GROUNDWATER MONITORING AT THE WASTE ISOLATION PILOT PLANT*

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ABSTRACT

This paper discusses the Groundwater Monitoring Program (GMP) being conducted at the Waste Isolation Pilot Plant (WIPP) in Carlsbad, New Mexico. The Regulatory and Environmental Programs (REP) section of the Environment, Safety and Health department (ES&H) is responsible for conducting environmental monitoring at the WIPP. Groundwater monitoring is one of the ongoing environmental activities currently taking place. The REP section includes water-quality sampling and water-level monitoring.

The WIPP Project is a research and development facility designed to demonstrate the safe disposal of defense-generated TRU and mixed waste in a geologic repository. The Salado Formation of Permian age serves as the repository medium. The Salado Formation consists of bedded salt and associated evaporites. The formation is 602 meters thick at the site area; the top surface is located at a subsurface depth of 262 meters (10). The repository lies at a subsurface depth of 655 meters.

Water-quality sampling for physical, chemical, and radiological parameters has been an ongoing activity at the WIPP site for the past six years, and will continue through the life of the project. Data collected from this program to date, has been used by Sandia National Laboratories for site characterization and performance assessment work. The data has also been used to establish a baseline of preoperational radiological and nonradiological groundwater quality. Once the facility begins receiving waste, this baseline will be used to determine if the WIPP facility influences or alters groundwater quality over time.

The water quality of a well is determined while the well is continuously pumped. Serial samples of the pumped water are collected and tested for pH, Eh, temperature, specific gravity, specific conductivity, alkalinity, chlorides, divalent cations, ferrous iron, and total iron. Stabilization of serial sampling parameters determines if a representative sample is being obtained. Representative samples are sent to contract laboratories and analyzed for general chemistry and radionuclides. Samples are provided to the New Mexico Environmental Evaluation Group and Sandia National Laboratories for independent analysis.

INTRODUCTION

The WIPP, located approximately 30 miles east of Carlsbad, New Mexico, is a first-of-a-kind research and development facility, illustrated in Fig. 1. Public Law 96-164 defines the WIPP mission as "... a defense activity ... for the express purpose of providing a research and development facility to demonstrate the safe disposal of radioactive wastes resulting from the defense activities and programs of the United States exempted from regulation by the Nuclear Regulatory Commission."

This mission has been carried out by constructing a geologic repository 655 meters below the ground surface in a bedded salt deposit. Waste will be emplaced into this repository and the salt openings will be allowed to creep shut, effectively isolating the waste from the biosphere. The Department of Energy (DOE) manages the project; Sandia National Laboratories serves as the scientific advisor, and Westinghouse serves as the managing and operating contractor (MOC). To date no waste has been emplaced at the WIPP. The project is awaiting approval by the Secretary of the DOE to begin a five-year operational test phase.

As the MOC, Westinghouse operates the WIPP facility for the DOE, and is responsible for assuring that operations comply with all applicable federal and state regulations; this compliance effort includes groundwater. REP has the responsibility for monitoring the quality of groundwater. This paper discusses the REP GMP.

Groundwater in the area of the WIPP site has been studied extensively; results have been summarized both in the WIPP Final Environmental Impact Statement (FEIS) of 1980 (Section 7.4), and the draft version of the WIPP Final Safety Analysis Report (FSAR), 1988, Section 2.5. It is known that groundwater exists in other formations both above and below the repository, but no known hydrologic

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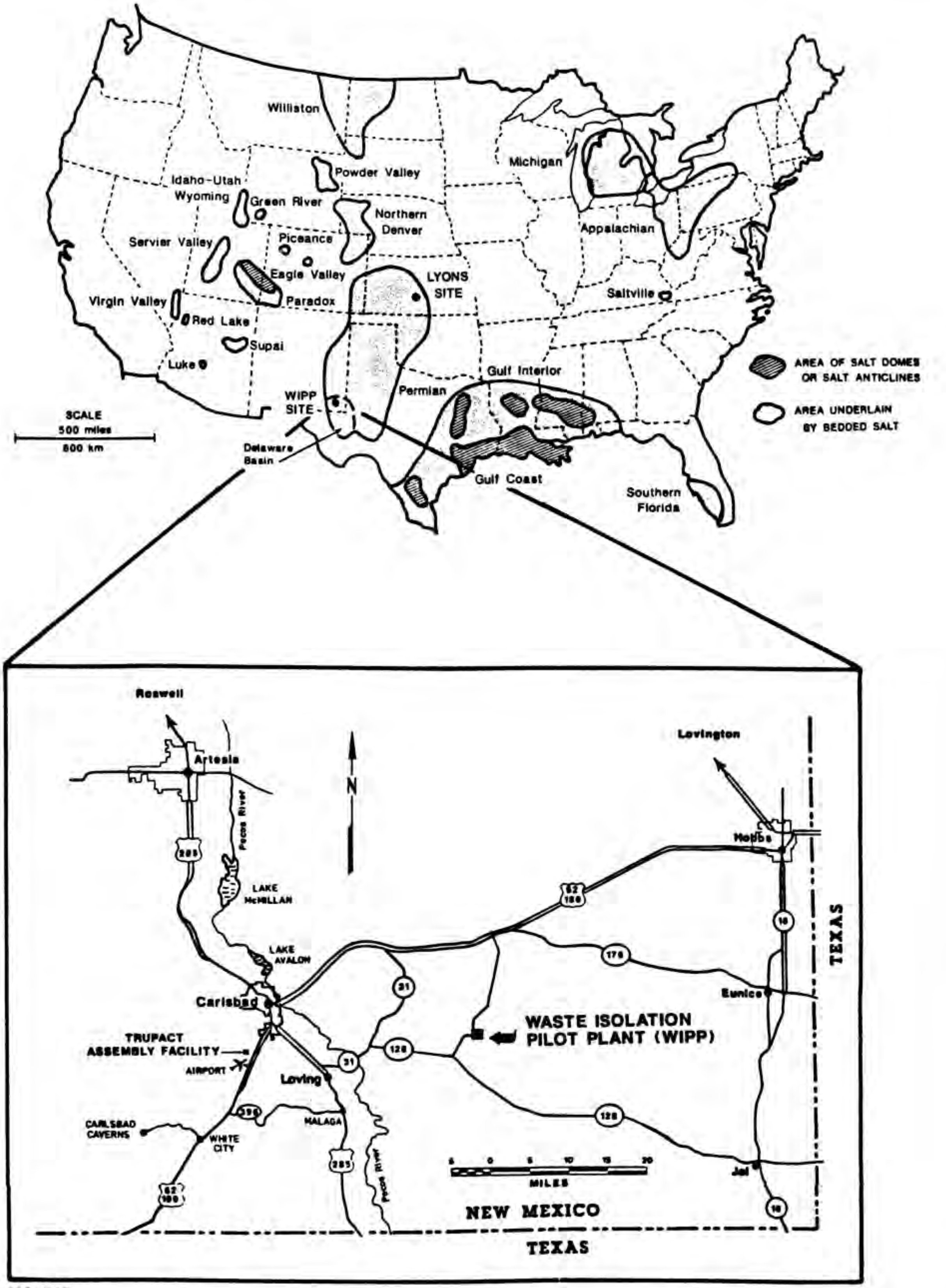

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Fig. 1. WIPP Site Location.

continuity exists between the repository and the groundwater.

Groundwater below the repository occurs in the sandstones of the Delaware Mountain Group (8), but is isolated from the repository by the bedded salt deposit in the lower part of the Salado Formation and the underlying Castile Formation. This groundwater is of very poor quality and, for the most part, can be considered a brine, as illustrated in Fig. 2 (8).

Groundwater above the facility is only found in limited quantities, and is usually of such poor quality that it is not usable (11, 12). The water occurs in three water-bearing zones: the Culebra Dolomite and Magenta Dolomite (both members of the Rustler Formation), and the Dewey Lake Redbeds. These zones appear to be isolated from one another by low permeable units. At some locations the water is of marginal quality and is used for watering livestock. One private well (located approximately 10 kilometers south southeast of the WIPP site) supplies drinking water to a local ranch from the shallowest water-bearing zone, the Dewey Lake (9). With the exception of the man-made shafts at the WIPP, all of the water-bearing zones above the repository are isolated from the repository excavations by the bedded salt deposits in the upper two-thirds of the Salado Formation.

Of the Rustler Aquifers, the Culebra and Magenta are of primary importance in the WIPP safety analysis for two reasons: the travel times to the biosphere are shorter there than in the Delaware Mountain Group, and the greater hydraulic potentials in the Delaware Mountain Group provide a driving force for upward flow into the Rustler Formation (4). Because the Rustler Formation is considered to be the most feasible pathway for the transport and release to the environment of radionuclides, should the repository ever be breached, groundwater monitoring being conducted through the GMP focuses on this formation. No monitoring of water below the repository is currently being performed.

Water-Bearing Zones Above the Repository

The Culebra Dolomite member of the Rustler Formation is located approximately 37 meters above the Salado Formation and approximately 430 meters above the repository, as measured at ERDA-9 (10). The Culebra is persistent, but yields and the quality of water vary considerably from location to location. The dolomite is vuggy and is commonly associated with anhydrite (6). The Culebra has a low hydraulic conductivity; and it is a fractured unit that is best modeled as a dual-fracture permeable material. Water yields are small and the quality is saline (8).

The Magenta Dolomite member of the Rustler Formation is located approximately 69 meters above the top of the Salado Salt Formation and approximately 463 meters above the repository, as measured at ERDA-9 (10). The Magenta Dolomite is finely crystalline and dense. The Magenta also has a low hydraulic conductivity, mainly through fractures and contains limited amounts of poor quality water (8).

The Dewey Lake Redbeds are located approximately 94 meters above the top of the Salado Formation and approximately 488 meters above the repository, as measured at ERDA-9 (10). The formation consists of orange-red siltstone, mudstone, and some sandstone. The Dewey Lake Redbeds do not form a regional aquifer, but some permeable sand lenses are present that do yield small quantities of fresh water to a few private wells in and around the WIPP site (8).

Program Objectives

The objective of the REP GMP is to provide quantitative documentation characterizing the groundwater within and immediately surrounding the WIPP site, so that any quality variations with time can be documented. The program currently consists of two long-term activities: water-quality sampling and water-level monitoring. Data from the program is used by Sandia National Laboratories for groundwater studies (related to compliance with 40 CFR 191 Performance Assessment), and by Westinghouse to document water quality (that may impact operation of the facility).

The WIPP Project is mandated by the DOE to conduct a groundwater monitoring program in accordance with draft DOE Order 5400.1. Requirements of this program are that it supports resource management and complies with applicable environmental laws and regulations.

WATER-QUALITY SAMPLING PROCESS

The water-quality sampling process has been developed around the logistics of using groundwater wells that were not constructed for water monitoring activities. The wells that are available (a total of 62) were constructed for site characterization efforts and later transformed into monitoring wells. Their designs did not consider the geochemistry of the area, anticipated lifetime of the monitoring program, and the chemical parameters to be monitored.

Twenty-five of the 62 available wells are utilized for water-quality analyses, as shown in Fig. 3. Construction of the 25 water-quality sampling wells are of either K-55 or J-55 iron well casing ranging in diameter from 11.43 centimeters to 27.30 centimeters. The wells are considered to be fully penetrating with 13 completions of perforated casing, 11 open-hole completions, and one 6-meter Johnson 316 stainless steel well screen. As will be discussed later, a serial sampling process is utilized to decrease the sampling bias created by well construction deficiencies.

Two types of water samples are collected 1) serial samples, and 2) final samples. Serial samples are taken once a

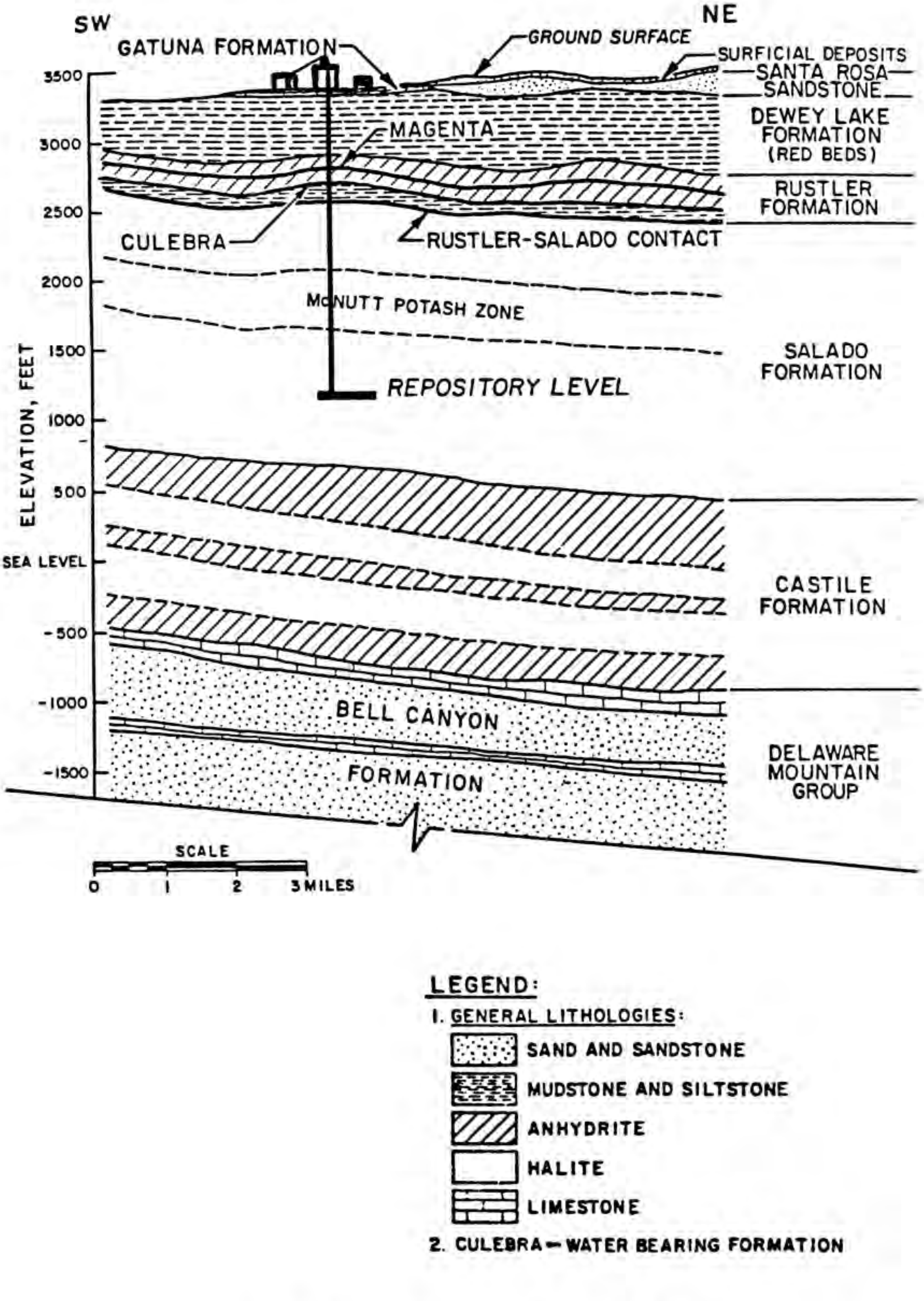

Fig. 2. Generalized Stratigraphy of the WIPP Site.

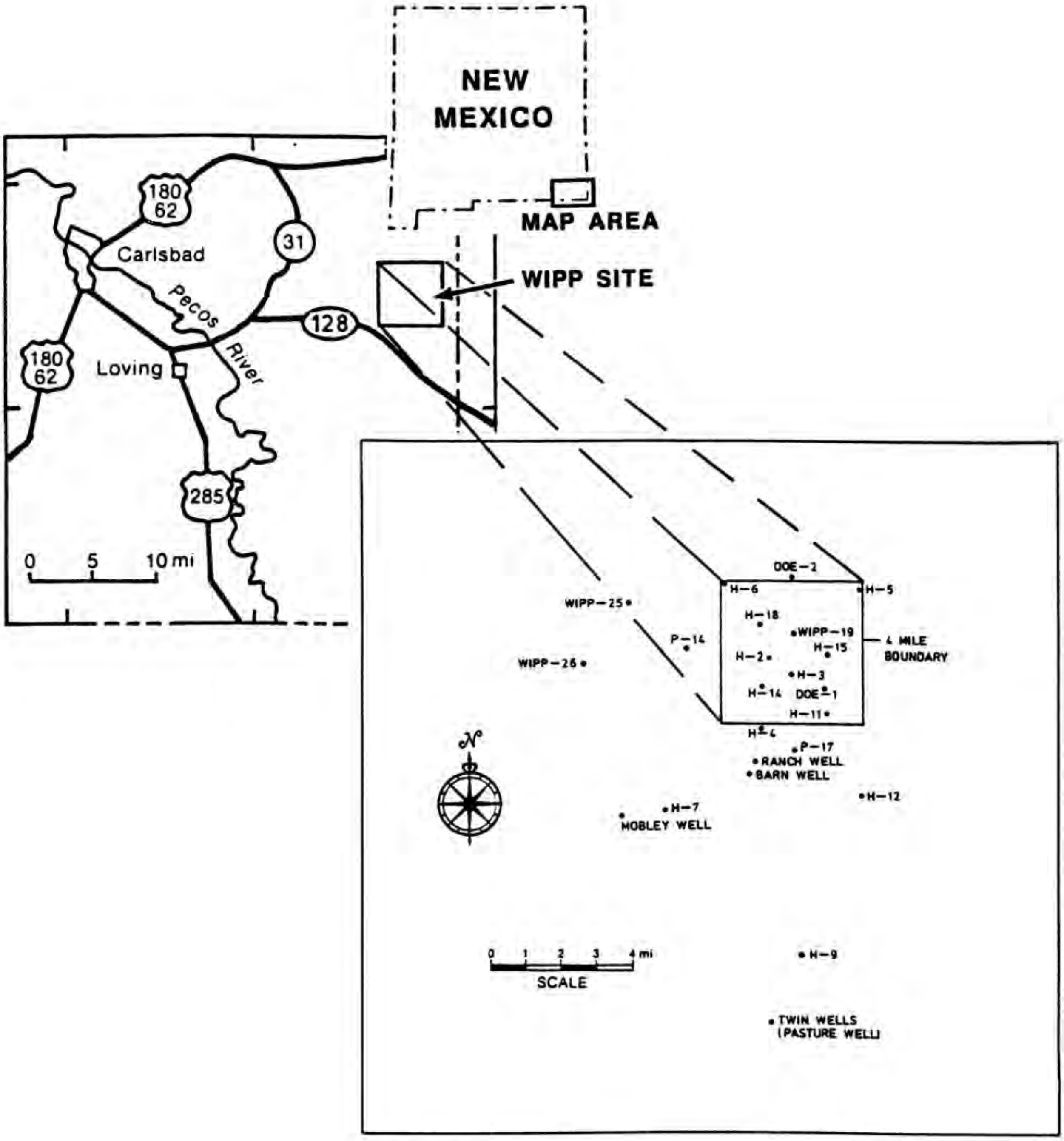

Fig. 3. Water-Quality Sampling Program (WQSP) Groundwater Sampling Locations.

day until key field parameters have stabilized. Stabilization of the field parameters indicates that the pumped groundwater is representative of the zone being sampled. A final sample is collected, once the pumped water has achieved a representative state, and is sent off the site to contract laboratories for analysis.

<u>Sampling Equipment</u>

Whenever possible, sampling is accomplished using a Bennett model air-operated piston-driven sample pump. In cases where the Bennett pump is not feasible a Grundfos SP-1-34s electric submersible pump is installed. Getting water to the surface involves use of the following equipment: 1) a pump packer assembly, 2) a pressure monitoring system, and 3) a data logging system.

<u>Pump-Packer Assemblies</u>

Figure 4 shows the typical Bennett pump-packer assembly used for water-quality sampling. The length of the average assembly is approximately nine feet. The pump is actually mounted above the packer and a drop tube (approximately two meters long) is fed through the packer base via a specially fabricated packer feedthrough nipple. The pump intake screen is attached below the packer. A packer is used in order to isolate the sampling zone from overhead stagnant wellbore fluid. The pump and packer are constructed of stainless steel, and a dedicated nylon sampling line is used for each individual wellbore.

The packer feedthrough nipple, in addition to the drop tube port, is equipped with additional feedthrough ports, one of which is utilized for a transducer feedthrough for pressure monitoring in the sampling zone. An additional bubbler tube may be attached in case of a transducer failure. The bubbler ports are optional and can be easily capped in the event that bubblers are not used.

<u>Pressure Monitoring Systems</u>

Pressures are monitored both above and below the packer to assure that the well is not pumped dry and to verify that the packer is properly sealed. If the packer seal is not good, stagnant wellbore fluid from above the packer can leak down into the sampling zone and bias analytical results. If the packer has a good seal the pressure above the packer should remain constant. Geokon 4500H vibrating wire downhole transducers are the primary monitoring devices used. If bubbler tubes have been installed, they will not be utilized unless a failure in the transducers occurs. In the event a transducer failure does occur, the downhole bubbler tube is connected to a continuous air line bubbler and a backup transducer is attached to the airline bubbler at the surface.

<u>Data Logging System</u>

Pressure data is continuously logged utilizing a Geokon Micro-10 Data Logger. The data logger has the capability to monitor six transducers simultaneously. This capability provides the option to monitor additional wells in the immediate area for drawdown due to pumping.

Pressure readings start before the packer is inflated and continue until after the pump is shut down at the end of the sampling period. Pressure data is logged at one minute intervals until formation pressures begin to stabilize. The logging interval is gradually increased until the intervals reach 30 minutes. Pressures and temperatures are logged every half hour until the end of the sampling period.

WATER-QUALITY ANALYTICAL PROCESS

Contamination of groundwater caused by inadequate well designs and construction materials (i.e., deterioration of the iron casing) biases analytical results. To overcome these problems, wells are not just purged a set number of times before a water sample is collected. Continuous pumping is established and wells are serial sampled until key physical and chemical parameters have stabilized. Stabilization of the key parameters indicates that the water is representative. This procedure provides for a more quantitative means of assuring that a representative sample is obtained for analysis.

The objective of the water-quality serial sampling effort is to obtain representative water samples in a reproducible manner. By definition a representative groundwater sample is undisturbed groundwater. A groundwater sample is considered to be representative of the undisturbed groundwater only if it is chemically identical to the undisturbed groundwater (i.e., unaltered by the effects of drilling, wellbore deterioration, and pumping agitation). A representative groundwater sample is, obviously, a theoretical ideal.

From 1985 to 1989 a groundwater quality baseline was constructed for groundwater within and surrounding the WIPP site (11, 12). The same parameters used to construct the baseline are now being monitored to document the quality of the groundwater through time in relation to the baseline.

Water-quality sampling analysis begins by taking serial samples at regular intervals, usually once per day, and analyzing them in the field for various physical and chemical parameters (herein called field parameters). When these field parameters appear stable the water is believed to be as representative as can be achieved. The stability is based upon the average of the previous three serial sampling analytical results, or baseline data. If key serial sampling

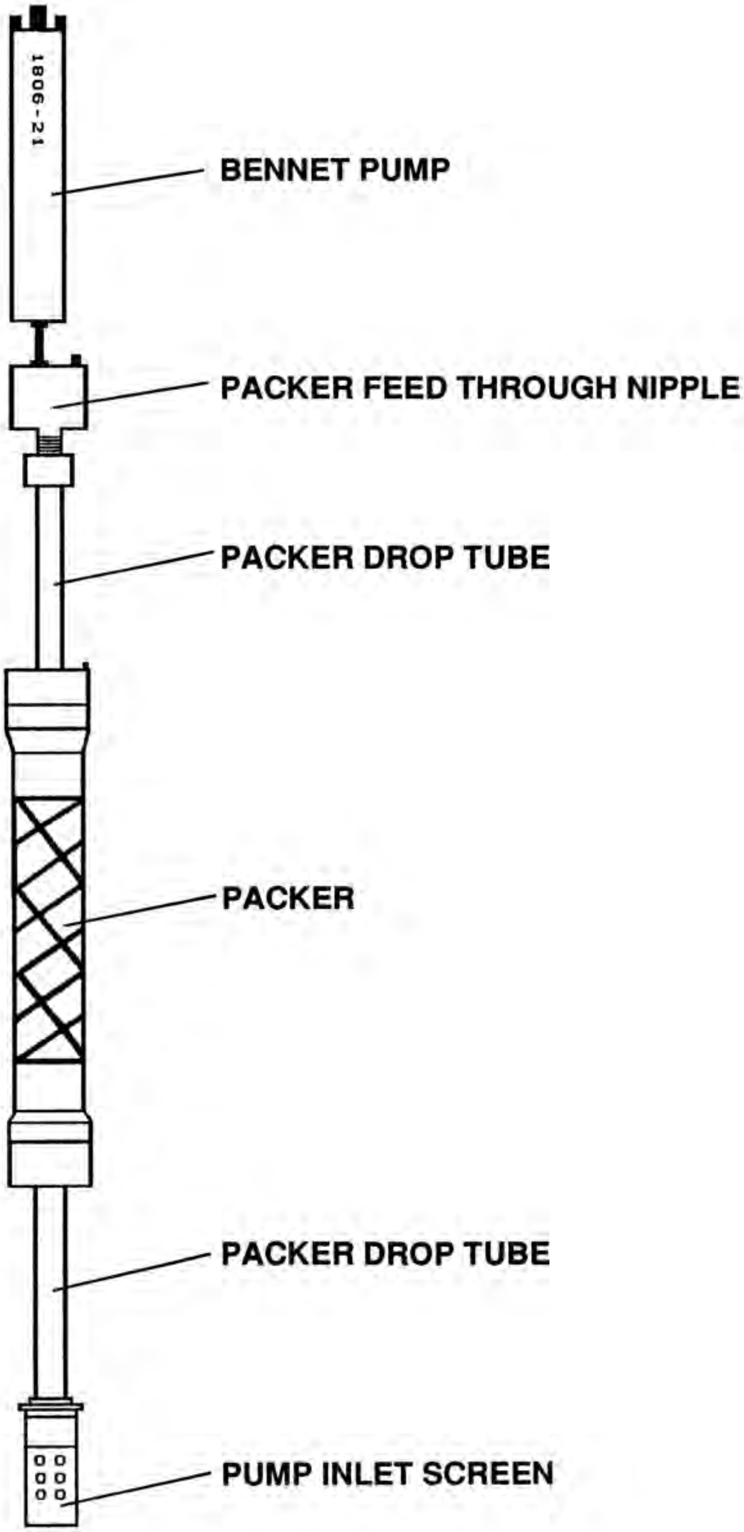

Fig. 4. Bennett Pump-Packer Assembly.

parameters are within ±5% of the average of the last three measurements for the present round, or to the average of the baseline data, then the water is judged as representative and a sample is collected for off-site laboratory analysis.

Water-Quality Sampling Field Parameters

The field parameters that are measured while serial sampling is in process and the frequency with which the analyses are performed are outlined in Table I. A mobile-field laboratory is utilized for conducting the analytical work on field parameters. An insulated sampling line is run directly from the wellhead into the lab. A detachable inline 45 μm sample filter is used for collecting filtered samples.

Physical field parameters include Eh, pH, temperature, specific gravity, and specific conductivity. Chemical field parameters include alkalinity, hardness (divalent cations), chlorides, and iron (both ferrous and total). Eh, pH, temperature, and specific gravity measurements are taken from unfiltered samples. Alkalinity, specific conductivity, hardness, chlorides, and iron (both ferrous and total) measurements are taken from filtered samples.

Standard field procedures are used for measuring physical parameters (13). Eh and pH are measured using an Orion SAS720 meter, Orion electrodes, and filling solutions. A printer is attached to each meter and readouts are incorporated into the sampling notes. Each meter is calibrated before use and a single point reference check is performed at the end of each analysis.

Hardness, alkalinity, and chlorides are measured using standard wet laboratory titration procedures (1, 2). Because of the high chloride content of the water (1,000 to 177,000 mg/l), these methods are usually performed on diluted samples. The same methods and titrants are used at every well, only the dilution ratios are changed to compensate for the location changes in groundwater composition.

Testing for total iron and ferrous iron (1) is made by spectrophotometric comparisons with standard concentration curves. The iron content is useful in determining the amount of interaction that has occurred between the wellbore fluid and the iron well casing through time.

Collection of a Final Sample

A final sample is collected once the pumped groundwater has been judged to be representative. Final samples are sent to contract laboratories and analyzed for general chemistry, radionuclides, and metals. Organics are analyzed periodically to verify that baseline organic levels have not changed. Gases and redox-couples were analyzed during the baseline study, but this data is not needed for environmental monitoring and is no longer obtained on a routine basis. Final samples are also supplied to Sandia National Laboratories and to the New Mexico Environmental Evaluation Group for independent analysis.

Final samples are collected at atmospheric pressure utilizing either the filtered (0.45 μm filter membrane) or unfiltered nylon sampling lines. The samples are collected in new and unused glass and plastic containers. Prior to collection of the final sample, all metal and radionuclide sample bottles are acid soaked with 10% reagent grade nitric acid solution for a minimum of 24 hours. Immediately before the final sample is taken, all containers are rinsed a minimum of six times with the pumped groundwater, either filtered or unfiltered, depending upon which parameter the

TABLE I
Serial Sampling Field Parameters

FIELD PARAMETER	APPROXIMATE FREQUENCY
Temperature	Daily
pH	Daily
Eh	Daily
Iron (total and ferrous)	Daily
Divalent cations	Daily
Chloride	Daily
Alkalinity	Daily
Specific conductance	First and Final Day
Specific gravity	First and Final Day

water will be tested for. Once the rinsing is completed the final sample is collected.

Many of the chemical constituents that are measured are not chemically stable and need to be preserved. Samples requiring acidification are treated with either high purity nitric acid or sulfuric acid.

Water-Quality Sampling Data Management and Results

Data is organized into computerized spreadsheets (Lotus 1-2-3) and translated into data base files (dBase III) for long-term storage. Work is currently underway to utilize statistical software (Statgraf) to develop time variation plots for key parameters at each well being monitored per guidelines issued by the U.S. Environmental Protection Agency (3).

WATER-LEVEL MONITORING

Water-level data is used to support ongoing groundwater modeling activities being performed by Sandia National Laboratories. The data is also used to determine the effects of pumping on regional flow systems and to predict flow directions.

Long-term water-level monitoring is conducted in 60 wellbores open to four separate water-bearing formations. Forty-eight wells are monitored on a monthly basis and twelve additional wells are monitored each quarter. Currently being monitored are 47 Culebra wells, 10 Magenta wells, 2 Rustler/Salado contact wells, and 1 Bell Canyon well.

Water-level measurements are conducted each month. An electronic water-level conductance probe is lowered to the water level, tripping a buzzer alarm when water is encountered. The graduated tape on the conductance probe is read, adjusted to the top of casing and recorded. The probe is then brought to the surface, rinsed with fresh water and wiped clean with a cloth or disposable towel. The procedure is repeated at each wellbore. Data is entered into a data base where the water level is calculated in feet and meters relative to mean sea level.

CONCLUSION

The groundwater monitoring situation at the WIPP is unique in that no known communication exists between the repository excavations and the groundwater zones located both above and below the excavations. Hydrologic modeling has shown that the groundwater zones above the repository excavations, within the Rustler Formation (specifically the Culebra and Magenta Dolomite members), represent the most feasible pathway for the transport and release to the environment of radionuclides, should the repository ever be breached. The REP GMP monitors the quality of water both within the Culebra and the Magenta.

The program does not utilize wellbores that were initially constructed for use as groundwater monitoring wells. The wellbores are constructed of iron casing, and the construction materials bias the character of the water. To alleviate this condition wells are continuously pumped and serial sampled until field parameters have stabilized. Then the sample is sent to a contract laboratory for analysis.

All nonradiological data for this program is published on a yearly basis in annual water-quality data reports. The data reports list all information connected with the data acquisition, as well as the analytical data determined both in the field and through contract laboratories. The radiological data is published annually in Radiological Monitoring Program Reports. Both reports are prepared by the REP section.

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