles before it crosses the drainage divide and enters the Flint Creek basin. Because this canal is unlined, some channel loss of water

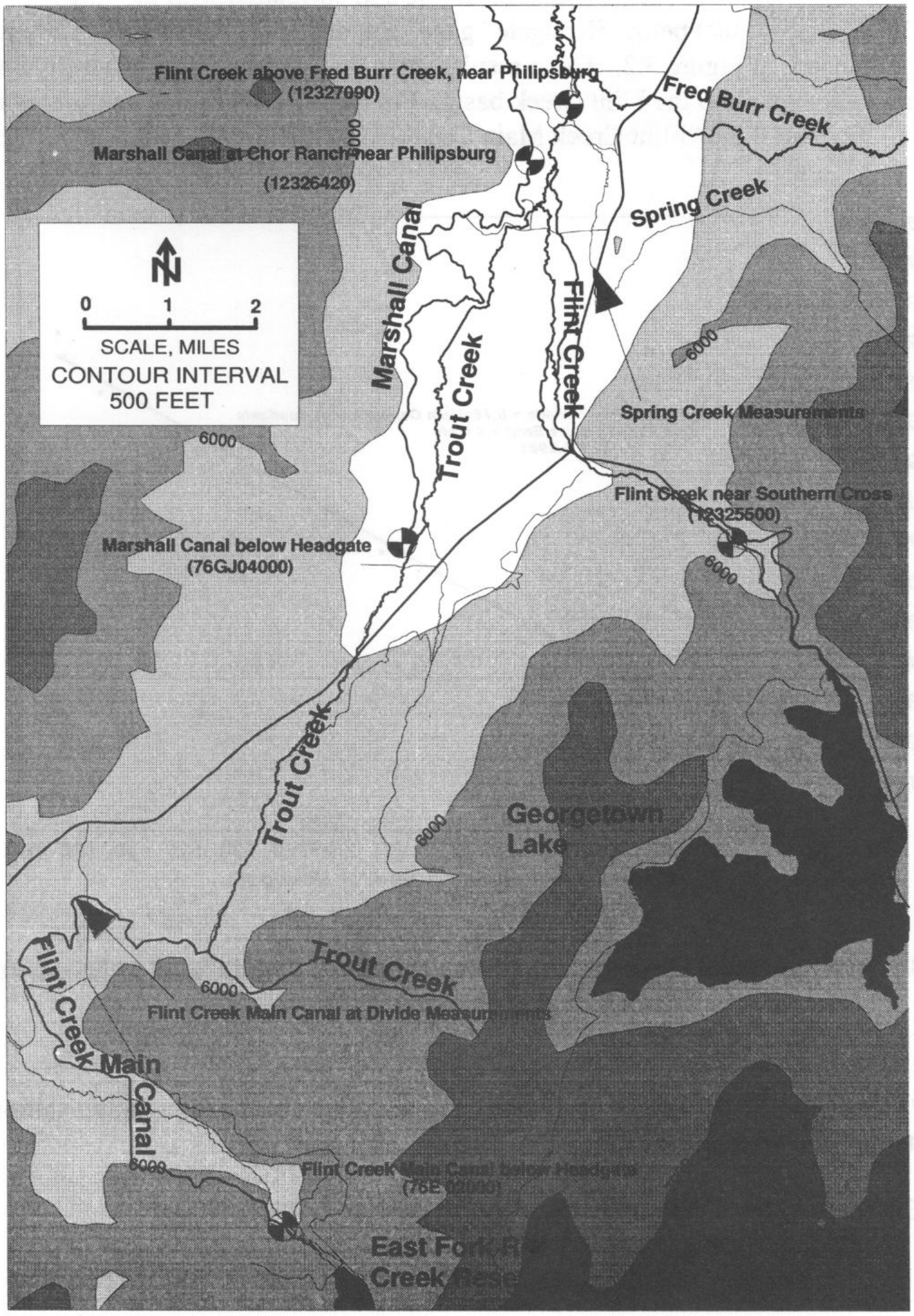


Figure 3.1 Headwater Unit - Study Design

is expected. To determine the amount of channel loss, nine discharge measurements were made on the Flint Creek Main Canal at the drainage divide and correlated with the flows recorded at the "Flint Creek Main Canal below Headgate" gage. Results of this ordinary least-squares regression are shown in Figure 3.2. These results show that 76 percent of water diverted at the headgate makes its way into the Flint Creek basin. For the purpose of this study, this value is applied to all records of the "Flint Creek Main Canal below Headgate" gage.

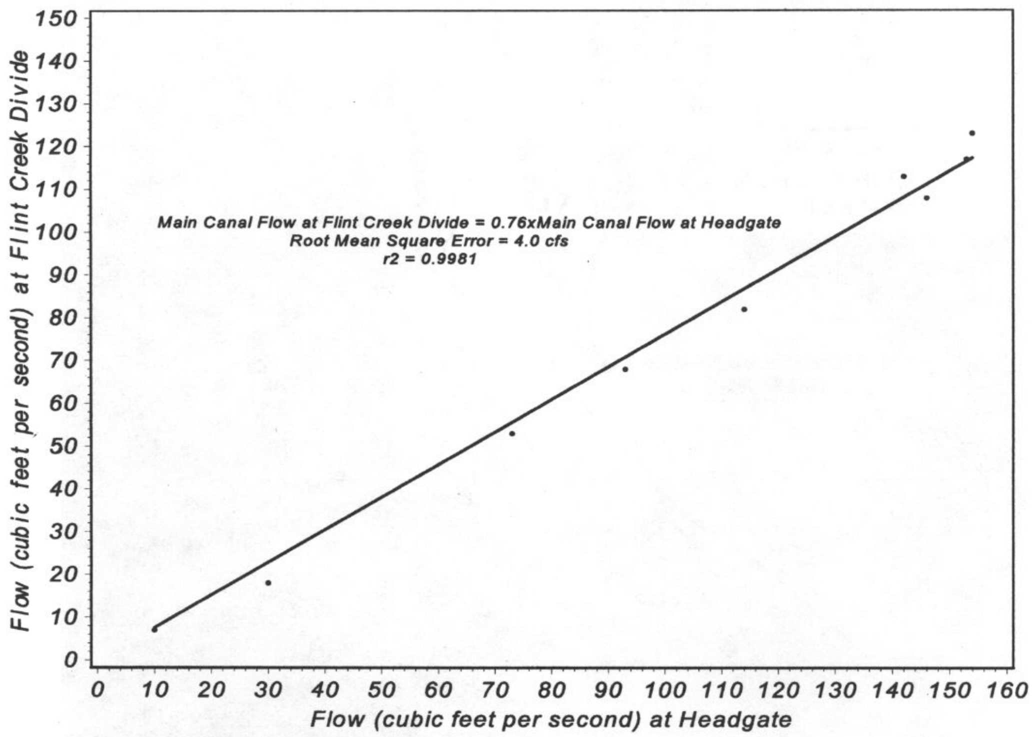


Figure 3.2 Relationship of Streamflow Diverted into the Main Canal at Headgate and the Main Canal at the Flint Creek Divide

To determine the outflow of this hydrologic unit, two streamflow-gaging stations were installed and are shown in Figure 3.1.

12327090 - "Flint Creek above Fred Burr Creek, near Philipsburg"
Period of record: June 1994 - Current
Drainage area = 108 square miles

12326420 - "Marshall Canal at Chor Ranch near Philipsburg"
Period of record: 1995 and 1996 irrigation season

Streamflow data were not gathered during 1994 at the "Marshall Canal at Chor Ranch near Philipsburg" gage, so a simple linear regression was used to correlate the records from this gage with the data from the "Marshall Canal below Headgate" (station 76GJ04000) streamflow-gaging station. Results of this analysis are shown in Figure 3.3. Approximately 76 percent of flows diverted at the headgate moves out of the Headwater unit, and this value was applied to the 1994 streamflow data recorded at the "Marshall Canal below Headgate" gage. Through this adjustment, the hydrology of the Headwater unit can be analyzed for 1994. The fact that ditch loss is the same percentage from the Main Canal to the Flint Creek divide as from the Marshall Canal to the Chor Ranch is coincidental.

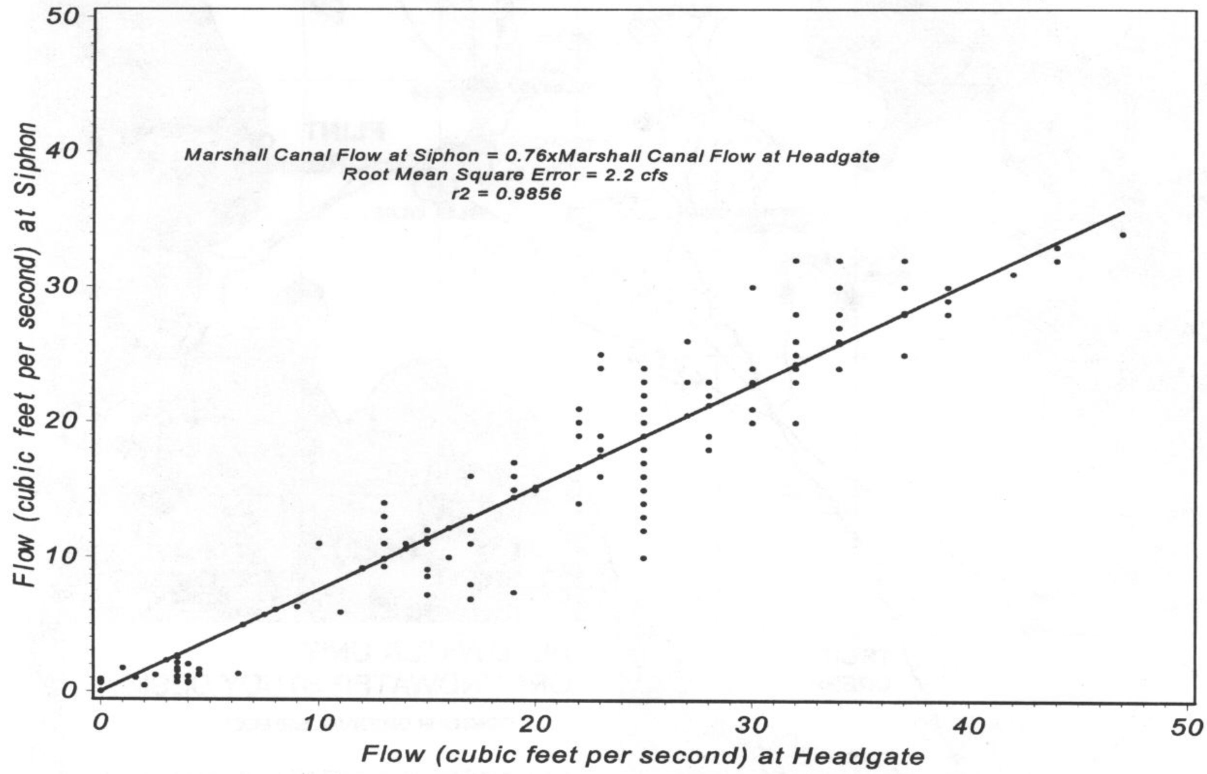


Figure 3.3 Relationship of Streamflow Diverted into the Marshall Canal at Headgate and the Marshall Canal near Philipsburg at Chor Ranch

Groundwater levels were monitored in 12 existing stock and domestic wells and in 2 project wells installed for this study in the Headwater unit. A map showing the distribution and identification of monitoring wells, project wells, and well logs compiled during the study is shown in Figure 3.4. Two wells (FC44 and FC45) are part of the MBMG statewide groundwater monitoring network. Most of the monitoring wells are located within irrigated lands in the lower part of the Headwater Unit.

Project well FCC1 was drilled in the central part of a bench between Trout Creek and

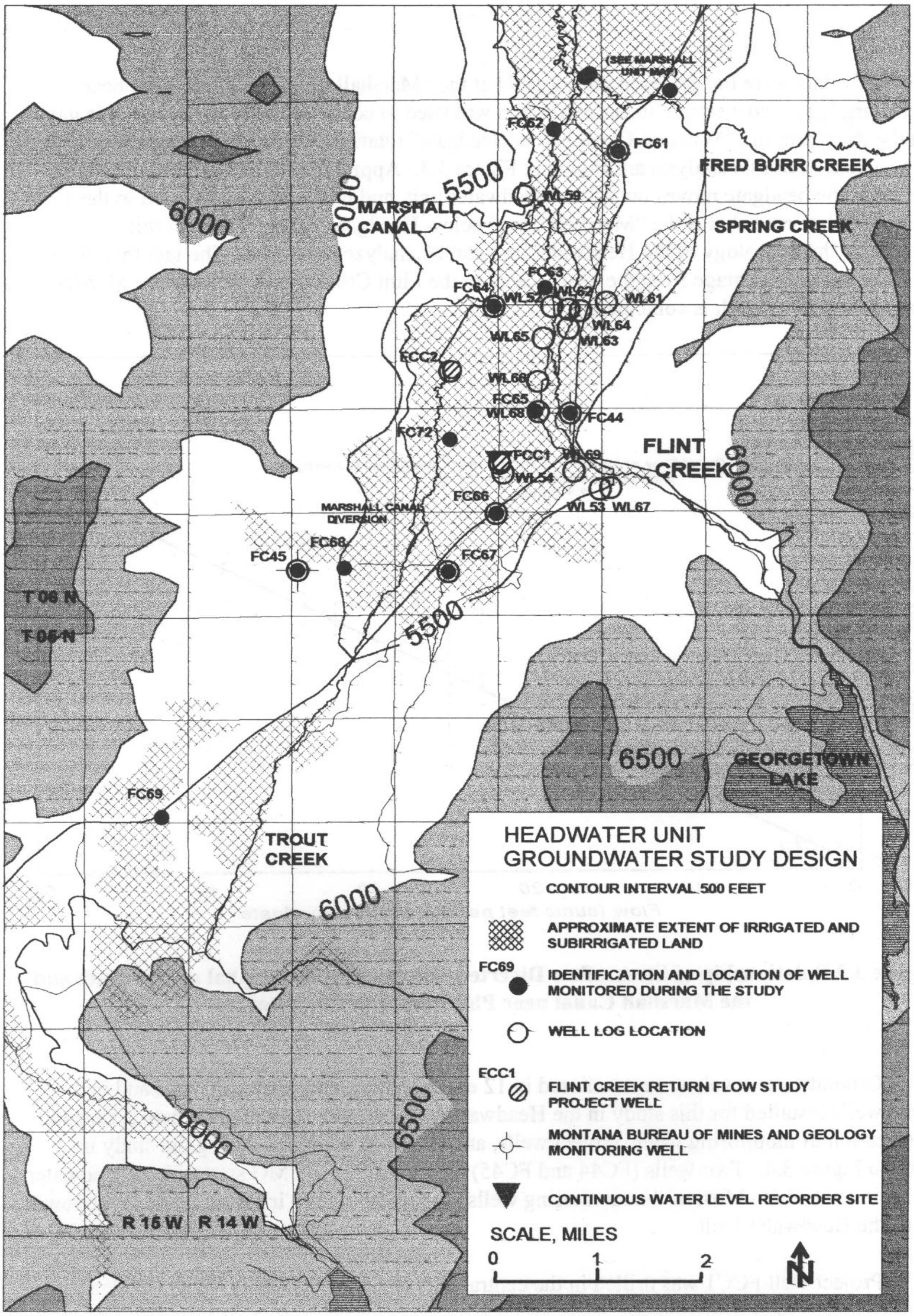


Figure 3.4 Headwater Unit - Groundwater Study Design

Flint Creek. The bench is underlain by Tertiary age sediments, in contrast to the recent alluvium that flanks the two creeks. A continuous water level recorder was placed on this well by MBMG. The recording device did not always work properly so only periodic measurements are available for the 1996 irrigation season. Project well FCC2 was drilled along the northwest edge of the same bench, close to Trout Creek. Springs issue from the edge of the bench and in the Trout Creek alluvium near the location of well FCC2.

Marshall Unit

Inflows into this unit are recorded at the "Flint Creek above Fred Burr Creek, near Philipsburg" gage, "Marshall Canal at Chor Ranch" gage, and the following streamflow-gaging station:

12327100 - "Fred Burr Creek near Philipsburg"
Period of record: April, 1995 through September, 1996
Drainage area = 15.7 square miles

This gage is placed below irrigation withdrawals. Therefore, its use for determining natural streamflow is not ideal. However, since a large portion of Fred Burr Creek runoff is recorded at this gage, it was used without adjustment as an inflow station. The location of this station is shown in Figure 3.5.

The largest ungaged tributary within this unit is Marshall Creek. Although this creek is a wasteway for the Marshall Canal, discharge measurements taken on this stream show very little flow attributable to the canal. The natural flow of Marshall Creek was measured, occasionally running higher than 30 cfs during spring runoff, and usually less than 1 cfs in the late summer. Several other tributaries, including Camp Creek, Dirty Dick Creek, and Douglas Creek, were measured between 1994 and 1995. None of these tributaries had a measured discharge above 4 cfs.

The outflow from the Marshall unit is recorded at the "Flint Creek at Maxville" (station 12329500) streamflow-gaging station. Initially, we planned to determine the outflow of this unit at the southern inlet of the narrow canyon area upstream of the "Flint Creek at Maxville" gage. Therefore, the following streamflow-gaging station was re-established and the location is shown in Figure 3.5.

12328500 - "Flint Creek near Philipsburg"
Period of record: May 1939 - Oct 1941, May 1995 - Oct 1995, and May 1996 - Dec 1996
Drainage area = 192 square miles

A comparison of 1995 and 1996 daily streamflow from the "Flint Creek at Maxville" and "Flint Creek near Philipsburg" gages is shown in Figures 3.6 and 3.7. Shaded in gray is the flow

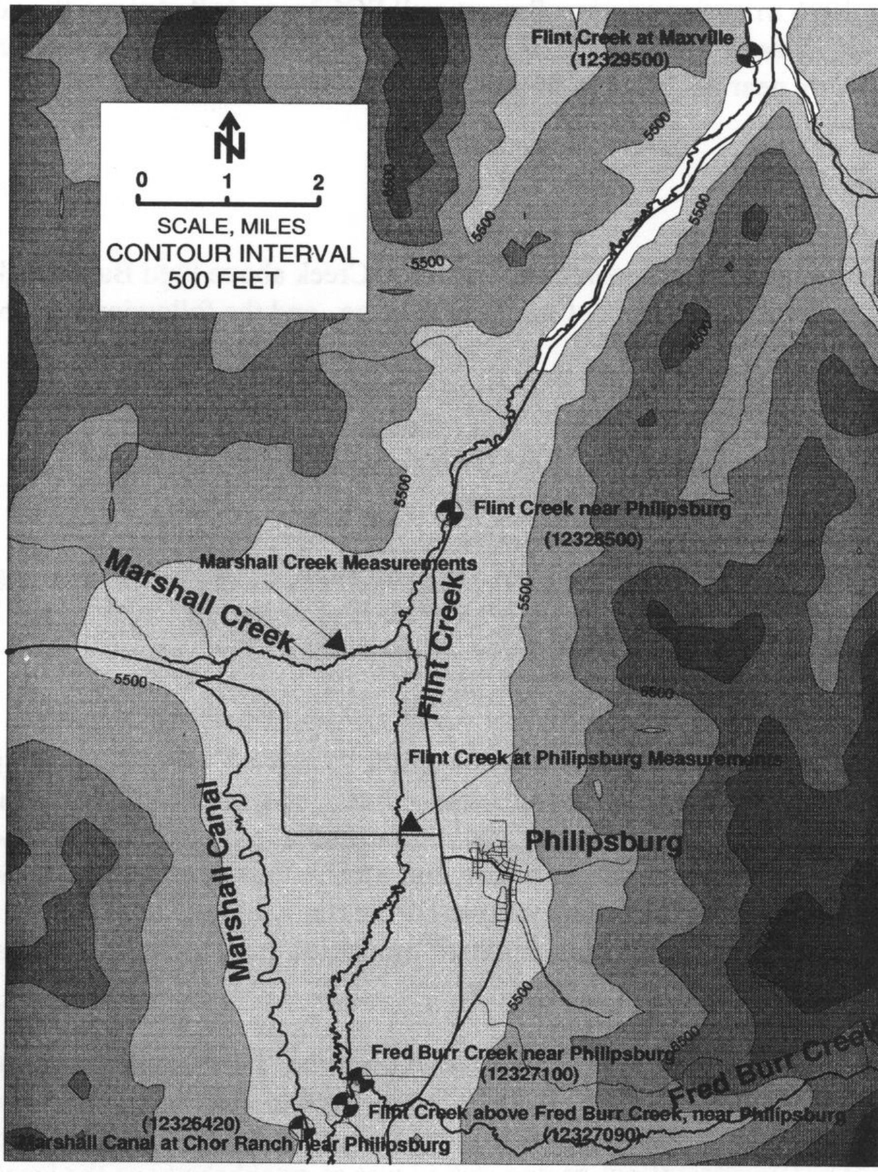


Figure 3.5 Marshall Unit - Study Design

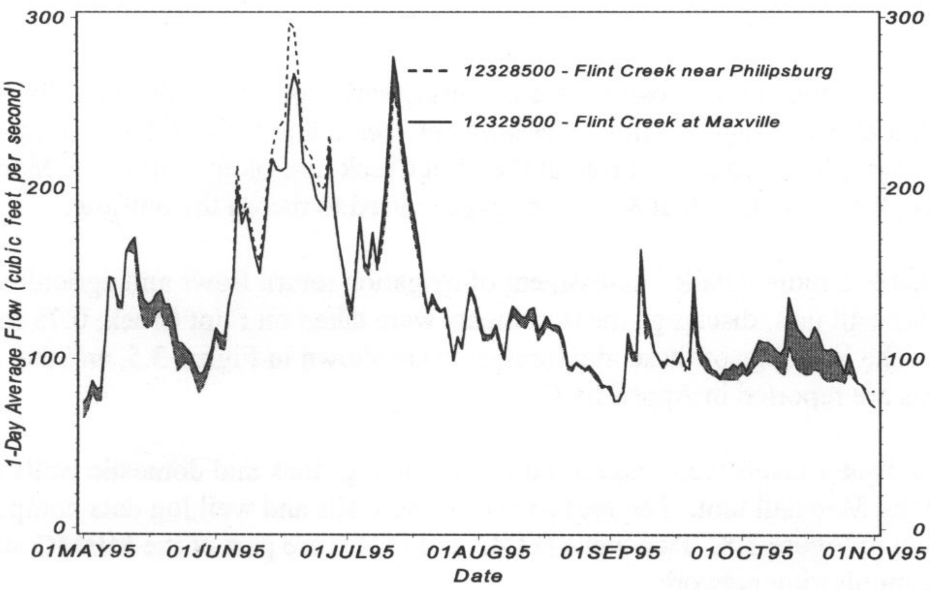


Figure 3.6 Streamflow Gains in the Canyon Area Separating the Philipsburg and Drummond Valleys During 1995

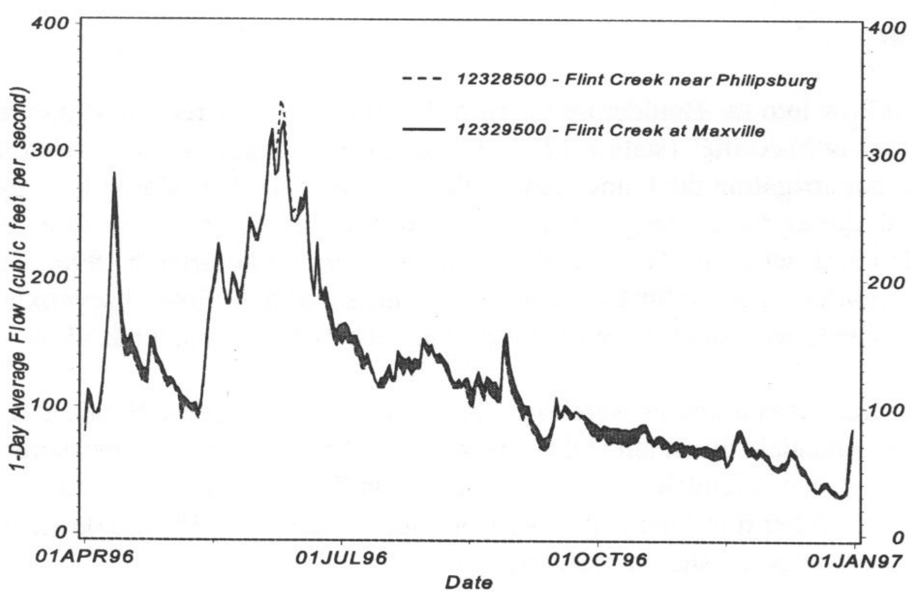


Figure 3.7 Streamflow Gains in the Canyon Area Separating the Philipsburg and Drummond Valleys During 1996

from the 16-square-mile narrow canyon area. During early spring months, this flow can be more than 20 cfs, but by early June the flow is usually between 3 and 8 cfs. Obviously, this small drainage does not play a significant role in the Flint Creek hydrology within the Marshall unit, and, therefore, the "Flint Creek at Maxville" gage is used to record the outflow.

To enable a more detailed assessment of irrigation return flows and agricultural water use within the Marshall unit, discharge measurements were taken on Flint Creek, 0.75 mile west of Philipsburg. The locations of these measurements are shown in Figure 3.5, and the measurements are reported in Appendix C.

Groundwater levels were monitored in 14 existing stock and domestic wells and 2 project wells within the Marshall unit. The locations of these wells and well log data compiled for this unit are shown in Figure 3.8. Two wells (FC42 and FC43) are part of the MBMG statewide groundwater monitoring network.

Project well FCD1 was drilled to gain some information for the west side of the valley in an area where there were no existing wells. This well was fitted with a continuous water level recorder by MBMG during the study. Project well FCF1 was drilled in the central part of the outwash plain that extends northwest from the terminal moraine of Fred Burr Creek to Flint Creek.

Boulder Unit

The inflow into the Boulder unit is recorded at the "Flint Creek at Maxville" gage and the "Boulder Creek at Maxville" (station 1233000) streamflow-gaging station. Although water is diverted into one irrigation ditch upstream of the "Boulder Creek at Maxville" gage, the amount of withdrawal, during the irrigation season, is usually around 10 cfs. Therefore, 10 cfs is added to all recorded data between May 15 and September 15 for 1994 through 1996. Two ungaged tributaries within the area are Smart Creek, with a measured base flow of approximately 2 cfs, and Douglas Creek, with streamflows measured as high as 17 cfs and a baseflow of roughly 3 cfs.

Discharge measurements were made on Flint Creek at both the Henderson Creek Road and below the Allendale diversion and are reported in Appendix C. The measurements downstream from the Allendale diversion are taken on Flint Creek between the Allendale diversion and the other miscellaneous diversions approximately 0.25 mile downstream. The locations of these sites are shown in Figure 3.9.

The outflow location from the Boulder unit is more difficult to define than for both the Headwater and Marshall units. The transition from the Boulder unit into the Hall unit occurs as an abrupt increase in valley width, rather than a geologic confinement of the basin. Therefore, measurement of the outflow cannot be defined as accurately as for the previous two units. The surface-water outflow from the Boulder unit is considered a combination of the flows in

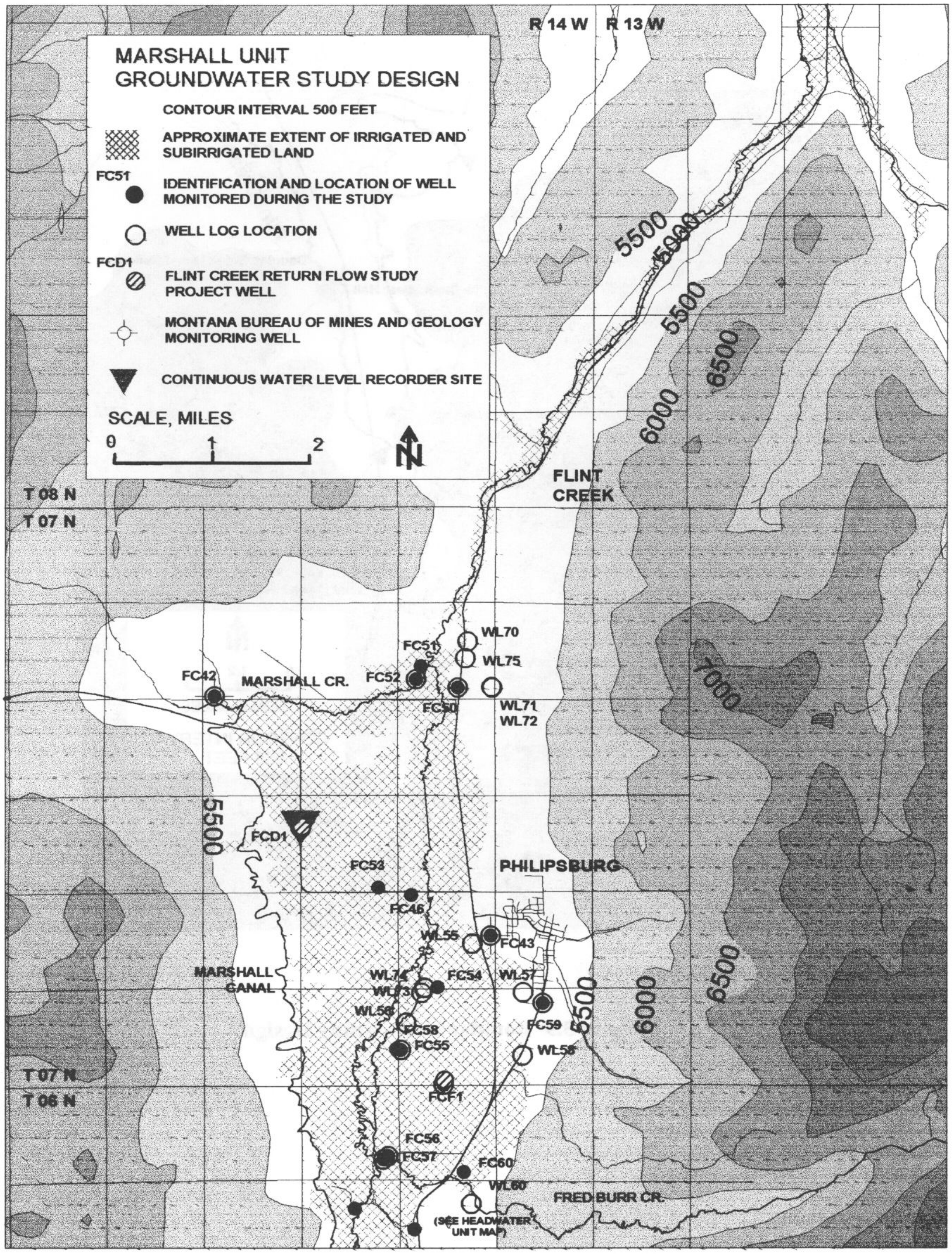


Figure 3.8 Marshall Unit - Groundwater Study Design

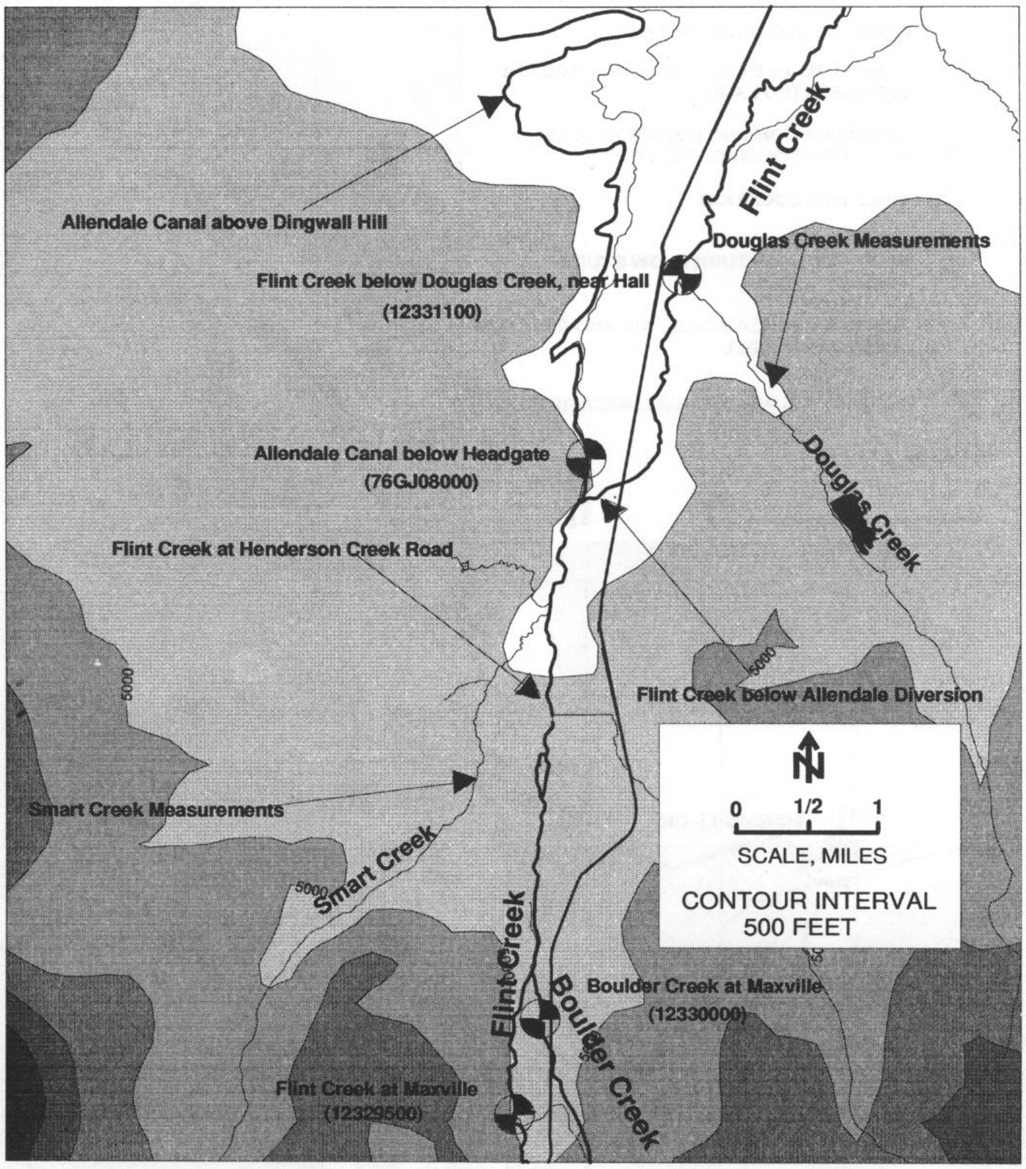


Figure 3.9 Boulder Unit - Study Design

Allendale Canal above Dingwall Hill and the flows measured at the following streamflow-gaging station:

12331100 - "Flint Creek below Douglas Creek, near Hall"
Period of record: April, 1995 - Current
Drainage area = 339 square miles

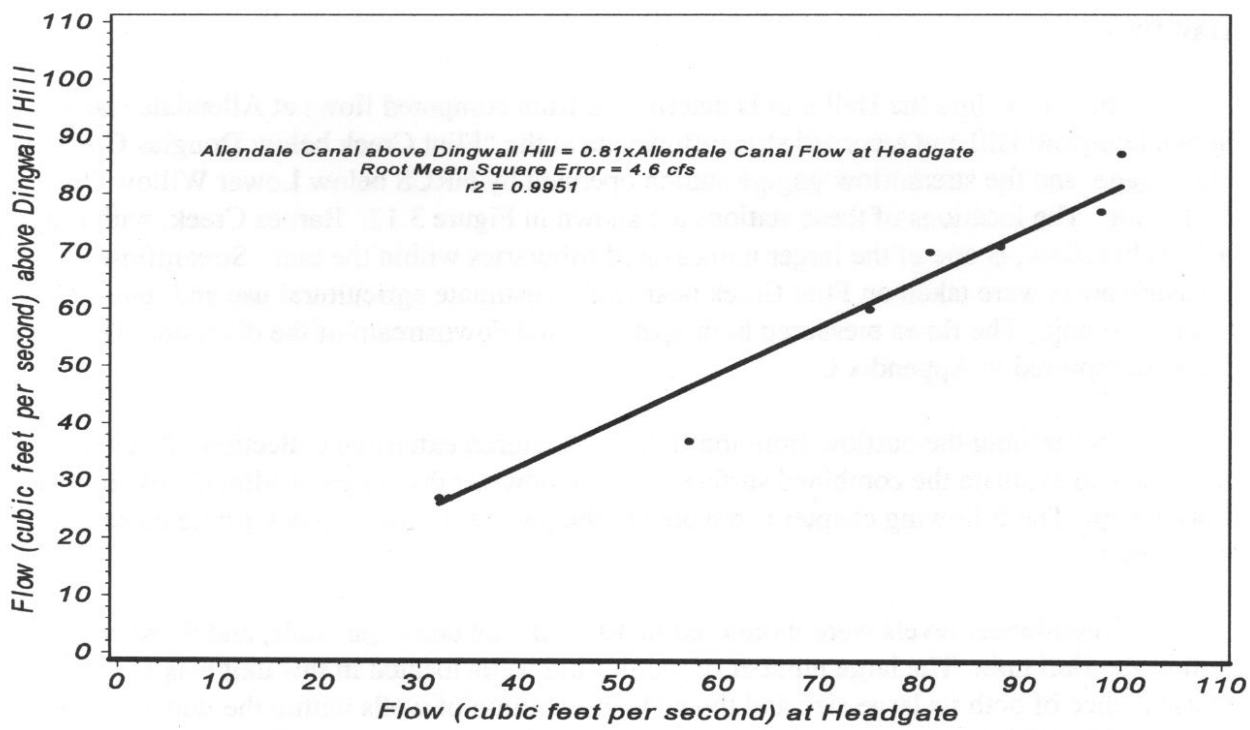


Figure 3.10 Relationship of Streamflow Diverted into the Allendale Canal at Headgate and the Allendale Canal above Dingwall Hill

Because of limited access, the Allendale Canal measurements above Dingwall Hill are taken about 1.5 miles northwest of the "Flint Creek below Douglas Creek" gage.

A streamflow-gaging station was not established on Allendale Canal above Dingwall Hill, but eight streamflow measurements were taken to correlate with records from the "Allendale Canal below Headgate" (station 76GJ08000) gage. Only a few small diversions exist between these two points. The results of this analysis are shown in Figure 3.10. It was found that, on average, 81 percent of the water diverted at the headgate still remained in the Allendale Canal above Dingwall Hill. Therefore, all records from the "Allendale Canal below Headgate" gage are multiplied by 0.81 to enable continuous records to be developed for determining Allendale Canal outflows from the Boulder unit.

Groundwater levels were monitored in five stock and domestic wells within the Boulder unit. Only seven well logs were obtained for this area. One NRCS shallow monitoring well located in Section 22 (SCS10) provided a record of shallow groundwater fluctuations during the summer months of 1990, 1991, and 1992 at this location. The well was not monitored during this study. These features are mapped in Figure 3.11.

Hall Unit

The inflow into the Hall unit is determined from computed flows at Allendale Canal above Dingwall Hill and recorded streamflow data at the "Flint Creek below Douglas Creek, near Hall" gage, and the streamflow-gaging station operated by NRCS below Lower Willow Creek Reservoir. The locations of these stations are shown in Figure 3.12. Barnes Creek, with roughly a 2 cfs baseflow, is one of the larger unmeasured tributaries within the unit. Streamflow measurements were taken on Flint Creek near Hall to estimate agricultural use and return flows within the unit. The flows measured both upstream and downstream of the diversion dam near Hall are reported in Appendix C.

Determining the outflow from the Hall unit required extensive collection of field data necessary to evaluate the combined surface and groundwater discharge of Flint Creek to the Clark Fork River. The following chapter is devoted to the procedures used to determine these discharges.

Groundwater levels were monitored in 40 stock and domestic wells, and 9 project wells within the Hall unit. The large number of monitoring wells located in this unit was a consequence of both its large size and the wide distribution of wells within the unit as shown in Figure 3.13. Well log data compiled for this unit are shown separately in Figure 3.14. Previous groundwater level records were available from other sources. MBMG established two statewide observation wells in the basin in 1993, and these wells were monitored during the return flow study. About a dozen area wells had been inventoried by USGS in 1985, and these had a variety of previous water level measurements and water quality data available. Where possible, the same wells were used for this study. NRCS emplaced nine shallow piezometers during soil studies within the unit, which had some records of shallow groundwater levels in the early 1990s. Two of these wells were monitored during the study.

Twelve project wells were drilled within the Hall unit during the return flow study. Six of these were drilled at two sites designed for aquifer testing and monitoring. The other six were drilled for water level monitoring. Six continuous water level recorders were operated on project wells in the area.

Project wells FCA1, FCA2, FCA3, and FCA4, drilled near the Drummond airport, provided two sets of wells for aquifer tests in shallow and deep aquifers in the central part of the

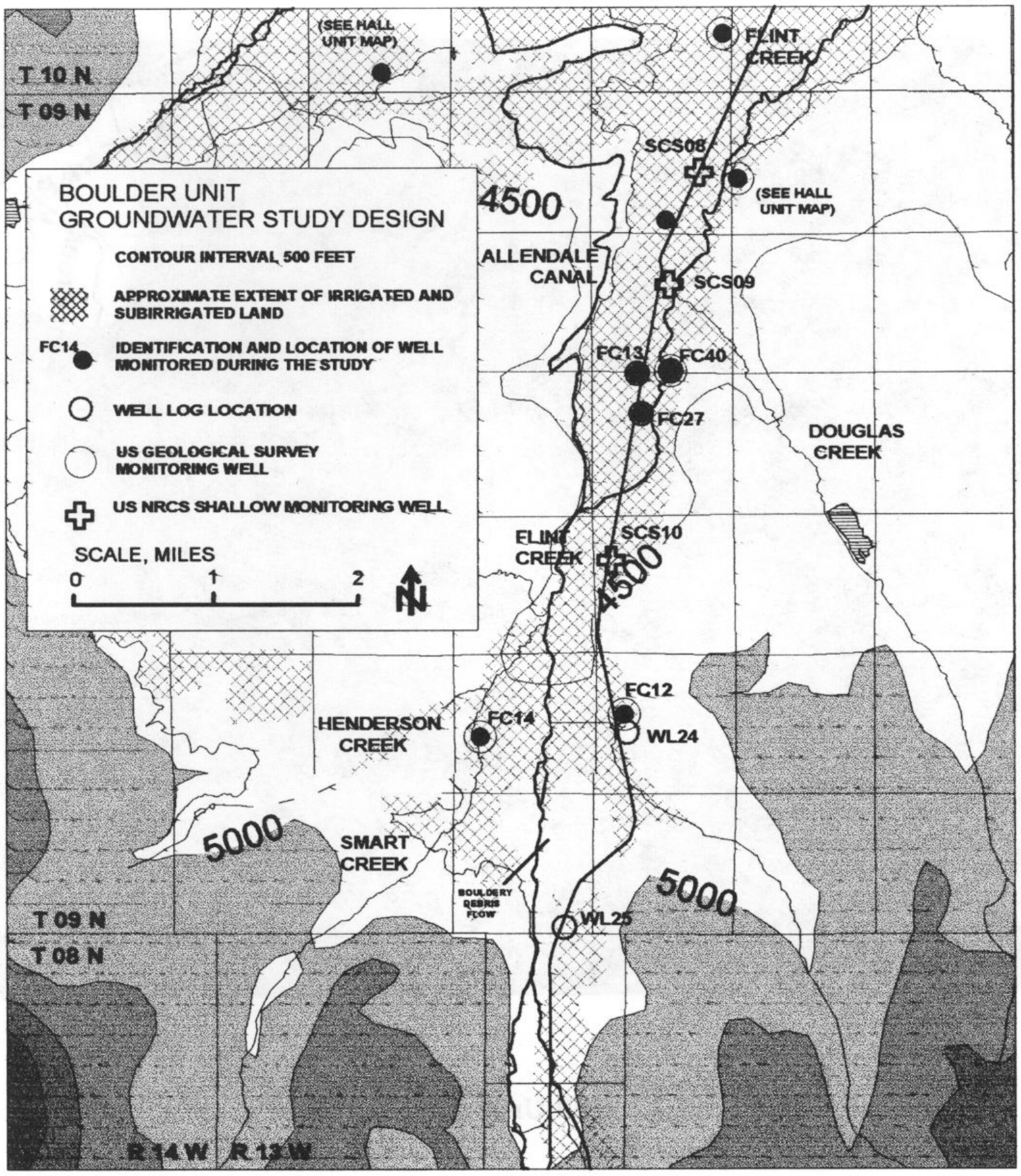


Figure 3.11 Boulder Unit - Groundwater Study Design

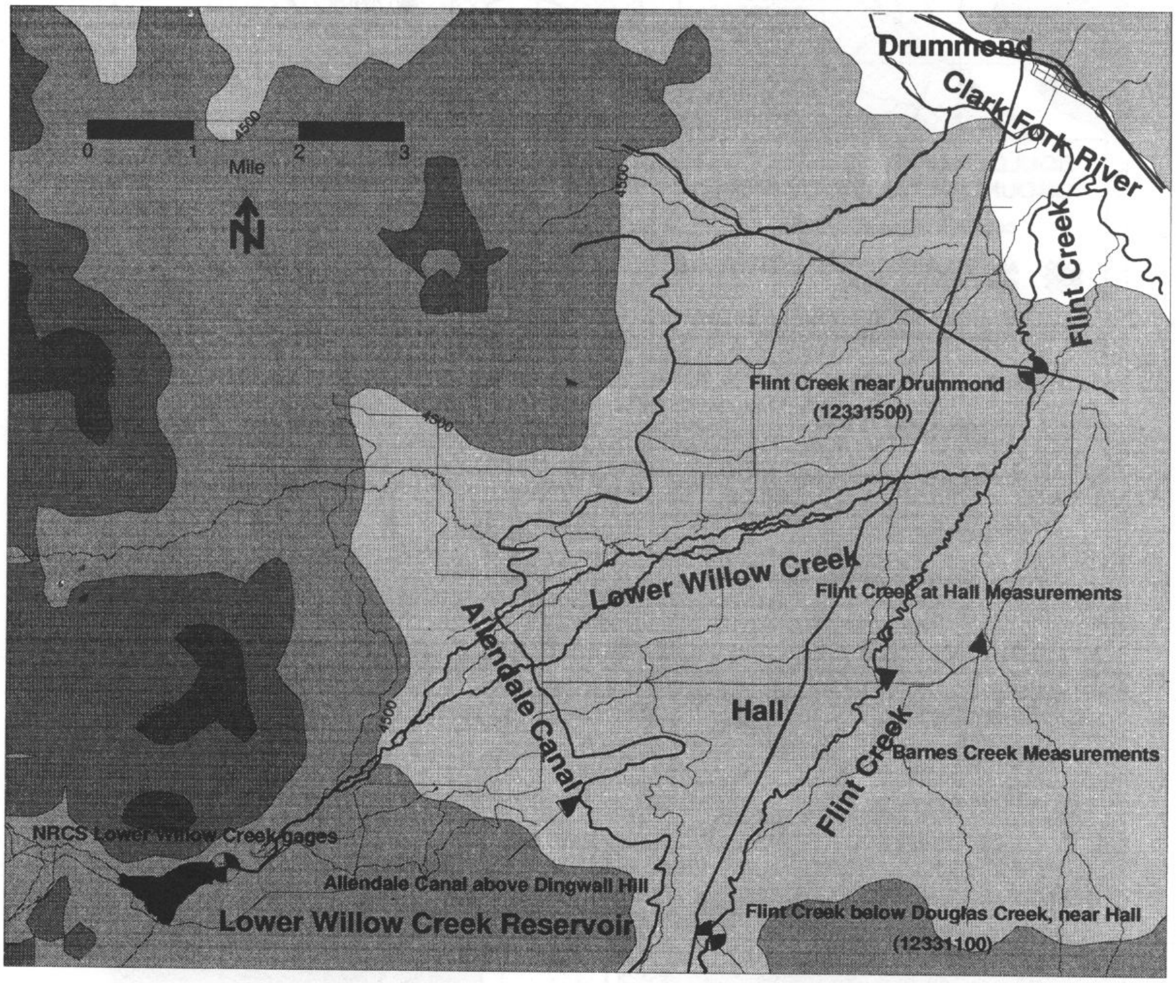


Figure 3.12 Hall Unit - Study Design

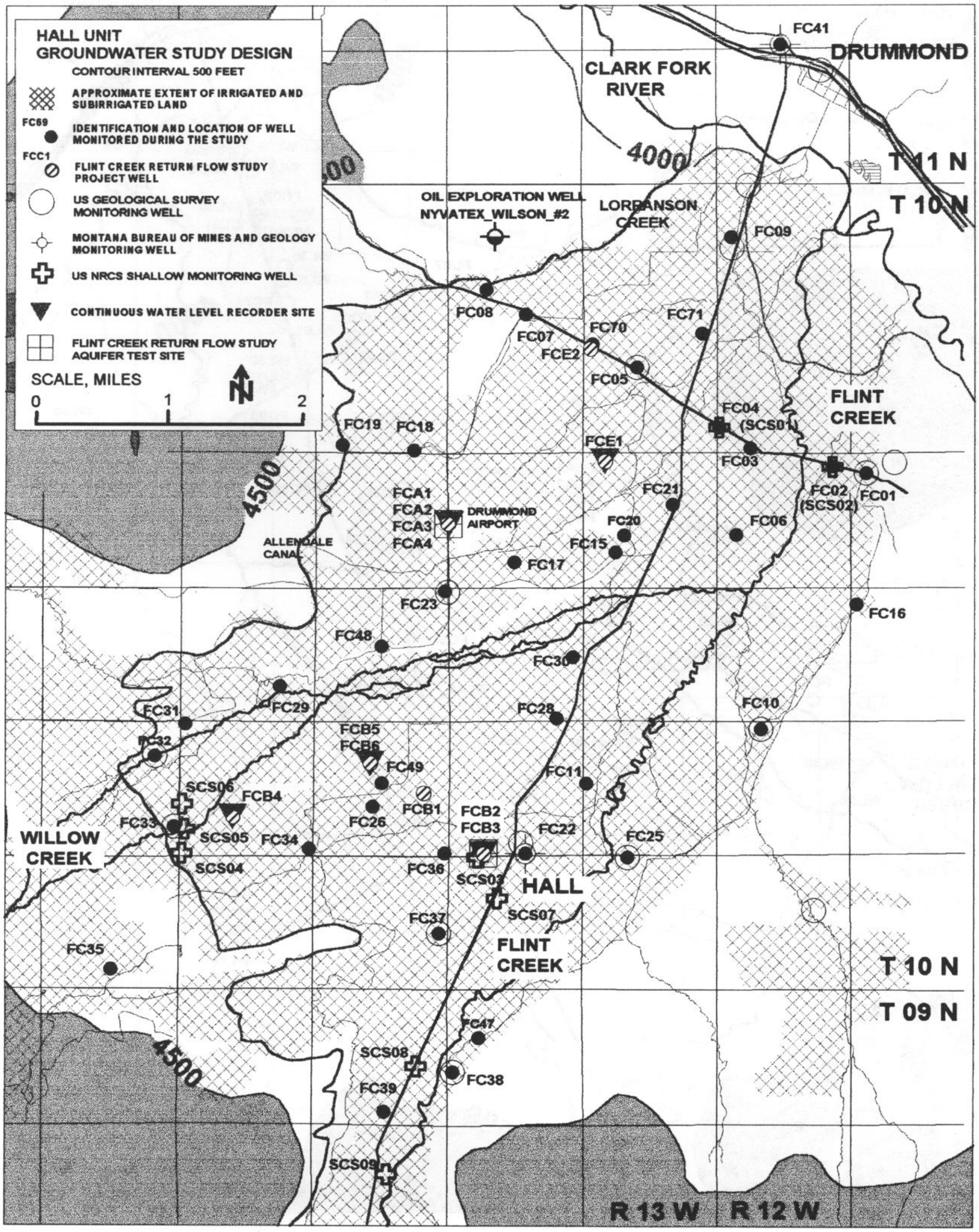


Figure 3.13 Hall Unit - Groundwater Study Design

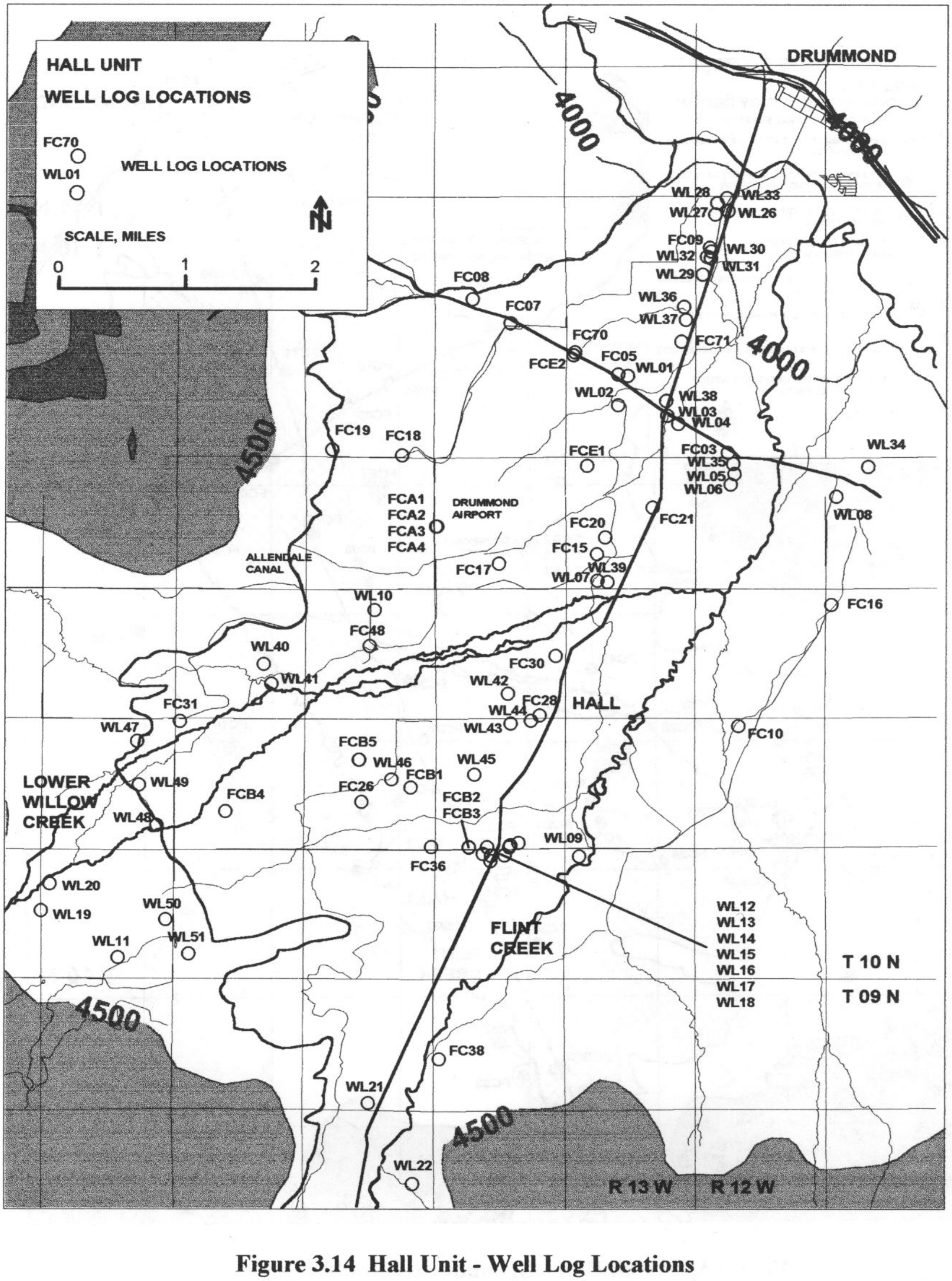


Figure 3.14 Hall Unit - Well Log Locations

irrigated bench north of Lower Willow Creek. Continuous water level recorders were operated in one deep well and one shallow well at this site. The second pair was used only for the aquifer tests. Project wells FCB2 and FCB3 were used for an aquifer test in the abandoned channel of Lower Willow Creek just west of Hall. A continuous water level recorder was operated at well FCB2, while well FCB3 served as a pumping well for the aquifer test. Wells FCB1 and FCB4 were drilled for monitoring purposes, and FCB4 was used as continuous water level recorder site. Wells FCB5 and FCB6, a deep and shallow well pair, were placed in the middle of the isolated bench remnant between Lower Willow Creek and the abandoned channel of Lower Willow Creek west of Hall. This site was designed to complement the similar airport site on the bench to the north. A continuous water level recorder was operated in the deeper well, FCB5. Well FCE1 was drilled as a monitoring well and was equipped with a continuous water level recorder. Well FCE2 was drilled near an existing well to create a shallow/deep well pair.

CHAPTER 4 - FLINT CREEK OUTFLOW

During summer and fall, when irrigation and resulting return flows affect the hydrology of the Flint Creek basin, the flows recorded at the "Flint Creek near Drummond" (station 12331500) streamflow-gaging station do not completely reflect the total basin outflow. Because the gage is located two miles upstream from the confluence with the Clark Fork, and approximately 1,000 acres are irrigated downstream from the gage, the total irrigation effects cannot be accounted for. Even if the gage was located downstream at the mouth of Flint Creek, the total outflow could still not be determined since there are additional surface and sub-surface discharges that enter the Clark Fork from the Flint Creek basin. Two of these larger sources are Rodeo Grounds Spring, which derives a large portion of its water from return flows downstream from the "Flint Creek near Drummond" gage, and Lorranson Creek, which, in addition to conveying return flows, is used as one of several waste channels for the Allendale Canal. Both of these sources empty into the Clark Fork downstream from its confluence with Flint Creek.

In addition to these irrigation effects downstream from the gage, a significant amount of flow bypasses the station via either irrigation ditches or return flow ditches. In 1994, the discharges of all these visible ditches and drains were measured and totaled with the results shown in Table 4.1. The potential exists for the flows bypassing the gage to be higher than the flows within the Flint Creek channel. For example the streamflow measured at the "Flint Creek near Drummond" gage on August 29, 1995, was 9 cfs. Although the bypass flow discharges were not measured on this day, they can exceed 30 cfs, as shown in Table 4.1.

Table 4.1 Total Flow Bypassing "Flint Creek near Drummond" Gaging Station

March 22, 1994	4.1 cfs
June 7, 1994	36.4 cfs
June 30, 1994	17.5 cfs
September 16, 1994	17.5 cfs

Due to bypass flows, irrigation downstream from the gage, and basin flows entering the Clark Fork from sources outside the Flint Creek channel, considerable effort was made to estimate the total Flint Creek outflow. Without reasonable estimates of this outflow, it would be impractical to quantify both water usage and return flows. USGS and DNRC used approaches involving additional streamflow-gaging stations (to collect continuous flow data) and synoptic flow measurements. The locations of these streamflow-gaging stations and measurement points are shown in Figure 4.1.

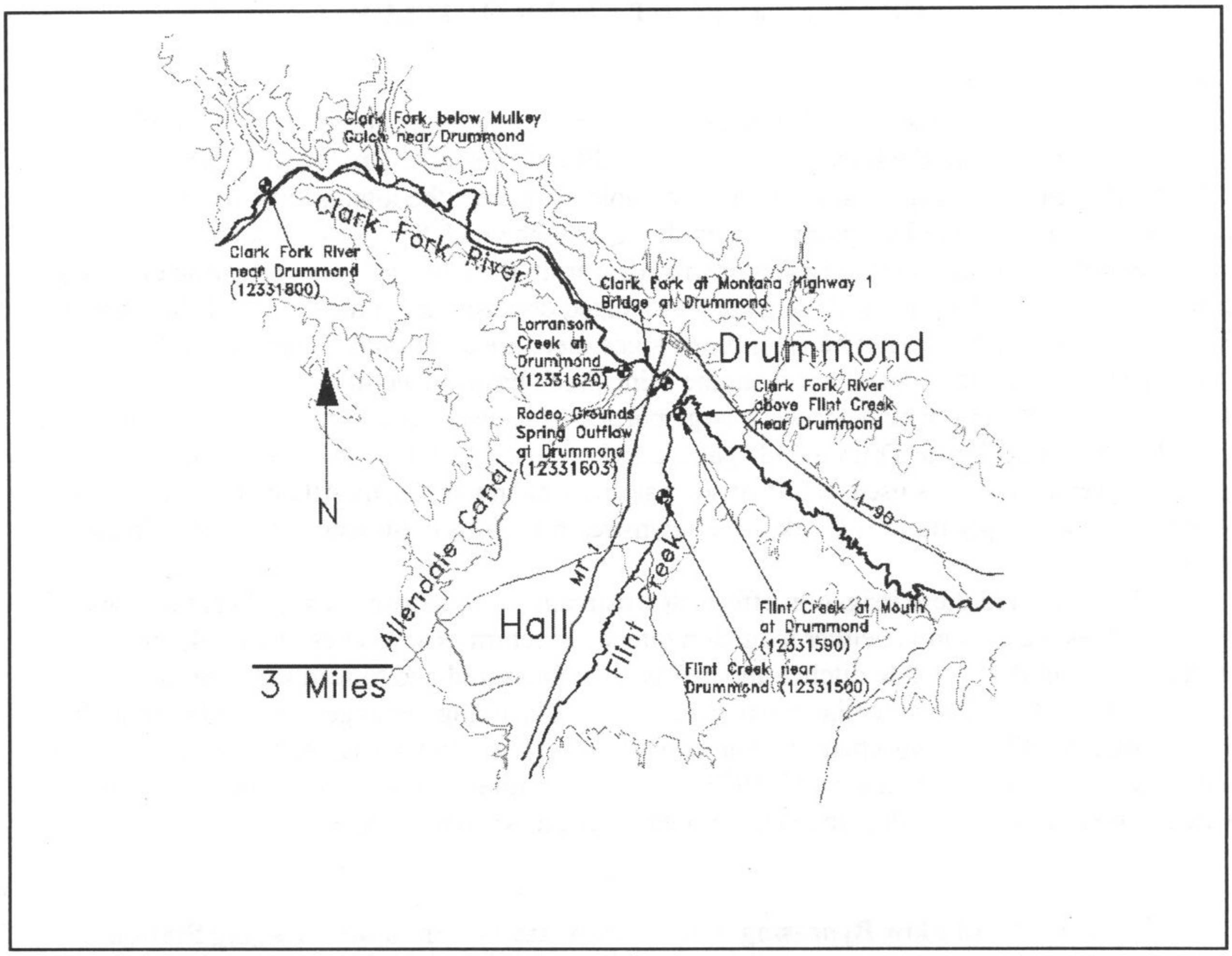


Figure 4.1 Measurement and Streamflow-Gaging Station Locations Used to Determine the Total Flint Creek Outflow

Synoptic Flow Measurements

The concept behind synoptic flow measurements is to obtain a "snapshot" of streamflow conditions at a given time. More than 20 sets of concurrent measurements were taken from 1994 through 1996 to determine the gain in Clark Fork flows upstream and downstream of the Flint Creek basin. Concurrent measurements were made at Flint Creek at the mouth (station 12331590), Rodeo Grounds Spring (station 12331603), and Lorranson Creek (station 12331620) to verify the Clark Fork differences. It is imperative that near-constant flow conditions should exist when synoptic measurements are taken, so periods during spring runoff or ice conditions were avoided. Therefore, all measurements were taken during the early spring period before runoff or during the summer and fall months after spring runoff. Ice conditions generally prevented further measurements by the end of November.

Initially, the use of streamflow records from the following two USGS streamflow-gaging stations was contemplated for measuring Clark Fork flows above and below the Flint Creek drainage.

12324680 - "Clark Fork at Goldcreek"
Period of Record: 1977-Current
Located 19 miles upstream of the Flint Creek confluence.

12331800 - "Clark Fork near Drummond"
Period of Record: April 1993-Current
Located 14 miles downstream of the Flint Creek confluence.

Unfortunately, both irrigation usage and inflows not attributable to Flint Creek occur between these two sites. For example, more than 50 cfs of irrigation withdrawal from the Clark Fork can occur between Goldcreek and the Flint Creek confluence. Although irrigation withdrawals are less downstream of Flint Creek, several large springs empty into the Clark Fork immediately upstream of the "Clark Fork near Drummond" streamflow-gaging station. The source of these springs is currently undetermined, but they amount to one of the larger spring flows measured in western Montana.

The site chosen for measuring the Clark Fork upstream of Flint Creek is beyond all visual inflows attributable to the Flint Creek basin. Two downstream measurement locations were required on the Clark Fork because of limited access. The first downstream measurement site is at the Montana Highway 1 bridge in Drummond, upstream of Lorranson Creek. The second downstream measurement site is downstream of Mulkey Gulch, only three miles upstream of the "Clark Fork near Drummond" gage. All of these sites are shown in Figure 4.1.

Shown in Table 4.2 are the flows measured on the Clark Fork above Flint Creek, Clark Fork at Montana Highway 1 bridge, Flint Creek at the mouth, and Rodeo Grounds Spring. Because the Lorranson Creek outflow is located downstream from the Montana Highway 1 bridge, it is not included in this table. Since there are inflows from the Flint Creek basin into the Clark Fork from sources other than Rodeo Grounds Spring and the Flint Creek channel, it is expected when subtracting flows in the Clark Fork above Flint Creek from the Clark Fork flows at the Montana Highway 1 bridge that these differences would exceed the combined flows of Flint Creek and Rodeo Grounds Spring.

Streamflows measured on the Clark Fork and Flint Creek, when irrigation ceases in the fall, were much higher than streamflows measured during the irrigation season. Because the error associated with measurements is a percentage of the discharge rather than a set amount, it is expected that results shown in Table 4.2 are more accurate during the irrigation season when the streamflows measured are significantly less. To help minimize the error, duplicate measurements were taken at each site along the Clark Fork by two different hydrographers and averaged. Nevertheless, there exists a percentage error for all streamflow measurements, and when differences and totals of the measurements are analyzed, these errors are compounded.

As shown in Table 4.2, when comparing the Clark Fork gains with the sum of Flint Creek and Rodeo Grounds Spring, there is approximately 30 cfs of unmeasured inflow that occurs immediately after the spring runoff, and this amount decreases to about 10 cfs by the end of the

Table 4.2 Flint Creek Outflow Using the Clark Fork Above and Below the Flint Creek Confluence

	(1) Clark Fork above Flint Creek (cfs)	(2) Clark Fork at Highway 1 Bridge (cfs)	(3) = (2)-(1) River Gain (cfs)	(4) Flint Creek at the Mouth (cfs)	(5) Rodeo Grounds Spring Outflow (cfs)	(6)=(4)+(5) Sum of Flint Creek and Rodeo Grounds Spring (cfs)
Mar. 10, 1994	404	518	**114**	122	1	**123**
Mar. 22, 1994	385	504	**119**	112	1	**113**
Jun. 30, 1994	187	254	**67**	31	10	**41**
Jul. 28, 1994	124	194	**70**	50	5	**55**
Aug. 18, 1994	67	106	**39**	15	8	**23**
Sep. 14, 1994	80	146	**66**	51	5	**56**
Nov. 15, 1994	330	456	**126**	122	1	**123**
Mar. 23, 1995	370	534	**164**	106	1	**107**
Apr. 6, 1995	384	529	**145**	112	1	**113**
Aug. 8, 1995	234	308	**74**	53	3	**56**
Aug. 16, 1995	193	255	**62**	26	9	**35**
Aug. 29, 1995	153	192	**39**	12	8	**20**
Sept. 26, 1995	400	599	**199**	160	5	**165**
Oct. 18, 1995	457	668	**211**	197	2	**199**
Jul. 9, 1996	414	603	**189**	120	9	**129**
Jul. 23, 1996	284	407	**123**	82	5	**87**
Aug. 8, 1996	211	294	**83**	58	5	**63**
Sep. 10, 1996	198	300	**102**	85	5	**90**
Sep. 24, 1996	299	502	**203**	188	4	**192**
Nov. 13, 1996	406	571	**165**	164	2	**166**

irrigation season. Most likely, these flows become as high as 30 cfs because groundwater storage occurs during the spring runoff. The amount attributable to unmeasured return flows from the Flint Creek basin is about 10 cfs. The gains in discharge that occur downstream from the Montana Highway 1 bridge along the Clark Fork are shown in Table 4.3. If the streamflows measured at the bridge are combined with the outflows from Lorranson Creek, they differ little from the streamflows determined downstream of Mulkey Gulch. Therefore, the only outflow attributable to the Flint Creek basin below Montana Highway 1 is Lorranson Creek.

Table 4.3 Clark Fork Flows Below the Montana Highway 1 Bridge at Drummond

	(1) Clark Fork at Highway 1 Bridge (cfs)	(2) Lorranson Creek Outflow (cfs)	(3)=(1)+(2) Sum (cfs)	(4) Clark Fork below Mulkey Gulch (cfs)	(5) Clark Fork near Drummond (12331800) (cfs)
March 10, 1994	518	1	519		555
March 22, 1994	504	1	505		555
June 30, 1994	254	8	262	261	302
July 28, 1994	194	7	201	204	233
August 18, 1994	106	8	114	121	150
Sep. 14, 1994	146	10	156	153	179
November 15, 1994	456	2	458	472	510
March 23, 1995	534	1	535		526
April 6, 1995	529	1	530	534	525
April 13, 1995	575	1	576	589	584
August 8, 1995	308	6	314	307	344
August 16, 1995	255	10	265		293
August 29, 1995	192	7	199	187	199
Sep. 26, 1995	599	11	610		616
October 18, 1995	668	5	673		702
July 9, 1996	603	7	610		649
July 23, 1996	407	10	417		467
August 8, 1996	294	9	303		337
Sep. 10, 1996	300	11	311		371
Sep. 24, 1996	502	15	517		544
November 13, 1996	571	5	576		618

Also shown in Table 4.3, a significant increase in streamflow occurs in the three-mile stretch between Mulkey Gulch and the "Clark Fork near Drummond" gaging station. This inflow into the Clark Fork comes from several springs in the area that collectively produce one of the larger spring outflows measured in western Montana. The source of this water is currently undetermined. Although quantifying the amount of spring flow that occurs is difficult because several of the springs are not visible as they flow into the Clark Fork, enough measurements were taken to estimate this spring flow to be between 30 and 40 cfs.

Additional Streamflow-Gaging Stations

The synoptic measurements indicate there is 10 cfs of unmeasured inflow into the Clark Fork from the Flint Creek basin. To use data from the "Flint Creek near Drummond" streamflow-gaging station to estimate total Flint Creek outflows, more information is needed on the gains or losses of Flint Creek from the gage to the mouth as well as on the flows occurring in both Rodeo Grounds Spring and Lorranson Creek. For this reason, three streamflow-gaging stations were installed and operated in 1995 at "Flint Creek at Mouth at Drummond" (station 12331590), "Rodeo Grounds Spring Outflow at Drummond" (station 12331603), and "Lorranson Creek at Drummond" (station 12331620). Combining the streamflow records of these three stations with the 10 cfs inflow from other miscellaneous sources provides an estimate of the total Flint Creek outflow.

The combined flows from all three gages with the 10 cfs inflow from ungaged sources is shown in Figure 4.2. Also, shown are the flows recorded at the two gage sites, "Flint Creek near Drummond" and "Flint Creek at Mouth at Drummond". The lightly shaded area represents the gains in Flint Creek flow from the "Flint Creek near Drummond" gage location to the mouth of Flint Creek. Because there are irrigation withdrawals below the "Flint Creek near Drummond" gage site, flows at the mouth can be less than the flows measured above, and during these times, no lightly shaded area is shown. The more darkly shaded area represents the total contributions of Rodeo Grounds Spring, Lorranson Creek, and the 10 cfs miscellaneous inflow.

From Figure 4.2, based upon the differences between the line representing the total Flint Creek contribution to the Clark Fork and the line representing the data from the "Flint Creek near Drummond" gage, the Flint Creek outflow not recorded by the upstream gage can be determined. These differences, on average, amounted to 35 cfs between July 1 and September 30, 1995, and about 20 cfs during all other months. To account for these differences, it is assumed that a large portion of the early irrigation flow is being used to restore aquifer levels in the Flint Creek basin and is not directly returning into the Clark Fork. This assumption is supported by increased inflows into the Clark Fork below the "Flint Creek near Drummond" gage once the aquifer has been recharged, which normally occurs by July. In this study, total Flint Creek outflow is estimated by adding 35 cfs to all daily flow records from July 1 through September 30, and 20 cfs to daily flows recorded at the "Flint Creek near Drummond" gage for all other months.

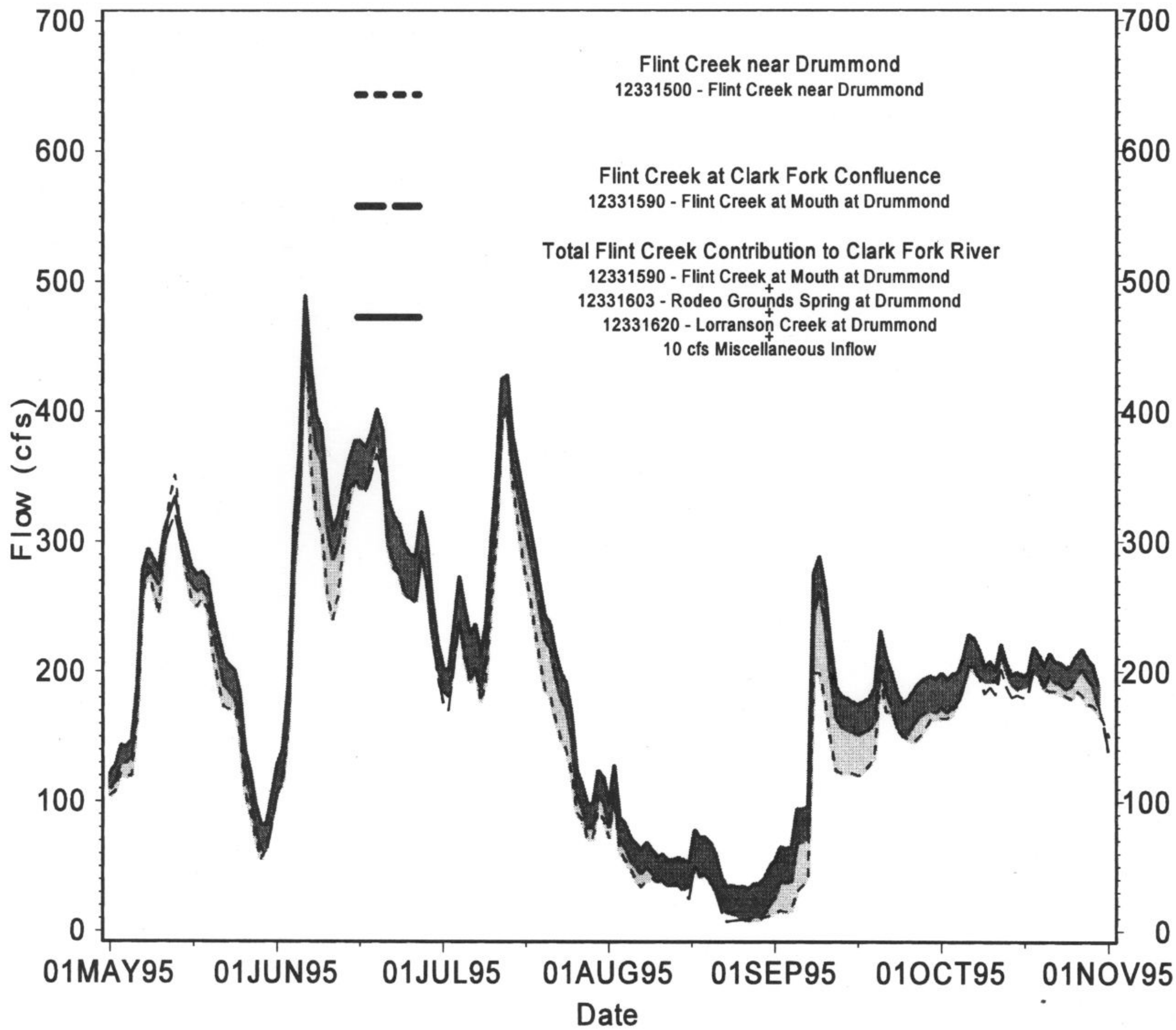


Figure 4.2 Flint Creek Outflow into the Clark Fork

CHAPTER 5 - SURFACE-WATER STUDY RESULTS

Presented in this chapter are hydrographs comparing the inflows and outflows from each hydrologic unit. If adequate information were present, these hydrographs would have been developed for the years 1994, 1995, and 1996. However, limited availability of continuous streamflow data for some units prevented development of these graphs for all three years. The time series for all hydrographs is average daily streamflows in cubic feet per second (cfs).

As explained in earlier chapters, it was not practical to continuously measure all inflows within each hydrologic unit. The inflows shown on all the hydrographs presented in this chapter are based only on those tributaries that were gaged during the study period. Therefore, the inflows shown are lower than the actual total inflows into each hydrologic unit. The significance of underestimated inflows is low from August through March and higher from April through July. Nevertheless, these hydrographs remain highly useful for analyzing return flow storage when irrigation ceases during either September or October, when the inflow from ungaged tributaries is small relative to irrigation recharge. Use of these graphs to assess total annual irrigation water depletion within each hydrologic unit is inappropriate.

Even if all inflows could be measured and irrigation did not occur within the Flint Creek basin, we would still not expect the inflow to always equal the outflow. During spring runoff, some surface water would be stored within the alluvial aquifer. This stored water would cause the basin outflow to exceed basin inflow after the spring runoff was completed. The outflow from this groundwater storage would be expected to be short lived because it occurs in the alluvial valleys near the stream. With the addition of flood irrigation, the flood period is extended into summer and early fall, and because irrigation often takes place in areas well beyond the stream, additional aquifers are recharged that would not be affected by floods. Therefore, when outflow exceeds inflow during the fall and winter months, these differences are attributed to irrigation return flows. These differences are shaded gray on all hydrographs.

Headwater Unit

Shown in Figures 5.1 and 5.2 are inflow and outflow hydrographs of the Headwater unit for the periods April 1, 1994, through December 31, 1995, and April 1, 1995, through December 31, 1996. The time overlap of these graphs is provided to enable easier transition from one graph to the other. The inflow to the Headwater unit is a combination of both Flint Creek below Georgetown Lake and the water from East Fork Rock Creek Reservoir that makes its way into the Flint Creek basin. A few of the larger tributaries not considered are Trout Creek and Spring Creek, but streamflows from these tributaries were observed to be relatively small during the fall months. The high peak outflows shown during January and February of 1995 and 1996 are attributable to unseasonably warm temperatures and high snow melt.

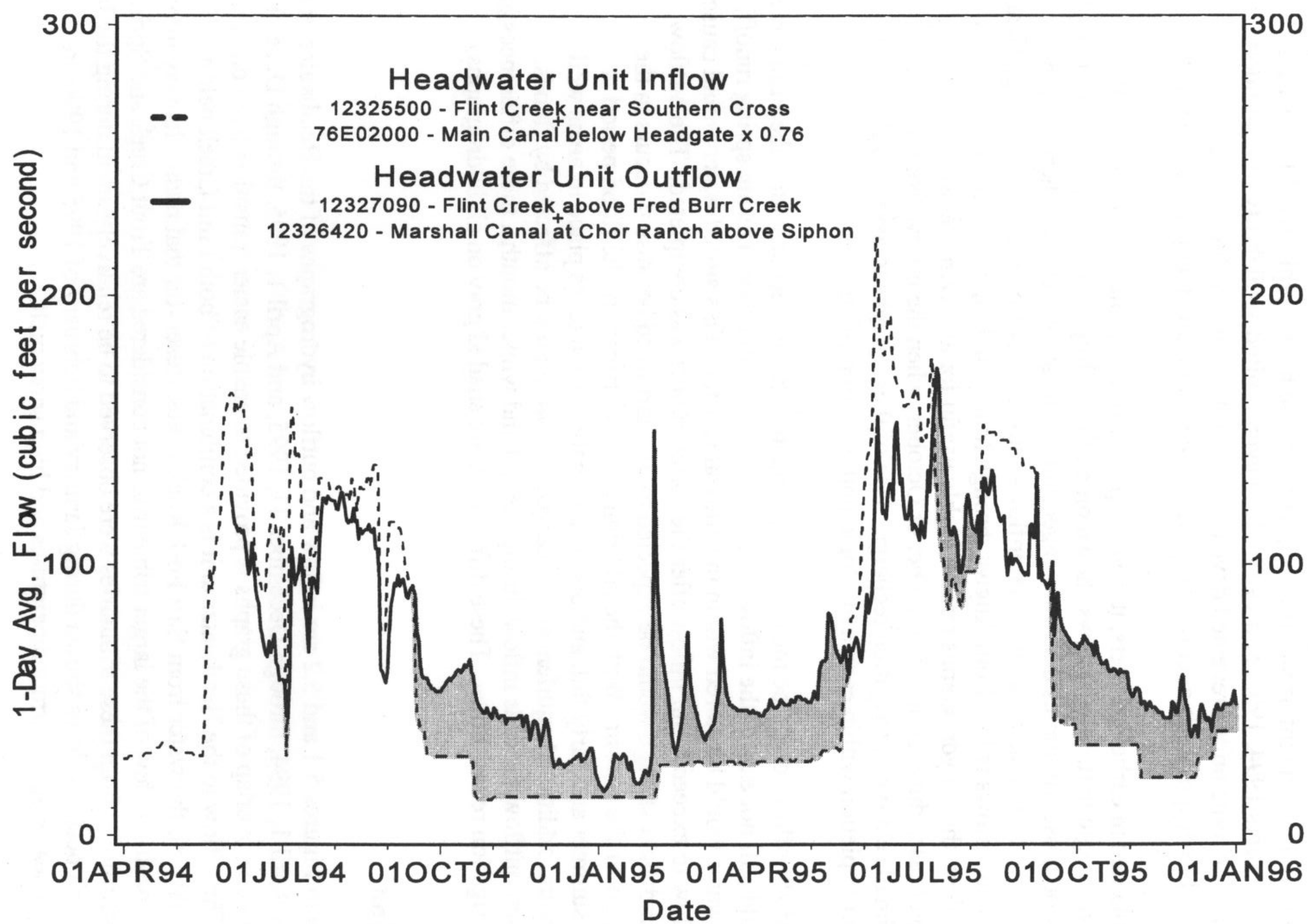


Figure 5.1 Headwater Unit Inflow and Outflow Hydrographs April 1, 1994, through December 31, 1995

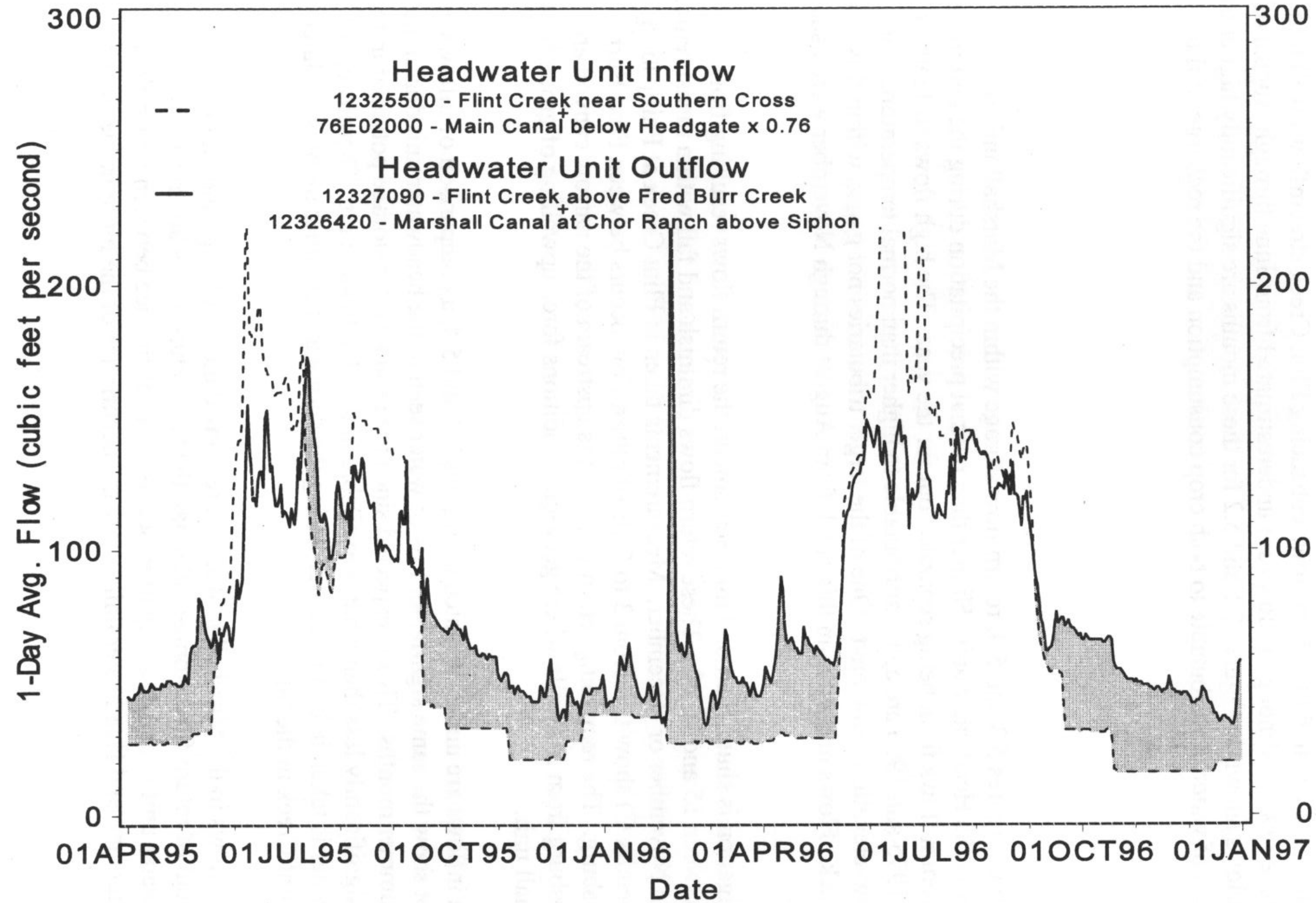


Figure 5.2 Headwater Unit Inflow and Outflow Hydrographs
April 1, 1995, through December 31, 1996

As shown in Figures 5.1 and 5.2, irrigation is usually shut off in the Headwater unit sometime in mid-September. The return flows, resulting from irrigation within the unit, total almost immediately between 30 and 35 cfs. The aquifer storage capacity of this unit is the highest within the entire basin, with return flows enhancing Flint Creek streamflows well into January for all three years. Although inflows are underestimated from June through August of each year, the inflows shown in Figures 5.1 and 5.2 for these months are significantly higher than outflow. This loss of water is attributable to both crop consumption and the recharge of the aquifer.

Marshall Unit

As shown in Figures 5.3 and 5.4, return flow storage within the Marshall unit is not nearly as large as in the Headwater unit. Higher than normal precipitation during the autumn of 1995 prevented return flows from being separated out for the year. The high flows in January and February of 1995 and 1996 are again attributable to higher than normal temperatures and corresponding low-elevation snow melt. One of the larger tributaries not gaged within this unit was Marshall Creek. Flows measured in this creek from August through November were usually less than 1 cfs.

Once irrigation is shut off around mid-September, the return flows resulting from irrigation total between 15 and 20 cfs. These return flows diminish and fall within measurement error sometime in November or December. Measurements taken at Flint Creek at Philipsburg (reported in Appendix C) show that from 3 to 5 cfs of return flow occurs between Fred Burr Creek and Philipsburg. The remaining return flow occurs upstream of the narrow canyon area separating Philipsburg from Maxville where geologic conditions force upwelling of groundwater within the Marshall unit.

Although inflows are underestimated in Figures 5.3 and 5.4, a comparison of inflows and outflows does not show the same significant loss of water seen in the headwater unit during the late spring and summer months. This is expected since the groundwater storage potential in the Marshall unit is significantly less than what is available in the Headwater unit. Therefore, not nearly as much water is taken in by the aquifer during the spring and summer months for later contribution to Flint Creek in the fall.

The return flows in the Marshall unit are more immediate. Although the unit does not have a large amount of return flow storage potential, the total return flows are most likely higher than in the Headwater unit where less irrigation occurs. The difference between return flow schemes of the Marshall and Headwater units show the occurrence of the more immediate return flows.

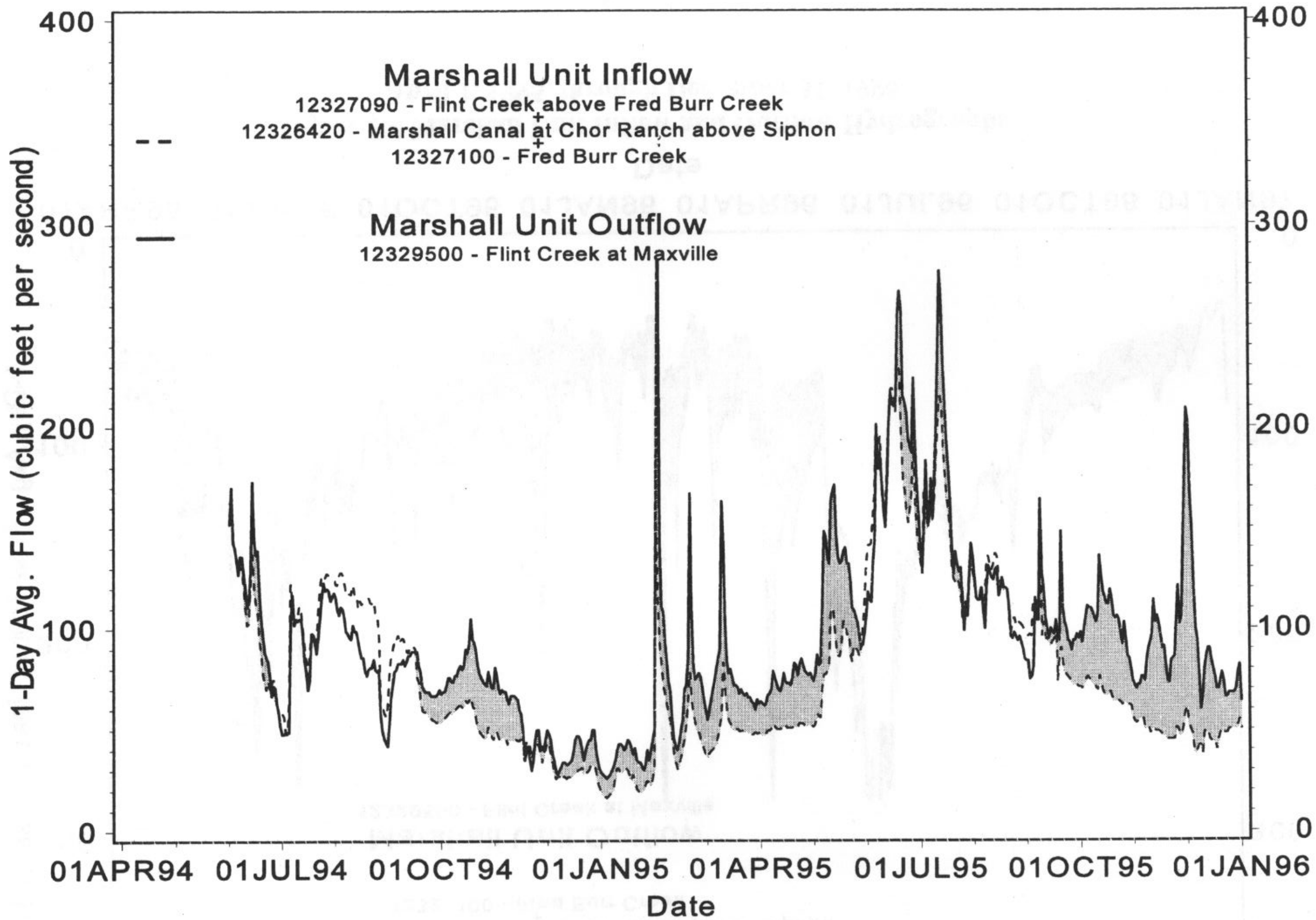


Figure 5.3 Marshall Unit Inflow and Outflow Hydrographs
April 1, 1994, through December 31, 1995

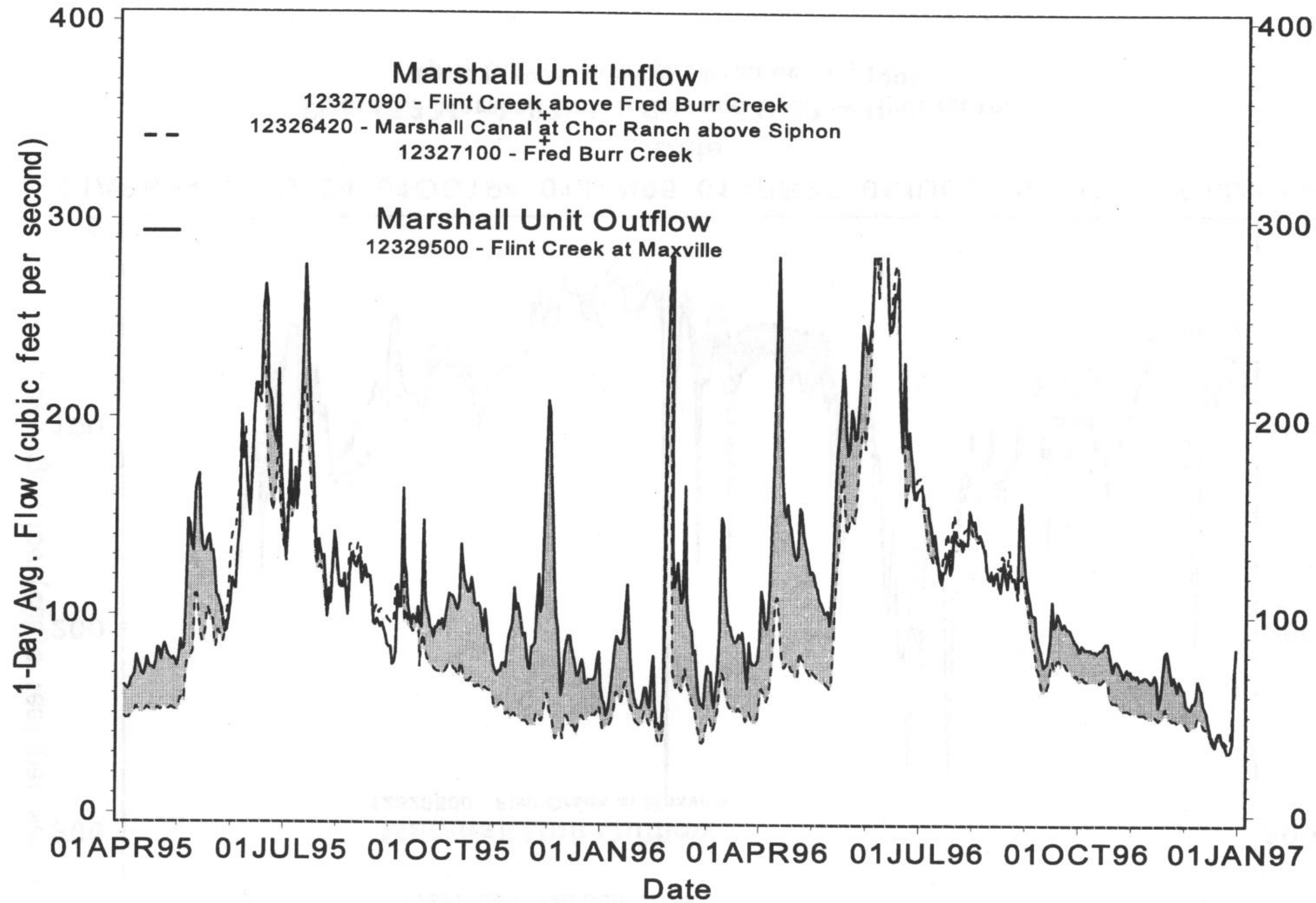


Figure 5.4 Marshall Unit Inflow and Outflow Hydrographs
April 1, 1995, through December 31, 1996

Boulder Unit

The irrigated acreage within the Boulder unit is less than in any other unit. Also, unlike the other units, a significant portion of the irrigated acreage occurs within the alluvial valley of Flint Creek. Because data collection at the "Flint Creek below Douglas Creek, near Hall" (12331100) streamflow-gaging station did not begin until April 1995, the hydrograph for this basin is developed for only 1995 through 1996 and is shown in Figure 5.5.

Due to the basin characteristics of the Boulder unit, it is expected that return flow storage would be minimal. Surprisingly, the storage and duration are comparable with that of the Marshall unit. The increase in Flint Creek flows attributable to return flows is between 20 and 25 cfs once irrigation ceases, and the effects of return flows extend into November or December. Observation of flows in both Smart Creek and Douglas Creek show little contribution from these streams during the autumn months.

Appendix C lists the streamflow measurements taken at both Flint Creek at Henderson Creek road and Flint Creek below Allendale diversion. These measurements indicate virtually no return flow enters Flint Creek from Boulder Creek to the Henderson Creek road. Between the Henderson Creek Road and the Allendale diversion, the return flow is between 10 and 15 cfs in mid-September and is depleted by the end of October. Due to geologic conditions, some return flow occurring in this reach could be from irrigation within the reach between Boulder Creek and the Henderson Creek road. The remaining return flow occurs between the Allendale diversion and Douglas Creek. The return flow from this reach extends into November or December.

Hall Unit

Figure 5.6 is the inflow-outflow hydrograph for the Hall unit from October 1, 1995, through December 31, 1996. Because data were limited prior to October 1, 1995, any analysis for an earlier period needs to be completed for the entire Drummond valley. Figure 5.7 is the inflow-outflow hydrograph for the entire Drummond valley from January 1, 1994, through December 31, 1994 . The large difference between outflow and inflow between January 1, 1994, and April 1, 1994, could be attributable to the unusually high precipitation that occurred in the Flint Creek valley during the entire summer of 1993 and/or return flows from the summer and fall of 1993.

Interestingly, the largest flow that occurred from Flint Creek into the Clark Fork River during the study period occurred during February 1996. This high flow was again attributable to unseasonably warm temperatures and a corresponding low-elevation snow melt.

As displayed in Figures 5.6 and 5.7, the return flow discharge after irrigation ceases

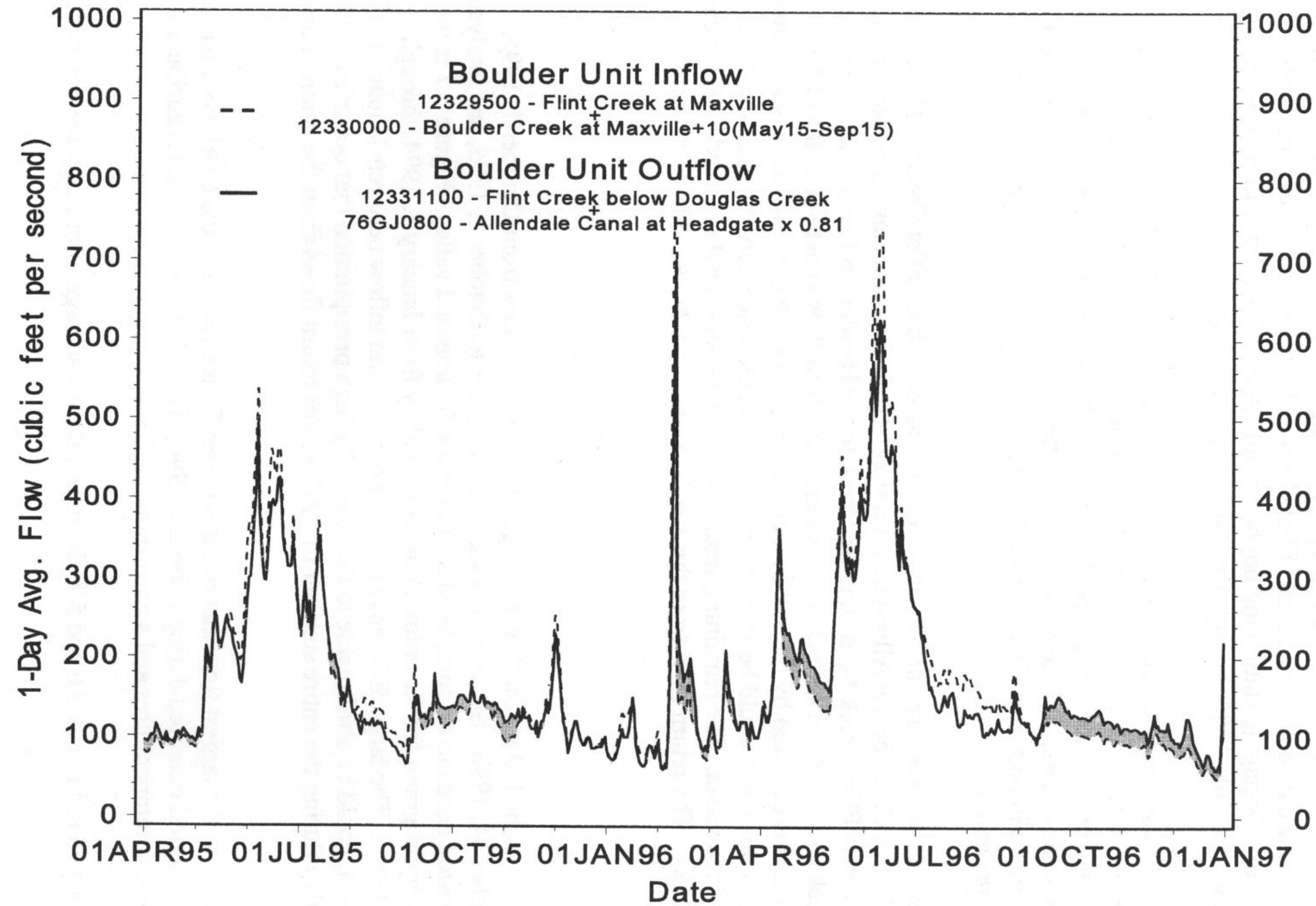


Figure 5.5 Boulder Unit Inflow and Outflow Hydrographs
April 1, 1995, through December 31, 1996

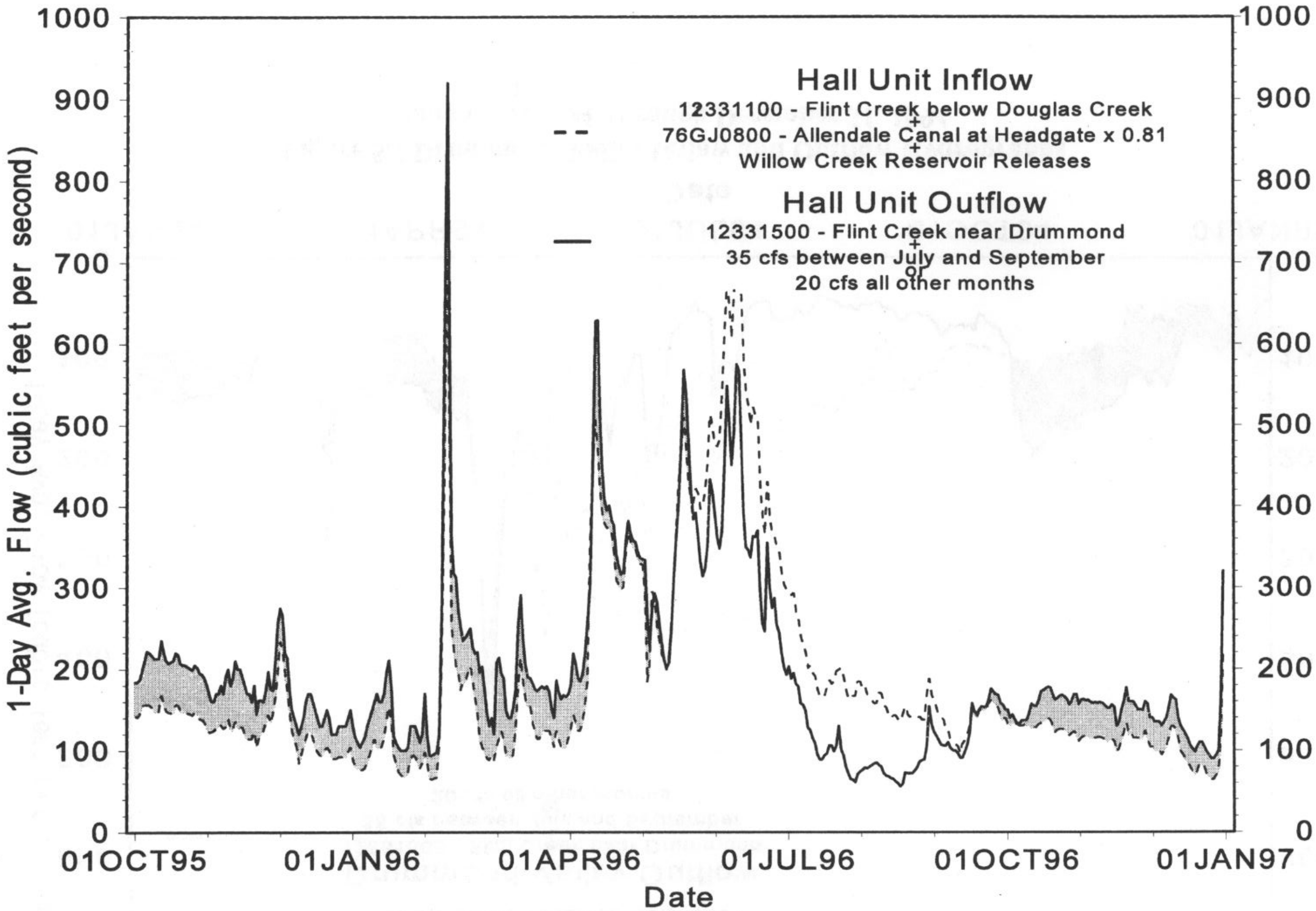


Figure 5.6 Hall Unit Inflow and Outflow Hydrographs
October 1, 1995, through December 31, 1996

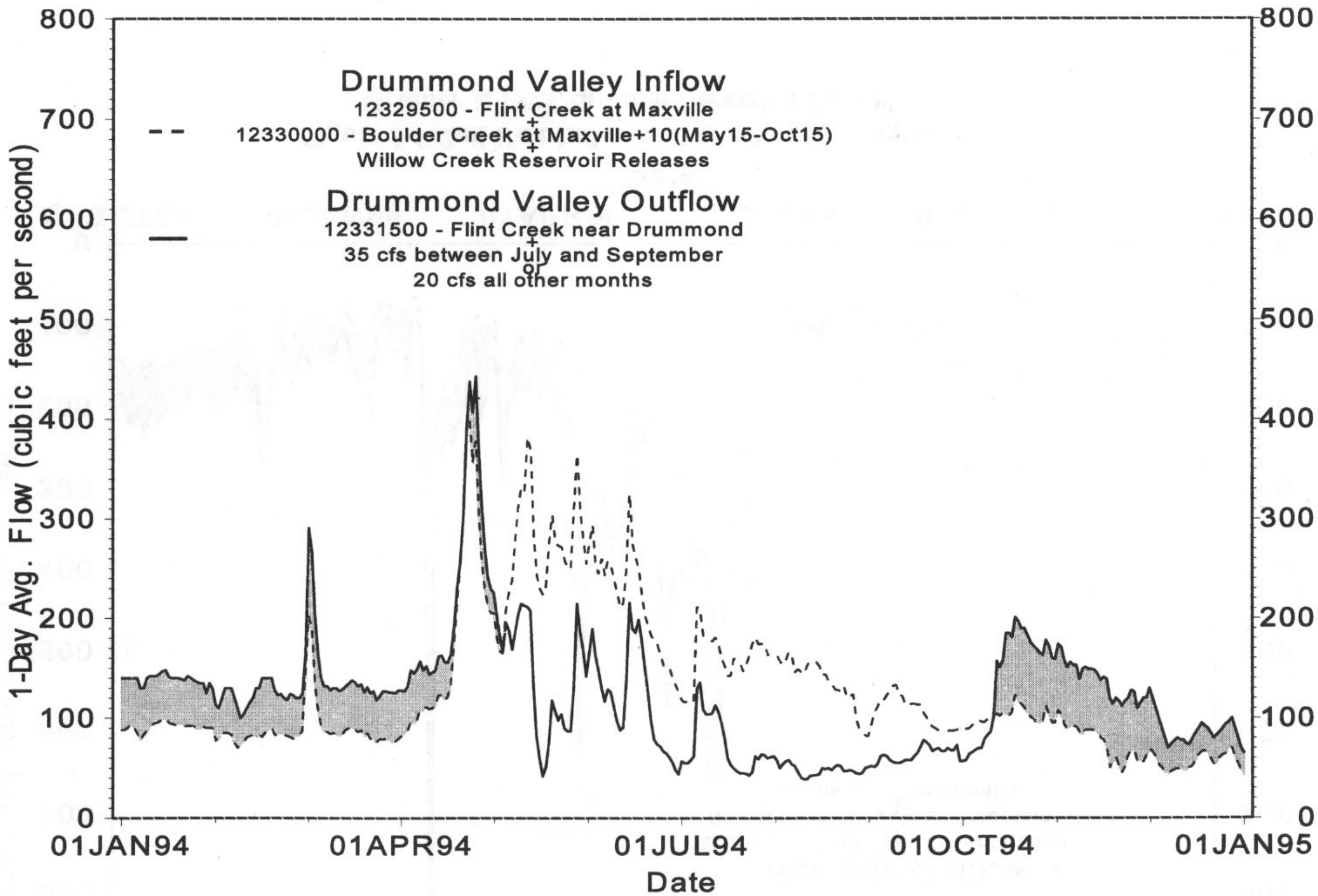


Figure 5.7 Drummond Valley Inflow and Outflow Hydrographs
January 1, 1994, through December 31, 1994

in October is between 40 and 50 cfs. Although the effects of return flows lessen as time advances past the irrigation season, they remain measurable into the following spring runoff. The total return flow amount that carries into the following runoff period was measured as approximately 5 cfs. Obviously, the return flow storage potential within the Hall unit is the highest in the Flint Creek basin. Many of the reasons are discussed in the following chapter, but much of the return flow is attributable to the large amount of irrigated acreage within the unit. Streamflow measurements taken on Flint Creek at Hall and shown in Appendix C demonstrate that approximately a third of the return flows enter Flint Creek between Douglas Creek and Hall. The remaining return flows enter Flint Creek between Hall and the confluence with the Clark Fork.

As with the hydrographs for the other units, the inflow hydrographs shown in Figures 5.6 and 5.7 are low because many of the tributaries (such as Barnes Creek) were not measured continuously. Nevertheless, a large difference between inflows and outflows is evident during the summer months. This difference would be more significant if all inflows could be measured. As was the case with the Headwater unit, during the summer, the Hall unit shows a large decrease in flows within the unit because of crop consumption and groundwater recharge.

CHAPTER 6 - GROUNDWATER STUDY RESULTS

Measurements of surface-water discharge provide the most accurate means of quantifying irrigation return flows in the basin. Groundwater information gathered during this study demonstrates the presence of groundwater irrigation return flow, provides an independent verification of the timing of return flows, and shows the relative importance of different aquifers and areas in storing and releasing irrigation return flows.

Well logs and geologic maps were used to identify subsurface features that influence groundwater flow in the basin. Water-level measurements in wells reveal seasonal changes in groundwater levels. These water-level changes combined with other information, such as aquifer materials and thicknesses, groundwater gradients, surface-water gains, and aquifer tests, allow estimation of aquifer properties and groundwater flow rates. The following section gives general results of the groundwater analysis that apply to the entire basin. Subsequent sections summarize groundwater results for each hydrologic unit described in Chapter 2.

Overview

Most of the irrigated areas in the Philipsburg and Drummond valleys are located on floodplain alluvium or elevated areas that form benches or high terraces within the basins. Alluvial deposits typically are composed of silt, sand, and gravel, with some clay layers. Thickness of coarse alluvium is estimated to be less than 30 feet in most areas, based on well log information. In the following sections, the approximate extent of alluvial deposits is shown on the groundwater surface maps for each hydrologic unit, and the approximate extent of irrigated and subirrigated land is shown on the seasonal groundwater fluctuation maps. Irrigated and subirrigated land shown in these maps and the groundwater study design maps in Chapter 3 are derived from a 1:250,000 scale satellite image map (USGS, 1985) made from an image dated August 29, 1985. The areas that appeared as growing crops or deciduous vegetation in the valley areas are the basis of the cross-hatching on the maps. Due to the small scale of the satellite image map and other factors, these should be considered an approximation to actual irrigated or subirrigated lands.

Although the benches are underlain by a variety of sediments, there is an identifiable sequence of sediment types at most locations. Deeper wells tend to "bottom out" in shale. Clay, more than 100 feet thick in places, commonly overlies the shale. Above the shale or clay, at shallow depths, pinkish-brown silty sand, gravel, and cobbles are typically present. These deposits are capped by nearly pure pinkish-brown silt at some locations. Appendix D contains lithologic logs derived from well logs throughout the basin, which were used in the geologic cross sections in this chapter.

Shale encountered at depth occurs in a variety of colors, including shades of tan to dark brown or black, and shades of blue, green, or red. The blue, green, and red shales have the distinctive coloration of their source rock, Missoula Group argillites. The Missoula Group argillites outcrop in much of the Lower Willow Creek basin. The blue, green, and red shales are most commonly reported in the Lower Willow Creek area within a few miles north and west of Hall. The composition of small gravels encountered in one project well west of Hall was blue-green, tan, and maroon argillites. At some locations, chips of shale recovered while drilling include distinct laminations, or thin layering. Sand or sand and gravel lenses occur within the shale. Many well logs indicate sand or gravel was encountered in the bottom of the boring, beneath shales, ranging from a few feet to as much as 20 feet thick. Some wells encountered dark brown to black carbonaceous shale.

The shale has water-bearing fracture zones in it at some localities. These zones are evident on some driller's well logs, and were also found while drilling some project wells for this study. During drilling, these zones were identified by rust-colored weathered surfaces on shale chips, often associated with a noticeable increase in water produced by the well during drilling.

Clays encountered at intermediate depths are commonly similar in color to deeper, underlying shales and may contain sand and small gravels. Yellow or yellow brown, ashy, muscovite-rich clay is present in some areas, and if present it is usually the shallowest clay encountered.

The silty, sand, gravel, and cobble deposits are found at shallow depths, typically have a distinctive pinkish hue, and are up to 60 feet thick northwest of Hall. They include gravelly clay layers in places, and are capped by up to 6 feet of pinkish-brown silt south of the Drummond airport.

Groundwater levels in the basin generally rise in late spring, largely in response to irrigation. High groundwater levels persist through the irrigation season. At many wells in the basin, interruptions in irrigation for summer haying show up as slight to moderate midsummer declines. At the end of the irrigation season, groundwater levels decline and typically approach some lower limit within a few months. Groundwater surface maps presented in the following sections are based on groundwater-level measurements in wells shown on the maps and on other information such as elevations of springs and the distribution of soils with shallow groundwater tables. These soils were mapped in the Soil Survey of Granite County (NRCS, 1996). The groundwater surface may represent either water table elevations or potentiometric surface elevations. Well depths shown on the maps and lithologic log data in Appendix D provide information about the specific conditions at a particular site.

Maps of seasonal groundwater fluctuations in the following sections show the approximate range of seasonal groundwater fluctuations at all wells monitored. The maps also include graphs for selected wells in each hydrologic unit for the 1996 irrigation season. Water-level measurements for all wells monitored are tabulated in Appendix E.

The storage and movement of subsurface irrigation return flow is controlled by aquifer properties and groundwater gradients. Soil percolation rates, the permeability of sediments underlying the soils, and sediment types and textures influence the movement of water underground. In areas where groundwater is shallow and unconfined, the amount of irrigation return flow that can be stored in the sediments is limited by available unsaturated space. Once groundwater increases to a certain level in these areas, the outflow of springs, drain ditches, and direct runoff tend to drain any additional water. These areas include alluvial deposits, especially where groundwater is less than five feet below the surface, and may also apply to perched water tables and groundwater discharge areas on higher ground. In areas where the water table or potentiometric surface is deep, available unsaturated space is not a factor limiting storage. Thick clay underlying the gravelly caps on the benches, above the floodplains, undoubtably forms a barrier that causes much of the water in the gravelly caps to move horizontally. Groundwater in the gravelly caps discharges in springs in gullies along the edges of the benches, especially west of the highway between Drummond and Hall.

Groundwater levels in the basin are highest between the end of June and mid-September. Groundwater levels decline dramatically after mid-September, in response to the end of the irrigation season and return flow to streams. As noted in Chapters 3 and 5, the highest return flow was typically measured just after most diversions shut off for the season, and return flows diminished over the following months. The summer groundwater-level pattern suggests that groundwater return flow would approach rates similar to those measured at the end of the irrigation season as early as the end of June.

Headwater Unit

Much of the valley within the Headwater unit is underlain by Tertiary sediments. Most alluvial deposits are concentrated in the lower, flatter parts of the unit, generally at the north end. Well log data are concentrated in the lower portion of the unit. Figure 6.1 shows the locations of geologic cross sections shown in Figure 6.2.

Cross Section A (Figure 6.2) extends from the bench area in the central part of the Headwater unit, down-valley to the vicinity of Spring Creek near the outflow area of the unit. As shown in the cross section, the bench area near wells FCC1 and WL68 is underlain first by silty sand, gravel, and boulder deposits, followed by yellow to tan clay and shale, and finally brown to black shale. In the central part of Cross Section A, well logs for wells WL52, WL61, WL62, and WL63 all show less than 20 feet of coarse alluvium, which is underlain by thick (70 to 100 feet) clay with some gravel. At these sites, a variety of deep sediments are logged, including cemented gravel, "mild" limestone, and black rock. Note on Cross Section A (Figure 6.2) that the groundwater surface is at depths of 30 to 50 feet below ground surface in southern portions of the cross section, but is about 20 feet deep beneath the alluvial sediments to the north.

Cross Section B (Figure 6.2) crosses the valley from Marshall Canal at its northwest end southeastward toward an area just south of Flint Creek as it enters the valley from Georgetown Lake. Project wells FCC1 and FCC2 were drilled in the northwest half of the cross section.

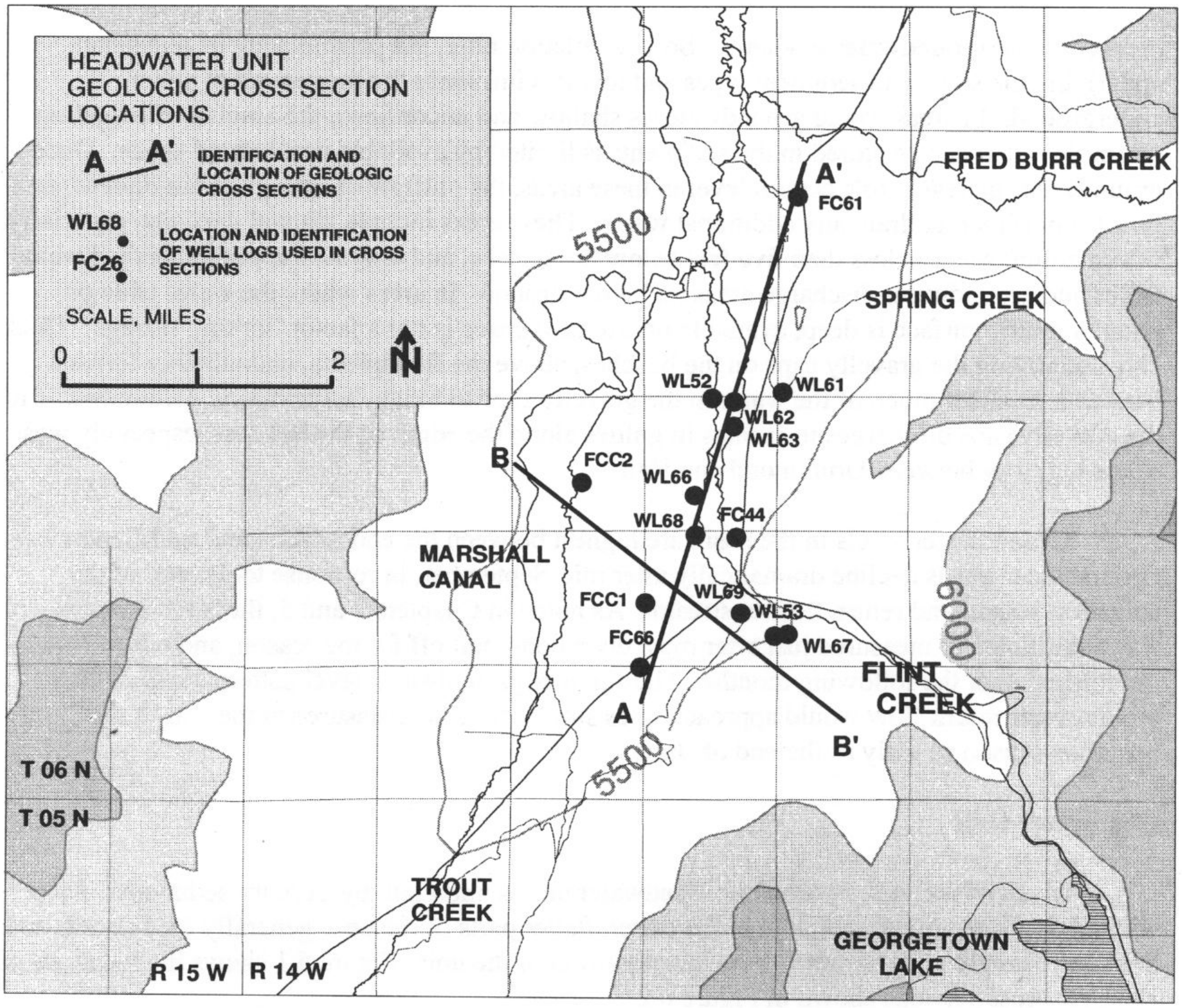


Figure 6.1 Headwater Unit - Geologic Cross Section Locations

Both wells encountered a limited (15 to 20 feet) thickness of sandy or gravelly sediments near the surface followed by yellow-brown clay, and finally tan to black shale at depth.

Figure 6.3 is a groundwater surface map for the Headwater unit. Groundwater moves down gradient, perpendicular to the groundwater contours shown on the map. As expected, the groundwater gradient slopes in the same general direction as the surface of the valley. Note the much steeper groundwater gradient present in the upper part of the unit southwest of the gages near the Marshall Canal diversion. At the north end of the unit, a bedrock mass blocks much the valley, leaving only a narrow area of alluvium near well FC62. As noted above, the alluvium is of limited thickness and is underlain by clay. Much of the groundwater that is moving down-valley is likely forced out of the ground, appearing as spring water along the lower reach of Spring Creek and as gains in Flint Creek.

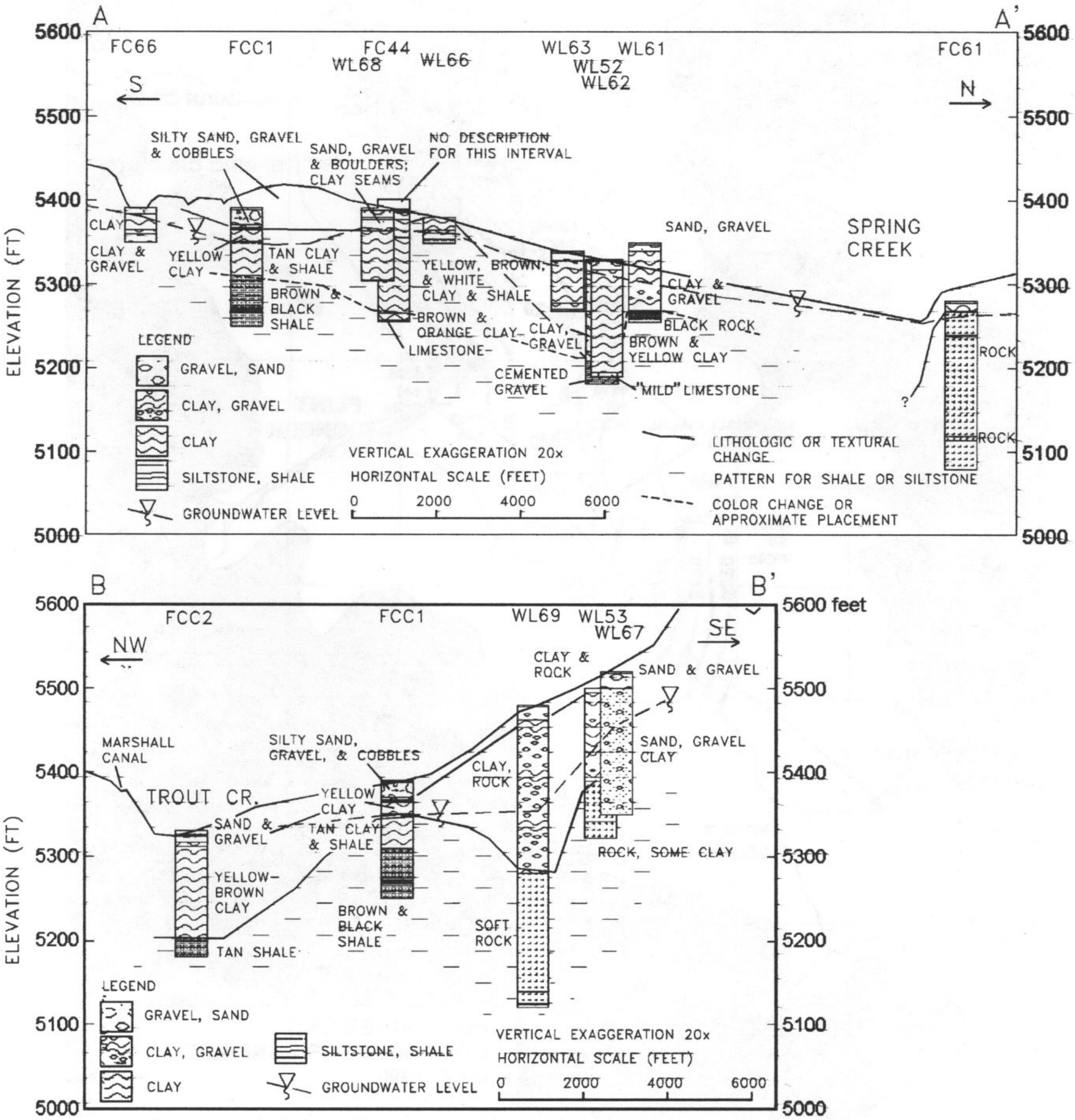


Figure 6.2 Headwater Unit - Geologic Cross Sections

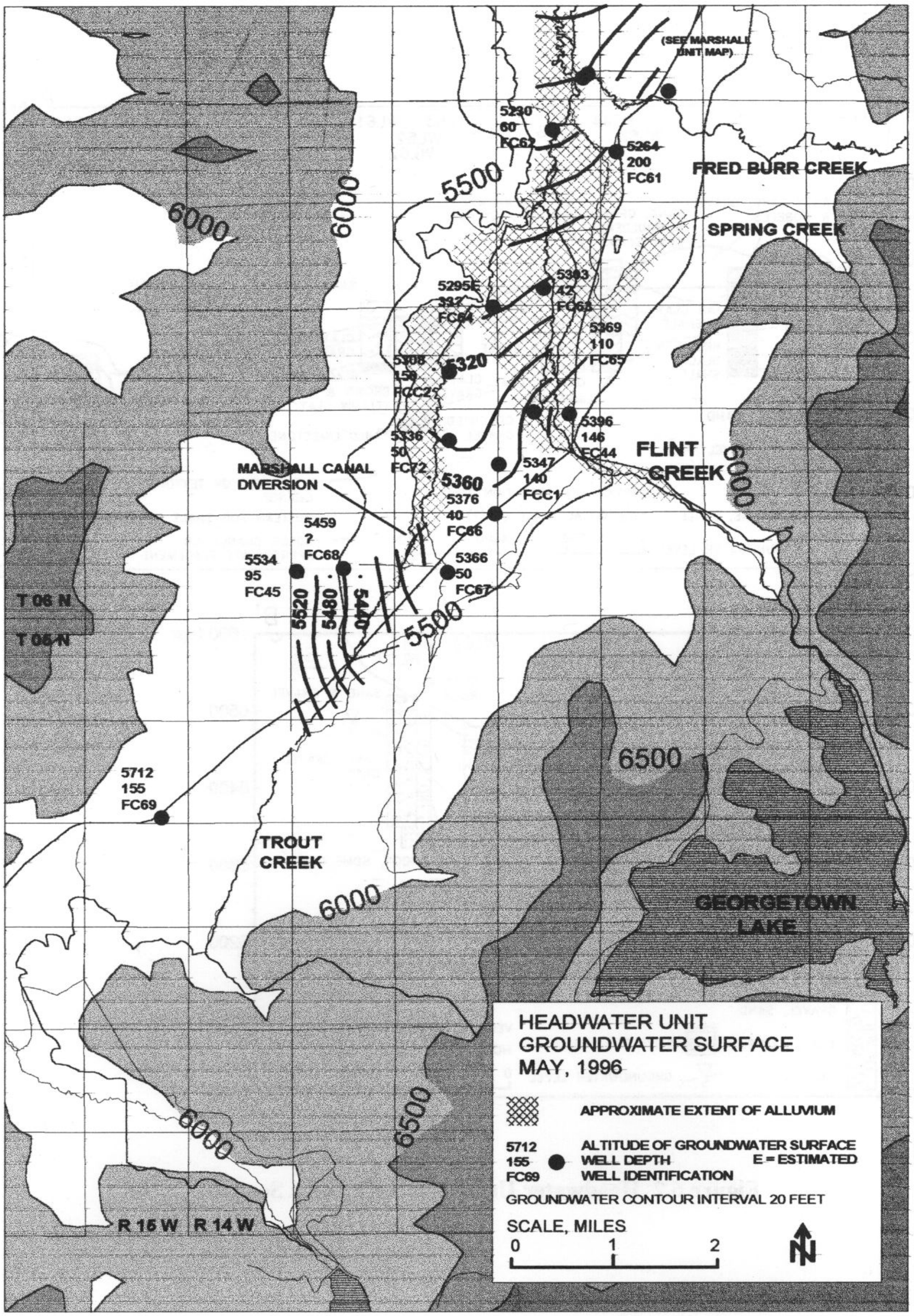


Figure 6.3 Headwater Unit - Groundwater Surface Map

An estimate of the rate of groundwater moving through the limited extent of alluvium at the constriction at the north end of the unit can be made using the groundwater gradient from Figure 6.3, the width of the floodplain, and estimates of the transmissivity of the alluvial deposits. The gradient is approximately 0.008, the floodplain is 0.3 mile wide, and from Figure 6.2, the saturated alluvium is estimated to be 20 feet thick. Using a hydraulic conductivity of 100 feet per day (ft/d), approximately mid-range for sand, the groundwater outflow at the north end of the unit is estimated to be about 0.3 cfs in May. Summer groundwater outflow could increase this estimate by about 20 percent. Deeper aquifers, such as rock and gravel lenses below thick clay at wells in the central part of Cross Section A, Figure 6.2, are moderately productive, with well yields of 10 to 25 gallons per minute (gpm) and specific capacities of 0.2 to 4 gpm/ft. Therefore, these aquifers, if present at the narrow outflow area, may move less groundwater out of the Headwater unit than that estimated for the alluvium. These calculations, although approximate, show that there is limited potential for irrigation return flow to bypass the gaging stations as groundwater at the outflow area of the Headwater unit. Compared to surface water, the groundwater outflow rates are negligible.

The northwestward gradient between Flint Creek near well FC65 and Trout Creek near well FCC2 provides a reasonable explanation for the freshwater springs along the east side of Trout Creek in that area. One freshwater spring about 800 feet southwest of project well FCC2 issues directly out of hard, fractured shale exposed along the edge of the terrace. Fractures in this shale are coated with rust-colored, weathered surfaces similar to those seen in drill cuttings from a depth of 77 feet at project well FCB4 west of Hall.

There is ample opportunity for excess irrigation water to be stored as groundwater in the Headwater unit. Groundwater levels lie at depths of 20 to 25 feet at wells FC63 and FC64 within the alluvium (shown in figure 6.3) during winter months, and depths of 20 to 80 feet beneath terraces and benches. This provides a substantial unsaturated thickness throughout much of the unit that can absorb and store water.

Groundwater levels rise 7 to 10 feet at wells FC63 and FC64 within the alluvium during the irrigation season. Figure 6.4 shows the approximate range of groundwater fluctuations at each well monitored in the Headwater unit. Also shown are selected graphs of water levels measured in wells. After the irrigation season, groundwater levels decline and generally return to lower, winter levels by sometime in December. Based on observed water level declines at wells within or near the alluvium from mid-September to the end of November, it is estimated that groundwater levels drop about five feet in the alluvium during this period. This includes both irrigated lands and non-irrigated, or subirrigated lands. The area of alluvium is estimated to be about 2,500 acres. If shallow groundwater in the alluvium is unconfined with a specific yield between 0.15 and 0.20, a groundwater level decline of five feet could yield some 1,800 to 2,500 acre-feet of water. This amount of water, if delivered at a constant rate for 2.5 months, would result in a flow rate of about 12 to 17 cfs. This calculation shows that irrigation return flow from the alluvial area alone could account for about half the measured gains from the Headwater unit as shown in the surface-water analysis. These gains ranged from 30 to 35 cfs in mid-September

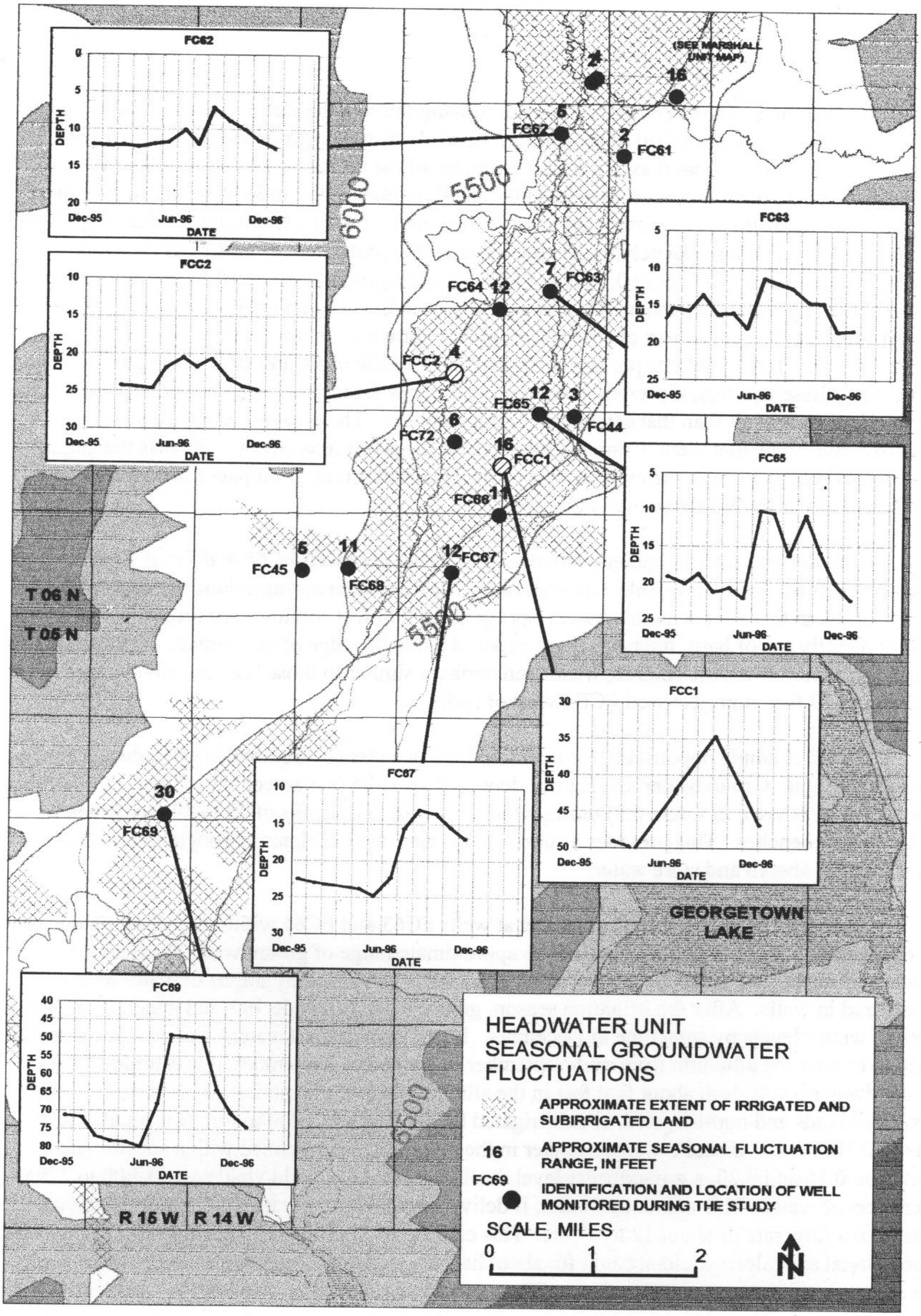


Figure 6.4 Headwater Unit - Seasonal Groundwater Fluctuations

to 10 to 15 cfs at the end of November in 1994 and 1995.

The gravelly sediments capping benches above the floodplain are largely unsaturated in areas where data are available, such as those shown in the cross sections in Figure 6.2. Water levels in wells located throughout the irrigated Tertiary benches respond to irrigation, with seasonal fluctuations ranging from 11 to 30 feet (Figure 6.4). Confined conditions at most monitoring sites prevent direct calculations of volumes of water stored with available information. However, irrigation water clearly recharges the aquifers during summer months, as water levels are either high or rising during July, August, and September. By November or December, water levels return to lower levels, suggesting that much of the return flow water is depleted by the end of December.

Marshall Unit

Irrigated land within the Marshall Unit can be categorized into three landforms. These are the sloping bench below the Marshall Canal along the west side of the valley, the alluvium in the floodplain, and the gently sloping plain on the east side of the valley between Philipsburg and Fred Burr Creek. Well log information is limited, with vast areas west of Flint Creek having no recorded wells. Figure 6.5 shows the locations of geologic cross sections shown in Figure 6.6.

Cross Section A extends from near the confluence of Flint Creek and Fred Burr Creek, north-northeast along the base of the gently sloping plain east of Flint Creek, to near the junction of Rock Creek Road and Montana Highway 1. The well logs shown in the cross section indicate that clayey or dense sand, gravel, and boulders are encountered at shallow depths ranging from 30 to 45 feet. Project well FCF1, located east of the central part of the cross section, penetrated sand and gravel to a depth of 16 feet, and yellow-brown sand and clay to 20 feet where the well was finished. The sand and gravel deposits were likely derived from the Fred Burr Creek drainage, as the gently sloping plain extends outward from the base of the terminal moraine at the mouth of Fred Burr canyon. The available well logs are insufficient to characterize deeper sediments, as they vary in different areas. The well log for WL73, the deepest well shown in Cross Section A, describes clay with sandstone ledges from depths of 48 to 93 feet, underlain by heaving sand and gravel. Yellow and brown shale and rock, at depths of 20 to 44 feet are reported at well FC57 near Fred Burr Creek. From these limited data, and the data shown near Philipsburg on Cross Section B, it appears that predominately fine-grained Tertiary sediments are present in this area beneath clay-rich, gravelly surficial deposits.

Cross Section B crosses the valley from Marshall Canal at the northwest end to the south edge of Philipsburg. Although there are no well logs for wells in the central part of the cross section, groundwater levels are about five feet from the surface at two shallow monitoring wells, FC46 and FC53, within the alluvium west of Flint Creek. Project well FCD1 is the only known well on the sloping west bench area below Marshall Canal. This well encountered unusual deposits compared with wells of similar depth throughout the basin. Red-brown clay four feet

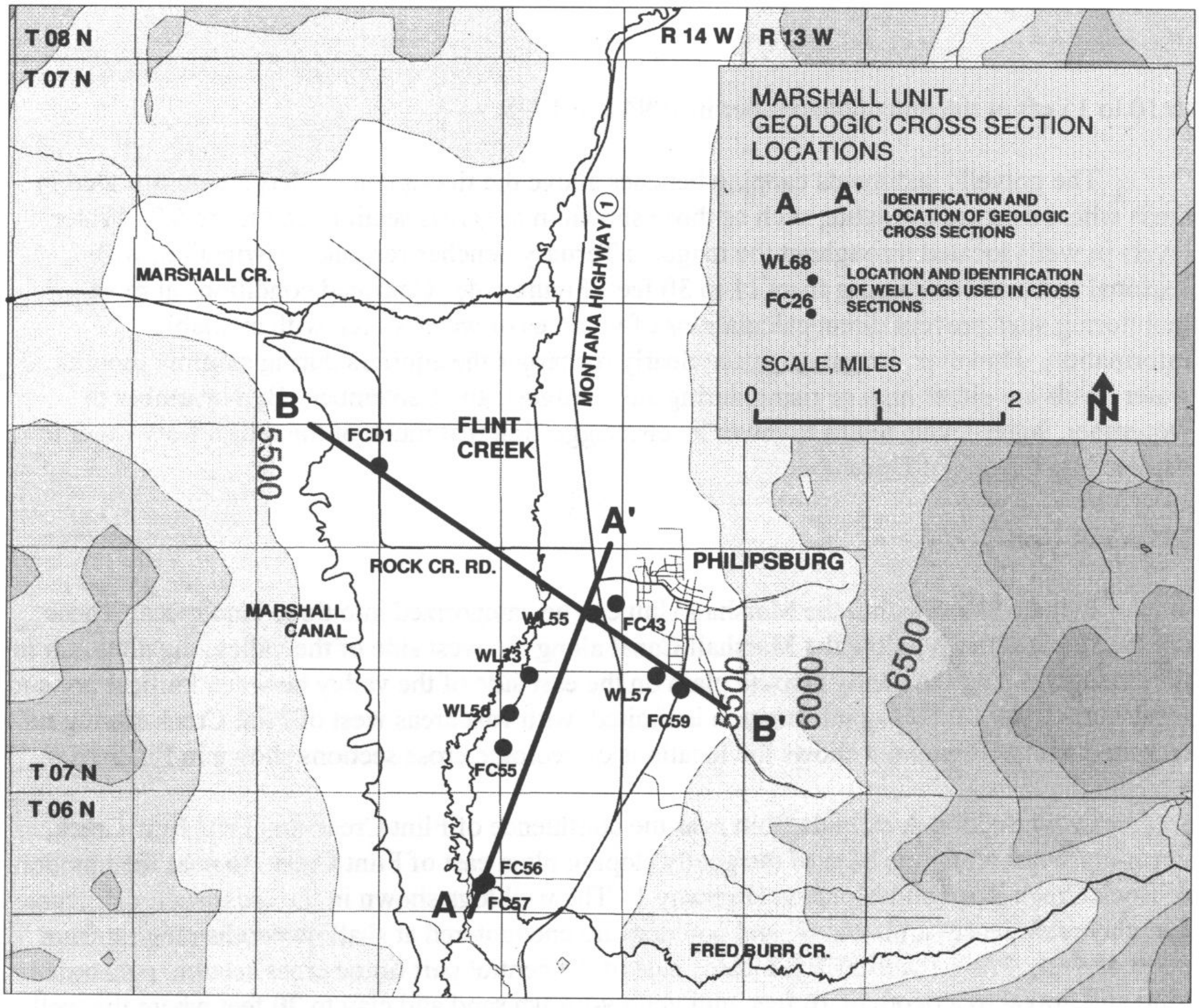


Figure 6.5 Marshall Unit - Geologic Cross Section Locations

thick was encountered at the surface. Red-brown clayey sand and gravel about 35 feet thick is present beneath the clay, followed by red-brown clay with some gravels from depths of 40 to 90 feet, and finally red-brown, angular gravel and coarse sand with clay at depths of 90 to 140 feet. Saturated sediments were encountered near 40 feet, but little water was produced. Even the most productive gravels encountered at the bottom of the well produced only about five gpm. The static water level in the deep gravel is about 70 feet, so shallower water is perched above the intermediate depth thick clays.

Well logs for five wells describe conditions along the edges of benches, on both sides of the floodplain, at the extreme north end of the valley. These wells include well FC52, shown in Figure 6.7 (see also Figure 3.8). These well logs report a sediment sequence more typical for bench areas, with gravel and boulders about 20 feet thick near the surface, followed by clay or soft rock to depths of 60 to 80 feet, and finally sandstone, rock, or fractured rock at greater depths.

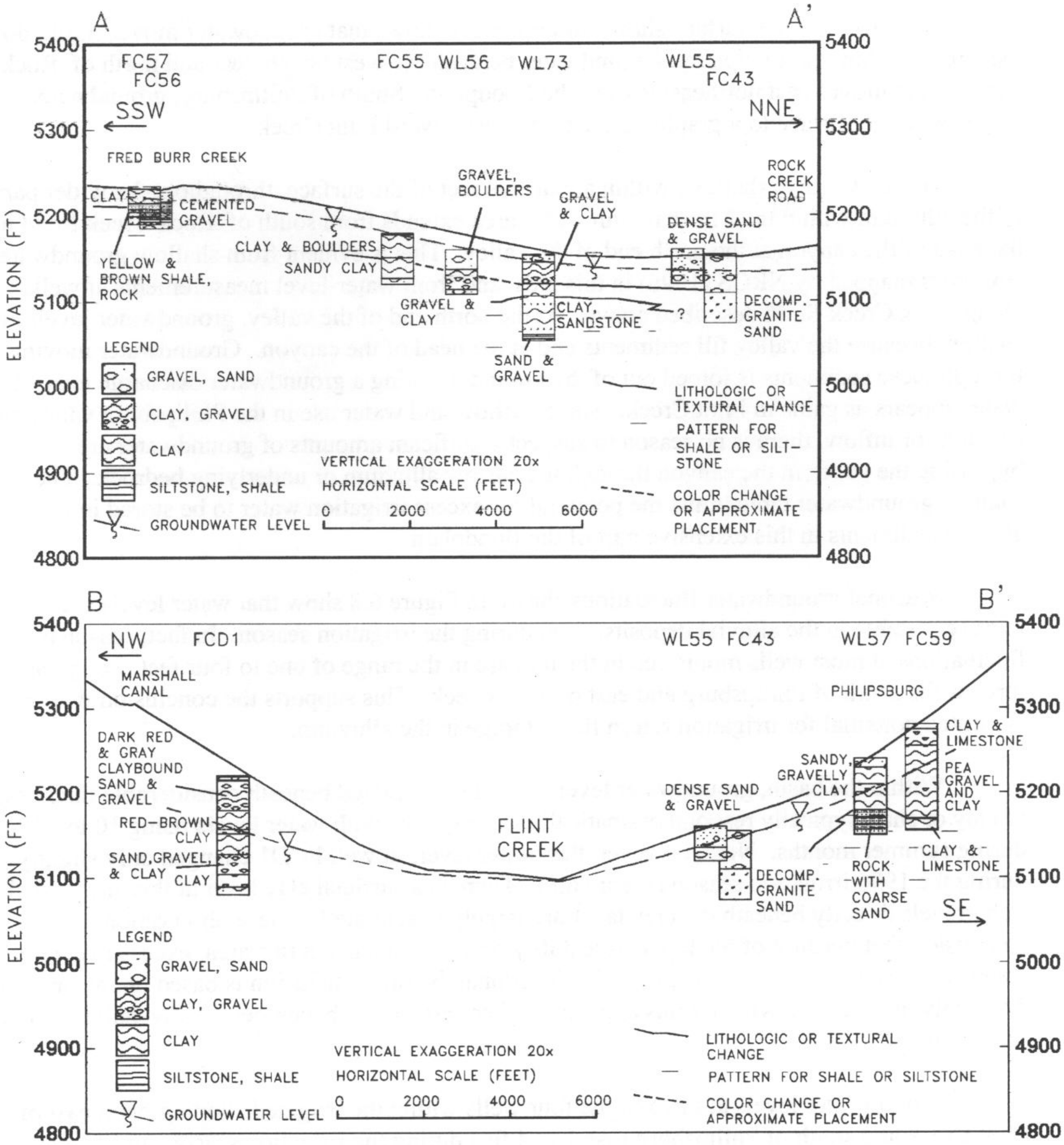


Figure 6.6 Marshall Unit - Geologic Cross Sections

The groundwater surface shown in Figure 6.7 shows that groundwater moves north, down the valley within the floodplain. Groundwater beneath the west bench near and north of Rock Creek Road moves east northeast toward the floodplain. South of Philipsburg, groundwater slopes with the surface topography to the northwest toward Flint Creek.

Groundwater is shallow, within about five feet of the surface, throughout the wider part of the alluvium within the Marshall unit. This area extends from south of Rock Creek Road to the head of the canyon at the north end of the valley. This is evident from shallow groundwater soil types mapped by NRCS (1996) in this area and from water-level measurements at wells along Rock Creek Road described above. At the north end of the valley, groundwater levels are shallow because the valley fill sediments end at the head of the canyon. Groundwater moving through these sediments is forced out of the ground, creating a groundwater discharge area. This water appears as gains in Flint Creek. Since outflow and water use in the Philipsburg valley can account for inflow, there is no reason to suspect significant amounts of groundwater are bypassing the gages in the canyon through the narrow alluvium or underlying bedrock. The shallow groundwater table limits the potential for excess irrigation water to be stored in the alluvial sediments in this extensive part of the floodplain.

Seasonal groundwater fluctuations shown in Figure 6.8 show that water levels are relatively stable in the alluvial deposits, even during the irrigation season. In fact, seasonal fluctuations at most wells monitored in the unit are in the range of one to four feet, except at three wells south of Philipsburg and east of Flint Creek. This supports the conclusion that there is limited potential for irrigation return flow storage in the alluvium.

Within the basin, groundwater levels in wells completed beneath considerable thicknesses of clay or shale typically respond dramatically to irrigation, with water levels rising 10 to 30 feet during summer months. Note, however, that water levels at well FCD1 changed only slightly during the 1996 irrigation season (Figure 6.8). There is a surficial clay layer at this site, and clay-rich gravels directly beneath the clay layer are largely unsaturated. These observations support a conclusion that because of the low permeability of the sediments in this area, excess irrigation water may occur mainly as direct runoff. Unfortunately, this conclusion is based on information from only one well, so whether this applies to other parts of the bench below Marshall Canal is unknown.

Groundwater levels at three of the four wells within the irrigated, sloping plain east of Flint Creek and south of Philipsburg rose 1 to 4 feet during the irrigation season, and 11 feet in well FC55. At wells FC59 and FC60, along the eastern margin of irrigated areas, the groundwater fluctuation range is 14 and 16 feet, more like fluctuations observed in wells located on terraces and benches in the other hydrologic units studied.

Groundwater levels typically return to lower, winter levels by the end of November in the Marshall unit. This compares favorably with the surface-water study results for the unit, which

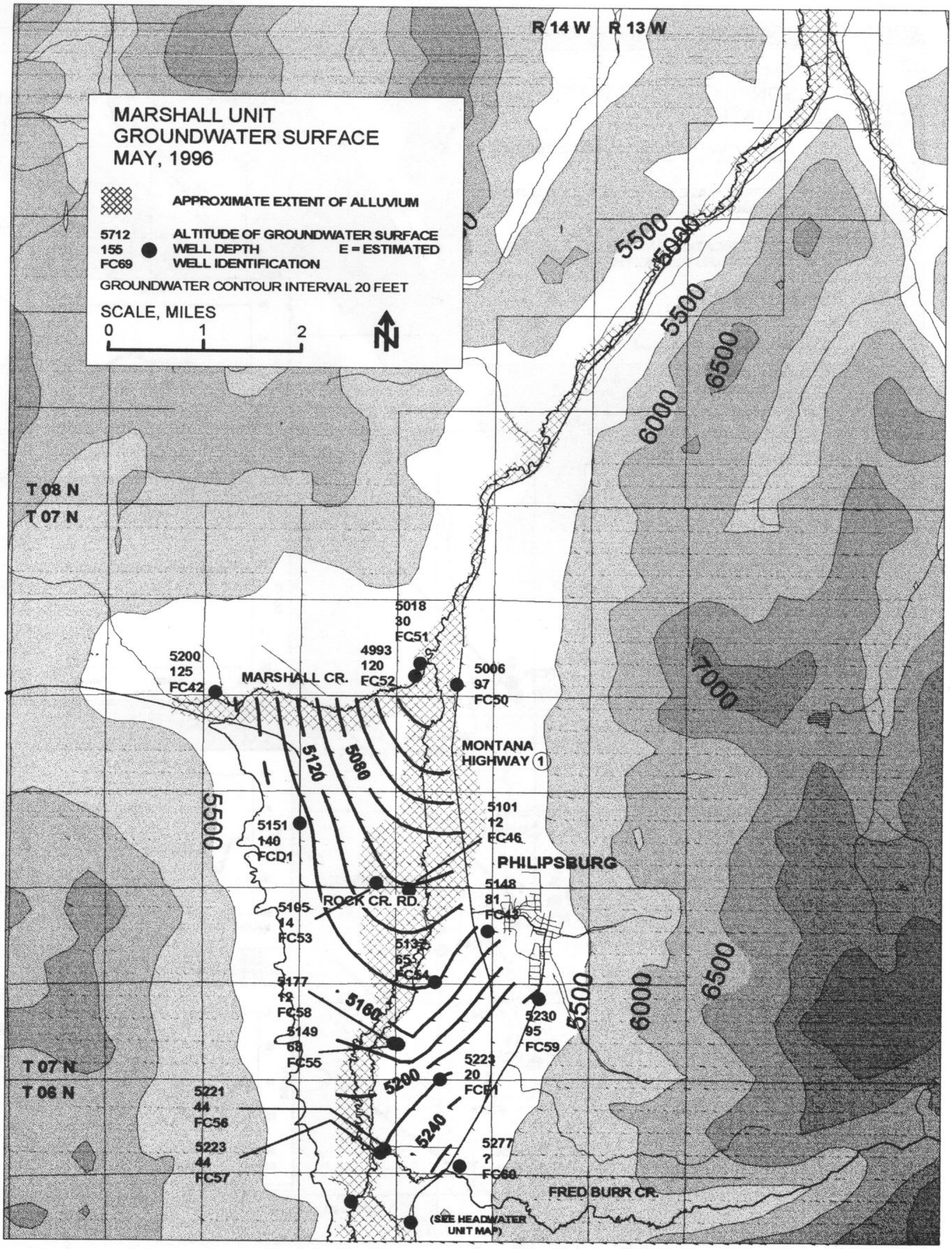


Figure 6.7 Marshall Unit - Groundwater Surface Map

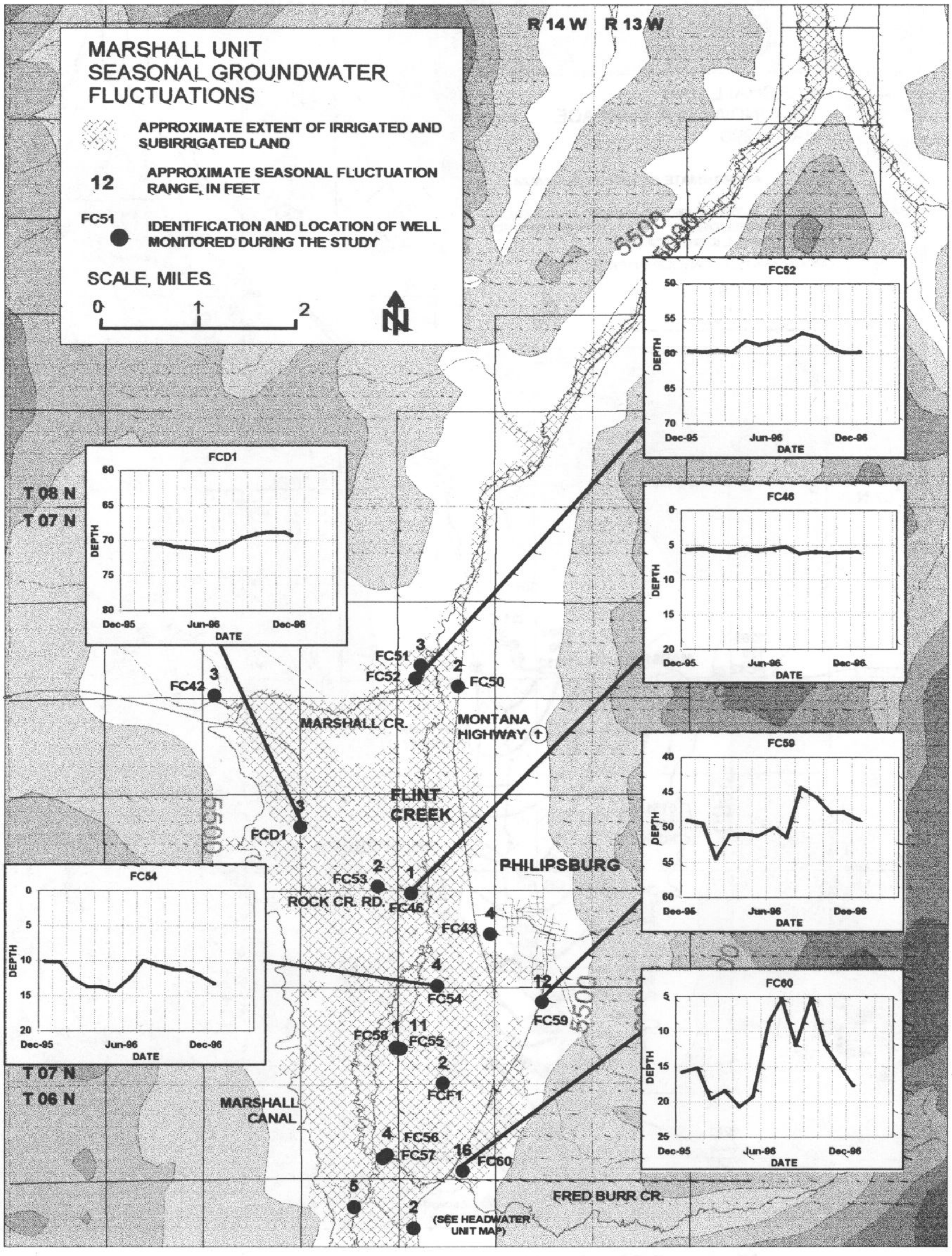


Figure 6.8 Marshall Unit - Seasonal Groundwater Fluctuations

show that return flows from the unit are depleted by about the end of November. Results of the groundwater study in the Marshall unit show that there is limited storage potential for irrigation return flow in a large part of the floodplain, and groundwater return flow may be limited by low permeability materials underlying the higher ground west of the floodplain. These findings provide an explanation for the lower rates and limited duration of return flow gains from the Marshall unit compared with the Headwater unit as determined in the surface-water analysis.

Boulder Unit

The small size of the Boulder unit and the limited area of irrigation located almost entirely on the alluvium of the valley floor make this unit unique. Alluvium within the unit is shown on the groundwater surface map, Figure 6.9, and the approximate extent of irrigated and subirrigated land is shown in Figure 6.10. As Flint Creek exits the canyon area, it enters a valley floor about 1.5 mile wide. At this point, Flint Creek passes through a lobate, bouldery debris flow deposit. Large boulders are scattered about the debris fan, and this area is not irrigated. The valley narrows again to about 2,000 feet within two miles, where bedrock is exposed on both

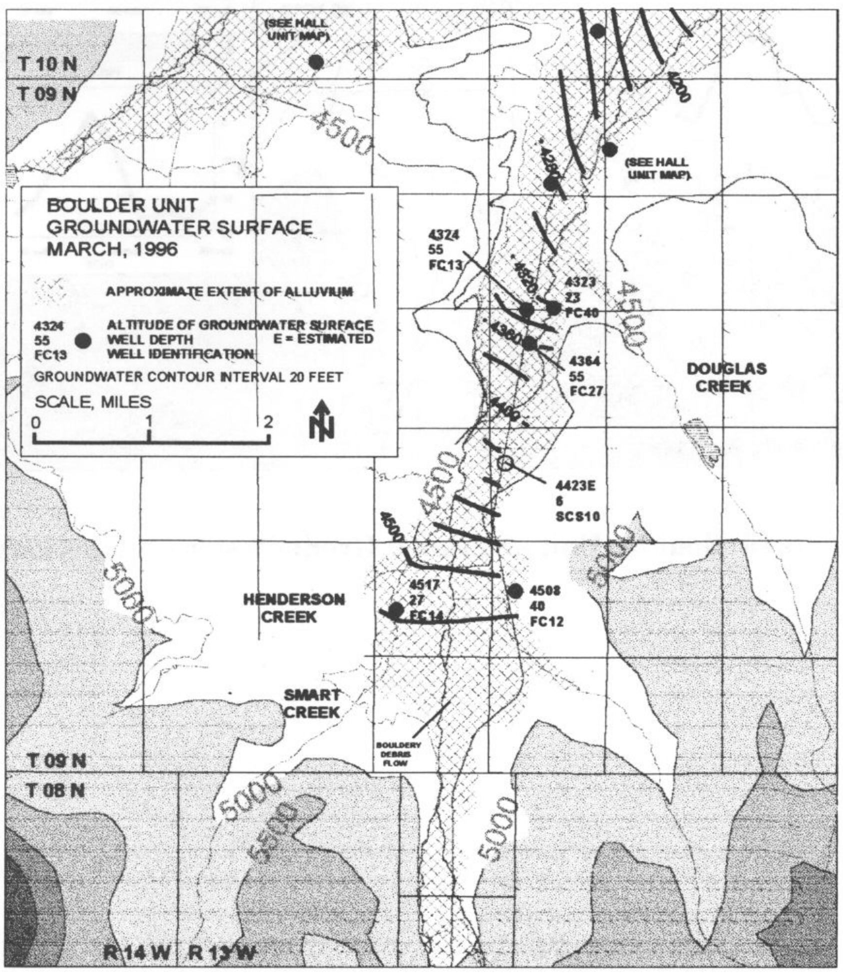


Figure 6.9 Boulder Unit - Groundwater Surface Map

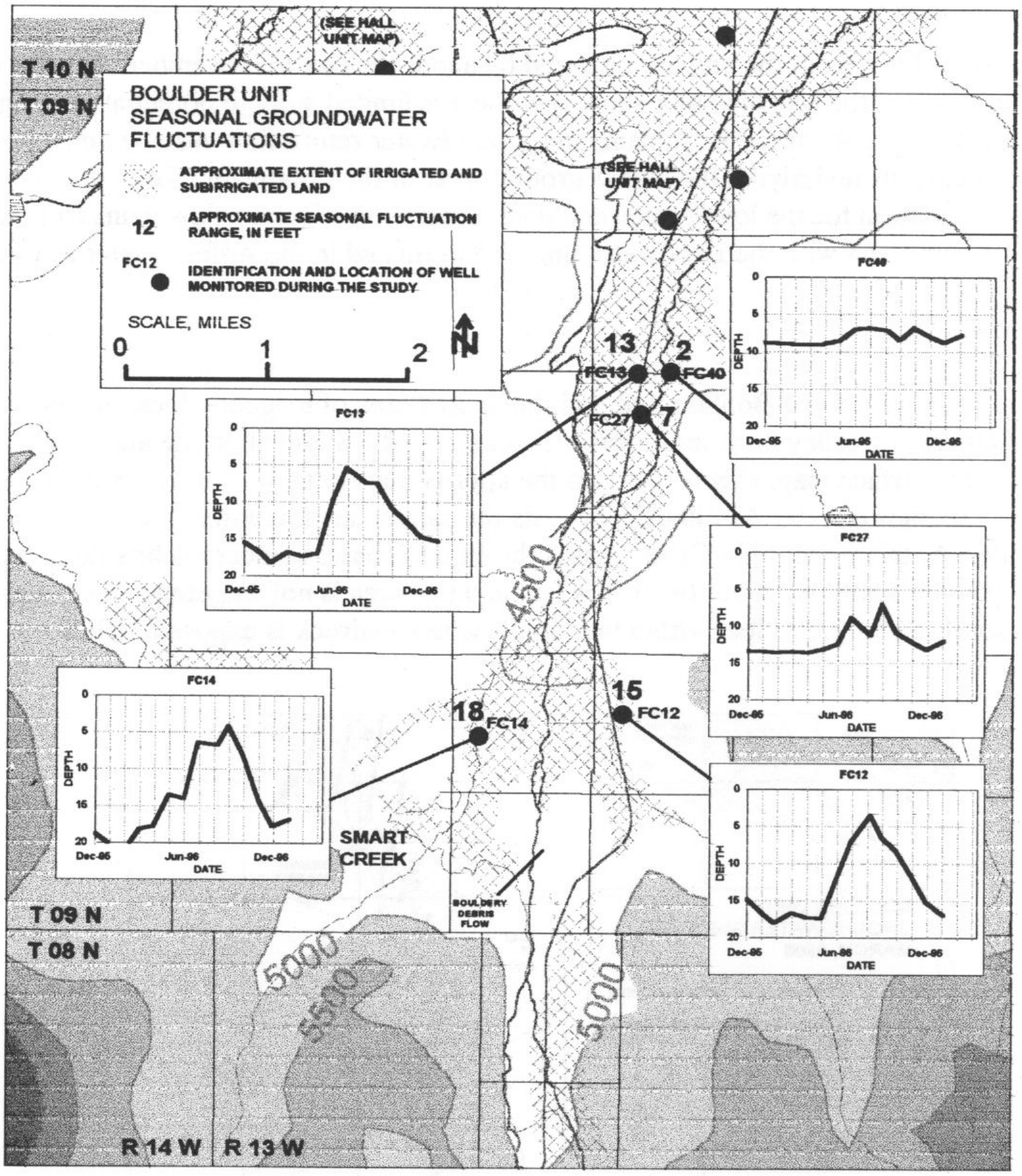


Figure 6.10 Boulder Unit - Seasonal Groundwater Fluctuations

sides of the canyon. The floodplain remains less than a mile wide north to the confluence of Flint Creek and Douglas Creek.

Below the debris fan, smaller boulders and cobbles mixed with sand and gravel form the upper part of the alluvium. Well logs for wells WL24 and WL25 in the upper part of the unit (see Figure 3.11) show sand, gravel, and boulders to total depths of 40 and 52 feet. At the lower end of the unit, monitoring well FC13 is next to a large gravel pit, and the walls of the pit are composed of boulders and cobbles in a sand and gravel matrix. Well logs for wells FC13 and FC27 nearby describe boulders to a depth of 18 feet, followed by sand and gravel from 18 to about 35 feet, clay, sand, and gravel from about 35 to 40 feet, and finally fractured bedrock. The total depth of both wells was 55 feet.

Because only five wells were monitored in the unit, data from a shallow NRCS monitoring well were used to estimate the groundwater elevation in the central part of the unit. The groundwater surface, as mapped, slopes down-valley, so groundwater flow is expected to move in that general direction (Figure 6.9). However, the groundwater map is based on so few wells that it shows only the most prominent slope direction. The groundwater gradient is suspected to shift toward the creek during the months of high groundwater levels, as irrigation return flow drains back to the stream.

Figure 6.10 shows seasonal fluctuations observed in the five monitoring wells. Groundwater lies within about 20 feet from the surface at all of the five wells monitored, and rises during the irrigation season to within about 5 feet of the surface. NRCS (1996) maps show high water table type soils throughout much of the valley floor, except in the debris fan. Well FC40 exhibits the most stable groundwater level, and is about 200 feet from Flint Creek. Well FC27 has a seasonal range of about 7 feet, and is about 400 feet from the stream. The more stable water levels at these wells are probably a result of their proximity to the stream, in which the stage is relatively constant compared with groundwater levels. These wells are both yard wells at ranches, so there may also be less irrigation effects near the wells. The other three wells with the greatest seasonal variations are 1,000 feet or more away from the stream. Note the similarity between groundwater level changes in wells that are a mile or more apart. In summer months, water fills the gravel pit near well FC13.

Figure 6.11 is a graph comparing water level changes in wells to the surface-water analysis for the Boulder unit presented in Chapter 5. During May and June, stream flow is high and groundwater levels rise as irrigation water is applied to crops. Near the beginning of July, less water is diverted while hay is dried for cutting, and this is reflected in the surface-water data and in slight groundwater level declines. By August, diversions are increased and groundwater levels rise again. Note that high groundwater levels are essentially sustained throughout the summer, well after spring runoff has ceased. About the middle of September, irrigation diversions cease and gains in surface-water outflow are apparent in surface-water flow.

A gross estimate of the specific yield of the alluvium can be made from the fall

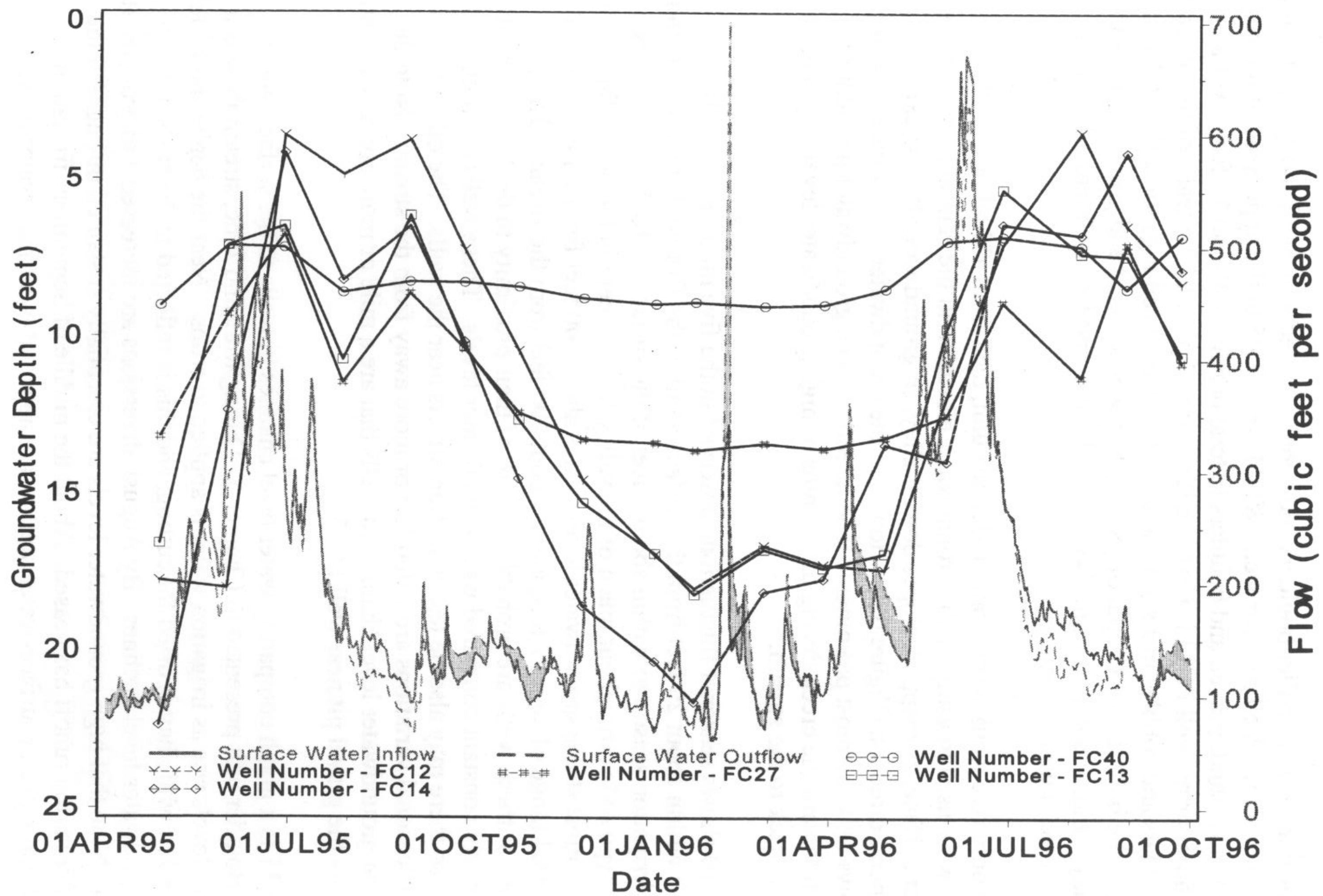


Figure 6.11 Boulder Unit - Comparison of Groundwater Levels to Surface Water Hydrographs

groundwater level decline in wells during October and November, and the simultaneous measured streamflow gains. For this calculation, it is assumed that the entire irrigated area is unconfined, and that the water levels in four of the five wells monitored represent conditions throughout the irrigated portion of the alluvium. Well FC 40 was not included in the calculation. The area of alluvium, excluding the debris fan area, within the Boulder unit above the "Flint Creek at Douglas Creek" gage is estimated to be 1,860 acres. The average decline measured in wells FC12, FC13, FC14, and FC15 between September 28, 1995, and November 28, 1995, was 5.9 feet. Therefore, the volume of aquifer dewatered is approximately 11,000 acre-feet (1,860 acres × 5.9 feet). Streamflow gains during October and November for the Boulder unit are estimated to have been approximately 15 cfs, although they were obscured by October rain. Over the 61-day period, this rate yields a total estimated streamflow gain from return flow of 1,830 acre-feet from the Boulder unit. A specific yield of 0.17 was estimated by dividing the 1,830 acre-feet gain volume by the 11,000 acre-feet aquifer volume.

Summer groundwater return flow rates are expected to approach those measured through surface-water flow by the time groundwater levels reach high summer levels. The maximum measured gain in Flint Creek from the unit was about 20 cfs just after irrigation ceased in both 1995 and 1996 (Figure 6.11). High summer groundwater levels were measured during the period June 28, 1995, to September 28, 1995. Applying the high groundwater return flow value of 20 cfs to this period, estimated summertime groundwater return flow would be approximately 3,680 acre-feet. Combined with fall gains, this results in an estimated total of some 5,500 acre-feet of groundwater return flow from the unit, which is equivalent to about 3 feet of water spread over the 1,860 acres of irrigated and subirrigated alluvium.

As noted above, fractured bedrock is reported at depths of 55 feet on well logs FC13 and FC27 at the north end of the unit. An estimate of the groundwater outflow from alluvium in the Boulder unit can be made. Since groundwater is about 15 feet deep at seasonal lows, the minimum saturated thickness of the valley fill aquifer is about 40 feet. Using a groundwater gradient of 0.016 from Figure 6.9, a hydraulic conductivity of 100 ft/d (approximately mid-range for sand), and a valley width of 4,000 feet, the estimated groundwater outflow from the unit is about 3 cfs.

Hall Unit

As noted in Chapter 2, irrigated land within the Hall unit is located either on the extensive alluvial deposits of Flint Creek and Lower Willow Creek, or on older deposits that form elevated benches west of Flint Creek. This section describes geologic cross sections and aquifer tests, and discusses the groundwater surface map, seasonal groundwater level changes, and return flow behavior in the unit.

Geologic Cross Sections

Figure 6.12 shows the locations of geologic cross sections shown in Figures 6.13 and

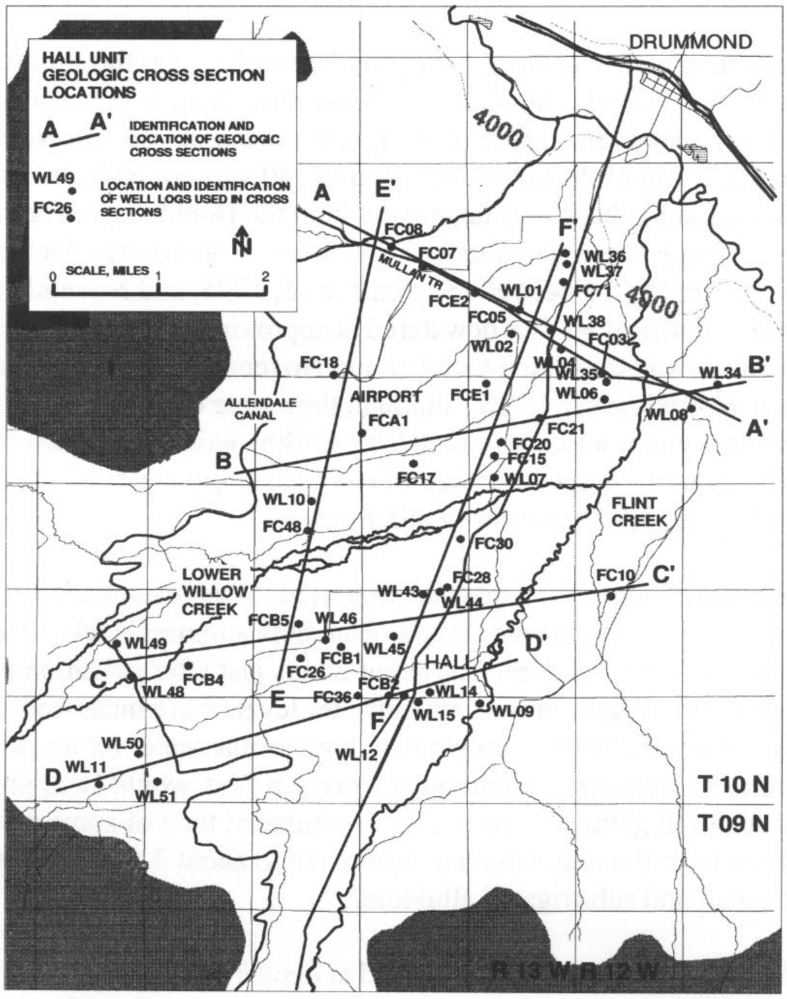


Figure 6.12 Hall Unit - Geologic Cross Section Locations

6.14. Cross Sections A and B extend from the west edge of the large, irrigated bench area west of Flint Creek and north of Lower Willow Creek, across the Flint Creek floodplain to New Chicago. Cross Section C extends from the area where Allendale Canal crosses Lower Willow Creek to the Flint Creek floodplain, passing through an isolated bench between Lower Willow Creek and the abandoned channel of Lower Willow Creek west of Hall. Cross Section D follows the abandoned channel from Lower Willow Creek, through Hall, to the Flint Creek floodplain. Cross Sections E and F run from south to north through the bench areas from the abandoned channel of Lower Willow Creek to north of Mullan Trail.

Cross Section A is aligned with the Mullan Trail from Lorranson Creek to New Chicago. Based on well logs, including project well FCE2, the bench between Lorranson Creek and the Flint Creek floodplain is capped by silty sand, gravel, and cobble deposits about 10 to 20 feet thick. About 90 to 135 feet of brown and blue clay was found beneath the gravelly caps in most wells. The clay is underlain by shale, and several wells are finished in the shale. In the floodplain area along Cross Section A, coarse alluvium is limited to depths of about 20 to 30

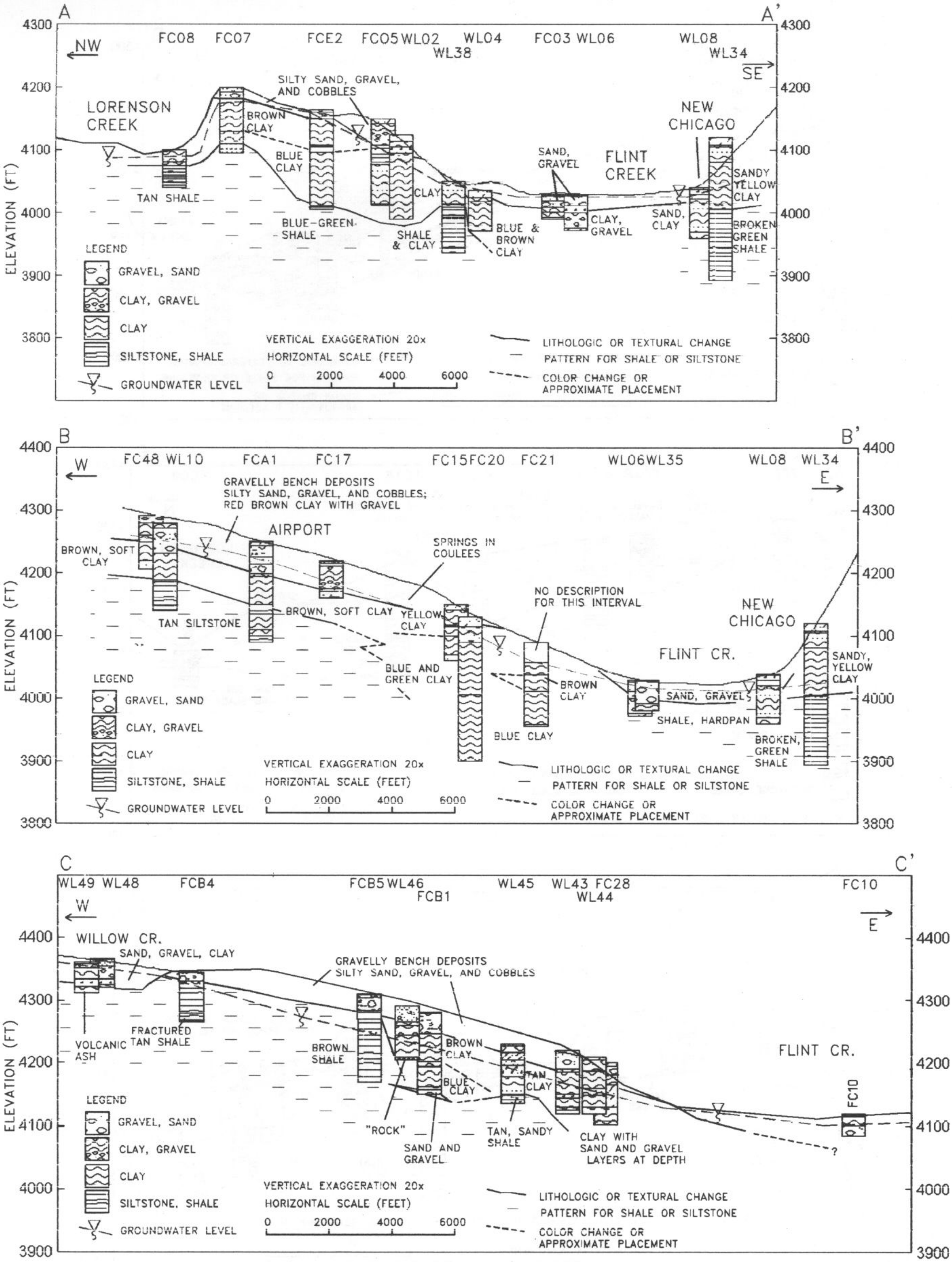


Figure 6.13 Hall Unit - Geologic Cross Sections

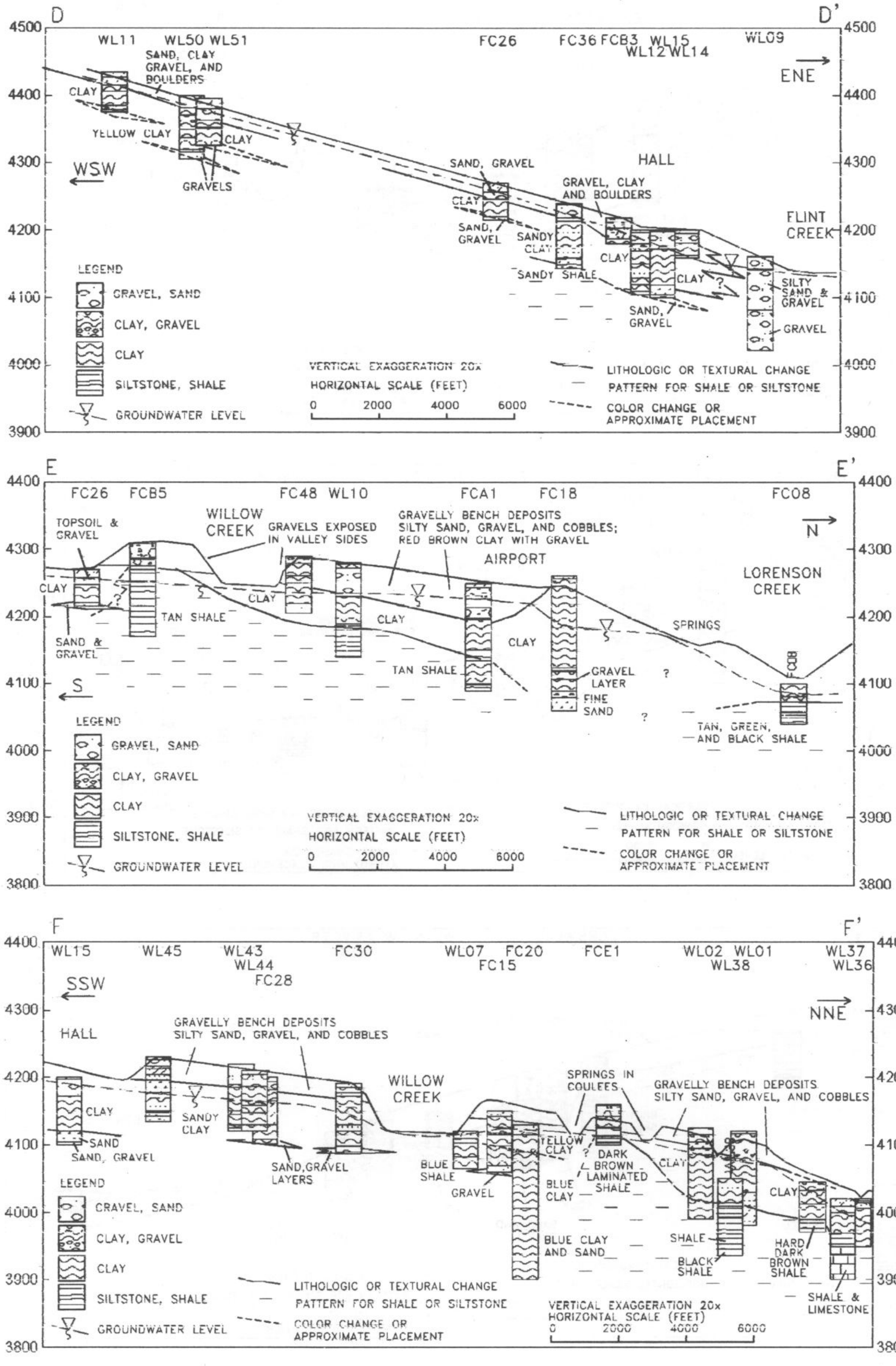


Figure 6.14 Hall Unit - Geologic Cross Sections (cont.)

feet. Groundwater lies at or near ground surface, year-round, near project well FCE2, which is an unusual condition on elevated benches in the basin. Groundwater is shallow in the Flint Creek floodplain, within about 3 to 10 feet of the ground surface.

Cross Section B extends from Allendale Canal west of the Drummond airport to New Chicago. Here, the near-surface gravelly bench deposits are as much as 60 feet thick. These deposits are underlain by soft clay about 50 feet thick, followed by poorly consolidated shale that is reported on most well logs at a depth of about 100 feet. Groundwater levels generally lie at depths of about 20 to 45 feet in most wells on the bench in this area. This cross section shows the same general area of the Flint Creek floodplain as Cross Section A.

Cross Section C, as noted above, crosses through the isolated bench northwest of Hall. Along this cross section, the near-surface, gravelly deposits on the bench are underlain by shale in the western part, and both clay and shale toward the east edge of the bench. Groundwater is deeper beneath the bench, as compared with Cross Section B, with static water levels in wells lying below the base of the gravelly bench deposits. Little information on the Flint Creek alluvium is available in the area where this cross section crosses the floodplain.

Cross Section D follows the course of the abandoned channel of Lower Willow Creek. Within this channel, alluvial deposits are consistently reported to be about 20 to 25 feet thick and consist predominately of silt, sand, gravel, and cobbles, with some clay. Clay is reported in most wells beneath the alluvium to depths of 80 to 100 feet, and most deeper wells are finished in gravel lenses within the clay. Along this cross section, shale was reported in only one well, FC36 just west of Hall. This well log describes shale beneath alluvium and clay from a depth of 80 feet to the total depth of 97 feet.

Only one well log was found for the Flint Creek alluvium east of Hall. The well log for well WL09, from the lumber mill near Flint Creek, lists largely coarse sediments for the total depth of 140 feet. The deepest interval, from 79 to 140 feet, is reported as gravel. This well produced 70 gpm with 65 feet of drawdown, as shown on the well log. This the deepest well log available within the Flint Creek floodplain, and the well is one of the more productive in the valley. Even so, 70 gpm is a modest production rate for 61 feet of saturated gravel, which suggests that the deep gravel may be hard packed, cemented, or otherwise tight.

Cross Section E runs south to north from the abandoned channel of Lower Willow Creek to Lorensen Creek. The gravelly bench deposits pinch out to the north near well FC18, where the underlying clay is thicker. Also, this cross section shows the absence of soft clay found at well FCB5 discussed above in the description of Cross Section C.

Cross Section F crosses the eastern edge of the benches just west of Montana Highway 1. Along this cross section, the gravelly bench deposits extend north past Mullan Trail. These gravels are truncated by both the present and abandoned channels of Lower Willow Creek. Coulees originating on the bench north of Lower Willow Creek, west of the cross section, form spring-fed gullies. Wells in the southern half of the cross section tend to be completed in sand and gravel layers within clay, while wells further north are typically completed in shale.

Aquifer Tests

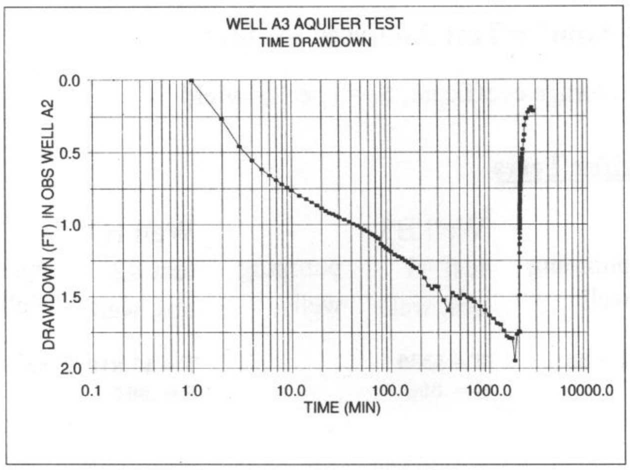
Two aquifer test sites were constructed for this study within the Hall unit, as described in Chapter 3. Two constant-rate aquifer tests were conducted at each site, providing four separate aquifer tests. Before each aquifer test, a step-drawdown test was conducted to determine the pumping rate for the constant-rate test. Appendix F includes summaries and graphs of data collected at pumping and observation wells during both the step-drawdown tests and the constant-rate tests. The tests are named according to the last two figures in the pumping well identification and the type of test performed. For example, the aquifer test using pumping well FCA3 is named *well A3 aquifer test* in Appendix F. Lithologic log summaries for all wells used in the tests are included with other well log data in Appendix D. Graphs of observation well time-drawdown data from the each of the constant-rate aquifer tests are presented in Figure 6.15. Table 6.1 provides results of various analyses on the test data for comparison.

Wells FCA1, FCA2, FCA3, and FCA4 are located just south of the Drummond airport. These wells form two pairs, with one pair being completed in the gravelly bench deposits at depths of about 40 to 60 feet, and the other pair being completed in deeper sediments at depths of about 100 to 160 feet. One aquifer test was performed on each pair of wells at this site.

The general conditions at this site are shown at well FCA1 on Cross Section B (Figure 6.13). The gravelly bench deposits at the wells drilled at the site extended to depths of 55 to 60 feet. They are capped with about 6 feet of silt, and include a gravelly clay about 10 to 15 feet thick that separates silty sand, gravel, and cobble deposits into an upper and lower portion.

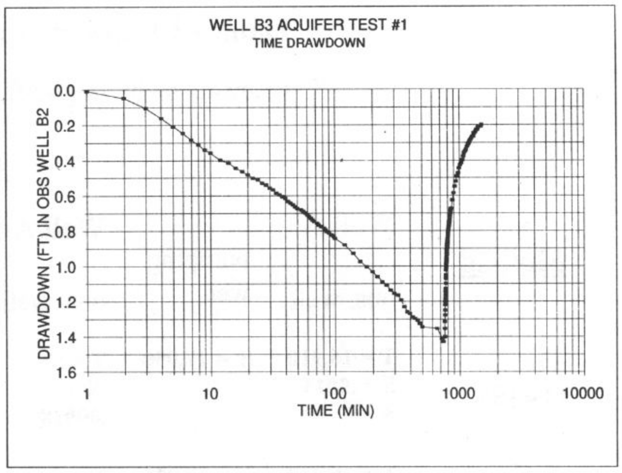
The target aquifer for the test at well FCA3 was the lower portion of the gravelly bench deposits, beneath the gravelly clay. The aquifer thickness is about 9 feet. Observation well FCA2 was constructed with steel casing extending to a depth of 58 feet, perforated from depths of 40 to 48 feet. Pumping well FCA3 was completed with open-hole casing at a depth of 48 feet. The open hole completion made a much more productive well than the perforation method.

The pumping rate for the constant-rate aquifer test at well FCA3 was 30 gpm, which was close to the maximum capability of the pump used. This induced about 5 feet of drawdown in the pumping well, and close to 2 feet of drawdown in the observation well, 30.5 feet away. The well was pumped for 34 hours. Both the Theis (1935) and Cooper-Jacob (1946) methods provided good matches to observation well drawdown data, and both yielded a transmissivity of 16,900 gallons per day per foot (gpd/ft) and a storage coefficient of 0.001. Analysis of the pumping well drawdown and recovery data yielded a value of 17,100 gpd/ft using the Theis method. The aquifer is relatively horizontal and extensive, so many of the assumptions of the methods are met at this site. Perhaps this explains the unusually good agreement between pumping and observation well data. Hydraulic conductivity of the aquifer is estimated to be



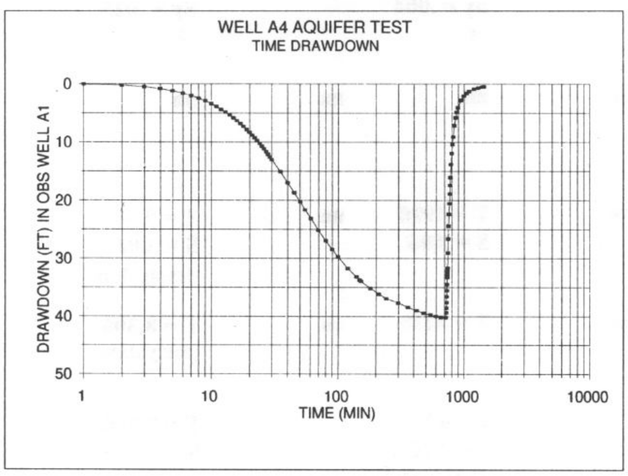
A3 CONSTANT RATE PUMPING TEST OBS WELL DATA FROM WELL A2 r = 30.5 ft
TEST STARTED 09/26/1996 09:00 AM
LOCATION: NWNWNWSW SECTION 14 T10N R13W
SWL 15.07 ft b = 9 ft PUMPING RATE = 30 gpm
CONFINED SILTY SAND, GRAVEL, AND COBBLES

PUMP ON @ t = 0 PUMP OFF @ t = 2040



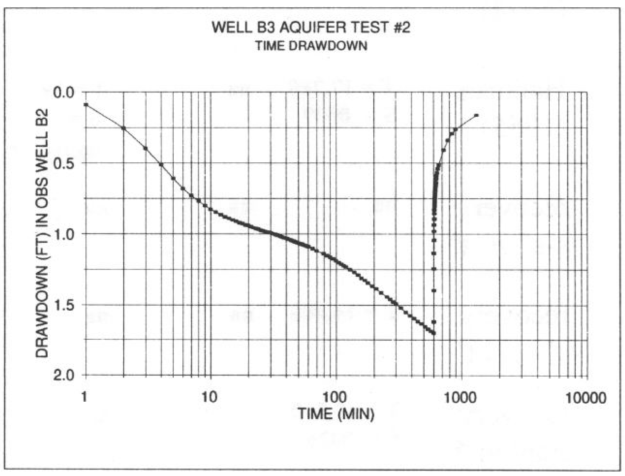
B3 CONSTANT RATE PUMPING TEST #1 OBS WELL DATA FROM WELL B2 r = 32 ft
TEST STARTED 04/25/96 08:00 AM
LOCATION: SWSWSESW SECTION 26 T10N R13W
SWL 17.38 ft b = 16 ft PUMPING RATE = 13.04 GPM
UNCONFINED SILTY SAND AND GRAVEL

PUMP ON @ t = 0 PUMP OFF @ t = 760



A4 CONSTANT RATE PUMPING TEST OBS WELL DATA FROM WELL A1 r = 35.9 ft
TEST STARTED 09/05/96 08:00 AM
LOCATION: NWNWNWSW SECTION 14 T10N R13W
SWL 27.83 ft b = AQUIFER THICKNESS UNKNOWN PUMPING RATE = 7.8 GPM
CONFINED GRAVELLY SAND, SHALE

PUMP ON @ t = 0 PUMP OFF @ t = 720



B3 CONSTANT RATE PUMPING TEST #2 OBS WELL DATA FROM WELL B2 r = 32 ft
TEST STARTED 10/17/96 09:00 AM
LOCATION: SWSWSESW SECTION 26 T10N R13W
SWL 11.00 ft b = 22.5 ft PUMPING RATE = 28.2 GPM
UNCONFINED SILTY SAND AND GRAVEL

PUMP ON @ t = 0 PUMP OFF @ t = 600

Figure 6.15 Constant-Rate Aquifer Tests - Time Drawdown Data from Observation Wells

Table 6.1 Comparison of Aquifer Test Analyses Results

T = transmissivity in gpd/ft, S = storage coefficent, S_y = specific yield

Aquifer Tests

Method	Well A3 obs. well	pumping well	Well A4 obs. well	pumping well	Well B3 test #1 obs. well	pumping well	Well B3 test #2 obs. well	pumping well
Theis (1935)	**T = 16,910 S = .0011 ***	**T = 17,090**	**T = 57 S = .00018**	**T = 86**	**T = 5330 S = .006**		**T = 11,810 S = .004**	**na**
Cooper-Jacob (1946)	**T = 16,940 S = .0011**	**T = 15,930**	**T = 61 S = .00012**	**na**	**T = 5550 S = .006**	**T = 2,820**	**T = 11,660 S = .004**	**T = 14,970**
Neuman (1974)	**na**	**na**	**na**	**na**	**T = 4840 Sy = .004 ***	**na**	**T = 6,310 Sy = .025 ***	
Hantush (1955)	**T = 17,260 S = .0009**	**na**	**T = 39 S = .00016 ***	**na**	**na**	**na**	**na**	
recovery s-s' vs. t'	**na**	**na**	**na**	**na**	**T = 4990 S = .006**	**na**	**T = 9,300 S = .002 (early data)**	
recovery s' vs. t/t'	**T = 14,400**	**na**	**na**	**na**	**T = 4410**	**na**	**T = 8,300 (early data)**	
recovery Banton & Bangoy (1996)	**T = 17,380 S = .0026**		**na**		**T = 4790 S = .017 (late data)**		**T = 7,800 S = .01**	

* selected method   na = not applied

about 250 ft/d based on the analysis. Groundwater levels in the deep well pair were unaffected by this test.

The perturbations in the observation well data at times t = 380 and t = 1800 minutes that include declines of about 0.2 foot, were intermittent daily occurrances in the some of the transducer recorder data collected at this and other sites where the same type of instruments were used. These fluctuations did not show up in manually gathered data during the test, and were ignored for the aquifer test analysis.

The target aquifer for pumping well FCA4 was the deep shale aquifer in which many area wells are completed. At this site, water is produced from both sand and gravel layers and fractures in the shale. Both the pumping and observation wells were steel cased completely through the overlying soft clay, to depths of 118 and 98 feet respectively. Both wells were drilled to a total depth of 160 feet and used 4-inch diameter, saw-cut PVC liners in the shale. The aquifer thickness at this site is speculative, because lithologic data below 160 feet are unavailable. The pumping well, as constructed, draws water from numerous lenses of sand or gravel and fractures in the upper 60 feet of the shale.

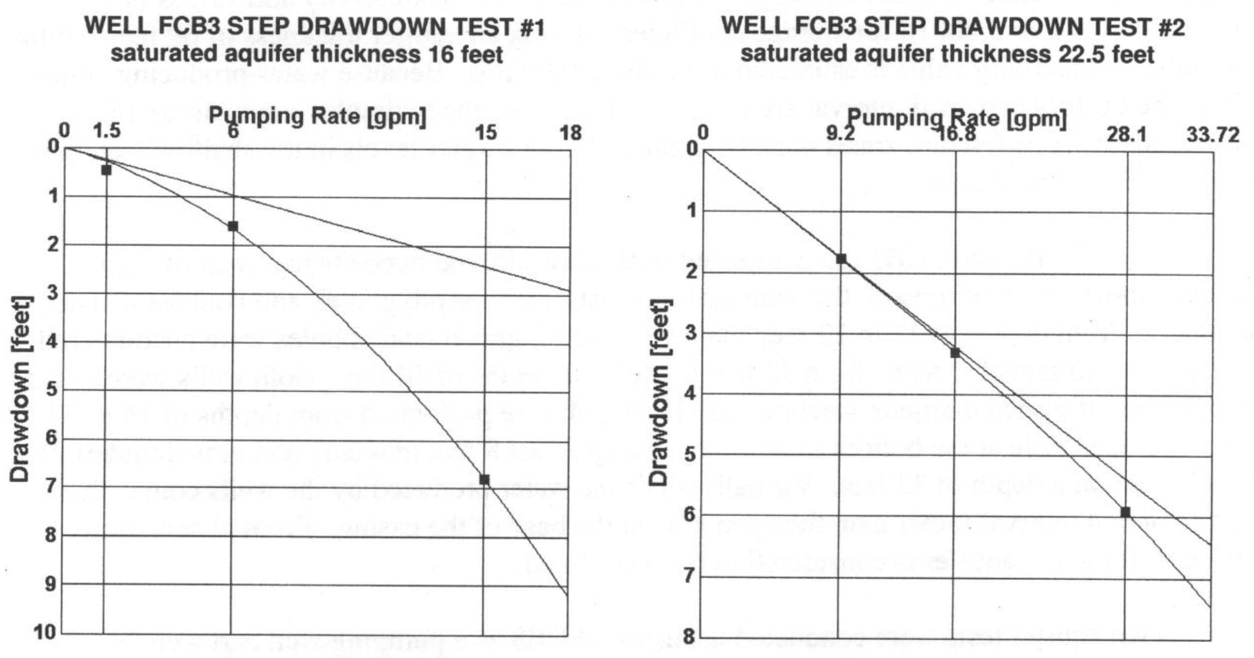
Well FCA4 was pumped at a constant rate of 7.8 gpm for 12 hours. This resulted in more than 50 feet of drawdown in the pumping well, and 40 feet of drawdown at observation well FCA1, located 35.9 feet away. The Hantush (1955) leaky aquifer method, with no storage in the aquitards, provided the best curve fit, and seems reasonable for the situation. This analysis gave a transmissivity of 39 gpd/ft and a storage coefficient of 0.00016. For comparison, the Theis and Cooper-Jacob methods yielded values of about 60 gpd/ft for transmissivity and values in the range of 0.00012 to 0.00018 for storage coefficient. Using an aquifer thickness of 60 feet, a bulk hydraulic conductivity value is estimated to be about 0.09 ft/d. Because water-producing zones within the 60-foot screened interval are of limited thickness, the hydraulic conductivity of individual layers or fracture zones must be greater. Groundwater levels in the shallow well pair were unaffected by this test.

Wells FCB2 and FCB3 are completed in shallow alluvial deposits just west of Hall. Beneath about a foot of topsoil, the sediments consist of silty sand, gravel, and cobbles to a depth of 16 feet. From depths of 16 to 32 feet, clayey silt, sand, gravel, and cobbles were encountered. Sandy clay and gravel extends from 32 feet to the total depths of 40 feet. Both wells were cased with 40 feet of 6-inch diameter steel casing. Both wells are perforated from depths of 14 to 32 feet. The open hole at the bottom of the steel casings is set 8 feet into clay and gravel underlying the alluvium at a depth of 32 feet. Virtually all of the water produced by the wells comes from the perforated interval rather than the open hole at the base of the casing. From observations during drilling, the aquifer is considered to be unconfined.

Two aquifer tests were conducted using well FCB3 as a pumping well and well FCB2, 32 feet away, as an observation well. The first test was conducted in April 1996, when groundwater levels were near their seasonal low. The saturated thickness of the aquifer was 16 feet during the first test. The second test was conducted in October, when the groundwater level was 40 percent higher, having a saturated thickness of 22.5 feet.

During the first test, well FCB3 was pumped at a rate of 13 gpm for 12 hours and 40 minutes. This induced about 8 feet of drawdown in the pumping well and about 1.4 feet of drawdown in the observation well. A faulty valve caused significant fluctuations in the flow rate after about 9 hours of pumping. The aquifer pumping and recovery data combined were analyzed using the Neuman (1974) method for unconfined conditions. This analysis yielded a transmissivity of 4,700 gpd/ft. The same method applied to the pumping data without recovery gave a value of 4,840 gpd/ft. These values are lower than those obtained applying the Theis and Jacob methods, which gave results of 5,300 and 5,550 gpd/ft. Specific yield was in the range of 0.004 to 0.006 for all methods of analysis applied. It was partly because of this unexpectedly low value of specific yield that a second test was conducted.

The higher groundwater levels at the time of the second test allowed for a greater pumping rate. Figure 6.16 provides a comparison of data from the step-drawdown tests conducted before the two aquifer tests. Note the increased efficiency of the well for the second test when the saturated thickness of the aquifer is 40 percent greater. A pumping rate of 15 gpm caused about 7 feet of drawdown in the first test, compared to 28 gpm for similar drawdown in the second test, nearly doubling the specific capacity of the well. This figure shows how lower static groundwater levels can impact well yield, a common source of water rights complaints, especially during droughts.



Drawdown	0.46	1.6	6.8	9.2
Pumping Rate	1.5	6	15	18 *
Aquifer Loss	0.24	0.97	2.41	2.9
Well Loss	0.04	0.7	4.38	6.31
Efficiency [%]	52.4	60.3	35.5	31.5

Drawdown	1.77	3.3	5.91	7.48
Pumping Rate	9.2	16.8	28.1	33.72 *
Aquifer Loss	1.76	3.21	5.37	6.45
Well Loss	0.01	0.09	0.54	1.03
Efficiency [%]	99.4	97.4	90.9	86.3

* The last step is extrapolated for 20% higher last Q

Figure 6.16 Comparison of Well Efficiency at Well FCB3

For the second aquifer test, well FCB3 was pumped at a constant rate of 28.2 gpm for ten hours. This provided about 1.4 feet of drawdown in the observation well and about 7 feet of drawdown in the pumping well. Application of the Neuman method to the drawdown data resulted in a transmissivity value of 6,310 gpd/ft, and a specific yield of 0.025. The transmissivity value is about 30 percent greater than that calculated using the same method (4,840 gpd/ft) on the first aquifer test. Ideally, a 40 percent increase might have been expected based on the change in saturated thickness. Hydraulic conductivity of the saturated materials is approximately 40 ft/d, based on the two tests.

The specific yield of 0.025 is questionable. At the time of drilling, the character of the sediments suggested that the aquifer should be unconfined, and would be expected to have a specific yield more in the range of 0.1 to 0.3. It is possible that because the sediments are silty, or because of layering of fine materials, that a much longer test is needed to adequately evaluate the unconfined delayed drainage effect at the site. Aquifer tests conducted for the Gallatin Valley study described in the introduction of this report (Hackett et al, 1960) produced similar, lower than expected storage coefficients, and the authors noted that several weeks of pumping could be required to obtain much larger storage coefficient values. In that study, the data were sufficient to arrive at a specific yield of 0.15 for the Gallatin Valley based on an analysis of surface-water gains and changes in the volume of groundwater in storage within the valley aquifer.

The aquifer tests provided evaluations of the hydrologic properties of the aquifers tested, and were useful in interpreting the data collected during this study. As explained under the *Irrigation Return Flow* section below, certain problems limit the application of the aquifer test results in this study. Such limitations should be considered in future studies.

Groundwater

Figure 6.17 is a groundwater surface map for the Hall unit for late March 1996, when groundwater was near its seasonal low in most wells in the unit. The groundwater surface mimics the overall configuration of the landscape. Groundwater west of the Flint Creek floodplain moves east or east-northeast toward the Flint Creek floodplain, except for the area north of the Drummond airport where Lorranson Creek sets in a topographic low. In that area, the groundwater gradient slopes toward Lorranson Creek. Within the floodplain, groundwater moves generally downvalley.

Groundwater is typically less than 20 feet deep beneath alluvial deposits in the unit. Groundwater in the Flint Creek alluvium at Mullan Trail is especially shallow, within less than 10 feet of the surface. It is deeper beneath the irrigated benches, in the range of about 30 to 100 feet at most locations.

Irrigation on the extensive west-side bench north of Lower Willow Creek provides recharge to the shallow, gravelly bench deposits. As noted earlier, the thick clays underlying the gravelly bench deposits undoubtably form a barrier that causes groundwater in the gravelly caps

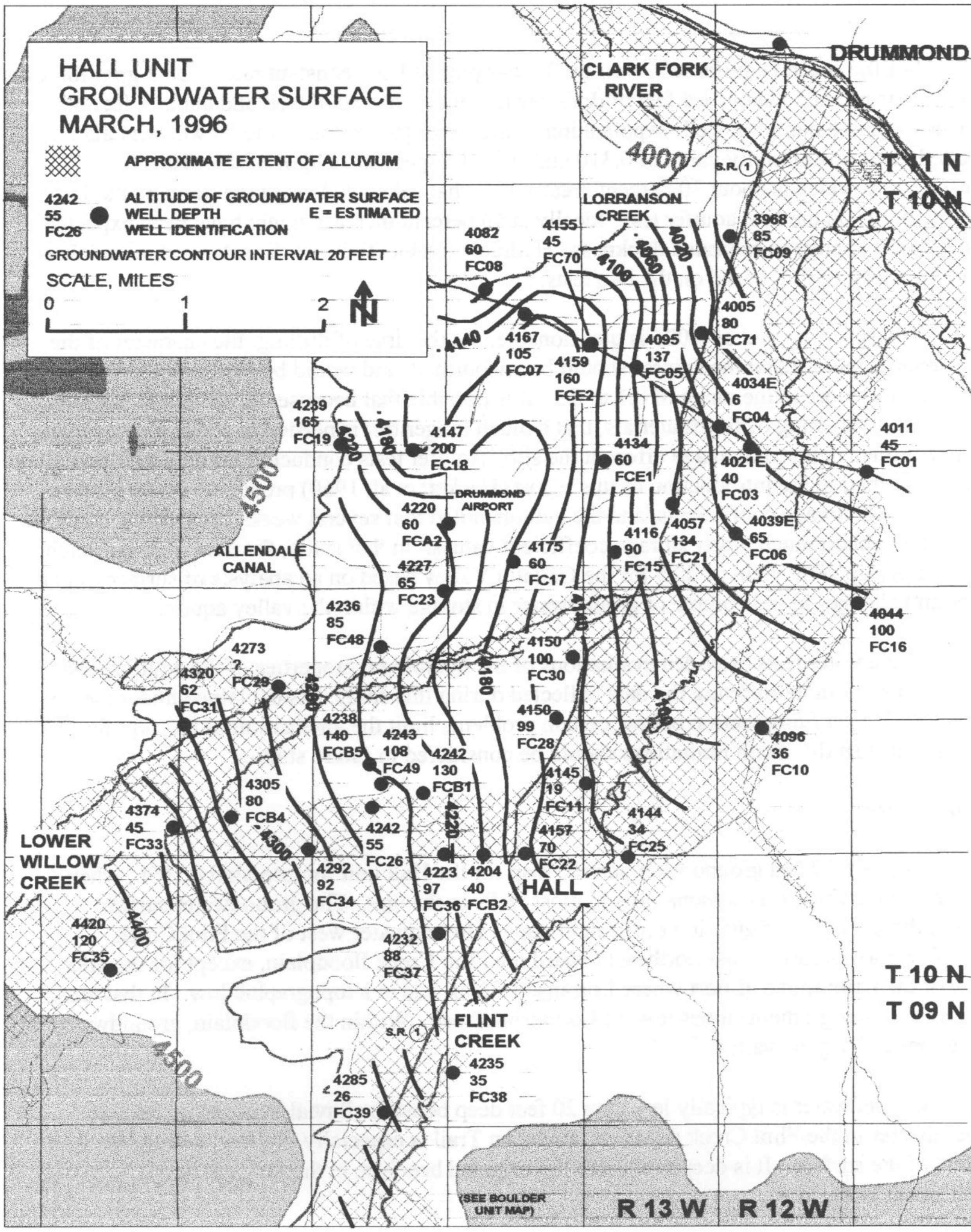


Figure 6.17 Hall Unit - Groundwater Surface Map

to move laterally, with limited leakage to deeper aquifers. Groundwater in the gravelly bench deposits discharges at springs in coulees along the east edge of the bench.

The vertical component of the groundwater gradient at the aquifer test site near well FCA2 and the Drummond airport is downward. At that site, water levels in wells completed in the gravelly bench deposits were about 12 feet higher than those in wells completed beneath the underlying thick clay. Along Mullan Trail, at well FCE2, the gradient appears to be upward based on a comparison of water levels in this well and nearby well FC70, which is shallower. Here the difference in water levels is only a foot or two. The water levels in both wells were measured at or above ground surface during summer months, an unusual condition on the benches. Shallow groundwater type soils mapped by NRCS and visible on aerial photographs are present within a half-mile radius of well FCE2, concentrated to the northeast. Poor quality groundwater is reported in some of the deeper wells in this general area. Groundwater quality data (Nimick, 1993) indicate that the water is a calcium-sulfate type that exceeds secondary drinking water standards for total dissolved solids, sulfate, and manganese. These observations suggest that a groundwater discharge area exists in the vicinity of well FCE2. Discharge of poor quality groundwater in this area probably contributes to the high specific conductance of Lorranson Creek relative to other surface water in the basin.

Cretaceous strata underlie Tertiary deposits at the roadcut on Montana Highway 1 just south of the Clark Fork River (Rasmussen and Fields, 1980). The geologic summary for an oil exploration well drilled about 0.3 mile north of well FC08, the location of which is shown in Figure 3.13, indicates that Tertiary deposits are only about 110 feet thick at that location. Based on this information, it seems possible that Tertiary deposits generally thin out north of Mullan Trail west of Montana Highway 1. Since Cretaceous deposits consist primarily of shale, groundwater in the Tertiary beds may be forced upward, resulting in the groundwater discharge area near well FCE2.

The reason for the steep, northward gradient in the vicinity of well FC18 just north of the Drummond airport is shown in Cross Section E, Figure 6.14. At the location of well FC18, thick clay separates groundwater ponded high on the bench deposits from the topographic low created by Lorranson Creek. Perennial springs are present north of well FC18 as shown on the cross section.

Seasonal Groundwater Fluctuations

Figure 6.18 shows the approximate seasonal range of groundwater fluctuations in wells within the Hall unit. Note the distinctive pattern of high water levels during summer months and low and declining water levels during winter throughout the unit. The greatest range of seasonal fluctuations within the unit typically occurs in irrigated areas away from shallow groundwater areas or springs. Such areas include much of the irrigated bench west of Flint Creek and north of Willow Creek, the abandoned channel of Lower Willow Creek west of Hall, and the isolated

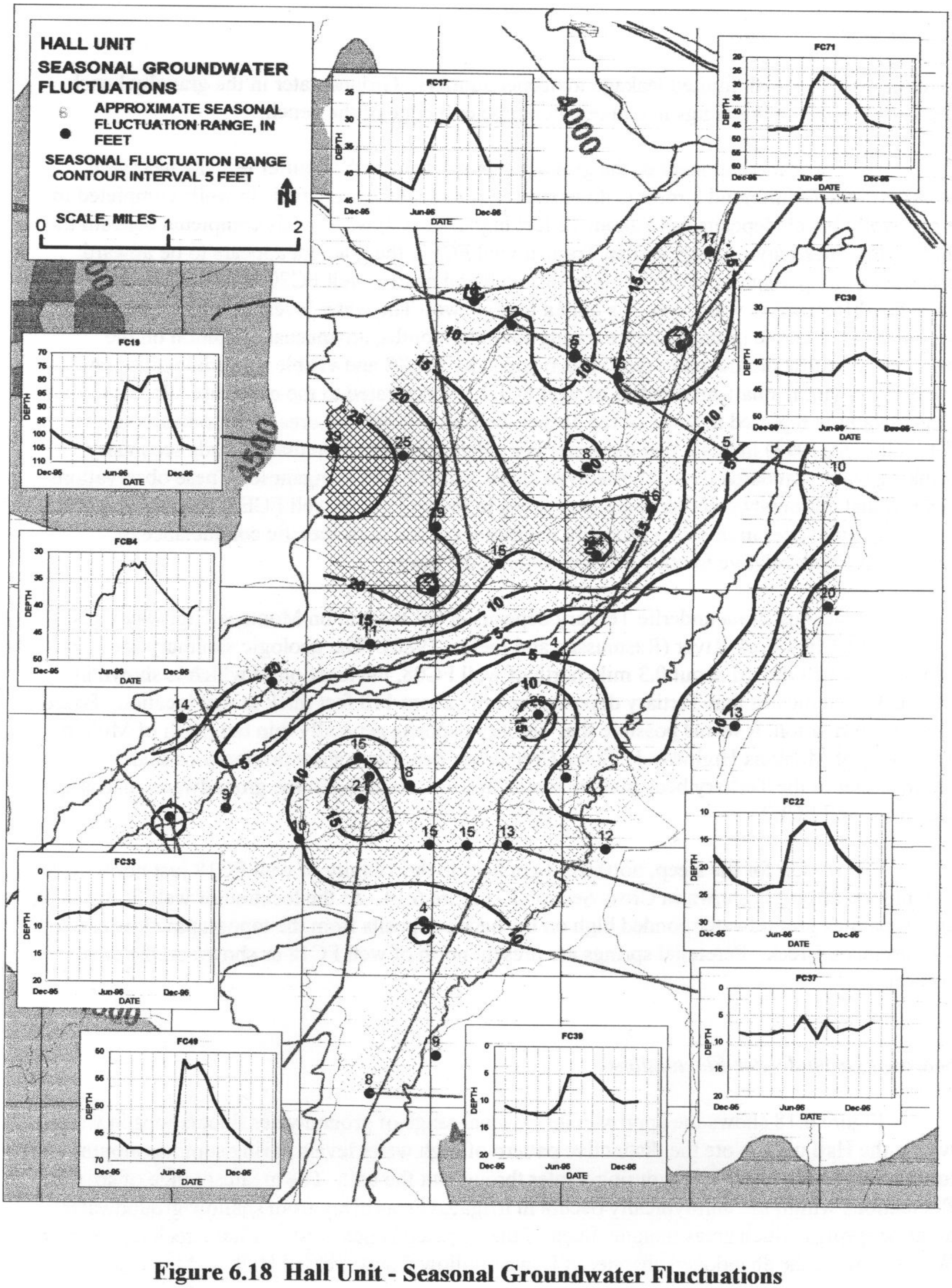


Figure 6.18 Hall Unit - Seasonal Groundwater Fluctuations

bench just north of the channel. Wells at the east edge of the Flint Creek floodplain also have greater seasonal water-level changes. All of these areas have permeable sediments near the surface that can store and move excess irrigation water, and many of the wells reflect confined aquifer conditions.

Seasonal groundwater changes are lowest in areas of groundwater discharge or shallow, unconfined groundwater tables. This condition exists in much of the alluvium in the unit. In contrast to most wells on the bench, the seasonal range is only 5 to 8 feet at wells FCE2, FC70, and FCE1. This area of lower seasonal water-level ranges coincides with the groundwater discharge area along Mullan Trail and spring-fed coulees in the gravelly bench deposits. Especially shallow groundwater conditions in the Flint Creek floodplain in the north part of the unit, as at the north end of Philipsburg valley, probably limit the potential to store excess irrigation water in this portion of the alluvium.

The interpretation of groundwater level changes in wells completed in confined sand and gravel layers or shale aquifers is more elusive than for an unconfined aquifer. The water-level changes are actually a result of pressure changes in the aquifer, rather than a change in saturated thickness. These pressure changes can reflect water-level changes in shallower aquifers above the confining layer near the measurement site or at distant locations. Head changes at one location can be transferred simultaneously to other points in the system, even at great distances. Therefore, water-level changes at any individual well are best interpreted by considering water-level changes at other wells, the geologic framework, and hydrologic occurances at any location that could be hydrologically linked to the aquifer being monitored. Fortunately, the abundance of groundwater data collected within the Hall unit provides much of this type of information.

Figure 6.19 shows the results from the six wells equipped with continuous groundwater level recorders. Note the almost identical water-level change pattern in wells FCA1 and FCA2. Well FCA1 is steel cased to about 100 feet through the gravelly bench deposits and underlying clay (see Cross Sections B and E), while well FCA2 is completed in a confined layer within the gravelly bench deposits at depths of 40 to 48 feet. They are 6 feet apart. In this general area on the bench, several observations during summer months showed the effect of irrigation water saturating the uppermost gravelly bench deposits. A gravel pit perhaps 20 feet deep about 0.25 mile north of well FC48 (well locations shown in Figure 6.17) partially fills with water for most of the summer. The well pits at wells FC17 and FC19 were observed to be flooded at some times. Work on a ditch being dug for a water line running west from well FC18 had to be postponed until the end of the irrigation season due to flooding. These observations show that a considerable amount of water is temporarily stored in the shallow gravel deposits in this area.

Well FCB5, drilled to a depth of 140 feet on the isolated bench south of Lower Willow Creek (Cross Sections C and E), was designed to provide information to compare with well FCA1 near the airport. A shallow observation well, FCB6, was installed adjacent to well FCB5. This well was drilled about 3 feet into sandy clay that was encountered at a depth of about 35 feet. Forty feet of steel casing was installed and perforated at the base of the gravelly bench

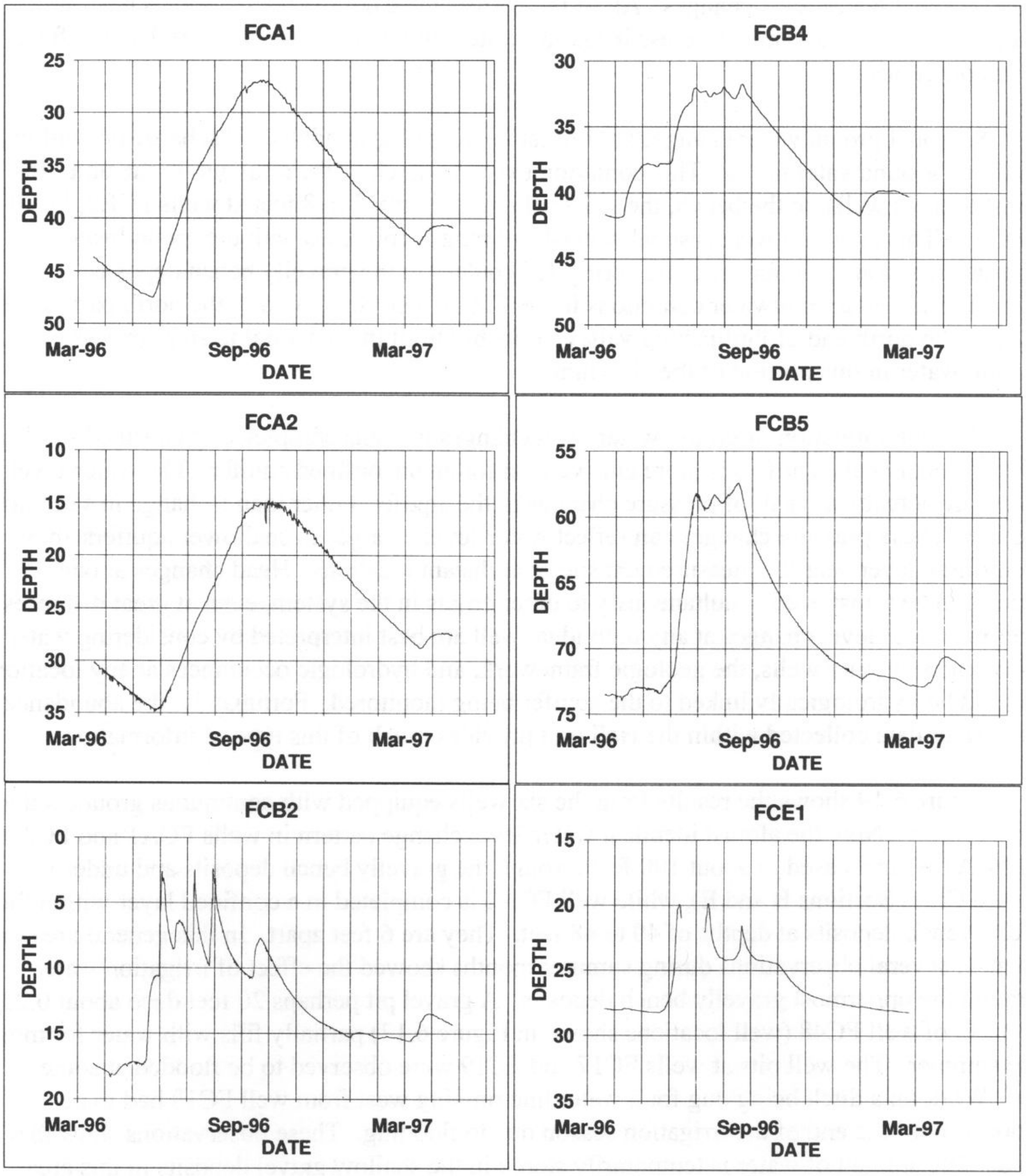


Figure 6.19 Hall Unit - Continuous Water Level Recorder Data

deposits, from depths of 25 to 35 feet. There was no water in the gravelly deposits when the well was drilled in January 1996. Groundwater levels rose about 15 feet in well FCB5, comparable to the 20-foot range recorded at well FCA1. Groundwater was measured in the shallower well, FCB6, only on two occasions, and these were both in midsummer (July 11 and August 1st). On these occasions, groundwater was measured near 33 feet below ground surface. This shows a small amount of water, perhaps 3 feet, ponded in the lower part of the gravelly bench deposits at the well site, but certainly not 15 feet of water as one might expect to see based on the deeper well observations.

The response of area wells equipped with continuous recorders shows that high groundwater levels in the alluvium of Lower Willow Creek can affect groundwater levels in the deep shale aquifer at well FCB5. High flow in Lower Willow Creek in April 1996 is believed to be the principle cause of the 4-foot groundwater level rise at well FCB4 that month (Figure 6.19). This well is about 0.25 mile away from the creek, and even closer to the flat-lying alluvial sediments of Lower Willow Creek. The groundwater level at well FCB2, completed in the shallow alluvium of the abandoned channel of Lower Willow Creek more than 1.5 miles downgradient from well FCB4 rose about 1 foot. The water-level rise in well FCB2 has the same pattern as that in well FCB4, rising during the last two-thirds of April and leveling off near the end of the month. This seems logical, since the alluvium of the abandoned channel is believed to be in direct connection with the Lower Willow Creek sediments as shown in Cross Section D. Interestingly, well FCB5, located high on the isolated bench, also responded almost exactly like well FCB2. This shows that the groundwater level in the deep shale aquifer at well FCB5 responds to changes in alluvial groundwater levels at considerable distances. This same phenomenon occurred in January 1997, when Lower Willow Creek rose due to ice jams, although the water-level rise was smaller.

Another notable observation is the comparison of groundwater level changes at well FCB2, completed in shallow alluvium, and well FC36, which is steel cased through both the shallow alluvium and about 55 feet of clay to a depth of 83 feet, and completed in shale from depths of 83 to 97 feet. These wells are 0.25 mile apart, both located in the central part of the abandoned channel of Lower Willow Creek. The water level in well FC36 was unreliable on some occasions because of pumping effects, but monthly measurements show the water level generally tracks that of well FCB2 in Figure 6.19, minus the sharp peaks occurring during the application of flood irrigation. For example, the water level in well FC36 was 18.3 feet below top of casing on April 29, 1996, compared to 17.2 feet in well FCB2. By June 27, 1996, the water level was 11.1 feet below top of casing in well FC36 and 6.7 feet below top of casing in well FCB2. This shows that even though no obvious direct connection exists at the site, the groundwater levels in the deep confined aquifer at this location reasonably reflect conditions in the overlying unconfined alluvial deposits.

Finally, snowmelt in the spring of 1997 is believed to be the cause of the 1.5- to 2-foot rise in the four wells (FCA1, FCA2, FCB2, and FCB5) that were still recording water levels. This indicates that even deep, confined aquifers respond to head changes caused by rain or snowmelt. There was about 8 inches of packed, icy snow on the ground.

Based on the above discussion, water-level changes observed in the deeper aquifers within the Hall unit provide aquifer pressure measurements that in many cases reflect water-level changes in shallower sediments. In the case of the wells near the airport, including FCA1, FCA2, and other wells in that area, and in the alluvium of the abandoned channel of Lower Willow Creek, they are believed to largely reflect the storage and release of water in overlying gravelly deposits or alluvium. In the case of wells on the isolated bench where well FCB5 is situated, the water levels may largely reflect changes in the Lower Willow Creek alluvium, both of the present channel to the north and the abandoned channel to the south. Alternately, because static groundwater levels are deep, and thick clay is not present at well FCB5, water may move directly into the shale aquifer with minimal ponding at the base of the gravelly bench deposits. Other factors, such as localized mounding of groundwater due to canal leakage on the bench or flood irrigation at the east end of the bench could also influence water levels in the wells in this area.

Irrigation Return Flow

Irrigation return flow is measured as surface-water gains after the irrigation season. It is useful to compare estimates of the amount of excess irrigation water released from aquifers during the fall months in the Hall unit to the results of the surface-water investigation. The total volume of water gained in the fall of 1996 and 1997 between the second week of October and the end of December is estimated to average about 6,000 acre-feet, based on the surface-water analysis. The gains during this period range from some 40 to 50 cfs as irrigation shuts down to about 20 to 30 cfs by the end of December.

Estimates of the amount of irrigation return flow stored and released as groundwater based on areas, specific yield estimates, and measured groundwater level changes are in reasonable agreement with the surface-water analysis. Groundwater return flow estimates based on transmissivity estimates, gradients, and aquifer widths produced results about an order of magnitude less than expected. The reason for this difference is uncertain. It is likely that details of return flow processes, especially of shallow groundwater discharge features, are not adequately shown by the wide spacing of monitoring wells used for this study. For example, as calculated below, some 1,050 acre-feet of groundwater are estimated to drain out of the abandoned channel west of Hall between mid-October and the end of December. This would represent an average flow on the order of 7 cfs for the period. Based on the transmissivity obtained at the aquifer test at well FCB3 in the central portion of the abandoned channel west of Hall, the mapped groundwater gradient in the area, and the width of the valley, it is estimated that the groundwater flux through the valley is about 0.5 cfs for low groundwater conditions. The 40 percent or more increase in saturated thickness that occurs as a result of irrigation increases this flow estimate, but because the groundwater levels rise over the whole length of the valley, there is little net difference in the overall groundwater gradient in the channel, and the estimated high groundwater flux is still less than 1 cfs. The high groundwater is released largely in a matter of months after irrigation ceases, based on the observed declines in water levels. It is speculated that lateral gradients develop that cannot be mapped with the density of observation wells used in this study, and that much of the return flow appears in drain ditches, springs, and channels. In this manner it is removed as surface water, and thus cannot be evaluated by determinations of down-valley groundwater flux. Because of this problem, the evaluation of return flow by evaluating groundwater flux based on aquifer properties and gradients can produce unreliable results in certain situations. Accurate surface-water measurements are crucial to any evaluation of irrigation return flow.

For the purpose of estimating how much irrigation return flow is stored as groundwater within the unit, the unit is divided into four areas as shown in Figure 6.20: 1) The west bench north of Lower Willow Creek, 2) the Flint Creek alluvium, 3) the Lower Willow Creek alluvium, and 4) the abandoned channel of Lower Willow Creek west of Hall and the isolated bench south of Lower Willow Creek. Figure 6.21 is a map showing the distribution of groundwater level declines that occur in wells within the Hall unit from mid-October to the end of December.

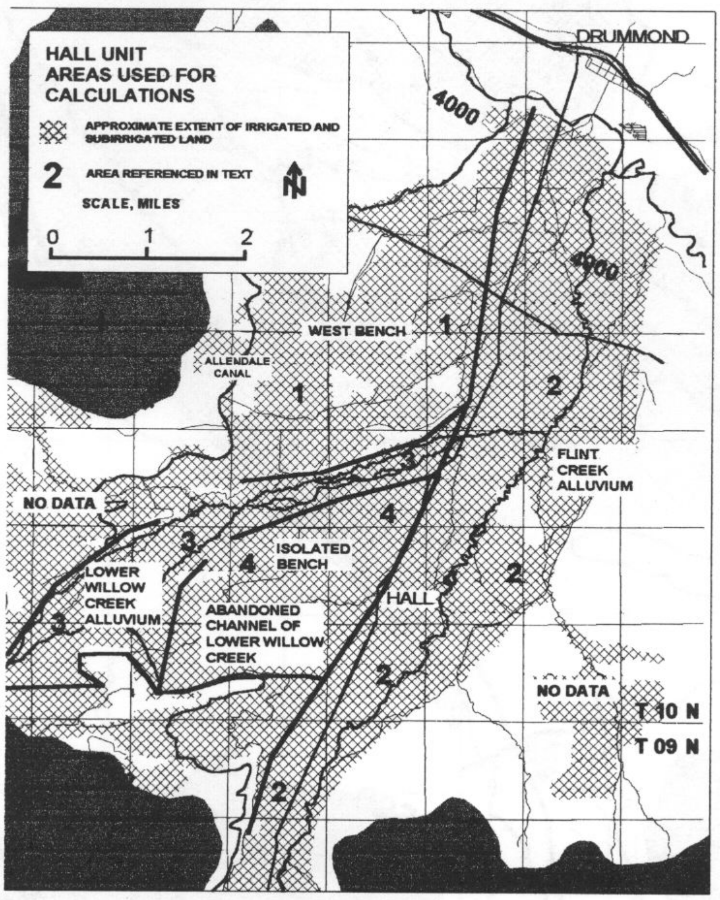


Figure 6.20 Hall Unit - Areas Used for Calculations

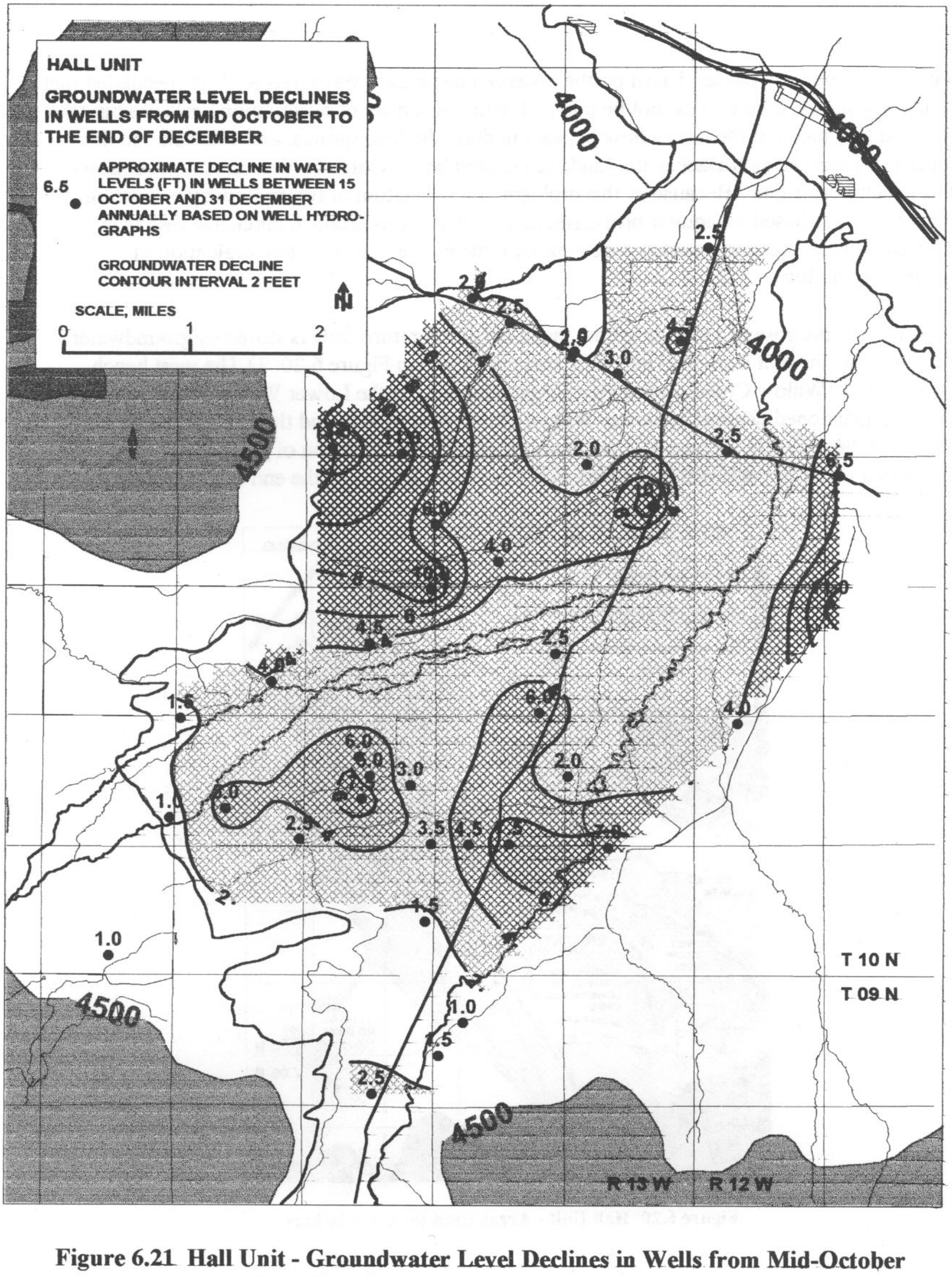


Figure 6.21 Hall Unit - Groundwater Level Declines in Wells from Mid-October to the End of December

Area 1, the west bench north of Lower Willow Creek, is irrigated primarily with water passing through the gage Allendale Canal above Tail End (76GJ08080). On average, about 12,500 acre-feet of water passed this gage each irrigation season during the three-year study period (1994, 1995, and 1996). Based on streamflow measurements, Lorranson Creek flows about 8 cfs during summer months. It is estimated that another 5 to 15 cfs flows out of the many spring-fed coulees eminating from the west bench during the summer. This estimate is based on the flows bypassing the "Flint Creek near Drummond" gaging station. For the approximately 4-month duration of the irrigation season, these outflows can account for about 3,100 to 5,500 acre-feet of water. From the surface-water analysis, crop use is about 1.5 to 1.75 acre-feet per acre. For the approximate irrigated area of 3,600 acres on the west bench, crop use can account for another 5,400 to 6,300 acre-feet. Based on these figures, the amount of Allendale Canal water that could be stored temporarily in the gravelly bench deposits as groundwater ranges from 700 to 4,000 acre-feet.

The gravelly bench deposits are present beneath about 2,800 acres of the irrigated area on the west bench (Area 1). Based on groundwater levels measured in 12 wells on the west bench, the average groundwater level decline from mid-October to the end of December is estimated to be about 6 feet. Assuming that the gravelly bench deposits have a specific yield in the range of 0.15 to 0.20, and that the water levels in the wells completed in confined aquifers reflect conditions in the overlying bench deposits, a 6-foot water-level decline over 2,800 acres would represent some 2,500 to 3,400 acre-feet of water. As discussed below, the results of the surface-water analysis show that this estimate should be reduced by about 25 percent. Much of the return flow from this area would be expected to be visible as surface water in the spring-fed creeks around the edges of the west bench and Lorranson Creek. While many wells on the bench have returned to pre-irrigation levels by the end of December, wells in the vicinity of the Drummond airport continue to decline throughout winter until the next irrigation season, suggesting that some return flow occurs throughout winter. This is observed in the perennial springs in several coulees.

Using the same approach, estimates of the volume of water stored in the other three areas shown in Figure 6.20 can be made. As in the calculated volumes for Area 1, these estimates are shown to be high by the results of the surface-water analysis. The area of the Flint Creek alluvium (Area 2) within the Hall unit is about 6,200 acres. The average water-level decline in 12 wells completed in both the Flint Creek alluvium and the Lower Willow Creek alluvium from mid-October to the end of December was 2.5 feet. A decline of closer to 5 feet was observed east of Hall, so this value was applied to 640 of the 6,200 acres. Again using a specific yield range of 0.15 to 0.20, an estimated 2,550 to 3,400 acre-feet of water is released from the Flint Creek alluvium. The third area, the Lower Willow Creek alluvium, has an area of about 2,500 acres. Using the same fall water-level decline of 2.5 feet used for the Flint Creek alluvium, and the same range of specific yield, about 900 to 1,200 acre-feet of water is released from the Lower Willow Creek alluvium. For Area 4, including both the abandoned channel of Lower Willow Creek and the isolated bench to the north, it is assumed that most of the water-level changes observed on the bench largely reflect head increases in the abandoned channel. This assumption is based on the lack of any appreciable saturation of the gravelly bench deposits in the shallow well FCB6 adjacent to well FCB5, and the fact that sprinkler irrigation is applied on most of the isolated bench with only a few delivery ditches. So for this area, the average groundwater level decline of area wells of 4.5 feet from mid-October to the end of December is considered as mainly dewatering of the shallow alluvial sediments occupying the abandoned channel, which has an area of about 1,300 acres. Assuming a specific yield of 0.15 to 0.2, this represents about 900 to 1,300 acre-feet of return flow.

The combined volume of return flow estimated from the four areas within the Hall unit from mid-October to the end of December by using the groundwater estimates is in the range of 6,850 to 9,300 acre-feet. While these calculations are simple and require certain assumptions, they show that it is possible for the approximate measured surface-water gain volume of 6,000 acre-feet to be stored and released from the groundwater system. The volume of water derived from the surface-water analysis is considered the more accurate volume. For this reason, the groundwater estimates are reduced by 25 percent to match the actual return flow volumes measured in streams.

For the Hall unit, based on the groundwater analysis, it is estimated that about half of the groundwater return flow gains observed during the fall months are stored in the alluvium of Flint Creek and Lower Willow Creek. The approximately 3,000 acre-feet of water stored in the alluvium in mid-October would provide an average of about 20 cfs during the fall months. About 35 or 40 percent of the groundwater return flow from the unit is stored in the gravelly bench deposits west of Flint Creek and north of Lower Willow Creek, providing about another 15 cfs of fall return flow. The remaining 10 to 20 percent is stored in the abandoned channel of Lower Willow Creek west of Hall, contributing another 5 cfs of fall return flow.

The timing and rate of groundwater level declines after the irrigation season in wells throughout the unit generally agree with the timing of surface-water gains. Groundwater levels decline rapidly after the end of the irrigation season when surface-water gains are the greatest, and the rate of decline decreases over the following 2 to 3 months as surface-water gains diminish.

Groundwater storage changes and flow rates in deeper confined aquifers, such as those found in the project wells near the Drummond airport, were also considered. Using the water-level changes observed at wells, the storage coefficients calculated from aquifer test data, and the areal extent of the irrigated bench, total storage changes in the deep shale aquifer in the west bench (Area 1) is less than 10 acre-feet, and the storage change in the confined, deeper portion of the gravelly bench deposits is calculated to be less than 40 acre-feet even if it extends over the entire bench. These volumes are insignificant compared to return flow gains in the basin.

Groundwater return flow would be expected to approach the maximum fall return flow gains determined in the surface-water analysis once groundwater reaches summer high levels. This occurs by the end of June in most wells. If groundwater return flow gains from the Hall unit are about 50 cfs from the beginning of July to mid-October, then 16,600 acre-feet of water is estimated to return to the surface-water system as groundwater irrigation return flow from July to December. This represents about a foot of water spread over the irrigated land in the Hall unit. Recall that for the Boulder unit, a value of 3 feet was calculated. The groundwater storage capacity of the extensive alluvium in most of the Hall unit is limited by shallow water table conditions, causing a greater percentage of excess irrigation water to occur as direct runoff. This could account for much of the difference between the calculated summer and fall groundwater return flows from the Boulder unit and the Hall unit. The difference may also be partly due to more widespread use of sprinkler irrigation systems within the Hall unit compared with the Boulder Unit.

CHAPTER 7 - WATER USAGE AND RETURN FLOWS

Within the overall Flint Creek basin, irrigation usage and resulting return flows have yielded lower streamflows in the spring and summer and higher streamflows in the fall and winter. In addition, the construction of East Fork Rock Creek Reservoir and the interbasin transfer of water into Flint Creek has made more water available in Flint Creek for both agriculture and instream flow uses. Presented in this chapter is an assessment of these human impacts in the Flint Creek basin.

Water usage for a given year is quantified by subtracting the total volume of outflow from the total volume of inflow for each study unit. If the Flint Creek study area is downstream from all reservoirs, then by far the largest consumer of water are plants. In this study, there is no separation of water consumed by either crops or phreatophytes, but a visual inspection of the area shows that irrigated acreage is much larger than the vegetated areas along stream banks.

Although a small amount of return flow enters Flint Creek beyond December 31 of each year, the basin benefits from comparable return flows due to irrigation the previous year. For this reason, the calender year was assumed sufficient to analyze water usage for an irrigation season.

The measured and computed inflows and outflows into the Philipsburg and Drummond valleys are shown in Table 7.1. Water usage is not determined in the Drummond valley during 1995 because limited discharge data were available downstream from Lower Willow Creek Reservoir. The inflows from miscellaneous tributaries were estimated from discharge measurements taken on several tributaries, shown in Appendix C, in combination with the methods presented by Potts (1983) and Parrett and Hull (1985).

The total outflow from the Philipsburg valley is the same as measured at the "Flint Creek at Maxville" (12329500) streamflow-gaging station. The average annual runoff at this site for the period August 1941 to October 1996 is 70,820 acre-feet (Shields et. al, 1997). Therefore, the year 1994, with 59,500 acre-feet of runoff, is considered a drought year, 1995 a close-to-average year, and 1996 an above average year. During these three years, the average annual consumption of irrigation water by plants in the Philipsburg valley was 6,000 acre-feet per year or 0.75 acre-feet per acre of irrigation. In the Drummond valley, the average consumption of irrigation water by plants was between 25,000 and 30,000 acre-feet per year or between 1.5 and 1.75 acre-feet per acre of irrigation.

To determine the distribution of total inflows within each year requires a subjective determination of the runoff patterns of the miscellaneous tributaries. It would be expected that the spring runoff period would occur early because most of the drainage areas not gaged within the Flint Creek basin have lower average elevations than those streams that were gaged. In fact, the high runoff measured in Flint Creek during February of 1995 and 1996 was due to low-elevation snow melt in many of these small tributaries. Nevertheless, the estimate of the runoff pattern requires considerable judgment. Because of these uncertainties, the runoff distribution is estimated for a monthly time step and not the daily time steps used in Chapter 5.

The total inflow distribution into the Flint Creek basin at Maxville for the years 1994, 1995, and 1996 are shown as light-gray bars in Figures 7.1, 7.2, and 7.3. These inflows are the combination of releases from Georgetown Reservoir and East Fork Rock Creek Reservoir and runoff from Fred Burr Creek and the other miscellaneous tributaries. These same light-gray bars could be considered the hydrograph that would occur at Maxville if East Fork Rock Creek Reservoir was diverted into the basin, but not used for irrigation.

Table 7.1 Flint Creek Basin Water Usage in Acre-Feet (Abbrev. ac-ft)

Philipsburg Valley	1994	1995	1996
East Fork Rock Creek Reservoir	19,600 ac-ft	19,000 ac-ft	21,600 ac-ft
Georgetown Reservoir	20,900 ac-ft	25,200 ac-ft	27,300 ac-ft
Fred Burr Creek	5,400 ac-ft	7,100 ac-ft	9,400 ac-ft
Miscellaneous Tributaries	20,000 ac-ft	30,000 ac-ft	33,000 ac-ft
Total Inflow	**65,900 ac-ft**	**81,300 ac-ft**	**91,300 ac-ft**
Total Outflow	**59,500 ac-ft**	**75,900 ac-ft**	**85,000 ac-ft**
Usage by Plants	**6,400 ac-ft**	**5,400 ac-ft`**	**6,300 ac-ft**

Drummond Valley	1994		1996
Philipsburg Valley Outflow	59,500 ac-ft		85,000 ac-ft
Boulder Creek	23,000 ac-ft		37,100 ac-ft
Lower Willow Creek Reservoir	12,000 ac-ft		23,000 ac-ft
Miscellaneous Tributaries	17,000 ac-ft		30,000 ac-ft
Total Inflow	**111,500 ac-ft**		**175,100 ac-ft**
Total Outflow	**87,000 ac-ft**		**144,000 ac-ft**
Usage by Plants	**24,500 ac-ft**		**31,100 ac-ft**

The lines shown in Figures 7.1, 7.2, and 7.3 represent the recorded flows measured at the "Flint Creek at Maxville" (12329500) streamflow-gaging station. The effects of irrigation above Maxville can be observed for all three years by comparing the light-gray bars, representing non-irrigation flows, with the line representing recorded flows at Maxville that includes the influences of irrigation. The use of water by plants and for aquifer recharge is high during the month of June. In 1994 this use was 65 cfs, in 1995 the use was 110 cfs, and in 1996 it was 130 cfs. It was beyond the scope of this study to determine the amount of water that would have been stored in the alluvial aquifers naturally from high water. Therefore, this water is lumped with the water used by irrigators that feeds these aquifers. It is important to note that significant overbank flooding did not occur in Flint Creek in June during any of these three years. Less water was used during June 1994 due most likely to drought conditions and the unavailability of free spilled water from East Fork Rock Creek Reservoir that was available in 1995 and 1996.

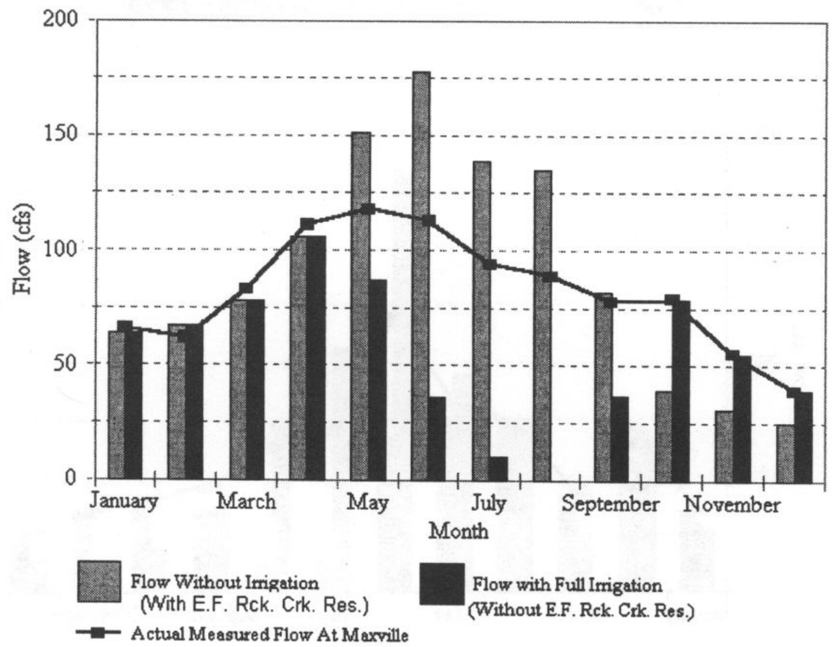


Figure 7.1 Flint Creek at Maxville - 1994

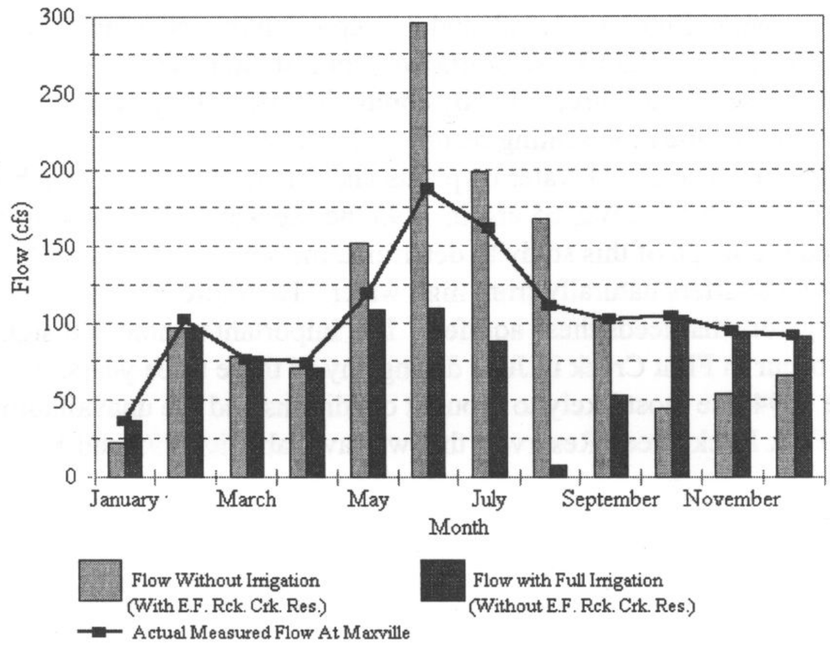


Figure 7.2 Flint Creek at Maxville - 1995

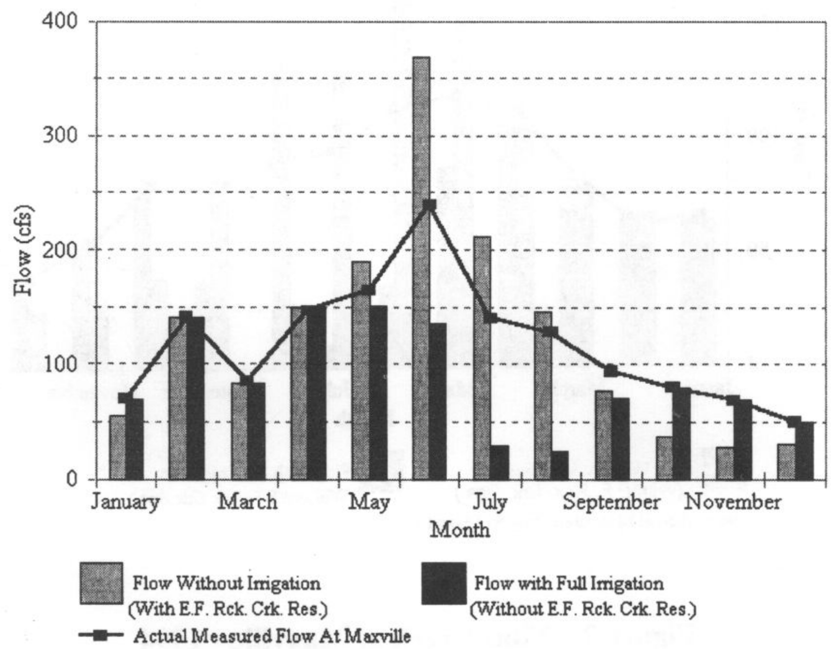


Figure 7.3 Flint Creek at Maxville - 1996

The water use in August for all three years was 45 cfs in 1994, 55 cfs in 1995, and 20 cfs in 1996. The lesser amount of water needed in 1996 could be due to the large amount of East Fork Rock Creek water made available in July to irrigators when, for repairs, larger than normal amounts of water were taken from the reservoir. This could have resulted in August return flows being higher than normal.

The average return flow for the three years in October was 50 cfs, resulting in streamflows almost twice as high as would be observed naturally at Maxville. By February of the following year, the return flows resulting from irrigation are insignificant when compared to the natural flow of Flint Creek.

Shown as the dark gray bars in Figures 7.1, 7.2, and 7.3 are the average monthly flows at Maxville if full irrigation took place but the East Fork Rock Creek Reservoir had not been used. These bars were computed by subtracting the inflows from East Fork Rock Creek Reservoir from the total inflow and then accounting for the effects of irrigation shown by the differences between the line and the light-gray bars. Obviously, this situation is hypothetical because full irrigation would not take place without East Fork Rock Creek Reservoir. Nevertheless, the differences shown between the measured flows at Maxville and the flows that would have occurred without East Fork Rock Creek Reservoir are dramatic. For example, in August 1994, Flint Creek would have been completely dry, but because of the reservoir it ran at nearly 80 cfs. The small differences between the line and dark shaded bars during the months of January through April are attributable to error within this procedure because East Fork Rock Creek Reservoir does not contribute to the Flint Creek basin during these months.

Presented in Figures 7.4 and 7.5 is the same type of analysis for the entire Flint Creek basin for the years 1994 and 1996. Because the Flint Creek outflow is estimated using the procedures discussed in Chapter 4, the error associated with this analysis is greater than the one discussed above. The procedures used are similar to what was used for the Maxville site, but instead, the entire inflow into the basin was considered in the development of Figures 7.4 and 7.5.

The total stored return flow results in an increase of between 80 and 100 cfs in flows into the Clark Fork River during October and November. These return flows become less but remain significant through January. Plant usage and more significantly aquifer recharge can exceed 300 cfs in the spring when water is plentiful. By August, depletion by plants and aquifer recharge is between 100 and 150 cfs within the entire Flint Creek basin.

In addition to the high return flows, Figures 7.4 and 7.5 also reveal the influence of East Fork Rock Creek Reservoir in the hydrology of Flint Creek. If the level of irrigation remained the same in 1994 and 1996, Flint Creek would have been virtually dry at the Clark Fork confluence in both July and August of both years. When it is considered that 1996 was an above average year for precipitation, it is obvious that the East Fork Rock Creek Reservoir project is a major component of the Flint Creek hydrology.

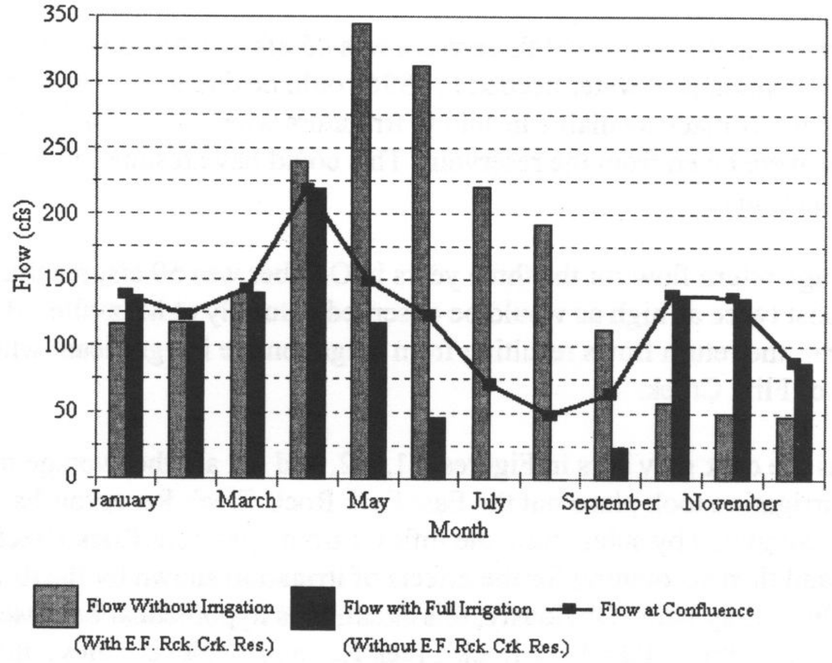


Figure 7.4 Flint Creek into the Clark Fork - 1994

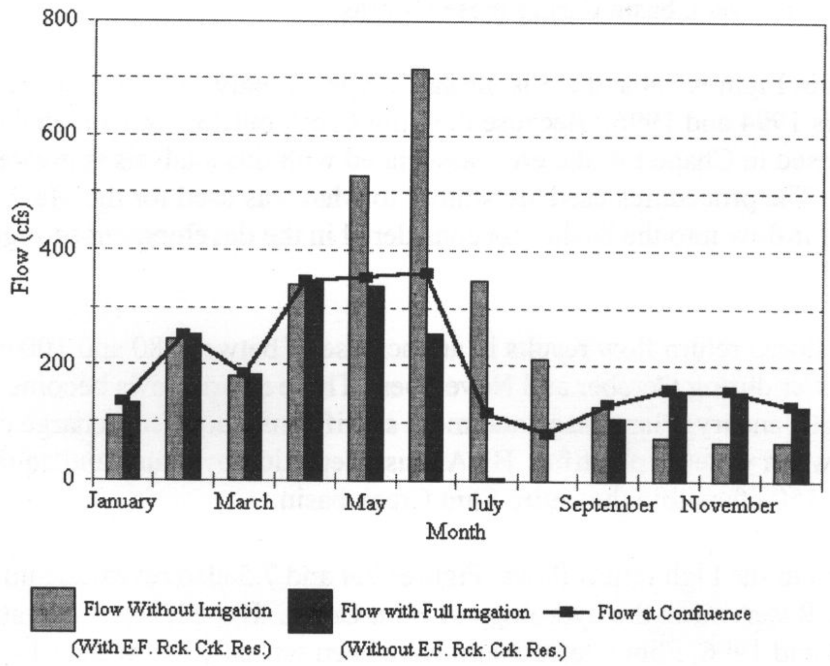


Figure 7.5 Flint Creek into the Clark Fork - 1996

CHAPTER 8 - CONCLUSIONS

Return flows result from ditch leakage and field applications regardless of where flood irrigation occurs in the Flint Creek basin. Soil profile characteristics and the location of irrigation, whether it is in the floodplain alluvium or on elevated areas that form benches or high terraces, are key in determining storage potential and subsequent return flows. Low storage potential results in near immediate return flows back into Flint Creek. High storage potential allows for excess irrigation water to be stored for later release into Flint Creek well into the winter months following the irrigation season.

From the headwaters of Flint Creek to Fred Burr Creek, south of Philipsburg, there is a substantially thick aquifer within the alluvium and beneath the terraces and benches that can absorb and store water. Flows into this reach are enhanced by 30 to 35 cfs by return flows in October, and return flows continue to contribute to Flint Creek well into January of the following year.

Return flow storage between Fred Burr Creek and Maxville is not as significant as in the irrigated areas to the south. After irrigation is completed in mid-September, return flows into Flint Creek are between 15 and 20 cfs in this reach. These return flows become insignificant sometime in November or December. Results of the groundwater study in this area show that there is limited storage potential for irrigation return flow in a large part of the floodplain, and groundwater return flow may be limited by the low permeability of materials underlying the higher ground west of the floodplain.

The irrigated acreage between Maxville and Douglas Creek is small. A significant portion of the irrigated acreage lies within the alluvial valley of Flint Creek. Well levels increase during May and June when streamflows are high and irrigation water is applied to crops. Groundwater levels are essentially sustained throughout the summer, well after spring runoff has occurred. About the middle of September, irrigation is ceased and gains in surface water of between 20 and 25 cfs are apparent while groundwater levels drop. Effects of return flows extend into November or December.

The irrigated acreage between Douglas Creek and the Clark Fork is located on the extensive alluvial deposits of Flint Creek and Lower Willow Creek, and on older deposits that form elevated benches west of Flint Creek. After irrigation is shut off in October, the return flow discharge is between 40 and 50 cfs. The return flow storage potential per acre of the alluvium within this area is limited, but because of its extensive area, it still contributes about half of the fall return flows. These alluvial return flows are largely depleted by the end of each year. The benches and other non-alluvial aquifers provide the remaining half of the return flows once irrigation ceases. These return flows diminish during the fall and early winter but persist into the next irrigation season.

Irrigation water depleted by crops in the Philipsburg valley averages approximately 6,000 acre-feet per year or 0.75 acre-feet per acre irrigated. As much as 7,500 acre-feet is used during June to replenish the aquifers and, to a much smaller extent, water crops. The filling of the aquifer during this month is key in the headwater areas of Flint Creek and Trout Creek above Fred Burr Creek. Flood irrigation in this area during July and August, without the spring application of water, would seriously deplete the water supply of Flint Creek. Flooding of fields between Fred Burr Creek and Maxville during the spring months is not nearly as critical.

Within the Drummond valley, water depleted by irrigated crops averages between 25,000 and 30,000 acre-feet per year, or between 1.5 and 1.75 acre-feet per acre irrigated. As much as 15,000 acre-feet of water is used to replenish aquifers during the month of June. These areas are spread throughout the valley. After June, the extensive alluvial aquifers are largely filled, and excess irrigation water returns almost immediately to Flint Creek. On the benches, some aquifers continue to be filled through the entire irrigation season.

The total amount of return flow from Flint Creek into the Clark Fork amounts to between 80 and 100 cfs during the months of October and November. This amount decreases during the winter months and becomes quite small but still measurable by February of the next year. In a sense, for downstream irrigators, the more immediate return flows from floodplain aquifers with shallow water tables may be more valuable. This excess irrigation water is available for immediate use downstream. In the aquifers with more storage potential, much of the water diverted in the spring is used to fill aquifers. During the summer, much of the water diverted is needed to maintain the aquifers at high levels. The benefit to streamflows is not fully realized until the fall months.

The most dramatic change within the Flint Creek basin was the construction of East Fork Rock Creek Reservoir in 1938. During the drought year of 1994, summer flows into Flint Creek were almost doubled by releases from this reservoir. Because much of the water diverted from this project is used to replenish aquifers or reenters the stream immediately as return flow, many irrigators have benefited from this project whether they belong to the Flint Creek Water Users Association or not.

Although less water is diverted to irrigate the same amount of land under sprinkler than flood, the amount of water consumed by plants is similar. The excess water used for flood irrigation eventually returns to the stream. Modification of water rights from flood to sprinkler systems would reduce water availability within the Flint Creek basin if more land were put into irrigation. Because of the availability of stored water in East Fork Rock Creek Reservoir and Lower Willow Creek Reservoir, conversion from flood to sprinkler systems on existing irrigated lands would have minimal impact to ranchers who have contracts for this water. But the impact to decreed water right users, who have benefited from return flows from both projects, would likely be significant during drought years.

Allowing increased flood irrigation (and to a lesser extent sprinkler irrigation) on new lands--only during the spring runoff period--would increase water availability during the summer months. The benefits would be linked to the aquifer characteristics and other physical properties associated with such irrigation. The model being completed by the U.S. Bureau of Reclamation will provide greater detail regarding many of these issues.

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APPENDIX A

Flint Creek Return Flow Study Monitoring Wells

APPENDIX A

FLINT CREEK RETURN FLOW STUDY MONITORING WELLS

WELL ID	LOCATION	NAME	DEPTH	MAP ELEVATION	USGS LOCAL NUMBER	MBMG #
FC01	10N12W17BBDB	PARKE	45	4040		
FC02	10N12W18AAAC	USDA SCS WELL 2	6	4030		
FC03	10N12W07CDCC	LACEY	40	4030		M:63198
FC04	10N12W07CCBB	USDA SCS WELL 1	6	4040		
FC05	10N13W12BDAC	LOUMA	137	4150	10N13W12BDDA01	M:5806
FC06	10N12W18CBAC	LACEY	65	4050		M:130196
FC07	01N13W02DCCC	BAKER	105	4200		M:127478
FC08	10N13W02CDBB	MENTZER	60	4100		M:63231
FC09	10N12W06BCCA	ANDERSON	85	4040		
FC10	10N12W30BABD	BOWERS	36	4120	10N12W30BABD01	M:5804
FC11	10N13W25BCCC	STRUNA	19	4160		
FC12	09N13W27BCDD	RANSFORD	40	4524	09N13W27BCDD01	
FC13	09N13W15BABA	CONN	55	4340		M:126208
FC14	09N13W28CBAA	HAMILTON	27	4535	09N13W28CBAA01	M:5516
FC15	10N13W13CACC	BROWNING	90	4150		M:63252
FC16	10N12W20BBCB	VERLANIC	100	4090		M:130197
FC17	10N13W14CDAA	MCGOWEN	60	4220		M:63254
FC18	10N13W10DCDD	MENTZER	200	4260		M:63237
FC19	10N13W10CCDD	MENTZER	165	4350		M:63235
FC20	10N13W13CABD	MCGREGOR	230	4130		M:63251
FC21	10N13W13ACAC	MCGREGOR	134	4090		M:63249
FC22	10N13W26DCCC	THOMAS	70	4180		M:63339
FC23	10N13W22AAAA	MONTGOMERY	65	4260		
FC24	10N13W10CCCC	MENTZER	380	4380		
FC25	10N13W36BABA	HEADY	34	4164	10N13W36BABA01	M:63344
FC26	10N13W27CADA	SKINNER	55	4270		M:63307
FC27	09N13W15BDBA	CONN	55	4375		M:126207
FC28	10N13W23DDCC	WALLACE CEDAR LANE RANCH	99	4200		M:63269
FC29	10N13W21DBDD	MCGOWEN	?	4280		
FC30	10N13W23DAAB	PRUITT	100	4190		M:63266
FC31	10N13W28BBBB	LUND	62	4345		M:63308

FLINT CREEK RETURN FLOW STUDY MONITORING WELLS (CONTINUED)

WELL ID	LOCATION	NAME	DEPTH	MAP ELEVATION	USGS LOCAL NUMBER	MBMG #
FC32	10N13W29ABDD	HAUPTMAN SWISS RANCH	50	4360	10N13W29ABDD01	
FC34	10N13W28DDDD	SKINNER	92	4310		M:63310
FC35	10N13W32DCBC	PETERSON	120	4435		
FC36	10N13W27DDDD	SKINNER	97	4240		M:130198
FC37	10N13W34DAAC	JOHNSON	88	4240	10N13W34DAAC01	M:63327
FC38	09N13W02CBBC	CONN	35	4250	09N13W02CBBC01	M:5515
FC39	09N13W03DCCB	HAUPTMAN	26	4295		
FC40	09N13W10DCCC	SKAW ANDERSEN OPEN CROSS RANCH	23	4330	09N13W10DCCC01	M:59379
FC41	11N12W30DCCC	PFENDLER	48	3960		M:65787
FC42	07N14W09CCCD	COLLINS MARSHALL CR RANCH	125	5245		M:55950
FC43	07N14W26ADDD	MT DEPT OF TRANSPORTATION	81	5155		M:55965
FC44	06N14W27ABAA	PAULSEN	146	5401		M:53632
FC45	06N14W32CBBB	MCCLAIN	95	5550		M:53637
FC46	07N14W26BBAB	WALDBILLIG	12	5105		
FC47	09N13W02BCAD	JOHNSON	?	4245		
FC48	10N13W22BDDA	CORLETT	85	4290	10N13W22BDDA01	M:63262
FC49	10N13W27BDDD	HENDRIX HENDRIX RANCH	108	4310		
FC50	07N14W11DCCA	KESLER	97	5045		M:124439
FC51	07N14W11CBDA	KESLER	30	5035		M:55953
FC52	07N14W11CCAA	KESLER	120	5055		M:55954
FC53	07N14W22DDCC	JOHNSON	14	5110		M:55959 ?
FC54	07N14W26CDDC	VIETOR	65	5150		
FC55	07N14W35CBCB	MCDONALD	68	5180		
FC56	06N14W03DDAB	MCDONALD	44	5230		M:53610
FC57	06N14W03DDBA	MCDONALD	44	5235		M:53609
FC58	07N14W34DAAD	MCDONALD	12	5180		
FC59	07N14W36BADA	ZIEGLER	125	5280		M:55981
FC60	06N14W02DCDB	HOLLINGSWORTH	?	5300		

FLINT CREEK RETURN FLOW STUDY MONITORING WELLS (CONTINUED)

WELL ID	LOCATION	NAME	DEPTH	MAP ELEVATION	USGS LOCAL NUMBER	MBMG #
FC61	06N14W11CBAB	HOUG	200	5280		
FC62	06N14W10ACBB	CHOR	60	5240		M:53611? M:53612?
FC63	06N14W15CDAD	METESH	42	5320		
FC64	06N14W21AAAA	YARDLEY	33 ?	5320		
FC65	06N14W27BABA	METESH	110	5390		M:53634?
FC66	06N14W33AAAA	LORD	40	5390		M:53639
FC67	06N14W33DBBC	LORD	50	5395		
FC68	06N14W32DBBB	DALLASERRE	?	5480		
FC69	05N15W12DCDD	LORD	155	5790		
FC70	10N13W12BBCC	SWANSON	45	4160		M:63240
FC71	10N13W12AAAC	OHRMANN	80	4050		
FC72	6N14W28ACBB	DENNIS	50	5365		M:53636
FLINT CREEK RETURN FLOW STUDY - PROJECT WELLS						
FCA1	10N13W14CBBB	MCGOWEN	160	4250		M:154583
FCA2	10N13W14CBBB	MCGOWEN	60	4250		M:154584
FCA3	10N13W14CBBB	MCGOWEN	48	4250		M:154585
FCA4	10N13W14CBBB	MCGOWEN	160	4250		M:154586
FCB1	10N13W27DABA	SKINNER	130	4280		M:154587
FCB2	10N13W26CDCC	SKINNER	40	4220		M:154588
FCB3	10N13W26CDCC	SKINNER	40	4220		M:154589
FCB4	10N13W28DBCB	SKINNER	80	4345		M:154590
FCB5	10N13W27ACBB	HENDRIX HENDRIX RANCH	140	4310		M:154591
FCB6	10N13W27ACBB	HENDRIX HENDRIX RANCH	40	4310		M:154592
FCC1	06N14W27CBBB	DENNIS	140	5390		M:154593
FCC2	06N14W21DBCB	MCCLAIN	150	5330		M:154594
FCD1	07N14W21ADAD	WALDBILLIG	140	5220		M:154595
FCE1	10N13W13BBAB	KESLER	60	4160		M:154596
FCE2	10N13W12BBCC	BRADSHAW	160	4165		M:154597
FCF1	07N14W35CDDD	MCDONALD	20	5230		M:154598

APPENDIX B

Well Log Sources

APPENDIX B

WELL LOG SOURCES

WELL ID	SOURCE*	LOCATION				NAME	DEPTH (FT)	SWL
WL01	M:63241	10N	13W	12	BD	BRADSHAW	140	60
WL02	M:63246	10N	13W	13	AB	NELSON	135	41
WL03	M:63244	10N	13W	12	DCA	DIMAGGIO	78	20
WL04	C032269	10N	13W	12	DAC	LACEY	65	15
WL05	M:63219	10N	12W	18	CC	JEMISON	40	10
WL06	M:63218	10N	12W	18	BB	SPINCER	57	
WL07	M:63250	10N	13W	13	C	HENDERSON	55	2
WL08	M:123122	10N	12W	17	BB	VERLANIC	80	25
WL09	M:120441	10N	13W	36	BB	EAGLE STUD MILL	140	5
WL10	M:132269	10N	13W	22	AB	MANLEY	140	46
WL11	M:63319	10N	13W	32	DCB	PETERSON	60	10
WL12	M:63298	10N	13W	26	DC	NELSON	95	26
WL13	M:63297	10N	13W	26	DC	HOUSEHOLDER	50	13
WL14	M:63299	10N	13W	26	DC	CUNNINGHAM	40	7
WL15	M:63331	10N	13W	35	AB	WILLIAMS	100	28
WL16	M:63340	10N	13W	35	BAA	GRANITE COUNTY	50	15
WL17	C013147	10N	13W	35	BAA	ROBINSON	70	15
WL18	M:63332	10N	13W	35	B	WESTERN MT CO-OP	85	10
WL19	M:63314	10N	13W	31	DBDD	MASON	33	10
WL20	M:63315	10N	13W	32	B	MASON	50	10
WL21	M:59371	09N	13W	03	DC	JENSEN	30	7
WL22	M:59378	09N	13W	10	DA	COMINCO AMERICAN	50	30
WL23	M:59382	09N	13W	21	DCC	WIGHT	60	50
WL24	M:132262	09N	13W	27	CA	WIGHT	40	14
WL24	M:59391	09N	13W	33	DDC	CRONIN	52	30
WL26	M:63191	10N	12W	06	BB	MONTANA STATE	115	45
WL27	W006796	10N	12W	06	BBC	SKAGGS	100	60
WL28	M:63192	10N	12W	06	BBA	APPLEGATE	109	7
WL29	M:63197	10N	12W	06	CBB	GREANY	85	58
WL30	M:63195	10N	12W	06	BC	REEVES	80	63
WL31	M:63187	10N	12W	06		WANGLER	120	60
WL32	M:63194	10N	12W	06	BC	WANGLER	100	62
WL33	M:5801	10N	12W	06	BBAA	DRUMMOND COMMUN	125	50
WL34	M:63207	10N	12W	17	BA	VALLEY CEMETERY	227	104
WL35	M:124548	10N	12W	18	BA	SPENCER	50	10
WL36	M:63230	10N	13W	01	DD	BRADSHAW	70	31
WL37	M:63239	10N	13W	12	AAD	LDS CHURCH	120	60
WL38	M:63243	10N	13W	12	DAB	ALLEN	114	23
WL39	M:63253	10N	13W	13	CDC	JACOBSEN	73	35
WL40	M:137473	10N	13W	21	BD	MCGOWAN RANCH	150	41
WL41	M:63260	10N	13W	21	DA	MCGOWEN	36	5
WL42	M:63268	10N	13W	23	DCB	HENDERSON	115	50
WL43	M:63280	10N	13W	26	AB	CEDER LANE RANCH	100	18
WL44	M:63283	10N	13W	26	CA	WALLACE	90	
WL45	M:63282	10N	13W	26	BC	PERKINS	95	23
WL46	M:63306	10N	13W	27	BD	HENDRIX	85	45
WL47	M:121482	10N	13W	29	AA	SWISS RANCH	83	10
WL48	M:63313	10N	13W	29	DD	DIAMOND BAR RANC	45	10
WL49	M:63312	10N	13W	29	BC	OLSEN	48	11
WL50	M:63318	10N	13W	32	DAA	HAUPTMAN	95	14

* Numbers begining with "M:" are Montana Bureau of Mines and Geology identification numbers, all others are Mont Department of Natural Resources and Conservation water right numbers

APPENDIX B (continued)

WELL LOG SOURCES

WELL ID	SOURCE	LOCATION				NAME	DEPTH (FT)	SWL
WL51	M:63325	10N	13W	33	CA	JAMES RANCH CORP	70	18
WL52	M:53623	06N	14W	22	BA	PAGE	150	30
WL53	M:53630	06N	14W	26	CC	RUTTIG	178	76
WL54	M:53635	06N	14W	27	DDB	DENNIS	140	40
WL55	M:55969	07N	14W	26	DC	WICKBERG	40	21
WL56	M:55974	07N	14W	35	ACAA	MCDONALD	52	22
WL57	M:55980	07N	14W	36	BA	CITY OF PHILLIPS	90	38
WL58	M:55983	07N	14W	36	CACC	HEIMARK	68	48
WL59	M:53613	06N	14W	10	CCAC	HAACKE	82	16
WL60	M:53614	06N	14W	11	ABDD	ANDRE	141	77
WL61	M:53620	06N	14W	22	A	MUNIS	96	40
WL62	M:53621	06N	14W	22	ABAB	GROOMES	140	18
WL63	M:53622	06N	14W	22	ACAB	GROOMES	73	10
WL64	M:53619	06N	14W	22	A	GROOMES	42	12
WL65	M:53624	06N	14W	22	BDDC	YARDLEY	58	11
WL66	M:53625	06N	14W	22	CD	SMITH	31	9
WL67	M:130482	06N	14W	26	CBC	MCGUIRE	170	46
WL68	M:53634	06N	14W	27	BA	METESH	86	17
WL69	M:128661	06N	14W	27	DA	BATES	360	134
WL70	M:55952	07N	14W	11	ACD	ROBISON	120	50
WL71	M:55957	07N	14W	11	DD	KESLER	80	35
WL72	M:124440	07N	14W	11	DD	PRICE	200	85
WL73	M:55970	07N	14W	26	DDC	ROCKING CHAIR RA	101	
WL74	M:55973	07N	14W	35	AA	VIETOR	37	8
WL75	M:55956	07N	14W	11	DBA	TROTTER	158	55

APPENDIX C

Synoptic Flow Measurements in the Flint Creek Basin

Synoptic Flow Measurements in the Flint Creek Basin

Measurements Taken by USGS and DNRC

----- Station="Clark Fork above Flint Creek near Drummond" ID=12324890 ------

Date	Flow (cfs)	Temperature (Celcius)	Conductivity (micro Mho)
10MAR94	404	4.5	
22MAR94	385	3.3	442
30JUN94	187	15.1	460
28JUL94	124	19.0	416
18AUG94	67	13.7	520
14SEP94	80	11.5	535
15NOV94	330	0.0	503
23MAR95	370	4.0	465
06APR95	384	7.5	464
08AUG95	234	14.0	434
16AUG95	193	15.7	444
29AUG95	153	16.0	486
26SEP95	400	9.2	475
18OCT95	457	7.4	447
09JUL96	414	16.4	385
23JUL96	284	15.4	425
08AUG96	211	14.2	462
10SEP96	198	12.5	500
24SEP96	299	7.1	483
13NOV96	406	2.0	454

---------- Station="Flint Creek near Southern Cross" ID=12325500 ----------

Date	Flow (cfs)	Temperature (Celcius)	Conductivity (micro Mho)
17MAY94	29		
25MAY94	48	10.0	208
29JUN94	27	14.0	194
14JUL94	31	16.0	180
18AUG94	30	16.0	170
15SEP94	30	15.0	164
29SEP94	29	12.0	165
25OCT94	13	6.0	180
16NOV94	14	4.0	196
20APR95	27		
09MAY95	31	6.5	245
09AUG95	32	14.5	180
30AUG95	32	13.5	170
26SEP95	33	12.0	179
19OCT95	33	6.5	160
03JUL96	46		
01AUG96	31		
25SEP96	31		
14NOV96	16		

Synoptic Flow Measurements in the Flint Creek Basin

Measurements Taken by USGS and DNRC

--------------------- Station="Yandell Ditch" ID=' ' ---------------------

Date	Flow (cfs)	Temperature (Celcius)	Conductivity (micro Mho)
17MAY94	10		
25MAY94	9		
29JUN94	13		
14JUL94	15		
18AUG94	18		
15SEP94	19		
29SEP94	20		
25OCT94	4		
16NOV94	0		
09AUG95	9		
26SEP95	4		
19OCT95	0		

------- Station="Flint Creek Main Canal below Head Gate" ID=76E 02000 -------

Date	Flow (cfs)	Temperature (Celcius)	Conductivity (micro Mho)
17MAY94	0		
25MAY94	85		
29JUN94	106		
14JUL94	85		
18AUG94	129		
15SEP94	82		
29SEP94	0		
25OCT94	0		
16NOV94	0		
08JUN95	93		
15JUN95	114		
18JUL95	73		
09AUG95	154		
23AUG95	146		
30AUG95	142		
27SEP95	10		
19OCT95	0		
03JUL96	150		
01AUG96	153		
11SEP96	30		
25SEP96	0		
14NOV96	0		

----- Station="Flint Creek Main Canal above County Road Bridge" ID=' ' ------

Date	Flow (cfs)	Temperature (Celcius)	Conductivity (micro Mho)
08JUN95	68		
15JUN95	82		
18JUL95	53		
09AUG95	123		

Synoptic Flow Measurements in the Flint Creek Basin

Measurements Taken by USGS and DNRC

----- Station="Flint Creek Main Canal above County Road Bridge" ID=' ' ------
(continued)

Date	Flow (cfs)	Temperature (Celcius)	Conductivity (micro Mho)
23AUG95	108		
30AUG95	113		
27SEP95	7		
19OCT95	0		
01AUG96	117		
11SEP96	18		
26SEP96	0		
14NOV96	0		

-- Station="Flint Creek Main Canal below County Road Bridge" ID=76GJ02089 ---

Date	Flow (cfs)	Temperature (Celcius)	Conductivity (micro Mho)
17MAY94	0		
25MAY94	64		
29JUN94	53		
14JUL94	46		
18AUG94	110		
15SEP94	56		
29SEP94	0		
25OCT94	0		
16NOV94	0		
08JUN95	46		
15JUN95	60		
18JUL95	53		
09AUG95	102		
23AUG95	87		
30AUG95	83		
27SEP95	0		
19OCT95	0		
03JUL96	92		
01AUG96	102		
25SEP96	0		
14NOV96	0		

----------- Station="Marshall Canal below Head Gate" ID=76GJ04000 -----------

Date	Flow (cfs)	Temperature (Celcius)	Conductivity (micro Mho)
17MAY94	0		
25MAY94	30		
29JUN94	25		
14JUL94	28		
18AUG94	25		
15SEP94	14		
29SEP94	0		
25OCT94	0		
16NOV94	0		

Synoptic Flow Measurements in the Flint Creek Basin

Measurements Taken by USGS and DNRC

----------- Station="Marshall Canal below Head Gate" ID=76GJ04000 -----------
(continued)

Date	Flow (cfs)	Temperature (Celcius)	Conductivity (micro Mho)
08JUN95	37		
15JUN95	34		
18JUL95	23		
09AUG95	25		
23AUG95	28		
30AUG95	30		
27SEP95	0		
19OCT95	0		
03JUL96	47		
01AUG96	44		
25SEP96	0		
14NOV96	0		

----- Station="Trout Creek below Marshall Canal Diversion" ID=76GJ05000 -----

Date	Flow (cfs)	Temperature (Celcius)	Conductivity (micro Mho)
17MAY94	1.0		
25MAY94	25.0	10.5	207
29JUN94	0.0	12.5	255
14JUL94	20.0	11.0	215
18AUG94	65.0	12.0	208
15SEP94	35.0	12.0	227
29SEP94	9.0	7.0	290
25OCT94	7.5	4.0	279
16NOV94	9.4	3.0	
09MAY95	7.5	15.0	235
08JUN95	17.0		
15JUN95	5.0		
18JUL95	31.0		
09AUG95	63.0	8.0	165
23AUG95	41.0		
30AUG95	38.0	18.5	145
27SEP95	15.0	6.0	245
19OCT95	10.0	4.0	240
30OCT95	11.0	1.7	269
03JUL96	22.0		
01AUG96	71.0		
25SEP96	18.0		

Synoptic Flow Measurements in the Flint Creek Basin

Measurements Taken by USGS and DNRC

--- Station="Spring Creek along Montana Highway 1 near Philipsburg" ID=' ' --

Date	Flow (cfs)	Temperature (Celcius)	Conductivity (micro Mho)
26MAY94	5.0		
29JUN94	2.3		
09MAY95	2.0		
08JUN95	6.0		
15JUN95	7.0		
18JUL95	4.0		

---- Station="Marshall Canal at Chor Ranch near Philipsburg" ID=12326420 ----

Date	Flow (cfs)	Temperature (Celcius)	Conductivity (micro Mho)
24MAY95	15		
26MAY95	16		
08JUN95	30		
15JUN95	27		
09AUG95	18		
30AUG95	21		
03JUL96	34		
01AUG96	23		
25SEP96	0		
14NOV96	0		

- Station="Flint Creek above Fred Burr Creek near Philipsburg" ID=12327090 --

Date	Flow (cfs)	Temperature (Celcius)	Conductivity (micro Mho)
17MAY94	39	7.00	263
25MAY94	64	14.00	254
29JUN94	38	14.00	304
14JUL94	62	15.00	288
18AUG94	96	10.00	260
15SEP94	81	14.00	273
29SEP94	53	7.75	290
25OCT94	46	6.00	288
16NOV94	43	4.50	281
20APR95	50		
09MAY95	63	15.00	210
15JUN95	103	9.00	240
09AUG95	114	7.50	233
30AUG95	77	10.00	250
27SEP95	71	7.50	276
19OCT95	61	6.30	230
03JUL96	95		
01AUG96	116		
25SEP96	70	7.50	276
14NOV96	48	6.30	230

Synoptic Flow Measurements in the Flint Creek Basin

Measurements Taken by USGS and DNRC

---------- Station="Fred Burr Creek near Philipsburg" ID=12327100 ----------

Date	Flow (cfs)	Temperature (Celcius)	Conductivity (micro Mho)
17MAY94	24.0	5.0	32
25MAY94	32.0	11.0	33
29JUN94	0.6		
14JUL94	6.8	19.0	60
18AUG94	0.7	12.0	94
15SEP94	0.9	13.0	85
29SEP94	0.8		
25OCT94	0.9	2.0	74
16NOV94	0.9	0.0	72
20APR95	2.8		
09MAY95	15.0	9.5	33
15JUN95	89.0	5.5	18
18JUL95	17.0		
09AUG95	3.6	9.0	62
30AUG95	0.1		
27SEP95	0.6	7.5	126
19OCT95	4.7	4.0	65
03JUL96	28.0		
01AUG96	2.2		
25SEP96	3.5		

---------- Station="Dirty Dick Creek near Philipsburg" ID=' ' ----------

Date	Flow (cfs)	Temperature (Celcius)	Conductivity (micro Mho)
26MAY94	0.8		

---------- Station="Douglas Creek at Philipsburg" ID=' ' ----------

Date	Flow (cfs)	Temperature (Celcius)	Conductivity (micro Mho)
26MAY94	3.2		
29JUN94	1.5		
09MAY95	2.5		

---------- Station="Camp Creek at Philipsburg" ID=' ' ----------

Date	Flow (cfs)	Temperature (Celcius)	Conductivity (micro Mho)
26MAY94	0.7		
09MAY95	0.7		

Synoptic Flow Measurements in the Flint Creek Basin

Measurements Taken by USGS and DNRC

------------- Station="Flint Creek at Philipsburg" ID=12327400 -------------

Date	Flow (cfs)	Temperature (Celcius)	Conductivity (micro Mho)
17MAY94	66.1	7.3	189
25MAY94	88.5	17.0	186
29JUN94	32.8		300
14JUL94	58.2	19.5	263
18AUG94	73.9	11.0	268
15SEP94	76.7	15.0	274
29SEP94	48.5	8.0	300
25OCT94	54.7	8.0	279
16NOV94	47.5	2.0	
20APR95	56.2	4.0	255
09AUG95	119.0	10.0	230
30AUG95	84.5	11.0	250
27SEP95	79.3	9.0	275
19OCT95	80.3	5.5	250
03JUL96	136.0	14.5	228
01AUG96	117.0	16.5	255
25SEP96	77.0	9.5	272
14NOV96	53.0	4.7	266

------ Station="Marshall Creek at mouth near Philipsburg" ID=12328000 -------

Date	Flow (cfs)	Temperature (Celcius)	Conductivity (micro Mho)
21APR94	21.1	10.0	
17MAY94	5.0		
25MAY94	9.2	19.0	118
29JUN94	2.9	15.0	179
14JUL94	2.4	20.0	190
18AUG94	0.3	12.0	285
15SEP94	0.7	16.0	271
25OCT94		6.0	207
04APR95	3.1	2.0	75
20APR95	6.2	2.5	94
09MAY95	26.0	10.0	35
26JUL95	12.3	17.0	186
09AUG95	0.5	18.0	186
30AUG95	0.5	18.0	186
27SEP95	0.7	8.1	200
19OCT95	0.4	4.5	170
03JUL96	4.2	16.7	167

----------- Station="Flint Creek near Philipsburg" ID=12328500 ------------

Date	Flow (cfs)	Temperature (Celcius)	Conductivity (micro Mho)
17MAY94	75.6	8.5	206
25MAY94	109.0		
29JUN94	44.5	14.0	330
14JUL94	66.0	19.0	290

Synoptic Flow Measurements in the Flint Creek Basin

Measurements Taken by USGS and DNRC

------------ Station="Flint Creek near Philipsburg" ID=12328500 -------------
(continued)

Date	Flow (cfs)	Temperature (Celcius)	Conductivity (micro Mho)
18AUG94	81.4	12.0	288
15SEP94	88.0	16.0	295
28SEP94	60.7	12.0	320
17OCT94	88.3	8.0	300
25OCT94	71.6	7.0	311
15NOV94	51.5	0.0	
16NOV94	58.0	1.0	
20APR95	70.7	5.0	255
27APR95	73.0	7.0	256
09MAY95	130.0	7.0	205
15JUN95	234.0	7.5	165
06JUL95	149.0	15.0	243
26JUL95	103.0	15.5	262
09AUG95	125.0	11.5	250
30AUG95	83.0	12.0	270
27SEP95	88.0	9.0	295
19OCT95	93.0	5.3	244
03JUL96	150.0		
01AUG96	140.0		
25SEP96	92.0		
14NOV96	61.0		

-------------- Station="Flint Creek at Maxville" ID=12329500 --------------

Date	Flow (cfs)	Temperature (Celcius)	Conductivity (micro Mho)
16MAY94	89		
17MAY94	89		
25MAY94	114	17.0	215
29JUN94	58		337
30JUN94	52		341
14JUL94	86		
14JUL94	82	18.0	300
17AUG94	88	18.0	280
18AUG94	82	13.0	295
15SEP94	89	15.0	302
28SEP94	66	11.0	325
29SEP94	66	9.0	350
17OCT94	94	7.5	300
25OCT94	73	6.5	313
15NOV94	53	0.0	
16NOV94	60	1.0	
20APR95	83	6.0	264
09MAY95	135	6.0	205
10MAY95	132		
15JUN95	211	11.0	186
06JUL95	154	16.5	246
26JUL95	99	14.5	262
09AUG95	131	12.0	256
30AUG95	85	12.5	280

Synoptic Flow Measurements in the Flint Creek Basin

Measurements Taken by USGS and DNRC

--------------- Station="Flint Creek at Maxville" ID=12329500 ---------------
(continued)

Date	Flow (cfs)	Temperature (Celcius)	Conductivity (micro Mho)
27SEP95	94	9.0	290
19OCT95	131	5.5	272
30OCT95	106	2.6	273
03JUL96	163		
01AUG96	147		
02AUG96	149		
25SEP96	94		
14NOV96	71		

--------------- Station="Boulder Creek at Maxville" ID=12330000 ---------------

Date	Flow (cfs)	Temperature (Celcius)	Conductivity (micro Mho)
16MAY94	104		
30JUN94	28		151
14JUL94	29		
17AUG94	14	14	193
15SEP94	8	12	197
28SEP94	6	9.5	200
25OCT94	18	5.5	191
15NOV94	17	0.0	
20APR95	15		
10MAY95	48	4.0	150
09AUG95	17	10.3	164
30AUG95	8	10.0	170
27SEP95	20	9.0	179
19OCT95	33	4.5	137
30OCT95	24	2.0	173
02AUG96	18		
25SEP96	24		
14NOV96	22		

--------------- Station="Smart Creek near Maxville" ID=' ' ---------------

Date	Flow (cfs)	Temperature (Celcius)	Conductivity (micro Mho)
08JUN95	4		
14JUN95	3		
18JUL95	3		

Synoptic Flow Measurements in the Flint Creek Basin

Measurements Taken by USGS and DNRC

-- Station="Flint Creek at Henderson Creek Road near Maxville" ID=12330200 --

Date	Flow (cfs)	Temperature (Celcius)	Conductivity (micro Mho)
17AUG94	105.7	16.0	280
15SEP94	98.7	12.5	300
28SEP94	73.8	10.5	325
25OCT94	88.1	5.0	305

---------- Station="Allendale Canal below Head Gate" ID=76GJ0800 ----------

Date	Flow (cfs)	Temperature (Celcius)	Conductivity (micro Mho)
16MAY94	91		
30JUN94	78		
14JUL94	73		
17AUG94	69		
15SEP94	60		
29SEP94	51		
25OCT94	0		
15NOV94	0		
31MAY95	100		
14JUN95	88		
18JUL95	57		
09AUG95	81		
15AUG95	75		
30AUG95	63		
26SEP95	29		
19OCT95	0		
30OCT95	0		
28MAY96	32		
02AUG96	99		
25SEP96	39		
14NOV96	0		

- Station="Flint Creek below Allendale diversion near Maxville" ID=12330500 -

Date	Flow (cfs)	Temperature (Celcius)	Conductivity (micro Mho)
17AUG94	45.4	16.0	285
15SEP94	43.9	12.3	300
29SEP94	35.3	9.5	330
25OCT94	98.7	5.0	305
15NOV94	69.1	0.0	
09AUG95	88.4	14.0	260
30AUG95	43.4	13.0	315
27SEP95	98.1	10.0	262
30OCT95	127.0	2.9	238
02AUG96	73.0	13.9	285
25SEP96	95.0	5.6	290
14NOV96	96.0	3.7	278

Synoptic Flow Measurements in the Flint Creek Basin

Measurements Taken by USGS and DNRC

------------ Station="Misc. Ditches near Allendale Canal" ID=' ' ------------

Date	Flow (cfs)	Temperature (Celcius)	Conductivity (micro Mho)
16MAY94	10.0		
30JUN94	8.8		
14JUL94	4.2		
17AUG94	13.2		
15SEP94	23.7		
29SEP94	24.6		
25OCT94	0.0		
15NOV94	0.0		
09AUG95	38.0		
30AUG95	31.5		
19OCT95	2.4		
30OCT95	2.1		
02AUG96	35.0		
25SEP96	1.0		
14NOV96	2.5		

------------ Station="Flint Creek near Allendale Canal" ID=' ' ------------

Date	Flow (cfs)	Temperature (Celcius)	Conductivity (micro Mho)
16MAY94	61.5		

---------------- Station="Douglas Creek near Hall" ID=' ' ----------------

Date	Flow (cfs)	Temperature (Celcius)	Conductivity (micro Mho)
30JUN94	4		
14JUL94	3		
15SEP94	2		
28SEP94	3		
15NOV94	4		
08JUN95	9		
14JUN95	17		
18JUL95	10		
30AUG95	2		

------ Station="Flint Creek below Douglas Creek near Hall" ID=12331100 ------

Date	Flow (cfs)	Temperature (Celcius)	Conductivity (micro Mho)
16MAY94	86.8	9.0	184
30JUN94	27.2		384
14JUL94	71.8	14.8	305
17AUG94	37.2	14.0	325
15SEP94	35.8	12.0	290
28SEP94	17.9	10.8	355
25OCT94	112.0	4.0	305

Synoptic Flow Measurements in the Flint Creek Basin

Measurements Taken by USGS and DNRC

------ Station="Flint Creek below Douglas Creek near Hall" ID=12331100 ------
(continued)

Date	Flow (cfs)	Temperature (Celcius)	Conductivity (micro Mho)
15NOV94	84.7	0.0	
19APR95	96.0	8.0	
09AUG95	55.0	16.0	302
30AUG95	25.0	16.0	375
27SEP95	112.0	10.5	279
19OCT95	152.0	6.0	240
30OCT95	131.0	3.4	248
02AUG96	50.0		
25SEP96	119.0	6.2	309
14NOV96	110.0	3.8	301

----------- Station="Allendale Canal above Dingwall Hill" ID=' ' ------------

Date	Flow (cfs)	Temperature (Celcius)	Conductivity (micro Mho)
31MAY95	87		
14JUN95	71		
18JUL95	37		
09AUG95	70		
15AUG95	60		
28MAY96	27		
02AUG96	77		
25SEP96	27		

----------- Station="Allendale Canal below Dingwall Hill" ID=' ' ------------

Date	Flow (cfs)	Temperature (Celcius)	Conductivity (micro Mho)
31MAY95	82		
14JUN95	68		
18JUL95	34		

--------------- Station="Allendale Canal at Hall Road" ID=' ' ---------------

Date	Flow (cfs)	Temperature (Celcius)	Conductivity (micro Mho)
31MAY95	69		
18JUL95	39		
09AUG95	60		
16AUG95	46		
30AUG95	48		
26SEP95	33		

Synoptic Flow Measurements in the Flint Creek Basin

Measurements Taken by USGS and DNRC

---------------- Station="Flint Creek at Hall" ID=12331200 ----------------

Date	Flow (cfs)	Temperature (Celcius)	Conductivity (micro Mho)
16MAY94	76.2	8.5	208
30JUN94	13.2		
14JUL94	52.6	15.9	355
17AUG94	18.6	16.0	380
15SEP94	27.5	10.5	415
28SEP94	23.5	8.5	455
09AUG95	50.4	18.5	306
30AUG95	9.6	16.5	435
25SEP96	127.0		

------- Station="Flint Creek below diversion dam at Hall" ID=12331220 -------

Date	Flow (cfs)	Temperature (Celcius)	Conductivity (micro Mho)
16MAY94	46.1	8.5	207
30JUN94	6.6		413
14JUL94	43.3	16.9	359
17AUG94	4.7	17.0	360
15SEP94	12.7	10.5	415
28SEP94	19.4	8.5	455
25OCT94	125.0	4.0	315
15NOV94	110.0	1.0	
19APR95	101.0	8.3	276
10MAY95	173.0	11.0	220
27JUL95	71.0	16.5	293
09AUG95	29.0	18.0	305
30AUG95	1.0	16.5	435
26SEP95	116.0	20.5	330
19OCT95	170.0	6.7	279
25SEP96	124.0	9.3	330
14NOV96	116.0	3.8	301

----------------- Station="Barnes Creek near Hall" ID=' ' -----------------

Date	Flow (cfs)	Temperature (Celcius)	Conductivity (micro Mho)
08JUN95	6		
14JUN95	5		
18JUL95	2		

------------- Station="Willow Creek at mouth near Hall" ID=' ' -------------

Date	Flow (cfs)	Temperature (Celcius)	Conductivity (micro Mho)
16MAY94	3.5		

Synoptic Flow Measurements in the Flint Creek Basin

Measurements Taken by USGS and DNRC

------------- Station="Flint Creek near Drummond" ID=12331500 -------------

Date	Flow (cfs)	Temperature (Celcius)	Conductivity (micro Mho)
10MAR94	110.0	5.0	298
22MAR94	106.0	2.5	296
16MAY94	50.0		
17MAY94	19.5	11.0	323
07JUN94	119.0	10.3	341
30JUN94	25.0	18.5	485
14JUL94	60.0	18.5	403
28JUL94	28.0	11.0	514
17AUG94	14.0	16.0	490
14SEP94	23.0	11.0	514
15SEP94	27.0	11.0	580
28SEP94	34.0	8.0	505
29SEP94	38.0		
25OCT94	151.0	3.0	410
15NOV94	119.0	1.0	350
15NOV94	104.0		
04APR95	107.0	5.0	310
19APR95	106.0		
10MAY95	244.0		
15JUN95	346.0	13.0	225
09AUG95	41.0		
11AUG95	39.0	12.5	382
29AUG95	9.0	16.0	477
26SEP95	146.0	12.0	366
19OCT95	198.0	7.3	306
23JUL96	66.0		
02AUG96	44.0		
08AUG96	47.0		
10SEP96	62.0		
24SEP96	141.0		
25SEP96	137.0	9.6	368
13NOV96	132.0		
14NOV96	136.0		

------ Station="Bypass flows around Flint Creek near Drummond" ID=' ' -------

Date	Flow (cfs)	Temperature (Celcius)	Conductivity (micro Mho)
22MAR94	4.1		
07JUN94	36.4		
30JUN94	17.5		
16SEP94	17.5		

Synoptic Flow Measurements in the Flint Creek Basin

Measurements Taken by USGS and DNRC

---------- Station="Flint Creek at mouth at Drummond" ID=12331590 ----------

Date	Flow (cfs)	Temperature (Celcius)	Conductivity (micro Mho)
10MAR94	122.0	5.0	
22MAR94	112.0	3.9	310
17MAY94	29.2	11.2	409
07JUN94	152.0	12.3	388
30JUN94	30.7	16.0	517
14JUL94	83.0	12.5	445
28JUL94	50.0	17.5	427
17AUG94	15.1	12.0	560
14SEP94	50.8	15.0	560
28SEP94	53.1	7.0	560
25OCT94	159.0	2.5	
15NOV94	134.0	1.0	383
15NOV94	122.0	1.0	
23MAR95	106.0	3.1	317
06APR95	112.0	7.0	325
19APR95	103.0	8.0	312
26APR95	118.0	9.0	320
27JUL95	113.0	18.0	411
08AUG95	53.0	12.1	463
16AUG95	26.0	14.5	487
29AUG95	12.0	12.5	623
26SEP95	160.0	8.1	425
19OCT95	197.0	7.1	311
09JUL96	120.0	15.0	408
23JUL96	82.0	13.6	416
08AUG96	58.0	12.7	484
10SEP96	85.0	11.0	538
24SEP96	188.0	6.3	423
13NOV96	164.0	2.8	353

------ Station="Rodeo Grounds Spring outflow at Drummond" ID=12331603 -------

Date	Flow (cfs)	Temperature (Celcius)	Conductivity (micro Mho)
24MAR94	1.0	10.3	
07JUN94	5.4		831
30JUN94	10.0	18.0	747
15JUL94	4.3	14.5	900
28JUL94	4.9	19.0	810
17AUG94	8.3	14.0	650
14SEP94	4.5	10.8	966
15NOV94	1.0	4.0	856
24MAR95	0.8	8.2	834
26APR95	0.9	5.7	850
27JUL95	2.8	11.8	900
08AUG95	2.5	12.0	900
16AUG95	8.6		
29AUG95	8.2	10.5	725
26SEP95	4.7	10.1	885
18OCT95	2.1	8.5	885
09JUL96	8.5	15.5	985

Synoptic Flow Measurements in the Flint Creek Basin

Measurements Taken by USGS and DNRC

------ Station="Rodeo Grounds Spring outflow at Drummond" ID=12331603 -------
(continued)

Date	Flow (cfs)	Temperature (Celcius)	Conductivity (micro Mho)
23JUL96	4.5	15.2	960
10SEP96	4.5	13.7	888
24SEP96	4.0	8.1	933
13NOV96	2.0	5.3	850

-- Station="Clark Fork at Montana Highway 1 Bridge at Drummond" ID=12331605 --

Date	Flow (cfs)	Temperature (Celcius)	Conductivity (micro Mho)
10MAR94	518	5.0	420
22MAR94	504	5.0	414
30JUN94	254	17.0	487
28JUL94	194	21.5	439
18AUG94	106	18.0	557
14SEP94	146	12.5	553
15NOV94	456	1.5	470
23MAR95	534	5.5	434
06APR95	529	9.5	387
13APR95	575	11.0	428
08AUG95	308	14.6	437
16AUG95	255	16.2	450
29AUG95	192	17.5	485
26SEP95	599	10.8	462
18OCT95	668	7.9	376
09JUL96	603	19.0	395
23JUL96	407	16.4	425
08AUG96	294	15.5	466
10SEP96	300	13.2	511
24SEP96	502	7.2	478
13NOV96	571	2.6	428

------------- Station="Lorranson Creek at Drummond" ID=12331620 -------------

Date	Flow (cfs)	Temperature (Celcius)	Conductivity (micro Mho)
22MAR94	0.9	8.8	1240
07JUN94	6.2	15.8	1140
30JUN94	7.5	21.0	1140
28JUL94	7.2	18.0	968
17AUG94	7.9	12.0	1210
14SEP94	9.8	9.5	1240
25OCT94	2.6	8.5	1300
15NOV94	2.0	4.0	1290
27APR95	0.9	9.0	1305
06JUL95	6.5	11.5	1280
27JUL95	5.3	19.9	1265
08AUG95	6.0	11.6	1153
16AUG95	10.0	12.3	1130

Synoptic Flow Measurements in the Flint Creek Basin

Measurements Taken by USGS and DNRC

------------- Station="Lorranson Creek at Drummond" ID=12331620 -------------
(continued)

Date	Flow (cfs)	Temperature (Celcius)	Conductivity (micro Mho)
29AUG95	6.5	8.3	1270
26SEP95	11.0	10.0	1200
18OCT95	4.6	8.4	1179
09JUL96	6.8	13.8	1235
23JUL96	9.7	14.9	1063
08AUG96	9.3	13.1	1165
10SEP96	11.0	13.2	1149
24SEP96	15.0	8.2	1172
13NOV96	5.0	5.6	1296

---------- Station="Morris Creek inflow near Drummond" ID=12331720 ----------

Date	Flow (cfs)	Temperature (Celcius)	Conductivity (micro Mho)
22MAR94	0.1		

------------- Station="Drummond Sewage Lagoon outflow" ID=' ' -------------

Date	Flow (cfs)	Temperature (Celcius)	Conductivity (micro Mho)
22MAR94	0.4	8	665

---- Station="Clark Fork near Bradman Siding near Drummond" ID=12331750 -----

Date	Flow (cfs)	Temperature (Celcius)	Conductivity (micro Mho)
22MAR94	504	5	418
30JUN94	267	17	513
28JUL94	193	19	467

----- Station="Clark Fork below Mulkey Gulch near Drummond" ID=12331780 -----

Date	Flow (cfs)	Temperature (Celcius)	Conductivity (micro Mho)
04APR94	623	5.6	371
30JUN94	261	18.5	508
28JUL94	204	20.0	460
18AUG94	121	20.3	578
14SEP94	153	14.0	583
15NOV94	472	1.0	473
06APR95	534	10.0	390
13APR95	589	9.0	431

Synoptic Flow Measurements in the Flint Creek Basin

Measurements Taken by USGS and DNRC

----- Station="Clark Fork below Mulkey Gulch near Drummond" ID=12331780 -----
(continued)

Date	Flow (cfs)	Temperature (Celcius)	Conductivity (micro Mho)
08AUG95	307	16.0	457
29AUG95	187	18.5	560

--- Station="Springs measured 0.7 and 0.65 mi. upstream from gage" ID=' ' ----

Date	Flow (cfs)	Temperature (Celcius)	Conductivity (micro Mho)
22MAR94	8.6		

-------------- Station="Clark Fork near Drummond" ID=12331800 --------------

Date	Flow (cfs)	Temperature (Celcius)	Conductivity (micro Mho)
10MAR94	555	5.5	468
22MAR94	555	7.0	459
04APR94	665	7.5	429
30JUN94	302	20.0	547
28JUL94	233	22.0	497
18AUG94	150	21.0	630
14SEP94	179	16.0	640
15NOV94	510		
13APR95	584	9.0	281
08AUG95	344	17.0	503
29AUG95	199		
09JUL96	649	20.5	439
23JUL96	482	20.0	491
08AUG96	337	20.0	
10SEP96	371	16.5	568
24SEP96	544	9.5	522
13NOV96	617		

APPENDIX D

Lithologic Logs

APPENDIX D --- LITHOLOGIC LOGS

WELL: FC03
LOC: 10N12W07CDCC
MAP ELEVATION: 4030
LITHOLOGY:

0-2	TOPSOIL
2-10	GRAVEL
10-20	SURFACE WATER - GRAVEL
20-28	CLAY
28-37	SANDY CLAY
37-40	SAND & GRAVEL - WATER

WELL: FC05
LOC: 10N13W12BDAC
MAP ELEVATION: 4150
LITHOLOGY:

0-8	TOPSOIL
8-42	GRAVEL & CLAY
42-73	BLUE LIMESTONE (????)
73-135	CLAY & SANDSTONE
135-137	SAND & GRAVEL

WELL: FC07
LOC: 10N13W02DCCC
MAP ELEVATION: 4200
LITHOLOGY:

0-8	TOPSOIL
8-18	GRAVEL
18-70	BROWN CLAY
70-90	BLUE CLAY
90-105	DECOMPOSED ROCK

WELL: FC08
LOC: 10N13W02CDBB
MAP ELEVATION: 4100
LITHOLOGY:

0-19	CLAY
19-26	CLAY & GRAVEL
26-43	TAN SHALE, WATER
43-46	GREEN SHALE, WATER
46-51	BLACK SHALE, WATER
51-60	TAN SHALE, WATER

WELL: FC09
LOC: 10N12W06BCCA
MAP ELEVATION: 4040
LITHOLOGY:

0-3	TOPSOIL
3-17	GRAVEL
17-50	CLAY
50-55	ROCK
55-65	CLAY
65-75	GRAVEL & SAND
75-85	GRAVEL & SAND, WATER

WELL: FC10
LOC: 10N12W30BABD
MAP ELEVATION: 4120
LITHOLOGY:

0-3	TOPSOIL
3-6	BLACK DIRT & GRAVEL
6-20	TAN CLAY
20-36	SAND & GRAVEL, WATER

WELL: FC13
LOC: 09N13W15BABA
MAP ELEVATION: 4340
LITHOLOGY:

0-1	TOPSOIL
1-18	BOULDERS
18-33	SAND & GRAVEL
33-42	GRAVEL & CLAY
42-55	FRACTURED BEDROCK

WELL: FC15
LOC: 10N13W13CACC
MAP ELEVATION: 4150
LITHOLOGY:

0-8	TOPSOIL
8-32	CLAY, YELLOW
32-34	ROCK
34-50	CLAY
50-80	GREEN CLAY
80-90	GRAVEL, WATER BEARING

WELL: FC16
LOC: 10N12W20BBCB
MAP ELEVATION: 4090
LITHOLOGY:

0-2	TOPSOIL
2-35	SAND & GRAVEL
35-69	CLAY
69-80	CLAY WITH GRAVEL
80-100	GRAVEL & WATER

WELL: FC17
LOC: 10N13W14CDAA
MAP ELEVATION: 4220
LITHOLOGY:

0-2	TOPSOIL
2-4	TAN CLAY
4-9	SANDY GRAVEL
9-45	GRAVEL & CLAY
45-60	SANDY SHALE

WELL: FC18
LOC: 10N13W10DCDD
MAP ELEVATION: 4260
LITHOLOGY:

0-3	TOPSOIL
3-135	CLAY
135-140	CLAY & GRAVEL
140-141	GRAVEL
141-150	CLAY
150-153	GRAVEL
153-170	CLAY
170-180	CLAY WITH GRAVEL LENSES
180-200	SAND

WELL: FC19
LOC: 10N13W10CCDD
MAP ELEVATION: 4350
LITHOLOGY:

0-1	TOPSOIL
1-8	CLAY & BOULDERS
8-25	SANDY CLAY, RED
25-65	SHALE, TAN
65-120	BROWN SHALE
120-155	SANDY CLAY (SOME WATER)
155-160	SAND - WATER
160-165	CLAY

WELL: FC20
LOC: 10N13W13CABD
MAP ELEVATION: 4130
LITHOLOGY:

0-15	TOPSOIL & ROCKS
15-40	CLAY & ROCKS
40-123	BLUE CLAY
123-230	BLUE CLAY & SAND

WELL: FC21
LOC: 10N13W13ACAC
MAP ELEVATION: 4090
LITHOLOGY:

0-32	OLD WELL
32-52	BLUE CLAY
52-78	BROWN CLAY
78-132	BLUE CLAY
132-134	COARSE SAND & GRAVEL

WELL: FC22
LOC: 10N13W26DCCC
MAP ELEVATION: 4180
LITHOLOGY:

0-10	TOPSOIL
10-23	GRAVEL & COBBLESTONES
23-65	CLAY
65-70	GRAVEL WITH WATER

WELL: FC26
LOC: 10N13W27CADA
MAP ELEVATION: 4270
LITHOLOGY:

0-12	TOPSOIL & GRAVEL
12-22	SAND & GRAVEL
22-49	CLAY
49-55	SAND & GRAVEL WB

WELL: FC27
LOC: 09N13W15BDBA
MAP ELEVATION: 4375
LITHOLOGY:

0-18	BOULDERS
18-35	SAND & GRAVEL
35-38	CLAY SAND & GRAVEL
38-40	SAND & GRAVEL
40-55	FRACTURED BEDROCK

WELL: FC28
LOC: 10N13W23DDCC
MAP ELEVATION: 4200
LITHOLOGY:

0-6	TOPSOIL & GRAVEL
6-18	GRAVEL & BOULDERS
18-35	HARDPAN
35-70	SILT & SAND
70-92	SOFT CLAY
92-99	CLAY LAYERS-SMALL GRAVEL

WELL: FC30
LOC: 10N13W23DAAB
MAP ELEVATION: 4190
LITHOLOGY:

0-4	TOPSOIL
4-12	CLAY
12-18	ROCK
18-60	CLAY
60-70	CLAY AQUIFER
70-90	CLAY
90-100	SAND & GRAVEL

WELL: FC31
LOC: 10N13W28BBBB
MAP ELEVATION: 4345
LITHOLOGY:

0-6	TOPSOIL, ROCKS
6-17	CLAY
17-18	SEDIMENTARY ROCK
18-40	CLAY & GRAVEL
40-52	CLAY
52-62	GRAVEL, WB

APPENDIX D (CONT.)

WELL: FC36
LOC: 10N13W27DDDD
MAP ELEVATION: 4240
LITHOLOGY:

0-1	TOPSOIL
1-20	GRAVEL & BOULDERS
20-25	SAND & GRAVEL, WATER
25-80	SANDY CLAY
80-97	SHALE, SANDY, WATER

WELL: FC38
LOC: 10N13W02CBBC
MAP ELEVATION: 4250
LITHOLOGY:

0-12	BOULDERS & GRAVEL
12-35	CEMENTED SAND, GRAVEL & BOULDERS

WELL: FC40
LOC: 09N13W10DCCC
MAP ELEVATION: 4330
LITHOLOGY:

0-16	TAN CLAY, GRAVEL, & BOULDERS
16-23	SAND, GRAVEL, & WATER

WELL: FC42
LOC: 07N14W09CCCC
MAP ELEVATION: 5245
LITHOLOGY:

0-115	CLAY
115-125	SHALE

WELL: FC43
LOC: 07N14W26ADBD
MAP ELEVATION: 5155
LITHOLOGY:

0-45	DENSE GREY, SANDY GRAVEL WITH COBBLES & BOULDERS
45-81.5	DECOMPOSED GRANITE, SAND WITH FEW COBBLES - WATER

WELL: FC44
LOC: 06N14W27ABAA
MAP ELEVATION: 5401
LITHOLOGY:

0-12	OPEN HOLE
12-15	SAND & GRAVEL
15-23	SHALE & CLAY
23-44	ROCK WITH RED CLAY SEAMS
44-135	CLAY - YELLOW TO WHITE
135-144	CLAY - BROWN TO ORANGE
144-146	LIMESTONE - WATER BEARING

WELL: FC45
LOC: 06N14W32CBBB
MAP ELEVATION: 5550
LITHOLOGY:

0-4	TOPSOIL
4-40	BENTONITE CLAY
40-75	CLAY - BROKEN ROCK
75-95	LIMESTONE BEDROCK

WELL: FC48
LOC: 10N13W22BDDA
MAP ELEVATION: 4290
LITHOLOGY:

0-10	GRAVEL & CLAY
10-30	CLAY
30-40	CLAY & GRAVEL
40-70	CLAY
70-85	GRAVEL WITH WATER

WELL: FC50
LOC: 07N14W11DCCA
MAP ELEVATION: 5045
LITHOLOGY:

0-4	TOPSOIL
4-18	SMALL BOULDERS
18-55	GRAVEL & DIRT
55-65	SOFT ROCK
65-97	FRACTURED ROCK

WELL: FC52
LOC: 07N14W11CCAA
MAP ELEVATION: 5055
LITHOLOGY:

0-10	GRAVEL
10-60	CLAY
60-120	SANDSTONE

WELL: FC55
LOC: 07N14W35CBCB
MAP ELEVATION: 5180
LITHOLOGY:

0-2	TOPSOIL
2-28	CLAY & BOULDERS
28-52	SANDY CLAY
52-60	SAND, GRAVEL, WATER

WELL: FC56
LOC: 06N14W03DDAB
MAP ELEVATION: 5230
LITHOLOGY:

0-2	TOPSOIL
2-12	GRAVEL & BOULDERS
12-33	CEMENTED GRAVEL
33-36	SAND WITH CLAY
36-44	TIGHT SAND & GRAVEL, WATER

WELL: FC57
LOC: 06N14W03DDBA
MAP ELEVATION: 5235
LITHOLOGY:

0-3	BLACK DIRT & BOULDERS
3-20	YELLOW CLAY & BROKEN ROCK
20-30	YELLOW & BROWN SHALE ROCK
30-35	HARD ROCK WITH FRACTURES - WATER
35-44	ROCK WATER

WELL: FC59
LOC: 07N14W36BADA
MAP ELEVATION: 5280
LITHOLOGY:

0-6	TOPSOIL
6-25	CLAY & LIMESTONE
25-110	PEA GRAVEL & CLAY
110-112	PEA GRAVEL & WATER
112-124	CLAY & LIMESTONE
124-125	WATER & PEA GRAVEL

WELL: FC61
LOC: 06N14W11CBAB
MAP ELEVATION: 5280
LITHOLOGY:

0-2	TOPSOIL
2-12	CLAY & DIRT
12-40	ROCK
40-41	ROCK & WATER
41-160	ROCK
160-165	ROCK & WATER
165-200	ROCK

WELL: FC64
LOC: 06N14W21AAAA
MAP ELEVATION: 5320
LITHOLOGY:

0-10	TOPSOIL & SAND
10-20	SAND & COARSE GRAVEL
20-33	GRAVEL

WELL: FC66
LOC: 06N14W33AAAA
MAP ELEVATION: 5390
LITHOLOGY:

0-6	TOPSOIL WITH CLAY
6-25	CLAY
25-30	CLAY WITH FINE GRAVEL
30-40	CLAY WITH COARSE GRAVEL WITH WATER

WELL: FC67
LOC: 06N14W33DBBC
MAP ELEVATION: 5395
LITHOLOGY:

0-7	GRAVEL COBBLESTONES
7-50	GRAVEL, CLAY, MUDSTONE

WELL: FC70
LOC: 10N13W12BBCC
MAP ELEVATION: 4160
LITHOLOGY:

0-2	TOPSOIL
2-45	GRAVEL, CLAY & SAND

WELL: FC71
LOC: 10N13W12AAAC
MAP ELEVATION: 4050
LITHOLOGY:

0-1	TOPSOIL
1-15	DRY, PINKISH SILTY SAND & GRAVEL
15-35	MOIST, SOFT, YELLOW BROWN CLAY
35-35.5	LIMESTONE
35.5-60	SOFT BROWN TO YELLOW CLAY & SHALE, SOME DARK
60-78	HARD, DK BROWN GRAY & GRAY SHALE
78-80	VERY DARK BROWN TO BLACK SHALE, WATER

APPENDIX D (CONT.)

WELL: FCA1
LOC: 10N13W14CBBB
MAP ELEVATION: 4250
LITHOLOGY:

0-1	TOPSOIL
1-6	SILT WITH TRACE GRAVEL
6-24	SILTY SAND & GRAVEL
24-36	RED BROWN, GRAVELLY CLAY
36-51	SILTY SAND & GRAVEL
51-55	LIGHT BROWN CLAY WITH GRAVEL
55-100	SOFT TO STIFF TAN CLAY
100-115	HARD TAN CLAYSTONE
115-140	HARD TAN CLAYSTONE WITH SMALL GRAVEL
140-150	SOFT BROWN CLAY WITH SAND
150-151	SMALL GRAVEL WITH CLAY
151-160	HARD TAN CLAYSTONE, WATER

WELL: FCA2
LOC: 10N13W14CBBB
MAP ELEVATION: 4250
LITHOLOGY:

0-1	TOPSOIL
1-6	PINKISH BROWN SILT, TRACE GRAVEL
6-30	DRY, PINKISH BROWN SILTY SAND, GRAVEL & COBBLES
30-39	WET, RED BROWN CLAY WITH GRAVEL
39-48	SILTY GRAVEL, SOME WATER
48-60	BROWN STIFF SILT & SOFT CLAY

WELL: FCA3
LOC: 10N13W14CBBB
MAP ELEVATION: 4250
LITHOLOGY:

0-1	TOPSOIL
1-6	PINKISH BROWN SILT
6-26	PINKISH BROWN SILTY SAND, GRAVEL & COBBLES
26-35	BROWN CLAYEY GRAVEL
35-48	SILTY, COARSE SAND & GRAVEL

WELL: FCA4
LOC: 10N13W14CBBB
MAP ELEVATION: 4250
LITHOLOGY:

0-1	TOPSOIL
1-6	PINKISH BROWN SILT
6-26	PINKISH BROWN SILT, SAND, GRAVEL & COBBLES
26-38	BROWN SILTY, CLAYEY, GRAVEL
36-58	SILTY, COARSE SAND & GRAVEL, WATER
58-96	LIGHT BROWN SANDY CLAY, TRACES OF HARD GRAY SILT
96-98	COARSE SAND
98-158	STIFF LIGHT BROWN SILT & SILTSTONE
158-160	GRAY BROWN, GRAVELLY SAND, WATER

WELL: FCB1
LOC: 10N13W27DABA
MAP ELEVATION: 4280
LITHOLOGY:

0-1	TOPSOIL
1-33	DRY PINKISH BROWN, SILTY SAND & GRAVEL
33-78	DAMP BROWN SOFT TO FIRM CLAY, LENSES OF BLUE GRAY CLAY
78-85	STIFF BROWN CLAY, LENSES OF BLUE GRAY CLAY
85-86	BROWN CLAY WITH SOME COARSE SAND & SMALL GRAVEL
86-118	BLUE GRAY & MAROON CLAY, WITH SOME DARKER, HARD LAMINATIONS
118-122	BLUE-GREEN ARGILLITE, ROUNDED GRAVEL & COARSE SAND, WATER
122-130	BLUE-GREEN CLAY, SOME SAND

WELL: FCB2
LOC: 10N13W26CDCC
MAP ELEVATION: 4220
LITHOLOGY:

0-1	TOPSOIL
1-16	MOIST, PINKISH BROWN SILT, SAND, GRAVEL & COBBLES
16-32	CLAYEY, SILTY, SAND & GRAVEL & COBBLES
32-40	WET BROWN SANDY CLAY & GRAVEL

WELL: FCB3
LOC: 10N13W26CDCC
MAP ELEVATION: 4220
LITHOLOGY:

0-1	TOPSOIL
1-16	PINKISH BROWN SILTY SAND, GRAVEL, & COBBLES
16-32	CLAYEY, SILTY SAND & GRAVEL & COBBLES
32-40	WET BROWN, SANDY CLAY & GRAVEL

WELL: FCB4
LOC: 10N13W28DBCB
MAP ELEVATION: 4345
LITHOLOGY:

0-.5	TOPSOIL
.5-13	DRY, PINKISH BROWN, SILTY SAND & GRAVEL, COBBLES
13-25	MOIST, LIGHT BROWN CLAY WITH SOME SAND
25-67	TAN CLAYSTONE
67-77	GRAY & MAROON-GRAY CLAYSTONE
77-80	DARK GRAY WITH RUSTY COLORED PLANAR SURFACES, CLAYSTONE, WATER

WELL: FCB5
LOC: 10N13W27ACBB
MAP ELEVATION: 4310
LITHOLOGY:

0-1	TOPSOIL
1-23	DRY, PINKISH BROWN SILTY GRAVEL & COBBLES
23-26	CLAY LAYERS
26-35	DRY, PINKISH, SILTY GRAVEL & COBBLES
35-40	BROWN SOFT CLAY, SOME SAND
40-140	BROWN SANDY CLAYSTONE

WELL: FCB6
LOC: 10N13W27ACBB
MAP ELEVATION: 4310
LITHOLOGY:

0-1	TOPSOIL
1-26	DRY, PINKISH BROWN SILTY SAND & GRAVEL
26-29	SOFT, BROWN SANDY CLAY, TRACE GRAVEL
29-40	SOFT BROWN SANDY CLAY, SOME GRAVEL

WELL: FCC1
LOC: 06N14W27CBBB
MAP ELEVATION: 5390
LITHOLOGY:

0-1	TOPSOIL
1-2	MOIST CLAY, GRAVEL, SAND
2-19	DAMP, PINKISH BROWN, SILTY SAND & GRAVEL & COBBLES
19-22	FIRM, YELLOW-TAN, SANDY CLAY
22-25	REDDISH-TAN CLAY WITH SOME GRAVEL
25-39	SOFT, YELLOW-TAN, MICA-RICH CLAY
39-40	RED BROWN CLAY, TRACE SAND
40-80	TAN TO BROWN CLAY, COARSE SAND, & CLAYSTONE
80-118	HARD TAN TO DARK BROWN CLAYSTONE, TRACES LIGHT YELLOW GREEN BENTONITE 80 TO 100 FT
118-122	BLACK HARD SHALE
122-140	TAN CLAYSTONE, TRACES BLACK SHALE, GREEN BENTONITE, WHITE BENTONITE, WATER

WELL: FCC2
LOC: 06N14W21DBCB
MAP ELEVATION: 5330
LITHOLOGY:

0-4	SANDY CLAY
4-6	SANDY CLAY WITH SMALL ANGULAR GRAVEL
6-13	SAND SMALL GRAVEL
13-18	YELLOW-BROWN GRAVELLY, SANDY CLAY
18-127	YELLOW BROWN STICKY CLAY, TRACES GRAVEL
127-150	CLAYSTONE SILTSTONE 8 TO 10 GPM AT 141 FT

APPENDIX D (CONT.)

WELL: FCD1
LOC: 07N14W21ADAD
MAP ELEVATION: 5220
LITHOLOGY:

0-1	TOPSOIL
1-4	PINKISH BROWN CLAY
4-5	MAROON & BROWN, ORANGE BROWN SANDY GRAVEL
5-39	MAROON & DARK GRAY COARSE SAND & GRAVELS, LITTLE WATER, CEMENTED OR MIXED WITH CLAY
39-50	RED BROWN CLAY
50-53	RED BROWN CLAYEY GRAVEL
53-63	RED BROWN CLAY
63-67	TAN TO GRAY-BROWN STIFF CLAY
67-92	RED-BROWN CLAY, TRACES GRAVEL
92-115	RED-BROWN ANGULAR GRAVEL & COARSE SAND WITH SOME CLAY LAYERS
115-129	CLAY & GRAVEL
129-140	RED-BROWN, COARSE SANDY GRAVEL

WELL: FCE1
LOC: 10N13W13BBAB
MAP ELEVATION: 4160
LITHOLOGY:

0-1	TOPSOIL
1-18	DRY, PINKISH BROWN, SILTY SAND & GRǍVEL
18-34	MOIST, SOFT TO STIFF, PALE YELLOW-BROWN CLAY, SOME COARSE SAND & GRAVEL
34-51	STIFF, LIGHT BROWN CLAYSTONE
51-57	HARD, SATURATED, BROWN LAMINATED SHALE, TRACES OF CLAY, WATER
57-60	SOFT TAN CLAY

WELL: FCE2
LOC: 10N13W12BBCC
MAP ELEVATION: 4165
LITHOLOGY:

0-1	TOPSOIL
1-4	LIGHT BROWN, MOIST, GRAVELLY SANDY CLAY
4-15	WET, BROWN, SILTY SAND & GRAVEL, SOME CLAY
15-57	WET, SOFT, YELLOW BROWN CLAY, SOME COARSE SAND & GRAVEL AT 50 FT.
57-58	SOFT DARK BLUE-GRAY CLAY
58-60	BLUE-GRAY, SILTY COARSE SAND & SMALL GRAVEL
60-68	MAROON TO BLACK FIRM CLAY
68-152	BLUE-GRAY SOFT TO STIFF CLAY, MAROON COLORING @ 90 FT
152-153.5	COARSE SAND, SMALL GRAVEL
153.5-160	STIFF, WET, BLUE-GREEN CLAYSTONE

WELL: FCF1
LOC: 07N14W35CDDD
MAP ELEVATION: 5230
LITHOLOGY:

0-6	MOIST, YELLOW BROWN, MEDIUM SAND WITH SOME GRAVEL
6-16	GRAY, SAND & GRAVEL, COBBLES
16-20	YELLOW BROWN SAND, CLAY

WELL: WL01
LOC: 10N13W12BD
MAP ELEVATION: 4120
LITHOLOGY:

0-3	TOPSOIL
3-90	CLAY DIRT & GRAVEL
90-140	DIRT & ROCK

WELL: WL02
LOC: 10N13W13AB
MAP ELEVATION: 4125
LITHOLOGY:

0-10	SAND & GRAVEL
10-20	CLAY & GRAVEL
20-30	SAND
30-135	CLAY

WELL: WL03
LOC: 10N13W12DCA
MAP ELEVATION: 4036
LITHOLOGY:

0-3	TOPSOIL
3-45	CLAY (GREY)
45-47	SAND & GRAVEL
47-65	CLAY (BLUE)
65-72	GRAVEL & SAND
72-78	GRAVEL

WELL: WL04
LOC: 10N13W12DAC
MAP ELEVATION: 4036
LITHOLOGY:

0-10	TOPSOIL & GRAVEL
10-18	BOULDERS & CLAY
18-63	BLUE & BROWN CLAY
63-65	COARSE SAND & GRAVEL

WELL: WL05
LOC: 10N12W18CC
MAP ELEVATION: 4030
LITHOLOGY:

0-6	TOPSOIL
6-19	RED SAND & GRAVEL
19-27	TAN GRAVEL, SOME CLAY
27-40	SHALE - WATER

WELL: WL06
LOC: 10N12W18BB
MAP ELEVATION: 4030
LITHOLOGY:

0-3	TOPSOIL
3-18	GRAVEL
18-29	SAND
29-54	CLAY & GRAVEL
54-57	SAND & GRAVEL

WELL: WL07
LOC: 10N13W13C
MAP ELEVATION: 4120
LITHOLOGY:

0-10	SOIL, SAND, GRAVEL, COBBLE
10-16	SAND, GRAVEL, MOIST
16-37	BLUE SHALE
37-55	BLUE SHALE WITH WATER

WELL: WL08
LOC: 10N12W17BB
MAP ELEVATION: 4040
LITHOLOGY:

0-2	TOPSOIL
2-10	SANDY SOIL
10-18	GRAVEL
18-70	SAND CLAY
70-80	GRAVEL

WELL: WL09
LOC: 10N13W36BB
MAP ELEVATION: 4162
LITHOLOGY:

0-1	TOPSOIL
1-20	BOULDERS & GRAVEL
20-79	SILTY SAND & GRAVEL
79-140	GRAVEL

WELL: WL10
LOC: 10N13W22AB
MAP ELEVATION:: 4280
LITHOLOGY:

0-2	TOPSOIL
2-8	CLAY & DIRT
8-50	SAND & GRAVEL
50-90	CLAY
90-140	SHALE

WELL: WL11
LOC: 10N13W32DCB
MAP ELEVATION: 4435
LITHOLOGY:

0-8	TOPSOIL & BOULDERS
8-19	LIMESTONE & SAND
19-28	GRAVEL & CLAY
28-50	CLAY
50-56	GRAVEL
56-58	LIMESTONE
58-60	GRAVEL

WELL: WL12
LOC: 10N13W26DC
MAP ELEVATION: 4200
LITHOLOGY:

0-3	TOPSOIL
3-20	BOULDERS & GRAVEL
20-30	CEMENTED GRAVEL
30-50	CLAY
50-70	LOOSE SANDY CLAY
70-80	BROWN CLAY
80-90	SANDY CLAY
90-95	COARSE GRAVEL

WELL: WL13
LOC: 10N13W26DC
MAP ELEVATION: 4200
LITHOLOGY:

0-25	SAND & GRAVEL BOULDERS
25-45	CLAY
45-50	CLAY & GRAVEL

APPENDIX D (CONT.)

WELL: WL14
LOC: 10N13W26DC
MAP ELEVATION: 4200
LITHOLOGY:

0-4	TOPSOIL
4-18	BOULDERS & SAND
18-36	CLAY
36-40	SAND & GRAVEL, WB

WELL: WL15
LOC: 10N13W35AB
MAP ELEVATION: 4200
LITHOLOGY:

0-2	TOPSOIL
2-28	CLAY & BOULDERS
28-80	CLAY
80-95	SAND
95-100	COARSE SAND & GRAVEL

WELL: WL16
LOC: 10N13W35BAA
MAP ELEVATION: 4200
LITHOLOGY:

0-20	GRAVEL
20-30	GRAVEL WITH CLAY
30-40	SAND & GRAVEL
40-50	GRAVEL WITH WATER & CLAY

WELL: WL17
LOC: 10N13W35BAA
MAP ELEVATION: 4200
LITHOLOGY:

0-10	TOPSOIL
10-23	GRAVEL & COBBLESTONE
23-65	CLAY
65-70	GRAVEL & WATER

WELL: WL18
LOC: 10N13W35B
MAP ELEVATION: 4200
LITHOLOGY:

0-15	GRAVEL
15-18	GRAVEL & WATER
18-40	DRY SAND CLAY
40-45	SAND WATER
45-80	SAND & GRAVEL
80-85	WATER & GRAVEL

WELL: WL19
LOC: 10N13W31DBDD
MAP ELEVATION: 4453
LITHOLOGY:

0-2	TOPSOIL
2-10	GRAVEL & BOULDERS
10-15	CEMENTED GRAVEL
15-33	GRAVEL & WATER

WELL: WL20
LOC: 10N13W32B
MAP ELEVATION: 4440
LITHOLOGY:

0-4	TOPSOIL
4-10	GRAVEL & BOULDERS
10-24	CEMENTED GRAVEL
24-30	GRAVEL, SOME WATER, SANDY
30-50	LARGE GRAVEL - WATER

WELL: WL21
LOC: 09N13W03DC
MAP ELEVATION: 4295
LITHOLOGY:

0-18	BOULDERS & GRAVEL
18-30	BOULDERS, SAND, GRAVEL

WELL: WL22
LOC: 09N13W10DA
MAP ELEVATION: 4320
LITHOLOGY:

0-4	TOPSOIL
4-18	CLAY
18-38	GRAVEL & BOULDERS
38-44	WHITE CLAY
44-50	GRAVEL

WELL: WL23
LOC: 09N13W21DCC
LITHOLOGY:

0-10	TOPSOIL
10-40	CLAY
40-60	GRAVEL & WATER

WELL: WL24
LOC: 09N13W27CA
MAP ELEVATION: 4540
LITHOLOGY:

0-1	TOPSOIL
1-40	SAND, GRAVEL, BOULDERS

WELL: WL25
LOC: 09N13W33DDC
MAP ELEVATION: 4700
LITHOLOGY:

0-2	TOPSOIL
2-52	BOULDERS & GRAVEL

WELL: WL26
LOC: 10N12W06BB
MAP ELEVATION: 4000
LITHOLOGY:

0-9	CLAY
9-28	GRAVEL
28-60	CLAY
60-75	SILT & CLAY
75-80	SEAMS OF SMALL GRAVEL & CLAY
80-112	CLAY
112-115	SAND & SMALL GRAVEL

WELL: WL27
LOC: 10N12W06BBC
MAP ELEVATION: 4020
LITHOLOGY:

0-2	TOPSOIL
2-10	ROCKY
10-25	CLAY & ROCKS
25-70	CLAY & SAND
70-78	WATER SAND

WELL: WL28
LOC: 10N12W06BBA
MAP ELEVATION: 4020
LITHOLOGY:

0-6	TOPSOIL & CLAY
6-12	SMALL CLAY SEAMS & GRAVEL
12-45	RED CLAY
45-51	SOFT CLAY
51-87	VERY HARD CLAY
87-109	ROCK, VERY HARD 105-109'

WELL: WL29
LOC: 10N12W06CBB
MAP ELEVATION: 4040
LITHOLOGY:

0-78	CLAY & GRAVEL TO 78 FEET
78-82	SAND & GRAVEL, WATER
82-85	CLAY & GRAVEL

WELL: WL30
LOC: 10N12W06BC
MAP ELEVATION: 4040
LITHOLOGY:

0-18	TOPSOIL & ROCKS
18-40	BROWN SHALE
40-70	LIGHT BROWN SHALE
70-78	SAND, GRAVEL, & SHALE
78-80	BLUE SHALE - SAND

WELL: WL31
LOC: 10N12W06CBBC
MAP ELEVATION: 4040
LITHOLOGY:

0-10	STONE & SOIL
10-50	SOFT STONE & SILT
50-80	BLACK SHALE & LIMESTONE
80-120	BLACK SHALE LIMESTONE WITH WATER

WELL: WL32
LOC: 10N12W06BC
MAP ELEVATION: 4040
LITHOLOGY:

0-2	TOPSOIL
2-24	BROWN GRAVEL & CLAY
24-40	GRAY SHALE
40-53	BROWN SANDSTONE & CLAY
53-60	GRAY SHALE
60-70	BLACK CLAY
70-76	BROWN CLAY
76-88	GRAY SHALE, SOME WATER
88-90	BROWN CLAY
90-95	GRAY SHALE
95-100	GRAY SHALE, GOOD WATER

WELL: WL33
LOC: 10N12W06BBAA
MAP ELEVATION: 4010
LITHOLOGY:

0-8	GRAVEL
8-70	CLAY
70-88	WATER BEARING GRAY SHALE
88-97	CLAY
97-100	WATER BEARING GREEN SHALE
100-120	GRAY SHALE
120-124	WATER BEARING GREEN SHALE
124-125	LIMESTONE

WELL: WL34
LOC: 10N12W17BA
MAP ELEVATION: 4120
LITHOLOGY:

0-12	SAND & GRAVEL MIXED IN TAN CLAY
12-15	GREY SANDY CLAY
15-38	SAND MIXED IN TAN CLAY
38-113	SAND MIXED IN YELLOW CLAY
113-115	BLUE, SANDY CLAY
115-227	BROKEN GREEN SHALE WITH COARSE SAND PARTICLES IN CRACKS & SEAMS

WELL: WL35
LOC: 10N12W18BA
MAP ELEVATION: 4030
LITHOLOGY:

0-1	TOPSOIL
1-38	GRAVEL
38-50	HARDPAN

WELL: WL36
LOC: 10N13W01DD
MAP ELEVATION: 4020
LITHOLOGY:

0-2	TOPSOIL
2-13	GRAVEL & GRANITE ROCK
13-70	CLAY

WELL: WL37
LOC: 10N13W12AAD
MAP ELEVATION: 4020
LITHOLOGY:

0-10	TOPSOIL
10-20	GRAVEL
20-50	CLAY
50-70	SHALE
70-120	LIMESTONE & SHALE

WELL: WL38
LOC: 10N13W12DAB
MAP ELEVATION: 4050
LITHOLOGY:

0-36	CLAY & SAND
36-40	GRAY CLAY
40-57	SHALE & CLAY
57-58	SHALE & WATER
58-104	SHALE & CLAY
104-105	SANDY SHALE & WATER
105-114	BLACK SHALE

WELL: WL39
LOC: 10N13W13CDC
MAP ELEVATION: 4120
LITHOLOGY:

0-14	TOPSOIL & BOULDERS
14-35	YELLOW CLAY
35-60	GREEN CLAY
60-73	SAND & GRAVEL WB

WELL: WL40
LOC: 10N13W21BD
MAP ELEVATION: 4320
LITHOLOGY:

0-1	TOPSOIL
1-15	DIRT & GRAVEL
15-110	CLAY
110-150	ROCK

WELL: WL41
LOC: 10N13W21DA
MAP ELEVATION: 4280
LITHOLOGY:

0-8	GRAVEL
8-20	SAND & GRAVEL, WATER
20-33	CLAY
33-36	SAND, GRAVEL, WATER

WELL: WL42
LOC: 10N13W23DCB
MAP ELEVATION: 4280
LITHOLOGY:

0-20	ROCK AND GRAVEL
20-50	LIMESTONE
50-90	CLAY
90-115	SHALE

WELL: WL43
LOC: 10N13W26AB
MAP ELEVATION: 4220
LITHOLOGY:

0-30	GRAVEL
30-35	GRAVEL
35-70	CLAY
70-75	BROWN SAND
75-90	CLAY
90-95	CLAY
95-100	CLAY

WELL: WL44
LOC: 10N13W**26CA**
MAP ELEVATION: 4210
LITHOLOGY:

0-4	TOPSOIL
4-23	VERY TIGHT BOULDERS GRAVEL
23-51	BENTONITE
51-61	CLAY - GRAY
61-80	DIRTY SAND CLAY SOME WATER
80-90	CLAY, SEAMS OF TIGHT SAND, LAYERS OF CHALK CLAY&WATER

WELL: WL45
LOC: 10N13W26BC
MAP ELEVATION: 4230
LITHOLOGY:

0-3	TOPSOIL
3-12	GRAVEL & BOULDERS
12-24	CEMENTED GRAVEL & BOULDERS
24-33	WATER, SAND & GRAVEL
33-52	GREY SAND
52-80	TAN SANDY CLAY
80-95	TAN SANDY SHALE

WELL: WL46
LOC: 10N13W27BD
MAP ELEVATION: 4290
LITHOLOGY:

0-25	SAND & GRAVEL
25-30	CLAY
30-45	CLAY, GRAVEL & SAND
45-80	CLAY
80-85	ROCK

WELL: WL47
LOC: 10N13W29AA
MAP ELEVATION: 4360
LITHOLOGY:

0-1	TOPSOIL
1-30	SAND & GRAVEL
30-60	CLAY, SAND & GRAVEL
60-83	WATER SAND & GRAVEL

WELL: WL48
LOC: 10N13W29DD
MAP ELEVATION: 4365
LITHOLOGY:

0-1	TOPSOIL
1-12	SAND & GRAVEL, BOULDERS
12-32	GRAVEL & CLAY
32-40	SILTY SAND, WATER
40-45	COARSE SAND & GRAVEL, WATER

WELL: WL49
LOC: 10N13W229BC
MAP ELEVATION: 4360
LITHOLOGY:

0-3	TOPSOIL
3-9	GRAVEL
9-26	CLAY
26-37	DIRTY, WATER BEARING SAND
37-48	VOLCANIC ASH, WATER BEARING

WELL: WL50
LOC: 10N13W32DAA
MAP ELEVATION: 4400
LITHOLOGY:

0-18	TOPSOIL & BOULDERS
18-28	CLAY
28-50	CLAY & GRAVEL
50-62	GRAVEL WB
62-80	YELLOW CLAY
80-84	HARD GREEN CLAY
84-95	GRAVEL WB

WELL: WL51
LOC: 10N13W33CA
MAP ELEVATION: 4395
LITHOLOGY:

0-15	TOPSOIL
15-32	LIMESTONE GRAVEL
32-42	HARDPAN
42-68	CLAY
68-70	GRAVEL, COARSE, WATER

WELL: WL52
LOC: 06N14W22BA
MAP ELEVATION: 5330
LITHOLOGY:

0-2	TOPSOIL
2-18	CLAY & GRAVEL
18-30	CLAY
30-66	CLAY & GRAVEL
66-81	CLAY
81-110	CLAY & GRAVEL
110-121	CLAY
121-150	CEMENTED GRAVEL

WELL: WL53
LOC: 06N14W26CC
MAP ELEVATION: 5500
LITHOLOGY:

0-4	TOPSOIL
4-110	CLAY & ROCK
110-158	ROCK & A LITTLE CLAY
158-178	FRACTURED ROCK & WATER

WELL: WL54
LOC: 06N14W27DDB
MAP ELEVATION: 5410
LITHOLOGY:

0-50	DIRT & GRAVEL
50-140	ROCK & GRAVEL

WELL: WL55
LOC: 07N14W26DC
MAP ELEVATION: 5160
LITHOLOGY:

0-24	SAND & GRAVEL WITH CLAY & SOME BOULDERS
24-40	TIGHT PRESSED SAND & GRAVEL (WATER BEARING)

WELL: WL56
LOC: 07N14W35ACAA
MAP ELEVATION: 5160
LITHOLOGY:

0-22	GRAVEL & SMALL BOULDERS
22-46	GRAVEL WITH CLAY
46-52	TIGHT SAND & GRAVEL

WELL: WL57
LOC: 07N14W35ACAA
MAP ELEVATION: 5160
LITHOLOGY:

0-10	ROCK AND SOIL
10-30	RED AND BROWN SANDY CLAY
30-60	FINE GRAVEL AND CLAY
60-70	ROCK WITH COARSE SAND
70-90	ROCK WITH COARSE SAND WITH 60 GPM WATER

WELL: WL58
LOC: 07N14W36CACC
MAP ELEVATION: 5270
LITHOLOGY:

0-12	SAND, GRAVEL & TALC MIX
12-50	WEATHERED LIME STONE SLUFF
50-53	SANDY CLAY
53-66	INTERMITTENT LAYERS OF SAND, GRAVEL & CLAY MIX
66-68	WATER BEARING SAND & GRAVEL

WELL: WL59
LOC: 06N14W10CCAC
MAP ELEVATION: 5280
LITHOLOGY:

0-1	TOPSOIL
1-14	CLAY - A FEW ROCKS
14-35	CLAY - SOME GRAVEL
35-70	SANDY CLAY
70-82	SHALE ROCK

WELL: WL60
LOC: 06N14W11ABDD
MAP ELEVATION: 5350
LITHOLOGY:

0-118	BOULDERS, GRAVEL & CLAY TRACES, WATER AT 52 & 95 FT
118-135	CLAY & BROKEN ROCK
135-140	CLAY
140-140.5	WATER & BROKEN ROCK

WELL: WL61
LOC: 06N14W22A
MAP ELEVATION: 5350
LITHOLOGY:

0-2	TOPSOIL
2-10	GRAVEL
10-80	CLAY & GRAVEL
80-90	BLACK ROCK & WATER
90-96	YELLOW ROCK

WELL: WL62
LOC: 06N14W22ABAB
MAP ELEVATION: 5330
LITHOLOGY:

0-2	TOPSOIL
2-12	SAND & GRAVEL
12-135	CLAY, BROWN TO YELLOW INTERMITTANT
135-140	MILD LIMESTONE, WATER BEARING

WELL: WL63
LOC: 06N14W22ACAB
MAP ELEVATION: 5340
LITHOLOGY:

0-2	TOPSOIL
2-12	SAND & GRAVEL
12-63	CLAY, BROWN TO YELLOW
63-69	DIRTY CLAY
69-73	MILD LIMESTONE, WATER BEARING

WELL: WL64
LOC: 06N14W22A
MAP ELEVATION: 5335
LITHOLOGY:

0-15	OPEN HOLE
15-18	SAND & GRAVEL
18-28	SAND & GRAVEL WITH BROWN CLAY
28-31	CLAY
31-37	LIMESTONE, WATER BEARING
37-37.5	CLAY
37.5-42	LIMESTONE, FRACTURED

WELL: WL65
LOC: 06N14W22BDDC
MAP ELEVATION: 5360
LITHOLOGY:

0-2	TOPSOIL
2-10	BOULDERS & GRAVEL
10-52	CLAY (SOME BOULDERS)
52-58	GRAVEL & WATER

WELL: WL66
LOC: 06N14W22CD
MAP ELEVATION: 5380
LITHOLOGY:

0-15	HARD SHALE
15-19	CLAY & SURFACE WATER
19-25	CLAY
25-31	SHALE & WATER

WELL: WL67
LOC: 06N14W26CBC
MAP ELEVATION: 5520
LITHOLOGY:

0-2	TOPSOIL
2-20	SAND - GRAVEL
20-170	SAND - GRAVEL - CLAY

WELL: WL68
LOC: 06N14W27BA
MAP ELEVATION: 5390
LITHOLOGY:

0-1	TOPSOIL
1-10	SAND, GRAVEL & BOULDERS
10-13	CLAY & GRAVEL
13-26	SAND, GRAVEL & BOULDERS
26-85	CLAY & LIME SHALE
85-86	LIMESTONE GRAVEL, WATER BEARING

APPENDIX E

Static Groundwater-Level Measurements

APPENDIX E --- STATIC GROUNDWATER LEVEL MEASUREMENTS
MP = Measuring Point All measurements in feet.

WELL FC01
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 1.7

DATE:	DEPTH FROM MP:
10/19/1994	21.5
11/30/1994	26.25
01/12/1995	29
03/03/1995	30.4
04/27/1995	31.31
05/31/1995	31.62
06/28/1995	20.9
07/28/1995	23.54
08/31/1995	21.46
09/28/1995	24.03
10/26/1995	25.45
11/28/1995	23.63
12/28/1995	27.23
01/24/1995	28.52
02/28/1995	29.71
03/29/1996	30.27
04/29/1996	29.47
05/30/1996	31.18
06/27/1996	24.01
08/06/1996	21.41
08/29/1996	22.48
09/26/1996	24.96
10/31/1996	24.05
11/27/1996	25
01/02/1997	26.85

WELL FC02
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 0.7

DATE:	DEPTH FROM MP:
10/18/1994	5.2
11/30/1994	DRY
01/12/1995	DRY
03/03/1995	DRY
04/27/1995	DRY
05/31/1995	3.97
06/28/1995	4.83
07/28/1995	2.74
08/31/1995	4.81
09/28/1995	5.87
10/26/1995	DRY
12/28/1995	DRY
01/24/1996	DRY
02/28/1996	DRY
03/29/1996	DRY
04/29/1996	DRY
05/30/1996	DRY
06/27/1996	4.97
08/06/1996	5.11
08/29/1996	5.04
09/26/1996	5.81
10/31/1996	DRY
11/27/1996	DRY

WELL FC03
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 1.2

DATE:	DEPTH FROM MP:
10/18/1994	7.6
11/30/1994	9.54
01/12/1995	10.58
03/03/1995	11.1
04/27/1995	10.33
05/31/1995	7.88
06/28/1995	7.85

WELL FC04
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 1.1

DATE:	DEPTH FROM MP:
10/18/1994	3.86
11/30/1994	6.1
01/12/1995	DRY
03/03/1995	DRY
04/27/1995	DRY
05/31/1995	3.53
06/28/1995	4.07
07/28/1995	5.8
08/31/1995	3.23
09/28/1995	3.84
10/26/1995	4.9
11/28/1995	4.64
12/28/1995	6.45
01/24/1996	DRY
02/28/1996	DRY
03/29/1996	DRY
04/29/1996	6.07
05/30/1996	3.53
06/27/1996	3.41
08/06/1996	4.67
08/29/1996	3.83
09/26/1996	3.68
10/31/1996	5.22
11/27/1996	6.03

WELL FC05
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 1.55

DATE:	DEPTH FROM MP:
10/18/1994	49.17
11/30/1994	50.83
01/12/1995	52.2
03/03/1995	53.82
04/27/1995	52.19
06/28/1995	53.05
07/28/1995	60
08/31/1995	52.98
09/28/1995	50.75
10/26/1995	49.27
11/28/1995	50.34
12/28/1995	52.03
01/24/1996	50.2
02/28/1996	56.56
03/29/1996	56.15
04/29/1996	52.8
05/30/1996	54.37
06/27/1996	54.63
08/06/1996	58.02
08/29/1996	59.94
09/26/1996	66.3
10/31/1996	53.36
11/27/1996	55.35
01/02/1996	54.43

WELL FC06
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 0.5

DATE:	DEPTH FROM MP:
10/18/1994	8.37

WELL FC07
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 1.8

DATE:	DEPTH FROM MP:
10/18/1994	27.6
11/30/1994	28.93
01/12/1995	30.54
03/03/1995	32.02
04/27/1995	32.92
05/31/1995	34.56
06/28/1995	30.07
07/28/1995	29.4
08/31/1995	24.8
09/28/1995	26.29
10/26/1995	26.12
11/28/1995	31.54
12/28/1995	28.25
01/24/1996	29.68
02/28/1996	32.15
03/29/1996	34.58
04/29/1996	32.13
05/30/1996	32.45
06/27/1996	22.97
08/06/1996	28.76
08/29/1996	27.56
09/26/1996	29.63
10/31/1996	29.04
11/27/1996	32.11
01/02/1997	31.69

WELL FC08
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 2.2

DATE:	DEPTH FROM MP:
10/19/1994	18.41
11/30/1994	19.81
01/12/1995	20.46
03/03/1995	20.73
04/27/1995	21.03
05/31/1995	18.95
06/28/1995	17.57
07/28/1995	17.3
08/31/1995	19.23
09/28/1995	16.75
10/26/1995	18.93
11/28/1995	19.76
12/28/1995	19.98
01/24/1996	19.95
02/28/1996	20.09
03/29/1996	20.6
04/29/1996	20.51
05/30/1996	20.28
06/27/1996	18.26
08/06/1996	17.97
08/29/1996	18.08
09/26/1996	16.62
10/31/1996	19.48
11/27/1996	20.13
01/02/1997	19.96

APPENDIX E (CONT.)

WELL FC09
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 2.0

DATE:	DEPTH FROM MP:
12/01/1994	73.66
01/12/1995	74.62
03/03/1995	74.8
04/27/1995	75.04
05/31/1995	59
06/28/1995	59.6
07/28/1995	67.36
08/31/1995	60.32
09/28/1995	62.03
10/26/1995	71.67
11/28/1995	73.67
12/28/1995	74.1
01/24/1996	74.24
02/28/1996	73.97
03/29/1996	74.18
04/29/1996	73.35
05/30/1996	71.88
06/27/1996	57.28
08/06/1996	63.39
08/29/1996	61.21
09/26/1996	67.61
10/31/1996	72.41
11/27/1996	66.2
01/02/1997	72.72

WELL FC10
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 0.6

DATE:	DEPTH FROM MP:
10/19/1994	18.23
11/30/1994	20.99
01/12/1995	22.7
03/03/1995	24.25
04/27/1995	25.66
05/31/1995	23
06/28/1995	10.78
07/28/1995	14.75
08/31/1995	11
09/28/1995	13.59
10/26/1995	16.3
11/28/1995	20.18
12/28/1995	21.35
01/24/1996	22.63
02/28/1996	23.42
03/29/1996	24.19
04/29/1996	24.11
05/30/1996	13.82
06/27/1996	11.65
08/06/1996	12.97
08/29/1996	12.79
09/26/1996	11.96
10/31/1996	16.35
11/27/1996	18.14

WELL FC11
MP: CEMENT PAD
MP FROM LAND SURFACE (ft.): 0.4

DATE:	DEPTH FROM MP:
10/19/1994	12.4
11/30/1994	13.69
01/12/1995	14.61
03/03/1995	15.22
04/27/1995	15.2
05/31/1995	9.1
06/28/1995	10.29
07/28/1995	11.45
08/31/1995	7.69
09/28/1995	11.2
10/26/1995	12.31
11/28/1995	13.1
12/28/1995	13.22
01/24/1996	14.51
02/28/1996	14.85
03/29/1996	15.23
04/29/1996	14.81
05/30/1996	14.68
06/27/1996	8.11
08/06/1996	7.61
08/29/1996	9.81
09/26/1996	11.78
10/31/1996	13.2
11/27/1996	13.86
01/02/1997	13.86

WELL FC12
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 1.3

DATE:	DEPTH FROM MP:
12/01/1994	13.47
01/13/1995	18.37
03/03/1995	19.99
04/27/1995	17.78
05/31/1995	18.02
06/28/1995	3.61
07/28/1995	4.86
08/31/1995	3.75
09/28/1995	7.24
10/26/1995	10.45
11/28/1995	14.57
01/04/1996	16.95
01/24/1996	18.02
02/28/1996	16.65
03/29/1996	17.25
04/29/1996	17.41
05/30/1996	11.9
06/27/1996	7.05
08/06/1996	3.48
08/29/1996	6.44
09/26/1996	8.28
10/31/1996	11.96
11/27/1996	15.09
01/02/1997	17.02

WELL FC13
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 1.7

DATE:	DEPTH FROM MP:
12/01/1994	15.45
01/13/1995	17.5
03/03/1995	17.8
04/27/1995	16.6
05/31/1995	7.1
06/28/1995	6.49
07/28/1995	10.74
08/31/1995	6.15
09/28/1995	10.33
10/26/1995	12.65
11/28/1995	15.3
01/04/1996	16.9
01/24/1996	18.21
02/28/1996	16.77
03/29/1996	17.36
04/29/1996	16.89
05/30/1996	9.71
06/27/1996	5.29
08/06/1996	7.32
08/29/1996	7.4
09/26/1996	10.57
10/31/1996	12.78
11/27/1996	14.67
01/02/1997	15.28

WELL FC14
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 0.0

DATE:	DEPTH FROM MP:
03/13/1995	20.63
04/27/1995	22.39
05/31/1995	12.36
06/28/1995	4.17
07/28/1995	8.21
08/31/1995	6.48
09/28/1995	10.16
10/26/1995	14.52
11/28/1995	18.58
01/04/1996	20.34
01/24/1996	21.63
02/28/1996	18.13
03/29/1996	17.71
04/29/1996	13.42
05/30/1996	13.96
06/27/1996	6.39
08/06/1996	6.73
08/29/1996	4.12
09/26/1996	7.85
10/31/1996	14.31
11/27/1996	17.67
01/02/1997	16.78

APPENDIX E (CONT.)

WELL FC15
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 1.6

DATE:	DEPTH FROM MP:
12/01/1994	26.55
01/12/1995	25.6
03/03/1995	24.05
04/27/1995	24.28
05/31/1995	21.28
06/28/1995	34.63
07/28/1995	60.47
08/31/1995	41.77
09/28/1995	29.96
10/26/1995	29.65
11/28/1995	33.9
12/28/1995	36.5
01/24/1996	36.94
02/28/1996	35.02
03/29/1996	35.53
04/29/1996	35.32
05/30/1996	41.14
06/27/1996	48.53
08/06/1996	33.01
08/29/1996	56.82
09/26/1996	32.93
10/31/1996	45.49
11/27/1996	40.66
01/02/1997	33.18

WELL FC16
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 2.6

DATE:	DEPTH FROM MP:
10/19/1994	34.21
11/30/1994	41.6
01/12/1995	45.95
03/03/1995	48.58
04/27/1995	50.1
05/31/1995	50.13
06/28/1995	27.13
07/28/1995	34.65
08/31/1995	28.88
09/28/1995	33
10/26/1995	38.39
11/28/1995	41.68
12/28/1995	44.06
01/24/1996	46.06
02/28/1996	47.71
03/29/1996	48.75
04/29/1996	49.19
05/30/1996	46.43
06/27/1996	31.08
08/06/1996	30.28
08/29/1996	28.8
09/26/1996	33.28
10/31/1996	34.27
11/27/1996	39.16
01/02/1997	43.07

WELL FC17
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): -3.5

DATE:	DEPTH FROM MP:
11/30/1994	36.95
01/13/1995	39
03/03/1995	41.1
04/27/1995	43.56
05/31/1995	42.71
06/28/1995	31.12
07/28/1995	31.97
08/31/1995	27.4
09/28/1995	31.29
10/26/1995	36.14
11/28/1995	27.68
12/28/1995	39.57
01/04/1996	38.69
01/24/1996	39.63
03/29/1996	41.66
04/29/1996	42.75
05/30/1996	37.46
07/11/1996	30.06
08/06/1996	30.39
08/29/1996	27.82
09/26/1996	30.18
10/31/1996	34.09
11/27/1996	38.26
01/02/1997	38.26

WELL FC18
MP: ACCESS PORT
MP FROM LAND SURFACE (ft.): 0.7

DATE:	DEPTH FROM MP:
11/30/1994	109.4
01/12/1995	112.65
03/03/1995	114.6
04/27/1995	115.9
05/31/1995	116.35
06/28/1995	109.16
07/28/1995	99.85
08/31/1995	94.7
09/28/1995	95.39
10/26/1995	77.68
11/28/1995	59.19
12/28/1995	110.14
01/24/1996	111.9
02/28/1996	114.64
03/29/1996	114
04/29/1996	101.03
05/30/1996	114.68
06/27/1996	106.61
08/06/1996	93.98
08/29/1996	89.88
09/26/1996	90.87
10/31/1996	101.51
11/26/1996	106.57
01/02/1997	109.71

WELL FC19
MP: ACCESS PORT
MP FROM LAND SURFACE (ft.): -3.7

DATE:	DEPTH FROM MP:
11/03/1994	102.8
11/30/1994	108.85
03/03/1995	108.65
04/27/1995	111.27
05/31/1995	92.82
06/28/1995	85.15
07/28/1995	78.84
08/31/1995	80.55
09/28/1995	80.51
10/26/1995	90.87
11/28/1995	98.08
12/28/1995	101.33
01/24/1996	103.23
02/28/1996	104.74
03/29/1996	106.83
04/29/1996	106.95
05/30/1996	95.7
06/27/1996	81.05
08/06/1996	83.93
08/29/1996	78.66
09/26/1996	78.06
10/31/1996	94.3
11/27/1996	102.94
01/02/1997	104.74

WELL FC20
MP: ACCESS PORT
MP FROM LAND SURFACE (ft.): 1.4

DATE:	DEPTH FROM MP:
11/02/1994	108.65
11/30/1994	111.46
01/13/1995	97.88

WELL FC21
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 0.7

DATE:	DEPTH FROM MP:
11/02/1994	22.73
11/30/1994	28.87
01/12/1995	32.42
03/03/1995	33.87
04/27/1995	34.74
05/31/1995	18.04
06/28/1995	20.63
07/28/1995	23.96
08/31/1995	17.67
09/28/1995	21.68
10/26/1995	22.63
11/28/1995	28.08
12/28/1995	31.46
01/24/1996	34.75
02/28/1996	31.25
03/29/1996	33.58
04/29/1996	26.63
05/30/1996	18.97
06/27/1996	19.51
08/06/1996	28.81
08/29/1996	21.88
09/26/1996	20.74
10/31/1996	26.21
11/27/1996	29.75
01/02/1997	31.88

APPENDIX E (CONT.)

WELL FC22
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 0.95

DATE:	DEPTH FROM MP:
10/19/1994	12.42
11/30/1994	17.44
01/12/1995	21.01
03/03/1995	23.82
04/27/1995	24.58
05/31/1995	22.4
06/28/1995	12.56
07/28/1995	12.75
08/31/1995	11.05
09/28/1995	11.29
10/26/1995	14.81
11/28/1995	17.65
12/28/1995	19.92
01/24/1996	22.17
02/28/1996	23.08
03/29/1996	24.23
04/29/1996	23.41
05/30/1996	23.28
06/27/1996	14.28
08/06/1996	11.67
08/29/1996	12.12
09/26/1996	11.91
10/31/1996	16.45
11/27/1996	18.52
01/02/1997	20.57

WELL FC23
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 1.4

DATE:	DEPTH FROM MP:
10/19/1994	16.83
11/30/1994	23.24
01/12/1995	28.1
03/03/1995	32.71
06/28/1995	24.91
07/28/1995	21.91
08/31/1995	16.98
09/28/1995	12.19
10/26/1995	17.04
11/28/1995	22.44
12/28/1995	26.03
01/04/1996	26.86
01/24/1996	28.58
02/28/1996	31.48
03/29/1996	34
04/29/1996	36.46
05/30/1996	36.29
06/27/1996	20.57
08/06/1996	18.29
08/29/1996	14.5
09/26/1996	9.83
10/31/1996	14.81
11/27/1996	19.12
01/02/1997	23.91

WELL FC25
MP: ACCESS PLACE
MP FROM LAND SURFACE (ft.): 0.55

DATE:	DEPTH FROM MP:
11/03/1994	13.62
11/30/1994	16.83
01/12/1995	19.42
03/03/1995	20.34
04/27/1995	20.46
05/31/1995	13.2
06/28/1995	8.11
07/28/1995	11.1
08/31/1995	9.86
09/28/1995	12.41
10/26/1995	15.72
11/28/1995	18.64
12/28/1995	19.65
01/24/1996	20.22
02/28/1996	19.94
03/29/1996	20.37
04/29/1996	20.23
05/30/1996	12.44
06/27/1996	8.82
08/06/1996	8.09
08/29/1996	9.58
09/26/1996	10.42
10/31/1996	14.08
11/27/1996	16.97
01/02/1997	18.31

WELL FC26
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 1.5

DATE:	DEPTH FROM MP:
12/01/1994	26.82
01/12/1995	29.92
03/03/1995	31.6
04/27/1995	32.42
05/31/1995	24.54
06/28/1995	8.95
07/28/1995	12.52
08/31/1995	8.71
09/28/1995	18.44
10/26/1995	23.15
11/28/1995	25.37
12/28/1995	27.27
01/24/1996	28.78
02/28/1996	29.19
03/29/1996	29.86
04/29/1996	29.02
05/30/1996	28.81
06/27/1996	8.88
08/06/1996	11.05
08/29/1996	14.4
09/26/1996	20.27
10/31/1996	24.64
11/27/1996	12.57
01/02/1997	27.63

WELL FC27
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 2.4

DATE:	DEPTH FROM MP:
12/01/1994	13.52
01/13/1995	13.41
/03/03/1995	13.94
04/27/1995	13.2
05/31/1995	9.31
06/28/1995	6.75
07/28/1995	11.47
08/31/1995	8.62
09/28/1995	10.39
10/26/1995	12.42
11/28/1995	13.28
01/04/1996	13.38
01/24/1996	13.62
02/28/1996	13.39
03/29/1996	13.56
04/29/1996	13.2
05/30/1996	12.48
06/27/1996	8.88
08/06/1996	11.26
08/29/1996	7.04
09/26/1996	10.8
10/31/1996	12.16
11/27/1996	13.19
01/02/1997	11.91

WELL FC28
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 0.0

DATE:	DEPTH FROM MP:
01/13/1995	47
03/03/1995	49.51
04/27/1995	48.5
05/31/1995	45.8
06/28/1995	35.62
07/28/1995	38.3
08/31/1995	34.32
09/28/1995	35.36
10/26/1995	40.6
11/28/1995	43.3
12/28/1995	45.6
01/24/1996	47.44
02/28/1996	49.4
03/29/1996	49.85
04/29/1996	47.88
05/30/1996	47.1
06/27/1996	39.68
08/29/1996	30.34
09/26/1996	35.84
10/31/1996	41.55
11/27/1996	44.09
01/02/1996	46.96

APPENDIX E (CONT.)

WELL FC29
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 1.9

DATE:	DEPTH FROM MP:
11/03/1994	7.15
11/30/1994	8.69
01/12/1995	9.86
03/03/1995	10.18
04/27/1995	10.61
05/31/1995	8.69
06/28/1995	0
07/28/1995	4.9
08/31/1995	4.09
09/28/1995	3.78
10/26/1995	7.58
11/28/1995	9
12/28/1995	9.31
01/24/1996	9.47
02/28/1996	8.95
03/29/1996	9.39
04/29/1996	8.35
05/30/1996	7.82
06/27/1996	1.01
08/06/1996	5.51
08/29/1996	3.91
09/26/1996	0
10/31/1996	7.86
11/27/1996	8.85
01/02/1997	8.64

WELL FC30
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 2.1

DATE:	DEPTH FROM MP:
12/01/1994	41.27
01/12/1995	42.07
03/03/1995	42.62
04/27/1995	42.72
05/31/1995	41.62
06/28/1995	39.29
07/28/1995	38.28
08/31/1995	39.32
09/28/1995	38.37
10/26/1995	40.05
11/28/1995	41.02
12/28/1995	41.79
01/24/1996	42.15
02/28/1996	42.32
03/29/1996	42.47
04/29/1996	42.12
05/30/1996	42.28
06/27/1996	40.05
08/06/1996	38.7
08/29/1996	38.26
09/26/1996	39.57
10/31/1996	41.4
11/27/1996	41.56
01/02/1997	41.93

WELL FC31
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 1.3

DATE:	DEPTH FROM MP:
12/01/1994	26.25
01/12/1995	26.7
03/03/1995	26.59
04/27/1995	26.65
05/31/1995	15.36
06/28/1995	21.15
07/28/1995	24.2
08/31/1995	22.37
09/28/1995	22.83
10/26/1995	25.51
11/28/1995	26.22
12/28/1995	26.38
01/24/1996	26.55
02/28/1996	26.17
03/29/1996	26.49
04/29/1996	25.91
05/30/1996	22.46
06/27/1996	12.5
08/06/1996	16.42
08/29/1996	13.41
09/26/1996	22.18
10/31/1996	25.82
11/27/1996	26.85
01/02/1997	26.35

WELL FC32
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): -2.3

DATE:	DEPTH FROM MP:
11/0/1994	3 9.73

WELL FC33
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 1.5

DATE:	DEPTH FROM MP:
11/03/1994	7.93
11/30/1994	7.99
01/12/1995	8.07
03/03/1995	7.74
04/27/1995	8.04
05/31/1995	6.12
06/28/1995	5.69
07/28/1995	6.35
08/31/1995	6.68
09/28/1995	7.95
10/26/1995	7.49
11/28/1995	7.69
12/28/1995	8.56
01/24/1996	7.76
02/28/1996	7.38
03/29/1996	7.58
04/29/1996	6.08
05/30/1996	5.93
06/27/1996	5.69
08/06/1996	6.56
08/29/1996	6.5
09/26/1996	7.05
10/31/1996	7.86
11/27/1996	7.92
01/02/1997	9.55

WELL FC34
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 2.4

DATE:	DEPTH FROM MP:
12/01/1994	18.67
01/12/1995	20.95
03/03/1995	21.88
04/27/1995	22.79
05/31/1995	14.08
06/28/1995	11.15
07/28/1995	14.51
08/31/1995	11.47
09/28/1995	14.63
10/26/1995	16.77
11/28/1995	18.61
12/28/1995	19.21
01/24/1996	20.17
02/28/1996	19.18
03/29/1996	20.29
04/29/1996	17.92
05/30/1996	17.05
06/27/1996	11.65
08/06/1996	12.18
08/29/1996	10.53
09/26/1996	15.72
10/31/1996	17.41
11/27/1996	18.33
01/02/1997	16.29

WELL FC35
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 2.0

DATE:	DEPTH FROM MP:
12/01/1994	16.04
01/12/1995	16.64
03/03/1995	17.8
04/27/1995	16.81
05/31/1995	15.57
06/28/1995	14.84
07/28/1995	15.1
08/31/1995	20.9
09/28/1995	14.84
10/26/1995	15.23
11/28/1995	15.51
01/04/1996	16.24
01/24/1996	16.28
02/28/1996	16.41
03/29/1996	16.56
04/29/1996	15.94
05/30/1996	15.68
06/27/1996	15.41
08/06/1996	19.45
08/29/1996	15.29
09/26/1996	15.51
10/31/1996	15.59
11/27/1996	15.78
01/02/1997	10.99

APPENDIX E (CONT.)

WELL FC36
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 1.7

DATE:	DEPTH FROM MP:
11/30/1994	15.02
01/13/1995	18.34
03/03/1995	20.55
04/27/1995	23.1
05/31/1995	12.09
06/28/1995	10.94
07/28/1995	14.28
08/31/1995	13.35
09/28/1995	13.92
10/26/1995	13.85
11/28/1995	15.65
12/28/1995	17.28
01/24/1996	18.53
02/28/1996	18.69
04/29/1996	18.33
05/30/1996	12.39
06/27/1996	11.11
08/06/1996	10.47
08/29/1996	11.98
09/26/1996	11.34
10/31/1996	25.22
11/27/1996	20.55
01/02/1997	17.16

WELL FC37
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 0.85

DATE:	DEPTH FROM MP:
12/01/1994	7.36
01/13/1995	8.75
03/03/1995	8.97
04/27/1995	8.93
05/31/1995	8.78
06/28/1995	4.83
07/28/1995	8.9
08/31/1995	6.93
09/28/1995	5.28
10/26/1995	6.53
11/28/1995	7.26
01/04/1996	8.23
01/24/1996	8.61
02/28/1996	8.44
03/29/1996	8.45
04/29/1996	7.8
05/30/1996	7.85
06/27/1996	5.1
08/06/1996	9.22
08/29/1996	6
09/26/1996	8
10/31/1996	7.38
11/27/1996	7.67
01/02/1997	6.31

WELL FC38
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 1.8

DATE:	DEPTH FROM MP:
12/01/1994	16.42
01/13/1995	16.69
03/03/1995	17.1
04/27/1995	16.87
05/31/1995	10.21
06/28/1995	6.53
07/28/1995	12.08
08/31/1995	14.22
09/28/1995	13.4
10/26/1995	15.58
11/28/1995	16.38
01/04/1996	16.51
01/24/1996	16.68
02/28/1996	16.69
03/29/1996	16.84
04/29/1996	16.29
05/30/1996	14.28
06/27/1996	11.85
08/06/1996	7.41
08/29/1996	14.05
09/26/1996	14.31
10/31/1996	14.92
11/27/1996	16.52
01/02/1997	16.06

WELL FC39
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 2.1

DATE:	DEPTH FROM MP:
03/13/1995	12.89
04/27/1995	12.8
05/31/1995	10.33
06/28/1995	5.1
07/28/1995	6.33
08/31/1995	4.59
09/28/1995	6.79
10/26/1995	8.81
11/28/1995	10.04
01/04/1996	11.03
01/24/1996	11.66
02/28/1996	12.13
03/29/1996	12.59
04/29/1996	12.65
05/30/1996	10.7
06/27/1996	5.29
08/06/1996	5.31
08/29/1996	4.91
09/26/1996	6.77
10/31/1996	9.47
11/27/1996	10.3
01/02/1997	10.04

WELL FC40
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 2.0

DATE:	DEPTH FROM MP:
12/01/1994	8.97
01/12/1995	9.08
03/03/1995	9.1
04/27/1995	9.02
05/31/1995	7.11
06/28/1995	7.17
07/28/1995	8.6
08/31/1995	8.26
09/28/1995	8.28
10/26/1995	8.42
11/28/1995	8.78
01/04/1996	8.96
01/24/1996	8.9
02/28/1996	9.02
03/29/1996	8.97
04/29/1996	8.46
05/30/1996	6.93
06/27/1996	6.78
08/06/1996	7.09
08/29/1996	8.44
09/26/1996	6.78
10/31/1996	8.02
11/27/1996	8.78
01/02/1997	7.72

WELL FC41
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): -5.72

DATE:	DEPTH FROM MP:
11/03/1994	33.99
11/30/1994	34.25
01/12/1995	34.45
03/03/1995	33.5
04/27/1995	33.33
05/31/1995	33
06/28/1995	32.67
07/28/1995	33.41
08/31/1995	34.54
09/28/1995	34.33
10/26/1995	34.96
11/28/1995	33.97
12/28/1995	33.73
01/24/1996	33.3
02/28/1996	34.29
03/29/1996	30.66
04/29/1996	30.79
05/30/1996	31.49
06/27/1996	32.3
08/06/1996	33.58
08/29/1996	34.1
09/26/1996	34.06
10/31/1996	35.3
11/27/1996	34.02
01/02/1997	33.63

WELL FC42
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 1.66

DATE:	DEPTH FROM MP:
11/03/1994	48.95
12/01/1994	49.22
01/13/1995	49.58
03/13/1995	49.44
05/15/1995	48.82
07/11/1995	47.72
08/17/1995	47.75
09/12/1995	47.88
10/16/1995	48.15
11/22/1995	49.22
12/15/1995	47.87
01/17/1996	47.92
02/14/1996	47.95
03/15/1996	47.93
04/16/1996	46.93
05/14/1996	46.68
06/18/1996	45.4
07/15/1996	45.24
08/14/1996	45.78
09/17/1996	46.12
10/16/1996	46.58
11/14/1996	46.97
12/16/1996	48.69

WELL FC43
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 1.46

DATE:	DEPTH FROM MP:
11/03/1994	8.05
12/01/1994	8.27
01/13/1995	9.25
03/13/1995	10.16
05/15/1995	10.17
07/11/1995	6.3
08/17/1995	6.56
09/12/1995	7.15
10/16/1995	7.14
11/22/1995	7.65
12/15/1995	7.49
01/17/1996	7.36
02/14/1996	8.13
03/15/1996	8.75
04/16/1996	8.71
05/14/1996	8.26
06/18/1996	5.27
07/15/1996	4.86
08/14/1996	5.73
09/17/1996	6.65
10/16/1996	7.18
11/14/1996	7.79
12/16/1996	8.75

WELL FC44
MP: WOODEN FLOOR
MP FROM LAND SURFACE (ft.): 0.0

DATE:	DEPTH FROM MP:
11/03/1994	5.28
12/01/1994	5.43
01/13/1995	3.1
03/13/1995	2.44
05/16/1995	3.55
07/12/1995	1.41
08/17/1995	2.48
09/12/1995	2.79
10/16/1995	3.8
11/22/1995	5.43
12/15/1995	3.24
01/17/1996	4.01
02/14/1996	3.44
03/15/1996	4.98
04/16/1996	5.28
05/14/1996	5.4
06/18/1996	2.31
07/15/1996	3.15
08/14/1996	3.12
09/17/1996	3.57
10/16/1996	4.69
11/14/1996	3.44
12/16/1996	4.29

WELL FC45
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 0.97

DATE:	DEPTH FROM MP:
11/03/1994	16.6
12/01/1994	17.82
01/13/1995	19.24
03/13/1995	14.28
05/16/1995	17.94
07/12/1995	17.75
08/17/1995	19.13
09/12/1995	15.83
10/16/1995	17.11
11/22/1995	18.79
12/15/1995	18.68
01/17/1996	18.53
02/14/1996	19.08
03/15/1996	19.31
04/16/1996	18.68
05/14/1996	17.32
06/18/1996	16
07/15/1996	14.12
08/14/1996	14.01
09/17/1996	14.51
10/16/1996	16.14
11/14/1996	17.17

WELL FC46
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 2.0

DATE:	DEPTH FROM MP:
03/13/1995	5.99
05/15/1995	5.62
07/11/1995	4.82
08/17/1995	5.66
09/12/1995	5.63
10/16/1995	5.97
11/22/1995	6.1
12/15/1995	5.66
01/17/1996	5.52
02/14/1996	5.82
03/15/1996	5.97
04/16/1996	5.51
05/14/1996	5.73
06/18/1996	5.51
07/15/1996	5.25
08/14/1996	6.24
09/17/1996	5.93
10/16/1996	6.19
11/14/1996	6.03
12/16/1996	6.01

WELL FC47
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): -4.2

DATE:	DEPTH FROM MP:
12/01/1994	15.67
03/03/1995	16.2
04/27/1995	16.1
05/31/1995	12.52
06/28/1995	12.85
07/28/1995	13.1
08/31/1995	13.9
09/28/1995	14.19
10/26/1995	15.13
11/28/1995	15.61
01/04/1996	15.61

WELL FC48
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 1.7

DATE:	DEPTH FROM MP:
11/30/1994	54.08
01/12/1995	56.05
03/03/1995	57.09
04/27/1995	58.12
05/31/1995	54.54
06/28/1995	47.98
07/28/1995	48.37
08/31/1995	45.5
09/28/1995	47.64
10/26/1995	50.96
11/28/1995	53.02
12/28/1995	54.58
01/24/1996	55.24
02/28/1996	55.59
03/29/1996	56.09
04/29/1996	55.52
05/30/1996	53.7
06/27/1996	47.47
08/06/1996	45.25
08/29/1996	46.24
09/26/1996	47.92
10/31/1996	51.31
11/27/1996	53.46
01/02/1997	54.65

APPENDIX E (CONT.)

WELL FC49
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 1.5

DATE:	DEPTH FROM MP:
01/13/1995	68.57
03/03/1995	69.99
04/27/1995	70.82
05/31/1995	65.67
06/28/1995	50.55
07/28/1995	55.57
08/31/1995	49.9
09/28/1995	57.58
10/26/1995	62.2
11/28/1995	65.71
12/28/1995	66.05
01/24/1996	67.57
02/28/1996	67.59
03/29/1996	68.59
04/29/1996	67.87
05/15/1996	68.5
05/30/1996	67.6
06/12/1996	59.51
06/27/1996	51.37
07/11/1996	52.95
08/01/1996	52.35
08/06/1996	51.92
08/29/1996	54.71
09/20/1996	58.75
09/26/1996	59.64
10/31/1996	63.68
11/27/1996	65.51
01/02/1997	67.37

WELL FC50
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 1.5

DATE:	DEPTH FROM MP:
03/14/1995	40.98
05/15/1995	40.58
07/11/1995	39.15
08/17/1995	39.81
09/12/1995	39.97
10/16/1995	40.08
11/22/1995	41.31
12/15/1995	40.74
01/17/1996	40.92
02/14/1996	39.88
03/15/1996	40.48
04/16/1996	39.91
05/14/1996	40.02
06/18/1996	39.98
07/15/1996	39.16
08/14/1996	40.65
09/17/1996	39.6
10/16/1996	41.22
11/14/1996	41.51
12/16/1996	42.05

WELL FC51
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 1.1

DATE:	DEPTH FROM MP:
05/15/1995	18.5
07/11/1995	16.6
08/17/1995	17.6
09/12/1995	17.92
10/16/1995	18.28
11/22/1995	19.49
12/15/1995	19.08
01/17/1996	19.19
03/15/1996	19.42
04/16/1996	17.8
05/14/1996	18.2
06/18/1996	17.7
07/15/1996	17.25
08/14/1996	16.44
09/17/1996	17.41
10/16/1996	18.85
11/14/1996	19.55
12/16/1996	19.84

WELL FC52
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 1.3

DATE:	DEPTH FROM MP:
03/14/1995	60.38
05/15/1995	59.12
07/11/1995	57.54
08/17/1995	58.1
09/12/1995	60.5
10/16/1995	59.8
11/22/1995	59.91
12/15/1995	59.62
01/17/1996	59.79
02/14/1996	59.53
03/15/1996	59.75
04/16/1996	58.24
05/14/1996	58.77
06/18/1996	58.19
07/15/1996	58.11
08/14/1996	57.05
09/17/1996	57.69
10/16/1996	59.19
11/14/1996	59.85
12/16/1996	59.79

WELL FC53
MP: INNER CASING RIM
MP FROM LAND SURFACE (ft.): 0.0

DATE:	DEPTH FROM MP:
03/14/1995	5.4
05/15/1995	4.32
07/11/1995	4.8
08/17/1995	5.9
09/12/1995	5.83
10/16/1995	6.85
12/15/1995	5.15
01/17/1996	5.14
02/14/1996	6.49
03/15/1996	6.02
04/16/1996	5.05
05/14/1996	5.33
06/18/1996	6.08
07/15/1996	5.89
08/14/1996	4.82
09/17/1996	5.6
10/16 /1996	5.92
11/14 /1996	6.02
12/16/1996	6.98

WELL FC54
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 1.0

DATE:	DEPTH FROM MP:
03/13/1995	15.12
05/15/1995	15.25
07/12/1995	10.1
08/17/1995	11.95
09/12/1995	11.15
10/16/1995	10.77
11/22/1995	10.99
12/15/1995	10.12
01/17/1996	10.22
02/14/1996	12.58
03/15/1996	13.67
04/16/1996	13.73
05/14/1996	14.32
06/18/1996	12.39
07/15/1996	10.02
08/14/1996	10.7
09/17/1996	11.23
10/16/1996	11.31
11/14/1996	12.1
12/16/1996	13.29

WELL FC55
MP: ACCESS PORT
MP FROM LAND SURFACE (ft.): 1.6

DATE:	DEPTH FROM MP:
03/14/1995	34.58
05/15/1995	34.75
07/12/1995	25.27
08/17/1995	27.64
09/12/1995	26.69
10/16/1995	25.34
11/22/1995	25.55
12/15/1995	24.85
01/17/1996	24.79
02/14/1996	31.49
03/15/1996	30.17
04/16/1996	35.51
05/14 /1996	32.6
06/18/1996	28.68
07/15/1996	24.03
08/14/1996	26.83
10/16/1996	26.15
11/14/1996	27.47
12/16/1996	31.18

APPENDIX E (CONT.)

WELL FC56
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 1.5

DATE:	DEPTH FROM MP:
03/14/1995	11.6
05/15/1995	8.72
07/12/1995	8.8
08/17/1995	10.88
09/12/1995	9.9
10/16/1995	8.43
11/22/1995	8.84
12/15/1995	10.5
01/17/1996	10.58
02/14/1996	11.09
03/15/1996	11.5
04/16/1996	11.02
05/14/1996	11.03
06/18/1996	7.14
07/15/1996	10.1
08/14/1996	10.92
09/17/1996	11.2
10/16/1996	11.43
11/14/1996	11.67
12/16/1996	11.79

WELL FC57
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 2.0

DATE:	DEPTH FROM MP:
03/14/1995	14.37
05/15/1995	12.92
07/12/1995	12.72
08/17/1995	14.18
09/12/1995	13.69
10/16/1995	12.84
11/22/1995	13.02
12/15/1995	13.74
01/17/1996	14.06
02/14/1996	13.85
03/15/1996	14.32
04/16/1996	13.93
05/14/1996	14.12
06/18/1996	11.92
07/15/1996	13.01
08/14/1996	14.05
09/17/1996	14.27
10/16/1996	14.4
11/14 /1996	14.6
12/16/1996	14.69

WELL FC58
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 1.0

DATE:	DEPTH FROM MP:
05/15/1995	4.32
07/12/1995	4.03
08/17/1995	4.99
09/12/1995	4.22
10/16/1995	4.24
11/22/1995	3.35
12/15/1995	4.54
01/17/1996	4.62
04/16/1996	4.41
06/18/1996	3.86
07/15/1996	4.27
08/14/1996	4.54
09/17/1996	4.52
10/16/1996	4.69
11/14/1996	4.92

WELL FC59
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 1.6

DATE:	DEPTH FROM MP:
05/16/1995	53.77
07/11/1995	42.2
08/17/1995	45
09/12/1995	45.81
10/16/1995	47.28
11/22/1995	48.81
12/15/1995	49.03
01/17/1996	49.52
02/14/1996	54.51
03/15/1996	51.1
04/16/1996	50.96
05/14/1996	51.28
06/18/1996	50.11
07/15/1996	51.45
08/14/1996	44.37
09/17/1996	45.73
10/16/1996	47.9
11/14/1996	47.88
12/16/1996	48.89

WELL FC60
MP: ACCESS PORT
MP FROM LAND SURFACE (ft.): -3.7

DATE:	DEPTH FROM MP:
05/16/1995	21.73
07/12/1995	4.85
08/17/1995	12.03
09/12/1995	13.7
10/16/1995	11.55
11/22/1995	15.47
12/15/1995	15.83
01/17/1996	15.21
02/14/1996	19.6
03/15/1996	18.47
04/16/1996	20.7
05/14/1996	19.27
06/18/1996	8.67
07/15/1996	5.32
08/14/1996	11.96
09/17/1996	5.21
10/16/1996	11.93
11/14/1996	14.75
12/16/1996	17.74

WELL FC61
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 1.5

DATE:	DEPTH FROM MP:
05/16/1995	17.85
07/12/1995	15.85
08/17/1995	16.7
10/16/1995	16.58
11/22/1995	18.16
12/15/1995	17.94
01/17/1996	18.23
02/14/1996	17.5
03/15/1996	18.3
04/16/1996	17.58
05/14/1996	17.91
06/18/1996	15.85
07/15/1996	15.94
08/14/1996	16.78
09/17/1996	16.71
10/16/1996	16.92
11/14/1996	17.78
12/16/1996	18.82

WELL FC62
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 1.5

DATE:	DEPTH FROM MP:
05/15/1995	13
07/12/1995	9.13
08/17/1995	7.86
09/12/1995	8.66
10/16/1995	10.12
11/22/1995	11.86
12/15/1995	12.06
01/17/1996	12.21
02/14/1996	12.09
03/15/1996	12.37
04/16/1996	11.98
05/14/1996	11.73
06/18/1996	10.03
07/15/1996	12
08/14/1996	7.11
09/17/1996	8.92
10/16/1996	10
11/14/1996	11.57
12/16/1996	12.52

WELL FC63
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 1.0

DATE:	DEPTH FROM MP:
05/15/1995	15.8
07/12/1995	11.53
08/17/1995	13.77
09/12/1995	12.85
10/16/1995	14.5
11/22/1995	17.65
12/15/1995	15.43
01/17/1996	15.79
02/14/1996	13.64
03/15/1996	16.23
04/16/1996	16.11
05/14/1996	18.15
06/18/1996	11.44
07/15/1996	12.12
08/14/1996	12.79
09/17/1996	14.68
10/16/1996	14.8
11/14/1996	18.61
12/16/1996	18.46

WELL FC64
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 0.0

DATE:	DEPTH FROM MP:
05/16/1995	25.1
07/12/1995	12.91
08/17/1995	15.86
09/12/1995	14.28
10/16/1995	20.18
11/22/1995	23.64
12/15/1995	24.04
01/17/1996	24.29

APPENDIX E (CONT.)

WELL FC65
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 0.9

DATE:	DEPTH FROM MP:
05/16/1995	15.35
07/12/1995	6.95
08/17/1995	12.02
09/12/1995	5.45
10/16/1995	15.52
11/22/1995	19.44
12/15/1995	19.22
01/17/1996	20.21
02/14/1996	18.82
03/15/1996	21.34
04/16/1996	20.76
05/14/1996	22.18
06/18/1996	10.25
07/15/1996	10.6
08/14/1996	16.33
09/17/1996	10.84
10/16/1996	15.95
11/14/1996	20.11
12/16/1996	22.44

WELL FC66
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): -4.3

DATE:	DEPTH FROM MP:
07/12/1995	3.54
08/17/1995	7.8
09/12/1995	7.86
10/16/1995	7.38
11/22/1995	13.81
12/15/1995	13.14
01/17/1996	13.96
04/16/1996	5.71
06/18/1996	14.41
07/15/1996	8.06
08/14/1996	3.12
09/17/1996	4.57
10/16/1996	14.31
11/14/1996	13.02

WELL FC67
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): -4.6

DATE:	DEPTH FROM MP:
07/12/1995	21.17
08/17/1995	20.6
09/12/1995	19.65
10/16/1995	19.98
11/22/1995	21.99
12/15/1995	22.55
01/17/1996	23.05
04/16/1996	23.87
05/14/1996	24.81
06/18/1996	22.36
07/15/1996	15.6
08/14/1996	13.07
09/17/1996	13.62
10/16/1996	15.49
11/14 /1996	17.01

WELL FC68
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 1.8

DATE:	DEPTH FROM MP:
07/12/1995	18.32
08/17/1995	23.81
09/12/1995	13.91
10/16/1995	22.11
11/22/1995	25.03
12/15/1995	22.62
01/17/1996	22.96
02/14/1996	27.4
03/15/1996	26.51
04/16/1996	20.63
05/14/1996	22.99
06/18/1996	23.55
07/15/1996	16.14
08/14/1996	17.87
09/17/1996	22.98
10/16/1996	26.26
11/14/1996	27.06

WELL FC69
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 1.8

DATE:	DEPTH FROM MP:
07/11/1995	56.15
08/17/1995	55.12
09/12/1995	44.32
10/16/1995	62.28
11/22/1995	71.23
12/15/1995	71.3
01/17/1996	71.83
02/14/1996	77.04
03/15/1996	78.28
04/16/1996	78.59
05/14/1996	79.82
06/18/1996	67.99
07/15/1996	49.19
09/17/1996	49.88
10/16/1996	64.19
11/14/1996	70.71
12/16/1996	74.49

WELL FC70
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 2.0

DATE:	DEPTH FROM MP:
01/23/1996	4.41
02/28/1996	5.61
03/29/1996	6.7
04/29/1996	5.65
05/30/1996	5.33
06/27/1996	1.5
08/01/1996	1.71
08/06/1996	1.65
08/29/1996	1.22
09/20/1996	1.57
09/26/1996	1.78
10/18/1996	2.24
10/31/1996	2.59
11/27/1996	3.02
01/02/1997	3.06

WELL FC71
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 1.7

DATE:	DEPTH FROM MP:
02/07/1996	46.65
02/28/1996	46.16
03/29/1996	46.68
04/29/1996	45.05
05/30/1996	30.74
06/27/1996	25.19
08/06/1996	28.6
08/29/1996	32.68
09/26/1996	35.76
10/31/1996	42.81
11/27/1996	44.29
01/02/1997	45.15

WELL FC72
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): -5.5

DATE:	DEPTH FROM MP:
04/15/1996	28.35
05/01/1996	28.42
05/14/1996	29.58
06/18/1996	26.8
07/15/1996	26.82
08/14/1996	24.47
09/17/1996	23.69
10/16/1996	26.25
11/14/1996	27.76
12/16/1996	27.92

WELL FCA1
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 1.3

DATE:	DEPTH FROM MP:
12/26/1995	37.43
12/28/1995	37.48
01/04/1996	38.04
01/08/1996	38.33
01/16/1996	39.28
02/14/1996	41.44
03/19/1996	43.62
04/15/1996	45.41
05/15/1996	47.11
06/12/1996	42.58
07/11/1996	35.69
08/01/1996	32.44
09/04/1996	27.58
09/25/1996	27.08
12/20/1996	35.17

WELL FCA2
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 1.5

DATE:	DEPTH FROM MP:
12/26/1996	24.23
12/28/1996	24.3
01/04/1996	24.94
01/08/1996	25.23
01/16/1996	25.61
02/14/1996	28
03/19/1996	30.22
04/15/1996	32.13
05/15/1996	34.14
06/12/1996	32.79
07/11/1996	26.46
08/01/1996	22.6
09/04/1996	15.94
09/25/1996	15.04
12/20/1996	21.11

APPENDIX E (CONT.)

WELL FCA3
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 1.4

DATE:	DEPTH FROM MP:
02/14/1996	27.75

WELL FCA4
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 1.4

DATE:	DEPTH FROM MP:
02/14/1996	41.4

WELL FCB1
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 2.0

DATE:	DEPTH FROM MP:
01/16/1996	39.21
02/14/1996	39.81
03/19/1996	40.49
03/29/1996	40.22
04/29/1996	39.51
05/15/1996	39.98
05/30/1996	40.02
06/12/1996	40.39
06/27/1996	32.03
07/11/1996	33.4
08/01/1996	32.74
08/06/1996	33.08
08/29/1996	32.46
09/20/1996	32.52
09/26/1996	33.45
10/31/1996	37.2
11/27/1996	37.95
01/02/1997	38.4
01/23/1997	38.93

WELL FCB2
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 1.4

DATE:	DEPTH FROM MP:
01/23/1996	16.51
02/14/1996	15.35
03/19/1996	17.34
04/15/1996	17.96
04/24/1996	17.3
05/15/1996	17.22
06/12/1996	7.56
07/11/1996	4.54
08/01/1996	3.27
08/29/1996	9.96
09/20/1996	7.83
10/16/1996	10.87
01/23/1997	15.12

WELL FCB3
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 2.0

DATE:	DEPTH FROM MP:
01/23/1996	16.16
02/14/1996	15.16

WELL FCB4
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 1.7

DATE:	DEPTH FROM MP:
01/22/1996	40.62
02/14/1996	40.79
04/15/1996	40.17
05/15/1996	37.91
06/12/1996	34.55
07/11/1996	32.32
08/01/1996	31.98
08/30/1996	32.77
09/26/1996	35.19
10/18/1996	36.95
11/20/1996	39.48
01/23/1997	39.83

WELL FCB5
MP: COP OF CASING
MP FROM LAND SURFACE (ft.): 1.2

DATE:	DEPTH FROM MP:
01/16/1996	72.38
02/14 /1996	73.02
03/19/1996	73.52
04/15/1996	73.46
05/15/1996	73.52
06/12/1996	67.37
07/11/1996	59.53
08/01/1996	58.72
09/20/1996	64.56
12/20/1996	71.9

WELL FCB6
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 2.4

DATE:	DEPTH FROM MP:
07/11/1996	34.86
08/01/1996	35.62

WELL FCC1
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 2.4

DATE:	DEPTH FROM MP:
02/14/1996	49.09
03/15/1996	49.8
03/26/1996	50.29
06/19/1996	42.25
06/20/1996	41.94
09/06/1996	34.68
10/24/1996	41.11
12/04/1996	46.86

WELL FCC2
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 2.1

DATE:	DEPTH FROM MP:
02/14/1996	23.65
03/15/1996	24.27
04/16/1996	24.44
05/14/1996	24.65
06/18/1996	21.89
07/15/1996	20.52
08/14/1996	21.74
09/17/1996	20.66
10/16/1996	23.34
11/14/1996	24.38
12/16/1996	24.81

WELL FCD1
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 2.1

DATE:	DEPTH FROM MP:
02/14/1996	70.45
03/15/1996	70.62
03/20/1996	70.81
04/17/1996	70.99
06/20/1996	71.46
07/20/1996	70.84
08/20/1996	69.66
09/20/1996	69.08
10/20/1996	68.83
11/20/1996	68.86
12/04/1996	69.3

WELL FCE1
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 1.9

DATE:	DEPTH FROM MP:
01/16/1996	27.63
02/28/1996	27.5
03/20/1996	27.9
04/15/1996	27.95
05/15/1996	28.23
06/12/1996	20.18
07/11/1996	22.03
08/01/1996	24.13
08/30/1996	23.5
09/26/1996	24.42
10/18/1996	25.9
11/20/1996	27.22
12/20/1996	27.67
01/23/1997	27.98

WELL FCE2
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 1.7

DATE:	DEPTH FROM MP:
02/06/1996	5.31
02/14/1996	5.81
02/28/1996	6.52
03/29/1996	7.61
04/29/1996	7.42
05/30/1996	6.41
06/27/1996	0.4
07/11/1996	0
08/01/1996	0.76
08/06/1996	0.76
08/29/1996	0
09/20/1996	0.38
09/26/1996	0.54
10/18/1996	1.39
10/31/1996	1.91
11/27/1996	2.7
01/02/1997	4.01
01/23/1997	4.97

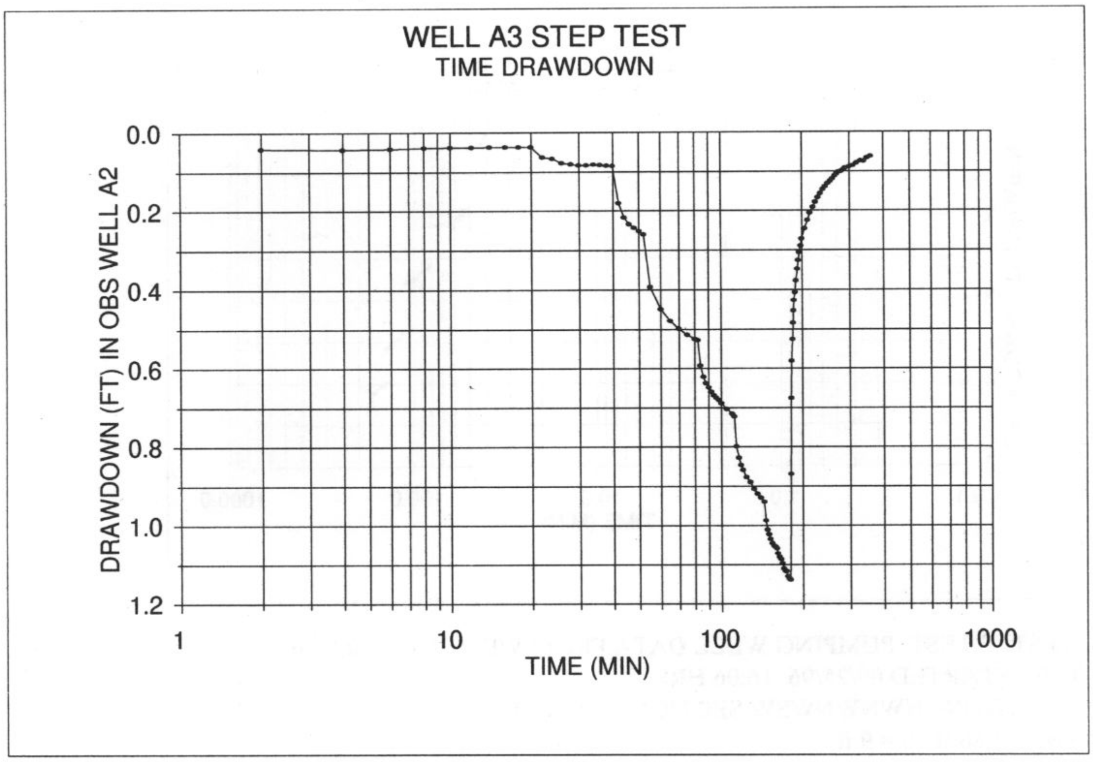
APPENDIX E (CONT.)

WELL FCF1
MP: TOP OF CASING
MP FROM LAND SURFACE (ft.): 1.8

DATE:	DEPTH FROM MP:
02/14/1996	8.33
03/15/1996	8.84
04/16/1996	9.19
05/14/1996	9.02
06/18/1996	7.23
07/15/1996	7.68
09/06/1996	7.59
09/17/1996	7.53
10/16/1996	7.49
11/14/1996	8.31
12/16/1996	8.83

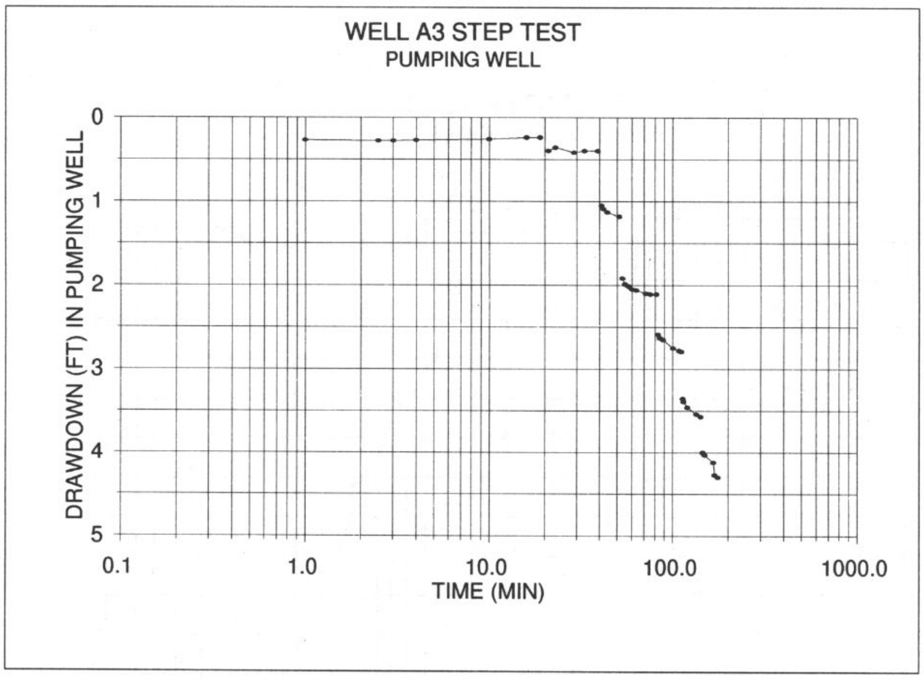
APPENDIX F

Aquifer Test Data



A3 STEP TEST` OBS WELL DATA FROM WELL A2 r = 30.5 ft
TEST STARTED 09/25/96 16:06 HRS
LOCATION: NWNWNWSW SECTION 14 T10N R13W
SWL 15.04 ft b = 9 ft
CONFINED SILTY SAND, GRAVEL, AND COBBLES

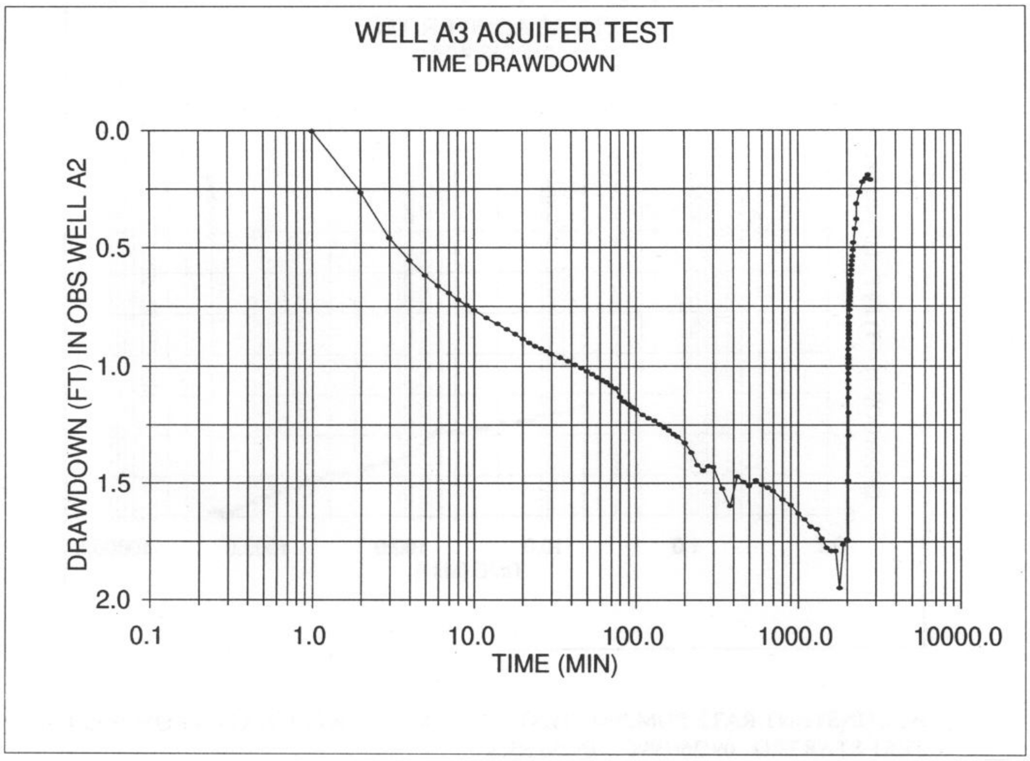
t (min)	s (ft)	Q (gpm)	t (min)	s (ft)	Q (gpm)	t (min)	s (ft)	Q (gpm)	t (min)	s (ft)	Q (gpm)
2	0.04	2.48	65	0.48	17.65	148	1.01	29.27	196	0.31	0.00
4	0.04	2.48	70	0.50	17.65	150	1.02	29.27	198	0.29	0.00
6	0.04	2.48	75	0.51	17.65	152	1.04	29.27	200	0.27	0.00
8	0.04	2.48	80	0.52	17.65	154	1.05	29.27	205	0.25	0.00
10	0.04	2.48	82	0.53	21.43	156	1.05	29.27	210	0.23	0.00
12	0.04	2.48	84	0.59	21.43	158	1.05	29.27	215	0.21	0.00
14	0.04	2.48	86	0.62	21.43	160	1.06	29.27	220	0.19	0.00
16	0.04	2.48	88	0.64	21.43	162	1.07	29.27	225	0.18	0.00
18	0.04	2.48	90	0.65	21.43	164	1.08	29.27	230	0.17	0.00
20	0.04	4.05	92	0.66	21.43	166	1.09	29.27	235	0.16	0.00
22	0.06	4.05	94	0.67	21.43	168	1.10	29.27	240	0.15	0.00
24	0.07	4.05	96	0.68	21.43	170	1.11	29.27	245	0.14	0.00
26	0.08	4.05	98	0.68	21.43	172	1.12	29.27	250	0.13	0.00
28	0.08	4.05	100	0.69	21.43	174	1.12	29.27	255	0.13	0.00
30	0.08	4.05	105	0.70	21.43	176	1.13	29.27	260	0.12	0.00
32	0.08	4.05	110	0.72	21.43	178	1.14	29.27	265	0.11	0.00
34	0.08	4.05	112	0.72	25.00	180	1.14	0.00	270	0.11	0.00
36	0.08	4.05	114	0.80	25.00	181	0.87	0.00	275	0.10	0.00
38	0.08	4.05	116	0.83	25.00	182	0.68	0.00	280	0.10	0.00
40	0.09	10.34	118	0.85	25.00	183	0.58	0.00	285	0.10	0.00
42	0.18	10.34	120	0.86	25.00	184	0.53	0.00	290	0.09	0.00
44	0.22	10.34	124	0.88	25.00	185	0.48	0.00	300	0.09	0.00
46	0.23	10.34	128	0.89	25.00	186	0.45	0.00	310	0.09	0.00
48	0.24	10.34	132	0.91	25.00	187	0.43	0.00	320	0.08	0.00
50	0.25	10.34	136	0.92	25.00	188	0.41	0.00	330	0.07	0.00
52	0.26	17.65	140	0.93	25.00	190	0.38	0.00	340	0.08	0.00
55	0.39	17.65	144	0.94	29.27	192	0.35	0.00	350	0.07	0.00
60	0.45	17.65	146	0.99	29.27	194	0.33	0.00	360	0.06	0.00



A3 STEP TEST PUMPING WELL DATA FROM WELL A3 r = 0.25 ft
TEST STARTED 09/25/96 16:06 HRS
LOCATION: NWNWNWSW SECTION 14 T10N R13W
SWL 14.80 ft b = 9 ft
CONFINED SILTY SAND, GRAVEL, AND COBBLES

t (min)	s (ft)	Q (gpm)
1	0.27	2.48
2.5	0.28	2.48
3	0.28	2.48
4	0.27	2.48
10	0.26	2.48
16	0.24	2.48
19	0.24	2.48
20		4.05
21	0.40	4.05
23	0.36	4.05
29	0.42	4.05
33	0.40	4.05
39	0.40	4.05
40		10.34
41	1.05	10.34
42	1.09	10.34
44	1.13	10.34
51	1.18	10.34
52		17.65
53	1.92	17.65
55	1.99	17.65
57	2.01	17.65
58	2.02	17.65
60	2.05	17.65

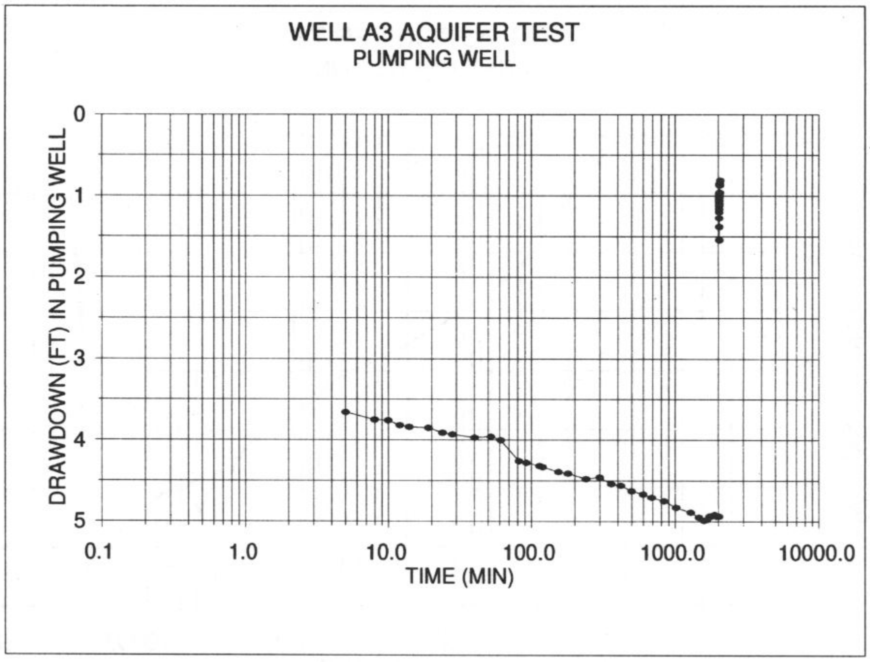
t (min)	s (ft)	Q (gpm)
63	2.06	17.65
71	2.10	17.65
75	2.11	17.65
81	2.11	17.65
82		21.43
83	2.59	21.43
85	2.63	21.43
88	2.65	21.43
100	2.75	21.43
108	2.78	21.43
111	2.79	21.43
112		25.00
113	3.35	25.00
114	3.39	25.00
120	3.46	25.00
134	3.54	25.00
142	3.57	25.00
144		29.27
146	4.00	29.27
149	4.03	29.27
166	4.12	29.27
169	4.27	29.27
176	4.30	29.27



A3 CONSTANT RATE PUMPING TEST   OBS WELL DATA FROM WELL A2 r = 30.5 ft
TEST STARTED 09/26/1996   09:00 HRS
LOCATION: NWNWNWSW SECTION 14 T10N R13W
SWL 15.07 ft   b = 9 ft   PUMPING RATE = 30 gpm
CONFINED   SILTY SAND, GRAVEL, AND COBBLES

PUMP ON @ t = 0   PUMP OFF @ t = 2040

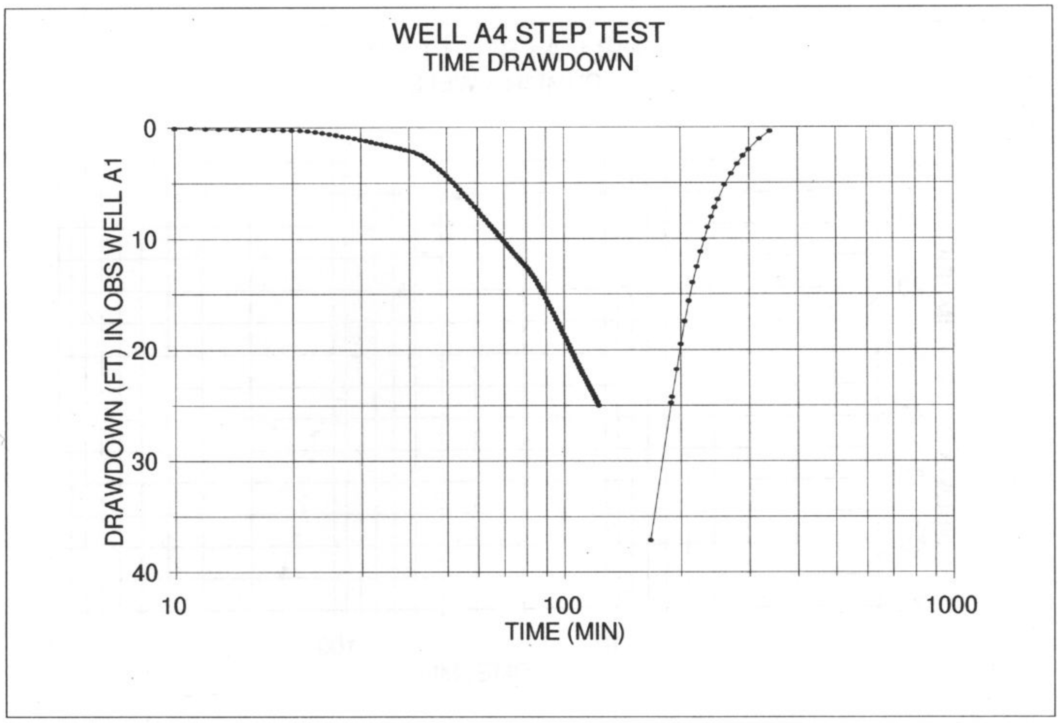
t (min)	s (ft)	t (min)	s (ft)	t (min)	s (ft)	t (min)	s (ft)	t (min)	s (ft)
1	0.00	66	1.07	600	1.51	2052	0.93	2300	0.38
2	0.27	70	1.08	650	1.52	2054	0.91	2400	0.31
3	0.46	75	1.10	700	1.54	2056	0.89	2500	0.27
4	0.56	80	1.13	800	1.57	2058	0.87	2600	0.22
5	0.62	85	1.15	900	1.59	2060	0.85	2700	0.21
6	0.66	90	1.16	1000	1.63	2062	0.83	2800	0.19
7	0.69	95	1.18	1100	1.66	2064	0.82	2900	0.21
8	0.72	100	1.19	1200	1.69	2066	0.80		
9	0.75	110	1.21	1300	1.70	2068	0.79		
10	0.77	120	1.22	1400	1.74	2070	0.79		
12	0.80	130	1.23	1500	1.78	2074	0.76		
14	0.82	140	1.25	1600	1.79	2078	0.75		
16	0.85	150	1.26	1700	1.79	2082	0.73		
18	0.87	160	1.28	1800	1.95	2086	0.71		
20	0.89	170	1.29	1900	1.76	2090	0.70		
22	0.91	180	1.30	2000	1.74	2094	0.69		
24	0.92	200	1.33	2039	1.75	2098	0.67		
26	0.93	220	1.37	2040	1.49	2102	0.66		
28	0.94	240	1.42	2041	1.30	2106	0.65		
30	0.95	260	1.45	2042	1.20	2110	0.64		
34	0.97	280	1.43	2043	1.14	2120	0.62		
38	0.98	300	1.43	2044	1.10	2130	0.60		
42	1.00	340	1.53	2045	1.06	2140	0.57		
46	1.01	380	1.60	2046	1.03	2150	0.56		
50	1.02	420	1.47	2047	1.01	2160	0.54		
54	1.04	460	1.50	2048	0.99	2180	0.51		
58	1.05	500	1.51	2049	0.97	2200	0.48		
62	1.06	550	1.49	2050	0.96	2250	0.42		



A3 CONSTANT RATE PUMPING TEST PUMPING WELL DATA FROM WELL A3 r = 0.25 ft
TEST STARTED 09/26/1996 09:00 HRS
LOCATION: NWNWNWSW SECTION 14 T10N R13W
SWL 14.86 ft b = 9 ft PUMPING RATE = 30 gpm
CONFINED SILTY SAND, GRAVEL, AND COBBLES

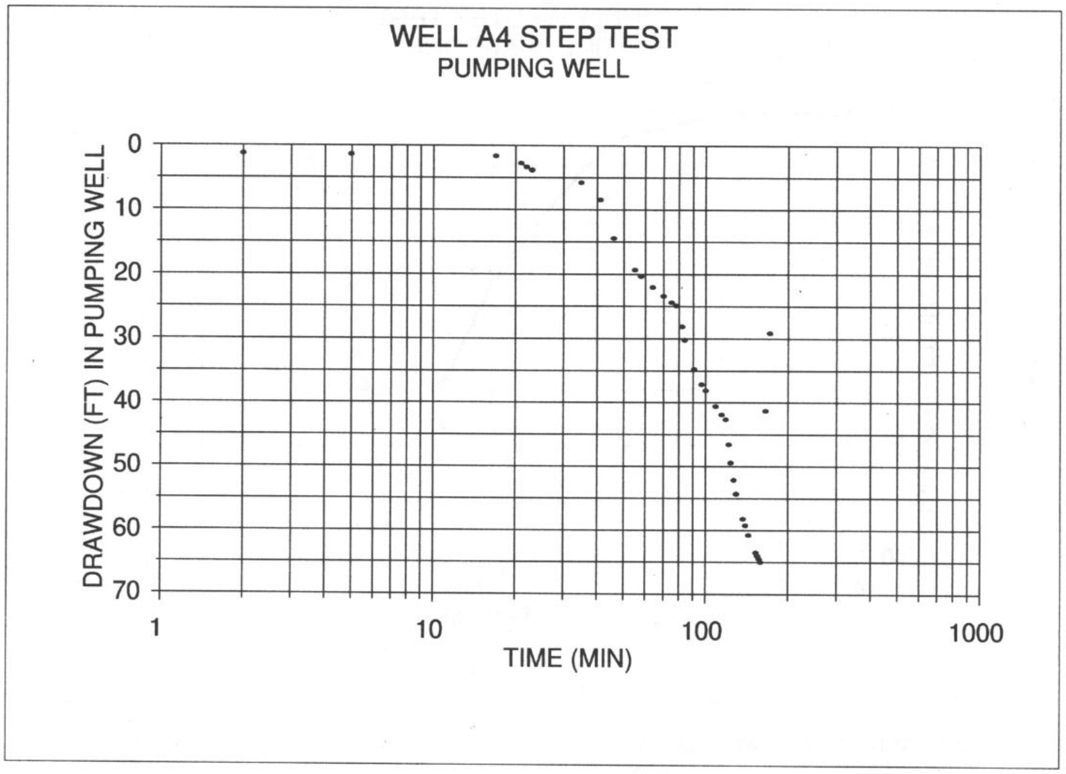
PUMP ON @ t = 0 PUMP OFF @ t = 2040

t (min)	s (ft)	t (min)	s (ft)
5	3.66	1290	4.89
8	3.75	1470	4.95
10	3.76	1600	4.99
12	3.82	1680	4.98
14	3.84	1740	4.94
19	3.85	1800	4.94
24	3.91	1900	4.92
28	3.93	1950	4.94
40	3.97	2025	4.94
52	3.96	2040	
61	4.00	2041	1.54
82	4.26	2042	1.38
92	4.28	2043	1.27
114	4.32	2044	1.20
120	4.33	2045	1.16
155	4.39	2046	1.12
180	4.41	2047	1.09
241	4.48	2048	1.06
300	4.46	2049	1.04
360	4.54	2050	1.02
420	4.56	2051	1.00
500	4.63	2052	0.98
600	4.67	2054	0.96
690	4.71	2062	0.87
840	4.75	2065	0.85
1020	4.83	2067	0.81



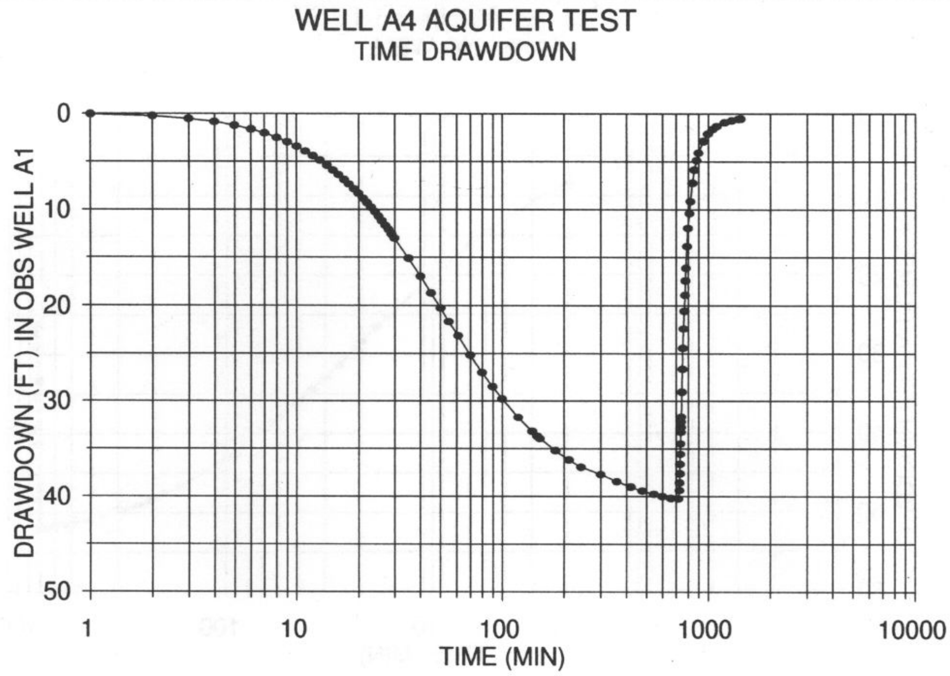
A4 STEP TEST OBS WELL DATA FROM WELL A1 r = 35.9 ft
TEST STARTED 09/04/96 17:16 HRS
LOCATION: NWNWNWSW SECTION 14 T10N R13W
SWL 30.15 ft b = AQUIFER THICKNESS UNKNOWN
CONFINED GRAVELLY SAND, SHALE

t (min)	s (ft)	Q (gpr	t (min)	s (ft)	Q (gpr	t (min)	s (ft)	Q (gpr	t (min)	s (ft)	8.60
5	0.03	0.88	41	2.22	6.25	77	11.89	6.25	113	22.41	8.60
6	0.04	0.88	42	2.36	6.25	78	12.12	6.25	114	22.67	8.60
7	0.05	0.88	43	2.54	6.25	79	12.33	6.25	115	22.93	8.60
8	0.07	0.88	44	2.76	6.25	80	12.55	8.60	116	23.19	8.60
9	0.09	0.88	45	2.99	6.25	81	12.77	8.60	117	23.44	8.60
10	0.11	0.88	46	3.25	6.25	82	13.00	8.60	118	23.68	8.60
11	0.13	0.88	47	3.52	6.25	83	13.26	8.60	119	23.93	8.60
12	0.15	0.88	48	3.80	6.25	84	13.54	8.60	120	24.17	12.50
13	0.16	0.88	49	4.09	6.25	85	13.83	8.60	121	24.42	12.50
14	0.18	0.88	50	4.39	6.25	86	14.13	8.60	122	24.69	12.50
15	0.20	0.88	51	4.69	6.25	87	14.44	8.60	123	24.99	12.50
16	0.22	0.88	52	5.00	6.25	88	14.75	8.60	160		0
17	0.23	0.88	53	5.31	6.25	89	15.07	8.60	167	37.15	0
18	0.25	0.88	54	5.63	6.25	90	15.39	8.60	189	24.77	0
19	0.27	0.88	55	5.93	6.25	91	15.72	8.60	190	24.23	0
20	0.29	2.14	56	6.24	6.25	92	16.05	8.60	195	21.76	0
21	0.31	2.14	57	6.54	6.25	93	16.37	8.60	200	19.51	0
22	0.36	2.14	58	6.85	6.25	94	16.70	8.60	205	17.48	0
23	0.43	2.14	59	7.15	6.25	95	17.03	8.60	210	15.66	0
24	0.52	2.14	60	7.45	6.25	96	17.35	8.60	215	14.02	0
25	0.61	2.14	61	7.75	6.25	97	17.67	8.60	220	12.56	0
26	0.70	2.14	62	8.04	6.25	98	17.99	8.60	225	11.25	0
27	0.81	2.14	63	8.33	6.25	99	18.31	8.60	230	10.08	0
28	0.91	2.14	64	8.61	6.25	100	18.62	8.60	235	9.03	0
29	1.01	2.14	65	8.89	6.25	101	18.94	8.60	240	8.10	0
30	1.12	2.14	66	9.16	6.25	102	19.24	8.60	245	7.26	0
31	1.22	2.14	67	9.43	6.25	103	19.55	8.60	250	6.51	0
32	1.33	2.14	68	9.70	6.25	104	19.85	8.60	260	5.22	0
33	1.43	2.14	69	9.96	6.25	105	20.15	8.60	270	4.18	0
34	1.54	2.14	70	10.22	6.25	106	20.45	8.60	280	3.32	0
35	1.64	2.14	71	10.47	6.25	107	20.74	8.60	290	2.61	0
36	1.73	2.14	72	10.72	6.25	108	21.03	8.60	300	2.01	0
37	1.83	2.14	73	10.96	6.25	109	21.31	8.60	320	1.07	0
38	1.93	2.14	74	11.20	6.25	110	21.59	8.60	340	0.41	0
39	2.02	2.14	75	11.44	6.25	111	21.87	8.60			
40	2.11	6.25	76	11.67	6.25	112	22.14	8.60			



A4 STEP TEST PUMPING WELL DATA FROM WELL A4 r =0.25 ft
TEST STARTED 09/04/96 17:16 HRS
LOCATION: NWNWNWSW SECTION 14 T10N R13W
SWL 29.20 ft b = AQUIFER THICKNESS UNKNOWN
CONFINED GRAVELLY SAND, SHALE

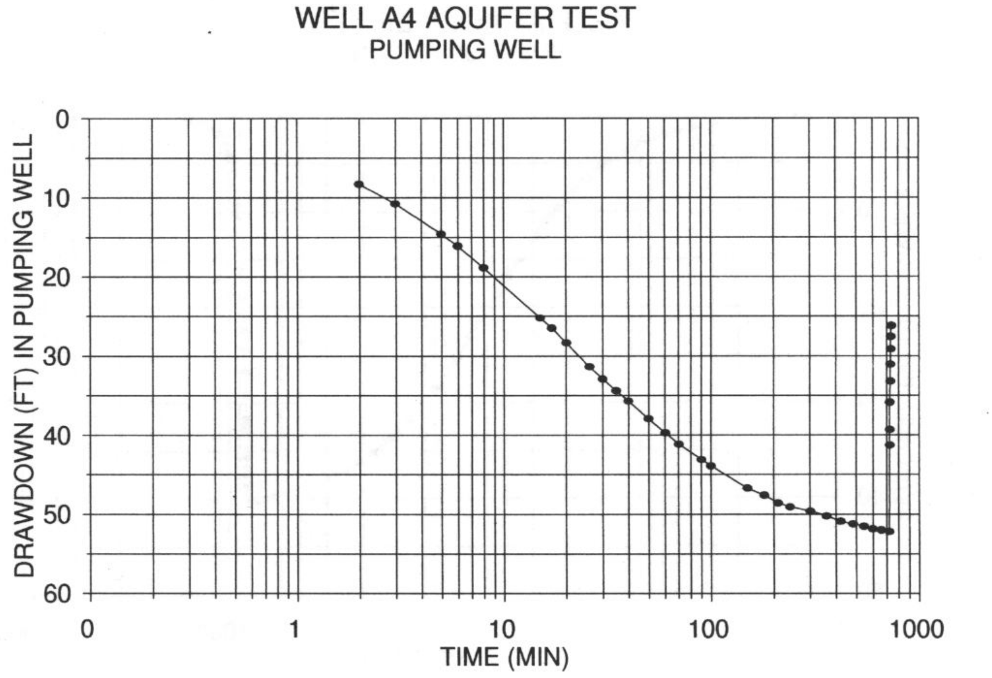
t (min)	s (ft)	Q (gpm)	t (min)	s (ft)	Q (gpm)
2	1.30	0.88	97	37.18	8.60
5	1.42	0.88	100	38.16	8.60
17	1.71	0.88	109	40.61	8.60
21	2.78	2.14	115	41.90	8.60
22	3.39	2.14	119	42.65	8.60
23	3.85	2.14	122	46.55	12.50
35	5.80	2.14	124	49.45	12.50
41	8.50	6.25	127	52.17	12.50
46	14.47	6.25	130	54.34	12.50
55	19.43	6.25	137	58.22	12.50
58	20.40	6.25	140	59.28	12.50
64	22.07	6.25	144	60.77	12.50
70	23.44	6.25	153	63.50	12.50
75	24.40	6.25	155	64.02	12.50
78	24.92	6.25	157	64.50	12.50
82	28.19	8.60	159	64.98	12.50
84	30.25	8.60	166	41.31	0
91	34.82	8.60	172	29.20	0



A4 CONSTANT RATE PUMPING TEST   OBS WELL DATA FROM WELL A1 r = 35.9 ft
TEST STARTED 09/05/96 08:00 AM
LOCATION: NWNWNWSW SECTION 14 T10N R13W
SWL 27.83 ft   b = AQUIFER THICKNESS UNKNOWN   PUMPING RATE = 7.8 GPM
CONFINED   GRAVELLY SAND, SHALE

PUMP ON @ t = 0   PUMP OFF @ t = 720

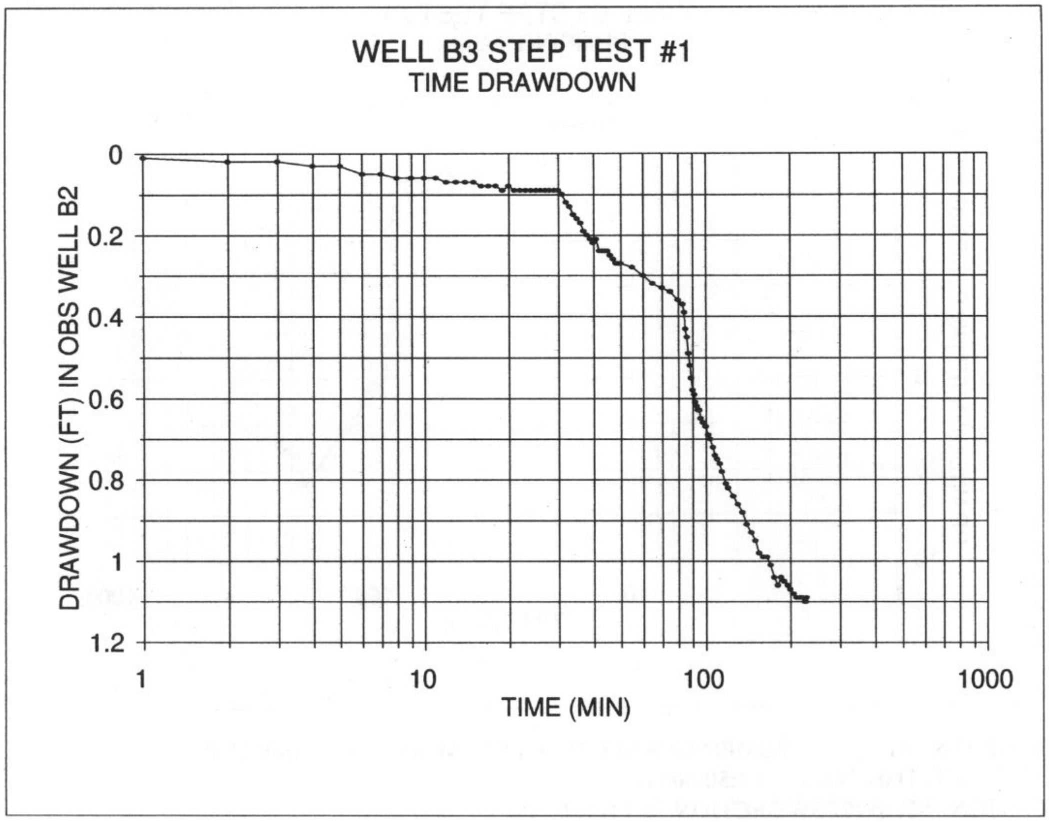
t (min)	s (ft)	t (min)	s (ft)	t (min)	s (ft)	t (min)	s (ft)
1	0.08	26	11.21	480	39.44	810	10.43
2	0.27	27	11.67	544	39.73	820	9.16
3	0.54	28	12.12	600	39.97	840	7.23
4	0.86	29	12.57	660	40.16	860	5.85
5	1.22	30	13.01	719	40.22	880	4.85
6	1.62	35	15.10	725	39.36	900	4.08
7	2.04	40	16.99	727	38.56	950	2.84
8	2.49	45	18.72	729	37.62	1000	2.11
9	2.95	50	20.27	731	36.62	1050	1.65
10	3.42	55	21.68	733	35.57	1100	1.33
11	3.90	61	23.20	735	34.50	1200	0.94
12	4.39	70	25.18	737	33.28	1300	0.72
13	4.88	80	27.00	738	32.72	1400	0.57
14	5.38	90	28.50	739	32.19	1440	0.53
15	5.88	100	29.75	740	31.66		
16	6.37	120	31.73	745	29.08		
17	6.87	140	33.21	750	26.67		
18	7.36	148	33.70	755	24.44		
19	7.86	152	33.96	760	22.42		
20	8.35	181	35.20	765	20.59		
21	8.83	211	36.19	770	18.94		
22	9.32	241	36.95	775	17.45		
23	9.80	301	37.69	780	16.12		
24	10.28	360	38.42	790	13.83		
25	10.75	420	38.98	800	11.97		



A4 CONSTANT RATE PUMPING TEST PUMPING WELL DATA FROM WELL A4 r = 0.25 ft
TEST STARTED 09/05/96 08:00 AM
LOCATION: NWNWNWSW SECTION 14 T10N R13W
SWL 27.62 ft b = AQUIFER THICKNESS UNKNOWN PUMPING RATE = 7.8 GPM
CONFINED GRAVELLY SAND, SHALE

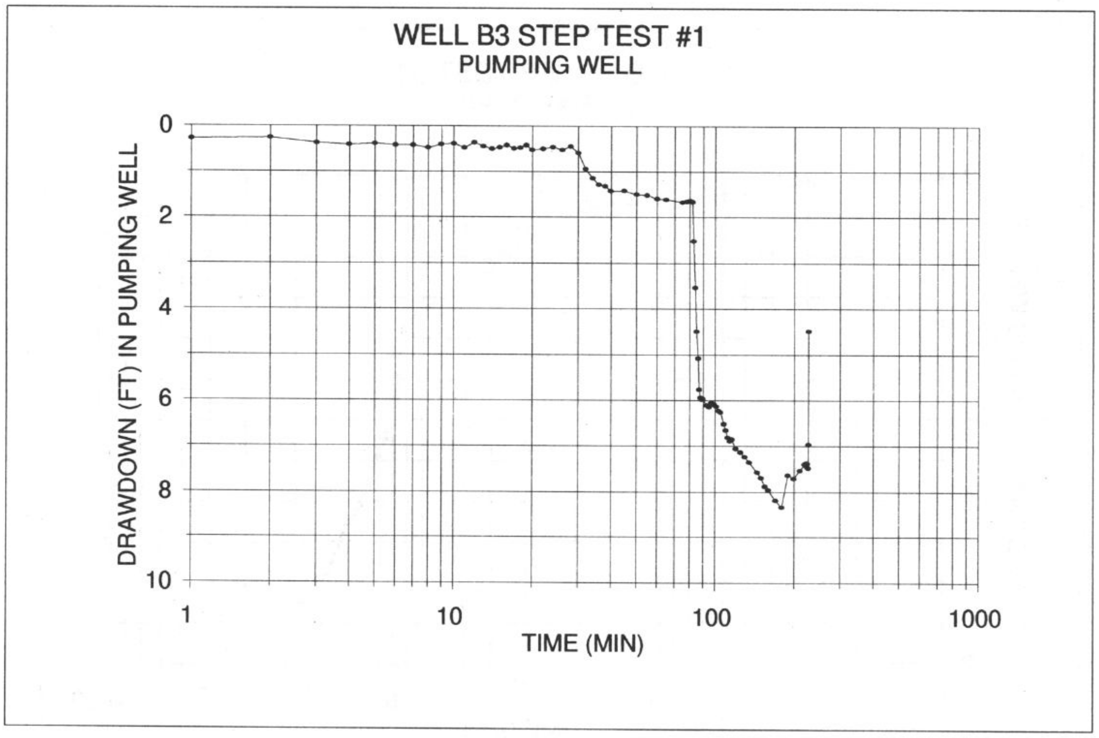
PUMP ON @ t = 0 PUMP OFF @ t = 720

t (min)	s (ft)	t (min)	s (ft)
2	8.30	543	51.51
3	10.76	600	51.84
5	14.61	660	52.00
6	16.13	719	52.17
8	18.86	723	41.26
15	25.23	724	39.31
17	26.53	726	35.90
20	28.38	728	33.20
26	31.38	730	31.11
30	32.93	732	29.18
35	34.41	734	27.62
40	35.71	736	26.20
50	37.94		
60	39.70		
70	41.12		
90	43.12		
100	43.93		
150	46.74		
180	47.61		
210	48.60		
240	49.09		
300	49.60		
360	50.22		
420	50.91		
480	51.23		



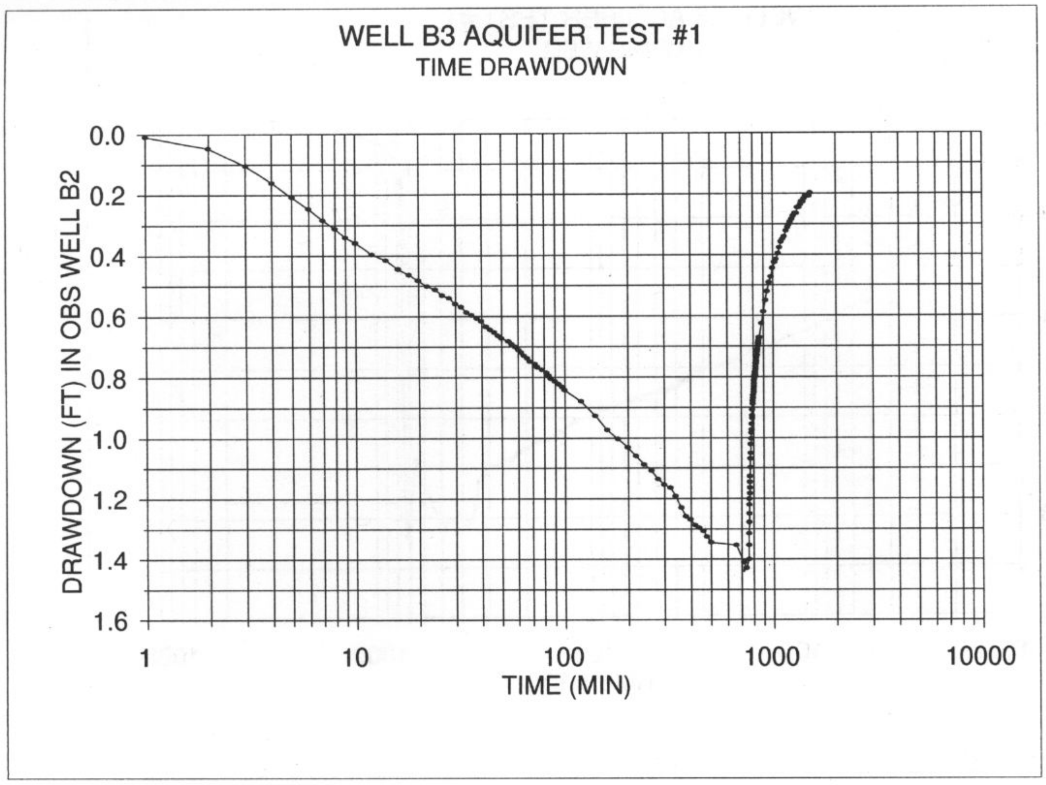
B3 STEP TEST #1 OBS WELL DATA FROM WELL B2 r = 32 ft
TEST STARTED 04/24/96 14:50:30 hrs
LOCATION: SWSWSESW SECTION 26 T10N R13W
SWL 17.31 FT b = 16 ft
UNCONFINED SILTY SAND AND GRAVEL

t (min)	s (ft)	Q (gpm)	t (min)	s (ft)	Q (gpm)	t (min)	s (ft)	Q (gpm)	t (min)	s (ft)	Q (gpm)
1	0.01	1.5	28	0.09	1.5	75	0.34	6.0	125	0.84	15.0
2	0.02	1.5	29	0.09	1.5	80	0.36	6.0	130	0.86	15.0
3	0.02	1.5	30	0.09	6.0	83	0.37	15.0	135	0.88	15.0
4	0.03	1.5	31	0.10	6.0	84	0.39	15.0	140	0.91	15.0
5	0.03	1.5	32	0.12	6.0	85	0.43	15.0	145	0.93	15.0
6	0.05	1.5	33	0.13	6.0	86	0.45	15.0	150	0.95	15.0
7	0.05	1.5	34	0.15	6.0	87	0.49	15.0	155	0.98	15.0
8	0.06	1.5	35	0.16	6.0	88	0.52	15.0	160	0.99	15.0
9	0.06	1.5	36	0.17	6.0	89	0.55	15.0	165	0.99	15.0
10	0.06	1.5	37	0.19	6.0	90	0.58	15.0	170	1.01	15.0
11	0.06	1.5	38	0.20	6.0	91	0.59	15.0	175	1.04	15.0
12	0.07	1.5	39	0.21	6.0	92	0.61	15.0	180	1.06	15.0
13	0.07	1.5	40	0.22	6.0	93	0.62	15.0	185	1.04	15.0
14	0.07	1.5	41	0.21	6.0	94	0.63	15.0	190	1.05	15.0
15	0.07	1.5	42	0.24	6.0	95	0.63	15.0	195	1.06	15.0
16	0.08	1.5	43	0.24	6.0	96	0.65	15.0	200	1.07	15.0
17	0.08	1.5	44	0.24	6.0	98	0.66	15.0	205	1.08	15.0
18	0.08	1.5	45	0.24	6.0	100	0.67	15.0	210	1.09	15.0
19	0.09	1.5	46	0.25	6.0	102	0.69	15.0	215	1.09	15.0
20	0.08	1.5	47	0.26	6.0	104	0.70	15.0	220	1.09	15.0
21	0.09	1.5	48	0.27	6.0	106	0.72	15.0	225	1.10	15.0
22	0.09	1.5	49	0.27	6.0	108	0.74	15.0	226.5	1.10	0.0
23	0.09	1.5	50	0.27	6.0	110	0.75	15.0	227	1.10	0.0
24	0.09	1.5	55	0.28	6.0	112	0.76	15.0	227.5	1.09	0.0
25	0.09	1.5	60	0.30	6.0	114	0.78	15.0			
26	0.09	1.5	65	0.32	6.0	118	0.81	15.0			
27	0.09	1.5	70	0.33	6.0	120	0.82	15.0			



B3 STEP TEST #1 PUMPING WELL DATA FROM WELL B3 r = 0.25 ft
TEST STARTED 04/24/96 14:50:30 hrs
LOCATION: SWSWSESW SECTION 26 T10N R13W
SWL 18.13 FT b = 16 ft
UNCONFINED SILTY SAND AND GRAVEL

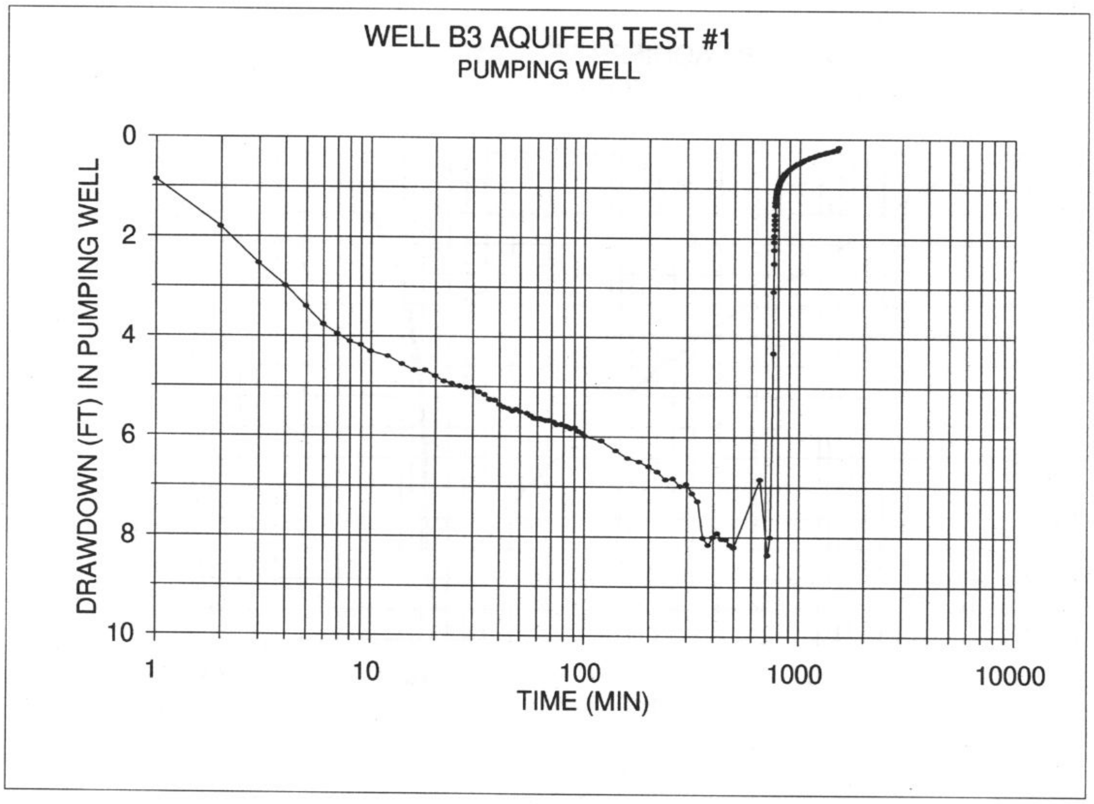
t (min)	s (ft)	Q (gpm)	t (min)	s (ft)	Q (gpm)	t (min)	s (ft)	Q (gpm)
1.0	0.29	1.5	38.0	1.32	6.0	108.0	6.52	15.0
2.0	0.26	1.5	40.0	1.44	6.0	110.0	6.66	15.0
3.0	0.38	1.5	45.0	1.43	6.0	112.0	6.82	15.0
4.0	0.42	1.5	50.0	1.50	6.0	114.0	6.89	15.0
5.0	0.39	1.5	55.0	1.52	6.0	116.0	6.85	15.0
6.0	0.42	1.5	60.0	1.60	6.0	120.0	7.06	15.0
7.0	0.42	1.5	65.0	1.61	6.0	125.0	7.14	15.0
8.0	0.48	1.5	75.0	1.68	6.0	130.0	7.23	15.0
9.0	0.41	1.5	78.0	1.66	6.0	135.0	7.36	15.0
10.0	0.39	1.5	79.0	1.65	6.0	145.0	7.57	15.0
11.0	0.48	1.5	80.0	1.64	6.0	150.0	7.70	15.0
12.0	0.37	1.5	81.0	1.64	6.0	155.0	7.88	15.0
13.0	0.44	1.5	82.0	1.67	6.0	160.0	7.96	15.0
14.0	0.50	1.5	83.0	2.52	15.0	170.0	8.19	15.0
15.0	0.47	1.5	84.0	3.53	15.0	180.0	8.34	15.0
16.0	0.42	1.5	85.0	4.49	15.0	190.0	7.64	15.0
17.0	0.49	1.5	86.0	5.09	15.0	200.0	7.70	15.0
18.0	0.48	1.5	87.0	5.77	15.0	210.5	7.53	15.0
19.0	0.42	1.5	88.0	5.95	15.0	220.0	7.39	15.0
20.0	0.53	1.5	89.0	5.99	15.0	221.0	7.39	15.0
22.0	0.50	1.5	90.0	5.97	15.0	222.0	7.41	15.0
24.0	0.46	1.5	93.0	6.11	15.0	223.0	7.43	15.0
26.0	0.53	1.5	95.0	6.16	15.0	224.0	7.36	15.0
28.0	0.44	1.5	97.0	6.05	15.0	225.0	7.38	15.0
30.0	0.59	6.0	99.0	6.09	15.0	226.0	7.48	15.0
32.0	0.94	6.0	101.0	6.14	15.0	227.0	6.97	0.0
34.0	1.15	6.0	103.0	6.23	15.0	227.5	4.49	0.0
36.0	1.29	6.0	105.0	6.26	15.0			



B3 CONSTANT RATE PUMPING TEST #1   OBS WELL DATA FROM WELL B2 r = 32 ft
TEST STARTED 04/25/96 08:00 AM
LOCATION: SWSWSESW SECTION 26 T10N R13W
SWL 17.38 ft   b = 16 ft   PUMPING RATE = 13.04 GPM
UNCONFINED   SILTY SAND AND GRAVEL

PUMP ON @ t = 0   PUMP OFF @ t = 760

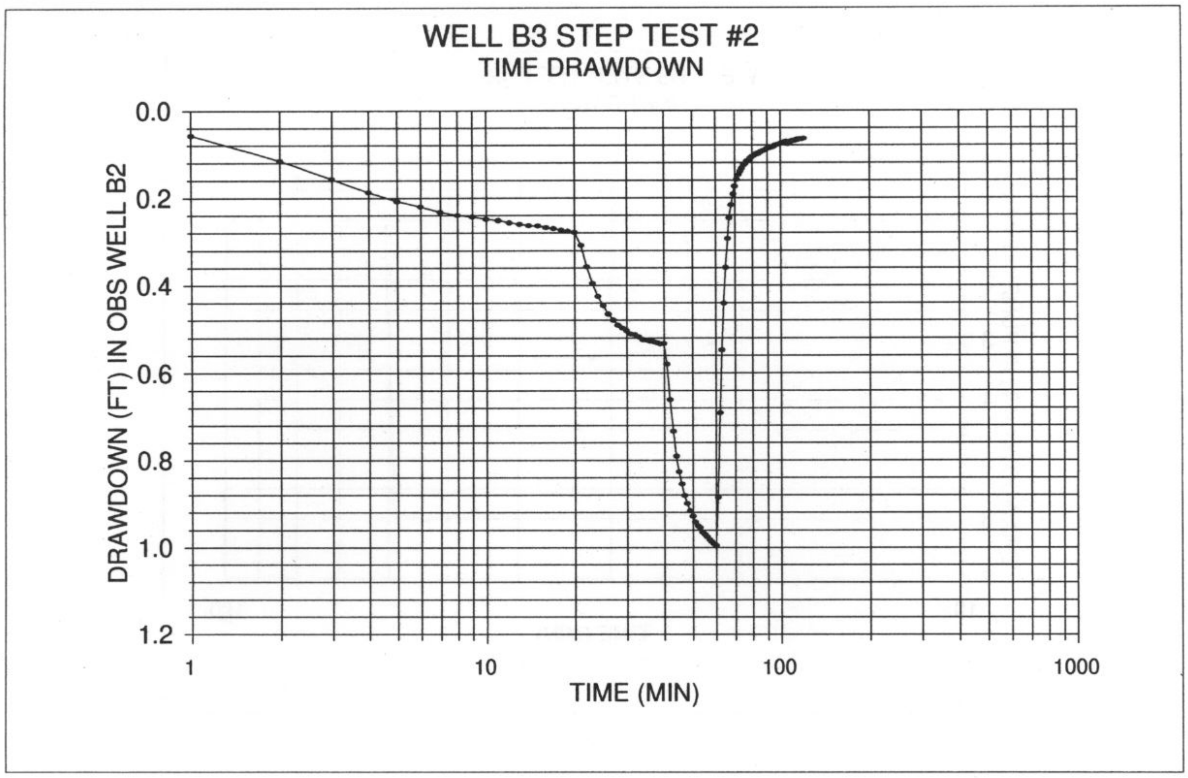
t (min)	s (ft)	t (min)	s (ft)	t (min)	s (ft)	t (min)	s (ft)	t (min)	s (ft)
1	0.01	58	0.70	440	1.30	802	0.86	920	0.55
2	0.05	60	0.71	460	1.31	804	0.85	940	0.52
3	0.10	62	0.72	480	1.33	806	0.84	960	0.49
4	0.16	64	0.73	500	1.35	808	0.83	980	0.47
5	0.21	66	0.74	660	1.35	810	0.82	1000	0.45
6	0.25	68	0.75	720	1.41	812	0.81	1020	0.43
7	0.28	72	0.76	740	1.43	814	0.81	1040	0.42
8	0.31	74	0.77	761	1.40	816	0.80	1060	0.40
9	0.34	78	0.78	762	1.35	818	0.80	1080	0.38
10	0.36	82	0.79	763	1.32	820	0.79	1100	0.36
12	0.40	84	0.80	764	1.28	822	0.78	1120	0.35
14	0.42	86	0.81	765	1.25	824	0.77	1140	0.34
16	0.45	90	0.81	766	1.22	826	0.76	1160	0.32
18	0.46	94	0.82	767	1.20	828	0.76	1180	0.31
20	0.48	98	0.83	768	1.18	830	0.75	1200	0.30
22	0.50	100	0.84	769	1.17	832	0.75	1220	0.29
24	0.51	120	0.88	770	1.15	834	0.74	1240	0.28
26	0.53	140	0.93	772	1.13	836	0.73	1260	0.27
28	0.54	160	0.98	774	1.10	838	0.72	1280	0.27
30	0.56	180	1.00	776	1.07	840	0.72	1300	0.27
32	0.57	200	1.03	778	1.05	842	0.71	1320	0.25
34	0.59	220	1.06	780	1.02	844	0.71	1340	0.25
36	0.60	240	1.09	782	1.00	846	0.70	1360	0.24
38	0.61	260	1.11	784	0.99	848	0.69	1380	0.23
40	0.62	280	1.14	786	0.98	850	0.69	1400	0.23
42	0.63	300	1.16	788	0.96	852	0.68	1420	0.22
44	0.64	320	1.17	790	0.94	854	0.68	1440	0.21
46	0.65	340	1.19	792	0.93	856	0.67	1460	0.21
48	0.66	360	1.23	794	0.91	858	0.67	1480	0.21
50	0.67	380	1.26	796	0.89	860	0.67	1500	0.21
54	0.68	400	1.27	798	0.88	880	0.63	1520	0.20
56	0.69	420	1.29	800	0.87	900	0.59		



B3 CONSTANT RATE PUMPING TEST #1 PUMPING WELL DATA FROM WELL B3 r = 0.25 ft
TEST STARTED 04/25/96 08:00 AM
LOCATION: SWSWSESW SECTION 26 T10N R13W
SWL 17.30 ft b = 16 ft PUMPING RATE = 13.04 GPM
UNCONFINED SILTY SAND AND GRAVEL

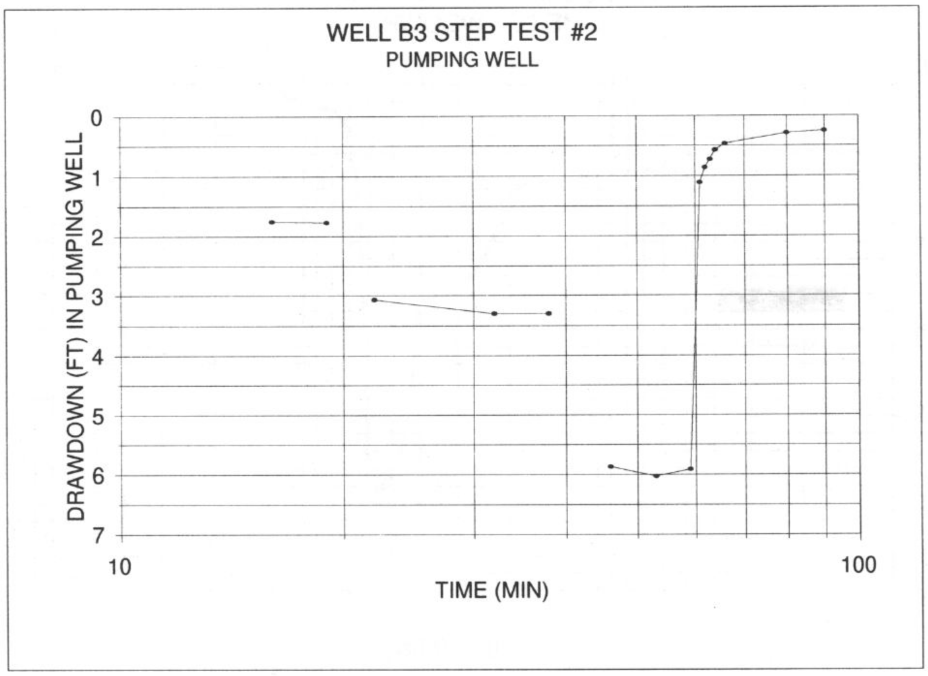
PUMP ON @ t = 0 PUMP OFF @ t = 760

t (min)	s (ft)	t (min)	s (ft)	t (min)	s (ft)	t (min)	s (ft)	t (min)	s (ft)
1	0.87	58	5.63	440	8.04	802	0.93	920	0.58
2	1.81	60	5.64	460	8.05	804	0.92	940	0.55
3	2.54	62	5.64	480	8.16	806	0.90	960	0.52
4	2.99	64	5.67	500	8.20	808	0.89	980	0.50
5	3.41	66	5.67	660	6.85	810	0.88	1000	0.48
6	3.77	68	5.67	720	8.37	812	0.86	1020	0.46
7	3.96	72	5.71	740	8.01	814	0.85	1040	0.44
8	4.11	74	5.76	761	4.32	816	0.84	1060	0.42
9	4.18	78	5.76	762	3.08	818	0.83	1080	0.41
10	4.31	82	5.79	763	2.51	820	0.82	1100	0.40
12	4.40	84	5.81	764	2.24	822	0.81	1120	0.38
14	4.56	86	5.84	765	2.08	824	0.80	1140	0.37
16	4.68	90	5.82	766	1.95	826	0.80	1160	0.36
18	4.68	94	5.89	767	1.82	828	0.79	1180	0.34
20	4.80	98	5.93	768	1.72	830	0.78	1200	0.33
22	4.90	100	5.99	769	1.63	832	0.77	1220	0.32
24	4.95	120	6.08	770	1.53	834	0.76	1240	0.31
26	4.99	140	6.28	772	1.35	836	0.76	1260	0.30
28	5.02	160	6.43	774	1.28	838	0.76	1280	0.29
30	5.02	180	6.50	776	1.23	840	0.75	1300	0.29
32	5.11	200	6.59	778	1.18	842	0.75	1320	0.27
34	5.16	220	6.69	780	1.15	844	0.74	1340	0.27
36	5.26	240	6.85	782	1.11	846	0.73	1360	0.26
38	5.28	260	6.83	784	1.09	848	0.73	1380	0.25
40	5.36	280	6.99	786	1.07	850	0.72	1400	0.25
42	5.41	300	6.94	788	1.04	852	0.71	1420	0.25
44	5.44	320	7.13	790	1.02	854	0.71	1440	0.24
46	5.49	340	7.29	792	1.00	856	0.70	1460	0.23
48	5.46	360	8.02	794	0.98	858	0.70	1480	0.23
50	5.50	380	8.16	796	0.97	860	0.69	1500	0.23
54	5.53	400	8.01	798	0.95	880	0.65	1520	0.17
56	5.58	420	7.92	800	0.93	900	0.61		



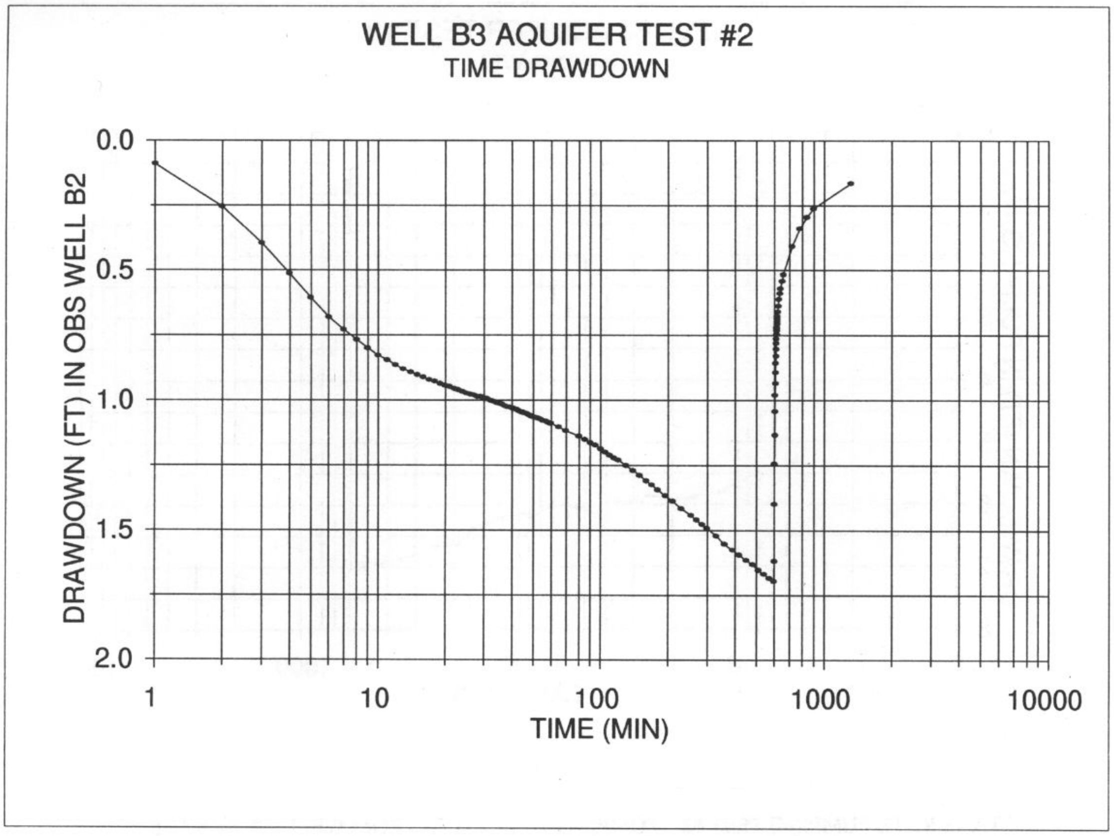
B3 STEP TEST #2 OBS WELL DATA FROM WELL B2 r = 32 ft
TEST STARTED 10/16/96 17:20 hrs
LOCATION: SWSWSESW SECTION 26 T10N R13W
SWL 10.88 ft b = 22.5 ft
UNCONFINED SILTY SAND AND GRAVEL

t (min)	s (ft)	Q (gpm)	t (min)	s (ft)	Q (gpm)	t (min)	s (ft)	Q (gpm)	t (min)	s (ft)	Q (gpm)
1	0.06	9.2	32	0.51	16.8	63	0.55	0	94	0.08	0
2	0.12	9.2	33	0.52	16.8	64	0.44	0	95	0.08	0
3	0.16	9.2	34	0.52	16.8	65	0.36	0	96	0.08	0
4	0.19	9.2	35	0.52	16.8	66	0.29	0	97	0.08	0
5	0.21	9.2	36	0.53	16.8	67	0.25	0	98	0.08	0
6	0.22	9.2	37	0.53	16.8	68	0.22	0	99	0.08	0
7	0.23	9.2	38	0.53	16.8	69	0.19	0	100	0.08	0
8	0.24	9.2	39	0.53	16.8	70	0.17	0	101	0.07	0
9	0.24	9.2	40	0.53	28.1	71	0.16	0	102	0.07	0
10	0.25	9.2	41	0.58	28.1	72	0.15	0	103	0.07	0
11	0.25	9.2	42	0.66	28.1	73	0.14	0	104	0.07	0
12	0.26	9.2	43	0.73	28.1	74	0.13	0	105	0.07	0
13	0.26	9.2	44	0.79	28.1	75	0.13	0	106	0.08	0
14	0.26	9.2	45	0.83	28.1	76	0.12	0	107	0.07	0
15	0.26	9.2	46	0.85	28.1	77	0.12	0	108	0.07	0
16	0.27	9.2	47	0.88	28.1	78	0.12	0	109	0.07	0
17	0.27	9.2	48	0.90	28.1	79	0.11	0	110	0.07	0
18	0.27	9.2	49	0.92	28.1	80	0.11	0	111	0.07	0
19	0.28	9.2	50	0.93	28.1	81	0.10	0	112	0.07	0
20	0.28	16.8	51	0.94	28.1	82	0.10	0	113	0.07	0
21	0.31	16.8	52	0.95	28.1	83	0.10	0	114	0.07	0
22	0.36	16.8	53	0.95	28.1	84	0.10	0	115	0.07	0
23	0.40	16.8	54	0.97	28.1	85	0.10	0	116	0.07	0
24	0.42	16.8	55	0.97	28.1	86	0.09	0	117	0.07	0
25	0.45	16.8	56	0.98	28.1	87	0.09	0	118	0.07	0
26	0.47	16.8	57	0.98	28.1	88	0.09	0	119	0.06	0
27	0.48	16.8	58	0.99	28.1	89	0.09	0	120	0.06	0
28	0.49	16.8	59	0.99	28.1	90	0.09	0			
29	0.50	16.8	60	1.00	28.1	91	0.09	0			
30	0.50	16.8	61	0.89	0	92	0.09	0			
31	0.51	16.8	62	0.69	0	93	0.08	0			



B3 STEP TEST #2 PUMPING WELL DATA FROM WELL B3 r = 0.25 ft
TEST STARTED 10/16/96 17:20 hrs
LOCATION: SWSWSESW SECTION 26 T10N R13W
SWL 11.05 ft b = 22.5 ft
UNCONFINED SILTY SAND AND GRAVEL

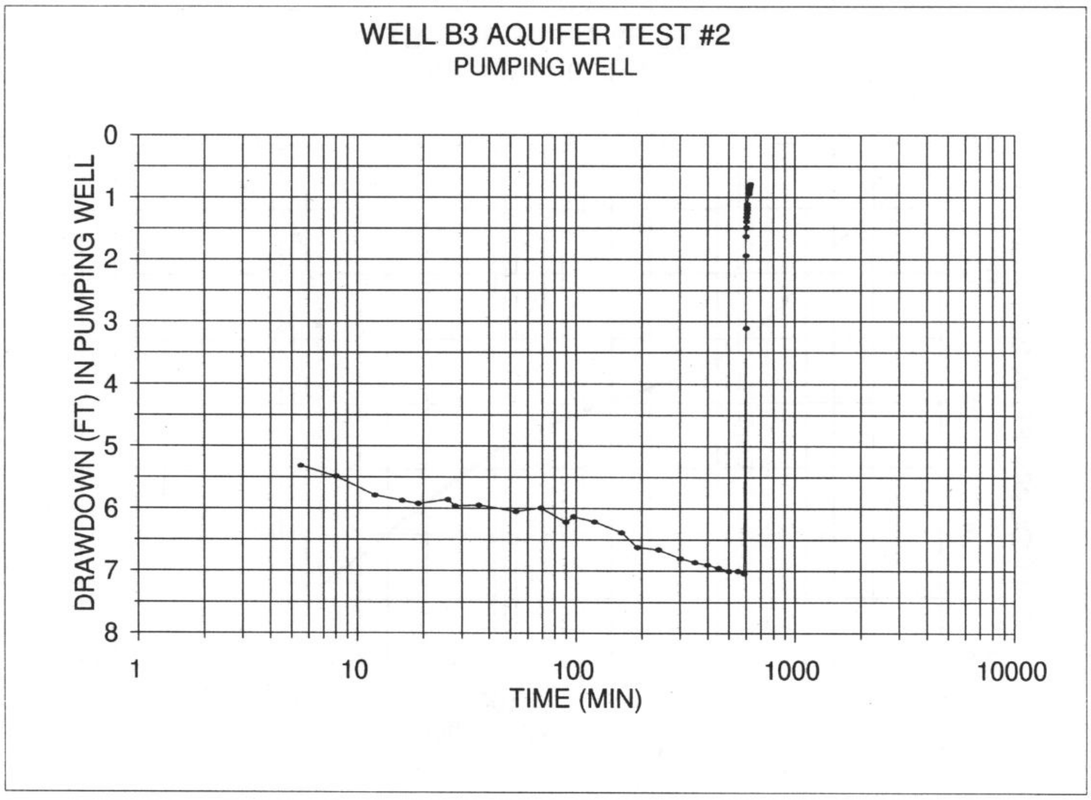
t (min)	s (ft)	Q (gpm)
16	1.75	9.2
19	1.77	
20		16.8
22	3.07	
32	3.30	
38	3.30	
40		28.1
46	5.87	
53	6.03	
59	5.91	
61	1.11	0.0
62	0.86	
63	0.73	
64	0.57	
66	0.47	
80	0.29	
90	0.25	



B3 CONSTANT RATE PUMPING TEST #2 OBS WELL DATA FROM WELL B2 r = 32 ft
TEST STARTED 10/17/96 09:00 AM
LOCATION: SWSWSESW SECTION 26 T10N R13W
SWL 11.00 ft b = 22.5 ft PUMPING RATE = 28.2 GPM
UNCONFINED SILTY SAND AND GRAVEL

PUMP ON @ t = 0 PUMP OFF @ t = 600

t (min)	s (ft)	t (min)	s (ft)	t (min)	s (ft)	t (min)	s (ft)
1	0.09	33	1.01	90	1.16	603.00	1.24
2	0.25	34	1.01	95	1.17	604.00	1.13
3	0.40	35	1.01	100	1.19	605.00	1.04
4	0.51	36	1.02	105	1.20	606.00	0.98
5	0.61	37	1.02	110	1.21	607.00	0.94
6	0.68	38	1.03	115	1.22	608.00	0.89
7	0.73	39	1.03	120	1.23	609.00	0.86
8	0.77	40	1.03	130	1.25	610.00	0.83
9	0.80	41	1.03	140	1.27	611.00	0.80
10	0.83	42	1.04	150	1.29	612.00	0.78
11	0.85	43	1.04	160	1.31	613.00	0.76
12	0.86	44	1.05	170	1.33	614.00	0.75
13	0.88	45	1.05	180	1.34	615.00	0.73
14	0.89	46	1.05	195	1.37	616.00	0.72
15	0.90	47	1.05	210	1.39	617.00	0.71
16	0.91	48	1.06	230	1.42	618.00	0.70
17	0.92	49	1.06	255	1.44	619.00	0.69
18	0.93	50	1.06	270	1.46	620.00	0.68
19	0.94	51	1.07	286	1.48	622.00	0.66
20	0.94	52	1.07	300	1.49	625.00	0.64
21	0.95	53	1.07	330	1.52	630.00	0.61
22	0.96	54	1.07	360	1.55	635.00	0.59
23	0.96	55	1.08	391	1.58	640.00	0.57
24	0.97	56	1.08	420	1.60	650.00	0.54
25	0.97	57	1.08	450	1.62	660.00	0.52
26	0.98	58	1.09	480	1.63	720.00	0.41
27	0.98	59	1.09	510	1.65	780.00	0.34
28	0.99	60	1.09	540	1.67	840.00	0.29
29	0.99	65	1.10	570	1.69	900.00	0.26
30	0.99	70	1.12	599	1.70	1320.00	0.16
31	1.00	80	1.14	601	1.62		
32	1.00	85	1.15	602	1.40		



B3 CONSTANT RATE PUMPING TEST #2 PUMPING WELL DATA FROM WELL B3 r = 0.25 ft
TEST STARTED 10/17/96 09:00 AM
LOCATION: SWSWSESW SECTION 26 T10N R13W
SWL 11.24 ft. b = 22.5 ft PUMPING RATE = 28.2 GPM
UNCONFINED SILTY SAND AND GRAVEL

PUMP ON @ t = 0 PUMP OFF @ t = 600

t (min)	s (ft)	t (min)	s (ft)
5.5	5.32	610	1.11
8	5.49	617	0.94
12	5.79	618	0.92
16	5.87	620	0.89
19	5.92	622	0.86
26	5.86	625	0.83
28	5.96	630	0.79
36	5.95		
53	6.05		
69	5.99		
90	6.22		
98	6.13		
122	6.21		
162	6.38		
192	6.62		
240	6.66		
300	6.80		
350	6.86		
400	6.90		
450	6.95		
502	7.00		
550	7.00		
590	7.04		
601	3.11		
602	1.94		
603	1.63		
604	1.49		
605	1.39		
606	1.32		
607	1.26		
608	1.20		
609	1.16		