Contract Report 546

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

Phase 7

by Ellis W. Sanderson and Robert D. Olson
Office of Ground-Water Resources Evaluation and Management

Prepared for the
Illinois Department of Transportation
Division of Highways

February 1993

Illinois State Water Survey
Hydrology Division
Champaign, Illinois

A Division of the Illinois Department of Energy and Natural Resources

DEWATERING WELL ASSESSMENT FOR THE HIGHWAY DRAINAGE SYSTEM AT FOUR SITES IN THE EAST ST. LOUIS AREA, ILLINOIS (FY90 - Phase 7)

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Illinois State Water Survey
2204 Griffith Drive
Champaign, Illinois 61820-7495

February 1993

ISSN 0733-3927

This report was printed on recycled and recyclable papers.

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ABSTRACT

In the East St. Louis vicinity, the Illinois Department of Transportation (IDOT) owns 48 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 four sites in the alluvial valley of the Mississippi River in an area known as the American Bottoms. At the dewatering sites, the alluvial deposits 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 a cooperative investigation has been conducted by IDOT and the Illinois State Water Survey to more adequately assess the operation and condition of the wells, to begin an attempt to understand the probable causes of well deterioration, and to evaluate rehabilitation procedures used on the wells. Seven phases of the investigation have now been completed.

During FY 90 (Phase 7), twelve step tests were performed on nine dewatering wells, the rehabilitation of five dewatering wells was reviewed, and eleven dewatering wells were investigated for sand pumpage. Five of the step tests were conducted to assess the present condition of wells to either determine their need for chemical treatment in the future or to monitor the results of previous chemical treatments. Three of the wells were found to be in good condition with an average specific capacity of about 120 gallons per minute per foot (gpm/ft). Two wells were found to be in poor condition with specific capacities of about 32 gpm/ft and are recommended for treatment.

Pretreatment and post-treatment step tests were used to help document the rehabilitation of five dewatering wells (I-70 Well 3, 25th Street Well 2 and Well 5, and Venice Well 2 and Well 5). Chemical treatments were used to restore the capacity of these five wells and they were generally successful as the improvement in specific capacity per well averaged about 179 percent based on specific capacity data from step tests. The average specific capacity prior to treatment was about 38 gpm/ft and after treatment was about 106 gpm/ft.

The sand pumpage investigation conducted during 12 step tests revealed that Venice Well 1 is pumping sand. This condition, while serious, is not considered an

immediate impediment to operating purposes. The well should be monitored during future investigative work and may be considered for inspection with underwater video equipment to attempt to determine if mitigative measures are possible.

The follow-up investigation of the condition of the detention pond relief wells was concluded with the testing of water samples from four wells for nuisance bacteria and the underwater video inspection of two wells. The nuisance bacteria tests showed a high degree of biological activity indicating a significant potential for plugging of the well screen, gravel pack, and aquifer materials. The video inspections yielded little additional information concerning the relief wells because the murky water encountered in the well casing severely limited visibility. It is not possible to determine whether the hydraulic condition of the relief wells has been adversely affected without conducting step tests on the wells. Mobilization requirements for such step tests would involve substantial effort. A rudimentary monitoring program that includes collection of ground-water level measurements and other visual observations at the site is recommended for trouble-shooting purposes.

INTRODUCTION

Background

The Illinois Department of Transportation (IDOT) operates 48 high-capacity water wells at four 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 Interstate (I) 55/70 and I-64 was originally designed, ground-water levels were at lower elevations because of large withdrawals by the area's industries. Because of a combination of water conservation, production cutbacks, and conversion from ground water to river water as a source, ground-water withdrawals by industry have decreased at least 50 percent since 1970, and as a result, ground-water levels in many areas have recovered to early development levels. This exacerbates IDOT's need to dewater the areas of depressed highways.

Scope of Study

The Illinois Department of Transportation first installed 12 dewatering wells in 1973, followed by an additional 30 in 1975. By 1977, the initial 12 wells were showing signs of loss of capacity. As a result, all 42 wells in use at that time were chemically treated to restore capacity. Although good results were obtained on most of the wells, routine monitoring by IDOT showed that deterioration problems were continuing to develop. Chemical treatment of isolated wells was made by IDOT personnel as required. In 1982, six more wells were installed. In October 1982, IDOT asked the Illinois State Water Survey to begin an investigative study of the dewatering wells to learn more about their condition, to determine efficient monitoring and operating procedures, and to determine suitable methods of rehabilitation.

The first phase of the work, begun in March 1983, included an assessment of the condition of 14 selected wells, a review of IDOT's monitoring program, a model study to outline efficient operating schemes, recommendations on wells to be treated, and recommendations for chemical treatment procedures.

Phase 2, begun in March 1984, included an assessment of the condition of 12 selected wells; testing of a non-invasive, portable flowmeter; and an initial study of the chemistry of the ground water as it moved toward an operating well.

Project work begun in July 1985 (Phase 3), included an assessment of the condition of six wells; demonstration of a non-invasive, portable flowmeter; a continued study of ground-water chemistry; and documentation of the rehabilitation of seven dewatering wells, along with follow-up step tests.

Project work begun in July 1986 (Phase 4), included ten step tests, documentation of the treatment of five wells, documentation of the construction of I-70 Well 14 (7A), investigation of I-70 Well 9 to determine the probable cause of gravel-pack settlement, specific-capacity testing using the non-invasive, portable flowmeter, and installation of piezometers at two underpass sites in East St. Louis.

Project work begun in July 1987 (Phase 5), 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-55/70.

Project work begun in July 1988 (Phase 6), 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 two replacement wells (I-70 Well 8A and I-70 Well 9A).

Project work begun in July 1989 (Phase 7), 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-55/70.

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 (see figure 1). The geology of the area consists of alluvial deposits overlying limestone and dolomite of the Mississippian and Pennsylvanian Ages. 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).

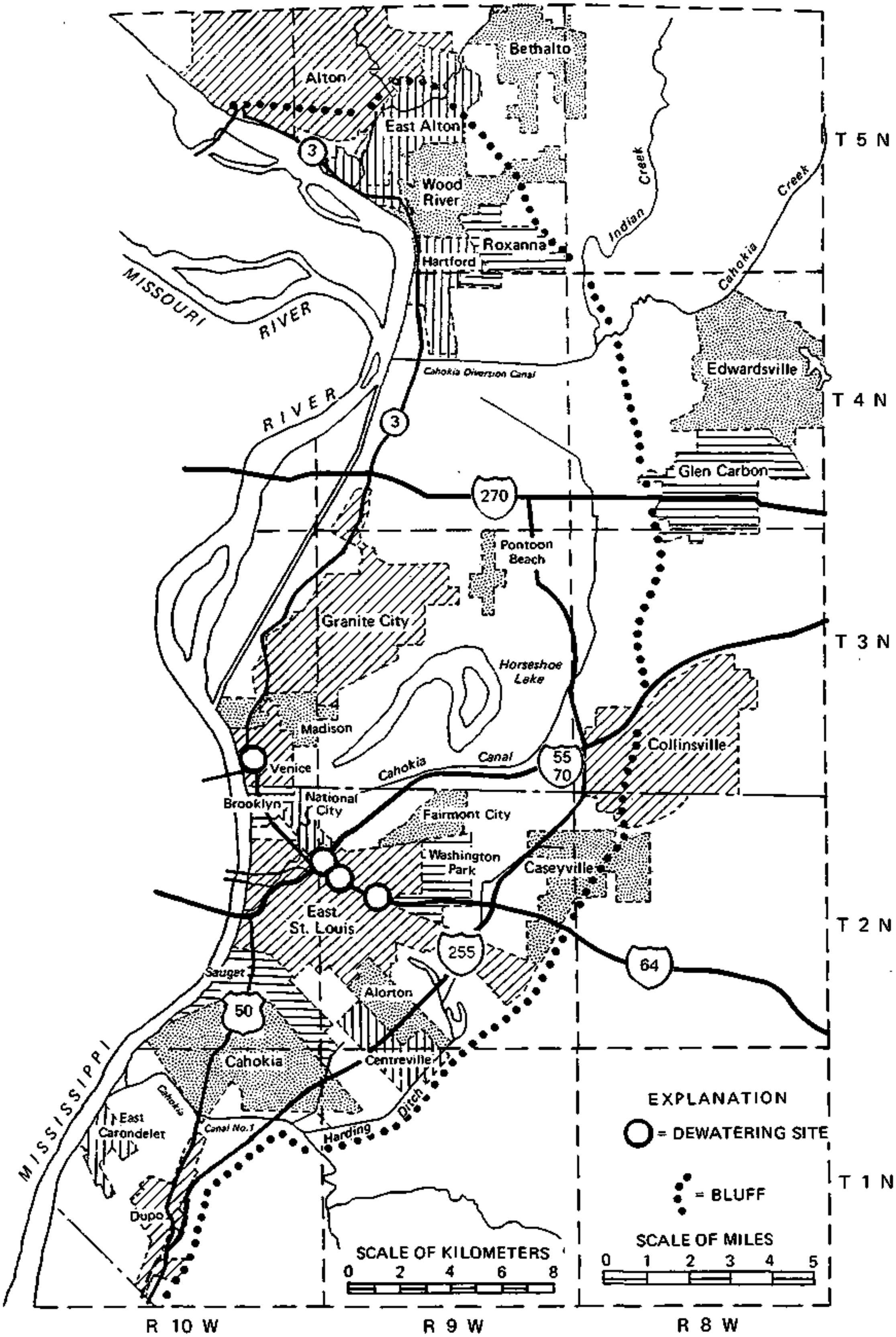


Figure 1. Location of the East St. Louis area

Ground water generally flows from the bluffs toward the river, except where it is diverted by pumpage or drainage systems.

Detailed location maps of the four dewatering sites operated by IDOT are shown in figures 2 and 3. 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). The alluvial deposits are about 90 to 115 feet thick, meaning 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 Illinois Department of Transportation, Gregory W. Baise, Secretary. Thanks are due Frank Opfer, Hydraulic Engineer, and Vic Modeer, Geotechnical Engineer, District 8, who reviewed and coordinated the investigation. The District 8 Bureau of Maintenance crew under the supervision of Carl Pinkston provided field support during the conduct of step-drawdown tests on the selected wells. Water Survey staff who ably assisted the authors with field data and water sample collection included Ken Hlinka and Nita Hingson.

Special thanks are due Steven D. Wilson, Assistant Hydrologist. Steve was directly involved in the proposal development for FY 90 and participated fully in the investigative field work.

Analytical work was done by the Water Survey's former Analytical Chemistry Unit under the direction of Mark Peden, with Brian Kaiser, Lauren Sievers, and Linda Fox performing the lab analyses. Manuscript editing was done by Laurie Talkington and Eva Kingston, and the illustrations were prepared by John Brother, Jr. (now retired), David Cox, and Linda Hascall. Word processing was done by Pamela Lovett.

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 383.5 feet above mean sea level (ft msl), or approximately 32 feet below natural ground surface. At the time of highway design in 1958 the ground-water levels were near an elevation of 390 ft msl, or about 6.5 feet above the planned highway (McClelland Engineers, Inc., 1971). Highway construction was carried out in 196I-1962.

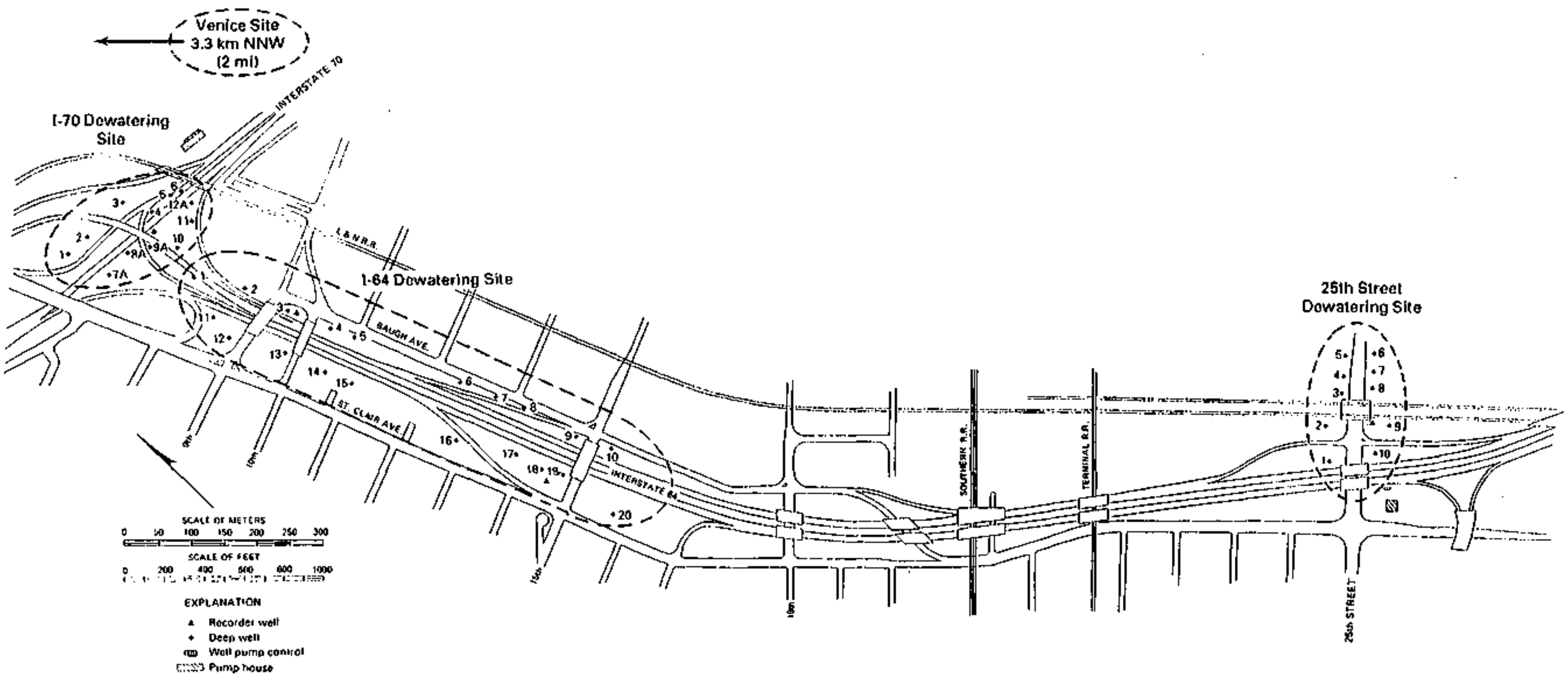


Figure 2. Locations of dewatering wells at the I-70 Tri-Level Bridge, I-64, and 25 Street

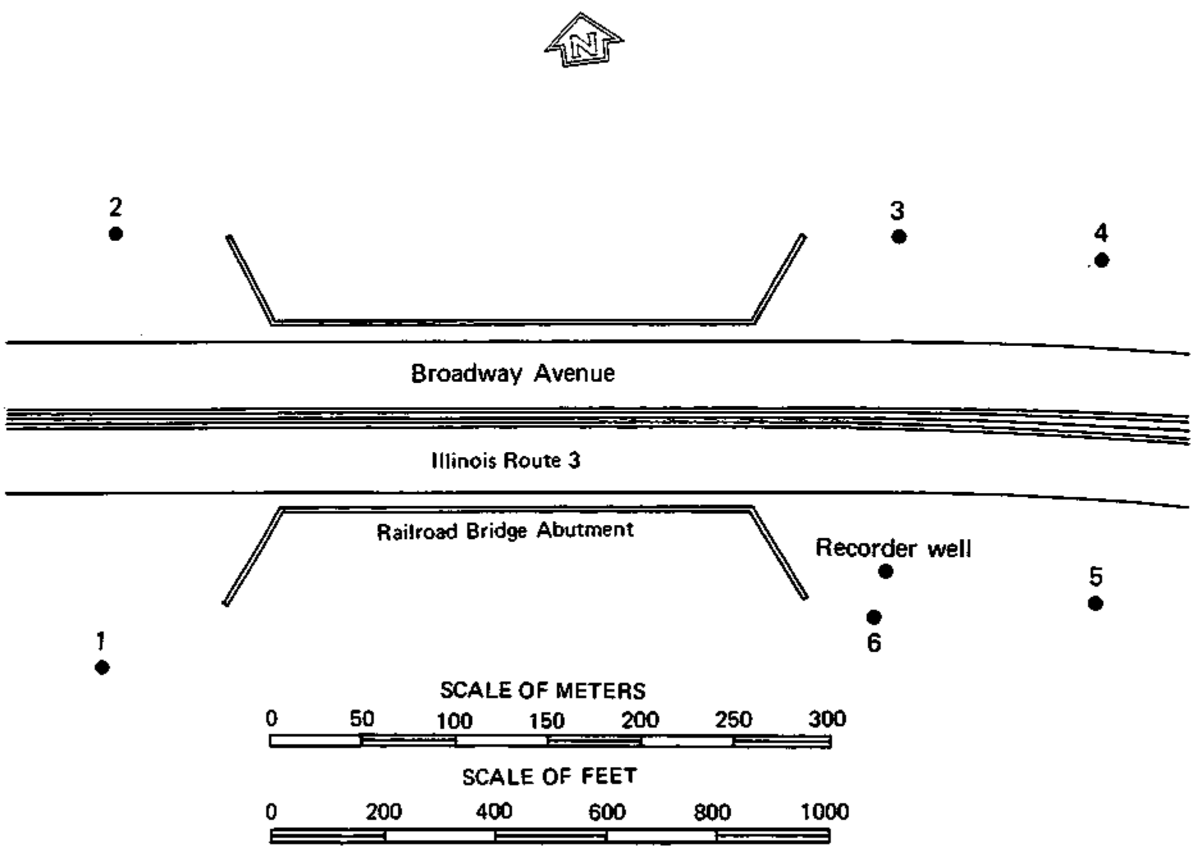


Figure 3. Locations of dewatering wells at the Venice Subway (Illinois Route 3)

Horizontal Drain System

A horizontal French drain system was designed for controlling the ground-water levels along an 800-foot reach of depressed highway. For highway construction, the excavation area was dewatered by pumping from seven wells 100 feet deep and 16 inches in diameter. The wells were equipped with 1800-gpm turbine pumps. The 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 construction dewatering system was turned off in the fall of 1962. The 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% of the filter sand was finer than the ¼-inch perforations in the drain pipes. As a result, when the construction dewatering system was turned off and ground-water levels rose above the drains, filter sand migrated through the holes into the drain pipes. After the filter sand migrated into the drain, the very fine "sugar" sand used as the pavement foundation was free to move downward to the drains, resulting in development of potholes above the drains. Further migration of sand into the French drainage system was halted by operating the construction dewatering system to lower the ground-water table. Since 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. The 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 1200 to 2000 gpm, compared to a computed design flow of 4500 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 rise of 1 foot 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 was also observed. Depressions in the earth slopes immediately adjacent to the curb and gutter sections were noticed. 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 of the collector pipes (using a hydrojet at the rate of 100 gpm under a pressure of about 800 pounds per square inch), a significant amount of scale was removed from inside the mild steel 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 shoulders indicated a distressed condition requiring 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 dissolved in the well water. Galvanic action was magnified by the lack of oxygen and the high chloride content of the water. A chemical analysis showed the extremely corrosive quality of the ground water as evidenced by:

- Extremely high concentrations of dissolved carbon dioxide, 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

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

Individual Deep Well Systems

Experience during highway construction in 196I-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 1972 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. An additional two wells were included to permit well rotation and maintenance. These 12 wells were constructed in 1973 and the new system placed in service in April 1974 (I-70 site). The wells are 16-inch gravel-packed (42-inch borehole) wells averaging about 96 feet deep and are equipped with 60 feet of Layne stainless steel well screen. The pumps are 600-gpm capacity with 6-inch-diameter stainless steel (flanged coupling) column pipe.

A recorder well was included in the well dewatering system to monitor ground-water levels near the critical elevation of the highway. The well is 8 inches in diameter and is constructed of stainless steel casing and screen. 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. The purpose of these piezometers is to provide information on ground-water levels and to monitor the performance of individual wells by measuring water-level differences between the wells and the piezometers.

In the late 1970s, the exit ramp from the I-64 westbound lanes onto the I-55/70 northbound lanes was relocated, necessitating the abandonment of I-70 Well 12. At that time replacement Well 12A was constructed at a nearby location using components similar to those in the original wells. Also in the 1970s, the well screen in I-70 Well 7 reportedly failed, 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 (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, 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 was also discovered at I-70 Wells 2 and 8, and at Venice Well 6. 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 were also designed and used in these wells as in I-70 Well 7A (Olson et al., 1992).

The western terminal of I-64 joins I-70 at the Tri-Level Bridge site. A 2200-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.

About 6200 feet southeast of the Tri-Level Bridge, at the East St. Louis 25th Street interchange with I-64, the street was designed to pass below the highway and adjacent railroad tracks. As a result, the 25th Street pavement would be about 3.5 feet below ground-water levels. Ten wells were installed at this site in 1975 to control ground-water levels (25th Street site). These wells are identical in design to the original I-70 wells. The 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 is 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 for monitoring the performance of each individual installation.

Approximately 2¼ miles north of the I-70 Tri-Level Bridge, Illinois Highway 3 passes beneath the N and W, ICG, 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 three to four months of continuous flood stage in the Mississippi River (about 2000 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 (Venice site). They 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 piezometers at each dewatering well were constructed to monitor system performance.

Thus at present the highway dewatering operation in the American Bottoms consists of 48 individual dewatering wells fully penetrating the water-bearing sand-and-gravel aquifer. The wells are distributed at four sites as follows:

I-70 (Tri-Level Bridge) -	12 wells
I-64 -	20 wells
25th Street -	10 wells
Venice (Route 3) -	6 wells

The wells are of similar construction, with 16-inch-diameter stainless steel casing and screen, and 6-inch-diameter stainless steel column pipe (figure 4). Each well is equipped with a 600-gpm submersible pump with bronze impellers, bowls, and jacket motors. The early experience with severe corrosion problems showed that corrosion-resistant materials are required to maximize service life. Five 8-inch

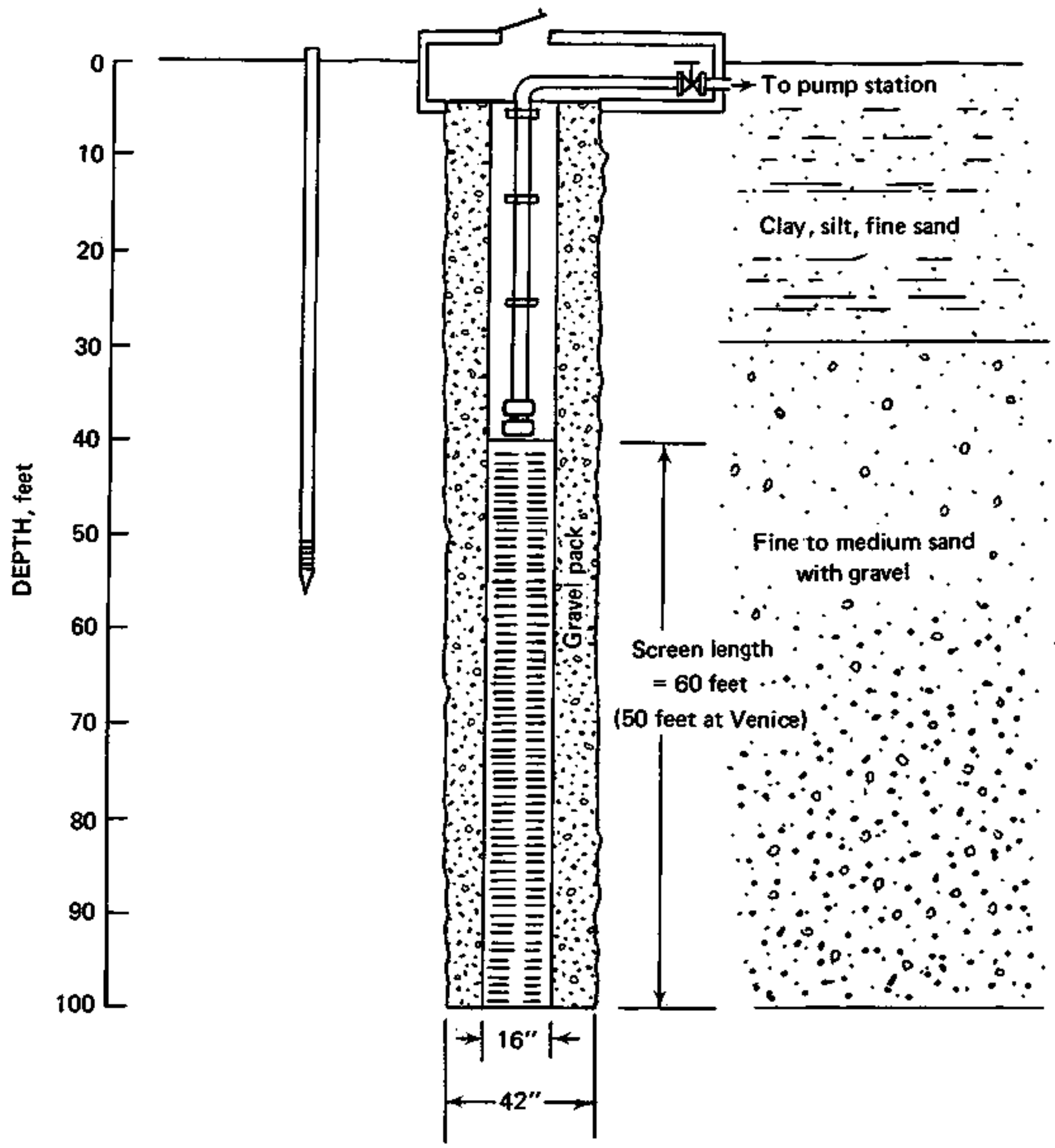


Figure 4. Typical features of a dewatering well

recorder wells are available to monitor ground-water elevations near critical locations at the four sites. Each of the 48 wells has a 2-inch-diameter piezometer for monitoring individual well performance.

Usually, about one-third of the wells are in operation simultaneously. Total pumpage was estimated to be about 11.2 million gallons per day (mgd) in 1990.

DEWATERING SYSTEM MONITORING

When originally constructed, the well installations at I-70, I-64, and 25th Street included pitot-tube flow-rate meters. Reportedly, a combination of corrosion and chemical deposition caused premature failure of these devices. Flow rates were occasionally checked with a pitot-tube meter temporarily inserted, but erratic results were reported by the field crew. The six installations at Venice included a venturi tube coupled to a bellows-type differential pressure indicator to measure the flow rate. Flow measurements from the venturi tube were reported to be accurate to within ± 1 percent of full pipe flow rate, and the differential pressure indicators to within ± 0.75 percent of the deflection. The bronze-lined venturi tubes will probably remain unaffected over time by the quality of water pumped from these wells; however, the water comes in direct contact with the bellows in the differential pressure indicators via two ¼-inch water lines from the venturi tubes. The same corrosion and chemical deposition affecting the pitot tubes has apparently, over time, caused obstructions in the water lines and/or water chambers or direct failure of the bellows as it is now impossible to obtain reliable flow measurement readings from most of the venturi instruments.

As part of the scope of work in FY 85 through FY 87 (Phases 2-4), a non-invasive, 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 and then left off for longer periods while another set of wells is operated. No standard sequence of pumping rotation is followed because of maintenance and rehabilitation requirements. Bar charts showing the periods of operation are prepared by IDOT for monitoring the accumulated hours of operation. Annual withdrawals currently are calculated on the basis of pumping time and estimated or measured pumping rates.

Water levels at each dewatering well were measured periodically to monitor the overall performance of the dewatering system by the IDOT highway maintenance personnel until November 1989. Due to internal reorganization of the highway maintenance staff in District 8, the Water Survey staff began monitoring the 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. These water-level data are reviewed by IDOT supervisors to monitor ground-water levels in relation to the pavement elevation. The data also are used to help assess the condition of individual dewatering wells. Water-level differences of 3 to 5 feet between the pumping wells and the adjacent piezometers usually are considered normal by IDOT. Greater differences are interpreted to indicate that well deterioration is occurring.

Finally, each dewatering well site includes an observation well (I-64 has two) equipped with a Leupold-Stevens water-level recorder. The 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 the monthly servicing of the recorders beginning at the end of November 1989.

INVESTIGATIVE METHODS AND PROCEDURES

Well Loss

When a well is pumped, water is removed from the aquifer surrounding the well, and the water levels are lowered. The distance that the water level is lowered, whether within the well or in the surrounding aquifer, is referred to as drawdown, which under ideal conditions is a function of pumping rate, time, and the aquifer's hydraulic properties. Specific capacity, pumping rate divided by the water-level drawdown in the pumped well following an established pumping period is often used to describe well performance. However, because other non-ideal geohydrologic and hydraulic factors can affect the observed drawdown (particularly within the pumped well) the specific capacity may not provide the full well performance picture, especially when pumping rates change. Aquifer boundaries, spacial variation in aquifer thickness or hydraulic properties, interference from nearby wells, partial-penetration conditions, and well losses all can affect observed drawdowns. Well losses, usually associated only with the pumped well, are a refection of the hydraulic efficiency of the well components and are the only non-ideal condition addressed in this report.

The observed drawdown in a pumped well is usually greater than that in the aquifer formation outside the borehole because of the well losses caused by the water moving from the fully penetrated aquifer into the well. The amount of well loss depends on the materials used and the job done in constructing the well. A limited amount of well loss is to be expected as 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 unacceptable well losses. In addition, well losses often reflect a deterioration in the condition of an existing well, especially if they are observed to increase with time.

Well losses are related to pumping rate and ideally are not a function of time. These losses are 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. In some cases, well loss occurs entirely under conditions of laminar flow; however, velocities may become sufficiently large that a change from laminar to turbulent flow occurs. Under these conditions the well-loss component of drawdown can rapidly become excessive, increasing in a non-linear manner with increases in pumping rate.

Thus, under near-ideal conditions, the observed drawdown (s_o) in a pumping well is made up of two components: the formation loss (s_a), resulting from laminar (and sometimes turbulent) flow head loss within the aquifer; and well loss (s_w), resulting from the turbulent (and sometimes laminar) flow of water into and inside the well, as shown in equation 1.

$$\mathbf{S_o = S_a + S_w} \qquad \textbf{(1)}$$

Jacob (1947) devised a technique for separating the well losses from the 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:

$$s = BQ + CQ^2 \qquad (2)$$

where B is the formation loss coefficient at the well-aquifer interface per unit discharge, and C is the well loss coefficient, and s is calculated well loss. Rorabaugh (1953) suggested that the well-loss component be expressed as CQ, where n is a constant greater than 1. He thus expressed the drawdown as

$$s = BQ + CQ^n \qquad (3)$$

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). This analysis requires a controlled pumping test, called a step drawdown test, 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:

$$s/Q = B + CQ \qquad (4)$$

After this modification, a plot of s_o/Q versus Q can be prepared on arithmetic graph paper from data collected during a step drawdown test, with the observed drawdown, s_o, substituted for s. The slope of a line fitted to these data is equal to C, while the y-intercept is equal to B, as shown in figure 5. If the data do not fall on a straight line, but instead curve concavely upward, then Rorabaugh's method usually is suggested. The curvature of the plotted data indicates that the second-order relationship between Q and s_o is not valid.

Occasionally the data plot may yield a line with zero or a negative slope, or be too random to provide a reasonable fit to one line. In these instances, the coefficients are immeasurable. Possible causes of this are: 1) turbulent well loss is negligible over the pumping rates tested; 2) inadequate data collection or test methods were employed during the test; 3) the hydraulic condition of the well is unstable, such as happens during well development; and 4) the contribution of water from the entire length of well screen over the range of test pumping rates is unequal, as might occur due to vertical heterogeneity of the aquifer materials.

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

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

Taking logs of both sides of the equation leads to

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

A plot of $(s_o/Q) - B$ versus Q can be made on logarithmic graph paper from step test data, replacing s with s_o. Values of B are tested until the data fall on a straight line (figure 6). 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, the graphical procedure is facilitated if Q is plotted as cubic feet per second (cfs), and $(s_o/Q) - B$ is plotted as seconds per foot squared. It is also 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 determination of 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 a number of 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.

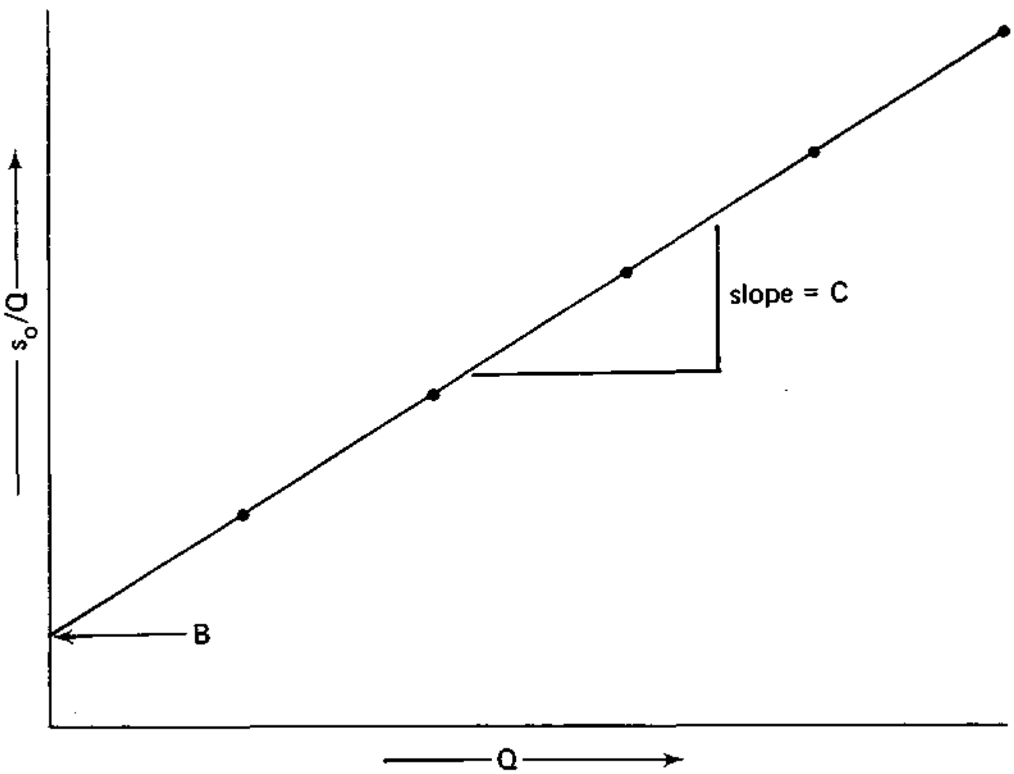


Figure 5. Graphical solution of Jacob's equation
for well-loss coefficient, C

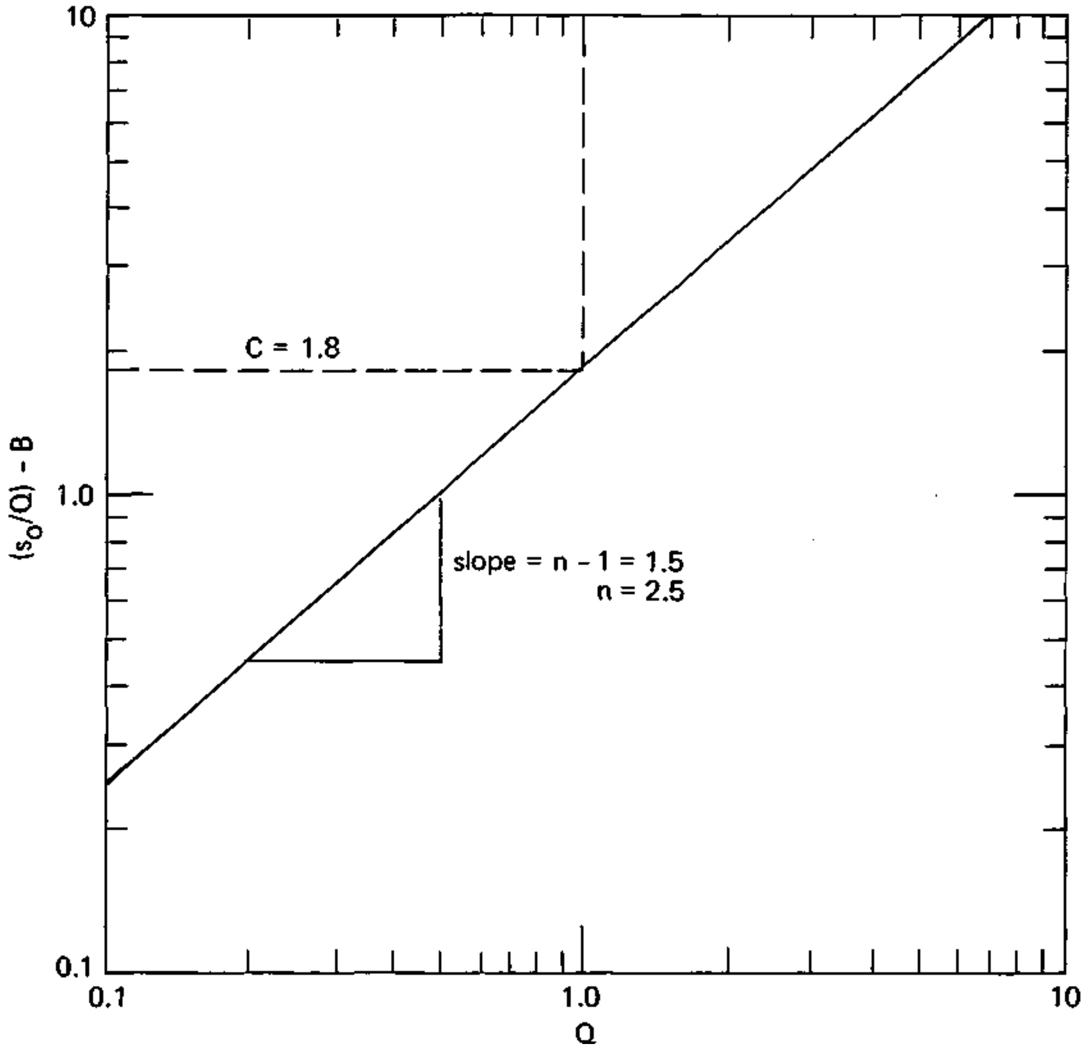


Figure 6. Graphical solution of Rorabaugh's equation
for well-loss coefficient, C, and exponent, n

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, and then every four to five minutes thereafter until the end of the step. For the step tests in this study, the Water Survey's Microcomputer Data Acquisition System (referred to as McDAS) was used to collect the data. It can be set to read the data either at a selected frequency or logarithmically as conditions dictate. If the logarithmic frequency is selected, the readings progress from several readings a second at the start of the step to readings every two to three minutes at the end of each step. In this investigation, water levels were measured for 30 minutes per step. At the end of each 30-minute interval, the pumping rate was immediately changed, the water-level measurements reverted to the initial frequency again, and so on 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 7. 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 non-pumping 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, all 48 of the IDOT dewatering wells 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 (Ah) between water levels in the well and those 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 difference in heads should be non-linear with increasing pumping rate. In addition, it can sometimes 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, then this relationship will be non-linear.

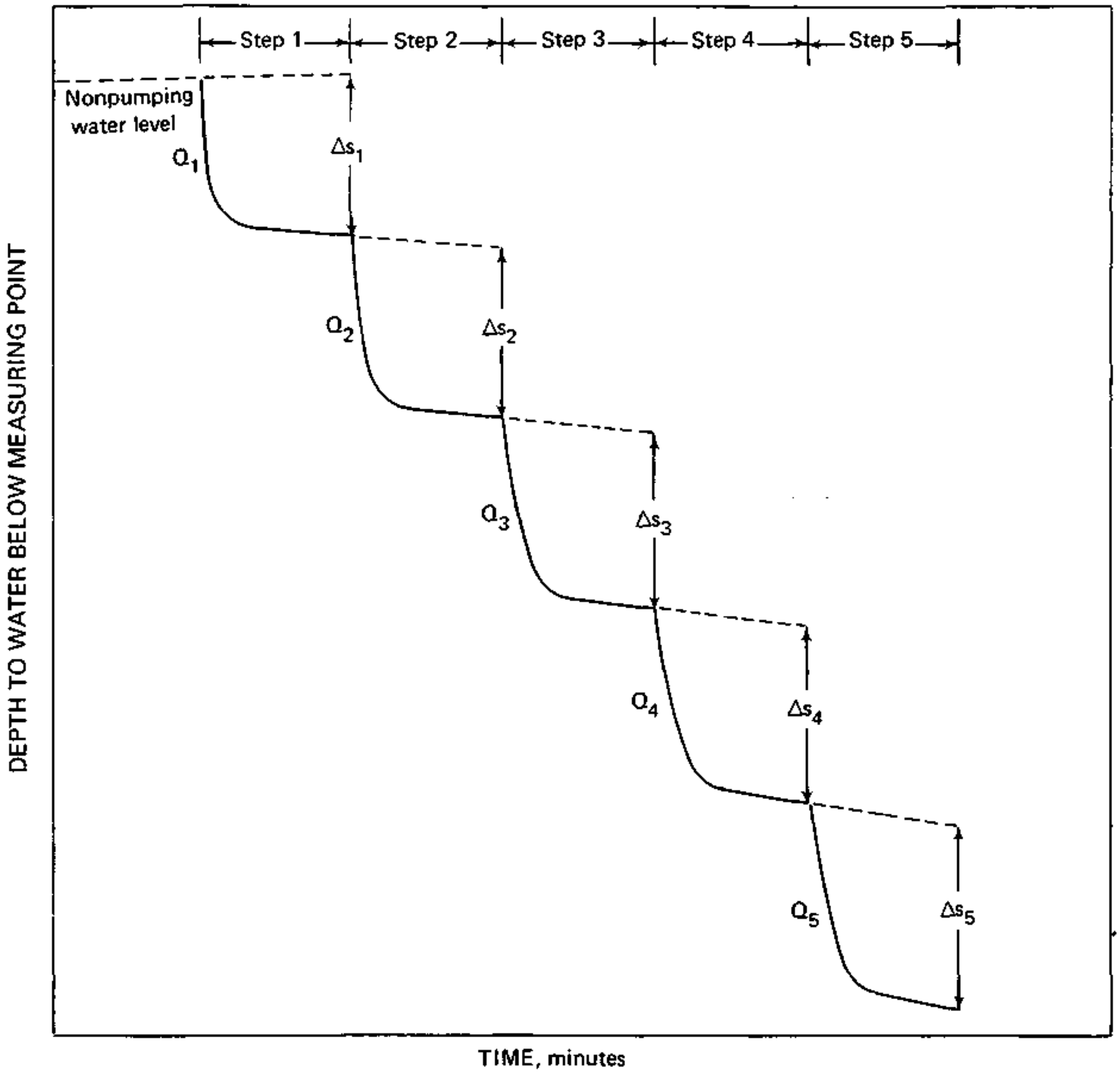


Figure 7. Relationship between time and water-level during a five-step drawdown test

FIELD RESULTS

Well Selection

Ten wells were step-tested in FY 90 (Phase 7). Five wells were selected for step tests to assess their condition and seven step tests were conducted on the five wells chemically treated to restore production capacity. Pretreatment step tests on two wells and a post-treatment step test on each of the five treated wells were conducted.

The five wells that were selected for condition assessment step tests were:

I-70	Well 7A
I-70	Well 9A
25th St.	Well 1
25th St.	Well 3
Venice	Well 1

Pretreatment step tests were conducted on I-70 Well 3 and Venice Well 5. The five wells chemically treated and then tested in post-treatment step tests were:

I-70	Well 3
25th St.	Well 2
25th St.	Well 5
Venice	Well 2
Venice	Well 5

Originally it was intended to rehabilitate an additional three wells using a new, patented process referred to as "Blended Chemical Heat Treatment." The treatment of these wells was delayed until the details of completing suitable job specifications can be worked out.

Step Tests

Field Testing Procedure

Field work was conducted by Water Survey staff with the assistance of the IDOT Bureau of Maintenance crew under the supervision of Carl Pinkston. The IDOT crew made all necessary pipe modifications and provided special piping adapters. This allowed the water from the pumped wells to be discharged through a flexible hose and orifice tube, provided by the Water Survey, 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 were 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 steps as possible at 300 gpm or greater for each well. Prior to the start of each test, the non-pumping water levels in the well and piezometer were measured with a steel tape or electric dropline. Pressure transmitters coupled to the previously described McDAS field computer system for analog to digital conversion and data storage, were placed in the pumped well and piezometer to measure water levels during the step tests.

During the step tests, the discharge from each well was also checked for the presence of sand by directing the open flow from the orifice tube into a 1000-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.

The data for the 12 step tests are included in appendix A and summarized in table 1. Three wells were tested in August and September 1989 (25th Street Wells 1 and 3 and Venice Well 1) and two wells were tested in June 1990 (I-70 Wells 7A and 9A). The pretreatment step tests were conducted in December 1989 (I-70 Well 3 and Venice Well 5) while the post-treatment step tests were done in April and May 1990 following the chemical treatments done during the period December through February. Water samples were collected at the time of each test and analyzed for chemical/mineral content. The results from the analyses are summarized in table 6 and presented in appendix B.

Results of Step Tests

The step test data were analyzed using the Jacob method described earlier in this report. The results of the analyses performed on the data from the 12 step tests conducted in FY 90 are summarized in table 1.

Step tests were conducted on five wells to assess their present condition. At the I-70 site these included Wells 7A and 9A, replacement wells that were drilled in 1986 and 1989, respectively. After construction, Well 7A had a specific capacity of about 72 gpm/ft and a Δh of about 2.1 ft based on a step test conducted on July 23, 1987. About two years later the specific capacity was found to be about 53 gpm/ft, a decline of about 26 percent and the Δh had increased to an estimated 9.0 ft. During the step test on June 27, 1990, the specific capacity was found to be only about 25 gpm/ft, the well loss was calculated to be about 25 percent of the observed draw-down, and the estimated Δh had further increased to about 13.2 ft.

Well 9A was step-tested on October 3, 1989, after being drilled in April 1989. The specific capacity was found to be about 99 gpm/ft and the estimated Δh about 1.7 ft, but the test data did not allow a well loss to be determined. On June 26, 1990, about 8½ months after the first step test, the specific capacity was observed to be

Table 1. Results of SWS Step Tests on IDOT Wells, FY 90 (Phase 7)

Well	*Date of test*	*Well loss @ 600 gpm (ft)*	*Drawdown @ 600 gpm (ft)*	*Well loss portion (%)*	*Observed specific capacity (gpm/ft)*	*Δh*@ 600 gpm (ft)*	*Observed Q_{max}, gpm*	*Remarks*
I-70								
No. 3	12/11/89	0.46	13.4 e	3.4	44.9	7.3 e	530	Pretreat
No. 3 (T)	4/17/90	4.8 e	8.7 e	54.5	84.0	2.9 e	440	Post-treat
No. 7A	6/27/90	6.8 e	26.7 e	25.3	24.6	13.2 e	425	
No. 9A	6/26/90	0.4 e	6.2 e	6.3	97.1	2.1 e	575	
25th Street								
No. 1	8/11/89	1.0 e	3.6 e	27.2	184.7	P	375	
No. 2 (T)	4/18/90	0.45	4.87	9.3	120.4	0.6	795	Post-treat
No. 3	9/7/89	0.80 e	14.9 e	5.4	40.9	4.5 e	560	
No. 5 (T)	4/19/90	**	4.92	**	122.0	1.0	790	Post-treat
Venice								
No. 1	9/6/89	0.81	6.94	11.7	85.1	1.9	740	
No. 2 (T)	5/8/90	**	6.34	**	94.7	2.4	730	Post-treat
No. 5	12/7/89	4.3 e	13.7 e	31.4	43.8	9.6 e	500	Pretreat
No. 5 (T)	5/2/90	**	5.38	**	109.7	1.6	740	Post-treat

* 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
T = Post-treatment step test
p = Piezometer plugged or partially plugged

about 97 gpm/ft and the estimated Δh about 2.1 ft. Again, the well loss could not be determined from the step test data.

Two wells also were step-tested at the 25th Street site, Wells 1 and 3. The first step test on Well 1 at this site was conducted on August 11, 1989. The results were unusual as compared to previous step tests on other dewatering wells at this site. The observed specific capacity was about 185 gpm/ft or about 45-50 percent higher than expected for this site, and the well loss was calculated to be about 27 percent of the observed drawdown, or significantly more than has been found in most other wells at this site. The Δh could not be measured due to a plugged piezometer.

Well 3 at 25th Street was step-tested on September 7, 1989, and the specific capacity was found to be only about 41 gpm/ft with a well loss of about 5 percent and an estimated Δh of about 4.5 ft. This compares with an observed specific capacity of about 122 gpm/ft, a well loss of less than 1 percent, and a Δh of about 1.8 ft in September 1985.

A step test also was conducted on September 6, 1989, on Well 1 at the Venice site. The specific capacity was found to be about 85 gpm/ft, the well loss about 12 percent of drawdown, and the Δh about 1.9 ft. During the original step test in 1983, the well was found to be in poor condition and was chemically treated in 1985 to restore production capacity. After treatment, the specific capacity was about 74 gpm/ft, the well loss was calculated to be about 5 percent, and the Δh was about 2.3 ft based on the step test data collected on December 4, 1985.

Eighty-two step tests have been completed at all sites since FY 84 (Phases I-7). The results of these step tests are included in appendix C, and the specific capacity data are summarized in table 2. The average specific capacity for all 82 step tests is about 84 gpm/ft. If the 26 pretreatment step tests and 5 other step tests that show wells in poor condition are excluded, then the average specific capacity of 51 step tests is about 105 gpm/ft. The highest specific capacities are generally found at the 25th Street site where 14 step tests have been completed. Specific capacities for all step tests at the 25th Street site averaged about 98 gpm/ft, but without five pretreatment step tests the average is about 125 gpm/ft. At the I-70, I-64, and Venice sites, respectively, 40, 14, and 14 step tests have been completed with average specific capacities of about 75, 94, and 85 gpm/ft. Without the pretreatment step tests and other step tests on wells in poor condition at these sites, the specific capacities are about 100, 100, and 106 gpm/ft, respectively.

Well Rehabilitation

Chemical Treatment Procedure

The 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

Table 2. Average Specific Capacity of Dewatering Wells
Based on Step Test Data

SITE:	*I-70*	*I-64*	*25th St.*	*Venice*
All wells:				
Number of step tests	40	14	14	14
Average specific capacity, gpm/ft	75	94	98	85
Wells in good condition or post-treatment:				
Number of step tests	21	12	9	9
Average specific capacity, gpm/ft	100	100	125	106
Wells in poor condition or pretreatment:				
Number of step tests	19	2	5	5
Average specific capacity, gpm/ft	47	58	50	46

results and experience. Similar treatment procedures were used for all of the wells treated in FY 90, 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, Brotcke Engineering Company, Inc., varied in some instances, and the significant changes are noted in the table.

The typical injection assembly/discharge apparatus used by the contractor for injecting solutions and acid into the wells, pumping spent solutions to waste, and conducting drawdown pumping tests during the treatment work is shown schematically in figure 8.

The well rehabilitation work was periodically observed by Water Survey staff and the documentation developed by the Resident Engineer and the contractor was reviewed by Water Survey personnel as the treatment work progressed. The field notes for each well treated in FY 90 are included in appendix D. In addition, during the treatment work, the chemical treatment contractor arranged to inspect three of the wells (I-70 Well 3 and 25th Street Wells 2 and 5) prior to treatment with underwater video equipment. These wells and the remaining two wells treated (Venice Wells 2 and 5) were also inspected after chemical treatment. Notes made from a review of the film of these inspections are included in appendix E.

Chemical Treatment Results

The wells to be chemically treated were selected on the basis of data from the most recent Water Survey step tests and available water-level difference (Ah) information. Work completed in FY 89 indicated that I-70 Wells 1 and 7A, 25th Street Wells 2 and 5, and Venice Well 2 were in poor condition and should be chemically treated. However, field observations and routine monitoring information in early FY 90 indicated that I-70 Well 3 and Venice Well 5 also were in poor condition. Because the chemical treatment specifications had not been prepared and there were no plans to repair a problem with the discharge piping at I-70 Well 1, these two wells (I-70 Well 3 and Venice Well 5) were substituted for I-70 Wells 1 and 7A, which were considered to have lower priority.

The chemical treatment of five dewatering wells (I-70 Well 3, 25th Street Wells 2 and 5, and Venice Wells 2 and 5) during FY 90 (Phase 7) was carried out by Brotcke Engineering Company, Inc. The treatment work was performed from December 5, 1989, to February 27, 1990.

As indicated in table 3, the chemical treatment procedure required the treatment contractor to conduct 60-minute drawdown tests to approximately determine 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. The table shows the approximate specific capacity prior to the start of treatment and following each step in the

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 lbs., and displacement with 16,000 gallons water containing at least 500 ppm (mg/l) chlorine.
   a. Initial chlorination of well with 2500 gallons water containing 500 ppm or more chlorine injected at a minimum rate of 750 gpm.
   b. Injection of polyphosphate solution at a minimum rate of 2000 gpm (actual, 1333 to 2842 gpm) in two 1800-gallon batches, each batch containing 200 lbs. polyphosphate, at least 500 ppm chlorine.
   c. Injection of 16,000 gallons water chlorinated to at least 500 mg/l in 2000-gallon batches at a minimum rate of 1500 gpm (actual rates 333 to 500 gpm).
   d. Time allowance for chemicals to react, 1 to 2 hours (actual time: 1 hr 50 min to 2 hr 30 min).

3. Pump to waste and check specific capacity.
   a. Pump continuously 6 or more hours to clear well of chemicals (actual time: 6 to 90 hours).
   b. Same procedure for specific capacity check as step 1 above.

Day 2

1. Acidization with 1000 gallons 20° Baume-inhibited muriatic (hydrochloric) acid and displacement with 4000 to 5000 gallons water (not chlorinated).
   a. Pump 1000 gallons of bulk-inhibited acid into well at 500 to 1277 gpm (17 gpm required).
   b. Allowance time for acid to react, 1 hour.
   c. Injection of 4000 to 5000 gallons water at 1000 to 2000 gpm.
   d. Allowance for reaction, 2 to 3 hours.

2. Pump to waste and check specific capacity.
   a. Pump continuously 3 hours or more (actual time: 18 to 19¼ hours) to clear well of acid.
   b. Same procedure for specific capacity check as Day 1, step 1 above.

Table 3. Concluded

Day 3

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

   Same procedure as Day 1, step 2 above, except three batch injections of 1800 gallons (5400 gallons total) with 200 lbs. phosphate each in part b, and injection of 30,000 gallons in part c.

2. Pump to waste and check specific capacity.

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

Day 4 (Optional)

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

   Same procedure as Day 1, step 2 above, except three batch injections of 1800 gallons (5400 gallons total) with 200 lbs. phosphate each in part b, and injection of 54,000 gallons in part c.

2. Pump to waste and check specific capacity.

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

Day 5 (Optional)

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

   Same procedure as Day 1, step 2 above.

2. Pump to waste and final specific capacity test.

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

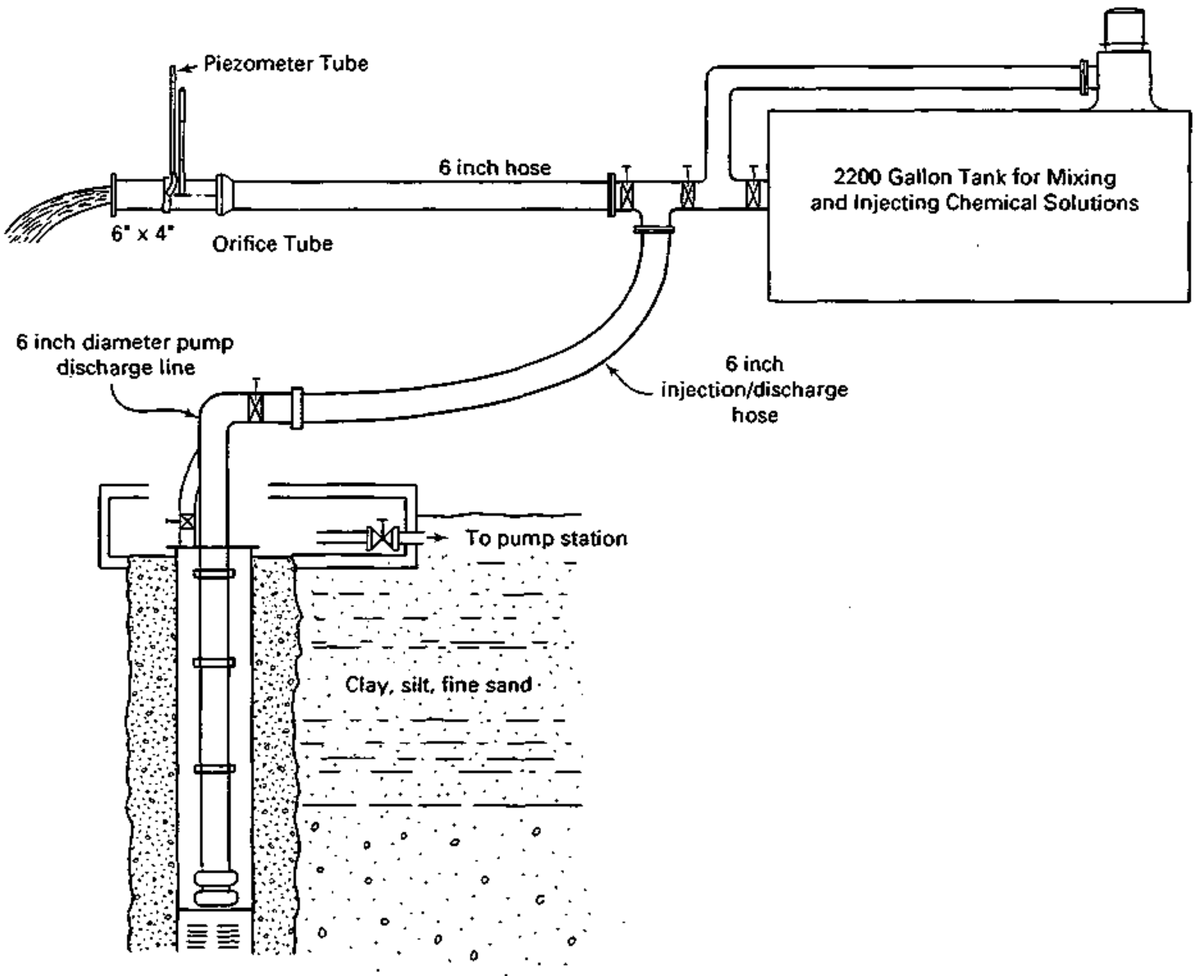


Figure 8. Schematic diagram of equipment used in well rehabilitation

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

I-70 No. 3

	Pretreatment	1st PPP treatment	Acid treatment	2nd PPP treatment	3rd PPP treatment	4th PPP treatment	5th PPP treatment
Date ('90)	2/21 AM	2/22 AM	2/23 AM	2/23 PM	2/27 AM	2/28 AM	
SWL	30.58	29.62	31.0	31.17	31.08	31.17	
PWL	50.42	45.42	45.5	44.75	43.92	43.92	
s	19.84	15.80	14.5	13.58	12.84	12.75	
Piez.	37	40	39	40.5	40.5	40.5	
Q	748	781	770	786	786	786	
Q/s	37.7	49.4	53.1	57.9	61.2	61.6	

25th St. No. 2

	Pretreatment	1st PPP treatment	Acid treatment	2nd PPP treatment	3rd PPP treatment	4th PPP treatment	5th PPP treatment
Date ('90)	2/2 AM	2/3 AM	2/6 AM	2/8 PM	2/10 AM	2/13 AM	
SWL	17.82	18.71	18.25	18.33	18.67	18.75	
PWL	38.0	29.54	26.75	26.58	26.25	26.25	
s	20.18	10.83	8.50	8.25	7.58	7.50	
Piez.	26.5	36	28	33.5	34	33.5	
Q	626	737	644	709	715	709	
Q/s	31.0	68.1	75.8	85.9	94.3	94.5	

25th St. No. 5

	Pretreatment	1st PPP treatment	Acid treatment	2nd PPP treatment	3rd PPP treatment	4th PPP treatment	5th PPP treatment
Date ('90)	1/22 AM	1/25 AM	1/26 AM	1/27 AM	1/31 AM	2/1 AM	
SWL	18.67	21.08	21.25	21.4	21.08	21.25	
PWL	39.50	30.0	29.08	28.5	27.5	27.58	
s	20.83	8.92	7.83	7.1	6.42	6.33	
Piez.	27.5	28	25	28	26.5	28	
Q	638	644	608	644	626	644	
Q/s	30.6	72.2	77.7	90.7	97.5	101.7	

Venice No. 2

	Pretreatment	1st PPP treatment	Acid treatment	2nd PPP treatment	3rd PPP treatment	4th PPP treatment	5th PPP treatment
Date ('89)	12/5 AM	12/6 AM	12/7 AM	12/8 AM	12/11 AM	12/12 AM	12/13 AM
SWL	25.11	26.46	28.08	28.33	27.58	28.67	29.54
PWL	37.21	35.71	37.67	37.50	35.92	36.18	36.58
s	12.10	9.25	9.59	9.17	8.34	7.51	7.04
Piez.	-	11.5	16	17.5	17	-	16
Q	230 e	421	495	517	510	524	495
Q/s	19.0	45.5	51.6	56.4	61.2	69.8	70.3

Table 4. Concluded

	Pretreatment	*1st PPP treatment*	*Acid treatment*	*2nd PPP treatment*	*3rd PPP treatment*	*4th PPP treatment*	*5th PPP treatment*
Venice No. 5							
Date ('90)	**1/2 AM**	**1/3 AM**	**1/4 AM**	**1/5 AM**	**1/9 AM**		
SWL	**23.0**	**24.33**	**25.0**	**25.08**	**25.54**		
PWL	**37.67**	**35.75**	**36.83**	**37.17**	**36.79**		
s	**14.67**	**11.42**	**11.83**	**12.09**	**11.25**		
Piez.	**28.5**	**28.5**	**29.5**	**34.5**	**33.5**		
Q	**650**	**650**	**662**	**720**	**709**		
Q/s	**44.3**	**56.9**	**56.0**	**59.6**	**63.0**		
Averages							
Q/s	**32.5**	**58.4**	**62.8**	**70.1**	**75.4**	**81.9**	
ΔQ/s		**25.9**	**4.4**	**7.3**	**5.3**	**6.5**	
% increase over original Q/s		79.7	13.5	22.5	16.3	20.0	
% of total improvement		52.4	8.9	14.8	10.7	13.2	

Note: Total ΔQ/s = 49.4 gpm/ft (152% improvement over initial Q/s)

Legend

SWL - Static (nonpumping) water level, feet
PWL - Pumping water level, feet
s - Drawdown (PWL-SWL), feet
Piez - Piezometer head, inches
Q - Pumping rate, gpm
Q/s - Specific capacity, gpm/ft
PPP - Polyphosphate

treatment process (polyphosphate or acid injection episode). The average specific capacity for all of the wells at each step in the treatment process is given at the end of the table along with an analysis of the improvement between steps. In general, the percent improvement in specific capacity is diminished for each successive step of the treatment except for the fourth polyphosphate injection. (This trend has been more evident in the results of the well treatment in some prior years as discussed later.) About one-half of the total improvement occurred with the first polyphosphate treatment, and about 15 percent during the second polyphosphate treatment (following acidization). By the end of this second polyphosphate treatment, about 76 percent of the total improvement was obtained, on the average. However, during the contractor's drawdown test on the last well treated in FY 90 (I-70 Well 3), the orifice plate on the orifice tube was found to be cracked. When this may have occurred is unknown. This flaw probably would result in the actual discharge rate being greater than indicated. Thus it is possible that the improvement for each well is greater than shown by the contractor's drawdown test.

The trend of reduced improvement for successive treatment steps has been shown by the results of the treatment for each of the five years that this general well treatment procedure has been followed. For the previous four years, from about 79 to 96 percent of the improvement was in place after the second polyphosphate treatment step. Depending on the specific response of each well, it is possible to eliminate treatment steps if expectations for specific capacity have been achieved. An overall reduction in the treatment cost may thus be realized by eliminating any unnecessary treatment steps. To do this, progress and results from each step in the rehabilitation work must be closely monitored in the field.

Following the chemical treatments in FY 90, the Water Survey conducted step tests on each of the treated wells to evaluate their condition and response to treatment as well as to provide results for comparison with the contractor's drawdown tests conducted during the well treatment. The results of these tests are summarized in table 5. Improvement in 25th Street Well 5 and Venice Well 2 was excellent with the specific capacities increasing about 373 and 607 percent to about 122 and 95 gpm/ft, respectively, based on the SWS step test data. It must be noted that these two dewatering wells had the lowest specific capacities prior to treatment, but that the resulting specific capacities were near the averages for the sites. Well loss was not significantly reduced in either of these wells, but the Δh values were dramatically lowered.

The data in table 5 also show that for each well treated the post-treatment step test shows a significantly better specific capacity than the treatment contractor's final drawdown test. In general, this has been the case (although to a lesser extent) in each of the five years that this well treatment procedure has been used. However, these data may be suspect because of the cracked orifice plate found on the contractor's orifice tube resulting in the actual discharge rate probably being greater than indicated. Thus the improvement based on the contractor's drawdown test data shown in tables 4 and 5 must be regarded as uncertain.

Table 5. Results of Chemical Treatment, FY90 (Phase 7)

			Pretreatment		Post-treatment		
Site	*Well*		*Date*	*Q/s (gpm/ft)*	*Date*	*Q/s (gpm/ft)*	*% Change*
I-70	Well 3	ISWS	12/11/89	44.9	4/17/90	84.0	+87
		BEC	2/21/90	37.7	2/28/90	61.6	+63
25th St.	Well 2	ISWS	8/9/89	58.3	4/18/90	120.4	+ 107
		BEC	2/2/90	31.0	2/13/90	94.5	+205
	Well 5	ISWS	5/16/89	25.8	4/19/90	122.0	+373
		BEC	1/22/90	30.6	2/1/90	101.7	+232
Venice	Well 2	ISWS	9/5/89	13.4	5/8/90	94.7	+607
		BEC	12/5/90	19.0	12/13/90	70.3	+270
	Well 5	ISWS	12/7/89	43.8	5/2/90	109.7	+ 150
		BEC	1/2/90	44.3	1/9/90	63.0	+42
Average		ISWS		37.2		106.2	+ 185
		BEC		32.5		78.2	+ 141

Q/s = Specific capacity, gpm/ft
ISWS = Illinois State Water Survey
BEC = Brotcke Engineering Company, Inc.

The pretreatment underwater video inspection of I-70 Well 3 and 25th Street Wells 2 and 5 showed that the well screens had chemical encrustation on the inside surface of the screen. In general, the encrustation was more pronounced on the upper portion of the well screens. Although a residual floc in the water hampered the post-treatment video inspections, in general, they indicated the chemical treatment had resulted in cleaning the chemical encrustation from the well screen.

Sand Pumpage Investigation

Field Procedure

Several prior occurrences of sand pumpage from the dewatering wells have resulted in the standard practice to check for the presence of sand in the discharge during each step test unless prevented by site conditions and available equipment. To continue to address these concerns, the possibility of sand pumpage was investigated during 11 of the 12 step tests conducted on nine wells during FY 90 (Phase 7). During the step tests water is discharged from the orifice tube into a portable 1000-gallon tank (see figure 9). Siphon tubes are used as necessary to help control the discharge from the tank. The tank acts as a sedimentation basin that, under ideal conditions, should allow sand with minimum grain diameters of no more than 0.1 millimeter (mm) 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 interval of the wells exceeds the 0.1 mm grain size.

Sand Pumpage Results

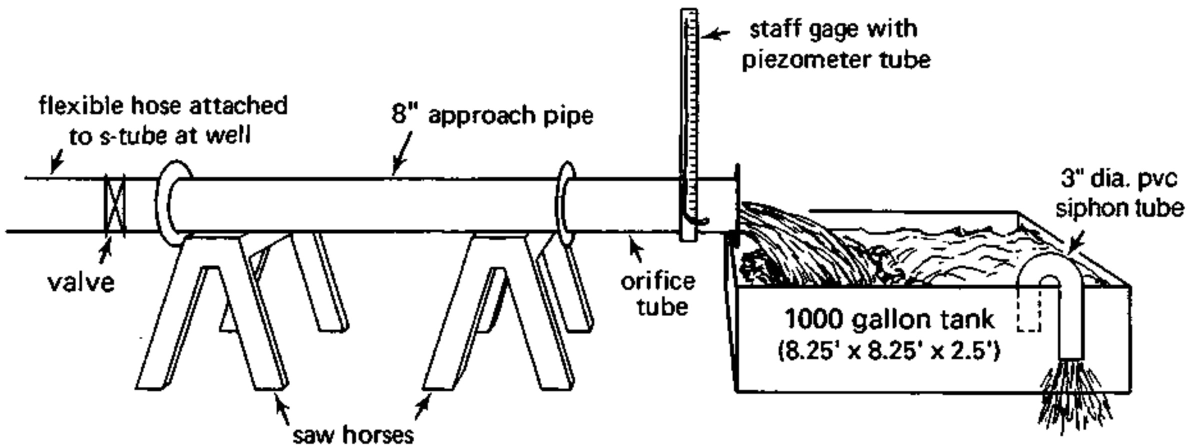
There was no sand detected in the tank after the pretreatment step test on December 11, 1989, on I-70 Well 3 and after the condition assessment step test conducted June 26, 1990, on I-70 Well 9A.

During the post-treatment step test conducted April 17, 1990, on I-70 Well 3 and the condition assessment step test conducted June 27, 1990, on I-70 Well 7A a very small amount of fine sand was collected in the portable tank. The amount was judged to be insignificant and no sample was collected for laboratory analysis.

There was no sand detected in the tank after the condition assessment step tests August 11, 1989, and September 7, 1989, on 25th Street Wells 1 and 3, respectively, and the post-treatment step test conducted April 19, 1990, on 25th Street Well 5.

There was no check of the possible sand content in the discharge from 25th Street Well 2 due to the site conditions.

An amount (about ⅓ to ½ cup) of sand was found in the tank following the condition assessment step test conducted September 6, 1989, on Venice Well 1. A sample was collected and later sieved in the laboratory to determine its grain-size distribution. The results of this analysis are shown in figure 10. Also shown are



SIDE VIEW

Figure 9. Sand pumpage test setup

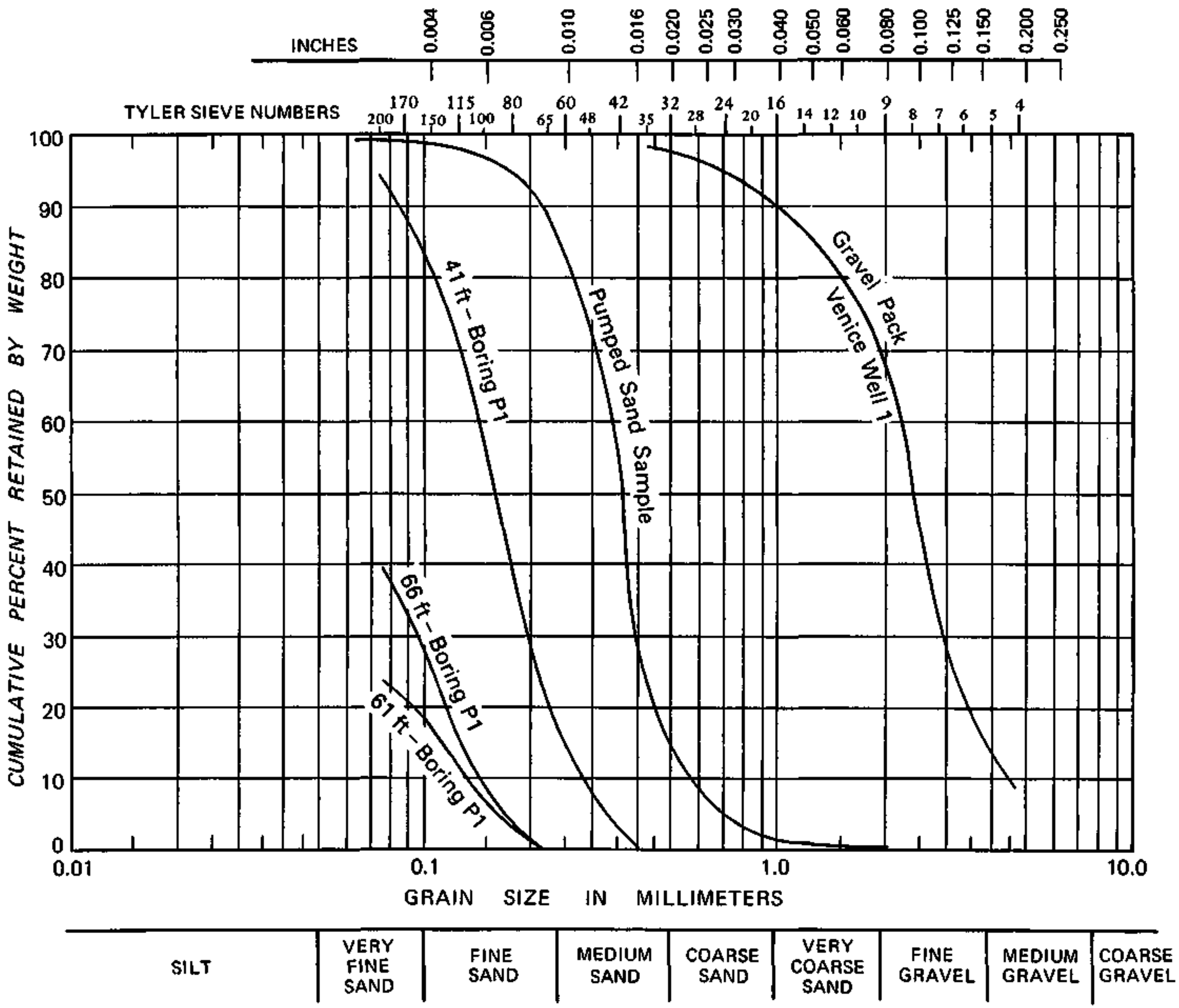


Figure 10. Sieve analysis of sand pumped from Venice Well 1

grain-size curves for three samples collected from Test Boring 1 located 30 feet from Venice Well 1 and the grain-size curve for the gravel pack used in Venice Well 1. This information is from the 1980 consultant's report investigating the feasibility of using a deep well dewatering system (Johnson, Depp, and Quisenberry, 1980). These curves show that the 50 percent grain-size of the three samples from the nearby Test Boring 1 are all more than ten times smaller than the 50 percent grain-size of the gravel pack. This grain-size difference is great enough to allow a well to pump sand (Smith, 1954). The unusual fact here is that the pumped sand sample is coarser-grained than the boring samples. However, this may be due to variations in the collected samples, the possible loss of the finest fraction of pumped sand from the portable tank, and that the boring was about 30 feet from Venice Well 1. The important matter in this instance is that the construction features of the well and the aquifer materials are such that the well could easily pump sand. It cannot be determined whether the well has always done so since construction. Or, if the well did not pump sand originally, whether the well treatment in August-September 1985 disturbed the gravel pack or aquifer material and caused the well to begin pumping sand, cannot be determined. If the well is pumped continuously, the amount of sand pumped in one year is estimated to be less than ½ cubic yard. Considering the likely operating times, this is not considered to be serious at this time. The well should be step-tested periodically in future work to monitor its condition.

There was no sand detected in the tank after the pretreatment step test conducted December 7, 1989, on Venice Well 5 and the post-treatment step tests conducted May 8, 1990, and May 2, 1990, on Venice Wells 2 and 5, respectively.

Evaluation of Ground-Water Quality

All ten wells were sampled for analysis by the Water Survey Analytical Chemistry Unit. The results are reported in appendix B. Analytical methods conform to procedures presented in the 16th edition of *Standard Methods for the Examination of Water And Wastewater* (1985). Samples were preserved with acid for determining iron, calcium, and magnesium concentrations. The sample temperature was determined at each well site, and pH was determined in the laboratory immediately after transit of the samples. The range of concentrations and potential influence of each parameter are presented in table 6.

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 samples previously analyzed and reported for wells in the nearby area.

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

Parameter	Concentration, mg/l Min.	Max.	Potential influence
Iron (Fe)	4.8	17.4	Major - incrustative
Calcium (Ca)	129.	246.	Major - incrustative
Magnesium (Mg)	35.2	68.8	Minor - incrustative
Sodium (Na)	16.5	254.	Neutral
Silica (SiO_2)	31.4	32.1	Minor - incrustative
Nitrate (NO_3)	< 0.1	0.2	Neutral
Chloride (C1)	23.2	86.8	Moderate - corrosive
Sulfate (SO_4)	160.	972.	Major - corrosive
Alkalinity (as $CaCO_3$)	360.	522.	Major - incrustative
Hardness (as $CaCO_3$)	467.	889.	Major - incrustative
Total dissolved solids	661.	1925.	Major - corrosive
pH	6.9	7.8	Major - incrustative

Condition of Relief Wells at Two I-255 Detention Ponds

IDOT maintains two stormwater detention ponds southeast of the intersection of I-255 and I-55/70. To help maintain stability of the reservoir berms and bottoms and to mitigate other problems at the site caused by high ground-water levels, 39 relief wells were built around the ponds (figure 11) during February-April 1985. Typical construction features of the relief wells are depicted in figure 12.

A periodic inspection and testing program were recommended by the consultant in the original design specifications prepared for the relief well system. As part of the FY 88 (Phase 5) work, IDOT directed the Water Survey to implement this program by conducting a preliminary investigation of the condition of the relief wells. The investigation was subsequently limited to visual observations from the vault manhole at ground level upon discovering that the well-heads, located at the bottom of the vaults about 10 feet below grade, were submerged with no provisions available for draining the vaults. Heavy concrete vault covers and poor location of vault entry ladders further restricted access. However, four wells were inspected, two at the north pond and two at the south pond. Results of the visual inspections appear in the Phase 5 report (Wilson et al., 1991).

Although the visual inspections in FY 88 did not reveal any obvious evidence that the condition of the relief wells might be in jeopardy, a more thorough investigation was recommended on four additional wells for precautionary purposes. Step-testing the wells, the established method of condition evaluation used on the dewatering wells, was ruled out because it would require the temporary installation of a

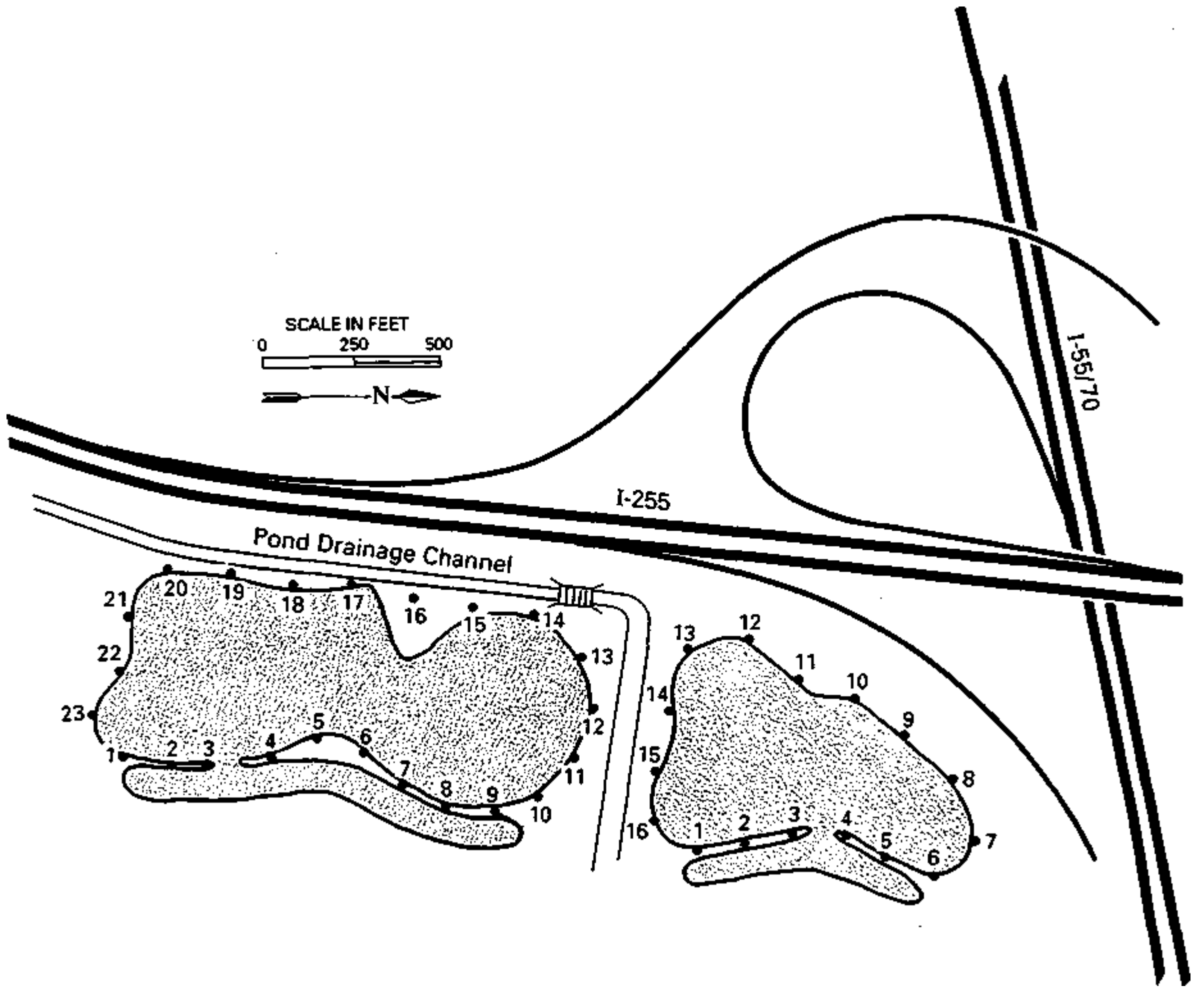


Figure 11. Locations of relief well around two stormwater detention ponds
(Adapted from John Matties and Associates, Inc., 1986)

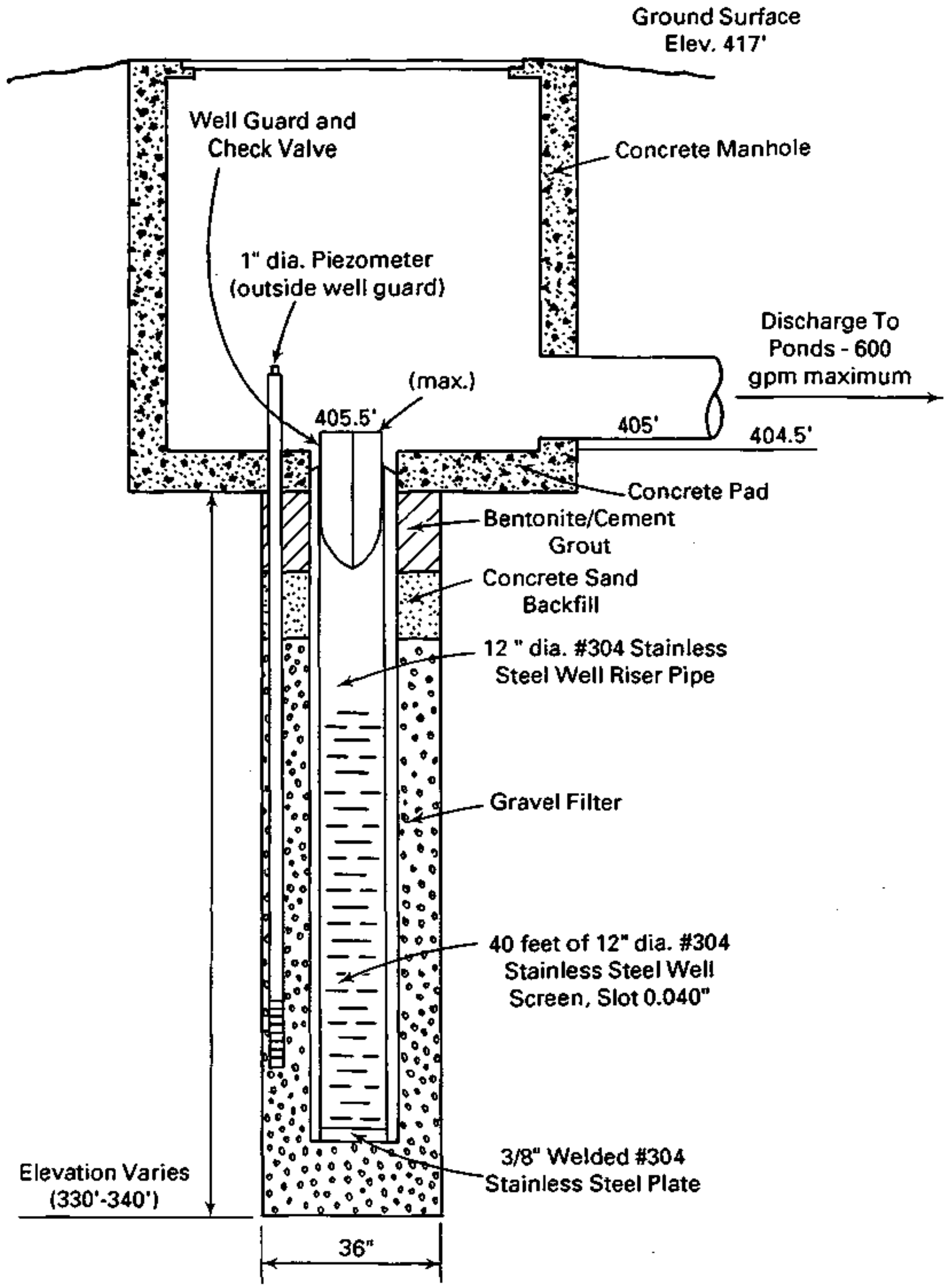


Figure 12. Relief well construction features
(From John Mathes and Associates, Inc., 1986)

high-capacity pump, discharge plumbing, and power supply for each test. Such an effort and the associated cost were deemed unnecessary for the relief wells at this time. As an alternative approach to step-test evaluation of the wells, recently developed nuisance bacteria tests was used to check for the presence of these organisms, which are often associated with loss of hydraulic efficiency in wells. This approach was consistent with the recommendations included in the consultant's original design specifications.

The follow-up investigation, originally scheduled in FY 89 (Phase 6) but delayed to FY 90 (Phase 7), included: visual inspection of the vault floor, well-head check valve and well casing; collection of water samples to check for the presence of nuisance bacteria; and other measurements/tests as might be both appropriate and possible. This work was scheduled as soon as the detention ponds could be pumped down, lowering water levels in the vaults, and inflatable plugs inserted in the vault outlet pipes to allow access to the well-heads independent of the pond water levels.

Biological Activity Reaction Tests (BART) were used to check water collected from the wells for nuisance bacteria. These tests have been customized to detect for the presence of three general classes of nuisance bacteria in water samples. These classes are iron-related bacteria (IRB), sulfate-reducing bacteria (SRB), and slime-forming bacteria (SLYM). The testing protocol requires a sample of water to be placed in the test vial and examined over a period of days, documenting any reactions that may occur. The level of bacterial activity in the water is directly related to the length of time before reactions occur, as well as the reaction patterns and types which show up.

South Detention Pond (SDP) Relief Wells (RW) 4 and 18 and North Detention Pond (NDP) RW 4 and 10 were selected for investigation during FY 90. SDP RW 10 was inspected on August 1, 1989, and the other wells were inspected during October 19-20, 1989. In addition, an underwater video inspection was conducted on SDP RW 4 and NDP RW 4 on March 1, 1990.

The same inspection procedure was used for each well. A ladder was lowered into the vaults, and the retainers on the well-heads were removed. A suction line, attached to a single-stage jet pump, was dropped into the well and pumping began at about 10 gpm. Two sets of samples were then collected for the nuisance bacteria tests. One set was collected after pumping each well for about 5 minutes and another was collected after pumping about 1 hour. The 5-minute samples allow the water within the borehole to be checked for bacterial activity whereas the lrhour samples should allow water to be checked that includes a substantial fraction originating from the gravel pack and, to a lesser extent, the sand-and-gravel aquifer.

The results of all BART samples showed a very high amount of nuisance bacteria activity in the discharge water from the wells. In general, the IRB and SRB tests showed positive reactions somewhat sooner than the SLYM tests. The positive response for the IRB and SRB tests occurred within two days, which is considered to indicate major bacterial activity. For the SLYM tests, the response varied from one to four days, indicating major to moderate bacterial activity.

Positive responses for the 5-minute and I-hour water samples occurred in about the same time interval indicating the presence of similar-sized bacterial populations, although there were several cases where either the 5-minute or I-hour sample from the same well responded somewhat sooner than the other sample. The quick response of all samples probably means that a substantial biomass development within the well casing and screen is slowly sloughing off during the pumping or that the bacteria are present in both the gravel pack/aquifer materials and the well.

The visual detail from the video inspections was severely limited because of the very murky water encountered in both wells. The murkiness probably is the result of the nuisance bacteria activity identified with the BART sampling. The video pictures added little to our understanding of the condition of the wells. The clarity of the water and resulting video picture might be improved if the wells were pumped at a sufficient rate before and during the inspection.

When taking into consideration that all relief well-heads inspected so far are in direct connection with the detention pond water, the high degree of nuisance bacteria activity is not surprising. Most of these types of bacteria as well as many other microorganisms are relatively common in surface water. Although nuisance bacteria can be present in ground water, the submergence of the well-heads virtually assures that the wells are inoculated with those nuisance bacteria present in the pond water along with many of the nutrients needed for their proliferation.

Even though the nuisance bacteria have been identified in the wells, in sufficiently high numbers to indicate a significant potential for plugging, it is not possible to determine whether the hydraulic efficiency has been affected. Step-testing each well would address this question; however, conducting step tests will require the installation of a suitable pump, plumbing, and power source at each well. In addition, the vaults will need to be isolated from the detention ponds with inflatable plugs or some other type of valve installed in the outlet pipes.

Based on the information collected to date and the apparent overdesign of the detention pond/relief well system, it appears that step-testing the wells is unnecessary at this time. Rather it would seem that a combination of piezometer ground-water level measurements and periodic visual inspection of the well-heads in the vaults should be adequate for the immediate future. If these observations begin to show symptoms that would suggest that a problem is developing, then a more detailed assessment of the system can be initiated. Although measurements probably are not necessary from each relief well piezometer, nearly all of the piezometers available at the two ponds are inaccessible for measurement of ground-water levels without removing the heavy concrete vault covers. Either the existing piezometers need to be modified so that regular measurements can be obtained using a reasonable amount of effort or several new piezometers will need to be constructed at strategic locations around each detention pond for this purpose.

CONCLUSIONS AND RECOMMENDATIONS

Condition of Wells

The results of the step tests show that I-70 Well 9A, 25th Street Well 1, and Venice Well 1 are in good condition. The wells are considered to be in good condition primarily on the basis of specific capacity and water-level difference (Ah) data. Although the well loss for I-70 Well 9A is low, for the other two wells it was 12 and 27 percent of the total drawdown, which is considered high.

Two wells are in poor condition. This conclusion for I-70 Well 7A is on the basis of specific capacity, well loss, and Δh data, and for 25th Street Well 3, on the basis of specific capacity and Δh data. The inability to calculate turbulent well loss for some tests probably results from laminar conditions at low pumping rates or from unstable conditions in the vicinity of the well screens. The polyphosphate/acid treatment used on the dewatering wells in previous years is recommended to improve the condition of these two wells.

The five wells step-tested after chemical treatment (I-70 Well 3, 25th Street Wells 2 and 5, and Venice Wells 2 and 5) appear to be restored to acceptable condition on the basis of specific capacity and Δh data. Two of the wells show well loss of 9 and 55 percent while well losses could not be calculated for the three other wells. In this case, the high percentage of drawdown attributed to well loss in the wells is not judged to be a major factor in determining their condition. Perhaps more important are the specific capacity and Δh values, which are reasonable for each of these wells.

Well Rehabilitation

The chemical treatments used to restore well capacity in FY 90 (Phase 7) were successful. The drawdown data collected during the treatment by the contractor indicate that the average increase in specific capacity of the five wells was about 141 percent while the Water Survey step test data show the improvement to be about 185 percent. The post-treatment specific capacity of three of the wells is within 5 gpm/ft of the site average given in table 2. One well (I-70 Well 3) is about 16 gpm/ft and the other (Venice Well 2) is about 11 gpm/ft less than the site average for wells in good condition.

The project specification change in FY 90 to provide for optional polyphosphate treatment steps after the second application, did not reduce the total number of polyphosphate treatments applied to these five wells. One polyphosphate step was dropped at Venice Well 5 while a fifth treatment was added at Venice Well 2 in an attempt to further improve the specific capacity. The data in table 6 show little or no improvement in specific capacity after the third polyphosphate step except for Venice Well 2. After the fact, it is apparent that the fourth polyphosphate step did not significantly improve the specific capacity of these five wells.

Sand Pumpage Investigation

The discharge from nine dewatering wells was tested for sand pumpage during eleven step tests. The tenth well, 25th Street Well 2, was not checked because site conditions and available equipment did not allow placement of the portable tank. Sand was found in the portable tank after the step test conducted on Venice Well 1. At this time the amount of the pumped sand does not appear to pose a serious operational problem as it is estimated that less than ½ cubic yard of sand would be pumped in one year of continuous pumping. It is recommended that this well be placed on reduced usage status and that future investigations include monitoring its condition.

The investigation also revealed indications of possible sand pumpage at I-70 Wells 3 and 7A. Only a very small amount was detected in the discharge from these wells and no sample was collected for laboratory analysis. However, later during the summer of 1990, substantial caving was found to have occurred adjacent to the well vault of I-70 Well 3. To date, there has been no further investigation of this matter. A downhole video inspection and placement of a boring next to the well (for formation sampling and grain size analysis) should be considered to help in planning the course of remediation to pursue. This well requires immediate attention before the caving causes irreparable damage to the well, and it is recommended that the well be placed on emergency-use only status until repairs have been completed.

Detention Pond Relief Wells

The follow-up investigation of the condition of the detention pond relief wells was concluded with the testing of water samples from four wells for nuisance bacteria, and the underwater video inspection of two wells. The nuisance bacteria tests showed a high degree of biological activity both from within the well and possibly from water in the gravel pack/aquifer materials located in the immediate vicinity of the relief well. The activity level of all three general types of bacteria tested for-iron-related bacteria, sulfate-reducing bacteria, and slime-forming bacteria—was high although the former two showed positive reactions somewhat sooner than the latter type. The video inspections yielded little additional information concerning the condition of the relief wells because of the murky water that was encountered. Additional video inspections should not be considered until measures can be taken to clarify the water.

The high degree of bacterial activity indicates a significant potential for plugging of the sand-and-gravel aquifer, gravel pack, and well screen. However, it is not possible at this time to determine whether the hydraulic condition of the relief wells has been adversely affected. Step-testing the relief wells would help address this issue but the effort and cost probably is not justified at this time based on the apparent overdesign of the detention pond/ relief well system. It is recommended that a combination of piezometer ground-water level measurements and periodic visual inspection of the well-heads be conducted on a continuing basis. If these observations show that a potential problem is developing, then a more detailed assessment of the system can be initiated.

Future Investigations

A program of continued investigation of the condition of the dewatering wells is recommended. Measuring the difference between water levels in the piezometer and the adjacent well will continue to be important as a first step in determining whether wells are candidates for future step tests or treatment. In addition, if a well is pumping sand, it suggests a potentially major problem and indicates that further investigation is warranted. A sand pumpage investigation is recommended as a standard part of each step test.

BIBLIOGRAPHY

Arceneaux, W. 1974. Operation and maintenance of wells. Journal, American Water Works Association, March.

Bergstrom, R. E., and T. R. Walker. 1956. Ground-water geology of the East St. Louis area, Illinois. Illinois State Geological Survey Report of Investigation 191.

Collins, M. A., and S. Richards. 1986. Groundwater levels and pumpage in the East St. Louis area, 1978-1980. Illinois State Water Survey Circular 165.

Cowan, J. C, and D. J. Weintritt. 1976. Water-formed scale deposits. Gulf Publishing Company.

Cullimore, D. R. 1990. An evaluation of the risk of microbial clogging and corrosion in boreholes. Water Wells Monitoring, Maintenance, Rehabilitation: Proceedings of the International Groundwater Engineering Conference, September 1990. E.& F.N. Spon, University Press, Cambridge, Great Britain, pp 25-34.

Driscoll, F. G. 1986. Groundwater and wells. Johnson Division, St. Paul, MN, 1089 p.

Emmons, J. T. 1979. Groundwater levels and pumpage in the East St. Louis area, Illinois, 1972-1977. Illinois State Water Survey Circular 134.

Freese, R. A., and J. A. Cherry. 1979. Groundwater. Prentice-Hall, Englewood Cliffs, NJ, 604 p.

Garske, E. E., and M. R. Schock. 1986. An inexpensive flow-through cell and measurement device for monitoring selected ground water chemical parameters. Ground Water Monitoring Review, Summer.

Jacob, C. E. 1947. Drawdown tests to determine effective radius of artesian well. Transactions, American Society of Civil Engineers, v. 72.

John Mathes and Associates, Inc. 1981. Venice subway FAUS Report 8807 Section 27T, Madison County, Illinois, Job No. P-98-04I-79. Consultant's report to the Division of Highways.

John Mathes and Associates, Inc. 1984. Geotechnical evaluation of retention pond design alternatives FAI-255, Section 60-71. Consultant's report to IDOT.

John Mathes and Associates, Inc. 1986. Relief well construction and maintenance FAI-255, Section 60-71. Consultant's report to IDOT District 8.

Johnson, Depp, and Quisenberry. 1980. Venice subway dewatering. Consultant's report to the Division of Highways.

Kohlhase, R. C. 1987. Ground-water levels and pumpage in the East St. Louis area, Illinois, 198I-1985. Illinois State Water Survey Circular 168.

Larson, T. E. 1955. Report on loss of carrying capacity of water mains. Journal, American Water Works Association, November.

Layne-Western Company, Inc. 1972. Ground water drainage system F.A.I. Route 70 Tri-level location, East St. Louis, Illinois. Consultant's report to the Division of Highways.

Mansuy, N., C. Nuzman, and D. R. Cullimore. 1990. Well problem identification and its importance in well rehabilitation. Water Wells Monitoring, Maintenance, Rehabilitation: Proceedings of the International Groundwater Engineering Conference, September 1990. E.& F.N. Spon, University Press, Cambridge, Great Britain, pp 87-99.

McClelland Engineers, Inc. 1971. Highway I-70 drainage system at Tri-Level Bridge, East St. Louis, Illinois. Consultant's report to the Division of Highways.

Mogg, J. L. 1973. Corrosion and incrustation guidelines for water wells. Water Well Journal, March.

Moss, R., Jr. 1966. Evaluation of materials for water well casings and screens. Proceedings, National Association of Corrosion Engineers Western Region Meeting, October.

Olson, R. D., E. W. Sanderson, S. H. Smothers, and M. R. Schock. 1990. Dewatering well assessment for the highway drainage system at four sites in the East St. Louis area, Illinois (Phase 3). Illinois State Water Survey Contract Report 479.

Olson, R. D., S. D. Wilson, and E. W. Sanderson. 1991. Dewatering well assessment for the highway drainage system at four sites in the East St. Louis area, Illinois (FY 89 - Phase 6). Illinois State Water Survey Contract Report 540.

Ritchey, J. D., R. J. Schicht, and L. S. Weiss. 1984. Groundwater level analysis by computer modeling: American Bottoms groundwater study. Illinois State Water Survey Contract Reports 352A-E.

Rorabaugh, M.I. 1953. Graphical and theoretical analysis of step drawdown test of artesian well. Proceedings, American Society of Civil Engineers, v. 79, Separate No. 362.

Rupani, N. 1976. Highway I-55 & 70 and I-64 deep drainage system at Tri-Level Bridge in East St. Louis, Illinois. Division of Highways file report.

Ryznar, J. W. 1944. A new index for determining amount of calcium carbonate scale formed by a water. Journal, American Water Works Association, April.

Sanderson, E. W., and M. R. Schock. 1987. Dewatering well assessment for the highway drainage system at four sites in the East St. Louis area, Illinois (Saskatoon Conference Report). Illinois State Water Survey, Champaign.

Sanderson, E. W., M. R. Schock, and R. D. Olson. 1987. Dewatering well assessment for the highway drainage system at four sites in the East St. Louis area, Illinois (Phase 2). Illinois State Water Survey Contract Report 424.

Sanderson, E. W., A. P. Visocky, M. A. Collins, R. D. Olson, and C. H. Neff. 1984. Dewatering well assessment for the highway drainage system at four sites in the East St. Louis area (Phase 1). Illinois State Water Survey Contract Report 341.

Saner, J. L. 1976. Corrosion study of East St. Louis dewatering wells. Bureau of Materials and Physical Research Report.

Schicht, R. J. 1965. Ground-water development in the East St. Louis area, Illinois. Illinois State Water Survey Report of Investigation 51.

Skougstad, M. W., et al. 1978. Methods for analysis of inorganic substances in water and fluvial sediments. U.S. Geological Survey Open-File Report 78-679, 1005 p.

Smith, H. F. 1954. Gravel packing water wells. Illinois State Water Survey Circular 44.

Standard methods for the examination of water and wastewater. 1985. 16th edition, APHA-AWWA-WPCF, 1268 p.

Suiden, M. T. 1989. Physical principles of environmental engineering processes. University of Illinois course notes, Champaign, IL.

Theis, C. V. 1935. The relation between the lowering of piezometric surface and the rate and duration of discharge of a well using ground-water storage. Transactions, American Geophysical Union 16th Annual Meeting, pt. 2.

U.S. Environmental Protection Agency. 1979. Methods for chemical analysis of water and wastes, EPA 600/4-79-020, 460 p.

Viessman, W., and M. J. Hammer. 1985. Water supply and pollution control. Harper and Row, New York, NY, 796 p.

Walton, W. C. 1962. Selected analytical methods for well and aquifer evaluation. Illinois State Water Survey Bulletin 49.

Wilson, S. D., R. D. Olson, and E. W. Sanderson. 1991. Dewatering well assessment for the highway drainage system at four sites in the East St. Louis area, Illinois (Phase 5). Illinois State Water Survey Contract Report 509.

Wilson, S. D., E. W. Sanderson, and R. D. Olson. 1990. Dewatering well assessment for the highway drainage system at four sites in the East St. Louis area, Illinois (Phase 4). Illinois State Water Survey Contract Report 480.

Appendix A.

Step Test Data
FY 90 (Phase 7)

I-70	Well	3	12/11/89
	Well	3	4/17/90
	Well	7A	6/27/90
	Well	9A	6/26/90
25th St.	Well	1	8/11/89
	Well	2	4/18/90
	Well	3	9/ 7/89
	Well	5	4/19/90
Venice	Well	1	9/ 6/89
	Well	2	5/ 8/90
	Well	5	12/ 7/89
	Well	5	5/ 2/90

DEWATERING WELL DATA

	Well No. 170 W3	Piezometer No. I70 P3
Date Drilled:	1973	1973
Casing		
Top elevation:	397.3	406.7
Diameter:	16-in. SS	2-in. PVC
Length:	33	na
Screen		
Bottom elevation:	304.43	na
Diameter:	16-in. SS	2-in. PVC
Length:	60 ft	3 ft
Slot size:	0.080-in.	na
Measuring Point Elevation:	398.2	406.7
Nonpumping Water Level		
Depth below temp. MP:	23.48	-
Length of temp. MP extension:	7.4	-
Depth below perm. MP:	16.08	24.30
Elevation:	382.12	382.4
Date of Step Test:	12/11/89	-
Water Sample		
Time:	Not recorded	-
Temperature:	Not recorded	-
Laboratory No.:	223290	-
Distance and Direction to Piez. from PW:		9.0 ft North
Time PW Off Before Step Test:		na

Wells in Operation at Site at Time of Step Test: na

Notes: SWS 8-in. dia. orifice tube w/plate No. 4; Data collected using McDAS; No sand noted in tank at end of test.

SWS Crew: S. Wilson, K. Hlinka

WATER LEVEL MEASUREMENTS
I-70 Well No. 3
Pre-Treatment Step Test

Hour	Time (min)	Adjusted depth to water in well (ft)	Adjusted depth to water in piezometer (ft)	Orifice tube piez. (ft)	Pumping rate (gpm)	Remarks
12/11/89						
11:26 am	0.0		24.30			Measured Depth
11:29 am	0.0	23.45				Measured Depth
						Problems with McDAS
12:21 pm	0.0	23.48				Measured Depth
12:36 pm	0.0					Pump On
12:37 pm	1.0			2.50	530	Step 1; Max rate
	2.0			2.20	500	
	4.0			2.18	500	
	29.0			2.15		
01:06 pm	30.0					Reduce rate
01:06 pm	1.0			1.80	450	Step 2
	2.0			1.80	450	
01:11 pm	5.0					Excess water on highway; stopped step test
						McDAS data deleted
02:29 pm	0.0	23.48	24.30			McDAS re-started
	1.0	23.50	24.21			Water Level Trend
02:31 pm	2.0	23.52	24.19			
	3.0	23.45	24.20			
	4.0	23.44	24.26			
	5.0	23.46	24.17			
	6.0	23.46	24.21			
	6.8	23.49	24.20			
02:36 pm	0.0					Pump On
02:37 pm	1.0	33.55	26.35			Step 1
	2.0	33.65	27.50	2.20	500	
	3.0	33.81	27.94			
	4.0	33.85	28.10	2.20	500	
	5.0	33.88	28.13			
	6.0	33.91	28.23			
	8.1	34.02	28.32			
02:46 pm	10.0	34.10	28.33			
	12.0	34.15	28.36			
	14.1	34.20	28.41			
	16.1	34.23	28.45			
	18.1	34.25	28.46			
02:56 pm	19.8	34.28	28.50			
	22.2	34.30	28.51			
	23.8	34.31	28.52			
	24.9	34.34	28.54			
	26.1	34.37	28.55	2.14	490	

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

Hour	Time (min)	Adjusted depth to water in well (ft)	Adjusted depth to water in piezometer (ft)	Orifice tube piez. (ft)	Pumping rate (gpm)	Remarks
	26.7	34.36	28.57			
	27.3	34.37	28.54			
	27.9	34.36	28.56			
	28.6	34.37	28.55			
	29.2	34.40	28.56	2.14	490	
03:06 pm	30.0					Reduce rate
03:07 pm	1.0	33.67	28.52	1.80	450	Step 2
	2.0	33.69	28.41			
	3.0	33.67	28.38			
	4.0	33.65	28.36			
	5.0	33.67	28.34			
	6.0	33.70	28.35			
	8.0	33.69	28.33			
03:16 pm	10.0	33.70	28.39			
	12.0	33.70	28.35			
	14.1	33.71	28.39			
	16.2	33.74	28.38			
	18.1	33.74	28.40			
03:26 pm	19.8	33.74	28.40	1.80	450	
	22.2	33.76	28.41			
	23.8	33.69	28.33			
	24.9	33.64	28.28			
	26.1	33.68	28.28			
	26.7	33.66	28.30			
	27.3	33.64	28.29			
	28.0	33.64	28.28			
	29.3	33.61	28.24	1.80	450	
03:36 pm	30.0	33.61	28.22			
	30.7	33.60	28.24			
03:37 pm	31.0					Reduce rate
03:38 pm	1.0	32.57	28.01	1.41	400	Step 3
	2.0	32.52	27.87			
	3.0	32.47	27.85			
	4.0	32.46	27.75			
	5.0	32.48	27.81	1.41	400	
	6.0	32.44	27.76			
	8.1	32.43	27.73			
03:47 pm	9.9	32.45	27.75			
	11.9	32.40	27.71			
	14.0	32.39	27.72			
	16.1	32.39	27.72			
	18.0	32.39	27.71			

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

Hour	Time (min)	Adjusted depth to water in well (ft)	Adjusted depth to water in piezometer (ft)	Orifice tube piez. (ft)	Pumping rate (gpm)	Remarks
03:57 pm	20.2	32.39	27.69	1.42	400	
	22.1	32.37	27.68			
	24.2	32.36	27.68			
	24.8	32.37	27.67			
	26.0	32.36	27.67			
	27.2	32.37	27.66			
	27.8	32.33	27.67			
	28.5	32.37	27.69			
04:06 pm	29.0			1.42	400	Reduce rate
04:07 pm	1.0	31.32	27.52	1.09	350	Step 4
	2.0	31.31	27.35			
	3.0	31.23	27.29			
	4.0	31.23	27.22			
	5.0	31.23	27.23			
	6.0	31.22	27.23			
	8.1	31.19	27.22			
04:16 pm	10.2	31.17	27.47			
	11.9	31.18	27.19			
	14.0	31.16	27.16			
	16.1	31.16	27.18			
	18.0	31.15	27.17	1.10	350	
04:26 pm	20.2	31.15	27.17			
	22.1	31.12	27.18			
	24.2	31.13	27.16			
	24.8	31.15	27.15	1.07	347	
	26.0	31.13	27.14			
	27.2	31.15	27.14			
	27.8	31.13	27.17			
	28.5	31.13	27.16			
	29.1	31.14	27.15			
	29.8	31.13	27.16			
04:36 pm	30.0					End of Test

Water sample was collected; time and water temperature was not recorded.

DEWATERING WELL DATA

	Well No. I70 W3	Piezometer No. I70 P3
Date Drilled:	1973	1973
Casing		
Top elevation:	397.3	406.7
Diameter:	16-in. SS	2-in. PVC
Length:	33	na
Screen		
Bottom elevation:	304.43	na
Diameter:	16-in. SS	2-in. PVC
Length:	60 ft	3 ft
Slot size:	0.080-in.	na
Measuring Point Elevation:	398.2	406.7
Nonpumping Water Level		
Depth below temp. MP:	29.05	-
Length of temp. MP extension:	7.35 ft	-
Depth below perm. MP:	21.70	29.85
Elevation:	376.5	376.9
Date of Step Test:	4/17/90	-
Water Sample		
Time:	1:35 pm	-
Temperature:	Not recorded	-
Laboratory No.:	223481	-

Distance and Direction to Piez. from PW: 9.0 ft North

Time PW Off Before Step Test: Not recorded

Wells in Operation at Site at Time of Step Test:* I70 W4; I70 W5; I70 W6; I70 W7; I70 W8; I70 W10

Notes: SWS 8-in. dia. orifice tube w/plate No. 4; Data collected using McDAS; Show of fine sand in tank at end of test, no sample collected.

SWS Crew: S. Wilson, K. Hlinka

* Operation based upon IDOT records

WATER LEVEL MEASUREMENTS
I-70 Well No. 3
Post-Treatment Step Test

Hour	Time (min)	Adjusted depth to water in well (ft)	Adjusted depth to water in piezometer (ft)	Orifice tube piez. (ft)	Pumping rate (gpm)	Remarks
04/17/90						
11:06 am	0.0		29.85			Measured Depth
11:16 am	0.0	29.05				Measured Depth
11:26 am	0.0	29.05	29.84			McDAS started
	1.0	29.06	29.87			Water Level Trend
	2.0	29.05	29.86			
	3.0	29.06	29.87			
	4.0	29.06	29.85			
	5.0	29.05	29.84			
	6.0	29.04	29.84			
	6.6	29.04	29.83			
11:33 am	0.0					Pump On
11:34 am	1.0	33.78	31.75	1.73	440	Step 1; Max rate
	2.0	33.96	32.49			Adjust rate
	3.0	34.00	32.70			
	4.0	33.59	32.65	1.42	400	
	5.0	33.59	32.58			
	6.0	33.61	32.58			
	8.1	33.66	32.60			
11:43 am	10.1	33.68	32.63	1.42	400	
	12.1	33.70	32.65			
	13.9	33.72	32.66			
	16.0	33.73	32.67			
	17.9	33.74	32.68			
11:53 am	20.1	33.76	32.69			
	22.0	33.77	32.70			
	24.1	33.78	32.71			
	25.2	33.78	32.71	1.42	400	
	25.8	33.78	32.72			
	27.0	33.79	32.72			
	27.6	33.79	32.72			
	28.3	33.79	32.72			
	28.9	33.80	32.72			
	29.6	33.80	32.73			
12:03 pm	30.0					Reduce rate
12:04 pm	1.0	33.25	32.54	1.09	350	Step 2
	2.0	33.37	32.44			
	3.0	33.41	32.48			
	4.0	33.12	32.42			
	5.0	33.11	32.36			
	6.0	33.09	32.33			
	8.0	33.08	32.31	1.08	350	

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

Hour	Time (min)	Adjusted depth to water in well (ft)	Adjusted depth to water in piezometer (ft)	Orifice tube piez. (ft)	Pumping rate (gpm)	Remarks
12:13 pm	10.0	33.08	32.31			
	12.0	33.07	32.29			
	14.1	33.07	32.30			
	16.1	33.06	32.30	1.08	350	
	18.1	33.06	32.29			
12:23 pm	19.8	33.06	32.29			
	22.2	33.06	32.29			
	23.8	33.05	32.28			
	24.9	33.06	32.28	1.08	350	
	26.1	33.06	32.28			
	27.3	33.05	32.28			
	27.9	33.05	32.28			
	29.2	33.05	32.28	1.08	350	
	29.9	33.08	32.28			
12:33 pm	30.0					Reduce rate
12:34 pm	1.0	32.52	32.09	0.79	300	Step 3
	2.0	32.51	31.98			
	3.0	32.50	31.96			
	4.0	32.48	31.96			
	5.0	32.48	31.94			
	6.0	32.47	31.94			
	8.1	32.46	31.93	0.79	300	
12:43 pm	10.0	32.45	31.92			
	12.0	32.44	31.91			
	14.0	32.44	31.91			
	16.0	32.45	31.91	0.79	300	
	18.0	32.44	31.91			
12:53 pm	20.1	32.43	31.91			
	22.1	32.43	31.90			
	24.2	32.42	31.90			
	25.3	32.43	31.89	0.79	300	
	25.9	32.43	31.90			
	27.1	32.43	31.89			
	27.7	32.42	31.90			
	29.0	32.42	31.89	0.79	300	
	29.7	32.43	31.89			
01:03 pm	30.0					Reduce rate
01:04 pm	1.0	31.83	31.68	0.55	250	Step 4
	2.0	31.79	31.58			
	3.0	31.79	31.53			
	4.0	31.78	31.51			
	5.0	31.76	31.50			

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

Hour	Time (min)	Adjusted depth to water in well (ft)	Adjusted depth to water in piezometer (ft)	Orifice tube piez. (ft)	Pumping rate (gpm)	Remarks
	6.0	31.76	31.49	0.55	250	
	8.1	31.74	31.49			
01:13 pm	10.0	31.74	31.49			
	11.9	31.68	31.48			
	14.0	31.66	31.47			
	16.0	31.65	31.46			
	17.9	31.65	31.46			
01:23 pm	20.1	31.65	31.46			
	22.0	31.65	31.45			
	24.1	31.65	31.45			
	25.3	31.64	31.45	0.55	250	
	25.9	31.66	31.45			
	27.1	31.65	31.45			
	28.3	31.64	31.45			
	29.0	31.65	31.45			
	29.7	31.64	31.45			
01:33 pm	30.0					End of Test
01:35 pm						Water sample collected; (temp not recorded)

DEWATERING WELL DATA

	Well No. I70 W7A (14th)	Piezometer No. I70 P7A
Date Drilled:	11/86	1986
Casing		
Top elevation:		393.56
Diameter:	16-in. SS	2-in. PVC
Length:	60 ft	na
Screen		
Bottom elevation:		na
Diameter:	16-in. SS	2-in. PVC
Length:	60 ft	3 ft
Slot size:	0.080-in.	na
Measuring Point Elevation:	390.17	393.56
Nonpumping Water Level		
Depth below temp. MP:	12.84	-
Length of temp. MP extension:		-
Depth below perm. MP:		13.02
Elevation:		380.54
Date of Step Test:	6/27/90	-
Water Sample		
Time:	12:48	-
Temperature:	16° C	-
Laboratory No.:	223575	-
Distance and Direction to Piez. from PW:		5.2 ft East
Time PW Off Before Step Test:		Not recorded
Wells in Operation at Site at Time of Step Test:		Not recorded

Notes:
- SWS 8-in. dia. orifice tube w/plate No. 4
- Pit discharge pipe has ½- to ¾-inch thick incrustation
- Check valve leaks when discharge pipe is disconnected from system
- Small amount of very fine sand and incrustation particles in settling tank at end of test
- Data collected with McDAS

SWS Crew: S. Wilson, R. Olson, E. Sanderson

WATER LEVEL MEASUREMENTS
I-70 Well No. 7A (14th)
Condition Assessment Step Test

Hour	Time (min)	Adjusted depth to water in well (ft)	Adjusted depth to water in piezometer (ft)	Orifice tube piez. (ft)	Pumping rate (gpm)	Remarks
06/27/90						
10:48 am	0.0	12.84				Measured Depth
10:50 am	0.0		13.02			Measured Depth
11:08 am	0.0	12.85	13.02			McDAS started
	1.0	12.86	13.23			Water Level Trend
	2.0	12.82	13.30			
	3.0	12.81	13.32			
	4.0	12.83	13.35			
	5.1	12.89	13.37			
	5.3	12.83	13.36			
11:14 am	0.0					Pump On
11:15 am	1.0	29.67	20.99			Step 1
	2.0	29.59	21.17	1.60	425	Maximum rate
	3.0	29.64	21.24			
	4.0	29.23	21.13	1.43		
	5.1	28.81	20.98	1.40	400	
	6.1	28.83	21.02			
	8.0	28.93	21.06			
11:24 am	10.1	28.98	21.10			
	12.1	29.01	21.12			
	13.9	29.03	21.14			
	15.9	29.04	21.15			
	18.2	29.07	21.17	1.39	400	
11:34 am	20.0	29.08	21.18			
	21.9	29.09	21.16			Transducer came loose but reset it
	24.0	29.12	21.18			
	25.1	29.12	21.18			
	26.3	29.10	21.17			
	26.9	29.09	21.17			
	27.5	29.12	21.18			
	28.2	29.12	21.19			
	28.8	29.13	21.19			
	29.5	29.12	21.19			
11:44 am	30.0					Reduce rate
11:45 am	1.0	27.67	20.63	1.16	360	Step 2
	2.0	27.60	20.58			
	3.0	27.54	20.56	1.16	360	
	4.0	27.55	20.56			
	5.1	27.54	20.55			
	6.0	27.57	20.57			
	8.0	27.54	20.58			
11:54 am	10.1	27.57	20.57			

WATER LEVEL MEASUREMENTS (Continued)
I-70 Well No. 7A (14th)

Hour	Time (min)	Adjusted depth to water in well (ft)	Adjusted depth to water in piezometer (ft)	Orifice tube piez. (ft)	Pumping rate (gpm)	Remarks
	12.1	27.57	20.57			
	13.9	27.57	20.59			
	15.9	27.57	20.58	1.17	360	
12:04 pm	20.0	27.60	20.58			
	21.9	27.59	20.58			
	24.0	27.59	20.61			
	25.1	27.59	20.61			
	26.3	27.59	20.59			
	26.9	27.62	20.59			
	28.2	27.60	20.62	1.16	360	
	28.8	27.60	20.60			
	29.5	27.60	20.60			
12:14 pm	30.0					Reduce rate
12:15 pm	1.0	25.66	19.84			Step 2
	2.0	25.53	19.74	0.88	320	
	3.0	25.47	19.71			
	4.0	25.48	19.71			
	5.0	25.50	19.72			
	6.0	25.46	19.71			
	8.1	25.46	19.67			
12:24 pm	10.0	25.43	19.65			
	12.0	25.43	19.65			
	14.0	25.43	19.67			
	16.1	25.44	19.71			
	17.2	25.46	19.70	0.88	320	
	18.0	25.44	19.69			
12:34 pm	20.2	25.45	19.68			
	22.2	25.46	19.67			
	23.8	25.44	19.67			
	24.9	25.46	19.67			
	26.0	25.45	19.66			
	27.3	25.46	19.69			
	27.9	25.46	19.69			
	29.2	25.47	19.70	0.88	320	
	29.9	25.46	19.68			
12:44 pm	30.0					Reduce rate
12:45 pm	1.0	23.98	19.08			Step 4
	2.0	23.77	18.96	0.68	280	Water sample collected; T=16°C
	3.0	23.76	18.95			
	4.0	23.76	18.94	0.68	280	
	5.0	23.76	18.96			
	6.0	23.75	18.96			

WATER LEVEL MEASUREMENTS (Continued)
I-70 Well No. 7A (14th)

Hour	Time (min)	Adjusted depth to water in well (ft)	Adjusted depth to water in piezometer (ft)	Orifice tube piez. (ft)	Pumping rate (gpm)	Remarks
	8.0	23.73	18.95			
12:54 pm	10.0	23.72	18.94			
	12.0	23.74	18.92			
	14.0	23.74	18.95			
	16.1	23.73	18.94			
	18.0	23.74	18.91			
01:04 pm	19.8	23.74	18.93			
	22.2	23.72	18.91			
	23.3	23.73	18.91	0.68	280	
	23.8	23.72	18.92			
	24.9	23.71	18.91			
	26.1	23.71	18.90			
	26.7	23.73	18.90			
	28.0	23.74	18.91			
	29.3	23.72	18.91			
01:14 pm	30.0	23.73	18.91	0.68	280	End of Test

DEWATERING WELL DATA

	Well No. I70 W9A (15th)	Piezometer No. I70 P9A
Date Drilled:	4/89	-
Casing		
Top elevation:		
Diameter:	16-in. SS	2-in. PVC
Length:		na
Screen		
Bottom elevation:		na
Diameter:	16-in. SS	2-in. PVC
Length:		3 ft
Slot size:	0.080-in.	na
Measuring Point Elevation:		407.52
Nonpumping Water Level		
Depth below temp. MP:	31.39	
Length of temp. MP extension:		
Depth below perm. MP:		30.30
Elevation:		377.22
Date of Step Test:	6/26/90	-
Water Sample		
Time:	2:06 pm	-
Temperature:	16.5° C	-
Laboratory No.:	223574	-
Distance and Direction to Piez. from PW:		6.4 ft East
Time PW Off Before Step Test:		Not recorded
Wells in Operation at Site at Time of Step Test:		Not recorded

Notes: SWS 8-in. dia. orifice tube w/plate No. 4; McDas;
No sand noted in settling tank at end of test

SWS Crew: R. Olson, S. Wilson, E. Sanderson

WATER LEVEL MEASUREMENTS
I-70 Well No. 9A (15th)
Condition Assessment Step Test

Hour	Time (min)	Adjusted depth to water in well (ft)	Adjusted depth to water in piezometer (ft)	Orifice tube piez. (ft)	Pumping rate (gpm)	Remarks
06/26/90						
10:58 am	0.0	31.39				Measured Depth
11:07 am	0.0		30.30			Measured Depth
11:13 am	0.0	31.40				Measured Depth
	0.0	31.41	30.29			McDAS started
	1.0	31.41	30.29			Water Level Trend
	2.0	31.40	30.29			
	3.0	31.40	30.30			
	4.0	31.40	30.30			
	5.1	31.40	30.32			
	6.0	31.40	30.31			
	6.4	31.40	30.30			
11:28 am	0.0					Pump On
11:29 am	1.0	36.71	33.80	2.95	575	Step 1; Max rate
	2.0	36.76	33.86	2.69	550	
	3.0	36.68	33.77			
	4.0	36.71	33.80			
	5.0	36.74	33.83	2.69	550	
	6.0	36.77	33.83			
	8.1	36.80	33.87			
11:38 am	10.0	36.83	33.89			
	12.0	36.83	33.89			
	14.0	36.85	33.90			
	15.0	36.86	33.91	2.65	540	
	16.1	36.87	33.92			
	18.0	36.90	33.95			
11:48 am	20.2	36.91	33.94			
	22.2	36.93	33.94			
	23.7	36.94	33.95			
	24.8	36.93	33.94			
	26.0	36.95	33.95			
	27.2	36.95	33.95	2.65	540	
	27.8	36.95	33.95			
	29.2	36.96	33.96			
	29.8	36.96	33.96			
11:58 am	30.0					Reduce rate
11:59 am	1.0	36.56	33.70	2.22	500	Step 2
	2.0	36.53	33.68			
	3.0	36.54	33.67			
	4.0	36.55	33.69			
	5.0	36.54	33.69			
	6.0	36.55	33.69			

WATER LEVEL MEASUREMENTS (Continued)
I-70 Well No. 9A (15th)

Hour	Time (min)	Adjusted depth to water in well (ft)	Adjusted depth to water in piezometer (ft)	Orifice tube piez. (ft)	Pumping rate (gpm)	Remarks
	8.1	36.53	33.68			
12:08 pm	10.0	36.55	33.70	2.21	500	
	12.0	36.55	33.71			
	14.0	36.55	33.72			
	16.0	36.54	33.70			
	18.0	36.54	33.70			
12:18 pm	20.1	36.56	33.72			
	22.1	36.56	33.72			
	23.1	36.57	33.74	2.20	500	
	24.2	36.57	33.74			
	25.3	36.57	33.73			
	25.9	36.59	33.74			
	27.2	36.59	33.73			
	27.8	36.59	33.74			
	29.1	36.59	33.74	2.20	500	
	29.8	36.59	33.74			
12:28 pm	30.0					Reduce rate
12:29 pm	1.0	36.18	33.48	1.81	450	Step 3
	2.0	36.15	33.47			
	3.0	36.13	33.46			
	4.0	36.14	33.44			
	5.0	36.13	33.44			
	6.0	36.13	33.46			
	8.0	36.12	33.45			
12:38 pm	10.1	36.12	33.44			
	12.1	36.11	33.45			
	15.9	36.09	33.43			
	18.2	36.07	33.41			
12:48 pm	20.0	36.01	33.37			
	21.9	36.02	33.38			
	22.9	36.02	33.38	1.71		Adjust rate
	24.0	36.03	33.38	1.81	450	
	25.1	36.14	33.45			
	26.2	36.15	33.46			
	26.9	36.15	33.47			
	28.1	36.16	33.47			
	28.8	36.15	33.46			
	29.4	36.15	33.47			
12:58 pm	30.0					Reduce rate
12:59 pm	1.0	35.70	33.18	1.42	400	Step 4
	2.0	35.69	33.18			
	3.0	35.69	33.20			

WATER LEVEL MEASUREMENTS (Continued)
I-70 Well No. 9A (15th)

Hour	Time (min)	Adjusted depth to water in well (ft)	Adjusted depth to water in piezometer (ft)	Orifice tube piez. (ft)	Pumping rate (gpm)	Remarks
	4.0	35.69	33.17			
	5.0	35.67	33.17			
	6.0	35.68	33.17			
	8.1	35.68	33.18	1.42	400	
01:08 pm	10.2	35.68	33.17			
	11.9	35.68	33.18			
	13.9	35.67	33.16			
	16.0	35.68	33.17			
	17.9	35.66	33.15			
01:18 pm	20.0	35.67	33.17			
	21.9	35.66	33.16			
	24.0	35.68	33.17			
	25.2	35.68	33.17			
	25.8	35.68	33.18			
	27.0	35.67	33.16			
	28.2	35.68	33.18	1.42	400	
	28.9	35.69	33.18			
	29.6	35.69	33.18			
01:28 pm	30.0					Reduce rate
01:29 pm	1.0	35.20	32.86			Step 5
	2.0	35.19	32.86	1.08	350	
	3.0	35.19	32.85			
	4.0	35.18	32.85			
	5.0	35.18	32.84			
	6.0	35.18	32.86			
	8.1	35.16	32.84			
01:38 pm	10.0	35.17	32.84			
	11.9	35.17	32.85			
	14.0	35.17	32.84			
	16.0	35.15	32.84			
	18.0	35.16	32.85			
01:48 pm	20.1	35.15	32.85			
	22.0	35.17	32.86			
	24.2	35.16	32.84	1.07	350	
	25.3	35.15	32.84			
	25.9	35.16	32.85			
	27.1	35.16	32.85			
	27.7	35.17	32.86			
	29.0	35.16	32.85			
	29.7	35.16	32.85			
01:58 pm	30.0					Reduce rate
01:59 pm	1.0	34.69	32.56			Step 6

WATER LEVEL MEASUREMENTS (Continued)
I-70 Well No. 9A (15th)

Hour	Time (min)	Adjusted depth to water in well (ft)	Adjusted depth to water in piezometer (ft)	Orifice tube piez. (ft)	Pumping rate (gpm)	Remarks
	2.0	34.70	32.54	0.78	300	
	3.0	34.70	32.53			
	4.0	34.70	32.55			
	5.0	34.68	32.54			
	6.0	34.70	32.54			
	8.1	34.70	32.53	0.78	300	Water sample collected;
02:08 pm	10.0	34.69	32.53			T=16.5°C
	11.9	34.67	32.52			
	14.0	34.68	32.54			
	16.0	34.68	32.54			
	18.0	34.68	32.55			
02:18 pm	20.1	34.68	32.54			
	22.1	34.67	32.53			
	24.2	34.68	32.54	0.78	300	
	24.7	34.66	32.53			
02:23 pm	25.3	34.67	32.54			End of Test

DEWATERING WELL DATA

	Well No. 25th St. W1	Piezometer No. 25th St. P1
Date Drilled:	1975	1975
Casing		
Top elevation:	398.85	407.75
Diameter:	16-in. SS	2-in. PVC
Length:	33.55	na
Screen		
Bottom elevation:	305.30	na
Diameter:	16-in. SS	2-in. PVC
Length:	60 ft	3 ft
Slot size:	0.080-in.	na
Measuring Point Elevation:	399.70	407.3
Nonpumping Water Level		
Depth below temp. MP:	-	Plugged
Length of temp. MP extension:	-	-
Depth below perm. MP:	5.83	-
Elevation:	393.87	-
Date of Step Test:	8/11/89	-
Water Sample		
Time:	10:36	-
Temperature:	60° F	-
Laboratory No.:	223141	-
Distance and Direction to Piez. from PW:		3.8 ft SE
Time PW Off Before Step Test:		-

Wells in Operation at Site at Time of Step Test:

Notes: SWS 8-in. dia. orifice tube w/plate No. 4; McDas; Piezometer plugged; No sand noted in settling tank at end of test

SWS Crew: S. Wilson, N. Hingson

WATER LEVEL MEASUREMENTS
25th St. Well No. 1
Condition Assessment Step Test

Hour	Time (min)	Adjusted depth to water in well (ft)	Adjusted depth to water in piezometer (ft)	Orifice tube piez. (ft)	Pumping rate (gpm)	Remarks
08/11/89						
08:49 am	0.0	11.17	12.83			McDAS started
	1.0	11.17	12.84			Water Level Trend
	2.0	11.16	12.83			
	3.0	11.16	12.83			
	4.0	11.16	12.83			
08:54 am	5.0	11.16	12.83			
08:55 am	5.8	11.16	12.83			Pump On
	0.0	11.17	12.83			
08:56 am	1.0	11.25	12.84			Pump would not run
	2.0	11.18	12.84			Water Level Trend
	3.0	11.18	12.84			
	4.0	11.18	12.84			
	5.0	11.17	12.84			
	6.0	11.18	12.83			
	8.1	11.18	12.84			
09:05 am	10.0	11.17	12.84			
	10.9	11.17	12.83			
	15.0	11.17	12.82			
09:15 am	20.2	11.17	12.82			
	24.8	11.17	12.81			
09:25 am	29.8	11.17	12.83			
	35.0	11.10	12.80			
	36.6	11.16	12.80			
	37.5	11.16	12.80			
	38.3	11.16	12.80			
	39.2	11.16	12.80			
09:35 am	40.2	11.16	12.80			
	41.1	11.16	12.80			
	42.1	11.17	12.80			
09:37 am	0.0	11.17	12.83			Pump On
09:38 am	1.0	12.40	12.77	0.60	262	Pumping rate low
	2.0	12.48	12.81			Encrustation slaking off
	3.0	12.53	12.79			pump column pipe
	4.0	12.57	12.78			
	5.0	12.64	12.79			
	6.0	12.81	12.81			
	7.0	12.91	12.80			
	8.0	12.98	12.78	0.80	300	
09:47 am	10.1	13.01	12.78			Rate gradually increasing
	12.1	13.03	12.77			due to encrustation
	13.9	13.04	12.77			chunks being dislodged
	15.9	13.11	12.77			

WATER LEVEL MEASUREMENTS (Continued)
25th St. Well No. 1

Hour	Time (min)	Adjusted depth to water in well (ft)	Adjusted depth to water in piezometer (ft)	Orifice tube piez. (ft)	Pumping rate (gpm)	Remarks
	18.2	13.13	12.77			
09:57 am	20.0	13.15	12.77	1.20	370	Increased flow rate
	21.9	13.18	12.77			
	24.0	13.19	12.77			
10:03 am	25.1	13.19	12.77			
	26.3	13.19	12.75			
	26.9	13.19	12.75			
	27.5	13.20	12.75			
	28.1	13.20	12.75	1.25	375	
10:07 am	28.8	13.19	12.75			
	29.5	13.20	12.75			
10:08 am	30.0	13.20	12.76			Reduce rate
10:09 am	1.0	12.79	12.75	0.80	300	Step 2
	2.0	12.78	12.75			
	3.0	12.78	12.75	0.79	300	
	4.0	12.77	12.75			
	5.1	12.77	12.75			
	6.0	12.77	12.75			
	8.0	12.77	12.75			
10:18 am	10.1	12.76	12.75	0.78	300	
	12.1	12.77	12.75			
	13.9	12.76	12.75			
	15.9	12.77	12.75			
	17.8	12.77	12.74			
10:28 am	20.0	12.77	12.74			
	20.4	12.77	12.74			
10:29 am	21.0	12.78	12.74			Reduce rate
10:30 am	1.0	12.46	12.74	0.52	242	Step 3
	2.0	12.46	12.74	0.50	240	
	4.0	12.46	12.74			
	5.0	12.46	12.74			
	6.0	12.46	12.74	0.51	241	Water sample collected, T=60°F
	8.1	12.46	12.74			
10:39 am	10.0	12.46	12.74			
	12.0	12.46	12.74			
	14.0	12.46	12.74			
	16.1	12.46	12.74	0.51	241	
	18.0	12.46	12.74			
10:49 am	20.2	12.46	12.74			
	22.2	12.46	12.74	0.50	240	
	22.7	12.46	12.74			
10:52 am	23.2	12.46	12.74			End of Test

DEWATERING WELL DATA

	Well No. 25th St. W2	Piezometer No. 25th St. P2
Date Drilled:	7/16/75	-
Casing		
Top elevation:	393.50	401.9
Diameter:	16-in. SS	2-in. PVC
Length:	31.89	na
Screen		
Bottom elevation:	301.58	na
Diameter:	16-in. SS	2-in. PVC
Length:	60 ft	3 ft
Slot size:	0.080-in.	na
Measuring Point Elevation:	394.60	401.9
Nonpumping Water Level		
Depth below temp. MP:	16.72	-
Length of temp. MP extension:	8.2	-
Depth below perm. MP:	8.52	15.46
Elevation:	386.1	386.4
Date of Step Test:	4/18/90	-
Water Sample		
Time:	4:42 pm	-
Temperature:	60° F	-
Laboratory No.:	223480	-
Distance and Direction to Piez. from PW:		5.0 ft SE
Time PW Off Before Step Test:		Not recorded
Wells in Operation at Site at Time of Step Test:		Not recorded

Notes: SWS 8-in. dia. orifice tube w/plate No. 4; Data collected with McDas. Settling tank not used.

SWS Crew: S. Wilson, K. Hlinka

WATER LEVEL MEASUREMENTS
25th St. Well No. 2
Post-Treatment Step Test

Hour	Time (min)	Adjusted depth to water in well (ft)	Adjusted depth to water in piezometer (ft)	Orifice tube piez. (ft)	Pumping rate (gpm)	Remarks
04/18/90						
12:20 pm	0.0	16.72	15.46			Measured Depths
12:32 pm	0.0	16.71	15.47			McDAS started
	1.0	16.72	15.47			Water Level Trend
	2.0	16.72	15.47			
	3.0	16.72	15.47			
	3.5	16.72	15.47			
	4.0	16.72	15.47			
12:37 pm	0.0					Pump On
12:38 pm	1.0	18.63	17.20			
	2.0	18.65	17.22			Pump running backwards
	3.0	17.10	15.74			Pump Off
	4.0	16.76	15.50			Water Level Trend
	5.0	16.74	15.46			
12:47 pm	10.0	16.72	15.45			
	15.0	16.72	15.43			
	20.1	16.71	15.44			
	29.7	16.71	15.42			
	40.0	16.71	15.43			
01:27 pm	50.4	16.72	15.42			
	60.6	16.71	15.40			
	69.6	16.71	15.41			
	79.9	16.71	15.41			
	89.6	16.71	15.42			
	101	16.71	15.40			
02:27 pm	110	16.71	15.41			
	115	16.70	15.41			
	118	16.70	15.40			
02:36 pm	0.0					Pump On
02:36 pm	1.0	23.02	20.95	5.65	795	Step 1; Max rate
	2.0	23.16	21.07			
	3.0	22.88	20.83	5.08	750	
	4.0	22.88	20.85			
	5.0	22.87	20.86	5.09	750	
	6.0	22.91	20.87			
	8.0	22.92	20.87			
02:46 pm	10.0	22.93	20.90			
	12.0	22.89	20.85			
	14.1	22.88	20.84			
	16.1	22.90	20.86	5.07	750	
	18.1	22.89	20.86			
02:56 pm	19.8	22.90	20.86	5.09	750	

WATER LEVEL MEASUREMENTS (Continued)
25th St. Well No. 2

Hour	Time (min)	Adjusted depth to water in well (ft)	Adjusted depth to water in piezometer (ft)	Orifice tube piez. (ft)	Pumping rate (gpm)	Remarks
	22.2	22.91	20.85			
	23.8	22.91	20.86			
	24.9	22.92	20.86			
	26.1	22.93	20.87			
	27.3	22.93	20.88			
	27.9	22.93	20.88			
	28.6	22.92	20.88			
	29.2	22.93	20.88	5.10	750	
03:06 pm	30.0					Reduce rate
03:07 pm	1.0	22.45	20.50			Step 2
	2.0	22.42	20.47	4.41	700	
	3.0	22.43	20.46			
	4.0	22.46	20.47			
	5.0	22.46	20.47			
	6.0	22.45	20.46			
	8.1	22.47	20.46			
03:16 pm	10.0	22.47	20.47			
	11.9	22.47	20.47			
	14.0	22.46	20.47			
	16.0	22.47	20.47			
	17.2	22.47	20.48	4.41	700	
	18.0	22.48	20.47			
03:26 pm	20.1	22.48	20.48			
	22.0	22.49	20.48			
	24.2	22.48	20.49			
	25.3	22.49	20.48			
	25.9	22.49	20.48			
	27.1	22.50	20.49			
	27.7	22.49	20.48	4.42	700	
	29.0	22.51	20.49			
	29.7	22.51	20.49			
03:36 pm	30.0					Reduce rate
03:37 pm	1.0	22.11	20.14	3.80	650	Step 3
	2.0	22.08	20.15			
	3.0	22.07	20.12			
	4.0	22.08	20.13	3.84	650	
	5.0	22.08	20.12			
	6.0	22.10	20.13			
	7.9	22.09	20.13			
03:46 pm	10.0	22.11	20.13			
	11.9	22.10	20.14			
	14.0	22.11	20.15			

WATER LEVEL MEASUREMENTS (Continued)
25th St. Well No. 2

Hour	Time (min)	Adjusted depth to water in well (ft)	Adjusted depth to water in piezometer (ft)	Orifice tube piez. (ft)	Pumping rate (gpm)	Remarks
	16.0	22.10	20.14			
	18.0	22.12	20.14			
03:56 pm	20.1	22.13	20.15			
	22.0	22.13	20.16			
	24.2	22.13	20.15			
	25.3	22.12	20.16			
	25.9	22.13	20.16			
	27.1	22.13	20.16			
	27.7	22.13	20.16			
	29.0	22.14	20.17	3.84	650	
	29.7	22.13	20.17			
04:06 pm	30.0					Reduce rate
04:06 pm	1.0	21.70	19.78	3.22	600	Step 4
	2.0	21.68	19.75			
	3.0	21.65	19.73			
	4.0	21.66	19.74			
	5.0	21.66	19.75			
	6.0	21.67	19.74	3.20	600	
	7.9	21.66	19.74			
04:16 pm	10.0	21.67	19.74			
	12.0	21.67	19.75			
	14.1	21.67	19.74			
	16.1	21.66	19.74			
	18.1	21.67	19.75			
04:26 pm	19.8	21.67	19.74	3.21	600	
	22.2	21.68	19.75			
	23.8	21.67	19.75			
	24.9	21.68	19.76			
	25.5	21.67	19.75			
	26.1	21.67	19.74	3.21	600	
04:33 pm	27.0					Reduce rate
04:34 pm	1.0	21.22	19.40	2.70	550	Step 5
	2.0	21.26	19.39			
	3.0	21.29	19.40			
	4.1	21.27	19.40			
	5.0	21.26	19.41			
	6.0	21.27	19.40			
	8.1	21.26	19.39	2.70	550	Water sample collected;
04:43 pm	10.0	21.27	19.40			T=60°F
	11.9	21.27	19.40			
	14.0	21.27	19.40			
	16.0	21.27	19.39	2.69	550	

WATER LEVEL MEASUREMENTS (Continued)
25th St. Well No. 2

Hour	Time (min)	Adjusted depth to water in well (ft)	Adjusted depth to water in piezometer (ft)	Orifice tube piez. Cft)	Pumping rate (gpm)	Remarks
	17.9	21.27	19.40			
04:53 pm	20.1	21.27	19.39			
	22.0	21.27	19.39			
	24.1	21.27	19.39			
	25.3	21:27	19.40			
	25.9	21.28	19.40			
	27.1	21.27	19.40			
	27.7	21.27	19.39			
	29.0	21.27	19.39	2.69	550	
	29.7	21.28	19.39			
05:03 pm	30.0					End of Test

DEWATERING WELL DATA

	Well No. 25th St. W3	Piezometer No. 25th St. P3
Date Drilled:	1975	1975
Casing		
Top elevation:	389.44	400.14
Diameter:	16-in. SS	2-in. PVC
Length:	30.13	na
Screen		
Bottom elevation:	299.31	na
Diameter:	16-in. SS	2-in. PVC
Length:	60 ft	3 ft
Slot size:	0.080-in.	na
Measuring Point Elevation:	390.4	400.14
Nonpumping Water Level		
Depth below temp. MP:	-	-
Length of temp. MP extension:	-	-
Depth below perm. MP:	4.86	14.56
Elevation:	385.54	385.58
Date of Step Test:	9/7/89	-
Water Sample		
Time:	Not recorded	-
Temperature:	60° F	-
Laboratory No.:	223167	-
Distance and Direction to Piez. from PW:		4.1 ft South
Time PW Off Before Step Test:		Not available

Wells in Operation at Site at Time of Step Test:

Notes: SWS 8-in. dia. orifice tube w/plate No. 4; McDas;
No sand noted in settling tank at end of test

SWS Crew: S. Wilson, ?

WATER LEVEL MEASUREMENTS
25th St. Well No. 3
Condition Assessment Step Test

Hour	Time (min)	Adjusted depth to water in well (ft)	Adjusted depth to water in piezometer (ft)	Orifice tube piez. (ft)	Pumping rate (gpm)	Remarks
09/07/89						
08:10 am	0.0	4.86				Steel Tape
08:12 am	0.0	4.86				Steel Tape
08:32 am	0.0		14.56			Steel Tape
08:34 am	0.0		14.56			Steel Tape
08:45 am	0.0	4.86	14.56			McDAS started
	0.9	4.87	14.56			Water Level Trend
	2.1	4.86	14.57			
	3.0	4.86	14.57			
08:49 am	3.9	4.86	14.57			
	5.1	4.86	14.57			
	6.0	4.85	14.57			
	6.9	4.86	14.57			
	8.1	4.86	14.56			
08:54 am	9.0	4.86	14.56			
	9.6	4.85	14.56			
08:55 am	0.0	4.86	14.56			Pump On
08:56 am	1.0	18.28	23.70	2.65	545	Step 1
	2.0	18.43	23.87	2.82	560	
	3.0	18.65	23.99	2.70	550	Adjusted rate
	4.1	18.35	23.81			
	5.0	18.34	23.81			
	6.0	18.33	23.82			
	8.1	18.34	23.83			
09:05 am	10.0	18.33	23.83			
	12.0	18.35	23.85			
	14.1	18.40	23.89	2.74	555	Adjusted tube position
	16.2	18.40	23.90			
	18.1	18.42	23.91			
09:15 am	19.9	18.42	23.91	2.74	555	
	21.8	18.42	23.92			
	23.8	18.41	23.93			
	25.0	18.43	23.93			
	26.1	18.44	23.93			
	26.7	18.43	23.94			
	27.3	18.44	23.94	2.74	555	
	28.0	18.43	23.94			
	28.6	18.44	23.94			
	29.3	18.44	23.95			
09:25 am	0.0					Reduce rate
09:26 am	1.0	17.48	23.30	2.24	500	Step 2
	2.0	17.49	23.33	2.22	500	

WATER LEVEL MEASUREMENTS (Continued)
25th St. Well No. 3

Hour	Time (min)	Adjusted depth to water in well (ft)	Adjusted depth to water in piezometer (ft)	Orifice tube piez. (ft)	Pumping rate (gpm)	Remarks
	3.0	17.13	23.13			
	4.0	17.08	23.09			
	5.0	17.12	23.13			
	6.0	17.15	23.13	2.22	500	
09:33 am	8.1	17.12	23.14			
	10.0	17.14	23.14			
	11.9	17.13	23.15			
	14.0	17.16	23.15			
	16.0	17.17	23.16			
	18.0	17.17	23.17			
09:45 am	20.1	17.16	23.17	2.22	500	
	22.0	17.16	23.18			
	24.1	17.17	23.18			
	25.3	17.17	23.19			
	25.8	17.18	23.19			
	26.4	17.19	23.19			
	27.1	17.18	23.19			
	27.7	17.18	23.19			
	28.3	17.18	23.19			
	29.0	17.19	23.19	2.23	500	
09:55 am	0.0					Reduce rate
09:56 am	1.0	15.87	22.36	1.78	450	Step 3
	2.0	15.87	22.35			
	3.0	15.86	22.35			
	4.0	15.86	22.35			
	5.0	15.87	22.35			
	6.0	15.87	22.35			
	8.0	15.90	22.36			
10:05 am	10.0	15.88	22.36			
	12.0	15.89	22.37			
	14.1	15.90	22.37			
	15.1	15.91	22.38	1.79	450	
	16.1	15.91	22.38			
10:13 am	18.1	15.91	22.38			
	19.8	15.91	22.39			
	22.2	15.92	22.39			
	23.8	15.92	22.39			
	24.9	15.93	22.39			
10:21 am	26.1	15.93	22.40			
	26.7	15.94	22.40			
	27.3	15.93	22.41			
	27.9	15.94	22.41			
	28.6	15.94	22.41			

WATER LEVEL MEASUREMENTS (Continued)
25th St. Well No. 3

Hour	Time (min)	Adjusted depth to water in well (ft)	Adjusted depth to water in piezometer (ft)	Orifice tube piez. (ft)	Pumping rate (gpm)	Remarks
	29.2	15.94	22.41			
10:25 am	29.9	15.95	22.41			
	30.6	15.94	22.41			
10:26 am	31.3	15.94	22.41	1.79	450	
10:27 am	32.1	15.94	22.41			
	32.8	15.94	22.41	1.79	450	
10:28 am	0.0					Reduce rate
10:33 am	4.9					McDAS problem
10:34 am	1.0			1.42	400	Step 4
	2.0					McDAS water level data lost due to operational error
	3.0					
	4.0					
	5.0					
	6.0					
	8.1					
10:43 am	10.0			1.42	400	
	11.9					
	14.3					
	16.0					
	18.0					
10:53 am	20.1					
	22.0					
	23.1			1.42	400	
	24.2					
	24.7					
	25.3					
	25.9					
	26.5					
	27.1					
	27.7					
	28.4					
11:01 am	0.0					Reduce rate
11:02 am	1.0	13.54	20.84	1.08	350	Step 5
	2.0	13.59	20.85			
	3.0	13.53	20.83			
	4.0	13.52	20.84			
	5.0	13.52	20.84			
	6.0	13.53	20.84			
	8.1	13.53	20.84			
	10.0	13.53	20.83			
	12.0	13.53	20.84			
11:15 am	14.0	13.53	20.85			
	16.1	13.54	20.85			

WATER LEVEL MEASUREMENTS (Continued)
25th St. Well No. 3

Hour	Time (min)	Adjusted depth to water in well (ft)	Adjusted depth to water in piezometer (ft)	Orifice tube piez. (ft)	Pumping rate (pgm)	Remarks
	18.0	13.53	20.84			
11:21 am	20.2	13.54	20.85			
	22.1	13.54	20.85			
	23.1	13.54	20.85	1.08	350	
	24.2	13.54	20.85			
	24.8	13.55	20.85			
	25.3	13.54	20.85			
	25.9	13.55	20.85			
	26.5	13.54	20.85			
	27.1	13.54	20.84			
	27.8	13.55	20.85			
	28.4	13.55	20.85			
	29.1	13.55	20.85			
11:31 am	0.0					Reduce rate
11:32 am	1.0	12.34	20.02	0.78	300	Step 6
	2.0	12.30	20.00			
	3.0	12.26	19.98			
	4.0	12.26	19.99			
11:35 am	5.0	12.27	19.99			
	6.0	12.26	19.99			
	8.0	12.25	19.99	0.78	300	
	10.1	12.25	19.98			
	12.1	12.25	19.98			
	13.9	12.24	19.97			
	15.9	12.25	19.96			
	18.2	12.25	19.98			
11:50 am	20.0	12.24	19.98			
	21.9	12.24	19.97			
	24.0	12.24	19.98			Water sample collected
	25.1	12.24	19.98			(time not recorded)
	25.7	12.24	19.98			T=60°F
	26.3	12.25	19.98			
	26.9	12.25	19.98			
	27.5	12.25	19.98			
	28.2	12.25	19.97			
	28.8	12.25	19.97	0.78	300	
12:00 pm	29.5	12.24	19.97			
	31.6	12.25	19.97			
12:03 pm	32.3	12.25	19.97			End of Test

DEWATERING WELL DATA

	Well No. 25th St. W5	Piezometer No. 25th St. P5
Date Drilled:	7/21/75	-
Casing		
Top elevation:	395.63	403.8
Diameter:	16-in. SS	2-in. PVC
Length:	28.27 ft	na
Screen		
Bottom elevation:	307.36	na
Diameter:	16-in. SS	2-in. PVC
Length:	60 ft	3 ft
Slot size:	0.080-in.	na
Measuring Point Elevation:	396.2	403.8
Nonpumping Water Level		
Depth below temp. MP:	18.12	-
Length of temp. MP extension:	8.0	-
Depth below perm. MP:	10.12	17.60
Elevation:	386.08	386.20
Date of Step Test:	4/19/90	-
Water Sample		
Time:	11:50 am	-
Temperature:	58.5° F	-
Laboratory No.:	223479	-
Distance and Direction to Piez. from PW:		5.0 ft South
Time PW Off Before Step Test:		Not recorded
Wells in Operation at Site at Time of Step Test:		Not recorded

Notes: SWS 8-in. dia. orifice tube w/plate No. 4
Pumped water discharged to 1000-gpm tank.
No sand observed in tank after step test.

SWS Crew: R. Olson, S. Wilson, K. Hlinka

WATER LEVEL MEASUREMENTS
25th St. Well No. 5
Post-Treatment Step Test

Hour	Time (min)	Adjusted depth to water in well (ft)	Adjusted depth to water in piezometer (ft)	Orifice tube piez. (ft)	Pumping rate (gpm)	Remarks
04/19/90						
08:45 am	0.0	18.12	17.60			Measured Depths
08:57 am	0.0	18.08	17.60			McDAS started
	1.0	18.10	17.61			Water Level Trend
	2.0	18.11	17.61			
	3.0	18.10	17.60			
	4.0	18.09	17.60			
	5.1	18.09	17.61			
	6.0	18.10	17.61			
	8.0	18.10	17.61			
09:07 am	10.0	18.10	17.60			
	12.0	18.08	17.59			
	14.0	18.07	17.59			
	16.0	18.08	17.59			
	17.0	18.09	17.59			
	18.0	18.07	17.59			
	19.0	18.09	17.59			
	19.3	18.07	17.59			
09:17 am	0.0					Pump On
09:18 am	1.0	24.09	22.35	5.65	790	Step 1; Max rate
	2.0	23.95	22.27			
	3.0	23.99	22.30			
	4.0	24.03	22.33			
	5.0	24.04	22.34	5.10	750	
	6.0	24.06	22.36			
	8.0	24.08	22.38			
09:27 am	10.1	24.10	22.40			
	12.1	24.12	22.42			
	14.2	24.13	22.43			
	15.9	24.14	22.44	5.08	750	
	18.2	24.16	22.45			
09:37 am	19.9	24.16	22.46			
	21.8	24.18	22.47			
	23.9	24.19	22.48			
	25.0	24.20	22.49			
	26.2	24.20	22.49			
	26.8	24.21	22.50			
	28.1	24.22	22.50			
	28.7	24.21	22.50	5.10	750	
	29.4	24.22	22.50			
09:47 am	30.0					Reduce rate
09:48 am	1.0	23.81	22.20	4.41	700	Step 2

WATER LEVEL MEASUREMENTS (Continued)
25th St. Well No. 5

Hour	Time (min)	Adjusted depth to water in well (ft)	Adjusted depth to water in piezometer (ft)	Orifice tube piez. (ft)	Pumping rate (gpm)	Remarks
	2.0	23.81	22.18			
	3.0	23.79	22.18			
	4.0	23.81	22.18			
	5.0	23.80	22.18			
	6.1	23.79	22.19			
	8.0	23.79	22.19			
09:57 am	10.1	23.82	22.20			
	12.1	23.83	22.20			
	14.1	23.82	22.21			
	16.2	23.82	22.21			
	18.2	23.84	22.22			
10:07 am	19.9	23.84	22.22			
	21.8	23.86	22.23			
	22.8	23.86	22.23	4.41	700	
	23.9	23.86	22.24			
	25.0	23.86	22.24			
	26.2	23.86	22.24			
	26.8	23.86	22.24			
	28.1	23.87	22.25			
	28.7	23.87	22.25	4.41	700	
	29.4	23.87	22.25			
10:17 am	30.0					Reduce rate
10:18 am	1.0	23.49	21.97	3.80	650	Step 3
	2.0	23.50	21.96			
	3.0	23.49	21.97			
	4.0	23.50	21.97			
	5.0	23.50	21.97			
	6.0	23.51	21.97			
	7.9	23.49	21.97			
10:27 am	10.0	23.51	21.97			
	12.0	23.51	21.98			
	14.0	23.52	21.98	3.80	650	
	16.1	23.52	21.98			
	18.0	23.52	21.99			
10:37 am	20.2	23.53	21.99			
	22.2	23.54	22.00			
	23.7	23.54	22.00			
	24.8	23.54	22.00			
	26.0	23.54	22.00			
	27.2	23.56	22.00			
	27.8	23.54	22.00			
	29.1	23.56	22.01	3.80	650	
	29.6	23.55	22.01			

WATER LEVEL MEASUREMENTS (Continued)
25th St. Well No. 5

Hour	Time (min)	Adjusted depth to water in well (ft)	Adjusted depth to water in piezometer (ft)	Orifice tube piez. (ft)	Pumping rate (gpm)	Remarks
10:47 am	30.0					Reduce rate
10:48 am	1.0	23.13	21.70	3.22	600	Step 4
	2.0	23.14	21.69			
	3.0	23.14	21.69			
	4.0	23.13	21.68			
	5.0	23.13	21.68			
	6.0	23.13	21.69			
	8.1	23.14	21.69			
10:57 am	10.0	23.14	21.69			
	12.0	23.13	21.69			
	14.0	23.14	21.69			
	16.0	23.15	21.69			
	18.0	23.15	21.70			
11:07 am	20.2	23.15	21.70			
	22.1	23.15	21.70			
	24.2	23.15	21.70			
	24.8	23.16	21.71			
	25.9	23.15	21.70			
	27.1	23.15	21.70			
	27.7	23.16	21.70			
	29.1	23.16	21.71	3.22	600	
	29.7	23.16	21.71			
11:17 am	30.0					Reduce rate
11:18 am	1.0	22.79	21.42	2.70	550	Step 5
	2.0	22.77	21.41			
	3.0	22.76	21.41			
	4.0	22.77	21.41			
	5.0	22.76	21.40			
	6.0	22.76	21.41			
	8.1	22.76	21.41			
11:27 am	10.0	22.78	21.41			
	12.0	22.77	21.41			
	14.0	22.77	21.41			
	16.1	22.77	21.40			
	18.0	22.77	21.41	2.70	550	
11:37 am	19.8	22.77	21.40			
	22.2	22.77	21.41			
	23.8	22.77	21.41			
	24.9	22.78	21.41			
	26.0	22.78	21.41			
	27.3	22.77	21.41			
	27.9	22.78	21.41			

WATER LEVEL MEASUREMENTS (Continued)
25th St. Well No. 5

Hour	Time (min)	Adjusted depth to water in well (ft)	Adjusted depth to water in piezometer (ft)	Orifice tube piez. (ft)	Pumping rate (gpm)	Remarks
	29.2	22.78	21.41			Water sample collected;
	29.9	22.79	21.42			T=58.5°F
11:47 am	30.0					End of Test

DEWATERING WELL DATA

	Well No. Venice W1	Piezometer No. Venice P1
Date Drilled:	1979	1979
Casing		
Top elevation:	405.3	411.21
Diameter:	16-in. SS	2-in. PVC
Length:	32.3	na
Screen		
Bottom elevation:	322.1	na
Diameter:	16-in. SS	2-in. PVC
Length:	50.9	3 ft
Slot size:	0.080-in.	na
Measuring Point Elevation:	405.55	411.21
Nonpumping Water Level		
Depth below temp. MP:	23.19	-
Length of temp. MP extension:	5.9	-
Depth below perm. MP:	17.29	23.12
Elevation:	388.26	388.09
Date of Step Test:	9/6/89	-
Water Sample		
Time:	1:28 pm	-
Temperature:	59° F	-
Laboratory No.:	223166	-
Distance and Direction to Piez. from PW:		4.9 ft NE
Time PW Off Before Step Test:		Not recorded
Wells in Operation at Site at Time of: Step Test:		Not recorded

Notes: SWS 8-in. dia. orifice tube w/plate No. 4; McDas;
About ⅓-½ cup of sand in settling tank at end of test,
sample collected

SWS Crew: Not recorded

WATER LEVEL MEASUREMENTS
Venice Well No. 1
Condition Assessment Step Test

Hour	Time (min)	Adjusted depth to water in well (ft)	Adjusted depth to water in piezometer (ft)	Orifice tube piez. (ft)	Pumping rate (gpm)	Remarks
09/06/89						
09:28 am	0.0	23.19	23.12			Measured Depth
09:31 am	0.0	23.19	23.12			Measured Depth
	0.0	23.19	23.12			McDAS started
	0.3	23.22	23.15			Water Level Trend
	0.6	23.18	23.18			
09:39 am	0.9	23.18	23.20			
	1.2	23.18	23.22			
	1.5	23.18	23.24			
	1.8	23.19	23.25			
	2.1	23.17	23.27			
	2.4	23.16	23.28			
	2.7	23.18	23.28			
09:41 am	3.0	23.17	23.28			
	3.3	23.18	23.29			
	3.6	23.16	23.29			
	3.9	23.18	23.29			
	4.2	23.16	23.29			
	4.5	23.16	23.30			
09:43 am	0.0	23.19	23.12			Pump On
09:44 am	1.0	23.18	23.35			Pump did not start
	2.0	23.17	23.36			Water Level Trend
	4.0	23.14	23.34			
	5.0	23.18	23.34			
	6.1	23.17	23.33			
09:50 am	7.1	23.16	23.31			
	7.6	23.18	23.31			Pump On
09:51 am	0.0					
09:52 am	1.0	31.00	28.59	5.00	740	Step 1, Max rate
	2.0	31.26	28.86	4.16	685	
	3.0	30.89	28.70			
	4.0	30.77	28.62			
	5.0	30.83	28.69	4.36		Adjusting rate
	6.0	30.86	28.73			
	8.1	31.09	28.90			
10:01 am	10.0	31.11	28.96			
	12.0	31.19	29.02			
	14.0	31.22	29.05			
	16.1	31.25	29.09			
	18.0	31.27	29.12			
	18.9	31.29	29.15			
10:11 am	20.2	31.30	29.17	4.34	695	
	22.1	31.32	29.20			

WATER LEVEL MEASUREMENTS (Continued)
Venice Well No. 1

Hour	Time (min)	Adjusted depth to water in well (ft)	Adjusted depth to water in piezometer (ft)	Orifice tube piez. (ft)	Pumping rate (gpm)	Remarks
	24.3	31.33	29.20			
	24.9	31.34	29.20			
	26.1	31.34	29.22			
	26.7	31.35	29.24			
	27.3	31.36	29.24			
	27.9	31.33	29.21			
	28.6	31.34	29.22			
	29.2	31.35	29.22	4.34	695	
10:21 am	30.0					Reduce rate
10:22 am	1.0	30.88	28.95			Step 2
	2.0	30.93	28.96	3.80	650	
	3.0	30.91	28.95			
	4.0	30.90	28.96			
	5.0	30.91	28.97			
	6.0	30.91	28.98			
	8.0	30.91	28.97			
10:31 am	10.0	30.91	28.97			
	12.0	30.91	28.95			
	14.1	30.91	28.94			
	16.2	30.92	28.96	3.81	650	
	18.1	30.91	28.97			
10:41 am	19.8	30.91	28.99			
	22.2	30.91	29.00			
	23.8	30.90	29.01			
	24.9	30.92	29.00			
	26.1	30.92	28.98	3.80	650	
	26.7	30.92	28.97			
	28.0	30.92	28.97			
	28.6	30.94	28.97			
	29.3	30.92	28.96			
10:51 am	30.0					Reduce rate
10:52 am	1.0	30.34	28.60			Step 3
	2.0	30.35	28.61	3.18		
	3.0	30.33	28.60			
	4.0	30.32	28.60			
	5.0	30.31	28.60			
	6.0	30.32	28.60			
	8.0	30.33	28.60			
11:01 am	10.0	30.33	28.60			
	12.0	30.33	28.60			
	14.1	30.34	28.61			
	16.2	30.34	28.59			

WATER LEVEL MEASUREMENTS (Continued)
Venice Well No. 1

Hour	Time (min)	Adjusted depth to water in well (ft)	Adjusted depth to water in piezometer (ft)	Orifice tube piez. (ft)	Pumping rate (gpm)	Remarks
	18.1	30.35	28.59			
11:11 am	19.9	30.35	28.57	3.21	600	
	21.8	30.35	28.57			
	23.9	30.36	28.58			
	25.0	30.37	28.57			
	26.2	30.36	28.58			
	26.8	30.36	28.58			
	28.0	30.36	28.58			
	28.7	30.36	28.57	3.22	600	
	29.4	30.36	28.57			
11:21 am	30.0					Reduce rate
11:22 am	1.0	29.81	28.20	2.70	550	Step 4
	2.0	29.75	28.16			
	3.0	29.75	28.15			
	4.0	29.76	28.16			
	5.0	29.76	28.16			
	6.0	.29.75	28.12			
	8.1	29.77	28.16			
11:31 am	10.0	29.77	28.19			
	12.0	29.77	28.19			
	14.0	29.77	28.13			
	16.1	29.76	28.14	2.72	550	
	18.0	29.75	28.14			
11:41 am	20.2	29.75	28.15			
	22.1	29.74	28.13			
	24.2	29.73	28.09			
	24.8	29.74	28.09			
	26.0	29.73	28.08			
	27.2	29.72	28.07	2.71	550	
	27.8	29.73	28.08			
	29.1	29.72	28.07			
	29.8	29.74	28.08			
11:51 am	30.0					Reduce rate
11:52 am	1.0	29.14	27.71	2.22	500	Step 5
	2.0	29.14	27.71			
	3.0	29.15	27.73			
	4.0	29.13	27.73			
	5.0	29.14	27.73			
	6.1	29.11	27.71			
	8.0	29.11	27.71			
12:01 pm	10.1	29.11	27.70			
	12.1	29.10	27.68			

WATER LEVEL MEASUREMENTS (Continued)
Venice Well No. 1

Hour	Time (min)	Adjusted depth to water in well (ft)	Adjusted depth to water in piezometer (ft)	Orifice tube piez. (ft)	Pumping rate (gpm)	Remarks
	14.2	29.10	27.67			
	16.2	29.08	27.65			
	18.2	29.08	27.65			
12:11 pm	19.9	29.07	27.64			
	21.8	29.07	27.61			
	23.9	29.07	27.60			
	25.0	29.07	27.58			
	26.2	29.07	27.60			
	26.8	29.07	27.60			
	28.1	29.07	27.60	2.22	500	
	28.7	29.07	27.58			
	29.4	29.07	27.58			
12:21 pm	30.0					Reduce rate
12:21 pm	1.0	28.48	27.23	1.78	450	Step 6
	2.0	28.45	27.23	1.78	450	
	3.0	28.43	27.20			
	4.0	28.45	27.18			
	5.0	28.42	27.17			
	6.0	28.41	27.16			
	8.0	28.41	27.17			
12:31 pm	10.0	28.39	27.15			
	12.0	28.38	27.17			
	14.1	28.38	27.14			
	16.2	28.36	27.15			
	18.1	28.36	27.18			
12:41 pm	19.8	28.35	27.12			
	22.2	28.33	27.10			
	23.8	28.31	27.07			
	24.9	28.30	27.04			
	26.1	28.28	27.03			
	27.3	28.27	27.04			
	28.0	28.28	27.04			
	29.3	28.28	27.05	1.78	450	
12:51 pm	30.0	28.28	27.04			End of Test
01:23 pm						Pump On
01:28 pm						Collected water sample, T=59°F

DEWATERING WELL DATA

	Well No. Venice W2	Piezometer No. Venice P2
Date Drilled:	1982	
Casing		
Top elevation:	405.3	
Diameter:	16-in. SS	2-in. PVC
Length:	28.9 ft	na
Screen		
Bottom elevation:	325.5	na
Diameter:	16-in. SS	2-in. PVC
Length:	50.9 ft	3 ft
Slot size:	0.080-in.	na
Measuring Point Elevation:	405.55	410.30
Nonpumping Water Level		
Depth below temp. MP:	23.34	-
Length of temp. MP extension:	5.4 ft	-
Depth below perm. MP:	17.94	22.81
Elevation:	387.61	387.49
Date of Step Test:	5/8/90	-
Water Sample		
Time:	12:37	-
Temperature:	Not recorded	-
Laboratory No.:	223505	-
Distance and Direction to Piez. from PW:		6.1 ft West

Time PW Off Before Step Test:

Wells in Operation at Site at Time of Step Test:

Notes: SWS 8-in. dia. orifice tube w/plate No. 4;
McDas; No sand noted in tank at end of test

SWS Crew: R. Olson, S. Wilson

WATER LEVEL MEASUREMENTS
Venice Well No. 2
Post-Treatment Step Test

Hour	Time (min)	Adjusted depth to water in well (ft)	Adjusted depth to water in piezometer (ft)	Orifice tube piez. (ft)	Pumping rate (gpm)	Remarks
05/08/90						
10:06 am	0.0	23.34				Measured Depth
10:09 am	0.0		22.81			Measured Depth
10:19 am	0.0	23.33	22.82			McDAS started
	1.0	23.32	22.84			Water Level Trend
	2.0	23.32	22.84			
	3.0	23.31	22.83			
	4.0	23.30	22.82			
	5.0	23.30	22.81			
	6.0	23.30	22.81			
	8.0	23.30	22.81			
	10.0	23.30	22.82			
	10.7	23.29	22.82			
10:30 am	0.0					Pump On
10:31 am	1.0	29.26	26.00	4.70	730	Step 1; Max rate
	2.0	29.50	26.27	4.44	700	
	3.0	29.76	26.49			
	4.0	29.91	26.64			
	5.0	30.04	26.77			
	6.0	30.13	26.86			
	7.1	30.20	26.94	4.42	700	
	8.1	30.26	27.00			
10:40 am	10.0	30.35	27.09			
	12.0	30.41	27.15			
	14.0	30.46	27.21			
	16.1	30.51	27.25			
	18.0	30.55	27.29			
10:50 am	20.2	30.58	27.33			
	21.1	30.59	27.34	4.41	700	
	22.1	30.60	27.35			
	24.2	30.63	27.38			
	24.8	30.63	27.38			
	26.0	30.65	27.40			
	27.2	30.66	27.41			
	27.8	30.66	27.42			
	28.5	30.67	27.42			
	29.1	30.68	27.43	4.41	700	
	29.8	30.68	27.44			
11:00 am	30.0					Reduce rate
11:01 am	1.0	30.23	27.21			Step 2
	2.0	30.23	27.21	3.79	650	Adjust rate
	3.0	30.19	27.19			

WATER LEVEL MEASUREMENTS (Continued)
Venice Well No. 2

Hour	Time (min)	Adjusted depth to water in well (ft)	Adjusted depth to water in piezometer (ft)	Orifice tube piez. (ft)	Pumping rate (gpm)	Remarks
	4.0	30.19	27.18			
	5.0	30.19	27.18			
	6.0	30.19	27.18			
	8.1	30.20	27.18			
11:10 am	10.0	30.20	27.17			
	11.9	30.20	27.18			
	14.0	30.20	27.18			
	16.0	30.24	27.21	3.72		Adjust rate
	17.2	30.28	27.23	3.80	650	
	18.0	30.27	27.23			
11:20 am	20.1	30.28	27.24			
	22.1	30.29	27.25			
	24.2	30.30	27.26			
	25.3	30.30	27.26			
	25.9	30.30	27.25			
	27.1	30.30	27.25			
	27.7	30.30	27.26			
	28.3	30.30	27.26			
	29.0	30.30	27.26	3.80	650	
	29.7	30.29	27.26			
11:30 am	30.0					Reduce rate
11:32 am	2.0	29.83	27.02	3.22	600	Step 3
	3.0	29.82	27.00			
	4.0	29.81	26.99			
	5.0	29.80	26.99			
	6.0	29.79	26.98			
	8.1	29.80	26.98			
11:40 am	10.0	29.79	26.98			
	11.9	29.79	26.97			
	14.0	29.79	26.97			
	15.0	29.78	26.97	3.20	600	
	16.0	29.79	26.97			
	18.0	29.79	26.97			
11:50 am	20.1	29.79	26.96			
	22.0	29.80	26.97			
	24.1	29.79	26.97	3.20	600	
	25.3	29.79	26.97			
	25.9	29.79	26.96			
	27.1	29.79	26.97			
	27.7	29.80	26.97			
	28.4	29.80	26.97			
	29.0	29.80	26.97			
	29.7	29.80	26.97			

WATER LEVEL MEASUREMENTS (Continued)
Venice Well No. 2

Hour	Time (min)	Adjusted depth to water in well (ft)	Adjusted depth to water in piezometer (ft)	Orifice tube piez. (ft)	Pumping rate (gpm)	Remarks
12:00 pm	30.0					Reduce rate
12:01 pm	1.0	29.41	26.76	2.72	550	Step 4
	2.0	29.39	26.76			
	3.0	29.38	26.75			
	4.0	29.37	26.74			
	5.0	29.36	26.73			
	6.0	29.37	26.73			
	8.1	29.36	26.73			
12:10 pm	10.0	29.36	26.75			
	12.0	29.35	26.72			
	14.0	29.36	26.71			
	16.1	29.37	26.71			
	18.0	29.36	26.72			
12:20 pm	20.2	29.35	26.71	2.72	550	
	22.2	29.36	26.73			
	23.7	29.36	26.73			
	24.9	29.36	26.73			
	26.0	29.36	26.72			
	27.2	29.37	26.72			
	27.9	29.36	26.72			
	28.5	29.37	26.72			
	29.2	29.36	26.72	2.72	550	
	29.9	29.37	26.72			
12:30 pm	30.0					Reduce rate
12:31 pm	1.0	28.94	26.50	2.23	500	Step 5
	2.0	28.91	26.48			
	3.0	28.90	26.46			
	4.0	28.89	26.45			
	5.0	28.87	26.45			
	6.0	28.87	26.44			
	7.1	28.86	26.44	2.22	500	Water sample collected; (temp not recorded)
	8.1	28.86	26.44			
12:40 pm	10.0	28.89	26.45			
	11.9	28.89	26.45			
	14.0	28.89	26.45			
	16.0	28.89	26.46			
	18.0	28.89	26.47			
12:50 pm	20.1	28.88	26.44			
	22.0	28.88	26.44			
	24.1	28.88	26.44			
	25.3	28.88	26.43			
	25.9	28.88	26.44			

WATER LEVEL MEASUREMENTS (Continued)
Venice Well No. 2

Hour	Time (min)	Adjusted depth to water in well (ft)	Adjusted depth to water in piezometer (ft)	Orifice tube piez. (ft)	Pumping rate (gpm)	Remarks
	27.1	28.89	26.44			
	27.7	28.89	26.45			
	28.3	28.89	26.46			
	29.0	28.89	26.46	2.24	500	
	29.7	28.89	26.46			
01:00 pm	30.0					End of Test

DEWATERING WELL DATA

	Well No. Venice W5	Piezometer No. Venice P5
Date Drilled:	1982	1982
Casing		
Top elevation:	400.8	407.21
Diameter:	16-in. SS	2-in. PVC
Length:	21.3 ft	na
Screen		
Bottom elevation:	328.6	na
Diameter:	16-in. SS	2-in. PVC
Length:	50.9 ft	3 ft
Slot size:	0.080-in.	na
Measuring Point Elevation:	401.05	407.21
Nonpumping Water Level		
Depth below temp. MP:	20.80	-
Length of temp. MP extension:	6.4	-
Depth below perm. MP:		20.54
Elevation:	386.65	386.67
Date of Step Test:	12/7/89	-
Water Sample		
Time:	4:09 pm	-
Temperature:	59° F	-
Laboratory No.:	223289	-
Distance and Direction to Piez. from PW:		4.3 ft SW
Time PW Off Before Step Test:		Not recorded
Wells in Operation at Site at Time of Step Test:		Not recorded

Notes: SWS 8-in. dia. orifice tube w/plate No. 4;
Discharge to portable tank for sand check;
No sand noted

SWS Crew: Not recorded

WATER LEVEL MEASUREMENTS
Venice Well No. 5
Pre-Treatment Step Test

Hour	Time (min)	Adjusted depth to water in well (ft)	Adjusted depth to water in piezometer (ft)	Orifice tube piez. (ft)	Pumping rate (gpm)	Remarks
12/07/89						
12:55 pm	0.0		20.54			Measured Depth
01:08 pm	0.0	20.80				Measured Depth
01:36 pm	0.0	20.80	20.54			McDAS started
	1.0	20.80	20.54			Water Level Trend
	2.0	20.80	20.54			
	3.0	20.81	20.54			
	4.0	20.80	20.54			
	5.1	20.81	20.54			
	6.0	20.82	20.54			
	6.8	20.82	20.54			
01:43 pm	0.0					Pump On
01:44 pm	1.0			2.23	500	Step 1
	2.0	32.09	24.49	2.20	495	
	3.0	32.09	24.60			
	4.0	32.08	24.64			
	5.0	32.10	24.67			
	6.0	32.10	24.69			
	8.0	32.09	24.71			
01:53 pm	10.0	32.09	24.74			
	12.0	32.10	24.75			
	14.1	32.10	24.76			
	16.2	32.10	24.78			
	18.1	32.09	24.78			
02:03 pm	19.9	32.09	24.79			
	21.8	32.10	24.80			
	23.9	32.10	24.81			
	25.0	32.10	24.82			
	26.1	32.09	24.82			
	26.8	32.10	24.83			
	28.0	32.10	24.83			
	28.7	32.10	24.83			
	29.3	32.11	24.83			
02:13 pm	30.0					Reduce rate
02:14 pm	1.0	30.74	24.54	1.81	450	Step 2
	2.0	30.23	24.30			
	3.0	30.19	24.28			
	4.0	30.20	24.28			
	5.0	30.20	24.28			
	6.0	30.20	24.28			
	8.1	30.21	24.28			
02:23 pm	9.9	30.23	24.29	1.81	450	

WATER LEVEL MEASUREMENTS (Continued)
Venice Well No. 5

Hour	Time (min)	Adjusted depth to water in well (ft)	Adjusted depth to water in piezometer (ft)	Orifice tube piez. (ft)	Pumping rate (gpm)	Remarks
	11.9	30.23	24.30			
	14.0	30.25	24.30			
	16.0	30.28	24.31	1.81	450	
	18.0	30.28	24.32			
02:33 pm	20.1	30.30	24.33			
	22.0	30.33	24.33			
	24.1	30.34	24.34			
	25.3	30.34	24.34			
	25.9	30.34	24.34			
	27.1	30.35	24.35			
	27.7	30.35	24.35			
	28.3	30.36	24.36			
	29.0	30.35	24.36			
	29.7	30.37	24.36			
02:43 pm	30.0			1.81	450	Reduce rate
02:44 pm	1.0	29.16	24.01			Step 3
	2.0	29.07	23.97	1.41	400	
	3.0	29.08	23.96			
	4.0	29.08	23.96			
	5.0	29.08	23.96			
	6.0	29.09	23.95			
	8.1	29.10	23.96	1.41	400	
02:53 pm	10.0	29.09	23.96			
	11.9	29.10	23.96			
	14.0	29.11	23.97			
	16.1	29.12	23.97			
	18.0	29.11	23.97			
03:03 pm	20.2	29.12	23.98			
	22.1	29.12	23.98			
	24.2	29.13	23.99			
	24.8	29.13	23.99			
	25.9	29.14	23.99			
	27.1	29.14	23.99			
	27.8	29.14	23.99	1.41	400	
	28.4	29.14	23.99			
03:12 pm	29.1	29.15	24.00			Reduce rate
03:13 pm	1.0	28.07	23.68	1.04		Step 4
	2.0	28.02	23.65	1.09	350	
	3.0	28.01	23.64			
	4.0	28.01	23.63			
	5.0	28.00	23.63			
	6.0	28.01	23.63			

WATER LEVEL MEASUREMENTS (Continued)
Venice Well No. 5

Hour	Time (min)	Adjusted depth to water in well (ft)	Adjusted depth to water in piezometer (ft)	Orifice tube piez. (ft)	Pumping rate (gpm)	Remarks
	8.1	28.01	23.63			
03:22 pm	10.0	28.01	23.63			
	11.9	28.01	23.63			
	14.0	28.02	23.63			
	16.1	28.01	23.63	1.08	350	
	18.0	28.02	23.63			
03:32 pm	20.2	28.02	23.64			
	22.1	28.02	23.64			
	24.2	28.02	23.64			
	24.8	28.03	23.64			
	26.0	28.03	23.65			
	27.2	28.03	23.64			
	27.8	28.03	23.64	1.06	350	
	28.4	28.03	23.64			
	29.1	28.03	23.64			
03:42 pm	30.0					Reduce rate
03:43 pm	1.0	26.95	23.31	0.79	300	Step 5
	2.0	26.92	23.28	0.79	300	
	3.0	26.91	23.27			
	4.0	26.91	23.27			
	5.0	26.88	23.27			
	6.0	26.87	23.27			
	8.1	26.87	23.26			
03:52 pm	10.0	26.88	23.27			
	12.0	26.89	23.27			
	14.0	26.88	23.27			
	16.1	26.87	23.26			
	18.0	26.87	23.26			
04:02 pm	20.2	26.88	23.27	0.79	300	Water sample collected; T=59°F
	22.2	26.88	23.27			
	23.8	26.89	23.27			
	24.9	26.88	23.26			
	26.1	26.86	23.26			
	27.3	26.86	23.25			
04:10 pm	27.9	26.86	23.26			
04:10 pm	28.6	26.87	23.26			
04:11 pm	29.0					End of Test

DEWATERING WELL DATA

	Well No. Venice W5	Piezometer No. Venice P5
Date Drilled:	1982	
Casing		
Top elevation:	400.8	407.21
Diameter:	16-in. SS	2-in. PVC
Length:	21.3 ft	na
Screen		
Bottom elevation:	328.6	na
Diameter:	16-in. SS	2-in. PVC
Length:		3 ft
Slot size:	0.080-in.	na
Measuring Point Elevation:	401.05	407.21
Nonpumping Water Level		
Depth below temp. MP:	19.67	-
Length of temp. MP extension:	6.3	-
Depth below perm. MP:	13.37	19.54
Elevation:	387.68	387.67
Date of Step Test:	5/2/90	-
Water Sample		
Time:	2:15 pm	-
Temperature:	60° F	-
Laboratory No.:	223504	-
Distance and Direction to Piez. from PW:		4.3 ft SW
Time PW Off Before Step Test:		Not recorded
Wells in Operation at Site at Time of Step Test:		Not recorded

Notes: SWS 8-in. dia. orifice tube w/plate No. 4;
McDas; Portable tank; no sand noted.

SWS Crew: R. Olson, S. Wilson

WATER LEVEL MEASUREMENTS
Venice Well No. 5
Post-Treatment Step Test

Hour	Time (min)	Adjusted depth to water in well (ft)	Adjusted depth to water in piezometer (ft)	Orifice tube piez. (ft)	Pumping rate (gpm)	Remarks
5/2/90						
11:10 am	0	19.67	19.54			Measured depth
11:46	0					Pump on, Step 1
	1	25.27	22.35	5.03	740	Valve full open
	2	25.80	23.40			Adjust rate
	3	25.99	23.72			
	4	25.80	23.80			
	6	25.74	23.71	4.36		
	8	25.84	23.78	4.41	700	
11:56	10	25.87	23.82			
	12	25.90	23.86			
	14	25.93	23.89	4.41	700	
	16	25.96	23.91			
12:06 pm	20	25.99	23.95			
	24	26.01	23.97			
	26	26.02	23.98			
	29	26.04	24.00			
12:16	30	26.05	24.01			Reduce rate
12:17	1	25.67	23.82	3.79	650	Step 2
	2	25.62	23.75			
	3	25.61	23.73			
	4	25.60	23.73			
	6	25.61	23.73			
	8	25.62	23.73			
12:26	10	25.61	23.73			
	12	25.62	23.74			
	14	25.62	23.74			
	16	25.63	23.75			
12:36	20	25.64	23.76	3.79	650	
	23	25.64	23.76			
	26	25.64	23.77			
	29	25.65	23.77	3.79	650	
12:46	30	25.65	23.77			Reduce rate
12:47	1	25.24	23.58	3.20	600	Step 3
	2	25.21	23.50			
	3	25.18	23.47			
	4	25.19	23.47			
	6	25.18	23.46			
	8	25.18	23.46			
12:56	10	25.19	23.46			
	12	25.19	23.46			
	14	25.19	23.47			

WATER LEVEL MEASUREMENTS (Continued)
Venice Well No. 5

Hour	Time (min)	Adjusted depth to water in well (ft)	Adjusted depth to water in piezometer (ft)	Orifice tube piez. (ft)	Pumping rate	Remarks
	16	25.19	23.47			
	18	-	-	3.20	600	
1:06	20	25.19	23.47			
	23	25.19	23.48			
	26	25.21	23.48			
	29	25.21	23.49	3.20	600	
1:16	30	25.21	23.49			Reduce rate
1:17	1	24.81	23.28	2.67		Step 4
	2	24.80	23.23	2.70	550	
	3	24.79	23.21			
	4	24.79	23.21			
	5			2.71	550	
	6	24.78	23.21			
	8	24.78	23.21			
1:26	10	24.78	23.21			
	12	24.79	23.21			
	14	24.79	23.21	2.71	550	
	16	24.79	23.21			
1:36	20	24.80	23.22			
	23	24.80	23.22			
	26	24.81	23.23			
	29	24.81	23.23	2.72	550 .	
1:46	30	24.81	23.24			Reduce rate
1:47	1	24.40	23.04	2.22	500	Step 5
	2	24.34	22.95			
	3	24.35	22.93			
	4	24.33	22.92			
	6	24.34	22.92			
	8	24.33	22.91			
1:56	10	24.33	22.91			
	12	24.32	22.91			
	14	24.32	22.91			
	15	-	-	2.22	500	
	16	24.32	22.91			
2:06	20	24.33	22.91			
	23	24.33	22.92			
	26	24.33	22.92			
	29	24.34	22.92	2.22	500	
2:16	30	24.33	22.92			Water sample collected, T=60° F
2:18	32	-	-			Pump off

Appendix B.

Results from Chemical Analysis of
Dewatering Well Water Samples
FY 90 (Phase 7)

Appendix B. Chemical Quality of Ground Water at IDOT Dewatering Sites
FY90 (Phase 7)

Site	I-70	I-70	I-70	I-70
Well No.	3	3	7A	9A
Section Location T2N, R9W, St. Clair Co.	7.7b	7.7b	7.7b	7.7b
Date Collected	12/11/89	4/17/90	6/27/90	6/26/90
Laboratory No.	223290	223481	223575	223574
Iron (Fe), mg/l	7.57	6.11	10.70	16.60
Manganese (Mn), mg/l	0.76	0.71	0.87	0.70
Calcium (Ca), mg/l	162	156	220	232
Magnesium (Mg), mg/l	38.8	35.2	49.2	54.9
Sodium (Na), mg/l	33.2	45.2	78.9	230
Potassium (K), mg/l	-	-	-	
Silica (SiO_2), mg/l	32.0	-	-	
Fluoride (F), mg/l	0.6	0.4	0.7	1.0
Nitrate (NO_3), mg/l	<0.1	<0.1	<0.1	<0.1
Chloride (C1), mg/l	69.0	86.8	75.8	70.8
Sulfate (SO_4), mg/l	222	188	403	694
Alkalinity (as $CaCO_3$), mg/l	385	369	461	522
Hardness (as $CaCO_3$), mg/l	564	534	751	805
Total dissolved minerals, mg/l	826	834	1198	1642
Turbidity (lab), NTU	[1]75	[1]10	<1	<1
Color, PCU	5	<1	<1	<1
Odor	None	None	None	None
pH (lab)	7.7	7.2	7.3	7.8
Temperature, °F	ND	ND	61	62

[1] Turbidity due to precipitation of originally dissolved iron

< = Below detection limit (i.e. <1.0 = less than 1.0 mg/L)
mg/L = milligrams per liter
uS/cm = microsiems per centimeter
ND = Not determined/Information not available

Appendix B. Continued

Site	25th St.	25th St.	25th St.	25th St.
Well No.	1	2	3	5
Section Location T2N, R9W, St. Clair Co.	17.6d	17.6d	17.6d	17.6d
Date Collected	8/11/89	4/18/90	9/7/89	4/19/90
Laboratory No.	223141	223480	223167	223479
Iron (Fe), mg/l	8.52	5.41	14.90	4.85
Manganese (Mn), mg/l	0.66	0.39	0.62	0.49
Calcium (Ca), mg/l	166	240	246	129
Magnesium (Mg), mg/l	46.8	68.8	66.9	35.4
Sodium (Na), mg/l	120	226	254	16.5
Potassium (K), mg/l	6.5	-	-	-
Silica (SiO_2), mg/l	-	-	32.1	-
Fluoride (F), mg/l	0.9	1.2	1.3	0.4
Nitrate (NO_3), mg/l	0.2	<0.1	<0.1	<0.1
Chloride (C1), mg/l	33.6	34.7	47.2	23.2
Sulfate (SO_4), mg/l	548	972	939	160
Alkalinity (as $CaCO_3$), mg/l	415	451	474	360
Hardness (as $CaCO_3$), mg/l	607	882	889	467
Total dissolved minerals, mg/l	1226	1891	1925	661
Turbidity (lab), NTU	[1]40	[1]10	[1]80	[1]10
Color, PCU	50	<1	45	<1
Odor	Musty	None	None	None
pH (lab)	6.9	7.2	7.3	7.4
Temperature, °F	60	60	60	58.5

[1] Turbidity due to precipitation of originally dissolved iron

< = Below detection limit (i.e. <1.0 = less than 1.0 mg/L)
mg/L = milligrams per liter
uS/cm = microsiems per centimeter
ND = Not determined/Information not available

Appendix B. Concluded

Site	Venice	Venice	Venice	Venice
Well No.	1	2	5	5
Section Location T3N, R10W, St. Clair Co.	35.3g	35.4g	35.3g	35.3g
Date Collected	9/6/89	5/8/90	12/7/89	5/2/90
Laboratory No.	223166	223505	223289	223504
Iron (Fe), mg/l	17.36	15.10	11.00	15.10
Manganese (Mn), mg/l	0.55	0.66	0.52	0.58
Calcium (Ca), mg/l	220	193	185	187
Magnesium (Mg), mg/l	53.6	44.9	50.6	50.9
Sodium (Na), mg/l	35.2	35.8	44.7	50.2
Potassium (K), mg/l	-	-	-	-
Silica (SiO_2), mg/l	31.4	-	31.6	-
Fluoride (F), mg/l	0.8	0.6	0.7	0.7
Nitrate (NO_3), mg/l	<0.1	<0.1	<0.1	<0.1
Chloride (C1), mg/l	42.8	44.1	68.0	73.8
Sulfate (SO_4), mg/l	372	297	313	314
Alkalinity (as $CaCO_3$), mg/l	475	462	425	443
Hardness (as $CaCO_3$), mg/l	769	666	670	676
Total dissolved minerals, mg/l	1114	970	990	1011
Turbidity (lab), NTU	[1]70	[1]50	[1]100	[1]50
Color, PCU	5	<1	<1	<1
Odor	None	None	None	None
pH (lab)	7.1	7.4	7.5	7.5
Temperature, °F	59	ND	59	60

[1] Turbidity due to precipitation of originally dissolved iron

< = Below detection limit (i.e. <1.0 = less than 1.0 mg/L)
mg/L = milligrams per liter
uS/cm = microsiems per centimeter
ND = Not determined/Information not available

Appendix C.

Step Test Results
FY 84 - FY 90 (Phases I-7)

Well	Date of test	Well loss @ 600 gpm (ft)	Drawdown @ 600 gpm (ft)	Well loss portion (%)	Observed specific capacity (gpm/ft)	Ah* @ 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. 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. 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. 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. 5	7/10/84	0.89	6.53	13.6	91.9	2.11	740	
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. 6	7/19/85	0.23	5.39	4.3	111.3	P	625	
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	

Appendix C. Continued

Well	Date of test	Well loss (§600 gpra (ft)	Drawdown @ 600 gpm (ft)	Well loss portion (%)	Observed specific capacity (gpm/ft)	Ah* @ 600 gpm (ft)	Observed Q_{max} (gpm)	Remarks
I-70 (Cont'd)								
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. 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. 9	6/28/84	**	9.46	**	63.4	5.94	630	
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. 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. 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. 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
No. 12A	11/16/87	1.45	2.36	61.4	254.2	P	750	PostTreat

Appendix C. Continued

Well	Date of test	Well loss @ 600 gpm (ft)	Drawdown @ 600 gpm (ft)	Well loss portion (%)	Observed specific capacity (gpm/ft)	Ah* @ 600 gpm (ft)	Observed Q_{max} (gpm)	Remarks
I-64								
No. 1	7/21/87	**	4.13	**	145.3	0.85	660	
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. 9	10/5/83	0.37	6.22	5.9	96.5	2.3		
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	
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. 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. 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

Appendix C. Continued

Well	Date of test	Well loss @ 600 gpm (ft)	Drawdown @ 600 gpm (ft)	Well loss portion (%)	Observed specific capacity (gpm/ft)	Ah* @ 600 gpm (ft)	Observed (gpm)	Remarks
25th St. (Cont'd)								
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
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. 8	6/15/83	0.11	4.70	2.3	127.7	1.5		
No. 9	6/25/86	**	5.55 e	**	110.4	2.04 e	520	
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. 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. 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. 4	12/1/83	0.39	5.15	7.6	116.5	2.3		
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

Appendix C. Continued

Well	Date of test	Well loss @ 600 gpm (ft)	Drawdown @ 600 gpm (ft)	Well loss portion (%)	Observed specific capacity (gpm/ft)	Δh* @ 600 gpm (ft)	Observed (gpm)	Remarks
Venice (Cont'd)								
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

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

Appendix D.

Chemical Treatment Field Data FY 90 (Phase 7)

WELL REHABILITATION FIELD NOTES

WELL SITE: I-70 Well 3 OBSERVER: A1 Brown, IDOT

CONTRACTOR: Brotcke Engineering Company, Inc.

MEASURING POINT: Not recorded (NR)

MEASURING EQUIP.: Contractor's 6 x 5 inch orifice tube, electric dropline

1. SPECIFIC CAPACITY TEST

DATE: 2/21/90

Time	Depth (ft)	Drawdown (ft)	Piez. tube (in.)	Pumping rate (gpm)	Remarks
8:30 am	30.58		38	759	Static water level (SWL)
9:30 am	50.42	19.84	37	748	Pumping water level (PWL)

Note: 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: 37.7 gpm/ft

2. 400 LBS POLYPHOSPHATE APPLICATION

DATE: 2/21/90

A. INITIAL CHLORINATION

Quantity: 2500 gal Strength: 500 mg/L (ppm)

Time - initial: NR Injection rate:
- complete: NR

B. POLYPHOSPHATE INJECTION, 400 lbs total

	Batch 1	Batch 2
Phosphate:	200 lbs	200 lbs
Quantity H_2O:	1800 gal	1800 gal
Time - initial:		
- complete:	42 sec	44 sec
Injection rate:	2570 gpm	2455 gpm

C. DISPLACEMENT, 16,000 gallons chlorinated water (500 mg/l)

Time - initial/complete	Quantity (gal)	Q (gpm)
Not recorded	16,000	2000 gal/6 min (-333 gpm)

Comments: 8 injections of 2000 gallons each

WELL REHABILITATION -- I-70 Well 3 (Continued')

D. PUMPED TO WASTE

Time - initial: 2:00 pm (2/21/90)
- complete: 8:00± pm (2/21/90)

Q: (40"=piez) 781 gpm   Quantity: 281,160 gal

3. SPECIFIC CAPACITY TEST   DATE: 2/22/90

Time	Depth (ft)	Drawdown (ft)	Piez. tube (in.)	Pumping rate (gpm)	Remarks
8:15 am	29.62		40	781	SWL
NR	45.42	15.80			PWL

60 min. specific capacity: 49.4 gpm/ft

4. ACIDIZATION - INHIBITED MURIATIC ACID   DATE: 2/22/90

A. ACID INJECTION

Acid strength: 20° Baume   Quantity: 1000 gal

Time - initial: NR   Q:
- complete: NR

B. DISPLACEMENT, 4,000-5,000 gallons nonchlorinated water

Time - initial/complete	Quantity (gal)	Q (gpm)
Not recorded	5000	

C. PUMPED TO WASTE

Time - initial: 1:00 pm (2/22/90)
- complete: 8:00 am (2/23/90)

Q: 770 gpm   Quantity: 877,800 gal

5. SPECIFIC CAPACITY TEST   DATE: 2/23/90

Time	Depth (ft)	Drawdown (ft)	Piez. tube (in.)	Pumping rate (gpm)	Remarks
8:00 am	45.5		39	770	PWL
NR	31.0	14.5			SWL

60 min. specific capacity: 53.1 gpm/ft

6. 600 LBS POLYPHOSPHATE APPLICATION DATE: 2/23/90

A. INITIAL CHLORINATION

Quantity: 2500 gal Strength: 500 mg/L (ppm)

Time - initial: NR Injection rate:
- complete: NR

B. POLYPHOSPHATE INJECTION, 600 lbs total

	Batch 1	Batch 2	Batch 3
Phosphate:	200 lbs	200 lbs	200 lbs
Quantity H_2O:	1800 gal	1800 gal	1800 gal
Time - initial:			
- complete:	0:53 min:sec	1:03 min:sec	1:06 min:sec
Injection rate:	2038 gpm	1714 gpm	1636 gpm

C. DISPLACEMENT, 30,000 gallons chlorinated water (500 mg/l)

Time - initial/complete	Quantity (gal)	Q (gpm)
2/23/90 - 90 min	30,000	-333

Comments: 15 injections of 2000 gallons each

D. PUMPED TO WASTE

Time - initial: 1:30 pm (2/23/90)
- complete: 6:55 am (2/24/90)

Q: 786 gpm Quantity: 821,370 gal

7. SPECIFIC CAPACITY TEST DATE:

Time	Depth (ft)	Drawdown (ft)	Piez. tube (in.)	Pumping rate (gpm)	Remarks
6:55 am	44.75		40.5	786	PWL
7:25 am	31.17	13.58			SWL

30 min. specific capacity: 57.9 gpm/ft

8. 600 LBS POLYPHOSPHATE APPLICATION (Additional N-1) DATE: 2/26/90

A. INITIAL CHLORINATION

Quantity: 2500 Strength: 500 mg/L (ppm)

Time - initial: NR Injection rate:
- complete: NR

B. POLYPHOSPHATE INJECTION, 600 lbs total

	Batch 1	Batch 2	Batch 3
Phosphate:	200 lbs	200 lbs	200 lbs
Quantity H_2O:	1800 gal	1800 gal	1800 gal
Time - initial:			
- complete:	54 sec	53 sec	57 sec
Injection rate:	2000 gpm	2038 gpm	1895 gpm

C. DISPLACEMENT, 54,000 gallons chlorinated water (500 mg/l)

Time - initial/complete	Quantity (gal)	Q (gpm)
Not recorded		

Comments: 27 injections of 2000 gallons each

D. PUMPED TO WASTE

Time - initial: 2:00 pm (2/26/90)
- complete: 8:30 am (2/27/90)

Q: 786 gpm Quantity: 872,460 gal

9. SPECIFIC CAPACITY TEST DATE: 2/27/90

Time	Depth (ft)	Drawdown (ft)	Piez. tube (in.)	Pumping rate (gpm)	Remarks
8:30 am	43.92		40.5	786	PWL
9:00 am	31.08	12.84			SWL

60 min. specific capacity: 61.2 gpm/ft

10. 600 LBS POLYPHOSPHATE APPLICATION (Additional N-2) DATE: 2/27/90

A. INITIAL CHLORINATION (No data recorded)

Quantity: Strength:

Time - initial: Injection rate:
- complete:

B. POLYPHOSPHATE INJECTION, 600 lbs total

	Batch 1	Batch 2	Batch 3
Phosphate:	200 lbs	200 lbs	200 lbs
Quantity H_2O:	1800 gal	1800 gal	1800 gal
Time - initial:			
- complete:	NR	NR	NR
Injection rate:			

C. DISPLACEMENT, 16,000 gallons chlorinated water (500 mg/l)

Time - initial/complete	Quantity (pal)	Q (gpm)
Not recorded		

Comments: 8 injections of 2000 gallons each

D. PUMPED TO WASTE

Time - initial: 1:00 pm (2/27/90)
- complete: 8:05 am (2/28/90)

Q: 786 gpm Quantity: 899,970 gal

11. SPECIFIC CAPACITY TEST DATE: 2/28/90

Time	Depth (ft)	Drawdown (ft)	Piez. tube (in.)	Pumping rate (gpm)	Remarks
8:05 am	43.92		40.5	786	PWL
NR	31.17	12.75			SWL

60 min. specific capacity: 61.6 gpm/ft

WELL REHABILITATION FIELD NOTES

WELL SITE: 25th St. Well 2 OBSERVER: A1 Brown, IDOT

CONTRACTOR: Brotcke Engineering Company, Inc.

MEASURING POINT: Not recorded (NR)

MEASURING EQUIP.: Contractor's 6 x 5 inch orifice tube, electric dropline

1. SPECIFIC CAPACITY TEST

DATE: 2/2/90

Time	Depth (ft)	Drawdown (ft)	Piez. tube (in.)	Pumping rate (gpm)	Remarks
8:35 am	17.82				Static water level (SWL)
			43.5	815	
9:35 am	43.33		42	800	Valved rate back
9:36 am	38.0		26	620	Pumping water level (PWL)
10:00 am	38.0	20.18	26.5	626	

Note: 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: 31.0 gpm/ft

2. 400 LBS POLYPHOSPHATE APPLICATION

DATE: 2/2/90

A. INITIAL CHLORINATION

Quantity: 2500 gal   Strength: 500 mg/L (ppm)

Time - initial: NR   Injection rate:
- complete: NR

B. POLYPHOSPHATE INJECTION, 400 lbs total

	Batch 1	Batch 2
Phosphate:	200 lbs	200 lbs
Quantity H_2O:	1800 gal	1800 gal
Time - initial:		
- complete:	44 sec	43 sec
Injection rate:	2455 gpm	2512 gpm

C. DISPLACEMENT, 16,000 gallons chlorinated water (500 mg/l)

Time - initial/complete	Quantity (gal)	Q (gpm)
40 min.	16,000	-400

Comments: 8 injections of 2000 gallons each

D. PUMPED TO WASTE

Time - initial: 1:00 pm (2/2/90)
- complete: 7:50 am (2/3/90)

Q: 737 gpm   Quantity: 832,810 gal

3. SPECIFIC CAPACITY TEST   DATE: 2/3/90

Time	Depth (ft)	Drawdown (ft)	Piez. tube (in.)	Pumping rate (gpm)	Remarks
7:50 am	29.54		36	737	PWL
8:20 am	18.71	10.83			SWL

30 min. specific capacity: 68.1 gpm/ft

4. ACIDIZATION - INHIBITED MURIATIC ACID   DATE: 2/5/90

A. ACID INJECTION

Acid strength: 20 Baume   Quantity: 1000 gal

Time - initial: NR   Q:
- complete: NR

B. DISPLACEMENT, 4,000-5,000 gallons nonchlorinated water

Time - initial/complete	Quantity (gal)	Q (gpm)
Not recorded		

C. PUMPED TO WASTE

Time - initial: 1:00 pm (2/5/90)
- complete: 8:15 am (2/6/90)

Q: 644 gpm   Quantity: 743,820 gal

5. SPECIFIC CAPACITY TEST   DATE: 2/6/90

Time	Depth (ft)	Drawdown (ft)	Piez. tube (in.)	Pumping rate (gpm)	Remarks
8:15 am	26.75		28	644	PWL
8:45 am	18.25	8.50			SWL

30 min. specific capacity: 75.8 gpm/ft

6. 600 LBS POLYPHOSPHATE APPLICATION — DATE: 2/7/90

A. INITIAL CHLORINATION

Quantity: 2500 gal — Strength: 500 mg/L (ppm)

Time - initial: NR — Injection rate:
- complete: NR

B. POLYPHOSPHATE INJECTION, 600 lbs total

	Batch 1	Batch 2	Batch 3
Phosphate:	200 lbs	200 lbs	200 lbs
Quantity H_2O:	1800 gal	1800 gal	1800 gal
Time - initial:			
- complete:	42 sec	44 sec	39 sec
Injection rate:	2571 gpm	2455 gpm	2769 gpm

C. DISPLACEMENT, 30,000 gallons chlorinated water (500 mg/l)

Time - initial/complete	Quantity (gal)	Q (gpm)
10:20 am - 75 min	-30,000	-400

Comments: 15 injections of 2000 gallons each

D. PUMPED TO WASTE

Time - initial: 8:00 am (2/8/90)
- complete: 2:00 pm (2/8/90

Q: 709 gpm — Quantity: 255,240 gal

Comments: The valves were tampered with overnight. At 8:00 am 2/8/90 turned valves open. Will start 6 hours count at 8:00 am.

7. SPECIFIC CAPACITY TEST — DATE: 2/8/90

Time	Depth (ft)	Drawdown (ft)	Piez. tube (in.)	Pumping rate (gpm)	Remarks
2:00 pm	26.58		33.5	709	PWL
2:30 pm	18.33	8.25			SWL

30 min. specific capacity: 85.9 gpm/ft

WELL REHABILITATION -- 25th St. Well 2 (Continued)

8. 600 LBS POLYPHOSPHATE APPLICATION (Additional N-1) DATE: 2/9/90

A. INITIAL CHLORINATION

Quantity: 2500 Strength: 500 mg/L (ppm)

Time - initial: NR Injection rate:
- complete: NR

B. POLYPHOSPHATE INJECTION, 600 lbs total

	Batch 1	Batch 2	Batch 3
Phosphate:	200 lbs	200 lbs	200 lbs
Quantity H_2O:	1800 gal	1800 gal	1800 gal
Time - initial:			
- complete:	44 sec	42 sec	43 sec
Injection rate:	2455 gpm	2571 gpm	2512 gpm

C. DISPLACEMENT, 54,000 gallons chlorinated water (500 mg/l)

Time - initial/complete	Quantity (gal)	Q (gpm)
Not recorded		

Comments: 27 injections of 2000 gallons each

D. PUMPED TO WASTE

Time - initial: 12:30 pm (2/9/90)
- complete: 7:35 am (2/10/90)

Q: 715 gpm Quantity: 818,675 gal

9. SPECIFIC CAPACITY TEST DATE: 2/10/90

Time	Depth (ft)	Drawdown (ft)	Piez. tube (in.)	Pumping rate (gpm)	Remarks
7:35 am	26.25		34	715	PWL
8:05 am	18.67	7.58			SWL

30 min. specific capacity: 94.3 gpm/ft

10. 400 LBS POLYPHOSPHATE APPLICATION (Additional N-2) DATE: 2/12/90

A. INITIAL CHLORINATION

Quantity: 2500 gal Strength: 500 mg/L (ppm)

Time - initial: NR Injection rate:
- complete: NR

WELL REHABILITATION -- 25th St. Well 2 (Continued)

B. POLYPHOSPHATE INJECTION, 400 lbs total

	Batch 1	Batch 2	Batch 3
Phosphate:	200 lbs	200 lbs	
Quantity H_2O:	1800 gal	1800 gal	
Time - initial:			
- complete:	42 sec	43 sec	
Injection rate:	2571 gpm	2512 gpm	

C. DISPLACEMENT, 16,000 gallons chlorinated water (500 mg/l)

Time - initial/complete	Quantity (gal)	Q (gpm)
Not recorded		

Comments: 8 injections of 2000 gallons each

D. PUMPED TO WASTE

Time - initial: 11:30 am (2/12/90)
- complete: 8:00 am (2/13/90)

Q: 709 gpm   Quantity: 872,070 gal

11. SPECIFIC CAPACITY TEST   DATE: 2/13/90

Time	Depth (ft)	Drawdown (ft)	Piez. tube (in.)	Pumping rate (gpm)	Remarks
8:00 am	26.25		33.5	709	PWL
8:30 am	18.75	7.50			SWL

30 min. specific capacity: 94.5 gpm/ft

WELL REHABILITATION FIELD NOTES

WELL SITE: 25th St. Well 5 OBSERVER: A1 Brown, IDOT

CONTRACTOR: Brotcke Engineering Company, Inc.

MEASURING POINT: Not recorded (NR)

MEASURING EQUIP.: Contractor's 6 x 5 inch orifice tube, electric dropline

1. SPECIFIC CAPACITY TEST DATE: 1/22/90

Time	Depth (ft)	Drawdown (ft)	Piez. tube (in.)	Pumping rate (gpm)	Remarks
10:00 am	18.67		35	726	Pump shut off @ 10:15 am
11:40 am	18.67		38	759	Sucking air
12:05 pm			27.5	638	Valved back
12:40 pm	39.50	20.83	27.5	638	Pumping water level (PWL)

Note: 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: 30.6 gpm/ft

2. 400 LBS POLYPHOSPHATE APPLICATION DATE: 1/24/90

A. INITIAL CHLORINATION

Quantity: 2500 gal Strength: 500 mg/L (ppm)

Time - initial: NR Injection rate:
- complete: NR

B. POLYPHOSPHATE INJECTION, 400 lbs total

	Batch 1	Batch 2
Phosphate:	200 lbs	200 lbs
Quantity H_2O:	1800 gal	1800 gal
Time - initial:		
- complete:	49 sec	50 sec
Injection rate:	2204 gpm	2160 gpm

C. DISPLACEMENT, 16,000 gallons chlorinated water (500 mg/l)

Time - initial/complete	Quantity (gal)	Q (gpm)
10:10 am/10:45*	14,000*	400 ± gal

Comments: *Well vault started to fill up. Stopped pumping displacement water.

D. PUMPED TO WASTE

Time - initial: 1:00 pm (1/24/90)
- complete: 8:10 am (1/25/90)

Q: 644 gpm Quantity: 740,600 gal

3. SPECIFIC CAPACITY TEST DATE: 1/25/90

Time	Depth (ft)	Drawdown (ft)	Piez. tube (in.)	Pumping rate (gpm)	Remarks
8:10 am	30.00		28	644	PWL
8:45	21.08	8.92			SWL

30 min. specific capacity: 72.2 gpm/ft

4. ACIDIZATION - INHIBITED MURIATIC ACID DATE: 1/25/90

A. ACID INJECTION

Acid strength: 20 Baume Quantity: 1000 gal

Time - initial: Q: 909 gpm
- complete: 1 min 6 sec

B. DISPLACEMENT, 4,000-5,000 gallons nonchlorinated water

Time - initial/complete	Quantity (gal)	Q (gpm)
Not recorded	5000	

C. PUMPED TO WASTE

Time - initial: 2:15 pm (1/25/90)
- complete: 8:15 am (1/26/90)

Q: 608 gpm Quantity: 656,640 gal

5. SPECIFIC CAPACITY TEST DATE: 1/26/90

Time	Depth (ft)	Drawdown (ft)	Piez. tube (in.)	Pumping rate (gpm)	Remarks
8:15 am	29.08		25	608	PWL
NR	21.25	7.83			SWL

60 min. specific capacity: 77.7 gpm/ft

6. 600 LBS POLYPHOSPHATE APPLICATION DATE: 1/26/90

A. INITIAL CHLORINATION

Quantity: 2500 gal Strength: 500 mg/L (ppm)

Time - initial: NR Injection rate:
- complete: NR

B. POLYPHOSPHATE INJECTION, 600 lbs total

	Batch 1	Batch 2	Batch 3
Phosphate:	200 lbs	200 lbs	200 lbs
Quantity H_2O:	1800 gal	1800 gal	1800 gal
Time - initial:			
- complete:	47 sec	49 sec	47 sec
Injection rate:	2298 gpm	2204 gpm	2298 gpm

C. DISPLACEMENT, 30,000 gallons chlorinated water (500 mg/l)

Time - initial/complete	Quantity (gal)	Q (gpm)
1/26/90 - 75 min	30,000	-400

Comments: 15 injections of 2000 gallons each

D. PUMPED TO WASTE

Time - initial: 2:45 pm (1/26/90)
- complete: 7:35 am (1/27/90)

Q: 644 gpm Quantity: 650,440 gal

7. SPECIFIC CAPACITY TEST DATE: 1/27/90

Time	Depth (ft)	Drawdown (ft)	Piez. tube (in.)	Pumping rate (gpm)	Remarks
7:35 am	28.5		28	644	PWL
8:05 am	21.4	7.1			SWL

30 min. specific capacity: 90.7 gpm/ft

8. 600 LBS POLYPHOSPHATE APPLICATION (Additional N-1) DATE: 1/30/90

A. INITIAL CHLORINATION

Quantity: 2500 Strength: 500 mg/L (ppm)

Time - initial: NR Injection rate:
- complete: NR

B. POLYPHOSPHATE INJECTION, 600 lbs total

	Batch 1	Batch 2	Batch 3
Phosphate:	200 lbs	200 lbs	200 lbs
Quantity H_2O:	1800 gal	1800 gal	1800 gal
Time - initial:			
- complete:	39 sec	38 sec	NR
Injection rate:	2769 gpm	2842 gpm	

C. DISPLACEMENT, 54,000 gallons chlorinated water (500 mg/l)

Time - initial/complete	Quantity (gal)	Q (gpm)
1/30/90 - 2 hrs 15 min	54,000	400

Comments: 27 injections of 2000 gallons each

D. PUMPED TO WASTE

Time - initial: 1:00 pm (1/30/90)
- complete: 7:45 am (1/31/90)

Q: 626 gpm Quantity: 704,250 gal

9. SPECIFIC CAPACITY TEST DATE: 1/31/90

Time	Depth (ft)	Drawdown (ft)	Piez. tube (in.)	Pumping rate (gpm)	Remarks
7:45 am	27.50		26.5	626	PWL
NR	21.08	6.42			SWL

60 min. specific capacity: 97.5 gpm/ft

10. 400 LBS POLYPHOSPHATE APPLICATION (Additional N-2) DATE: 1/31/90

A. INITIAL CHLORINATION

Quantity: 2500 gal Strength: 500 mg/L (ppm)

Time - initial: NR Injection rate:
- complete: NR

B. POLYPHOSPHATE INJECTION, 400 lbs total

	Batch 1	Batch 2	Batch 3
Phosphate:	200 lbs	200 lbs	
Quantity H_2O:	1800 gal	1800 gal	
Time - initial:			
- complete:	54 sec	53 sec	
Injection rate:	2000 gpm	2038 gpm	

WELL REHABILITATION -- 25th St. Well 5 (Continued')

C. DISPLACEMENT, 16,000 gallons chlorinated water (500 mg/l)

Time - initial/complete	Quantity (gal)	Q (gpm)
1/31/90 - 40 min	16,000	400

Comments: 8 injections of 2000 gallons each

D. PUMPED TO WASTE

Time - initial: 12:30 pm (1/31/90)
- complete: 7:50 am (2/1/90)

Q: 644 gpm Quantity: 747,040 gal

11. SPECIFIC CAPACITY TEST DATE: 2/1/90

Time	Depth (ft)	Drawdown (ft)	Piez. tube (in.)	Pumping rate (gpm)	Remarks
7:50 am	27.58		28	644	PWL
8:20 am	21.25	6.33			SWL

30 min. specific capacity: 101.7 gpm/ft

WELL REHABILITATION FIELD NOTES

WELL SITE: Venice Well 2 OBSERVER: A1 Brown, IDOT

CONTRACTOR: Brotcke Engineering Company, Inc.

MEASURING POINT: Not recorded (NR)

MEASURING EQUIP.: Contractor's 6 x 5 inch orifice tube, electric dropline

1. SPECIFIC CAPACITY TEST DATE: 12/5/89

Time	Depth (ft)	Drawdown (ft)	Piez. tube (in.)	Pumping rate (gpm)	Remarks
9:22 am	25.11		3	225-230	Static water level (SWL)
10:22 am	37.21	12.10	3	225-230	Pumping water level (PWL)

Note: 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 gpm/ft

Comments: Pumping rate estimated

2. 400 LBS POLYPHOSPHATE APPLICATION DATE: 12/5/89

A. INITIAL CHLORINATION

Quantity: 3000 gal Strength: 500 mg/L (ppm)

Time - initial: 1:42/2000 gal Injection rate: 1175-1363 gpm
- complete: 0:44/1000 gal

B. POLYPHOSPHATE INJECTION, 400 lbs total

	Batch 1	Batch 2
Phosphate:	200 lbs	200 lbs
Quantity H_2O:	1800 gal	1800 gal
Time - initial:		
- complete:	1:21	1:12
Injection rate:	1333 gpm	1500 gpm

Comments: Well would not accept minimum rate of 2000 gpm

C. DISPLACEMENT, 16,000 gallons chlorinated water (500 mg/l)

Time - initial/complete	Quantity (gal)	Q (gpm)
11:20 am/12:12 am	16,000	2000 gal/6 min (-333 gpm)

Comments: 8 injections of 2000 gallons each

D. PUMPED TO WASTE

Time - initial: 2:30 pm (12/5/89)
- complete: 8:00 am (12/6/89)

Q: 372 gpm Quantity: 390,600 gal

3. SPECIFIC CAPACITY TEST DATE: 12/6/89

Time	Depth (ft)	Drawdown (ft)	Piez. tube (in.)	Pumping rate (gpm)	Remarks
7:55 am	34.92		9	372	
8:03 am	38.18		18	524	Broke suction
8:30 am	35.71		11.5	421	PWL
9:05 am	26.46	9.25			SWL

60 min. specific capacity: 45.5 gpm/ft

4. ACIDIZATION - INHIBITED MURIATIC ACID DATE: 12/6/89

A. ACID INJECTION

Acid strength: 20 Baume Quantity: 1000 gal

Time - initial: Q: 500 gpm
- complete: 2 min

B. DISPLACEMENT, 4,000-5,000 gallons nonchlorinated water

Time - initial/complete	Quantity (gal)	Q (gpm)
11:20 am/11:30 am	5000	

Comments: 2.5 injections of 2000 gallons each

C. PUMPED TO WASTE

Time - initial: 1:30 pm (12/6/89)
- complete: 8:30 am (12/7/89)

Q: 524 gpm Quantity: 597,360 gal

5. SPECIFIC CAPACITY TEST DATE: 12/7/89

Time	Depth (ft)	Drawdown (ft)	Piez. tube (in.)	Pumping rate (gpm)	Remarks
7:55 am	38.33		18	524	
8:10 am	37.67		16	495	PWL
8:15 am					Pump off
8:45 am	28.08	9.59			SWL

30 min. specific capacity: 51.6 gpm/ft

6. 600 LBS POLYPHOSPHATE APPLICATION DATE: 12/7/89

A. INITIAL CHLORINATION

Quantity: 2000 gal Strength: 500 mg/L (ppm)

Time - initial: NR Injection rate:
- complete: NR

B. POLYPHOSPHATE INJECTION, 600 lbs total

	Batch 1	Batch 2	Batch 3
Phosphate:	200 lbs	200 lbs	200 lbs
Quantity H_2O:	1800 gal	1800 gal	1800 gal
Time - initial:			
- complete:	47 sec	46 sec	44 sec
Injection rate:	2298 gpm	2348 gpm	2454 gpm

C. DISPLACEMENT, 30,000 gallons chlorinated water (500 mg/l)

Time - initial/complete	Quantity (gal)	Q (gpm)
9:40 am/11:10 am	30,000	2000/6 min (-333 gpm)

Comments: 15 injections of 2000 gallons each

D. PUMPED TO WASTE

Time - initial: 1:00 pm (12/7/89)
- complete: 8:30 am (12/8/89)

Q: 524 gpm Quantity: 613,080 gal

7. SPECIFIC CAPACITY TEST DATE: 12/8/89

Time	Depth (ft)	Drawdown (ft)	Piez. tube (in.)	Pumping rate (gpm)	Remarks
8:15 am	37.54		18	524	
8:30 am	37.50		17.5	517	PWL
9:00 am	28.33	9.17			SWL

30 min. specific capacity: 56.4 gpm/ft

8. 600 LBS POLYPHOSPHATE APPLICATION (Additional N-1) DATE: 12/8/89

A. INITIAL CHLORINATION

Quantity: 2500 gal Strength: 500 mg/L (ppm)

Time - initial: NR Injection rate:
- complete: NR

B. POLYPHOSPHATE INJECTION, 600 lbs total

	Batch 1	Batch 2	Batch 3
Phosphate:	200 lbs	200 lbs	200 lbs
Quantity H_2O:	1800 gal	1800 gal	1800 gal
Time - initial:			
- complete:	42 sec	44 sec	42 sec
Injection rate:	2571 gpm	2455 gpm	2571 gpm

C. DISPLACEMENT, 54,000 gallons chlorinated water (500 mg/l)

Time - initial/complete	Quantity (gal)	Q (gpm)
10:20 am/1:05 pm	54,000	2000/6 min

Comments: 27 injections of 2000 gallons each

D. PUMPED TO WASTE

Time - initial: 3:00 pm (12/8/89)
- complete: 8:00 am (12/9/89)

Q: 554 gpm Quantity: 565,080 gal

WELL REHABILITATION -- Venice Well 2 (Continued)

9. SPECIFIC CAPACITY TEST DATE: 12/11/89

Time	Depth (ft)	Drawdown (ft)	Piez. tube (in.)	Pumping rate (gpm)	Remarks
9:00 am	27.58				SWL
10:10 am	35.92	8.34	17	510	PWL

60 min. specific capacity: 61.2 gpm/ft

10. 400 LBS POLYPHOSPHATE APPLICATION (Additional N-2) DATE: 12/11/89

A. INITIAL CHLORINATION

Quantity: 2500 gal Strength: 500 mg/L (ppm)

Time - initial: NR Injection rate:
- complete: NR

B. POLYPHOSPHATE INJECTION, 400 lbs total

	Batch 1	Batch 2
Phosphate:	200 lbs	200 lbs
Quantity H_2O:	1800 gal	1800 gal
Time - initial:		
- complete:	55 sec	46 sec
Injection rate:	1963 gpm	2348 gpm

C. DISPLACEMENT, 16,000 gallons chlorinated water (500 mg/l)

Time - initial/complete	Quantity (gal)	Q (gpm)
11:20/12:08	16,000	2000/6 min (-333 gpm)

Comments: 8 injections of 2000 gallons each

D. PUMPED TO WASTE

Time - initial: 2:30 pm (12/11/89)
- complete: 8:43 am (12/12/89)

Q: 524 gpm Quantity: 572,732 gal

11. SPECIFIC CAPACITY TEST DATE: 12/12/89

Time	Depth (ft)	Drawdown (ft)	Piez. tube (in.)	Pumping rate (gpm)	Remarks
8:43 am	36.18			524	PWL
9:13 am	28.67	7.51			SWL

30 min. specific capacity: 69.8 gpm/ft

12. 400 LBS POLYPHOSPHATE APPLICATION (Additional N-2A) DATE: 12/12/89

A. INITIAL CHLORINATION

Quantity: 2500 gal Strength: 500 mg/L (ppm)

Time - initial: NR Injection rate:
- complete: NR

B. POLYPHOSPHATE INJECTION, 400 lbs total

	Batch 1	Batch 2
Phosphate:	200 lbs	200 lbs
Quantity H_2O:	1800 gal	1800 gal
Time - initial:		
- complete:	44 sec	44 sec
Injection rate:	2455 gpm	2455 gpm

C. DISPLACEMENT, 16,000 gallons chlorinated water (500 mg/l)

Time - initial/complete	Quantity (gal)	Q (gpm)
48 min	16,000	2000/6 min (-333 gpm)

Comments: 8 injections of 2000 gallons each

D. PUMPED TO WASTE

Time - initial: 3:00 pm (12/12/89)
- complete: 8:00 am (12/13/89)

Q: 800 gpm Quantity: 816,000 gal

WELL REHABILITATION -- Venice Well 2 (Continued')

13. SPECIFIC CAPACITY TEST DATE: 12/13/89

Time	Depth (ft)	Drawdown (ft)	Piez. tube (in.)	Pumping rate (gpm)	Remarks
8:00 am	42.08		42	800	
8:30 am	29.54		16	495	SWL
9:30 am	36.58	7.04	16	495	PWL

60 min. specific capacity: 70.3 gpm/ft

WELL REHABILITATION FIELD NOTES

WELL SITE: Venice Well 5 OBSERVER: A1 Brown, IDOT

CONTRACTOR: Brotcke Engineering Company, Inc.

MEASURING POINT: Not recorded (NR)

MEASURING EQUIP.: Contractor's 6 x 5 inch orifice tube, electric dropline

1. SPECIFIC CAPACITY TEST DATE: 1/2/90

Time	Depth (ft)	Drawdown (ft)	Piez. tube (in.)	Pumping rate (gpm)	Remarks
10:45 am	23.0				Static water level (SWL)
			41.5	795	Breaking suction
11:45 am	37.67	14.67	28.5	650	Pumping water level (PWL)

Note: 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: 44.3 gpm/ft

2. 400 LBS POLYPHOSPHATE APPLICATION DATE: 1/2/90

A. INITIAL CHL0RINATI0N

Quantity: 2500 gal Strength: 500 mg/L (ppm)

Time - initial: NR Injection rate:
- complete: NR

B. POLYPHOSPHATE INJECTION, 400 lbs total

	Batch 1	Batch 2
Phosphate:	200 lbs	200 lbs
Quantity H_2O:	1800 gal	1800 gal
Time - initial:		
- complete:	40 sec	39 sec
Injection rate:	2700 gpm	2769 gpm

C. DISPLACEMENT, 16,000 gallons chlorinated water (500 mg/l)

Time - initial/complete	Quantity (gal)	Q (gpm)
1:13 pm/l:38 pm	12,500*	2000 gal/4 min (-500 gpm)

Comments: *Vault filled with water. Well would not accept more water.

D. PUMPED TO WASTE

Time - initial: 3:40 pm (1/2/90)
- complete: 8:00 am (1/3/90)

Q: 650 gpm Quantity: 637,000 gal

3. SPECIFIC CAPACITY TEST DATE: 1/3/90

Time	Depth (ft)	Drawdown (ft)	Piez. tube (in.)	Pumping rate (gpm)	Remarks
8:00 am	35.75		28.5	650	PWL
8:30 am	24.33	11.42			SWL

30 min. specific capacity: 56.9 gpm/ft

4. ACIDIZATION - INHIBITED MURIATIC ACID DATE: 1/3/90

A. ACID INJECTION

Acid strength: 20 Baume Quantity: 1000 gal

Time - initial: Q: 1277 gpm
- complete: 47 sec

B. DISPLACEMENT, 4,000-5,000 gallons nonchlorinated water

Time - initial/complete	Quantity (gal)	Q (gpm)
Not recorded	5000	

Comments: 2.5 injections of 2000 gallons each

C. PUMPED TO WASTE

Time - initial: 1:20 pm (1/3/90)
- complete: 8:30 am (1/4/90)

Q: 759 gpm Quantity: 872,850 gal

5. SPECIFIC CAPACITY TEST DATE: 1/4/90

Time	Depth (ft)	Drawdown (ft)	Piez. tube (in.)	Pumping rate (gpm)	Remarks
8:28 am	36.83		29.5	662	PWL
9:00 am	25.00	11.83			SWL

30 min. specific capacity: 56.0 gpm/ft

6. 600 LBS POLYPHOSPHATE APPLICATION DATE: 1/4/90

A. INITIAL CHLORINATION

Quantity: 2500 gal Strength: 500 mg/L (ppm)

Time - initial: NR Injection rate:
- complete: NR

B. POLYPHOSPHATE INJECTION, 600 lbs total

	Batch 1	Batch 2	Batch 3
Phosphate:	200 lbs	200 lbs	200 lbs
Quantity H_2O:	1800 gal	1800 gal	1800 gal
Time - initial:			
- complete:	45 sec	41 sec	43 sec
Injection rate:	2400 gpm	2634 gpm	2512 gpm

C. DISPLACEMENT, 30,000 gallons chlorinated water (500 mg/l)

Time - initial/complete	Quantity (gal)	Q (gpm)
9:23 am/10:25 am	31,000	2000/4 min (-500 gpm)

Comments: 15.5 injections of 2000 gallons each

D. PUMPED TO WASTE

Time - initial: 12:45 pm (1/4/90)
- complete: 8:15 am (1/5/90)

Q: 720 gpm Quantity: 864,000 gal

7. SPECIFIC CAPACITY TEST DATE: 1/5/90

Time	Depth (ft)	Drawdown (ft)	Piez. tube (in.)	Pumping rate (gpm)	Remarks
8:10 am	37.17		34.5	720	PWL
8:50 am	25.08	12.09			SWL

30 min. specific capacity: 59.6 gpm/ft

WELL REHABILITATION -- Venice Well 5 (Continued')

8. 600 LBS POLYPHOSPHATE APPLICATION (Additional N-1) DATE: 1/5/90

A. INITIAL CHLORINATION

Quantity: 2500 gal   Strength: 500 mg/L (ppm)

Time - initial: NR   Injection rate:
- complete: NR

B. POLYPHOSPHATE INJECTION, 600 lbs total

	Batch 1	Batch 2	Batch 3
Phosphate:	200 lbs	200 lbs	200 lbs
Quantity H_2O:	1800 gal	1800 gal	1800 gal
Time - initial:			
- complete:	42 sec	42 sec	42 sec
Injection rate:	2571 gpm	2571 gpm	2571 gpm

C. DISPLACEMENT, 54,000 gallons chlorinated water (500 mg/l)

Time - initial/complete	Quantity (gal)	Q (gpm)
9:23 am/11:15 am	56,000	2000/4 min (-500 gpm)

Comments: 28 injections of 2000 gallons each

D. PUMPED TO WASTE

Time - initial: 1:45 pm (1/5/90)
- complete: 8:10 am (1/9/90)

Q: 709 gpm   Quantity: 3,846,325 gal

9. SPECIFIC CAPACITY TEST DATE: 1/9/90

Time	Depth (ft)	Drawdown (ft)	Piez. tube (in.)	Pumping rate (gpm)	Remarks
8:10 am	36.79		33.5	709	PWL
8:40 am	25.54	11.25			SWL

30 min. specific capacity: 63.0 gpm/ft

Comments: No additional treatments

Appendix E.

Review of Pre- and Post-Treatment Underwater Video Inspections

Appendix E. Review of Well Pre- and Post-Treatment Underwater Video Inspections

During the chemical treatment work, the contractor, Brotcke Engineering Company, Inc., arranged for the wells to be inspected with underwater video equipment. The first inspections on January 23, 1990, were conducted after the treatment work had been completed on Venice Wells 2 and 5 but prior to the treatment work on the other three wells. Additional inspections on March 1, 1990, were conducted on these three wells after treatment work had been completed.

I-70 Well 3 Pretreatment, January 23, 1990

Depth (ft)	Comments
18	Static water level
33	Top of well screen - dirty, encrusted appearance
38	Still encrusted
40	Well screen becomes much cleaner
45	Becoming somewhat encrusted again
47.5	Well screen clean but becomes encrusted again a short distance below
57	Screen not as dirty
65	" " "
70	" " "
71.5	Very little encrustation
76.5	" " "
80	Very clean section of screen
81	" " "
85	Small amount of encrustation
89	Bottom, retrieve camera

I-70 Well 3 Post-Treatment, March 1, 1990

Depth (ft)	Comments
20	In water
33	Top of well screen - clean
40	Well screen clean
45	" " "
50	" " "
55	" " "
60	" " "
65	" " "
70	" " "
75	" " "
80	" " "
85	" " "
90	Bottom - clean, retrieve camera

25th Street Well 2 Pretreatment, January 23, 1990

Depth (ft)	Comments
5.5	Static water level - water cloudy
10	Cloudy water
15	" "
20	" "
25	Water not quite as cloudy
31	Top of well shutter screen - encrusted heavily; material can be seen hanging on screen
35	Still encrusted heavily - murky, reddish colored water darkens picture
44	Water still murky with encrustation visible on screen
50	Water clearing up - encrustation not nearly as bad
45	Brought camera back up to identify zone of heaviest encrustation
41	Encrustation appears very heavy here
50.5	At screen joint; some shiny areas on screen
55.5	" " " "
60	At screen joint. Little change, some areas of encrustation visible on screen
65	" " " "
70	Encrustation slightly heavier
75	About the same as at 70 ft
79	" " "
81	" " "
84	Encrustation not quite as bad
87.5	Bottom, retrieve camera

25th Street Well 2 Post-Treatment, March 1, 1990

Depth (ft)	Comments
6	Static Water Level
31	Top of well screen
35	Some patches of red encrustation on screen
40	Well screen clean
45	" " "
50	Water contains a small patch of suspended light floc material
55	Some floc still suspended in water
60	Floc is somewhat heavier
65	Less floc suspended in water
70	About the same as at 65 ft
75	Floc suspension is light
80	" " "
85	" " "
88	Bottom, retrieve camera

Note: Using a jar strapped to the camera light so that it was in view, we attempted to collect a sample of the floc from the well. The camera was lowered into the zone with the floc and retrieved until some had collected in the jar. The camera was retrieved and the jar capped with the floc inside. The material appears to be light or fluffy and probably organic in nature.

25th Street Well 5 Pretreatment, January 23, 1990

Depth (ft)	Comments
7	Static water level
27	Top of screen - encrustation evident
30	Well screen encrusted
32	" " "
34	" " "
35	Encrustation beginning to diminish
37	Encrustation not as heavy as in upper screen sections
39	Encrustation even lighter
46	Bottom of pump motor - some encrustation present
48	Light encrustation
50	" "
55	Some encrustation evident
60	" " "
65	" " "
70	" " "
75	Encrustation becomming heavier
80	" " "
84	Bottom - encrustation heavy, retrieve camera

25th Street Well 5 Post-Treatment, March 1, 1990

Depth (ft)	Comments
8	Static water level - a light floc substance is suspended in the water limiting visibility
27.5	Top of well screen - good picture of floc and screen
30	Less floc, screen appears to be clean
45	Floe embedded or settled into screen louvers
55	Good picture of floc in suspension and on screen
64	Picture becomes dark below this depth because of floc - shaking camera as chunks of floc get caught on lens
75	Mostly dark because of floe chunks
80	" " "
85	Very dense floc - picture mostly dark
85.5	Bottom - retrieve camera

Venice Well 2 Post-Treatment, January 23, 1990

Depth (ft)	Comments
20	Static water level - water cloudy
25	Cloudy water
30	In screen - water much clearer, screen is wire wrapped
28.5	Moved camera back up to top of screen - water cloudy at this spot
35	What appear to be stains are on screen - some fine floc material in water
38.5	At screen joint - floc material heavier
40	Screen is clean
45	Some floc attached to screen
55	Floc not quite as heavy
58	Screen joint - some floc around joint
60	Floc is light
75	Nearly totally clear, little floc
75.5	Bottom, retrieve camera
40	While viewing during the camera retrieve, it is apparent that the floc is heaviest in this area

Venice Well 5 Post-Treatment, January 23, 1990

Depth (ft)	Comments
15	Static water level
20	Top of wire-wrapped well screen - very clean - water a little cloudy in the upper 5 ft or so of well screen
30	At screen joint - screen very clean
35	" " " "
40	Screen is clean - it appears that some very fine suspended floc is forming
44	About the same as at 40 ft
49	Screen joint - screen is very clean; a very small patch of something is on screen
58	Stain on screen - extends down for several feet - doesn't look like encrustation
60	Stains still present
65	Stains more prevalent
66	Near bottom, can see some encrustation or floc on bottom 5 ft or so of screen
67	At bottom, retrieve camera

Appendix F.

Sieve Analysis Data
Related to Venice Well 1

Appendix F. Sieve Results Related to Venice Well 1
(cumulative percent retained)

	Boring P1			Venice Well 1	
U.S. Sieve	*Sample 8 @ 41 ft*	*Sample 12 @ 61 ft*	*Sample 13 @ 66 ft*	*Pumped Sand*	*Gravel Pack*
3/8					0
4					9
8					50
10				0.4	71
18				1.9	
20					93
25				3.9	
35				15.4	
40	0			26.0	98
45				51.8	
50	8			69.8	
60				81.0	
70	25		0		
80	50	3	3	95.2	
100	75	8	9		
120				98.2	
140	84	19	28		
200	86	23	40		
230				99.6	
Pan					

Notes: Boring P1 and Gravel Pack data from Johnson, Depp, and Quisenberry, 1980.
Boring P1 located 30 ft from Venice Well 1.
Percent retained for boring B1 samples approximate; values are from plotted curves as raw sieve data are not available.