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LONG-TERM HYDROLOGIC MONITORING PROGRAM

PROJECT GASBUGGY

RIO ARRIBA COUNTY, NEW MEXICO

Prepared by:
Environmental Branch
Health Physics Division
Nevada Operations Office
U. S. Department of Energy

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ABSTRACT

The Gasbuggy site is located in Rio Arriba County, New Mexico, approximately 55 air miles (88.6 kilometers) east of Farmington, New Mexico. The Gasbuggy device with a yield of 29 kilotons, was detonated December 10, 1967. It was the first U.S. underground nuclear experiment for the stimulation of low-productive natural gas reservoirs (Reference 1).

The purpose of the Long-Term Hydrologic Monitoring Program at the Gasbuggy site is to obtain data that will assure the public safety; inform the public, the news media, and the scientific community relative to radiological contamination; and to document compliance with federal, state, and local antipollution requirements.

The Gasbuggy site geographical setting, climate, geology, and hydrology are described. Site history, including Gasbuggy event information and Gasbuggy monitoring by the U.S. Public Health is described.

Site cleanup activities conducted in 1978 are described. Postoperational surveys indicate that the Gasbuggy site is well below the established decontamination criteria and that no hazard exists or will likely occur during public use of the land surface of the Gasbuggy site.

The Long-Term Hydrologic Monitoring Program for the Gasbuggy site is described.

LONG-TERM HYDROLOGIC MONITORING PROGRAM

PROJECT GASBUGGY

RIO ARRIBA COUNTY, NEW MEXICO

I. INTRODUCTION

The Nevada Operations Office (NV), U.S. Department of Energy (DOE)*, acknowledges the responsibility of obtaining and having available for dissemination, data for all locations where nuclear devices have been tested appropriate and adequate to:

1. Assure the public safety.

2. Inform the public, the news media, and the scientific community relative to radiological contamination.

3. Document compliance with existing federal, state, and local anti-pollution requirements.

This responsibility can best be fulfilled by execution of a long-term hydrologic monitoring program. This program is carried out by the Nuclear Radiation Assessment Division, Environmental Monitoring Systems Laboratory, U.S. Environmental Protection Agency, Las Vegas, Nevada (EPA/EMSL-LV) under the cognizance of the NV/DOE. The program was initiated in 1972.

It is contemplated that the long-term monitoring program will remain in effect until, based on program results, action is taken to modify or terminate it.

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*Under the provisions of the Energy Reorganization Act of 1974, the U.S. Atomic Energy Commission (AEC) was abolished on January 19, 1975, and the U.S Energy Research and Development Administration (ERDA) established in its place. By executive order, ERDA was abolished on September 30, 1977, and the Department of Energy (DOE) was created to perform essentially all of the programs carried out by the AEC/ERDA. Most of the activities described herein occurred prior to the establishment of ERDA/DOE; therefore, for the purpose of this report, AEC will be used for activities prior to January 19, 1975, ERDA for activities from January 20, 1975, to September 30, 1977, and DOE for activities after that date. Any and all commitments made by the AEC and ERDA will be honored by DOE.

II. SITE DESCRIPTION

A. Geographic and Topographic Setting

The Project Gasbuggy site is located in the southwest quarter of Section 36, T29N, R4W, New Mexico Principal Meridian. It is located on the eastern side of the San Juan Basin, a structural feature of the Colorado Plateau Province located in northwestern New Mexico and southwestern Colorado (References 2 and 3). (See Figure 1). The nearest town is Farmington, New Mexico, 55 air miles (88.6 kilometers) to the west of the site with a population of 23,000. The nearest community is Dulce, New Mexico, 20 miles (32.2 kilometers) to the northeast with a population of about 500. There were no habitations within a 5-mile (8.1 kilometers) radius at the time the Gasbuggy experiment was conducted (Reference 4). The population remains the same at the date of this publication. The test location is surrounded by typical canyon and plateau topography of the Colorado Plateau province. Elevations range from 6,800 to 7,500 feet (2073.2 to 2286.6 meters) in the surrounding area and from 7,000 to 7,300 feet (2134.1 to 2225.6 meters) in the immediate test area. The San Juan River, at its nearest point, is 20 miles (32.2 kilometers) away. Navajo Dam, which was completed in 1963, is located some 23 miles (37 kilometers) distant (Reference 5).

B. Climate and Meteorology

Climatological data for the Gasbuggy area have been collected at Governador, New Mexico (El Paso Camp) for a 20-year period of record.

This station, located about 10 miles (16.1 kilometers) from ground zero is considered representative of the Gasbuggy area. The average annual precipitation is 48.91 inches (122.28 cm), which includes an average annual snowfall of 37.2 inches (93 cm). Temperatures range from the lower 70°s F (21°C) in July and August to the upper 20°s F (-6.7°C) in December. Recorded extremes are +105°F (40.6°C) in August to -28°F (-33.3°C) in February.

Event-oriented forecasts of winds, weather, vertical atmospheric stability, and air trajectories as well as estimates of potential radiation effects were presented to the Test Manager and his Advisory Panel in daily briefings. Flaring activities were conducted only when weather conditions were such that no off-site contamination was predicted (Reference 6).

C. Geology

Project Gasbuggy is located on the eastern side of the San Juan Basin. This structural feature is about 180 miles (289.8

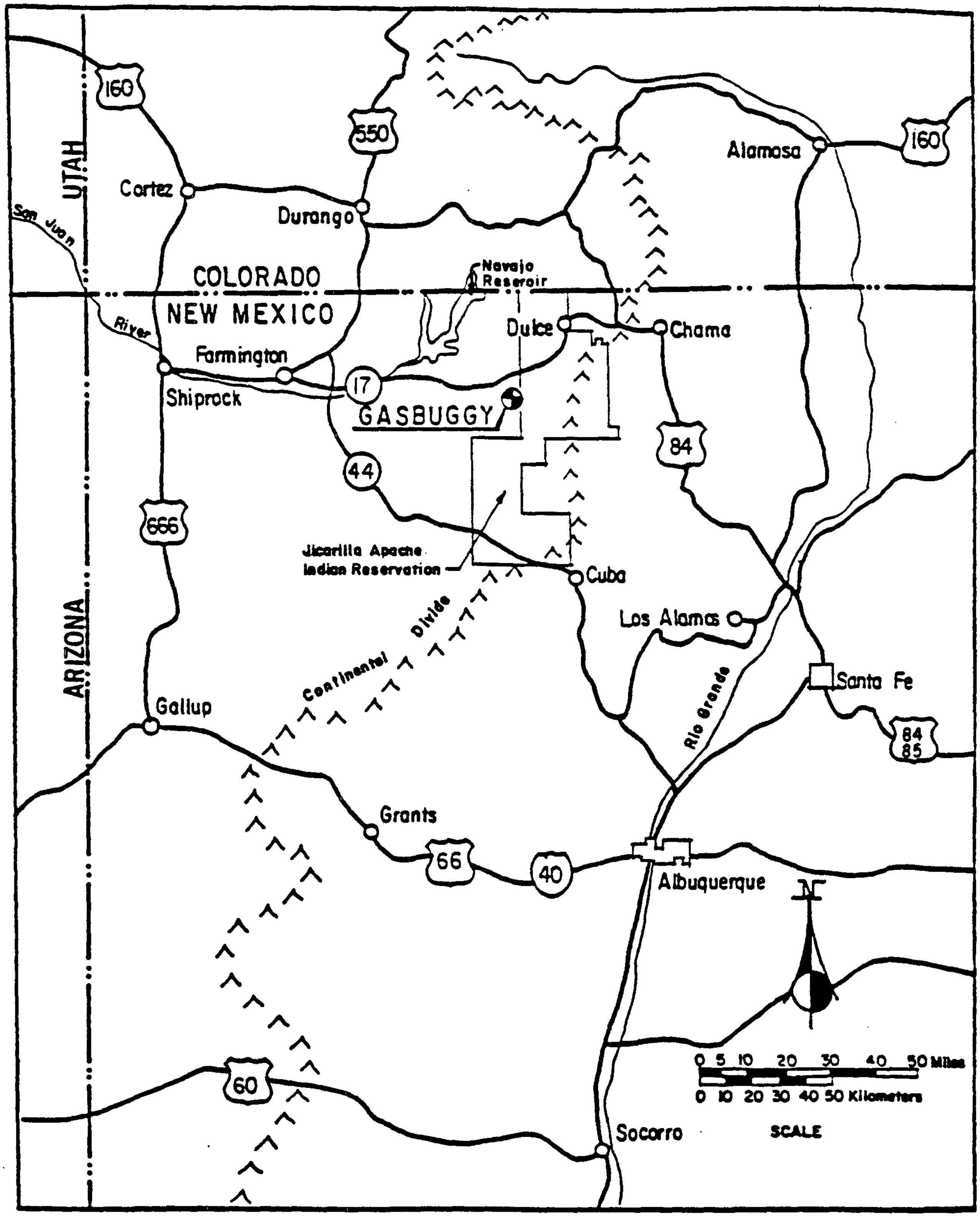


Figure 1. Location Map

kilometers) long and 135 miles (217.4 kilometers) wide. It covers the eastern part of the Navajo physiographic section of the Colorado Plateau Province. Rocks in and around the test site range in age from pre-Cambrian to recent. Total thickness of sedimentary rocks in the Central Basin range from 10,000 to 15,000 feet (3,048.8 to 4,573.2 meters). The formations penetrated by drilling at the Gasbuggy site are in descending order: Surficial alluvium (recent), San Jose formation, Nacimiento formation, the Ojo Alamo Sandstone formation all of Tertiary age, the Kirtland shale formation, the Fruitland formation, Pictured Cliffs sandstone formation, and Lewis Shale formation all of late Cretaceous age. The Pictured cliffs sandstone is of primary importance because it was within this formation that the Gasbuggy chimney was formed by the detonation in the underlying Lewis Shale (Reference 7). See Figures 2, 3, and 4 for stratigraphic section and geologic cross section.

1. <u>Pictured Cliffs Sandstone</u>

The Pictured Cliffs Sandstone is predominantly a marine sandstone. It is underlain by the Lewis Shale. At the Gasbuggy test site, the Pictured Cliffs Sandstone is about 290 feet (88.4 meters) thick and is chiefly a light-gray, fine- to very fine-grained sandstone interbedded with dark, sandy shales. The sandstone beds bear natural gas and contain minor coal fragments, carbonaceous layers, and traces of oil. The formation is not known to yield substantial amounts of water and is not a water producer at the Gasbuggy site.

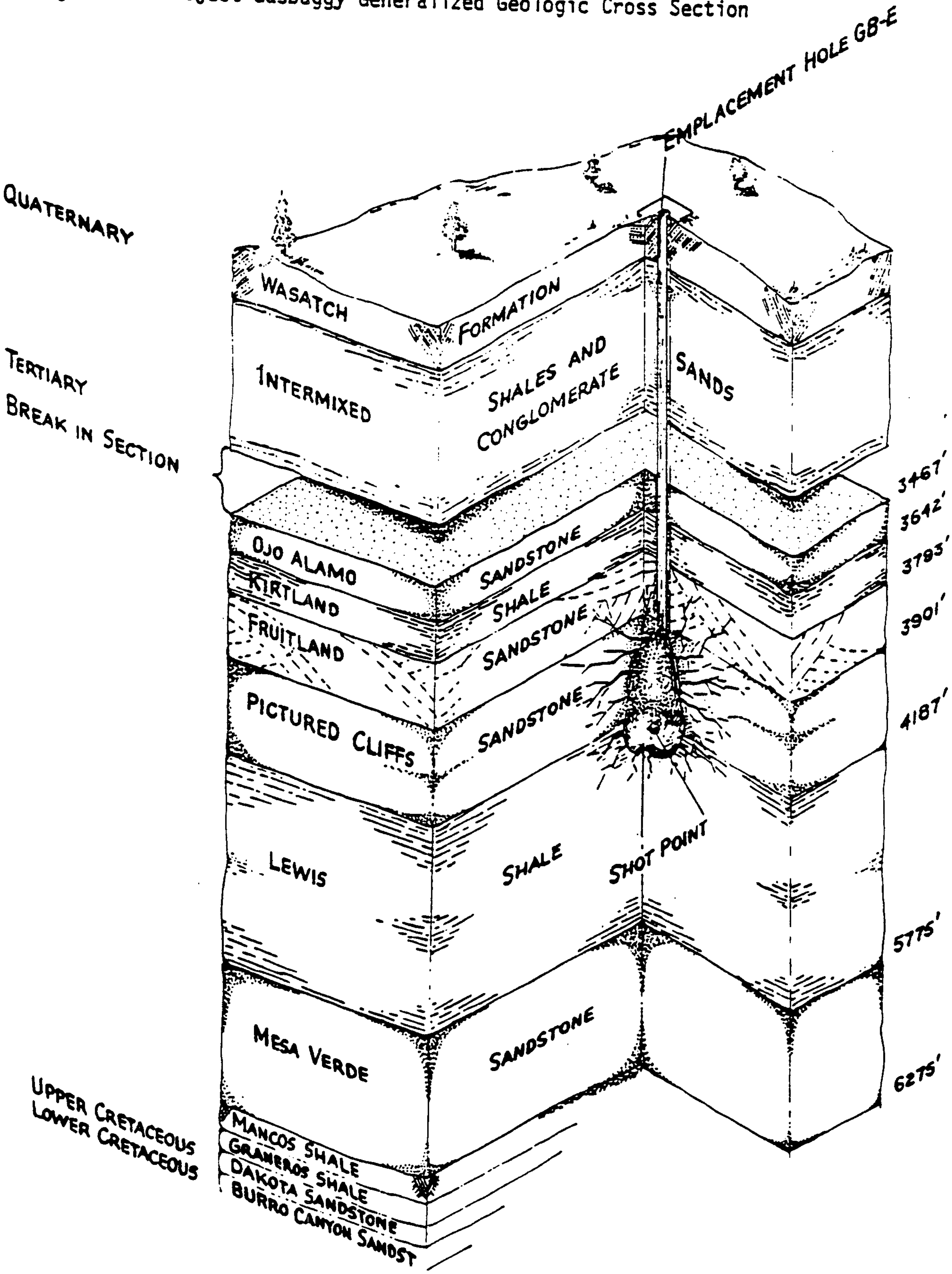
2. <u>Fruitland Formation and Kirtland Shale The Fruitland</u>

Formation and the Kirtland Shale overlie the Pictured Cliffs Sandstone in ascending stratigraphic order. These formations comprise a 260-foot (79.2 meter) interval of gray to dark-green shale and siltstone interbedded with thin, very fine- to medium-grained sandstone. Abundant carbonaceous material and coal generally are associated with beds of shale. Coal stringers in the Fruitland Formation yield small amounts of water in some parts of the basin. The Kirtland Shale lacks aquifer characteristics and probably does not release water to wells in the Gasbuggy area.

3. <u>Ojo Alamo Sandstone</u>

The Ojo Alamo Sandstone overlies the Kirtland Shale, and is about 180 feet (54.9 meters) thick at the Gasbuggy site. The formation consists primarily of a light-gray, fine- to medium-grained, clayey sandstone, but also contains a few

Figure 2. Project Gasbuggy Generalized Geologic Cross Section



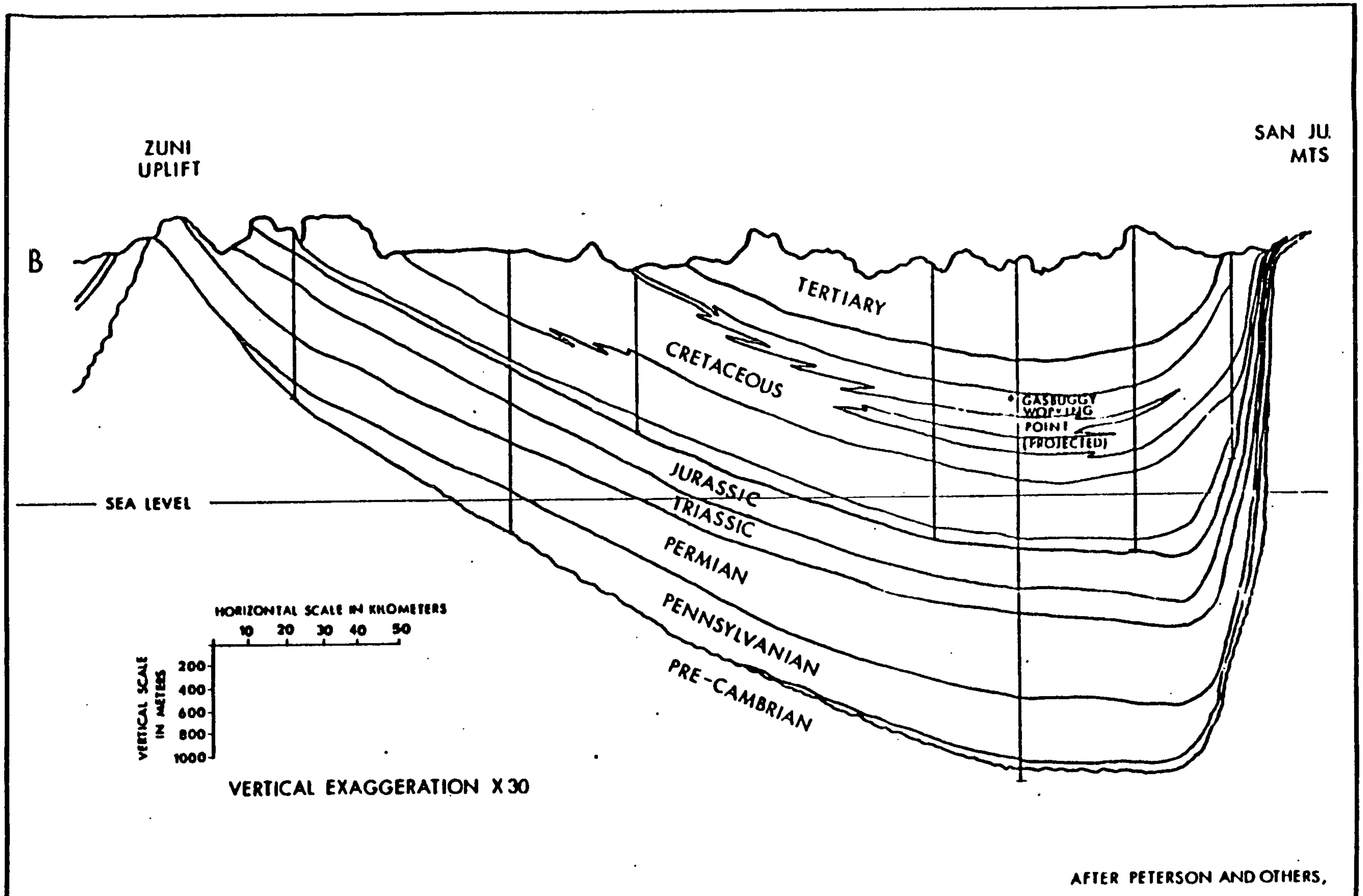


Figure 3. South-North Geologic Cross Section Across the San Juan Basin

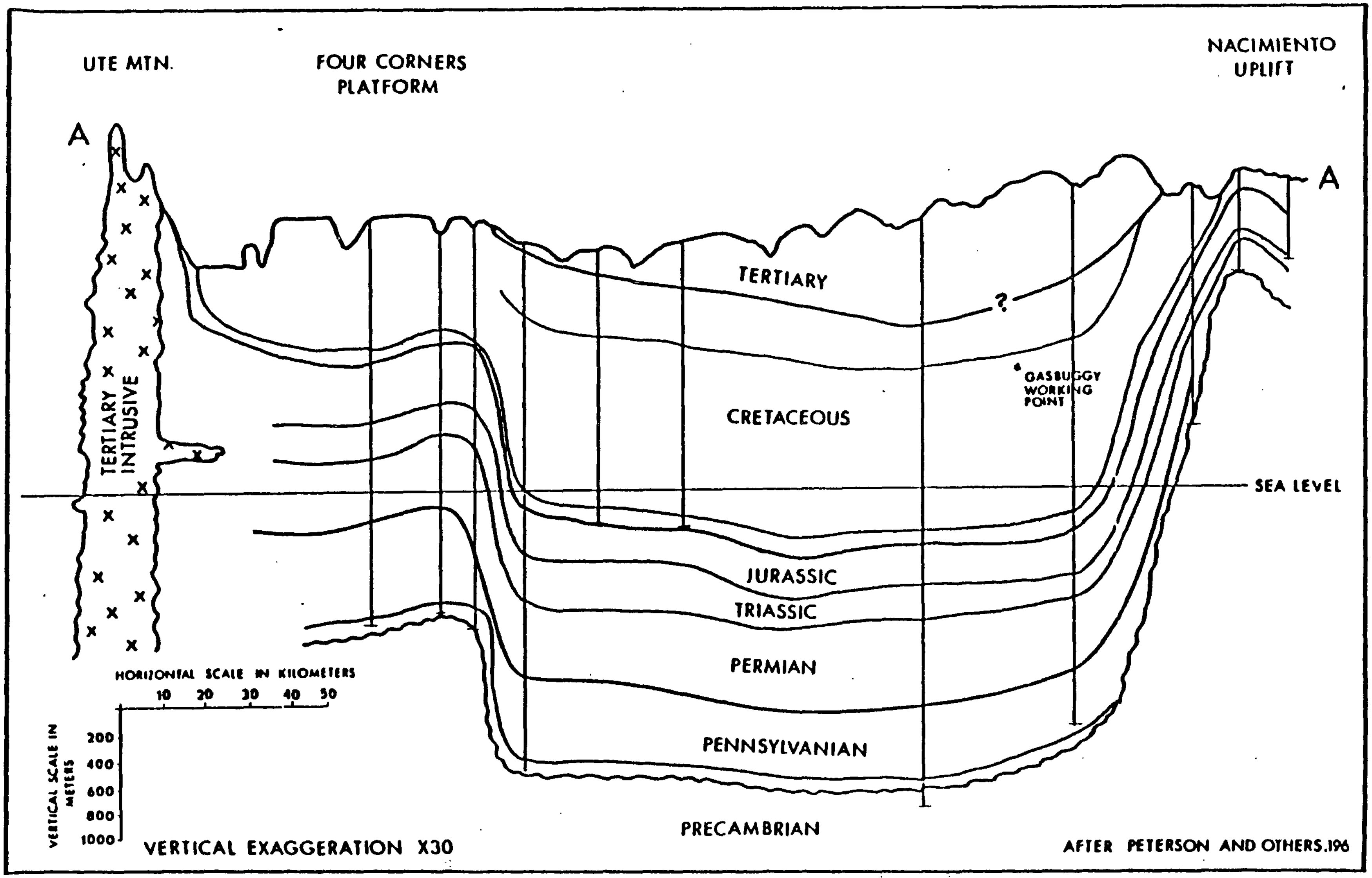


Figure 4. West-East Geologic Cross Section Across the San Juan Basin

minor beds of shale. The Ojo Alamo Sandstone generally is water bearing, and it yields water to domestic wells along the San Juan River 50 miles (80.5 kilometers) west of the test site where the formation is 1,700 feet (518.3 meters) higher than it is at the Gasbuggy site. At the test site, the formation yields minor amounts of water.

4. <u>Nacimiento and San Jose Formations</u>

The Nacimiento and San Jose Formations are continental flood-plain deposits and are the predominant surface formations in the Gasbuggy area. At the test site, they comprise a 3,500-foot (1,067.1 meters) sequence of fine- to medium-grained, locally conglomeratic sandstone, interbedded with claystone and sandy, varigated shale. The beds of sandstone in the San Jose and Nacimiento Formations commonly contain water, but these water-bearing zones probably are far enough above the explosion point at the test site to be unaffected by the nuclear event (Reference 8). See Tables 1 and 2 for stratigraphic sequences and Figures 3 and 4 for geologic cross sections across the San Juan Basin.

D. <u>Hydrology</u>

The surficial alluvium, the San Jose formation, the Nacimiento formation, and the Ojo Alamo sandstone are the principal acquifiers in the Gasbuggy area. The Ojo Alamo sandstone was the only water-producing formation considered to be within the "unlikely but remotely possible" range of fracturing from the nuclear detonation. Hydrologic testing was, therefore, limited to the Ojo Alamo sandstone.

The direction of groundwater movement in the San Juan Basin is not well known. The major discharge point for water moving in the Ojo Alamo Sandstone probably is the San Juan River, 50 miles (80.5 kilometers) northwest of the test site. An estimate of the rate of groundwater movement is computed by using known, or assumed, values for the permeability and porosity of the aquifer and for the hydraulic gradient of the water in the aquifer.

The coefficient of permeability of the Ojo Alamo Sandstone was determined to be about 0.017 gallons per day per square foot. This value was derived by using a coefficient of transmissibility of 3 gallons per day per foot (0.3 meter) and an effective aquifer thickness of 180 feet (54.9 meters), as determined from data collected from holes GB-1 and GB-2 (Reference 9). A hydraulic gradient of 30 feet (9.1 meters) per mile (1.61 kilometers) across the Central Basin was assumed. An average porosity of 13 percent was determined from core samples analyzed by Core Laboratories, Inc. Calculations based upon these values

TABLE 1: STRATIGRAPHIC SEQUENCE AT THE GASBUGGY SITE

Depth Meters (Feet)	System	Thickness Meters (Feet)	Description
	Tertiary	1,060 (3,476.8)	Shale and sandstone, varigated; of fluviolacustrine origin.
1,060 (3,476.8)			
	Cretaceous	1,420 (4,657.6)	(see Table 2)
2,580 (8,462.4)			
	Jurassic	520 (1,705.6)	Interstratified sandstone, siltstone, and shale with some evaporite deposits; of fluviolacustrine origin.
3,100 (10,168.0)			
	Triassic	200 (656.0)	Shale, siltstone, and sandstone, red; of continental origin.
3,300 (10,824.0)			
	Permian	700 (2,296.0)	Shale, siltstone, and sandstone, predominantly red, with evaporites; chiefly of continental origin with limestone of marine origin.
4,000 (13,120.0)			
	Pennsylvanian	500 (1,640.0)	Limestone and shale of marine origin and red sandstone of continental origin.
4,500 (14,760.0)			

TABLE 2: STRATIGRAPHIC SEQUENCE OF ROCKS OF CRETACEOUS AGE AT THE GASBUGGY SITE

Depth Meters (Feet)	Formation	Thickness Meters (Feet)	Description
1,060 (3,476.8)	Ojo Alamo Sandstone	50 (164.0)	Sandstone and conglomerate, yellow and gray; of fluvial origin. May be partly of Tertiary Age.
1,110 (3,640.8)	Kirtland Shale	40 (131.2)	Shale and Clay, with gray; of fluviolacustrine origin.
1,150 (3,772.0)	Fruitland Siltstone	40 (131.2)	Shale and fine-grained sandstone, gray; containing coal beds; of lagoonal and marine origin.
1,190 (3,903.2)	Pictured Cliffs Sandstone	90 (295.2)	Sandstone, grayish-white, fine- to medium-grained; containing bentonite shale; of marine origin. Gas-bearing.
1,280 (4,198.4)	Lewis Shale	480 (1,574.4)	Shale, gray, with sandy streaks; of marine origin.
1,760 (5,772.8)	Mesaverde Group	150 (492.0)	Sandstone, brown, with gray shale; of marine and lagoonal origin.
1,910 (6,264.8)	Mancos Shale	530 (1,738.4)	Shale, gray, with black shale, marl, limestone, and sandstone of marine origin.
2,440 (8,003.2)	Dakota Sandstone and Burro Canyon Formation	140 (459.2)	Sandstone, brown, with black shale.
2,580 (8,462.4)	Dakota Sandstone and Burro Canyon Formation		Sandstone, brown, with black shale.

indicate that the average rate of groundwater movement in the Ojo Alamo Sandstone across the basin is about 0.0001-foot ($3x10^{-5}$ meters) per day or 0.04 foot (0.012 meter) per year (Reference 10). In the unlikely event that fracturing reached this formation, the entry of water into the chimney would cause filling at an estimated rate of about 0.5 foot (0.15 meter) per day.

High total dissolved solids make water from this aquifer unsuitable for irrigation or domestic use (References 18 and 19).

The major discharge area for water moving from the event location in the Ojo Alamo sandstone is a point on the San Juan River, some 50 miles (80.5 kilometers) distant from the Gasbuggy site (Reference 11).

III. SITE HISTORY

A. Event Information

Project Gasbuggy (Plowshare Series) was sponsored by the Division of Peaceful Nuclear Explosives (DPNE). The Gasbuggy site is on an El Paso Natural Gas (EPNG) Company lease in the San Juan Basin and is surrounded by other EPNG lease holdings.

The primary purpose of the Gasbuggy experiment was to determine if nuclear stimulation could economically release gas that could not be economically produced from underground reservoirs by conventional methods. The experiment involved the detonation of a nuclear device designed to have a 29 kiloton (Kt) yield. This nuclear explosive was emplaced at a depth of 4,240 feet (1,292.7 meters) below the land surface in the Lewis Shale just below the natural gas-producing Pictured Cliffs sandstone formation. The Gasbuggy device was detonated on December 10, 1967 (Reference 12).

B. Contamination at the Site

There was no release of radioactivity and no report of damage from ground shock resulting from the detonation (Reference 15). Radiation from the event was essentially all contained in the event cavity, over 90 percent is contained in fused glass at the bottom of the cavity. Only drillback and flaring activities brought radionuclides to the surface.

The extent and levels of surface contamination at the Gasbuggy site were documented by soil and water sampling programs and site surveys by EPA, EPNG, and DOE (References 15 and 16).

During GB-2R reentry and flow tests of GB-ER and GB-2R in June and July 1968, 1,000 curies of ^{3}H and 141 curies of ^{85}Kr

were intentionally released to the atmosphere. The first GB-ER flow test, conducted from June 27 through July 4, released an estimated 500 curies of ^{3}H and 80 curies of ^{85}Kr. The second GB-ER flow test, which extended from July 5 to 15, resulted in the release of 500 curies of ^{3}H and 61 curies of ^{85}Kr.

USPHS monitoring and dosimetry data showed no detectable activity in the off-site area at any time during the above test period. The environmental sampling program indicated no radioactivity above background in daily air samples or water samples. Levels of ^{3}H above background, however, were observed in special air samples which collected moisture from the air and also in soil and vegetation samples. The highest concentration of ^{3}H in any of the air samples was 1,200 pCi/m^3 on June 29 at a distance of about 0.3 miles (0.48 kilometers) from the release point. This is less than 2 percent of the maximum permissible concentration for continuous exposure to a suitable sample of the population in uncontrolled area, 6.7×10^{4} pCi/m^3 for air.

During the reentry, flow testing and flaring operations, the weather and radiation predictions served to alert representatives of the AEC and USPHS to potential levels and probable trajectories of any radioactive effluent. On the basis of this information, radiological monitors were deployed and the capability was maintained to adequately protect both on- and off-site personnel in the event of a significant release of radioactivity. In those cases where radioactivity was released under a controlled situation, e.g., flaring, the release of radioactivity could have been reduced or terminated if unacceptable downwind radiation levels had been predicted or observed.

During the entire period from event execution through completion of flow testing operations, in July 1968, at no time were observed radiation levels high enough to constitute any hazard to the off-site population. All releases were well documented and controlled. No significant radiation exposures occurred (Reference 17). Analyses from these surveys indicated that there was no radiological contamination of soil or surface water which exceeded the DOE site restoration criteria listed in Table 3 below (References 15 and 16).

C. Site Cleanup

The extent and levels of surface contamination at the Gasbuggy site had been documented by soil and water sampling programs and site surveys by the EPA, EPNG, and DOE. For the site cleanup, the U.S. Department of Energy (DOE/NV) developed the restoration plan, provided the contractors to perform the required radiological and general support tasks, and directed and coordinated field activities through on-site project engineering and radiological personnel. Fenix and Scisson (F&S) provided the technical and administrative services to accomplish all well plugging and site restoration objectives except those associated with radiological support. Eberline Instrument Corporation (EIC) provided the technical direction and on-site supervision to accomplish all radiological decontamination and monitoring in accordance with DOE radiological criteria. El Paso Natural Gas Co. (EPNG) provided logistical support to include electrical and gas utilities supply and maintenance and liaison with U.S. Forest Service and U.S. Geological Survey personnel (Reference 13).

The site cleanup and restoration operations were conducted by these organizations from August through September of 1978 (Reference 14).

No burial of radioactive material was made at the Gasbuggy site during the cleanup operation. The tritium contaminated water and sludge from the "Red Tank" and decon sump were injected into the GB-ER cavity before the reentry well was plugged. Barrels of materials known to be slightly contaminated or difficult to determine actual radioactive content were sealed, externally steam cleaned, and labeled as low-level radioactive waste for shipment to NTS and burial in the low-level waste facility (Reference 18).

TABLE 3. **GASBUGGY SITE CLEARANCE CRITERIA**

SURFACE WATER	
Tritium	300 pCi/ml
BUILDINGS, EQUIPMENT, & MATERIALS	
Tritium (nonremovable)	5,000 pCi/100 cm^2
Tritium (removable)	1,000 pCi/100 cm^2
SOIL	
Tritium in Soil Moisture	30,000 pCi/ml
Beta-Gamma (including worldwide fallout) (measured at 1 cm)	0.05 mrad/hr

Items of material and equipment were radiologically surveyed in place and then either released for unrestricted public use or returned to the NTS for disposal.

All personnel participating in Gasbuggy cleanup were required to wear thermoluminescent dosimeter (TLD) badges and to provide baseline and final day urine samples. TLDs were sent to the EIC facility in Santa Fe, New Mexico, for readout. No radiation exposure was detected above normal background on the TLDs. The urine samples were analyzed on site. None exceeded the lower limit of detectability (LLD) (References 15 and 16).

D. Groundwater Contamination Prediction

Teledyne Isotopes, Palo Alto Laboratory, prepared a groundwater contamination prediction for Project Gasbuggy. This prediction is based in part on hydrologic data gathered and interpreted by the U. S. Geological Survey (USGS). Teledyne Isotopes determined that it was most unlikely that fratures or radioactive contamination from the detonation would even reach the Ojo Alamo Sandstone formation. In the exceedingly unlikely event that they did reach Ojo Alamo Sandstone, it would be the only viable route for radionuclide transport away from the Gasbuggy site. Groundwater in Ojo Alamo flows in a generally westward direction. Its most probable discharge point is the San Juan River, some 50 miles (80.5 kilometers) northwest of the Gasbuggy site. Hydraulic tests on the Ojo Alamo sandstone by the USGS showed it to have low transmissivity. Groundwater moving away from the site is estimated to have a velocity of 0.04 feet (0.012 meters) per year. The low transmissivity and the decreasing head with depth preclude any significant areal contamination of the aquifer. Tritium, Strontium-90, and Cesium-137 will decay to concentrations well below concentration guides before moving even a small fraction of the 50-mile distance. High total dissolved solids make water from this aquifer unsuitable for irrigation or domestic use (References 19 and 20).

E. Event Monitoring

Pre- and postevent monitoring was conducted by the Southwestern Radiological Health Laboratory of the U. S. Public Health Service (SWRHL/PHS) now called the Nuclear Radiation Assessment Division, Environmental Monitoring Systems Laboratory, U.S. Environmental Protection Agency, Las Vegas, Nevada (EMSL/EPA), the U.S. Geological Survey (USGS), Teledyne Isotopes (TI), and the Eberline Instrument Corporation (EIC).

1. Air Sampling (SWRHL/PHS)

Thirty-six air sampling stations ranging from 10 to 300 miles (16.1 to 483 kilometers) from Ground Zero were sampled. Background sampling was carried out for 13 days preceding the event. The Gasbuggy Network began operation on November 27, 1967, and continued through December 13, 1967, three days after the detonation. The nine stations nearest the site were operated throughout the GB-ER drill-back period until January 19, 1968. A total of 1,120 sets of samples was collected. In mid-April 1968, 16 of the 28 special stations were discontinued, leaving 11 on stand-by. The remaining stations were operated from June 30, 1968, to July 18, 1968. A total of 200 sets of samples was collected during this period.

2. Milk Sampling (SWRHL/PHS)

Milk samples were collected from 22 dairies and ranch locations ranging in distance from 15 to 150 miles (24.2 to 241.5 kilometers) from Ground Zero. Samples were collected at each location during the following periods: July 30-August 1, 1967; September 4-7, 1967; October 20-25, 1967; and January 19-20, 1968. In addition, five samples were collected on December 14, 1967. A total of 75 one-gallon samples was collected and shipped to SWRHL for analysis.

3. Vegetation Sampling (SWRHL/PHS)

Thirty-five vegetation samples were collected at 31 air sampling stations before the shot. The stations selected were within an approximate two-mile (3.2 kilometer) radius of GZ (Reference 21). No samples were taken post-shot since no radiation was detected off site, and the area was covered by 1 to 3 feet (0.3 to 0.9 meters) of snow. However, samples were taken during flaring operations.

No fresh fission products were found in any air, milk, water, or vegetation samples. The TLDs and film badges in the network and the TLDs worn by personnel showed no exposure above background. No radiation was observed by monitors in the off-site area following the test (Reference 22).

4. Hydrologic Monitoring (SWRHL/PHS, USGS, TI)

The original hydrologic sampling network was established in 1967 by Teledyne Isotopes (TI) and the U.S. Geological

Survey (USGS) to provide data for preevent and postevent comparison of radionuclide concentrations in surface and groundwater in the area surrounding the event site (Reference 23).

Water samples were collected by the USGS at 36 locations ranging from 1 mile to 150 miles (1.61 to 241.5 kilometers) from ground zero (GZ). A total of 77 water samples were collected and analyzed.

Teledyne Isotopes inventoried all known wells and springs within a 5-mile (8.1 kilometer) radius of Ground Zero and all accessible wells and springs between the 5-and 10-mile (8.1 and 16.1 kilometer) radius. (See Figure 5.) This inventory was conducted to assist in appraising possible well damage claims and also to establish background radiological values. TI, Palo Alto Laboratory, was responsible for sampling and subsequent analysis of water samples from the well and spring network. A total of 13 wells and 23 springs were inventoried and sampled.

A slightly modified network was sampled by TI personnel in June 1967 and again starting in January 1968. Samples were analyzed for tritium, gross beta, gamma emitters, gross alpha. No increase in radionuclide concentrations was detected. Repeat samplings were made in March 1968 with similar results (Reference 24).

F. Production Testing Phase (Flaring) Monitoring

Two major monitoring programs were carried out during production testing. The results of these programs are well documented in EIC and AEC reports:

NVO-37 Project Manager's Report, dated November 1971.

PNE-1006 Gasbuggy - On-site Radiological Safety During Production Testing, January 25, 1968, to December 31, 1969; issued October 29, 1971.

No significant radiation exposures have occurred during flaring nor have levels of tritium or other isotopes been detected off site in concentrations which constitute a hazard.

1. Eberline Instrument Corporation (EIC) provided on-site radiological safety and monitoring of gas and liquid effluents during the initial flaring phase and for the remainder of the production test.

2. SWRHL/PHS provided both on- and off-site radiological monitoring of air, soil, vegetation, and water before, during, and after the production tests.

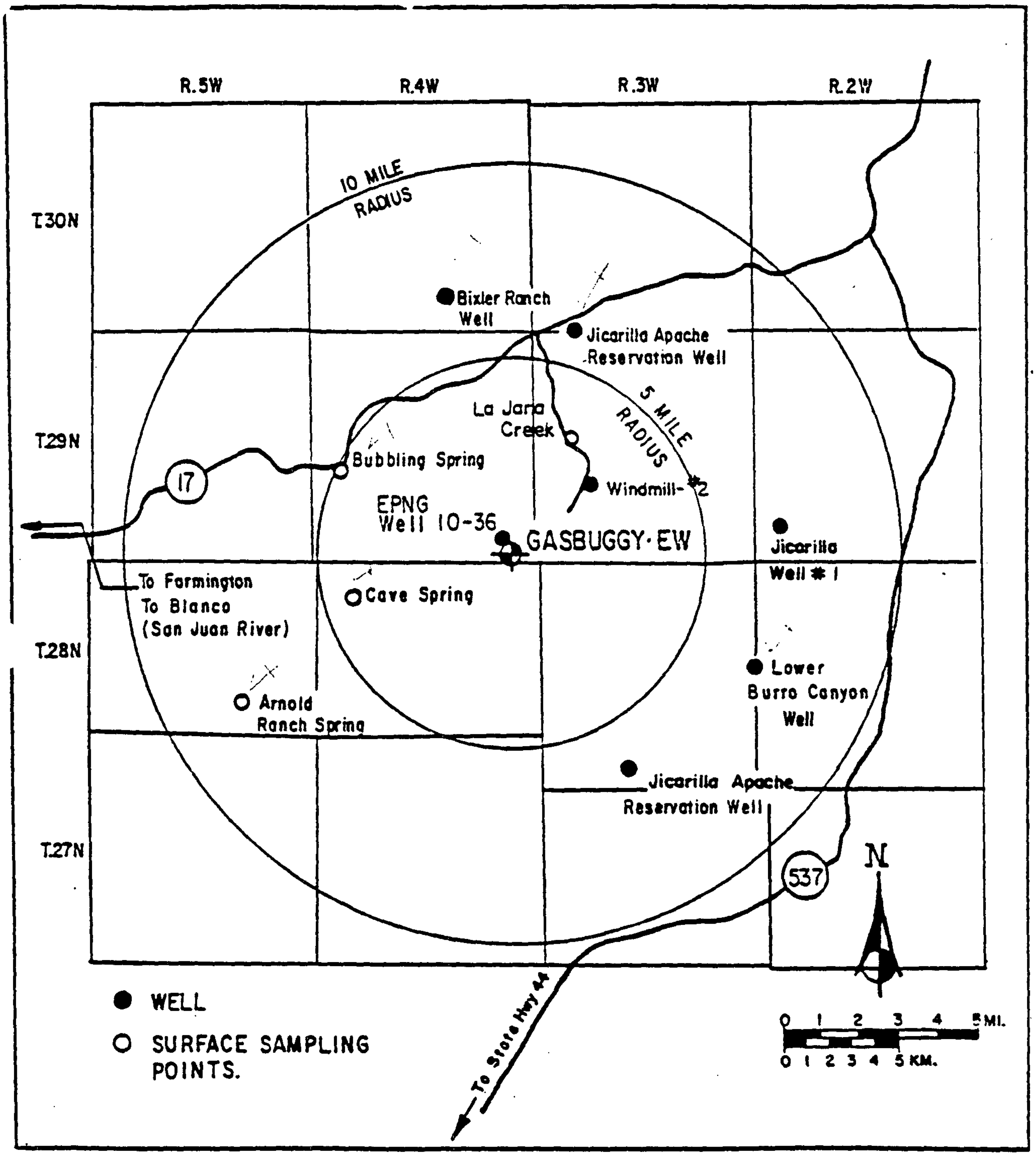


Figure 5. Long-Term Hydrologic Monitoring Program Sampling Points

In the vegetation, soil, air, and water samples which were collected and analyzed, no levels of tritium or other isotopes were detected which would present a hazard to people or livestock in the off-site area (Reference 25).

IV. LONG-TERM HYDROLOGIC MONITORING PROGRAM

A. Introduction

In accordance with DOE/NV policy, a long-term hydrologic monitoring program was established for the Gasbuggy site and initiated in 1972.

B. Sampling Points (Figure 5)

Wells	Depth (ft) (Meters)	Aquifer	Location
1. EPNG Well 10-36	3,620 (1,103.7)	Ojo Alamo	436 feet NNW of Gasbuggy GZ. In unsurveyed T29N, R4W.
2. *Jicarilla Apache Reservation South Well	Unknown		28.3.33.233
3. *Jicarilla Apache Reservation North Well	200 (60.9)	Wasatch	30.3.33.343
4. Lower Burro Canyon Well	Unknown		28.2.18.331
5. Fred Bixler Ranch Well	175 (53.4)	Wasatch	30.4.34.221
6. Windmill Well No. 2	Unknown		30.4.34.221
7. Jicarilla Well No. 1	Unknown		

*Sample points no longer monitored because pumps are inoperative.

Surface and Municipal Supplies

1.	Arnold Ranch Spring	28.5.34.114
2.	Cave Springs	28.4.17.311
3.	Bubbling Spring (SE side Highway 17)	
4.	La Jara Creek	29.4.19.412

Flexibility remains in the monitoring program to the extent that monitors are directed to collect for analysis, water samples from any water system about which there is local public concern. Appropriate wells will be added to the monitoring network as they became available. Some wells eventually will be lost to the program by destruction.

C. EPA Sample Results for Tritium, 1972-1982

(See Appendix)

D. Sampling Point Location Explanation

28.3.33.233 represents township, range, section, and starting from the upper right quarter and moving counterclockwise the quarter quarter quarter of the section.

E. Frequency of Sampling

Samples will be collected annually, at about the same dates each year. Sampling frequency will be increased appropriately if analytical results suggest this would be advantageous.

F. Analyses

The hydraulic head (depth to water), temperature in ^{o}C, pH and electrical conductance are recorded at the time of sample collection.

Prior to October 1, 1979, each sample was analyzed for gamma emitters and tritium. Gross alpha and beta radioactivity measurements were made on all samples collected. After October 1, 1979, these analyses were discontinued in favor of high-resolution gamma spectrometry using a GeLi detector. For each sample location, samples of raw water and filtered and acidified water are collected. The raw water samples are analyzed for tritium by the conventional method. Those samples with concentrations that are below the detection level for this method are then analyzed by the enrichment method. Portions of the filtered and acidified samples are analyzed for gamma emitters.

G. Sample Retention

A split of each sample collected is retained for specific nuclide determination until it is demonstrated that the need to retain them does not exist (normally one year from date of collection.)

H. Flagging System

A computer flagging system to detect anomalous analytical results and make appropriate notification is operational on a routine basis.

Incoming analytical results are compared by computer with historical results. In the event that significant change is observed, appropriate DOE and EPA staff are notified. Steps are taken, as necessary, including reanalysis of sample splits retained for this purpose and, in some cases, resampling to explain the cause for anomalous analytical result.

I. Reports

In the event that a meaningful increase in radionuclide concentration is demonstrated, the Health Physics Division, NV, is to be notified immediately.

Annual reports are to be prepared by EPA/EMSL-LV, which contain the following:

1. Description of the sampling network.
2. Results, with a comment on analytical techniques used and degree of accuracy achieved.
3. Interpretation of results.
4. Evaluation of the monitoring program with suggested modifications for its improvement.

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