Rob

AFFIDAVIT

STATE OF NEW MEXICO)
) ss.
COUNTY OF SANTA FE)

We, Dennis McQuillan, Robert Pine and Baird Swanson being first duly sworn upon our oaths depose and state as follows:

1. We are the authors of individual affidavits attached hereto.

2. This joint affidavit provides facts and conclusions, supported by our individual affidavits, that each of us can attest to based on our education and experience.

3. Re-injection of treated ground water is a technically and economically feasible option used at many sites in New Mexico.

4. Re-injection can be accomplished by use of an injection well.

5. Fouling of the injection apparatus and injection zone can be prevented and controlled.

6. Re-injection of treated ground water, rather than pumping to waste, complies with the water-conservation directive of New Mexico Governor Gary Johnson as per Executive Order 96-30.

FURTHER AFFIANTS SAYETH NAUGHT.

Dennis McQuillan
AFFIANT, DENNIS MCQUILLAN

Robert Pine
AFFIANT, ROBERT PINE

Baird Swanson
AFFIANT, BAIRD SWANSON

SUBSCRIBED AND SWORN to before me this 24th day of February, 1997 by Dennis McQuillan, Robert Pine and Baird Swanson, Affiants.

Gloria S. Lopez
NOTARY PUBLIC

My Commission Expires:

June 1st 1998

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STATE OF NEW MEXICO)
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COUNTY OF SANTA FE)

I, Dennis McQuillan being first duly sworn upon my oath depose and state as follows:

1. My name is Dennis Martin McQuillan.

2. I received a Bachelor of Science Degree in Geology from the University of New Mexico with a minor in Chemistry, Mathematics and Physics.

3. I have 19 years of professional experience, including experience as a government regulator, private consultant, educator and free-lance writer.

4. I have provided expert technical testimony to the U.S. Congress, N.M. Legislature, N.M. Water Quality Control Commission (WQCC), N.M. Environmental Improvement Board, and to N.M. District Court. I have been judicially qualified as an expert in the investigation and remediation of soil and ground-water contamination.

5. I am currently employed by the New Mexico Environment Department (NMED), as the Ground Water Quality Bureau, Remediation Manager. I and my staff oversee and conduct the investigation and remediation of soil and ground-water contamination. For a decade, I have maintained a computerized data base on all forms of anthropogenic ground-water contamination in New Mexico, including information on remediation. As such, I have personal knowledge of many remedial actions involving re-injection of treated ground water.

Atex/Fina

6. I am familiar with the Fina case referenced in the statement of Mr. Gary Richardson, and worked on that case from 1981 to 1985. At that time, the case was known as Atex Station 213. The site is located at 3501 Isleta SW, in the inner Rio Grande Valley. Nearly 40,000 gallons of unleaded gasoline were discharged from a leaking underground storage tank.

7. The site is located in an area of chemically reducing conditions in the shallow ground water. Reducing conditions are those where redox-sensitive elements such as nitrogen, iron, manganese and sulfur, can undergo chemical reactions involving electron gain. Conversely, oxidizing chemical reactions involve electron loss. Moderate reducing conditions are characterized by low concentrations of nitrate, with elevated concentrations of iron and manganese. In more strongly reducing conditions, sulfate reduction and methanogenesis also can occur.

8. I have conducted studies in the Albuquerque South Valley over many years and have concluded that reducing conditions naturally occur in many Valley areas, and that these conditions were regionally exacerbated by septic-tank discharges. Locally, as occurred at the

Atex/Fina site, conditions have been made even more reducing by intrinsic biodegradation of petroleum hydrocarbons. Dissolved ground-water concentrations of iron and manganese at the Atex/Fina site in 1984 were as high as 140 mg/L and 3.4 mg/L respectively. WQCC standards for iron and manganese are 1.0 mg/L and 0.2 mg/L respectively.

9. An air stripper and injection wells used to treat and dispose of the ground water were installed at the site in 1986, modified in 1987, and shut down in 1989 due to numerous problems. One of the problems was mineral fouling in the injection wells. This problem was caused by the water not being properly treated for iron, manganese and other minerals prior to either air stripping or re-injection.

10. Atex/Fina is not an appropriate case to compare with the Sparton case for the following reasons:

a. Atex/ Fina is located in a chemically reducing, inner-valley hydrogeologic environment, while Sparton is located outside of the inner valley in an oxidizing environment;

b. Atex/Fina involves gasoline, while Sparton involves chlorinated solvents; and

c. at Atex/Fina, the water was not properly treated for minerals prior to air stripping or re-injection.

Singer/Digital

11. The Singer/Digital case is much more appropriate to compare with Sparton. This site, located at 5600 Jefferson Blvd., NE in Albuquerque, was used as a manufacturing facility by the Singer Company and then by Digital Equipment Corporation. Like Sparton, the Singer/Digital site is located outside of the inner Rio Grande Valley in an oxidizing environment, and involves chlorinated solvents.

12. Pursuant to WQCC Regulations, and with NMED oversight and approval, Digital conducted a hydrogeologic investigation, completed soil-vapor extraction, and installed a ground-water, air-stripping and re-injection system. I approved Digital's ground-water treatment system in my official NMED capacity on September 28, 1995. Digital's design included three extraction wells, water-treatment with a sequestrant scale-corrosion control product, a tray air-stripping unit, and two re-injection wells.

13. The system became operational on February 28, 1996, and has successfully processed approximately 114 gallons per minute (gpm) of ground water for the past year. In fact, system performance demonstrated that only one of the two designed injection wells was necessary.

Other Cases

14. Re-injection of treated ground water is occurring at many other sites in New Mexico. Based on my knowledge and experience, mineral and biological fouling problems have been

successfully prevented and controlled by chlorination, acidification and by the use of sequestrant scale-corrosion control products. Aqua Mag is such a commercial product commonly used in New Mexico.

15. New Mexico Governor Gary Johnson signed Executive Order 96-30 directing state agencies to improve water conservation. Pursuant thereto, NMED Secretary Mark E. Weidler issued a directive that treated ground water should be re-injected rather than pumped to waste.

FURTHER AFFIANT SAYETH NAUGHT.

Dennis McQuillan
AFFIANT

SUBSCRIBED AND SWORN to before me this 24th day of February, 1997 by Dennis McQuillan, Affiant.

Gloria S. Lopez
NOTARY PUBLIC

My Commission Expires:

June 1st 1998

A F F I D A V I T

STATE OF NEW MEXICO)
) SS
COUNTY OF SANTA FE)

I, Baird Hemingway Swanson, being first duly sworn upon my oath, depose and state as follows:

1. My name is Baird Hemingway Swanson.

2. I have a Bachelor of Science Degree in Geology from the University of New Mexico with a minor in Chemistry, Mathematics and Physics, and in Spanish language.

3. I have 19 years of professional experience: eight years in petroleum exploration as a consultant and ten years as a regulator for the State of New Mexico, including private geologic consulting.

4. I have provided technical testimony for the N.M. Legislature, the New Mexico Water Quality Control Commission, and in N.M. District Court in the area of investigation and remediation of soil and ground-water contamination.

5. I am currently employed by the New Mexico Environment Department (NMED) Ground Water Quality Bureau as senior technical staff for the Assessment and Abatement Program.

General Electric Superfund Site

6. The G.E. Superfund site, is located in Albuquerque's south valley on Broadway SW between Woodward Rd. and Rio Bravo Rd. The groundwater at the site is contaminated with both chlorinated solvents and petroleum hydrocarbon contamination. The ground water cleanup pump-and-treat system was designed and constructed by Smith Technology Corporation (Smith). Treated ground water is reinjected utilizing one 6 inch diameter by 400 +/- foot depth and nine 8 inch diameter by 400+/- foot depth injection wells at the site.

7. The first 6-inch diameter well, IW-631, was constructed as the

first well to receive pumping test water and well development water. It was first able to inject approximately 120 gallons per minute (gpm) for about 15-20 minutes. Thereafter, the injection rate slowed to a constant 35-40 gpm. Smith had initially believed the injection problems to be related to bio-fouling, however, that turned out not to be the case. Instead, Smith discovered that their descalant injection system was defective because it was not adding enough descalant. Smith also believed that at least part of the problem with IW-631 was due to the size limitation of having to use a 200 gpm pump in a 6-inch diameter well for development purposes. The 8-inch wells were subsequently developed with 600 gpm pumps.

8. Smith's review of logs and cuttings revealed that IW-631 was completed with the top of screen set through a thick section of clay, which was not previously recognized as extensive in the area. Further review of the IW-631 well development and injection curves showed that the clay layer was acting as a laterally extensive confining layer. The injection capacity, even after redevelopment, never exceeded 35-40 gpm, further supporting this evaluation. Such confining layers and silty to clayey units do not exist at the Sparton site.

9. The additional nine 8-inch diameter injection wells, IW-632 through IW-640, were redesigned due to the performance of the IW-631 to be screened above the extensive clay layer, so as to allow for unconfined aquifer injection capacity. This, along with better development possible from tripling allowable development rates to 600 gpm, resulted in injection wells that have all been tested for injection capacity of 300 gpm each, or a grand total injection capacity of 2735 gpm, not the 820 gpm cited by Gary Richardson. Actual reinjection flow is currently averaging 788 gpm. While it is true that one of the 8 inch wells is scheduled for redevelopment, it was attributed to the descalant injection problem allowing precipitation to occur in the well nearest the treatment building.

10. Each of the above-described wells initially cost $ 80,000.00 per well, and if necessary, Smith plans to redevelop once every 2 years of operation with a cost of 10,000.00 per well.

Chevron Site

11. The Chevron Bulk Terminal is situated to the east of the GE site. There are four 8-inch diameter wells 120+/- feet deep at the site to reinject treated ground water. Gravity feed, rather than pumping, is used to dispose of ground water. The total gravity feed capacity of these wells is 40 gpm per well (total 160 gpm), however, the pumping injection capacity is 140 gpm per well (total 560) gpm. No problems have been reported at the Chevron site.

FURTHER AFFIANT SAYETH NAUGHT.

[signature]

AFFIANT

SUBSCRIBED AND SWORN before me this day 24th day of Feb, 1997, by Affiant.

[signature]

NOTARY PUBLIC

My Commission Expires:

June 1st 1998

AFFIDAVIT

STATE OF NEW MEXICO)
) ss.
COUNTY OF SANTA FE)

I, Robert Adam Pine being first duly sworn upon my oath depose and state as follows:

1) I received a Master of Science degree in Hydrology from The New Mexico Institute of Mining and Technology, a Master of Arts degree in Mathematics from the University of Utah and a Bachelor of Science degree in Mathematics from the University of Utah.

2) I have worked as a hydrologist for the Ground Water Quality Bureau of the New Mexico Environment Department from June of 1993 to the present.

3) I have been qualified as an expert witness in hydrology on two different occasions for public hearings concerning ground water discharge plans.

4) I received a copy of a report submitted by Gary Richardson of METRIC Corporation (METRIC) to the USEPA titled "On the Use of Injection wells at Groundwater Remediation Sites". In this report, Mr. Richardson lists what he considers to be the 12 potential causes of injection well clogging and states that all 12 potential problems would have to be overcome if treated water is reinjected at the Sparton site.

5) In pursuit of the listed references in Richardson's report, I asked METRIC for copies of these documents. METRIC was only able to furnish 2 of the 8 references that I asked for. I was told that the other 6 references could be obtained at the University of New Mexico science and engineering library. I was unable to locate the remaining 6 references through the use of the library's computerized database system and consequently did not review them.

6) Each of the 12 problems listed by Mr. Richardson associated with reinjection must be considered when designing a reinjection system. Each of these problem is listed below with some additional comments on cause, prevention and remedy and on the relation to the Sparton site:

7) Suspended Particles in the Recharge Water - This is one of the most common causes of injection well clogging. The rate of clogging and the extent of clogging depends on the sediment load, the particle size distribution in the injection water, and on the aquifer and gravel pack characteristics. Suspended particle clogging can be dramatically reduced by filtration of the water prior to reinjection. The finer the filter, the fewer the particles that will be injected, but the more expensive the filtration system. Maintenance requirements will also increase with a finer filter.

According to Huisman and Olsthoorn (1983, *Artificial Groundwater Recharge*, Pitman Advanced

Publishing Program), "the removal of clogging by suspended matter can easily be obtained by well cleaning". They state that back-pumping can remove 80% - 90% of the sediment. Back-pumping (or redevelopment) is a standard maintenance procedure for injection wells.

8) Bacterial Contamination of the Aquifer by the Recharge Water and Subsequent Clogging by Bacterial Growths - For pump and treat systems with reinjection, this problem is more likely to occur in hydrocarbon contamination sites than solvent contamination sites due to the hydrocarbons acting as a food source for bacteria. Hydrocarbons are not present at the Sparton site. However, other environmental conditions can favor the growth of certain bacteria such as iron bacteria.

The growth of bacteria in an injection well or surrounding gravel pack or aquifer can be prevented by treating the injection water to inhibit bacterial growth (e.g., adding chlorine to a 1 - 2 ppm residual). Another method if bacterial growth is not a severe problem is to periodically dose the well with chlorine to "burn" away any bacterial growth.

9) Chemical Reactions Between the Groundwater and Recharge Water of Different Quality Causing Precipitation of Insoluble Products - These reactions take place in the mixing zone between the injected water and the native ground water. The most common reactions that may occur are the precipitation of calcium carbonate and the precipitation of iron and manganese oxide hydrates. The more similar the two waters are, the less the chemical reaction between them. Differences in temperature between the two waters can result in carbonate precipitation since the carbonate system equilibrium constants are strongly temperature dependent.

There are various ways to help prevent clogging due to chemical precipitation. pH adjustment of the injection water to prevent calcium carbonate precipitation is one effective preventative measure. Technologies exist to precipitate calcium carbonate out of the injection water prior to injection (as is being done at the Chevron site in Albuquerque). To minimize metal oxide precipitation, injection water can be pre-treated to sequester the metals. Metals can be sequestered by the addition of a sequestering agent such as an ortho/polyphosphate blend (as is being done at the Digital and the GE South Valley sites in Albuquerque). If clogging due to precipitates does occur, an acid treatment can be applied to attempt to dissolve the precipitates. The degree of success of this treatment will depend on the extent of clogging.

Currently, as Sparton pumps ground water as part of their existing interim pump-and-treat system, a considerable amount of calcium carbonate is precipitated out in the delivery pipe system and in the air stripper lowering the calcium and bicarbonate concentrations in this water. Such water if it were reinjected into ground water would not be likely to precipitate calcium carbonate. Clearly, Sparton could remove calcium carbonate in a controlled manner from extracted ground water and eliminate the threat of calcium carbonate clogging from reinjection. Presently, Sparton is not having problems with metals precipitation in the piping or air stripper suggesting that Sparton would not have problems with metal precipitation due to the reinjection of treated water.

10) Mechanical Jamming of the Aquifer - This is a decrease in pore space, thus lowering the permeability of the aquifer in the immediate vicinity of the well, due to the periodic reversal of

flow in the well. According to Huisman and Olsthoorn (1983) the adverse effects from mechanical jamming are small.

This is not expected to be a concern at the Sparton site as adverse effects are small and flow reversal will not be a frequent occurrence.

11) Swelling of Clay Colloids in the Aquifer - This is caused by lowering of the ionic strength of the ground water in the aquifer or by the reduction of the ratio $(Ca^{2+} + Mg^{2+})/(Na^{+} + K^{+})$. This problem, once created, cannot be readily reversed. If the injection water is of significantly lower ionic strength than the native ground water, $CaCl_2$ can be added to the water to prevent swelling (assuming that this would not cause calcium carbonate precipitation problems).

If calcium carbonate is removed from the water to be reinjected, this would lower the ionic strength and the $(Ca^{2+} + Mg^{2+})/(Na^{+} + K^{+})$ ratio of the reinjection water relative to the native ground water and so some pretreatment to prevent swelling in the mixing zone might be required.

12) Incrustation Created by Injection Water that is High in Mineral Content - This is effectively covered in # 9 and is would not be a problem at the Sparton site.

13) Ion Exchange Reactions resulting in Clay-Particle Dispersal - According to Huisman and Olsthoorn (1983), this is caused when fresh water is injected into a saline aquifer.

This is not expected to be a factor at the Sparton site.

14) Precipitation of Iron in the Injection Water Due to Aeration - This may be a problem only if the water to be injected is sufficiently high in dissolved iron. Aeration of the water through air stripping to remove volatile contaminants will raise the oxidation potential of the water and may cause the precipitation of iron hydroxides. This problem can be prevented by the same methods described in #9 above.

15) Injection Tubing Corrosion - If this should prove to be a problem, occasional replacement of the injection tube may be required.

16) Biochemical Changes in the Recharge Water and Groundwater Involving Iron Reducing Bacteria or Sulfate-Splitting Organisms - Effectively covered in #8 above. If injection water is kept free of bacteria through pretreatment, this will not be a problem.

17) Gas Binding or Air Entrainment in the Aquifer - This can be a serious problem. There are two processes by which air bubbles can be injected into the aquifer where they can effectively clog the aquifer and cause increased injection head. The first is if water is injected in such a way that air bubbles are introduced into the water within the injection system (e.g. free fall of water down the injection well). This can be easily prevented by insuring that the injection tube extends well below the static water level in the well and that the water is diffused into the well. The other way that air bubbles can form is if the injection water is sufficiently colder than the native ground water that it is being injected into. The solubility of air in water decreases with temperature so the

warming of the injection water could liberate air into the aquifer. According to Huisman & Olsthoorn (1983), this can be compensated for by increasing the injection pressure which can be simply accomplished by maintaining the water in the well sufficiently higher than the static water level.

18) Change in Viscosity of Recovered Groundwater due to Temperature Difference between Recovered Groundwater to be reinjected and Receiving Groundwater - This in fact does not cause clogging, but will cause some head buildup in the aquifer surrounding the well which could be misinterpreted as a clogging problem. If the two waters are similar in temperature, this will not occur.

This is not a concern at the Sparton site.

19) The subsurface material at and around the Sparton site consists primarily of permeable sands and gravels with the occasional high clay-content layer. This type of material is excellent for reinjection and should easily accept 250 gpm from a single sufficiently deep 10 inch well if clogging is prevented.

20) Richardson notes that spreading basins are less problematic than injection wells. This should be restated to read "spreading basins may require less pretreatment than injection wells". I believe that Sparton should consider this technology in addition to injection wells and surface disposal.

21) In summary, reinjection is a fairly common and feasible means of disposal of treated water. If the chemistry of the injection water, the native ground water and the aquifer material is understood, injection water can be sufficiently pretreated to minimize problems and maximize the life of the injection well.

FURTHER AFFIANT SAYETH NAUGHT.

[signature]
AFFIANT

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