1.0 Introduction

The West Valley Site

Location

The West Valley Demonstration Project is located in a rural area approximately 50 km (30 mi) south of Buffalo, New York (Figure 1-1), at an average elevation of 400 m (1,300 ft) on New York State's western plateau. The plant facilities used by the Project occupy approximately 63 hectares (156 acres) of chain-link fenced area within a 1,350-hectare (3,300-acre) reservation that constitutes the Western New York Nuclear Service Center (WNYNSC). The communities of West Valley, Riceville, Ashford Hollow, and the village of Springville are located within 8 km (5 mi) of the plant. Several roads and one railway pass through the Center, but no human habitation, hunting, fishing, or public access are permitted on the WNYNSC.

Economic Activities

The land immediately adjacent to the WNYNSC is used primarily for agriculture and arboriculture. Cattaraugus Creek serves as a water recreation area (swimming, canoeing, and fishing). Although limited irrigation water for adjacent golf course greens and tree farms is taken from Cattaraugus Creek, no public water supply is drawn from the creek downstream of the WNYNSC.

Climate

Although there are recorded extremes of 37 °C (98.6 °F) and -42 °C (-43.6 °F) in the region, the Western New York climate is moderate, with an average annual temperature of 7.2 °C (45.0 °F). Rainfall is relatively high, averaging about 104 cm (41 in.) per year. Precipitation is evenly distributed throughout the year and is markedly influenced by Lake Erie to the west and Lake Ontario to the north. All surface drainage from the WNYNSC is to Buttermilk Creek, which flows into Cattaraugus Creek and ultimately into Lake Erie. Regional winds are predominantly from the west and south at about 4 m/s (9 mph) during most of the year.

Vegetation and Wildlife

The WNY Nuclear Service Center lies within the northeastern deciduous forest biome, and the diversity of its vegetation is typical of the region. Equally divided between forest and open land, the site provides habitats especially attractive to white-tailed deer and various indigenous birds, reptiles, and small mammals. No endangered species are known to be present on the WNYNSC.

Geology

The site is characterized by glacial deposits of varying thickness in the valley areas, underlain by sedimentary rocks which are exposed in the upper drainage channels in the hillsides. The soil is principally silty till consisting of unconsolidated rock fragments, pebbles, sand, and clays. The uppermost till unit is the Lavery, a very compact, gray, silty clay. Below the Lavery till is a more granular area referred to as the lacustrine unit, which is made up of silts, sands, and, in some places, gravels that overlie a layered clay.

There are two aquifers in the site area but neither are considered highly permeable. The upper aquifer is a transient water table in the upper 6 m (20 ft) of weathered till and alluvial gravels concentrated near the western edge of the site. High ground to the west and the Buttermilk Creek drainage to the east intersect this aquifer, precluding off-site continuity. Several shallow, isolated, water-bearing strata also occur at various other locations within the site boundary but do not appear to be continuous.

The zone at which the till meets bedrock forms another aquifer consisting of decomposed shale and rubble that ranges in depth from 2 m (6 ft) underground on the hillsides to 170 m (560 ft) deep just east of the Project's exclusion area. The groundwater flow patterns are related to the recharge and downgradient movement for the two aquifers. Groundwater in the surficial unit tends to move east or northeast, close to Rock Springs Road. Most of this groundwater empties into Frank's Creek. Groundwater from the second aquifer tends

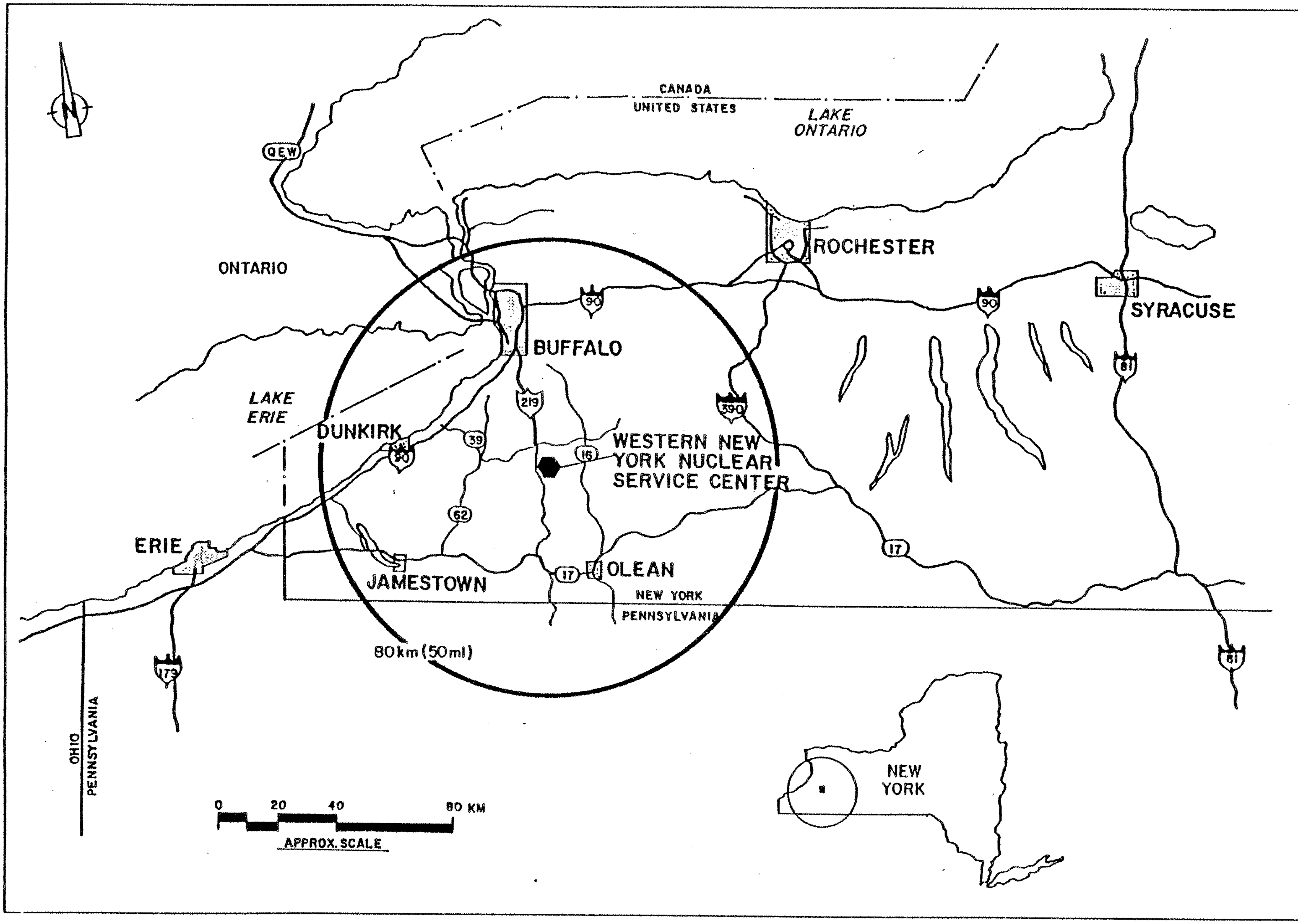

Figure 1-1. Location of the Western New York Nuclear Service Center

to move east toward the lowest point of the site, about 300-350 meters west of Buttermilk Creek, and turns to flow north-northwest.

Radiation and Radioactivity

As the Western New York Nuclear Service Center is no longer an active nuclear fuel reprocessing facility, the major interest of the environmental monitoring program is with the radiation and radioactivity levels associated with the cleanup activities. The following information about radiation and radioactivity may be useful in understanding the activities of the Project and the terms used in reporting the results of environmental testing measurements.

Radioactivity is a property of unstable atomic nuclei that spontaneously disintegrate or change into atomic nuclei of another isotope (see Glossary) or element. As they decay the total radioactivity is reduced until only a stable nonradioactive isotope remains. This process can take anywhere from less than a second to hundreds of thousands of years.

Radiation is a general term used to describe several forms of energy, including the energy that accompanies decay of atomic nuclei. Radiations from radioactive materials that are of primary interest take three forms: alpha or beta particles, and gamma rays.

- Alpha Particles

An alpha particle may be emitted as a fragment from a much larger nucleus. It consists of two protons and two neutrons, just like a helium nucleus, and is positively charged. Alpha particles are relatively large and heavy and do not travel very far when ejected by a decaying nucleus. Alpha radiation thus is easily stopped by a thin layer of material such as paper or skin. However, if radioactive material is ingested or inhaled, the alpha particles released inside the body can damage soft internal tissues.

- Beta Particles

A beta particle is an electron that results from the breakdown of a neutron in a radioactive nucleus. Beta particles are small compared to alpha particles, travel at a higher speed (close to the speed of light), and can be stopped by a material such as wood or aluminum an inch or so thick. If beta particles are released inside the body they do much less damage than alpha particles (assuming that equal amounts of energy are absorbed by the tissue).

- Gamma Rays

Gamma rays are high-energy "packets" of electromagnetic radiation called photons. They are similar to x-rays but have a shorter wavelength and therefore are more energetic than x-rays. If the alpha or beta particle released by the decaying nucleus does not carry off all the energy available, the nucleus rids itself of the excess energy by emitting gamma rays. The released energy produces a very penetrating gamma ray which can only be effectively reduced by several inches of a heavy element such as lead. Although large amounts of gamma radiation are dangerous, gamma rays are also used in many lifesaving medical procedures.

Ionizing Radiation

Radiation can be damaging if, in colliding with other material, the alpha or beta particles or gamma rays knock loose electrons from the absorber atoms. This process is called ionization, and the radiation that produces it is referred to as ionizing radiation because it changes a previously neutral atom into a charged atom called an ion. (See Glossary).

Various kinds of ionizing radiation produce different degrees of damage. The **relative biological effectiveness** (RBE) or **quality factor** (QF) of a particular kind of radiation indicates the extent of cell damage it can cause compared with equal amounts of other ionizing radiations. Alpha particles cause twenty times as much damage to internal tissues as x-rays, and so alpha radiation has a QF of 20 compared to gamma rays, x-rays, or beta particles.

Background Radiation

Background radiation is always present and everyone is constantly exposed to low levels of such radiation from both naturally occurring and man-made sources. The average total annual exposure to this low-level background radiation is estimated to be about 360 millirem (mrem). Most of this radiation, approximately 300 mrem, comes from natural sources. The rest comes from medical procedures and from consumer products.

Background radiation includes cosmic rays, the decay of natural elements such as potassium, uranium, thorium, and radon, and radiation from sources such as chemical fertilizers, smoke detectors, and televisions. Actual doses vary depending on such factors as geographic location, building ventilation, and personal health and habits.

Units of Measurement

Radiation is described in three ways: The rate of emission, the amount of energy absorbed, or the biological effect.

Nuclear disintegrations.

The rate at which radiation is emitted can be described by the number of nuclear transformations that occur as an isotope decays and changes into another isotope. This process, or radioactivity, is measured in curies or becquerels. One becquerel equals one decay per second. One curie equals 37 billion nuclear disintegrations per second (3.7×10^{10}d/s). Very small amounts of radioactivity are sometimes measured in picocuries. A picocurie is one-trillionth (10^{-12}) of a curie.

Energy absorbed:

Radiation effects can be predicted based on the amount of energy absorbed by the receiving material, measured in rads (radiation absorbed dose) or grays. A rad is defined as a dose of 100 ergs of radiation energy absorbed per gram of material while a gray is one joule per kilogram. Energy can also be expressed in terms of electron volts (eV). However, as an electron volt is such a small amount of energy one usually refers to a million electron volts or MeV. Thus, a gamma ray photon from barium-137m (from cesium-137) would have an energy of 662,000 eV or 0.662 MeV. (One rad equals 62.5×10^6 MeV of energy per gram of material).

Biological effect:

A third measure of radiation is the rem, the unit of "dose equivalent" which is proportional to the biological damage to tissue produced by different kinds of ionizing radiation. Rems are equal to the number of rads multiplied by a "quality factor" which is related to the relative biological effectiveness of the radiation involved. Dose equivalents can also be measured in sieverts. One sievert equals 100 rem. (See Chapter 4, " Radiological Dose Assessment" for more information).

Potential Effects of Radiation

The biological effects of radiation can be either somatic or genetic. *Somatic* effects are restricted to the person exposed to radiation. For example, sufficiently high exposure to radiation can cause clouding of the lens of the eye, or loss of white blood cells.

Radiation also can cause chromosomes to break or rearrange themselves or to join incorrectly with others. These changes may produce *genetic* effects and may show up in future generations. Genetic defects and mutations, while not positively identified in humans, have been observed in some animal studies.

The effect of radiation depends on the amount absorbed. Temporary effects such as vomiting might be caused by an instantaneous dose of 100-200 rem, but with no long-lasting side effects. At 50 rem a single instantaneous dose might cause a reduction in white blood cell count. The West Valley Demonstration Project work force is limited to 0.1 rem for individual daily work exposures, not to exceed 1 rem per calendar quarter. At such low exposures no clinically observable effects have ever been seen. The calculated doses from Project operations for the maximally exposed off-site individual is about one twenty-thousandth of a rem or 0.051 millirem.

The difficulty in assessing biological damage from radiation is that other factors can cause the same symptoms as radiation exposure. Moreover, the body apparently is able to repair damage caused by low-level radiation.

The effect most often associated with exposure to relatively high levels of radiation is an increased risk of cancer. However, scientists have not been able to demonstrate that exposure to low-level radiation causes an increase in deleterious biological effects, nor have they been able to determine if there is a level of radiation exposure below which there are no biological effects.

Measuring Radiation at the West Valley Demonstration Project

Human beings are exposed to radioactivity primarily through air, water, and food. At the West Valley Demonstration Project all three pathways are monitored, but air and surface water pathways are the two major means by which radioactive material can move off-site.

The geology of the site (kinds and structures of rock and soil), the hydrogeology (water presence and flow), and meteorological characteristics of the site (windspeed, patterns, and direction) are all considered in evaluating potential exposure through the major pathways.

Monitoring Program

The on-site and off-site monitoring program at the West Valley Demonstration Project includes measuring the concentration of total alpha and beta radioactivity, conventionally referred to as "gross alpha" and "gross beta," in air and water effluents. Measuring the total alpha and beta radioactivity in several samples, which can be done within a matter of hours, produces a comprehensive picture of current on-site and off-site radiation levels from all sources. In a facility such as the West Valley Demonstration Project, tracking the overall levels of radioactivity in effluents is an important tool in maintaining acceptable operations.

Other radioactive elements are measured, of course. Strontium-90 and cesium-137 are measured because of their relative abundance in WVDP waste streams. Certain radionuclides such as tritium or iodine-129 are not sufficiently energetic to be detected with the gross alpha and beta measurements, so these must be analyzed separately with instruments having greater sensitivity. Heavy elements such as uranium require special analysis to be detected as they exist at such low levels at the WVDP.

The radionuclides monitored at the Project are those which produce relatively higher doses and/or are most abundant in the air and water effluents and in the animal and plant life. Because sources of radiation at the Project have been decaying for more than fifteen years, the monitoring program does not routinely include short-lived radionuclides, i.e., anything with a half-life of less than five years. (See Appendix A for a schedule of samples and radionuclides measured and Appendix B for related Department of Energy protection standards).

Radioactive Waste Treatment at the West Valley Demonstration Project

The Integrated Radwaste Treatment System (IRTS)

By 1988 the West Valley Project was operating the Integrated Radwaste Treatment System (IRTS), a four-step process that converts high-level radioactive liquid waste stored at the site in underground steel tanks into low-level waste stabilized in cement. The system eventually will remove approximately 90% of the water from the high-level waste tanks and most of the salts.

Half of the radioactivity is in the supernatant or liquid portion of the waste, and the other half is in the sludge on the bottom of the tank. The supernatant is composed mostly of sodium and potassium salts plus water. Dissolved radioactive cesium makes up more than 99% of the total fission products in the supernatant. The largest chemical constituent of the sludge is iron hydroxide, and most of the radioactivity in the sludge is strontium-90.

THE SUPERNATANT TREATMENT SYSTEM (STS), housed in a spare storage tank identical to the one that holds most of the high-level waste, removes more than 99.9% of the radioactive cesium from the liquid by passing it through four ion-exchange columns filled with zeolite. This produces a mildly radioactive liquid salt solution.

THE LIQUID WASTE TREATMENT SYSTEM (LWTS) concentrates the salt solution by evaporation and separates it into radioactive concentrates and a distilled water effluent.

THE CEMENT SOLIDIFICATION SYSTEM (CSS) blends the LWTS concentrates into cement in lined drums which are then stored in the drum cell.

THE DRUM CELL was completed in 1987 to store Class B and Class C low-level radioactive wastes. (See Glossary). The drum cell is a large, shielded structure inside a building which protects the cell and its contents from the weather. It is located southwest of the main plant near the NRC-licensed disposal area. The building can store seventeen thousand 270-liter (71 gallon) square drums of solidified low-level waste.

1989 Monitoring Program at the West Valley Demonstration Project

The following chapters describe in detail the 1989 effluent monitoring and environmental surveillance program at the Project. Several primary factors influenced the West Valley Demonstration Project environmental monitoring program in 1989 :

- The Department of Energy issued Order 5400.1, "General Environmental Protection Program" in late 1988, together with draft documents expanding regulations concerning air emissions.
- Dose assessment methods were revised to maintain consistency and compliance with new guidelines and regulations.
- High- and low-level waste continued to be processed.
- Monitoring of hazardous and radioactive mixed waste was increasingly emphasized.
- Planning for the eventual closing of the West Valley site (Phase II) began with work on site characterization.
- Installation of an extensive groundwater monitoring system began.
- Regulatory agencies with co-jurisdiction over the site cooperated in establishing compliance guidelines.
- Staff and space available for environmental monitoring and analysis were doubled in order to provide even more comprehensive environmental surveillance.

Airborne Emissions

As mandated by Department of Energy Order 5400.1 and amplified in associated draft documents, 1989 saw a greater focus on airborne emissions from DOE facilities at the West Valley Demonstration Project. Ventilation monitoring necessary for the future operation of the vitrification cell was investigated, and National Emission Standards for Hazardous Air Pollutants permitted sources were evaluated for compliance with the stricter rules. Detailed maps showing locations of air discharge points and vented tanks on the premises were prepared to pinpoint the locations of potential sources of airborne radioactive emissions. Interior air concentrations were measured to verify that storage facilities for low-level radioactive wastes were not sources of airborne radioactive emissions. No problem areas were identified.

Dose Assessment

Several improvements in dose assessment methods were implemented in 1989. More sophisticated and accurate models and spreadsheets were adopted for estimating the dose from airborne and liquid effluents. The newer models can be easily adapted to reflect new point sources or changes in limits. A review of meteorological data and of the impact of various metereological factors on the estimation of annual off-site radiation doses from airborne releases was completed in November of 1989. In December another procedural change streamlined computer calculations for predicting off-site concentrations from unplanned airborne releases. These improved methods and models enhance the speed of response in the event of accidental releases.

Processing of Low-level Waste

Throughout 1989 the low-level waste treatment facility (LLWTF) processed aqueous wastes before discharge. In 1989 the Project released 39 million liters (10 million gallons) to the environment. The discharge waters contained an estimated 40.5 millicuries (mCi) of radioactivity (gross alpha plus gross beta). Comparable releases during the previous five years, 1984 through 1988, averaged about 54.5 mCi per year. The 1989 release was roughly 26% below this level. The 3.9 curies of tritium released was almost six times the amount released in 1988, however, and was attributed to normal operation of the STS process.

During the second year of operations of the supernatant treatment system (STS), 246,000 gallons of waste were processed into 4523 cement drums, bringing the total to 7119 drums thus far. Gamma radiation measurements taken around the drum cell suggested no need to place cold drums in the top layer of the storage facility. Calculation of the maximum scattered radiation dose rate to which the public might be exposed indicated no significant risk to public health or safety from this source.

Hazardous and Mixed Wastes

Although the major emphasis in monitoring continues to be on the radiological materials on the site, an increasing emphasis on monitoring hazardous wastes and radioactive mixed wastes focused upon these activities:

- Emergency preparedness in the event that chemicals are released from the site
- Assessments of lead and asbestos on site
- Conducting an inventory of on-site bulk storage tanks
- Testing on-site wastes stored in drums
- Measuring leachate from the state disposal area (SDA)
- Investigating traces of 1,1-dichloroethane in two on-site monitoring wells
- Determining that radioactively contaminated solvent was migrating from the NRC-licensed disposal area (NDA) and beginning an interceptor trench for its containment.

Phase II Site Characterization

A significant part of the preliminary work for the Phase II Site Characterization necessary for closure of the WVDP was completed in 1989. Several draft documents were issued, including the Site Characterization Plan, a Phase II Environmental Impact Statement (EIS) Implementation Plan, and a Phase II Analytical Plan. Initial steps included meeting with the public to discuss the scope of the work for the Phase II EIS, reviewing the literature concerning the geology of the site, and aerial photography and digital topographical mapping of the Project area and selected portions of the Western New York Nuclear Service Center.

Groundwater Monitoring Program

Throughout 1989 a groundwater monitoring plan was developed to meet Resource Conservation Recovery Act (RCRA) requirements at existing solid waste management units (SWMUs) on-site, as well as to provide necessary information for Phase II (site closure) Site Characterization. An inventory of more than 100 existing monitoring wells produced recommendations on which wells to abandon or retain. Late in the year, a draft of the Sampling and Analysis Plan (SAP) for the groundwater monitoring network was issued. This plan included a review of the geology of the area, a description of the SWMUs on-site, and maps of the locations of monitoring wells up- and downgradient from each of the SWMUs. Drilling for new wells began in October 1989, with 35 wells of a planned total of 62 new wells completed by the end of the year. When the network of new wells is completed in mid-1990 it will actually include more than 70 wells.

Regulatory Agencies

Continued compliance with federal and state regulations was a primary concern in 1989. Discussions with the New York State Department of Environmental Conservation and the U.S. Environmental Protection Agency on the requirements for handling mixed waste led in November to the beginning of negotiations to resolve potential regulatory issues concerning mixed waste. The guidelines developed identified Phase II-related issues requiring agreement among West Valley Nuclear Services Co. , the Department of Energy, and the New York State Energy Research and Development Authority and suggested a schedule for completion of the Phase II National Environmental Policy Act processes.

Several appraisals of the West Valley Demonstration Project related to environment, safety, and health (ES & H) were conducted by the Department of Energy during 1989. These reviews included a technical safety appraisal (TSA) of the Project, a "Tiger Team" investigation of the site, and visits from the Federal Bureau of Investigation and the Environmental Protection Agency. Environmental reviewers evaluated all aspects of the sampling and measurement program conducted by the laboratory staff. (See Appendix A). According to the *Environmental Safety And Health Management And Organization Compliance Assessment*, DOE/EH-0114, "The Assessment Team did not identify any problems at the WVDP that present any undue risk to public or worker health or the environment."