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REPORTS

DATE:

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PROGRESS REPORT ON
FLORA VISTA CONTAMINATION
STUDY
JANUARY 1986

A Report to the Flora Vista
Water Users Association
Flora Vista, New Mexico

Prepared by David G. Boyer
Hydrogeologist

Environmental Bureau
New Mexico Oil Conservation Division

Paul L. Biderman
Secretary, Energy and Minerals
Department

R. L. Stamets, Director
Oil Conservation Division

STATE OF NEW MEXICO
ENERGY AND MINERALS DEPARTMENT
OIL CONSERVATION DIVISION

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SANTA FE, NEW MEXICO 87501
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January 31, 1986

Mr. Bert Barnes, President
Flora Vista Water Users
Association
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Flora Vista, NM 87415

Mr. Richard P. Cheney,
Vice President
Lawrence A. Brewer &
Associates, Inc.
P.O. Box 2079
Farmington, NM 87401

Gentlemen:

The New Mexico Oil Conservation Division (OCD) has completed a report on the activities through January, 1986, of this Division and the Environmental Improvement Division (EID) regarding the contamination investigation of Flora Vista Water Well No. 1 (S1). This well, which was contaminated by oil and grease in early 1983, has been out of service since that date. OCD activities in 1985 included installation of five monitoring wells, sampling of water quality from these wells and other ground water at this location, and measurement of water levels to determine ground water direction and rate of flow. EID supplied material and staff to assist in well installation.

The OCD report is enclosed with this letter but its major conclusions and recommendations for further study are summarized below:

1) No verifiable contamination was detected in 1985 in either the unused water supply wells or the monitor wells except for low level contamination detected in samples taken within 24 hours of cleaning the well with an air compressor. The latest sampling for which results are available (October 1985) did not detect hydrocarbons either in the monitor wells or in a composite of the water wells currently supplying the system.

2) Methane at concentrations 1200 times ambient levels was detected in the monitor well closest to the gas well in August. The source is likely the decay of

shallow buried organic material. The gas well itself is not a likely source of methane since it has 227 feet of surface casing cemented back to the surface.

3) Ground water movement in the vicinity of the monitor wells in fall 1985 - winter 1986 was towards the river and away from the currently used water supply wells. The flow has a seepage velocity range of 3 to 4 feet per day.

4) Based on the available information, the produced water tank at the Manana Mary Wheeler 1E gas well, the gas well itself, and the dehydrator pit are all likely to have been within the zone of influence ("cone of depression") of the pumping S1 well at the time the water well was contaminated in February 1983. Actual pumping rates and pumping cycle information at the time of contamination would better define the extent of pumping well influence.

5) The estimate of travel time for unretarded soluble contaminants to have moved from the vicinity of the gas well to the pumping water well is approximately 100 days.

6) The rate of ground water movement is such that a single plume of contaminated produced water originating in the vicinity of the gas well in 1983 has now moved beyond the water well.

7) Because of the passage of time, water pumped from well S1 would not show contamination unless a zone of residual oil saturation is present at or near the produced water tank or other facilities.

8) To determine the presence and concentrations of any residual oil between the site of the leaky pit and well S1, exploration digging with the backhoe is recommended, followed by sampling. If oil is found, capture of soluble constituents is again a possibility and well No. 1 (S1) may again evidence contamination if pumped continually.

9) The OCD intends to measure water levels and sample water quality of the monitor wells and other available wells through at least the fall of 1986.

10) Well S5 should be capped to prevent introduction of contaminants. However, both wells S1 and S5 should have caps that allow for access for periodic water level measurements, water quality sampling, and pumping if necessary.

11) An aquifer test using well S1 as the pumped well should be performed for at least 72 hours at a rate of 60 gpm or at the rate the well would be pumped if put back in service. This test would determine accurate aquifer parameters and detect any contamination in the immediate vicinity of the well.

12) Since well S5 is at a distance greater than 500 feet from the gas well and out of the direct path of ground water flow, it is unlikely that pumping S5 will cause capture of any remaining contaminants from the gas well. To test this assumption, additional flow calculations should be made before placing back in service.

13) Sampling of individual pumping water supply wells for purgeable aromatic hydrocarbons should be performed on a regular basis. For convenience, a sampling schedule identical to that required for total trihalomethanes is initially suggested.

The OCD would like to schedule a 72-hour aquifer test in March using well S1. Since we do not have a pump or a water flow measuring device, any assistance the Association could provide would be appreciated. A flow device could either be a calibrated in-line meter, orifice weir, or other accurate device. The pump should have a valve to control discharge so that a constant rate is maintained. Also, a pipe or hose will be needed to divert the water away from the monitor wells to prevent recharge. If these items can be obtained, the test can be performed.

The attached report and the proposed work represent a substantial commitment of time and effort by the three-person staff of the OCD Environmental Bureau. I hope that the information we have provided, and that which we will provide over the next eleven months, will be useful in any action you take to resolve the matter.

If you have any questions regarding this letter or the report, please contact me at 827-5812.

Sincerely,

David G. Boyer

DAVID G. BOYER,
Hydrogeologist
Environmental Bureau Chief

DGB/dp

Enc.

cc: Paul Biderman, Secretary EMD
R. L. Stamets, Director OCD
NM OCD, Aztec District Office
NM EID Water Supply Section
NM EID Ground Water/Hazardous Waste Bureau
NM EID, Farmington Field Office

PROGRESS REPORT ON
FLORA VISTA CONTAMINATION
STUDY - JANUARY, 1986

Introduction

This report was prepared by the New Mexico Oil Conservation Division to summarize the work performed to date at the Flora Vista well field, to review the results of water quality sampling and hydrologic mesurements, to present preliminary conclusions based on this work, and to make recommendations for future testing. The assistance of the staff of the Flora Vista Water Users Association, Lawrence A. Brewer & Associates, and the Environmental Improvement Division in providing data, reports, support equipment, and services is gratefully aknowledged.

Background

The Flora Vista Water Users Association operates an approved community water system for the Flora Vista area located approximately halfway between Farmington and Aztec on U S highway 550. In 1983 the system served approximately 1500 residents and small businesses through 431 connections. Maximum system delivery, as reported in New Mexico Environmental Improvement Division (EID) community water supply system inspection reports, was reported at 170,000 gallons per day (gpd) with average delivery in 1983 of about 100,000 gpd. The system was placed in service in 1981 with two wells each with pump capacities of 60-70 gallons per minute (gpm).

In January, 1980, a gas well owned by Manana Gas, Inc. of Albuquerque was drilled in unit M (SW/4 SW/4) of Section 23, Township 30 North, Range 12 West. The well, Mary Wheeler No. 1-E, was placed in service in July, 1980, with the natural gas being received by El Paso Natural Gas via a pipeline at the site.

Manana facilities at the site include the well, an oil-water separator, a fiberglass tank (capacity approximately 120 barrels) holding produced water and some oil from the separator, an oil tank for storing oil produced with the gas and a tank drain pit for discharging water separated from the oil (now replaced with a small fiberglass tank). A reserve (mud pit) and a blowdown pit were both likely present at one time but have been covered over. The original fiberglass tank was replaced with a second identical tank in early 1983 due to discovery of a leak. El Paso Natural Gas facilities include a gas dehydrator, a dehydrator pit with a 55 gallon drum serving as a collector, and a gas meter house.

The entire site occupies an area of approximately 220 x 75 feet and is located northeast of water supply well S1. Distances from the water well to the fiberglass produced water tank, gas well, and dehydrator pit are 235 feet, 255 feet, and 285 feet, respectively. Figure 1 shows the relationship of the various oil and gas facilities to the water wells.

In 1982, OCD records show production of 39,584 million cubic feet of natural gas and 1022 barrels of oil. Water production is estimated by the company (1985) at approximately 210 gallons per day or about 76.6 thousand gallons per year. All produced water collected is removed from the site.

In February, 1983, at least one well, S1, became contaminated with oil and grease and was taken out of service. The level of contamination was reported in Association records as 16 mg/l. To avoid further contamination, the system was shut down and water was purchased from the City of Aztec and delivered via an existing pipeline. At that time, the Association dug a pit between S1 and the gas well and detected a noticeable odor and an oily film. Between February and August, 1983, additional backhoe pits were dug and sampled for oil and grease. In August, the OCD sampled the water well S1, the Manana separator, the El Paso dehydrator, and a previously dug pit. Oil and grease levels reported ranged from 32 to 38 mg/l except for the dehydrator which was not reported. However, the dehydrator was reported to have 13 mg/l of both benzene and toluene.

In the summer of 1984, the EID attempted to drill monitoring wells in the area for the purposes of determining the contamination sources and the risk to the other supply wells. However, the hollow-stem auger drill rig was not able to penetrate the large boulders in the shallow subsurface and the attempt was discontinued.

Investigation in 1985

The following is a summary of work performed in 1985:

1) Five monitoring wells were placed around the original contaminated well in late March by OCD and EID staff. Due to large boulders in the shallow subsurface, the wells were installed with a backhoe provided by the water users association. The wells are 2-inch diameter steel casing, with a 48-inch long Johnson wire-wound stainless steel screen having a slot size of 0.07 inches. This slot size is too large for effective sand control, but it was the only screen available for immediate use. The wells and casing were provided by EID. Gravel packing was tried for the first well, but the large pit size and rapid slumping of the hole precluded further gravel use. The lack of a gravel envelope made the wells subject to rapid silting. Total depths of the wells range from 7 to 10.8 feet from the casing top. The wells extend about 20 inches above the land surface and are cemented at the surface.

2) Samples were taken from the water supply and monitor wells for organic analyses in March, June, August, September, and October, 1985; and again in January, 1986. The 1985 results are shown in Tables 1 and 2. Results from the Mary Wheeler No. 1E gas well are shown in Table 3. Inorganic analyses were run on the water supply wells (including the previously contaminated well) and the Animas River in March.

3) As expected, several monitor wells filled with sand and were cleaned twice using compressed air from two different compressors. The use of these compressors apparently affected the water quality as discussed below.

4) In September all monitor and supply wells were surveyed by Brewer and Associates for both location and elevation. Several well elevations were resurveyed in October. Blueprints from recent aerial photos were received in late December. Water levels were measured in September and October 1985, and January, 1986. This information allows ground water elevations to be directly compared, and estabishes the hydraulic gradient, direction of ground water flow, and flow velocity. These calculations and the resultant conclusions and interpretations are presented below.

Hydrogeology

The valley of the Animas River contains alluvium consisting mainly of sand and gravel which is outwash material from Pleistocene glaciers in the San Juan Mountains in Colorado. In the vicinity of the Flora Vista wells this alluvium is about 25 feet thick. Examination of the aerial photograph blueprints provided by Brewer & Associates shows old river channels and meanders in the flood plain. Finer grained silts and clays can be expected to have been deposited in low velocity areas such as point bars and areas of overbank flooding. However, the area where the monitor wells were drilled was found to be a zone of very coarse sand and gravel with some rocks exceeding a foot in diameter.

The presence of a coarse sand and gravel zone usually indicates high ground water permeability. Examination of the pumping level estimates provided in the 1982 EID community water system environmental survey, together with a 1982 Brewer and Associates infiltration gallery feasibility study shows an aquifer permeability of about 750 gallons per day per square foot, or 100 feet per day. This value is at the lower end of the range for clean sand and gravel mixtures, but still allows for rapid ground water movement.

In September and October, 1985, ground water levels were measured in those monitoring wells where fluid levels were present. The results were used to calculate the direction of ground water flow and the hydraulic gradient. The gradient values were 0.0080 and 0.0105, respectively, or about 42 and 55 feet per mile. These values are intermediate between the average river gradient at Flora Vista of 0.004 and the topographic gradient of 0.014 perpendicular to the river at the well field location. The January, 1986, water levels, measured after hand-augering sand out of holes, showed a gradient of 0.0097, or about 51 feet per mile.

The ground water flow directions in September and October are shown on Figures 1 and 2. The direction on September 20 is slightly east of south. On October 25 the direction had changed to nearly 25° east of south. The January 17 direction (Figure 3) is intermediate between the autumn directions. As shown in the figures, the direction of ground water flow on all sampling dates was towards the river. In the fall and early winter of 1985, ground water flow in the vicinity of the Manana Mary Wheeler 1E Well moves in the direction of the river and not towards any of the water supply wells or monitor wells.

Based on these water level measurements and some assumptions about surface and ground water interaction in the area, Figure 4 showing estimated fall-winter ground water flow directions was prepared. The assumptions used are:

1) River flows are generally low in fall and winter months;

2) Water stored in the permeable alluvial material in the immediate vicinity of the river during times of spring and summer high flows is discharged back into the river at low flow;

3) Additional ground water discharge to the river comes from sources to the northwest of the well field including ground water recharged to the alluvium from the Flora Vista Arroyo, the Halford Independent Ditch, the Farmers Ditch, irrigation seepage, recharge due to septic tank discharges, and any runoff from precipitation events.

Figure 5 shows a possible flow regimen for spring-summer ground water movement taking into account higher river runoff levels. Spring and summer measurements will be taken in 1986 to better define flow during these months.

In February, 1983, with river water levels quite low (Table 4), water supply well No. 1 (S1) was contaminated by hydrocarbons. One suspected source was a leaky fiberglass tank containing produced water from the Mary Wheeler No. 1E gas well. The tank is located approximately 230 feet to the northeast of well S1. If the direction of ground water flow at this time was towards the river, other factors must have been operating for this to be the contaminant source. Using the available hydrologic data and the EID's January, 1983, report of estimated water use, drawdown calculations were made (Table 5) using the Theis non-equilibrium well formula. The calculations were made assuming 100,000 gallons per day pumped from two wells with a daily average of Q =35 gpm/well. The results show a drawdown of 0.1 foot at the tank after only two days of pumping at the above rate. Though small, this value is enough to cause movement of water towards the well. After 100 days of pumping, the calculated drawdown is 1.1 feet at the tank location.

Since this well (S1) is only 250 feet from the river, it is reasonable to expect that river water is recharging a portion of the water removed from the aquifer by the well. However, calculations assuming steady state flow show that the zone of capture only extends 63 feet down gradient for an average daily pumping rate of 35 gpm. This is because more water up gradient is captured, and the resultant asymmetrical cone of depression (zone of influence) does not extend as far down gradient in the direction of the flow (Figure 6). Since the well was reported to have pumped at a maximum of 60 to 70 gpm, a down gradient capture distance of 117 feet was calculated for Q = 65 gpm.

Because the pump was cycled on and off, the stress on the aquifer would fluctuate. If the pump was on more than 50% of the time, the parabolic envelope shown in Figure 6 would approach that of the Q = 65 gpm curve. These capture curves were drawn assuming the flow direction in early 1983 was the same as January 1986; other variables that could change curve shape include non-homogenuous sediments, variations in permeability, non-equilibrium (vs. steady-state) flow, and the pumping cycles.

If there is a drawdown of water under the produced water tank due to well S1, this would allow capture by the well of water under the tank. Calculations for a drawdown of 1.1 feet after 100 days of pumping (average Q = 35 gpm) and taking into account changes in flow velocity near the well show that travel times for water movement from the tank location to the well would range between 96 and 103 days. These times do not take into account constant pumping at a higher rate or any mechanisms of attenuation such as contaminant retardation due to sorption, or biochemical transformation. More sophisticated techniques can produce more exact estimates of both flow and solute transport rates if actual pumping rates, pumping cycles, and measured aquifer parameters at well S1 were known.

Under non-pumping conditions, ground water movement will be determined by the local hydraulic gradients, and the rates of movement can be calculated as shown in Table 5. Using an average gradient of 0.009, for fall 1985 - winter 1986 and a porosity of 0.25, an approximate horizontal seepage velocity of 3.7 feet per day, or 1350 feet per year, was calculated. This shows rapid particle movement under natural conditions for that season. If these rates prevail all year, and the contaminant source was a one-time release of produced water with only a small oil phase, movement would be out of the zone of influence of the well after only one year. In addition dilution with other water and other mechanisms would be expected to attenuate a single incident plume. Again, more sophisticated techniques using computers can produce a ground water model of plume movement and dispersion.

If a large oil phase was discharged, the presence of residual oil in the soil together with seasonal water level changes could cause continued leaching of soluble oil constituents into ground water. If present, these contaminants could again reach the well if it was put back into service.

Water Quality

The inorganic chemistry analyses of the water supply wells sampled show generally very good water quality. For three samples from two wells and a composite of two others, total dissolved solids average 403 mg/l, chlorides average 17 mg/l and sulfates average 189 mg/l. A sample of Animas River water had concentrations of 368 mg/l, 12.5 mg/l and 116.3 mg/l for the same constituents. Only manganese with an average of 0.37 mg/l is elevated above acceptable levels. Manganese is naturally occurring in salt and minerals and the New Mexico Ground Water Standard is 0.2 mg/l. The effects of slightly elevated levels are generally limited to unpleasant taste and plumbing fixture staining.

A sampling program for organic chemicals in the affected water supply wells, monitor wells, and operating supply wells was begun by the OCD in March, 1985. Subsequent testing was performed in June, August, September, and October; and January, 1986. The results (except for the most recent sampling) are shown in Tables 1 to 3.

The wells were sampled for aromatic hydrocarbons which have been found to be present in water and fluids produced concurrently with oil and gas. Once dissolved in water, these contaminants migrate with the ground water in the subsurface. At a point of use, such as a well, the hydrocarbons can be present in the water even though a separate oil phase may not be detected. Samples for aromatic hydrocarbon testing require only a small 40 ml volume of water, and no special treatment or preservation except chilling needs to be performed prior to analysis. In addition to aromatic hydrocarbons, tests for methane gas and halogenated hydrocarbons can be performed on the same sample. Prior to sampling, the monitor wells were "purged" by use of a clean bailer to obtain fresh samples.

Results for three samplings of the water supply well originally shut down (S1) show a small amount (6 ppb) of toluene detected in the June sampling. The newly adopted New Mexico Ground Water Standard is 750 ppb, down from 15,000 ppb. The compound was detected only once and a sampling error cannot be ruled out. The well, which had remained open since the pump was removed, now has a plate welded over the top and is inaccessible for sampling.

Benzene, a known human carcinogen, was not detected in well S1 or in any other well in any sampling. Also, no separate oil phase was found in any of the wells during any of the samplings.

Sampling of the other unused well (S5) detected no contamination until September when it was pumped by introduction of air to displace several well volumes to acquire a "fresh" sample. Samples taken that day and the following day from S5 had low levels of toluene and several other aromatic hydrocarbons. These levels were many times lower than either New Mexico or newly proposed EPA recommended levels.

After examination of these and other September results showing low levels of contamination, the air compressor was tested and found to have lubrication or combustion pollutants in the air line. The air line is thought to be the major source for the pollutants detected in wells S5, M1, M2, M3, and M5 for the September sampling . However, well M4, which could not be reached by the air line in September, also showed a slight, but detectable level of toluene. Well S5 was resampled in October and trace levels less than 1 ppb were found for several aromatic hydrocarbons, not including benzene. Well M4 was dry at the time of the October sampling and no hydrocarbons were detected in the other wells.

Three samples representing a composite of the pumping wells were taken from the pump house tap in March, August, and October, 1985, and January, 1986. No contaminants were detected except for a very small volume of chloroform. Chloroform might have been present as a result of chlorination which occurs immediately adjacent to, but downpipe from the pump house tap.

In March, 1985, water samples were taken from the backhoe-dug pits prior to monitor well installation. An oily sheen appeared on the water in the pits. Examination of the backhoe bucket determined that hydraulic fluid was leaking from either a fitting or a cylinder and dripping into the pit. Samples of the pit water taken that day showed no contamination. Later, a sample of water mixed with hydraulic fluid showed a dissolved toluene concentration of 1700 ppb in the water.

Sampling of the monitor wells was complicated by fine sand that entered the well as a result of the large screen size and lack of a gravel pack. Also, water levels in the monitor wells dropped between 4.6 and 7.6 inches from September to October. Wells M1, M2, and M4 were dry for one or more of the samplings.

On June 27, cleaning of all monitor wells was attempted using a small air compressor like that used for spray painting. Sampling done the following day detected low or trace levels of hydrocarbons in three of the five wells. At that time the use of air from a compressor to clean out shallow monitoring wells was thought by both OCD and EID to be a practical solution. Although EID had used this small compressor previously and not detected contamination, its air line was never tested for hydrocarbons, and the compressor is no longer available for testing. Therefore, the small compressor as a source for those contaminants detected in the June sampling cannot be ruled out.

As previously mentioned, the compressor used in September to pump well S5 and to clean the monitor wells was known to have introduced low levels of contaminants. Therefore, it cannot be determined whether hydrocarbons were in the wells in September prior to the introduction of air. For the August and October samplings, no contamination was detected in any of the monitor wells having water. Since the range of seepage velocities was from 3 to 4 feet per day, low level contamination from the compressors would have been diluted and quickly moved beyond the capture radius of the monitor wells.

Prior to the January, 1986 sampling, all monitor wells were cleaned by use of a homemade PVC hand auger that effectively removed all but a small volume of sand. January test results are not yet available.

Tests for dissolved methane gas were made on samples collected on several dates. Monitor wells 3 and 5 had elevated levels of the gas in August but not in October. M5, the monitor well nearest the gas well, had the largest volume of gas and also was located in an area where dark black soil was present. Soil sampling did not show oil present at detectable levels. The source of the gas may be natural material since the area is swampy, or it may be from shallow buried organic material deposited in the reserve pit during drilling and/or testing. Produced water containing small amounts of oil previously discharged from the leaky tank may also be the source. The gas well itself is not suspected because the surface casing extends to a depth of 227 feet and is cemented back to the surface.

Produced water from the Manana Oil Mary Wheeler 1E gas well was collected from the fiberglass tank at the separator in September and October. Benzene values were 8,700 and 16,000 ppb and other aromatic hydrocarbons exceeded 1,000 ppb except for ethylbenzene. Total dissolved solids exceeded 34,000 mg/l (ppm) with chlorides about 20,000 mg/l.

In summary, the March, August, and October 1985 samplings detected no dissolved aromatic hydrocarbons in the monitor wells. With one exception, when such hydrocarbons were detected in the June and September samplings, air compressors had been used to clean the wells the previous day. Well M4, cleaned with a compressor in June but not in September, contained a very low level of toluene close to the detection limit at the time of the September sampling. This well was dry for the August and October samplings.

Conclusions

1) No verifiable contamination was detected in 1985 in either the unused water supply wells or the monitor wells except for low level contamination detected in samples taken within 24 hours of cleaning with an air compressor.

2) In wells S1 and M4 low levels of toluene near detection limits were found in one sampling, but the possibility of a sampling error cannot be ruled out.

3) The latest sampling for which results are available (October 1985), detected no hydrocarbons either in the monitor wells or in a composite of the water wells currently supplying the system.

4) Methane at concentrations 1200 times ambient levels was detected in the monitor well closest to the gas well in August. The source is likely the decay of shallow buried organic material. It may be from natural material, from gas well drilling and testing fluids, or from the leaked produced water. The gas well itself is not likely the source of methane since it has 227 feet of surface casing cemented back to the surface.

5) Ground water movement in the vicinity of the monitor wells in fall 1985 - winter 1986 was towards the river with a seepage velocity range of 3 to 4 feet per day. Ground water flow at this location is away from the currently used water supply wells.

6) Based on the available information, the produced water tank at the Manana Mary Wheeler 1E gas well, the gas well itself, and the dehydrator pit are all likely to have been within the zone of influence ("cone of depression") of the pumping S1 well at the time the water well was contaminated in February 1983. Actual pumping rates and pumping cycle information at the time of contamination would better define the extent of pumping well influence.

7) The distance between the water well S1 and the closest pit or tank at the gas well is 230 feet. The estimate of travel time for unretarded soluble contaminants to have moved that distance and reach the pumping water well is from 96 to 103 days.

8) The rate of ground water movement is such that a single plume of contaminated produced water originating in the vicinity of the gas well in 1983 has moved past the water well (S1). The current location and disposition of a plume is unknown because of the uncertainty of seasonal hydrologic conditions between the well field and river.

9) Because of the passage of time, water pumped from well S1 would not show contamination unless a zone of residual oil saturation is present at or near the produced water tank or other facilities. Extended pumping at 60 to 70 gpm in excess of 55 days would be required to detect by pumping any remaining oil present, since it would take at least that long for soluble constituents to travel 230 feet. Exploratory digging would also detect the zone, and it would define the extent of such a zone.

10) If residual oil is present, some soluble constituents will dissolve into ground water due to water level fluctuations and migrate towards the pumping well. These constituents are most likely to be purgeable aromatic hydrocarbons (i.e. benzenes, toluene, and xylenes). Whether these contaminants would actually reach the well, and what their concentrations would be, cannot be determined with the present information.

Recommendations and Proposed Future Work

1) To better define the hydrologic regimen at the site, the OCD intends to measure water levels and sample water quality of the monitor wells and other available wells through at least the fall of 1986. Spring-summer measurements, especially, will provide ground water movement data not yet available.

2) Well S5 should be capped to prevent introduction of contaminants. However both wells S1 and S5 should have caps that allow for access for periodic water level measurements, and pumping if necessary.

3) An aquifer test using well S1 as the pumped well should be performed for at least 72 hours at a rate of 60 gpm or at the rate the well would be pumped if put back in service. This test would determine accurate aquifer parameters and detect any contamination in the immediate vicinity of the well.

4) Since well S5 is at a distance of greater than 500 feet from the gas well and out of the direct path of ground water flow, it is unlikely that pumping S5 will cause capture of any remaining contaminants from the gas well location. To test this assumption, some additional ground water flow calculations should be performed using actual aquifer parameter data before placing S5 back in service.

5) To determine the presence and concentrations of any residual

oil (or any remaining free oil) between the gas well site and well S1, exploration digging with the backhoe is recommended, followed by immediate, witnessed sampling for purgeable and extractable hydrocarbons. The backhoe bucket should be cleaned prior to each use and all hydraulic lines should be checked for integrity. If residual oil is found, capture of soluble constituents is again a possibility and well No. 1 (S1) may again evidence contamination if pumped continually.

6) Sampling of individual pumping water supply wells for purgeable aromatic hydrocarbons should be performed on a regular basis. For convenience, a sampling schedule identical to that required for total trihalomethanes is initially suggested.

REPORT FIGURES

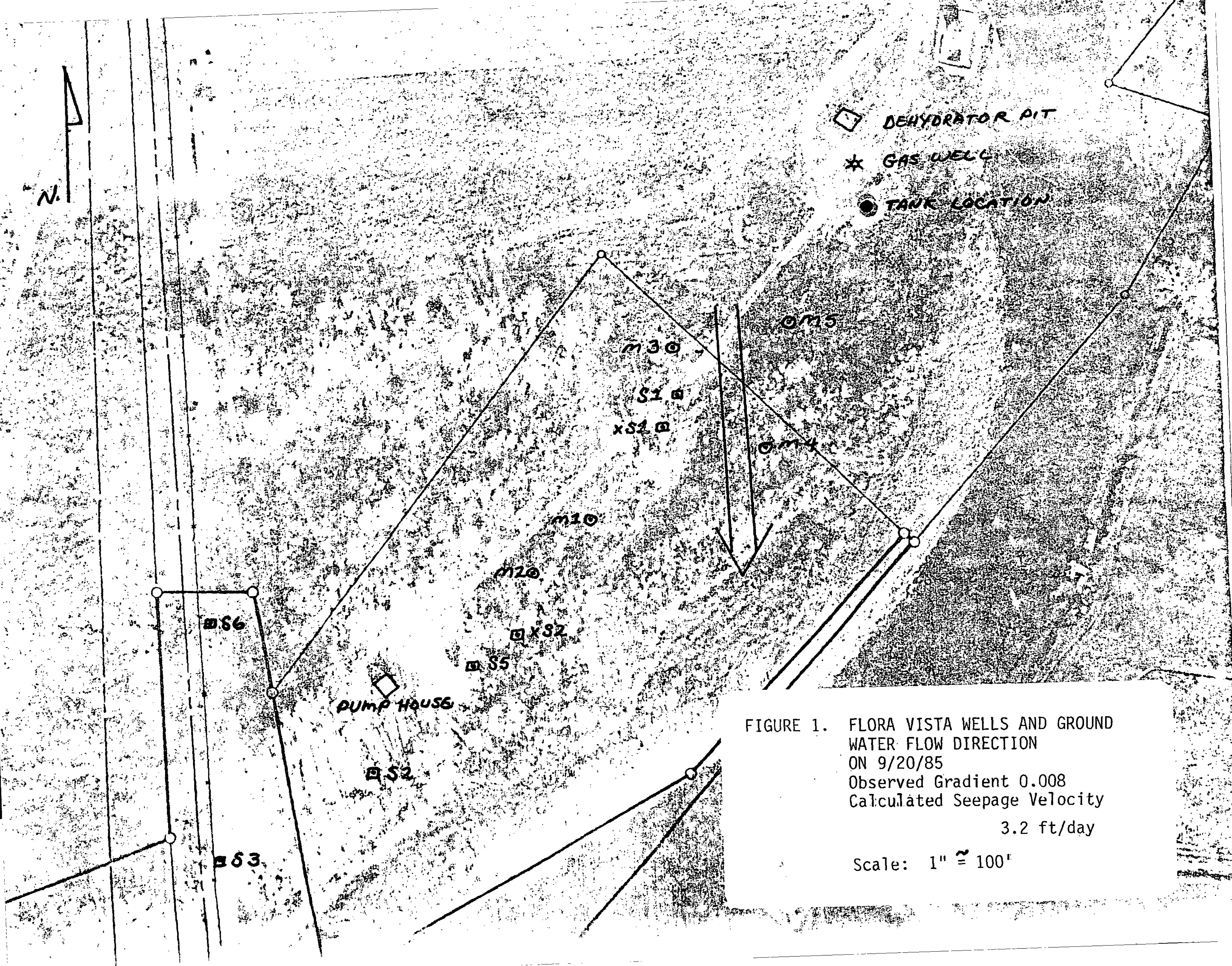


FIGURE 1. FLORA VISTA WELLS AND GROUND WATER FLOW DIRECTION ON 9/20/85
Observed Gradient 0.008
Calculated Seepage Velocity 3.2 ft/day

Scale: 1" ≅ 100'

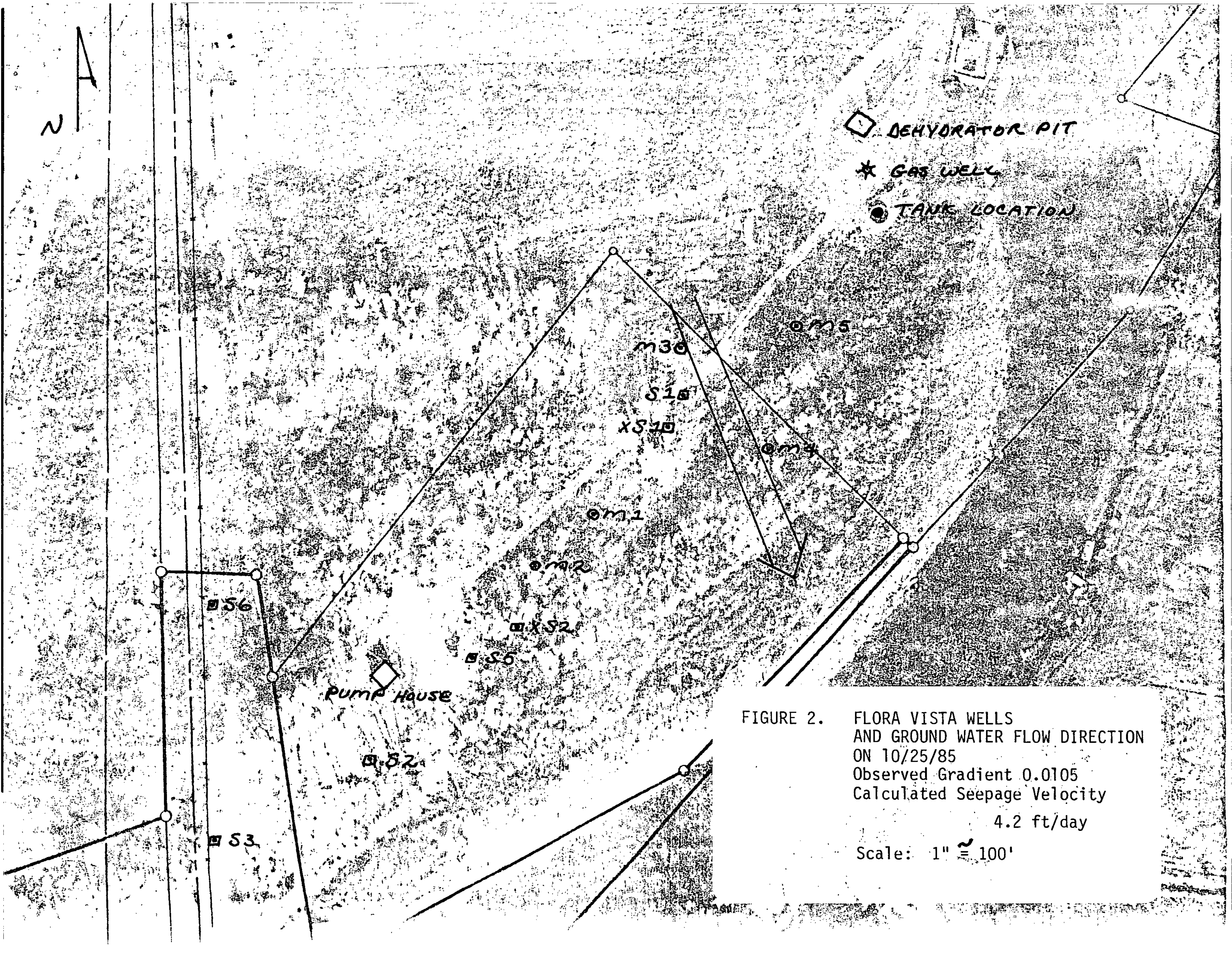


FIGURE 2. FLORA VISTA WELLS AND GROUND WATER FLOW DIRECTION ON 10/25/85
Observed Gradient 0.0105
Calculated Seepage Velocity
4.2 ft/day

Scale: 1" ≅ 100'

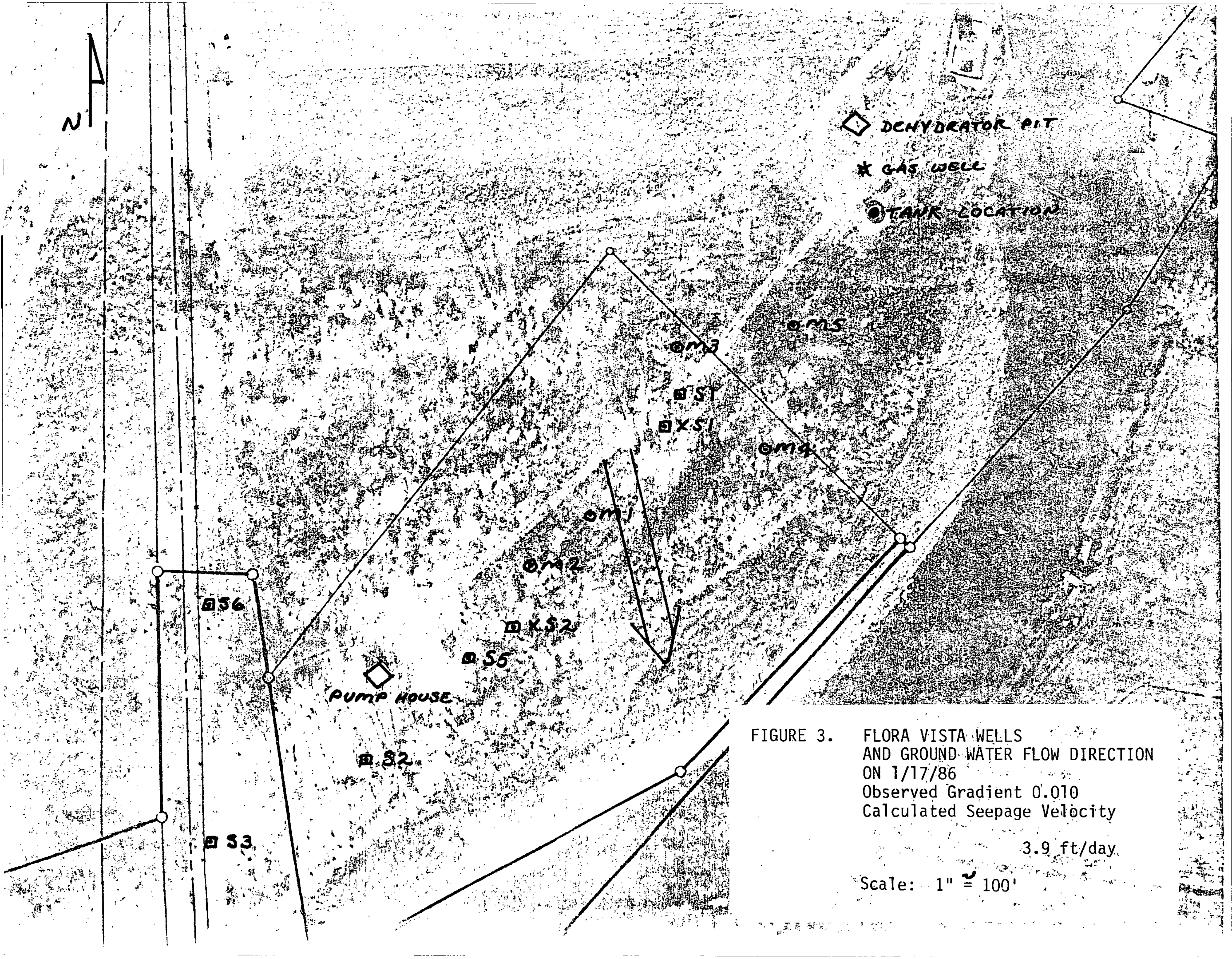


FIGURE 3. FLORA VISTA WELLS
AND GROUND WATER FLOW DIRECTION
ON 1/17/86
Observed Gradient 0.010
Calculated Seepage Velocity

3.9 ft/day

Scale: 1" ≅ 100'

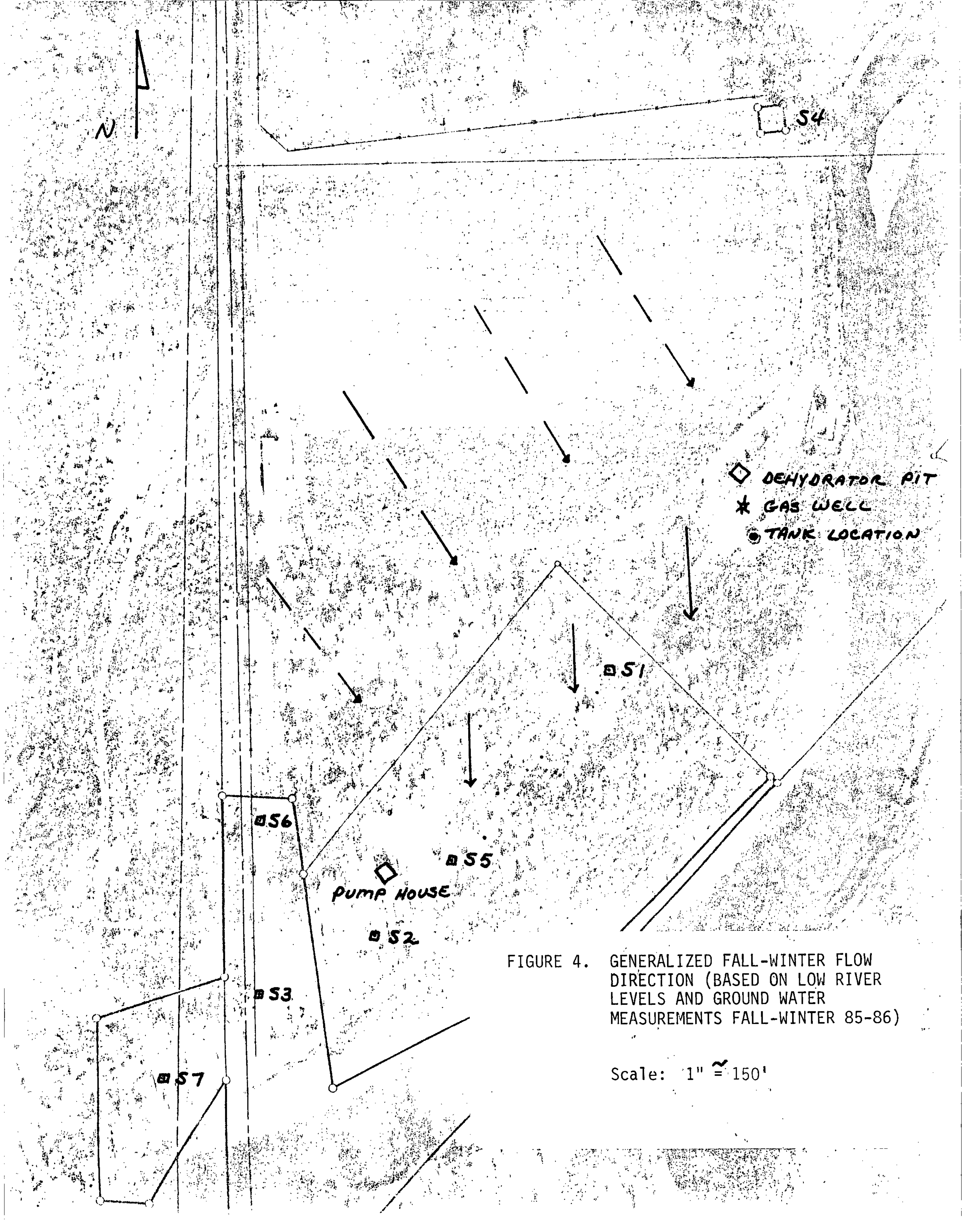


FIGURE 4. GENERALIZED FALL-WINTER FLOW DIRECTION (BASED ON LOW RIVER LEVELS AND GROUND WATER MEASUREMENTS FALL-WINTER 85-86)

Scale: 1" ≅ 150'

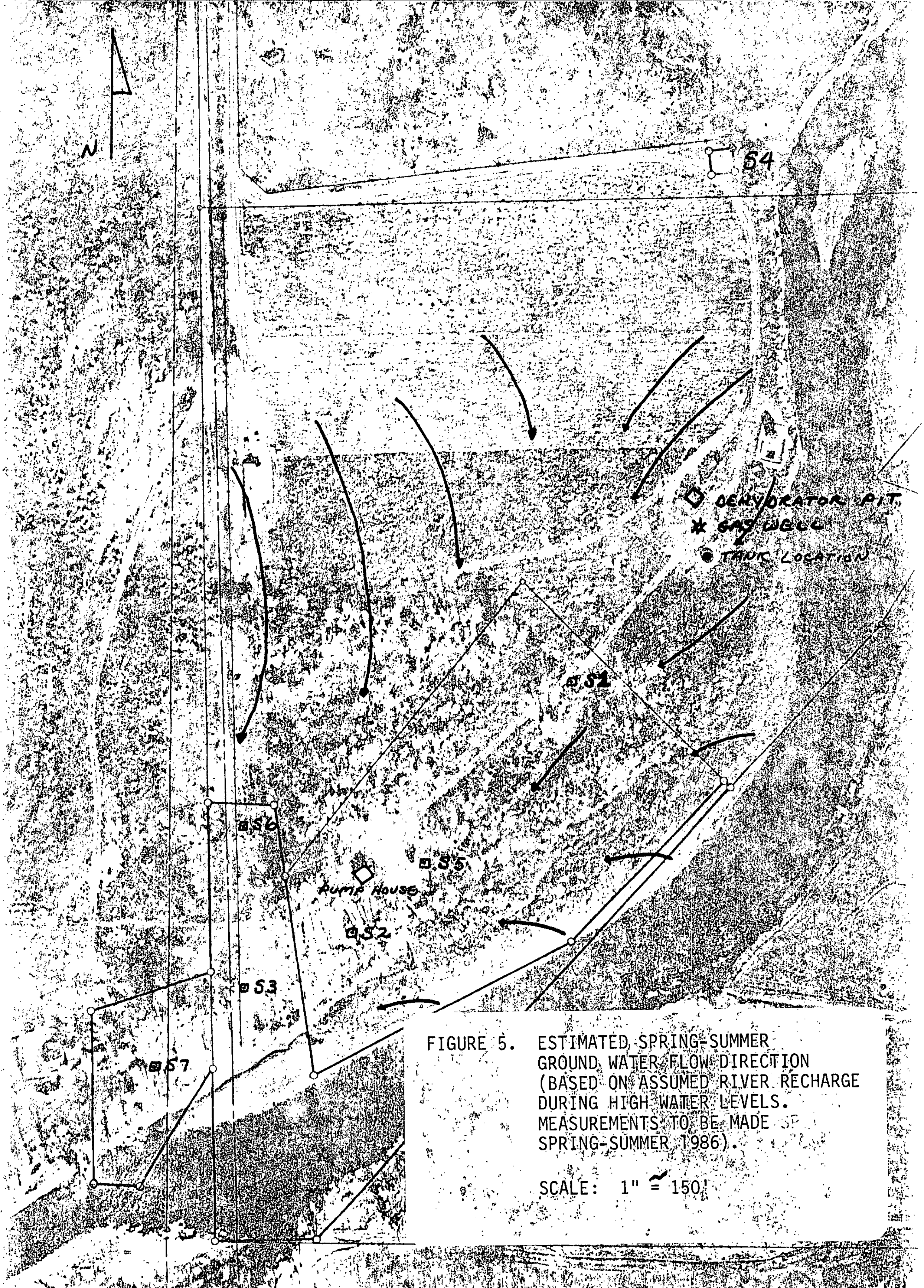


FIGURE 5. ESTIMATED SPRING-SUMMER GROUND WATER FLOW DIRECTION (BASED ON ASSUMED RIVER RECHARGE DURING HIGH WATER LEVELS. MEASUREMENTS TO BE MADE SPRING-SUMMER 1986).

SCALE: 1" ≈ 150'

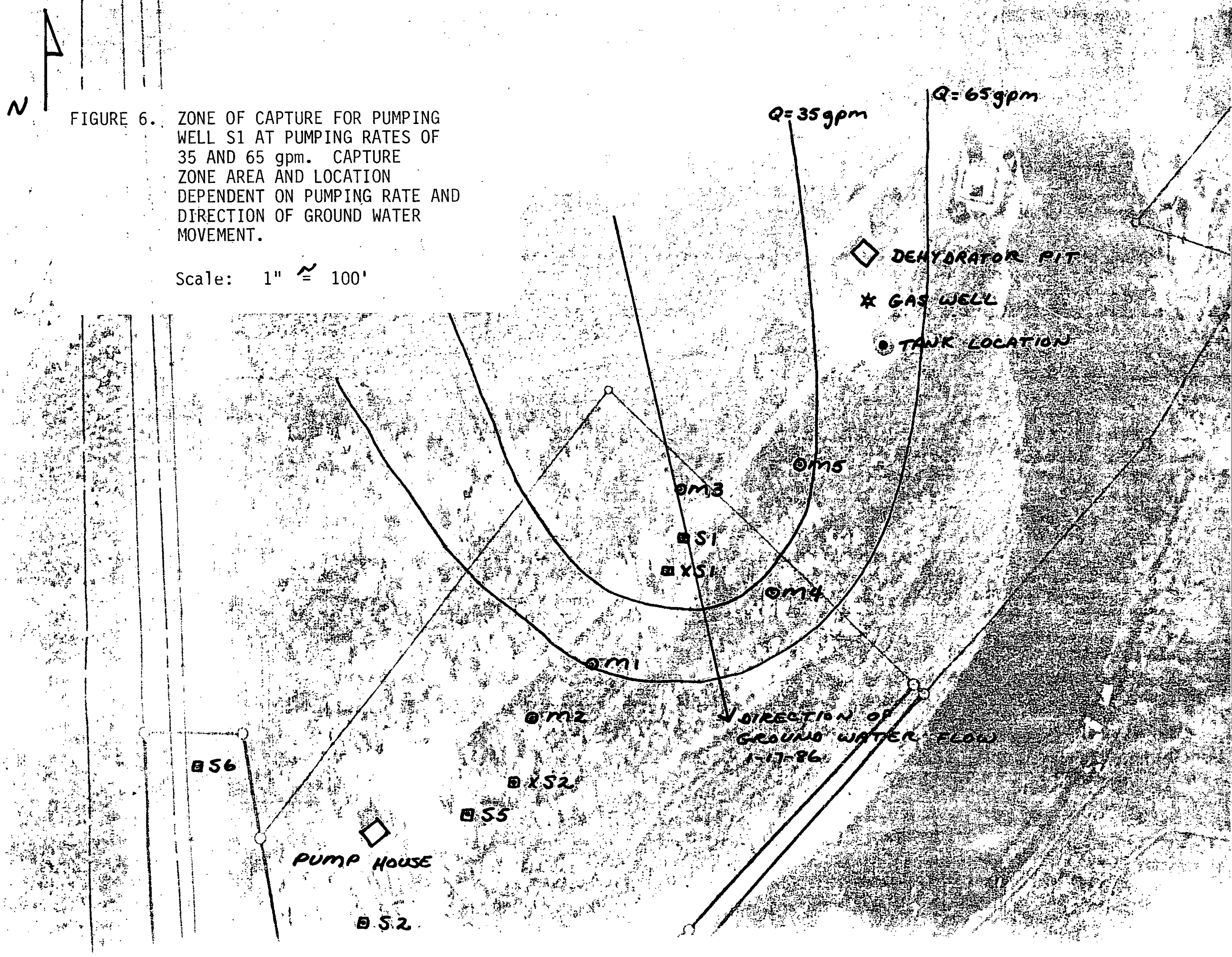


FIGURE 6. ZONE OF CAPTURE FOR PUMPING WELL S1 AT PUMPING RATES OF 35 AND 65 gpm. CAPTURE ZONE AREA AND LOCATION DEPENDENT ON PUMPING RATE AND DIRECTION OF GROUND WATER MOVEMENT.

Scale: 1" ≃ 100'

REPORT TABLES

TABLE 1. - Results[1] of Organic Chemical Analyses for Flora Vista Supply Wells
Supply Well No. 1 (Survey Point No. 6)

STANDARD	NM GROUND WATER STANDARD [2]	EPA RMCL [3]	8/83	1538 3/20/85	1610 3/20/85	6/28/85
Benzene	10	0 f	ND	ND	ND	ND
Toluene	15,000 750 a	2000 p	ND	ND	ND	6
Ethyelbenzene	750 a	680 p	-	ND	ND	ND
p-xylene	Total	Total	-	ND	ND	ND
m-xylene	xylenes	xylenes	-	ND	ND	ND
o-xylene	620 a	440 p	-	ND	ND	ND
Chloroform	100 a	Total Trihalomethanes	-	ND	ND	1
Other Trihalomethanes	-	100 m	-	ND	ND	ND
Detection Limit	-	-	10	1	1	1
Analyzed by [4]	-	-	Ana Cor	SLD	SLD	SLD
Methane [5] (dissolved)	-	-	-	-	-	1.3ppm
Detection Limit	-	-	-	-	-	1ppm

Comments: Well shut down in 1983 due to hydrocarbon contamination. Well capped and welded, shut July 1985. One unsaturated hydrocarbon detected 6/28/85 at 5ppb but unidentified.

Footnotes:

1) Results in parts per billion or micrograms per liter unless otherwise noted 1,000 ppb = 1 ppm or mg/l). ND- not detected, L-less than.

2) a - adopted December 1985 but not yet in effect.

3) p - proposed, f-final EPA Recommended Maximum Contaminant level (RMCL) for community drinking water supplies (RMCL's non-enforceable). m - maximum contaminant level (enforceable).

4) SLD- New Mexico Scientific Laboratory Division

5) Methane may be from natural gas or marsh gas dissolved in sample. Normal range level in atmosphere from about 0.8 to 1.5 ppm.

TABLE 1 (Continued)
Supply Well No. 5 (Survey Point No. 14)

STANDARD	NM GROUND WATER STANDARD [2]	EPA RMCL [3]	3/20/85	8/5/85	9/20/85	9/21/85	10/25/85
Benzene	10	0 f	ND	ND	ND	ND	ND
Toluene	15,000 750 a	2000 p	ND	ND	3	3	L1
Ethyelbenzene	750 a	680 p	ND	ND	2	2	L1
p-xylene	Total xylenes 620 a	Total xylenes 440 p	ND	ND	2	1	ND
m-xylene			ND	ND	4	4	L1
o-xylene			ND	ND	5	3	L1
Chloroform	100a	Total Trihalomethanes 100 m	ND	ND	ND	ND	ND
Other Trihalomethanes	-		ND	ND	ND	ND	ND
Detection Limit	-	-	1	2	2	2	1
Analyzed by [4]	-	-	SLD	SLD	SLD	SLD	SLD
Methane [5] (dissolved)	-	-	-	1.3ppm	-	-	1.8
Detection Limit	-	-	-	1ppm	-	-	0.4

Comments: Well on-line until July 85. Pump then removed and well left open. Well pumped with air 9/20/85. Air compressor exhaust present in air line introduced small quanitities of contaminants which may be those seen on 9/20 and 9/21.

Footnotes:

1) Results in parts per billion or micrograms per liter unless otherwise noted (1,000 ppb = 1 ppm or mg/1). ND- not detected, L-less than.

2) a - adopted December 1985 but not yet in effect.

3) p - proposed, f-final EPA Recommended Maximum Contaminant level (RMCL) for community drinking water supplies (RMCL's non-enforceable).
m - maximum contaminant level (enforceable).

4) SLD - New Mexico Scientific Laboratory Division

5) Methane may be from natural gas or marsh gas dissolved in sample. Normal range level in atmosphere from about 0.8 to 1.5 ppm.

Table 1. (Cont'd) System Composites

STANDARD	NM GROUND WATER STANDARD [2]	EPA RMCL [3]	3/20/85	8/5/85	10/25/85
Benzene	10	0 f	ND	ND	ND
Toluene	15,000 750 a	2000 p	ND	ND	ND
Ethyelbenzene	750 a	680 p	ND	ND	ND
p-xylene	Total	Total	ND	ND	ND
m-xylene	xylenes	xylenes	ND	ND	ND
o-xylene	620 a	440 p	ND	ND	ND
Chloroform	100 a	Total	4	ND	ND
Other		Trihalo-			
Trihalo-		Methanes			
methanes	-	100 m	ND	ND	ND
Detection Limit	-	-	1	2	1
Analyzed by [4]	-	-	SLD	SLD	SLD
Methane [5] (dissolved)	-	-	-	13.6ppm	1.1ppm
Detection Limit	-	-	-	1ppm	0.4ppm

Comments: 3/20/85-Wells S2 & S3 on line; 10/25/85 (and likely 8/5)-wells S2, S3 and S6 on line. All samples prior to chlorinator entry point several feet down pipe. By comparison City of Farmington sample on 10/23 had 50 ppb chloroform and total of 76 ppb THM.

Footnotes:

1) Results in parts per billion or micrograms per liter unless otherwise noted (1,000 ppb = 1 ppm or mg/l). ND- not detected, L-less than.

2) a - adopted December 1985 but not yet in effect.

3) p - proposed, f-final EPA Recommended Maximum Contaminant level (RMCL) for community drinking water supplies (RMCL's non-enforceable). m - maximum contaminant level (enforceable).

4) SLD - New Mexico Scientific Laboratory Division

5) Methane may be from natural gas or marsh gas dissolved in sample. Normal range level in atmosphere from about 0.8 to 1.5 ppm.

TABLE 2. - Results[1] of Organic Chemical Analyses For Monitor Wells at Flora Vista Monitor Well No. 1 (Survey Point No. 11).

STANDARD	NM GROUND WATER STANDARD [2]	EPA RMCL [3]	3/20/85	6/28/85	9/21/85	10/25/85
Benzene	10	0 f	ND	ND	ND	ND
Toluene	15,000 750 a	2000 p	ND	13	4	ND
Ethyelbenzene	750 a	680 p	ND	ND	2	ND
p-xylene	Total xylenes 620 a	Total xylenes 440 p	ND	ND	2	ND
m-xylene			ND	ND	7	ND
o-xylene			ND	1	7	ND
Chloroform	100 a	Total Trihalomethanes 100 m	ND	ND	ND	ND
Other Trihalomethanes	--		ND	ND	ND	ND
Detection Limit	-	-	1	1	2	1
Analyzed by [4]	-	-	SLD	SLD	SLD	SLD
Methane [5] (dissolved)	-	-	-	-	-	1.8ppm
Detection Limit	-	-	-	-	-	0.4ppm

Comments: 3/20 sample from pit prior to well installation. Well developed using compressed air on 6/27. Well dry on 8/5/85. Well cleaned and pumped with air 9/20/85. Air compressor exhaust present in air line introduced small quantities of contaminants which may be those seen in 9/21 analysis. Air compressor used on 6/27 not available for contaminant testing.

Footnotes:

1) Results in parts per billion or micrograms per liter unless otherwise noted (1,000 ppb = 1 ppm or mg/1). ND- not detected, L-less than.

2) a - adopted December 1985 but not yet in effect.

3) p - proposed, f-final EPA Recommended Maximum Contaminant level (RMCL) for community drinking water supplies (RMCL's non-enforceable). m - maximum contaminant level (enforceable).

4) SLD - New Mexico Scientific Laboratory Division.

5) Methane may be from natural gas or marsh gas dissolved in sample. Normal range level in atmosphere from about 0.8 to 1.5 ppm.

TABLE 2. (Continued)
Monitor Well No. 2 (Survey Point No. 12)

STANDARD	NM GROUND WATER STANDARD [2]	EPA RMCL [3]	3/20/85	6/28/85	9/21/85	10/25/85
Benzene	10	0 f	ND	ND	ND	ND
Toluene	15,000 750 a	2000 p	ND	5	3	ND
Ethyelbenzene	750 a	680 p	ND	ND	ND	ND
p-xylene	Total	Total	ND	ND	L2	ND
m-xylene	xylenes	xylenes	ND	ND	2	ND
o-xylene	620 a	440 p	ND	L1	L2	ND
Chloroform	100 a	Total Trihalo-methanes	ND	ND	ND	ND
Other Trihalo-methanes	-	100 m	ND	ND	ND	ND
Detection Limit	-	-	1	1	2	1
Analyzed by [4]	-	-	SLD	SLD	SLD	SLD
Methane [5] (dissolved)	-	-	-	-	-	0.7ppm
Detection Limit	-	-	-	-	-	0.4ppm

Comments: 3/20 sample from pit prior to well installation. Well developed using compressed air 6/27. Well dry 8/5/85. Well cleaned and pumped with air 9/20/85. Air compressor exhaust present in air line introduced small quantities of contaminants which may be those seen in 9/21 analysis. Air compressor used on 6/27 not available for contaminant testing.

Footnotes:

1) Results in parts per billion or micrograms per liter unless otherwise noted (1,000 ppb = 1 ppm or mg/l). ND- not detected, L-less than.

2) a - adopted December 1985 but not yet in effect.

3) p - proposed, f-final EPA Recommended Maximum Contaminant level (RMCL) for community drinking water supplies (RMCL's non-enforceable). m - maximum contaminant level (enforceable).

4) SLD - New Mexico Scientific Laboratory Division.

5) Methane may be from natural gas or marsh gas dissolved in sample. Normal range level in atmosphere from about 0.8 to 1.5 ppm.

TABLE 2. (Continued)
Monitor Well No. 3 (Survey Pt. No. 8)

STANDARD	NM GROUND WATER STANDARD [2]	EPA RMCL [3]	3/20/85	6/28/85	8/5/85	9/21/85	10/25/85
Benzene	10	0 f	ND	ND	ND	ND	ND
Toluene	15,000 750 a	2000 p	ND	ND	ND	ND	ND
Ethyelbenzene	750 a	680 p	ND	ND	ND	L2	ND
p-xylene	Total xylenes 620 a	Total xylenes 440 p	ND	ND	ND	L2	ND
m-xylene			ND	ND	ND	L2	ND
o-xylene			ND	L1	ND	L2	ND
Chloroform	100 a		ND	ND	ND	ND	ND
Other Trihalomethanes	-	Total Trihalomethanes 100 m	ND	ND	ND	ND	ND
Detection Limit	-	-	1	1	2	2	1
Analyzed by [4]	-	-	SLD	SLD	SLD	SLD	SLD
Methane [5] (dissolved)	-	-	-	-	175ppm	-	8.4ppm
Detection Limit	-	-	-	-	1ppm	-	0.4

Comments: 3/20 sample from pit prior to well installation. Well developed using compressed air on 6/27. Well cleaned and pumped with air 9/20/85. Air compressor exhaust present in air line introduced small quanitities of contamiants which may be those seen in 9/21 analysis. Air compressor used on 6/27 not available for contaminant testing.

Footnotes:

1) Results in parts per billion or micrograms per liter unless otherwise noted (1,000 ppb = 1 ppm or mg/l). ND- not detected, L-less than.

2) a - adopted December 1985 but not yet in effect.

3) p - proposed, f-final EPA Recommended Maximum Contaminant level (RMCL) for community drinking water supplies (RMCL's non-enforceable). m - maximum contaminant level (enforceable).

4) SLD - New Mexico Scientific Laboratory Division.

5) Methane may be from natural gas or marsh gas dissolved in sample. Normal range level in atmosphere from about 0.8 to 1.5 ppm.

TABLE 2. (Continued)
Monitor Well No. 4 (Survey Point No. 10)

STANDARD	NM GROUND WATER STANDARD 2	EPA RMCL 3	3/20/85	6/28/85	9/21/85
Benzene	10	0 f	ND	ND	ND
Toluene	15,000 750 a	2000 p	ND	ND	4
Ethyelbenzene	750 a	680 p	ND	ND	ND
p-xylene	Total	Total	ND	ND	ND
m-xylene	xylenes	xylenes	ND	ND	ND
o-xylene	620 a	440 p	ND	ND	ND
Chloroform	100 a	Total	ND	1	ND
Other Trihalomethanes	-	Trihalomethanes 100 m	ND	ND	ND
Detection Limit	-	-	1	1	2
Analyzed by 4	-	-	SLD	SLD	SLD
Methane 5 (dissolved)	-	-	-	-	-
Detection Limit	-	-	-	-	-

Comments: 3/20 sample from pit prior to well installation. Well developed using compressed air on 6/27. Well dry on 8/5 and 10/25/85.

Footnotes:

1) Results in parts per billion or micrograms per liter unless otherwise noted (1,000 ppb = 1 ppm or mg/l). ND- not detected, L-less than.

2) a - adopted December 1985 but not yet in effect.

3) p - proposed, f-final EPA Recommended Maximum Contaminant level (RMCL) for community drinking water supplies (RMCL's non-enforceable). m - maximum contaminant level (enforceable).

4) SLD - New Mexico Scientific Laboratory Division.

5) Methane may be from natural gas or marsh gas dissolved in sample. Normal range level in atmosphere from about 0.8 to 1.5 ppm.

TABLE 2. (Continued)
Monitor Well No. 5 (Survey Point No. 4)

STANDARD	NM GROUND WATER STANDARD [2]	EPA RMCL [3]	3/20/85	6/28/85	8/5/85	9/21/85	10/25/85
Benzene	10	0 f	ND	ND	ND	ND	ND
Toluene	15,000 750 a	2000 p	ND	ND	ND	2	ND
Ethyelbenzene	750 a	680 p	ND	ND	ND	3	ND
p-xylene	Total xylenes 620 a	Total xylenes 440 p	ND	ND	ND	2	ND
m-xylene			ND	ND	ND	1	ND
o-xylene			ND	ND	ND	ND	ND
Chloroform	100 a	Total Trihalomethanes 100 m	ND	1	ND	ND	ND
Other Trihalomethanes	-		ND	ND	ND	ND	ND
Detection Limit	-	-	1	1	5	2	1
Analyzed by [4]	-	-	SLD	SLD	SLD	SLD	SLD
Methane [5] (dissolved)	-	-	-	-	1256ppm	-	1.1ppm
Detection Limit	-	-	-	-	1ppm	-	0.4ppm

Comments: 3/20 sample from pit prior to well installation. Dark black soil layer sampled 3/20 but oil not present at detectable levels. Well developed using compressed air on 6/27. 8/5 sample has strong swampy sulfur smell. Well cleaned and pumped with air 9/20/85. Air compressor exhaust present in air line introduced small quanitities of contamiants which may be those seen in 9/21 analysis.

Footnotes:

1) Results in parts per billion or micrograms per liter unless otherwise noted (1,000 ppb = 1 ppm or mg/1). ND- not detected, L-less than.

2) a - adopted December 1985 but not yet in effect.

3) p - proposed, f-final EPA Recommended Maximum Contaminant level (RMCL) for community drinking water supplies (RMCL's non-enforceable). m - maximum contaminant level (enforceable).

4) SLD - New Mexico Scientific Laboratory Division.

5) Methane may be from natural gas or marsh gas dissolved in sample. Normal range level in atmosphere from about 0.8 to 1.5 ppm.

TABLE 3. - Results[1] of Organic Chemical Analyses for produced water from the Manana Oil Company Mary Wheeler No. 1E Gas Well

STANDARD	NM GROUND WATER STANDARD [2]	EPA RMCL [3]	8/83	9/21/85	10/25/85
Benzene	10	0 f	180	16000	8700
Toluene	15,000 750 a	2000 p	L10	20000	12000
Ethyelbenzene	750 a	680 p	-	630	570
p-xylene	Total	Total	-	1200	1000
m-xylene	xylenes	xylenes	-	3800	3000
o-xylene	620 a	440 p	-	1300	1200
Chloroform	100 a	Total	-	-	-
Other	-	Trihalo-	-	-	-
Trihalo-		methanes			
methanes	-	100 m	-	-	-
Detection Limit	-	-	10	10	100
Analyzed by [4]	-	-	AnaCor	SLD	SLD
Methane [5] (dissolved)	-	-	-	-	-
Detection Limit	-	-	-	-	-

Comments: 8/83 sample from separator, Oil & Grease 37.1 ppm. 1985 samples from fiberglass tank at separator.

Footnotes:

1) Results in parts per billion or micrograms per liter unless otherwise noted (1,000 ppb = 1 ppm or mg/l). ND- not detected, L-less than.

2) a - adopted December 1985 but not yet in effect.

3) p - proposed, f-final EPA Recommended Maximum Contaminant level (RMCL) for community drinking water supplies (RMCL's non-enforceable).
m - maximum contaminant level (enforceable).

4) SLD - New Mexico Scientific Laboratory Division.

5) Methane may be from natural gas or marsh gas dissolved in sample. Normal range level in atmosphere from about 0.8 to 1.5 ppm.

09364500 ANIMAS RIVER AT FARMINGTON, NM
(National stream-quality accounting network station)

LOCATION.--Lat 36°43'17", long 108°12'05", in SW¼SW¼ sec.15, T.29 N., R.13 W., San Juan County, Hydrologic Unit 14080104, in Boyd City Park, on right bank 900 ft upstream from bridge on Miller Ave., 0.4 mi downstream from bridge on U.S. Highway 64 in Farmington, and 1.5 mi upstream from mouth.

DRAINAGE AREA.--1,360 mi^2, approximately.

WATER-DISCHARGE RECORDS

PERIOD OF RECORD.--June 1904 to October 1905 (published as "near Farmington"), September 1912 to current year. Monthly discharge only for some periods, published in WSP 1313.

REVISED RECORDS.--WSP 1243: 1931. WSP 1313: 1913.

GAGE.--Water-stage recorder. Altitude of gage is 5,280 ft, from topographic map. Prior to Nov. 1, 1905, non-recording gage at old bridge 0.1 mi upstream at different datum. Sept. 17, 1912, to Oct. 4, 1938, water-stage recorder at site 0.8 mi downstream at lower datums (datum lowered 2.0 ft Aug. 15, 1927, and raised 0.2 ft Dec. 16, 1929). Oct. 5, 1938 to Nov. 1, 1973 at site 900 ft downstream at datum 1.74 ft lower.

REMARKS.--Water-discharge records good except those for winter period, which are fair. Diversions for irrigation of about 30,000 acres above station.

AVERAGE DISCHARGE.--72 years, 916 ft^3/s, 663,600 acre-ft/yr.

EXTREMES FOR PERIOD OF RECORD.--Maximum discharge, about 25,000 ft^3/s June 29, 1927, gage height, 8.5 ft, site and datum then in use, from rating curve extended above 10,000 ft^3/s; minimum, 1.0 ft^3/s Aug. 11, 1972.

EXTREMES OUTSIDE PERIOD OF RECORD.--Maximum flood occurred Oct. 6, 1911, when a stage of about 16.5 ft was reached (datum in use Oct. 1938 to Nov. 1973). Flood of Sept. 6, 1909, reached a stage of 11.1 ft, 1904-5 site and datum (discharge, about 19,000 ft^3/s).

EXTREMES FOR CURRENT YEAR.--Peak discharges above base of 4,000 ft^3/s and maximum (*):

Date	Time	Discharge (ft^3/s)	Gage height (ft)	Date	Time	Discharge (ft^3/s)	Gage Height (ft)
May 31	2330	*6320	8.59	Aug. 6	0100	5320	8.31
June 25	0330	5920	8.61				

Minimum daily discharge, 268 ft^3/s Sept. 20.

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1982 TO SEPTEMBER 1983
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	858	411	432	345	353	564	692	1780	5810	3610	1260	421
2	890	409	415	341	336	510	652	1540	5250	3470	1270	406
3	790	411	395	346	332	508	636	1400	4370	3430	1390	442
4	746	389	385	385	353	593	652	1330	3630	3560	1320	400
5	710	396	405	391	365	633	660	1300	3640	3480	1230	379
6	656	390	380	390	330	498	572	1480	3650	3310	1810	349
7	592	390	388	355	298	468	588	1760	3570	3150	1330	343
8	554	380	384	369	296	465	561	1870	3740	3180	1430	345
9	535	395	411	376	308	481	527	1730	3810	2930	1280	387
10	511	462	553	358	311	503	559	2030	3510	2840	1150	385
11	499	450	544	365	302	548	555	2610	3340	2670	1090	353
12	491	444	481	376	317	611	573	2980	3920	2290	1080	335
13	448	395	432	365	328	647	630	2770	3930	2070	972	308
14	430	390	404	367	335	678	672	2340	3120	1860	859	297
15	429	390	396	370	336	830	645	2160	2730	1740	801	303
16	436	370	374	373	319	703	591	1900	2920	1590	757	293
17	455	370	382	376	341	606	602	1720	3190	1500	648	304
18	471	405	400	380	336	604	646	1620	3730	1470	547	278
19	464	405	391	366	341	597	783	1490	4610	1480	536	270
20	442	434	366	352	341	553	923	1450	5410	1570	607	268
21	430	428	363	350	345	490	1030	1470	5310	1530	504	275
22	398	405	373	351	345	500	1020	1360	5330	1520	471	295
23	387	387	423	335	390	580	1060	1430	5160	1610	435	312
24	389	390	416	328	444	540	1220	1950	5140	1690	414	326
25	387	374	367	332	468	540	1600	2660	5540	1660	415	302
26	384	377	339	330	504	548	1970	3900	4930	1810	466	304
27	425	371	348	318	480	556	1950	4210	4520	2110	473	298
28	437	371	325	321	492	528	1810	4940	4270	1690	579	309
29	407	385	306	341	---	522	1720	5510	3760	1430	480	322
30	403	385	288	334	---	556	1770	5460	3680	1360	466	392
31	404	---	336	321	---	660	---	5800	---	1340	433	---
TOTAL	15858	11959	12202	11007	10046	17620	27869	75950	125520	68950	26503	10001
MEAN	512	399	394	355	359	568	929	2450	4184	2224	855	333
MAX	890	462	553	391	504	830	1970	5800	5810	3610	1810	442
MIN	384	370	288	318	296	465	527	1300	2730	1340	414	268
AC-FT	31450	23720	24200	21830	19930	34950	55280	150600	249000	136800	52570	19840

CAL YR 1982 TOTAL 364553 MEAN 999 MAX 3660 MIN 209 AC-FT 723100
WTR YR 1983 TOTAL 413485 MEAN 1133 MAX 5810 MIN 268 AC-FT 820100

TABLE 4. Flow of Animas River at Farmington, 1983 Water Year
(Source: USGS Water Resources Data, New Mexico, W.Y. 1983)

TABLE 5. SUMMARY OF FORMULAS USED IN CALCULATIONS

1) Seepage velocity using Darcy's Law:

$$v = \frac{K}{n} i$$

Where: K = Permeability (K = 750 gallons/day/ft^2 from Ranney report to Brewer & Assoc.)

n = Porosity (N = 0.25 assumed value for sand/gravel)

i = measured gradient (i = change in water level elevation per unit distance)

Reference: Todd, Eq. 3.21.

2) Drawdown using Theis non-equilibrium formula:

$$s = \frac{Q}{4\pi T} W(u) \text{ where } u = \frac{r^2 S}{4Tt}$$

Where: Q = pumping rate (Q = 35 gallons per minute, or Q = 65 gpm)

T = Transmissivity (T = Kb where K is permeability, b = saturated aquifer thickness = 17 feet from Ranney report; T = 12750 gpd/ft)

r = distance (from well to produced water tank, r = 230 feet)

S = storage coefficient (S = 0.2 for water table conditions)

t = time of pumping (t = 100 days for example used here)

Reference: Todd, Eq. 4.38, 4.36.

3) Zone of capture in a uniform flow field under steady state conditions:

a) Boundary equation: $-\frac{y}{x} = \tan\left(\frac{2\pi Kbi}{Q} y\right)$

b) y - Limit: $y_L = \pm \frac{Q}{2Kbi}$

c) x - Limit: $x_L = -\frac{Q}{2\pi Kbi}$

TABLE 5. (con't)

Reference: Todd, Eq. 4.31 to 4.33.

4) Time of transport to pumping well:

a) $$t = \sum_j \left[\frac{n \Delta r_j^2}{K \Delta s_j} \right]$$

Where: Δs = change in drawdown over distance, Δr, moving towards pumping well.

b) $$\Delta s_j = \Delta s_Q \log \frac{r_{j+1}}{r_j}$$

Where: Δs_Q = change in drawdown over one log cycle of distance for given Q.
$\Delta s_{35} = 1.45, \Delta s_{65} = 2.70$

Reference: Todd, Eq 3.23; Johnson Eq. 8, p. 123

References

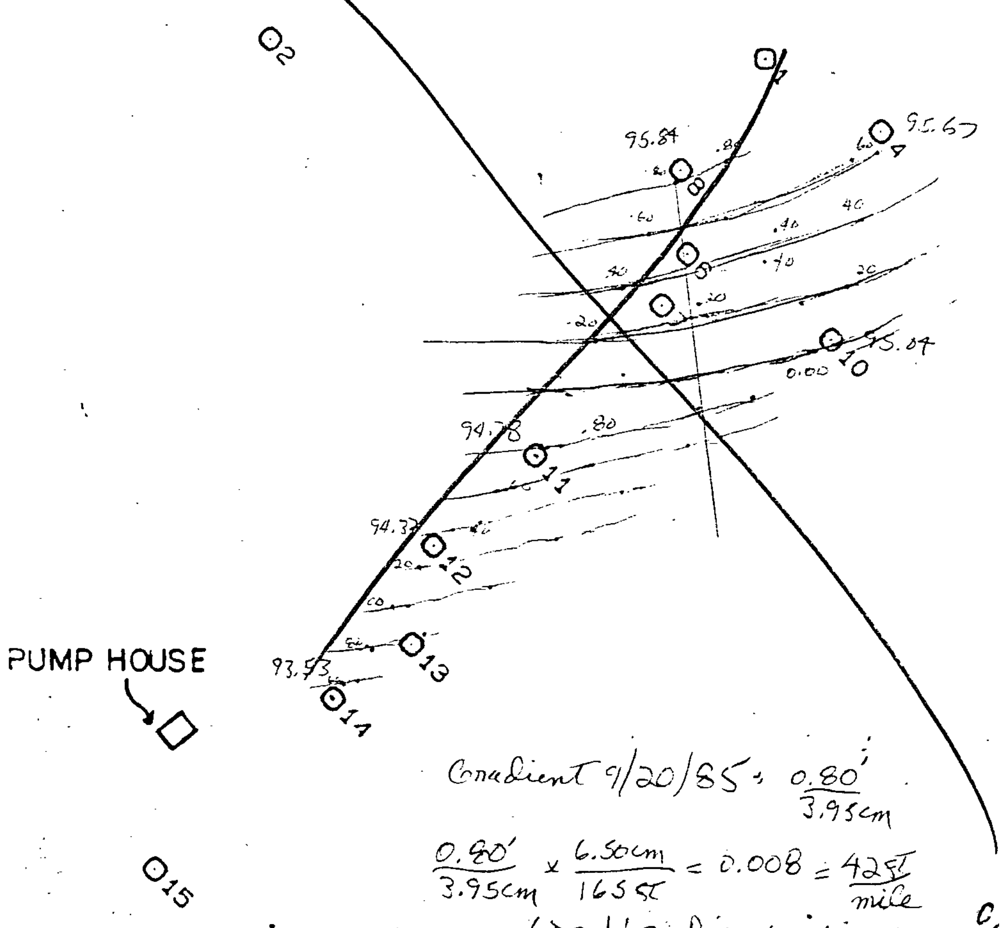
Johnson Division , UOP Inc., "Ground Water and Wells", 2nd ed. Edward E. Johnson, St. Paul, Minn. 440 pp, 1972.

Ranney Method Western Corporation, "Ranney Collector Water Supply, Flora Vista Water Users Association, Flora Vista New Mexico", 4p., tables, 10/28/81.

Todd, D. K., Groundwater Hydrology, 2nd ed. John Wiley & Sons, NY, 535 p. 1980.

9/20/85

		DTW	9/20/85
PT. 4 = MW 5	Elev = 100.18	4.510	95.67
PT. 8 = MW 3	101.90	6.065	95.84
PT. 10 = MW 4	98.51	3.468	95.04
PT. 11 = MW 1	100.61	5.830	94.78
PT 12 = MW 2	100.46	6.140	94.32
PT 14 = SW	99.45	5.925	93.53



Gradient 9/20/85 = $\frac{0.80'}{3.95cm}$

$\frac{0.80'}{3.95cm} \times \frac{6.50cm}{165 ft} = 0.008 = \frac{42 ft}{mile}$

(Double River Gradient of ~~[illegible]~~ 0.004,
Less than Topographic Gradient of 0.014)

$\frac{10 ft}{700 ft} = .0143$

$\frac{20}{1100} = .0182$

$\bar{v} = \frac{K}{n}(i) = \frac{100 ft\ (0.008)}{day\ (.25)}$ = 3.2 ft/day
= 1168 ft/yr.