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Dewatering Well Assessment for the Highway Drainage System at Five Sites in the East St. Louis Area, Illinois

(FY95 - Phase 12)

by

Robert D. Olson and Ellis W. Sanderson, P.E.

Prepared for the
Illinois Department of Transportation
Division of Highways

July 2000

Illinois State Water Survey
Ground-Water Section
Champaign, Illinois

A Division of the Illinois Department of Natural Resources

DEWATERING WELL ASSESSMENT

FOR THE HIGHWAY DRAINAGE SYSTEM

AT FIVE SITES IN THE EAST ST. LOUIS AREA, ILLINOIS

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Abstract

In the East St. Louis vicinity, the Illinois Department of Transportation, Division of Highways (IDOT) owns 55 high-capacity wells that are used to maintain the elevation of the ground-water table below the highway surface in areas where the highway is depressed below the original land surface. The dewatering systems are located at five sites in the alluvial valley of the Mississippi River in an area known as the American Bottoms. The alluvial deposits at the dewatering sites are about 90 to 115 feet thick and consist of fine sand, silt, and clay in the upper 10 to 30 feet, underlain by medium to coarse sand about 70 to 100 feet thick.

The condition and efficiency of a number of the dewatering wells became suspect in 1982 on the basis of data collected and reviewed by IDOT staff. Since 1983, IDOT and the Illinois State Water Survey (ISWS) have conducted a cooperative investigation to more adequately assess the operation and condition of the wells, to attempt to understand the probable causes of well deterioration, and to evaluate rehabilitation procedures used on the wells.

Work conducted during FY 95 (Phase 12) included monitoring the rehabilitation of four wells, step-testing the rehabilitated wells and checking the discharge from two wells for sand pumpage, checking the quality of the water discharged during the step tests, and monitoring the ground-water levels at the dewatering system sites.

Posttreatment step tests were used to help document the rehabilitation of four dewatering wells, Interstate-70 (I-70) Wells 3A, 5, 11A, and 15, during FY 95 (Phase 12). Chemical treatments used to restore the capacity of these four wells were moderately successful. The improvement in specific capacity per well averaged about 103 percent based on data from pre- and posttreatment step tests. The specific capacity of I-70 Well 15 was restored to about 109 percent of the average observed specific capacity of wells in good condition at the I-70 site and the other three wells were restored to about 72 to 87 percent of the average observed specific capacity for wells in good condition.

The sand pumpage investigation conducted during the posttreatment step tests on I-70 Wells 3A and 11A showed little or insignificant amounts of sand in the portable settling tank after the step tests. The tank was required to divert the discharged water into the stormwater drainage system during the other two step tests, precluding a check for sand pumpage.

Introduction

Background

The Illinois Department of Transportation, Division of Highways (IDOT) operates 55 high-capacity water wells at five sites in the East St. Louis area. The wells are used to control and maintain ground-water levels at acceptable elevations to prevent depressed sections of interstate and state highways from becoming inundated by ground water. When the interchange of Interstates I-55/I-70 and I-64 was originally designed, ground-water levels were at lower elevations because of large withdrawals by the area's industries. Due to a combination of water conservation, production cutbacks, and conversion from ground water to river water as a source, industrial ground-water withdrawals have decreased at least 50 percent since 1970. As a result, ground-water levels in many areas have recovered to early development levels, which exacerbates IDOT's need to keep ground-water levels below the areas of depressed highways.

Scope of Study

In 1973, IDOT first installed 12 dewatering wells, followed by an additional 30 wells in 1975. By 1977, the initial 12 wells were showing signs of loss of capacity. As a result, all 42 wells in use then were chemically treated to restore capacity. Although good results were obtained for most of the wells, routine monitoring by IDOT showed that deterioration problems were continuing to develop. Isolated wells were chemically treated by IDOT personnel as required. Six more wells were installed in 1982. In October 1982, IDOT asked the Illinois State Water Survey (ISWS) to begin an investigative study to learn more about the condition of the dewatering wells, to determine efficient monitoring and operating procedures, and to determine suitable methods of well rehabilitation.

Phase 1 of the work, conducted from March 1983 through February 1984, included an assessment of the condition of 14 selected wells, a review of the IDOT monitoring program, a model study to outline efficient operating schemes, recommendations on wells to be treated, and recommendations for chemical treatment procedures (Sanderson et al., 1984).

Phase 2, conducted from March 1984 through June 1985, included an assessment of the condition of 12 selected wells; testing of a noninvasive, portable flowmeter; and an initial study of the chemistry of the ground water as it moved toward an operating well (Sanderson et al., 1987).

Phase 3, begun in July 1985 for Fiscal Year 1986 (FY 86), included an assessment of the condition of six wells; demonstration of a noninvasive, portable flowmeter; continued study of ground-water chemistry; and documentation of the rehabilitation of seven dewatering wells, along with follow-up step tests (Olson et al., 1990).

Phase 4, begun in July 1986 (FY 87), included ten step tests; documentation of the treatment of five wells; documentation of the construction of I-70 Well 7A (14th well at this site); investigation of I-70 Well 9 to determine the probable cause of gravel-pack settlement;

specific-capacity testing using the noninvasive, portable flowmeter; and installation of piezometers at two underpass sites in East St. Louis (Wilson et al., 1990).

Phase 5, begun in July 1987 (FY 88), included nine step tests, documentation of the treatment of four wells, investigation of possible sand pumpage at three wells, and initial investigation of the condition of relief wells at two detention ponds near the intersection of I-255 and I-70/I-55 (Wilson et al., 1991).

Phase 6, begun in July 1988 (FY 89), included 12 step tests, review of the chemical treatment of four wells, investigation of possible sand pumpage at nine wells, continued investigation of the relief wells at the two detention ponds along I-255, and documentation of the installation of replacement wells I-70 Wells 8A and 9A (15th and 16th wells at this site) (Olson et al., 1992).

Phase 7, begun in July 1989 (FY 90), included 12 step tests, review of the chemical treatment of five wells, investigation of possible sand pumpage at ten wells, and the conclusion of the investigation of the condition of relief wells at the two detention ponds near the intersection of I-255 and I-55/I-70 (Sanderson et al., 1993).

Phase 8, begun in July 1990 (FY 91), included 20 step tests, review of the chemical treatment of four wells, documentation of the construction of four new wells (I-70 Wells 13 and 14 and Venice Wells 6A and 7), investigation of possible sand pumpage at 17 wells, and implementation of a ground-water-level measurement program (Sanderson and Olson, 1993).

Phase 9, begun in July 1991 (FY 92), included 16 step tests, review of the chemical treatment of three wells, documentation of the construction of five new or replacement wells (I-70 Wells 1A, 2A, 3A, 11A, and 15), downhole video inspection of I-70 Well 3 and 25th Street Well 6 to determine the probable cause of sand pumpage and settlement, and continuation of the ground-water-level measurement program implemented in FY 90 (Olson and Sanderson, 1997).

Phase 10, begun in July 1992 (FY 93), included 14 step tests, review of the chemical treatment of two wells, investigation of possible sand pumpage at ten wells, continuation of the ground-water-level measurement program, and an investigation of the chemical quality of the ground water being discharged from the pumping stations that handle the discharge from the dewatering system (Sanderson and Olson, 1998).

Phase 11, begun in July 1993 (FY 94), included 11 step tests, monitoring of the chemical treatment of two wells, investigation of possible sand pumpage at eight wells, and continuation of the ground-water-level measurement program (Sanderson and Olson, 1999).

Phase 12, begun in July 1994 (FY 95), included four step tests, monitoring of the chemical treatment of four wells, investigation of possible sand pumpage at two wells, and continuation of the ground-water-level measurement program. Data collected during the field investigations are included in appendices A-F.

Physical Setting of Study Area

The study area is located in the alluvial valley of the Mississippi River in East St. Louis, Illinois, in an area known as the American Bottoms (figure 1). The geology of the area consists of alluvial deposits overlying limestone and dolomite of Mississippian and Pennsylvanian Age. The alluvium varies in thickness from zero to more than 170 feet, averaging about 120 feet. The region is bounded on the west by the Mississippi River and on the east by upland bluffs. The regional ground-water hydrology of the area is well documented (Bergstrom and Walker, 1956; Schicht, 1965; Collins and Richards, 1986; Ritchey et al., 1984; Kohlhase, 1987; Schicht and Buck, 1995). Except where it is diverted by pumpage or drainage systems, ground water generally flows from the bluffs toward the river.

Detailed location maps of the five dewatering sites operated by IDOT are shown in figures 2-4. The geology at these sites is consistent with regionally mapped conditions. The land surface lies at about 410 to 415 feet above mean sea level (ft-msl). Alluvial deposits are about 90 to 115 feet thick, which means the bedrock surface lies at approximately 300 to 320 ft-msl. The alluvium becomes progressively coarser with depth. The uppermost 10 to 30 feet consists of extremely fine sand, silt, and clay, underlain by the aquifer, which is about 70 to 100 feet thick. The elevation of the top of the aquifer is about 390 to 395 ft-msl.

Acknowledgments

This phase of the assessment of the condition of the highway dewatering well systems in the American Bottoms was funded by the IDOT, Division of Highways, Kirk Brown, secretary. Barry Roberts, pump technician, District 8, reviewed and coordinated the investigation. He and maintenance personnel provided field support during step-drawdown tests on the selected wells. Mark Anliker, assistant hydrologist, ably assisted the authors with field data collection. Ellis Sanderson, co-author of this report, retired in 1998.

Analytical work by the Water Survey's Chemistry Division, Office of Analytical and Water Treatment Services, was performed under the direction of Loretta Skowron, with Brian Kaiser, Lauren Sievers, and Daniel Webb performing the lab analyses. Eva Kingston and Agnes Dillon edited the manuscript, Linda Hascall prepared the illustrations, and Pamela Lovett provided word processing support.

Any opinions, findings, and conclusions or recommendations expressed in this report are those of the authors and do not necessarily reflect those of the sponsor or the Illinois State Water Survey.

Historical Summary of Dewatering Development

The eastbound lanes of I-70 below the Tri-Level Bridge between St. Clair and Bowman Avenues in East St. Louis dip to an elevation of 383.5 ft-msl, or approximately 32 feet below natural ground surface. When the highway was designed in 1958, ground-water levels were near

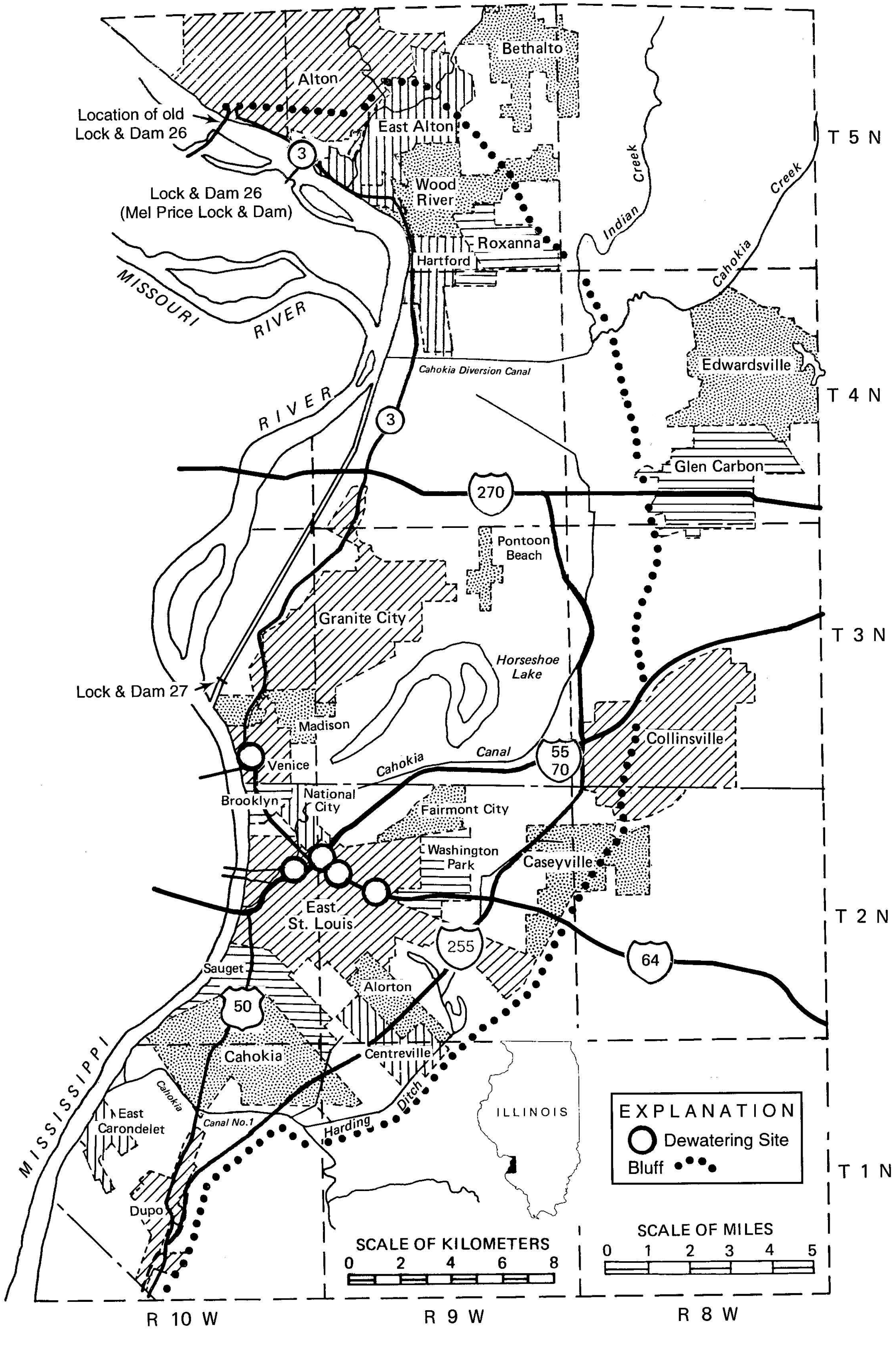

Figure 1. Location of the East St. Louis area

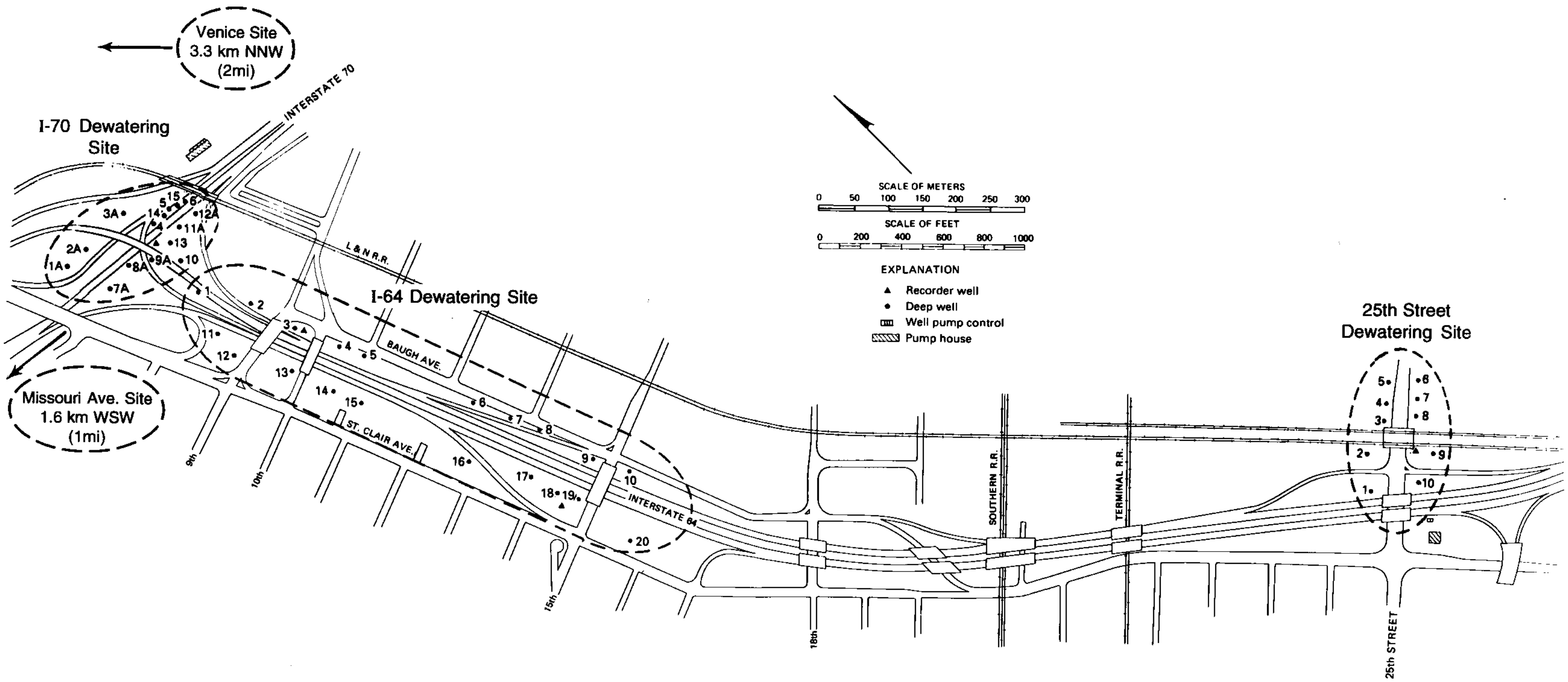

Figure 2. Locations of dewatering wells at the I-70 Tri-Level Bridge, I-64, and 25th Street

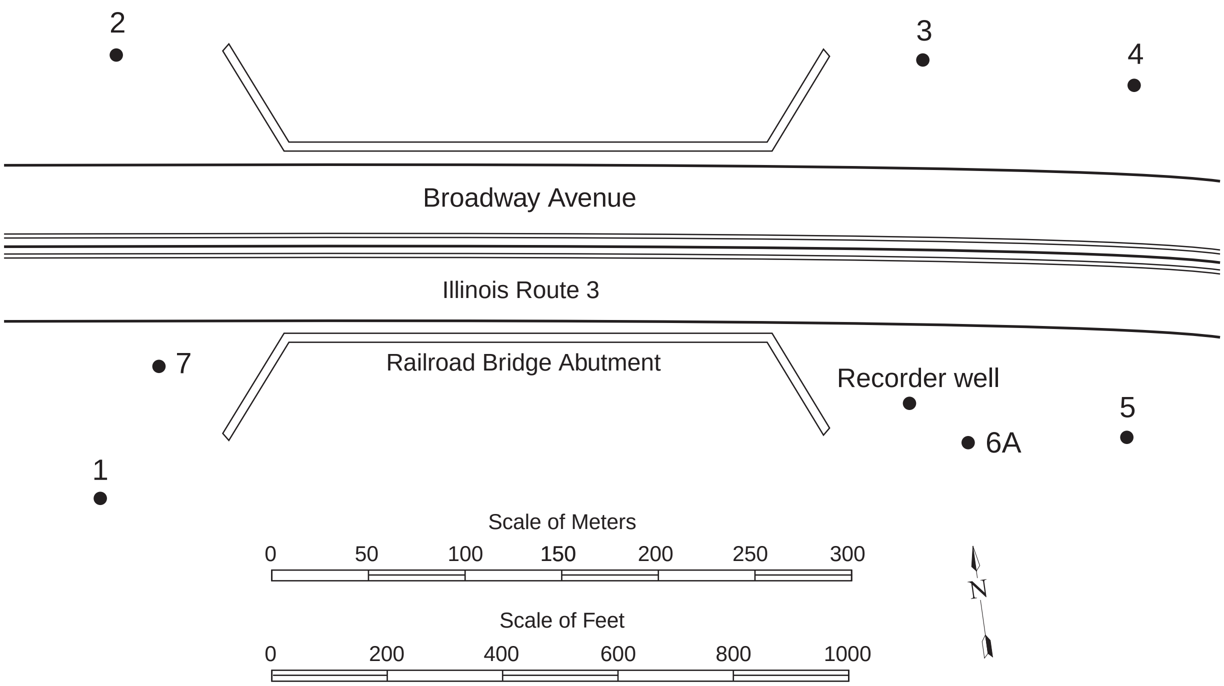

Figure 3. Locations of dewatering wells at the Venice Subway (Illinois Route 3)

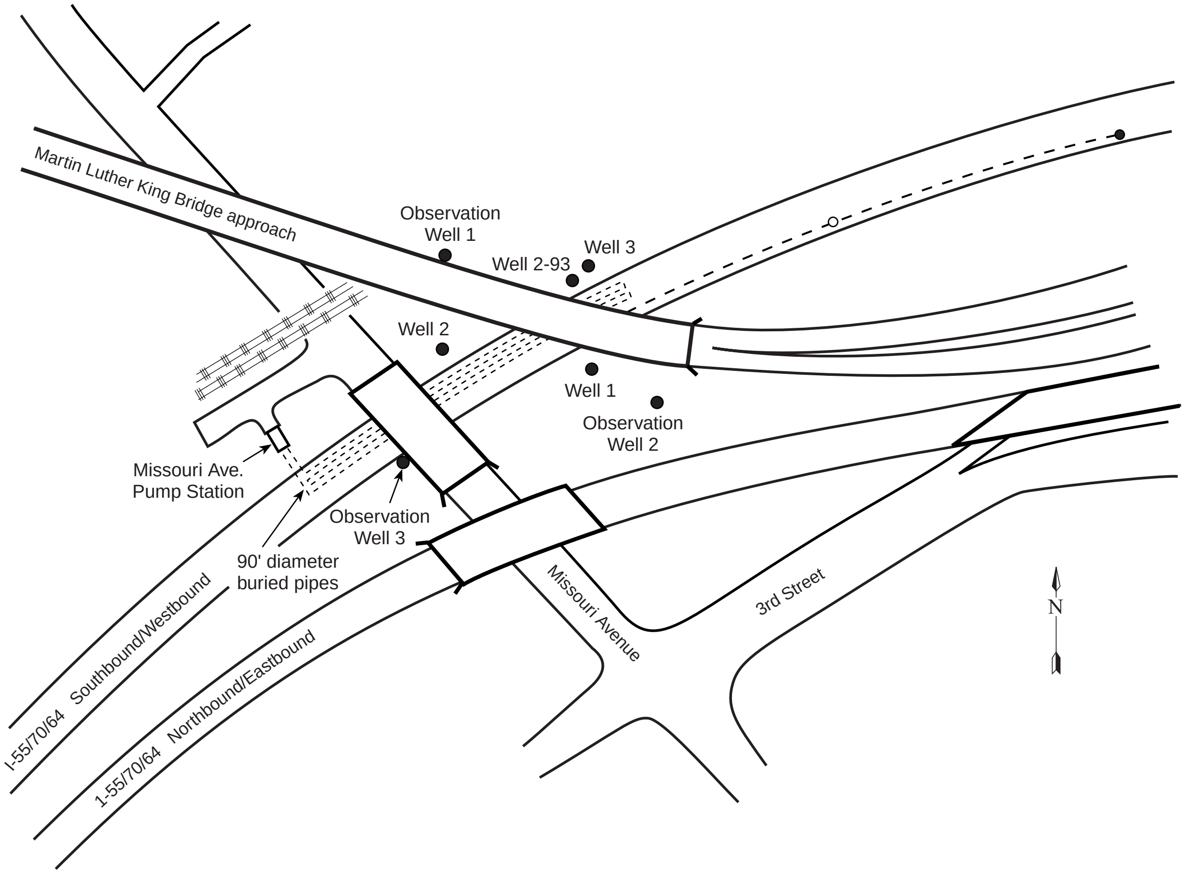

Figure 4. Locations of dewatering wells at Missouri Avenue

an elevation of 390 ft-msl, or about 6.5 feet above the planned highway (McClelland Engineers, Inc., 1971). Highway construction occurred in 1961-1962.

Horizontal Drain System

A horizontal French drain system was designed to control the ground-water levels along an 800-foot reach of depressed highway. However, for highway construction, the excavation area was temporarily dewatered by pumping from seven wells 100 feet deep and 16 inches in diameter. The wells were equipped with 1800-gallon per minute (gpm) turbine pumps. The temporary construction dewatering system was designed to maintain the ground-water level at the site near an elevation of 370 ft-msl.

The French drain system failed shortly after the temporary construction dewatering system was turned off in the fall of 1962. This failure was attributed to the fact that the filter sand around the perforated diagonal drains and collector pipes was too fine for the ¼-inch holes in the drain pipes. A sieve analysis on the filter sand showed that 98.5 percent of the filter sand was finer than the ¼-inch perforations in the drain pipes. As a result, when the temporary construction dewatering system was turned off and ground-water levels rose above the drains, filter sand migrated through the holes into the drain pipes. The very fine "sugar" sand, used as the pavement foundation, was then free to move downward to the drains, resulting in development of potholes above the drains. Further migration of sand into the French drain system was halted by operating the temporary construction dewatering system to lower the ground-water table. Because it was very likely that the foundation sands had been piped from beneath the pavement, the diagonal drains beneath the pavement were cement-grouted to prevent any further loss of support beneath the pavement (McClelland Engineers, Inc., 1971).

Horizontal and Vertical Well Drainage System

A new drainage system was designed and installed in early 1963. It consisted of 20 vertical wells and 10-inch- to 12-inch-diameter horizontal drain pipes. The 20 wells (10 wells on each side of the highway) were spaced about 75 feet apart. They were 6 inches in diameter, about 50 feet deep, and equipped with 32 feet of stainless steel well screen (Doerr) with 0.010-inch slots. Horizontal drains were sized for a flow of about 1 gpm/ft of drain, perforated with ⅜-inch-diameter holes on 3-inch centers, and surrounded with 6 inches of gravel-and-sand filter. A total of six 2-inch-diameter piezometers were installed for ground-water-level measurements.

Tests immediately after the installation indicated that the new system was performing satisfactorily, with a discharge of about 1,200 to 2,000 gpm, compared to a computed design flow of 4,500 gpm. Ground-water levels were lowered to an elevation of ±375.5 ft-msl, about 2 feet below the design ground-water elevation of 377.5 ft-msl, or about 8 feet below the top of the concrete pavement.

The system performed efficiently until March 1965, when a gradual rise in ground-water levels was detected. By July 1967, a 1-foot rise had occurred, and from July 1967 to April 1969 an additional 4-foot rise was observed. No additional rise was observed between August 1969 and August 1970.

Visual inspection during the late 1960s revealed some sinking of the asphalt shoulders and areas around the storm drainage inlets. Several breaks and/or blockages of the horizontal transit drain pipes were noted on both sides of the pavement, and a break in the steel tee in Well 17 also was observed. Depressions were noticed in the earth slopes immediately adjacent to the curb and gutter sections. Loss of foundation sands through the transit pipe breaks appeared to be the cause of these depressions. One manhole had settled a total of 15 inches. The attempt to correct this condition was suspended with the detection of a shift in the bottom of this manhole.

A thorough field investigation was begun to correct the damages to the underground system, or to replace it if necessary. During the cleaning process (using a hydrojet at the rate of 100 gpm under pressure of about 800 pounds per square inch or psi), a significant amount of scale was removed from inside the mild steel collector pipes, indicating serious corrosion. Nearly all the transit drain pipes also showed signs of stress. Some drains were broken and filled with sand. Attempts to clean or restore the drain pipes were abandoned in favor of a complete replacement of the system.

The field investigation also showed that the tees in the manholes, the collector pipes, and the aluminum rods on the check valves were badly corroded. Sinks, potholes, and general settlement of the road shoulders required immediate attention. Television inspection of the vertical wells showed no damage to the stainless steel well screens.

Excessive corrosion of the mild steel tees, well risers, and collector pipes was one of the major causes or contributors to the overall failure of the drainage system. The investigations concluded that the corrosion was caused primarily by galvanic action between the stainless steel (cathode) and mild steel (anode) components of the drainage system, with anaerobic bacteria and carbonic acid attack from the carbon dioxide (CO_2) dissolved in the well water. Galvanic action was magnified by the lack of oxygen and the high chloride content of the water. Chemical analysis showed the extremely corrosive quality of the ground water as evidenced by:

- Extremely high concentrations of dissolved CO_2: 160 to 240 parts per million (ppm)
- Complete lack of oxygen: 0 ppm
- High chloride, 54 to 128 ppm; sulfates, 294 to 515 ppm, and iron concentrations, 12 ppm
- Biological activity

To withstand the possibility of severe corrosion caused by the chemical contents of ground water and to prevent galvanic action between different metals, the field investigators recommended the use of 304 stainless steel pipes throughout any replacement system (McClelland Engineers, Inc., 1971).

Individual Deep Well Systems

I-70 System

Experience during highway construction in 1961-1962 and during the 1963 drainage system replacement showed that individual deep wells were effective in temporarily maintaining ground-water levels at desired elevations. This alternative was, therefore, given further study as a permanent system. A consultant's report (Layne-Western Company, Inc., 1972) showed that water levels at the I-70 Tri-Level Bridge site could be maintained at desired elevations with 10 deep wells equipped with 600 gpm pumps. Two additional wells were included to permit well rotation and maintenance. These 12 wells were constructed in 1973, and the new system was placed in service in April 1974 (I-70 site). The 16-inch gravel-packed (42-inch borehole) wells had an average depth of about 96 feet, and they were equipped with 60 feet of Layne stainless steel well screen. Pumps with 600-gpm capacity and 6-inch-diameter stainless steel (flanged coupling) column pipe were set in the wells.

A recorder well, 8 inches in diameter and constructed of stainless steel casing and screen, was included in the well dewatering system to monitor ground-water levels near the critical elevation of the highway. A Leupold-Stevens Type F recorder is in use. Additionally, 2-inch-diameter piezometers with 3-foot-long screens were placed about 5 feet from each dewatering well to depths corresponding to the upper third point of each dewatering well screen. These piezometers provide information on ground-water levels and monitor the performance of individual wells by measuring water-level differences between the wells and the piezometers.

The exit ramp from the I-64 westbound lanes onto the I-55/I-70 northbound lanes was relocated in the late 1970s, necessitating the abandonment of I-70 Well 12. Replacement Well 12A was then constructed at a nearby location using components similar to those in the original wells. The well screen in I-70 Well 7 reportedly failed in the 1970s, and an attempt was made to rehabilitate the well by inserting a new screen inside the old screen. The well's pumping capacity remained unsatisfactory following this modification, so the well was used only on an emergency basis until it was replaced in 1986. The replacement well (Well 7A) was constructed using components similar to those used in the original wells, with the exception of a continuous slot well screen designed on the basis of the sieve data from the nearest original test boring (Wilson et al., 1990).

In late 1986, a loss of gravel pack was discovered at I-70 Well 9, and subsequent investigation revealed pumpage of fine sand, apparently from the upper 5 to 10 feet of well screen. In 1987, sand pumpage also was discovered at I-70 Wells 2 and 8. Replacement wells were constructed in the spring of 1989 for I-70 Well 8 (now Well 8A) and I-70 Well 9 (now Well 9A). Continuous-slot well screens also were designed and used in these wells as in I-70 Well 7A (Olson et al., 1992).

In 1990 (FY 91), two new wells were added at the I-70 site to provide greater flexibility in operation, maintenance, treatment, and repair of the other wells at the site. These wells (I-70 Wells 13 and 14) were located on either side of the eastbound lanes of I-55/I-70 near the lowest point of the highway. The wells were similar in construction to the replacement wells (Wells 7A, 8A, and 9A) that were drilled in 1987 and 1989.

In 1991-1992 (FY 92), four replacement wells and one new well were added to the I-70 site. Because of various sand pumpage, settlement, and potential operational problems, replacement wells were constructed for Wells 1, 2, 3, and 11 (now Wells 1A, 2A, 3A, and 11A). The new well (Well 15) was placed between Wells 5 and 6. The wells were similar in construction to the new/replacement wells drilled in 1987, 1989, and 1990.

I-64 System

The western terminal of I-64 joins I-70 at the Tri-Level Bridge site. A 2,200-foot stretch of this highway also is depressed below the original land surface as it approaches the Tri-Level Bridge site. To maintain ground-water levels along I-64, a series of 20 wells was added to the dewatering system (I-64 site). The wells were built in 1975 and are essentially identical to the original wells constructed for the Tri-Level Bridge site.

25th Street System

About 6,200 feet southeast of the Tri-Level Bridge, at the interchange with I-64 in East St. Louis, 25th Street was designed to pass below the interstate highway and adjacent railroad tracks (now abandoned). As a result, the 25th Street pavement is about 3.5 feet below ground-water levels. Ten wells were installed in 1975 to control ground-water levels at the 25th Street site. These wells are identical in design to the original I-70 wells. Pumps installed in the wells along I-64 and at 25th Street have nominal pumping capacities of 600 gpm. Two 8-inch observation wells, located near each end of the I-64 depressed section, are used to monitor ground-water levels. An 8-inch observation well also was installed near the critical location at the 25th Street underpass. As at the I-70 wells, each dewatering well for I-64 and 25th Street has a piezometer located approximately 5 feet away to monitor performance at the installation.

Venice System

At Venice, Illinois, approximately 2¼ miles north of the I-70 Tri-Level Bridge, Illinois Highway 3 passes beneath the Norfolk and Western, Illinois Central Gulf, and Conrail railroad tracks. When the highway was constructed, ground-water levels were controlled with a horizontal drain system placed 3 feet below the pavement. Problems with the pavement and drainage system were noted in May 1979 and were attributed to the above-normal ground-water levels resulting from 3 to 4 months of continuous flood stage in the Mississippi River (about 2,000 feet west). Subsequent investigation showed deterioration of the drainage system, and the consultants recommended installation of six wells to control ground-water levels at the site (Johnson, Depp, and Quisenberry, 1980). The wells were installed in 1982 and are 16 inches in diameter with 50 feet of well screen, range in depth from 78 to 89 feet below grade, and are equipped with submersible turbine pumps with nominal capacities of 600 gpm. One recorder well for the site and a piezometer at each dewatering well were installed to monitor system performance.

Problems were encountered with Venice Well 6 after chemical treatment in 1987 (FY 88). The well pumped sand-formation and gravel-pack particles, indicating a possible split or weld failure of the well screen or well casing. Replacement Well 6A was drilled, and a new Well 7 was added at the Venice site in FY 91 (Phase 8). District highway staff considered the additional well desirable because of operational problems maintaining appropriate ground-water levels in 1984 when the Mississippi River was at high stages for several months. These wells are similar in construction to the original wells at this site.

Missouri Avenue System

During the spring and summer of 1993, the Mississippi River was at flood elevation for an extended period. Just east of the Martin Luther King Bridge near downtown East St. Louis and beneath the southbound/westbound lanes of I-55/I-64/I-70, two large diameter, stormwater detention structures were found to be subject to failure due to excessive infiltration of ground water and piping of foundation material into the structures. The IDOT engineers contracted, on an emergency basis, for the construction of four high-capacity dewatering wells to drawdown the high ground-water levels at the stormwater structures to help minimize the chance for their failure. Three wells presently are equipped with 1,200 to 1,500 gpm well pumps and are in regular use. The fourth well (Well 2-93) is capped to remain available as an alternate for nearby Well 3. Periodic water-level measurements in Well 2-93 are used to track the condition of Well 3 in a way similar to the method used for the piezometers near the dewatering wells at the other sites.

Summary

The highway dewatering operation in the American Bottoms presently consists of 55 individual dewatering wells fully penetrating the water-bearing sand-and-gravel aquifer. The wells are distributed at five sites as follows:

I-70 (Tri-Level Bridge)	-	15 wells	(eight of these wells are replacements)
I-64	-	20 wells	
25th Street	-	10 wells	
Venice (Route 3)	-	7 wells	(one of these wells is a replacement)
Missouri Avenue	-	3 wells	

The wells are of similar construction, generally with 16-inch-diameter stainless steel casing and screen (figure 5). The IDOT's early experience with severe corrosion problems showed that corrosion-resistant materials are required to maximize service life. Except for the three Missouri Avenue wells, each well is equipped with a 600-gpm submersible pump with bronze impellers, bowls, and jacket motors and a 6-inch-diameter stainless steel column pipe. Five 8-inch recorder wells are available to monitor ground-water elevations near critical locations at these four sites. Most of the 52 wells have a 2-inch-diameter piezometer to help monitor individual well performance. The three wells at Missouri Avenue are equipped with 1,200 to 1,500 gpm pumps with niresist impellers and bowls, stainless steel jacket motors, and 6- to 8-

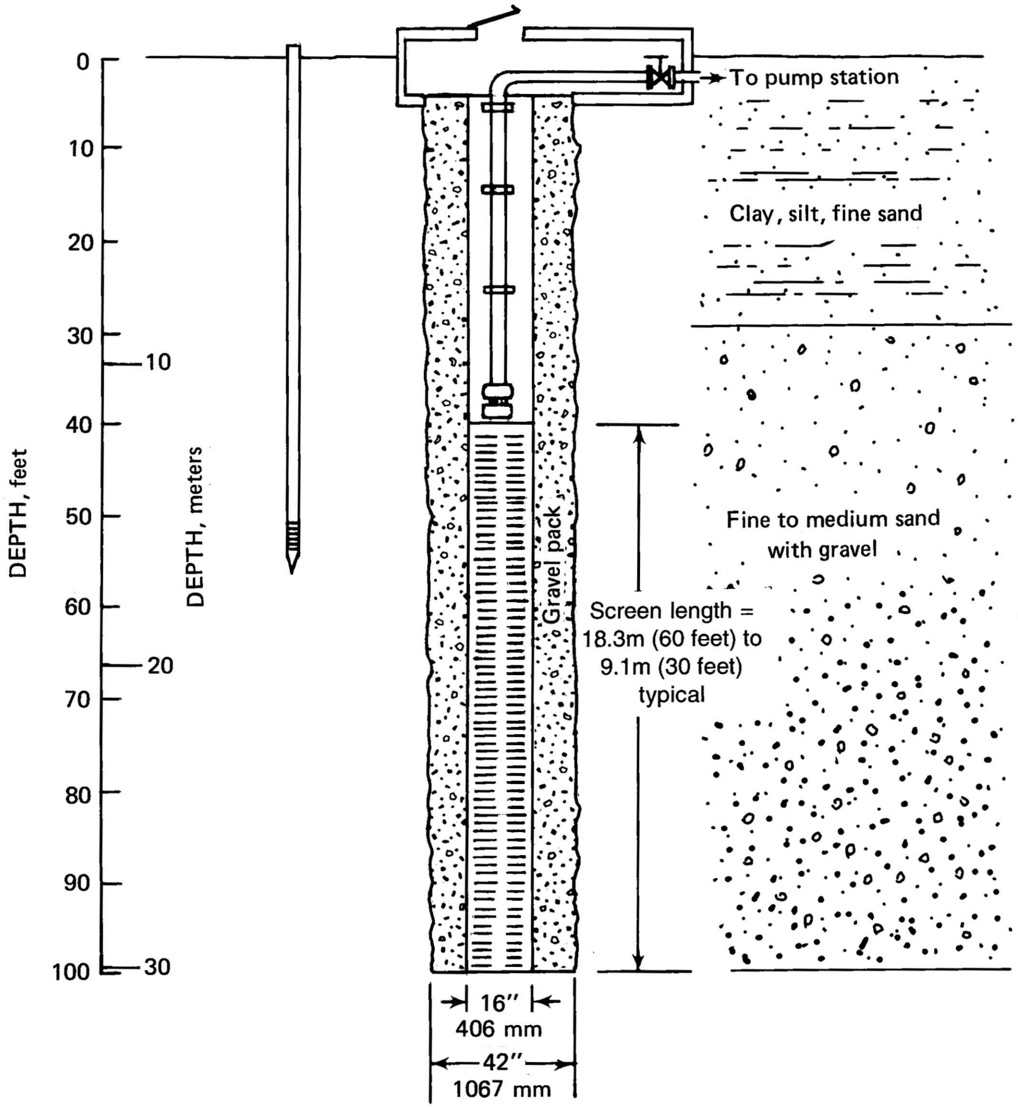

Figure 5. Typical features of a dewatering well

inch-diameter stainless steel column pipes. Three 2-inch diameter piezometers are measured periodically to monitor ground-water elevations at the site.

Usually, about one-third of the wells operate simultaneously. Total pumpage in 1994 was estimated by IDOT to be about 26.2 million gallons per day (mgd).

Dewatering System Monitoring

When originally constructed, the well installations at I-70, I-64, and 25th Street included pitot-tube flow-rate meters. A combination of corrosion and chemical deposition caused premature failure of these devices. Flow rates were occasionally checked with a temporarily inserted pitot-tube meter, but the field crew reported erratic results. The six installations at Venice in 1982 included a venturi tube coupled to a bellows-type differential pressure indicator to measure the flow rate. However, the water quality and environment in the well pits also adversely impacted the operation of these instruments. Accurate flow measurements became impossible within a few years, and the field crew reported at least one direct failure of the venturi tube. These meters were subsequently disconnected.

As part of the scope of work in FY 85-FY 87 (Phases 2-4), a noninvasive, portable ultrasonic flowmeter was tested, calibrated, and used to check the specific capacity of 21 dewatering wells. Although the application of this meter was found to be limited in some cases, it was turned over to IDOT for use in their routine monitoring program.

Operational records have shown that wells are pumped for periods of about two to nine months, then not pumped for longer periods while another set of wells is operated. No standard sequence of pumping rotation is followed because of maintenance and rehabilitation requirements. Annual withdrawals currently are calculated on the basis of pumping time and estimated pumping rates.

Until November 1989, IDOT highway maintenance personnel periodically measured water levels at each dewatering well to monitor the overall performance of the dewatering system. Due to internal reorganization of the highway maintenance staff in District 8, Water Survey staff began monitoring ground-water levels at the dewatering sites at the end of February 1990. Water levels are measured every two months in each dewatering well and in the adjacent piezometer of each pumping well. Data collected during FY 95 (Phase 12) have been tabulated (appendix F).

Each dewatering well site (except at Missouri Avenue) also includes at least one observation well (two at the I-64 site) equipped with a Leupold-Stevens Type F water-level recorder. Recorder charts are changed monthly and provide a continuous record of water levels near the critical location at each dewatering site. Because of the District 8 reorganization activities mentioned above, the Water Survey also assumed responsibility for the monthly servicing of the recorders beginning at the end of November 1989.

Each time measurements are collected, the Water Survey forwards to IDOT a report of the ground-water level data, including any recommendations. This information is used to monitor ground-water levels in relation to the pavement elevation for determining whether any adjustments in pumpage are necessary. The data also are useful for assessing the condition of individual dewatering wells. Water-level differences of 3 to 5 feet between the pumping wells and the adjacent piezometers are considered normal by IDOT. Greater differences are interpreted to indicate that well deterioration is occurring.

Investigative Methods and Procedures

Well Loss

When a well is pumped, water is removed from storage within the aquifer and water levels decline over time in the vicinity of the well. This effect, referred to as drawdown, is most pronounced at the pumped well and gradually diminishes at increasing distances away from the well. Drawdown is the distance the water level declines from its nonpumping stage. Under ideal conditions, drawdown is a function of pumping rate, time, and the aquifer's hydraulic properties. Aquifer boundaries, spatial variation in aquifer thickness or hydraulic properties, interference from nearby wells, and partial-penetration conditions all can affect observed drawdowns at both pumping and observation wells. However, well loss or additional drawdown inside the pumped well due to turbulent flow of water into and inside the well is a measure of the hydraulic efficiency of the pumping well only, reflecting the unique flow geometry of the borehole, well screen, and pump placement.

Because of well loss, the observed drawdown in a pumped well is usually greater than that in the aquifer formation outside the borehole. In addition to considerations of flow geometry, as noted above, the amount of well loss also can depend on the materials used (screen openings, gravel-pack size distribution, drilling fluids, etc.) and the care taken in constructing and developing the well using mechanical and hydraulic means to remove drilling fluids from the borehole. Some well loss is natural because of the physical blocking of the aquifer interstices caused by the well screen and the disturbance of aquifer material around the borehole during construction. However, an improperly designed well and/or ineffective well construction and development techniques can result in excessive well losses. In addition, well losses often reflect a deterioration in the condition of an existing well, especially if well losses increase over time.

Specific capacity, the quotient of pumping rate divided by the drawdown observed after a given time period, is often used in the field as an indicator of well performance. However, specific capacity combined with an analysis of well loss provides a more complete picture of the condition of the well that allows for normalization and comparison at various pumping rates.

Well loss is a function of pumping rate but ideally not of time. It is associated with changes in flow velocity in the immediate vicinity of the well, resistance to flow through the well screen, and changes in flow path and velocity inside the well, all of which cause the flow to change from laminar to turbulent in form. Head losses under turbulent conditions are nonlinear;

that is, drawdowns increase more rapidly with increases in pumping rate than under laminar conditions, as discussed below.

Although it is possible to have turbulent flow within the aquifer and laminar flow within a pumping well, under usual conditions the observed drawdown (s_o) in a pumping well is made up of two components: the formation loss (s_a), resulting from laminar flow head loss within the aquifer; and well loss (s_w), resulting from the turbulent flow of water into and inside the well, as shown in equation 1:

$$s_o = s_a + s_w \tag{1}$$

Jacob (1947) devised a technique for separating well losses from formation losses, assuming that all formation losses are laminar and all well losses are turbulent. These components of theoretical drawdown, s, in the pumped well are then expressed as being proportional to pumping rate, Q, in the following manner:

$$s = BQ + CQ^2 \tag{2}$$

where B is the formation-loss coefficient per unit discharge, and C is the well-loss coefficient. For convenience, s is expressed in feet, and Q is in cubic feet per second (ft^3/sec). Thus, the well-loss coefficient C is expressed as sec^2/ft^5.

Rorabaugh (1953) suggested that the well-loss component be expressed as CQ^n, where n is a constant greater than 1. He thus expressed the drawdown as:

$$s = BQ + CQ^n \tag{3}$$

To evaluate the well-loss component of the total drawdown, one must know the well-loss coefficient (if using equation 2) or both the coefficient and the exponent (if using equation 3). These analyses require a controlled pumping test, called a step drawdown test (described below), in which total drawdown is systematically measured while pumping rates are varied in a stepwise manner.

Methodology for Determining Well Loss

If Jacob's equation is used to express drawdown, then the coefficients B and C must be determined. A graphical procedure can be employed after first modifying equation 2 as:

$$s/Q = B + CQ \tag{4}$$

A plot of s_o/Q versus Q can be prepared on arithmetic graph paper from data collected during a step drawdown test, substituting the observed drawdown, s_o, for s. The slope of a line fitted to these data is equal to C, and the y-intercept is equal to B, as shown in figure 6. If the data do not fall along a straight line, but instead curve concavely upward, the curvature of the plotted data

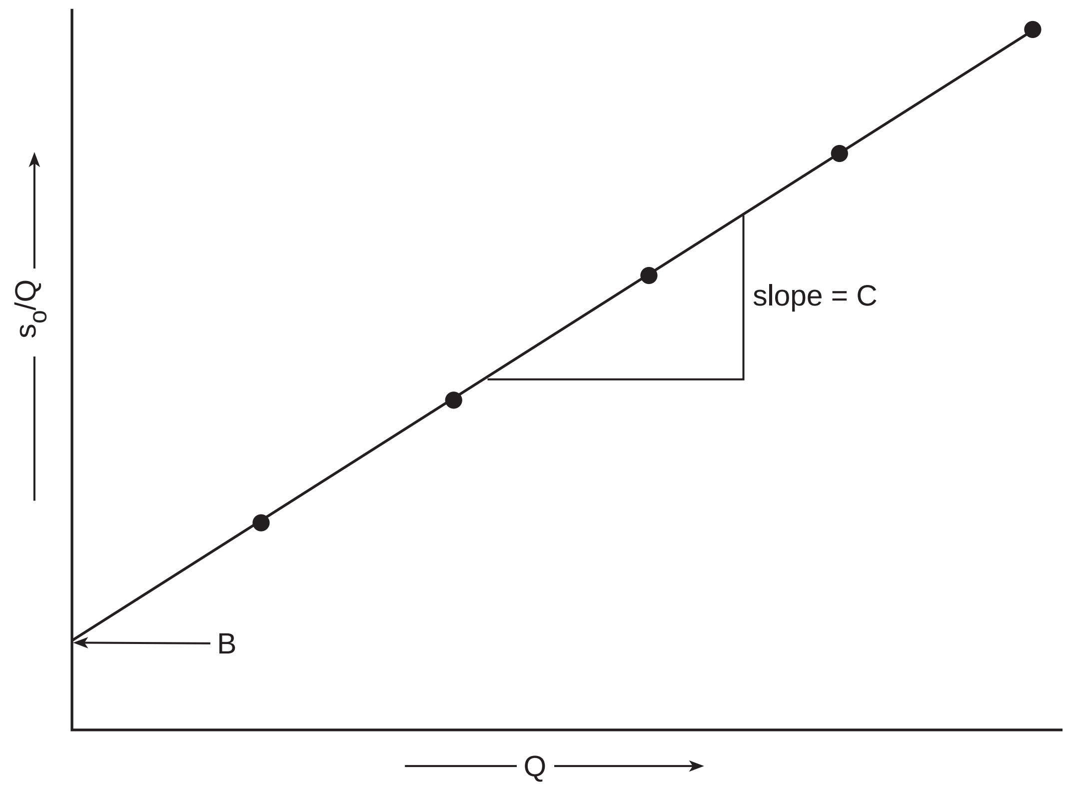

Figure 6. Graphical solution of Jacob's equation for well loss coefficient, C

indicates that the second-order relationship between Q and s_o is invalid and that the Rorabaugh method of analysis usually is appropriate.

Occasionally the data plot of s_o/Q versus Q may yield a straight-line fit with essentially zero slope or with a negative slope, or the data may be too scattered to allow a reasonable fit to be made at all. In these instances, the well-loss parameters are immeasurable. Possible explanations for this are: 1) turbulent well loss was negligible for the range of pumping rates used during the test; 2) inadequate data collection or test methods were used during the test; 3) the hydraulic condition of the well was unstable, as is the case during well development; or 4) the contribution of water from the aquifer was not uniform along the entire length of well screen over the range of pumping rates, as might occur due to the pump setting in relation to the screen or to vertical heterogeneity of the aquifer materials.

If Rorabaugh's equation is used, then coefficients B and C as well as the exponent n must be determined. To facilitate the graphical procedure, equation 3 is rearranged as:

$$(s/Q) - B = CQ^{n-1} \tag{5}$$

Taking logs of both sides of the equation,

$$\log [(s/Q) - B] = \log C + (n - 1) \log Q \tag{6}$$

A plot of (s_o/Q) - B versus Q can be made on logarithmic graph paper from step-test data by replacing s with s_o. Values of B are determined by trial and error until the data form a straight line (figure 7). The slope of the line equals n - 1, from which n can be found. The value of C is determined from the y-intercept at Q = 1. In the example shown, plotting the data is facilitated if Q is plotted as cubic feet per second, and (s_o/Q) - B is plotted as seconds per foot squared. It also is convenient (although not mandatory) to use these same units in the Jacob method.

Step-Test Procedure

The primary objective of a step drawdown test (or step test) is to determine the well-loss coefficient (and exponent if Rorabaugh's method is used). With this information, the turbulent well-loss portion of drawdown for any pumping rate of interest can be estimated. During the test, the well is pumped successively at several selected pumping rates. Equally spaced pumping rates are selected to facilitate the data analysis. Each pumping period at a given rate is called a step, and all steps are of equal time duration. Generally, the pumping rates increase from step to step, but the test also can be conducted by decreasing pumping rates. Conducting the steps at decreasing rates has been found to be the most efficient procedure at the dewatering well sites.

During each step, pumpage is held constant. If data are collected manually, water-level measurements are made every minute for the first six minutes, every two minutes for the next ten minutes, then every four to five minutes thereafter until the end of the step. For the step tests in this study, data were collected using an Omnidata datalogger or an InSitu Hermit datalogger.

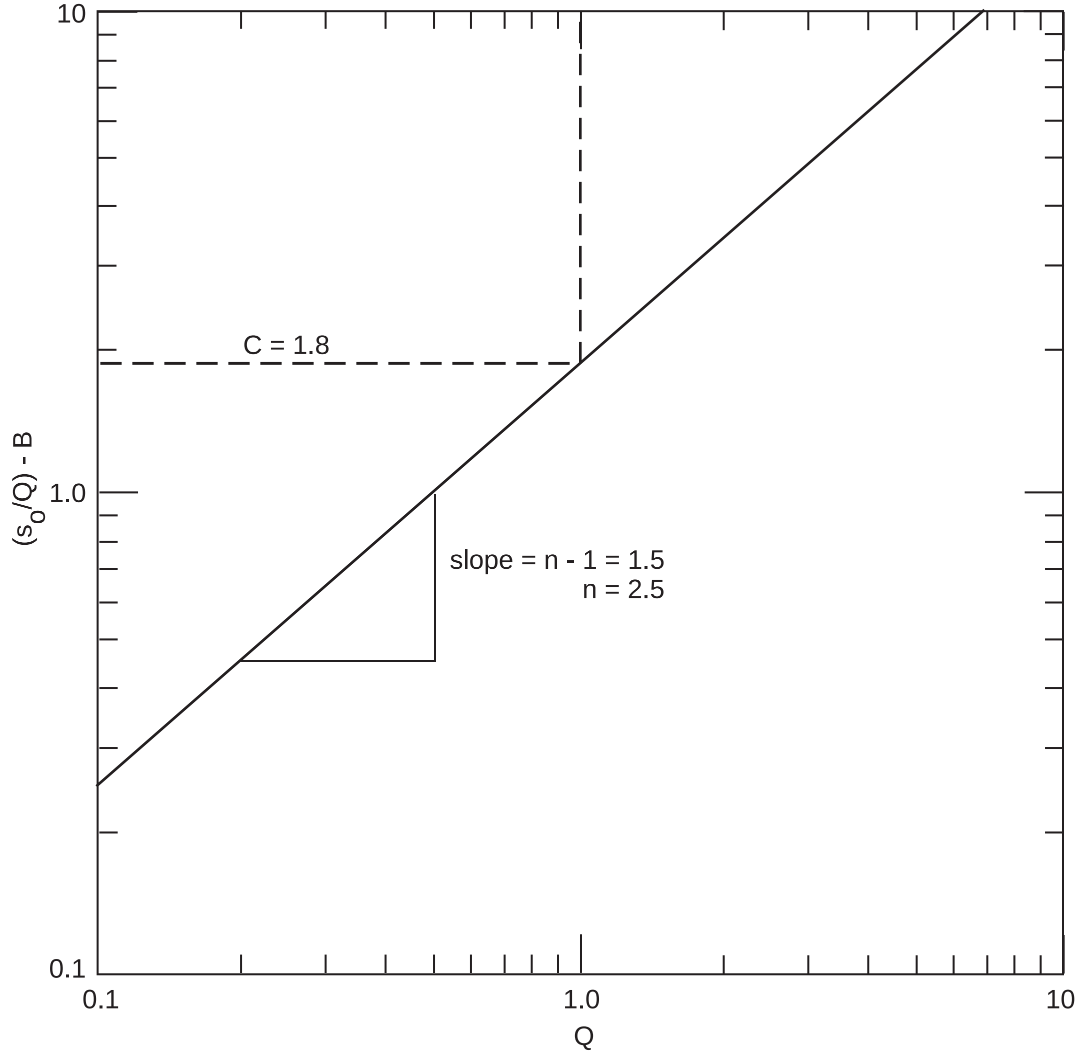

Figure 7. Graphical solution of Rorabaugh's equation for well loss coefficient (C) and exponent(n)

Generally, the dataloggers were programmed to collect water-level data at least once each minute during the step test. Water levels were measured for 30 minutes per step for this investigation. At the end of each 30-minute interval, the pumping rate was immediately changed, and water levels were monitored for another 30-minute interval, until a wide range of pumping rates within the capacity of the pump was tested.

Schematically, the relationship between time and water level resembles that shown for a five-step test in figure 8. Drawdowns for each step (shown as Δs_i) are measured as the distance between the extrapolated water levels from the previous step and the final water level of the current step. For step 1, the nonpumping water-level trend prior to the start of the test is extrapolated, and Δs_1 is measured from this datum. All data extrapolations should be performed on semilog graph paper for the most accurate results. For the purpose of plotting s_o/Q versus Q or $(s_o/Q) - B$ versus Q, values of observed drawdown s_o are equal to the sum of Δs_i for the step of interest. Thus, for step 3, $s_o = \Delta s_1 + \Delta s_2 + \Delta s_3$.

Piezometers

Piezometers, small-diameter wells with a short length of screen, are used to measure water levels (head) at a point in space within an aquifer and are often used in clustered sets to measure variations in water levels with depth. In the case of well-loss studies, piezometers can be employed to measure head losses across a well screen, gravel pack, or well bore. As previously described, 52 of the IDOT dewatering wells (except at Missouri Avenue) have piezometers drilled approximately 5 feet from the center line of each well and finished at a depth corresponding to approximately the upper third point of the screen in the pumping well. Historical monitoring of the difference in head (Δh) between water levels in the well and in the adjacent piezometer has been used to help detect and track well deterioration problems.

Measuring piezometer water levels continuously during each step test also allows an indication of turbulent well losses in the pumped well to be found by plotting the Δh data over a large range of pumping rates. If turbulent losses exist within that range, the head differences should be nonlinear with increasing pumping rate. In addition, it sometimes can be useful to simply plot depth to water (or drawdown) in the piezometer versus pumping rate. If turbulence extends outward from the well to the piezometer, this relationship will be nonlinear.

Field Results

Well Selection for Step Tests

The IDOT highway construction projects and the aftereffects of flood conditions experienced in 1993 limited the number of wells step tested in FY 95 to just four wells. Four step tests were conducted on the four wells treated chemically to restore production capacity. Pretreatment step tests were previously conducted on these four wells in October 1993 for FY 92.

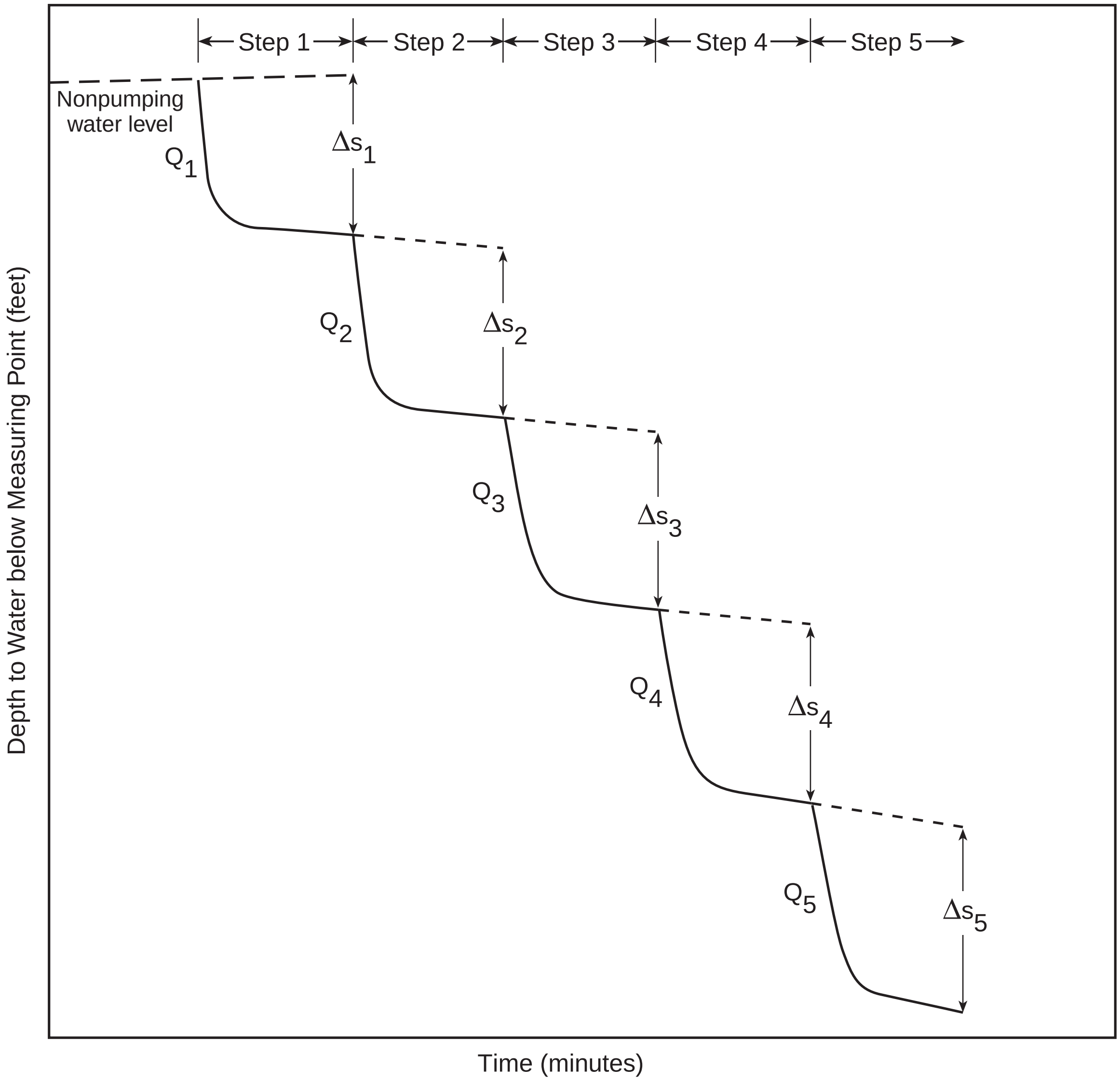

Figure 8. Relationship between time and water level during a five-step drawdown test

The four wells treated and then tested in posttreatment step tests were:

I-70   Wells 3A, 5, 11A, and 15

Step Tests

Field Testing Procedure

Water Survey staff conducted field work with the assistance of the IDOT Bureau of Operations Pump Crew under the supervision of Barry Roberts. The IDOT crew made all necessary wellhead pipe modifications and provided special piping adapters that allowed connection of the Water Survey's flexible hose and orifice tube to measure the flow rate. Discharge from the orifice tube was directed to nearby stormwater drains.

Orifice tubes are standard equipment for accurately measuring flow rates. The orifice tube and orifice plate used to measure the range of flow rates was previously calibrated at the University of Illinois Hydraulics Lab under discharge conditions similar to those expected in the field.

The objective of each step test on the selected wells was to control the flow rate at increments of 50 gpm and to include as many 30-minute steps as possible at 300 gpm or greater for each well. Early experience with the step tests showed that, at rates of less than about 300 gpm, well-loss coefficients rarely could be determined from the collected data. Also, such a low pumping rate often results from a very low specific capacity, indicating a well in poor condition. When there is a maximum pumping rate less than about 300 gpm during a step test for a dewatering well, the drawdown in water levels is observed for a period of 30 to 60 minutes to obtain an approximate specific capacity for later comparison; this is then called a drawdown test instead of a step test.

Prior to the start of each test, the nonpumping water levels in the well and piezometer were measured with a steel tape or electric dropline. Pressure transmitters, coupled to one of the previously mentioned dataloggers, were placed in the pumped well and adjacent piezometer to measure water levels during the step tests.

During the step tests, the discharge from each well also was checked for the presence of sand (unless the site accessibility or site condition precluded set-up of the testing equipment) by directing the open flow from the orifice tube into a 1,000-gallon portable tank. The tank acts as a sedimentation basin, allowing sand grains to be caught, collected at the end of the step test as the tank is drained, and delivered to the geotechnical laboratory for analysis.

Wells were step tested in August 1994 (I-70 Well 3A), September 1994 (I-70 Well 11A), and May 1995 (I-70 Wells 5 and 15). The four wells had been rehabilitated between July 20 and August 29, 1994.

Data for the four step tests are included in appendix A. Water samples were collected at the time of each test and analyzed for chemical/mineral content and nuisance bacteria. The results from the water sample analyses are described in the following sections and are presented in appendix B.

Results of Step Tests

Step-test data were analyzed by using the Jacob method, as described earlier in this report. Table 1 summarizes results of the analyses of data from the four step tests conducted for the FY 95 investigation. Because the amount of drawdown due to well loss is proportional to the pumping rate squared, the well loss reported in table 1 has been calculated for a standardized rate of 600 gpm using the well-loss coefficient determined from the analysis of the step-test data. This enables comparison among dewatering wells that operate at different rates. The standardized well loss also is reported in table 1 as a percentage of total drawdown calculated using equation 2 ($s = BQ + CQ^2$) at the base rate of 600 gpm. Likewise, the Δh values reported in table 1 also have been observed or estimated for the standardized rate of 600 gpm. However, comparisons of Δh values are only valid among step tests on the same well because of the varying distances of the piezometers from the individual dewatering wells. All step tests conducted in FY 95 were run with steps at decreasing rates so the observed specific capacities included in table 1 were calculated based on the total observed drawdown at the end of the first step when the highest pumping rate was used. Thus, observed specific capacity values are calculated after 30 minutes of pumping, but they are not standardized to the 600 gpm rate.

Step tests were scheduled to assess the results of chemical treatment of four existing wells during FY 95. The results of the posttreatment step tests conducted on I-70 Wells 3A, 5, 11A, and 15 are included in the summary of step test data in table 1, and they subsequently are discussed in the following section "Well Rehabilitation, Chemical Treatment Results."

Since FY 84 (Phases 1-12), 147 step tests (including six drawdown tests) have been completed at all sites. The results are included in appendix C, and the observed specific capacity data are summarized in table 2. The average observed specific capacity for all 147 step tests is about 79 gpm/ft. By excluding the results from 61 pretreatment step tests and other step tests that show wells in poor condition, the average observed specific capacity of the remaining 86 step tests is about 102 gpm/ft. The highest observed specific capacities are generally found at the 25th Street site, where 25 step tests have been completed. Observed specific capacities for all step tests at the 25th Street site averaged about 94 gpm/ft; and about 119 gpm/ft if the nine pretreatment step tests are excluded. At the I-70, I-64, Venice, and Missouri Ave sites, respectively, 73, 18, 28, and 3 step tests have been completed with average observed specific capacities of about 71, 92, 76, and 66 gpm/ft. Without the pretreatment step tests and other step tests on wells in poor condition at these sites, the observed specific capacities were about 95, 105, 99, and 100 gpm/ft, respectively.

Table 1. Results of State Water Survey Step Tests on IDOT Wells, FY 95 (Phase 12)

Well	*Date of step test*	*Well loss at 600 gpm (ft)*	*Drawdown at 600 gpm (ft)*	*Well loss portion (%)*	*Observed specific capacity (gpm/ft)*	*Δh* at 600 gpm (ft)*	*Observed Q_{max}, gpm*	*Remarks*
<u>I-70</u>								
No. 3A	8/17/94	4.40	8.96	49.2	67.6	2.2	610	Posttreatment
No. 5	5/10/95	**	7.53	**	79.9	P	625	Posttreatment
No. 11A	9/20/94	0.07	7.28	0.9	82.5	3.7 e	575	Posttreatment
No. 15	5/11/95	**	5.67	**	103.5	1.2	650	Posttreatment

Notes:
* Head difference between pumped well and adjacent piezometer.
** Coefficient immeasurable. Turbulent well loss negligible over the pumping rates tested.
e = Estimate based on interpolated values adjusted to 600 gpm.
P = Piezometer plugged or partially plugged.

Table 2. Average Observed Specific Capacity of Dewatering Wells Based on Step-Test Data from 147 Tests Since FY 84

Wells	*I-70*	*I-64*	*25th St.*	*Venice*	*MO Ave.*	*All sites*
All wells:						
Number of step tests	73	18	25	28	3	147
Average observed specific capacity, gpm/ft	71	92	94	76	66	79
Wells in good condition or posttreatment:						
Number of step tests	39	14	16	16	1	86
Average observed specific capacity, gpm/ft	95	105	119	99	100	102
Wells in poor condition or pretreatment:						
Number of step tests	34	4	9	12	2	61
Average observed specific capacity, gpm/ft	44	49	49	47	49	46

Well Rehabilitation

Chemical Treatment Procedure

Specifications for the well rehabilitation work initially were developed in FY 86 by IDOT and the Water Survey based on chemical treatment practices in common use. Revisions to the specifications have been made periodically, based on results and experience from chemical treatment of the dewatering wells since 1986. Similar treatment procedures were used for all wells treated in FY 95, although adjustments occurred as specific conditions were encountered from day to day and from well to well. Table 3 summarizes the treatment procedure as required by IDOT specifications. The actual procedure used by the contractor, Layne-Western Company, Inc., varied in some instances, and the significant changes are noted in the table 3.

Figure 9 shows schematically the typical injection assembly/discharge apparatus used by the contractor to inject solutions and acid into the wells, to pump spent solutions to waste, and to conduct drawdown pumping tests during the treatment work.

The well rehabilitation work was observed and documented by Water Survey staff. Field notes for each well treated in FY 95 are included in appendix D.

Chemical Treatment Results

The wells were selected for chemical treatment on the basis of data from the most recent Water Survey step tests and available Δh information (see the section "Piezometers"). Step tests completed for FY 92 for I-70 Wells 3A, 5, 11A, and 15 indicated that these dewatering wells were in poor condition and should be chemically treated. Under a FY 94 IDOT contract, Layne-Western Company, Inc., chemically treated the four dewatering wells between July 20 and August 29, 1994.

Table 3. Outline of Typical Well Rehabilitation

Day 1

1. Pretreatment specific capacity test (contractor orifice tube, open to free discharge, used for flow measurements).
    a. Measurement of SWL (static water level) following 30 or more minutes of well inactivity.
    b. Measurement of PWL (pumping water level) and orifice piezometer tube following 60 or more minutes of pumping.

2. Polyphosphate application, 400 pounds, and displacement with 16,000 gallons of water containing at least 500 ppm (mg/L) chlorine.
    a. Initial chlorination of well with 2,500 gallons of water containing 500 ppm or more chlorine injected at a minimum rate of 750 gpm (actual rate: 1,300 to 2,100 gpm).
    b. Injection of polyphosphate solution at a minimum rate of 2,000 gpm (actual rate: 1,500 to 2,100 gpm) in two 1,800-gallon batches, each batch containing 200 pounds polyphosphate.
    c. Displacement injection of 16,000 gallons of water chlorinated to at least 500 mg/L in 2,000-gallon batches at a minimum rate of 1,500 gpm (actual rate: 800 to 2,900 gpm).
    d. Time allowance for chemicals to react, 1 to 2 hours.
    e. Repeatedly surge and backflush well to loosen encrustants with multiple cycles (actual 9 to 19) of pumping well at high rates (actual: 700 to 2,300 gpm) to fill 2,000 gallon holding tank and pumping the contents of tank back into the well at high rates (actual rate: 960 to 3,600 gpm).

3. Pump to waste and check specific capacity.
    a. Pump continuously 6 or more hours to clear well of chemicals (actual time, when known: 15.5 to 19.75 hours).
    b. Same procedure for specific capacity check as step 1 above.

Day 2

1. Acidization with 1,000 gallons 20° Baume-inhibited muriatic (hydrochloric) acid and displacement with 4,000 to 5,000 gallons of water (not chlorinated).
    a. Pump 1,000 gallons of bulk-inhibited acid into well within 1 hour, 17 gpm minimum (actual rate: 23 to 130 gpm).
    b. Allowance time for acid to react, 1 hour.
    c. Injection of 4,000 to 5,000 gallons of water at 1,000 to 2,000 gpm (actual rate: 1,500 to 3,000 gpm).
    d. Allowance for reaction, 2 to 3 hours.
    e. Repeatedly surge and backflush well to loosen encrustants with multiple cycles (actual 9 to 14) of pumping well at high rates (actual rates: 222 to 1,100 gpm) to fill 2,000 gallon holding tank and pumping the contents of tank back into the well at high rates (actual rate: 1,000 to 2,700 gpm).

Table 3. Continued

2. Pump to waste and check specific capacity.

   a. Pump continuously 3 hours or more (actual time: 17 hours) to clear well of acid.
   b. Same procedure as for specific capacity check as Day 1, step 1.

<u>Day 3</u>

1. Polyphosphate application, 600 pounds, and displacement with 30,000 gallons of water containing at least 500 ppm chlorine.

   Same procedure as Day 1, step 2, except three batch injections of 1,800 gallons (5,400 gallons total) with 200 pounds of phosphate each in part b, and injection of 30,000 gallons in part c.

   Noted actual pumping rates and surging cycles for indicated steps of procedure.

   a. Initial chlorination: 1,800 to 2,500 gpm.
   b. Polyphosphate solution injections: 1,300 to 3,000 gpm.
   c. Displacements: 1,500 to 3,000 gpm.
   d. No change.
   e. Surging/backflushing actual cycles: 18 to 25; well to tank pumping rate: 800 to 1,400 gpm; tank to well pumping rate: 1,800 to 2,900 gpm).

2. Pump to waste and check specific capacity.

   a. Pump continuously 6 or more hours to clear well of chemicals (actual time: 17.5 to 65.5 hours).
   b. Same procedure as for specific capacity check as Day 1, step 1.

<u>Day 4</u> (Optional)

1. Polyphosphate application, 600 pounds, and displacement with 54,000 gallons of water containing at least 500 ppm chlorine.

   Same procedure as Day 1, step 2, except three batch injections of 1,800 gallons (5,400 gallons total) with 200 pounds of phosphate each in part b, and injection of 54,000 gallons in part c.

   Noted actual pumping rates and surging cycles for indicated steps of procedure.

   a. Initial chlorination: 1,412 gpm.
   b. Polyphosphate solution injections: 2,300 to 2,700 gpm.
   c. Displacements: 1,100 to 2,600 gpm.
   d. No change.
   e. Surging/backflushing actual cycles: 25; well to tank pumping rate: 1,300 to 1,500 gpm; tank to well pumping rate: 2,400 to 3,000 gpm.

Table 3. Concluded

2. Pump to waste and check specific capacity.

   a. Pump continuously 6 or more hours to clear well of chemicals (actual time: 14 hours).
   b. Same procedure as for specific capacity check as Day 1, step 1.

Day 5 (Optional)

1. Polyphosphate application, 400 pounds, and displacement with 16,000 gallons of water containing at least 500 ppm chlorine.

   Same procedure as Day 1, step 2.

2. Pump to waste and final specific capacity test.

   a. Pump continuously 6 or more hours to clear well of chemicals.
   b. Same procedure as for specific capacity check as Day 1, step 1.

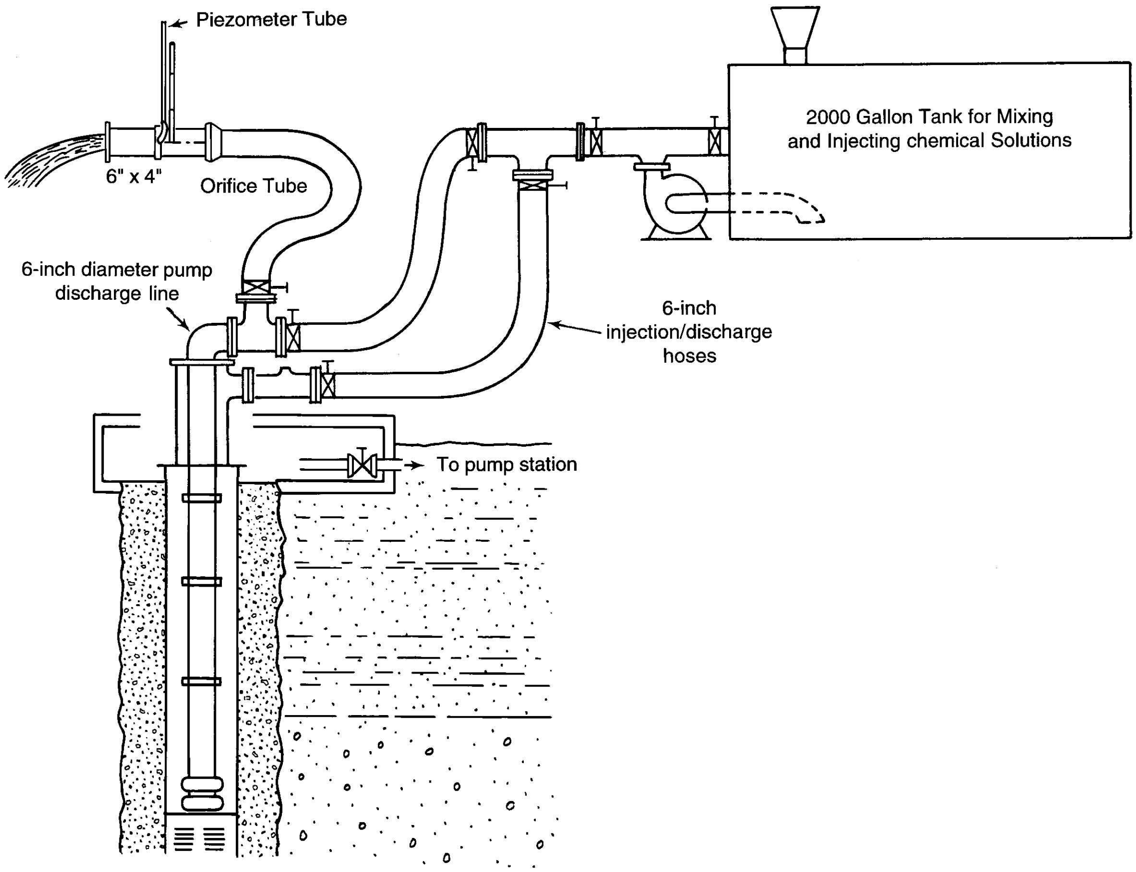

Figure 9. Schematic diagram of equipment used in well rehabilitation

The condition of I-70 Well 3A was checked during the initial step test on October 29, 1993, when the well was nearly new but had been in heavy use since its construction about April 1993. The observed specific capacity of the well was only about 40 gpm/ft, the well loss was about 8.8 percent, and the Δh was about 7.7 feet. These results of the initial step test showed that the well had surely deteriorated during the intervening 6 months. The well was chemically treated during July 20-25, 1994. For the FY 95 posttreatment step test conducted on August 17, 1994, the observed specific capacity was about 68 gpm/ft, the estimated well loss was 49 percent, and the estimated Δh was 2.2 feet. Well 3A appeared to be in fair condition after chemical treatment, with an observed specific capacity about 72 percent of the average observed specific capacity of wells at the I-70 site that were in good condition.

The previous step test on I-70 Well 5 was conducted on October 14, 1993. The observed specific capacity of the well was about 45 gpm/ft and the well loss was about 8.7 percent. The Δh could not be determined because of the plugged piezometer. The well was chemically treated during August 16-19, 1994. The results of the posttreatment step test conducted for FY 95 on May 10, 1995, showed an observed specific capacity of about 80 gpm/ft. The well loss could not be determined from the collected data, and the piezometer was still plugged, preventing determination of the Δh value. Well 5 appeared to be in fair condition after chemical treatment, with an observed specific capacity about 84 percent of the average observed specific capacity of wells at the I-70 site that were in good condition.

The condition of I-70 Well 11A was checked during the initial step test on October 28, 1993, when the well was nearly new but had been in heavy use since its construction about April 1993. The observed specific capacity of the well was only about 38 gpm/ft, the well loss was about 2.5 percent, and the Δh was about 12.5 feet. These results showed the well had surely deteriorated since its construction. The well was chemically treated during August 5-11, 1994. The results of the posttreatment step test conducted for FY 95 on September 20, 1994, showed the observed specific capacity increased to about 83 gpm/ft, the well loss declined to about 0.9 percent, and the Δh declined to an estimated 3.7 feet. Well 11A appeared to be in fair condition after chemical treatment, with an observed specific capacity about 87 percent of the average observed specific capacity of wells at the I-70 site that were in good condition.

The previous step test on I-70 Well 15 was conducted on October 15, 1993. The observed specific capacity of the well was about 42 gpm/ft, the well loss was about 19.8 percent, and the Δh was about 9.1 feet. The well was chemically treated during August 23-29, 1994. The results of the posttreatment step test conducted for FY 95 on May 11, 1995, showed an observed specific capacity of about 104 gpm/ft, and the Δh value was about 1.2 feet. The well loss could not be determined from the collected data. Well 15 appeared to be in good condition after chemical treatment, with an observed specific capacity about 109 percent of the average observed specific capacity of wells at the I-70 site that were in good condition.

As indicated in table 3, the chemical treatment procedure required the treatment contractor to conduct 60-minute drawdown tests to measure the specific capacity after each successive treatment step. Table 4 summarizes these drawdown pumping test data collected as part of the field documentation during the chemical treatment of each dewatering well. Table 4

Table 4. Drawdown Test Data Collected by Contractor during Well Rehabilitation

Parameters 1994	*Pretreatment*	*1st PPP treatment*	*Acid treatment*	*2nd PPP treatment*	*3rd PPP treatment*	*4th PPP treatment*
<u>I-70 Well 3A</u>						
Date	7/20 a.m.	7/21 a.m.	7/22 a.m.	7/25 a.m.	none	none
SWL	32.71	33.95	33.96	34.42		
PWL	51.22	44.09	43.016	42.98		
s	18.51	10.14	9.05	8.56		
Q	597	597	603	635		
Q/s	32.3	58.9	66.6	74.2		
<u>I-70 Well 5</u>						
Date	8/16 a.m.	8/17 a.m	8/18 a.m.	8/19 a.m.	none	none
SWL	19.50	17.23	17.026	18.69		
PWL	36.65	25.21	24.09	25.21		
s	17.15	7.98	7.07	6.52		
Q	594	619	616	626		
Q/s	34.6	77.6	87.1	95.9		
<u>I-70 Well 11A</u>						
Date	8/5 a.m.	8/8 a.m.	8/10 a.m.	8/11 a.m.	none	none
SWL	29.90	28.80	29.56	29.72		
PWL	60.99	39.20	37.95	37.83		
s	31.09	10.4	8.39	8.11		
Q	616	577	622	622		
Q/s	19.8	55.5	74.1	76.7		
<u>I-70 Well 15</u>						
Date	8/23 a.m.	8/24 a.m.	8/25 a.m.	8/26 a.m.	8/29 a.m.	none
SWL	17.06	18.45	18.83	19.05	19.78	
PWL	42.30	26.72	25.00	24.17	24.58	
s	25.24	8.27	6.17	5.12	4.80	
Q	622	635	635	635	635	
Q/s	24.6	76.8	102.9	124.0	132.3	
<u>Averages</u>						
Q/s	27.8	67.2	82.7	92.7		
ΔQ/s		39.4	15.5	10.0		
% increase over original Q/s		141.7	55.8	36.0		
% of total improvement		60.7	23.9	15.4		

Notes:

Total ΔQ/s = 64.9 gpm/ft (233 percent improvement over initial Q/s)

SWL - Static (nonpumping) water level, feet

PWL - Pumping water level, feet

s - Drawdown (PWL-SWL), feet

Q - Pumping rate, gpm

Q/s - Specific capacity, gpm/ft

PPP - Polyphosphate

also shows the computed specific capacities before treatment and after each step in the treatment process (polyphosphate or acid injection episode). The average specific capacity for all wells at each step in the treatment process is given at the end of table 4, along with an analysis of the improvement between steps. In general, the percentage improvement in specific capacity diminishes with each successive step of the treatment. This trend also has been noted in the results of the chemical treatment in some prior years. In FY 95, about 61 percent of the total improvement occurred with the first polyphosphate treatment and about 15 percent occurred during the second polyphosphate treatment (following acidization). Based on the water level and pumping rate data collected by the contractor during chemical treatment, the observed specific capacities for the wells were about 98 percent of the average observed specific capacity for wells in good condition at the I-70 site.

The trend of reduced improvement for successive treatment steps has been shown by the results of the treatment for each of the 10 years that this general well treatment procedure has been followed (one polyphosphate treatment, followed by a muriatic acid treatment, followed by up to three polyphosphate treatments). In these instances, about 76 to 96 percent of the improvement occurred after the second polyphosphate treatment step.

Following recommendations presented in the FY 87 (Phase 4) report (Wilson et al., 1990), the chemical treatment specifications were modified to allow a basic treatment scheme consisting of one polyphosphate treatment, followed by a muriatic acid treatment, followed by a polyphosphate treatment, and, if necessary, up to two additional polyphosphate treatments (table 3). Depending on the response of each well to the basic treatments, the additional polyphosphate treatments are only used when expectations for improvement of specific capacity have not been achieved. An overall reduction in the treatment cost may thus be realized by eliminating unnecessary, additional polyphosphate treatment steps. To do this, a target specific capacity for improvement is selected, based on the specific capacities observed during previous step tests and the site average specific capacity for wells in good condition. Also, progress and results from each step in the rehabilitation work must be closely monitored in the field to verify significant improvement in specific capacity between treatment steps.

During the FY 95 rehabilitation work, the only well selected for an additional polyphosphate treatment was I-70 Well 15 because of the significant improvement in specific capacity between the acid treatment and the second polyphosphate treatment. Examination of the field data in table 4, collected by the treatment contractor, suggests that at least the third polyphosphate treatment should have been performed on I-70 Wells 3A and 11A to attempt to achieve an observed specific capacity result nearer the average for the I-70 site. However, budgetary constraints in the IDOT FY 94 maintenance contract influenced the decision to withhold additional polyphosphate treatment steps for these two wells.

Following the chemical treatments in FY 95, the Water Survey conducted step tests on each treated well to evaluate the condition of the well and the response to treatment; the tests also provided data for comparison with the contractor's drawdown tests conducted during the well treatment. Table 5 summarizes the results of these tests. The improvement in I-70 Well 15 was significant, with an increase of about 149 percent in observed specific capacity based on the pre-

Table 5. Results of Chemical Treatment, FY 95 (Phase 12)

Site	Well		*Pretreatment* Date	*Pretreatment* Q/s (gpm/ft)	*Posttreatment* Date	*Posttreatment* Q/s (gpm/ft)	% change
I-70	Well 3A	ISWS	10/29/93	40.0	08/17/94	67.6	+69
		LWC	07/20/94	32.3	07/25/94	74.2	+130
I-70	Well 5	ISWS	10/14/93	44.8	05/10/95	79.9	+80
		LWC	08/16/94	34.6	08/19/94	95.9	+177
I-70	Well 11A	ISWS	10/28/93	37.6	09/20/94	82.5	+119
		LWC	08/05/94	19.8	08/10/94	76.7	+287
I-70.	Well 15	ISWS	10/15/93	41.5	05/11/95	103.5	+149
		LWC	08/23/94	24.6	08/29/94	132.3	+438
Average		ISWS		41.0		83.4	+103
		LWC		27.8		94.8	+241

Notes:
Q/s = Specific capacity, gpm/ft
ISWS = Illinois State Water Survey
LWC = Layne-Western Company, Inc.

and posttreatment step tests, and achieved an observed specific capacity of about 109 percent of the average observed specific capacity of wells in good condition at the I-70 site (see table 2). Another well, I-70 Well 11A, had an increase of about 119 percent in observed specific capacity, and achieved about 87 percent of the average observed specific capacity of wells that were in good condition at the I-70 site. The other two wells showed an improvement of about 69 and 80 percent in observed specific capacity, and achieved about 72 and 84 percent of the average observed specific capacity of wells that were in good condition at the I-70 site. The posttreatment step tests for I-70 Wells 5 and 15 were delayed for several months; their operation after treatment was not extensive, and any loss in capacity between chemical treatment and the posttreatment step test is judged to be limited.

A number of wells have now been rehabilitated in each of 10 years, with a total of 40 chemical treatments on 32 wells (seven in FY 86, five in FY 87, four in FY 88, four in FY 89, five in FY 90, four in FY 91, three in FY 92, two in FY 93, two in FY 94, and four in FY 95). Three contractors performed the treatments: one during the first 2 years (FY 86 and FY 87) and the 4th year (FY 89); a second contractor in the 3rd, 5th, 6th, (FY 88, FY 90, and FY 91), and 8th years (FY 93); and the third contractor during the 7th (FY 92), 9th, and 10th years (FY 94 and FY 95).

Sand Pumpage Investigation

Field Procedure

Prior occurrences of sand pumpage from the dewatering wells have resulted in the standard practice of checking for the presence of sand in the discharge during each step test, unless precluded by site conditions and available equipment. To continue to address these concerns, the possibility of sand pumpage was investigated during two of the four step tests conducted on four wells in FY 95 (Phase 12). The other two wells, I-70 Wells 5 and 15, were not checked because the portable tank was required for unconventional use as a conduit to divert the well pump discharge during the step tests into a drainage system manhole to prevent water on the pavement.

During each step test, water is discharged from the orifice tube into a portable 1,000-gallon tank (figure 10). Siphon tubes are used, as necessary, to help control the overflow discharge from the tank. The tank itself acts as a sedimentation basin that, under ideal conditions, should allow sand with grain diameters of about 0.1 millimeter (mm) and larger to settle out at the design pumping rates of the wells (600 to 800 gpm). Usually 80 to 90 percent or more of the aquifer material in the screened portion or segment of the wells exceeds the 0.1 mm grain size.

Sand Sample Collection and Results

Samples can be collected after the step tests whenever a sufficient amount of sediment remains in the tank to allow analysis of the grain size distribution. Samples are then prepared and sieved at the Quaternary Materials Laboratory of the Illinois State Geological Survey. During FY 95, neither of the two step tests in which the portable sand tank was used generated a sample large enough for collection. The other two wells, I-70 Wells 5 and 15, also would have been checked but were not because the portable tank was required to divert discharged water into a drainage system manhole to prevent water on the pavement. To divert discharged water, the tank was positioned primarily for water flow-through rather than detention and sedimentation of sand. A discussion of the results for each well follows.

I-70 Well 3A:

A very small amount (perhaps 1 teaspoon) of encrustation material, and no sand, was observed in the tank after the step test on August 17, 1994. No sample was collected. A very small amount of fine sand was detected in the settling tank after the initial step test on October 29, 1993. The amount was insufficient for sample collection.

I-70 Well 5:

The settling tank was used to divert the discharged water into a manhole for the step test on May 10, 1995. This arrangement allowed the settlement of some sand; less than two tablespoons of very fine sand were detected after the step test. Consequently, no sample was collected. The previous step test on Well 5 was on October 14, 1993, and site conditions at that time precluded use of the portable settling tank.

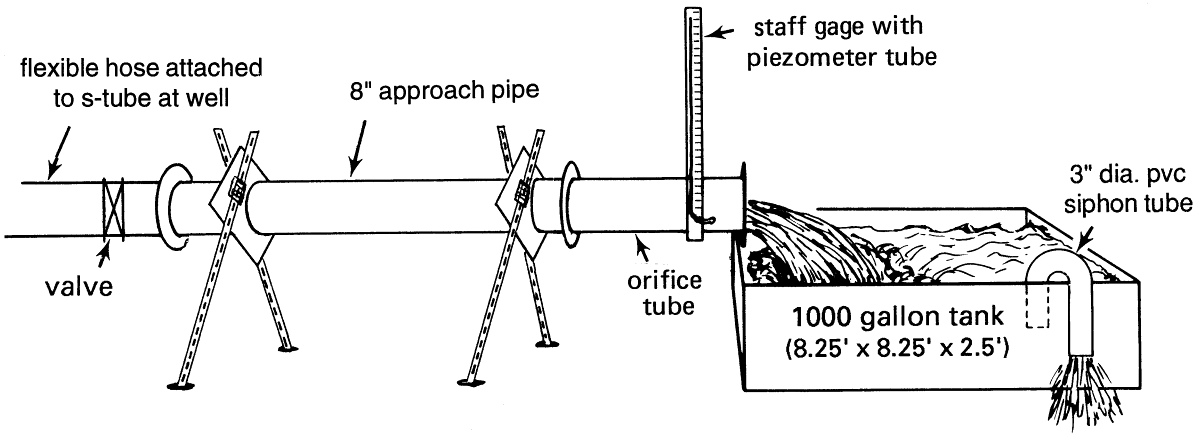

Figure 10. Sand pumpage test setup

I-70 Well 11A:

A very small amount (<½ teaspoon) of fine sand was detected in the settling tank after the step test on September 20, 1994. The amount was insufficient for sample collection. No sand was observed in the settling tank after the initial step test on October 28, 1993.

I-70 Well 15:

The settling tank was used to divert the discharged water into a manhole for the step test on May 11, 1995. The position of the tank was not intended to allow settlement of sand from the discharge. No sample was collected. A few grains of sand were detected in the settling tank after the initial step test on October 15, 1993. The amount of sand was insufficient for the collection of a sample.

Sand Pumpage Summary

Since sand pumpage tests began in FY 87 (Phase 4), a total of 40 dewatering wells have been checked for sand pumpage. Twenty-one of these wells have pumped an amount of sand judged to be significant during at least one step test; five of these wells have been abandoned and replaced with new wells. (Three additional wells that exhibited settlement or other symptoms indicative of excess sand pumpage have been replaced.) Sand has been pumped on at least one occasion in 9 of 20 different dewatering wells tested at the I-70 site (23 wells have existed), 3 of 4 wells tested at the I-64 site, 3 of 8 wells tested at the 25th Street site, and 6 of 8 wells tested at the Venice site. Of the 12 new/replacement dewatering wells built since FY 87, 4 have pumped sand when checked during 6 of 13 step tests.

Evaluation of Ground-Water Quality

The Water Survey's Office of Analytical and Water Treatment Services analyzed water samples collected during all four step tests on the dewatering wells. Appendix B reports the results. Analytical methods used conform to the latest procedures certified by the U.S. Environmental Protection Agency (1979). The sample temperature was determined at each well site, and the pH of samples was determined in the laboratory. Table 6 presents the range of concentrations and potential influence of the major water quality parameters analyzed for the FY 95 samples.

Although the ground-water samples vary in water chemistry, generally the ground water can be described as highly mineralized, very hard, and alkaline, with unusually high concentrations of soluble iron. The water quality is consistent with that of previously analyzed samples from the dewatering wells.

A total of 143 water samples have been analyzed since our studies began in FY 84 (Phase 1). Appendix E contains results from all of the analyses, grouped according to site and summarized in table 7. There appear to be few important differences between the sites in terms of these water-quality parameters. Iron concentrations are typically higher in the water from the I-64 and Venice sites, and the water from the I-64 and 25th Street sites contains more dissolved

Table 6. Range of Concentrations and Potential Influence of Common Dissolved Constituents

Parameter	*Concentration, mg/L* *Minimum*	*Maximum*	*Potential influence*
Iron (Fe)	12.57	15.94	Major - incrustative
Manganese (Mn)	0.55	0.87	Major - incrustative
Calcium (Ca)	175	209	Major - incrustative
Magnesium (Mg)	41.1	54.3	Minor - incrustative
Sodium (Na)	34.7	90.7	Neutral
Silica (SiO_2)	32.2	35.1	Minor - incrustative
Nitrate (NO_3)	< 0.02	<0.02	Neutral
Chloride (Cl)	60.4	198	Moderate - corrosive
Sulfate (SO_4)	188	367	Major - corrosive
Alkalinity (as $CaCO_3$)	371	508	Major - incrustative
Hardness (as $CaCO_3$)	605	744	Major - incrustative
Total dissolved solids (@180°C)	870	1149	Major - corrosive
pH (lab)	7.1	7.4	Major - incrustative

minerals; however, these trends probably do not matter much from a practical standpoint because the concentrations are already very high at all locations.

Nuisance Bacteria Sampling

Nuisance bacteria that inhabit wells, gravel packs, and the aquifer matrix often produce well-plugging biofilms, as well as an environment favorable for chemical deposition and corrosion processes. To explore the possibility that such nuisance bacteria might be present in the dewatering wells, the Biological Activity Reaction Test (BART), developed by Droycon Bioconcepts, Inc., Regina, Saskatchewan, Canada, was run on water samples collected from the well discharge at the time of the step tests. The BART sampling system is designed to detect three general classes of nuisance bacteria commonly associated with problems in wells: iron-related bacteria (IRB), slime-forming bacteria (SLYM), and sulfate-reducing bacteria (SRB). The BART system was used during FY 90 to identify the presence of nuisance bacteria in the I-255 detention pond relief wells, with 14 step-tested dewatering wells during FY 91 (Sanderson et al., 1993), 16 step-tested dewatering wells during FY 92 (Olson and Sanderson, 1997), 12 step-tested dewatering wells during FY 93 (Sanderson and Olson, 1998), and 11 step-tested dewatering wells during FY 94 (Sanderson and Olson, 1999).

The plugging potential of a nuisance bacteria population in a well is believed to be related to the dominant bacterial groups present, population size, and growth potential in the well environment. To help determine this, the testing protocol requires placing a water sample in the BART vial for examination over a period of days, noting the type and time of any reactions that may occur. The nuisance bacteria population activity or aggressivity, which encompasses size

Table 7. Ground-Water Chemical Quality Summary, FY 84 - FY 95 (Phases 1-12)

Site		*Iron*	*Manganese*	*Calcium*	*Magnesium*	*Sodium*	*Silica*	*Nitrate*	*Chloride*	*Sulfate*	*Alkalinity**	*Hardness**	*TDS*
I-70	Average	12.00	0.77	191	45.5	76.9	32.4	0.39	99	302	420	664	1050
	Minimum	2.97	0.44	131	35.2	26.2	20.0	<0.02	39	151	316	507	736
	Maximum	18.84	1.49	239	63.8	230.0	38.0	3.7	234	694	593	834	1642
	No. of samples	71	55	71	71	71	62	40	71	71	71	71	71
I-64	Average	16.51	0.57	236	58.9	152.1	33.8	0.5	115	617	457	834	1558
	Minimum	12.30	0.47	202	44.3	29.8	30.5	<0.1	41	350	412	725	974
	Maximum	21.04	0.70	295	74.1	558.0	35.8	2.3	390	1438	545	1039	2821
	No. of samples	17	8	17	17	17	15	8	17	17	17	17	17
25th St.	Average	12.18	0.58	177	51.0	123.6	34.2	0.1	34	520	397	651	1235
	Minimum	4.50	0.36	123	35.4	14.2	31.2	<0.1	21	122	331	467	612
	Maximum	22.90	0.82	250	73.1	314.0	39.4	0.2	49	1171	477	898	2335
	No. of samples	24	20	24	24	24	17	10	24	24	24	24	24
Venice	Average	17.27	0.56	207	50.3	41.4	32.9	0.2	60.8	329	433	724	1022
	Minimum	8.28	0.39	180	42.2	28.9	24.4	<0.02	25	218	387	635	878
	Maximum	25.7	0.76	261	61.2	65.1	39.6	0.8	124	490	476	890	1241
	No. of samples	28	21	28	28	28	24	12	28	28	28	28	28

Table 7. Concluded

Site		*Iron*	*Manganese*	*Calcium*	*Magnesium*	*Sodium*	*Silica*	*Nitrate*	*Chloride*	*Sulfate*	*Alkalinity**	*Hardness**	*TDS*
MO Ave.	Average	10.42	1.07	226	50.5	65.7	28.9	0.20	82.2	306	472	772	1081
	Minimum	7.16	0.99	205	40	59	23.8	<0.02	70.4	254	398	676	925
	Maximum	12.82	1.18	243	65.3	72.4	32.2	0.53	88.9	348	521	875	1168
	No. of samples	3	3	3	3	2	3	3	3	3	3	3	3

Notes:
* Reported as $CaCO_3$
All concentration units are in milligrams per liter
TDS = Total dissolved solids at 180°C

and growth potential, is inversely related to the length of time before reactions occur, referred to as delay. Reaction type and pattern of occurrence depend on the dominant bacterial groups present in the water (Cullimore, 1990). Thus, the type, size, and growth potential of the bacterial community can be inferred from this reaction signature. Multiple sets of samples collected at time intervals of pumping are recommended for detailed analysis of the bacterial community and its activity in the water (Mansuy et al., 1990).

The BART samples were collected from the pump discharge during three step tests on four dewatering wells step-tested for FY 95 (BART samples are missing for the fourth FY 95 step test because the step test was shut down early due to water on the highway pavement) all using the same procedure. Because the purpose was to simply determine whether nuisance bacteria are present in the wells, only one sample set, consisting of IRB, SLYM, and SRB vials, was collected for each step-tested well. The BART vials were filled from the orifice tube discharge, usually in sequence with the other water samples being collected for analysis of the dissolved constituents, near the end of the test and transported to the office for observation.

A signature classification method from Droycon Bioconcepts, Inc., was used to rank aggressivity of the bacterial population in the water based on sample reaction delay, in days. All of the IRB BART samples and two of the SLYM samples indicated moderately aggressive nuisance bacteria populations; all of the SRB samples and one of the SLYM BART samples indicated very aggressive populations. All tests had positive reaction signatures in eight days or less. Similar results have been reported for samples collected from dewatering wells step tested in FY 91, FY 92, FY 93, and FY 94.

There continues to be poor correlation and consistency between the indication of well conditions from the step tests and reaction response signatures from the BART samples. For example, BART samples collected from the wells in the poorest hydraulic condition have shown similar response patterns in a comparable time frame to samples collected from wells in very good condition.

Results from the FY 95 BART samples, collected during the posttreatment step tests on three wells, were compared to results from samples collected during the pretreatment steps tests on these wells conducted in FY 92. Although reaction delays for the IRB tests perhaps suggest the presence of more aggressive bacterial populations after chemical treatment, the comparison of the results for the SLYM and SRB tests on these wells is inconclusive.

Since our use of BART samples began in FY 91, a total of 14 rehabilitated dewatering wells have been sampled during their posttreatment step tests and 9 of these wells also have been sampled during their pretreatment step test. Little, if any, difference is apparent in the comparison of the results for the pre- and posttreatment BART samples. Collectively, the BART sample results for the 14 posttreatment tests and the vast majority of test results from the nontreated wells fall within the same range of moderate to very aggressive bacterial activity.

The BART samples have been collected near the end of the step tests after many well casing and screen volumes of water have been pumped from the wells, so it is assumed that the water sampled is being derived totally from the aquifer. Therefore, the aggressive bacterial activity typically observed means that there is substantial biomass development within the well casing and screen that is slowly sloughing off during the step test pumping on most of the wells, or a significant population of the bacteria is present in the aquifer, or both.

When taking into consideration that all of the dewatering wells (except for Missouri Avenue) have vented wellheads located in pits that can be readily subjected to contamination from pit seepage or spill water, the high degree of nuisance bacteria activity is not that surprising. Although nuisance bacteria can be present in ground water, most of these types of bacteria are ubiquitous in the surface environment. Good preventative measures to help keep the wells free of bacterially induced problems include using Illinois Well Code approved and properly installed sanitary wellhead sealing devices while taking precautions, such as disinfection of the wells after performing intrusive maintenance and repair operations.

Conclusions and Recommendations

Condition of Wells

All four dewatering wells step tested in FY 95 were tested following chemical treatment to restore well capacity. To assess the condition of the dewatering wells and their response to chemical treatment, data from these tests were compared to data from previously conducted step tests and pumpage/drawdown data collected by the contractor at the time of treatment.

Based on the Water Survey step tests, I-70 Wells 3A, 5, and 11A are in fair condition, and I-70 Well 15 is in good condition. Observed specific capacities from the posttreatment step tests on Wells 3A, 5, 11A, and 15 were about 72, 84, 87, and 109 percent of the average observed specific capacity of wells that were in good condition at the I-70 site. Well loss could be determined for only two of the step tests: well loss was proportionally a high percentage of total drawdown for Well 3A and was very low for Well 11A. The Δh data (except for Well 5, which has a plugged piezometer) ranged from an acceptable 1.2-3.7 feet. The step tests for I-70 Wells 5 and 15 were delayed for several months after chemical treatment, but these dewatering wells were used very little during these months; this made changes in their conditions caused by pumping unlikely.

Well Rehabilitation

Chemical treatments used to restore well capacity in FY 95 (Phase 12) were moderately successful. Drawdown data collected at the time of chemical treatment by the contractor indicated that the average increase in specific capacity of the four wells was about 241 percent, but the Water Survey step-test data showed the average improvement to be only about 103 percent. The drawdown data collected by the contractor for I-70 Wells 5 and 15 indicated that they were restored to an acceptable condition based on the specific capacities. However, the data collected for I-70 Wells 3A and 11A showed specific capacities less than target values.

Budgetary constraints in the IDOT FY 94 well treatment contract influenced the decision to withhold additional chemical treatment steps for these wells.

The observed specific capacities from the Water Survey step tests on I-70 Wells 3A and 5 are less than those observed by the contractor and are below the site average for wells judged to be in good condition. For I-70 Well 11A, the observed specific capacity from the step test was greater than that shown by data collected by the contractor; however, it still was less than the site average for wells judged to be in good condition. The step test data for I-70 Well 15 confirmed its acceptable condition, although the observed specific capacity was less than that observed by the contractor. The Δh values were reduced by an average of 7.4 feet for the three wells that could be tested. The fourth well (I-70 Well 5) could not be evaluated because of a plugged piezometer.

The change in chemical treatment specifications, introduced in FY 90, made third and fourth polyphosphate treatment steps optional; it was intended to reduce the number of potentially unnecessary polyphosphate treatments applied to the wells. However, the field data suggested that optional polyphosphate treatments might have been beneficial for these four wells. It is recommended that future well treatment contracts be structured to allow the third and fourth polyphosphate treatment steps when deemed necessary by the field data.

Sand Pumpage Investigation

Discharge from I-70 Wells 3A and 11A was tested for sand pumpage during their respective step tests. The other two wells, I-70 Wells 5 and 15, were not checked because the portable tank was required for use as a conduit to divert discharged water into a drainage system manhole to prevent water on the highway pavement rather than checking for sand sedimentation. No sand was detected in the tank following any of the step tests in quantities sufficient for sample collection.

Results of the tests for sand pumpage from the dewatering wells to date have yielded interesting information. Previously, it appeared that the chemical treatment of some dewatering wells increased the tendency for these wells to pump sand. In some instances, it is believed the treatment may sufficiently disturb the gravel pack and native aquifer material to cause a well either to pump sand for some period of time after treatment or to pump sand of a somewhat coarser grain size than is pumped in routine operation. Previous examples of this have included I-70 Wells 6, 8A, and 10 and the 25th Street Well 4. However, the two dewatering wells tested for sand pumpage in FY 95 did not appear to pump sand following chemical treatment.

It is recommended that testing for the presence of sand in the discharge be continued during future step tests. This will continue to allow a qualitative assessment of the sand pumpage problem. It is possible that some of the wells produce sand occasionally because of well development, especially immediately after an idle well is restarted. This can be verified as more wells are repeatedly checked during the step tests.

Nuisance Bacteria Sampling

The BART samples were collected from the pump discharge during three step tests on four dewatering wells step-tested in FY 95. All of the BART samples had positive reaction signatures in eight days or less, indicating moderate to very aggressive nuisance bacteria populations. These results are similar to those noted in the previous BART samplings of the dewatering well step tests. Results from the FY 91-FY 95 BART samples continue to show poor correlation and consistency between the indication of well conditions from the step tests and reaction response signatures from the BART samples. Even though the relatively high level of nuisance bacteria identified in the dewatering wells represents considerable potential for causing well plugging, the data clearly show that wells in good condition often contain significant numbers (that approach or exceed those in poor condition) of active bacteria.

Therefore, it appears that chemical treatments used to rehabilitate the wells do not eliminate the nuisance bacteria from the wells. Widespread occurrence of nuisance bacteria in the wells, as the sampling indicates, might mean that the bacteria are indigenous to the local ground water, or that they are being regularly introduced into the wells from some other source. In either case, the problems associated with their presence will need to be managed on a continual basis. It is recommended that more BART samples be collected as additional dewatering wells are step tested. Although the use of BART sampling for more detailed analysis of some of the wells probably is not warranted now, it may be worthwhile in the future.

Future Investigations

A continued program of investigating of the condition of the dewatering wells is recommended. Measuring the difference between water levels in a well and the adjacent piezometer will continue to be an important criterion in determining whether a well is a candidate for future step tests or treatment. In addition, if a well is pumping sand, this signals a potentially major problem with the well. A sand pumpage investigation is recommended as a standard part of each step test.

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Appendix A

Step Test Data
FY 95 (Phase 12)

I-70	**Well 3A**	**8/17/94**
	Well 5	**5/10/95**
	Well 11A	**9/20/94**
	Well 15	**5/11/95**

DEWATERING WELL DATA
Posttreatment Step Test

	Well No. I-70 W3A	Piezometer No. I-70 P3A
Date Drilled:	1/21/92	1992
Casing		
Top elevation:	402.4	na
Diameter:	16-in. SS	2-in. PVC
Length (ft):	49.7	na
Screen		
Bottom elevation:	302.7	na
Diameter:	16-in. SS	2-in. PVC
Length, lower (ft):	30	3
Slot size, lower:	0.055-in.	na
Length, upper (ft):	20	-
Slot size, upper:	0.020-in.	-
Measuring Point Elevation:	402.62	na
Nonpumping Water Level		
Depth below temp. MP (ft):	32.40	-
Height of temp. MP (ft):	4.90	-
Depth below perm. MP (ft):	27.50	32.40
Elevation:	375.12	-
Date of Step Test:	8/17/94	-
Water Sample		
Time:	3:44 pm	-
Temperature:	57.7°F	-
Laboratory No.:	227954	-
Distance and Direction to Piezometer from PW:		7.9 ft east
Time PW Off Before Step Test:		Not recorded

Notes: SWS 8-in. dia. orifice tube w/plate No. 4, Omnidata datalogger, sand tank, no BART samples
All elevations in feet above mean sea level
na - information not available

SWS Crew: E. Sanderson, M. Anliker, R. Olson (intermittently)

WATER-LEVEL MEASUREMENTS
I-70 Well No. 3A
Posttreatment Step Test

Hour	*Time (min)*	*Adjusted depth to water in well (ft)*	*Adjusted depth to water in piezometer (ft)*	*Orifice tube piezometer (ft)*	*Pumping rate (gpm)*	*Remarks*
08/17/94						
01:45 pm	0	32.40				Solinst measurement
01:46 pm	0		32.40			Solinst measurement
						Water-level measurements approx. due to surging Well 5
01:59 pm	0	22.58				Set head
02:00 pm	0		9.19			Set head
02:01 pm	1	32.40	32.40			Data logging started
02:02 pm	2	32.50	32.53			Water-level trend
02:03 pm	3	32.62	32.66			
02:04 pm	4	32.83	32.89			
02:05 pm	5	32.70	32.77			
02:06 pm	6	32.40	32.48			Well 5 pump on for
02:07 pm	7	32.52	32.61			pumping to waste
02:08 pm	8	32.62	32.72			
02:09 pm	9	32.74	32.84			
02:10 pm	10	32.79	32.91			
02:11 pm	11	32.82	32.95			
02:12 pm	12	32.89	33.02			
02:13 pm	13	32.94	33.06			
02:14 pm	14	32.96	33.08			
02:15 pm	15	32.98	33.09			
02:16 pm	16	32.99	33.12			
02:17 pm	17	33.01	33.13			
02:18 pm	18	33.02	33.14			
02:19 pm	19	33.03	33.15			
02:20 pm	20	33.04	33.16			
02:21 pm	21	33.04	33.17			
02:22 pm	22	33.05	33.18			
02:23 pm	23	33.06	33.19			
02:24 pm	24	33.07	33.20			
02:25 pm	25	33.08	33.20			
02:26 pm	26	33.08	33.22			
02:27 pm	27	33.08	33.22			
02:28 pm	28	33.08	33.22			
02:29 pm	29	33.09	33.22			
02:30 pm	30	33.10	33.23			
02:31 pm	31	33.10	33.23			
02:32 pm	0	33.10	33.24			Pump On
02:33 pm	1	40.91	38.91	3.35	610	Step 1; Maximum rate
02:34 pm	2	41.18	39.16	3.22	600	
02:35 pm	3	41.17	39.18			
02:36 pm	4	41.25	39.26			
02:37 pm	5	41.30	39.31			

WATER-LEVEL MEASUREMENTS
I-70 Well No. 3A (Continued)

Hour	*Time (min)*	*Adjusted depth to water in well (ft)*	*Adjusted depth to water in piezometer (ft)*	*Orifice tube piezometer (ft)*	*Pumping rate (gpm)*	*Remarks*
02:38 pm	6	41.37	39.37	3.20	596	
02:39 pm	7	41.43	39.41			
02:40 pm	8	41.48	39.46			
02:41 pm	9	41.50	39.49			
02:42 pm	10	41.54	39.52			
02:43 pm	11	41.60	39.54	3.18	593	Adjust rate
02:44 pm	12	41.62	39.56	3.22	600	
02:45 pm	13	41.70	39.63			
02:46 pm	14	41.72	39.66			
02:47 pm	15	41.79	39.69			
02:48 pm	16	41.79	39.72			
02:49 pm	17	41.80	39.74			
02:50 pm	18	41.83	39.76	3.22	600	
02:51 pm	19	41.85	39.77			
02:52 pm	20	41.87	39.79			
02:53 pm	21	41.89	39.81			
02:54 pm	22	41.89	39.83			
02:55 pm	23	41.91	39.85	3.20	596	Adjust rate
02:56 pm	24	41.94	39.86	3.22	600	
02:57 pm	25	42.00	39.89			
02:58 pm	26	42.01	39.92			
02:59 pm	27	42.03	39.93			
03:00 pm	28	42.05	39.95			
03:01 pm	29	42.05	39.96	3.22	600	
03:02 pm	30	42.06	39.97	3.22	600	Reduce rate
03:03 pm	1	41.45	39.54	2.71	550	Step 2
03:04 pm	2	41.43	39.53			
03:05 pm	3	41.43	39.52			
03:06 pm	4	41.44	39.53			
03:07 pm	5	41.43	39.53	2.70	550	
03:08 pm	6	41.44	39.53			
03:09 pm	7	41.46	39.54			
03:10 pm	8	41.46	39.54			
03:11 pm	9	41.46	39.55			
03:12 pm	10	41.46	39.55	2.70	550	
03:13 pm	11	41.47	39.56			
03:14 pm	12	41.48	39.57			
03:15 pm	13	41.47	39.57			
03:16 pm	14	41.48	39.57	2.70	550	
03:17 pm	15	41.50	39.59			
03:18 pm	16	41.50	39.59			
03:19 pm	17	41.50	39.59			
03:20 pm	18	41.50	39.59			
03:21 pm	19	41.51	39.60			
03:22 pm	20	41.52	39.61			

WATER-LEVEL MEASUREMENTS
I-70 Well No. 3A (Concluded)

Hour	*Time (min)*	*Adjusted depth to water in well (ft)*	*Adjusted depth to water in piezometer (ft)*	*Orifice tube piezometer (ft)*	*Pumping rate (gpm)*	*Remarks*
03:23 pm	21	41.52	39.61			
03:24 pm	22	41.41	39.49	2.72	550	
03:25 pm	23	41.29	39.38			
03:26 pm	24	41.25	39.34			
03:27 pm	25	41.24	39.32			
03:28 pm	26	41.23	39.31			
03:29 pm	27	41.23	39.30			
03:30 pm	28	41.22	39.29			
03:31 pm	29	41.21	39.28	2.72	550	
03:32 pm	30	41.21	39.28	2.72	550	Reduce rate
03:33 pm	1	40.53	38.80	2.22	500	Step 3
03:34 pm	2	40.48	38.77			
03:35 pm	3	40.46	38.74			
03:36 pm	4	40.45	38.73	2.22	500	
03:37 pm	5	40.43	38.73			
03:38 pm	6	40.44	38.72			
03:39 pm	7	40.42	38.72			
03:40 pm	8	40.41	38.71			
03:41 pm	9	40.40	38.72			
03:42 pm	10	40.40	38.71	2.22	500	
03:43 pm	11	40.41	38.71			
03:44 pm	12	40.39	38.70	2.22	500	
03:45 pm	13	40.39	38.70			
03:46 pm	14	40.39	38.69			
03:47 pm	15	40.38	38.69			
03:48 pm	16	40.38	38.69			
03:49 pm	17	40.38	38.69			
03:50 pm	18	40.37	38.69			
03:51 pm	19	40.38	38.69			
03:52 pm	20	40.37	38.68			Water sample collected;
03:53 pm	21	40.37	38.68			T = 57.7°F
03:54 pm	22	40.37	38.68			
03:55 pm	23	40.36	38.68			
03:56 pm	24	40.35	38.68			
03:57 pm	25	40.36	38.68			
03:58 pm	26	40.36	38.68			
03:59 pm	27	40.35	38.68			
04:00 pm	28	40.36	38.68			
04:01 pm	29	40.34	38.67			
04:02 pm	30	40.33	38.66			Step test terminated

Notes:
No BART samples collected.
Probably less than 1 teaspoon of incrustation in tank after step test; no sand observed.

DEWATERING WELL DATA
Posttreatment Step Test

	Well No. I-70 W5	Piezometer No. I-70 P5
Date Drilled:	1973	1973
Casing		
Top elevation:	385.3	391.1
Diameter:	16-in. SS	2-in. PVC
Length (ft):	21.4	na
Screen		
Bottom elevation:	303.91	na
Diameter:	16-in. SS	2-in. PVC
Length (ft):	60	3
Slot size:	0.080-in.	na
Measuring Point Elevation:	385.9	391.1
Nonpumping Water Level		
Depth below temp. MP (ft):	12.66	-
Height of temp. MP (ft):	5.3	-
Depth below perm. MP (ft):	7.36	Plugged
Elevation:	378.54	-
Date of Step Test:	5/10/95	-
Water Sample		
Time:	2:10 pm	-
Temperature:	58.8°F	-
Laboratory No.:	228698	-
Distance and Direction to Piezometer from PW:		6.5 ft east
Time PW Off Before Step Test:		Not recorded

Notes: SWS 8-in. dia. orifice tube w/plate No. 4; sand tank used to divert flow into stormwater drainage system manhole; Hermit datalogger
All elevations in feet above mean sea level
na - information not available

SWS Crew: R. Olson, E. Sanderson

WATER-LEVEL MEASUREMENTS
I-70 Well No. 5
Posttreatment Step Test

Hour	*Time (min)*	*Adjusted depth to water in well (ft)*	*Adjusted depth to water in piezometer (ft)*	*Orifice tube piezometer (ft)*	*Pumping rate (gpm)*	*Remarks*
05/10/95						
12:18 pm	0	12.66	Piezometer			Water-level measurement
12:24 pm	0	25.17	plugged			Set head
12:40 pm	0	12.66				Data logging started
12:41 pm	1	12.66				Water-level trend
12:42 pm	2	12.66				
12:43 pm	3	12.65				
12:44 pm	4	12.66				
12:45 pm	5	12.66				
12:46 pm	6	12.66				
12:47 pm	7	40.73				
12:48 pm	8	12.66				
12:49 pm	9	12.66				
12:50 pm	10	12.67				
12:51 pm	11	12.66				
12:52 pm	12	12.65				
12:53 pm	13	12.65				
12:54 pm	14	12.65				
12:55 pm	15	12.65				
12:56 pm	16	12.65				
12:57 pm	17	12.65				
12:58 pm	18	12.66				
12:59 pm	19	12.65				
01:00 am	0	14.94				Pump On
01:01 am	1	20.03		3.50	625	Step 1; Maximum rate
01:02 am	2	20.04				
01:03 am	3	19.77		3.23	600	
01:04 am	4	19.84				
01:05 am	5	19.85				
01:06 am	6	19.87		3.25	601	
01:07 am	7	19.90				
01:08 am	8	20.03		3.25	601	
01:09 am	9	19.94		3.27	603	Adjust rate
01:10 am	10	19.99		3.25	601	
01:11 am	11	20.02				
01:12 am	12	20.02				
01:13 am	13	20.00		3.25	601	
01:14 am	14	20.06				
01:15 am	15	20.10				
01:16 am	16	20.07				
01:17 am	17	20.04				
01:18 am	18	20.06				

WATER-LEVEL MEASUREMENTS
I-70 Well No. 5 (Continued)

Hour	*Time (min)*	*Adjusted depth to water in well (ft)*	*Adjusted depth to water in piezometer (ft)*	*Orifice tube piezometer (ft)*	*Pumping rate (gpm)*	*Remarks*
01:19 am	19	20.11				
01:20 am	20	20.12		3.26	602	
01:21 am	21	20.15				
01:22 am	22	20.09				
01:23 am	23	20.14				
01:24 am	24	20.19				
01:25 am	25	20.15		3.26	602	
01:26 am	26	20.17				
01:27 am	27	20.19				
01:28 am	28	20.14				
01:29 am	29	20.15		3.26	602	
01:30 am	30	20.03				Reduce rate
01:31 am	1	19.54		2.70	550	Step 2
01:32 am	2	19.57				
01:33 am	3	19.57				
01:34 am	4	19.56				
01:35 am	5	19.56		2.69	549	
01:36 am	6	19.55				
01:37 am	7	19.53				
01:38 am	8	19.56				
01:39 am	9	19.58				
01:40 am	10	19.56				
01:41 am	11	19.58		2.69	549	
01:42 am	12	19.56				
01:43 am	13	19.53				
01:44 am	14	19.52				
01:45 am	15	19.58				
01:46 am	16	19.53		2.69	549	
01:47 am	17	19.56				
01:48 am	18	19.58				
01:49 am	19	19.62				
01:50 am	20	19.56				
01:51 am	21	19.56		2.69	549	
01:52 am	22	19.58				
01:53 am	23	19.62				
01:54 am	24	19.61				
01:55 am	25	19.57				
01:56 am	26	19.56				
01:57 am	27	19.60				
01:58 am	28	19.64		2.69	549	
01:59 am	29	19.60				
02:00 am	30	19.49		2.69	549	Reduce rate
02:01 am	1	18.97				Step 3

WATER-LEVEL MEASUREMENTS
I-70 Well No. 5 (Continued)

Hour	*Time (min)*	*Adjusted depth to water in well (ft)*	*Adjusted depth to water in piezometer (ft)*	*Orifice tube piezometer (ft)*	*Pumping rate (gpm)*	*Remarks*
02:02 am	2	19.04		2.21	499	
02:03 am	3	19.02				
02:04 am	4	19.04				
02:05 am	5	18.95				
02:06 am	6	19.00				
02:07 am	7	18.92				
02:08 am	8	19.00		2.21	499	
02:09 am	9	18.95				
02:10 am	10	18.93		2.21	499	Water sample collected;
02:11 am	11	18.94				T = 58.8°F
02:12 am	12	19.02				
02:13 am	13	19.00				
02:14 am	14	19.01				
02:15 am	15	19.06		2.21	499	
02:16 am	16	19.06				
02:17 am	17	18.97				
02:18 am	18	18.95				
02:19 am	19	19.04				
02:20 am	20	19.06		2.20	499	BART samples collected
02:21 am	21	18.99				
02:22 am	22	18.96				
02:23 am	23	19.04		2.21	499	
02:24 am	24	19.04				
02:25 am	25	19.04				
02:26 am	26	19.08				
02:27 am	27	19.02				
02:28 am	28	18.99		2.20	499	
02:29 am	29	18.95				
02:30 am	30	18.87				Reduce rate
02:31 am	1	18.23				Step 4
02:32 am	2	18.36		1.79	448	
02:33 am	3	18.47				
02:34 am	4	18.38				
02:35 am	5	18.41		1.79	448	
02:36 am	6	18.50				
02:37 am	7	18.41				
02:38 am	8	18.45				
02:39 am	9	18.46				
02:40 am	10	18.36				
02:41 am	11	18.48				
02:42 am	12	18.50		1.78	447	
02:43 am	13	18.40				
02:44 am	14	18.40				

WATER-LEVEL MEASUREMENTS
I-70 Well No. 5 (Continued)

Hour	*Time (min)*	*Adjusted depth to water in well (ft)*	*Adjusted depth to water in piezometer (ft)*	*Orifice tube piezometer (ft)*	*Pumping rate (gpm)*	*Remarks*
02:45 am	15	18.50				
02:46 am	16	18.41				
02:47 am	17	18.45				
02:48 am	18	18.37				
02:49 am	19	18.48				
02:50 am	20	18.50		1.78	447	
02:51 am	21	18.40				
02:52 am	22	18.38				
02:53 am	23	18.47				
02:54 am	24	18.40		1.78	447	
02:55 am	25	18.37				
02:56 am	26	18.50				
02:57 am	27	18.44				
02:58 am	28	18.46				
02:59 am	29	18.36				
03:00 am	30	17.95		1.78	447	Reduce rate
03:01 am	1	17.72				Step 5
03:02 am	2	17.95		1.44	401	
03:03 am	3	17.97				
03:04 am	4	17.93				
03:05 am	5	17.83		1.44	401	
03:06 am	6	17.85				
03:07 am	7	17.90				
03:08 am	8	17.93				
03:09 am	9	17.94				
03:10 am	10	17.95				
03:11 am	11	17.95				
03:12 am	12	17.95		1.43	400	
03:13 am	13	17.81				
03:14 am	14	17.88				
03:15 am	15	17.81				
03:16 am	16	17.93				
03:17 am	17	17.86		1.44	401	
03:18 am	18	17.81				
03:19 am	19	17.95				
03:20 am	20	17.82				
03:21 am	21	17.82				
03:22 am	22	17.95				
03:23 am	23	17.91				
03:24 am	24	17.84				
03:25 am	25	17.84		1.44	401	
03:26 am	26	17.95				
03:27 am	27	17.94				

WATER-LEVEL MEASUREMENTS
I-70 Well No. 5 (Concluded)

Hour	*Time (min)*	*Adjusted depth to water in well (ft)*	*Adjusted depth to water in piezometer (ft)*	*Orifice tube piezometer (ft)*	*Pumping rate (gpm)*	*Remarks*
03:28 am	28	17.84				
03:29 am	29	17.87				
03:30 am	30	17.97				End of step test

Note:
About ½ cup of material in settling tank after step test; most was incrustation deposits with only about 1 tablespoon of extremely fine sand present.

DEWATERING WELL DATA
Posttreatment Step Test

	Well No. I-70 W11A	Piezometer No. I-70 P11A
Date Drilled:	2/4/92	1992
Casing		
Top elevation:	392.1	na
Diameter:	16-in. SS	2-in. PVC
Length (ft):	39.1	na
Screen		
Bottom elevation:	303.0	na
Diameter:	16-in. SS	2-in. PVC
Length, lower (ft):	40	3
Slot size, lower:	0.055-in.	na
Length, upper (ft):	10	-
Slot size, upper:	0.020-in.	-
Measuring Point Elevation:	392.1 (?)	na
Nonpumping Water Level		
Depth below temp. MP (ft):	29.11	-
Height of temp. MP (ft):	7.7	-
Depth below perm. MP (ft):	21.41	33.05
Elevation:	370.69	-
Date of Step Test:	9/20/94	-
Water Sample		
Time:	10:14 am	-
Temperature:	58.8°F	-
Laboratory No.:	228172	-
Distance and Direction to Piezometer from PW:		12.2 ft south
Time PW Off Before Step Test:		Not recorded

Notes: SWS 8-in. dia. orifice tube w/plate No. 4. Using Omnidata w/transmitter No. 16 (15 psi); sand tank
All elevations in feet above mean sea level
na - information not available

SWS Crew: E. Sanderson, R. Olson

WATER-LEVEL MEASUREMENTS
I-70 Well No. 11A
Posttreatment Step Test

Hour	*Time (min)*	*Adjusted depth to water in well (ft)*	*Adjusted depth to water in piezometer (ft)*	*Orifice tube piezometer (ft)*	*Pumping rate (gpm)*	*Remarks*
09/20/94						
08:26 am	0		33.05			Water-level measurement
08:27 am	0	29.11				Water-level measurement
08:50 am	0	20.03				Set head
08:52 am	0		11.91			Set head
08:55 am	0	29.08	33.04			Data logging started
08:56 am	1	29.08	33.04			Water-level trend
08:57 am	2	29.08	33.05			
08:58 am	3	29.08	33.05			
08:59 am	4	29.08	33.06			
09:00 am	5	29.08	33.06			
09:01 am	6	29.08	33.07			
09:02 am	7	29.08	33.07			
09:03 am	8	29.07	33.07			
09:04 am	9	29.07	33.08			
09:05 am	10	29.06	33.08			
09:06 am	11	29.07	33.08			
09:07 am	12	29.07	33.09			
09:08 am	13	29.07	33.09			
09:09 am	14	29.07	33.09			
09:10 am	0	29.07	33.09			Pump On
09:11 am	1	35.73	36.33	2.98	575	Step 1; Maximum rate
09:12 am	2	35.68	36.27			
09:13 am	3	35.60	36.25	2.70	550	
09:14 am	4	35.60	36.26			
09:15 am	5	35.62	36.28			
09:16 am	6	35.62	36.28			
09:17 am	7	35.64	36.30			
09:18 am	8	35.63	36.31			
09:19 am	9	35.65	36.32			
09:20 am	10	35.65	36.32	2.70	550	
09:21 am	11	35.66	36.33			
09:22 am	12	35.66	36.33			
09:23 am	13	35.66	36.34			
09:24 am	14	35.67	36.34			
09:25 am	15	35.66	36.34			
09:26 am	16	35.68	36.35			
09:27 am	17	35.68	36.35			
09:28 am	18	35.69	36.36	2.70	550	
09:29 am	19	35.70	36.36			
09:30 am	20	35.69	36.37			
09:31 am	21	35.70	36.38			
09:32 am	22	35.71	36.38			

WATER-LEVEL MEASUREMENTS
I-70 Well No. 11A (Continued)

Hour	*Time (min)*	*Adjusted depth to water in well (ft)*	*Adjusted depth to water in piezometer (ft)*	*Orifice tube piezometer (ft)*	*Pumping rate (gpm)*	*Remarks*
09:33 am	23	35.71	36.38			
09:34 am	24	35.71	36.39	2.70	550	
09:35 am	25	35.71	36.39			
09:36 am	26	35.72	36.39			
09:37 am	27	35.72	36.39			
09:38 am	28	35.72	36.40			
09:39 am	29	35.73	36.40	2.70	550	
09:40 am	30	35.74	36.41			Reduce rate
09:41 am	1	35.13	36.13			Step 2
09:42 am	2	35.13	36.12			
09:43 am	3	35.13	36.12			
09:44 am	4	35.15	36.14	2.24	500	
09:45 am	5	35.15	36.14			
09:46 am	6	35.15	36.14			
09:47 am	7	35.16	36.14			
09:48 am	8	35.16	36.14			
09:49 am	9	35.16	36.15			
09:50 am	10	35.16	36.15			
09:51 am	11	35.17	36.15			
09:52 am	12	35.17	36.16	2.24	500	
09:53 am	13	35.17	36.16			
09:54 am	14	35.17	36.16			
09:55 am	15	35.16	36.16			
09:56 am	16	35.18	36.17			
09:57 am	17	35.18	36.17			
09:58 am	18	35.18	36.17			
09:59 am	19	35.16	36.16			
10:00 am	20	35.17	36.17	2.24	500	
10:01 am	21	35.17	36.17			
10:02 am	22	35.17	36.17			
10:03 am	23	35.18	36.17			
10:04 am	24	35.19	36.18			
10:05 am	25	35.18	36.18			
10:06 am	26	35.19	36.18			
10:07 am	27	35.18	36.18			
10:08 am	28	35.18	36.18			
10:09 am	29	35.19	36.19	2.24	500	
10:10 am	30	35.18	36.18			Reduce rate
10:11 am	1	34.60	35.91	1.80	450	Step 3
10:12 am	2	34.59	35.90			
10:13 am	3	34.58	35.90			
10:14 am	4	34.59	35.90			Water sample collected;
10:15 am	5	34.58	35.90			T = 58.8°F
10:16 am	6	34.59	35.91			

WATER-LEVEL MEASUREMENTS
I-70 Well No. 11A (Continued)

Hour	*Time (min)*	*Adjusted depth to water in well (ft)*	*Adjusted depth to water in piezometer (ft)*	*Orifice tube piezometer (ft)*	*Pumping rate (gpm)*	*Remarks*
10:17 am	7	34.59	35.90			
10:18 am	8	34.59	35.90			
10:19 am	9	34.59	35.91			
10:20 am	10	34.59	35.91			
10:21 am	11	34.58	35.91			
10:22 am	12	34.59	35.90	1.80	450	
10:23 am	13	34.59	35.90			
10:24 am	14	34.59	35.90			
10:25 am	15	34.59	35.91			
10:26 am	16	34.60	35.91			
10:27 am	17	34.59	35.91			
10:28 am	18	34.59	35.91			
10:29 am	19	34.60	35.92			
10:30 am	20	34.59	35.91	1.80	450	
10:31 am	21	34.60	35.92			
10:32 am	22	34.60	35.92			
10:33 am	23	34.59	35.92			
10:34 am	24	34.60	35.92			
10:35 am	25	34.60	35.92			
10:36 am	26	34.60	35.92	1.80	450	
10:37 am	27	34.61	35.92			
10:38 am	28	34.60	35.92			
10:39 am	29	34.59	35.92			
10:40 am	30	34.60	35.92	1.80	450	Reduce rate
10:41 am	1	34.00	35.64			Step 4
10:42 am	2	34.00	35.64			
10:43 am	3	34.00	35.63	1.42	400	
10:44 am	4	34.00	35.63			
10:45 am	5	33.99	35.64			
10:46 am	6	34.00	35.63			
10:47 am	7	33.99	35.63			
10:48 am	8	34.00	35.63			
10:49 am	9	33.99	35.63			
10:50 am	10	33.99	35.63			
10:51 am	11	33.99	35.62			
10:52 am	12	34.00	35.63	1.42	400	BART samples collected
10:53 am	13	34.00	35.63			
10:54 am	14	34.00	35.63			
10:55 am	15	33.99	35.62	1.42	400	
10:56 am	16	34.00	35.63			
10:57 am	17	33.99	35.63			
10:58 am	18	34.00	35.63			
10:59 am	19	33.99	35.63			
11:00 am	20	34.00	35.63			

WATER-LEVEL MEASUREMENTS
I-70 Well No. 11A (Concluded)

Hour	*Time (min)*	*Adjusted depth to water in well (ft)*	*Adjusted depth to water in piezometer (ft)*	*Orifice tube piezometer (ft)*	*Pumping rate (gpm)*	*Remarks*
11:01 am	21	34.00	35.64			
11:02 am	22	34.00	35.64			
11:03 am	23	34.00	35.64	1.42	400	
11:04 am	24	34.00	35.64			
11:05 am	25	34.00	35.64			
11:06 am	26	33.99	35.63			
11:07 am	27	34.00	35.63			
11:08 am	28	34.00	35.63			
11:09 am	29	34.00	35.64			
11:10 am	30	33.99	35.63	1.42	400	Reduce rate
11:11 am	1	33.43	35.36	1.09	350	Step 5
11:12 am	2	33.42	35.36			
11:13 am	3	33.42	35.36			
11:14 am	4	33.43	35.36			
11:15 am	5	33.42	35.36			
11:16 am	6	33.43	35.37			
11:17 am	7	33.43	35.36			
11:18 am	8	33.42	35.36			
11:19 am	9	33.43	35.36			
11:20 am	10	33.42	35.37	1.09	350	
11:21 am	11	33.42	35.36			
11:22 am	12	33.42	35.36			
11:23 am	13	33.42	35.37			
11:24 am	14	33.42	35.36	1.09	350	
11:25 am	15	33.42	35.36			
11:26 am	16	33.42	35.36			
11:27 am	17	33.42	35.36			
11:28 am	18	33.42	35.35			
11:29 am	19	33.42	35.36			
11:30 am	20	33.42	35.36			
11:31 am	21	33.41	35.35			
11:32 am	22	33.41	35.35			
11:33 am	23	33.42	35.35	1.09	350	
11:34 am	24	33.41	35.35			
11:35 am	25	33.41	35.35			
11:36 am	26	33.41	35.35			
11:37 am	27	33.41	35.35			
11:38 am	28	33.41	35.36			
11:39 am	29	33.42	35.36			
11:40 am	30	33.41	35.36	1.09	350	End of step test

Note:
Very little fine sand observed in tank after step test; probably less than ½ teaspoon.

DEWATERING WELL DATA

Posttreatment Step Test

	Well No. I-70 W15	Piezometer No. I-70 P15
Date Drilled:	1/28/92	1992
Casing		
Top elevation:	384.0	na
Diameter:	16-in. SS	2-in. PVC
Length:	31.5	na
Screen		
Bottom elevation:	302.5	na
Diameter:	16-in. SS	2-in. PVC
Length, lower (ft):	40	3
Slot size, lower;	0.055-in.	na
Length, upper (ft):	10	-
Slot size, upper:	0.020-in.	-
Measuring Point Elevation:	385.3	na
Nonpumping Water Level		
Depth below temp. MP (ft):	11.58	-
Height of temp. MP (ft):	6.80	-
Depth below perm. MP (ft):	4.78	11.75
Elevation:	379.22	-
Date of Step Test:	5/11/95	-
Water Sample		
Time:	10:38 am	-
Temperature:	58.1°F	-
Laboratory No.:	228700	-
Distance and Direction to Piezometer from PW:		5.0 ft east
Time PW Off Before Step Test:		Not recorded

Notes: SWS 8-in. dia. orifice tube w/plate No. 4; Hermit datalogger (using 30-second sampling rate); sand tank used to divert flow into stormwater drainage system manhole.
All elevations in feet above mean sea level
na - information not available

SWS Crew: E. Sanderson, R. Olson

WATER-LEVEL MEASUREMENTS
I-70 Well No. 15
Posttreatment Step Test

Hour	*Time (min)*	*Adjusted depth to water in well (ft)*	*Adjusted depth to water in piezometer (ft)*	*Orifice tube piezometer (ft)*	*Pumping rate (gpm)*	*Remarks*
05/11/95						
08:20 am	0.0	11.58				Water-level measurement
08:21 am	0.0		11.75			Water-level measurement
08:42 am	0.0	20.36				Set head
08:44 am	0.0		11.89			Set head
08:50 am	0.0	11.57	11.74			Data logging started
08:50 am	0.5	11.57	11.74			Water-level trend
08:51 am	1.0	11.57	11.75			
08:51 am	1.5	11.57	11.74			
08:52 am	2.0	11.57	11.75			
08:52 am	2.5	11.57	11.74			
08:53 am	3.0	11.57	11.73			
08:53 am	3.5	11.57	11.74			
08:54 am	4.0	11.57	11.73			
08:54 am	4.5	11.57	11.75			
08:55 am	5.0	11.57	11.75			
08:55 am	5.5	11.56	11.73			
08:56 am	6.0	11.57	11.74			
08:56 am	6.5	11.57	11.74			
08:57 am	7.0	11.57	11.74			
08:57 am	7.5	11.57	11.73			
08:58 am	8.0	11.57	11.74			
08:58 am	8.5	11.57	11.73			
08:59 am	9.0	11.57	11.73			
08:59 am	9.5	11.57	11.73			
09:00 am	0.0	13.07	12.12			Pump On
09:00 am	0.5	15.81	14.95			Step 1
09:01 am	1.0	16.30	15.30			
09:01 am	1.5	17.08	15.93			
09:02 am	2.0	17.18	15.98	3.80	650	
09:02 am	2.5	17.40	16.19			
09:03 am	3.0	17.43	16.22			
09:03 am	3.5	17.46	16.24			
09:04 am	4.0	17.47	16.26			
09:04 am	4.5	17.46	16.26			
09:05 am	5.0	17.47	16.29	3.80	650	
09:05 am	5.5	17.48	16.29			
09:06 am	6.0	17.54	16.30			
09:06 am	6.5	17.49	16.31			
09:07 am	7.0	17.53	16.33			
09:07 am	7.5	17.52	16.34			
09:08 am	8.0	17.53	16.34			

WATER-LEVEL MEASUREMENTS
I-70 Well No. 15 (Continued)

Hour	*Time (min)*	*Adjusted depth to water in well (ft)*	*Adjusted depth to water in piezometer (ft)*	*Orifice tube piezometer (ft)*	*Pumping rate (gpm)*	*Remarks*
09:08 am	8.5	17.53	16.34			
09:09 am	9.0	17.55	16.34			
09:09 am	9.5	17.63	16.38			
09:10 am	10.0	17.61	16.41	3.78	648	Adjust rate
09:10 am	10.5	17.60	16.42			
09:11 am	11.0	17.66	16.43	3.80	650	
09:11 am	11.5	17.69	16.42			
09:12 am	12.0	17.69	16.43			
09:12 am	12.5	17.67	16.45			
09:13 am	13.0	17.70	16.46			
09:13 am	13.5	17.67	16.45			
09:14 am	14.0	17.67	16.46	3.78	648	Adjust rate
09:14 am	14.5	17.72	16.48			
09:15 am	15.0	17.72	16.48	3.79	650	
09:15 am	15.5	17.75	16.49			
09:16 am	16.0	17.69	16.50			
09:16 am	16.5	17.69	16.50			
09:17 am	17.0	17.74	16.51			
09:17 am	17.5	17.75	16.51			
09:18 am	18.0	17.77	16.48			
09:18 am	18.5	17.73	16.52			
09:19 am	19.0	17.77	16.52			
09:19 am	19.5	17.72	16.53			
09:20 am	20.0	17.75	16.53			
09:20 am	20.5	17.75	16.52			
09:21 am	21.0	17.78	16.53			
09:21 am	21.5	17.78	16.54			
09:22 am	22.0	17.78	16.54			
09:22 am	22.5	17.80	16.54			
09:23 am	23.0	17.78	16.55	3.78	648	
09:23 am	23.5	17.77	16.53			
09:24 am	24.0	17.77	16.56			
09:24 am	24.5	17.81	16.56			
09:25 am	25.0	17.78	16.56			
09:25 am	25.5	17.78	16.56			
09:26 am	26.0	17.76	16.56			
09:26 am	26.5	17.83	16.55			
09:27 am	27.0	17.79	16.57	3.79	650	
09:27 am	27.5	17.75	16.57			
09:28 am	28.0	17.83	16.58			
09:28 am	28.5	17.82	16.58			
09:29 am	29.0	17.85	16.59			
09:29 am	29.5	17.84	16.58			

WATER-LEVEL MEASUREMENTS
I-70 Well No. 15 (Continued)

Hour	*Time (min)*	*Adjusted depth to water in well (ft)*	*Adjusted depth to water in piezometer (ft)*	*Orifice tube piezometer (ft)*	*Pumping rate (gpm)*	*Remarks*
09:30 am	30.0	17.82	16.60	3.78	648	Reduce rate
09:30 am	0.5	17.19	16.14			Step 2
09:31 am	1.0	17.27	16.20			
09:31 am	1.5	17.28	16.21			
09:32 am	2.0	17.30	16.20			
09:32 am	2.5	17.32	16.21			
09:33 am	3.0	17.31	16.20	3.23	600	
09:33 am	3.5	17.30	16.20			
09:34 am	4.0	17.30	16.20			
09:34 am	4.5	17.26	16.20			
09:35 am	5.0	17.29	16.21			
09:35 am	5.5	17.29	16.21			
09:36 am	6.0	17.28	16.21			
09:36 am	6.5	17.29	16.21			
09:37 am	7.0	17.30	16.20			
09:37 am	7.5	17.28	16.21			
09:38 am	8.0	17.31	16.21			
09:38 am	8.5	17.29	16.21			
09:39 am	9.0	17.31	16.21			
09:39 am	9.5	17.33	16.22			
09:40 am	10.0	17.35	16.22	3.23	600	
09:40 am	10.5	17.26	16.23			
09:41 am	11.0	17.33	16.23			
09:41 am	11.5	17.32	16.22			
09:42 am	12.0	17.30	16.23			
09:42 am	12.5	17.28	16.22			
09:43 am	13.0	17.34	16.24			
09:43 am	13.5	17.33	16.22			
09:44 am	14.0	17.30	16.23	3.23	600	
09:44 am	14.5	17.33	16.24			
09:45 am	15.0	17.34	16.23			
09:45 am	15.5	17.33	16.24			
09:46 am	16.0	17.28	16.24			
09:46 am	16.5	17.31	16.24			
09:47 am	17.0	17.31	16.24			
09:47 am	17.5	17.38	16.23			
09:48 am	18.0	17.36	16.25			
09:48 am	18.5	17.31	16.25			
09:49 am	19.0	17.32	16.25			
09:49 am	19.5	17.35	16.25			
09:50 am	20.0	17.33	16.25			
09:50 am	20.5	17.36	16.26			

WATER-LEVEL MEASUREMENTS
I-70 Well No. 15 (Continued)

Hour	*Time (min)*	*Adjusted depth to water in well (ft)*	*Adjusted depth to water in piezometer (ft)*	*Orifice tube piezometer (ft)*	*Pumping rate (gpm)*	*Remarks*
09:51 am	21.0	17.34	16.24	3.23	600	
09:51 am	21.5	17.36	16.25			
09:52 am	22.0	17.37	16.25			
09:52 am	22.5	17.32	16.25			
09:53 am	23.0	17.34	16.26			
09:53 am	23.5	17.33	16.26			
09:54 am	24.0	17.34	16.26			
09:54 am	24.5	17.36	16.26			
09:55 am	25.0	17.36	16.26			
09:55 am	25.5	17.33	16.26			
09:56 am	26.0	17.36	16.27	3.22	600	
09:56 am	26.5	17.38	16.25			
09:57 am	27.0	17.34	16.28			
09:57 am	27.5	17.34	16.27			
09:58 am	28.0	17.35	16.28			
09:58 am	28.5	17.34	16.28			
09:59 am	29.0	17.41	16.28			
09:59 am	29.5	17.38	16.28			
10:00 am	30.0	17.38	16.27	3.22	600	Reduce rate
10:00 am	0.5	16.92	15.96			Step 3
10:01 am	1.0	16.89	15.95	2.70	550	
10:01 am	1.5	16.91	15.93			
10:02 am	2.0	16.87	15.94			
10:02 am	2.5	16.94	15.94			
10:03 am	3.0	16.90	15.94			
10:03 am	3.5	16.93	15.93			
10:04 am	4.0	16.90	15.94			
10:04 am	4.5	16.91	15.94			
10:05 am	5.0	16.88	15.92			
10:05 am	5.5	16.87	15.93			
10:06 am	6.0	16.92	15.93			
10:06 am	6.5	16.91	15.94			
10:07 am	7.0	16.93	15.93			
10:07 am	7.5	16.93	15.94			
10:08 am	8.0	16.90	15.94			
10:08 am	8.5	16.91	15.94			
10:09 am	9.0	16.90	15.94			
10:09 am	9.5	16.91	15.93			
10:10 am	10.0	16.89	15.94	2.70	550	
10:10 am	10.5	16.94	15.95			
10:11 am	11.0	16.94	15.94			
10:11 am	11.5	16.90	15.94			
10:12 am	12.0	16.88	15.94			
10:12 am	12.5	16.92	15.95			

WATER-LEVEL MEASUREMENTS
I-70 Well No. 15 (Continued)

Hour	*Time (min)*	*Adjusted depth to water in well (ft)*	*Adjusted depth to water in piezometer (ft)*	*Orifice tube piezometer (ft)*	*Pumping rate (gpm)*	*Remarks*
10:13 am	13.0	16.93	15.95			
10:13 am	13.5	16.86	15.94			
10:14 am	14.0	16.94	15.95			
10:14 am	14.5	16.97	15.94			
10:15 am	15.0	16.90	15.95			
10:15 am	15.5	16.90	15.95			
10:16 am	16.0	16.90	15.95			
10:16 am	16.5	16.95	15.95			
10:17 am	17.0	16.93	15.95	2.69	550	
10:17 am	17.5	16.94	15.96			
10:18 am	18.0	16.96	15.95			
10:18 am	18.5	16.89	15.95			
10:19 am	19.0	16.95	15.95	2.69	550	
10:19 am	19.5	16.96	15.96			
10:20 am	20.0	16.95	15.95			
10:20 am	20.5	16.94	15.96			
10:21 am	21.0	16.92	15.96			
10:21 am	21.5	16.95	15.94			
10:22 am	22.0	16.96	15.95			
10:22 am	22.5	16.93	15.96			
10:23 am	23.0	16.94	15.96			
10:23 am	23.5	16.91	15.96			
10:24 am	24.0	16.95	15.96			
10:24 am	24.5	16.93	15.96			
10:25 am	25.0	16.94	15.96			
10:25 am	25.5	16.92	15.97			
10:26 am	26.0	16.94	15.97	2.69	550	
10:26 am	26.5	16.96	15.95			
10:27 am	27.0	16.97	15.96			
10:27 am	27.5	16.90	15.97			
10:28 am	28.0	16.93	15.97			
10:28 am	28.5	16.97	15.97			
10:29 am	29.0	17.01	15.97			
10:29 am	29.5	16.94	15.96			
10:30 am	30.0	16.89	15.97	2.69	550	Reduce rate
10:30 am	0.5	16.51	15.62			Step 4
10:31 am	1.0	16.45	15.62	2.22	500	
10:31 am	1.5	16.46	15.62			
10:32 am	2.0	16.50	15.63			
10:32 am	2.5	16.48	15.63			
10:33 am	3.0	16.45	15.62			
10:33 am	3.5	16.42	15.62			
10:34 am	4.0	16.52	15.62			

WATER-LEVEL MEASUREMENTS
I-70 Well No. 15 (Continued)

Hour	*Time (min)*	*Adjusted depth to water in well (ft)*	*Adjusted depth to water in piezometer (ft)*	*Orifice tube piezometer (ft)*	*Pumping rate (gpm)*	*Remarks*
10:34 am	4.5	16.44	15.62			
10:35 am	5.0	16.45	15.62			
10:35 am	5.5	16.45	15.62			
10:36 am	6.0	16.49	15.62			
10:36 am	6.5	16.48	15.63			
10:37 am	7.0	16.46	15.62			
10:37 am	7.5	16.46	15.60			
10:38 am	8.0	16.50	15.62	2.21	498	Water sample collected;
10:38 am	8.5	16.49	15.62			T = 58.1°F
10:39 am	9.0	16.46	15.61			
10:39 am	9.5	16.47	15.62			
10:40 am	10.0	16.57	15.62			
10:40 am	10.5	16.50	15.62			
10:41 am	11.0	16.57	15.62			
10:41 am	11.5	16.53	15.62			
10:42 am	12.0	16.52	15.63			
10:42 am	12.5	16.48	15.63			
10:43 am	13.0	16.47	15.63			
10:43 am	13.5	16.50	15.63			
10:44 am	14.0	16.46	15.62			
10:44 am	14.5	16.45	15.63			
10:45 am	15.0	16.52	15.63			
10:45 am	15.5	16.45	15.62			
10:46 am	16.0	16.50	15.63	2.21	498	BART samples collected
10:46 am	16.5	16.50	15.62			
10:47 am	17.0	16.48	15.62			
10:47 am	17.5	16.50	15.63			
10:48 am	18.0	16.48	15.62			
10:48 am	18.5	16.47	15.63			
10:49 am	19.0	16.52	15.62			
10:49 am	19.5	16.50	15.63			
10:50 am	20.0	16.50	15.63			
10:50 am	20.5	16.53	15.63			
10:51 am	21.0	16.50	15.63			
10:51 am	21.5	16.48	15.62			
10:52 am	22.0	16.50	15.63			
10:52 am	22.5	16.51	15.63			
10:53 am	23.0	16.52	15.63			
10:53 am	23.5	16.48	15.64			
10:54 am	24.0	16.53	15.64			
10:54 am	24.5	16.52	15.62			
10:55 am	25.0	16.52	15.64			
10:55 am	25.5	16.48	15.63			

WATER-LEVEL MEASUREMENTS
I-70 Well No. 15 (Continued)

Hour	*Time (min)*	*Adjusted depth to water in well (ft)*	*Adjusted depth to water in piezometer (ft)*	*Orifice tube piezometer (ft)*	*Pumping rate (gpm)*	*Remarks*
10:56 am	26.0	16.53	15.64	2.21	498	
10:56 am	26.5	16.57	15.64			
10:57 am	27.0	16.45	15.64			
10:57 am	27.5	16.50	15.63			
10:58 am	28.0	16.55	15.64			
10:58 am	28.5	16.47	15.64			
10:59 am	29.0	16.51	15.62			
10:59 am	29.5	16.52	15.64			
11:00 am	30.0	16.50	15.60	2.21	498	Reduce rate
11:00 am	0.5	16.16	15.34			Step 5
11:01 am	1.0	16.02	15.34	1.81	450	
11:01 am	1.5	16.08	15.32			
11:02 am	2.0	16.06	15.33			
11:02 am	2.5	16.10	15.33			
11:03 am	3.0	16.02	15.33	1.81	450	
11:03 am	3.5	16.06	15.32			
11:04 am	4.0	16.11	15.32			
11:04 am	4.5	16.06	15.31			
11:05 am	5.0	16.10	15.31			
11:05 am	5.5	16.08	15.33			
11:06 am	6.0	16.09	15.32			
11:06 am	6.5	16.08	15.31			
11:07 am	7.0	16.06	15.32			
11:07 am	7.5	16.13	15.31			
11:08 am	8.0	16.13	15.33			
11:08 am	8.5	16.12	15.32			
11:09 am	9.0	16.09	15.30			
11:09 am	9.5	16.10	15.31			
11:10 am	10.0	16.14	15.32			
11:10 am	10.5	16.11	15.32			
11:11 am	11.0	16.09	15.31			
11:11 am	11.5	16.12	15.31			
11:12 am	12.0	16.10	15.32			
11:12 am	12.5	16.13	15.31			
11:13 am	13.0	16.06	15.32			
11:13 am	13.5	16.09	15.32			
11:14 am	14.0	16.14	15.32			
11:14 am	14.5	16.11	15.31			
11:15 am	15.0	16.08	15.32			
11:15 am	15.5	16.06	15.32			
11:16 am	16.0	16.09	15.32			
11:16 am	16.5	16.10	15.32			
11:17 am	17.0	16.09	15.33	1.81	450	

WATER-LEVEL MEASUREMENTS
I-70 Well No. 15 (Concluded)

Hour	*Time (min)*	*Adjusted depth to water in well (ft)*	*Adjusted depth to water in piezometer (ft)*	*Orifice tube piezometer (ft)*	*Pumping rate (gpm)*	*Remarks*
11:17 am	17.5	16.09	15.32			
11:18 am	18.0	16.06	15.32			
11:18 am	18.5	16.06	15.32			
11:19 am	19.0	16.13	15.31			
11:19 am	19.5	16.07	15.32			
11:20 am	20.0	16.08	15.32			
11:20 am	20.5	16.08	15.32			
11:21 am	21.0	16.09	15.32			
11:21 am	21.5	16.07	15.32			
11:22 am	22.0	16.12	15.32			
11:22 am	22.5	16.08	15.32			
11:23 am	23.0	16.08	15.31			
11:23 am	23.5	16.13	15.33			
11:24 am	24.0	16.12	15.31	1.81	450	
11:24 am	24.5	16.09	15.33			
11:25 am	25.0	16.06	15.33			
11:25 am	25.5	16.08	15.34			
11:26 am	26.0	16.11	15.33	1.81	450	
11:26 am	26.5	16.11	15.31			
11:27 am	27.0	16.09	15.31			
11:27 am	27.5	16.11	15.33			
11:28 am	28.0	16.11	15.32			
11:28 am	28.5	16.14	15.32			
11:29 am	29.0	16.08	15.33			
11:29 am	29.5	16.07	15.33			
11:30 am	30.0	16.13	15.33	1.81	450	End of step test

Note:
Tank used to divert well discharge into drainage system manhole.

Appendix B

Chemical Quality of Ground Water from Dewatering Wells
FY 95 (Phase 12)

Appendix B. Chemical Quality of Ground Water from Dewatering Wells
FY 95 (Phase 12)

Site	I-70	I-70	I-70	I-70
Well No.	3A	5	11A	15
Section Location T2N, R9W, St. Clair Co.	7.7b	7.7b	7.7b	7.7b
Date Collected	08/17/94	05/10/95	09/20/94	05/11/95
Laboratory No.	227954	228698	228172	228700
Iron (Fe), mg/L	12.57	15.94	14.57	14.40
Manganese (Mn), mg/L	0.87	0.87	0.55	0.58
Calcium (Ca), mg/L	175	209	202	180
Magnesium (Mg), mg/L	41.1	54.3	52.0	49.2
Sodium (Na), mg/L	34.7	90.7	50.8	89.4
Silica (SiO_2), mg/L	33.6	34.1	35.1	32.2
Fluoride (F), mg/L	0.2	0.3	0.1	0.3
Nitrate (NO_3-N), mg/L	<0.02	<0.02	<0.02	<0.02
Chloride (Cl), mg/L	67	198	60.4	91.2
Sulfate (SO_4), mg/L	235	188	367	224
Aluminum (Al), mg/L	<0.017	0.03	0.029	<0.02
Arsenic (As), mg/L	<0.11	<0.11	<0.11	<0.11
Barium (Ba), mg/L	0.08	0.13	0.10	0.12
Beryllium (Be), mg/L	<0.003	<0.003	<0.003	<0.003
Boron (B), mg/L	0.29	0.41	0.21	0.60
Cadmium (Cd), mg/L	<0.017	<0.017	<0.017	<0.017
Chromium (Cr), mg/L	0.018	<0.007	<0.007	0.009
Copper (Cu), mg/L	<0.007	<0.007	<0.007	<0.007
Lead (Pb), mg/L	<0.066	<0.066	<0.066	<0.066
Nickel (Ni), mg/L	<0.031	<0.031	<0.031	<0.031
Potassium (K), mg/L	7.0	5.2	7.1	5.6
Selenium (Se), mg/L	<0.18	<0.18	<0.18	<0.18
Silver (Ag), mg/L	<0.014	<0.014	<0.014	<0.014
Zinc (Zn), mg/L	<0.02	<0.02	<0.02	<0.02
Alkalinity (as $CaCO_3$), mg/L	371	493	410	508
Hardness (as $CaCO_3$), mg/L	605	744	718	651
Total dissolved solids, mg/L (at 180°C)	870	1149	1075	908
Turbidity (lab), NTU	107	122	122	84
Color, PCU	7	7	7	6
Odor	None	Musty	None	Musty
pH (lab)	7.1	7.1	7.4	7.3
Temperature, °F	57.7	58.8	58.8	58.1

Notes:
< = below detection limit (i.e., <1.0 = less than 1.0 mg/L)
mg/L = milligrams per liter

Appendix C

Results of Step Tests on Dewatering Wells
FY 84 - FY 95 (Phases 1-12)

Appendix C. Results of Step Tests on Dewatering Wells
FY 84 - FY 95 (Phases 1-12)

Well	*Date of test*	*Well loss at 600 gpm (ft)*	*Drawdown at 600 gpm (ft)*	*Well loss portion (%)*	*Observed specific capacity (gpm/ft)*	*Δh* at 600 gpm (ft)*	*Observed Q_{max} (gpm)*	*Remarks*
I-70								
No. 1	8/15/84	**	18.1 e	**	33.1 e	12.8 e	328	Pretreat
No. 1	8/14/85	**	8.89 e	**	67.5 e	3.3 e	390	Posttreat
No. 1	5/17/89	3.31 e	14.68 e	22.5	40.9 e	8.5 e	250	
No. 1A	4/26/95	0.92	14.98 e	6.1	40.8	8.7 e	445	New well, initial test
No. 2	7/19/83	**	11.9 e	**	50.4 e	7.9 e	500	Pretreat
No. 2	8/15/85	**	8.32 e	**	72.1 e	P	410	Posttreat
No. 2	6/20/88	**	11.98 e	**	50.1 e	P	365	Pretreat
No. 2	2/1/89	0.19 e	8.31 e	2.3	72.2 e	P	270	Posttreat; Piezometer partially plugged
No. 2A	11/16/93	1.78 e	20.82 e	8.5	29.7	14.0 e	438	New well, initial test
No. 2A	8/22/94	0.28	7.59	3.7	79.7	2.3 e	525	Posttreat
No. 3	6/28/83	**	8.53	**	70.9	5.65		
No. 3	6/24/86	1.11	7.47	14.9	80.3	3.64	610	Pretreat
No. 3	1/14/87	0.82	6.09	13.5	98.5	2.40	620	Posttreat
No. 3	12/11/89	0.46	13.4 e	3.4	44.9	7.3 e	530	Pretreat
No. 3	4/17/90	4.8 e	8.7 e	54.5	84.0	2.9 e	440	Posttreat
No. 3A	10/29/93	1.34 e	15.25 e	8.8	40.0	7.7 e	540	New well, initial test
No. 3A	8/17/94	4.40	8.96	49.2	67.6	2.2	610	Posttreat
No. 4	8/16/84	0.07	9.33	0.8	64.3	P		Pretreat
No. 4	1/8/87	**	5.89	**	101.9	P	660	Posttreat
No. 4	5/11/95	**	6.70	**	89.7	P	685	
No. 5	7/10/84	0.89	6.53	13.6	91.9	2.11	740	

Appendix C. (Continued)

Well	*Date of test*	*Well loss at 600 gpm (ft)*	*Drawdown at 600 gpm (ft)*	*Well loss portion (%)*	*Observed specific capacity (gpm/ft)*	*Δh* at 600 gpm (ft)*	*Observed Q_{max} (gpm)*	*Remarks*
I-70 (Continued)								
No. 5	1/13/87	**	7.98	**	75.2	4.76	665	Posttreat
No. 5	2/2/89	0.71	6.23	11.4	96.3	P	650+	Posttreat
No. 5	10/14/93	1.19 e	13.67 e	8.7	44.8	P	500	
No. 5	5/10/95	**	7.53	**	79.9	P	625	Posttreat
No. 6	7/19/85	0.23	5.39	4.3	111.3	P	625	
No. 6	8/1/90	--	--	--	16.1		145	
No. 6	10/29/91	0.19	4.93	3.8	121.7	--	750	Posttreat; Piezometer buried
No. 6	5/12/95	**	6.72	**	89.3	2.5	610	
No. 7	6/30/83	1.88	18.55	10.1	32.3	15.0		Replaced 11/86
No. 7A	7/23/87	**	8.39	**	71.5	2.13	770	
No. 7A	6/15/89	2.25	11.43	19.7	52.5	8.97 e	520	
No. 7A	6/27/90	6.8 e	26.7 e	25.3	24.6	13.2 e	425	Pretreat
No. 7A	8/6/91	0.32	8.58	3.7	69.9	1.4	625	Posttreat
No. 7A	5/5/94	0.54 e	11.1 e	4.8 e	54.5	2.9 e	465	
No. 8	8/1/84	2.68	13.54	19.8	44.3	9.94	625	Pretreat
No. 8	12/5/85	0.07	6.83	1.0	87.8	2.21	750	Posttreat
No. 8	6/22/88	**	12.62	**	47.5 e	8.22	600	
No. 8A	10/4/89	**	6.10	**	98.4	1.38	778	
No. 8A	10/1/91	0.29	11.61	2.5	51.7	6.4	620	
No. 8A	12/17/92	0.17 e	9.8 e	1.2 e	61.1	5.3 e	590	Pretreat
No. 8A	3/16/94	0.27 e	7.9 e	3.4 e	76.0	2.5 e	588	Posttreat
No. 9	6/28/84	**	9.46	**	63.4	5.94	630	

Appendix C. (Continued)

Well	*Date of test*	*Well loss at 600 gpm (ft)*	*Drawdown at 600 gpm (ft)*	*Well loss portion (%)*	*Observed specific capacity (gpm/ft)*	*Δh* at 600 gpm (ft)*	*Observed Q_{max} (gpm)*	*Remarks*
I-70 (Continued)								
No. 9A	10/3/89	**	6.04 e	**	99.4 e	1.72 e	523	
No. 9A	6/26/90	0.4 e	6.2 e	6.3	97.1	2.1 e	575	
No. 9A	4/26/91	**	5.95 e	--	100.8	2.7 e	535	
No. 9A	7/23/92	0.24 e	7.8 e	3.1	78.7	2.9 e	525	
No. 9A	5/12/94	0.13 e	7.7 e	1.6 e	78.3	3.1 e	470	
No. 9A	9/9/94	**	5.9 e	**	99.8	1.6 e	515	Posttreat
No. 10	7/31/84	5.97 e	16.93 e	35.3	35.4 e	P	480	Pretreat
No. 10	9/4/85	0.66	6.61 e	10.0	90.8	P	490	Posttreat
No. 10	8/13/87	1.07	18.98 e	5.6	31.6 e	10.4 e	390	Pretreat
No. 10	1/30/89	1.74 e	11.51 e	15.1	52.1 e	4.34 e	370	Posttreat
No. 10	2/7/91	--	19.3 e	--	31.1	P	270	Pretreat; Drawdown test only
No. 10	8/8/91	0.95	9.4 e	10.0	65.2	P	450	Posttreat
No. 10	8/1/95	**	6.2 e	**	57.9	P	455	
No. 11	8/2/84	1.58 e	15.55 e	10.2	38.6 e	13.35 e	555	Pretreat
No. 11	9/5/85	**	5.63	**	106.6	P		Posttreat
No. 11	8/12/87	**	11.56 e	**	51.9 e	P	550	Pretreat
No. 11	1/31/89	0.03	6.62 e	0.5	90.6 e	P	570	Posttreat; Piezometer partially plugged
No. 11A	10/28/93	0.40 e	16.09 e	2.5	37.6	12.5 e	474	New well, initial test
No. 11A	9/20/94	0.07	7.28	0.9	82.5	3.7 e	575	Posttreat
No. 12A	6/16/83	0.20	3.82	5.2	157.1	P		
No. 12A	7/30/86	**	13.3 e	**	45.1	P	450	Pretreat

Appendix C. (Continued)

Well	*Date of test*	*Well loss at 600 gpm (ft)*	*Drawdown at 600 gpm (ft)*	*Well loss portion (%)*	*Observed specific capacity (gpm/ft)*	*Δh* at 600 gpm (ft)*	*Observed Q_{max} (gpm)*	*Remarks*
I-70 (Continued)								
No. 12A	11/16/87	1.45	2.36	61.4	254.2	P	750	Posttreat
No. 12A	5/15/91	1.09	4.7 e	23.2	132.6	2.0 e	520	
No. 12A	8/2/95	0.68	11.2 e	6.1	54.3	P	517	
No. 13	4/25/91	0.47	7.57 e	6.2	79.9	2.9 e	560	New well, initial test
No. 13	4/25/95	**	20.1 e	**	29.9	4.4 e	208	Drawdown test
No. 14	12/20/90	0.13	5.93	2.2	100.5	3.0	750	New well, initial test
No. 14	6/22/94	**	16.0 e	**	34.0	14.6 e	396	
No. 15	10/15/93	2.95 e	14.88 e	19.8	41.5	9.1 e	545	New well, initial test
No. 15	5/11/95	**	5.67	**	103.5	1.2	650	Posttreat
I-64								
No. 1	7/21/87	**	4.13	**	145.3	0.85	660	
No. 1	9/24/91	0.12	4.33	2.8	138.6	P	630	
No. 2	7/25/85	0.09	5.32 e	1.7	112.8	5.22	550	
No. 3	6/26/84	0.52	10.73 e	4.8	55.9 e	P	525	Pretreat
No. 3	6/21/88	0.68 e	5.68 e	12.0 e	105.6 e	P	555	Posttreat
No. 4	7/15/85	0.66	4.40	15.0	136.4	P		
No. 8	4/15/96	2.19	11.0 e	19.9	57.9	P	435	
No. 9	10/5/83	0.37	6.22	5.9	96.5	2.3		
No. 9	8/18/94	**	26.2 e	**	22.9	19.7 e	470	
No. 10	7/11/84	**	7.46	**	80.4	2.73	605	
No. 11	8/14/84	**	7.22 e	**	83.1 e	3.2 e	520	
No. 11	6/16/89	0.52	7.45 e	7.0	80.5 e	P	505	

Appendix C. (Continued)

Well	*Date of test*	*Well loss at 600 gpm (ft)*	*Drawdown at 600 gpm (ft)*	*Well loss portion (%)*	*Observed specific capacity (gpm/ft)*	*Δh* at 600 gpm (ft)*	*Observed Q_{max} (gpm)*	*Remarks*
I-64 (Continued)								
No. 12	7/18/85	0.17	6.22 e	2.8	96.5	1.62 e	590	
No. 13	7/12/84	**	6.44	**	93.2	2.65	600	
No. 14	8/3/90	0.31	4.71 e	6.5	128.2	P	585	Initial test
No. 15	6/29/83	0.73	9.94	7.3	60.4	4.6		Pretreat
No. 15	8/13/85	0.71	7.24	9.8	82.9	2.97	615	Posttreat
No. 15	7/22/87	0.84 e	6.94 e	12.1 e	86.5 e	2.52	570	
25th St.								
No. 1	8/11/89	1.0 e	3.6 e	27.2	184.7	P	375	
No. 1	9/4/91				31.6	P	235	Drawdown test only
No. 2	7/20/83	0.54	5.69	9.5	105.4	1.1		
No. 2	8/9/89	**	10.3 e	**	58.3 e	--	550	Pretreat; Δh elevation data not available
No. 2	4/18/90	0.45	4.87	9.3	120.4	0.6	795	Posttreat
No. 3	9/6/85	0.03	4.89	0.6	122.7	1.75		
No. 3	9/7/89	0.80 e	14.9 e	5.4	40.9	4.5 e	560	Pretreat
No. 3	12/19/90	0.28	10.29	2.7	58.1	3.0	650	Pretreat
No. 3	5/14/91	0.17	5.59	3.0	106.5	0.9	780	Posttreat
No. 4	8/2/90	1.86	10.87	17.1	55.2	--	635	Initial test
No. 4	11/19/91	0.62	4.75	13.1	119.9	P	840	Posttreat
No. 4	7/24/92	**	6.24	**	98.8	P	820	
No. 5	5/16/89	0.47 e	23.28 e	0.02	25.8 e	15.2 e	352	Pretreat
No. 5	4/19/90	**	4.92	**	122.0	1.0	790	Posttreat

Appendix C. (Continued)

Well	*Date of test*	*Well loss at 600 gpm (ft)*	*Drawdown at 600 gpm (ft)*	*Well loss portion (%)*	*Observed specific capacity (gpm/ft)*	*Δh* at 600 gpm (ft)*	*Observed Q_{max} (gpm)*	*Remarks*
25th St. (Continued)								
No. 6	6/27/84	0.14	9.44	1.5	63.6	P	775	Pretreat
No. 6	1/7/87	0.23	4.38	5.3	137.0	P	775	Posttreat
No. 6	2/8/91	**	4.96	**	122.5	1.9	810	
No. 7	3/21/91	1.56	5.15	30.3	110.8	P	735	Initial test
No. 8	6/15/83	0.11	4.70	2.3	127.7	1.5		
No. 8	4/24/91	--	13.2 e	--	45.5	9.5 e	255	Drawdown test only
No. 8	11/15/93	**	6.23	**	96.3	4.81	620	Posttreat
No. 9	6/25/86	**	5.55 e	**	110.4	2.04 e	520	
No. 9	9/18/91	0.66 e	5.10 e	12.9	117.6	1.8 e	580	
No. 10	7/26/85	**	9.56	**	62.8	3.59		Pretreat
No. 10	11/18/87	0.43	6.24	6.9	96.2	2.06	800	Posttreat
Venice								
No. 1	11/30/83	2.29	18.33 e	12.5	32.7	10.9 e	500	Pretreat
No. 1	12/4/85	0.39	7.89	4.9	74.5	2.33	870	Posttreat
No. 1	9/6/89	0.81	6.94	11.7	85.1	1.9	740	
No. 1	3/29/94	2.9	17.4	16.6	34.5	P	680	
No. 2	11/17/83	0.05	4.70	1.0	127.7	1.2		
No. 2	9/5/89	12.49	44.70 e	27.9	13.4 e	33.3 e	200	Pretreat; Water level below intake
No. 2	5/8/90	**	6.34	**	94.7	2.4	730	Posttreat
No. 2	10/2/91	1.30	6.14	21.1	92.8	2.3	780	
No. 2	6/21/94	**	9.0	**	67.6	4.37	745	

Appendix C. (Continued)

Well	*Date of test*	*Well loss at 600 gpm (ft)*	*Drawdown at 600 gpm (ft)*	*Well loss portion (%)*	*Observed specific capacity (gpm/ft)*	*Δh* at 600 gpm (ft)*	*Observed Q_{max} (gpm)*	*Remarks*
Venice (Continued)								
No. 3	11/28/83	**	9.20	**	65.2	4.2		Pretreat
No. 3	1/6/87	0.35	7.60	4.6	78.3	P	775	Posttreat
No. 3	12/5/90	**	9.54	**	62.9	6.1	700	
No. 3	12/16/91	**	6.26 e	**	97.2	2.3	840	Posttreat
No. 3	7/1/94	**	9.2	**	65.8	5.03	760	
No. 4	12/1/83	0.39	5.15	7.6	116.5	2.3		
No. 4	12/6/90	--	30.0 e	--	20.0	26.0 e	262	Pretreat; Drawdown test only
No. 4	9/17/91	0.66	5.86	11.3	102.4	2.7	795	Posttreat
No. 4	5/11/94	**	13.5	**	44.7	P	760	
No. 5	11/15/83	0.16	4.98	3.2	120.5	1.9		
No. 5	12/7/89	4.3 e	13.7 e	31.4	43.8	9.6 e	500	Pretreat
No. 5	5/2/90	**	5.38	**	109.7	1.6	740	Posttreat
No. 5	3/24/92	0.73	5.28	13.8	110.5	P	760	
No. 6	11/29/83	0.16	7.82	2.0	76.7	6.1		Pretreat
No. 6	11/17/87	3.18	4.13	77.0	145.3	2.61	800	Posttreat
No. 6A	3/20/91	1.89	6.84 e	27.6	78.6	3.7	900	New well, initial test
No. 6A	6/23/94	**	9.9	**	61.5	6.1	825	
No. 7	2/27/91	**	7.48	**	80.2	4.1	895	New well, initial test
No. 7	5/4/94	**	17.5	**	35.2	13.9 e	845	
MO Ave.								
No. 1†	2/10/95	**	11.7 e	**	51.4		1,260	
No. 2	2/16/95	0.06	5.92 e	1.0	100.1	9.1	1,450	

Appendix C. (Concluded)

Well	*Date of test*	*Well loss at 600 gpm (ft)*	*Drawdown at 600 gpm (ft)*	*Well loss portion (%)*	*Observed specific capacity (gpm/ft)*	*Δh* at 600 gpm (ft)*	*Observed Q_{max} (gpm)*	*Remarks*
MO Ave. (Continued)								
No. 3‡	2/16/95	**	12.9 e	**	46.7		1,170	

Notes:
* Head difference between pumped well and adjacent piezometer.
**Coefficient immeasurable. Turbulent well loss negligible over the pumping rates tested.
† Drawdown test only (450 gpm). Cascading water interfered with water-level measurement.
‡ Drawdown test only; cascading water interfered with water-level measurement. Δh calculated with water-level data from Well 2-93 at 606 gpm.
e - Estimate based on interpolated values adjusted to 600 gpm.
P - Piezometer plugged or partially plugged.

Appendix D

Well Rehabilitation Field Notes
FY 95 (Phase 12)

Appendix D. Well Rehabilitation Field Notes

WELL SITE: I-70 Well 3A   OBSERVER: Bob Olson

CONTRACTOR: Layne-Western Company, Inc.

MEASURING POINT: Access hole in temporary wellhead about 2.85 ft above pit cover

MEASURING EQUIPMENT: Layne 6x5 orifice tube, steel tape

1. SPECIFIC CAPACITY TEST   DATE: 7/20/94

Time	Depth (ft)	Drawdown (ft)	Piezometer tube (in.)	Pumping rate (gpm)	Remarks
9:30 AM	32.72				Static water level (SWL)
9:42	32.71				Start pump
9:43			24.0	610	
10:03	50.54		23.5	603	
11:11	51.16		23.0	597	Pumping rate unsteady
11:25	51.22	18.51	23.0	597	Pumping water level (PWL)

Notes: All specific capacity tests--static water level (SWL) measured after minimum 30-min. period of well inactivity. Minimum period of pumpage for drawdown measurements is 60 min.

60-min. specific capacity: 32.3 gpm/ft

Comments: None

2. 400 LB POLYPHOSPHATE APPLICATION   DATE: 7/20/94

A. INITIAL CHLORINATION

Quantity: 2,000 gal   Strength: 500 mg/L

Time - initial: 11:36:55 AM   Injection rate: 1,765 gpm
- complete: 11:38:03 AM

Comments: Well 2A is supply well for treatment

I-70 Well 3A (Continued)

B. POLYPHOSPHATE INJECTION, 400 lb total

	Batch 1	Batch 2
Phosphate:	200 lb	200 lb
Quantity H_2O:	2,000 gal	2,000 gal
Time - initial:	11:43:27 AM	11:49:47 AM
- complete:	11:44:28 AM	11:50:44 AM
Injection rate:	1,967 gpm	2,105 gpm

Comments: None

C. DISPLACEMENT, 16,000 gal chlorinated water (500 mg/L)

Time - initial/complete	Quantity (gal)	Q (gpm)
11:56:08/11:57:20 AM	2,000	1,167
12:02:35/12:03:17 PM	2,000	2,857
12:08:55/12:09:52	2,000	2,105
12:15:44/12:16:40	2,000	2,143
12:22:36/12:23:37	2,000	1,967
12:29:30/12:30:42	2,000	1,667
12:36:55/12:38:03	2,000	1,765
12:44:12/12:45:19	2,000	1,791

Comments: None

D. SURGING, cycles of 2,000 gal each

Well to tank		**Tank to well**	
Time - initial/seconds	Q (gpm)	Time - seconds	Q (gpm)
1:59 PM/123	976	55	2,182
2:06/120	1,000	60	2,000
2:12/125	960	57	2,105
2:18/115	1,043	54	2,222
2:25/115	1,043	57	2,105
2:33/105	1,143	60	2,000
2:38/110	1,091	53	2,264
2:45/110	1,091	53	2,264
2:52/90	1,333	38	3,158
2:58/94	1,277	43	2,791
3:06/83	1,446	36	3,333
3:13/95	1,263	40	3,000
3:23/85	1,412	38	3,158
3:31/84	1,429	33	3,636
3:37/100	1,200	48	2,500
3:43/90	1,333	39	3,077
3:50/85	1,412	42	2,857

Comments: None

E. PUMPED TO WASTE

Time - initial: 4:20 PM (7/20)
- complete: 7:49 AM (7/21)

Q - initial: 610 gpm
- complete: 597 gpm

Quantity: 557,00 gal

Comments: None

3. SPECIFIC CAPACITY TEST — DATE: 7/21/94

Time	Depth (ft)	Drawdown (ft)	Piezometer tube (in.)	Pumping rate (gpm)	Remarks
7:36 AM	44.09		23	597	PWL
7:49	44.09		23	597	Pump Off
8:31	33.95	10.14			SWL

60-min. specific capacity: 58.9 gpm/ft

Comments: 26.6 gpm/ft increase (82%)

4. ACIDIZATION - INHIBITED MURIATIC ACID — DATE: 7/21/94

A. ACID INJECTION

Acid strength: 20° Baume

Quantity: 1,000 gal

Time - initial: 8:45 AM
- complete: 9:25 AM

Q: 25 gpm

Comments: None

B. DISPLACEMENT, 5,000 gal nonchlorinated water

Time - initial/complete	Quantity (gal)	Q (gpm)
10:27:15/10:27:57AM	2,000	2,857
10:33:05/10:33:55	2,000	2,400
10:36:43/10:37:03	1,000	3,000

Comments: Gas locking initially

C. SURGING, cycles of 2,000 gal each

Well to tank		Tank to well	
Time - initial/min:sec	Q (gpm)	Time - seconds	Q (gpm)
12:42 PM/25	air locked		
12:45/50	air locked		
12:48/55	air locked		
12:51/255	312	49	2,449
12:58/105	air locked		
1:01	air locked		
1:03/7:15	222	45	2,667
1:14/8:27	237	55	2,182
1:27/6:30	308	55	2,182
1:37/4:50	414	50	2,400
1:45/4:15	471	54	2,222
1:52/4:00	500	55	2,182
2:03:15/4:20	462	57	2,105
2:11:25/3:13	622	53	2,264

Comments: None

D. PUMPED TO WASTE

Time - initial: 2:25 PM (7/21)
- complete: 7:47 AM (7/22)

Q - initial: 622 gpm (25 in.)
- complete: 603 gpm (23.5 in.)

Quantity: 600,000 gal

Comments: None

5. SPECIFIC CAPACITY TEST DATE: 7/22/94

Time	Depth (ft)	Drawdown (ft)	Piezometer tube (in.)	Pumping rate (gpm)	Remarks
7:47 AM			23.5	603	
7:51	43.01				PWL - Pump Off
8:30	33.96	9.05			SWL

60-min. specific capacity: 66.6 gpm/ft

Comments: 7.8 gpm/ft increase (13%)

6. 600 LB POLYPHOSPHATE APPLICATION DATE: 7/22/94

A. INITIAL CHLORINATION

Quantity: 2,500 gal

Strength: 500 mg/L

Time - initial: 8:51:48 AM
- complete: 8:52:36 AM

Injection rate: 2,500 gpm

B. POLYPHOSPHATE INJECTION, 600 lb total

	Batch 1	Batch 2	Batch 3
Phosphate:	200 lb	200 lb	200 lb
Quantity H_2O:	2,000 gal	2,000 gal	2,000 gal
Time - initial:	8:58:00 AM	9:04:15 AM	9:11:13 AM
- complete:	8:58:50 AM	9:05:03 AM	9:12:10 AM
Injection rate:	2,400 gpm	2,500 gpm	2,105 gpm

Comment: None

C. DISPLACEMENT, 30,000 gal chlorinated water (500 mg/L)

Time - initial/complete	Quantity (gal)	Q (gpm)
9:17:43/9:18:35 AM	2,000	2,308
9:19:14/9:20:08	2,000	2,222
9:31:10/9:31:58	2,000	2,500
9:37:19/9:38:16	2,000	2,105
9:59:00/10:00:10	2,000	1,714
10:05:50/10:06:55	2,000	1,846
10:12:36/10:13:28	2,000	2,308
10:19:07/10:20:03	2,000	2,143
10:25:50/10:26:41	2,000	2,353

10:32:27/10:33:21	2,000	2,222
10:39:05/10:40:00	2,000	2,182
10:45:35/10:46:32	2,000	2,264
10:52:13/10:53:08	2,000	2,182
10:58:54/10:59:48	2,000	2,222
11:05:30/11:06:50	2,000	1,500

Comments: None

D. SURGING, cycles of 2,000 gal each

Well to tank		**Tank to well**	
Time - initial/seconds	Q (gpm)	Time - seconds	Q (gpm)
12:11 PM/93	1,290	41	2,927
12:15/106	1,132	47	2,553
12:21/100	1,200	44	2,727
12:25/96	1,250	42	2,857
12:30/93	1,290	43	2,791
12:33/103	1,165	43	2,791
12:38/99	1,212	45	2,667
12:43/97	1,237	44	2,727
12:48/87	1,379	46	2,609
12:56/98	1,224	42	2,857
1:05/100	1,200	45	2,667
1:16/95	1,263	41	2,927
1:27/100	1,200	44	2,727
1:32/100	1,200	43	2,791
1:38/103	1,165	48	2,500
1:43/104	1,154	45	2,667
1:48/102	1,176	45	2,667
1:53/102	1,176	44	2,727
2:01/103	1,165	46	2,609
2:05/89	1,348	43	2,791
2:10/97	1,237	46	2,609
2:19/102	1,176	45	2,667
2:26/100	1,200	45	2,667

Comments: None

E. PUMPED TO WASTE

Time - initial: 2:36 PM (7/24)
- complete: 8:20 AM (7/25)

Q: 635 gpm Quantity: 676,000 gal

Comments: None

7. SPECIFIC CAPACITY TEST DATE: 7/25/94

Time	Depth (ft)	Drawdown (ft)	Piezometer tube (in.)	Pumping rate (gpm)	Remarks
8:19 AM	42.98		26.0	635	PWL
8:20					Pump Off
8:52	34.42	8.56			SWL

60-min. specific capacity: 74.2 gpm/ft

Comments: 7.55 gpm/ft increase (11%). Treatment concluded.

Well Rehabilitation Field Notes

WELL SITE: I-70 Well 5 OBSERVER: Bob Olson

CONTRACTOR: Layne-Western Company, Inc.

MEASURING POINT: Access hole in temporary wellhead approximately 1.85 ft above pit cover

MEASURING EQUIPMENT: Layne 6x5 orifice tube, steel tape

1. SPECIFIC CAPACITY TEST DATE: 8/16/94

Time	Depth (ft)	Drawdown (ft)	Piezometer tube (in.)	Pumping rate (gpm)	Remarks
7:14 AM	19.50				SWL
7:22			23.0	597	Pump On
7:47			23.0	597	
8:06			23.0	597	
8:22	~32				Cascading water–steel tape no good for measurements
8:40	36.65	17.15	22.75	594	PWL - Solinst dropline

Notes: All specific capacity tests--static water level (SWL) measured after minimum 30-min. period of well inactivity. Minimum period of pumpage for drawdown measurements is 60 min.

60-min. specific capacity: 34.6 gpm/ft

Comments: I-70 Well 14 is supply well for treatment

2. 400 LB POLYPHOSPHATE APPLICATION DATE: 8/16/94

A. INITIAL CHLORINATION

Quantity: 2,000 gal

Strength: 500 mg/L

Time - initial: 9:47:54 AM
- complete: 9:49:10 AM

Injection rate: 1,579 gpm

Comments: None

B. POLYPHOSPHATE INJECTION, 400 lb total

	Batch 1	Batch 2
Phosphate:	200 lb	200 lb
Quantity H_2O:	2,000 gal	2,000 gal
Time - initial:	11:10:27 AM	11:16:46 AM
- complete:	11:11:36 AM	11:18:05 AM
Injection rate:	1,739 gpm	1,519 gpm

Comments: Pump is valved back during injection–less than 20 psi back pressure

C. DISPLACEMENT, 16,000 gal chlorinated water (500 mg/L)

Time - initial/complete	Quantity (gal)	Q (gpm)
11:23:11/11:24:19 AM	2,000	1,765
11:29:42/11:30:55	2,000	1,644
11:36:09/11:37:17	2,000	1,765
11:42:38/11:43:38	2,000	2,000
11:48:52/11:49:56	2,000	1,875
11:55:17/11:56:26	2,000	1,739
12:01:50/12:02:55 PM	2,000	1,846
12:08:17/12:09:25	2,000	1,765

Comments: None

D. SURGING, cycles of 2,000 gal each

Well to tank		**Tank to well**	
Time - initial/complete	Q (gpm)	Time - initial/complete	Q (gpm)
1:10:42/1:12:20 PM	1,224	1:12:40/1:13:40 PM	2,000
1:16:35/1:18:02	1,379	1:18:18/1:19:11	2,264
1:22:05/1:23:36	1,319	1:23:58/1:25:01	1,905
1:27:20/1:28:52	1,304	1:29:04/1:30:05	1,967
1:33:48/1:35:19	1,319	1:35:37/1:36:31	2,222
1:38:04/1:40:35	795	1:40:50/1:41:49	2,034
1:43:48/1:45:19	1,319	1:45:30/1:46:30	2,000
1:48:43/1:50:14	1,319	1:50:22/1:51:22	2,000
1:54:47/1:56:17	1,333	1:56:30/1:57:24	2,222
1:59:02/2:00:33	1,319	2:00:49/2:01:46	2,105
2:03:26/2:04:56	1,333	2:05:10/2:06:08	2,069
2:08:16/2:09:45	1,348	2:10:03/2:11:01	2,069
2:13:22/2:14:50	1,364	2:15:05/2:16:02	2,105
2:17:56/2:19:24	1,364	2:19:44/2:20:41	2,105
2:22:13/2:23:42	1,348	2:24:01/2:25:00	2,034

Comments: None

E. PUMPED TO WASTE

Time - initial: 2:27 PM
- complete: ?

Q - initial: 662 gpm | Quantity: ?
- complete:

Comments: Pump blew fuses overnight. Fuses replaced for specific capacity test.

3. SPECIFIC CAPACITY TEST | DATE: 8/17/94

Time	Depth (ft)	Drawdown (ft)	Piezometer tube (in.)	Pumping rate (gpm)	Remarks
7:19 AM	17.23				SWL
7:22			25.0	622	Pump On
7:46			24.75	619	
8:14			24.75	619	
8:22	25.21	7.98	24.75	619	PWL

60-min. specific capacity: 77.6 gpm/ft

Comments: 42.9 gpm/ft increase (124%)

4. ACIDIZATION - INHIBITED MURIATIC ACID | DATE: 8/17/94

A. ACID INJECTION

Acid strength: 20° Baume | Quantity: 1,000 gal

Time - initial: 8:56:40 AM | Q: 23 gpm
- complete: 9:40 AM

Comments: 13 psi pressure buildup in pump discharge line slowing acid injection. Cleared lines with 500 gal water at 9:49 AM

B. DISPLACEMENT, 4,000 gal nonchlorinated water

Time - initial/complete	Quantity (gal)	Q (gpm)
10:41:10/10:42:32 AM	2,000	1,463
10:48:00/10:49:18	2,000	1,538

Comments: None

C. SURGING, cycles of 2,000 gal each

Well to tank		**Tank to well**	
Time - initial/complete	Q (gpm)	Time - initial/complete	Q (gpm)
12:52:12/12:53:30 PM	Well pump gas locked		
12:54:09/12:56:42	784	12:57:22/12:58:36 PM	1,622
1:01:00/1:03:15	889	1:03:35/1:04:41	1,818
1:07:00/1:09:12	909	1:09:35/1:10:45	1,714
1:14:00/1:16:01	992	1:16:32/1:17:41	1,739
1:20:30/1:22:18	1,111	1:22:48/1:23:57	1,739
Missed one cycle			
1:38:45/1:40:33	1,111	1:40:52/1:42:09	1,558
1:44:00/1:45:51	1,081	1:46:19/1:47:28	1,739
1:50:00/1:52:52	698	1:52:20/1:53:26	1,818
1:56:00/1:57:50	1,091	1:58:11/1:59:19	1,765
Missed one cycle			

Comments: None

D. PUMPED TO WASTE

Time - initial: 2:06 PM (8/17)
- complete: 7:18 AM (8/18)

Q - initial: 616 gpm
- complete: 616 gpm

Quantity: 636,000 gal

Comments: None

5. SPECIFIC CAPACITY TEST DATE: 8/18/94

Time	Depth (ft)	Drawdown (ft)	Piezometer tube (in.)	Pumping rate (gpm)	Remarks
7:15 AM	24.09		24.5	616	PWL
7:18					Pump Off
7:52	17.02	7.07			SWL

60-min. specific capacity: 87.1 gpm/ft

Comments: 9.6 gpm/ft increase (12%)

6. 600 LB POLYPHOSPHATE APPLICATION DATE: 8/18/94

A. INITIAL CHLORINATION

Quantity: 2,000 gal + well discharge   Strength: 500 mg/L

Time - initial: 7:52:44 AM   Injection rate: 1,846 gpm
- complete: 7:53:49 AM

B. POLYPHOSPHATE INJECTION, 600 lb total

	Batch 1	Batch 2	Batch 3
Phosphate:	200 lb	200 lb	200 lb
Quantity H_2O:	2,000 gal	2,000 gal	2,000 gal
Time - initial:	7:59:20 AM	8:05:15 AM	8:11:04 AM
- complete:	8:00:00 AM	8:06:06 AM	8:12:07 AM
Injection rate:	3,000 gpm	2,353 gpm	1,905 gpm

Comment: None

C. DISPLACEMENT, 30,000 gal chlorinated water (500 mg/L)

Time - initial/complete	Quantity (gal)	Q (gpm)
8:16:59/8:18:04 AM	2,000	1,846
8:22:57/8:24:04	2,000	1,791
8:29:00-8:30:03	2,000	1,905
8:34:55/8:35:56	2,000	1,967
8:40:48/8:41:48*	2,000	2,000
8:46:52/8:47:50	2,000	2,069
8:52:42/8:53:43	2,000	1,967
8:58:29/8:59:32	2,000	1,905
9:04:19/9:05:21	2,000	1,935

9:10:15/9:11:25	2,000	1,714
9:16:20/9:17:23*	2,000	1,905
9:21:00/9:22:05	2,000	1,846
9:28:20/9:29:22	2,000	1,935
9:34:17/9:35:18	2,000	1,967
9:40:16/9:41:25	2,000	1,739

Comments: 10 to 12 inches of water in vault throughout displacement. 20 psi back pressure indicated on rig pressure gauge. *Beginning new 55 gal drum chlorine.

D. SURGING, cycles of 2,000 gal each

Well to tank		**Tank to well**	
Time - initial/complete	Q (gpm)	Time - seconds	Q (gpm)
Data recorded by Layne-Western			
10:50:00/10:52:30 AM	1,333	55	2,182
10:56:00/10:57:30	1,333	55	2,182
11:01:30/11:03:00	1,333	55	2,182
11:06:00/11:07:25	1,412	55	2,182
11:10:00/11:11:30	1,333	60	2,000
11:14:00/11:15:30	1,333	55	2,182
11:18:00/11:19:30	1,333	55	2,182
11:22:00/11:23:30	1,333	55	2,182
11:26:00/11:27:30	1,333	55	2,182
11:30:00/11:31:30	1,333	60	2,000
11:34:00/11:35:30	1,333	55	2,182
11:38:00/11:39:30	1,333	60	2,000
11:42:00/11:43:30	1,333	55	2,182
11:46:00/11:47:30	1,333	60	2,000
11:50:00/11:51:30	1,333	60	2,000
11:54:00/11:55:30	1,333	55	2,182
11:58:00/11:59:30	1,333	55	2,182
12:02:00/12:03:30 PM	1,333	55	2,182
12:06:00/12:07:30	1,333	66	1,818
12:10:00/12:11:30	1,333	60	2,000
Data recorded by ISWS			
12:14:00/12:15:30 PM	1,333	50	2,400
12:19:40/12:21:06	1,395	55	2,182
12:23:37/12:25:05	1,364	57	2,105
12:27:37/12:29:07	1,333	52	2,308
12:31:38/12:33:02	1,429	56	2,143
12:35:36/12:37:04	1,364	54	2,222
12:39:36/12:41:06	1,333	58	2,069
12:43:36/12:45:03	1,379	55	2,182
12:47:37/12:49:01	1,429	56	2,143
12:51:36/12:53:04	1,364	60	2,000

Comments: None

E. PUMPED TO WASTE

Time - initial: 12:55 PM (8/18) (29 inches, 670 gpm)
- complete: 7:19 AM (8/19)

Q: 625.5 gpm Quantity: 691,000 gal

Comments: Later reduced to 616 gpm (24.5 in.)

7. SPECIFIC CAPACITY TEST DATE: 8/19/94

Time	Depth (ft)	Drawdown (ft)	Piezometer tube (in.)	Pumping rate (gpm)	Remarks
7:18 AM	25.21		25.25	625.5	PWL
7:19					Pump Off
7:50	18.69	6.52			SWL

60-min. specific capacity: 95.9 gpm/ft

Comments: 8.8 gpm/ft increase (10%). Treatment concluded.

Well Rehabilitation Field Notes

WELL SITE: I-70 Well 11A — OBSERVER: Bob Olson

CONTRACTOR: Layne-Western Company, Inc.

MEASURING POINT: Access hole in temporary wellhead about 4.95 ft above pit cover

MEASURING EQUIPMENT: Layne 6x5 orifice tube, steel tape

1. SPECIFIC CAPACITY TEST — DATE: 8/5/94

Time	Depth (ft)	Drawdown (ft)	Piezometer tube (in.)	Pumping rate (gpm)	Remarks
7:59 AM	29.90				SWL
8:00			24.5	616	Pump On
8:24			24.5	616	
8:55			24.5	616	
9:05	60.99	31.09			PWL

Notes: All specific capacity tests--static water level (SWL) measured after minimum 30-min. period of well inactivity. Minimum period of pumpage for drawdown measurements is 60 min.

60-min. specific capacity: 19.8 gpm/ft

Comments: None

2. 400 LB POLYPHOSPHATE APPLICATION — DATE: 8/5/94

A. INITIAL CHLORINATION

Quantity: 2,000 gal — Strength: 500 mg/L

Time - initial: 9:09:46 AM — Injection rate: 2,105 gpm
- complete: 9:10:43 AM

Comments: I-70 Well 13 is supply well for treatment

B. POLYPHOSPHATE INJECTION, 400 lb total

	Batch 1	Batch 2
Phosphate:	200 lb	200 lb
Quantity H_2O:	2,000 gal	2,000 gal
Time - initial:	9:19:41 AM	9:24:02 AM
- complete:	9:20:59 AM	9:30:05 AM
Injection rate:	1,538 gpm	1,905 gpm

Comments: None

C. DISPLACEMENT, 16,000 gal chlorinated water (500 mg/L)

Time - initial/complete	Quantity (gal)	Q (gpm)
9:43:03/9:44:20 AM	2,000	1,558
9:52:41/9:54:13	2,000	1,304
10:02:15/10:03:29	2,000	1,622
10:11:35/10:12:49	2,000	1,622
10:20:30/10:21:59	2,000	1,348
10:29:04/10:29:45	1,000*	1,463
10:33:50/10:35:45	1,000	522

Comments: *Injection rate decreased because of increased back pressure - 20 psi on pressure gauge. Water in pit. During 10:29:04 injection, noticed water flowing up around pit on ground. Last two injections were reduced to partial loads for this reason. Because of the continued upflow of water around the pit, it was decided it was safest to discontinue injections and begin surging after 1 hour contact time.

D. SURGING, cycles of 2,000 gal each

Well to tank		**Tank to well**	
Time - initial/complete	Q (gpm)	Time - initial/complete	Q (gpm)
11:42:05/11:43:25 AM	1,500	11:43:40/11:44:53 AM	1,644
11:58:20 AM/12:00:07 PM	1,121	12:00:25/12:01:37 PM	1,667
12:02:50/12:04:50 12:04:45/12:05:58 〉*	811	12:06:35/12:07:37	1,935
12:09:58/12:11:47	1,101	12:12:00/12:13:12	1,667
12:14:44/12:16:43	1,008	12:17:02/12:18:07	1,846
12:20:17/12:22:05	1,111	12:22:19/12:23:26	1,791
12:27:38/12:29:27	1,101	12:29:39/12:30:45	1,818
12:32:03/12:34:13	923	12:34:21/12:35:27	1,818
12:37:13/12:38:05	2,308	12:38:20/12:40:25	960
12:43:18/12:45:03	1,143	12:45:22/12:46:30	1,765
12:48:07/12:50:01	1,053	12:50:15/12:51:25	1,714
12:53:19/12:55:05	1,132	12:55:24/12:56:23	2,034
12:58:10/1:00:05	1,043	1:00:27/1:01:24	2,105
1:04:05/1:06:07	984	1:06:22/1:07:16	2,222

1:10:11/1:12:00	1,101	1:12:20/1:13:16	2,143
1:15:13/1:17:01	1,111	1:17:15/1:18:14	2,034
1:20:03/1:21:59	1,034	1:22:19/1:23:12	2,264
1:24:05/1:26:57	698	1:27:16/1:28:12	2,143
1:30:04/1:31:58	1,053	1:32:25/1:33:25	2,000
1:41:18/1:43:10	1,071	1:43:30/1:44:26	2,143
1:45:58/1:47:57	1,008	1:48:13/1:49:13	2,000
1:50:58/1:52:46	1,111	1:53:03/1:54:15	1,667

Comments: *Gasing caused pump to air lock. Must stop and restart pump to fill tank.

E. PUMPED TO WASTE

Time - initial: 2:05 PM (8/5)
- complete: ?

Q - initial: 659 gpm   Quantity: ?
- complete:

Comments: Pump was off upon arrival in morning on 8/8/94

3. SPECIFIC CAPACITY TEST   DATE: 8/8/94

Time	Depth (ft)	Drawdown (ft)	Piezometer tube (in.)	Pumping rate (gpm)	Remarks
8:09 AM	28.80				SWL
8:23					Pump On
8:30			22.5	590	
9:30			21.5	577	
9:56	39.20	10.4			PWL

60-min. specific capacity: 55.5 gpm/ft

Comments: 35.7 gpm/ft increase (180%)

4. ACIDIZATION - INHIBITED MURIATIC ACID   DATE: 8/9/94

A. ACID INJECTION

Acid strength: 20° Baume   Quantity: 1,000 gal

Time - initial: 9:19:10 AM   Q: 128 gpm
- complete: 9:27:00 AM

Comments: Acid injected from delivery tanker into the well through the treatment pump. Back-siphoned 200-300 gal water down well pump to flush acid out of lines.

B. DISPLACEMENT, 5,000 gal nonchlorinated water

Time - initial/complete	Quantity (gal)	Q (gpm)
10:30:42/10:31:24 AM	2,000	2,857
10:39:04/10:39:58	2,000	2,222
10:43:36/10:44:04	1,000	2,143

Comments: None

C. SURGING, cycles of 2,000 gallons each

Well to tank		**Tank to well**	
Time - initial/complete	Q (gpm)	Time - initial/complete	Q (gpm)
12:44:43/12:46:00 PM	Well pump gas locking		
12:47:47/12:48:35	Well pump gas locking		
12:50:23/12:54:10	529	12:54:37/12:55:40 PM	1,905
12:57:02/1:00:51	524	1:01:07/1:02:11	1,875
1:04:28/1:07:48	600	1:07:48/1:08:50	1,935
1:11:58/1:14:53	686	1:15:04/1:16:07	1,905
1:18:36/1:21:03	816	1:21:19/1:22:18	2,034
1:28:17/1:30:56	755	1:31:13/1:32:08	2,182
1:35:35/1:38:15	750	1:38:33/1:39:35	1,935
1:42:28/1:45:08	750	1:45:30/1:46:32	1,935
1:49:41/1:51:52	916	1:52:03/1:53:59	1,034
1:56:17/1:58:13	1,034	1:58:29/1:59:27	2,069
2:01:54/2:03:56	984	2:03:57/2:05:02	1,846
2:13:18/2:15:27	930	2:15:40/2:16:38	2,069
2:20:30/2:22:35	960	2:22:51/2:23:57	1,818
2:27:46/2:29:52	956	2:30:05/2:31:06	1,967

Comments: None

D. PUMPED TO WASTE

Time - initial: 2:32 PM (8/9)
- complete: 7:56 AM (8/10)

Q - initial: 610 gpm
- complete: 622 gpm

Quantity: 637,000 gal

Comments: Pumped to waste overnight

5. SPECIFIC CAPACITY TEST DATE: 8/10/94

Time	Depth (ft)	Drawdown (ft)	Piezometer tube (in.)	Pumping rate (gpm)	Remarks
7:53 AM	37.95		25.0	622	PWL
7:56					Pump Off
8:28	29.56	8.39			SWL

60-min. specific capacity: 74.1 gpm/ft

Comments: 18.7 gpm/ft increase (34%)

6. 600 LB POLYPHOSPHATE APPLICATION DATE: 8/10/94

A. INITIAL CHLORINATION

Quantity: 2,000 gal Strength: 500 mg/L

Time - initial: 8:30:35 AM Injection rate: 1,905 gpm
- complete: 8:31:38 AM

B. POLYPHOSPHATE INJECTION, 600 lb total

	Batch 1	Batch 2	Batch 3
Phosphate:	200 lb	200 lb	200 lb
Quantity H_2O:	2,000 gal	2,000 gal	2,000 gal
Time - initial:	8:37:03 AM	8:45:18 AM	8:52:45 AM
- complete:	8:37:47 AM	8:46:05 AM	8:53:26 AM
Injection rate:	2,727 gpm	2,553 gpm	2,927 gpm

Comment: None

C. DISPLACEMENT, 30,000 gal chlorinated water (500 mg/L)

Time - initial/complete	Quantity (gal)	Q (gpm)
9:00:33/9:01:25 AM	2,000	2,308
9:08:39/9:09:29*	2,000	2,400
9:16:15/9:17:03	2,000	2,500
9:24:00/9:24:55	2,000	2,182
9:31:47/9:32:38	2,000	2,353
9:39:44/9:40:34	2,000	2,400
9:47:42/9:48:36	2,000	2,222
9:55:57/9:57:00*	2,000	1,905
10:04:27/10:05:39	2,000	1,667

10:12:56/10:13:57	2,000	1,967
10:21:35/10:22:27	2,000	2,308
10:29:35/10:10:31*	2,000	2,143
10:38:02/10:39:04	2,000	1,935
10:46:48/10:47:45	2,000	2,105
10:55:23/10:56:22	2,000	2,034

Comments: Some seepage evident around well vault at ground surface and into bottom of vault. Some sand washed into vault. 20 psi back pressure registered on rig pressure gauge. *Begin using new 55 gal drum chlorine.

D. SURGING, cycles of 2,000 gal each

Well to tank		**Tank to well**	
Time - initial/complete	Q (gpm)	Time - initial/complete	Q (gpm)
12:02:50/12:04:38 PM	1,111	12:05:00/12:05:59 PM	2,034
12:09:31/12:11:23	1,071	12:11:37/12:12:26	2,449
12:16:00/12:17:52	1,071	12:18:11/12:18:58	2,553
12:23:35/12:25:27	1,071	12:25:40/12:26:35	2,182
12:32:14/12:34:04	1,091	12:34:19/12:35:07	2,500
12:41:16/12:43:13	1,026	12:43:52/12:44:44	2,308
12:45:25/12:47:53	811	12:48:08/12:48:57	2,449
12:53:22:12:55:15	1,062	12:55:34/12:56:26	2,308
1:00:41/1:02:26	1,143	1:02:45/1:03:34	2,449
1:06:53/1:08:44	1,071	1:09:00/1:09:50	2,400
1:12:33/1:14:24	1,081	1:14:40/1:15:37	2,105
1:18:33/1:20:23	1,091	1:20:43/1:21:31	2,500
1:24:35/1:26:24	1,101	1:26:36/1:27:27	2,353
1:33:37/1:35:27	1,091	1:35:42/1:36:37	2,182
1:46:03/1:47:52	1,101	1:48:11/1:49:02	2,353
1:53:57/1:55:44	1,121	1:56:03/1:56:57	2,222
2:00:02/2:01:55	1,062	2:02:03/2:02:55	2,308
2:06:02/2:07:48	1,132	2:07:59/2:08:50	2,353

Comments: None

E. PUMPED TO WASTE

Time - initial: 2:11 PM (8/10)(25")
- complete: 7:50 AM (8/11)

Q: 622 gpm   Quantity: 659,000 gal

Comments: None

I-70 Well 11A (Concluded)

7. SPECIFIC CAPACITY TEST DATE: 8/11/94

Time	Depth (ft)	Drawdown (ft)	Piezometer tube (in.)	Pumping rate (gpm)	Remarks
7:47 AM	37.85		25.0	622	
7:50	37.83				Pump Off - PWL
8:25	29.72	8.11			SWL

60-min. specific capacity: 76.7 gpm/ft

Comments: 2.6 gpm/ft increase (3%). Treatment concluded.

Well Rehabilitation Field Notes

WELL SITE: I-70 Well 15 OBSERVER: Bob Olson

CONTRACTOR: Layne-Western Company, Inc.

MEASURING POINT: Access hole in temporary wellhead about 0.95 ft above pit cover

MEASURING EQUIPMENT: Layne 6x5 orifice tube, steel tape

1. SPECIFIC CAPACITY TEST DATE: 8/23/94

Time	Depth (ft)	Drawdown (ft)	Piezometer tube (in.)	Pumping rate (gpm)	Remarks
7:12 AM	17.06				SWL
7:13			26.0	635	Pump On
7:45			25.0	622	
8:18	42.30	25.24			PWL

Notes: All specific capacity tests--static water level (SWL) measured after minimum 30-min. period of well inactivity. Minimum period of pumpage for drawdown measurements is 60 min.

60-min. specific capacity: 24.6 gpm/ft

Comments: Layne-Western reported that the well pump had a lot of iron deposits on it. The pump would not run before it was pulled.

2. 400 LB POLYPHOSPHATE APPLICATION DATE: 8/23/94

A. INITIAL CHLORINATION

Quantity: 2,000 gal Strength: 500 mg/L

Time - initial: 8:20:42 AM Injection rate: 1,304 gpm
- complete: 8:22:19 AM

Comments: None

B. POLYPHOSPHATE INJECTION, 400 lb total

	Batch 1	Batch 2
Phosphate:	200 lb	200 lb
Quantity H_2O:	2,000 gal	2,000 gal
Time - initial:	8:27:47 AM	8:36:13 AM
- complete:	8:29:07 AM	8:38:43 AM
Injection rate:	1,500 gpm	800 gpm

Comments: Well taking water very slowly

C. DISPLACEMENT, 16,000 gal chlorinated water (500 mg/L)

Time - initial/complete	Quantity (gal)	Q (gpm)
8:44:10/8:46:39 AM	2,000	805
8:51:55/8:54:05	2,000	923
8:59:38/8:02:07	2,000	805
9:07:20/9:09:32	2,000	909
9:15:00/9:17:31	2,000	795
9:22:52/9:25:01	2,000	930
9:30:19/9:32:22	2,000	976
9:37:39/9:39:06	2,000	1,379

Comments: None

D. SURGING, cycles of 2,000 gal each

Well to tank		**Tank to well**	
Time - initial/complete	Q (gpm)	Time - initial/complete	Q (gpm)
10:41:28/10:43:00 AM	1,304	10:43:18/10:44:25 AM	1,791
10:46:41/10:48:14	1,290	10:48:59/10:50:06	1,791
10:53:42/10:55:12	1,333	10:55:27/10:56:45	1,538
11:00:43/11:02:11	1,364	11:02:58/11:03:59	1,967
11:06:57/11:08:23	1,395	11:08:51/11:09:57	1,818
11:11:40/11:13:13	1,290	11:13:32/11:14:37	1,846
11:16:40/11:18:07	1,379	11:18:24/11:19:28	1,875
11:20:41/11:22:09	1,364	11:22:25/11:23:26	1,967
11:24:40/11:26:09	1,348	11:26:32/11:27:31	2,034
11:28:40/11:30:09	1,348	11:30:33/11:31:30	2,105
11:32:41/11:34:08	1,379	11:34:34/11:35:33	2,034
11:37:35/11:39:07	1,304	11:39:36/11:40:33	2,105
11:42:40/11:44:07	1,379	11:44:37/11:45:33	2,143
11:47:40/11:49:07	1,379	11:49:40/11:50:37	2,105
11:51:40/11:53:08	1,364	11:53:33/11:54:31	2,069
11:55:40/11:57:07	1,412	11:57:32/11:58:32	2,000
12:05:45/12:07:12 PM	1,379	12:07:47/12:08:49 PM	1,935
12:10:40/12:12:06	1,395	12:12:19/12:13:20	1,967

12:15:40/12:17:08	1,364	12:17:32/12:18:25	2,264
12:19:40/12:21:08	1,364	12:21:32/12:22:23	2,353
12:23:39/12:25:04	1,412	12:25:34/12:26:23	2,449
12:27:40/12:29:03	1,446	12:29:24/12:30:13	2,449
12:31:40/12:33:08	1,364	12:33:37/12:34:26	2,449
12:35:39/12:37:04	1,412	12:37:21/12:38:11	2,400
12:39:39/12:41:04	1,412	12:41:24/12:42:17	2,264

Comments: None

E. PUMPED TO WASTE

Time - initial: 12:43 PM (8/23)
- complete: 7:27 AM (8/24)

Q - initial: 641 gpm
- complete: 635 gpm

Quantity: 714,000 gal

Comments: None

3. SPECIFIC CAPACITY TEST — DATE: 8/24/94

Time	Depth (ft)	Drawdown (ft)	Piezometer tube (in.)	Pumping rate (gpm)	Remarks
7:27 AM	26.72		26.0	635	PWL
8:01	18.45	8.27			SWL

60-min. specific capacity: 76.8 gpm/ft

Comments: 52.1 gpm/ft increase (212%)

4. ACIDIZATION - INHIBITED MURIATIC ACID — DATE: 8/24/94

A. ACID INJECTION

Acid strength: 20° Baume

Quantity: 1,000 gal

Time - initial: 9:01:25 AM
- complete: 9:44:15 AM

Q: 23 gpm

Comments: Approximately 500 gal run through lines to clear of acid

B. DISPLACEMENT, 4,500 gal nonchlorinated water

Time - initial/complete	Quantity (gal)	Q (gpm)
9:46:49/9:47:58 AM	2,000	1,739
9:53:32/9:54:50	2,000	1,538

Comments: None

C. SURGING, cycles of 2,000 gal each

Well to tank		**Tank to well**	
Time - initial/complete	Q (gpm)	Time - initial/complete	Q (gpm)
12:56:53/12:57:15 PM	Well pump gas locked		
1:00:55/1:02:07	Well pump gas locked		
1:03:25/1:04:09	Well pump gas locked		
1:05:11/1:07:50	755	1:08:11/1:09:08 PM	2,105
1:10:14/1:12:59	727	1:13:25/1:14:20	2,182
1:15:39/1:18:58	603	1:19:22/1:20:18	2,143
1:22:07/1:25:07	667	1:25:20/1:26:21	1,967
1:28:31/1:31:38	642	1:32:00/1:32:55	2,182
1:35:37/1:38:45	577	1:38:59/1:39:50	2,353
1:43:03/1:45:57	690	1:46:10/1:47:04	2,222
1:48:11/1:51:03	698	1:51:17/1:52:10	2,264
1:53:06/1:55:52	723	1:56:08/1:57:01	2,264
1:59:35/2:02:20	727	2:02:38/2:03:32	2,222
2:05:29/2:08:19	706	2:08:44/2:09:30	2,609
2:11:38/2:13:55	876	2:14:14/2:15:07	2,264
2:16:11/2:18:39	811	2:18:57/2:19:47	2,400
2:21:02/2:23:02	1,000	2:23:19/2:24:15	2,143

Comments: Well blowing gas and water from well

D. PUMPED TO WASTE

Time - initial: 2:25 PM (8/24)
- complete: 7:15 AM (8/25)

Q - initial: 641 gpm
- complete: 635 gpm

Quantity: 641,000 gal

Comments: None

5. SPECIFIC CAPACITY TEST DATE: 8/25/94

Time	Depth (ft)	Drawdown (ft)	Piezometer tube (in.)	Pumping rate (gpm)	Remarks
7:15 AM	25.00				PWL - Pump Off
7:45	18.83	6.17	26.0	635	SWL (Data collected by Layne-Western)

60-min. specific capacity: 102.9 gpm/ft

Comments: 26.1 gpm/ft increase (34%)

6. 600 LB POLYPHOSPHATE APPLICATION DATE: 8/25/94

A. INITIAL CHLORINATION

Quantity: 2,500 gal Strength: 500 mg/L

Time - initial: 7:51:30 AM Injection rate: 2,500 gpm
- complete: 7:52:30 AM

B. POLYPHOSPHATE INJECTION, 600 lb total

	Batch 1	Batch 2	Batch 3
Phosphate:	200 lb	200 lb	200 lb
Quantity H_2O:	2,000 gal	2,000 gal	2,000 gal
Time - initial:	7:58:00 AM	8:05:00 AM	8:10:30 AM
- complete:	7:59:30 AM	8:06:30 AM	8:11:30 AM
Injection rate:	1,333 gpm	1,333 gpm	2,000 gpm

Comment: Data for this application and displacement of polyphosphate collected by Layne-Western

C. DISPLACEMENT, 30,000 gal chlorinated water (500 mg/L)

Time - initial/complete	Quantity (gal)	Q (gpm)
8:17:00/8:18:00 AM	2,000	2,000
8:23:30/8:24:30	2,000	2,000
8:30:00/8:31:00	2,000	2,000
8:36:30/8:37:30	2,000	2,000
8:43:00/8:44:00	2,000	2,000
8:49:30/8:50:30	2,000	2,000

8:56:00/8:57:00	2,000	2,000
9:02:30/9:03:30	2,000	2,000
9:09:00/9:10:00	2,000	2,000
9:15:30/9:16:30	2,000	2,000
9:22:00/9:23:00	2,000	2,000
9:28:30/9:29:30	2,000	2,000
9:35:00/9:36:00	2,000	2,000
9:41:50/9:42:30	2,000	3,000
9:48:00/9:49:00	2,000	2,000

Comments: None

D. SURGING, cycles of 2,000 gal each

Well to tank		**Tank to well**	
Time - initial/complete	Q (gpm)	Time - seconds	Q (gpm)
10:50:00/10:51:30 AM	1,333	50	2,400
10:55:00/10;56:30	1,333	50	2,400
11:00:00/11:01:30	1,333	50	2,400
11:05:00/11:06:30	1,333	50	2,400
11:10:00/11:11:30	1,333	50	2,400
11:15:00/11:16:30	1,333	50	2,400
11:20:00/11:21:30	1,333	50	2,400
11:25:00/11:26:30	1,333	50	2,400
11:30:00/11:31:30	1,333	50	2,400
11:35:00/11:36:30	1,333	50	2,400
11:40:00/11:41:30	1,333	50	2,400
11:45:00/11:46:30	1,333	50	2,400
11:50:00/11:51:30	1,333	50	2,400
11:55:00/11:56:30	1,333	50	2,400
12:00:00/12:01:30 PM	1,333	50	2,400
12:05:00/12:06:30	1,333	50	2,400
12:10:00/12:11:30	1,333	50	2,400
12:15:00/12:16:30	1,333	50	2,400
12:20:00/12:21:30	1,333	50	2,400
12:25:00/12:26:30	1,333	50	2,400
12:30:00/12:31:30	1,333	50	2,400
12:35:00/12:36:30	1,333	50	2,400
12:40:00/12:41:30	1,333	50	2,400
12:45:00/12:46:30	1,333	50	2,400
12:50:00/12:51:30	1,333	50	2,400

Comments: None

E. PUMPED TO WASTE

Time - initial: 12:53 PM (8/25)
- complete: 7:15 AM (8/26)

Q: 635 gpm | Quantity: 784,000 gal

Comments: None

7. SPECIFIC CAPACITY TEST — DATE: 8/26/94

Time	Depth (ft)	Drawdown (ft)	Piezometer tube (in.)	Pumping rate (gpm)	Remarks
7:15 AM	24.17		26.0	635	PWL - Pump Off
7:48	19.05	5.12			SWL

60-min. specific capacity: 124.0 gpm/ft

Comments: 21.1 gpm/ft increase (21%)

8. 600 LB POLYPHOSPHATE APPLICATION — DATE: 8/26/94

A. INITIAL CHLORINATION

Quantity: 2,000 gal | Strength: 500 mg/L

Time - initial: 7:59:45 AM | Injection rate: 1,412 gpm
- complete: 8:01:10 AM

B. POLYPHOSPHATE INJECTION, 600 lb total

	Batch 1	Batch 2	Batch 3
Phosphate:	200 lb	200 lb	200 lb
Quantity H_2O:	2,000 gal	2,000 gal	2,000 gal
Time - initial:	8:06:58 AM	8:13:35 AM	8:19:50 AM
- complete:	8:07:50 AM	8:14:20 AM	8:20:40 AM
Injection rate:	2,308 gpm	2,667 gpm	2,400 gpm

Comment: None

I-70 Well 15 (Continued)

C. DISPLACEMENT, 54,000 gal chlorinated water (500 mg/L)

Time - initial/complete	Quantity (gal)	Q (gpm)
8:26:06/8:27:05 AM	2,000	2,034
8:32:52/8:33:42	2,000	2,400
8:39:01/8:39:56	2,000	2,182
8:45:39/8:46:28	2,000	2,449
8:51:47/8:52:45	2,000	2,069
8:57:44/8:58:36	2,000	2,308
9:03:45/9:04:36	2,000	2,353
9:09:43/9:10:31	2,000	2,500
9:15:36/9:16:57	2,000	1,481
9:22:55/9:23:44	2,000	2,449
9:28:03/9:29:52	2,000	1,101
9:35:11/9:36:00	2,000	2,449
9:41:19/9:42:12	2,000	2,264
9:47:37/9:48:30	2,000	2,264
9:53:52/9:54:43	2,000	2,353
10:00:04/10:00:56	2,000	2,308
10:06:15/10:07:09	2,000	2,222
10:12:26/10:13:26	2,000	2,000
10:19:12/10:20:02	2,000	2,400
10:25:15/10:26:01	2,000	2,609
10:31:13/10:32:05	2,000	2,308
10:37:35/10:38:25	2,000	2,400
10:43:30/10:44:18	2,000	2,500
10:49:26/10:50:16	2,000	2,400
10:55:24/10:56:12	2,000	2,500
11:01:37/11:02:28	2,000	2,353
11:07:45/11:08:37	2,000	2,308

Comments: Pressure (23 psi) building up in pump discharge line. Used five 55-gal barrels chlorine.

D. SURGING, cycles of 2,000 gal each

Well to tank		**Tank to well**	
Time - initial/complete	Q (gpm)	Time - initial/complete	Q (gpm)
12:10:28/12:11:57 PM	1,348	12:12:20/12:13:10 PM	2,400
12:14:46/12:16:15	1,348	12:16:36/12:17:20	2,727
12:19:44/12:21:05	1,481	12:21:27/12:22:15	2,500
12:24:44/12:26:09	1,412	12:26:27/12:27:14	2,553
12:29:45/12:31:10	1,412	12:31:30/12:32:13	2,791
12:34:45/12:36:11	1,395	12:36:36/12:37:19	2,791
12:39:44/12:41:10	1,395	12:41:25/12:42:10	2,667
12:44:46/12:46:08	1,463	12,46:24/12:47:10	2,609
12:49:43/12:51:08	1,412	12:51:39/12:52:23	2,727

12:54:43/12:56:09	1,395	12:56:33/12:57:17	2,727
12:59:41/1:01:09	1,364	1:01:32/1:02:17	2,667
1:04:42/1:06:09	1,379	1:06:27/1:07:12	2,667
1:09:49/1:11:13	1,429	1:11:30/11:12:16	2,609
1:14:40/1:16:05	1,412	1:16:27/1:17:14	2,553
1:19:40/1:21:05	1,412	1:21:30/1:22:15	2,667
1:24:41/1:26:07	1,395	1:26:52/1:27:37	2,667
1:29:39/1:31:05	1,395	1:31:25/1:32:14	2,449
1:34:39/1:36:03	1,429	1:36:29/1:37:16	2,553
1:39:40/1:41:07	1,379	1:41:29/1:42:14	2,667
1:44:48/1:46:13	1,412	1:46:35/1:47:19	2,727
1:49:41/1:51:06	1,412	1:51:36/1:52:14	3,158
1:54:39/1:56:05	1,395	1:56:55/1:57:40	2,667
1:59:39/2:01:02	1,446	2:01:22/2:02:07	2,667
2:04:39/2:06:04	1,412	2:06:25/2:07:13	2,500
2:09:37/2:11:04	1,379	2:11:22/2:12:09	2,553

Comments: None

E. PUMPED TO WASTE

Time - initial: 2:15 PM (26.5") - 641 gpm
- complete: 7:10 AM (8/29)

Q: 635 gpm   Quantity: 2,470,000 gal

Comments: None

9. SPECIFIC CAPACITY TEST   DATE: 8/29/94

Time	Depth (ft)	Drawdown (ft)	Piezometer tube (in.)	Pumping rate (gpm)	Remarks
7:10 AM	24.58		26.0	635	PWL - Pump off
7:43	19.78	4.80			SWL

60-min. specific capacity: 132.3 gpm/ft

Comments: 8.3 gpm/ft increase (7%). Treatment concluded.

Appendix E

Chemical Quality Data
FY 84 - FY 95 (Phases 1-12)

Appendix E. Chemical Quality Data, FY 84-FY 95 (Phases 1-12)

Well	*Date*	*Lab No.*	*Iron*	*Manganese*	*Calcium*	*Magnesium*	*Sodium*	*Silica*	*Nitrate*	*Chloride*	*Sulfate*	*Alkalinity**	*Hardness**	*TDS*
I-70 Site														
1	08/15/84	220249	10.20		201	45.0	124.0	29.8	3.7	136	320	480	687	1203
1	08/14/85	221273	10.98		218	48.0	112.0	23	2.9	140	360	488	741	1279
1	05/17/89	223086	6.02	1.40	177	37.6	118.0	28.6	1.6	85	347	479	596	1046
1A	04/26/95	228642	11.33	1.49	232	48.7	182	33.3	0.20	192	369	510	779	1446
2	07/19/83	218825	11.90		180	40.0	127.0	31.4		131	290	464	614	1105
2	08/15/85	221272	5.55		182	42.4	124.0	20		140	360	464	628	1159
2	06/20/88	222598	11.20	1.20	177	40.0	110.0	30.9	0.4	138	246	465	606	1088
2	02/01/89	222892	10.60	0.61	160	45.0	68.9	28.9	0.2	128	261	395	584	967
2A	11/16/93	227238	14.00	1.35	228	49.6	176	36.9	0.03	200	299	482	773	1308
2A	08/22/94	227955	12.54	1.32	216	45.8	208	31.8	0.05	234	354	507	727	1435
3	06/28/83	218685	14.40		224	52.2	112.0	32.8		198	307	440	774	1238
3	06/24/86	221686	14.80	0.86	162	40.0	180.0	31.6		230	300	444	569	1250
3	01/14/87	221954	8.70	0.81	211	40.8	99.0	31.6		154	266	416	694	1074
3	12/11/89	223290	7.57	0.76	162	38.8	33.2	32		69	222	385	564	826
3	04/17/90	223481	6.11	0.71	156	35.2	45.2			87	188	369	534	834
3A	10/29/93	227203	12.83	0.83	175	41.0	38.5	35.0	<0.02	53.1	175	374	605	877
3A	08/17/94	227954	12.57	0.87	175	41.1	34.7	33.6	<0.02	67.0	235	371	605	870
4	08/17/84	220250	9.20		197	46.2	62.8	29.7	0.7	125	247	408	632	982
4	01/08/87	221949	6.90	0.95	219	40.0	33.6	29.6	0.9	79	221	369	711	854
4	05/11/95	228699	13.18	0.83	153	38.1	26.2	34.8	<0.02	73.6	153	349	538	743
5	07/10/84	220112	11.60		148	37.2	29.3	32		84	169	336	524	775
5	01/13/87	221953	7.50	0.88	187	38.8	33.2	31.1	1.2	83	195	360	626	787
5	02/02/89	222891	7.73	1.07	175	38.2	124.0	30		113	305	495	594	1099
5	10/14/93	227164	13.36	0.54	163	43.4	61.7	37.1	0.3	106	151	404	585	883
5	05/10/95	228698	15.94	0.87	209	54.3	90.7	34.1	<0.02	198	188	493	744	1149
6	08/01/90	223646	10.80	0.44	152	40.5	55.5		0.3	58	242	355	546	858
6	10/29/91	225019	11.52	0.47	158	40.7	55.0	30.7	<0.1	81.0	218	363	562	839
6	05/12/95	228701	11.91	0.45	153	41.2	54.6	30.4	<0.02	64.9	192	386	551	832
7	06/30/83	218687	12.10		189	41.8	51.7	31.1		77	285	367	643	936
7A	07/23/87	222215	8.30	0.63	152	36.8	50.8	33.8		98	244	355	531	926
7A	06/27/90	223575	10.70	0.87	220	49.2	78.9			76	403	461	751	1198
7A	08/06/91	224511	12.10	0.79	196	43.0	77.9	34.1		98	304	429	666	1075
7A	05/05/94	227595	11.66	0.85	197	41.4	59.5	31.7	0.02	93.5	279	413	662	1005
8	08/01/84	220187	13.50		210	44.5	69.6	30.4		89	332	438	707	1076
8	12/05/85	221485	12.20		193	43.2	65.8	29.8		87	310	412	659	1011
8	06/22/88	222600	15.50	0.80	210	46.5	43.2	31		57	317	451	715	1089
8A	10/04/89	223203	10.59	0.95	208	42.7	72.4	30.8		103	322	457	695	1055
8A	10/01/91	224907	12.70	1.03	201	42.9	104.0	27.0	<0.1	144	317	447	678	1198
8A	12/17/92	226432	14.26	0.84	228	49.8	47.0	36.4	<0.1	67.0	302	441	774	1044
8A	03/16/94	227449	11.54	0.73	194	40.4	48.1	35.3	0.04	73.8	267	374	650	897
9	06/28/84	220091	12.20		178	43.4	81.5	32.2	0.4	108	320	376	623	1082
9A	10/03/89	223202	10.90	0.67	231	49.6	41.0	33.5		63	378	466	780	1099
9A	06/26/90	223574	16.60	0.70	232	54.9	230.0			71	694	522	805	1642
9A	04/26/91	224140	15.24	0.59	224	50.8	40.8	37.2		58	356	440	768	1112
9A	07/23/92	226027	16.96	0.60	232	55.5	76.6	36.4	0.3	64.0	441	477	807	1238
9A	05/12/94	227662	16.6	0.68	239	54.9	51.8	35.7	<0.02	66.5	422	462	822	1218
9A	09/09/94	227970	17.41	0.70	233	55.4	137		<0.02	82.7	521	497	809	1332
10	07/31/84	220186	13.10		202	51.2	47.9	33.3		67	332	424	715	1042
10	09/04/85	221318	16.10		234	58.4	50.4			57	450	432	824	1181
10	08/13/87	222254	11.30	0.60	218	54.4	44.4	36.5	0.2	68	376	424	768	1132
10	01/30/89	222889	11.42	0.56	189	47.0	38.8	33.7		63	354	436	665	1024
10	02/07/91	223980	12.65	0.54	225	56.6	60.4			73	455	424	794	1242
10	08/08/91	224512	14.20	0.54	198	50.4	65.4	35.7		78	399	388	701	1150
10	08/01/95	228881	15.04	0.58	213	52.3	114	37.3	<0.02	71	442	454	746	1280

Appendix E. Chemical Quality Data (Continued)

Fluoride	*Aluminum*	*Arsenic*	*Barium*	*Beryllium*	*Boron*	*Cadmium*	*Chromium*	*Copper*	*Lead*	*Mercury*	*Nickel*	*Potassium*	*Selenium*	*Silver*	*Zinc*	*Well*
																1
																1
																1
0.3	<0.017	<0.11	0.11	<0.003	1.07	<0.017	<0.007	<0.007	<0.066		<0.031	9.2	<0.18	<0.014	<0.02	1A
																2
																2
																2
																2
0.4	0.02	<0.11	0.12		1.03	<0.017	0.02	<0.01	<0.063		<0.031	12.6	<0.18	<0.014	<0.02	2A
0.3	0.018	<0.11	0.11	<0.003	1.01	<0.017	0.020	<0.007	<0.066		<0.031	10.0	<0.18	<0.014	<0.02	2A
																3
																3
																3
																3
																3
0.3	0.02	<0.11	0.08		0.1	<0.017	<0.007	<0.01	<0.063		<0.031	9.8	<0.18	<0.014	<0.02	3A
0.2	<0.017	<0.11	0.08	<0.003	0.29	<0.017	0.018	<0.007	<0.066		<0.031	7.0	<0.18	<0.014	<0.02	3A
																4
																4
0.3	0.03	<0.11	0.07	<0.003	0.20	<0.017	<0.007	<0.007	<0.066		<0.031	3.4	<0.18	<0.014	<0.02	4
																5
																5
																5
0.3	<0.017	<0.11	0.10		0.10	<0.017	0.01	<0.01	<0.063		<0.031	5.9	<0.18	<0.014	<0.02	5
0.3	0.03	<0.11	0.13	<0.003	0.41	<0.017	<0.007	<0.007	<0.066		<0.031	5.2	<0.18	<0.014	<0.02	5
																6
0.3												7.8				6
0.5	0.04	<0.11	0.09	<0.003	0.34	<0.017	<0.007	<0.007	<0.066		<0.031	6.0	<0.18	<0.014	<0.02	6
																7
																7A
																7A
																7A
0.2	<0.017	<0.11	0.12		0.62	<0.017	<0.01	<0.01	<0.066		<0.031	9.0	<0.18	<0.014	<0.02	7A
																8
																8
																8
																8A
0.5																8A
0.7	0.03	<0.11	0.11		0.84	<0.017	<0.007	<0.006	<0.063		<0.031	10.4	<0.18	<0.014	<0.02	8A
0.3	0.03	<0.11	0.10		0.79	<0.017	0.009	<0.01	<0.063		<0.031	8.0	<0.18	<0.014	<0.02	8A
																9
																9A
																9A
																9A
0.7	0.027	<0.11	0.09		0.76	<0.017	<0.007	<0.006	<0.066	<0.05	<0.031	10.1	<0.18	<0.014	<0.02	9A
0.3	0.02	<0.11	0.09		0.98	<0.017	0.008	<0.01	<0.066		0.060	8.5	<0.18	<0.014	<0.02	9A
0.2	0.053	<0.11	0.09	<0.003	0.78	<0.017	0.019	<0.007	<0.066		<0.031	8.3	<0.18	<0.014	0.10	9A
																10
																10
																10
																10
																10
																10
0.2	0.09	<0.11	0.09	<0.003	0.65	<0.017	<0.007	<0.007	<0.066		<0.031	6.5	<0.18	<0.014	<0.02	10

Appendix E. Chemical Quality Data (Continued)

Well	Date	Lab No.	Iron	Manganese	Calcium	Magnesium	Sodium	Silica	Nitrate	Chloride	Sulfate	Alkalinity*	Hardness*	TDS
11	08/02/84	220188	13.10		169	43.0	47.5	31.8		72	270	362	599	893
11	09/05/85	221319	15.90		204	53.3	65.4			57	420	396	728	1127
11	08/12/87	222253	9.00	0.50	170	44.8	55.6	28.6	0.2	102	271	349	608	930
11	01/31/89	222890	9.11	0.55	154	43.0	39.9	32.6		73	300	346	561	889
11A	10/28/93	227202	13.04	0.48	175	44.7	34.3	37.2	<0.02	38.7	192	399	620	912
11A	09/20/94	228172	14.57	0.55	202	52.0	50.8	35.1	<0.02	60.4	367	410	718	1075
12A	06/16/83	218640	13.80		167	46.6	49.4	30.7		67	350	352	608	971
12A	07/30/86	221717	18.10	0.69	172	47.0	86.0	34.4		185	250	360	622	1050
12A	11/16/87	222342	8.50	0.50	158	43.6	62.5	27.3		113	222	316	574	816
12A	05/15/91	224201	11.84	0.48	131	43.8	92.4	33.4	0.2	158	224	341	507	987
12A	08/02/95	228882	10.71	0.63	152	38.7	46.2	34.2	<0.02	82.7	194	338	538	811
13	04/25/91	224138	9.72	0.46	147	37.0	33.2	36.8	0.1	39	184	322	519	736
13	04/25/95	228641	14.29	0.75	213	50.4	123.0	38.0	0.08	73.2	412	491	739	1257
14	12/20/90	223933	8.36	0.97	166	38.7	42.9	26.9	0.6	77	220	368	573	835
14	06/22/94	227793	2.97	1.37	206	47.2	59.8		0.46	83.9	285	422	708	1031
15	10/15/93	227163	18.84	0.75	229	63.8	111	34.4	0.2	140	265	593	834	1234
15	05/11/95	228700	14.40	0.58	180	49.2	89.4	32.2	<0.02	91.2	224	508	651	908
		Average	12.00	0.77	191	45.5	76.9	32.4	0.39	99	302	420	664	1050
		Minimum	2.97	0.44	131	35.2	26.2	20.0	<0.02	39	151	316	507	736
		Maximum	18.84	1.49	239	63.8	230.0	38.0	3.7	234	694	593	834	1642
		No. of samples	71	55	71	71	71	62	40	71	71	71	71	71

I-64 Site

Well	Date	Lab No.	Iron	Manganese	Calcium	Magnesium	Sodium	Silica	Nitrate	Chloride	Sulfate	Alkalinity*	Hardness*	TDS
1	07/21/87	222213	12.30	0.47	221	57.6	40.4	31.9		61	411	456	788	1183
1	09/24/91	224847	16.00	0.53	235	57.3	229	35.1	<0.1	73.0	685.0	504	822	1708
2	07/25/85	221219	16.60		228	56.8	33.1	35.6		50	410	428	802	1098
3	06/26/84	220089	20.00		227	61.8	87.1	33		55	625	428	821	1448
3	06/21/88	222599	18.40	0.60	258	62.0	64.8	33.4	0.4	64	516	461	899	1439
6	07/21/83	218827	17.60		225	60.3	85.4	33.8		45	580	424	809	1323
8	04/15/96	229408	21.04	0.70	295	73.7	487	35.8	<0.02	370	1438	514	1039	2821
9	10/05/83	219087	12.90		202	53.8	29.8	32.9	0.3	41	350	412	725	974
9	08/18/94	227956	16.12	0.55	240	57.5	558		<0.02	389	951	545	835	2624
10	07/11/84	220113	18.70		277	74.1	222.0	32.8		390	636	424	998	1997
11	08/14/84	220248	15.90		220	54.1	45.6	35.2	0.3	61	358	448	771	1111
11	06/16/89	223066	15.00	0.56	215	44.3	44.3	33.4		60	376	501	761	1198
13	07/12/84	220114	15.80		204	53.3	29.8	34.7	2.3	50	361	412	729	1080
14	08/03/90	223648	12.35	0.52	213	47.5	269.0		0.3	61	713	512	727	1762
15	06/29/83	218686	20.00		260	60.8	75.2	35.4		57	585	416	899	1388
15	08/13/85	221271	17.90		254	62.4	119.0	30.5		59	710	420	890	1580
15	07/22/87	222214	14.00	0.60	243	64.0	166.0	33.6		62	787	456	870	1750
		Average	16.51	0.57	236	58.9	152.1	33.8	0.5	115	617	457	834	1558
		Minimum	12.30	0.47	202	44.3	29.8	30.5	<0.1	41	350	412	725	974
		Maximum	21.04	0.70	295	74.1	558.0	35.8	2.3	390	1438	545	1039	2821
		No. of samples	17	8	17	17	17	15	8	17	17	17	17	17

Appendix E. Chemical Quality Data (Continued)

Fluoride	*Aluminum*	*Arsenic*	*Barium*	*Beryllium*	*Boron*	*Cadmium*	*Chromium*	*Copper*	*Lead*	*Mercury*	*Nickel*	*Potassium*	*Selenium*	*Silver*	*Zinc*	*Well*
																11
																11
																11
																11
0.4	0.02	<0.11	0.10		0.17	<0.017	<0.007	<0.01	<0.063		<0.031	10.2	<0.18	<0.014	<0.02	11A
0.1	0.029	<0.11	0.10	<0.003	0.21	<0.017	<0.007	<0.007	<0.066		<0.031	7.1	<0.18	<0.014	<0.02	11A
																12A
																12A
																12A
																12A
0.2	0.03	<0.11	0.08	<0.003	0.35	<0.017	<0.007	<0.01	<0.066		<0.031	5.2	<0.18	<0.014	<0.02	12A
																13
0.3	0.048	<0.11	0.13	<0.003	0.83	<0.017	<0.007	<0.007	<0.066		<0.031	6.1	<0.18	<0.014	<0.02	13
																14
0.3	<0.017	<0.11	0.07		0.62	<0.017	<0.007	<0.01	<0.066		<0.031	6.08	<0.18	<0.014	<0.02	14
0.3	<0.017	<0.11	0.14		0.51	<0.017	0.01	<0.01	<0.063		<0.031	8.5	<0.18	<0.014	<0.02	15
0.3	<0.02	<0.11	0.12	<0.003	0.60	<0.017	0.009	<0.007	<0.066		<0.031	5.6	<0.18	<0.014	<0.02	15
0.3	0.03	<0.11	0.10	<0.003	0.58	<0.017	0.01					7.8	<0.18	<0.014		Avg
0.1	<0.017		0.07		0.10		<0.007	<0.006	<0.063		<0.031	3.4			<0.02	Min
0.7	0.09		0.14		1.07		0.02	<0.01	<0.066		0.060	12.6			0.10	Max
25	23	23	23	12	23	23	23	23	23	1	23	24	23	23	23	No. of samples

																1
1.0																1
																2
																3
																3
																6
0.3	0.19	<0.11	0.11	<0.003	0.67	<0.017	0.009	<0.01	<0.066		<0.031	8.0	<0.18	<0.014	<0.02	8
																9
0.8	0.024	<0.11	0.09	<0.003	0.72	<0.017	<0.018	<0.007	<0.066		<0.031	9.5	<0.18	<0.014	<0.02	9
																10
																11
																11
																13
																14
																15
																15
																15
																Avg
																Min
																Max
3	2	2	2	2	2	2	2	2	2	0	2	2	2	2	2	No. of samples

Appendix E. Chemical Quality Data (Continued)

Well	Date	Lab No.	Iron	Manganese	Calcium	Magnesium	Sodium	Silica	Nitrate	Chloride	Sulfate	Alkalinity*	Hardness*	TDS
25th Street Site														
1	02/11/89	223141	8.50	0.66	166	46.8	120.0		0.2	34	548	415	607	1226
1	09/04/91	224802	15.10	0.55	200	55.7	262.0	34.0	<0.1	28.9	850	419	728	1777
2	08/09/89	223142	8.10	0.52	205	59.9	251.0		0.2	37	928	451	758	1816
2	04/18/90	223480	5.40	0.39	240	68.8	226.0			35	972	451	882	1891
3	09/06/85	221320	17.90		222	61.9	143.0			38	680	404	808	1484
3	09/07/89	223167	14.90	0.62	246	66.9	254.0	32.1		47	939	474	889	1925
3	05/14/91	224200	22.90	0.72	179	73.1	314.0	35.7		49	1171	477	747	2335
3	12/19/90	223932	18.30	0.69	239	65.2	220.0	31.2		33	911	449	864	1911
4	08/02/90	223647	14.90	0.62	250	66.8	276.0		0.1	39	944	457	898	2032
4	11/19/91	225122	9.04	0.56	175	47.3	75.0	36.4	<0.1	34	353	397	631	993
4	07/24/92	226026	17.69	0.64	234	61.4	261	35.1	<0.1	44	902	475	836	1880
5	05/16/89	223085	8.90	0.57	137	38.9	15.7	32.1		24	181	369	502	688
5	04/19/90	223479	4.90	0.49	129	35.4	16.5			23	160	360	467	661
6	06/27/84	220090	10.50		132	38.0	14.2	34		24	176	334	486	663
6	01/07/87	221948	8.40	0.36	152	38.0	15.2	33.3		26	167	334	536	644
6	02/08/91	223981	9.30	0.39	139	39.2	15.1			32	201	331	508	683
7	03/21/91	224038	12.20	0.45	145	43.1	22.3	33.4		48	191	331	539	738
8	06/15/83	218639	9.10		124	38.7	16.6	33.4		21	185	356	469	659
8	04/24/91	224139	11.90	0.78	134	39.1	17.4	38.1	0.2	31	122	351	495	612
8	11/15/93	227237	12.19	0.70	152	44.8	22.7	39.4	0.03	41.9	155	360	564	682
9	06/25/86	221687	18.90	0.82	123	42.0	17.5	32.5		21	190	352	480	688
9	09/18/91	224803	12.20	0.54	156	45.8	58.6	34.0	<0.1	28.9	325	369	578	911
10	07/26/85	221220	16.50		193	53.6	179.0	33.9		30	660	412	702	1408
10	11/18/87	222344	4.50	0.50	176	52.5	153.0	32.7	0.2	39	571	406	655	1332
		Average	12.18	0.58	177	51.0	123.6	34.2	0.1	34	520	397	651	1235
		Minumum	4.50	0.36	123	35.4	14.2	31.2	<0.1	21	122	331	467	612
		Maximum	22.90	0.82	250	73.1	314.0	39.4	0.2	49	1171	477	898	2335
		No. of samples	24	20	24	24	24	17	10	24	24	24	24	24

Appendix E. Chemical Quality Data (Continued)

Fluoride	*Aluminum*	*Arsenic*	*Barium*	*Beryllium*	*Boron*	*Cadmium*	*Chromium*	*Copper*	*Lead*	*Mercury*	*Nickel*	*Potassium*	*Selenium*	*Silver*	*Zinc*	*Well*
																1
0.8																1
																2
																2
																3
																3
																3
																3
																4
0.4																4
1.1	0.029	<0.11	0.12		0.22	<0.017	<0.007	<0.006	<0.066	<0.05	<0.031	9.4	<0.18	<0.014	<0.02	4
																5
																5
																6
																6
																6
																7
																8
																8
0.4	0.04	<0.11	0.09		0.08	<0.017	0.02	<0.01	<0.063		<0.031	6.0	<0.18	<0.014	<0.02	8
																9
0.3																9
																10
																10
0.6	0.035	<0.11	0.10		0.15	<0.017					<0.031	7.7	<0.18	<0.014	<0.02	Avg
0.3	0.029		0.09		0.08							6				Min
1.1	0.04		0.12		0.22							9.4				Max
5	2	2	2	0	2	2	2	2	2	1	2	2	2	2	2	No. of samples

Appendix E. Chemical Quality Data (Continued)

Venice Site

Well	Date	Lab No.	Iron	Manganese	Calcium	Magnesium	Sodium	Silica	Nitrate	Chloride	Sulfate	Alkalinity*	Hardness*	TDS
1	11/30/83	219239	25.70		256	61.2	38.3	26.7		66	465	444	890	1241
1	12/04/85	221486	17.80		226	60.8	36.8	33		59	460	420	814	1169
1	09/06/89	223166	17.36	0.55	220	53.6	35.2	31.4		43	372	475	769	1114
1	03/29/94	227474	18.40	0.65	207	47.0	32.6	36.5	<0.02	36.4	330	417	710	955
2	11/17/83	219213	21.60		261	54.2	30.1	31.8	0.8	42	440	476	874	1195
2	09/05/89	223165	23.80	0.60	199	50.9	39.6	32.6		50	328	470	706	1002
2	05/08/90	223505	15.10	0.66	193	44.9	35.8			44	297	462	666	970
2	10/02/91	224908	17.20	0.65	193	42.2	34.9	30.8	<0.1	53.1	273	445	655	984
2	06/21/94	227790	18.54	0.76	213	44.2	37.0	37.8	<0.02	43.9	227	454	713	878
3	11/28/83	219237	20.10		216	51.7	65.1	26.6	0.3	79	325	472	752	1097
3	01/06/87	221947	15.30	0.56	253	52.0	39.2	34.3		55	343	469	845	1060
3	12/05/90	223911	17.10	0.55	194	46.7	49.5	37.9		57	218	461	676	972
3	12/16/91	225267	8.28	0.39	182	46.9	34.0	39.6	<0.1	73.6	249	399	647	890
3	07/01/94	227791	16.96	0.51	198	50.9	46.1		<0.02	46.5	289	389	703	957
4	12/01/83	219241	20.70		208	52.8	50.0	25.3	0.6	86	330	424	735	1054
4	12/06/90	223912	10.93	0.52	196	47.9	40.9	34.6		62	284	417	686	950
4	09/17/91	224804	15.00	0.45	180	45.2	44.5	32.3		85	311	400	635	999
4	05/11/94	227661	18.4	0.52	195	48.6	43.6	38.4	<0.02	71.9	245	424	686	971
5	11/15/83	219212	20.30		224	55.8	38.5	31.8		65	380	428	788	1104
5	12/07/89	223289	11.00	0.52	185	50.6	44.7	31.6		68	313	425	670	990
5	05/02/90	223504	15.10	0.58	187	50.9	50.2			74	314	443	676	1011
5	03/24/92	225674	17.60	0.56	198	50.9	47.7	34.9	0.1	124	490	418	703	982
6	11/29/83	219238	22.70		226	56.0	38.1	24.4		62	410	402	794	1138
6	11/17/87	222343	9.60	0.40	196	55.4	41.3	33.8		55	419	387	717	1087
6A	03/20/91	224037	15.40	0.48	184	48.2	45.6	33.2		62	284	400	657	958
6A	06/23/94	227792	18.94	0.55	201	48.6	53.2		<0.02	77.1	243	440	701	991
7	02/27/91	224009	18.08	0.72	223	46.7	38.4	34.4		25	300	432	748	1000
7	05/04/94	227594	16.61	0.64	188	42.9	28.9	34.7	<0.02	35.8	262	426	645	892
		Average	17.27	0.56	207	50.3	41.4	32.9	0.2	60.8	329	433	724	1022
		Minimum	8.28	0.39	180	42.2	28.9	24.4	<0.02	25	218	387	635	878
		Maximum	25.7	0.76	261	61.2	65.1	39.6	0.8	124	490	476	890	1241
		No. of samples	28	21	28	28	28	24	12	28	28	28	28	28

Missouri Avenue Site

Well	Date	Lab No.	Iron	Manganese	Calcium	Magnesium	Sodium	Silica	Nitrate	Chloride	Sulfate	Alkalinity*	Hardness*	TDS
1	02/10/95	228405	7.16	0.99	205	40.0	59.0	23.8	0.53	88.9	254	398	676	925
2	02/16/95	228437	11.27	1.18	243	65.3		30.8	0.06	87.3	348	497	875	1168
3	02/16/95	228438	12.82	1.03	231	46.2	72.4	32.2	<0.02	70.4	317	521	766	1149
		Average	10.42	1.07	226	50.5	65.7	28.9	0.20	82.2	306	472	772	1081
		Minimum	7.16	0.99	205	40	59	23.8	<0.02	70.4	254	398	676	925
		Maximum	12.82	1.18	243	65.3	72.4	32.2	0.53	88.9	348	521	875	1168
		No. of samples	3	3	3	3	2	3	3	3	3	3	3	3

Notes:

TDS - Total dissolved solids
All chemical concentration data units are in mg/L
* - Reported as calcium carbonate ($CaCO_3$)

Appendix E. Chemical Quality Data (Concluded)

Fluoride	*Aluminum*	*Arsenic*	*Barium*	*Beryllium*	*Boron*	*Cadmium*	*Chromium*	*Copper*	*Lead*	*Mercury*	*Nickel*	*Potassium*	*Selenium*	*Silver*	*Zinc*	*Well*
																1
																1
																1
0.2	0.1	<0.11	0.14		1.43	<0.017	0.013	<0.01	<0.066		<0.031	7.8	<0.18	<0.014	<0.02	1
																2
																2
																2
0.4																2
0.2	<0.017	0.11	0.17		1.52	<0.017	0.014	<0.01	<0.066		<0.031	4.85	<0.18	<0.014	<0.02	2
																3
																3
																3
0.3																3
0.2	<0.017	<0.11	0.14		0.79	<0.017	<0.007	<0.01	<0.066		<0.031	4.25	<0.18	<0.014	<0.02	3
																4
																4
																4
0.3	0.02	<0.11	0.14		0.80	<0.017	<0.007	<0.01	<0.066		<0.031	5.6	<0.18	<0.014	<0.02	4
																5
																5
																5
0.5																5
																6
																6
																6A
0.2	0.018	<0.11	0.16		0.86	<0.017	<0.007	<0.01	<0.066		<0.031	5.70	<0.18	<0.014	<0.02	6A
																7
0.3	0.02	<0.11	0.12		0.64	<0.017	0.008	<0.01	<0.066		<0.031	7.07	<0.18	<0.014	<0.02	7
0.3	0.03		0.15		1.01	<0.017	0.008	<0.01	<0.066		<0.031	5.88	<0.18	<0.014	<0.02	Avg
0.2	0		0.12		0.64		<0.007					4.25				Min
0.5	0.1		0.17		1.52		0.014					7.8				Max
9	6	6	6	0	6	6	6	6	6	0	6	6	6	6	6	No. of samples

Fluoride	*Aluminum*	*Arsenic*	*Barium*	*Beryllium*	*Boron*	*Cadmium*	*Chromium*	*Copper*	*Lead*	*Mercury*	*Nickel*	*Potassium*	*Selenium*	*Silver*	*Zinc*	*Well*
0.4	0.066		0.13	<0.003	0.68		<0.007		0.42		0.046	6.1				1
0.4	<0.017	<0.11	0.14	<0.003	1.13	<0.017	<0.007	<0.007	<0.066		<0.031	6.3	<0.18	<0.015	<0.02	2
0.3	<0.017	<0.11	0.15	<0.003	1.25	<0.017	0.010	<0.007	<0.066		<0.031	8.1	<0.18	<0.015	<0.02	3
0.4	0.02		0.14	<0.003	1.02	<0.017		<0.007	<0.066			6.83	<0.18	<0.015	<0.02	Avg
0.3	<0.017		0.13		0.68							6.1				Min
0.4	0.066		0.15		1.25		0.01					8.1				Max
3	3	2	3	3	3	2	3	2	3	0	3	3	2	2	2	No. of samples

Appendix F

Dewatering Well Ground-Water Levels and Operation
FY 95 (Phase 12)

Appendix F. Dewatering Well Ground-Water Levels and Operation, FY 95 (Phase 12)

I-70 Site

			August 29, 1994		*November 4, 1994*		*December 21, 1994*		*February 27, 1995*		*April 25, 1995*		*June 28, 1995*	
Well Piez	*MP Elev*	*Temp MP*	*GW Elev*	*Pump* Δh	*GW Elev*	*Pump* Δh	*GW Elev*	*Pump* Δh	*GW Elev*	*Pump* Δh	*GW Elev*	*Pump* Δh	*GW Elev*	*Pump* Δh
W 1A	*			Off		Off	No access	On	No acc	On	35.58	Off	45.47	On
P 1A	*		42.98		43.26		44.92		47.78				37.59	
W 2A	*		49.13	On	49.29	On	41.20	Off	42.46	Off	36.21	Off	33.58	Off
P 2A	*		47.01		47.10				42.60					
W 3A	*		44.98	On	46.54	On	33.88	Off	45.80	On	40.44	On	38.47	On
P 3A	*		42.94		43.90				43.51		38.01		34.09	
W 4	389.1	396.6	370.0	Off	369.8	Off	373.0	Off	361.8	On	374.6	Off	380.1	Off
P 4			Piezometer destroyed by new concrete footing for road sign.											
W 5	385.9	391.1	366.3	On	365.4	Off	367.8	On	370.7	Off	375.6	Off	377.2	On
P 5	391.1		Plugged		Plugged		Plugged		Plugged		Plugged		Plugged	
W 6	386.6	391.7	373.0	Off	371.8	Off	No access	Off	368.0	On	371.6	On	383.9	Off
P 6	391.9						Cap stuck		Cap stuck		Cap stuck			
W 7A	*		27.82	On	26.64	On	16.95	Off	17.51	Off	12.67	Off	8.93	Off
P 7A	*		25.25		23.86		17.17							
W 8A	*		25.08	On	25.40	On	22.25	On	22.39	On	18.87	On	15.24	On
P 8A	*		22.39		21.38		18.98		19.96		14.81		10.63	
W 9A		407.8	363.8	On	371.2	Off	372.3	Off	370.2	Off	374.4	Off	380.9	Off
P 9A	407.5		365.4	1.6			372.5							
W 10	401.5	410.2	No access	?	No access	?	No access	On	No access	On	No access	On	No access	Off
P 10	409.8		Plugged		Plugged		Plugged		Plugged		Plugged		Plugged	

Appendix F. (Continued)

I-70 Site

			August 29, 1994		*November 4, 1994*		*December 21, 1994*		*February 27, 1995*		*April 25, 1995*		*June 28, 1995*	
Well Piez	*MP Elev*	*Temp MP*	*GW Elev*	*Pump* Δh	*GW Elev*	*Pump* Δh	*GW Elev*	*Pump* Δh	*GW Elev*	*Pump* Δh	*GW Elev*	*Pump* Δh	*GW Elev*	*Pump* Δh
W 11A	*		37.51	On	29.32	Off	28.17	Off	37.81	On	33.72	On	31.62	On
P 11A	*		37.00						37.64		32.82		26.87	
W 12A		395.8	365.9	On	363.8	On	363.7	On	364.4	On	378.0	Off	383.7	Off
P 12A	395.8		370.5	4.6	369.4	5.6	370.4	6.7	369.9	5.5				
W 13	397.0	407.0	360.4	On	360.2	On	371.4	Off	367.6	Off	372.9	Off	379.6	Off
P 13	407.2		368.4	8.0	370.7	10.5			368.0					
W 14	382.5	391.0	370.4	Off	359.8	On	372.3	Off	369.9	Off	368.2	On	374.7	On
P 14	390.8				368.7	8.9	372.8		369.3		374.6	6.4	380.0	5.3
W 15	*		19.78	Off	26.46	On	25.43	On	19.82	Off	15.26	Off	8.74	Off
P 15	*				25.90		23.67							
RW	390.6		367.3		371.0		372.1		368.9		373.6		380.6	

Appendix F. (Continued)

I-64 Site (Westbound)

			August 29, 1994		*November 4, 1994*		*December 21, 1994*		*February 27, 1995*		*April 25, 1995*		*June 28, 1995*	
Well Piez	*MP Elev*	*Temp MP*	*GW Elev*	*Pump* Δh	*GW Elev*	*Pump* Δh	*GW Elev*	*Pump* Δh	*GW Elev*	*Pump* Δh	*GW Elev*	*Pump* Δh	*GW Elev*	*Pump* Δh
W 1	399.7	407.6	375.0	Off	375.5	Off	375.7	Off	375.3	Off	378.9	Off	384.1	Off
P 1	406.6													
W 2	397.1	402.1	380.0	Off	379.1	Off	379.3	Off	379.7	Off	382.5	Off	386.8	Off
P 2	401.5													
W 3	394.6	402.1	382.3	Off	380.9	Off	381.0	Off	381.7	Off	384.0	Off	388.0	Off
P 3	400.0													
W 4	394.0	400.2	383.6	Off	382.0	Off	382.1	Off	382.8	Off	384.9	Off	388.7	Off
P 4	399.4													
W 5	396.5	401.1	384.8	Off	383.1	Off	383.3	Off	383.8	Off	385.9	Off	389.4	Off
P 5	400.2													
W 6	394.3	400.2	381.3	On	380.0	On	384.4	Off	380.6	On	386.7	Off	389.9	Off
P 6	399.9		383.8	2.5	382.3	2.3			382.6	2.0				
W 7	392.2	398.0	386.3	Off	384.6	Off	385.0	Off	385.3	Off	387.4	Off	390.1	Off
P 7	397.6													
W 8	396.7	405.5	384.3	On	382.7	On	385.2	Off	384.5	On	385.7	On	387.8	On
P 8	404.9		Plugged		Plugged		Plugged		Plugged		Plugged		Plugged	
W 9	391.4	397.4	364.3	On	367.5	On	366.4	On	387.1	Off	388.6	Off	391.3	Off
P 9	397.0		382.0	17.7	379.6	12.1	379.4	13.0						
W 10	395.4	404.7	388.8	Off	387.0	Off	386.9	Off	388.4	Off	389.6	Off	392.5	Off
P 10	404.6													
RW 1	403.0		382.4		381.5		381.8		382.2		384.1		388.4	

Appendix F. (Continued)

I-64 Site (Eastbound)

Well	*MP*	*Temp*	*August 29, 1994*		*November 4, 1994*		*December 21, 1994*		*February 27, 1995*		*April 25, 1995*		*June 28, 1995*	
Piez	*Elev*	*MP*	*GW Elev*	*Pump* Δh	*GW Elev*	*Pump* Δh	*GW Elev*	*Pump* Δh	*GW Elev*	*Pump* Δh	*GW Elev*	*Pump* Δh	*GW Elev*	*Pump* Δh
W 11	397.0	402.8	379.5	Off	378.7	Off	378.9	Off	379.3	Off	382.0	Off	386.4	Off
P 11	402.5													
W 12	395.2	401.6	381.5	Off	380.4	Off	380.5	Off	381.0	Off	383.4	Off	387.6	Off
P 12	401.5													
W 13	394.3	399.1	383.4	Off	381.9	Off	381.9	Off	382.6	Off	384.7	Off	388.5	Off
P 13	399.1													
W 14	396.0	400.5	384.6	Off	383.0	Off	383.1	Off	383.6	Off	385.6	Off	389.1	Off
P 14	399.7													
W 15	395.1	400.5	385.6	Off	383.9	Off	384.2	Off	384.3	Off	386.3	Off	389.6	Off
P 15	399.7													
W 16	393.7	399.8	386.3	Off	384.6	Off	384.9	Off	382.6	On	384.5	On	387.0	On
P 16	398.8								Plugged		385.2	0.7	Plugged?	
W 17	392.1	398.0	379.0	On	376.4	On	376.5	On	377.8	On	388.0	Off	381.7	On
P 17	397.8		Plugged		Plugged		Plugged		Plugged		Plugged		Plugged	
W 18	391.3	396.6	387.1	Off	385.4	Off	385.5	Off	387.0	Off	388.6	Off	391.3	Off
P 18	396.4													
W 19	391.8	397.0	387.8	Off	386.1	Off	386.1	Off	387.7	Off	389.1	Off	391.8	Off
P 19	397.0													
W 20	395.4	405.3	389.9	Off	388.1	Off	387.8	Off	389.1	Off	390.1	Off	393.0	Off
P 20	404.7													
RW 2	398.2		387.3		385.8		385.8		387.4		388.7		391.6	

Appendix F. (Continued)

25th Street Site

Well	*MP*	*Temp*	*August 25, 1994*		*November 4, 1994*		*December 21, 1994*		*February 27, 1995*		*April 25, 1995*		*June 28, 1995*	
Piez	*Elev*	*MP*	*GW Elev*	*Pump* Δh	*GW Elev*	*Pump* Δh	*GW Elev*	*Pump* Δh	*GW Elev*	*Pump* Δh	*GW Elev*	*Pump* Δh	*GW Elev*	*Pump* Δh
W 1	399.7	407.4	384.2	On	383.0	On	388.1	Off	388.9	Off	388.8	Off	395.7	Off
P 1	407.3		387.9	3.7	386.2	3.2								
W 2	394.6	402.8	388.3	Off	387.1	Off	381.2	On	381.1	On	380.5	On	Flooded	
P 2	401.9						382.2	1.0	382.2	1.1	381.6	1.1		
W 3	390.4	400.3	377.2	On	375.6	On	375.0	On	375.8	On	375.4	On	393.3	Off
P 3	400.2		379.4	2.2	377.8	2.2	377.3	2.3	377.9	2.1	377.6	2.2		
W 4	392.4	401.6	375.7	On	374.4	On	374.2	On	376.3	On	374.1	On	382.2	On
P 4	401.5		Plugged		Plugged		Plugged		Plugged		Plugged		Plugged	
W 5	396.2	404.2	383.1	On	381.4	Off	385.8	Off	386.8	Off	386.9	Off	393.2	Off
P 5	403.8		384.1	1.0										
W 6	396.5	405.4	387.5	**	386.3	**	386.5	**	387.5	**	387.5	**	393.4	**
P 6	404.5													
W 7	392.6	402.9	377.2	On	376.3	On	375.4	On	377.1	On	376.3	On	380.1	On
P 7	402.0		Plugged		Plugged		Plugged		Plugged		Plugged		Plugged	
W 8	390.8	401.0	382.3	On	381.0	On	380.3	On	381.2	On	380.7	On	386.5	On
P 8	400.5		384.8	2.5	383.6	2.6	382.9	2.6	383.7	2.5	384.0	3.3	389.2	2.7
W 9	409.4	414.5	380.3	On	378.7	On	387.3	Off	379.9	On	378.6	On	Flooded	
P 9	414.7		386.9	6.6	385.6	6.9			385.7	5.8	385.8	7.2		
W 10	398.6	407.5	390.2	Off	388.8	Off	388.6	Off	389.2	Off	389.2	Off	395.9	Off
P 10	406.1													
RW	401.4		388.2		387.1		386.8		387.2		387.1		394.1	

Appendix F. (Continued)

Venice Site

			August 25, 1994		*November 4, 1994*		*December 21, 1994*		*February 28, 1995*		*April 25, 1995*		*June 28, 1995*	
Well Piez	*MP Elev*	*Temp MP*	*GW Elev*	*Pump* Δh	*GW Elev*	*Pump* Δh	*GW Elev*	*Pump* Δh	*GW Elev*	*Pump* Δh	*GW Elev*	*Pump* Δh	*GW Elev*	*Pump* Δh
W 1	405.6	411.6	391.7	Off	377.2	On	385.8	Off	388.3	Off	391.0	Off	387.5	On
P 1	411.2		Plugged		Plugged		Plugged		Plugged		Plugged		Plugged	
W 2	405.6	411.0	391.6	Off	?	On	388.9	Off	391.7	Off	387.7	On	388.9	On
P 2	410.3				383.1						390.6	2.9	394.1	5.2
W 3	402.6	408.6	380.3	On		Off	389.2	Off	393.4	Off	394.4	Off	392.7	On
P 3	408.4		386.6	6.3	387.5								Flooded	
W 4	403.1	408.1	377.2	On	375.6	On	377.5	On	393.5	Off	388.8	On	397.3	Off
P 4	407.2		385.0	7.8	384.3	8.7	386.8	9.3			392.5	3.7		
W 5	401.1	407.4	384.6	On	382.2	On	389.8	Off	393.3	Off	395.1	Off	393.6	On
P 5	407.2		386.4	1.8	389.2	7.0							396.0	2.4
W 6A	400.8	408.4	381.6	On	378.4	On	390.5	Off	398.7	Off	395.1	Off	397.4	Off
P 6A	408.6		386.0	4.4	384.2	5.8								
W 7	399.3	407.5	387.5	Off	361.8	On	361.0	On	360.6	On	364.6	On	367.1	On
P 7	409.1				380.0	18.2	382.8	21.8	384.9	24.3	387.4	22.8	389.8	22.7
RW	407.3		386.9		386.0		389.8		392.9		394.0		396.8	

Appendix F. (Concluded)

Missouri Avenue Site

Well Piez	MP Elev	Temp MP	August 25, 1994 GW Elev	August 25, 1994 Pump Δh	November 4, 1994 GW Elev	November 4, 1994 Pump Δh	December 21, 1994 GW Elev	December 21, 1994 Pump Δh	February 27, 1995 GW Elev	February 27, 1995 Pump Δh	April 25, 1995 GW Elev	April 25, 1995 Pump Δh	June 28, 1995 GW Elev	June 28, 1995 Pump Δh
W 1	408.72		~371.5	On	Rain		381.5	On	~368.7	On	372.8	On	373.2	On
W 2	417.63		372.1	On	~368.2	On	369.1	On	367.1	On	370.9	On	379.3	On
W 3 P 2-93	415.44		~362.3	On	~365.4	On	~358.9	On	~360.4	On	366.0	On	367.4	On
OW 1	416.75		380.5		377.7		379.4		378.2		380.5		388.9	
OW 2	418.67		381.7		~380	Rain	382.4		379.3		381.1		388.8	
OW 3	402.49		383.6		?	Rain	382.3		381.2		383.4		391.9	

Notes:

GW Elev = ground-water elevation

MP Elev = measuring point elevation

OW = observation well

P or Piez = piezometer

Pump = pump operation status

RW = recorder well

Temp MP = elevation of temporary measuring point

W = well

~ Approximate because of measurement difficulties

? Status uncertain/not verified

* Measuring point elevations not available; depths to water recorded

** Pump removed from well

Δh = difference in ground-water elevation between well and piezometer

Illinois State WATER Survey (1895)

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