Montana Bureau of Mines and Geology
Open-File Report No. 242

Impacts on Water Quality from Plow-Out and Saline-Seep Reclamation Practices, Stillwater County, Montana

Contract No. WDG-86-5048
to
Stillwater Conservation District
Columbus, Montana 59019,
Beartooth RC&D
Joliet, Montana 59041
and
Montana Department of Natural Resources and Conservation
Helena, Montana 59620

by

Terence E. Duaime
John J. Metesh
Marvin R. Miller
Herman R. Moore
Antony R. Bergantino

Montana Bureau of Mines and Geology
Butte, Montana 59701
July 1991

The work upon which this report is based was supported by funds provided by the Montana Bureau of Mines and Geology, Stillwater Conservation District, Montana Department of Health and Environmental Sciences - Water Quality Bureau, and Montana Department of Natural Resources and Conservation - Water Development Bureau and Conservation Districts Division.

This report has been printed on recycled paper.

Tables of Contents

ABSTRACT

Studies relating to the extent, rate of development, origin and hydrogeologic nature of saline seeps began in Montana in the late 1960's. The first studies were conducted in the glaciated northern plains. Studies relating to methods of controlling the spread of saline seeps and reclaiming land lost to them were initiated shortly afterwards in glaciated north-central Montana. Saline-seeps are much less common in the southern Montana plains; a notable exception is an area in northern Stillwater County.

When some of the methods developed to control the spread of saline seep in north-central Montana began to prove effective, interest grew to see if those successful methods could be applied equally successfully in southern Montana despite the differences in geology and climate between these two areas. Consequently, a saline-seep demonstration project in Stillwater County was established among the U.S. Soil Conservation Service, Stillwater Conservation District and local farmers. A companion study to the demonstration project was established between the Montana Bureau of Mines and Geology, the Stillwater Conservation District and the Beartooth RC&D. The principle objectives of this study were 1) to determine the direction of groundwater flow in the demonstration site and 2) the impact that cropping changes used successfully in the northern plains might have on water levels and water-quality in this area.

During the 10 years of this study, it was discovered that most groundwater within the demonstration site contained substantial concentrations of sodium, magnesium, and sulfate—concentrations at this level are typical symptoms of saline-seep-impacted waters. Additionally, significant concentrations of selenium also were found throughout the demonstration site; the highest concentrations were within or adjacent to active saline-seep areas. As might be expected, water quality degraded as it moved from the recharge portion of the project site to the discharge portion. Although the sole change in cropping practices was to plant alfalfa in portions of the recharge areas of the demonstration site, this study showed that the cropping change proved successful in significantly lowering groundwater levels.

The findings of this 10-year study indicate that the principal saline-seep mitigation measures used in the northern plains of Montana can be applied successfully to reduce salinity in the unglaciated southern plains of Montana. Application of these measures also appears to retard the water-quality degradation associated with saline-seep development and its spread.

ACKNOWLEDGEMENTS

The authors would like to thank the Stillwater Conservation District, the Beartooth RC&D, and the U.S. Soil Conservation Service for their assistance, cooperation, and support in this investigation. Special thanks are extended to farm cooperators John Zinne and Don Herzog, without whose cooperation and assistance this project would not have been possible. Numerous others cooperated and assisted with this project, especially: Bob Van Oosten, Stillwater Conservation District; Warren Kellogg, U.S. Soil Conservation Service; Ken Chrest, Montana Department of Health and Environmental Sciences; and Ed Juvan, U.S. Soil Conservation Service.

Appreciation is extended to the Stillwater Conservation District clerks Jeanne Hogstad, Angie Adams, and Barbara Berry; District-employed summer students who provided monitoring assistance throughout this project; and Jane Holzer and the staff of the Montana Salinity Control Association.

Credit for technical support and data collection goes to Fred A. Schmidt and Robert N. Bergantino, Hydrogeologists; Chris Hawe, Research Assistant; and Roger Holmes, Cartographer. Credit for clerical support and thanks goes to Betty Babb and Betty McManus, Administrative Aides, without whose patience and competence this report could not have been completed. Errors and omissions remain the responsibilities of the authors.

Additional financial support for this project was received from the Stillwater Conservation District, the Montana Department of Health and Environmental Sciences - Water Quality Bureau, and the Montana Department of Natural Resources and Conservation - Conservation Districts Division.

Index of Appendices

Index of Tables

Index of Figures

IMPACTS ON WATER QUALITY FROM PLOW-OUT AND SALINE-SEEP RECLAMATION PRACTICES, STILLWATER COUNTY, MONTANA

INTRODUCTION

Saline-seep development has been a recognized problem in portions of Montana since the early 1950's, whereas the rise in the shallow water-table now associated with saline seeps has been evident in northern Stillwater County since the 1940's (Bahls and Miller, 1973). In the late 1960's, investigations detailing the extent, causes, rate of spread, origin, and methods of mitigating or reducing the spread of saline seeps were initiated. Most of these investigations took place in the glaciated northern plains of Montana, but some investigations were undertaken in portions of Stillwater County in south-central Montana. Lewis and others (1979) and Custer (1976 and 1979) described work in the Hailstone Basin, Stillwater County, whereas Kellogg (1984) prepared an overview of saline seeps in Stillwater County.

In the fall of 1983, the Stillwater Conservation District (SCD) and the Soil Conservation Service (SCS) initiated a saline-seep demonstration project in Stillwater County. One of the purposes of this study was to see if saline-seep reclamation practices that had been successful in the glaciated portions of the northern Montana plains could be used effectively in non-glaciated areas of the state. The SCD and SCS developed and implemented a reclamation plan for the demonstration site chosen for this project. The Montana Bureau of Mines and Geology (MBMG) in cooperation with the SCD and the Beartooth Resource, Conservation and Development District (RC&D) initiated a companion project to study water-quality conditions at the proposed demonstration site and at a former saline-seep monitoring site in Stillwater County.

PURPOSE AND SCOPE

The principal purposes of this study were to: 1) monitor water levels and water-quality conditions at the SCD-SCS demonstration site in order to document water-quality and water-level changes once saline-seep reclamation practices were implemented; 2) monitor the effects of the applied reclamation practices on the seep-affected areas; 3) monitor water levels and collect groundwater samples at the former investigation site (known as the Brickley Farm site) in the Hailstone Basin of Stillwater County where intensive-cropping practices had been applied for the past six to ten years; 4) compare findings to previous conditions to document changes; and 5) monitor and document water-quality conditions at a site where saline-seep mitigation practices were applied after the native sod was broken and the land farmed.

Once the project started, selenium concentrations that were well above normal levels were detected in monitoring wells at the two sites. Therefore, an additional goal was added to document selenium accumulations in the unsaturated zone at several locations adjacent to monitoring wells at each site. Figure 1 shows the project study sites in Stillwater County.

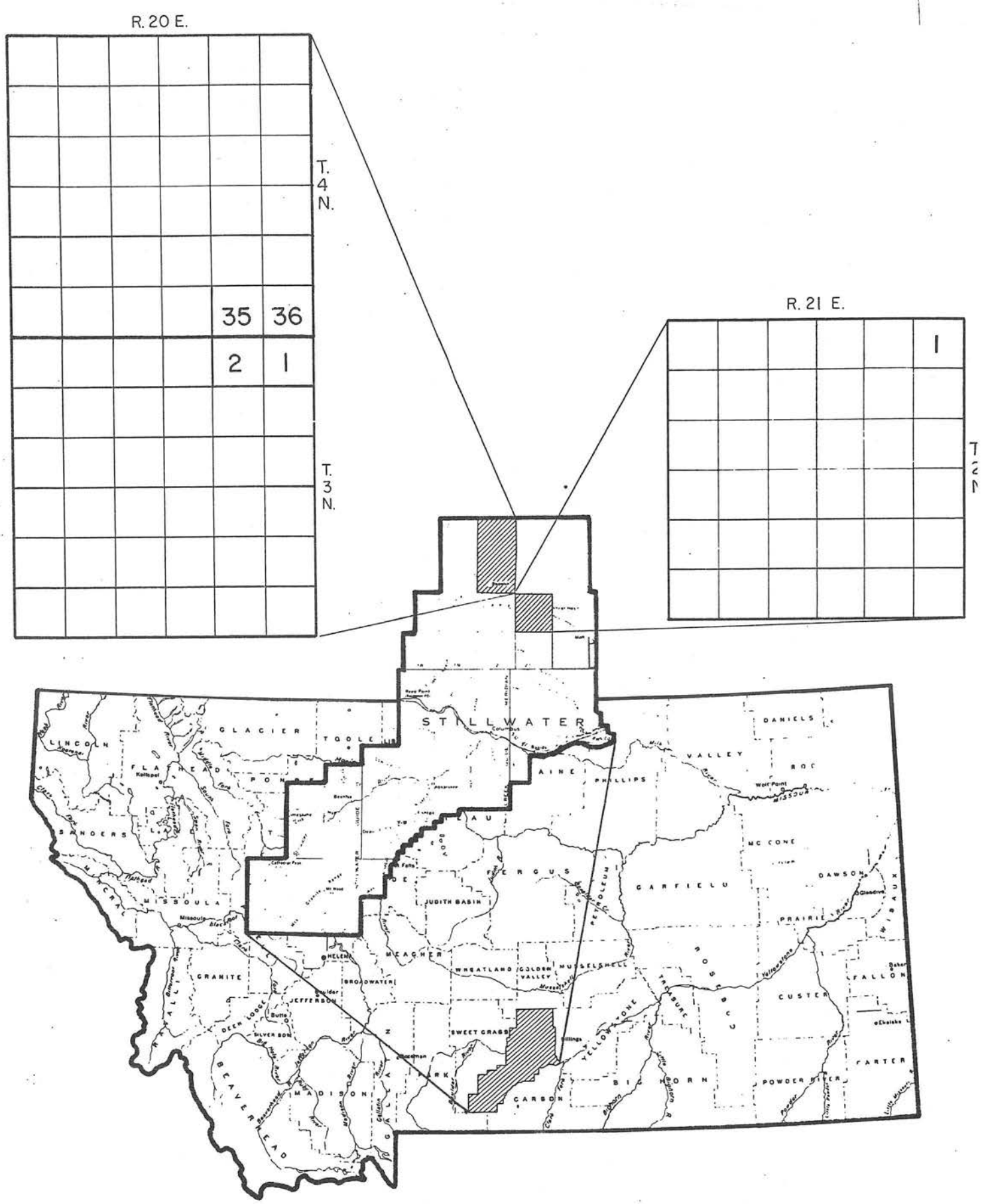


Figure 1 - Index map of Stillwater County, Montana, showing approximate locations of the Brickley and Herzog areas

SALINE-SEEP OVERVIEW

Salts of sodium, magnesium and calcium are common components of most geologic formations in eastern Montana. These salts are especially abundant in marine shales and deposits or soils derived from the shales. Because precipitation in this semiarid part of the state is insufficient to remove the salts, large concentrations of salts remain in the rocks and soil.

The first written reference to these salts in Montana is found in the journals of Lewis and Clark in 1805. Salts and salt crusts had been noted on sandbars and shores of the Missouri River and in western North Dakota, and observations were made of salt, salt crusts and saline water entering the Missouri River from tributaries there, also. But, as the Captains continued westward into Montana, they noted that the quantity of these "salts of tartar" increased. After the expedition reached the area just north of Great Falls, they saw no more of these salt areas except near Twin Bridges. Clark, on his eastward trip through Montana in 1806, did not mention seeing salts along the Yellowstone River.

Since the Homestead Days of the 1880's, ranchers and farmers were aware of, and often troubled by, alkali dust and alkali water. Many also had seen alkali soils occupying extensive flats or "slicks". Alkali in its various forms remained a local problem until in the early 1950's when agricultural officials noted that certain types of alkali areas were expanding and destroying some of the better croplands. The development and spread of saline areas downslope from irrigation ditches had been noted many years earlier, but the area of this new development was in areas of dryland farming.

The first known publication in Montana to express concern about this new alkali problem was the Montana Farmer Stockman with an article entitled "North Slope Alkali"; it appeared in 1954. In 1955, a report produced by the Soil Conservation Service in Fort Benton, Montana, discussed occurrences of saline seep near Fort Benton (Bahls and Miller, 1973). It was not until the late 1960's, however, that serious hydrogeologic investigations of this new phenomenon were begun. In one of the preliminary phases of the investigation, aerial photographs of the Highwood Bench area southeast of Fort Benton were used to quantify the rate of development of these saline areas. The aerial photographs, taken between 1941 and 1971, used together with observations made on the ground, showed that salinization in the Highwood Bench area had increased at the rate of 10 percent per year during the period of twenty years (Miller and others, 1980). Information from other areas in northern Montana suggested equivalent rates of saline-seep development.

Agricultural and hydrogeological experts ultimately labeled this new development of saline areas "saline seep". Many people, however, continued to call it "north-slope alkali" or "dryland salinity". Following many conferences and meetings, saline seeps were defined as, "recently developed [areas or conditions of] saline soils in non-irrigated areas that are wet some or all of the time, often with white salt crusts, where crop or grass production is reduced or eliminated".

The principal cause of salinized areas is simply the presence of more water in the soil profile than can be used by vegetation in a growing season—water which continues to accumulate for several years—until salts present in that water either reach the ground surface or are brought there by capillary action. Saline areas can develop as the result of climate change or by overgrazing by native animals. Nevertheless, naturally occurring saline areas were excluded from the term saline seep to accentuate their recent (post-circa 1950) origin and to stress their relationship to agricultural practices.

Once a saline seep is developed, its area can grow until the area susceptible to growth

is almost totally affected (Brown and Miller, 1978). This final area, however, is dependent upon the size and location of the recharge area that feeds the saline seep. Saline seeps have taken approximately 2 million acres out of production in the United States and Canada (Figure 2) with more than 200,000 acres being in Montana (Miller and Bergantino, 1983). In addition to the loss of cropland, there is the local (and potentially regional) degradation of surface and shallow groundwater resources.

Groundwater in and adjacent to saline-seeps may contain high concentrations of dissolved constituents, particularly sodium, magnesium, sulfate, nitrate, and selenium. In extreme instances, such as at Geraldine, Montana where the town is in the middle of a saline seep, springs that once were used for domestic purposes had to be replaced with deeper, more costly wells because of the elevated dissolved concentrations of minerals in the water (Figure 3). Saline-seep growth also caused considerable damage to residential basements and the local airport (Duaime and others, 1986).

SALINE-SEEP ORIGIN AND DEVELOPMENT

The Montana Bureau of Mines and Geology, in cooperation with numerous local, state, and federal agencies, has been conducting hydrogeological research at saline-seep sites throughout Montana since the late 1960's. Research results show that saline seeps (as defined) are caused by a combination of cultural, climatic, soil and hydrogeological conditions. The importance of any one of the conditions may vary significantly from area to area, but the formation of saline seeps follows the same general process throughout the state. Figure 4 (from ARS Report 30) illustrates this process.

In the Montana plains, the greatest potential for significant moisture is during the late spring and early summer (April, May, June and early July). A small precipitation peak often occurs in late September or early October. During the early spring, young, developing seedlings have shallow roots and their moisture usage is low compared to vegetation on a native range. Moisture that isn't used by the plants is able to migrate downward through the soil profile (unsaturated zone). Once this moisture moves below a depth of 4 to 5 feet, it is beyond the root zone of most cereal grains and continues to migrate downward, dissolving salts along the way. Eventually this moisture reaches an impermeable or less permeable layer, usually a shale or clay which impedes downward movement of the water, creating a saturated zone (shallow groundwater system) which moves laterally down gradient. As the water moves laterally, it leaches additional salts along its flow path, increasing the total dissolved solids (TDS) content of the water. Ultimately, this water resurfaces down slope to form a saline-seep (discharge area).

It takes many years for the water to travel from the recharge area to the discharge area. Meanwhile, if the precipitation has been above normal or the water used by the crops has been below normal, the level of water in this system will continue to build above the confining shale or clay layer. When the water-table rises to within about three feet of the ground surface, water can begin to move upward by capillary action. As the water moves up, it evaporates, and soluble salts precipitate out at or near ground surface. High water-table and high TDS of the groundwater are the main factors affecting vegetation growth.

Water moving through a system such as the one described above can accumulate roughly 50 milligrams per liter (mg/L) of TDS per foot of movement within the shallow groundwater flow system (Miller and Brown, 1981). The predominant soluble constituents are sodium, magnesium, sulfate, and nitrate. In addition, elevated concentrations of trace metals such as selenium commonly are persent.

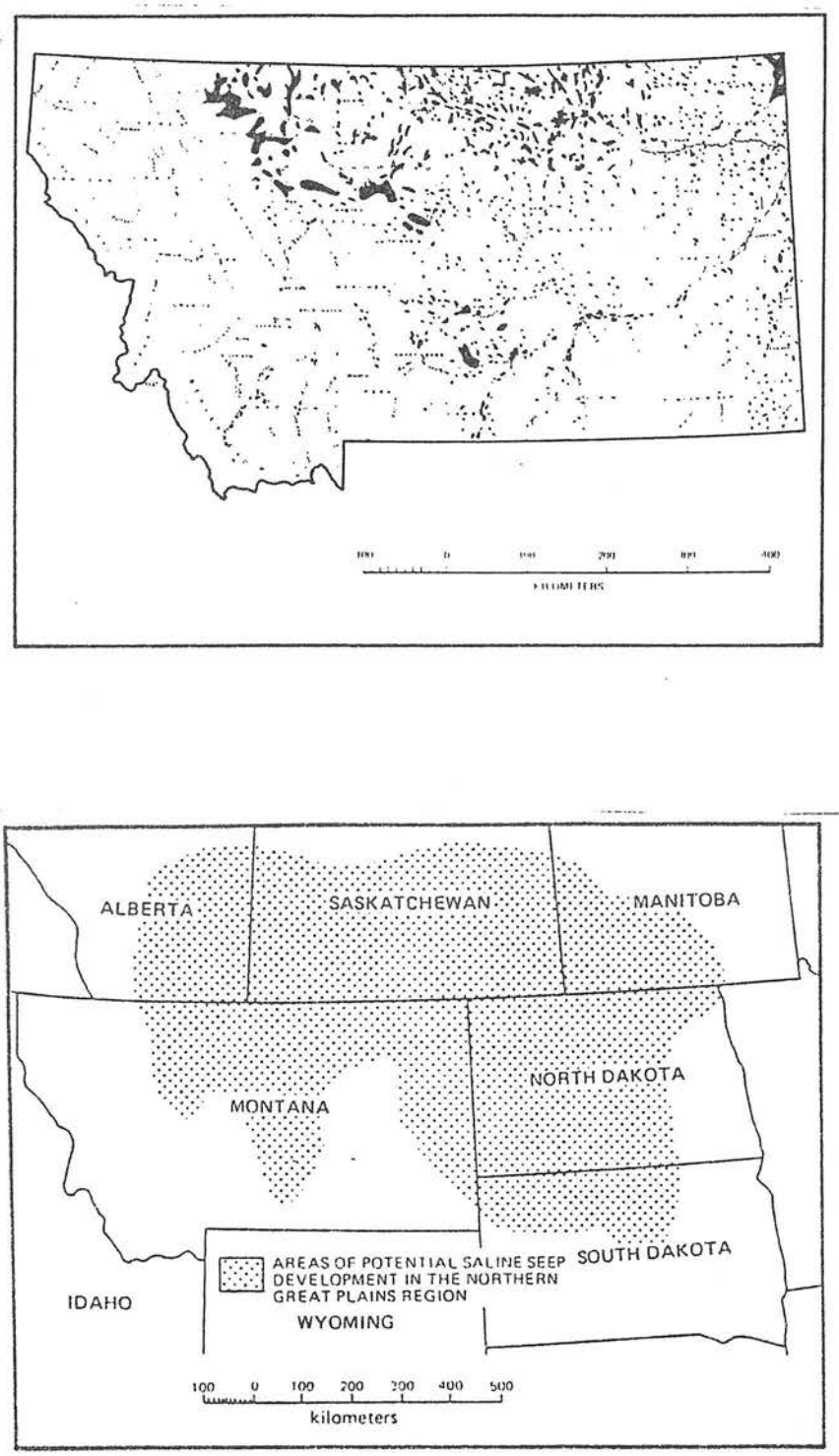


Figure 2 - Saline-seep areas in Montana (Top), and areas of potential saline-seep development (Bottom)

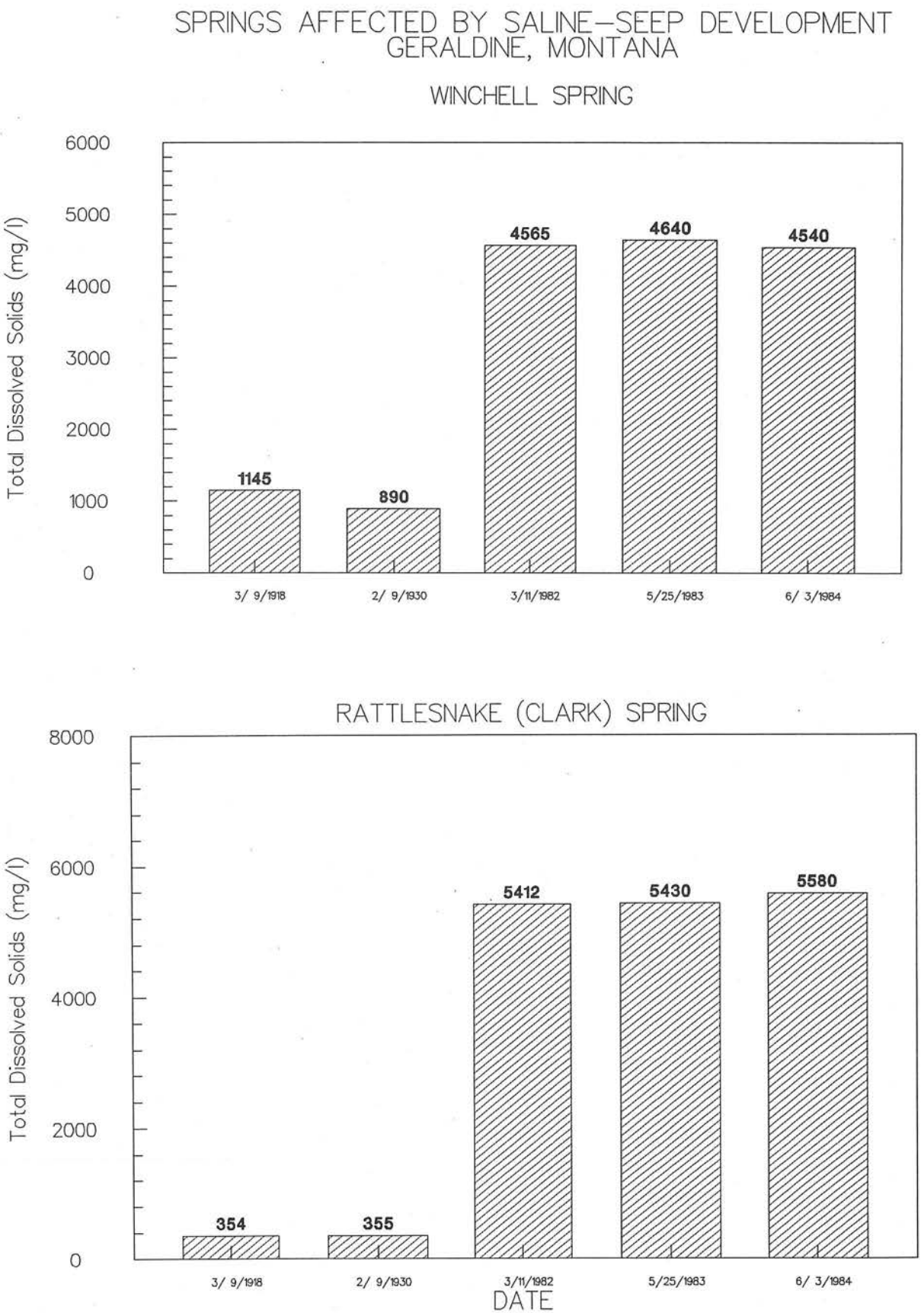


FIGURE 3 – Historic Water-Quality Degradation Associated with Saline-Seep Development

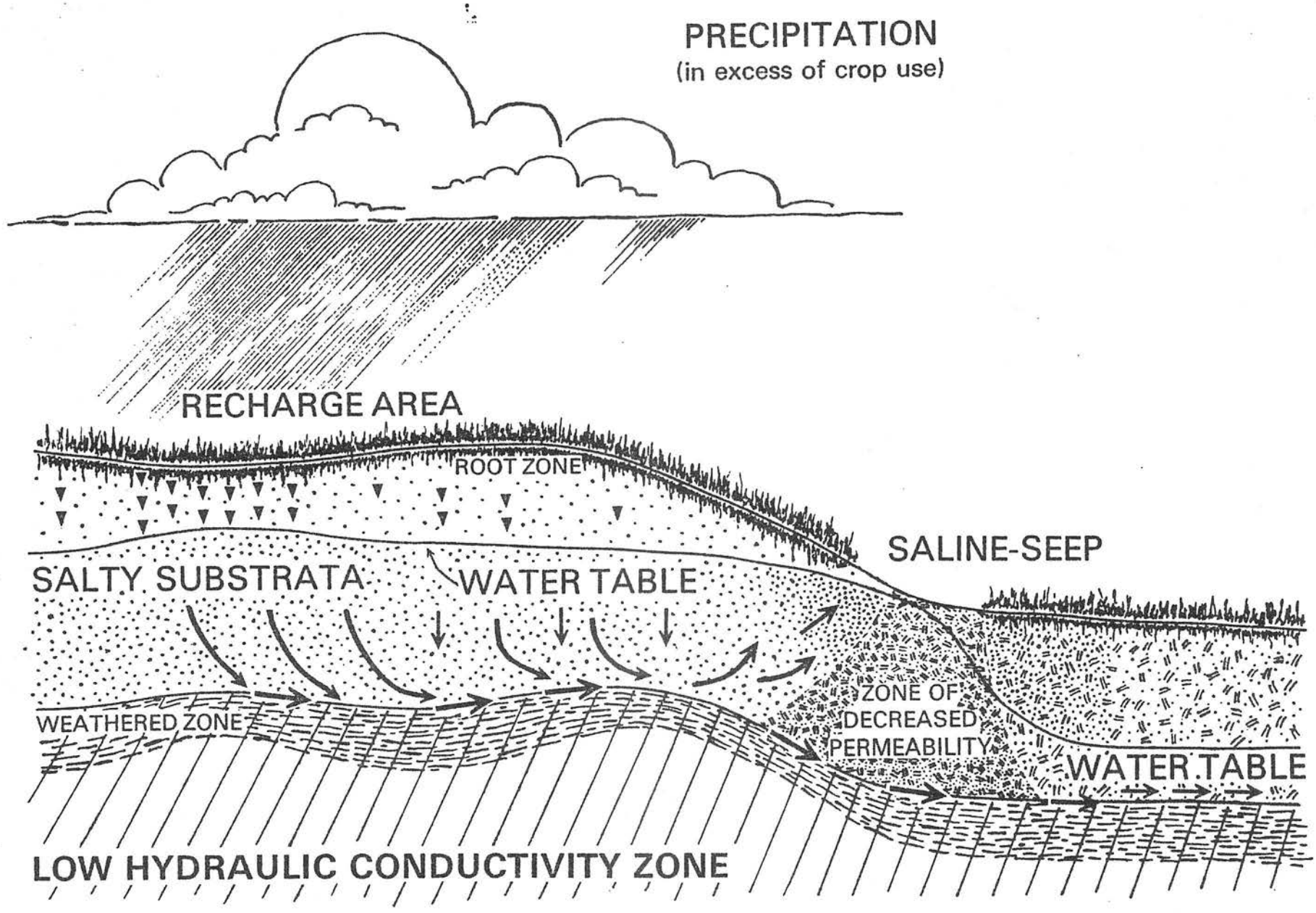


Figure 4 - Schematic diagram of saline-seep formation

Newly developed or recently expanded saline-seep growth usually is the result of changes in land-use practices. Land under native range conditions uses most of the annual precipitation, allowing very little moisture to move through the soil profile and into the groundwater flow system. If areas of native sod are broken and small cereal grains are planted using the crop-fallow method, a significantly larger percentage of annual moisture can move through the soil profile and enter the local groundwater flow system. To understand how a change in land use affects saline-seep development, it is important to understand how plant water-use changes once areas of native range are replaced by a crop-fallow system.

During a 24-month period, vegetation on a native range uses moisture during 14 of the 24 months. Natural vegetation with an established root system begins growth in the spring and utilizes most of the available precipitation as it occurs throughout the spring, summer and early fall. In contrast, areas under a typical crop-fallow system use moisture only during portions of every other growing season, or 3 to 6 months out of every 24 months. This allows up to 45 percent more moisture to enter the groundwater system.

GEOLOGIC SETTING OF THE PROJECT

PHYSIOGRAPHY

The following descriptions pertain only to the SCS-SCD 10-year demonstration site in T2N R21E Section 1 near Wheat Basin, a portion of the Lake Basin area. Other investigators have described the physiography, stratigraphy, and geology of the project site known as the Brickley Farm site in the Hailstone Basin (Custer, 1976, 1979 and Lewis and others, 1979).

The Lake Basin area is a low-lying, internally-drained basin. The Crazy Mountains lie 50 miles to the west; the Big Snowy Mountains 50 miles to the north, the Beartooth Mountains lie 50 miles to the southwest and the Bull Mountains lie about 20 miles to the northeast. The basin is isolated from the Musselshell drainage basin to the north and Yellowstone drainage basin to the south. Major topographic features within the basin are associated with the west-northwest-trending Lake Basin fault zone immediately north of the investigation area. Faulting and subsequent differential erosion of Cretaceous shales and sandstones has resulted in pronounced topographical features.

A buff-colored sandstone ridge traverses the northern portion of the study area. This ridge has a gentle dip-slope to the south which dominates the southern two-thirds of Section 1. Landscape dissection by surface water is limited to a poorly-developed drainage which cuts across the sandstone ridge in the northeastern portion of the section, but which dies out at the center of the section. Another smaller, immature drainage has developed in the southwestern corner of Section 1.

Precipitation is greatest during the late spring months. The average annual precipitation, as measured in Rapelje, Montana is 14.71 inches. Figure 5 shows monthly precipitation amounts from 1986 through 1990 compared to the 30-year average (1951-1980) at Rapelje (NOAA, 1990).

STRATIGRAPHY

The formations exposed in the study area all are of Late Cretaceous age. They are the Claggett Shale, the Judith River Formation, and the Bearpaw Shale. Investigations conducted by Hancock (1918) indicated that there is a significant difference in the lithology of the formations in the Lake Basin area compared to that of their respective type sections. Descriptions of the geologic formations within the study area are based on lithologic logs from monitoring wells, aerial photographs, and description of these units in nearby areas by Hancock.

Bearpaw Shale

The Bearpaw Shale, named by Stanton and Hatcher (1905), has its type section on the south side of the Bearpaw Mountains in north-central Montana. Although dominantly shale there, a few sandstone beds that are relatively competent and contain well-cemented andesitic tuffs are present in south-central Montana. These sandstone units are not well represented in outcrops here within the study area. Here, the formation is dominated by gray and blue-gray marine shales. Outcrops of the Bearpaw Shale are found only in depressions and immature drainages in the southwest quarter and extreme south portion of Section 1. The thickness within the study area is estimated at 110 feet.

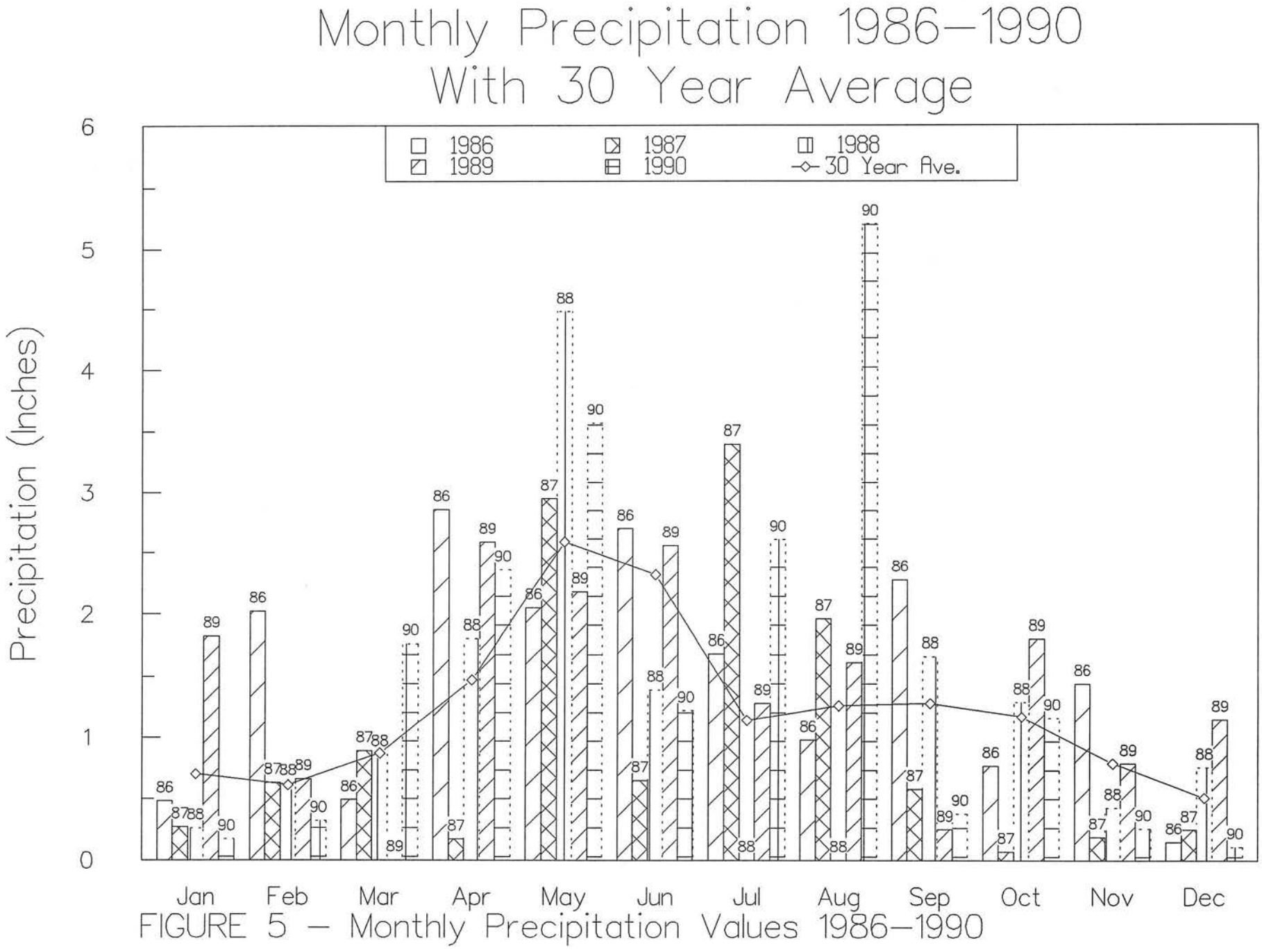


FIGURE 5 – Monthly Precipitation Values 1986–1990

Borehole Lithology

Only one well was completed in the area mapped as Bearpaw Shale. The only consolidated material representing this formation was an impenetrable sandstone which was encountered at a depth of 7 feet in well Z-1.

Judith River Formation

The type section for the Judith River Formation is near the mouth of the Judith River in north-central Montana. This section was first described by Hayden (1871). The Judith River Formation, which is stratigraphically above the Claggett Shale and below the Bearpaw Shale, is generally considered to be representative of a near-shore brackish and fresh water depositional environment. Near the study area, the formation consists of alternating beds of quartzitic sandstone and sandy clay with abundant plant material (Hancock, 1918). Within the project area and in the adjacent sections, ridges formed by the buff-colored basal-sandstone unit dominate. Near the base of the formation there is a fossiliferous unit characterized by ostracods and ichthyno-fossils (trace fossils); this unit often is well defined in outcrops throughout the area.

The thickness of the Judith River Formation ranges from over 550 feet in areas to the south of the study area (Knappen and Moulton, 1930) to 395 feet near Acton in T2N R24E Section 12. Within the study area, thickness is estimated at 400 feet.

Borehole Lithology

Drilling depth for monitoring wells completed in the area mapped as the Judith River Formation ranged from 11 feet (well Z-63) to 40 feet (wells Z-40 and Z-42). The general borehole lithology associated with the Judith River formation is consistent with that described in outcrops in other areas. Correlation of individual units across the section, however, was not possible because of the lack of bentonitic units in boreholes in the central portion of the demonstration site. The bentonite, as described in the well logs, is based on field observations during drilling. No further determination of the actual bentonite content of the material was made. The area where no bentonite was found at depth was mapped as K_{jr}(nb) in Figure 6. Those boreholes associated with the stratigraphic section above the ridge-forming basal-sandstone unit gave strong evidence of several bentonite layers.

Claggett Shale

The Claggett Shale was first described by Stanton and Hatcher in 1905 who named it after Fort Claggett, a military post just upstream from the mouth of the Judith River. The overlying Judith River Formation and the underlying Eagle Sandstone are considered to be fresh or brackish water delta deposits whose dark shale beds are the western extension of the Pierre Shale (Knappen and Moulton, 1930). Near the study area, however, the increase in sand content of the shales and the presence of thin-bedded sandstones indicate a shallower depositional environment (Hancock, 1918). Within the study area, the sandstone beds are not strongly evident at the surface but, rather, the formation is dominated by sandy shale in the northeastern portion of the demonstration site.

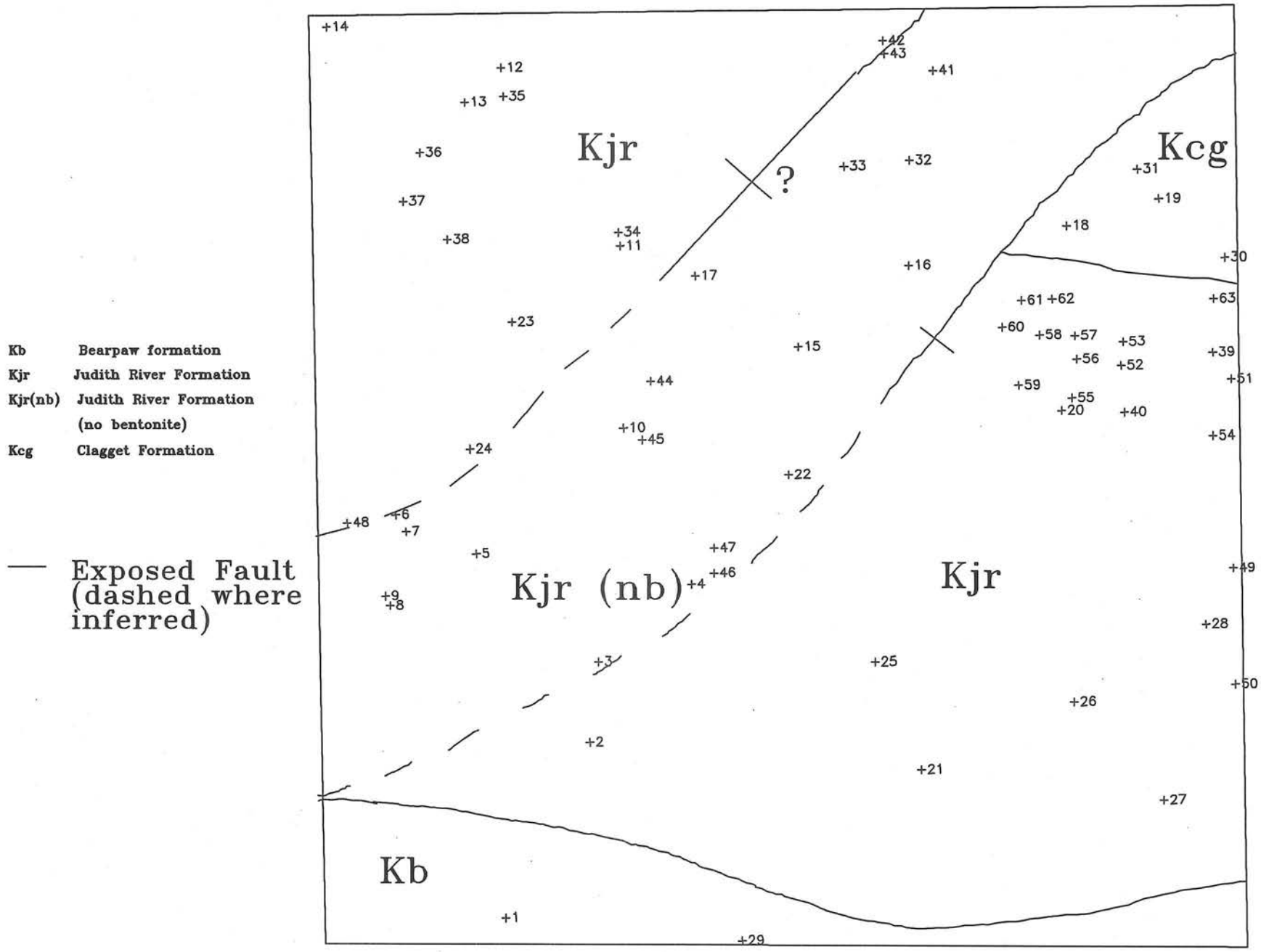


Figure 6 – Generalized Geologic Map of 10–Year Demonstration Site, Rapelje, Montana

Thickness of the Claggett Shale ranges from 675 feet in areas south of the Lake Basin (Knappen and Moulton, 1930) to 570 feet within the Lake Basin (Hancock, 1918). Thickness of this formation within the study area could not be determined.

Borehole Lithology

Only four monitoring wells (Z-18, Z-19, Z-30, & Z-31) were drilled in the area mapped as the Claggett Shale; the depth of the boreholes ranged from 13 feet to 30 feet. The lithologies in all four boreholes were similar: a sandy shale was encountered at a depth of approximately 8 feet. In the deeper boreholes, a competent sandstone, likely to be the upper sandstone unit of the Claggett Shale, was encountered immediately below this unit.

STRUCTURE

The study area is located adjacent to the Lake Basin fault zone, a narrow area of faulting extending in a northwest direction from southeast of Billings, Montana to a few miles east of Melville, Montana. Structural deformation associated with this zone is especially evident in the area north of the investigation site, but is not strongly evident within the boundaries of the study area. Beds generally dip approximately 18 degrees to the south with little deviation.

At least two faults are present within Section 1, but only one was mapped by Hancock (1918) as part of the Lake Basin fault zone. This fault trends from the northeast corner of the demonstration site to the southwest corner. Based on aerial photographs and an outcrop of an oyster bed common to the area, the displacement along this fault appears to be nearly vertical. The small drainage that passes through Section 1 appears to follow the fault—at least in the northern half of that section.

A second fault was identified based on two lines of evidence. As described in the section on Judith River Formation, borehole lithology, there is an area in the central portion of Section 1 oriented parallel to the fault mapped by Hancock where boreholes of variable depths gave no evidence of a bentonitic layer. Displacement of the oyster bed in the Judith River Formation along the ridge in the north-central portion of Section 1 provides further evidence of offset caused by faulting.

Relative movement along the fault likely was nearly vertical with the central block being the downthrown block. The primary line of evidence for this is the bentonite layer associated with the ridge-forming basal-sandstone.

STILLWATER CONSERVATION DISTRICT 10-YEAR DEMONSTRATION SITE WELL AND LYSIMETER INSTALLATION

The first phase of monitoring well installation took place during the late fall-early winter of 1983 under the Montana Salinity Control Association (MSCA), formerly known as the Triangle Conservation District. Wells numbered Z-1 through Z-29 were drilled by the MSCA using their Mobil B-29 auger drill. Because the MSCA drill was unable to penetrate indurated sandstone and many of the shale, clay and bentonite layers, wells could not be drilled deeper than 15 feet. In order to obtain deeper wells, the SCD requested that the MBMG finish the well drilling and completion using its Mobil B-50 auger drill. The MBMG began drilling in 1984 during the late winter. Most of the wells numbered Z-30 through Z-50 were drilled in the north and northeast portions of the site. When Water Development Grant monies were received, wells numbered Z-51 through Z-63 were drilled in the central portion of the northeast portion of the site. These wells were drilled during the late fall of 1985. Figure 7 shows the location of all monitoring wells at this site.

Part of this investigation had been established to monitor a site where native range had been broken a few years previous, and had been farmed using intensive cropping practices. But, because no suitable location was available once funds were available, the farm operators agreed to break an area in the central part of the northeast quarter of Section 1. Wells Z-51 through Z-63 were drilled during this phase of the investigation. Well logs for all drill holes and wells drilled at this site are contained in Appendix A.

A typical well installation consisted of drilling a 7-inch auger hole to a specific lithologic unit or to a specified depth (drill cuttings were collected and bagged every 5 feet for future reference, or evaluation). Once the hole was drilled to its desired depth, it was cased with a slotted 4-inch PVC pipe; the bottom of the casing was left open. Slots in the 4-inch PVC pipe were several inches apart and were made with a hacksaw or skillsaw. The slotting began near the bottom of the pipe and continued upwards until an appropriate length of pipe was slotted (this interval usually ranged from several to 20 feet). The well annulus was then filled with gravel to a level above the uppermost slots in the casing. Drill cuttings were then placed in the well annulus until they reached the ground surface. Additional cuttings were mounded around the casing above ground surface and sloped away from the well to prevent surface water from entering around the casing. A 4-inch PVC cap was then placed on the well casing. Figure 8 shows a typical well completion.

In addition to drilling the monitoring wells, porous cup lysimeters were installed in the unsaturated zone adjacent to five monitoring wells. These lysimeters were used to collect water samples from the soil for nitrate and selenium analysis. (The unsaturated zone is the area below ground surface and above the groundwater-table.) Figure 9 shows a typical lysimeter installation. Figures 10 through 14 show the depth at which each lysimeter was installed and the lithology associated with that lysimeter and its companion well.

GROUNDWATER MONITORING AND QUALITY

Water-Level Measurements

Water-level monitoring was initiated shortly after the installation and completion of monitoring wells Z-1 through Z-50. Water levels were measured every two weeks from April through June and then once a month through October of each year; measurements occasionally

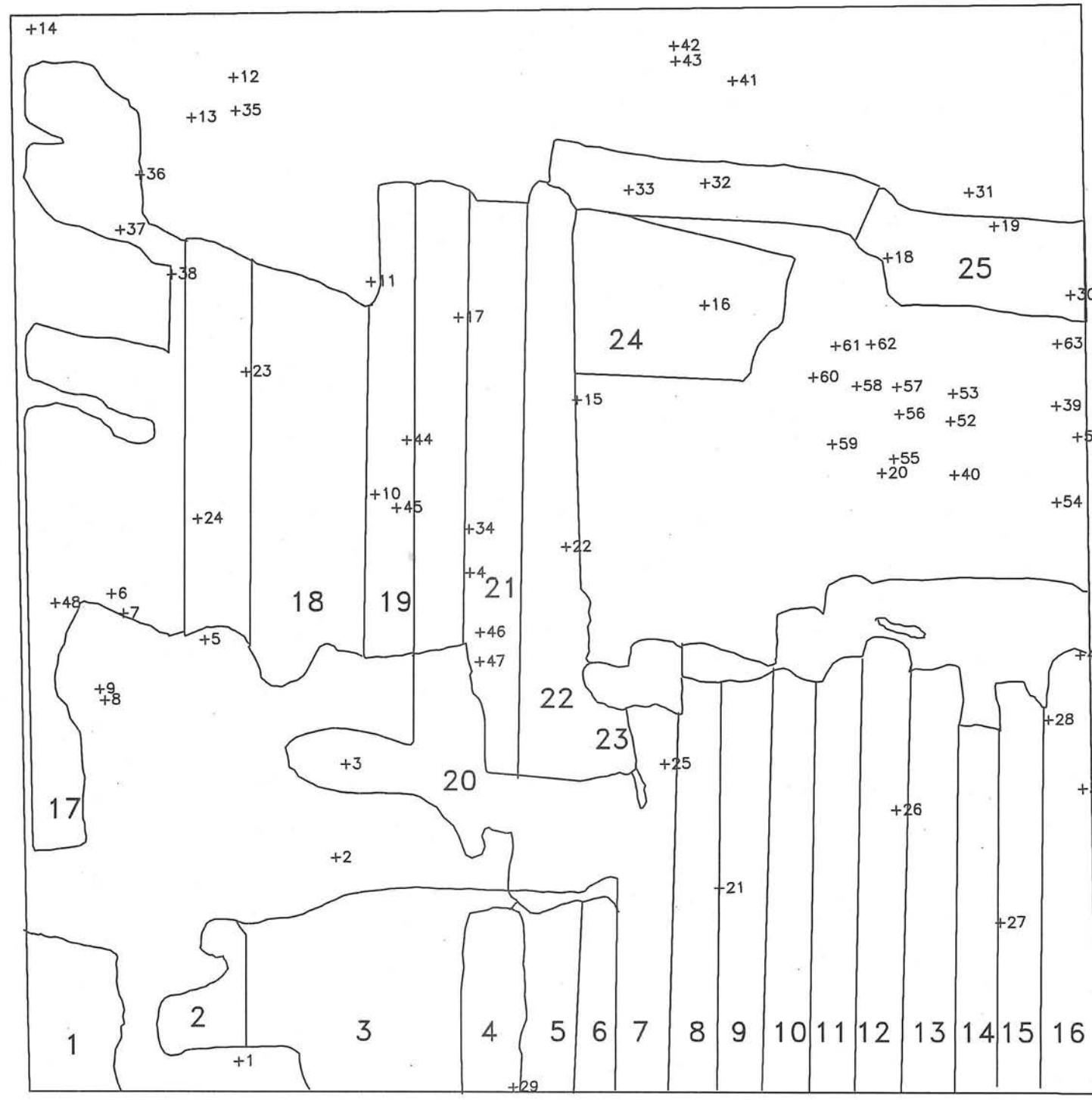


Figure 7 – Location of Monitoring Wells at 10–Year Demonstration Site, Rapelje, Montana

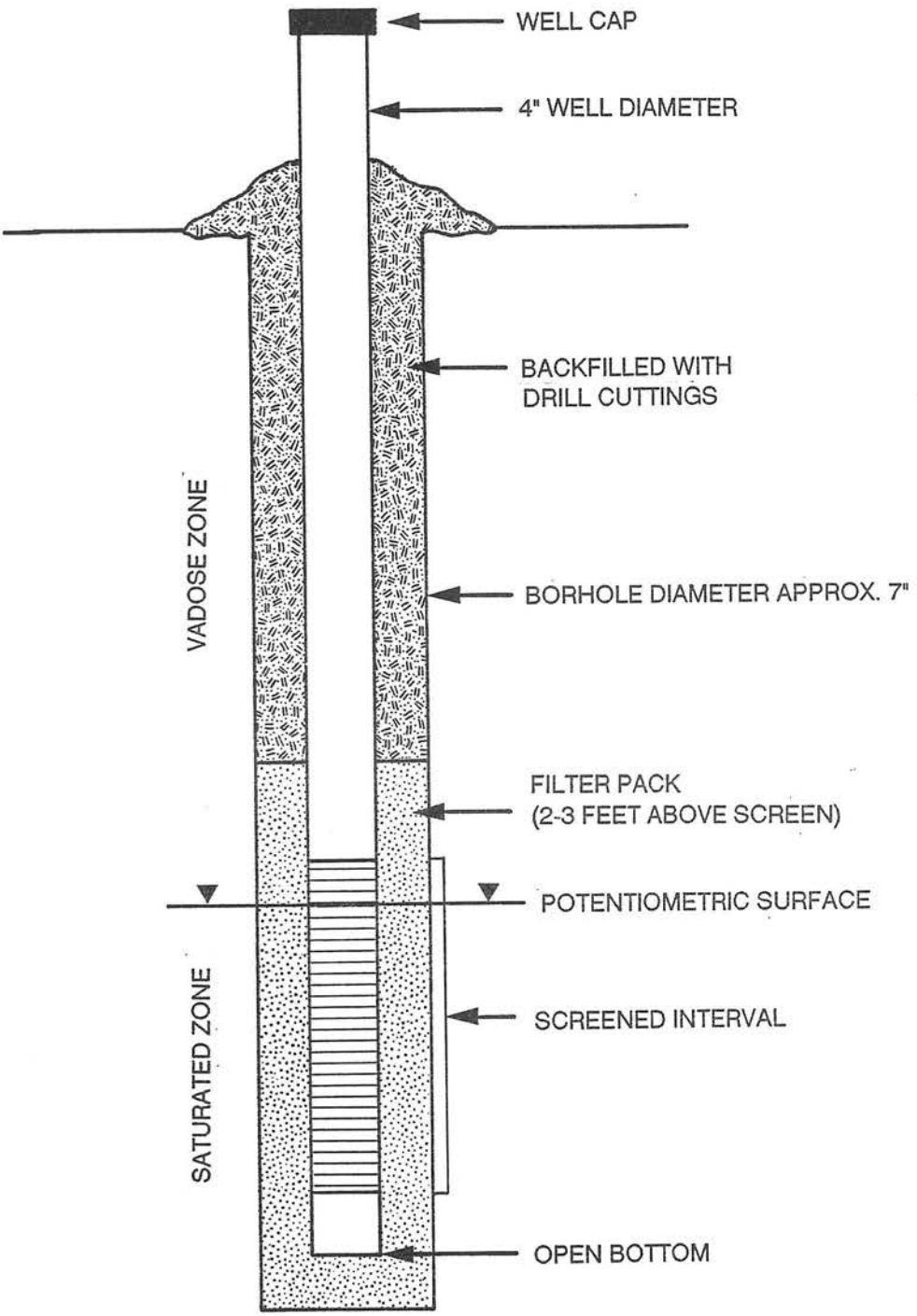


Figure 8 Schematic of a typical monitoring well completion.

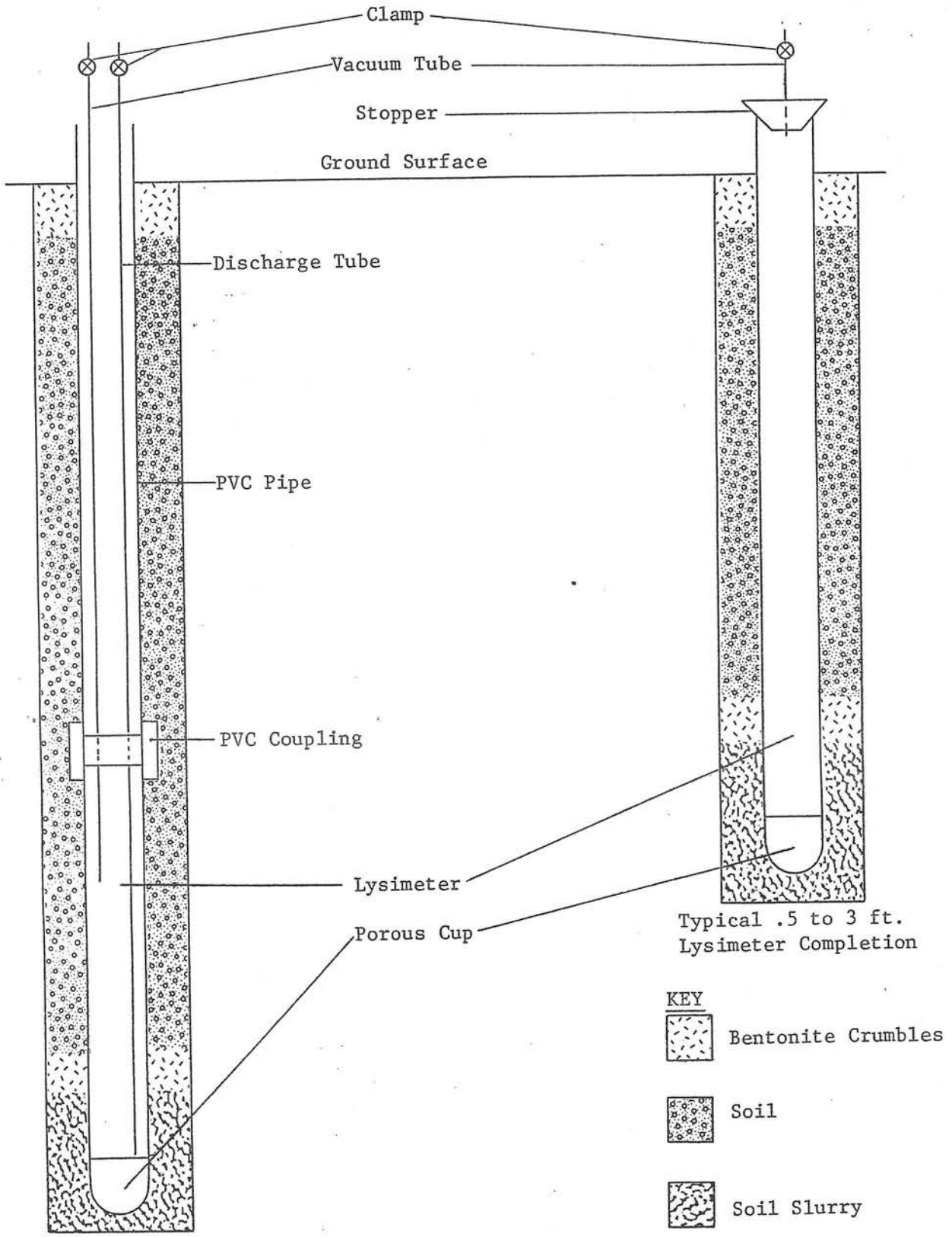


Figure 9 - Typical 5 and 10 ft Lysimeter Completion

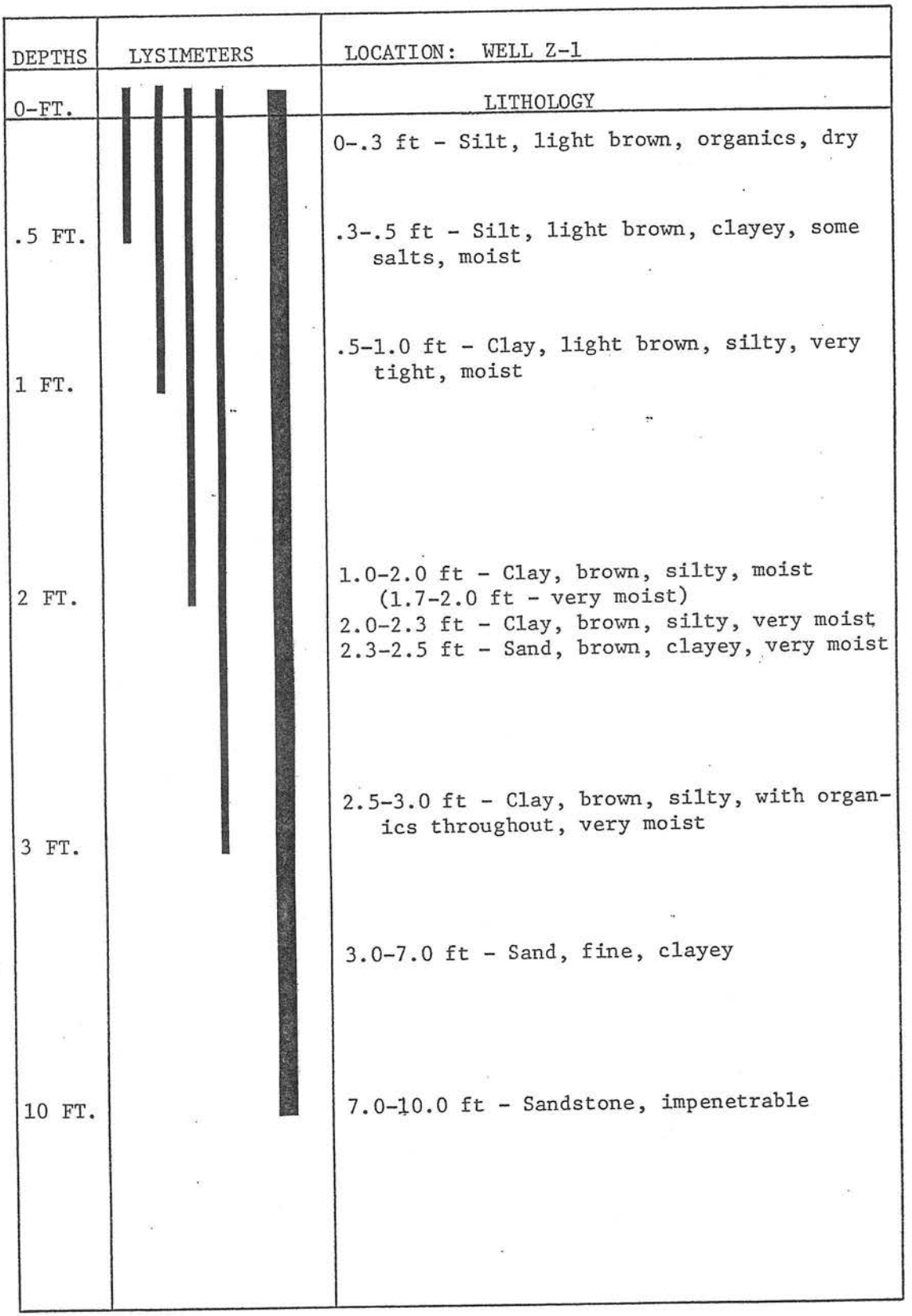


Figure 10 - Depth of Lysimeters and Lithology at Well Z-1

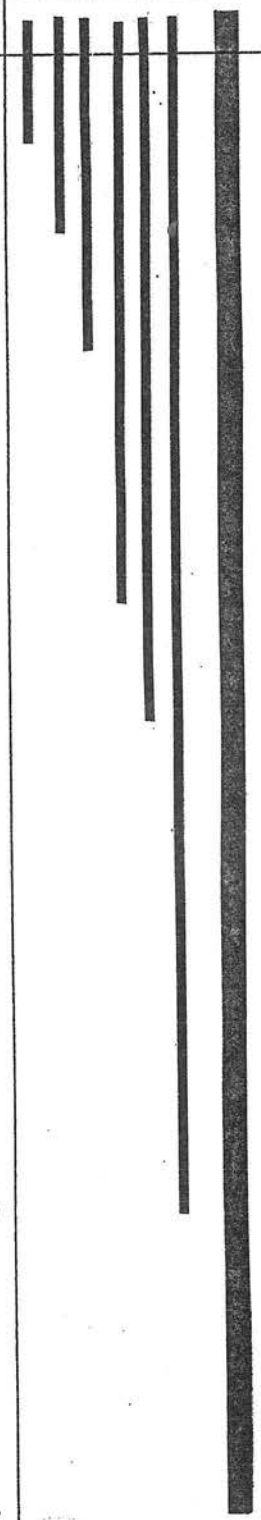
DEPTHS	LYSIMETERS	LOCATION: WELL Z-30
0-FT.		LITHOLOGY
.5 FT.		0-.8 ft - Silt, light brown, dry
1 FT.		.8-1.2 ft - Silt, brown, moist
2 FT.		1.2-2.0 ft - Silt, dark brown, slightly clayey, moist 2.0-2.4 ft - Silt, dark brown to black, organics, moist
3 FT.		2.4-4.2 ft - Silt, light brown, moist
5 FT.		4.2-5.7 ft - Sand, lt brown w/some oxidized (Fe) sandstone fragments, moist 5.7-6.4 ft - Silt, lt brown, slightly clayey, moist 6.4-8.4 ft - Sand, brown w/sandstone fragments 8.4-8.6 ft - Clay, lt green, silty, moist 8.6-8.8 ft - Sand, light brown to green, silty 8.8-9.5 ft - Silt, light brown, clayey 9.5-9.7 ft - Sand, light brown, silty
10 FT.		9.7-10.4 ft - Silt, lt brown, clayey, moist 10.4-18.0 ft - Interbedded sand & silt 18.0-23.0 ft - Interbedded sand & silt w/sandstone fragments 23.0-30.0 ft - Sandstone, very hard
30 FT.		

Figure 11 - Depth of Lysimeters and Lithology at Well Z-30

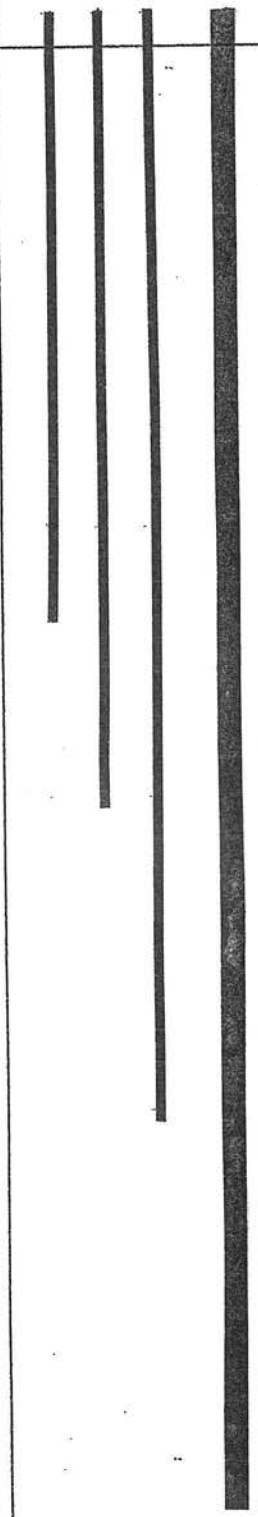
DEPTHS	LYSIMETERS	LOCATION: WELL Z-36
0-FT.		LITHOLOGY
		0-.5 ft - Silt, light brown, dry
		.5-.9 ft - Silt, light to dark brown, sandy, dry
		.9-2.0 ft - Silt, lt to dk brown, sandy w/sandstone fragments
		2.0-2.5 ft - Sand, brown, very fine to medium
3 FT.		2.5-3.0 ft - Shale, green, weathered
5 FT.		3.0-5.5 ft - Interbedded shale, green and sandy shale at 4.0 ft, very hard drilling
		5.5-9.8 ft - Clay, lt brown & yellowish orange, silty, w/lignite, moist
10 FT.		9.8-10.4 ft - Clay, orange to reddish brown, silty, moist
		10.4-11.0 ft - Sand, silty
		11.0-14.0 ft - Bentonite
18 FT.		14.0-18.0 ft - Sandstone and bentonite layers

Figure 12 - Depth of Lysimeters and Lithology at Well Z-36

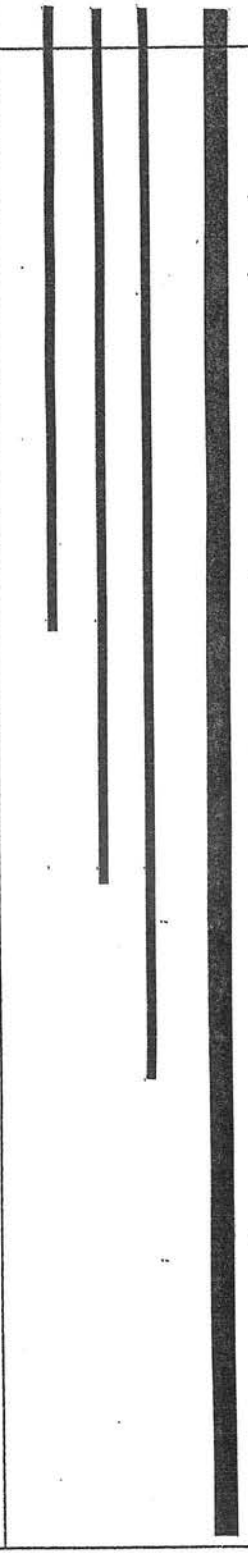
DEPTHS	LYSIMETERS	LOCATION: WELL Z-40
0-FT.		LITHOLOGY
		0-.5 ft - Silt, gray, lt brown & reddish brown, dry
		.5-13. ft - Silt, dark brown, slightly clayey w/sandstone fragments, dry
		1.3-2.5 ft - Silt, lt green, slightly clayey w/salts and shale chips, dry
3 FT.		2.5-4.0 ft - Clay, green, sandy w/salts, dry
		4.0-5.0 ft - Shale, lt green to brown, dry
5 FT.		5.0-6.0 ft - Shale, lt green w/thin sand stringers & lignite, dry
		6.0-9.8 ft - Interbedded green & reddish brown shale & sand, dry
10 FT.		9.8-10.1 ft - Sandstone, lt brown, very fine, dry
		10.1-13.0 ft - Clay, silty
		13.0-22.0 ft - Sandstone, gray & brown, soft to very hard
		22.0-30.0 ft - Clay, silts
		30.0-33.5 ft - Sandstone, hard
40 FT.		33.5-40.0 ft - Bentonite, greenish gray, with silt

Figure 13 - Depth of Lysimeters and Lithology at Well Z-40

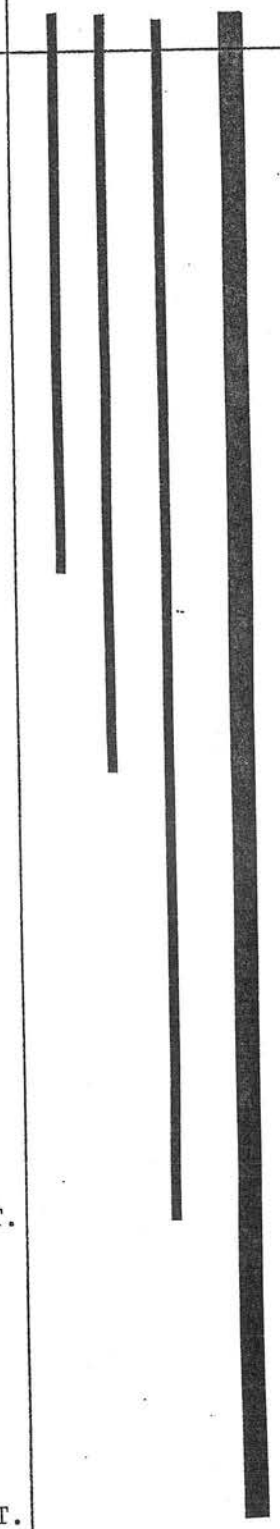
DEPTHS	LYSIMETERS	LOCATION: WELL Z-50
0-FT.		LITHOLOGY
		0-.7 ft - Silt, lt brown, w/organics
		.7-2.0 ft - Silt, brown, moist
		2.0-4.2 ft - Silt, greenish brown, slightly clayey, some salts, moist
3 FT.		
		4.2-5.0 ft - Sand, brown to reddish brown, silty & clayey w/some oxidized zones (Fe)
5 FT.		5.0-6.5 ft - Sand, brown, very fine w/small pieces of lignite
		6.5-7.0 ft - Sand, greenish brown, silty, clayey w/lignite, salts & oxidation (Fe)
		7.0-7.3 ft - Silt, brown w/lignite & salts, dry
		7.3-7.7 ft - Clay, dark brown to gray, silty, w/lignite stringers & salts
		7.7-9.0 ft - Clay, interbedded gray & orange layers, silty
10 FT.		9.0-10.1 ft - Shale, interbedded green & orange layers, weathered, silty
		10.1-11.0 ft - Hard zone
		11.0-15.0 ft - Sand, silty
		15.0-20.0 ft - Clay, brown, sandy, w/salt stringers
25 FT.		20.0-25.0 ft - Clay, very hard, dry

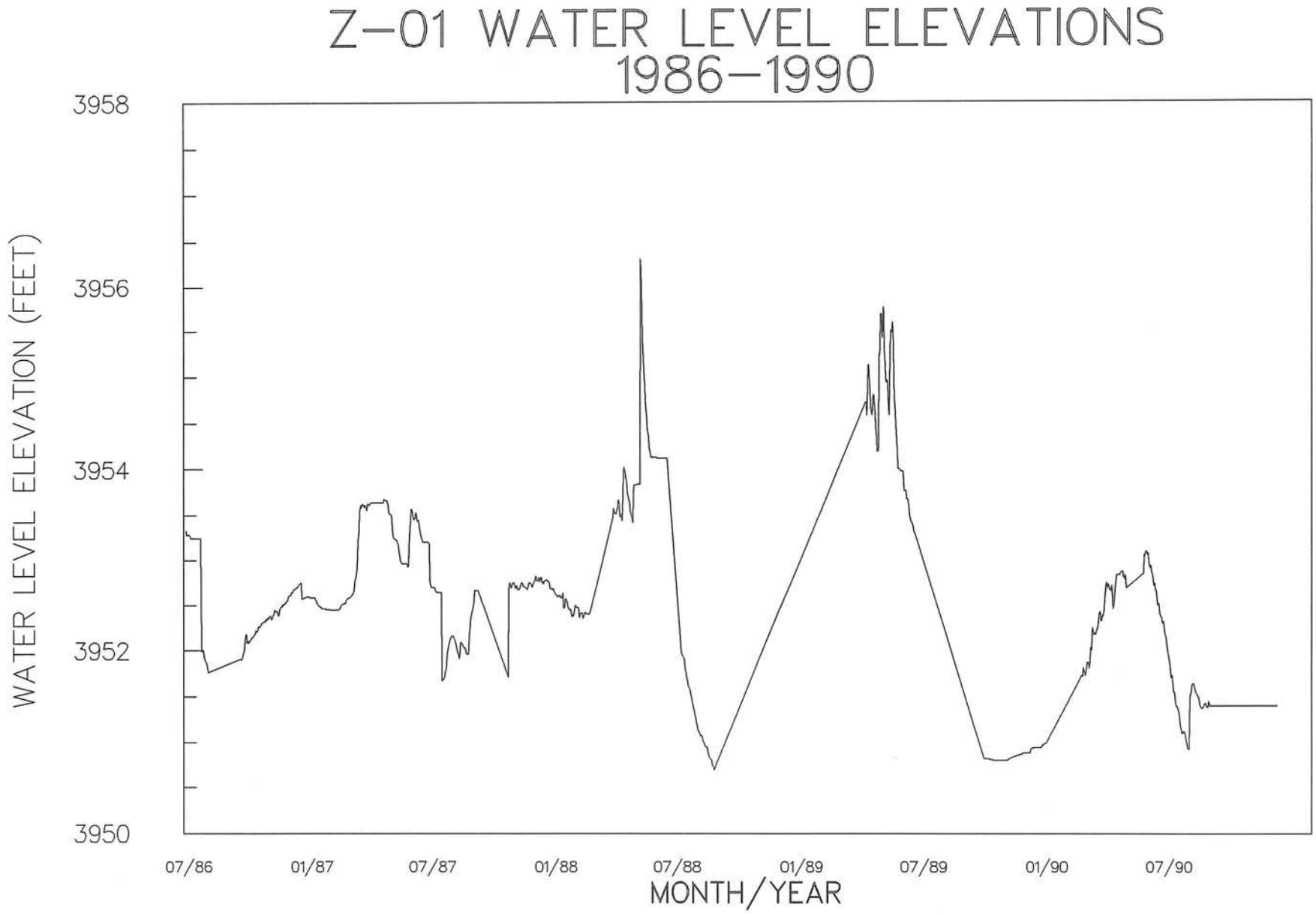
Figure 14 - Depth of Lysimeters and Lithology at Well Z-50

were taken between November and March. Appendix B contains a listing of water levels for all monitoring wells. Some deviations from this schedule occurred because of the lack of personnel to perform monitoring duties. As a part of this grant, money was allocated to hire a local high school student to perform this task. Occasionally the selection of a student was delayed, thus resulting in a delay starting the spring monitoring.

Continuous recorders were installed on four monitoring wells (Z-1, Z-26, Z-35, and Z-40) during 1986. These recorders provided a record of water-level variations on a daily basis for a 90-day period. At the end of this period, the charts were changed and new charts put on. Figures 15 through 18 are water-level hydrographs from those four sites. Water levels from all the observation wells were plotted on maps and contoured to show the direction of groundwater flow, thus enabling the delineation of recharge and discharge areas. Figures 19 through 22 are potentiometric maps that depict water-table contours for the late spring-early summer period of 1984, 1986, 1988, and 1990 respectively. These figures show that groundwater flow direction is from the north-northeast to the southwest.

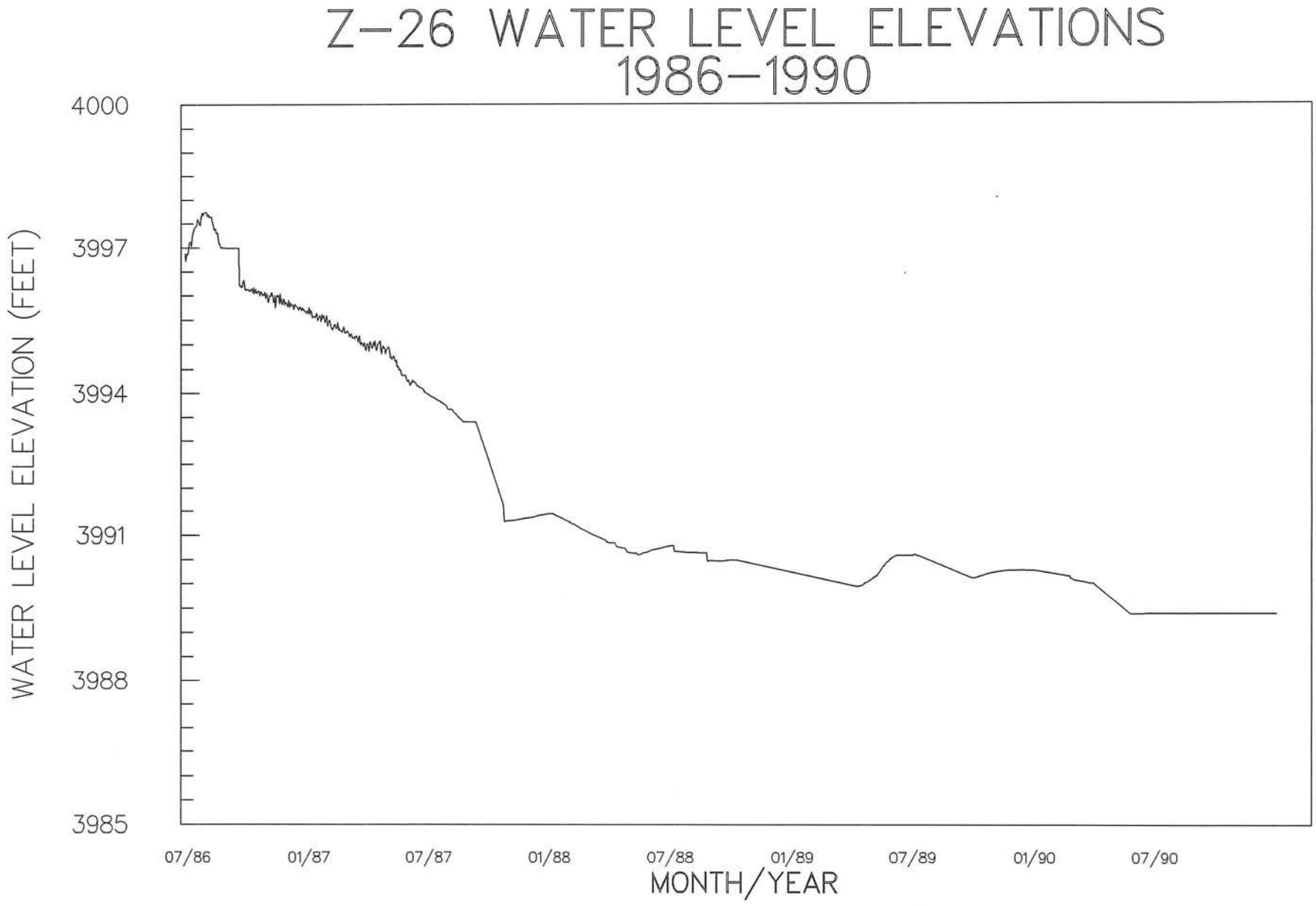
The operators of the farm at this site seeded alfalfa in the south-central portion of the site during the spring of 1985 and in the southeast portion of the site in the spring of 1986 (Figure 23). A total of 205 acres was seeded to alfalfa (SCS, 1985). Prior to the planting, the water level at monitoring well Z-26 in the north-central portion of the alfalfa field had a maximum elevation of 3998 feet; the depth to water was 4.90 feet below ground surface. By the fall of 1987, the water-level elevation had fallen to 3992 feet (depth to water: 11 feet), a decline of 6 feet. The water level continued to decline to an elevation of 3989.4 feet, at which point the well was dry. This change in static water level represents a total water-level decline of 9 feet. Observations from other saline-seep study sites strongly suggest that the increased water-usage of alfalfa (because it can extend its roots to a depth of about 19 feet) lowered the water-table an additional eight feet. It is interesting to note the relatively small effect precipitation events had on water levels at this well (Figure 24) in comparison to well Z-1 (Figure 25), which is located in the main portion of the discharge area. The quick response of water levels at well Z-1 are typical of a local groundwater system which shows response to precipitation. Well Z-26 shows no or very little response to precipitation events, signifying the effect alfalfa was having on moisture usage. It appears that very little excess moisture migrated beneath the root zone in the alfalfa field.

Figure 26 shows hydrographs of wells Z-35 and Z-40 with monthly precipitation amounts for the period of 1986 through 1990. Well Z-35 is in native sod in the northwest corner of Section 1, whereas well Z-40 is in the south-central portion of the area where the native sod was broken during the spring of 1987 (Figure 23). Water-level trends are similar for these two wells except that water levels appear to respond more quickly to precipitation events at well Z-40. The area surrounding well Z-40 has been intensively cropped since the sod was broken and, to date, does not show any adverse effects associated with this breakage. However, the resulting water-level decline in the alfalfa-cropped portion of the site to the south (near well Z-26) has increased the groundwater gradient, which might be masking water-level changes associated with cropping changes near well Z-40, in the near term. It will require a longer period of monitoring to determine if water-level deviations occur within this area as a result of the breakage of the native sod.



09/88 – 04/89 Loss of water level records

Figure 15 – Well Z-1 Water Levels



(Note: Total Depth Elevation of Monitoring Well – 3989.4 feet)
Figure 16 – Well Z-26 Water Levels

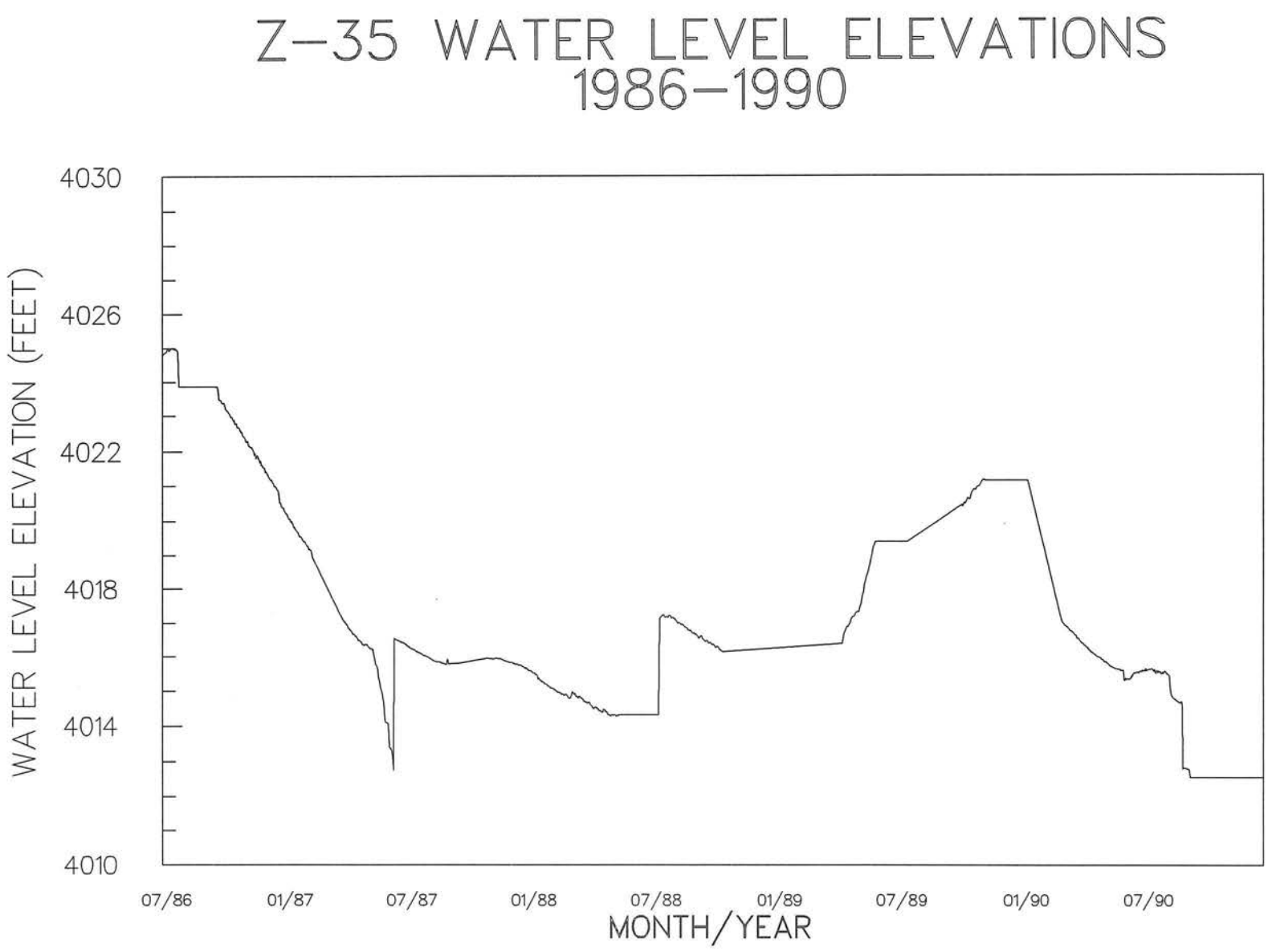
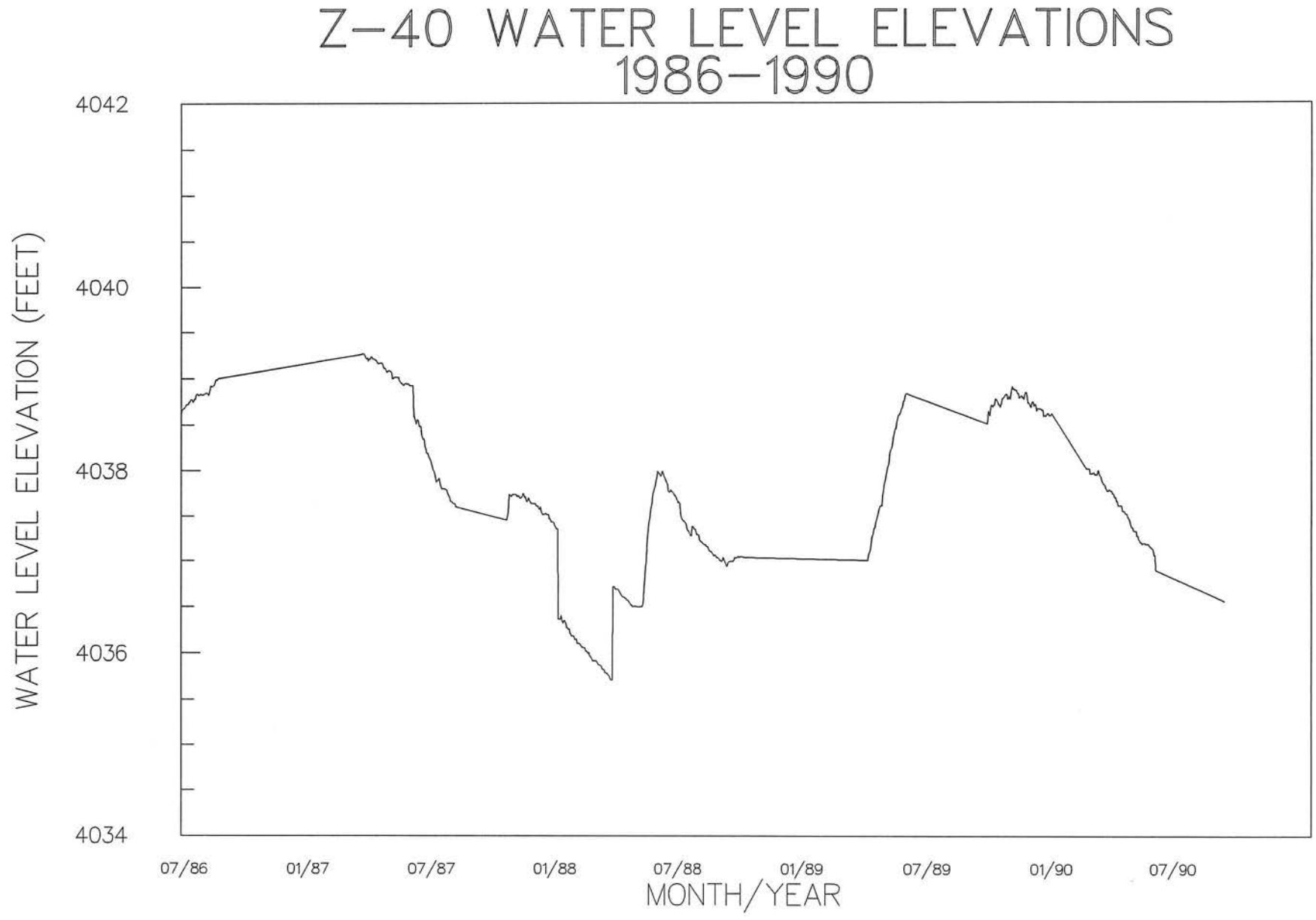


Figure 17 – Well Z-35 Water Levels



10/88 – 04/89, 06/89 – 10/89, 06/90 – 12/90 Loss of water level records

Figure 18 – Well Z–40 Water Levels

HERZOG - ZINNE DEMONSTRATION SITE

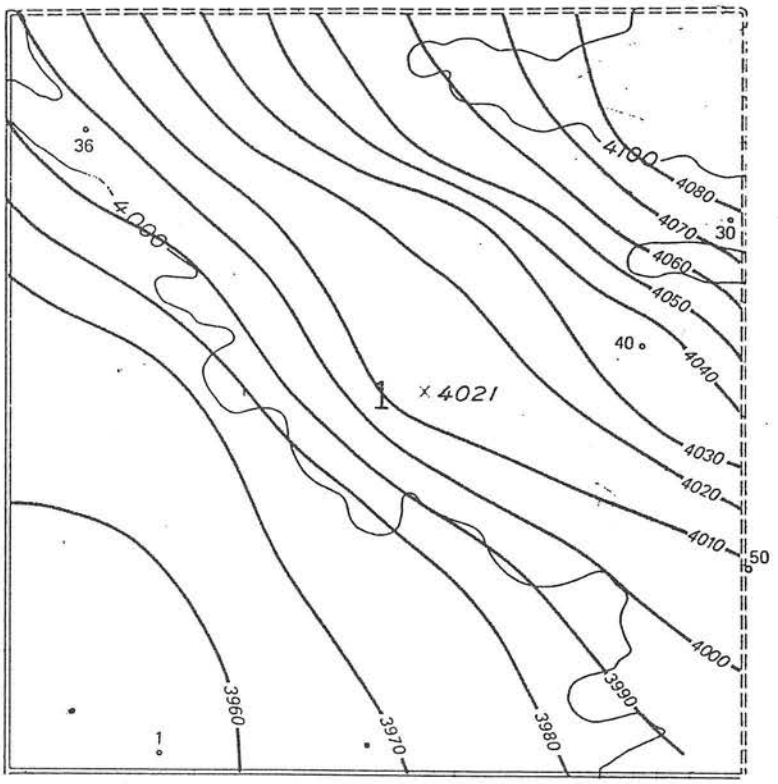


Figure 19 - Groundwater elevations (feet), May 1984

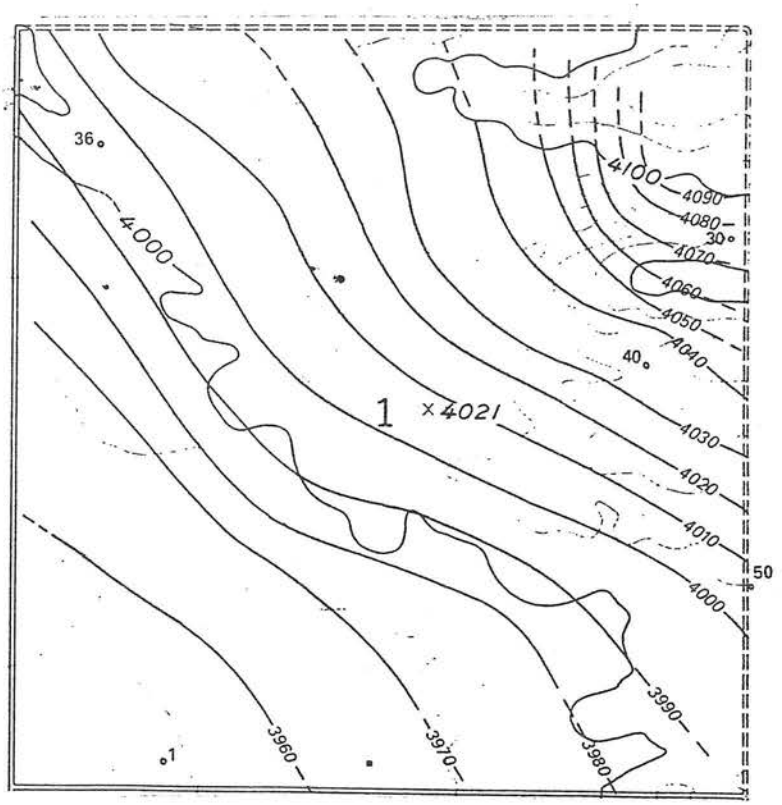


Figure 20 - Groundwater elevations (feet), April 1986

HERZOG - ZINNE DEMONSTRATION SITE

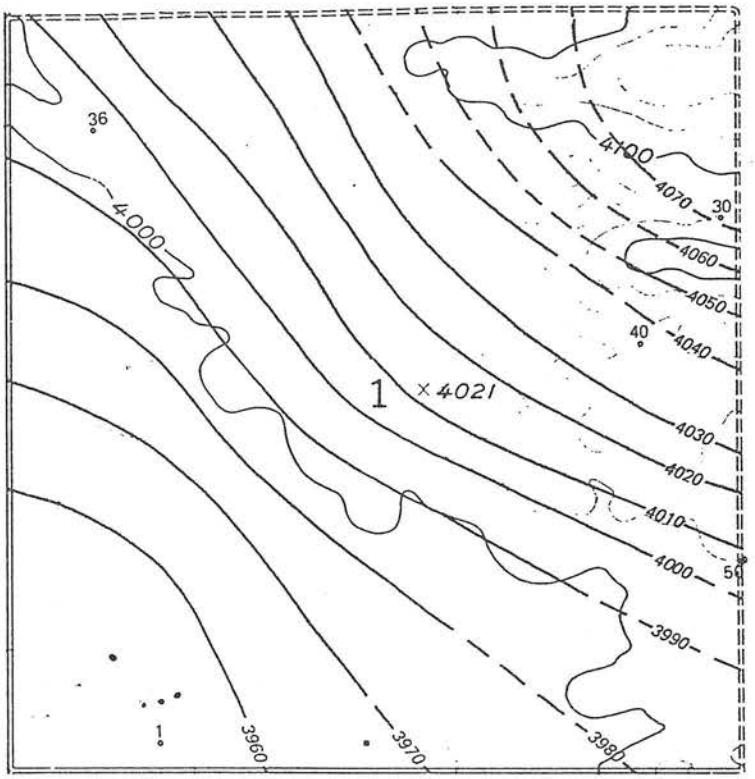


Figure 21 - Groundwater elevations (feet), March 1988

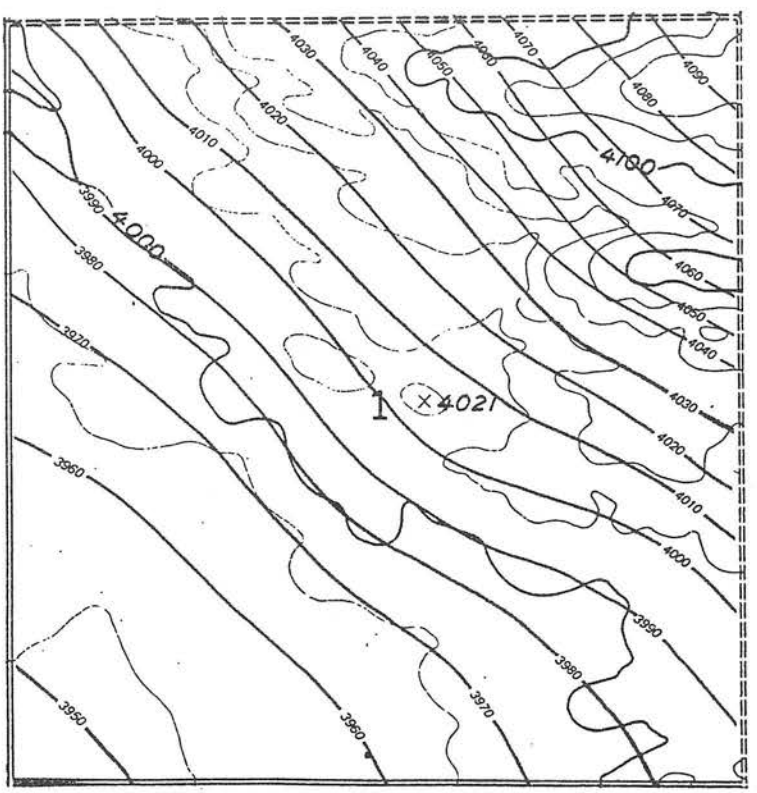


Figure 22 - Groundwater elevations (feet), May 1990

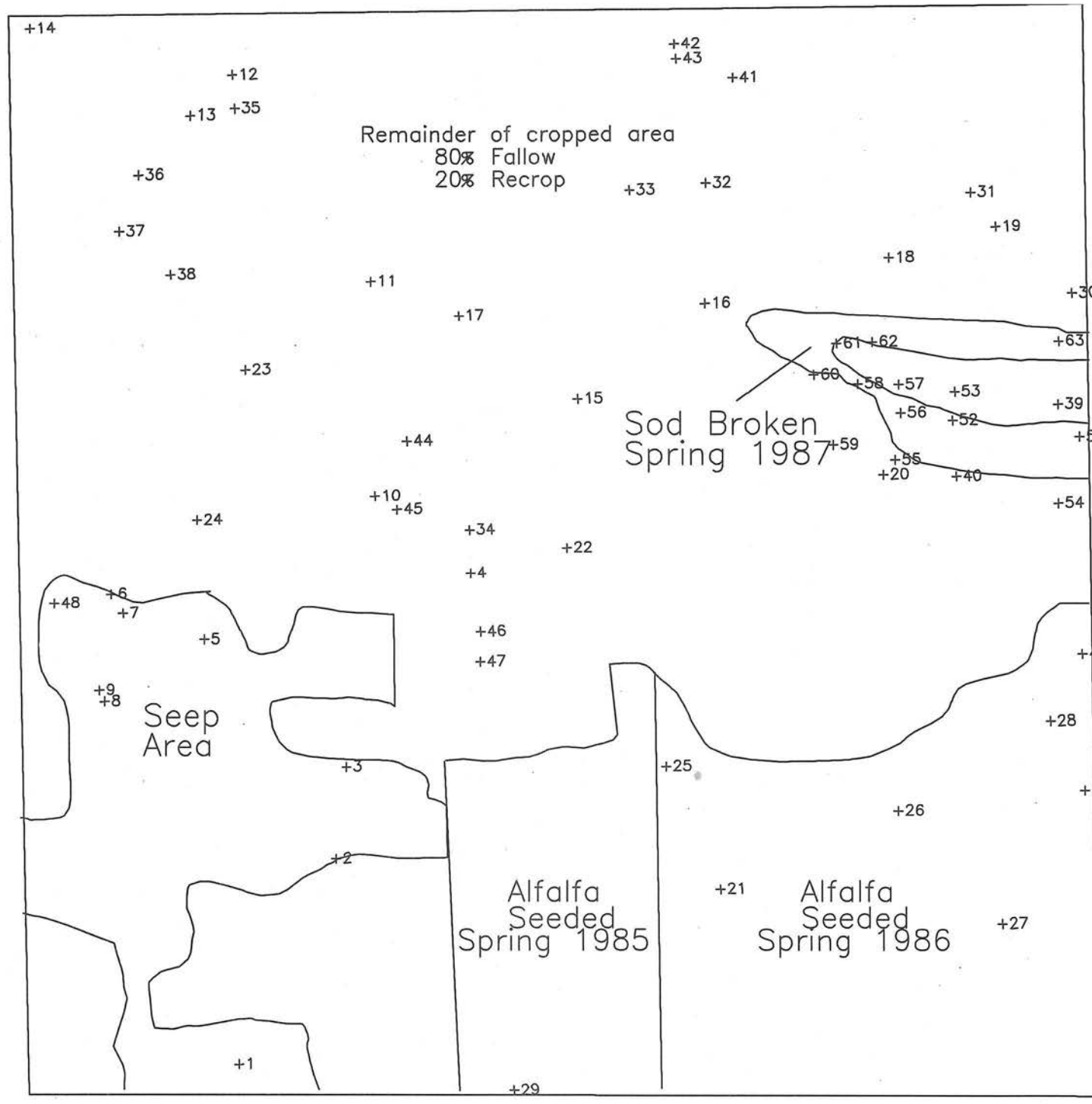
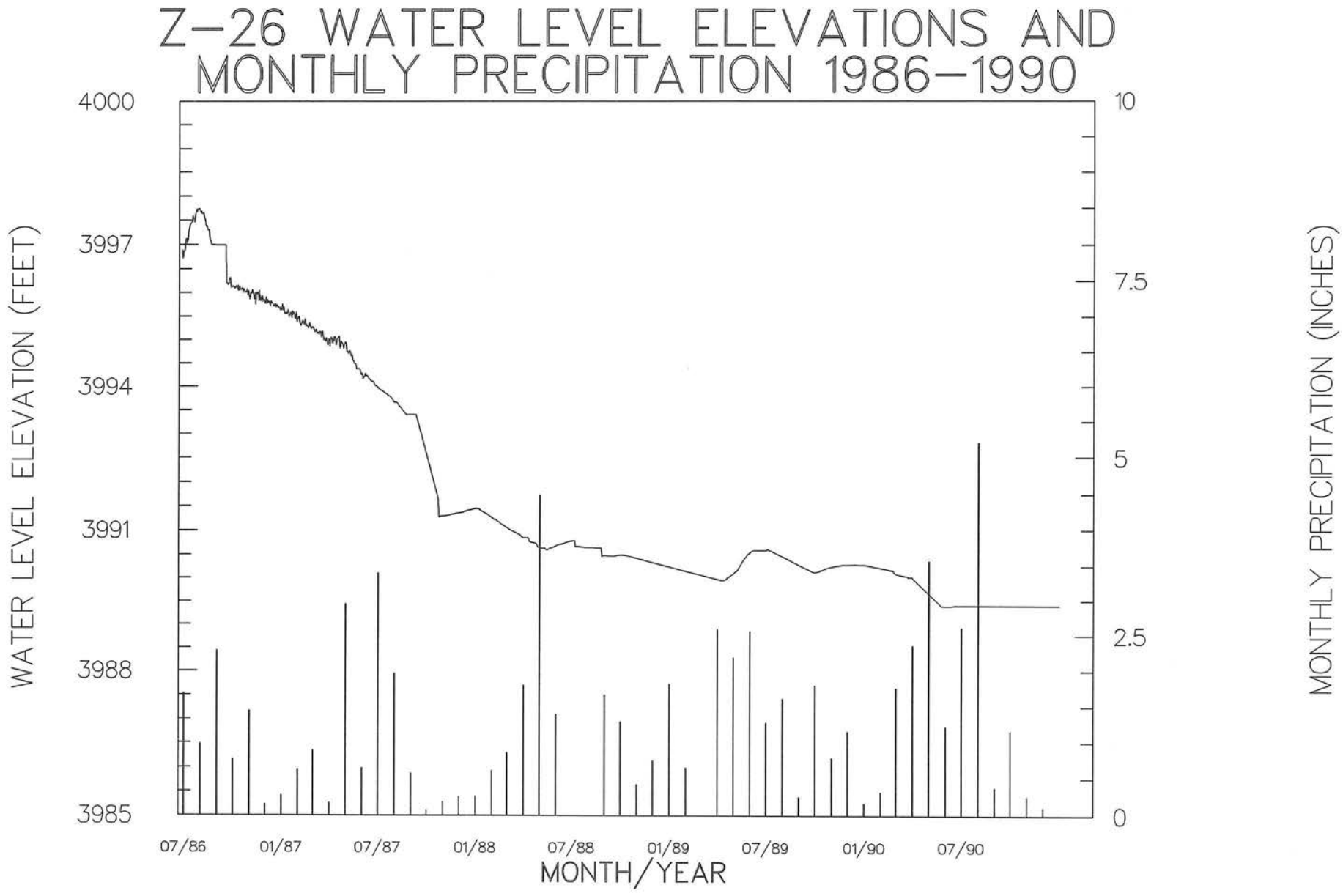
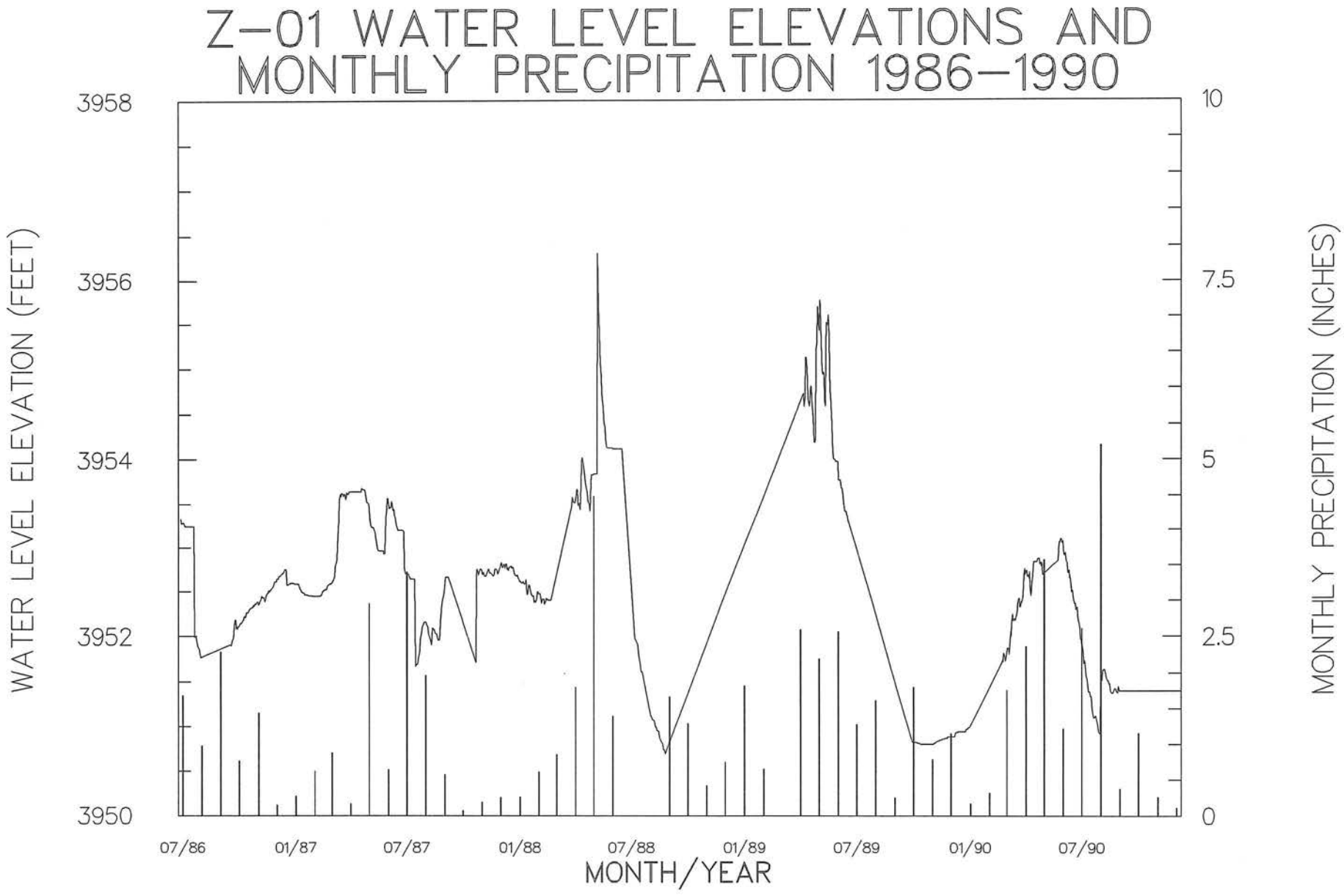


Figure 23 – Location and Dates of Cropping Changes, 10–Year Demonstration Site, Rapelje, Montana

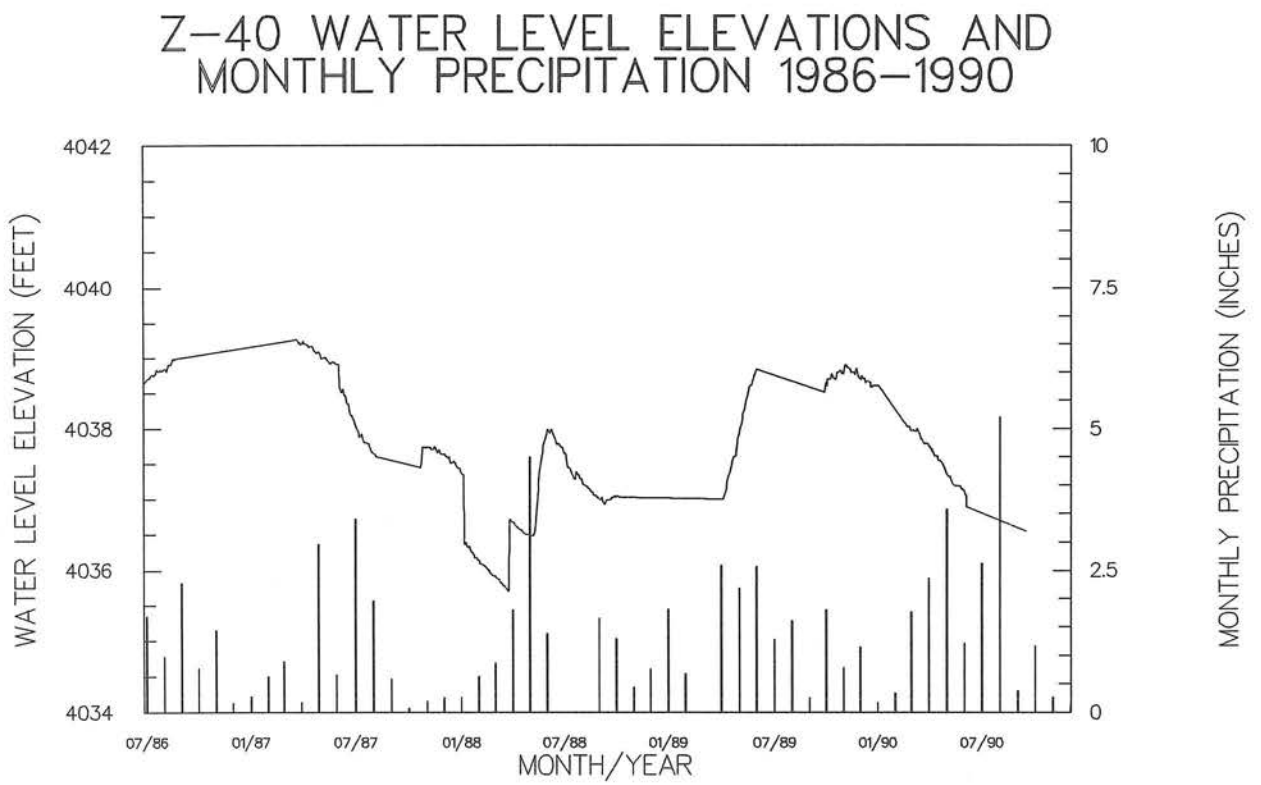


(Note: Total Depth Elevation of Monitoring Well – 3989.4 feet)
Figure 24 – Well Z–26 Water Levels with Monthly Precipitation



09/88 – 04/89 Loss of water level records

Figure 25 – Well Z-1 Water Levels with Monthly Precipitation



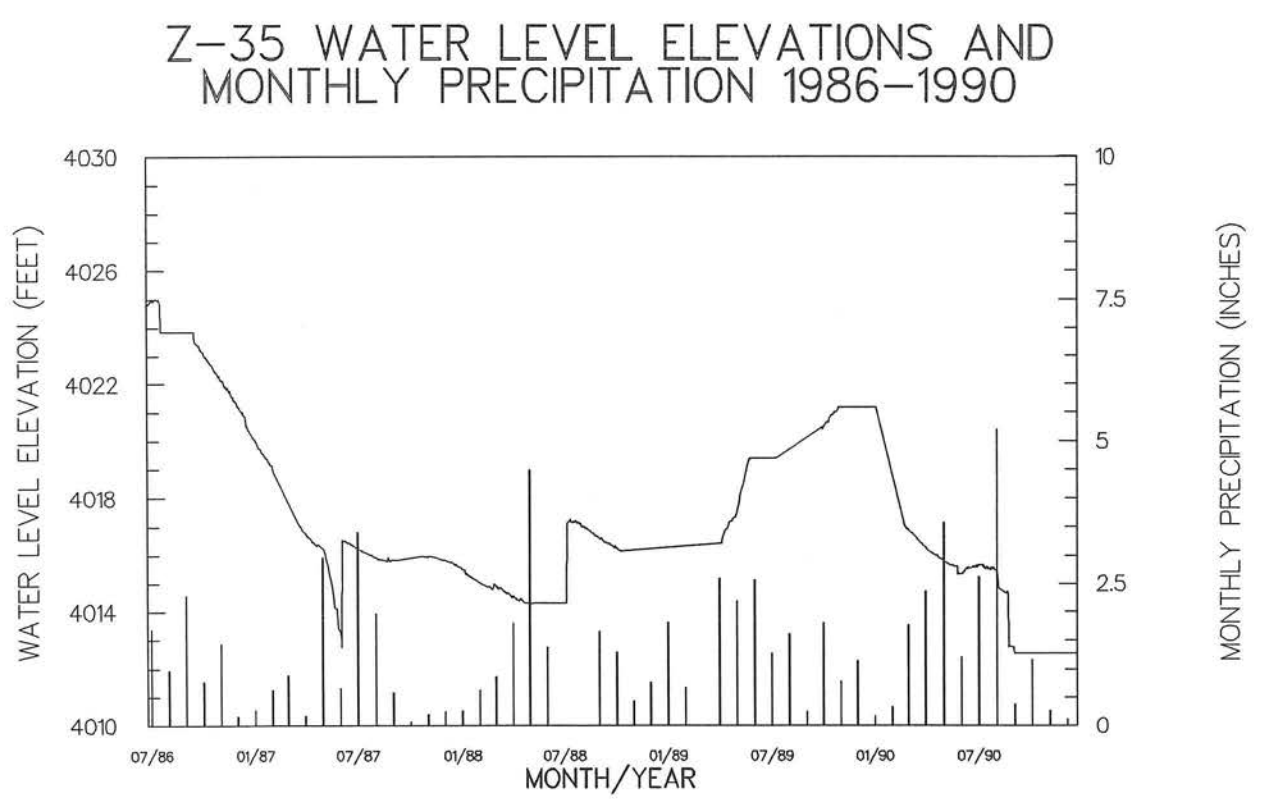


Figure 26 – Wells Z–35 and Z–40 Water Levels with Monthly Precipitation

Specific Conductance Measurements

Specific conductance (SC) readings were obtained as part of the monitoring activities at this site. These readings were taken concurrently with the water-level measurements. (Specific conductance is an approximate measure, in micromhos per centimeter (μmhos/cm), of the total concentration of minerals in solution in the water. This is also referred to as total dissolved solids.) Specific conductance readings were measured using a Yellow Springs Model 33 S-C-T Meter. These readings are contained in Appendix B. No SC measurements were taken from the four monitoring wells equipped with recorders except when water samples were collected. Typically, SC values are higher in wells located in the discharge areas than in wells located in recharge areas. Wells Z-1, Z-2, Z-5, Z-8, and Z-48 are located in the main seep area, whereas wells Z-13 and Z-14 are located in a seep area in the northwest corner of the site adjacent to an area where the SCD-SCS demonstration program had a field evaluation planting of various grasses on four acres (SCS, 1985). Figures 27 and 28 show SC values at wells Z-1 and Z-8, and wells Z-2 and Z-5 respectively, whereas Figure 29 shows SC values for wells Z-13 and Z-14. Also shown on these plots are the maximum recommended SC values for domestic and stock water uses (EPA, 1986). It is apparent that SC values range from moderately to excessively above the listed values of 500 μmhos/cm for domestic uses and 5000 μmhos/cm for stock-water use.

Wells Z-18, Z-30, Z-31, and Z-50 are located in the recharge portion of the site. Figures 30 and 31 show SC-value comparisons with respect to domestic and stock drinking-water standards at wells Z-18 and Z-31 and at Z-30 and Z-50, respectively. SC values at these wells, although elevated, are considerably below those observed in wells in the discharge portion of the site (Figures 27-29).

Figures 32, 33, and 34 show water levels and SC values for wells Z-55, Z-60, and Z-61 which are located within the area where the native sod was broken during 1985 and subsequently cropped. SC values are considerably lower than those observed in monitoring wells located in both the recharge and discharge portions of the site with no significant water-level rise apparent. One explanation for this is that because the land historically was in native sod, very little excess moisture moved through the soil profile and, consequently, little leaching of salts from the soil profile occurred. Since cropping began, the land has been intensively cropped. This intense cropping reduces the amount of unused moisture that can percolate through the soil profile to leach out salts. There appears to be a gradual increase in SC values at these sites; this increase indicates that some leaching of salts is occurring.

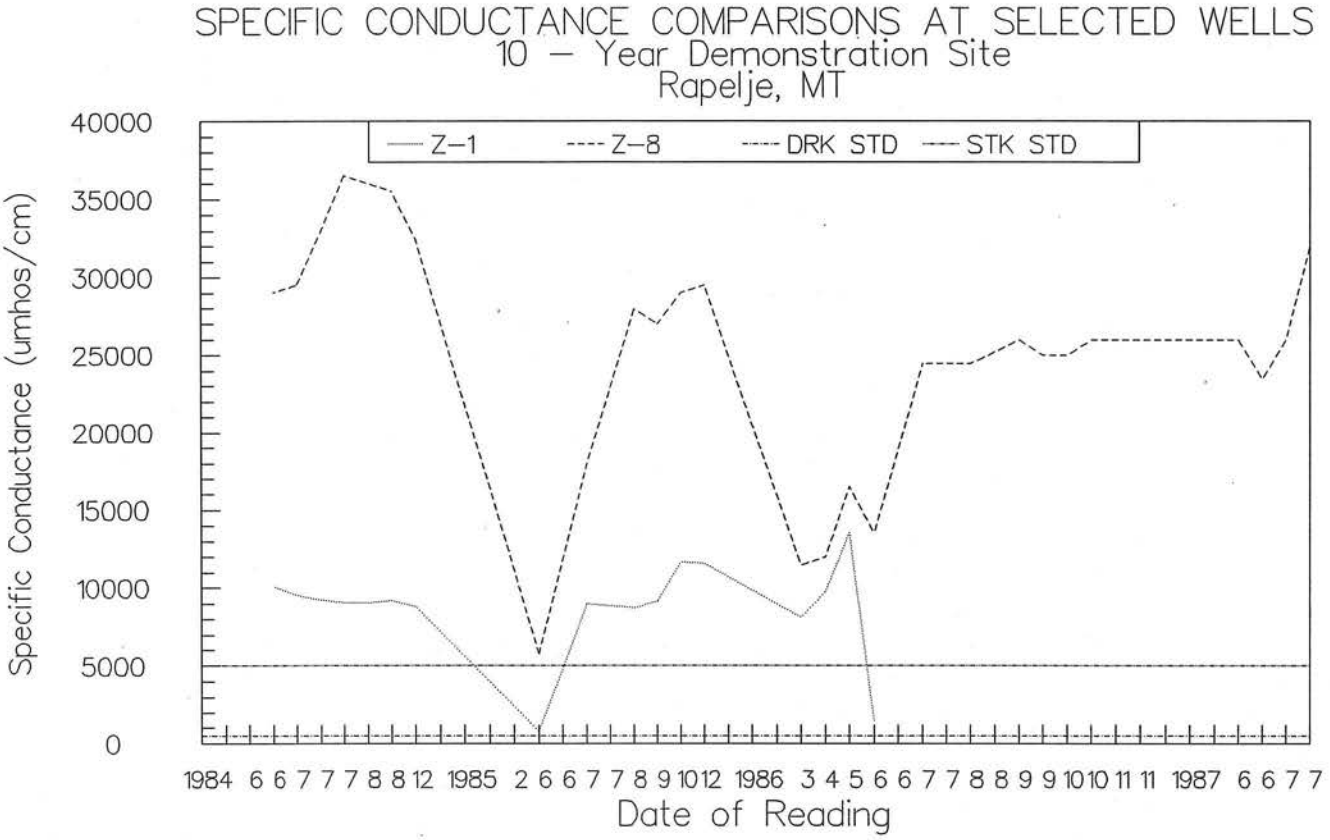


FIGURE 27 – Specific Conductance Comparisons, Wells Z–1 and Z–8

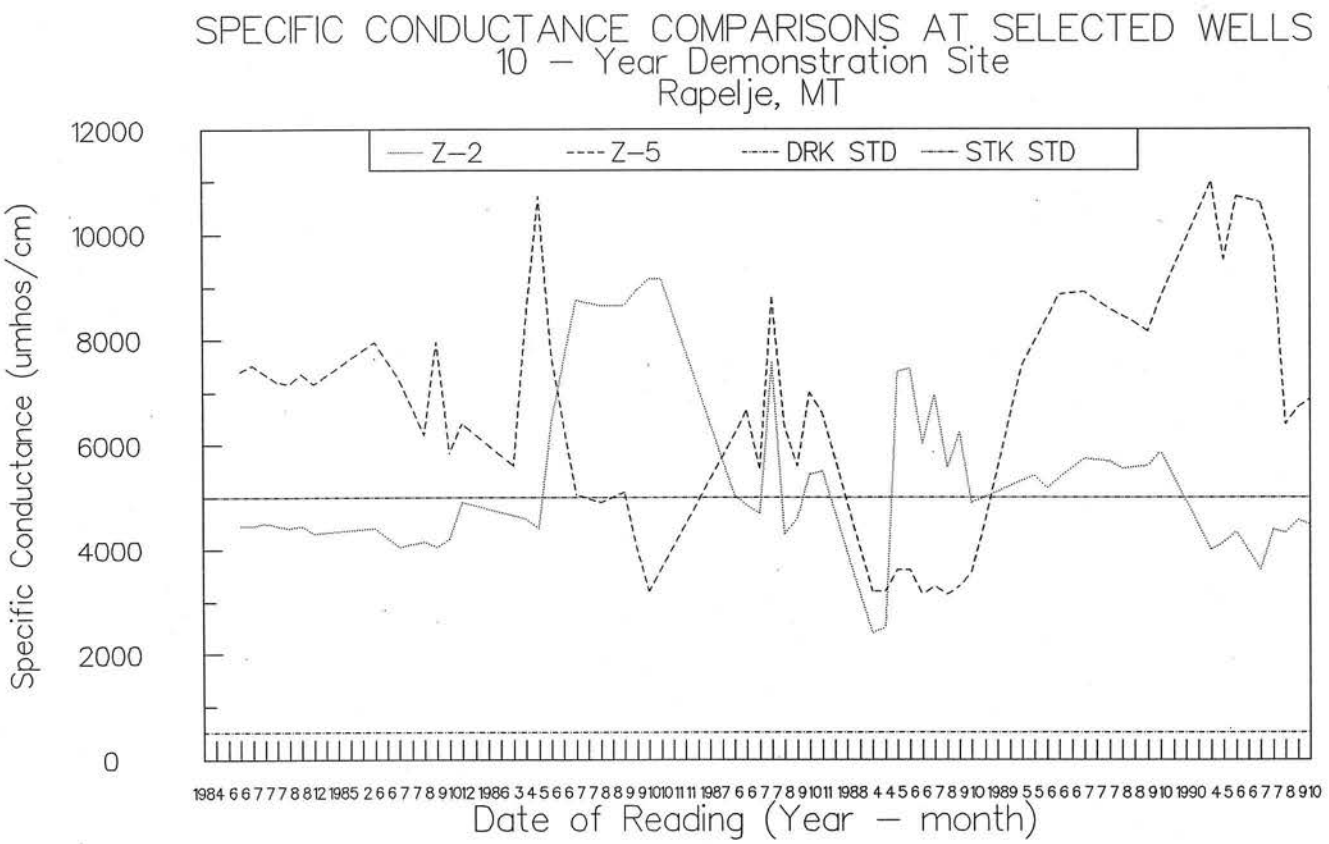


FIGURE 28 – Specific Conductance Comparisons, Wells Z–2 and Z–5

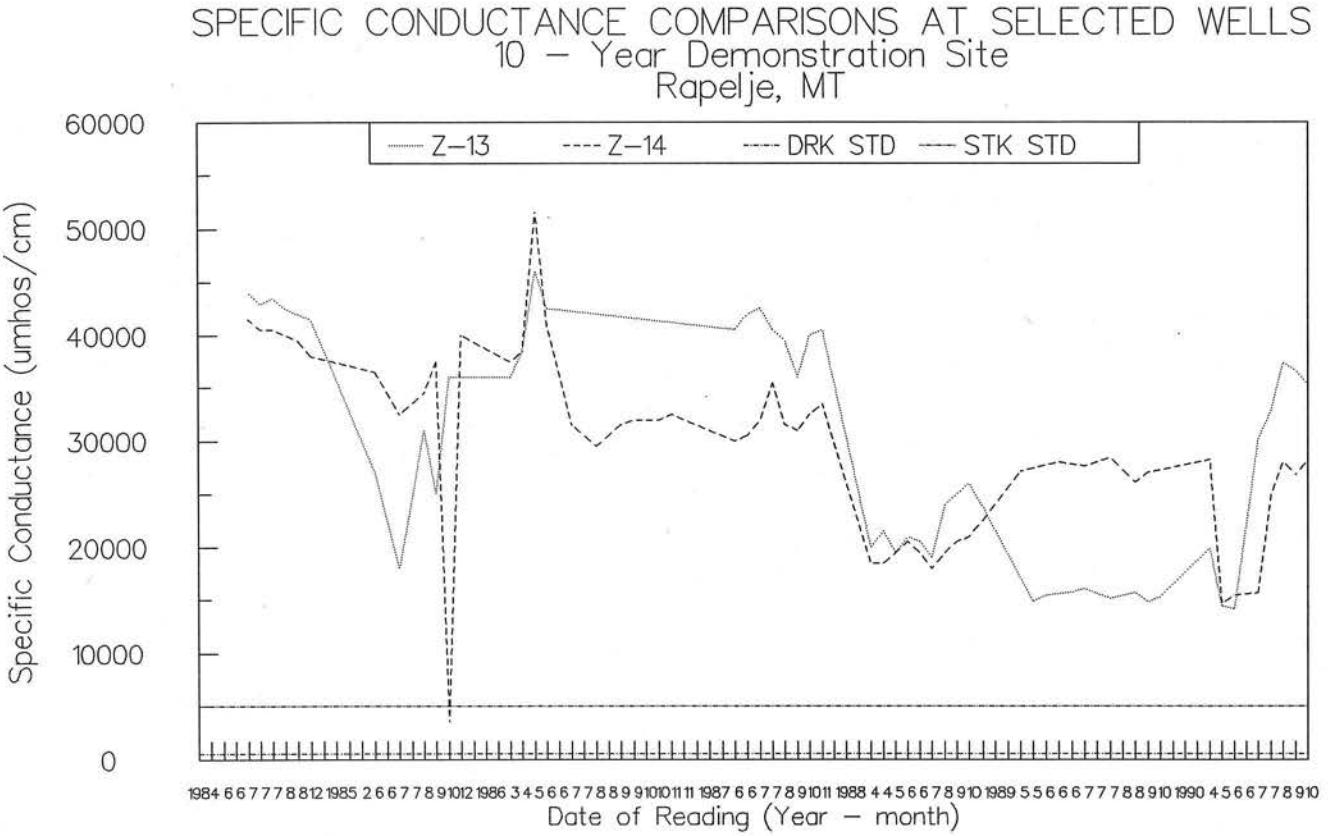


FIGURE 29 – Specific Conductance Comparisons, Wells Z–13 and Z–14

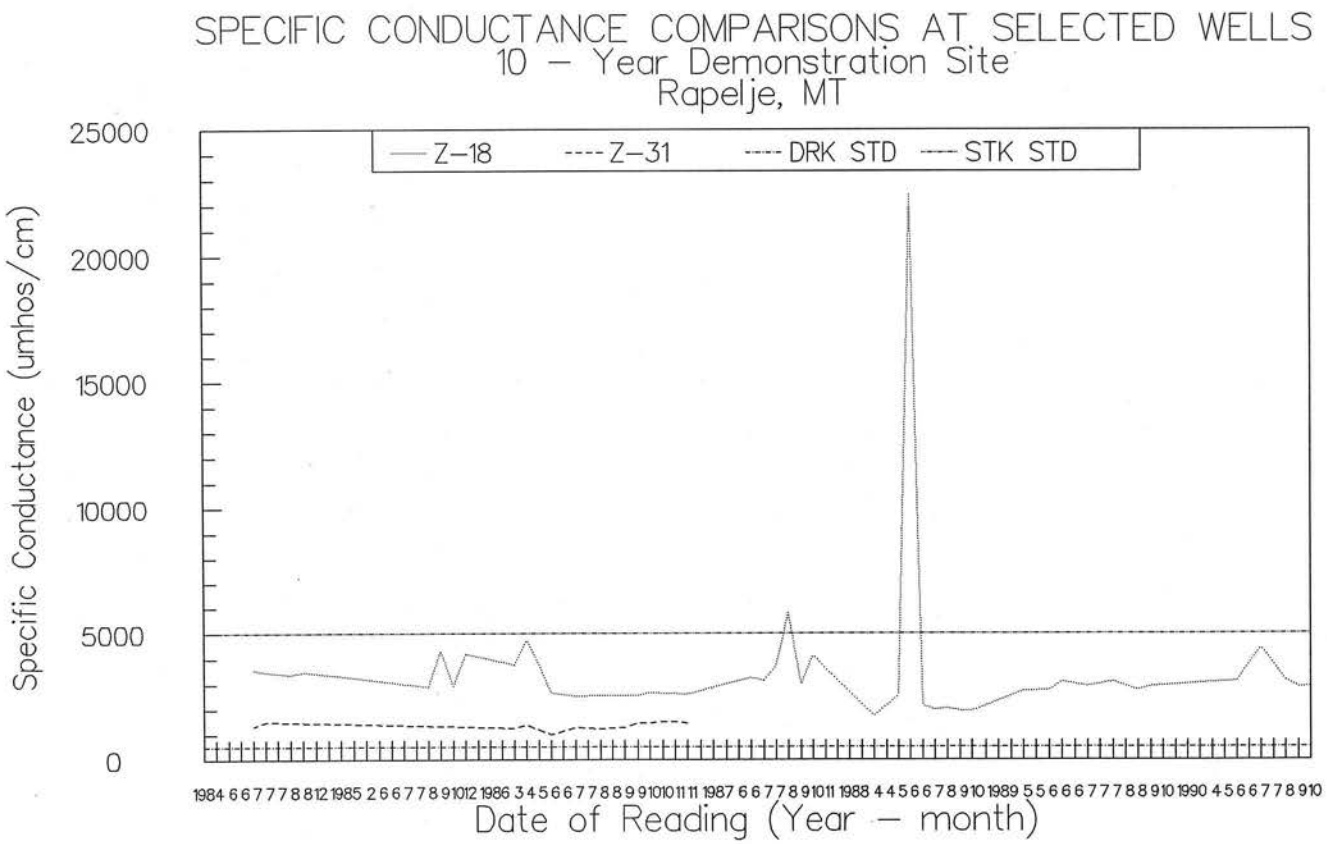


FIGURE 30 – Specific Conductance Comparisons, Wells Z–18 and Z–31

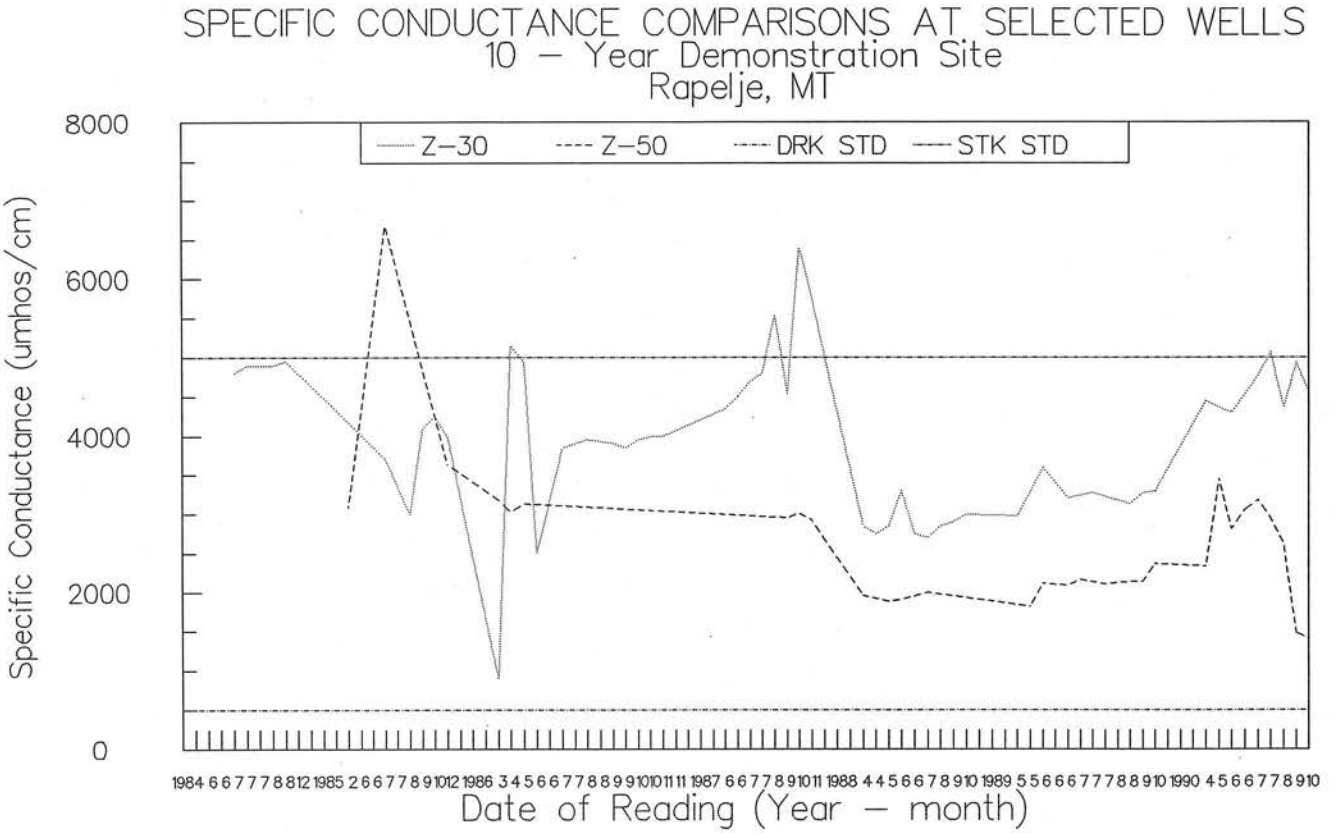


FIGURE 31 – Specific Conductance Comparisons, Wells Z–30 and Z–50

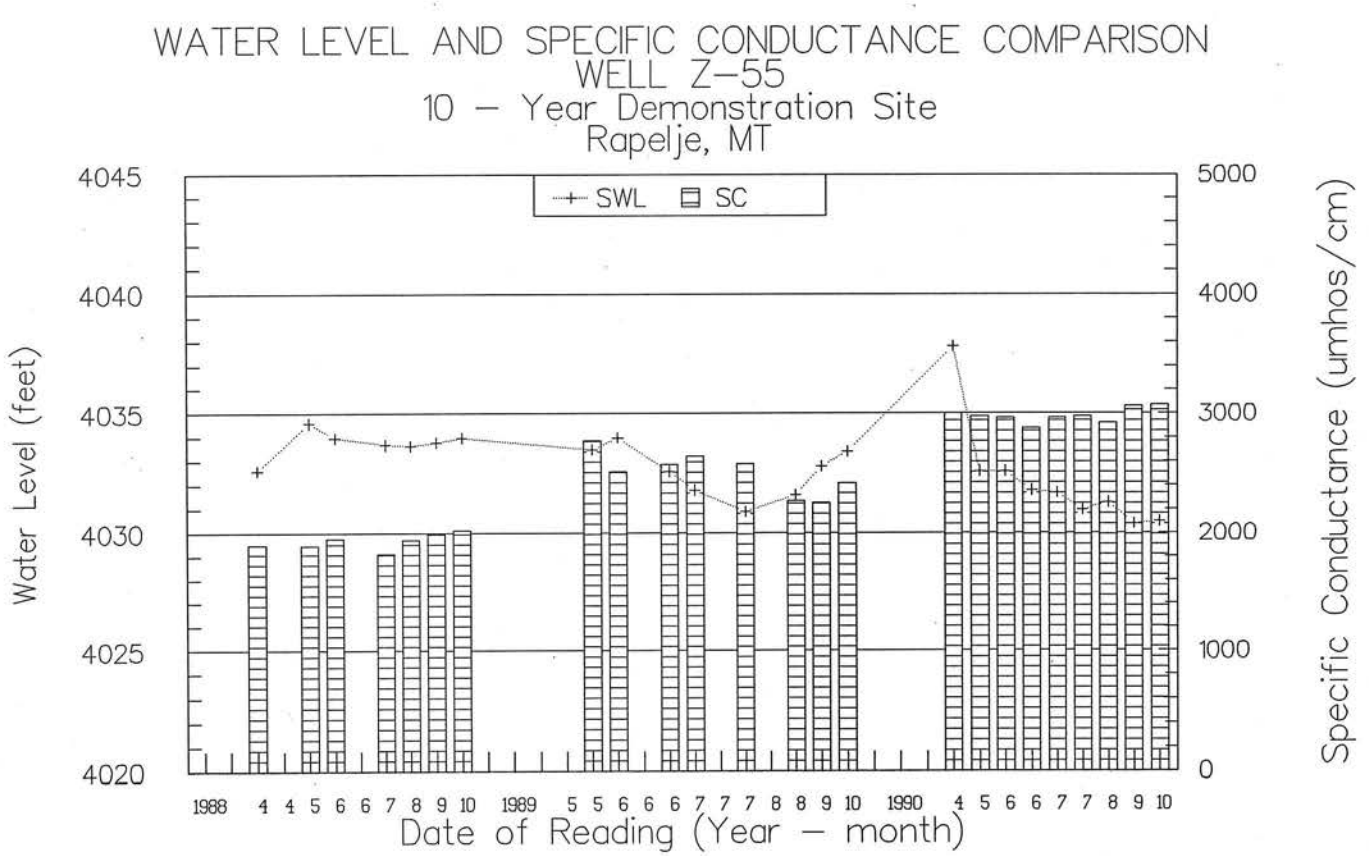


FIGURE 32 – Water Level and Specific Conductance Comparison, Well Z–55

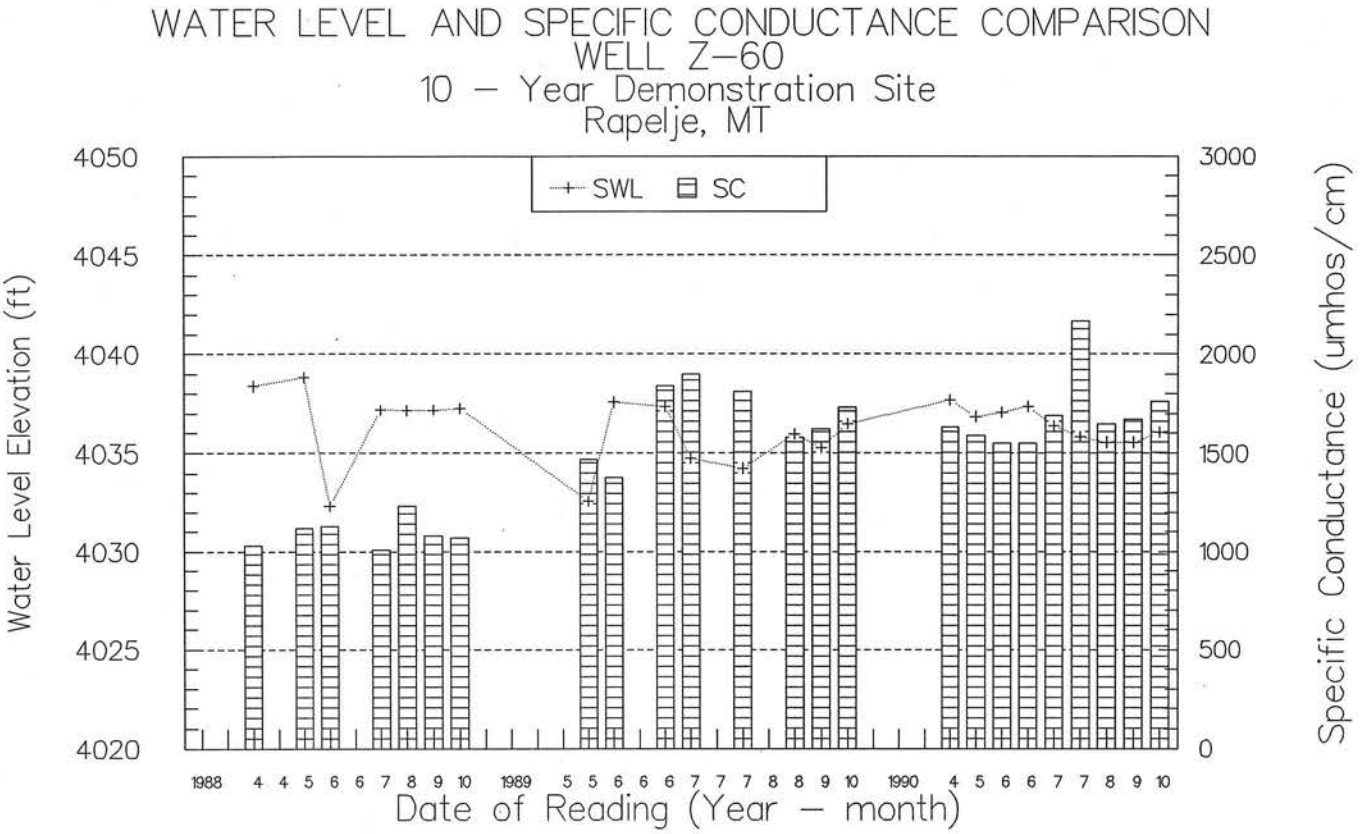


FIGURE 33 - Water Level and Specific Conductance Comparison, Well Z-60

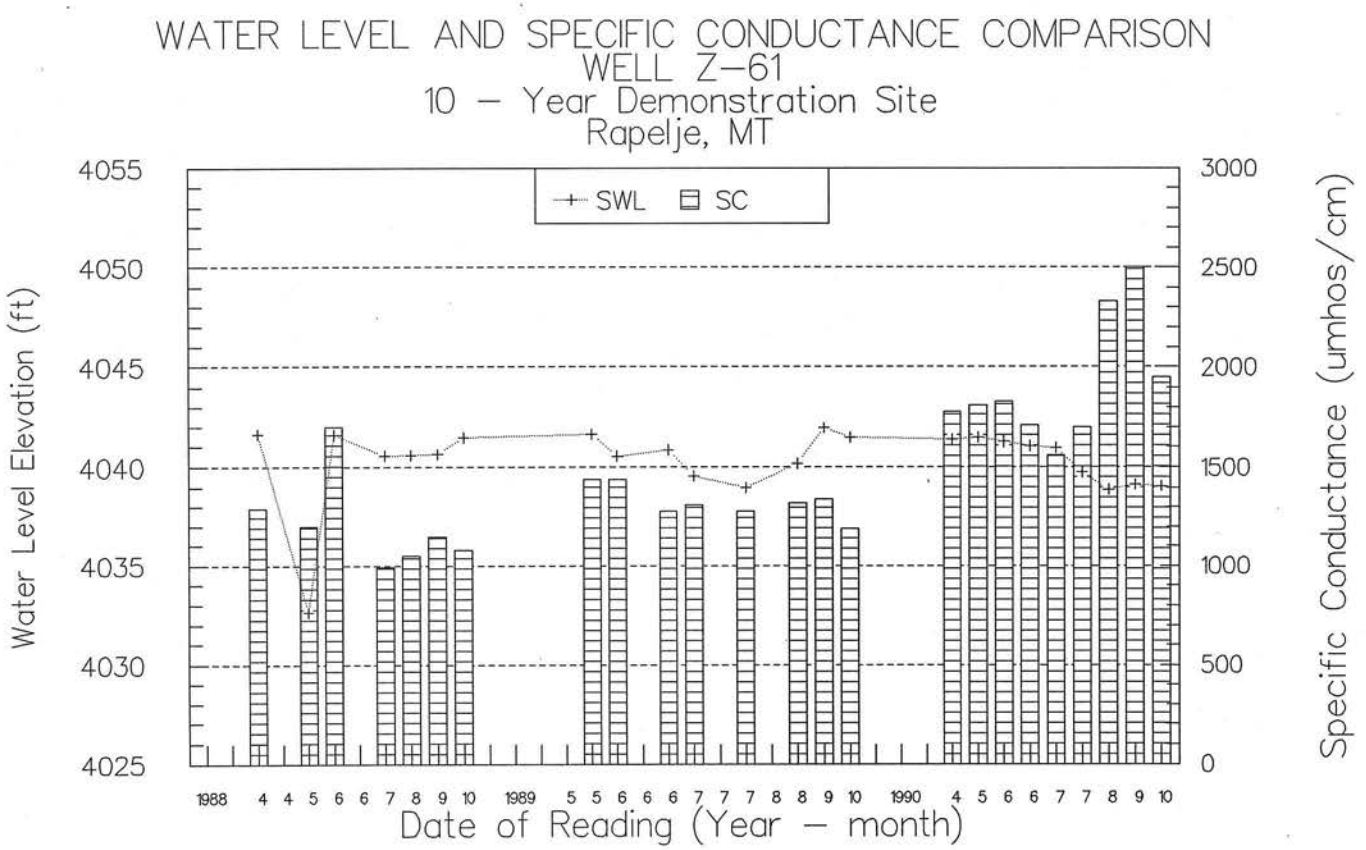


FIGURE 34 - Water Level and Specific Conductance Comparison, Well Z-61

WELL WATER-QUALITY SAMPLING AND RESULTS

Water-quality samples were collected periodically at selected wells throughout the site. Appendix C contains a listing of all wells sampled, plus analytical results. A total of 157 water-quality samples was collected at this site; 105 of these were well samples.

Samples were collected either by bailing or pumping water from the well. As a rule, three casing-volumes of water were removed from the well prior to sampling. Some wells contained small quantities of water or recharged slowly. Wells which exhibited either of these conditions were bailed the day prior to sampling, allowed to recharge overnight, then sampled the following day. All well samples were field filtered immediately through a 0.45 μ filter. Samples for the major cations and trace metals were preserved with 1% HNO_3 acid whereas samples for the anions and selenium analyses were filtered and chilled only. A raw sample (no filtering or acidification) was also collected and chilled. This sample was used for laboratory determination of SC, pH, alkalinity, and hardness. Field measurements were made at the time of sampling for: SC, pH, and water temperature. Prior to all sampling, the depth to water (static water level) was measured. Table 1 contains selected analytical results.

The dominant water types are $NaSO_4$ and $NaMgSO_4$; these water types occur in wells in both the recharge and discharge portions of the site. Both water types are indicative of saline-seep-affected waters with local groundwater flow systems. Although wells throughout the site have similar water types or composition, concentrations of the major constituents are considerably greater in wells located in the discharge portion of the site than those in the recharge portion. Figures 35, 36, 37, and 38 are Stiff diagrams of water-quality results for wells Z-1 (seep area), Z-26 (alfalfa field), Z-60 (newly broken area), and Z-30 (recharge area). (A Stiff diagram is a graphical method of showing water-quality results and portraying concentration differences. The larger the figure, the greater the concentrations and, therefore, the greater amount of total dissolved solids (TDS).) Included with Figure 35 is a Stiff diagram of a spring used by the farm operators for their pig nursery operation. This diagram was included to compare a suitable stock-water source with water from a well severely impacted by saline seep.

Based upon the data contained in Table 1 and Figure 35, it is apparent that well Z-1 is severely impacted by saline-seep development and has shown a continual degradation of water quality—most significantly noted is sodium (Na), magnesium (Mg), and sulfate (SO_4) concentrations. This water is a $NaMgSo_4$ type, and is indicative of saline-seep development. TDS concentrations have increased by more than 400% throughout the period of monitoring.

Results from water-quality sampling also show excessive concentrations of selenium in the groundwater at this site (Figure 39). Selenium concentrations range from 5.5 micrograms per liter (μg/l) to 3320 μg/l and had a mean of 1334 μg/l. From 1984 through 1987, selenium concentrations were below 1000 μg/l, but since 1988, concentrations have been considerably higher than and are closer to 3000 μg/l. Figure 39 can be interpreted to show that, except for the 1990 sampling, as water levels increase, selenium concentrations also increase.

Selenium in elevated concentrations can be toxic to humans and livestock and at lower concentrations can cause deformities. The EPA-recommended maximum concentration in water is 10 μg/l (EPA, 1986). The elevated concentrations observed at this well and throughout this site are of concern if local groundwater or reservoirs with similar concentrations are used for livestock. It is also possible for selenium uptake by plants to occur, resulting in toxic concentrations. Plant uptake should be considered when developing changes in cropping plans for saline-

Table 1 - Selected Water-Quality Results, 10-Year Demonstration Site

Well No.	Date mo/dy/yr	Water Type	SWL (ft)	SC @ 25C (µmhos/cm)	pH	Ca (mg/l)[1]	Mg (mg/l)	Na (mg/l)	K (mg/l)	Fe (mg/l)	Mn (mg/l)	HCO_3 (mg/l)	Cl (mg/l)	SO_4 (mg/l)	NO_3 (mg/l)	F (mg/l)
Z-1	06/13/85	$NaMgSO_4$	3.70	9680	7.3	402	629	1450	9.2	.14	1.04	490	480	5490	7.61	.1
Z-1	10/22/87	$NaMgSO_4$	3.74	6790	7.7	410	617	1440	7.5	.11	.87	641	389	5430	4.03	.4
Z-1	08/26/88	$NaMgSO_4$	5.81	20370	7.5	556	1920	4030	16.5	.62	.42	590	1460	14700	91.00	3.0
Z-1	08/01/90	$MgNaSO_4$	5.79	23600	6.6	538	2520	4640	8.4	.03	.26	717	2010	17900	8.42	1.5
Z-14	06/13/85	$NaSO_4$	5.60	39200	8.0	372	929	13300	14.8	.03	.55	1135	833	30300		.1
Z-14	08/03/90	$NaSO_4$	4.14	31800	7.8	268	578	9950	14.6	.06	.94	1260	634	22100	1.32	1.4
Z-18	06/13/85	$NaSO_4$	4.82	3030	7.6	27	22	709	2.1		.07	623	125	1020	.07	.3
Z-18	08/03/90	$NaSO_4$	4.74	3350	7.9	34	26	782	2.9	<.004	.07	600	109	1190	<.07	.6
Z-26	06/13/85	$NaMgSO_4$	8.50	4500	7.5	286	229	632	6.6	.08	.58	571	155	2220	5.40	.1
Z-26	10/22/87	$NaMgSO_4$	11.00	3450	7.3	271	217	628	5.7	.57	.93	458	146	2290	4.28	.6
Z-26	08/26/88	$NaMgSO_4$	12.67	4770	7.5	267	221	626	9.2	.24	1.64	514	152	2260	.05	.6
Z-30	06/13/85	$MgNaSO_4$	13.93	3470	7.2	313	252	411	7.4	.01	1.23	519	158	1980	.40	.1
Z-30	10/23/87	$MgNaSO_4$	14.31	3650	7.1	435	349	501	11.9	<.002	.84	305	334	2700	18.10	.4
Z-30	08/26/88	$MgNaSO_4$	14.00	5400	7.0	417	338	519	12.2	.01	.71	301	332	2710	17.20	.5
Z-30	08/03/90	$MgCaSO_4$	14.65	5100	7.1	423	333	482	12.6	<.004	1.06	315	328	2670	16.87	.1
Z-40	06/13/85	$NaCaSO_4$	19.55	3517	7.2	220	125	492	9.2	<.002	.14	415	157	1560	1.41	.1
Z-40	10/21/87	$NaSO_4$	19.08	3740	7.4	212	122	495	8.7	<.002	.03	418	146	1507	3.01	.3
Z-40	08/02/90	$NaSO_4$	20.10	3260	7.2	198	115	483	9.3	<.004	.12	426	127	1440	2.23	.4
Z-48	06/13/85	$NaSO_4$	4.93	6930	7.7	366	334	1140	5.5	.02	.64	528	338	3640	6.54	.1
Z-48	08/03/90	$NaSO_4$	7.03	6510	7.2	349	259	1060	7.3	.09	.36	456	275	3380	15.00	.4
Z-50	06/13/85	$NaCaSO_4$	13.71	3230	6.9	222	132	468	7.0	<.002	.30	426	125	1500	7.00	.1
Z-50	10/22/87	$NaCaSO_4$	13.34	2740	7.1	219	129	480	6.7	<.002	.05	380	138	1552	10.20	.3
Z-50	08/26/88	$NaSO_4$	13.60	3540	7.1	187	121	514	6.3	.04	.12	487	134	1456	.67	.3
Z-50	08/02/90	$NaCaSO_4$	18.05	3170	6.6	212	125	432	6.3	.17	.20	434	108	1390	7.51	.3
Z-55	08/25/88	$NaSO_4$	14.58	3770	6.9	185	111	549	9.0	.01		408	124	1529	2.93	.5
Z-55	08/02/90	$NaSO_4$	15.45	3470	7.2	176	105	509	9.6	.03	.01	334	114	1460	2.95	1.7
Z-56	08/25/88	$NaMgSO_4$	25.24	3450	6.5	267	182	372	17.2	.01	.32	312	125	1705	3.74	.2
Z-56	08/03/90	$NaMgSO_4$	24.75	3300	7.1	275	179	354	17.4	.03	.29	285	121	1740	2.62	.1
Z-60	08/25/88	$NaMgSO_4$	9.63	1910	7.0	134	83	180	4.1			372	65	658	1.05	.6
Z-60	08/02/90	$NaMgSO_4$	9.21	1820	7.3	126	80	167	4.1	.01	.02	373	59	556	.88	.5
Z-61	08/25/88	$NaMgSO_4$	15.46	1900	7.3	123	81	197	3.4		.01	428	40	647	1.04	.6
Z-61	08/02/90	$NaMgSO_4$	14.78	2310	7.5	168	114	242	3.9		.03	422	66	936	2.57	.5

1 - Milligrams per liter (mg/l), parts per million

Table 1 (Continued) - Selected Water-Quality Results, 10-Year Demonstration Site

Well No.	Date mo/dy/yr	Water Type	Al (µg/l)[2]	B (µg/l)	Cd (µg/l)	Cr (µg/l)	Cu (µg/l)	Li (µg/l)	Sr (µg/l)	Zn (µg/l)	As (µg/l)	Se (µg/l)
Z-1	06/13/85	$NaMgSO_4$	40	570	<2	16	39	160	6720	<3	2.9	443
Z-1	10/22/87	$NaMgSO_4$	<30	520	10	<2	<2	160	6690	12	N/A	315
Z-1	08/26/88	$NaMgSO_4$	1670	750	6	<2	30	360	9120	66	N/A	1420
Z-1	08/01/90	$MgNaSO_4$	293	471	28	32	207	451	2960	551	N/A	2960
Z-14	06/13/85	$NaSO_4$	80	4950	3	25	36	610	12200	<3	.9	16
Z-14	08/03/90	$NaSO_4$	<40	3230	<5	<5	<4	527	11400	9	N/A	5
Z-18	06/13/85	$NaSO_4$	<30	720	<2	<2	<2	64	2820	5	.7	<.1
Z-18	08/03/90	$NaSO_4$	<40	517	5	<5	<4	73	3280	<6	N/A	<.1
Z-26	06/13/85	$NaMgSO_4$	<30	520	<2	<2	20	50	8480	<3	7.7	71
Z-26	10/22/87	$NaMgSO_4$	<30	520	5	<2	3	67	8550	6	N/A	50
Z-26	08/26/88	$NaMgSO_4$	90	610	<2	2	11	60	8730	12	N/A	1
Z-30	06/13/85	$MgNaSO_4$	<30	610	<2	4	33	71	7620	<3	1.0	226
Z-30	10/23/87	$MgNaSO_4$	<30	470	8	<2	8	100	9990	12	N/A	346
Z-30	08/26/88	$MgNaSO_4$	50	540	<2	3	15	96	9970	15	N/A	390
Z-30	08/03/90	$MgCaSO_4$	<40	440	<5	<5	<4	101	10700	<6	N/A	311
Z-40	06/13/85	$NaCaSO_4$	<30	500	<2	3	28	82	8480	<3	.3	41
Z-40	10/21/87	$NaSO_4$	<30	380	<2	<2	8	81	7840	14	N/A	37
Z-40	08/02/90	$NaSO_4$	<40	324	5	<5	<4	86	7830	13	N/A	28
Z-48	06/13/85	$NaSO_4$	60	470	2	14	45	75	9860	7	1.8	96
Z-48	08/03/90	$NaSO_4$	49	338	<5	<5	<4	71	10000	18	N/A	139
Z-50	06/13/85	$NaCaSO_4$	40	400	5	5	33	50	6680	15	.1	83
Z-50	10/22/87	$NaCaSO_4$	<30	270	<2	<2	3	42	6590	12	N/A	93
Z-50	08/26/88	$NaSO_4$	<30	320	<2	<2	<2	53	6150	9	N/A	5
Z-50	08/02/90	$NaCaSO_4$	<40	235	<5	<5	<4	42	6640	<6	N/A	66
Z-55	08/25/88	$NaSO_4$	<30	430	<2	<2	9	75	7330	19	N/A	23
Z-55	08/02/90	$NaSO_4$	<40	329	<5	<5	<4	84	7230	18	N/A	14
Z-56	08/25/88	$NaMgSO_4$	60	520	<2	<2	4	180	8440	40	N/A	4
Z-56	08/03/90	$NaMgSO_4$	55	423	<5	<5	<4	211	8730	18	N/A	2
Z-60	08/25/88	$NaMgSO_4$	<30	290	<2	<2	<2	44	2860	8	N/A	11
Z-60	08/02/90	$NaMgSO_4$	<40	220	<5	<5	<4	45	3010	7	N/A	10
Z-61	08/25/88	$NaMgSO_4$	<30	270	<2	<2	<2	34	2220	6	N/A	19
Z-61	08/02/90	$NaMgSO_4$	50	272	6	<5	<4	45	3370	8	N/A	40

2 - Micrograms per liter (µg/l), parts per billion

Rapelje Demonstration Site
Well Z-1 Water Quality Comparison

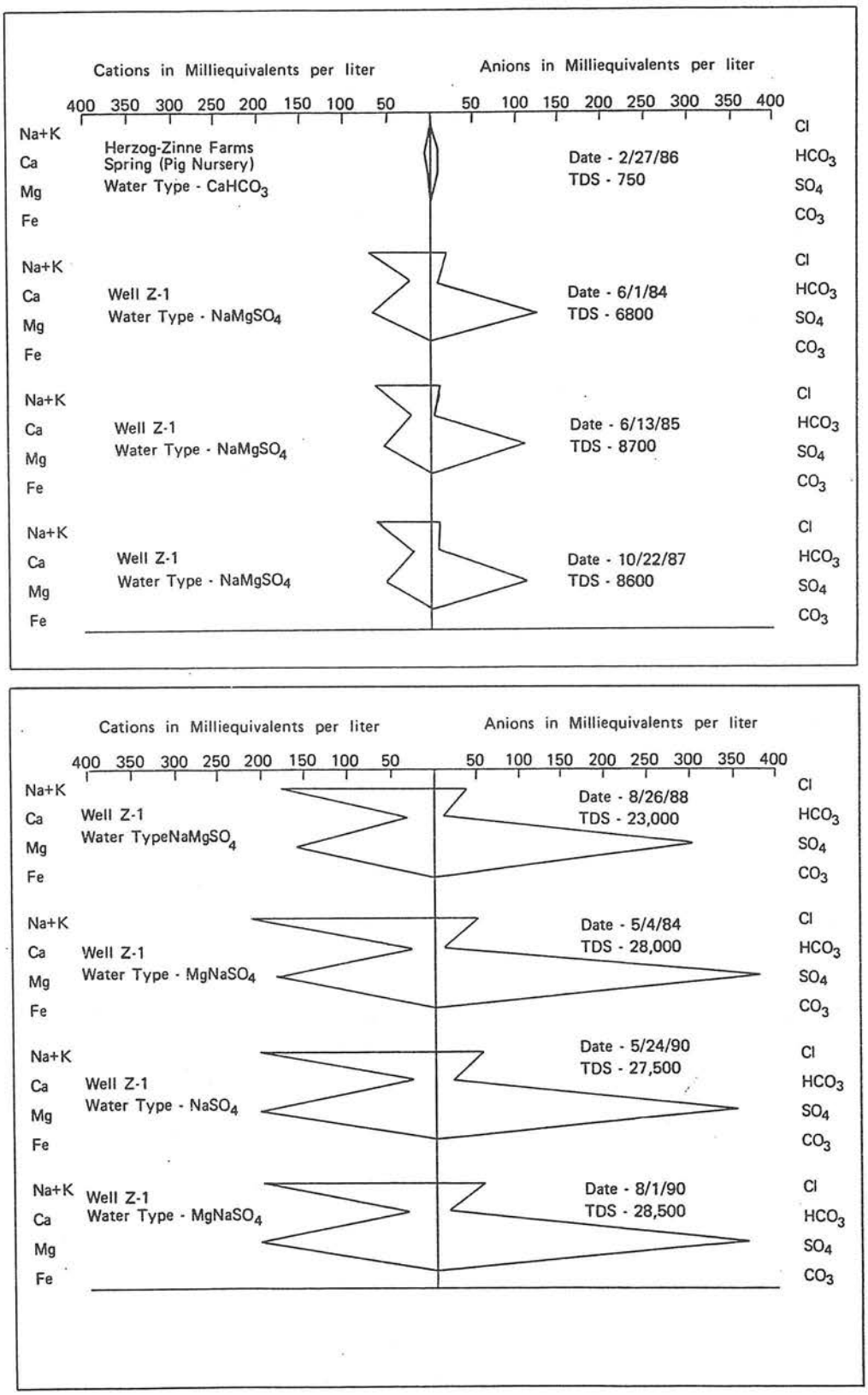


Figure 35 - Stiff Diagram Well Z-1

Rapelje Demonstration Site
Well Z-26 Water Quality Comparison

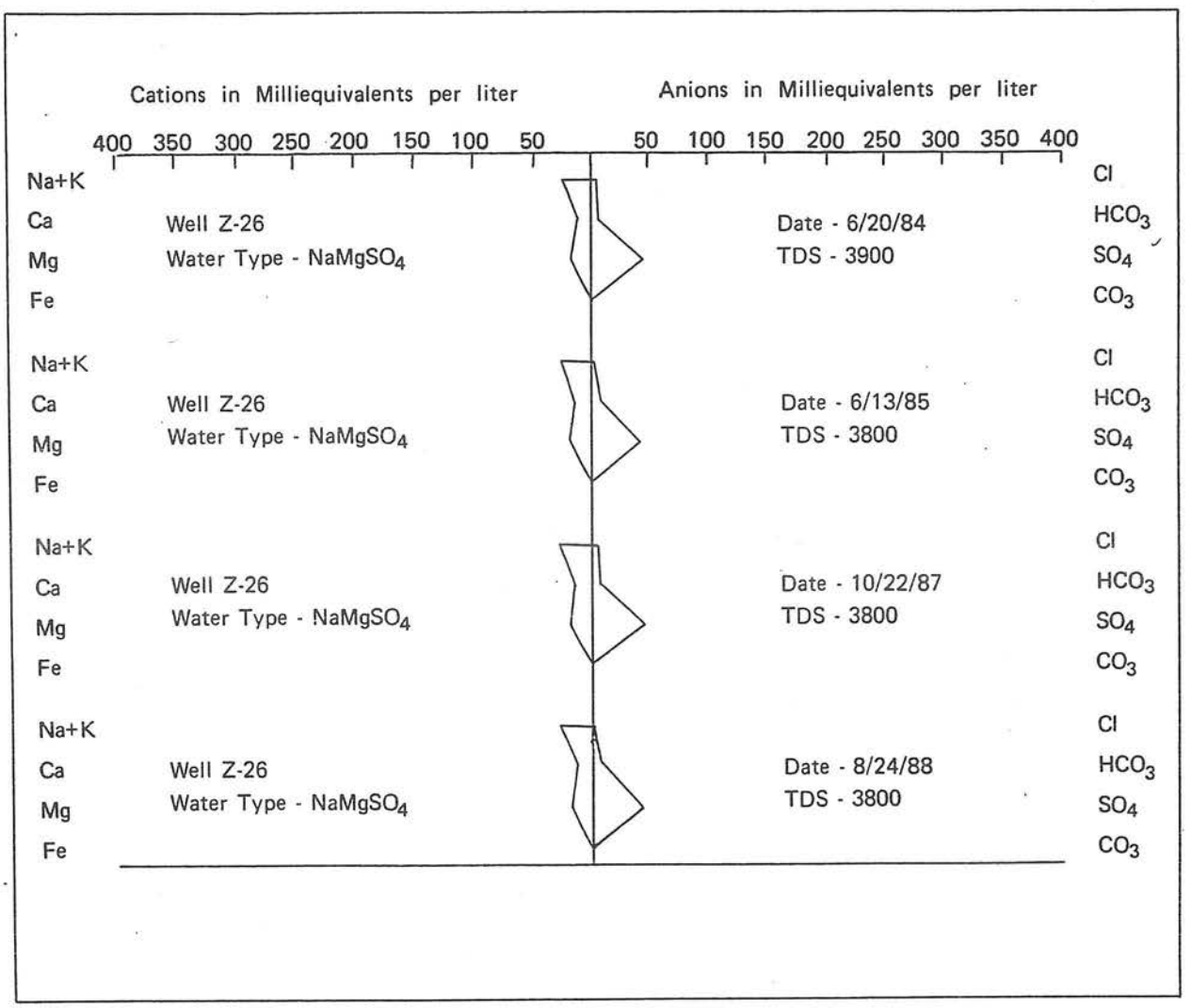


Figure 36 - Stiff Diagram well Z-26

Rapelje Demonstration Site
Well Z-60 Water Quality Comparison

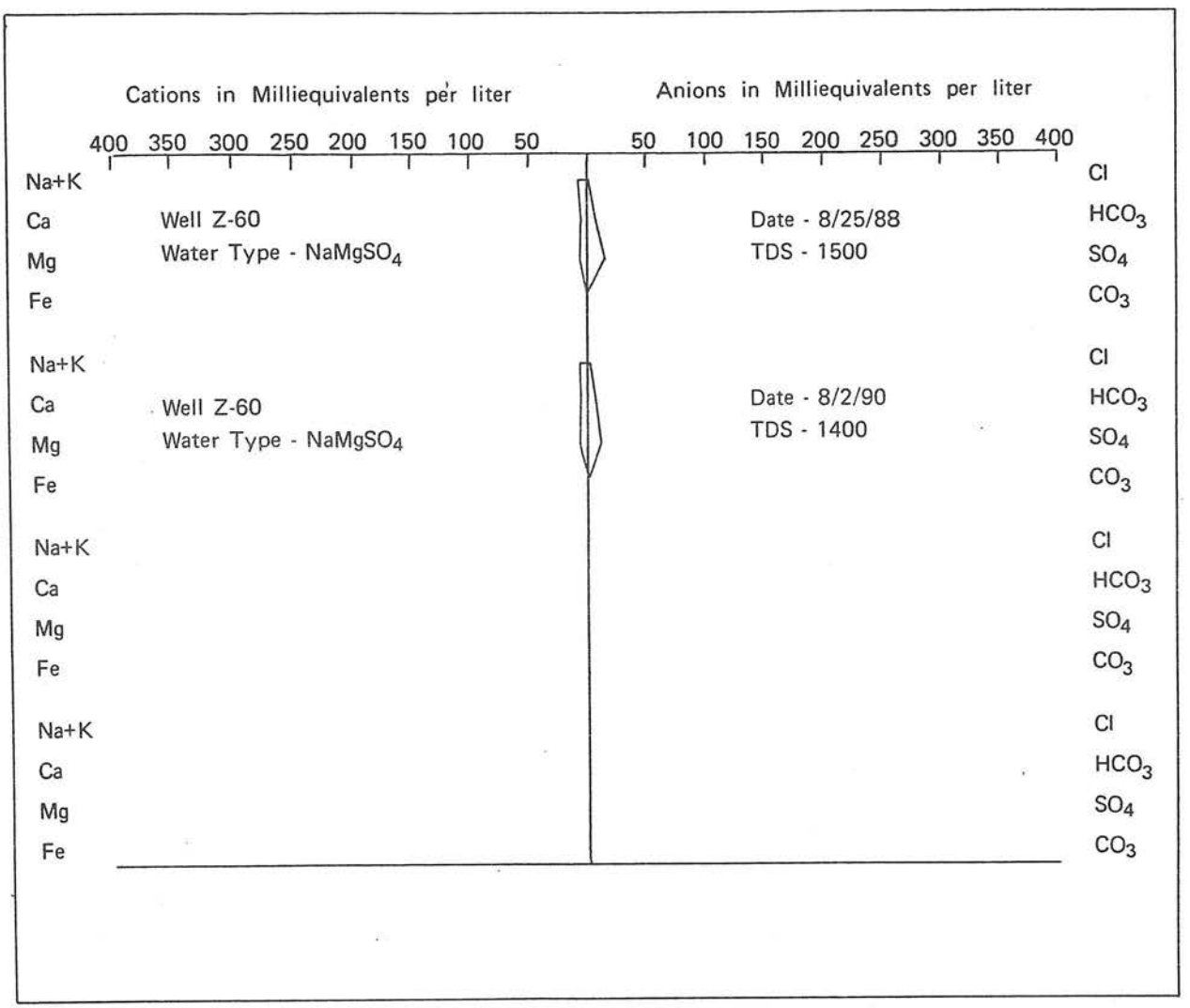


Figure 37 - Stiff Diagram Well Z-60

Rapelje Demonstration Site
Well Z-30 Water Quality Comparison

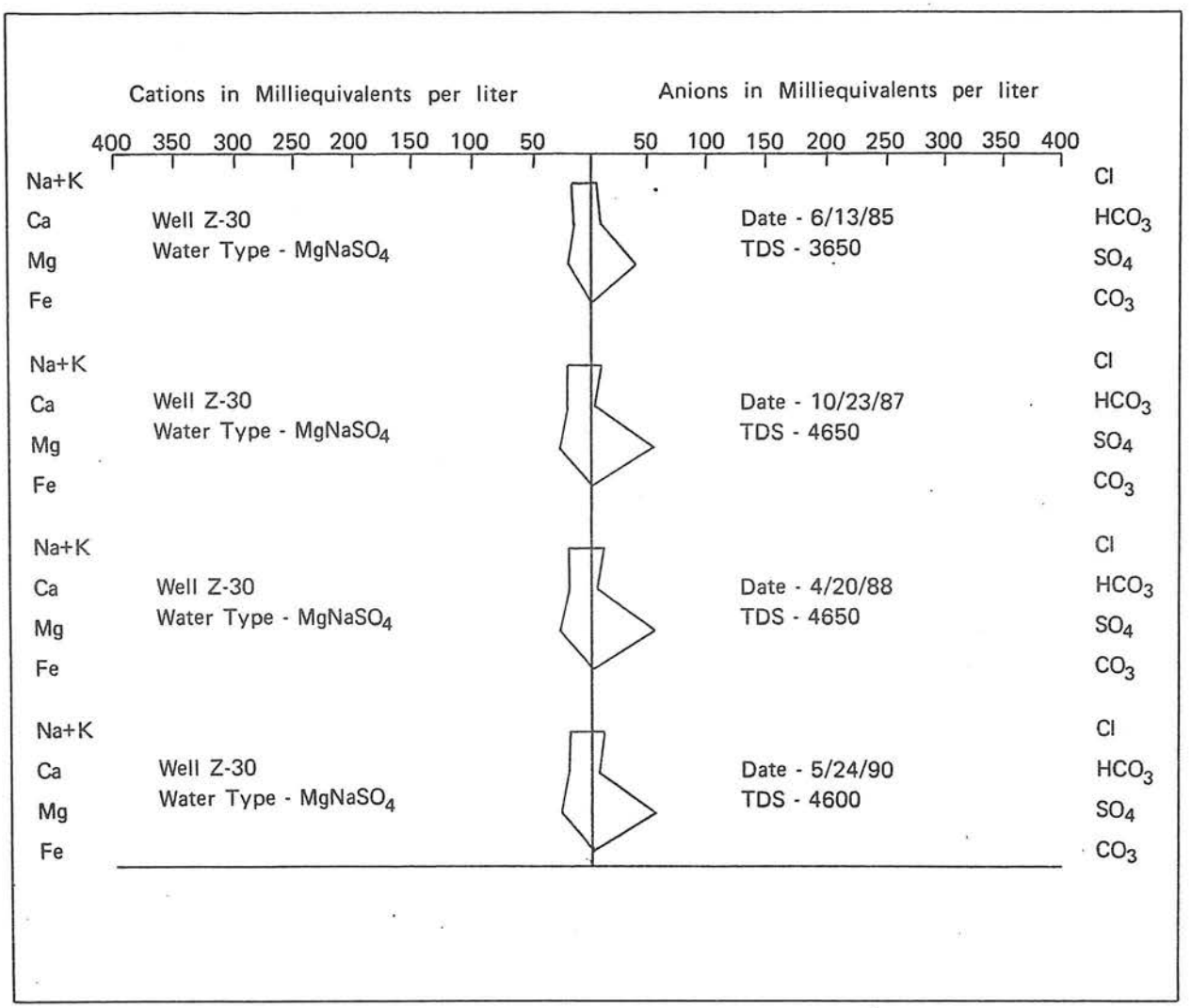


Figure 38 - Stiff Diagram Well Z-30

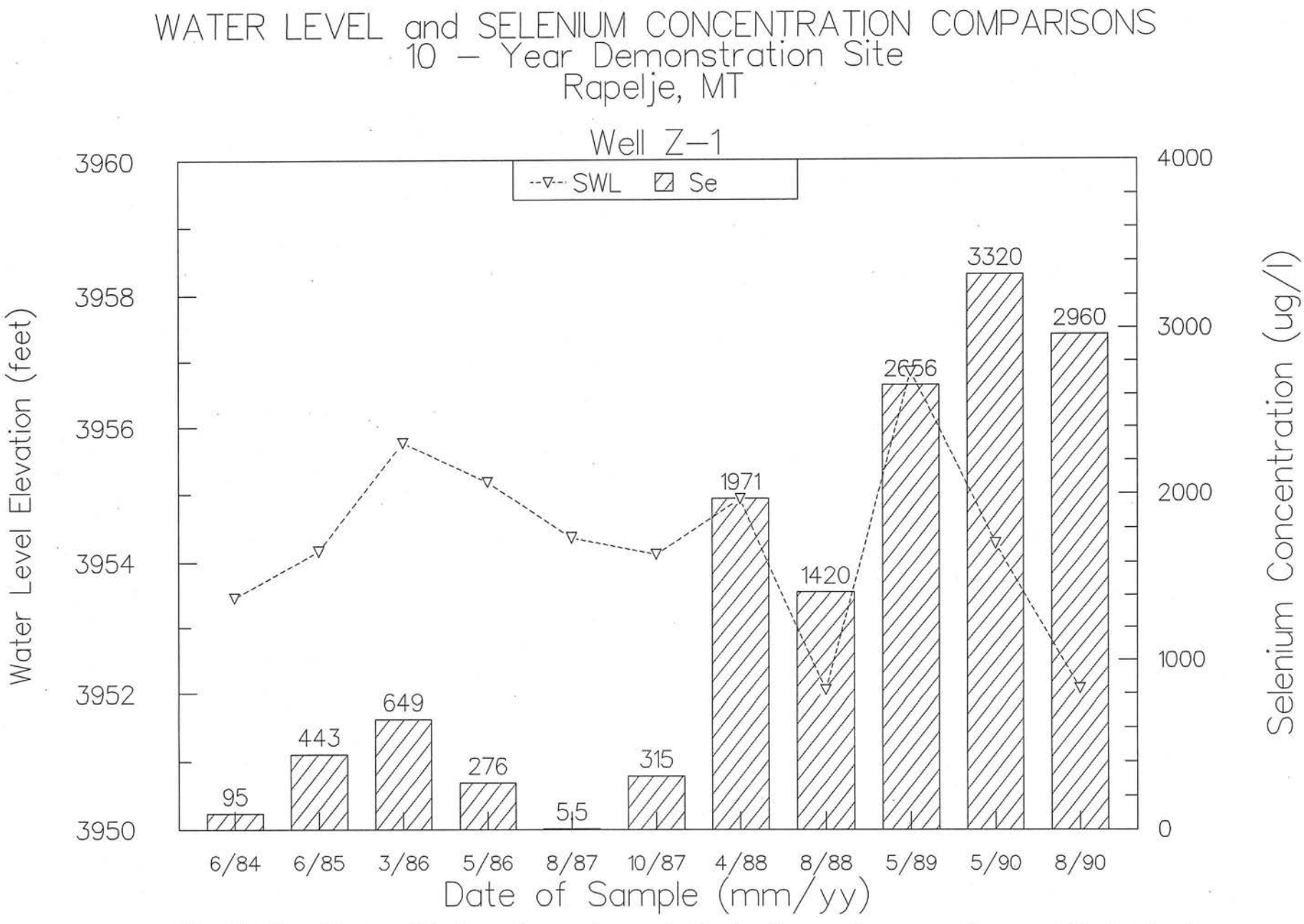


FIGURE 39 – Water Level and Selenium Comparison, Well Z–1

seep mitigation measures or prevention.

Well Z-26, although being a $NaMgSO_4$ type water also, does not appear to be as severely impacted by saline-seep development as well Z-1. Sodium, magnesium, and sulfate concentrations are the primary elevated constituents. TDS remained constant throughout sampling at this site (Figure 36) whereas selenium concentrations decreased over time (Figure 40). Selenium concentrations decreased as the water-level declined at this site—likely a result of cropping system changes. Selenium values ranged from 1.4 μg/l to 70 μg/l and had a mean of 40.5 μg/l. Fewer samples were collected at this site because of the lower water-table, consequently, interpretation of trends should be considered preliminary.

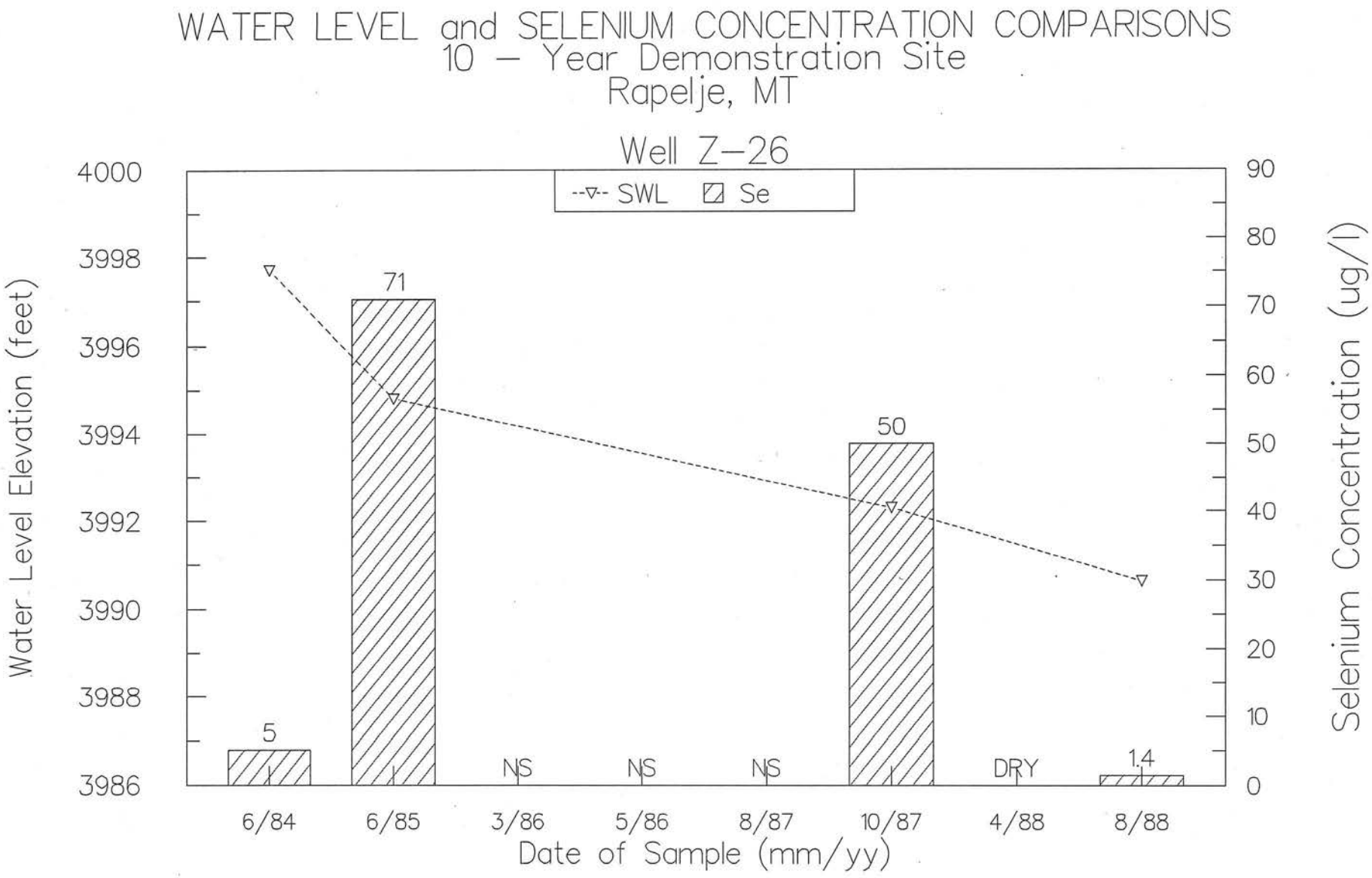
Well Z-60 is a $NaMgSO_4$ type water also, and shows little degradation based upon water-quality results. Monitoring data for SC (Figure 33) appear to show a gradual increase over the period of monitoring. Sodium, magnesium and sulfate concentrations for well Z-60 are 33 percent of the concentrations at well Z-26 and are only 4 percent that of the concentrations at well Z-1 (it should be noted that only two samples were collected at this location). Selenium concentrations were 9.7 μg/l and 11 μg/l in the samples collected.

Well Z-31, in the northeast portion (recharge) of the site, is primarily a $MgNaSO_4$ type water. This well contains elevated concentrations of magnesium, sodium, and sulfate; the concentration of these constituents increased by approximately 26 percent during the period of sampling. Field SC values (Figure 31), however, did not show the same level of degradation observed in other wells.

Selenium concentrations at well Z-30 ranged from <2 μg/l, that is, below the detection limit of the analysis equipment, to 346 μg/l; the mean was 183 μg/l. It appears from Figure 41 that the relationship of selenium to water levels is opposite to that observed for well Z-1. That is, as water levels increase, selenium concentrations decrease. One explanation for this difference is that well Z-30 is in the recharge area and no farm land is contributing to its flow system.

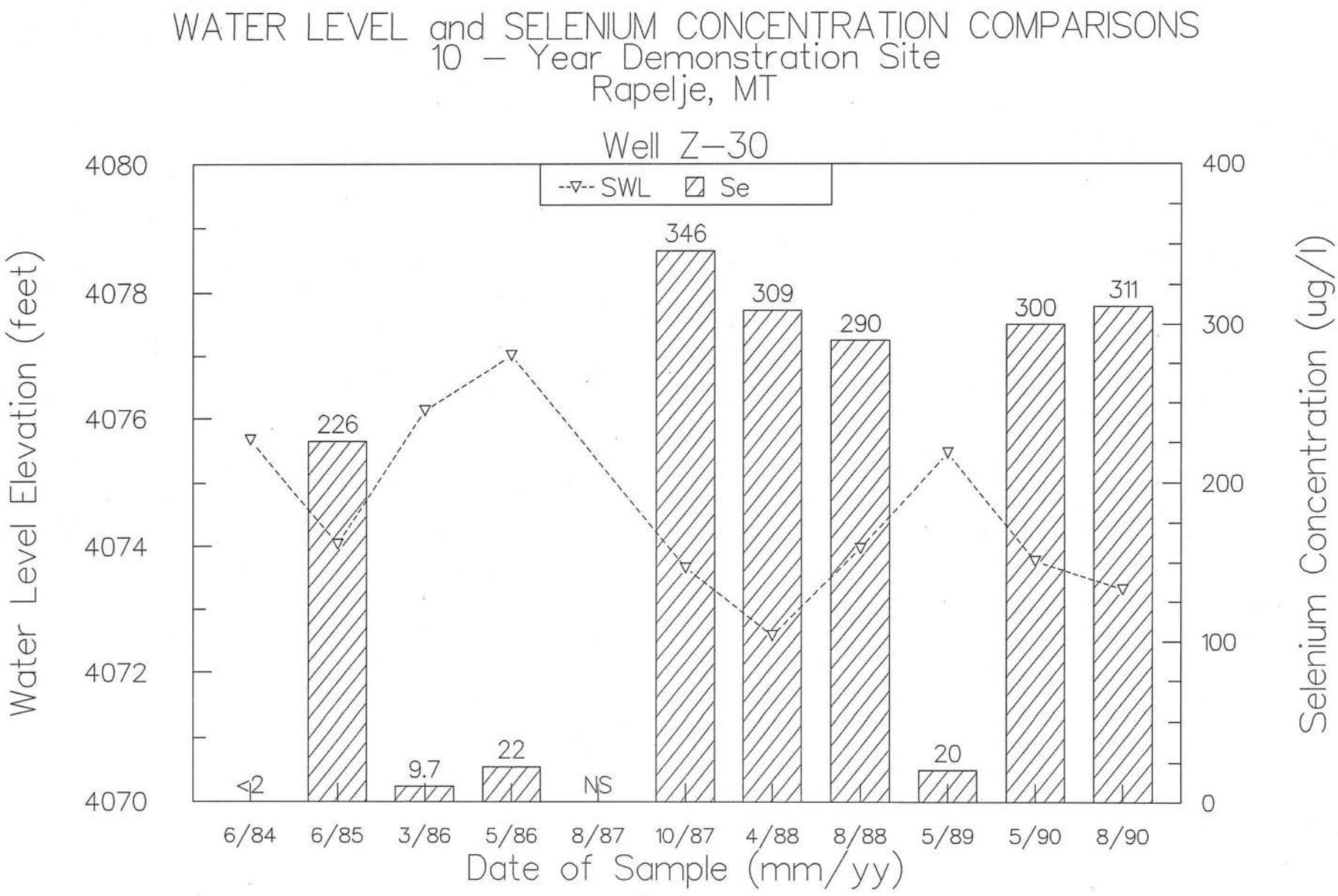
Water levels rise in accordance with precipitation events which act to dilute concentrations in the groundwater. As these water levels decrease, concentrations increase because there is less water in the system. Well Z-1, in the discharge portion of the site, receives water that has moved through cultivated areas during precipitation events resulting in additional salts being leached (including selenium) as this excess water moves through the system. As water levels decrease, concentrations also decrease as the salts are flushed out of the system, but—not to previous levels. Therefore, concentrations continue to build up from enhanced leaching of the soil profile.

Based upon these observations, water quality at this site degrades from the recharge area to the discharge area. Attempts to mitigate saline-seep development and spread, by planting alfalfa or doing intensive cropping, appear to slow the degradation of groundwater quality—as observed at sites Z-26 and Z-60. Once again, it needs to be emphasized that additional data are necessary to quantify these observations because the amount of data currently available, especially at well Z-60, is limited.



(Dry – well was dry, no sample collected)
(NS – no sample collected)

FIGURE 40 – Water Level and Selenium Comparison, Well Z–26



(NS – no sample collected)

FIGURE 41 – Water Level and Selenium Comparison, Well Z–30

LYSIMETER WATER-QUALITY SAMPLING AND RESULTS

Samples for selenium and nitrate analyses were collected at the five lysimeter locations mostly during the spring and summer. A number of samples were taken following precipitation and runoff events in an attempt to document constituent movement within the unsaturated zone as a result of infiltration.

Prior to sampling, a vacuum was applied to each lysimeter with a hand pump and its tubes then were clamped to retain the vacuum. Samples then were obtained from lysimeters that contained water. The time period between the application of the vacuum and sampling ranged from several hours to several months. Numerous lysimeters throughout the study site failed to produce any samples and several others were damaged and made inoperable when rodents ate the tubing, etc. Table 2 lists the lysimeters by location, depth and total number of samples obtained. Table 3 is a partial listing and statistical summary of nitrate and selenium concentrations in water obtained from lysimeters at this site. Appendix D contains a complete listing of lysimeter results.

A total of 39 samples were collected from lysimeters throughout this site, 26 of these were from lysimeters near well Z-1. The Z-1 lysimeter site is the only one located in the discharge portion of the study area. The other four lysimeter sites either were in native vegetation areas in the recharge portion of the study area or in native vegetation adjacent to cropped fields. The lysimeters were installed just outside the cropped areas to minimize damage to them that might result from normal farming activities and to minimize the inconvenience to the farm operator.

Most nitrate concentrations are below the EPA recommended limit of 10 milligrams per liter (mg/l). The exceptions are one sample each from lysimeters Z-1-3 and Z-36-10, and four of the eight samples from lysimeter Z-50-10. Figure 42 shows nitrate concentrations for lysimeter samples from sites Z-1, Z-36, and Z-50. Nitrate concentrations in lysimeters near well Z-1 appear to have remained fairly consistent or may have decreased slightly over time, the one exception being the sample obtained on July 24, 1986 from the 3-foot depth. This July 1986 sample is the only one at this well site that exceeded the maximum EPA-established nitrate levels.

Most of the lysimeter samples at site Z-36 were obtained from the 10-foot depth. Although analyses show that nitrate concentrations increased over the period of monitoring, the number of samples collected was insufficient to support a statistically verifiable conclusion. All samples were collected between April and July of 1988. April and May had above-average precipitation. May 1988, itself, had almost 4.5 inches of rain; this is almost 2 inches above normal. This increase in moisture probably accounts for the ability to collect samples in this lysimeter.

Four of the eight samples collected from the lysimeter at a depth of 10 feet near well Z-50 (Z-50-10) exceeded the recommended nitrate limit of 10 mg/l. Concentrations, as shown in Table 3, ranged from 0.36 mg/l to 16.50 mg/l with a mean of 8.46 mg/l. Figure 42 shows that nitrate concentrations increased considerably from 1987 through 1989 compared to levels first observed in 1986.

Selenium concentrations from lysimeters located near well Z-1 exceeded the EPA-recommended standard of 10 μg/l in all samples. Figure 43 shows selenium concentrations in samples obtained from the four lysimeters at the project site on April 20, 1988. This is the only date for which samples were obtained from all lysimeters at the project site. The samples from

Table 2 - Lysimeters and Number of Samples Collected per Lysimeter

Lysimeter Location (1)	Lysimeter Number/Depth (2)	Number Samples	Comments
Z-1	Z-1-0.5	1	
	Z-1-1	8	
	Z-1-2	10	
	Z-1-3	7	
Z-30	Z-30-0.5	0	Sample line destroyed by rodents
	Z-30-1	1	
	Z-30-2	0	
	Z-30-3	0	
	Z-30-5	0	
	Z-30-10	0	Sample line destroyed 1987, by rodents
Z-36	Z-36-3	1	Lysimeter located in native vegetation
	Z-36-5	2	
	Z-36-10	3	Sample line destroyed 1989
Z-40	Z-40-3	0	Lysimeters located 60 feet south of well
	Z-40-5	0	
	Z-40-10	0	
Z-50	Z-50-3	0	Lysimeters located in native vegetation
	Z-50-5	0	
	Z-50-10	8	Lysimeter depth close to ground water level on occasion

(1) Lysimeter Location - Well number which lysimeters are near.

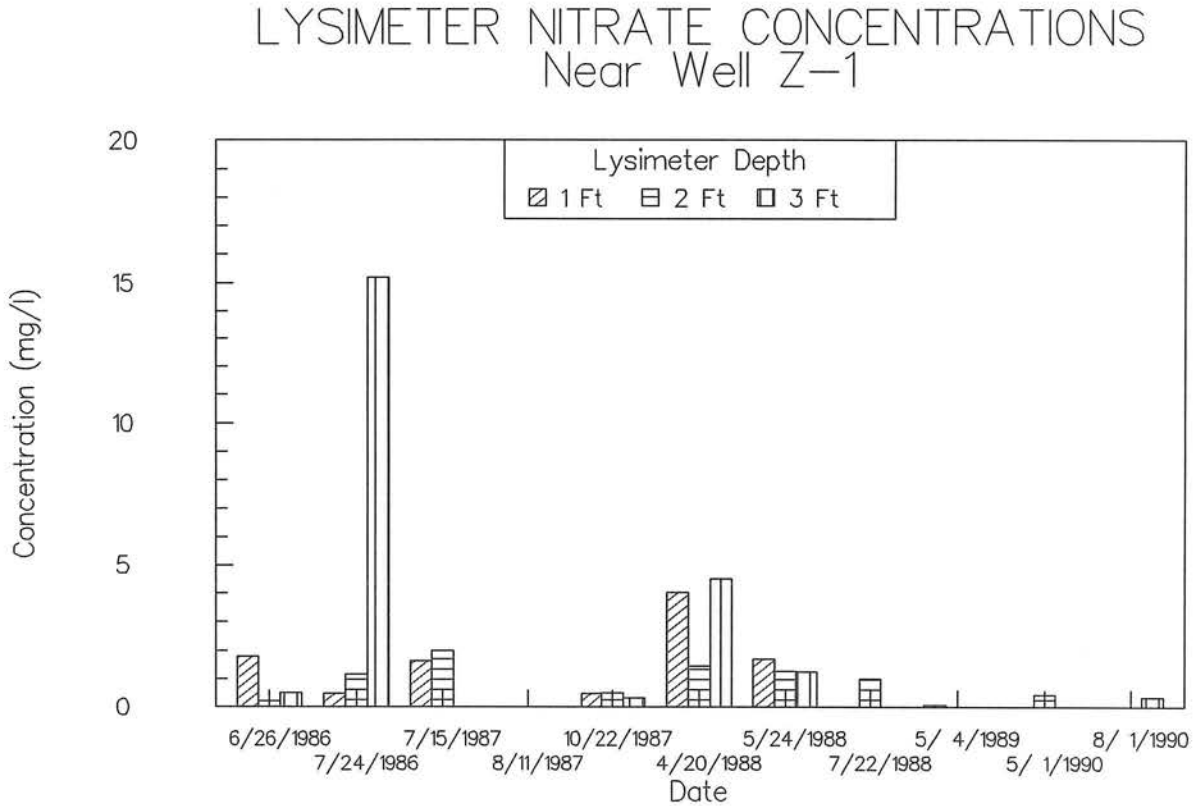
(2) Lysimeter Number/Depth - Lysimeter number corresponds to well number and depth in feet, of lysimeter where sample was obtained. Example Z-1-1 is at well Z-1 and sampling depth is 1 foot.

Table 3 - Selected Lysimeter Water-Quality Data and Statistics

LYSIMETER NITRATE AND SELENIUM CONCENTRATIONS AND STATISTICS
SCS-SCD 10-Year Demonstration Site, Wheat Basin
Rapelje, Montana
(This Table contains data only for sites with more than one sample.)

Lysimeter No. (well no-depth)	Date (mo/dy/yr)	Nitrate (mg/l)	Selenium (µg/l)
Z-1-1	06/26/86	1.8	78
Z-1-1	07/24/86	.5	160
Z-1-1	07/15/87	1.6	1800
Z-1-1	08/11/87	<.2	1715
Z-1-1	10/22/87	.5	1881
Z-1-1	04/20/88	4.0	1058
Z-1-1	05/24/88	1.7	526
Z-1-1	05/04/89	.0	911
Mean		1.4	1016
Maximum		4.0	1881
Minimum		.0	78
Standard Deviation		1.2	681
Number		7.0	8
Z-1-2	06/26/86	.2	187
Z-1-2	07/24/86	1.8	639
Z-1-2	07/15/87	2.0	1480
Z-1-2	08/11/87	<.2	1835
Z-1-2	10/22/87	.5	2096
Z-1-2	04/20/88	1.4	1810
Z-1-2	05/24/88	1.3	1370
Z-1-2	07/22/88	1.0	1833
Z-1-2	05/04/89	<.1	1391
Z-1-2	05/01/90	.4	2280
Mean		1.0	1492
Maximum		2.0	2280
Minimum		.2	187
Standard Deviation		.6	614
Number		8.0	10
Z-1-3	06/26/86	.5	193
Z-1-3	07/24/86	15.2	472
Z-1-3	10/22/87	.3	1257
Z-1-3	04/20/88	4.5	1121
Z-1-3	05/24/88	1.2	907
Z-1-3	05/04/89	<.1	1396
Z-1-3	08/01/90	.3	2390
Mean		3.7	1105
Maximum		15.2	2390
Minimum		.3	193
Standard Deviation		5.4	658
Number		6.0	7

Lysimeter No. (well no-depth)	Date (mo/dy/yr)	Nitrate (mg/l)	Selenium (µg/l)
Z-36-5	07/24/86	7.0	66
Z-36-5	07/15/87	1.4	35
Mean		4.2	50
Maximum		7.0	66
Minimum		1.4	35
Standard Deviation		2.8	16
Number		2.0	2
Z-36-10	04/21/88	7.4	46
Z-36-10	05/24/88	8.7	35
Z-36-10	07/22/88	17.3	33
Mean		11.1	38
Maximum		17.3	46
Minimum		7.4	33
Standard Deviation		4.4	6
Number		3.0	3
Z-50-10	06/26/86	5.4	1050
Z-50-10	07/24/86	7.0	1130
Z-50-10	10/16/86	.4	878
Z-50-10	06/05/87	16.5	564
Z-50-10	07/15/87	3.1	341
Z-50-10	08/12/87	13.1	581
Z-50-10	04/20/88	10.5	639
Z-50-10	05/04/89	11.7	759
Mean		8.5	743
Maximum		16.5	1130
Minimum		.4	341
Standard Deviation		5.1	248
Number		8.0	8



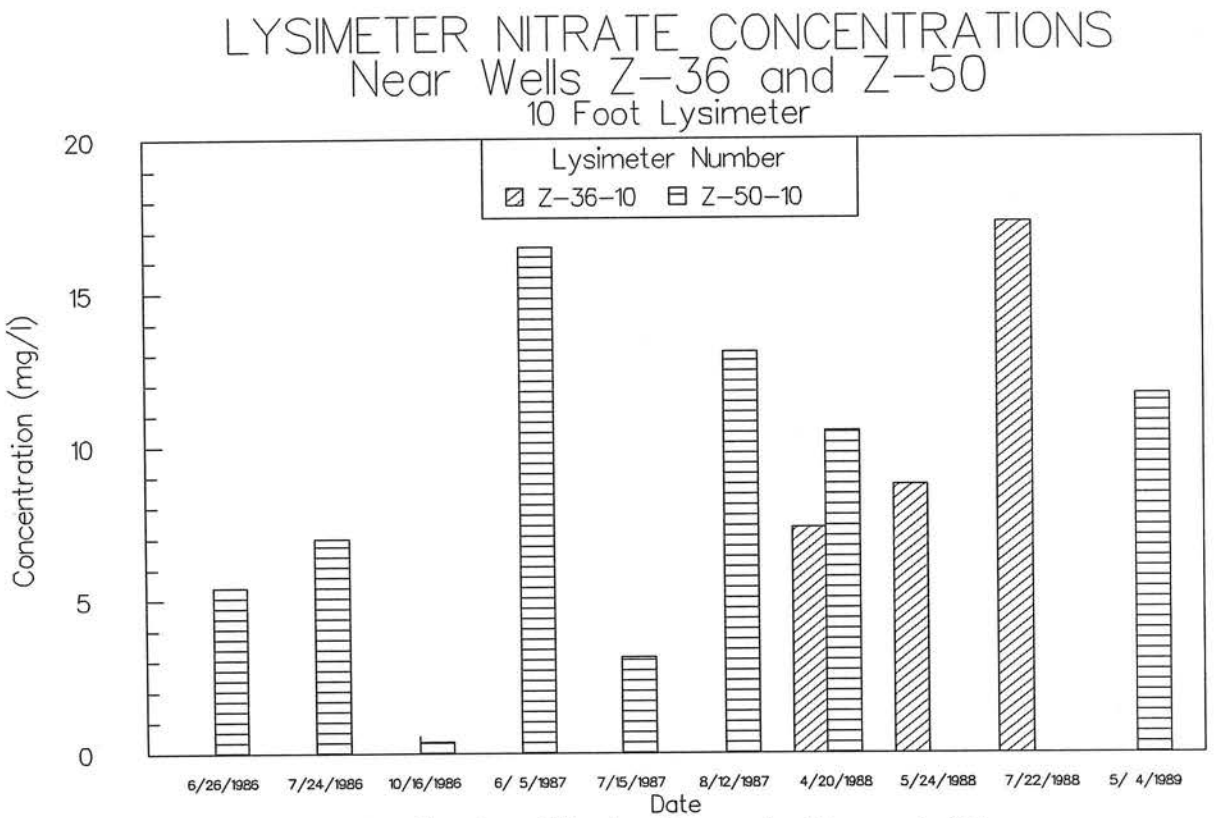


FIGURE 42 – Lysimeter Nitrate Concentrations at Sites Z-1, Z-36, and Z-50

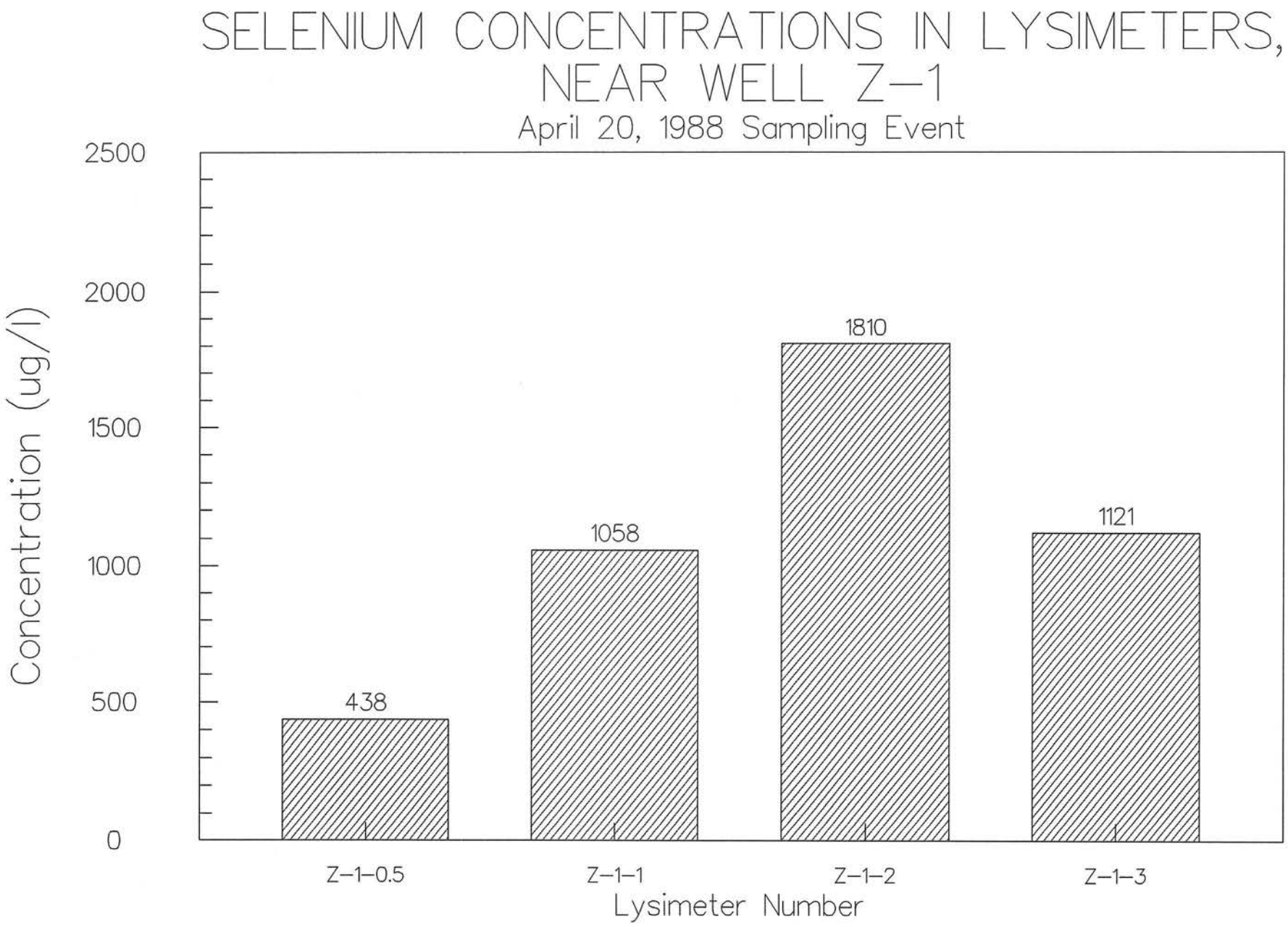


Figure 43 – Selenium Comparisons at Site Z-1

lysimeters at depths of 1 through 3 feet had concentrations two to four times greater those found in the samples from the lysimeter at a depth of 6 inches (Z-1-0.5), but all samples greatly exceeded the EPA standard of 10 μg/l.

Selenium concentrations at site Z-1-1 (the 1-foot deep lysimeter at well Z-1) ranged from 78 μg/l to 1881 μg/l and had a mean of 1016 μg/l. Concentrations in samples from 1987 through 1989 were substantially higher than those of 1986 samples, but showed considerable variation throughout this period. The samples collected in 1987 had the highest concentrations.

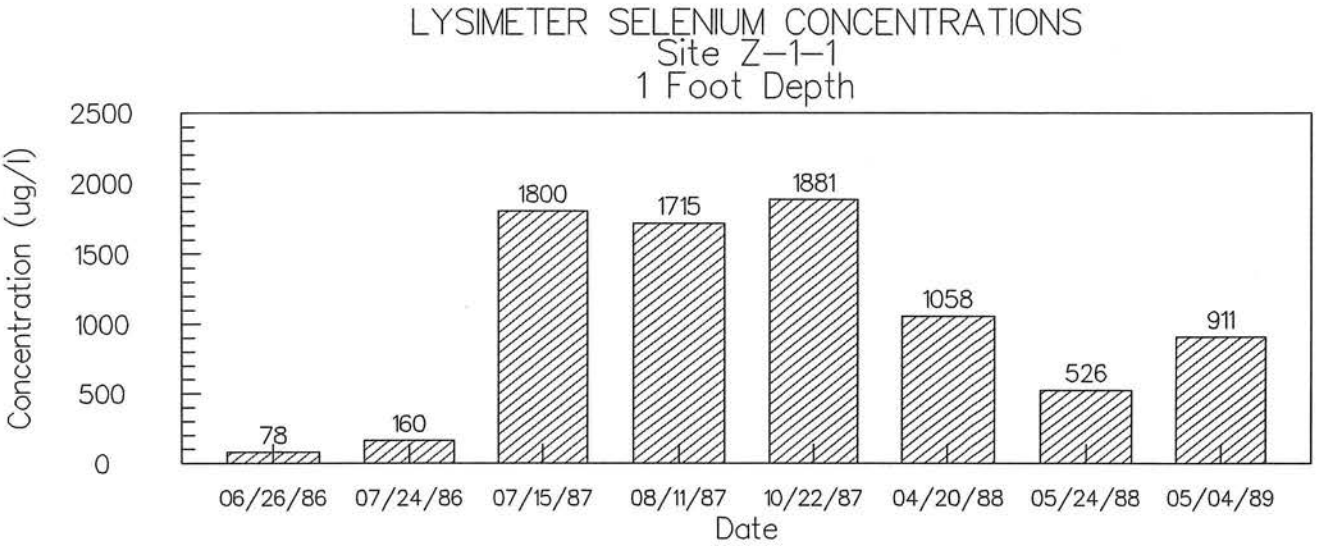
Selenium concentrations at site Z-1-2 ranged from 187 μg/l to 2280 μg/l with a mean of 1492 μg/l. Once again, concentrations were lowest in the 1986 samples and increased from 1987 through 1990. Throughout the 1987-1990 period, variability in concentrations was considerably less at this site than at site Z-1-1.

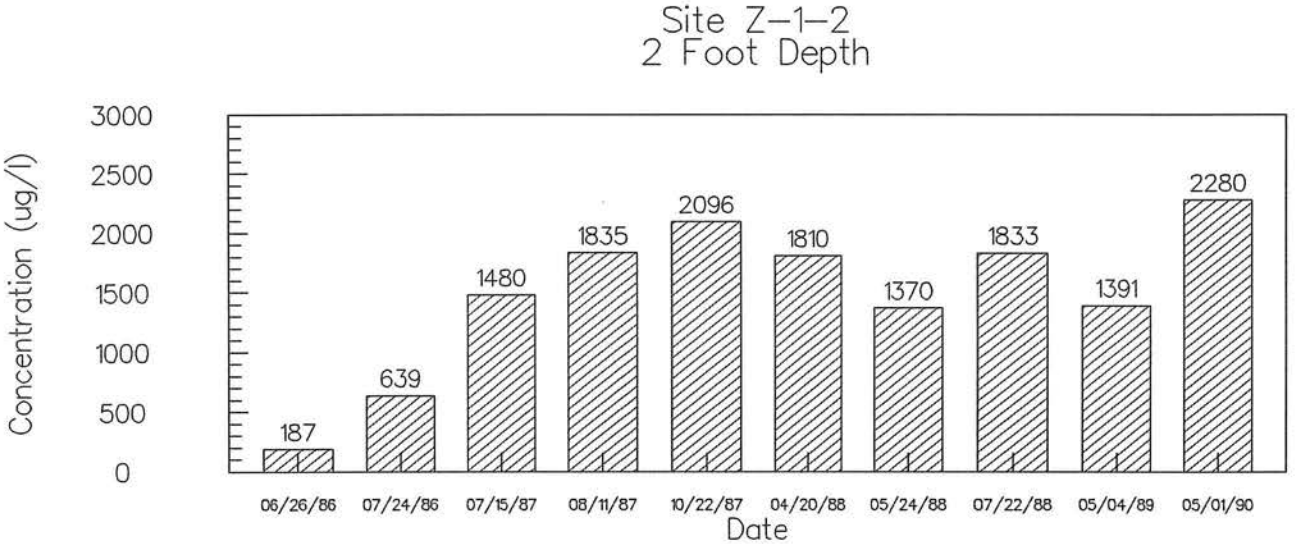
Selenium concentrations at site Z-1-3 ranged from 193 μg/l to 2390 μg/l with a mean of 1105 μg/l. Concentrations were the lowest in the 1986 samples and increased substantially in the following years. Concentrations were fairly consistent from 1987 through 1989 with values ranging from 907 μg/l to 1396 μg/l. By contrast the selenium concentration in the 1990 sample increased by 170 percent to 2390 μg/l. Figure 44 shows selenium concentrations at this site for lysimeters at depths of 1 foot, 2 feet and 3 feet.

Selenium concentrations at the Z-36 site lysimeters (Figure 45) were much lower and more consistent than those observed at site Z-1. Concentrations at the Z-36-5 site ranged from 35 μg/l to 66 μg/l with a mean of 50 μg/l. Concentrations at the Z-36-10 site ranged from 33 μg/l to 46 μg/l with a mean of 38 μg/l. The mean concentrations at these sites was more than 20 times less than the mean concentrations observed at the Z-1 sites. These concentrations, although lower, still exceed EPA-recommended limits of 10 μg/l.

Selenium concentrations at the Z-50-10 site ranged from 341 μg/l to 1130 μg/l with a mean of 743 μg/l. Concentrations at this site showed a different trend than that observed at the other lysimeter sites, that is, concentrations decreased over time from values obtained during 1986 (Figure 45). The mean concentrations at this site are 70 percent of that found at the Z-1 sites.

Results from lysimeter data throughout this study area confirm the presence of an elevated selenium concentration within the unsaturated zone. Concentration ranges at the Z-1 and Z-36 sites were similar to those observed in groundwater samples at those same sites, whereas concentrations in the unsaturated zone (lysimeter sample) at the Z-50 site were substantially above those found in groundwater samples. The mean concentration in lysimeter samples (Well Z-50-10) was 743 μg/l whereas the mean concentration from groundwater samples (Well Z-50) was 69 μg/l. Data collected from this study appear to show that, whereas elevated concentrations of selenium exist in the unsaturated zone in recharge areas of this site, they are considerably below concentrations found in both the unsaturated zone and the groundwater in the discharge areas (specifically the Z-1 site). It is probable that the enhanced infiltration that results from typical crop-fallow farming practices is responsible for these increases. Therefore, in addition to enhanced leaching of sodium and magnesium salts from the soil profile, selenium within the soil profile is also being leached. This enhanced leaching of selenium magnifies the saline-seep problem and causes additional concerns about the degradation of surface water and groundwater. Selenium may also have significant impacts on livestock, wildlife and waterfowl. These elevated selenium concentrations should be given serious consideration because of the proximity of this site to the Halfbreed Lake National Wildlife Refuge.





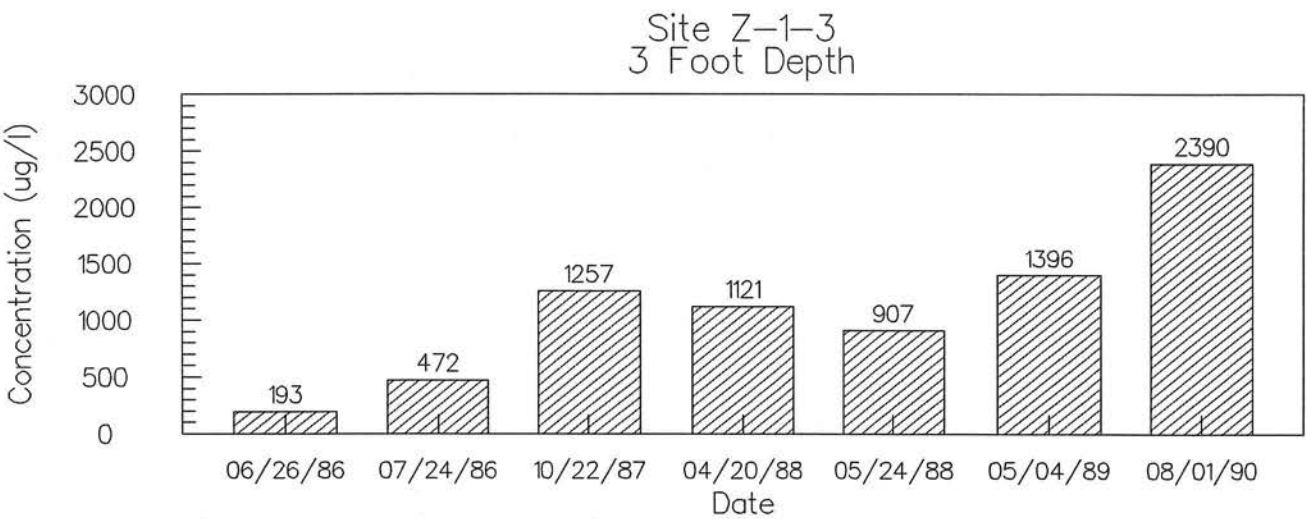
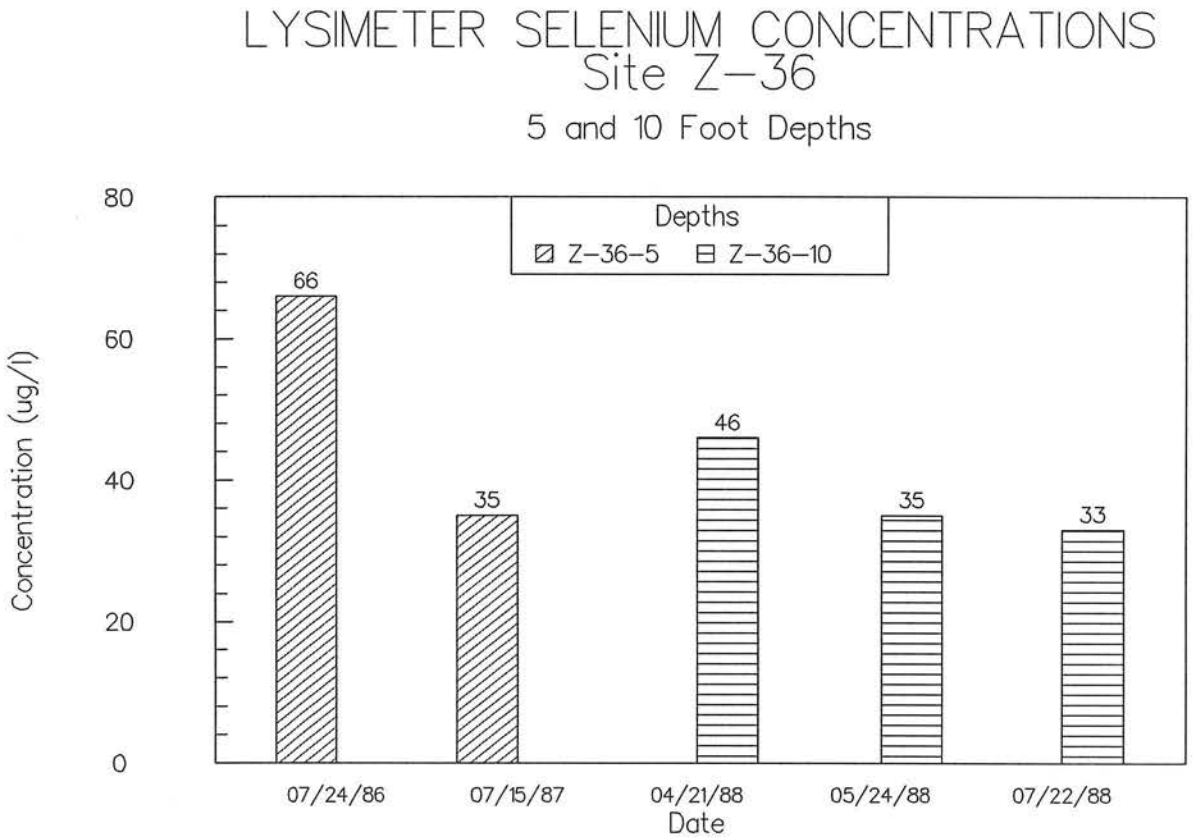


Figure 44 – Lysimeter Selenium Comparisons at Site Z-1, 1986 – 1990



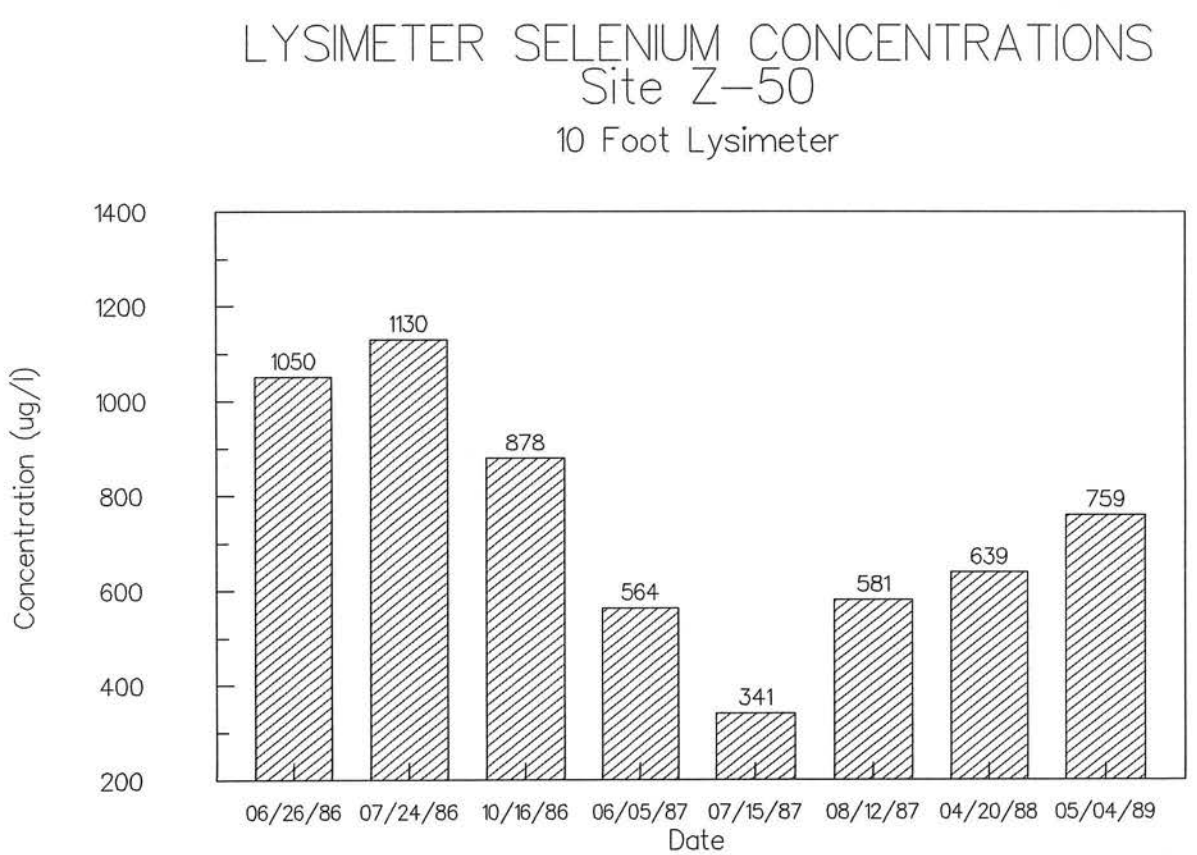


Figure 45 – Lysimeter Selenium Comparisons at Sites Z-36 and Site Z-50

BRICKLEY FARM SITE STUDY AREA

The activity level at this site was considerably less that at the SCS-SCD 10-Year Demonstration Site. As was previously discussed, the Brickley Farm Site was the location of saline-seep studies during the mid 1970's. The goal of this study was to go back to the site and collect limited water-level and water-quality data to document current conditions and compare those with historic data.

GROUNDWATER MONITORING AND QUALITY

Well and Lysimeter Installation

No new wells were installed at this site, but wells B-2 and B-8 were re-drilled. These wells were destroyed beyond refurbishment so, they were redrilled adjacent to the previous wells to similar depths and were completed similar to those at the Demonstration Site as shown in Figure 8. Three other wells that were monitored previously were destroyed, also, but were not replaced for this study. Figure 46 shows the location of wells monitored during this study.

Lysimeters were installed adjacent to wells B-8 and B-2 in a manner similar to those installed at the SCS-SCD Demonstration Site. These lysimeters were used to collect water samples from the unsaturated zone for nitrate and selenium analysis.

Water-Level Measurements

Water-level monitoring was initiated during the 1984 field season and was continued through the 1988 field season. Water levels were measured approximately every two weeks from April through June, then once a month until October of each year. A listing of water-level measurements at this site is contained in Appendix B. Added to this listing are historical water levels for wells within this site for comparison purposes. Most of the monitoring done at this site was performed by the local high-school student hired by the SCD.

There was considerable water-level variation during recent monitoring activities which might be a combination of climatic conditions and cropping practices. When monitoring first started at this site (1974), the site was all in the native vegetation. This native vegetation was then broken and cropped during the late 1970's and, from observations, has been intensively cropped since. For the most part, water levels were higher in monitoring wells during this period of monitoring than those found previously. Prime examples of this are shown at wells B-4 and B-8 which were dry during previous monitoring but, contained water during this study. Water levels appeared to rise from one to two feet to greater than six feet. An example of this is shown at well B-12, located in the discharge portion of the site. The maximum water-level elevation at this well during the 1970's monitoring was 3948.4 feet (depth-to-water, 14.73 feet), whereas it was 3955.1 feet (depth-to-water, 8.04 feet) during the 1980's monitoring. The minimum water-level elevation during the 1970's monitoring was 3946.2 feet (depth-to-water, 16.94 feet), whereas, during the 1980's, it was 3946.03 feet (depth-to-water, 17.10 feet). The total change from minimum to maximum water level during the 1970's was 2.21 feet, whereas, during the 1980's monitoring, it was 8.90 feet, which is over four times the range observed previously. The broader range in water-level fluctuations is, in part, a function of land-use changes that have occurred at this site over the past fifteen or so years. That is, native

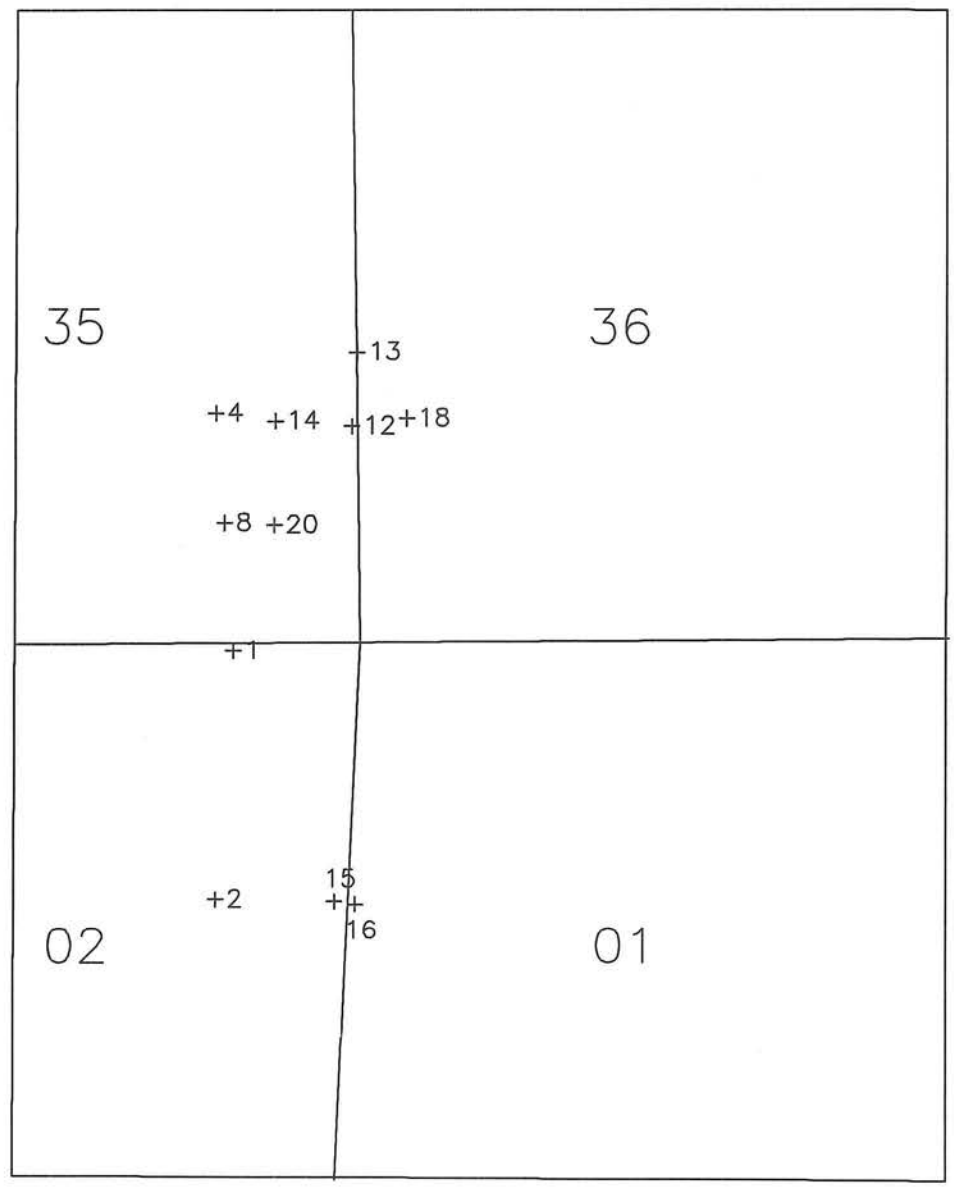


Figure 46 – Locations of Monitoring Wells at the Brickley Site

vegetation converted to small cereal grain fields. Figure 47 shows water levels for sites B-8 and B-12 for the period of record. The one exception to this trend occurred at well B-13 where water levels declined by two to three feet.

Specific Conductance Measurements

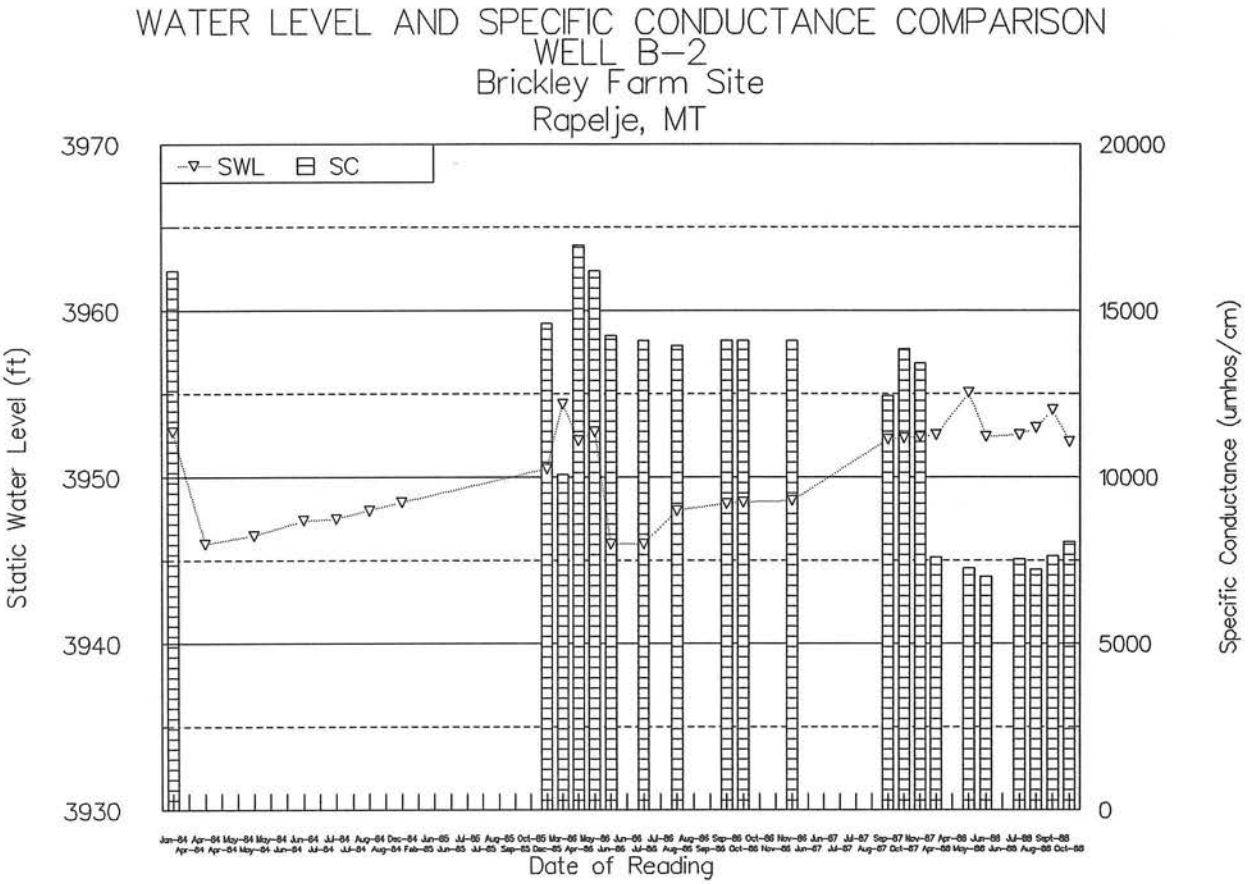
Specific conductance readings were made during 1986, portions of 1987, and 1988 simultaneously with water-level monitoring activities. Typically, SC values were higher in wells in the south portion of the site, sections 1 and 2, as shown in Figure 46. This area also corresponds to previously-identified discharge portions of the site (Custer, 1976).

Historic SC data are limited; wells B-1, B-4, B-8, B-12, and B-15 have little or no prior SC data, whereas the other remaining wells have data for portions of 1975 and 1976 only. Where SC data are available for comparison of 1970's and 1980's data, there appears to be only minor deviations between observed values, except at well B-2 and B-16, both of which are located in the discharge portion of the site. The mean SC values during the 1975-1976 monitoring at wells B-13 and B-20 were 5460 and 4730 μmhos/cm respectively, whereas SC values during the 1988 monitoring were 5120 and 4500 μmhos/cm respectively.

SC values in well B-2 showed considerable increases form prior monitoring. The mean SC value during the 1975-1976 monitoring was 5990μmhos/cm, whereas the mean value during the 1985-1988 monitoring was 11,950 μmhos/cm, or twice the concentrations observed previously. This increase is probably attributable to the fact that the native sod (vegetation) in this area was broken and put into cropland in early 1976. The 1975-1976 SC values probably do not reflect the additional moisture movement and subsequent leaching of salts through the soil profile as a result of land-use changes, whereas the 1980's readings do show this effect. This change would be expected since this well is located in the discharge area. Water-level comparisons also tend to verify these changes, see Figure 47. One interesting observation from this Figure and data contained in Appendix B is the decline in SC values during 1988 monitoring.

Wells B-4 and B-8, which were dry during prior monitoring activities, appear to have been affected by the change in land-use practices within this area. As a result, water-level and SC readings were obtained during the more recent monitoring activities. The same 1988 decrease in SC readings occurred at these wells as was noted previously in well B-2. Figure 47 shows the water-level and SC values at well B-8, also. It is interesting to note that, whereas SC values declined in both the B-2 and B-8 wells, water levels declined or remained fairly constant at well B-8 located within the recharge portion of the site. These occurrences might be a function of precipitation, infiltration, and leaching or the lack thereof. From Figure 5, it appears that precipitation was below the 30-year average for the most part during 1988, the exception being April, May, and October. Since precipitation was below average throughout the period, water levels remained constant or showed a small decline at well B-8. This would also mean that less unused-moisture is available for infiltration and subsequent leaching of salts from the soil profile, which is shown in the SC values from both B-2 and B-8.

Based upon 1980's monitoring results at this site, there is a definite change observed in both water levels and SC values found during the 1970's monitoring. There is a substantial increase in both water levels and SC concentration in discharge portions of the site, as shown in well B-2, Figure 47. There is also a significant increase in water levels within the recharge portion of the site as observed in wells B-4 and B-8, which were dry during the 1970's



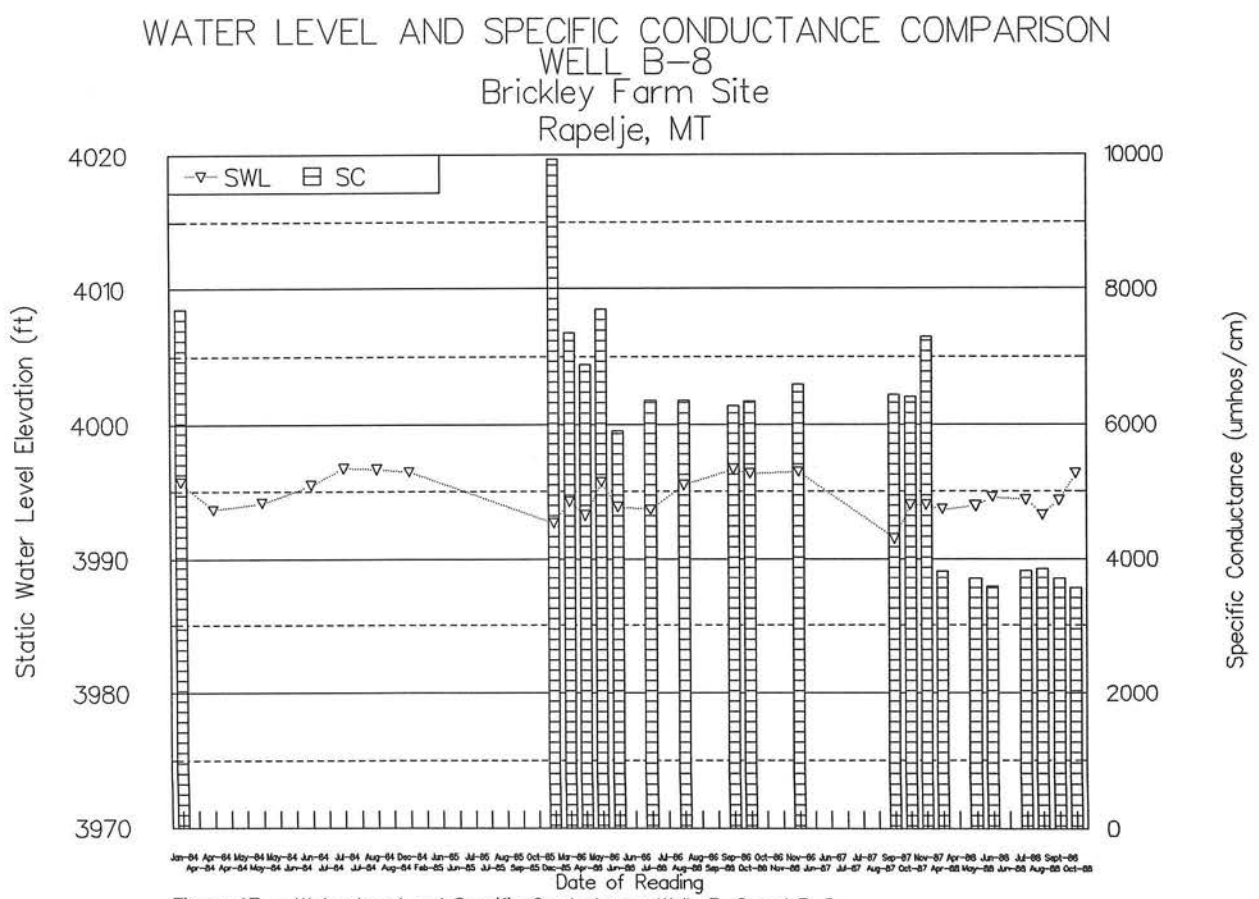


Figure 47 – Water Level and Specific Conductance, Wells B-2 and B-8

monitoring. It is apparent that the change in land-use practices at this site has affected both water levels and SC concentrations in wells throughout the site. One interesting observation was that SC values in wells which contained water during the 1970's monitoring, located in the recharge portion of the site, did not show much change. It could be assumed that the intensive cropping practices observed at this site have minimized the amount of unused moisture available for leaching of excess salts in this area, however, enough infiltration of unused moisture is occurring to show considerable increases in SC values in discharge portions of the site.

WELL WATER-QUALITY SAMPLING AND RESULTS

Water-quality samples were collected periodically at selected wells throughout this site, also. Appendix C contains a listing of all wells sampled plus analytical results. A total of 38 water-quality samples were collected at this site; 15 of those being well samples.

Well samples were collected following procedures used at the SCD-SCS 10-Year Demonstration Site described previously. Table 4 contains selected analytical results from wells at this site. All samples were collected between 1986 and 1988 as part of the field activities. Most of the sampling occurred at wells B-2 and B-8, which had lysimeter installations adjacent to them.

The dominant water type is $MgSO_4$, with $MgNaSo_4$, $NaMgSO_4$, and $CaMgSO_4$ type waters also occurring at one or more wells. All of these water types are indicative of saline-seep-affected waters with local groundwater flow systems. Whereas all wells exhibited saline-seep characteristics, regardless of whether they were in recharge or discharge areas, well B-14, located in the northern-most recharge portion of the site, showed the least impact from saline-seep development. It had the most unique water-type, $CaMgSO_4$, lowest SC value, and the lowest nitrate and selenium concentrations. This well and one sample from well B-8 are the only sites which did not exceed the maximum nitrate-concentration level of 10 mg/l. Samples from all wells sampled exceeded maximum allowable concentrations (10 μg/l) for selenium.

Although wells throughout the site have similar water types or composition, concentrations of the major ions are considerably greater in wells located in the discharge portion of the site than those in the recharge portion. This is apparent from the data contained in Table 4 and shown in Figure 48. Wells B-14, B-8, and B-20 are in the recharge portion of the site and have TDS or SC values one-third to one-half those found in wells B-2 and B-16, which are located in the discharge portion of the site. This is shown very dramatically by stiff diagrams for wells B-8 and B-2 shown in Figure 48.

Based upon data contained in Table 4 and shown in Figure 48, it is apparent that well B-2 is severely impacted by saline-seep development, and has shown a gradual degradation of water quality—most significantly noted in sodium, sulfate, and selenium concentrations. This is even more so when comparisons are made between recent concentrations and those observed in an April, 1976 water sample from this well. Magnesium, sodium, sulfate, and nitrate concentrations were: 490 mg/l, 920 mg/l, 4610 mg/l, and 5.7 mg/l, respectively, whereas concentrations found during the July, 1988 sampling for those same constituents were: 2265 mg/l, 2230 mg/l, 13,700 mg/l, and 67 mg/l, respectively. These changes in concentrations dramatically document the effects land-use practices had on water quality within the discharge portion of this site. However, this change was not as dramatic in the recharge portion of the site as shown by well B-8 in Figure 48. Unfortunately, no historic water-quality results exist for well B-8 comparison purposes since this well was previously dry. No wells sampled

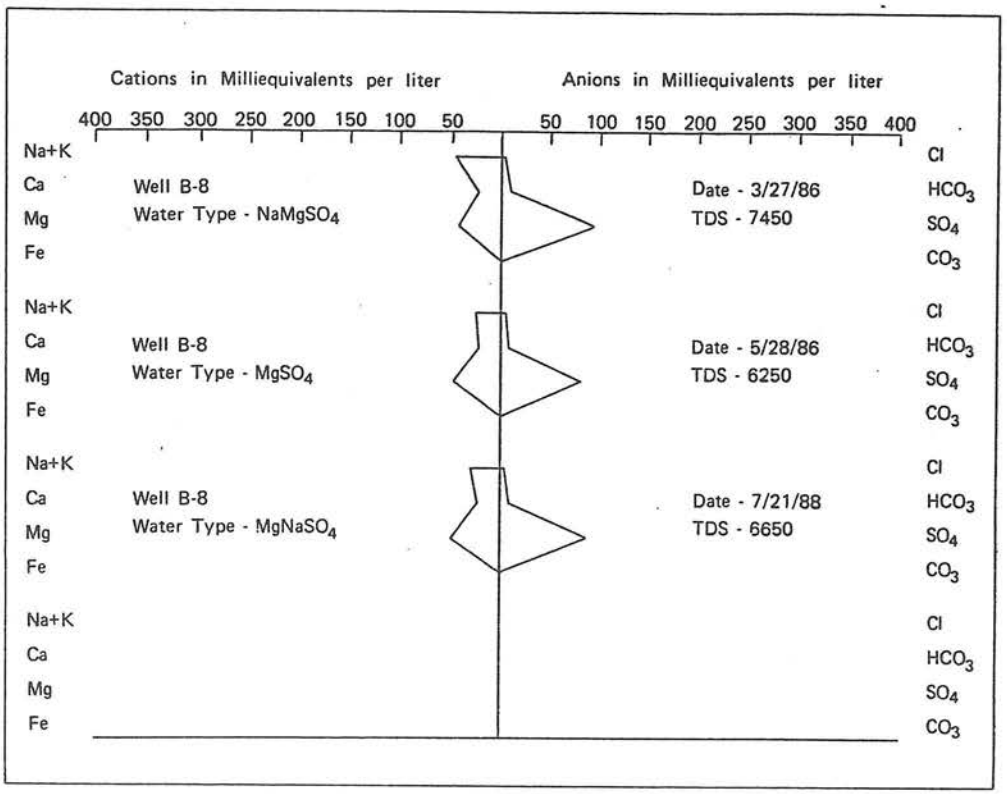
Table 4 - Selected Water-Quality Results, Brickley Test Site

Well No.	Date	Water	SWL	SC@25°C	pH	Ca	Mg	Na	K	Fe	Mn	HCO3	Cl	SO4	NO_3	F
	mo/dy/yr	Type	(ft)	(µmhos/cm)		(mg/l)[1]	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
B-1	03/27/86	$MgSO_4$	8.72	6660	7.6	362	645	590	14.7	<.002	.001	406	166	3750	100.00	1.5
B-1	07/21/88	$MgSO_4$	7.36	8450	7.1	415	885	729	21.8	.120	.110	396	163	5100	84.00	.1
B-2	03/27/86	$MgSO_4$	11.00	18860	7.4	371	2034	1764	23.0	<.002	.016	438	170	11690	107.00	1.6
B-2	07/21/88	$MgSO_4$	N/A	16860	7.1	397	2265	2230	26.6	.810	.980	513	175	13700	67.00	.2
B-8	03/27/86	$NaMgSO_4$	24.00	7160	7.4	454	520	1062	19.7	<.002	.370	630	126	4590	31.00	1.1
B-8	07/21/88	$MgNaSO_4$	23.57	7170	7.0	451	604	677	19.1	.006	.049	514	126	4200	40.00	.1
B-14	07/21/88	$CaMgSO_4$	26.61	3780	6.9	495	162	273	9.1	.048	.860	342	22	2092	6.68	N/A
B-16	07/21/88	$MgSO_4$	N/A	15600	7.0	388	2280	1640	26.0	<.002	.005	625	110	12500	66.00	.2
B-20	07/21/88	$MgNaSO_4$	N/A	7160	7.1	437	409	768	15.2	.002	.081	473	169	3440	70.00	.1

Well No.	Date	Al	B	Cd	Cr	Cu	Li	Sr	Zn	As	Se
	mo/dy/yr	(µg/l)[2]	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)
B-1	03/27/86	<30	640	8	<2	<2	685	8710	<3	N/A	1030
B-1	07/21/88	300	510	3	<2	17	920	10200	13	N/A	1137
B-2	03/27/86	1500	870	8	<2	<2	1.5	6850	7	N/A	591
B-2	07/21/88	560	580	38	36	21	1750	7180	24	N/A	998
B-8	03/27/86	<30	1330	<2	<2	<2	1350	863	19	N/A	332
B-8	07/21/88	<30	700	2	<2	25	1000	8610	24	N/A	572
B-14	07/21/88	<30	410	<2	<2	17	210	6870	3	N/A	76
B-16	07/21/88	<30	480	10	<2	25	1530	5850	69	N/A	385
B-20	07/21/88	<30	610	<2	<2	23	580	7180	20	N/A	1040

1 - Milligrams per liter (mg/l), parts per million
2 - Micrograms per liter (µg/l), parts per billion
N/A - Not measured or analyzed for

Brickley Site Water Quality Comparisons



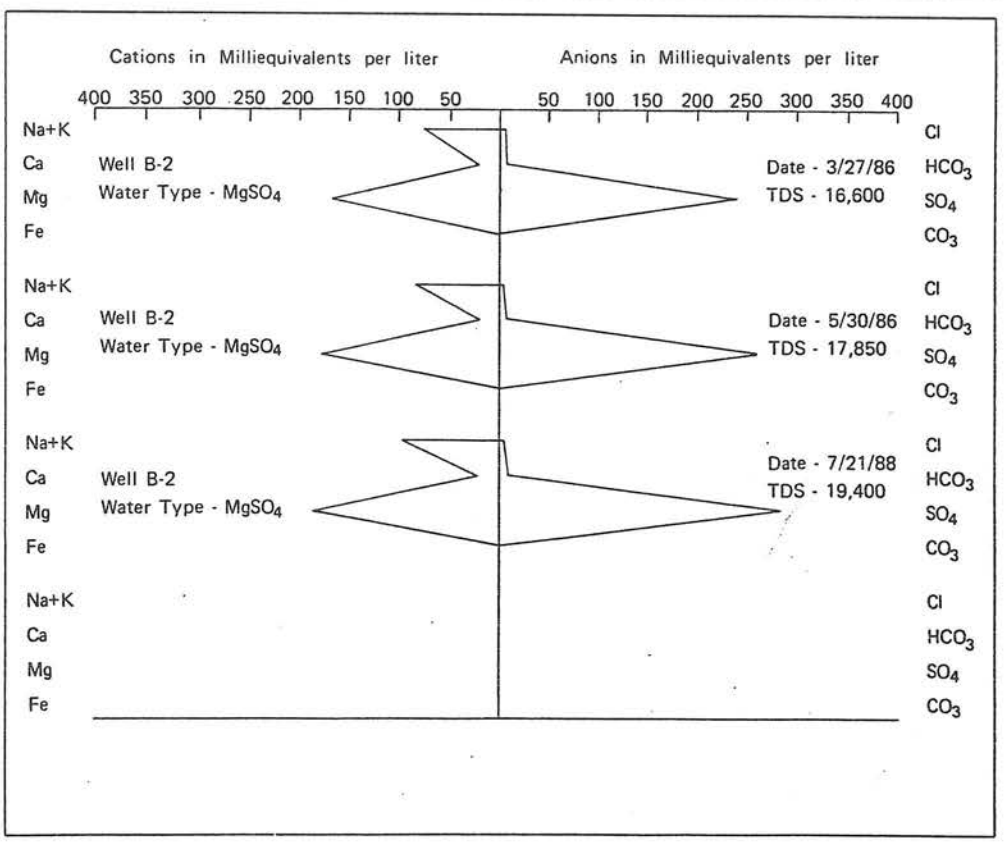


Figure 48 - Stiff Diagram - Well B-8 and B-2

previously in the recharge portion of the site by Custer were sampled during this study. Therefore, no comparisons can be made concerning changes in water quality between periods of monitoring in the recharge portion of the site besides those already made concerning water levels and SC values.

Nitrate concentrations were considerably elevated above recommended limits (10 mg/l) in all wells except well B-14 and one sample from well B-8 throughout this site. This occurrence seems to follow trends noted by Custer following the break-up of natural vegetation.

All nitrate and selenium concentrations from well B-1 exceeded the EPA-recommended limits of 10 mg/l and 10 μg/l respectively. Nitrate concentrations ranged from 84 mg/l to 121 mg/l with a mean of 102 mg/l. Selenium concentrations ranged from 1030 μg/l to 1410 μg/l with a mean of 1192 μg/l.

As previously noted, well B-2 shows a considerable degradation in water quality from a 1976 sample to sample results obtained during this study. Whereas the 1976 sample had a nitrate concentration of 5.7 mg/l, nitrate values from 1986 and 1988 samples ranged from 67 mg/l to 107 mg/l with a mean of 84.5 mg/l—a 1480 percent increase.

No selenium values exist for the 1976 sample at well B-2 for comparison purposes. However, selenium concentrations at this well ranged from 591 μg/l to 998 μg/l with a mean of 713 μg/l during the 1986-1988 sample periods. The mean concentration is over 7000 percent above recommended limits.

As mentioned above, no previous water-quality data exist for well B-8 since it was dry during the 1970's sampling. From data shown in Table 4 and Stiff Diagrams shown on Figure 48, it appears this well has not been impacted by saline-seep development as significantly as well B-2, located to the south. However, nitrate concentrations in water samples exceeded recommended limits in four of the five samples. Nitrate concentrations ranged from 9.1 mg/l to 72.1 mg/l with a mean of 41.4 mg/l. The mean concentration is 410 percent above recommended limits.

Selenium concentrations in water samples from well B-8 ranged from 135 μg/l to 690 μg/l with a mean of 463 μg/l. The mean concentration is, therefore, more than 4600 percent above the recommended limits.

Only single water-quality samples were collected from wells B-14, B-16 and B-20, therefore no trends can be determined for these wells. However, the samples from these wells all exceeded recommended selenium limits and wells B-16 and B-20 had nitrate concentrations in excess of recommended limits.

Based upon water level, specific conductance and water-sample results, it is apparent that water quality in monitoring wells at this site has degraded from previous conditions noted during the 1970's monitoring. This is very apparent where historic and recent data allow direct comparisons. Not only are water types from wells indicating saline-seep impacts, but concentration-increases in magnesium, sodium, sulfate and nitrate at well B-2 dramatically show the level of impact. Increases ranged from over 200 percent for sodium to over 1100 percent for nitrate.

Nitrate concentrations at this site are significantly higher than levels observed at the SCD-SCS Demonstration Site, whereas selenium concentrations appear to fall within the range observed at the demonstration site.

LYSIMETER WATER-QUALITY SAMPLING AND RESULTS

Samples for selenium and nitrate analysis were collected at the lysimeter locations adjacent to wells B-8 and B-2. Samples were collected primarily during June, July and August of 1986 and 1987. Sampling procedures followed those previously described at the SCD-SCS 10-Year Demonstration Site.

A total of 23 samples were collected from lysimeters throughout this site with 18 being from the lysimeter near well B-8. Appendix D contains a complete listing of lysimeter results, whereas Table 5 is a statistical summary of results.

Nitrate concentrations exceeded the EPA-recommended limit of 10 mg/l in all five lysimeter samples at the B-2 site. Concentrations, as shown in Table 5, from the 5-foot lysimeter (B-2-5) were fairly consistent between the two samples with a mean concentration of 16.9 mg/l. Concentrations from the 10 foot lysimeter (B-2-10) had a somewhat larger spread with a mean concentration of 168 mg/l. It is interesting to note the order of magnitude increase in nitrate concentrations from the 5-foot- to the 10-foot-depth lysimeters.

Nitrate concentrations in the unsaturated zone near well B-2 increased with depth with the concentrations at the 10-foot depth closer to those observed in groundwater samples from well B-2, although they are higher. The mean groundwater concentration for nitrate was 84.5 mg/l, whereas the mean concentration at 10 feet was 168 mg/l, or twice that found in groundwater. Therefore, it appears that nitrate concentrations observed in the unsaturated zone at depth are diluted in the groundwater system near the well.

Thirteen of the eighteen samples collected from the B-8 site lysimeter exceeded the EPA-recommended limit for nitrate of 10 mg/l. Concentrations at the 1-foot depth (B-8-1) were consistent during 3 of the 4 sampling events with the final sampling results showing over a four-fold increase—Table 5. Concentrations ranged from 15.2 mg/l to 91.1 mg/l with a mean of 38.4 mg/l.

Concentration ranges at the 2 foot depth (B-8-2) were consistently higher than those found in the 1-foot samples, and showed less variability between samples. Concentrations ranged from 76 mg/l to 96.9 mg/l with a mean of 84.8 mg/l.

Concentration ranges at the 3-foot depth (B-8-3) showed considerable variation with concentrations decreasing over time. Concentrations ranged from 26.9 mg/l to 99 mg/l with a mean of 53.4 mg/l.

Three of the five nitrate samples collected from the 5-foot depth (B-8-5) were below the recommended limit. Concentrations ranged from 0.6 mg/l to 19.6 mg/l with a mean of 8.2 mg/l.

Both nitrate samples from the 10-foot depth (B-8-10) were below recommended limits and were fairly consistent. Concentrations ranged from 5.5 mg/l to 6.8 mg/l with a mean of 6.2 mg/l.

Nitrate concentrations decreased with depth from 2 feet on down, Figure 49, in the unsaturated zone near well B-8, located in the recharge portion of this site. Nitrate concentrations increased by almost 1000 percent (or 10 times) in the unsaturated zone near well B-2, which is located in the discharge portion of the site.

Nitrate concentrations in the unsaturated zone near well B-8 in the 5- and 10-foot depths were less than twenty-five percent those found in the groundwater samples obtained from well B-8. Concentrations observed in the 1-foot and 3-foot depths were similar to groundwater samples, whereas concentrations observed at the 2-foot depth were almost twice that found in

Table 5 - Lysimeter Sites Nitrate and Selenium Concentrations

Brickley Test Site, Hailstone Basin
Sample results by site
(This Table contains sites with more than one sample.)

Lysimeter No. (well no-depth)	Date (mo/dy/yr)	Nitrate (mg/l)	Selenium (µg/l)
B-2-5	07/24/86	16.2	219
B-2-5	08/14/87	17.6	245
	Mean	16.9	232
	Maximum	17.6	245
	Minimum	16.2	219
	Number	2	2
B-8-1	06/26/86	15.2	1.3
B-8-1	07/24/86	22.8	1.0
B-8-1	07/15/87	24.6	.3
B-8-1	08/13/87	91.1	.3
	Mean	38.4	.7
	Maximum	91.1	1.3
	Minimum	15.2	.3
	Number	4	4
B-8-3	06/26/86	99.0	2.2
B-8-3	07/24/86	26.9	2.8
B-8-3	08/13/87	34.4	2.2
	Mean	53.4	2.4
	Maximum	99.0	2.8
	Minimum	26.9	2.2
	Number	3	3
B-8-10	06/26/86	5.5	103
B-8-10	07/24/86	6.9	107
	Mean	6.2	105
	Maximum	6.9	107
	Minimum	5.5	103
	Number	2	2

Lysimeter No. (well no-depth)	Date (mo/dy/yr)	Nitrate (mg/l)	Selenium (µg/l)
B-2-10	06/26/86	188	343
B-2-10	07/24/86	147	387
	Mean	168	365
	Maximum	188	387
	Minimum	147	343
	Number	2	2
B-8-2	06/26/86	76.0	.7
B-8-2	07/24/86	81.5	1.4
B-8-2	08/13/87	96.9	4.0
	Mean	84.8	2.0
	Maximum	96.9	4.0
	Minimum	76.0	.7
	Number	3.0	3.0
B-8-5	06/26/86	4	3.6
B-8-5	07/24/86	16	.5
B-8-5	07/15/87	.6	1.4
B-8-5	08/13/87	.7	1.8
B-8-5	07/22/88	19.6	54.0
	Mean	8.18	12.3
	Maximum	19.6	54.0
	Minimum	.63	.5
	Number	5	5

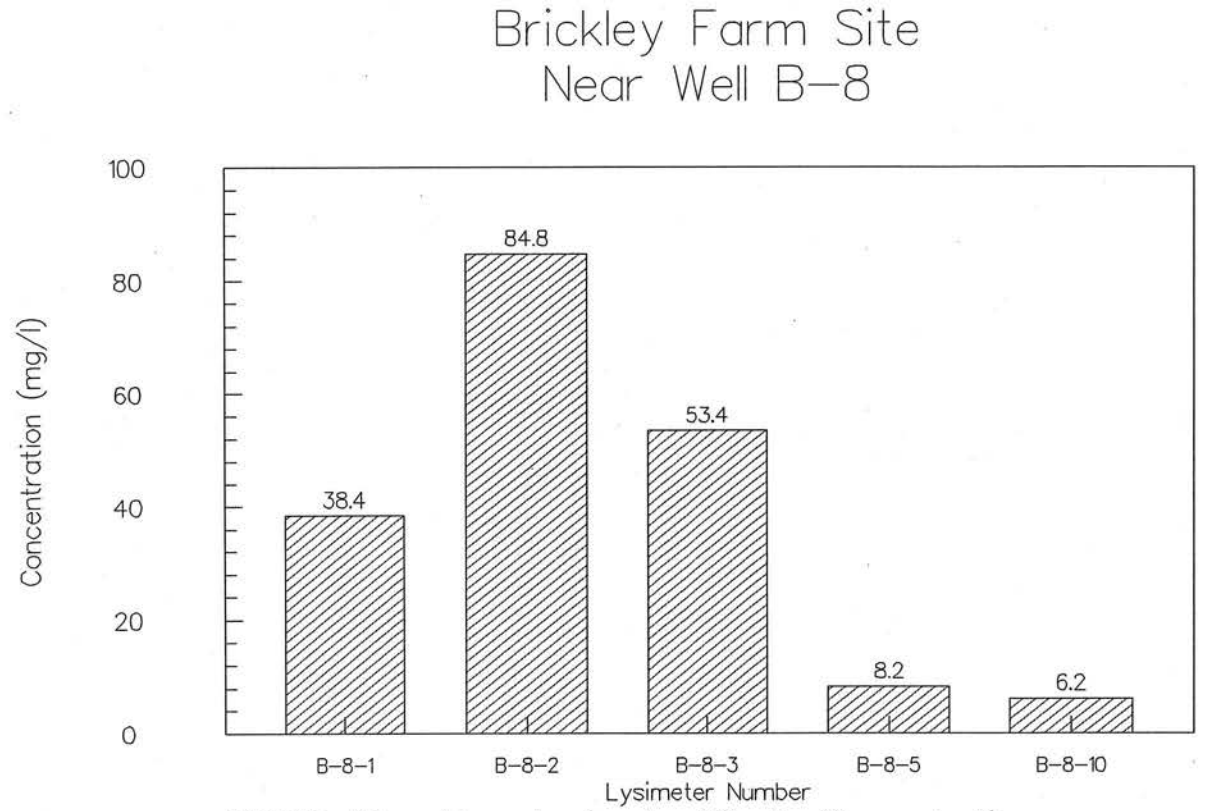


FIGURE 49 – Mean Lysimeter Nitrate Concentrations

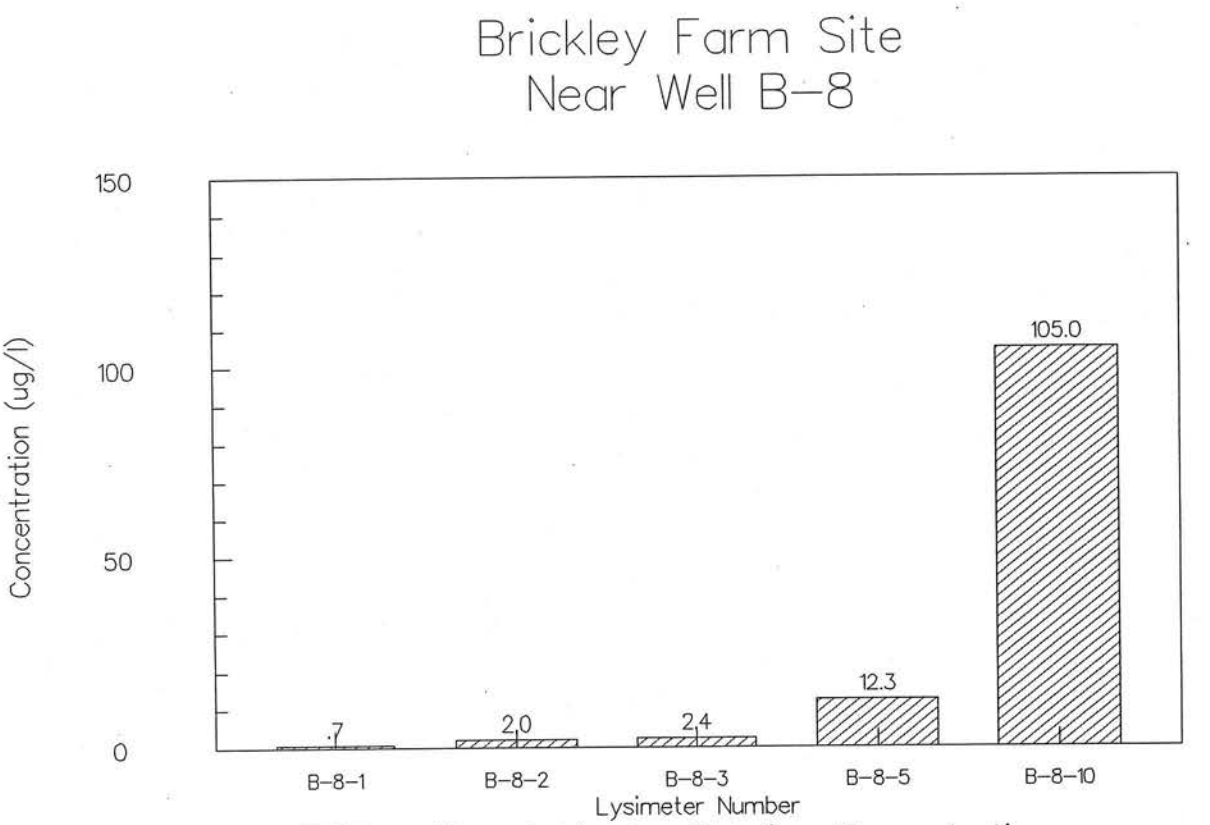


FIGURE 50 – Mean Lysimeter Selenium Concentrations

groundwater samples.

Selenium concentrations exceeded the EPA-recommended limit of 10 μg/l in all lysimeter samples collected at the B-2 site—Table 5. Selenium concentrations from the 5-foot depth were fairly consistent, ranging from 219 μg/l to 245 μg/l with a mean if 232 μg/l. Concentrations from the 10-foot depth were also fairly consistent, but were 50 percent higher in concentration than those observed at the 5-foot depth. Concentrations ranged from 343 μg/l to 387 μg/l with a mean of 365 μg/l. Only one sample was obtained from the 3-foot depth, 6.3 μg/l. It appears that selenium concentrations increase substantially with depth in the unsaturated zone near well B-2.

Selenium concentrations in the unsaturated zone near well B-2 are one-third to one-half those observed in groundwater samples from well B-2. This trend is the opposite of that observed for nitrate concentrations at this site.

Three of the eighteen selenium samples collected from the unsaturated zone near well B-8 exceeded the recommended limit of 10 μg/l. Those three samples consisted of one sample from the 5-foot depth and both samples from the 10-foot depth.

Selenium concentrations in the 1-foot depth (B-8-1) ranged from 0.3 μg/l to 1.3 μg/l with a mean of 0.7 μg/l. Concentrations were fairly consistent at this site, but appeared to decrease over time—Table 5.

Selenium concentrations at the 2-foot depth (B-8-2) increased over time. Concentrations ranged from 0.7 μg/l to 4 μg/l with a mean of 2 μg/l. Concentrations were above those observed in the 1-foot samples.

Selenium concentrations at the 3-foot depth (B-8-3) were very consistent among samples. Concentrations ranged from 2.2 μg/l to 2.8 μg/l with a mean of 2.4 μg/l.

Selenium concentrations at the 5-foot depth (B-8-5) were consistent throughout the 1986 and 1987 sample periods, but increased substantially in the 1988 samples—Table 5. Concentrations ranged from 0.5 μg/l to 54 μg/l with a mean of 12.3 μg/l.

Selenium concentrations at the 10-foot depth (B-8-10) were consistent, ranging from 103 μg/l to 107 μg/l with a mean of 105 μg/l. These concentrations are considerably above those found in the other lysimeters at this site. Figure 50 shows mean selenium concentrations in lysimeters located near well B-8. It is evident that selenium concentrations increase with depth in the unsaturated zone with a dramatic increase from 5 feet to 10 feet.

Selenium concentrations in the unsaturated zone near well B-8 are considerably below those observed in groundwater samples from well B-8. This trend is similar to that observed at well B-2.

Results from lysimeter data at the Brickley Site confirm the presence of elevated nitrate concentrations in the unsaturated zone. It also confirms the presence of elevated selenium concentrations in the discharge portion of the site (Well B-2), whereas only the 10-foot lysimeter samples in the recharge portion of the site (Well B-8) are elevated above recommended limits for selenium.

SUMMARY

This study documented the severity of the saline-seep problem at the SCD-SCS 10-Year Demonstration Site and the differences in water quality between the recharge and discharge portions of the site. It is obvious that the saline-seep problem is quite severe and groundwater quality in the discharge portion of the site has continued to degrade throughout this period of study.

This investigation also showed that the application of saline-seep mitigation or reclamation measures used successfully in glaciated potions of the northern Montana plains, namely the planting of alfalfa in recharge areas, can be applied successfully in non-glaciated areas of south-central Montana. Even though the alfalfa was not planted in the major portion of the recharge area, water levels declined by at least 9 feet and possibly as much as 19 feet.

Whereas a substantial water-level decline occurred within the alfalfa-planted area, no corresponding water-level decline was observed in the discharge portion of the site—as noted in well Z-1. To obtain the maximum benefits of alfalfa, the alfalfa should be moved northwest of its present location; this would put it within the major recharge portion of the site. This change would most likely result in a lowering of water levels in the discharge area in addition to lowering water levels adjacent to the alfalfa. The farm operators should consider this change to realize the maximum benefits of the alfalfa.

This study also failed to detect any substantial adverse effects from the breakage of native sod and the subsequent planting of cereal grains in the south-central portion of the site. Whereas water levels remained consistent in this area (well Z-40), specific conductance readings indicate that an increase in leaching of salts is occurring. However, a longer period of monitoring would be necessary to accurately document changes, or lack of changes, in this portion of the site.

Results of water-quality sampling showed a considerable variation in selenium concentrations in groundwater throughout this site. Concentrations near well Z-1, located in the discharge portion of the site, showed excessive concentrations with a mean of 1334 μg/l, compared to the EPA-recommended maximum concentration in water of 10 μg/l. Selenium concentrations in the unsaturated zone showed considerable variation throughout this site, but all exceeded the EPA-recommended limit. Maximum concentrations were observed in the discharge portion of the site near well Z-1, similar to that noted in groundwater results. The maximum groundwater selenium concentration occurred in well Z-1 and was 3320 μg/l, whereas the maximum unsaturated-zone selenium concentration occurred in the 3-foot lysimeter (Z-1-3) adjacent to well Z-1 and was 2390 μg/l.

Results of monitoring and sampling activities at the former Brickley Farm Site documented the continued degradation of water quality and the rise in groundwater levels, most likely a result of changing land-use practices. A number of wells that were dry prior to the breakage of land and its subsequent farming contained water during this period. Also, water levels increased in wells and showed greater variability over those previously noted.

Wells located in the recharge portion of the site (wells B-13 and B-20) showed little or no change in specific conductance values, whereas wells located in the discharge portion of the site (well B-2) showed a two-fold increase over previous values.

Little historic water-quality data was available for comparison with data collected during this study, but, where it was (well B-2), it showed significant increases over previous results. Nitrate concentrations increased over 1480 percent from those observed during 1976 sampling.

Nitrate concentrations in groundwater were considerably elevated and are substantially

above those noted at the SCD-SCS 10-Year Demonstration Site. Trends in nitrate concentrations noted by Custer in 1976 are still evident.

Selenium concentrations in groundwater at this site were elevated also. All groundwater samples had concentrations considerably above the EPA-recommended limit of 10 μg/l, irregardless of their location (recharge or discharge areas).

Unsaturated-zone nitrate concentrations showed considerable variation throughout the Brickley Site with 18 of the 23 samples exceeding the EPA-recommended maximum limit of 10 mg/l. The maximum concentration (188 mg/l) occurred in the 10-foot-deep sample near well B-2, located in the discharge portion of the site.

Selenium concentrations in the unsaturated zone were highly variable with only 8 of the 23 samples exceeding the EPA-recommended maximum limit of 10 μg/l. Maximum selenium concentrations occurred in the 10-foot-deep sample near well B-2 and was 387 μg/l.

Nitrate concentrations at the Brickley Site were considerably higher in both the unsaturated zone and groundwater samples in comparison to those found at the 10-Year Demonstration Site. Maximum nitrate concentrations in groundwater and the unsaturated zone at this site were 121 mg/l and 188 mg/l respectively. However, selenium concentrations at this site were considerably lower in both the groundwater and unsaturated zone samples than those found at the 10-Year Demonstration Site. Maximum selenium concentrations were 1410 μg/l and 387 μg/l in groundwater and unsaturated zone samples.

Even though monitoring and sampling results at the Brickley Site showed considerable degradation over observations made during 1970's activities at this site, one positive trend was noted. No significant change in specific-conductance readings in wells located in the upper portion of the recharge area was noted. It could be inferred from this that the continuous cropping, which appears to have been the practice at this site, had success in limiting the amount of excess moisture available for leaching of salts in the soil profile. However, water levels did increase in wells downgradient that were originally dry during the 1970's monitoring, so enough moisture is available to affect groundwater levels.

BIBLIOGRAPHY

Brown, P.L., Halvorsen, A.D., Siddoway, F.H., Mayland, H.F., and Miller, M.R., 1982, Saline-Seep Diagnosis, Control, and Reclamation: U.S. Department of Agricultural Conservation Research Report No. 30, 22 p.

Brown, P.L., and Miller, M.R., 1978, Soils and crop management practices to control saline seeps in the U.S. northern plains, *in* proceedings of the Subcommission on Salt-Affected Soils, 11th International Soil Science Society Congress, Canada, p. 7-9 to 7-15.

Bahls, L.L., and Miller, M.R., 1973, Saline seep in Montana; *in* Montana Environmental Quality Council Second Annual Report, p. 35-44.

Custer, S.G., 1976, Shallow ground-water salinization in dry-land-farm areas of Montana: Montana Universities Joint Water Resources Research Center Report No. 79, 214 p.

Custer, S.G., 1979, Regional identification of saline-seep recharge areas, Stillwater and Yellowstone Counties, Montana: Montana Universities Joint Water Resources Research Center Report No. 102, 58 p.

Duaime, T.E., Moore, H.R., Holzer, J.M., and Hockett, G.A., 1986, Saline-seep assessment of Geraldine, Montana and surrounding areas: Montana Bureau of Mines and Geology Open-File Report No. 169, 50 p.

Environmental Protection Agency, 1986, Quality criteria for water: U.S. Department of Commerce, 398 p.

Hancock, E.T., 1918, Geology and oil and gas prospects of the Lake Basin field, Montana: U.S. Geological Survey Bulletin 691-D, 147 p.

Hayden, F.V., 1871, Geology of the Missouri valley: U.S. Geological Survey Fourth Annual Report, 97 p.

Kellogg, S.P., 1984, An overview of saline seeps in Stillwater County: Stillwater Conservation District, 46 p.

Knappen, R.S., and Moulton, G.F., 1930, Geology and mineral resources of parts of Carbon, Big Horn, Yellowstone, and Stillwater Counties, Montana: U.S. Geological Survey Bulletin 822-A, 70 p.

Lewis, B.D., Custer, C.G., and Miller, M.R., 1979, Saline-seep development in the Hailstone Basin, northern Stillwater County, Montana: U.S. Geological Survey Waters-Resources Investigation 79-107, 28 p.

Miller, M.R., and Bergantino, R.N., 1983. Distribution of saline seep in Montana: Montana Bureau of Mines and Geology Hydrogeologic Map 7, 7 p., map 1:1,000,000.

Miller, M.R., Brown, P.L., Donovan, J.J, Bergantino, R.N., Sonderegger, J.L., and Schmidt, F.A., 1980, Saline-seep development and control in the North American Great Plains: Agricultural Water Management, 1981, vol. 4, p. 115-141.

National Oceanic and Atmospheric Administration, 1990, Climatological annual summary, Montana, 1990 vol. 93, number 13, p. 8-9.

Hogsted, Jeanne—Soil Conservation Service, March 8th, 1985, Personal communication.

Stanton, T.W., and Hatcher, J.B., 1905, Geology and paleontology of the Judith River beds: U.S. Geological Survey Bulletin 257, 13 p.

APPENDIX A

Well logs for drill holes, 10-Year Demonstration Site and Brickley Site

STILLWATER OBSERVATION WELLS

Well No: Z-1 Total Depth (ft): 10
Location: T02N, R21E, Sec 01, Tract CCDC Cased Depth (ft): 10
Drilled by: TCD Slotted Interval:
Date Drilled: 11/18/83 Altitude: 3957.3

Depths (FT.)
0-3 Sandy clay loam
3-7 Fine sandy clay Saturated zone at 6 feet
7-10 Sandstone - impenetrable

Well No: Z-2 Total Depth (ft): 13
Location: T02N, R21E, Sec 01, Tract CDBB Cased Depth (ft): 13
Drilled by: TCD Slotted Interval:
Date Drilled: 11/18/83 Altitude: 3966.2

Depths (FT.)
0-2 Silty clay loam
2-13 Silty clay (wet at 4') at 10' zone of gravels less than 6" thick, less than 10% gravel

Well No: Z-3 Total Depth (ft): 7
Location: T02N, R21E, Sec 01, Tract CACC Cased Depth (ft): Not Cased
Drilled by: TCD Slotted Interval:
Date Drilled: 11/18/83 Altitude:

Depths (FT.)
0-2 heavy sandy clay loam
2-3 heavily weathered sandy clay
3-7 hard shale

Well No: Z-4 Total Depth (ft): 3
Location: T02N, R21E, Sec 01, Tract CAAC Cased Depth (ft): Not Cased
Drilled by: TCD Slotted Interval:
Date Drilled: 11/18/83 Altitude:

Depths (FT.)
0-1 Sandy clay loam
1-2 Silt loam
2-3 Sandy shale

Well No: Z-5 Total Depth (ft): 7
Location: T02N, R21E, Sec 01, Tract CBAC Cased Depth (ft): 7
Drilled by: TCD Slotted Interval:
Date Drilled: 11/18/83 Altitude: 3970.2

Depths (FT.)
0-6 Fine sandy clay @ feet saturated
6-7 Sandstone

Well No: Z-6 Total Depth (ft): 6
Location: T02N, R21E, Sec 01, Tract CBBA? Cased Depth (ft): 6
Drilled by: TCD Slotted Interval:
Date Drilled: 11/18/83 Altitude: 3975.6

Depths (FT.)
0-1 Silty clay loam
1-2 gravels - very angular
2-5 Soft silty clay
5-6 Hard sandy shale

Well No: Z-7 Total Depth (ft): 6
Location: T02N, R21E, Sec 01, Tract CBBA Cased Depth (ft): 6
Drilled by: TCD Slotted Interval:
Date Drilled: 11/18/83 Altitude: 3970.1

Depths (FT.)
0-2 Fine sandy loam
2-6 Silty clay with 20% gravels

Well No: Z-8 Total Depth (ft): 13
Location: T02N, R21E, Sec 01, Tract CBCB Cased Depth (ft): 13
Drilled by: TCD Slotted Interval:
Date Drilled: 11/18/83 Altitude: 3963.8

Depths (FT.)
0-10 Silty clay
10-13 Bentonite shale

Well No: Z-9 Total Depth (ft): 15
Location: T02N, R21E, Sec 01, Tract CBCA Cased Depth (ft): 15
Drilled by: TCD Slotted Interval:
Date Drilled: 11/18/83 Altitude: 3964.0

Depths (FT.)
0-10 Silty clay
10-15 Bentonitic shale

Well No: Z-10 Total Depth (ft): 6
Location: T02N, R21E, Sec 01, Tract BDCD Cased Depth (ft): Not Cased
Drilled by: TCD Slotted Interval:
Date Drilled: 11/18/83 Altitude:

Depths (FT.)
0-1 Silty clay loam
1-5 Silt loam
5-6 Sandy shale

Well No: Z-11 Total Depth (ft): 11
Location: T02N, R21E, Sec 01, Tract BDBA Cased Depth (ft): Not Cased
Drilled by: TCD Slotted Interval:
Date Drilled: 11/18/83 Altitude: 4023.4

Depths (FT.)
0-2 Heavy sandy clay
2-4 Silty clay loam
4-6 Hard shale
6-9 Silty clay - moderate mottling
9-11 Hard shale

Well No: Z-12 Total Depth (ft): 9
Location: T02N, R21E, Sec 01, Tract BBAA Cased Depth (ft): Not Cased
Drilled by: TCD Slotted Interval:
Date Drilled: 11/19/83 Altitude: 4028.4

Depths (FT.)
0-4 Silt loam
4-6 Silty clay with visible salts
6-9 Silty clay loam with weak mottking

Well No: Z-13 Total Depth (ft): 13
Location: T02N, R21E, Sec 01, Tract BBAC Cased Depth (ft): 13
Drilled by: TCD Slotted Interval:
Date Drilled: 11/19/83 Altitude: 4011.3

Depths (FT.)
0-1 Silt loam - surface salts
1-13 Silty clay

Well No: Z-14 Total Depth (ft): 13
Location: T02N, R21E, Sec 01, Tract BBBB Cased Depth (ft): 13
Drilled by: TCD Slotted Interval:
Date Drilled: 11/19/83 Altitude: 4001.2

Depths (FT.)
0-10 Silty clay
10-13 Sandy shale

Well No: Z-15 Total Depth (ft): 10
Location: T02N, R21E, Sec 01, Tract ACBC Cased Depth (ft): 12
Drilled by: TCD Slotted Interval:
Date Drilled: 11/19/83 Altitude: 4025.4

Depths (FT.)
0-4 Fine sandy clay loam visible salts @ 3 feet
4-5 Silty clay
5-7 Sandy loam
7-10 Hard shale

Well No: Z-16 Total Depth (ft): 13
Location: T02N, R21E, Sec 01, Tract ACAB Cased Depth (ft): 13
Drilled by: TCD Slotted Interval:
Date Drilled: 11/19/83 Altitude: 4044.1

Depths (FT.)

0-2	Heavy silty clay loam
2-4	Silty clay with visible salts
4-9	Silty clay loam with visible salts
9-10	Sandy clay loam
10-13	Weathered shale with weak mottling

Well No: Z-17 Total Depth (ft): 12
Location: T02N, R21E, Sec 01, Tract BDAB Cased Depth (ft): Not Cased
Drilled by: TCD Slotted Interval:
Date Drilled: 11/19/83 Altitude: 4028.0

Depths (FT.)

0-2	Silt loam
2-4	Silty clay - compacted
4-8	Silty clay loam with visible salts
8-9	Weathered shale
9-12	Hard shale

Well No: Z-18 Total Depth (ft): 13
Location: T02N, R21E, Sec 01, Tract AACC Cased Depth (ft): 13
Drilled by: TCD Slotted Interval:
Date Drilled: 11/19/83 Altitude: 4068.4

Depths (FT.)

0-9	Silty clay
9-12	Weathered shale saturated zone @ 10 feet
12-13	Hard shale

Well No: Z-19 Total Depth (ft): 2.5
Location: T02N, R21E, Sec 01, Tract AADC Cased Depth (ft): Not Cased
Drilled by: TCD Slotted Interval:
Date Drilled: 11/19/83 Altitude: 4092.8

Depths (FT.)

0-2.5	Sandy clay loam
2.5	Sandy shale

Well No: Z-19A
Location: T02N, R21E, Sec 01, Tract AADC
Drilled by: TCD
Date Drilled: 11/19/83

Total Depth (ft): 7
Cased Depth (ft): Not Cased
Slotted Interval:
Altitude: 4092.8

Depths (FT.)

0-6	Sandy clay loam
6-7	Sandy shale

Well No: Z-20
Location: T02N, R21E, Sec 01, Tract ADCC
Drilled by: TCD
Date Drilled: 11/19/83

Total Depth (ft): 12
Cased Depth (ft): 12
Slotted Interval:
Altitude: 4044.7

Depths (FT.)

0-2	Sandy clay loam
2-5	Coimpacted sandy clay loam
5-9	silty clay
9-11	Weathered shale
11-12	Shale

Well No: Z-21
Location: T02N, R21E, Sec 01, Tract DCAC
Drilled by: TCD
Date Drilled: 11/19/83

Total Depth (ft): 13
Cased Depth (ft): 13
Slotted Interval:
Altitude: 3986.8

Depths (FT.)

0-1	Silty loam
1-12	Silty clay loam with visible salts, weak mottling saturated at 5 feet
12-13	Shale

Well No: Z-22
Location: T02N, R21E, Sec 01, Tract DBBB
Drilled by: TCD
Date Drilled: 11/19/83

Total Depth (ft): 9
Cased Depth (ft): 9
Slotted Interval:
Altitude: 4011.3

Depths (FT.)

0-1	Sandy clay loam
1-7	Sandy clay
7-8	Weathered shale
8-9	Hard sandy shale

Well No: Z-23 Total Depth (ft): 10
Location: T02N, R21E, Sec 01, Tract BCAD Cased Depth (ft): 10
Drilled by: TCD Slotted Interval:
Date Drilled: 11/19/83 Altitude: 3999.0

Depths (FT.)

0-4	Sandy loam
4-8	Fine sandy clay very moist @ 7 feet
8-9	Weathered shale with mottled
9-10	Shale

Well No: Z-24 Total Depth (ft): 10
Location: T02N, R21E, Sec 01, Tract BCDC Cased Depth (ft): 10
Drilled by: TCD Slotted Interval:
Date Drilled: 11/19/83 Altitude: 3979.40

Depths (FT.)

0-2	Silt loam
2-7	Fine sandy clay - compacted at 2 feet visible salts
7-9	Weathered shale
9-10	Shale

Well No: Z-25 Total Depth (ft): 13
Location: T02N, R21E, Sec 01, Tract DBCD Cased Depth (ft): 13
Drilled by: TCD Slotted Interval:
Date Drilled: 11/20/83 Altitude: 3996.3

Depths (FT.)

0-2	Silt loam
2-3	Silty clay
3-6	Sandy loam
6-8	Sandy clay loam (visible salts)
8-11	Silty clay (weak mottling)
11-13	Hard shale

Well No: Z-26 Total Depth (ft): 13
Location: T02N, R21E, Sec 01, Tract DACC Cased Depth (ft): 13
Drilled by: TCD Slotted Interval:
Date Drilled: 11/20/83 Altitude: 4003.3

Depths (FT.)

0-2	Sandy clay loam
2-5	Sandy clay
5-7	Gravely sandy clay less then 0.5" diameter gravels are well rounded
7-11	Sandy clay saturated at 9 feet
11-13	Hard shale

Well No: Z-27
Location: T02N, R21E, Sec 01, Tract DDAC
Drilled by: TCD
Date Drilled: 11/20/83

Total Depth (ft): 9
Cased Depth (ft): Not Cased
Slotted Interval:
Altitude:

Depths (FT.)

0-1	Silty clay loam
1-5	Silty clay
5-7	Weathered shale
7-9	Hard shale

Well No: Z-28
Location: T02N, R21E, Sec 01, Tract DADA
Drilled by: TCD
Date Drilled: 11/20/83

Total Depth (ft): 9
Cased Depth (ft): Not Cased
Slotted Interval:
Altitude: 4024.5

Depths (FT.)

0-2	Sandy clay loam
2-4	Compacted sandy clay
4-7	Sandy clay (visible salts)
6-7	Weathered shale
7-9	Hard shale

Well No: Z-29
Location: T02N, R21E, Sec 01, Tract CDDD
Drilled by: TCD
Date Drilled: 11/20/83

Total Depth (ft): 8
Cased Depth (ft): Not Cased
Slotted Interval:
Altitude: 3971.1

Depths (FT.)

0-3	Sandy clay
3-5	Weathered shale
5-8	Hard shale

Well No: Z-30
Location: T02N, R21E, Sec 01, Tract ADAA
Drilled by: MBMG
Date Drilled: 02/21/84

Total Depth (ft): 30
Cased Depth (ft): 30
Slotted Interval: 20-30
Altitude: 4086.6

Depths (FT.)

0-8	Fine sand, w/some silt, light brown, @7' moist w/ some pebbles
8-13	Fine sand and silt, very moist
13-18	Compacted and dry, darker brown, very small appearance of salts and oxdized zone
18-23	Sand and silt, harder zone @ 20', some ss chips
23-28	Moist thru 25', then dry, very hard sandstone (ss)

Well No: Z-31 Total Depth (ft): 13
Location: T02N, R21E, Sec 01, Tract AADB Cased Depth (ft): 13
Drilled by: MBMG Slotted Interval: 3-13
Date Drilled: 02/21/84 Altitude: 4103.0

Depths (FT.)

0-3	Sand w/pebbles, light brown
3-8	Medium sand w/pebbles (sub-angular), moderately hard drilling
8-13	Very hard sandstone, some moist balls of sand

Well No: Z-32 Total Depth (ft): 19
Location: T02N, R21E, Sec 01, Tract ABCB Cased Depth (ft): 19
Drilled by: MBMG Slotted Interval: 9-19
Date Drilled: 02/21/84 Altitude:

Depths (FT.)

0-3	Sand
3-11	Salts, silt w/clay moist
11-13	Sand, dry, color changed to light brown, ss pebbles, little harder drilling
13-15	Hard drilling, med-coarse sand
15-17	Softer, silt, light brown
17-19	Very hard, dark brown

Well No: Z-33 Total Depth (ft): 8
Location: T02N, R21E, Sec 01, Tract ABCA Cased Depth (ft): 8
Drilled by: MBMG Slotted Interval: 2-8
Date Drilled: 02/21/84 Altitude:

Depths (FT.)

0-3	Sand w/some pebbles
3-8	Medium sand and pebbles, damp @6', 8' very hard

Well No: Z-34 Total Depth (ft): 30
Location: T02N, R21E, Sec 01, Tract BACD Cased Depth (ft): 30
Drilled by: MBMG Slotted Interval: 10-30
Date Drilled: 02/21/84 Altitude: 4024.4

Depths (FT.)

0-7	Sand, silt w/some clay, binding to augers, salts and moist
7-11	Hard zone, med sand
11-12	Very hard ss
12-15	Moderately hard, dry ss w/chips and pebbles
15-16.5	Very hard
16.5-19	Soft drilling
19-20	Hard, coarse sand w/some silt, some salts and moisture
20-21	Moderately hard
21-24	Very soft
24-25	Moderately-very hard, saturated, color varies from black to tan
25-27.5	Very hard
27.5-30	Soft, weathered shale

Well No: Z-35 Total Depth (ft): 30
Location: T02N, R21E, Sec 01, Tract BBAD Cased Depth (ft): 30
Drilled by: MBMG Slotted Interval: 3-30
Date Drilled: 02/22/84 Altitude: 4027.2

Depths (FT.)

0-3	Sand
3-8	Sand and silt w/some clay
8-10	Some salts, moist, material binding to augers
10-15	Sand, silt and clay, moist
15-16	Very hard, grinding, ss chips
16-21	Soft, wet
21-21.5	Hard zone, ss chips, sand and silt
21.5-27	Soft, dry, bentonite, drab dark green color
27-30	Hard

Well No: Z-36 Total Depth (ft): 18
Location: T02N, R21E, Sec 01, Tract BBCA Cased Depth (ft): 18
Drilled by: MBMG Slotted Interval: 6-18
Date Drilled: 02/22/84 Altitude: 4006.9

Depths (FT.)

0-3	Silty sand (med) damp
3-5	Light brown silty sand w/some clay, moist
5-8	Silty sand w/some subangular to subrounded gravels
8-11	Silty sand, saturated
11-14	Bentonite
14-18	SS layer, bentonite, hard zone

Well No: Z-37 Total Depth (ft): 20
Location: T02N, R21E, Sec 01, Tract BBCD Cased Depth (ft): 20
Drilled by: MBMG Slotted Interval: 5-20
Date Drilled: 02/22/84 Altitude: 3998.6

Depths (FT.)

0-3	Weathered sand and silt
3-5	Dry consolidated ss
5-8	Sand and silt w/some prbbles
8-10	Sand, silt and clay
10-14	Hard zone, grinding, sand and silt
14-17	moist, very black organic clay
17-20	Hard ss

Well No: Z-38 Total Depth (ft): 25
Location: T02N, R21E, Sec 01, Tract BBCC Cased Depth (ft): 25
Drilled by: MBMG Slotted Interval: 5-25
Date Drilled: 02/22/84 Altitude: 3999.5

Depths (FT.)

0-3	Fine sand and silt, moist
3-5	Sand and clay w/ss chips and pebbles
5-10	Dark brown clay and silt, dry
10-14	Sand and silt, w/ss chips, light gray color
14-15	Moist, dark brown silt and clay
15-16.5	Hard zone
16.5-17	Soft, sand, silt and clay
17-19	Hard, silty sand w/ss chips
19-21	Soft, wet
21-25	Hard, grinding, bentonite

Well No: Z-39 Total Depth (ft): 26.5
Location: T02N, R21E, Sec 01, Tract ADAD Cased Depth (ft): 26.5
Drilled by: MBMG Slotted Interval: 4-26.5
Date Drilled: 02/23/84 Altitude:

Depths (FT.)

0-6	Fine sand w/silt, some ss pebbles, moist, light brown
6-7.5	Hard sandstone
7.5-10	Soft silty clay
10-15	Silt and clay, silt balls, moist
15-20	Hard, very dry, ground up ss, gray color
20-25	Ground up ss w/ss chips, tan color
25-26.5	Very hard

Well No: Z-40 Total Depth (ft): 40
Location: T02N, R21E, Sec 01, Tract ADCD Cased Depth (ft): 40
Drilled by: MBMG Slotted Interval: 6-36
Date Drilled: 02/23/84 Altitude: 4054.3

Depths (FT.)

0-3	Sand and silt, dry
3-6	Damp heavy clay w/some salt stringers
6-10	Fine sand and silt w/ss chips
10-13	Silty clay, some moisture
13-14	Hard sand and silt
14-17	Very hard, ss chips - gray
17-21	Softer, ground up ss - brown
21-22	Very hard
22-25	Silty clay, saturated
25-30	Silt and clay, dry @ 28'
30-33.5	Hard ss, dry
33.5-35	Silt and bentonite, saturated
35-40	Bentonite, greeninsh-gray, dry

Well No: Z-41 Total Depth (ft): 30
Location: T02N, R21E, Sec 01, Tract ABAC Cased Depth (ft): 30
Drilled by: MBMG Slotted Interval: 5-30
Date Drilled: 02/29/84 Altitude:

Depths (FT.)

0-2	Fine silt and silt balls
2-5	Fine-med sand w/pebbles
5-10	Silt w/some clay
10-15	Moderately hard, silt and clay and pebbles
15-20	Silt and clay, (with shale chips?)
20-25	Soft silty clay, moisture
25-27	Shale chips, clay and silt
27-30	Very tight, binding augers, 1st gear, shale

Well No: Z-42 Total Depth (ft): 40
Location: T02N, R21E, Sec 01, Tract ABBA Cased Depth (ft): Not Cased
Drilled by: MBMG Slotted Interval:
Date Drilled: 02/29/84 Altitude:

Depths (FT.)

0-4	Silt and shale
4-5	Hard siltstone
5-10	Silt w/clay
10-15	Clay and silt, dark brown
15-30	Clay and silt w/shale chips
30-40	Shale, black
	PLUGGED

Well No: Z-43 Total Depth (ft): 28
Location: T02N, R21E, Sec 01, Tract ABBA Cased Depth (ft): Not Cased
Drilled by: MBMG Slotted Interval:
Date Drilled: 03/01/84 Altitude:

Depths (FT.)

0-3	Fine silt and sand w/some clay, ss chips, light brown
3-5	Silt and sand w/some clay
5-10	Silt and sand w/ss and shale chips
10-25	Silt and shale, 17' harder
25-28	Very tight at 27'
	PLUGGED

Well No: Z-44 Total Depth (ft): 13
Location: T02N, R21E, Sec 01, Tract BDCA Cased Depth (ft): 13
Drilled by: MBMG Slotted Interval: 3-13
Date Drilled: 03/01/84 Altitude:

Depths (FT.)

0-4	Fine sand, silt, clay
4-5	SS zone, large chips
5-7	Dry ground up ss
7-10	Soft, gray fine sand w/some clay
10-13	Hard ground up ss, whitish gray

Well No: Z-45 Total Depth (ft): 27
Location: T02N, R21E, Sec 01, Tract BDCD Cased Depth (ft): 27
Drilled by: MBMG Slotted Interval: 5-27
Date Drilled: 03/01/84 Altitude:

Depths (FT.)

0-3	Sand and clay, moist
3-4	Hard ss, white-gray
4-8	Sand w/ss pebbles, brown
8-12	Hard zone
12-15	Soft, dark brown sand and clay w/some shale chips
15-20	Oxidized clay, very black organic layer
20-23	Organic clay w/brown clay == 22'
23-25	Hard brown sand and clay w/some chips
25-27	Very hard coarse sand and clay w/ss chips

Well No: Z-46 Total Depth (ft): 14
Location: T02N, R21E, Sec 01, Tract DACC Cased Depth (ft): 14
Drilled by: MBMG Slotted Interval: 4-14
Date Drilled: 03/01/84 Altitude:

Depths (FT.)

0-4	Dark brown silty clay, oxidized zone @ 2', salts @ 3'
4-8	Light brown silty clay
8-10	Yellow brown silty clay w/siltstone pebbles
10-14	Fine sand w/some clay, very hard @ 14'

Well No: Z-47 Total Depth (ft): 14
Location: T02N, R21E, Sec 01, Tract DACC Cased Depth (ft):
Drilled by: MBMG Slotted Interval: 4-14
Date Drilled: 03/01/84 Altitude: 3995.0

Depths (FT.)

0-4	Silt w/clay
4-5	Moderately hard, silt and clay w/ss chips
5-8	Silty clay w/some subrounded graels @ 6'
8-10	Fairly hard white-gray sand
10-14	Ground up ss

Well No: Z-48 Total Depth (ft): 25
Location: T02N, R21E, Sec 01, Tract CBBB Cased Depth (ft): 25
Drilled by: MBMG Slotted Interval: 5-25
Date Drilled: 03/01/84 Altitude: 3969.8

Depths (FT.)

0-5	Silt and clay, saturated @ 1'
5-10	Cilty clay
10-12	Dry dark bentonite, shale
12-15	Dry silty clay, oxidized
15-20	Very hard NO CUTTINGS
20-25	Very hard, grinding

Well No: Z-49 Total Depth (ft): 13
Location: T02N, R21E, Sec 01, Tract CAAC Cased Depth (ft): 13
Drilled by: MBMG Slotted Interval: 3-13
Date Drilled: 03/01/84 Altitude: 4035.0

Depths (FT.)

0-5	Silty clay, moist
5-10	Yellow brown clay, oxidized and salt stringers, dark green bentonite, moist
10-13	Very hard, grinding

Well No: Z-50 Total Depth (ft): 25
Location: T02N, R21E, Sec 01, Tract DDDA Cased Depth (ft): 25
Drilled by: MBMG Slotted Interval: 3-25
Date Drilled: 03/01/84 Altitude: 4019.7

Depths (FT.)

0-2	Fine sandy silt w/ss pebbles
2-3	Green bentonite
3-5	Tight sandy silt clay, light brown-black color
5-10	Fine sand and clay (brown), w/some angular to sub angular gravels
10-11	Hard zone
11-15	Silty sand
15-20	Brown sandy clay, oxidized and salt stringers
20-22	Moist, hard drilling
22-25	Dry clay, very hard

Well No: Z-51 Total Depth (ft): 28
Location: T02N, R21E, Sec 01, Tract ADDA Cased Depth (ft): 28
Drilled by: MBMG Slotted Interval: 18-28
Date Drilled: 10/17/85 Altitude: 4069.9

Depths (FT.)

0-1	Clay, brown, calc
1-3	Silt, light brown, calc, salts
3-7	Silt, light brown, non calc, sandstone fragments
7-8	Sandstone, light brown
8-11	Silt, light brown, non calc, sandstone fragments
11-13	Silt, dark brown, sandy, some clayey, non calc, some oxidized sandstone fragments
13-15	Silt, dark brown, clayey
15-16	Sandstone, light brown
16-18	Silt, dark brown, clayey
18-23	Sand, light to dark brown, clayey, non calc, some sandstone fragments, very moist
23-28	Clay, brown silty, bentonite stringers throughout, greeninsh gray
28	Very hard drilling

Well No: Z-52 Total Depth (ft): 37 (57)
Location: T02N, R21E, Sec 01, Tract ADCA Cased Depth (ft): 37 (57)
Drilled by: MBMG Slotted Interval: 17-37
Date Drilled: 10/17/85 Altitude: 4062.2 (4070.0)

Depths (FT.)

0-0.5	Clay, dark brown, non calc
0.5-8	Silt, light brown, sandy vf-fn, calc, salts and sandstone fragments
8-10	Clay, yellowish brown, sandy, salts, calc
10-13	Silt, dark brown, clayey, calc with sandstone fragments, moist
13-14	Hard layer, siltstone (?)
14-18	Silt, brown, clayey, non calc, some lignite and oxidation (Fe)
18-23	Clay, dark brown, silty, non calc with bentonite stringers, light gray, moist
23-28	Clay, dark brown, silty, non calc, hard drill 26-27'
28-30	Clay, dark brown, silty, non calc with oxidized zones (Fe) and bentonite stringers
30-37	Clay, dark brwn to grayish black, non calc, some lignite, moist
37	Very hard drilling

Well No: Z-53 Total Depth (ft): 25
Location: T02N, R21E, Sec 01, Tract ADBD Cased Depth (ft): 25
Drilled by: MBMG Slotted Interval: 15-25
Date Drilled: 10/17/85 Altitude: 4074.4 (4082.0)

Depths (FT.)

0-0.5	Clay, brown, silty, non calc
0.5-3	Silt, very light brown, calc, salts
3-5	Silt, yellowish brown, calc, oxidized (Fe)
5-9	Silt, yellow, clayey, calc
9-10	Bentonite, olive gray
10-18	Sand, yellow, clayey, VF, calc, oxidized (Fe) with bentonite stringers
23-25	Sandstone, brown, silty, non calc, hard drilling

Well No: Z-54 Total Depth (ft): 23.5
Location: T02N, R21E, Sec 01, Tract ADDD Cased Depth (ft): 23.5
Drilled by: MBMG Slotted Interval:16-23.5
Date Drilled: 10/22/85 Altitude: 4051.7 (4058.0)

Depths (FT.)

0-2.5	Clay, brown, silty, non calc, salts
2.5-3	Clay, light brown, silty, calc, salts
3-5	Silt, very light brown, calc
5-9	Sand, light brown to yellow, non calc with gray sand stringers, moist
9-13	Silt, dark brown, clayey, with bentonite gray
13-15	Silt, light yellow, non calc
15-15.5	Hard drilling, bentonite
15.5-17	Silt, light yellow, non calc
17-18	Clay, dark brown, very silty, non calc, very moist
18-22	Clay, light gray and dark brown, mottled, sandy, oxidized (Fe), very moist, hard drilling 18′
22-23	Clay, light gray and dark brown, sandy, slightly calc, slightly oxidized (Fe), saturated at 22′
23-23.5	Clay, dark brown to grayish black, slightly silty, organic dry
23.5	Very resistant bed

Well No: Z-55 Total Depth (ft): 27.5
Location: T02N, R21E, Sec 01, Tract ADCA Cased Depth (ft): 27.5
Drilled by: MBMG Slotted Interval: 17.5-27.5
Date Drilled: 10/22/85 Altitude: 4048.2

Depths (FT.)

0-1	Silt, yellowish brown, clayey, calc, moist
1-3	Clay, brown, very compact, calc, salts
3-5	Clay, light brown, very compact, calc
5-8	Sand, very light brown, clayey, calc, salts
8-8.5	Sandstone, olive gray
8.5-10	Interbedded sandstone, light gray and clay, brown, silty
10-20	Interbedded sandstone, light gray, sand light gray and siltstone light gray, clac
20-23	Clay, brown, very compact, non calc, very moist
23-25	Clay, light gray, sandy, compact, non calc
25-26	Sandstone
26-27.5	Clay, light gray
27.5	Sandstone

Well No: Z-56 Total Depth (ft): 34
Location: T02N, R21E, Sec 01, Tract ADCA Cased Depth (ft): 34
Drilled by: MBMG Slotted Interval: 24-34
Date Drilled: 10/22/85 Altitude: 4060.9

Depths (FT.)

0-2	Clay, dark brown
2-5	Silt, very light brown, sandy, non calc with sandstone fragments
5-7	Sandstone
7-8	Silt, olive gray, non calc
8-12	Silt, very light brown, non calc
12-13	Clay, dark brown, silty, with bentonite, moist
13-16	Silt, very light brown, clayey, calc, moist
16-18	Silt, brown, clayey, oxidized (Fe) with very fine gravels
18-23	Silt, brown, clayey, oxidized (Fe) with sandstone fragments
23-25	Silt, brown, clayey
25-27	Clay, dark brown, silty, with bentonite stringers, saturated 27'
27-30	Clay, dark brown to dark gray, with some coarse sand
30-32	Same as above with bentonite stringers
32-34	Shale, dark gray, weathered, non calc

Well No: Z-57 Total Depth (ft): 38
Location: T02N, R21E, Sec 01, Tract ADBD Cased Depth (ft): 38
Drilled by: MBMG Slotted Interval: 28-38
Date Drilled: 10/22/85 Altitude: 4073.1

Depths (FT.)

0-0.5	Silt, brown, clayey, non calc
0.5-3	Silt, very light brown to light gray, calc, salts
3-5	Silt, greenish gray with shale chips, olive green, calc
5-8	Silt, brown, non calc
8-10	Silt, yellowish brown, oxidized zones (Fe), slightly calc
10-13	Sandstone, light gray, calc
13-18	Silt, light gray, calc, with shale chips, olive green
18-19	Sandstone
19-28	Silt, dark brown, some sandstone fragments
28-33	Shale, olive green
33-36	Silt, light to dark brown with shale chips
36-38	Sandstone, bluish gray, saturated

Well No: Z-58 Total Depth (ft): 29
Location: T02N, R21E, Sec 01, Tract ADBC Cased Depth (ft): 29
Drilled by: MBMG Slotted Interval: 19-29
Date Drilled: 10/22/85 Altitude: 4063.6

Depths (FT.)

0-3	Shale, purple and silt, light pink
3-13	Siltstone, olive gray with interbedded shale, purple, moist
13-17	Clay, brown, silty with bentonite stringers, gray
17-18	Silt, light brown withh shale chips
18-23	Silt, light brown
23-28	Siltstone, reddish brown, oxidized (Fe) with clay stringers, olive gray, compact, silty
28-29	Clay, olive gray, saturated

Well No: Z-59 Total Depth (ft): 31
Location: T02N, R21E, Sec 01, Tract ADCB Cased Depth (ft): 31
Drilled by: MBMG Slotted Interval: 21-31
Date Drilled: 10/22/85 Altitude: 4047.4

Depths (FT.)

0-3	Silt, light brown, clayey
3-8	Silt, dark brown, clayey, moist
8-13	Clay, grayish brown, silty, mottled
13-18	Clay, grayish brown, silty with bentonite stringers
18-23	Clay, dark brown, silty with bentonite stringers and lignite, moist
23-28	Clay, dark gray, silty, with bentonite stringers
28-31	Clay, dark gray, silty, saturated
31	Hard drilling

Well No: Z-60 Total Depth (ft): 18
Location: T02N, R21E, Sec 01, Tract ACAD Cased Depth (ft): 18
Drilled by: MBMG Slotted Interval: 8-18
Date Drilled: 10/23/85 Altitude: 4046.06

Depths (FT.)

0-1	Silt, brown, clayey
1-2	Clay, brown, silty, salts
2-2.5	Siltstone, olive gray
2.5-3	Clay, brown, silty, salts
3-8	Interbedded siltstone, olive gray, and clay, dark brown, silty
8-12	Silt, brown, with shell fragments(?), moist
12-13	Siltstone, olive gray, clayey, moist
13-16	Clay, dark brown, with coarse sand to fine gravels, saturated
16-18	Shale, dark gray, weathered, with bentonite stringers, dry

Well No: Z-61 Total Depth (ft): 28
Location: T02N, R21E, Sec 01, Tract ADBC Cased Depth (ft): 28
Drilled by: MBMG Slotted Interval: 18-28
Date Drilled: 10/23/85 Altitude: 4056.06

Depths (FT.)

0-0.5	Silt, light brown, sandy, organics
0.5-3	Sand, very light gray, VF with sandstone fragments, weathered VF-F
3-6	Sandstone, reddish brown and greeninsh gray, VF, oxidized (Fe) with interbedded shale, olive gray
6-8	Sandstone, very light gray, VF
8-13	Interbedded sandstone, gray, VF, oxidized (Fe) and shale, olive gray
13-18	Sandstone, yellowish brown, VF, Some oxidation (Fe) with some interbedded shale, purple
18-23	Sandstone, yellowish brown, VF, oxidized (Fe), interbedded with shale and bentonite, gray, satturated at 22'
23-25	Clay, light gray to bluish gray, silty
25-28	Shale, dark gray, dry

Well No: Z-62 Total Depth (ft): 20
Location: T02N, R21E, Sec 01, Tract ADBC Cased Depth (ft): 20
Drilled by: MBMG Slotted Interval: 9.5-19.5
Date Drilled: 10/23/85 Altitude: 4076.94

Depths (FT.)

0-2	Silt, brown
2-3	Silt, very light brown
3-5	Sandstone, brown
5-8	Sand, very light brown
8-9	Sandstone, brown
9-13	Interbedded sandstone brown and clay brown
13-16	Siltstone, olive gray
16-18	Silt, light gray interbedded with shale olive gray
18-20	Sandstone
20	Very hard drilling

Well No: Z-63 Total Depth (ft): 11
Location: T02N, R21E, Sec 01, Tract ADAD Cased Depth (ft): 11
Drilled by: MBMG Slotted Interval: 9-11
Date Drilled: 10/23/85 Altitude: 4096.4

Depths (FT.)

0-0.5	Sand, dark brown, clayey
0.5-4	Sand, light yellow, VF with sandstone fragments
4-5	Shale, olive gray
5-8	Clay, light gray, shaley
8-11	No return, very hard zone

BRICKLEY OBSERVATION WELLS

Well No: B1 — Total Depth (ft): 23
Location: T04N, R20E, Sec 02, Tract AABB — Cased Depth (ft): 24
Drilled by: SCS — Slotted Interval:
Date Drilled: 10/10/74 — Altitude: 4080.0

DEPTHS (ft)

Quaternary - Colluvium

0.0 - 1.5	Silty clay loam; very little A horizon soil, shale chips noted, "loose".
1.5 - 3.0	Silty clay loam; zone of $CaCO_3$ concentration, shale chips noted.
3.0 - 15.0	Silty clay; very difficult drilling, shale chips and gypsum crystals noted; weathered red shaley zone with gypsum and calcite at about 10 feet (this may represent the top of the Colorado shale.)

Cretaceous - Colorado Shale

15.0 - 16.0	Weathered shale; wet.
16.0 - 18.0	Black shale; dry.
18.0 - 23.0	Black shale; powder dry, sulfur smell in the hole.

Well No: B2 — Total Depth (ft): 23
Location: T04N, R20E, Sec 02, Tract ADBA — Cased Depth (ft): 25
Drilled by: SCS — Slotted Interval:
Date Drilled: 10/10/74 — Altitude: 4065.0

DEPTHS (ft)

Quaternary - Colluvium

0.0 - 0.5	Soil: A horizon.
0.5 - 2.0	Soil: B horizon.
2.0 - 3.0	Subsoil: C horizon, caliche zone present.
3.0 - 10.0	Silty clay, blackish brown.

Cretaceous - Colorado Shale

10.0 - 17.0	Silty clay as above; iron stained calcite as vein fillings or stringers, shale chips present.
17.0 - 20.0	As above, wet.
20.0 - 23.0	Shale, dry.

Well No: B4 — Total Depth (ft): 23
Location: T04N, R20E, Sec 35, Tract DACC — Cased Depth (ft): 22
Drilled by: SCS — Slotted Interval:
Date Drilled: 11/10/74 — Altitude: 4130.0

DEPTHS (ft)

Quaternary - Colluvium

0.0 - 5.0	Silty clay loam with some fine sand; dry.
5.0 - 11.0	Sandy clay loam with angular pebbles (1 cm) of Eagle Sandstone.
11.0 - 13.0	Conglomeratic calcareous sandstone; tan, pebbles are derived from Eagle Sandstone.
13.0 - 14.0	Silty clay loam; brown (may be weathered shale).

Cretaceous - Colorado Shale

14.0 - 20.0	Shale; damp, weathered(?)
20.0 - 23.0	Shale.

Well No: B8 Total Depth (ft): 25
Location: T04N, R20E, Sec 35, Tract DDBB Cased Depth (ft): 24
Drilled by: SCS Slotted Interval:
Date Drilled: 10/24/74 Altitude: 4110.0

DEPTHS (ft)

Quaternary - Colluvium

0.0 - 2.5	Silty clay loam.
2.5 - 3.2	Silty clay; much gypsum.
3.2 - 7.3	Silty clay; gypsum in joints and fractures; less silty in interval 4.5 4.8 feet; brown calcite zone at 5.5 feet. Fractures are both vertical and horizontal.
7.3 - 7.5	Siltstone (?); gypsiferous, carbonaceous, oxidized red.
7.5 - 7.8	Clay
7.8 - 8.0	Siltstone(?); gypsiferous, carbonaceous, oxidized red.

Cretaceous - Colorado Shale

8.0 - 13.2	Shale, weatherd; calcareous with carbonaceous black chips, minor silt, 2 types of gypsum (crystalline and powdered)
13.2 - 13.4	Silty clay; crumbly.
13.4 - 13.5	Clay; gypsiferous, plant fragments noted; harder to core.
13.5 - 13.8	Clay; contains very fine sand.
13.8 - 18.0	Clay; contains some silt; horizontal layers of gypsum rich clay present, large crystals are easily crushed to powder.
18.0 - 18.7	Shale, fresh, black.
18.7 - 25.0	Siltstone with some sand and thin limestone stringers; fossils in limestone.

Well No: B12 Total Depth (ft): 45
Location: T04N, R20E, Sec 35, Tract DADD Cased Depth (ft): 45
Drilled by: SCS Slotted Interval:
Date Drilled: 08/26/75 Altitude: 4100.0

DEPTHS (ft)

0.0 - 2.5	Light gray brown silty sand - dry.
2.5 - 5.0	Light gray brown silty sand, slightly darker than above.
5.0 - 10.0	Light gray brown sandy silt.
10.0 - 15.0	Light gray brown sandy silt - increasing clay content - dry.
15.0 - 20.0	Gray brown silt - clay - crystal gypsum salts?
20.0 - 22.5	Drilling speed slowing, slightly moist clayey silt - light gray w/ brown cast.
22.5 - 25.0	Medium gray shale, weathered (hit shale about 21)
25.0 - 30.0	Water entering hole probably from above at about 18 - 20 feet. Very small amount - about 2 quarts.
30.0 - 35.0	Very blue mud - moist to wet.
35.0 - 40.0	Moist material w/ fragments of black shale - very little weathered.
40.0 - 45.0	Drilling very slow again - put in low speed - black weathered shale - dry.

Well No: B13 Total Depth (ft): 26
Location: T04N, R20E, Sec 35, Tract DADA Cased Depth (ft): 26
Drilled by: SCS Slotted Interval:
Date Drilled: 08/26/75 Altitude: 4120.0

DEPTHS (ft)

0.0 - 2.5	Light brown silty sand - soil dry.
2.5 - 5.0	Medium-light gray brown sandy silt - slightly darker than above - dry.
5.0 - 10.0	Medium-light brown numerous gypsum "crystals" - 1 was 10-12 mm across by 6mm thick.
10.0 - 15.0	Medium-brown silty clay increasing moisture at 14 feet.
15.0 - 20.0	Water came up with the auger at 20' probably from about 14' < 2 quarts.
20.0 - 25.0	Very weathered wet shale with much crystals - gypsum etc. More water again - a gallon or so.
25.0 - 26.0	Encountered resisted layer (probably hard shale or concretion) rig raising up and will not penetrate.

More water in this hole than in B12 500 feet down hill
Dry shale on auger near bottom.

Well No: B14 Total Depth (ft): 60
Location: T04N, R20E, Sec 35, Tract DADC Cased Depth (ft): 60
Drilled by: SCS Slotted Interval:
Date Drilled: 08/26/75 Altitude: 4110.0

DEPTHS (ft)

0.0 - 5.0	Medium-dark brown moist clayey silt.
5.0 - 10.0	Medium brown silt less moist and dark than above. Some VF sand some moistness may be from drill stem which is still wet from last hole.
10.0 - 15.0	Medium-dark brown moist clayey silt - little or no sand.
15.0 - 20.0	Medium-dark brown moist clay - silt some small crystals salts.
20.0 - 25.0	Gray brown moist silty clay - few fragments of very weathered shale.
25.0 - 30.0	Brown / gray brown moist clay - very moist at 30'.
30.0 - 35.0	Same as above.
35.0 - 40.0	Very moist brown clay - with some silt.
40.0 - 45.0	Moist brown clay - rock fragments - some weathered shale - rock fragments may be out of place.
45.0 - 50.0	Uniform moist brown clay - some small shale fragments - water.
50.0 - 55.0	Slow drilling probably encounter shale (weathered) nothing coming up on auger.
55.0 - 60.0	Rig raising up at times, slow drilling.

Well No: B15
Location: T04N, R20E, Sec 02, Tract ADAD
Drilled by: SCS
Date Drilled: 08/26/75

Total Depth (ft): 23
Cased Depth (ft): 20
Slotted Interval: 13-23
Altitude: 4050.0

DEPTHS (ft)

0.0 - 6.0	Topsoil; silt, dark gray-brown, slightly moist, w/ lumps of silty gray clay; some shaley pieces noted.
6.0 - 7.0	Same as above, darker; shalier, flakes of muscovite noted, firmer.
7.0 - 15.0	Silty shale, as above, somewhat softer than 6-7′ interval.
15.0 - 23.0	Becoming very clayey-shaley, "tight"; still fairly dry (only slightly moist). Drilling discontinued at 23′; water noted coming into well at 15-16′ BLS. Well caved to 20′; 4′ extension added.

Well No: B16
Location: T04N, R20E, Sec 01, Tract BCBC
Drilled by: SCS
Date Drilled: 08/26/75

Total Depth (ft): 18
Cased Depth (ft): 20
Slotted Interval: 18-Top
Altitude: 4050.0

DEPTHS (ft)

0.0 - 5.0	Topsoil, silt w/ clay, dark gray-brown.
5.0 - 7.0	Harder, micaceous zone.
7.0 - 12.0	More clay; shaley, otherwise as above (a silty clay w/ small shale bits; some limonite stains, flecks of muscovite)
14.0 - 18.0	Shale, "tight", gray-brown. Drilling stopped at 18′. Water seeping in at approximately 12′ BLS.

Well No: B18
Location: T04N, R20E, Sec 36, Tract CBCB
Drilled by: SCS
Date Drilled: 08/26/75

Total Depth (ft): 35
Cased Depth (ft): 35
Slotted Interval:
Altitude: 4030.0

DEPTHS (ft)

0.0 - 2.5	Soil - gray - gray-brown, dry.
2.5 - 7.5	Soil. Encounter harder drilling at 5′ lens of limonite; silty sand; dry.
7.5 - 12.5	harder lens at about 9′. Sandy silty-brown with small weathered shale fragments - dry.
12.5 - 17.5	Drill chattering, raising up at 15′ sandy silt coming up on auger. May have hit top of weathered shale.
17.5 - 20.0	Stem binding put drill in slow speed - softer lens.
20.0 - 22.5	Brown silt-clay with numerous weathered shale chips - dry hard drilling.
22.5 - 27.5	Brown silt-clay - hard drilling - weathered shale, shale chips.
27.5 - 32.5	Very hard drilling - <u>dry</u> weathered shale gray gray-brown crystals gypsum?
32.5 - 35.0	Extremely hard drilling. Chip of black weathered shale - <u>dry</u>.

About 17′ down hole appears to be a moister zone where seep <u>may</u> enter hole at later time. Hole was dry all the way down while drilling.

Well No: B20
Location: T04N, R20E, Sec 35, Tract DDAB
Drilled by: SCS
Date Drilled:

Total Depth (ft): 38
Cased Depth (ft):
Slotted Interval:
Altitude: 4100.0

DEPTHS (ft)

0.0 - 5.0	Dry. Tan-light gray brown soil - silty clay.
5.0 - 10.0	Dry. Medium gray brown sily clay - very little moisture.
10.0 - 15.0	Dry. Medium brown silty clay. Salts? visible.
15.0 - 20.0	Dry. Harder drilling, darker gray brown silty clay.
20.0 - 25.0	Dry. Gray brown - silty clay powdery.
25.0 - 30.0	Dry. Medium gray brown silty clay. Harder drilling. Driller added water to increase drillability.
30.0 - 35.0	Hard drilling - blue gray silty sandy clay - moisture from water added by driller. Dry material shows numerous weathered shale fragments.
35.0 - 38.0	Dry gray black weathered shale - powdered by auger.

Dry hole all the way - all moisture was added by driller.

APPENDIX B
Water-level and Specific-Conductance Readings, 10-Year Demonstration Site and Brickley Site

	Z-1			Z-2			Z-5		
	1.40			1.20			1.60		
	3957.30			3966.20			3970.20		
MM-DD-YY	SWL	ELEV	SC @25	SWL	ELEV	SC @25	SWL	ELEV	SC @25
01-20-84	.60	3956.70		1.20	3965.00		.10	3970.10	
04-04-84	2.20	3955.10		1.50	3964.70		1.30	3968.90	
04-14-89	2.50	3954.80		2.50	3963.70		1.70	3968.50	
04-29-84	2.00	3955.30		2.40	3963.80		1.00	3969.20	
05-10-84	1.30	3956.00		1.10	3965.10		.90	3969.30	
05-20-84	2.40	3954.90		2.40	3963.80		1.50	3968.70	
05-27-84	2.80	3954.50		2.80	3963.40		1.70	3968.50	
06-01-84	3.00	3954.30		2.80	3963.40		2.00	3968.20	
06-20-84	3.20	3954.10	10100	3.10	3963.10	4450	2.50	3967.70	7400
07-02-84	3.90	3953.40	9500	3.60	3962.60	4450	3.40	3966.80	7500
07-16-84	4.40	3952.90	9250	3.90	3962.30	4500	4.20	3966.00	7350
07-30-84	4.90	3952.40	9100	4.60	3961.60	4450	4.30	3965.90	7200
08-13-84	5.30	3952.00	9050	5.00	3961.20	4400	4.60	3965.60	7150
08-27-84	5.60	3951.70	9200	5.20	3961.00	4450	4.70	3965.50	7350
12-07-84	5.10	3952.20	8800	4.90	3961.30	4316	4.20	3966.00	7150
02-28-85	6.00	3951.30		4.80	3961.40		4.40	3965.80	
06-06-85	3.70	3953.60	810	3.90	3962.30	4400	3.80	3966.40	7950
06-20-85	4.20	3953.10		4.40	3961.80		4.80	3965.40	
07-05-85	4.80	3952.50	9000	5.40	3960.80	4050	4.90	3965.30	7250
07-20-85	5.20	3952.10		6.00	3960.20		5.50	3964.70	
08-15-85	4.80	3952.50	8750	6.20	3960.00	4150	5.60	3964.60	6200
09-20-85	5.80	3951.50	9150	6.50	3959.70	4050	5.40	3964.80	7950
10-24-85	3.30	3954.00	11700	6.70	3959.50	4200	5.90	3964.30	5850
12-07-85	4.70	3952.60	11600	6.50	3959.70	4900	5.00	3965.20	6400
03-18-86	2.90	3954.40	8100				2.76	3967.44	5600
04-22-86	3.45	3953.85	9750	3.70	3962.50	4600	.67	3969.53	8300
05-28-86	2.69	3954.61	13600	2.37	3963.83	4400	1.67	3968.53	10700
06-13-86	2.40	3954.90	1350	2.20	3964.00	6400	1.90	3968.30	7750
06-28-86	2.60	3954.70		2.40	3963.80		2.00	3968.20	
07-19-86	RECORDER INSTALLED			2.70	3963.50	8750	3.40	3966.80	5050
07-26-86				2.00	3964.20		2.90	3967.30	
08-16-86				1.80	3964.40	8650	2.00	3968.20	4900
08-31-86				1.70	3964.50		2.00	3968.20	
09-09-86				1.70	3964.50	8650	2.00	3968.20	5100
09-17-86				1.90	3964.30	8950	1.90	3968.30	4000
10-18-86				1.90	3964.30	9150	1.80	3968.40	3200
10-25-86				1.90	3964.30	9150	1.90	3968.30	
11-08-86									
11-17-86									
06-04-87				3.00	3963.20	5050	2.50	3967.70	6200
06-21-87				3.75	3962.45	4850	3.08	3967.12	6650
07-02-87				4.08	3962.12	4700	3.50	3966.70	5550
07-24-87				4.17	3962.03	7550	2.75	3967.45	8800
08-27-87				3.58	3962.62	4300	2.08	3968.12	6350
09-27-87				4.75	3961.45	4600	2.67	3967.53	5600
10-31-87				5.08	3961.12	5450	3.08	3967.12	7000
11-25-87				5.41	3960.79	5500	3.25	3966.95	6600
04-05-88				3.42	3962.78	2400	3.25	3966.95	3200
04-29-88				3.64	3962.56	2500	2.40	3967.80	3200
05-14-88				2.55	3963.65	7400	.71	3969.49	3600
06-10-88				3.45	3962.75	7450	2.01	3968.19	3600
06-26-88				4.56	3961.64	6000	3.28	3966.92	3150
07-23-88				6.13	3960.07	6950	4.37	3965.83	3300
08-88				5.86	3960.34	5550	4.40	3965.80	3150
09-88				7.22	3958.98	6250	5.54	3964.66	3300
10-88				6.69	3959.51	4900	3.31	3966.89	3550
05-19-89							3.00	3967.20	7500
05-20-89				5.00	3961.20	5420			
06-04-89				4.60	3961.60	5180	3.20	3967.00	8410
06-20-89				5.20	3961.00	5360	3.60	3966.60	8860
06-21-89									
07-06-89				5.60	3960.60	5740	4.00	3966.20	8920
07-07-89									
07-24-89				6.20	3960.00	5690	4.30	3965.90	8600
08-26-89				6.80	3959.40	5560			
08-27-89							4.00	3966.20	8330
09-21-89				7.20	3959.00	5603	4.50	3965.70	8160
10-08-89				6.70	3959.50	5866	5.20	3965.00	8800
04-08-90				8.30	3957.90	4010	5.00	3965.20	10990
05-09-90				6.20	3960.00	4140	5.00	3965.20	9520
06-03-90				5.40	3960.80	4340	5.00	3965.20	10710
06-20-90									
07-04-90				7.10	3959.10	3620	5.00	3965.20	10590
07-20-90				8.40	3957.80	4390	5.60	3964.60	9750
08-09-90				8.90	3957.30	4320	5.90	3964.30	6380
09-15-90				9.00	3957.20	4560	6.20	3964.00	6700
10-21-90				8.50	3957.70	4480	5.80	3964.40	6860

	Z-7			Z-8			Z-13		
		1.40						2.00	
		3970.10			3963.80			4011.30	
MM-DD-YY	SWL	ELEV	SC @25	SWL	ELEV	SC @25	SWL	ELEV	SC @25
01-20-84	3.80	3966.30		.10	3963.70		1.90	4009.40	
04-04-84	4.80	3965.30		1.10	3962.70		3.20	4008.10	
04-14-84	5.10	3965.00		1.90	3961.90		3.30	4008.00	
04-29-84	4.90	3965.20		1.60	3962.20		2.90	4008.40	
05-10-84	4.20	3965.90		.60	3963.20		1.80	4009.50	
05-20-84	4.85	3965.25		1.60	3962.20		2.00	4009.30	
05-27-84	5.50	3964.60		2.00	3961.80		2.30	4009.00	
06-01-84	5.10	3965.00		2.20	3961.60		2.40	4008.90	
06-20-84	5.55	3964.55	3450	2.60	3961.20	29000			
07-02-84	5.75	3964.35		3.10	3960.70	29500	3.40	4007.90	44000
07-16-84	D			3.60	3960.20	33000	4.30	4007.00	43000
07-30-84				3.90	3959.90	36500	4.70	4006.60	43500
08-13-84				4.30	3959.50	36000	5.20	4006.10	42500
08-27-84				4.60	3959.20	35500	5.50	4005.80	42000
12-07-84				4.50	3959.30	32500	4.70	4006.60	41500
02-28-85				4.90	3958.90		5.90	4005.40	
06-06-85				3.10	3960.70	5750	4.80	4006.50	27000
06-20-85				3.10	3960.70		5.70	4005.60	
07-05-85				3.80	3960.00	18000	5.60	4005.70	18000
07-20-85				4.20	3959.60		D		
08-15-85				4.20	3959.60	28000	6.50	4004.80	31000
09-20-85				4.70	3959.10	27000	6.30	4005.00	25000
10-24-85				4.80	3959.00	29000	6.30	4005.00	36000
12-07-85				4.30	3959.50	29500	D		
03-18-86				1.17	3962.63	11500	5.48	4005.82	36000
04-22-86				1.01	3962.79	12000	3.44	4007.86	38500
05-28-86				1.65	3962.15	16500	3.19	4008.11	46000
06-13-86				1.40	3962.40	13500	2.70	4008.60	42500
06-28-86				1.70	3962.10		3.00	4008.30	
07-19-86				3.30	3960.50	24500	D		
07-26-86				3.00	3960.80		D		
08-16-86				2.70	3961.10	24500	D		
08-31-86				2.70	3961.10		D		
09-09-86				2.50	3961.30	26000	D		
09-17-86				2.70	3961.10	25000	D		
10-18-86				2.70	3961.10	25000	D		
10-25-86				2.70	3961.10	26000	D		
11-08-86							D		
11-17-86							D		
06-04-87				2.67	3961.13	26000	3.33	4007.97	40500
06-21-87				2.58	3961.22	23500	5.00	4006.30	42000
07-02-87				2.67	3961.13	26000	3.67	4007.63	42500
07-24-87				2.25	3961.55	32000	3.67	4007.63	40500
08-27-87				FILLED IN			4.33	4006.97	39500
09-27-87							4.67	4006.63	36000
10-31-87							4.92	4006.38	40000
11-25-87							5.00	4006.30	40500
04-05-88							5.00	4006.30	20000
04-29-88							4.61	4006.69	21500
05-14-88							2.85	4008.45	19500
06-10-88							3.59	4007.71	21000
06-26-88							4.97	4006.33	20500
07-23-88							4.65	4006.65	19000
08-88							6.34	4004.96	24000
09-88							6.29	4005.01	25000
10-88							7.11	4004.19	26000
05-19-89									
05-20-89							4.80	4006.50	14880
06-04-89							4.40	4006.90	15470
06-20-89									
06-21-89							5.60	4005.70	15770
07-06-89							5.70	4005.60	16060
07-07-89									
07-24-89							6.30	4005.00	15200
08-26-89									
08-27-89							6.50	4004.80	15800
09-21-89							7.00	4004.30	14800
10-08-89							7.20	4004.10	15350
04-08-90							6.80	4004.50	19950
05-09-90							6.80	4004.50	14480
06-03-90							5.60	4005.70	14100
06-20-90									
07-04-90							5.70	4005.60	30250
07-20-90							7.20	4004.10	32880
08-09-90							7.10	4004.20	37410
09-15-90							6.20	4005.10	36620
10-21-90							6.00	4005.30	35320

	Z-14 2.20 4001.20			Z-15 1.60 4025.40			Z-16 1.80 4044.10		
MM-DD-YY	SWL	ELEV	SC @25	SWL	ELEV	SC @25	SWL	ELEV	SC @25
01-20-84	1.60	3999.60		8.20	4017.20		11.60	4032.50	
04-04-84	2.80	3998.40		10.30	4015.10		14.85	4029.25	
04-14-84	2.90	3998.30		10.35	4015.05		14.85	4029.25	
04-29-84	2.70	3998.50		9.45	4015.95		14.85	4029.25	
05-10-84	1.80	3999.40		10.65	4014.75		14.70	4029.40	
05-20-84	1.90	3999.30		10.40	4015.00		14.80	4029.30	
05-27-84	2.30	3998.90		9.65	4015.75		14.80	4029.30	
06-01-84	2.30	3998.90		9.70	4015.70		14.80	4029.30	
06-20-84									
07-02-84	3.20	3998.00	41500	10.45	4014.95		D		
07-16-84	3.70	3997.50	40500	10.70	4014.70		D		
07-30-84	4.10	3997.10	40500	D			D		
08-13-84	4.40	3996.80	40000	D			D		
08-27-84	4.80	3996.40	39500	D			D		
12-07-84	5.70	3995.50	38000	D			D		
02-28-85	5.50	3995.70		D			D		
06-06-85	3.80	3997.40	36500	D			D		
06-20-85	4.30	3996.90		D			D		
07-05-85	4.90	3996.30	32500	D			D		
07-20-85	5.20	3996.00		D			D		
08-15-85	5.80	3995.40	34500	D			D		
09-20-85	5.80	3995.40	37500	D			D		
10-24-85	6.40	3994.80	3600	D			D		
12-07-85	7.00	3994.20	40000	D			D		
03-18-86	4.98	3996.22	37500	D			11.90	4032.20	17740
04-22-86	3.90	3997.30	38500	D			D		
05-28-86	3.20	3998.00	51500	D			D		
06-13-86	3.20	3998.00	41000						
06-28-86	3.50	3997.70							
07-19-86	5.80	3995.40	31500						
07-26-86	5.20	3996.00							
08-16-86	4.70	3996.50	29500						
08-31-86	4.70	3996.50							
09-09-86	4.60	3996.60	31500						
09-17-86	4.10	3997.10	32000						
10-18-86	4.00	3997.20	32000						
10-25-86	4.10	3997.10	32000						
11-08-86	4.00	3997.20	32500						
11-17-86									
06-04-87	1.97	3999.23	30000				13.17	4030.93	21500
06-21-87	2.58	3998.62	30500				12.00	4032.10	21000
07-02-87	2.67	3998.53	32000				12.17	4031.93	19500
07-24-87	3.42	3997.78	35500				12.50	4031.60	21500
08-27-87	4.08	3997.12	31500				12.75	4031.35	19500
09-27-87	4.17	3997.03	31000				13.92	4030.18	21000
10-31-87	5.33	3995.87	32500				D		
11-25-87	4.75	3996.45	33500						
04-05-88	4.42	3996.78	18500						
04-29-88	4.45	3996.75	18500						
05-14-88	2.97	3998.23	19500						
06-10-88	3.49	3997.71	20500						
06-26-88	3.55	3997.65	19500						
07-23-88	3.64	3997.57	18000						
08-88	4.93	3996.27	19500						
09-88	5.33	3995.87	20500						
10-88	6.81	3994.39	21000						
05-19-89	5.00	3996.20	27120	D			D		
05-20-89				D			D		
06-04-89	4.60	3996.60	27730	D			D		
06-20-89	5.20	3996.00	27960	D			D		
06-21-89				D			D		
07-06-89	5.50	3995.70	27610	D			D		
07-07-89				D			D		
07-24-89	7.00	3994.20	28400	D			D		
08-26-89				D			D		
08-27-89	5.60	3995.60	26130	D			D		
09-21-89	6.00	3995.20	27070	D			D		
10-08-89	6.80	3994.40	27240	D			D		
04-08-90	5.11	3996.09	28220						
05-09-90	5.70	3995.50	14650						
06-03-90	5.90	3995.30	15510						
06-20-90									
07-04-90	5.10	3996.10	15700						
07-20-90	6.50	3994.70	24890						
08-09-90	6.90	3994.30	28050						
09-15-90	6.60	3994.60	26780						
10-21-90	6.70	3994.50	28140						

	Z-18 1.70 4068.40			Z-20 1.50 4044.70			Z-21 1.67 3986.80		
MM-DD-YY	SWL	ELEV	SC @25	SWL	ELEV	SC @25	SWL	ELEV	SC @25
01-20-84	1.20	4067.20		10.10	4034.60		6.50	3980.30	
04-04-84	3.10	4065.30		12.50	4032.20		7.40	3979.40	
04-14-84	3.10	4065.30		12.50	4032.20		8.15	3978.65	
04-29-84	3.20	4065.20		12.00	4032.70		8.10	3978.70	
05-10-84	3.20	4065.20		12.60	4032.10		7.60	3979.20	
05-20-84	3.10	4065.30		13.00	4031.70		6.80	3980.00	
05-27-84	3.20	4065.20		13.00	4031.70		7.70	3979.10	
06-01-84	3.30	4065.10		12.70	4032.00		8.00	3978.80	
06-20-84		4068.40		12.80	4031.90		7.90	3978.90	5500
07-02-84	3.10	4065.30	3550	D			8.60	3978.20	6800
07-16-84	3.20	4065.20	3450	D			9.10	3977.70	6900
07-30-84	3.40	4065.00	3400	D			9.30	3977.50	6900
08-13-84	3.50	4064.90	3350	D			9.40	3977.40	7150
08-27-84	3.70	4064.70	3450	D			9.40	3977.40	6800
12-07-84	4.60	4063.80	3400	D			10.40	3976.40	5450
02-28-85	5.10	4063.30		D			8.40	3978.40	
06-06-85	5.20	4063.20		D			8.80	3978.00	
06-20-85	5.20	4063.20		D			9.20	3977.60	5650
07-05-85	5.30	4063.10		D			9.00	3977.80	
07-20-85	5.30	4063.10		D			9.00	3977.80	
08-15-85	5.70	4062.70	2880	D			9.20	3977.60	5400
09-20-85	5.40	4063.00	4300	D			10.60	3976.20	5750
10-24-85	5.00	4063.40	2920	D			9.60	3977.20	4850
12-07-85	5.20	4063.20	4200	D			9.70	3977.10	9050
03-18-86	3.71	4064.69	3750	D					
04-22-86	2.10	4066.30	4750	D			9.91	3976.89	5250
05-28-86	+.33	4068.70	3750	D			7.62	3979.18	5700
06-13-86	+.7	4069.10	2650	D			10.50	3976.30	2000
06-28-86	.00	4068.40		D			10.70	3976.10	
07-19-86			2500	D			7.50	3979.30	3300
07-26-86				D			7.00	3979.80	
08-16-86			2550	D			6.60	3980.20	3300
08-31-86				D			6.40	3980.40	
09-09-86				D			6.30	3980.50	3500
09-17-86			2550	D			6.50	3980.30	3550
10-18-86			2650	D			6.10	3980.70	3500
10-25-86				D			6.10	3980.70	3550
11-08-86				D			6.00	3980.80	3600
11-17-86			2600	D			5.80	3981.00	3700
06-04-87	3.75	4064.65	3150				8.97	3977.83	4800
06-21-87	4.00	4064.40	3250				9.25	3977.55	4850
07-02-87	4.17	4064.23	3150				9.42	3977.38	4650
07-24-87	4.50	4063.90	3700				9.33	3977.47	11500
08-27-87	4.58	4063.82	5800				9.58	3977.22	3700
09-27-87	4.67	4063.73	3000				10.08	3976.72	3000
10-31-87	3.91	4064.49	4150				9.83	3976.97	2750
11-25-87	4.58	4063.82	3600				10.25	3976.55	6100
04-05-88	4.50	4063.90	1720				D		
04-29-88							D		
05-14-88	4.11	4064.29	2550				D		
06-10-88	3.25	4065.15	22500				D		
06-26-88	3.21	4065.19	2150				D		
07-23-88	3.21	4065.19	2000				D		
08-88	4.19	4064.21	2050				D		
09-88	3.21	4065.19	1950				D		
10-88	3.22	4065.18	1950				D		
05-19-89	4.40	4064.00	2740				D		
05-20-89							D		
06-04-89	3.80	4064.60	2750				D		
06-20-89	4.20	4064.20	3090				D		
06-21-89							D		
07-06-89	4.60	4063.80	2910				D		
07-07-89							D		
07-24-89	5.40	4063.00	3070				D		
08-26-89							D		
08-27-89	4.60	4063.80	2750				D		
09-21-89	5.00	4063.40	2900				D		
10-08-89	5.20	4063.20	2930				D		
04-08-90	5.90	4062.50	3060						
05-09-90	6.00	4062.40	3080						
06-03-90	5.30	4063.10	3110						
06-20-90									
07-04-90	5.90	4062.50	4460						
07-20-90	6.00	4062.40	3800						
08-09-90	5.50	4062.90	3120						
09-15-90	6.80	4061.60	2880						
10-21-90	6.90	4061.50	2920						

	Z-22 2.10 4011.30			Z-23 1.80 3999.00			Z-24 1.40 3979.40		
MM-DD-YY	SWL	ELEV	SC @25	SWL	ELEV	SC @25	SWL	ELEV	SC @25
01-20-84	.70	4010.60		D			D		
04-04-84	1.80	4009.50		D			D		
04-14-84	2.10	4009.20		D			D		
04-29-84	1.40	4009.90		D			D		
05-10-84	1.20	4010.10		D			10.70	3968.70	
05-20-84	2.10	4009.20		11.60	3987.40		11.00	3968.40	
05-27-84	2.20	4009.10		11.60	3987.40		10.85	3968.55	
06-01-84	2.30	4009.00		11.60	3987.40		11.00	3968.40	
06-20-84	1.60	4009.70	8600	D			D		
07-02-84	3.20	4008.10	8400	D			D		
07-16-84	3.80	4007.50	7700	D			D		
07-30-84	4.10	4007.20	6750	D			D		
08-13-84	4.40	4006.90	6850	D			D		
08-27-84	4.80	4006.50	6750	D			D		
12-07-84	4.50	4006.80	6650	D			D		
02-28-85	4.10	4007.20		D			D		
06-06-85	3.30	4008.00	8200	D			D		
06-20-85	4.00	4007.30		D			D		
07-05-85	4.50	4006.80	7150	D			D		
07-20-85	5.00	4006.30		D			D		
08-15-85	5.50	4005.80	5800	D			D		
09-20-85	5.90	4005.40	2000	D			D		
10-24-85	5.90	4005.40	4750	D			D		
12-07-85	5.80	4005.50	3800	D			D		
03-18-86	2.37	4008.93	1025						
04-22-86	1.96	4009.34	1050						
05-28-86	1.10	4010.20	750						
06-13-86	7.40	4003.90	550						
06-28-86									
07-19-86	2.60	4008.70	7000						
07-26-86	1.90	4009.40							
08-16-86	1.90	4009.40	7000						
08-31-86	1.80	4009.50							
09-09-86	1.80	4009.50	6550						
09-17-86	1.60	4009.70	5550						
10-18-86	1.40	4009.90	5550						
10-25-86	1.40	4009.90	5550						
11-08-86	1.30	4010.00	5000						
11-17-86	1.30	4010.00	5500						
06-04-87	1.67	4009.63	11500						
06-21-87	2.17	4009.13	9950						
07-02-87	2.50	4008.80	17500						
07-24-87	3.08	4008.22	13500						
08-27-87	2.42	4008.88	9950						
09-27-87	3.00	4008.30	9100						
10-31-87	3.25	3998.05	8350						
11-25-87	3.50	4007.80	9600						
04-05-88	3.00	4008.30	5350						
04-29-88	14.34	4006.96	5700						
05-14-88	2.28	4009.02	9350						
06-10-88	2.97	4008.33	8850						
06-26-88	2.95	4008.35	8450						
07-23-88	4.13	4007.17	8750						
08-88	6.15	4005.15	7200						
09-88	5.13	4006.17	5250						
10-88	5.26	4006.04	5900						
05-19-89	4.00	4007.30	13840						
05-20-89									
06-04-89	4.20	4007.10	14890						
06-20-89	5.50	4005.80	15190						
06-21-89									
07-06-89	5.70	4005.60	14470						
07-07-89									
07-24-89	6.80	4004.50	14740						
08-26-89									
08-27-89	6.00	4005.30	13590						
09-21-89	6.50	4004.80	13790						
10-08-89	7.00	4004.30	14250						
04-08-90	4.10	4007.20	4800						
05-09-90	4.20	4007.10	4790						
06-03-90	4.50	4006.80	5430						
06-20-90	4.10	4007.20	16580						
07-04-90	4.80	4006.50	15780						
07-20-90	5.80	4005.50	5360						
08-09-90	6.20	4005.10	5240						
09-15-90	7.00	4004.30	4230						
10-21-90	6.50	4004.80	4020						

	Z-25 .90 3996.30			Z-26 1.60 4003.30			Z-30 1.70 4086.60		
MM-DD-YY	SWL	ELEV	SC @25	SWL	ELEV	SC @25	SWL	ELEV	SC @25
01-20-84	10.80	3985.50		4.90	3998.40				
04-04-84	11.90	3984.40		5.40	3997.90		12.40	4074.20	
04-14-84	11.00	3985.30		5.30	3998.00		12.50	4074.10	
04-29-84	11.20	3985.10		5.90	3997.40		12.40	4074.20	
05-10-84	11.30	3985.00		5.40	3997.90		11.90	4074.70	
05-20-84	11.00	3985.30		5.00	3998.30		12.60	4074.00	
05-27-84	10.70	3985.60		5.20	3998.10		12.40	4074.20	
06-01-84	10.80	3985.50		5.30	3998.00		12.30	4074.30	
06-20-84	10.90	3985.40	8250	5.50	3997.80	4100			
07-02-84	10.80	3985.50	9700	4.80	3998.50	4750	12.30	4074.30	4800
07-16-84	11.00	3985.30	9900	6.20	3997.10	4800	12.40	4074.20	4900
07-30-84	11.20	3985.10	8450	6.50	3996.80	4850	12.50	4074.10	4900
08-13-84	11.40	3984.90	8500	6.60	3996.70	1780	12.40	4074.20	4900
08-27-84	11.50	3984.80		6.80	3996.50	4850	12.50	4074.10	4950
12-07-84	12.70	3983.60		7.60	3995.70	4850			
02-28-85	D			7.90	3995.40		D	4086.60	
06-06-85	D			8.90	3994.40	4050			
06-20-85	D			8.70	3994.60		14.30	4072.30	
07-05-85	D			8.70	3994.60	4350	14.50	4072.10	3700
07-20-85	D			9.10	3994.20		15.90	4070.70	
08-15-85	D			9.10	3994.20	4250	16.90	4069.70	3000
09-20-85	D			9.30	3994.00	4400	15.20	4071.40	4100
10-24-85	D			9.80	3993.50	4950	15.80	4070.80	4250
12-07-85	D			10.60	3992.70	9350	15.20	4071.40	4000
03-18-86				10.55	3992.75	3900	11.33	4075.27	880
04-22-86				10.19	3993.11	4400	12.02	4074.58	5150
05-28-86				7.84	3995.46	2950	11.27	4075.33	4950
06-13-86							26.80	4059.80	2500
06-28-86							27.00	4059.60	
07-19-86				RECORDER INSTALLED			12.30	4074.30	3850
07-26-86							11.90	4074.70	
08-16-86							9.90	4076.70	3950
08-31-86							9.90	4076.70	
09-09-86							9.80	4076.80	3900
09-17-86							9.70	4076.90	3850
10-18-86							9.90	4076.70	3950
10-25-86							9.90	4076.70	4000
11-08-86							9.80	4076.80	4000
11-17-86									
06-04-87							13.83	4072.77	4350
06-21-87							13.17	4073.43	4500
07-02-87							13.17	4073.43	4700
07-24-87							13.58	4073.02	4800
08-27-87							13.75	4072.85	5550
09-27-87							14.00	4072.60	4550
10-31-87							14.08	4072.52	6400
11-25-87							14.58	4072.02	5750
04-05-88							14.50	4072.10	2850
04-29-88							15.29	4071.31	2750
05-14-88							15.27	4071.33	2850
06-10-88							14.77	4071.83	3300
06-26-88							13.66	4072.94	2750
07-23-88							23.64	4062.96	2700
08-88							13.93	4072.67	2850
09-88							13.64	4072.96	2900
10-88							13.72	4072.88	3000
05-19-89							13.60	4073.00	2980
05-20-89									
06-04-89							13.90	4072.70	3600
06-20-89									
06-21-89							14.30	4072.30	3210
07-06-89									
07-07-89							14.60	4072.00	3270
07-24-89							15.30	4071.30	3220
08-26-89									
08-27-89							14.80	4071.80	3140
09-21-89							15.00	4071.60	3280
10-08-89							13.80	4072.80	3290
04-08-90							15.00	4071.60	4460
05-09-90							15.90	4070.70	4370
06-03-90							15.95	4070.65	4300
06-20-90									
07-04-90							15.65	4070.95	4780
07-20-90							15.11	4071.49	5070
08-09-90							15.60	4071.00	4360
09-15-90							15.60	4071.00	4940
10-21-90							15.00	4071.60	4570

	Z-31 2.10 4101.30			Z-34 3.20 4024.40			Z-35 2.30 4027.20		
MM-DD-YY	SWL	ELEV	SC @25	SWL	ELEV	SC @25	SWL	ELEV	SC @25
01-20-84									
04-04-84	D								
04-14-84	D			4.10	4020.30		10.20	4027.20	
04-29-84	D								
05-10-84	12.50	4088.80							
05-20-84	8.30	4093.00		14.50	4009.90		10.10	4018.90	
05-27-84	7.60	4093.70							
06-01-84	7.80	4093.50							
06-20-84				13.80	4010.60	6250	9.60	4027.20	1420
07-02-84	10.71	4090.59	1320						
07-16-84	12.65	4088.65	1500	14.20	4010.20	6360	9.80	4014.55	1560
07-30-84	12.80	4088.50							
08-13-84	D			14.70	4009.70	6380	10.50	4027.20	1510
08-27-84									
12-07-84				15.20	4009.20	6040	10.30	4027.20	1510
02-28-85	D			D			D		
06-06-85	D			15.20	4009.20	5460	13.10	4027.20	1400
06-20-85	10.40	4090.90							
07-05-85	D			15.60	4008.80	5450	13.90	4027.20	1440
07-20-85	D								
08-15-85	D			15.80	4008.60	5470	14.30	4027.20	1200
09-20-85	D			14.60	4009.80	5640	14.50	4027.20	1400
10-24-85	D			18.10	4006.30	5600	14.70	4027.20	1400
12-07-85	D			17.80	4006.60	6540			
03-18-86	3.30	4098.00	1220	16.50	4007.90	5240	11.44	4023.90	1350
04-22-86	2.26	4099.04	1380	16.23	4008.17	5900	8.96	4024.94	1600
05-28-86	1.23	4100.07		14.41	4009.99	5740	5.74	4025.97	1570
06-13-86	.00	4101.30	1000	13.20	4011.20	5160	4.70	4027.20	1340
06-28-86	.00	4101.30							
07-19-86	4.90	4096.40	1250	12.90	4011.50	5020	9.20	4022.30	1830
07-26-86	4.00	4097.30							
08-16-86	3.60	4097.70	1230	10.80	4013.60	4710	7.50	4023.60	1600
08-31-86	3.60	4097.70							
09-09-86	3.40	4097.90	1250						
09-17-86	3.60	4097.70	1450	10.50	4013.90	5160	6.20	4023.60	1460
10-18-86	3.60	4097.70	1450	11.40	4013.00	5090	6.10	4023.60	1510
10-25-86	3.60	4097.70	1480						
11-08-86	3.60	4097.70	1480						
11-17-86	3.60	4097.70	1450	11.40	4013.00	5360	6.00	4023.60	1640
06-04-87	D						RECORDER INSTALLED		
06-21-87	D								
07-02-87	D								
07-24-87	D								
08-27-87	D								
09-27-87	D			14.58	4009.82	5120			
10-31-87	D			15.08	4009.32	5130			
11-25-87	D			14.33	4010.07	5700			
04-05-88				14.00	4010.40	3050			
04-29-88									
05-14-88					D				
06-10-88				14.21	4010.19	3390			
06-26-88									
07-23-88				14.35	4010.05	2810			
08-88				15.82	4008.58	2940			
09-88				16.09	4008.31	2720			
10-88				17.08	4007.32	3130			
05-19-89				24.00	4000.40	11170			
05-20-89									
06-04-89				24.40	4000.00	11210			
06-20-89									
06-21-89				25.00	3999.40	11820			
07-06-89				25.30	3999.10	12110			
07-07-89									
07-24-89				25.60	3998.80	13040			
08-26-89									
08-27-89				25.10	3999.30	10960			
09-21-89				24.80	3999.60	10560			
10-08-89				25.30	3999.10	11420			
04-08-90				17.20	4007.20	4370			
05-09-90				17.30	4007.10	4390			
06-03-90				16.70	4007.70	4460			
06-20-90									
07-04-90				17.20	4007.20	4260			
07-20-90				17.40	4007.00	4230			
08-09-90				17.00	4007.40	4320			
09-15-90				18.00	4006.40	4650			
10-21-90				19.00	4005.40	4530			

	Z-36 2.30 4006.90			Z-37 1.60 3998.60			Z-38 4.20 3999.50		
MM-DD-YY	SWL	ELEV	SC @25	SWL	ELEV	SC @25	SWL	ELEV	SC @25
01-20-84									
04-04-84									
04-14-84	8.20	3998.70		4.40	3994.20		5.60	3993.90	
04-29-84									
05-10-84									
05-20-84	7.90	3999.00		4.00	3994.60		5.00	3994.50	
05-27-84									
06-01-84									
06-20-84									
07-02-84									
07-16-84	9.20	3997.70	5960	5.50	3993.10	4060	6.70	3992.80	4470
07-30-84									
08-13-84	9.70	3997.20	5560	5.90	3992.70	3970	7.20	3992.30	4440
08-27-84									
12-07-84	11.00	3995.90	4920	6.00	3992.60	4520	7.40	3992.10	4320
02-28-85	D			D			7.30	3992.20	
06-06-85	9.80	3997.10	2560	5.20	3993.40	4010	6.90	3992.60	3980
06-20-85									
07-05-85	10.30	3996.60	2800	6.00	3992.60	3450	7.80	3991.70	3930
07-20-85									
08-15-85	10.70	3996.20	1800	6.60	3992.00	3890	8.80	3990.70	4290
09-20-85	10.70	3996.20	1920	6.60	3992.00	3290	8.50	3991.00	4480
10-24-85	11.30	3995.60	1870	6.40	3992.20	3870	8.60	3990.90	4200
12-07-85				7.20	3991.40	4520	9.20	3990.30	4180
03-18-86	10.19	3996.71	2940	5.07	3993.53	3780	4.90	3994.60	3970
04-22-86	10.11	3996.79	4440	4.71	3993.89	5690	6.00	3993.50	4770
05-28-86	9.22	3997.68	4060	4.26	3994.34	4390	4.93	3994.57	4620
06-13-86	9.80	3997.10	3390	5.10	3993.50	3780	4.10	3995.40	4110
06-28-86									
07-19-86	10.60	3996.30	3620	5.80	3992.80	3400			
07-26-86									
08-16-86	9.90	3997.00	3450	4.90	3993.70	2750	6.00	3993.50	
08-31-86									
09-09-86									
09-17-86	9.10	3997.80	3460	4.10	3994.50	3400	6.10	3993.40	3740
10-18-86	9.00	3997.90	3480	4.00	3994.60	3500	5.90	3993.60	3740
10-25-86									
11-08-86									
11-17-86	9.00	3997.90	3570	4.10	3994.50	3690	5.70	3993.80	3790
06-04-87									
06-21-87									
07-02-87									
07-24-87									
08-27-87									
09-27-87	9.50	3997.40	4580	4.42	3994.18	3950			
10-31-87	10.08	3996.82	6090	4.67	3993.93	4700			
11-25-87	10.42	3996.48	5330	5.08	3993.52	4840			
04-05-88	10.00	3996.90	3200	4.00	3994.60	2320			
04-29-88									
05-14-88	8.38	3998.52	2920	2.79	3995.81	2120			
06-10-88	8.96	3997.94	3000	4.34	3994.26	3280			
06-26-88									
07-23-88	10.21	3996.69	3390	5.47	3993.13	2100			
08-88	15.24	3991.66	2580	6.07	3992.53	2100			
09-88		D		6.24	3992.36	2320			
10-88		D		6.45	3992.15	2420			
05-19-89	D						5.00	3994.50	3270
05-20-89	D			16.10	3982.50	3920			
06-04-89	D			17.20	3981.40	3850	5.50	3994.00	3240
06-20-89	D								
06-21-89	D			17.80	3980.80	4160	7.00	3992.50	3460
07-06-89	D			18.20	3980.40	4050	7.80	3991.70	3610
07-07-89	D								
07-24-89	D			19.70	3978.90	4380	8.30	3991.20	3590
08-26-89	D								
08-27-89	D			17.50	3981.10	3720	8.20	3991.30	3180
09-21-89	D			18.20	3980.40	4330	9.00	3990.50	3100
10-08-89	D			17.80	3980.80	4670	8.60	3990.90	3340
04-08-90				6.95	3991.65	1960			
05-09-90				6.70	3991.90	2320			
06-03-90				6.50	3992.10	1880			
06-20-90									
07-04-90				7.20	3991.40	1510			
07-20-90				7.60	3991.00	1340			
08-09-90				7.20	3991.40	2240			
09-15-90				8.00	3990.60	1960			
10-21-90				8.00	3990.60	2010			

	Z-40			Z-48			Z-49		
	3.40			2.40			2.50		
	4054.30			3969.80			4035.00		
MM-DD-YY	SWL	ELEV	SC @25	SWL	ELEV	SC @25	SWL	ELEV	SC @25
01-20-84							7.70	4027.30	4460
04-04-84									
04-14-84	18.40	4035.90							
04-29-84									
05-10-84									
05-20-84	18.60	4035.70							
05-27-84									
06-01-84									
06-20-84	18.90	4035.40	3640	4.10	3965.70	5880	7.70	4027.30	4460
07-02-84									
07-16-84	19.20	4035.10	3670	5.40	3964.40	6160	7.20	4027.80	4490
07-30-84									
08-13-84	19.60	4034.70	3650	6.00	3963.80	6350	7.40	4027.60	4710
08-27-84									
12-07-84	19.90	4034.40	3630	4.70	3965.10	6220			
02-28-85	20.30	4034.00	D	7.40	3962.40	6330	8.40	4026.60	3060
06-06-85	19.50	4034.80	3610	4.70	3965.10	6220			
06-20-85									
07-05-85	20.80	4033.50	3310	5.90	3963.90	6140	10.50	4024.50	6560
07-20-85									
08-15-85	20.50	4033.80	3200	7.40	3962.40	6330			
09-20-85	19.70	4034.60	3200						
10-24-85	21.40	4032.90	3170	6.20	3963.60	6690	9.40	4025.60	3800
12-07-85	22.00	4032.30	8520	4.15	3965.65	7380	7.76	4027.24	4050
03-18-86	19.90	4034.40	3520	5.80	3964.00	4750	5.80	4029.20	3700
04-22-86	19.51	4034.79	3910	4.70	3965.10	4600	5.00	4030.00	3600
05-28-86	18.14	4036.16	3830	5.00	3964.80	4650	5.00	4030.00	3650
06-13-86	32.00	4022.30	2400						
06-28-86	RECORDER INSTALLED								
07-19-86									
07-26-86									
08-16-86									
08-31-86									
09-09-86									
09-17-86									
10-18-86									
10-25-86									
11-08-86									
11-17-86									
06-04-87									
06-21-87									
07-02-87									
07-24-87									
08-27-87									
09-27-87				4.83	3964.97	6270	8.25	4026.75	3830
10-31-87				5.00	3964.80	6470	8.08	4026.92	3740
11-25-87				5.33	3964.47	7200	6.33	4028.67	6670
04-05-88				5.75	3964.05	3480	9.00	4026.00	2910
04-29-88									
05-14-88				2.48	3967.32	3700	7.98	4027.02	2960
06-10-88				1.45	3968.36	4040	7.81	4027.19	3100
06-26-88									
07-23-88				5.32	3964.48	3470	7.33	4027.67	2950
08-88				6.33	3963.47	3510	7.90	4027.10	3180
09-88				5.08	3964.72	3660	7.32	4027.68	2980
10-88				6.62	3963.18	3710	5.00	4030.00	3210
05-19-89									
05-20-89				5.40	3964.40	4020	8.10	4026.90	580
06-04-89				6.20	3963.60	3810	8.60	4026.40	620
06-20-89									
06-21-89				6.60	3963.20	4160	9.00	4026.00	760
07-06-89				6.11	3963.69	4220	10.40	4024.60	820
07-07-89									
07-24-89				7.40	3962.40	4200	10.80	4024.20	940
08-26-89									
08-27-89				7.00	3962.80	3840	9.30	4025.70	780
09-21-89				7.30	3962.50	4450	10.50	4024.50	820
10-08-89				7.60	3962.20	4730	11.20	4023.80	800
04-08-90				7.50	3962.30	5510	15.30	4019.70	2670
05-09-90				7.00	3962.80	5640	10.40	4024.60	3190
06-03-90				7.20	3962.60	5070	10.00	4025.00	2860
06-20-90				7.20	3962.60	4757	10.50	4024.50	2970
07-04-90				8.00	3961.80	5000	10.50	4024.50	3120
07-20-90				8.60	3961.20	5360	10.60	4024.40	2970
08-09-90				8.50	3961.30	5480	10.50	4024.50	2950
09-15-90				8.80	3961.00	6700	10.70	4024.30	3010
10-21-90				8.70	3961.10	59000	10.90	4024.10	3380

	Z-50			Z-53			Z-54		
	3.70			1.90					
	4019.70			4074.40			4051.70		
MM-DD-YY	SWL	ELEV	SC @25	SWL	ELEV	SC @25	SWL	ELEV	SC @25
01-20-84	10.70	4009.00	3470						
04-04-84									
04-14-84									
04-29-84									
05-10-84									
05-20-84									
05-27-84									
06-01-84									
06-20-84									
07-02-84									
07-16-84	D								
07-30-84									
08-13-84									
08-27-84									
12-07-84									
02-28-85	14.00	4005.70	3090						
06-06-85									
06-20-85									
07-05-85	14.80	4004.90	6690						
07-20-85									
08-15-85									
09-20-85									
10-24-85		4019.70		23.29	4051.11	2620	11.99	4039.71	3400
12-07-85	9.65	4010.05	3640	23.35	4051.05	2470	11.52	4040.18	3460
03-18-86	7.90	4011.80	3190	23.29	4051.11	2620	9.00	4042.70	
04-22-86	6.80	4012.90	3030	23.26	4051.14	2620	8.30	4043.40	
05-28-86	6.60	4013.10	3130	23.35	4051.05	2470	8.10	4043.60	
06-13-86				25.00	4049.40	1400	8.00	4043.70	
06-28-86									
07-19-86				24.10	4050.30	2230			
07-26-86									
08-16-86				21.00	4053.40	2090			
08-31-86									
09-09-86									
09-17-86				20.90	4053.50	2260			
10-18-86				20.60	4053.80	2330			
10-25-86									
11-08-86									
11-17-86				20.60	4053.80	2390			
06-04-87									
06-21-87									
07-02-87									
07-24-87									
08-27-87									
09-27-87	14.33	4005.37	2950						
10-31-87	12.67	4007.03	3010						
11-25-87	11.25	4008.45	2920						
04-05-88	15.00	4004.70	1950				13.00	4038.70	1780
04-29-88									
05-14-88	12.97	4006.73	1880				10.13	4041.57	1810
06-10-88	12.74	4006.96	1910				10.89	4040.81	1830
06-26-88									
07-23-88	23.31	3996.39	2000				10.06	4041.64	1730
08-88	13.32	4006.38					8.28	4043.42	1870
09-88	13.33	4006.37					11.16	4040.54	1840
10-88	13.54	4006.16					9.99	4041.71	1880
05-19-89									
05-20-89	16.80	4002.90	1820	23.70	4050.70	1760	11.85	4039.85	2580
06-04-89	17.50	4002.20	2110	24.00	4050.40	1780	11.90	4039.80	2300
06-20-89									
06-21-89	18.70	4001.00	2080	24.30	4050.10	1850	12.10	4039.60	2250
07-06-89	19.00	4000.70	2160	25.40	4049.00	1910	13.20	4038.50	2300
07-07-89									
07-24-89	20.80	3998.90	2100	25.60	4048.80	1840	14.50	4037.20	2350
08-26-89									
08-27-89	18.60	4001.10	2140	25.40	4049.00	1750	13.40	4038.30	2110
09-21-89	19.50	4000.20	2140	25.60	4048.80	1800	13.00	4038.70	2250
10-08-89	21.50	3998.20	2370	25.60	4048.80	1720	12.80	4038.90	2150
04-08-90	17.40	4002.30	2330				13.30	4038.40	2530
05-09-90	17.80	4001.90	3460				13.80	4037.90	2750
06-03-90	17.90	4001.80	2820				14.00	4037.70	2680
06-20-90	17.90	4001.80	3060				13.10	4038.60	2680
07-04-90	17.80	4001.90	3190				14.20	4037.50	2830
07-20-90	18.00	4001.70	2960				14.00	4037.70	2830
08-09-90	17.80	4001.90	2620				13.11	4038.59	2680
09-15-90	17.40	4002.30	1470				13.80	4037.90	3020
10-21-90	16.80	4002.90	1410				14.00	4037.70	2780

	Z-55			Z-56			Z-57		
MM-DD-YY	SWL	4048.19 ELEV	SC @25	SWL	4060.90 ELEV	SC @25	SWL	4073.60 ELEV	SC @25
01-20-84									
04-04-84									
04-14-84									
04-29-84									
05-10-84									
05-20-84									
05-27-84									
06-01-84									
06-20-84									
07-02-84									
07-16-84									
07-30-84									
08-13-84									
08-27-84									
12-07-84									
02-28-85									
06-06-85									
06-20-85									
07-05-85									
07-20-85									
08-15-85									
09-20-85									
10-24-85	14.85	4033.34	3480	23.71	4037.19	3450	27.09	4046.51	2230
12-07-85	14.26	4033.93	3880	23.43	4037.47	4030	27.75	4045.85	2290
03-18-86				23.70	4037.20		26.90	4046.70	
04-22-86				21.80	4039.10		25.60	4048.00	
05-28-86				21.60	4039.30		25.10	4048.50	
06-13-86									
06-28-86									
07-19-86									
07-26-86				21.60	4039.30		25.00	4048.60	
08-16-86									
08-31-86									
09-09-86									
09-17-86									
10-18-86									
10-25-86									
11-08-86									
11-17-86									
06-04-87									
06-21-87									
07-02-87									
07-24-87									
08-27-87									
09-27-87				23.83	4037.07	2840			
10-31-87				23.50	4037.40	3050			
11-25-87				23.25	4037.65	3060			
04-05-88	15.58	4032.61	1900	27.08	4033.82	1970	29.75	4043.85	1260
04-29-88									
05-14-88	13.61	4034.58	1890	28.00	4032.90	1180	24.24	4049.36	1940
06-10-88	14.21	4033.98	1950	24.07	4036.83	1940	28.22	4045.38	1230
06-26-88									
07-23-88	14.49	4033.70	1820	24.28	4036.62	1820	28.26	4045.34	1140
08-88	14.52	4033.67	1940	25.04	4035.86	1940	29.18	4044.42	1560
09-88	14.40	4033.79	1990	25.38	4035.52	2000	29.30	4044.30	1240
10-88	14.23	4033.96	2020	24.79	4036.11	1990	28.26	4045.34	1260
05-19-89									
05-20-89	14.70	4033.49	2770				D		
06-04-89	14.20	4033.99	2510				29.00	4044.60	1640
06-20-89									
06-21-89	15.60	4032.59	2570				30.00	4043.60	1780
07-06-89	16.40	4031.79	2640				30.60	4043.00	1780
07-07-89									
07-24-89	17.30	4030.89	2580				30.65	4042.95	1700
08-26-89									
08-27-89	16.60	4031.59	2270				29.40	4044.20	1610
09-21-89	15.40	4032.79	2250				29.60	4044.00	1420
10-08-89	14.80	4033.39	2420				29.80	4043.80	1380
04-08-90	10.40	4037.79	3000	25.00	4035.90	2820	30.11	4043.49	1880
05-09-90	15.60	4032.59	2970	25.00	4035.90	2920	31.10	4042.50	1900
06-03-90	15.60	4032.59	2960	25.00	4035.90	2880	30.80	4042.80	1900
06-20-90	16.40	4031.79	2880	25.00	4035.90	3080	30.20	4043.40	1920
07-04-90	16.50	4031.69	2960	25.60	4035.30	2960	31.40	4042.20	1970
07-20-90	17.20	4030.99	2970	26.50	4034.40	2960	31.60	4042.00	1970
08-09-90	16.90	4031.29	2920	26.80	4034.10	2880	D		
09-15-90	17.80	4030.39	3060	27.00	4033.90	3240	D		
10-21-90	17.70	4030.49	3070	27.00	4033.90	3100	D		

	Z-58			Z-59			Z-60		
		4063.62			4047.37			4046.06	
MM-DD-YY	SWL	ELEV	SC @25	SWL	ELEV	SC @25	SWL	ELEV	SC @25
01-20-84									
04-04-84									
04-14-84									
04-29-84									
05-10-84									
05-20-84									
05-27-84									
06-01-84									
06-20-84									
07-02-84									
07-16-84									
07-30-84									
08-13-84									
08-27-84									
12-07-84									
02-28-85									
06-06-85									
06-20-85									
07-05-85									
07-20-85									
08-15-85									
09-20-85									
10-24-85	21.83	4041.79	2020	10.73	4036.64	3440	7.19	4038.87	1780
12-07-85	22.08	4041.54	2100	10.54	4036.83	3540	7.17	4038.89	2080
03-18-86	22.00	4041.62		11.50	4035.87	3440	6.30	4039.76	
04-22-86	21.40	4042.22		10.70	4036.67	3540	6.00	4040.06	
05-28-86	21.00	4042.62		10.70	4036.67	3600	6.00	4040.06	
06-13-86	21.10	4042.52		13.70	4033.67	2100			
06-28-86									
07-19-86				11.00	4036.37	3130			
07-26-86									
08-16-86				10.80	4036.57	3230			
08-31-86									
09-09-86									
09-17-86				10.70	4036.67	3600			
10-18-86				10.60	4036.77	3600			
10-25-86									
11-08-86									
11-17-86				10.50	4036.87	3620			
06-04-87									
06-21-87									
07-02-87									
07-24-87									
08-27-87									
09-27-87				11.92	4035.45	3090			
10-31-87				11.08	4036.29	3070			
11-25-87				10.58	4036.79	3050			
04-05-88				1.17	4046.20	1780	7.67	4038.39	1030
04-29-88									
05-14-88				10.24	4037.13	1820	7.24	4038.82	1120
06-10-88				10.90	4036.47	1810	13.74	4032.32	1130
06-26-88									
07-23-88				13.24	4034.13	1700	8.88	4037.18	1010
08-88				12.68	4034.69	2100	8.89	4037.17	1230
09-88				8.77	4038.60	1900	8.88	4037.18	1080
10-88				12.22	4035.15	1950	8.82	4037.24	1070
05-19-89	D								
05-20-89	D			11.92	4035.45	2400	13.50	4032.56	1470
06-04-89	D			12.50	4034.87	2380	8.50	4037.56	1380
06-20-89	D								
06-21-89	D			16.00	4031.37	2390	8.70	4037.36	1840
07-06-89	D			17.40	4029.97	2310	11.30	4034.76	1900
07-07-89	D								
07-24-89	D			18.10	4029.27	2300	11.80	4034.26	1810
08-26-89	D								
08-27-89	D			15.10	4032.27	1640	10.10	4035.96	1580
09-21-89	D			16.00	4031.37	2280	10.80	4035.26	1620
10-08-89	D			15.80	4031.57	2380	9.60	4036.46	1730
04-08-90				12.00	4035.37	2820	8.40	4037.66	1630
05-09-90				12.15	4035.22	2820	9.20	4036.86	1590
06-03-90				10.70	4036.67	2750	9.00	4037.06	1550
06-20-90				11.10	4036.27	2780	8.70	4037.36	1550
07-04-90				13.00	4034.37	2820	9.70	4036.36	1690
07-20-90				13.11	4034.26	2830	10.25	4035.81	2170
08-09-90				13.90	4033.47	2880	10.50	4035.56	1650
09-15-90				14.00	4033.37	2880	10.50	4035.56	1670
10-21-90				14.50	4032.87	2820	10.00	4036.06	1760

Z-61

4056.06

MM-DD-YY	SWL	ELEV	SC @25
01-20-84			
04-04-84			
04-14-84			
04-29-84			
05-10-84			
05-20-84			
05-27-84			
06-01-84			
06-20-84			
07-02-84			
07-16-84			
07-30-84			
08-13-84			
08-27-84			
12-07-84			
02-28-85			
06-06-85			
06-20-85			
07-05-85			
07-20-85			
08-15-85			
09-20-85			
10-24-85	13.32	4042.74	1680
12-07-85	13.31	4042.75	2180
03-18-86	12.90	4043.16	
04-22-86	12.10	4043.96	
05-28-86	12.10	4043.96	
06-13-86	12.10	4043.96	
06-28-86			
07-19-86			
07-26-86			
08-16-86			
08-31-86			
09-09-86			
09-17-86			
10-18-86			
10-25-86			
11-08-86			
11-17-86			
06-04-87			
06-21-87			
07-02-87			
07-24-87			
08-27-87			
09-27-87			
10-31-87			
11-25-87			
04-05-88	14.42	4041.64	1290
04-29-88			
05-14-88	23.41	4032.65	1200
06-10-88	14.43	4041.63	1700
06-26-88			
07-23-88	15.51	4040.55	990
08-88	15.46	4040.60	1050
09-88	15.41	4040.65	1150
10-88	14.60	4041.46	1080
05-19-89			
05-20-89	14.40	4041.66	1440
06-04-89	15.50	4040.56	1440
06-20-89		4056.06	
06-21-89	15.20	4040.86	1280
07-06-89	16.50	4039.56	1310
07-07-89		4056.06	
07-24-89	17.10	4038.96	1280
08-26-89		4056.06	
08-27-89	15.90	4040.16	1320
09-21-89	14.11	4041.95	1340
10-08-89	14.60	4041.46	1190
04-08-90	14.70	4041.36	1780
05-09-90	14.60	4041.46	1810
06-03-90	14.80	4041.26	1830
06-20-90	15.00	4041.06	1710
07-04-90	15.10	4040.96	1560
07-20-90	16.30	4039.76	1700
08-09-90	17.20	4038.86	2330
09-15-90	16.90	4039.16	2500
10-21-90	17.00	4039.06	1950

	B-1			B-2			B-4			B-8		
		4000.00			3963.13			4023.87			4018.22	
MM-DD-YY	SWL	ELEV	SC @25	SWL	ELEV	SC @25	SWL	ELEV	SC @25	SWL	ELEV	SC @25
10-10-74	18.90			16.60								
10-11-74	15.55			16.70			dry					
10-14-74	15.52			16.53						dry		
01-21-75	15.41			16.83			dry			dry		
02-25-75	15.39			16.72			dry			dry		
03-27-75	15.48			16.94			dry			dry		
05-26-75	14.45			16.68			dry			dry		
06-10-75							dry			dry		
06-13-75	13.46			15.82			dry			dry		
07-03-75	12.92			14.73			dry			dry		
08-28-75	12.01			15.42			dry			dry		
12-30-75	10.96			15.65		7760	dry			dry		
02-24-76	13.00			15.72		6640	dry			dry		
06-04-76	12.89		4760	15.63		4480	dry			dry		
07-29-76	13.76			15.39			dry			dry		
09-14-76				15.49		4520	dry			dry		
10-27-76				15.41		6530	dry			dry		
01-20-84	6.73	3993.27	6480	10.37	3952.76	16210	25.43	3998.47	7072	22.57	3995.65	7700
04-04-84												
04-14-84	20.00	3980.00		17.10	3946.03		30.80	3993.10		24.60	3993.62	
04-29-84												
05-10-84												
05-20-84	19.70	3980.30		16.60	3946.53		29.80	3994.10		24.10	3994.12	
05-27-84												
06-01-84												
06-20-84	19.90	3980.10		15.70	3947.43		36.60	3987.30		22.80	3995.42	
07-02-84												
07-16-84	18.80	3981.20		15.60	3947.53		25.80	3998.10		21.50	3996.72	
07-30-84												
08-13-84	18.50	3981.50		15.10	3948.03		25.10	3998.80		21.60	3996.62	
08-27-84												
12-07-84	17.60	3982.40		14.60	3948.53		24.30	3999.60		21.80	3996.42	
02-28-85												
06-06-85												
06-20-85												
07-05-85												
07-20-85												
08-15-85												
09-20-85												
10-24-85												
12-07-85	8.30	3991.70	6790	12.60	3950.53	14630	23.00	4000.90	8425	25.60	3992.62	9930
03-18-86	7.83	3992.17	2620	8.74	3954.39	10080	25.54	3998.36	6301	23.99	3994.23	7360
04-22-86	7.74	3992.26	7200	10.91	3952.22	16980	25.53	3998.37	6802	25.05	3993.17	6880
05-28-86	6.73	3993.27	6480	10.37	3952.76	16210	25.43	3998.47	7072	22.57	3995.65	7700
06-13-86	21.60	3978.40	6630	17.10	3946.03	14260	31.50	3992.40	6051	24.40	3993.82	5900
06-28-86												
07-19-86	20.00	3980.00	5160	17.10	3946.03	14110	30.80	3993.10	6269	24.60	3993.62	6350
07-26-86												
08-16-86	19.90	3980.10	6700	15.10	3948.03	13960	36.60	3987.30	6199	22.80	3995.42	6350
08-31-86												
09-09-86												
09-17-86	17.90	3982.10	5430	14.70	3948.43	14110	25.10	3998.80	6279	21.60	3996.62	6280
10-18-86	17.70	3982.30	5790	14.60	3948.53	14110	24.50	3999.40	6209	21.90	3996.32	6340
10-25-86												
11-08-86												
11-17-86	17.60	3982.40	5640	14.50	3948.63	14110	24.40	3999.50	6445	21.80	3996.42	6590
06-04-87												
06-21-87												
07-02-87												
07-24-87												
08-27-87												
09-27-87	7.75	3992.25	6960	10.83	3952.30	12470	24.67	3999.23	6401	26.75	3991.47	6430
10-31-87	7.75	3992.25	7530	10.75	3952.38	13860	25.25	3998.65	5612	24.25	3993.97	6400
11-25-87	7.75	3992.25	7070	10.67	3952.46	13440	25.25	3998.65	3404	24.25	3993.97	7300
04-05-88	8.97	3991.03	4340	10.58	3952.55	7620	25.00	3998.90	3260	24.58	3993.64	3810
04-29-88												
05-14-88	8.05	3991.95	3650	8.04	3955.09	7270	24.90	3999.00	3802	24.33	3993.89	3700
06-10-88	8.18	3991.82	3810	10.70	3952.43	7030	34.15	3989.75	3782	23.67	3994.55	3580
06-26-88												
07-23-88	8.29	3991.71	4540	10.56	3952.57	7540	24.15	3999.75	4375	23.88	3994.35	3820
08-88	8.24	3991.76	4240	10.16	3952.97	7240	25.19	3998.71	4212	24.98	3993.24	3850
09-88	8.20	3991.80	4580	9.08	3954.05	7660	24.15	3999.75	4318	23.89	3994.33	3700
10-88	8.64	3991.36	4670	11.00	3952.13	8070	25.31	3998.59	4203	21.91	3996.31	3560

	B-12			B-13			B-14		
		4019.68			4043.32			4018.81	
MM-DD-YY	SWL	ELEV	SC @25	SWL	ELEV	SC @25	SWL	ELEV	SC @25
10-10-74									
10-11-74									
10-14-74									
01-21-75									
02-25-75									
03-27-75									
05-26-75									
06-10-75									
06-13-75									
07-03-75									
08-28-75									
12-30-75	17.00		3510	9.85		6840	30.80		3320
02-24-76	17.36		3110	10.87		6950	31.74		2890
06-04-76	16.84			8.66		3610	31.32		2100
07-29-76	15.96			8.15			31.12		
09-14-76	17.04		2240	9.13		3970	31.22		2260
10-27-76	17.13		3680	9.85		5910	31.62		3120
01-20-84	16.72	4002.96	4550				26.66	3992.15	3120
04-04-84									
04-14-84	18.60	4001.08							
04-29-84									
05-10-84									
05-20-84	18.10	4001.58							
05-27-84									
06-01-84									
06-20-84	16.90	4002.78							
07-02-84									
07-16-84	15.50	4004.18							
07-30-84									
08-13-84	15.50	4004.18							
08-27-84									
12-07-84	15.00	4004.68							
02-28-85									
06-06-85									
06-20-85									
07-05-85									
07-20-85									
08-15-85									
09-20-85									
10-24-85									
12-07-85	19.70	3999.98	4400						
03-18-86	17.98	4001.70	3390						
04-22-86	18.01	4001.67	10830						
05-28-86	16.72	4002.96	4550						
06-13-86	16.90	4002.78	4540						
06-28-86									
07-19-86									
07-26-86									
08-16-86	16.90	4002.78	4610						
08-31-86									
09-09-86									
09-17-86	15.50	4004.18	4520						
10-18-86	15.10	4004.58	4590						
10-25-86									
11-08-86									
11-17-86	15.00	4004.68	4710						
06-04-87									
06-21-87									
07-02-87									
07-24-87									
08-27-87									
09-27-87	17.08	4002.60	10070						
10-31-87	16.92	4002.76	5900						
11-25-87	16.67	4003.01	11510						
04-05-88	22.08	3997.60	6600				26.00	3992.81	2040
04-29-88									
05-14-88	18.45	4001.23	2050	13.49	4029.83	5090	26.71	3992.10	2270
06-10-88	18.40	4001.28	2890	12.81	4030.51	4910	25.75	3993.06	1640
06-26-88									
07-23-88	18.14	4001.54	3560	12.77	4030.55	5100	25.73	3993.08	1960
08-88	18.75	4000.93	2360	12.35	4030.97	5120	26.22	3992.59	1980
09-88	18.33	4001.35	3760	11.08	4032.24	5120	25.71	3993.10	1930
10-88	18.05	4001.63	3310	11.90	4031.42	5390	25.73	3993.08	1920

	B-15			B-16			B-18			B-20		
MM-DD-YY	SWL	4050 ELEV	SC @25	SWL	3964.03 ELEV	SC @25	SWL	4021.35 ELEV	SC @25	SWL	4007.79 ELEV	SC @25
10-10-74												
10-11-74												
10-14-74												
01-21-75												
02-25-75												
03-27-75												
05-26-75												
06-10-75												
06-13-75												
07-03-75												
08-28-75												
12-30-75	11.25		20350	12.50		21160	23.15		17680	23.50		590
02-24-76				13.32		18330	23.19		18530	23.57		6170
06-04-76				11.95		8090	22.54			23.45		3850
07-29-76				11.53			22.36			23.18		
09-14-76			10720	11.74		13330	27.78		8910	23.34		3250
10-27-76				12.49		24750	23.55		16220	23.35		5660
01-20-84	7.60		16730	12.61	3951.42	16540	22.70	3998.65	15730	15.26	3992.53	6870
04-04-84												
04-14-84	14.00			13.70	3950.33		23.00	3998.35		16.00	3991.79	
04-29-84												
05-10-84												
05-20-84	12.00			12.90	3951.13		22.80	3998.55		17.80	3989.99	
05-27-84												
06-01-84												
06-20-84	11.00			10.40	3953.63		20.00	4001.35		15.50	3992.29	
07-02-84												
07-16-84	10.20			10.00	3954.03		19.50	4001.85		14.70	3993.09	
07-30-84												
08-13-84	10.00			9.50	3954.53		19.70	4001.65		14.50	3993.29	
08-27-84												
12-07-84	9.90			9.60	3954.43		19.00	4002.35		14.00	3993.79	
02-28-85												
06-06-85												
06-20-85												
07-05-85												
07-20-85												
08-15-85												
09-20-85												
10-24-85												
12-07-85	10.70		3470							16.08	3991.71	6450
03-18-86	11.20		3590				23.36	3997.99	11660	15.71	3992.08	5890
04-22-86	11.40		3650				23.41	3997.94	10830	15.73	3992.06	6220
05-28-86	11.50		3620				22.70	3998.65	15730	15.26	3992.53	6870
06-13-86	11.90		3540				24.40	3996.95	11540	16.67	3991.12	3810
06-28-86												
07-19-86	D						23.00	3998.35	12050	16.00	3991.79	3880
07-26-86												
08-16-86	12.90		3280				20.00	4001.35	11540	15.50	3992.29	3740
08-31-86												
09-09-86												
09-17-86	13.60						19.50	4001.85	11990	14.50	3993.29	3620
10-18-86	14.00		3090				19.10	4002.25	12140	14.00	3993.79	3600
10-25-86												
11-08-86												
11-17-86	14.30		2910				19.00	4002.35	12210	14.00	3993.79	3690
06-04-87	13.60		2340									
06-21-87	14.80		6690									
07-02-87												
07-24-87	13.99		3260									
08-27-87	9.65		3640									
09-27-87	7.90		3190									
10-31-87	7.70									16.00	3991.79	5620
11-25-87	7.20		3100							16.08	3991.71	6760
04-05-88										14.58	3993.21	2960
04-29-88												
05-14-88	10.06		7990	13.00	3951.03	7090				15.81	3991.98	2780
06-10-88	10.08		7680	13.20	3950.83	6930				15.28	3992.51	3080
06-26-88												
07-23-88	9.71		7590	13.70	3950.33	6670				15.19	3992.60	3390
08-88	9.38		8150	12.73	3951.30	7620				15.11	3992.68	3470
09-88	10.65		8900	13.87	3950.16	8250				23.33	3984.46	3510
10-88	10.76		8070	14.40	3949.63	9290				12.40	3995.39	3620

APPENDIX C

Listing of Wells Sampled and Analytical Results, 10-Year Demonstration Site and Brickley Site

Cation Water Quality - Stillwater Demonstration Site - Wells

SAM #..	BOTTLE NO	CALCIUM MG/L.....	MAGNESIUM MG/L.....	SODIUM MG/L.....	POTASSIUM MG/L.....	IRON MG/L.....	MANGANESE MG/L.....	SILICA MG/L.....
86Q0104	Z-31	121.	72.8	65.4	1.5	<.002	.009	11.0
88Q1274	Z-60	134.	82.7	180.	4.1	.004	.003	15.7
90Q0275	Z-60	126.	79.7	167.	4.1	.005	.016	14.9
85Q0543	Z-30	313.	252.	411.	7.4	.005	1.23	9.8
86Q0103	Z-30	24.9	26.9	180.	1.6	<.002	.005	9.6
86Q0414	Z-30	332.	270.	435.	10.0	<.002	1.25	8.5
87Q0947	Z-30	435.	349.	501.	11.9	<.002	.84	8.5
88Q0251	Z-30	434.	349.	503.	12.4	.005	.012	10.4
88Q1267	Z-30	417.	338.	519.	12.2	.005	.71	8.5
89Q0562	Z-30	31.2	26.	85.	2.7	<.002	.012	6.1
90Q0142	Z-30	422.	342.	486.	12.12	<0.004	0.057	9.
90Q0265	Z-30	423.	333.	482.	12.61	<0.004	1.056	8.4
90Q0264	Z-18	33.83	26.2	782.	2.91	<0.004	0.074	8.1
88Q1275	Z-61	123.	80.6	197.	3.4	.004	.007	13.1
90Q0276	Z-61	168.	114.	242.	3.9	0.004	0.03	11.1
86Q0111	Z-53	198.	141.	205.	10.2	<.002	.035	15.8
86Q0421	Z-53	198.	134.	191.	6.5	<.002	.10	13.1
88Q1272	Z-57	171.	110.	190.	6.8	.025	.48	14.5
88Q1270	Z-55	185.	111.	549.	9.	.014	.004	10.6
90Q0272	Z-55	176.2	104.6	509.	9.55	.027	.008	10.5
86Q0110	Z-52							
86Q0420	Z-52							
88Q1271	Z-56	267.	182.	372.	17.2	.007	.32	17.9
90Q0273	Z-56	275.	179.	354.	17.36	0.03	0.29	18.1
88Q1273	Z-59	219.	122.	470.	8.	.007	.90	12.0
90Q0274	Z-59	194.	108.	477.	8.33	0.328	0.625	11.6
85Q0545	Z-40	220.	125.	492.	9.2	<.002	.14	11.3
86Q0107	Z-40							
86Q0417	Z-40							
87Q0949	Z-40	212.	122.	495.	8.7	<.002	.028	9.6
88Q0253	Z-40	214.	124.	484.	8.9	<.002	.041	9.9
90Q0268	Z-40	198.	115.	483.	9.31	<0.004	0.124	10.
86Q0112	Z-54	230.	176.	378.	8.8	.042	2.30	15.6
87Q0951	Z-54	214.	170.	385.	5.2	<.002	.058	11.3
88Q1269	Z-54	218.	171.	387.	5.6	.003	<.001	11.8
90Q0271	Z-54	214.	154.	357.	5.35	0.004	0.009	11.3
90Q0266	Z-35	98.8	63.1	149.	4.24	<0.004	0.087	10.3
85Q0539	Z-14	372.	929.	13300.	14.8	.034	.55	8.7
90Q0263	Z-14	268.	578.	9950.	14.6	.063	.937	8.15
87Q0317	Z-36	207.	196.	884.	6.6	<.002	.11	12.4
87Q0499	Z-36							
87Q0948	Z-36	209.	189.	832.	6.9	<.002	.48	13.3
88Q0252	Z-36	214.	197.	853.	7.5	.002	.038	12.4
88Q1004	Z-36							

Cation Water Quality - Stillwater Demonstration Site - Wells
-Continued-

SAM #..	BOTTLE NO	CALCIUM MG/L.....	MAGNESIUM MG/L.....	SODIUM MG/L.....	POTASSIUM MG/L.....	IRON MG/L.....	MANGANESE MG/L.....	SILICA MG/L.....
85Q0544	Z-38	175.	137.	703.	5.8	.012	.23	10.8
86Q0106	Z-38							
86Q0416	Z-38							
86Q0105	Z-37	193.	113.	769.	5.3	<.002	.064	11.7
86Q0415	Z-37	169.	99.2	711.	6.2	.002	.35	12.2
90Q0267	Z-37	168.	93.5	688.	6.74	1.559	3.799	14.1
86Q0102	Z-5							
86Q0413	Z-5							
90Q0262	Z-5	300.	268.	1530.	9.	0.31	0.572	13.5
85Q0546	Z-48	366.	334.	1140.	5.5	.017	.64	11.6
86Q0108	Z-48	368.	297.	1159.	6.5	<.002	.24	9.4
86Q0418	Z-48	384.	332.	1133.	5.4	<.002	.66	9.4
90Q0269	Z-48	349.	259.	1060.	7.25	.093	.363	9.77
85Q0538	Z-08	587.	1050.	6740.	17.8	.77	1.86	10.7
85Q0536	Z-1	402.	629.	1450.	9.2	.14	1.04	12.3
86Q0101	Z-1	471.	741.	1457.	13.6	.039	.630	12.4
86Q0412	Z-1	616.	1393.	2553.	12.0	.004	1.29	12.5
87Q0490	Z-1							
87Q0709	Z-1							
87Q0945	Z-1	410.	617.	1440.	7.5	.11	.87	11.9
88Q0250	Z-1	607.	1910.	3460.	3.2	.084	.053	5.5
88Q1003	Z-1							
88Q1265	Z-1	556.	1920.	4030.	16.5	.62	.42	6.9
89Q0558	Z-1	516.	2190.	4860.	9.1	.056	.025	5.3
90Q0141	Z-1	538.	2500.	4590.	6.93	0.162	0.091	6.4
90Q0261	Z-1	538.	2520.	4640.	8.40	.026	.263	6.55
85Q0537	Z-2	210.	111.	846.	3.6	.010	.21	13.6
85Q0542	Z-26	286.	229.	632.	6.6	.075	.58	11.9
87Q0946	Z-26	271.	217.	628.	5.7	.57	.93	10.2
88Q1266	Z-26	267.	221.	626.	9.2	.24	1.64	11.4
85Q0541	Z-22	124.	179.	1660.	4.4	.024	.73	10.0
85Q0547	Z-50	222.	132.	468.	7.	<.002	.30	11.7
86Q0109	Z-50	203.	124.	453.	6.8	<.002	.53	11.4
86Q0419	Z-50	218.	128.	463.	5.8	<.002	.078	9.8
86Q1009	Z-50							
87Q0316	Z-50	225.	137.	497.	6.5	.054	.025	10.6
87Q0497	Z-50							
87Q0712	Z-50							
87Q0950	Z-50	219.	129.	480.	6.7	<.002	.046	9.7
88Q0254	Z-50	188.	119.	479.	6.9	.17	.70	12.9
88Q1268	Z-50	187.	121.	514.	6.3	.036	.12	12.0
89Q0564	Z-50	124.	73.	335.	8.7	.48	.81	14.1
90Q0270	Z-50	211.9	125.	432.	6.34	.169	.204	9.81
88Q1009	B-16	388.	2280.	1640.	26.0	<.002	.005	7.0

Cation Water Quality - Stillwater Demonstration Site - Wells
-Continued-

SAM #..	BOTTLE NO	CALCIUM MG/L.....	MAGNESIUM MG/L.....	SODIUM MG/L.....	POTASSIUM MG/L.....	IRON MG/L.....	MANGANESE MG/L.....	SILICA MG/L.....
86Q0098	B-1	362.	645.	590.	14.7	<.002	.001	9.9
86Q0409	B-1	455.	741.	574.	16.7	.016	.005	10.4
88Q1005	B-1	415.	885.	729.	21.8	.12	.11	11.5
86Q0099	B-2	371.	2034.	1764.	23.0	<.002	.016	9.5
86Q0410	B-2	382.	2155.	1897.	24.6	<.002	.015	9.1
88Q1006	B-2	397.	2265.	2230.	26.6	.81	.98	10.0
88Q1008	B-14	495.	162.	273.	9.1	.048	.86	8.8
88Q1010	B-20	437.	409.	768.	15.2	.002	.081	10.4
86Q0100	B-8	454.	520.	1062.	19.7	<.002	.37	11.8
86Q0411	B-8	457.	588.	570.	18.4	<.002	.11	8.9
87Q0493	B-8							
87Q0704	B-8							
88Q1007	B-8	451.	604.	677.	19.1	.006	.049	6.9

Anion Water Quality - Stillwater Demonstration Site - Wells

SAM #..	BOTTLE NO	HCO3 MG/L.....	CO3 MG/L.....	CHLORIDE MG/L.....	SULFATE MG/L.....	NITRATE AS N MG/L.	FLUORIDE MG/L.....	STD DEV BALANCE...	LAB PH...	LAB COND MMOHS...	DISSOLVED SOLIDS MG/L
86Q0104	Z-31	401.	.0	30.1	308.	13.9	.6	-0.27	7.57	1340.	821.95
88Q1274	Z-60	372.	0.	65.2	658.	1.05	.6	0.62	7.56	1685.	1324.81
90Q0275	Z-60	373.		59.2	556.	.88	.52	-2.11	7.33	1841.9	1192.06
85Q0543	Z-30	519.	.0	158.	1980.	.40	.1	-0.46	7.50	4019.	3388.70
86Q0103	Z-30	561.	.0	4.5	63.1	7.76	1.0	-0.36	7.75	1032.0	595.82
86Q0414	Z-30	368.	0.	291.	2059.	7.1	.2	-0.58	7.43	4591.	3595.43
87Q0947	Z-30	305.	0.	334.	2700.	18.1	.4	-0.71	7.27	5560.	4509.19
88Q0251	Z-30	306.	0.	339.	2690.	32.1	.1	0.06	8.14	5224.	4520.76
88Q1267	Z-30	301.	0.	332.	2710.	17.2	.5	0.19	7.38	5192.	4503.39
89Q0562	Z-30					4.71					
90Q0142	Z-30	307.	0.0	340.	2680.	16.38	0.16	0.63	7.32	5226.	4458.94
90Q0265	Z-30	315.	0.0	328.	2670.	16.87	0.11	1.01	7.38	5305.1	4430.21
90Q0264	Z-18	600.	0.0	109.	1190.	<0.07	0.57	-0.46	7.88	3969.6	2448.18
88Q1275	Z-61	428.	0.	39.6	647.	1.04	.6	0.56	7.65	1837.	1316.29
90Q0276	Z-61	422.	0.0	65.7	936.	2.57	0.48	-0.01	7.30	2348.3	1751.67
86Q0111	Z-53	319.	.0	122.	1036.	3.86	1.1	-0.32	7.87	2591.0	1890.14
86Q0421	Z-53	362.	0.	98.7	1008.	1.30	.7	0.69	7.60	2457.	1829.93
88Q1272	Z-57	372.	0.	89.6	853.	.52	.5	0.67	7.60	2116.	1619.88
88Q1270	Z-55	408.	0.	124.	1529.	2.93	.5	-0.53	7.52	3490.	2722.23
90Q0272	Z-55	334.		114.	1460.	2.95	1.70	-0.82	7.88	2223.7	2553.07
86Q0110	Z-52					2.20			7.36	3275.0	
86Q0420	Z-52	427.	0.			1.61			7.18	3454.	
88Q1271	Z-56	312.	0.	125.	1705.	3.74	.2	-0.94	7.03	3462.	2844.06
90Q0273	Z-56	285.	0.0	121.	1740.	2.62	0.08	-0.01	6.66	3508.2	2847.87
88Q1273	Z-59	399.	0.	140.	1503.	.16	.4	0.00	7.36	3255.	2672.22
90Q0274	Z-59	396.	0.0	132.	1420.	0.13	0.39	0.06	7.35	3444.9	2547.48
85Q0545	Z-40	415.	.0	157.	1560.	1.41	.1	0.98	7.35	3517.	2780.68
86Q0107	Z-40					1.73			8.23	3646.0	
86Q0417	Z-40	416.	0.			2.12			7.40	3801.	
87Q0949	Z-40	418.	0.	146.	1507.	3.01	.3	0.05	7.72	3738.	2709.95
88Q0253	Z-40	434.	0.	132.	1530.	2.43	.2	0.73	7.80	3541.	2719.26
90Q0268	Z-40	426.	0.0	127.	1440.	2.23	0.39	-0.07	7.49	3451.	2594.90
86Q0112	Z-54	431.	0.	159.	1525.	.27	1.2	0.72	7.18	3994.0	2708.63
87Q0951	Z-54	437.	0.	135.	1535.	5.49	.8	2.30	7.74	3542.	2677.42
88Q1269	Z-54	431.	0.	131.	1457.	5.11	.9	-0.81	7.57	3285.	2599.73
90Q0271	Z-54	436.	0.0	110.	1350.	5.22	0.52	-0.62	7.37	3185.5	2422.18
90Q0266	Z-35	407.	0.0	61.	401.	0.74	0.55	0.09	7.47	1547.8	989.31
85Q0539	Z-14	1135.	.0	833.	30300.	.02	.1	-0.13	7.86	39164.	46317.32
90Q0263	Z-14	1260.		634.	22100.	1.32	1.36	0.60	8.14	31493.	34177.12
87Q0317	Z-36	482.	0.	175.	2502.	4.15	.6	0.02	7.54	5637.	4225.30
87Q0499	Z-36					2.04					
87Q0948	Z-36	477.	0.	165.	2390.	3.12	.3	-0.04	7.65	5394.	4044.38
88Q0252	Z-36	560.	0.	172.	2400.	5.78	.1	0.07	7.78	5182.	4137.68
88Q1004	Z-36					4.8					

Anion Water Quality - Stillwater Demonstration Site - Wells
-Continued-

SAM #..	BOTTLE NO	HCO3 MG/L.....	CO3 MG/L.....	CHLORIDE MG/L.....	SULFATE MG/L.....	NITRATE AS N MG/L.	FLUORIDE MG/L.....	STD DEV BALANCE...	LAB PH...	LAB COND MMOHS...	DISSOLVED SOLIDS MG/L
85Q0544	Z-38	372.	.0	159.	1950.	.35	.1	0.38	7.72	4333.	3324.64
86Q0106	Z-38					.03					
86Q0416	Z-38	582.	0.			.06			7.63	4636.	
86Q0105	Z-37	439.	.0	104.	2050.	5.50	.9	0.69	7.30	4564.0	3468.72
86Q0415	Z-37	448.	0.	98.4	1811.	7.00	.3	0.68	7.25	4237.	3135.54
90Q0267	Z-37	470.	0.0	101.	1720.	3.12	0.45	0.14	7.00	4006.4	3031.80
86Q0102	Z-5					2.41			8.17	6885.0	
86Q0413	Z-5	699.	0.			.54			7.52	7694.	
90Q0262	Z-5	769.	0.0	294.	4060.	2.39	0.62	0.95	7.70	8188.4	6857.21
85Q0546	Z-48	528.	.0	338.	3640.	6.54	.1	-0.86	7.67	6853.	6102.60
86Q0108	Z-48	449.	.0	326.	3660.	8.80	1.3	-0.12	7.82	7342.0	6057.42
86Q0418	Z-48	453.	0.	322.	3700.	21.1	.5	-0.72	7.63	7315.	6131.41
90Q0269	Z-48	456.		275.	3380.	15.0	.40	1.05	7.50	6630.4	5580.51
85Q0538	Z-08	852.	.0	885.	17800.	.01	.1	-0.03	7.68	30939.	27512.94
85Q0536	Z-1	490.	.0	480.	5490.	7.61	.1	0.54	7.30	9323.	8723.17
86Q0101	Z-1	477.	.0	530.	5880.	38.3	1.4	-0.17	7.52	10631.0	9380.34
86Q0412	Z-1	636.	0.	1160.	10220.	7.65	.2	-0.13	7.43	16285.	16289.04
87Q0490	Z-1					.60					
87Q0709	Z-1					.46					
87Q0945	Z-1	641.	0.	389.	5430.	4.03	.4	0.30	7.85	9823.	8627.07
88Q0250	Z-1	544.	0.	1290.	14000.	5.0	.1	-0.23	7.95	19839.	21548.92
88Q1003	Z-1					392.					
88Q1265	Z-1	590.	0.	1460.	14700.	91.	3.	0.32	7.71	20373.	23075.08
89Q0558	Z-1	628.	0.	1940.	18600.	126.	<1.	6.71	7.58	26703.	28555.84
90Q0141	Z-1	1160.	0.0	2040.	17200.	9.15	1.83	0.43	8.07	22980.	27463.99
90Q0261	Z-1	717.		2010.	17900.	8.42	1.51	0.81	7.77	24733.	27986.37
85Q0537	Z-2	579.	.0	153.	2189.	.02	.4	2.95	7.12	4936.	3812.26
85Q0542	Z-26	571.	.0	155.	2220.	5.40	.1	-0.66	7.51	4496.	3827.94
87Q0946	Z-26	458.	0.	146.	2290.	4.28	.6	0.57	7.49	5000.0	3800.20
88Q1266	Z-26	514.	0.	152.	2260.	.05	.6	0.61	7.53	4770.	3803.83
85Q0541	Z-22	571.	.0	264.	3700.	.71	.2	0.34	7.56	7529.	6224.34
85Q0547	Z-50	426.	.0	125.	1500.	7.	.1	-0.55	7.19	3668.	2682.95
86Q0109	Z-50	430.	.0	130.	1400.	5.56	.8	-0.10	7.56	3412.0	2546.91
86Q0419	Z-50	419.	0.	120.	1500.	8.99	.2	0.41	7.54	3523.	2660.47
86Q1009	Z-50					12.1					
87Q0316	Z-50	400.	0.	134.	1582.	11.8	.3	-0.43	7.30	3718.	2801.32
87Q0497	Z-50					7.07					
87Q0712	Z-50					9.67					
87Q0950	Z-50	380.	0.	138.	1552.	10.2	.3	0.60	7.47	3663.	2732.34
88Q0254	Z-50	1099.	0.	82.6	947.	.10	.1	-0.37	7.62	3590.	2378.85
88Q1268	Z-50	487.	0.	134.	1456.	.67	.3	0.26	7.39	3400.	2671.33
89Q0564	Z-50					<.02					
90Q0270	Z-50	434.		108.	1390.	7.51	.33	-0.48	7.12	3361.1	2505.06
88Q1009	B-16	625.	0.	110.	12500.	66.	.2	-0.18	7.21	15043.	17325.09

Anion Water Quality - Stillwater Demonstration Site - Wells
-Continued-

SAM #..	BOTTLE NO	HCO3 MG/L.....	CO3 MG/L.....	CHLORIDE MG/L.....	SULFATE MG/L.....	NITRATE AS N MG/L.	FLUORIDE MG/L.....	STD DEV BALANCE...	LAB PH...	LAB COND MMOHS...	DISSOLVED SOLIDS MG/L
86Q0098	B-1	406.	.0	166.	3750.	100.	1.5	-0.48	7.77	6768.0	5839.10
86Q0409	B-1	366.	0.	162.	4260.	121.	.3	-0.83	7.50	7404.	6520.72
88Q1005	B-1	396.	0.	163.	5100.	84.	.1	-1.45	7.21	7720.	7604.80
86Q0099	B-2	438.	.0	170.	11690.	107.	1.6	-0.10	7.61	15278.0	16385.88
86Q0410	B-2	462.	0.	161.	12670.	91.2	.6	0.67	7.06	15744.	17618.10
88Q1006	B-2	513.	0.	175.	13700.	67.	.2	-0.16	7.13	15933.	19126.30
88Q1008	B-14	342.	0.	22.0	2092.	6.68		-0.07	7.38	3675.	3238.26
88Q1010	B-20	473.	0.	169.	3440.	70.	.1	-0.19	7.43	6460.	5551.79
86Q0100	B-8	630.	.0	126.	4590.	31.0	1.1	-0.26	8.13	7993.0	7126.31
86Q0411	B-8	486.	0.	168.	3880.	54.6	.4	0.52	7.22	6684.	5984.92
87Q0493	B-8					9.11					
87Q0704	B-8					72.1					
88Q1007	B-8	514.	0.	126.	4200.	40.	.1	-0.03	7.23	6895.	6377.36

Trace Metal Water Quality - Stillwater Demonstration Site - Wells

SAM #..	BOTTLE NO	BORON UG/L.....	STRONTIUM UG/L.....	LITHIUM UG/L.....	SELENIUM UG/L.....	ARSENIC UG/L.....	COPPER UG/L.....	ZINC UG/L.....	LEAD UG/L.....	CHROMIUM UG/L.....	CADMIUM MG/L.....	BARIUM UG/L.....	SAMPLE TYPE.....
86Q0104	Z-31	200.	1670.	18.	26.		<2.	11.		<2.	3.		Dissolved
88Q1274	Z-60	290.	2860.	44.	11.		<2.	8.		<2.	<2.		Dissolved
90Q0275	Z-60	220.	3010.	45.	9.7		<4.	7.		<5.	<5.	11.	Dissolved
85Q0543	Z-30	610.	7620.	71.	226.	1.0	33.	<3.		4.	<2.		Dissolved
86Q0103	Z-30	500.	671.	34.	9.7		3.	<3.		<2.	2.		Dissolved
86Q0414	Z-30	690.	7730.	93.	22.		<2.	3.		<2.	<2.		Dissolved
87Q0947	Z-30	470.	9990.	100.	346.		8.	12.		<2.	8.		Dissolved
88Q0251	Z-30	400.	1080.E+01	100.	309.		34.	11.		3.	3.		Dissolved
88Q1267	Z-30	540.	9970.	96.	290.		15.	15.		3.	<2.		Dissolved
89Q0562	Z-30	240.	970.	24.	20.		<2.	7.	<40.	<2.	<2.		Dissolved
90Q0142	Z-30	270.	1020.E+01	101.	300.	0.6	<4.	34.	100.	<5.	<5.	13.	Dissolved
90Q0265	Z-30	440.	1070.E+01	101.	311.		<4.	<6.		<5.	<5.	12.	Dissolved
90Q0264	Z-18	517.	3280.	73.	<0.1		<4.	<6.		<5.	5.	14.	Dissolved
88Q1275	Z-61	270.	2220.	34.	19.		<2.	6.		<2.	<2.		Dissolved
90Q0276	Z-61	272.	3370.	45.	40.		<4.	8.		<5.	6.	30.	Dissolved
86Q0111	Z-53	370.	3990.	45.	16.0		<2.	<3.		<2.	<2.		Dissolved
86Q0421	Z-53	420.	3960.	62.	13.4		<2.	<3.		<2.	<2.		Dissolved
88Q1272	Z-57	290.	3520.	45.	2.2		<2.	9.		2.	<2.		Dissolved
88Q1270	Z-55	430.	7330.	75.	23.		9.	19.		<2.	<2.		Dissolved
90Q0272	Z-55	329.	7230.	84.	14.		<4.	12.		<5.	<5.	14.	Dissolved
86Q0110	Z-52				.2								Dissolved
86Q0420	Z-52				9.4								Dissolved
88Q1271	Z-56	520.	8440.	180.	3.5		4.	40.		<2.	<2.		Dissolved
90Q0273	Z-56	423.	8730.	211.	1.6		<4.	18.		<5.	<5.	11.	Dissolved
88Q1273	Z-59	560.	7720.	120.	<.1		<2.	19.		<2.	<2.		Dissolved
90Q0274	Z-59	411.	7030.	121.	0.6		<4.	13.		<5.	<5.	16.	Dissolved
85Q0545	Z-40	500.	8480.	82.	41.	.3	28.	<3.		3.	<2.		Dissolved
86Q0107	Z-40				35.								Dissolved
86Q0417	Z-40				34.								Dissolved
87Q0949	Z-40	380.	7840.	81.	37.		8.	14.		<2.	<2.		Dissolved
88Q0253	Z-40	330.	8120.	74.	259.		<2.	19.		<2.	<2.		Dissolved
90Q0268	Z-40	324.	7830.	86.	28.		<4.	12.		<5.	5.	26.	Dissolved
86Q0112	Z-54	500.	6450.	81.	8.6		<2.	<3.		<2.	<2.		Dissolved
87Q0951	Z-54	320.	7090.	76.	71.		<2.	10.		<2.	<2.		Dissolved
88Q1269	Z-54	360.	7110.	73.	61.		<2.	7.		<2.	<2.		Dissolved
90Q0271	Z-54	295.	6750.	75.	63.		<4.	10.		<5.	<5.	14.	Dissolved
90Q0266	Z-35	243.	3430.	38.	4.1		<4.	<6.		<5.	<5.	22.	Dissolved
85Q0539	Z-14	4950.	1220.E+01	610.	16.	.9	36.	<3.		25.	3.		Dissolved
90Q0263	Z-14	3230.	1140.E+01	527.	5.2		<4.	9.		<5.	<5.	11.	Dissolved
87Q0317	Z-36	500.	6880.	110.	116.		12.	42.		<2.	<2.		Dissolved
87Q0499	Z-36				77.								Dissolved
87Q0948	Z-36	370.	6770.	110.	82.		<2.	11.		<2.	<2.		Dissolved
88Q0252	Z-36	360.	6990.	98.	43.		13.	53.		<2.	<2.		Dissolved
88Q1004	Z-36				70.								Dissolved

Trace Metal Water Quality - Stillwater Demonstration Site - Wells
-Continued-

SAM #..	BOTTLE NO	BORON UG/L.....	STRONTIUM UG/L.....	LITHIUM UG/L.....	SELENIUM UG/L.....	ARSENIC UG/L.....	COPPER UG/L.....	ZINC UG/L.....	LEAD UG/L.....	CHROMIUM UG/L.....	CADMIUM MG/L.....	BARIUM UG/L.....	SAMPLE TYPE.....
85Q0544	Z-38	520.	6760.	71.	16.	1.0	16.	<1.		<2.	<2.		Dissolved
86Q0106	Z-38				9.2								Dissolved
86Q0416	Z-38				6.1								Dissolved
86Q0105	Z-37	450.	5580.	45.	19.		<2.	<3.		<2.	<2.		Dissolved
86Q0415	Z-37	500.	4750.	49.	20.		<2.	3.		<2.	3.		Dissolved
90Q0267	Z-37	326.	4660.	36.	5.8		<4.	12.		<5.	<5.	40.	Dissolved
86Q0102	Z-5				41.								Dissolved
86Q0413	Z-5				37.								Dissolved
90Q0262	Z-5	331.	1080.E+01	68.	18.0		<4.	<6.		<5.	<5.	<5.	Dissolved
85Q0546	Z-48	470.	9860.	75.	96.	1.8	45.	7.		14.	2.		Dissolved
86Q0108	Z-48	410.	1070.E+01	61.	112.		<2.	<3.		<2.	<2.		Dissolved
86Q0418	Z-48	560.	1050.E+01	74.	143.		<2.	4.		<2.	5.		Dissolved
90Q0269	Z-48	338.	1000.E+01	71.	139.		<4.	18.		<5.	<5.	13.	Dissolved
85Q0538	Z-08	1060.	1230.E+01	220.	2.7	4.6	57.	<3.		27.	<2.		Dissolved
85Q0536	Z-1	570.	6720.	160.	443.	2.9	39.	<3.		16.	<2.		Dissolved
86Q0101	Z-1	340.	7480.	160.	649.		<2.	5.		<2.	<2.		Dissolved
86Q0412	Z-1	760.	1030.E+01	260.	276.		<2.	21.		3.	11.		Dissolved
87Q0490	Z-1				66.								Dissolved
87Q0709	Z-1				5.5								Dissolved
87Q0945	Z-1	520.	6690.	160.	315.		<2.	12.		<2.	10.		Dissolved
88Q0250	Z-1	350.	1190.E+01	290.	1971.		55.	110.		<2.	14.		Dissolved
88Q1003	Z-1				1922.								Dissolved
88Q1265	Z-1	750.	9120.	360.	1420.		30.	66.		<2.	6.		Dissolved
89Q0558	Z-1	580.	9290.	330.	2656.		190.	640.		<2.	25.		Dissolved
90Q0141	Z-1	620.	1300.E+01	450.	3320.	7.2	80.	<6.	480.	<5.	<5.	<10.	Dissolved
90Q0261	Z-1	471.	1330.E+01	451.	2960.		207.	551.		32.	28.	7.	Dissolved
85Q0537	Z-2	290.	4650.	35.	.7	.6	21.	8.		<2.	<2.		Dissolved
85Q0542	Z-26	520.	8480.	50.	71.	7.7	20.	<3.		<2.	<2.		Dissolved
87Q0946	Z-26	520.	8550.	67.	50.		3.	6.		<2.	5.		Dissolved
88Q1266	Z-26	610.	8730.	60.	1.4		11.	12.		2.	<2.		Dissolved
85Q0541	Z-22	710.	6170.	53.	15.	.9	7.	<3.		<2.	<2.		Dissolved
85Q0547	Z-50	400.	6680.	50.	83.	.1	33.	15.		5.	5.		Dissolved
86Q0109	Z-50	1370.	6240.	40.	46.		<2.	25.		<2.	<2.		Dissolved
86Q0419	Z-50	520.	6670.	45.	92.		<2.	3.		<2.	<2.		Dissolved
86Q1009	Z-50				114.								
87Q0316	Z-50	430.	7140.	59.	117.		19.	75.		<2.	<2.		Dissolved
87Q0497	Z-50				93.								Dissolved
87Q0712	Z-50				110.								Dissolved
87Q0950	Z-50	270.	6590.	42.	93.		3.	12.		<2.	<2.		Dissolved
88Q0254	Z-50	260.	6000.	41.	6.1		<2.	25.		<2.	45.		Dissolved
88Q1268	Z-50	320.	6150.	53.	4.7		<2.	9.		<2.	<2.		Dissolved
89Q0564	Z-50	240.	3820.	25.	.7		<2.	23.	<40.	<2.	13.		Dissolved
90Q0270	Z-50	235.	6640.	42.	66.		<4.	<6.		<5.	<5.	39.	Dissolved
88Q1009	B-16	480.	5850.	1530.	385.		25.	69.		<2.	10.		Dissolved

Trace Metal Water Quality - Stillwater Demonstration Site - Wells
-Continued-

SAM #..	BOTTLE NO	BORON UG/L.....	STRONTIUM UG/L.....	LITHIUM UG/L.....	SELENIUM UG/L.....	ARSENIC UG/L.....	COPPER UG/L.....	ZINC UG/L.....	LEAD UG/L.....	CHROMIUM UG/L.....	CADMIUM MG/L.....	BARIUM UG/L.....	SAMPLE TYPE.....
86Q0098	B-1	640.	8710.	685.	1030.		<2.	<3.		<2.	8.		Dissolved
86Q0409	B-1	510.	1050.E+01	810.	1410.		<2.	72.		3.	4.		Dissolved
88Q1005	B-1	510.	1020.E+01	920.	1137.		17.	13.		<2.	3.		Dissolved
86Q0099	B-2	870.	6850.	1.55	591.		<2.	7.		<2.	8.		Dissolved
86Q0410	B-2	580.	7280.	1520.	629.		<2.	17.		<2.	16.		Dissolved
88Q1006	B-2	580.	7180.	1750.	998.		21.	28.		36.	38.		Dissolved
88Q1008	B-14	410.	6870.	210.	76.		17.	3.		<2.	<2.		Dissolved
88Q1010	B-20	610.	7180.	580.	1040.		23.	20.		<2.	<2.		Dissolved
86Q0100	B-8	1330.	863.	1350.	332.		<2.	19.		<2.	<2.		Dissolved
86Q0411	B-8	770.	7450.	880.	587.		<2.	56.		<2.	<2.		Dissolved
87Q0493	B-8				135.								Dissolved
87Q0704	B-8				690.								Dissolved
88Q1007	B-8	700.	8610.	1000.	572.		25.	24.		<2.	2.		Dissolved

Geographic Parameters - Water Quality Sites - Stillwater Demonstration Site - Wells

LOCATION.....	SITE NAME.....	TOTAL DEPTH FEET....	SAMPLE #	DATE SAMPLED	SAMPLE TYPE.....
02N 21E 01 AADB	ZINNE-HERZOG WELL 31 * SCS DEMO-SITE	13.0	86Q0104	26 MAR 86	Dissolved
02N 21E 01 ACAD	WELL 60 * HERZOG-ZINNE SITE * RAPELJE MT	18.0	88Q1274	25 AUG 88	Dissolved
			90Q0275	02 AUG 90	Dissolved
02N 21E 01 ADAA	WELL 30 * HERZOG-ZINNE SITE * RAPELJE MT	30.0	85Q0543	13 JUN 84	Dissolved
			86Q0103	26 MAR 86	Dissolved
			86Q0414	29 MAY 86	Dissolved
			87Q0947	23 OCT 87	Dissolved
			88Q0251	20 APR 88	Dissolved
			88Q1267	26 AUG 88	Dissolved
			89Q0562	04 MAY 89	Dissolved
			90Q0142	24 MAY 90	Dissolved
			90Q0265	03 AUG 90	Dissolved
02N 21E 01 ADBC	HERZOG-ZINNE WELL Z-18 * SCS DEMO SITE	13.0	90Q0264	03 AUG 90	Dissolved
02N 21E 01 ADBC	WELL 61 * HERZOG-ZINNE SITE * RAPELJE MT	28.0	88Q1275	25 AUG 88	Dissolved
			90Q0276	02 AUG 90	Dissolved
02N 21E 01 ADBD	ZINNE-HERZOG WELL 53*SCS DEMO-SITE*RAPELJE	25.0	86Q0111	27 MAR 86	Dissolved
			86Q0421	29 MAY 86	Dissolved
02N 21E 01 ADBD	WELL 57 * HERZOG-ZINNE SITE * RAPELJE MT	38.0	88Q1272	25 AUG 88	Dissolved
02N 21E 01 ADCA	WELL 55 * HERZOG-ZINNE SITE * RAPELJE MT	27.5	88Q1270	25 AUG 88	Dissolved
			90Q0272	02 AUG 90	Dissolved
02N 21E 01 ADCA	WELL 52 * HERZOG=ZINNE SITE * RAPELJE MT	57.0	86Q0110	27 MAR 86	Dissolved
			86Q0420	29 MAY 86	Dissolved
02N 21E 01 ADCA	WELL 56 * HERZOG-ZINNE SITE * RAPELJE MT	34.0	88Q1271	25 AUG 88	Dissolved
			90Q0273	03 AUG 90	Dissolved
02N 21E 01 ADCB	WELL 59 * HERZOG-ZINNE SITE * RAPELJE MT	31.0	88Q1273	25 AUG 88	Dissolved
			90Q0274	02 AUG 90	Dissolved
02N 21E 01 ADCD	WELL Z-40 * ZINNE-HERZOG SITE * RAPELJE MT	40.0	85Q0545	12 JUN 85	Dissolved
			86Q0107	27 MAR 86	Dissolved
			86Q0417	29 MAY 86	Dissolved
			87Q0949	21 OCT 87	Dissolved
			88Q0253	21 APR 88	Dissolved
			90Q0268	02 AUG 90	Dissolved
02N 21E 01 ADDD	WELL 54 * HERZOG-ZINNE SITE * RAPELJE MT	23.5	86Q0112	27 MAR 86	Dissolved
			87Q0951	22 OCT 87	Dissolved
			88Q1269	25 AUG 88	Dissolved
			90Q0271	02 AUG 90	Dissolved
02N 21E 01 BBAD	HERZOG-ZINNE WELL Z-35*SCS DEMO SITE*RAPEL	30.0	90Q0266	03 AUG 90	Dissolved
02N 21E 01 BBBB	HERZOG ZINNE WELL Z-14 * SCS DEMO SITE	13.0	85Q0539	13 JUN 85	Dissolved
			90Q0263	03 AUG 90	Dissolved
02N 21E 01 BBCA	ZINNE-HERZOG WELL Z-36 * RAPELJE MT	18.0	87Q0317	04 JUN 87	Dissolved
			87Q0499	15 JUL 87	Dissolved
			87Q0948	23 OCT 87	Dissolved
			88Q0252	21 APR 88	Dissolved
			88Q1004	22 JUL 88	Dissolved

Geographic Parameters - Water Quality Sites - Stillwater Demonstration Site - Wells
-Continued-

LOCATION.....	SITE NAME.....	TOTAL DEPTH FEET....	SAMPLE #	DATE SAMPLED	SAMPLE TYPE.....
02N 21E 01 BBCC	ZINNE-HERZOG WELL 38*SCS DEMO-SITE*RAPELJE	25.0	85Q0544	13 JUN 85	Dissolved
			86Q0106	27 MAR 86	Dissolved
			86Q0416	29 MAY 86	Dissolved
02N 21E 01 BBCD	ZINNE-HERZOG WELL 37*SCS DEMO-SITE*RAPELJE	20.0	86Q0105	27 MAR 86	Dissolved
			86Q0415	29 MAY 86	Dissolved
			90Q0267	03 AUG 90	Dissolved
02N 21E 01 CBAC	ZINNE-HERZOG WELL 5* SCS DEMO-SITE*RAPELJE	7.0	86Q0102	27 MAR 86	Dissolved
			86Q0413	29 MAY 86	Dissolved
			90Q0262	03 AUG 90	Dissolved
02N 21E 01 CBBB	ZINNE-HERZOG WELL 48*SCS DEMO-SITE*RAPELJE	25.0	85Q0546	13 JUN 85	Dissolved
			86Q0108	27 MAR 86	Dissolved
			86Q0418	29 MAY 86	Dissolved
			90Q0269	03 AUG 90	Dissolved
02N 21E 01 CBCB	ZINNE, JOHN * FARM SITE WELL-2-08	13.0	85Q0538	13 JUN 85	Dissolved
02N 21E 01 CCDC	HERZOG-ZINNE WELL Z-1 * SCS DEMO SITE	10.0	85Q0536	13 JUN 85	Dissolved
			86Q0101	27 MAR 86	Dissolved
			86Q0412	30 MAY 86	Dissolved
			87Q0490	15 JUL 87	Dissolved
			87Q0709	11 AUG 87	Dissolved
			87Q0945	22 OCT 87	Dissolved
			88Q0250	20 APR 88	Dissolved
			88Q1003	22 JUL 88	Dissolved
			88Q1265	26 AUG 88	Dissolved
			89Q0558	04 MAY 89	Dissolved
			90Q0141	24 MAY 90	Dissolved
			90Q0261	01 AUG 90	Dissolved
02N 21E 01 CDBB	ZINNE-HERZOG WELL 2 * SCS DEMO-SITE	15.0	85Q0537	13 JUN 85	Dissolved
02N 21E 01 DACC	WELL 26 * HERZOG-ZINNE SITE * RAPELJE MT	15.0	85Q0542	13 JUN 85	Dissolved
			87Q0946	22 OCT 87	Dissolved
			88Q1266	24 AUG 88	Dissolved
02N 21E 01 DBBB	ZINNE, JOHN * FARM SITE WELL Z-22	9.0	85Q0541	13 JUN 84	Dissolved
02N 21E 01 DDDA	WELL 50 * HERZOG-ZINNE SITE * RAPELJE MT	25.0	85Q0547	12 JUN 85	Dissolved
			86Q0109	26 MAR 86	Dissolved
			86Q0419	30 MAY 86	Dissolved
			86Q1009	16 SEP 86	
			87Q0316	05 JUN 87	Dissolved
			87Q0497	15 JUL 87	Dissolved
			87Q0712	12 AUG 87	Dissolved
			87Q0950	22 OCT 87	Dissolved
			88Q0254	20 APR 88	Dissolved
			88Q1268	26 AUG 88	Dissolved
			89Q0564	04 MAY 89	Dissolved
			90Q0270	02 AUG 90	Dissolved
03N 20E 01 BCBC	BRICKLEY SITE * WELL B-16	18.0	88Q1009	21 JUL 88	Dissolved

Geographic Parameters - Water Quality Sites - Stillwater Demonstration Site - Wells
-Continued-

LOCATION.....	SITE NAME.....	TOTAL DEPTH FEET....	SAMPLE #	DATE SAMPLED	SAMPLE TYPE.....
03N 20E 02 AABB	BRICKLEY SITE * WELL B-1 * RAPELJE MT	23.0	86Q0098	27 MAR 86	Dissolved
			86Q0409	28 MAY 86	Dissolved
			88Q1005	21 JUL 88	Dissolved
03N 20E 02 ADBA	BRICKLEY SITE * WELL B-2 * RAPELJE MT	23.0	86Q0099	27 MAR 86	Dissolved
			86Q0410	30 MAY 86	Dissolved
			88Q1006	21 JUL 88	Dissolved
04N 20E 35 DADC	BRICKLEY SITE * WELL B-14	60.0	88Q1008	21 JUL 88	Dissolved
04N 20E 35 DDAB	BRICKLEY SITE * WELL B-20 * RAPELJE MT	38.0	88Q1010	21 JUL 88	Dissolved
04N 20E 35 DDBB	BRICKLEY SITE * WELL B-8 * RAPELJE MT		86Q0100	27 MAR 86	Dissolved
			86Q0411	28 MAY 86	Dissolved
			87Q0493	15 JUL 87	Dissolved
			87Q0704	13 AUG 87	Dissolved
			88Q1007	21 JUL 88	Dissolved

APPENDIX D

Listing of Lysimeters Sampled and Analytical Results, 10-Year Demonstration Site and Brickley Site

Geographic Data - Water Quality Sites - Stillwater Demonstration Site - Lysimeters and Precipitation

LOCATION.....	SAM #..	SAMPLE SOURCE.....	SITE NAME.....	SAMPLE DATE.....	SAMPLE TYPE.....
02N 21E 01 ADAA 03	89Q0563	LYSIMETER	1-FT LYS * HERZOG-ZINNE SITE * RAPELJE MT	04 MAY 1989	Dissolved
02N 21E 01 ADAA 07	90Q0143	PRECIP	ZINNE-HERZOG SITE * SCS DEMO SITE* RAPELJE	25 MAY 1990	Dissolved
02N 21E 01 BBCA 05	86Q0603	LYSIMETER	ZINNE-HERZOG * WELL 36 * 3 FT LYSIMETER	26 JUN 1986	Dissolved
02N 21E 01 BBCA 06	86Q0768	LYSIMETER	ZINNE - HERZOG WELL 36 * 5 FT LYSIMETER	24 JUL 1986	
02N 21E 01 BBCA 06	87Q0500	LYSIMETER	ZINNE - HERZOG WELL 36 * 5 FT LYSIMETER	15 JUL 1987	Dissolved
02N 21E 01 CCDC 02	88Q0255	LYSIMETER	ZINNE-HERZOG SITE WELL Z-1 * 0.5 FT LYSI	20 APR 1988	Dissolved
02N 21E 01 CCDC 03	86Q0594	LYSIMETER	HERZOG-ZINNE WELL Z-1 * 1 FT LYSIMETER	26 JUN 1986	Dissolved
02N 21E 01 CCDC 03	86Q0775	LYSIMETER	HERZOG-ZINNE WELL Z-1 * 1 FT LYSIMETER	24 JUL 1986	
02N 21E 01 CCDC 03	87Q0491	LYSIMETER	HERZOG-ZINNE WELL Z-1 * 1 FT LYSIMETER	15 JUL 1987	Dissolved
02N 21E 01 CCDC 03	87Q0710	LYSIMETER	HERZOG-ZINNE WELL Z-1 * 1 FT LYSIMETER	11 AUG 1987	Dissolved
02N 21E 01 CCDC 03	87Q0954	LYSIMETER	HERZOG-ZINNE WELL Z-1 * 1 FT LYSIMETER	22 OCT 1987	Dissolved
02N 21E 01 CCDC 03	88Q0256	LYSIMETER	HERZOG-ZINNE WELL Z-1 * 1 FT LYSIMETER	20 APR 1988	Dissolved
02N 21E 01 CCDC 03	88Q0369	LYSIMETER	HERZOG-ZINNE WELL Z-1 * 1 FT LYSIMETER	24 MAY 1988	Dissolved
02N 21E 01 CCDC 03	89Q0559	LYSIMETER	HERZOG-ZINNE WELL Z-1 * 1 FT LYSIMETER	04 MAY 1989	Dissolved
02N 21E 01 CCDC 04	86Q0595	LYSIMETER	ZINNE-HERZOG WELL Z-1 * 2 FT LYSIMETER	26 JUN 1986	
02N 21E 01 CCDC 04	86Q0769	LYSIMETER	ZINNE-HERZOG WELL Z-1 * 2 FT LYSIMETER	24 JUL 1986	
02N 21E 01 CCDC 04	87Q0492	LYSIMETER	ZINNE-HERZOG WELL Z-1 * 2 FT LYSIMETER	15 JUL 1987	Dissolved
02N 21E 01 CCDC 04	87Q0711	LYSIMETER	ZINNE-HERZOG WELL Z-1 * 2 FT LYSIMETER	11 AUG 1987	Dissolved
02N 21E 01 CCDC 04	87Q0953	LYSIMETER	ZINNE-HERZOG WELL Z-1 * 2 FT LYSIMETER	22 OCT 1987	Dissolved
02N 21E 01 CCDC 04	88Q0257	LYSIMETER	ZINNE-HERZOG WELL Z-1 * 2 FT LYSIMETER	20 APR 1988	Dissolved
02N 21E 01 CCDC 04	88Q0370	LYSIMETER	ZINNE-HERZOG WELL Z-1 * 2 FT LYSIMETER	24 MAY 1988	Dissolved
02N 21E 01 CCDC 04	88Q1021	LYSIMETER	ZINNE-HERZOG WELL Z-1 * 2 FT LYSIMETER	22 JUL 1988	Dissolved
02N 21E 01 CCDC 04	89Q0560	LYSIMETER	ZINNE-HERZOG WELL Z-1 * 2 FT LYSIMETER	04 MAY 1989	Dissolved
02N 21E 01 CCDC 04	90Q0259	LYSIMETER	ZINNE-HERZOG WELL Z-1 * 2 FT LYSIMETER	01 AUG 1990	Dissolved
02N 21E 01 CCDC 05	86Q0596	LYSIMETER	ZINNE-HERZOG WELL Z-1 * 3 FT LYSIMETER	26 JUN 1986	
02N 21E 01 CCDC 05	86Q0776	LYSIMETER	ZINNE-HERZOG WELL Z-1 * 3 FT LYSIMETER	24 JUL 1986	
02N 21E 01 CCDC 05	87Q0952	LYSIMETER	ZINNE-HERZOG WELL Z-1 * 3 FT LYSIMETER	22 OCT 1987	Dissolved
02N 21E 01 CCDC 05	88Q0258	LYSIMETER	ZINNE-HERZOG WELL Z-1 * 3 FT LYSIMETER	20 APR 1988	Dissolved
02N 21E 01 CCDC 05	88Q0371	LYSIMETER	ZINNE-HERZOG WELL Z-1 * 3 FT LYSIMETER	24 MAY 1988	Dissolved
02N 21E 01 CCDC 05	89Q0561	LYSIMETER	ZINNE-HERZOG WELL Z-1 * 3 FT LYSIMETER	04 MAY 1989	Dissolved
02N 21E 01 CCDC 05	90Q0260	LYSIMETER	ZINNE-HERZOG WELL Z-1 * 3 FT LYSIMETER	01 AUG 1990	Dissolved
02N 21E 01 CCDC 06	90Q0041	PRECIP	HERZOG-ZINNE TEST SITE * SNOW SAMPLE	22 FEB 1990	Dissolved
02N 21E 01 CCDC 06	90Q0042	PRECIP	HERZOG-ZINNE TEST SITE * SNOW SAMPLE	22 FEB 1990	Total Recoverable
02N 21E 01 DDDA 04	86Q0604	LYSIMETER	HERZOG-ZINNE WELL Z-50 * 10 FT LYSIMETER	26 JUN 1986	Dissolved
02N 21E 01 DDDA 04	86Q0774	LYSIMETER	HERZOG-ZINNE WELL Z-50 * 10 FT LYSIMETER	24 JUL 1986	Dissolved
02N 21E 01 DDDA 04	86Q1010	LYSIMETER	HERZOG-ZINNE WELL Z-50 * 10 FT LYSIMETER	16 SEP 1986	Dissolved
02N 21E 01 DDDA 04	87Q0318	LYSIMETER	HERZOG-ZINNE WELL Z-50 * 10 FT LYSIMETER	05 JUN 1987	Dissolved
02N 21E 01 DDDA 04	87Q0498	LYSIMETER	HERZOG-ZINNE WELL Z-50 * 10 FT LYSIMETER	15 JUL 1987	Dissolved
02N 21E 01 DDDA 04	87Q0713	LYSIMETER	HERZOG-ZINNE WELL Z-50 * 10 FT LYSIMETER	12 AUG 1987	Dissolved
02N 21E 01 DDDA 04	88Q0260	LYSIMETER	HERZOG-ZINNE WELL Z-50 * 10 FT LYSIMETER	20 APR 1988	Dissolved
02N 21E 01 DDDA 04	89Q0565	LYSIMETER	HERZOG-ZINNE WELL Z-50 * 10 FT LYSIMETER	04 MAY 1989	Dissolved
03N 20E 02 ADBA 05	86Q0770	LYSIMETER	BRICKLEY SITE WELL B-2 * 3 FT LYSIMETER	24 JUL 1986	Dissolved
03N 20E 02 ADBA 06	86Q0780	LYSIMETER	BRICKLEY SITE WELL B-2 * 5 FT LYSIMETER	24 JUL 1986	Dissolved
03N 20E 02 ADBA 07	86Q0602	LYSIMETER	BRICKLEY SITE WELL B-2 * 10 FT LYSIMETER	26 JUN 1986	Dissolved
03N 20E 02 ADBA 07	86Q0772	LYSIMETER	BRICKLEY SITE WELL B-2 * 10 FT LYSIMETER	24 JUL 1986	Dissolved
04N 20E 35 DDBB 02	87Q0496	LYSIMETER	BRICKLEY TEST SITE*RAPELJE MT*6" LYSIMETER	15 JUL 1987	Dissolved

Geographic Data - Water Quality Sites - Stillwater Demonstration Site - Lysimeters and Precipitation
-Continued-

LOCATION.....	SAM #..	SAMPLE SOURCE.....	SITE NAME.....	SAMPLE DATE.....	SAMPLE TYPE.....
04N 20E 35 DDBB 06	86Q0600	LYSIMETER	BRICKLEY TEST WELL B-8 * 5 FT LYSIMETER	26 JUN 1986	Dissolved
04N 20E 35 DDBB 06	86Q0777	LYSIMETER	BRICKLEY TEST WELL B-8 * 5 FT LYSIMETER	24 JUL 1986	Dissolved
04N 20E 35 DDBB 06	87Q0494	LYSIMETER	BRICKLEY TEST WELL B-8 * 5 FT LYSIMETER	15 JUL 1987	Dissolved
04N 20E 35 DDBB 06	88Q1022	LYSIMETER	BRICKLEY TEST WELL B-8 * 5 FT LYSIMETER	22 JUL 1988	Dissolved
04N 20E 35 DDBB 07	86Q0601	LYSIMETER	BRICKLEY TEST WELL 8 * 10 FT LYSIMETER	26 JUN 1986	Dissolved
04N 20E 35 DDBB 07	86Q0779	LYSIMETER	BRICKLEY TEST WELL 8 * 10 FT LYSIMETER	24 JUL 1986	Dissolved

Cation Water Quality - Stillwater Demonstration Site - Lysimeters and Precipitation

SAM #..	BOTTLE NO	CALCIUM MG/L.....	MAGNESIUM MG/L.....	SODIUM MG/L.....	POTASSIUM MG/L.....	IRON MG/L.....	MANGANESE MG/L.....	SILICA MG/L.....
89Q0563	Z-30-1	146.	23.3	17.4	11.6	<.002	.030	21.7
90Q0143	ZRAIN	19.63	12.83	17.94	0.59	0.04	0.118	0.4
86Q0603	Z-36-3							
86Q0768	Z-36-5							
87Q0500	Z-36-5							
88Q0255	Z-1-0.5							
86Q0594	Z-1-1							
86Q0775	Z-1-1							
87Q0491	Z-1-1							
87Q0710	Z-1-1							
87Q0954	Z-1-1							
88Q0256	Z-1-1							
88Q0369	Z-1-1							
89Q0559	Z-1-1	328.	2390.	6870.	7.	.025	.002	5.
86Q0595	Z-1-2							
86Q0769	Z-1-2							
87Q0492	Z-1-2							
87Q0711	Z-1-2							
87Q0953	Z-1-2							
88Q0257	Z-1-2							
88Q0370	Z-1-2							
88Q1021	Z-1-2							
89Q0560	Z-1-2	334.	3320.	0.1	3.4	.057	<.001	3.8
90Q0259	Z-1-2							
86Q0596	Z-1-3							
86Q0776	Z-1-3							
87Q0952	Z-1-3							
88Q0258	Z-1-3							
88Q0371	Z-1-3							
89Q0561	Z-1-3	349.	3340.	8590.	3.2	<.002	<.001	3.9
90Q0260	Z-1-3							
90Q0041	71-SNOW	2.07	0.58	0.17	0.52	1.255	0.034	6.7
90Q0042	71-SNOW	2.79	1.18	0.68	1.26	3.64	0.073	18.7
86Q0604	Z-50-10							
86Q0774	Z-50-10							
86Q1010	Z-50-10							
87Q0318	Z-50-10							
87Q0498	Z-50-10							
87Q0713	Z-50-10							
88Q0260	Z-50-10							
89Q0565	Z-50-10	353.	965.	3490.	5.4	.012	.011	8.5
86Q0770	B-2-3							
86Q0780	B-2-5							
86Q0602	B-2-10							
86Q0772	B-2-10							
87Q0496	B-8-0.5							

Cation Water Quality - Stillwater Demonstration Site - Lysimeters and Precipitation
-Continued-

SAM #..	BOTTLE NO	CALCIUM MG/L.....	MAGNESIUM MG/L.....	SODIUM MG/L.....	POTASSIUM MG/L.....	IRON MG/L.....	MANGANESE MG/L.....	SILICA MG/L.....
86Q0600	B-8-5							
86Q0777	B-8-5							
87Q0494	B-8-5							
88Q1022	B-8-5							
86Q0601	B-8-10							
86Q0779	B-8-10							

Anion Water Quality - Stillwater Demonstration Site - Lysimeters and Precipitation

SAM #..	BOTTLE NO	HCO3 MG/L.....	CO3 MG/L.....	CHLORIDE MG/L.....	SULFATE MG/L.....	NITRATE AS N MG/L.	FLUORIDE MG/L.....	STD DEV BALANCE...	LAB PH.....	LAB SC MMHOS.....	DISSOLVED SOLIDS MG/L
89Q0563	Z-30-1					.47					
90Q0143	ZRAIN	7.3	0.0	12.2	109.	0.83	0.05	-0.46	6.35	405.	177.22
86Q0603	Z-36-3					2.26					
86Q0768	Z-36-5					7.01					
87Q0500	Z-36-5					1.43					
88Q0255	Z-1-0.5					2.39					
86Q0594	Z-1-1					1.80					
86Q0775	Z-1-1					.49					
87Q0491	Z-1-1					1.63					
87Q0710	Z-1-1					<.2					
87Q0954	Z-1-1					.47					
88Q0256	Z-1-1					4.03					
88Q0369	Z-1-1					1.71					
89Q0559	Z-1-1					.05					
86Q0595	Z-1-2					.20					
86Q0769	Z-1-2					1.17					
87Q0492	Z-1-2					1.99					
87Q0711	Z-1-2					<.2					
87Q0953	Z-1-2					.50					
88Q0257	Z-1-2					1.45					
88Q0370	Z-1-2					1.28					
88Q1021	Z-1-2					1.0					
89Q0560	Z-1-2					<.1	<1.				
90Q0259	Z-1-2					.43					
86Q0596	Z-1-3					.50					
86Q0776	Z-1-3					15.2					
87Q0952	Z-1-3					.30					
88Q0258	Z-1-3					4.52					
88Q0371	Z-1-3					1.25					
89Q0561	Z-1-3					<.1					
90Q0260	Z-1-3					.34					
90Q0041	71-SNOW	6.5	0.0	0.5	0.9	0.23	0.03	-2.21	6.32	33.3	16.19
90Q0042	71-SNOW										
86Q0604	Z-50-10					5.40					
86Q0774	Z-50-10					7.00					
86Q1010	Z-50-10					.36					
87Q0318	Z-50-10					16.5					
87Q0498	Z-50-10					3.11					
87Q0713	Z-50-10					13.1					
88Q0260	Z-50-10					10.5					
89Q0565	Z-50-10					11.7					
86Q0770	B-2-3					11.5					
86Q0780	B-2-5					16.2					
86Q0602	B-2-10					188.					
86Q0772	B-2-10					147.					
87Q0496	B-8-0.5					92.0					

Anion Water Quality - Stillwater Demonstration Site - Lysimeters and Precipitation
-Continued-

SAM #..	BOTTLE NO	HCO3 MG/L.....	CO3 MG/L.....	CHLORIDE MG/L.....	SULFATE MG/L.....	NITRATE AS N MG/L.	FLUORIDE MG/L.....	STD DEV BALANCE...	LAB PH.....	LAB SC MMHOS.....	DISSOLVED SOLIDS MG/L
86Q0600	B-8-5					3.64					
86Q0777	B-8-5					16.3					
87Q0494	B-8-5					.63					
88Q1022	B-8-5					19.6					
86Q0601	B-8-10					5.52					
86Q0779	B-8-10					6.88					

Trace Metal Water Quality - Stillwater Demonstration Site - Lysimeters and Precipitation

SAM #..	BOTTLE NO	BORON UG/L.....	STRONTIUM UG/L.....	LITHIUM UG/L.....	SELENIUM UG/L.....	ARSENIC UG/L.....	COPPER UG/L.....	ZINC UG/L.....	LEAD UG/L.....	CHROMIUM UG/L.....	CADMIUM MG/L.....	BARIUM UG/L.....	SAMPLE TYPE.....
89Q0563	Z-30-1	<20.	310.	3.	3.6		20.	530.	<40.	<2.	<2.		Dissolved
90Q0143	ZRAIN	<40.	420.	4.	13.	0.7	109.	420.	<50.	4.	6.	5.	Dissolved
86Q0603	Z-36-3				52.								Dissolved
86Q0768	Z-36-5												
87Q0500	Z-36-5				35.								Dissolved
88Q0255	Z-1-0.5				438.								Dissolved
86Q0594	Z-1-1				78.								Dissolved
86Q0775	Z-1-1				160.								
87Q0491	Z-1-1				1800.								Dissolved
87Q0710	Z-1-1				1715.								Dissolved
87Q0954	Z-1-1				1881.								Dissolved
88Q0256	Z-1-1				1058.								Dissolved
88Q0369	Z-1-1				526.								Dissolved
89Q0559	Z-1-1	910.	6100.	460.	911.		24.	160.		<2.	22.		Dissolved
86Q0595	Z-1-2				187.								
86Q0769	Z-1-2				639.								
87Q0492	Z-1-2				1480.								Dissolved
87Q0711	Z-1-2				1835.								Dissolved
87Q0953	Z-1-2				2096.								Dissolved
88Q0257	Z-1-2				1810.								Dissolved
88Q0370	Z-1-2				1370.								Dissolved
88Q1021	Z-1-2				1833.								Dissolved
89Q0560	Z-1-2	950.	7910.	580.	1391.		30.	30.		<2.	34.		Dissolved
90Q0259	Z-1-2				2280.								Dissolved
86Q0596	Z-1-3				193.								
86Q0776	Z-1-3				472.								
87Q0952	Z-1-3				1257.								Dissolved
88Q0258	Z-1-3				1121.								Dissolved
88Q0371	Z-1-3				907.								Dissolved
89Q0561	Z-1-3	820.	9740.	530.	1396.		30.	18.		<2.	30.		Dissolved
90Q0260	Z-1-3				2390.								Dissolved
90Q0041	71-SNOW	<40.	7.	<4.	0.5	0.4	12.	<6.	<50.	<5.	5.	48.	Dissolved
90Q0042	71-SNOW Recoverable	322.	10.	<4.	<0.1	1.6	14.	22.	<50.	7.	<5.	39.	Total
86Q0604	Z-50-10				1050.								Dissolved
86Q0774	Z-50-10				1130.								Dissolved
86Q1010	Z-50-10				878.								Dissolved
87Q0318	Z-50-10				564.								Dissolved
87Q0498	Z-50-10				341.								Dissolved
87Q0713	Z-50-10				581.								Dissolved
88Q0260	Z-50-10				639.								Dissolved
89Q0565	Z-50-10	530.	9310.	120.	759.		19.	20.		27.	10.		Dissolved
86Q0770	B-2-3				63.								Dissolved
86Q0780	B-2-5				219.								Dissolved
86Q0602	B-2-10				343.								Dissolved
86Q0772	B-2-10				387.								Dissolved

Trace Metal Water Quality - Stillwater Demonstration Site - Lysimeters and Precipitation
-Continued-

SAM #..	BOTTLE NO	BORON UG/L.....	STRONTIUM UG/L.....	LITHIUM UG/L.....	SELENIUM UG/L.....	ARSENIC UG/L.....	COPPER UG/L.....	ZINC UG/L.....	LEAD UG/L.....	CHROMIUM UG/L.....	CADMIUM MG/L.....	BARIUM UG/L.....	SAMPLE TYPE.....
87Q0496	B-8-0.5				.2								Dissolved
86Q0600	B-8-5				3.6								Dissolved
86Q0777	B-8-5				.5								Dissolved
87Q0494	B-8-5				1.4								Dissolved
88Q1022	B-8-5				54.								Dissolved
86Q0601	B-8-10				103.								Dissolved
86Q0779	B-8-10				107.								Dissolved