**KNOLLS ATOMIC POWER LABORATORY
ANNUAL ENVIRONMENTAL MONITORING REPORT**

CALENDAR YEAR 1993

This report contains data and information for the three government owned sites comprising the Knolls Atomic Power Laboratory operated for the Department of Energy by KAPL, Inc., a subsidiary of the Martin Marietta Corporation, Schenectady, New York

KAPL, Inc.
KNOLLS ATOMIC POWER LABORATORY
Schenectady, New York
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SUMMARY

The results of the effluent and environmental monitoring programs at the three Knolls Atomic Power Laboratory (KAPL) sites are summarized and assessed in this report. Operations at the three KAPL sites resulted in no significant release of hazardous substances or radioactivity to the environment.

The effluent and environmental monitoring programs conducted by KAPL are designed to determine the effectiveness of treatment and control methods, to provide measurement of the concentrations in effluents for comparison with applicable standards, and to assess resultant concentrations in the environment. The monitoring programs include analyses of samples of liquid and gaseous effluents for chemical constituents and radioactivity as well as monitoring of environmental air, water, sediment, and fish. Radiation measurements are also made around the perimeter of each site and at off-site background locations.

KAPL environmental controls are subject to applicable state and federal regulations governing use, emission, treatment, storage and/or disposal of solid, liquid and gaseous materials. Some non-radiological water and air emissions are generated and treated on-site prior to discharge to the environment. Liquid effluents and air emissions are controlled and monitored in accordance with permits issued by the Connecticut Department of Environmental Protection (CTDEP) for the Windsor Site and by the New York State Department of Environmental Conservation (NYSDEC) for the Knolls and Kesselring Sites. The liquid effluent monitoring data show that KAPL has maintained a high degree of compliance with permit requirements. Where required, radionuclide air emission sources are authorized by the U.S. Environmental Protection Agency (EPA). The non-radiological air emissions, with the exception of opacity for the boilers, are not required to be monitored. The use and maintenance of air emissions control equipment is sufficient for permit compliance. All air emissions conformed to applicable state and federal standards. KAPL no longer operates landfills at the Knolls and Kesselring Sites. Landfill operations were terminated in 1993. Non-hazardous solid wastes are disposed of through local permitted facilities.

Chemicals are not manufactured at KAPL but are used incidental to site operations. Those substances characterized as hazardous by Federal and State regulations are controlled through administrative procedures and personnel training. Small amounts of wastes are generated and disposed of off-site by waste vendors operating under permits issued by the cognizant state and federal regulatory agencies. Handling and storage incidental to shipment of wastes are controlled and monitored by trained personnel in compliance with applicable regulations. KAPL strives to minimize the quantity of hazardous and solid waste which it produces. Waste avoidance, beneficial reuse and recycling are practiced whenever practicable.

Accountability and radiation survey procedures are used at each KAPL site for the handling, packaging, and transportation of all radioactive materials. Shipments of radioactive materials are performed in accordance with detailed written procedures to ensure compliance with all applicable regulations of the DOT, the U.S. Department of Energy (DOE), and the U.S. Nuclear Regulatory Commission (NRC). All KAPL generated wastes that contain radioactive constituents are regulated under the Atomic Energy Act of 1954 and applicable DOE requirements. The volume of solid radioactive waste that requires disposal is minimized through the use of procedures that limit the amount of materials that become contaminated and by compaction of compressible wastes. Radioactive wastes are not disposed of at any of the three KAPL sites, but are shipped to government owned burial sites. During 1993, approximately 339 cubic meters (443 cubic yards) of low level radioactive waste were shipped from the KAPL sites for burial. This is less than one percent of the amount of radioactive solid waste buried annually at government owned burial sites.

KAPL is in full compliance with DOE and EPA standards governing the release of radioactivity to the environment. The annual average concentration of radioactivity in liquid and gaseous effluents from each site corresponded to less than one percent of the permissible DOE radioactivity concentration guides at the boundary of each site. Radionuclide air emissions were also less than one percent of the EPA air emission standard. The total quantity of radioactivity released in airborne and liquid effluents from the three sites in 1993 was approximately 2.8 curies. No radioactivity attributable to 1993 operations at the three KAPL sites was detected in any of the environmental samples. Radiation dose to the general public as a result of KAPL operations was too small to be measured and therefore must be estimated using conservative calculational techniques that overestimate the potential dose. The maximum potential annual

dose to an individual off-site was less than 0.1 millirem per year. This is less than one percent of the numerical guide established by the NRC for commercial reactor sites to demonstrate that radioactive materials in effluents released to unrestricted areas are "as low as is reasonably achievable". The maximum potential annual dose is also less than five percent of the total radiation a person aboard a commercial airplane would receive from cosmic sources during one coast-to-coast flight. The estimated annual collective dose to the entire population within 80 kilometers (50 miles) of any site was less than 0.1 person-rem, which corresponds to less than one thousandth of one percent of the dose received by the population from normal background radiation.

INTRODUCTION

The Knolls Atomic Power Laboratory (KAPL) is operated by KAPL, Inc., a wholly owned subsidiary of Martin Marietta, under contract with the U.S. Department of Energy (DOE). KAPL consists of three separate sites: the Knolls Site, the Kesselring Site and the Windsor Site, all of which are United States Government owned facilities. The principal function at the three KAPL sites is research and development in the design and operation of naval nuclear propulsion plants. The Kesselring and Windsor Sites are also used for the training of personnel in the operation of these plants.

The Knolls Site is located in the Town of Niskayuna, New York, approximately 3.2 kilometers (two miles) east of the City of Schenectady (Figure 12). The Site is situated on 170 acres of land on the south bank of the Mohawk River. Facilities at the Knolls Site include administrative offices, machine shops, wastewater treatment facilities, a closed landfill, a boiler house, oil storage facilities, cooling towers, waste storage facilities, and chemistry, physics, and metallurgical laboratories. The surrounding area is a mixture of open land, other light industry, small farms and suburban residential areas.

The Kesselring Site consists of 3900 acres on which are located four pressurized-water naval nuclear propulsion plants and support facilities, including administrative offices, machine shops, training facilities, equipment service buildings, chemistry laboratories, a boiler house, oil storage facilities, cooling towers, waste storage facilities and wastewater treatment facilities. During 1991, operations were ceased at one of the four nuclear propulsion plants. The Site is located near West Milton, New York, approximately 27.4 kilometers (17 miles) north of the City of Schenectady, 14.5 kilometers (9 miles) southwest of Saratoga Springs and 21 kilometers (13 miles) north-east of Amsterdam (Figure 12). The surrounding area is a rural, sparsely populated region of wooded lands through which flow the Glowegee Creek and several small streams that empty into the Kayaderosseras Creek.

The Windsor Site is situated on 10.8 acres of land in the Town of Windsor, Connecticut, approximately eight kilometers (five miles) north of the City of Hartford (Figure 13). One pressurized-water naval nuclear propulsion plant is located at the Windsor Site in addition to support facilities that include administrative offices, sanitary waste septic systems, machine shops, training facilities,

a boiler house, oil storage facilities, a cooling tower, waste storage facilities, wastewater treatment facility, a chemistry laboratory and an equipment service building. In March 1993, the nuclear propulsion plant completed its final shut-down. The area surrounding the Windsor Site is a mixture of open land, industrial regions, tobacco farms and suburban residential areas, through which the Farmington River flows in a generally southeasterly direction to its confluence with the Connecticut River.

The quantities of radioactivity contained in liquid and gaseous effluents during operations in 1993 at the three KAPL sites were too small to have a measurable effect on normal background radioactivity. Solid radioactive wastes are packaged and shipped from the sites in accordance with all applicable U.S. Department of Transportation (DOT), DOE and U.S. Nuclear Regulatory Commission (NRC) regulations.

Liquid effluents are monitored at the three KAPL sites for radioactivity and for the chemical parameters listed in the applicable state and national pollutant discharge elimination system permits. Analyses are also performed on effluent and receiving stream water samples for select chemical parameters, some of which have state water quality standards. Fish, water, and bottom sediment samples from the receiving streams are collected and analyzed for radioactivity. Stack exhaust air from the oil-fired boilers is routinely monitored for opacity. Other non-radiological industrial air emission sources do not require monitoring under the terms of current state air permits due to the very low levels of emissions and the air emission control equipment specified in some of the permits. Airborne effluents from all radiological emission points are continuously sampled for radioactivity. In addition, radiation levels around the perimeter of each site and at several off-site background locations are monitored with sensitive dosimeters.

The use of chemically hazardous substances at the KAPL sites is strictly limited to the types and quantities essential for operation. Handling, transportation and disposal of hazardous waste is limited to vendors operating under permits issued by the cognizant state and federal regulatory agencies. Additionally, all KAPL personnel participate in a training program on the hazards of chemical substances. Other types of solid waste produced on-site, such as cafeteria waste, are disposed of at local permitted facilities. Scrap metals are

recycled through local vendors.

Effluent and environmental surveillance programs are conducted at each KAPL site in accordance with applicable DOE Orders to monitor conformance with applicable state and federal standards and to confirm that operations have had no significant impact on the environment and the public. The KAPL policy is to minimize releases to levels that are as low as is reasonably achievable. A summary of the 1993 monitoring data for each KAPL site is presented and assessed in this report.

During 1993, the three KAPL sites were inspected 19 times by state and/or federal environmental inspectors. No significant deficiencies or notices of violation were identified during the inspections. Sixty-seven periodic monitoring reports were filed with state and federal agencies. Five reports identified minor deviations from permit conditions. Where appropriate, corrective action programs have been implemented. Areas were also found to have evidence of historical petroleum spills and were reported to state agen-

cies. Cleanup of these areas, to meet state requirements for residual soil contamination, has been completed or is in progress.

Numerous programs to reduce the potential for environmental effects from KAPL operations were conducted. As noted, above a major initiative resulted in the decommissioning and removal of underground storage tanks. All three sites initiated detailed hazardous waste reduction plans for specific waste streams. Additionally, an ongoing program exists which will result in the removal of all PCB transformers at KAPL sites. Since 1991, twenty-four PCB transformers were removed and replaced with non-PCB transformers. All PCB transformers at KSO and WSO have been replaced. The remaining seventeen transformers at the Knolls Site are scheduled for elimination by the end of 1996.

The appendix provides general information on radiation and radioactivity for those who may not be familiar with radiological terms and concepts.

STANDARDS

Federal and state effluent and environmental air and water quality standards are used to interpret monitoring data and to assess the environmental impact from operations at the KAPL sites. In instances where standards are not provided for a specially monitored medium, e.g., river bottom sediment, assessments are based on a comparison of monitoring results to relevant parameters such as normal background radioactivity levels.

Specific effluent and environmental radioactivity standards applicable to KAPL operations are taken from U.S. DOE Orders 5400.1 and 5400.5, References (1) and (2), respectively, and the radiation dose limits established by the EPA for air emissions from DOE facilities, Reference (3). In addition, the potential radiation doses from KAPL operations to individuals off-site are compared to the numerical guides given in Appendix I of Title 10 - Code of Federal Regulations - Part 50 (10CFR50), Reference (4), and the radiation dose limit established by the EPA for public drinking water, Reference (5). Conformance with all the above guides as verified through sampling is considered to be conclusive evidence that radioactivity in effluents is kept as low as is reasonably achievable.

For chemical constituents in wastewater, the specific effluent and environmental standards applicable to KAPL operations are taken from the applicable state and federal standards given in References (1), (6), (7), (8) and (9). New York State water quality standards applicable to the Mohawk River and Glowegee Creek are given in Reference (10) and the Connecticut State standards for the Farmington River are given in Reference (11). Applicable state air quality standards for chemical constituents are listed in Reference (12) for Connecticut and in References (13) and (14) for New York.

All environmental permits issued to the three KAPL Sites are listed in Table 46.

Any substance used at the three KAPL sites

that is considered hazardous by the EPA or the state is procured, controlled, used, transported and disposed of off-site in accordance with the applicable state and federal standards given in References (15), (16), (17), (18), and (19).

To ensure that accuracy and precision are maintained in the analyses of effluent and environmental samples, KAPL maintains a quality assurance program that includes participation in the EPA Environmental Monitoring Systems Laboratory Intercomparison Studies Program and the Quality Assurance Program of the DOE-Environmental Measurements Laboratory and an internal quality assurance program.

The internal quality assurance program involves routine analyses of calibration standards and background samples, as well as distribution of control samples to laboratory components and subcontractors that normally analyze effluent and environmental samples. Results of the analyses are evaluated by comparing the reported values with the known values. All calibration standards and control samples used in the quality assurance program are prepared and verified according to proven methods. Whenever possible, the calibration standards are based on the EPA or National Institute of Standards and Technology (NIST) standards.

Average values determined from the analyses of effluent and environmental samples are reported with their associated error limits. In some instances, the error limits might imply a negative value. The lowest possible value for any parameter is zero. A result that is below the minimum detectable level for a particular measurement is expressed as less than (<) the minimum detectable value. In calculating average values, sample results that are less than the minimum detectable levels are assigned the detection limit value, and the resultant average value is expressed as less than (<) the computed average value. This method of recording data is in accordance with that described in Reference (41) and is conservative.

KNOLLS SITE EFFLUENT AND ENVIRONMENTAL MONITORING

SITE DESCRIPTION

The Knolls Site (Figure 12) is located in the Town of Niskayuna, New York, approximately two miles (3.2 kilometers) east of the City of Schenectady. The Site is situated on 170 acres of land on the south bank of the Mohawk River. Facilities at the Knolls Site include administrative offices; machine shops, wastewater treatment facilities, a boiler house, oil storage facilities, a closed landfill, cooling towers, machine shops, waste storage facilities, and chemistry, physics, and metallurgical laboratories. The surrounding area is a mixture of open land, other light industry, small farms and suburban residential areas.

The climate in the region of the Knolls Site is primarily continental in character, but is subjected to some modification from the maritime climate which prevails in the extreme southeastern portion of New York State. Winters are usually cold and occasionally fairly severe. Maximum temperatures during the colder winter months often are below freezing, and nighttime low temperatures frequently drop to 10°F or lower. Subzero temperatures occur rather infrequently, about a dozen times a year. Snowfall in the area is quite variable, averaging approximately 65 inches per year. The mean annual precipitation for the region is approximately 40 inches/year. Westerly winds (W to NW) predominate, and a secondary maximum occurs about the SSE.

The Knolls Site is located in the Mohawk River Valley at an elevation of approximately 330 ft. above sea level. Monitoring wells and test borings in the vicinity of the Knolls Site show that unconsolidated materials, consisting of mainly glacial deposits, overlie bedrock. The depth of bedrock beneath the land surface generally ranges between 10 and 70 feet. Rock outcrops are visible on both banks of the Mohawk River between Rexford and a point about three quarters of a mile downstream from the Knolls Site. The outcrops are flat-lying shales and sandstones of the Schenectady formation of Ordovician age. These rocks are characteristically non-porous and impermeable, and form poor aquifers. The structure of most of the consolidated rocks in Schenectady County is relatively simple. Over 90 percent of the entire County is underlain by the Schenectady formation, a series of alternating beds of shale, sandstone and grit about 2,000 feet thick, which dip gently west and southwest. The Snake Hill forma-

tion is exposed along both sides of the Mohawk River near the dam at Lock 7, downstream from the Knolls Site. This formation consists of a considerable thickness of dark gray to black, bluish, and greenish-gray shale. It is the only formation in Schenectady County that is strongly folded, having been thrust westward against and over the Schenectady formation.

The glacial deposits consist almost entirely of glacial till. Basal till at the Knolls Site is a clay rich glacial drift. It is dense, compact, and is known locally as hardpan. The depth under the site ranges from 0 to 70 feet. The till appears a grayish-blue color but in the upper twelve feet portion it has been weathered to a yellowish brown color. Within the till occasional lenses of graded material, usually fine sand, exist. The till is almost entirely impermeable except for a few lenses of sand which are capable of transmitting water. It is believed that these lenses are small in size and isolated from one another based upon drilling records. Overlying the till are thin glacial lake sequences (silts and clays) and discontinuous ice-contact deposits (sand and gravel). The ice-contact deposits are capable of transmitting water but their limited extent diminishes the potential for yielding useable water volumes.

The Knolls Site is located adjacent to the Mohawk River which serves as the main water course for the Mohawk River Drainage Basin, covering an area of 3456 square miles. The river flows eastward to where it joins the Hudson River in Cohoes, N.Y. The average flow rate of the Mohawk River is 5,658 cubic feet per second (cfs) and the lowest recorded 10 day average flow is 644 cfs (416 million gallons per day) during 1947. Three streams drain to the Mohawk River from the Knolls Site. The East Boundary Stream is located on the Knolls Site between the Knolls and the Niskayuna Landfill. The Midline Stream drains the central area of the site and basically receives only runoff from the site property. The West Boundary Stream is located adjacent to the Knolls Site on GE Research and Development (R&D) Center property. The West Boundary Stream receives some surface water runoff from the Knolls Site, the surrounding land areas, and the GE R&D Center. The flow in these streams becomes extremely low during the dry summer weather. These streams are not accessible to the public except at the point where they meet the Mohawk River.

The groundwater under the Knolls Site is very limited due to the low permeability of the soil which prohibits the development of this area as a potable water supply. There are no underlying principal or primary bedrock or overburden aquifers. Water for site operations involving potable and limited cooling use is obtained from the Schenectady Municipal Water System. The majority of water for non-contact cooling at the lower level is obtained from the Mohawk River. There are no production wells for service water on site.

The Mohawk River is classified by the New York State Department of Environmental Conservation (NYSDEC) as a Class A stream. The best usages of Class A waters are considered to be: a source of water for drinking, culinary or food processing purposes, primary and secondary contact recreation, and fishing. The waters shall be suitable for fish propagation and survival. The Knolls Site is permitted to discharge water from its various operations within the concentrations and limits set by the state discharge permit, Reference (6).

LIQUID EFFLUENT MONITORING

Origins

Liquid effluent from the Knolls Site originates from several sources, including cooling tower water, boiler blowdown water, sewage treatment plant effluent, process water, and site service and Mohawk River waters that are used as non-contact cooling media for several heat exchangers. Stormwater runoff and groundwater infiltration are also part of the Knolls Site liquid effluent.

The concentrations of radioactivity in liquids released from the Knolls Site have always been below all applicable limits. A water reuse system is used whereby liquids from current laboratory operations that may contain radioactivity are collected, processed, and reused in certain laboratory operations to the maximum extent practicable. This minimizes the quantities of radioactivity released from the Knolls Site.

Where practicable, liquids from sources other than current laboratory operations that may contain radioactivity are collected in holdup tanks and are processed in batches. The processing system consists of a series of filters and demineralizers. Each batch of processed liquid is held in tanks and sampled to ensure that the radioactivity content is minimal and in compliance with applicable water quality standards. In addition, each tank of

processed water is sampled during release to provide a sensitive determination of the radioactivity actually released. The samples are combined into one or more monthly composite samples that are analyzed to determine the quantity and identity of the radionuclides present.

In addition, small amounts of groundwater that contain low level residual radioactivity from operations conducted during the 1950's and 1960's are released in the site drainage water. The principal radioactive constituents released to the Mohawk River from all sources are the longer lived fission products, notably strontium-90, and cesium-137.

The principal sources of effluent water are:

1. *Cooling Towers* - Cooling water, used for central air conditioning, is treated to maintain a pH range of 7.5 to 8.2 to minimize scale buildup, prevent corrosion of systems materials, and to inhibit the growth of algae and slime.
2. *Site Boiler Plant* - Site boiler water is treated demineralized water. Operations that result in releases are (1) periodic blow-downs to control solids content and (2) neutralization of ion exchange resin regeneration effluent. The blowdown waters are neutralized before release.
3. *Sewage Treatment Plant (STP)* - The Knolls Site STP treats primarily wastewater from restrooms and janitorial sinks. A small portion of dilute laboratory rinse/process water is also treated. This is a secondary treatment facility that utilizes the extended aeration of activated sludge followed by sand filtration as a polishing step. Prior to release, the plant effluent is chlorinated for disinfection. Waste sludge is periodically removed for disposal by a subcontractor at a state-approved facility.
4. *Cooling Water* - Untreated Mohawk River and site service waters are used as noncontact cooling media for several heat exchangers.
5. *Process Water* - Treated/untreated non-radiological wastewater, primarily from corrosion control testing, is generated on-site. Process water treatment typically consists of one or more of the following processes; filtration, ion exchange, activated carbon and/or neutralization.

6. *Site Drainage Water* - Storm drainage water and groundwater also make up a portion of the liquid effluent.

Approximate flows and chemical characteristics of these discharges were incorporated in the Reference (6) State Pollutant Discharge Elimination System (SPDES) permit application.

Effluent Monitoring

Liquid effluent from the Knolls Site that is not reused is released through a Parshall flume located at Building J-6 or through four small outfalls to the Mohawk River. The two effluent streams that mix in the entrance channel leading to the Parshall flume are identified in Reference (6) as discharge points 001 (sewage treatment plant effluent) and 002 (non-contact cooling water, storm water, and a small amount of groundwater).

The Parshall flume discharges directly to the Mohawk River. A monitoring station is installed at the Parshall flume to provide for the measurement and recording of effluent flow rate, total flow, pH and radioactivity, and for the collection of samples proportional to effluent flow. The Parshall flume monitoring station is also equipped with alarms to provide an alert in the event of out of specification pH levels and radioactivity concentrations and of sampling equipment malfunctions. A monthly composite sample is prepared from the proportional samples collected at the monitoring station and is analyzed for radioactivity.

In addition, periodic grab samples are also taken at discharge points 001 and 002 and analyzed for the constituents specified in the Knolls Site State Pollutant Discharge Elimination System (SPDES) Permit, Reference (6). The SPDES permit also specifies the minimum frequency of sampling and other on-site sample locations. In 1993, a SPDES permit renewal application was filed with the NYSDEC. Additional monitoring data were provided with this permit application.

The remaining liquid effluent from the Knolls Site passes through four small outfalls that discharge groundwater, small amounts of stormwater, and Mohawk River water used for once-through non-contact cooling. These outfalls are identified collectively as discharge point 003. They are monitored for flow rate and temperature as required by the SPDES permit. Outfalls 003A, 003B, 003D, and 003E are sampled at least quarterly for radioactivity.

Outfall 003X effluent is intermittent and con-

sists of river water that is used to backwash the traveling screen of the river water cooling system intake. This screen is used to remove large particles such as twigs and leaves from the intake river water. Outfall 003X is monitored for flow rate and is sampled quarterly for pH, suspended solids and oil and grease.

In October 1992, a stormwater discharge permit application was filed and provided effluent data during a rainfall event for three surface water streams which receive stormwater run-off at the Knolls Site. These three stormwater outfalls are designated as 004, 005, and 006 and correspond to the West Boundary Stream, Midline Stream and East Boundary Stream, respectively.

Effluent Analyses

The analyses for radioactivity performed on the composite samples of the processed liquid waste released from the holdup tanks are: (1) strontium-90 by chemical separation with subsequent beta counting, (2) cesium-137, cobalt-60, and other gamma-emitting radionuclides that may be present by gamma spectrometry, (3) uranium by chemical separation and mass spectrometry, (4) plutonium by chemical separation with alpha and mass spectrometry, (5) tritium by liquid scintillation counting, (6) iron-55 and promethium-147 by chemical separation and liquid scintillation counting, (7) gross beta radioactivity by direct sample evaporation and beta counting, and (8) alpha radioactivity by solvent extraction and alpha counting. With the exception of the spectrometry and liquid scintillation analyses, all counting is performed with a low-background, gas proportional counting system.

The monthly composite sample collected at the Parshall flume is analyzed for (1) strontium-90, (2) cesium-137 and other gamma-emitting radionuclides, (3) tritium, (4) gross beta radioactivity and (5) alpha radioactivity. In addition, samples from the small cooling and drainage water outfalls are analyzed for alpha radioactivity and gross beta radioactivity. If the gross beta radioactivity exceeds a specified concentration, analyses for strontium-90, cesium-137 and other gamma emitting radionuclides are performed. Analyses for strontium-90 are performed routinely for those outfalls that drain water from areas containing residual strontium radioactivity from prior operations at the site.

Periodic grab samples collected from discharge points 001, 002A, 002B, 003B, 003D, and 003X are analyzed for the chemical constituents listed

in Reference (6). Additional samples from various outfalls are analyzed for additional parameters for informational purposes only and are presented in the appropriate data tables.

Assessment

The analytical results for the chemical constituents, flow and temperature monitored in the Knolls Site liquid effluent during 1993 are summarized in Tables 1 and 2. The Knolls Site Sewage Treatment Plant (STP) operated within all specified parameters (see Table 1) and maintained a >98% removal for suspended solids and biochemical oxygen demand. The effluent from the STP is high quality and does not adversely impact the water quality of the Mohawk River. As shown in Table 2, the annual average values of all parameters were within the appropriate effluent standard where standards exist. However, the daily maximum limits for two parameters were exceeded on several occasions. The mass loading limit for iron at outfall 002B was exceeded three times, as explained in Footnote (6) of Table 2. The major source of iron in outfall 002B is from the river water itself, which is used for non-contact cooling. In August 1993, KAPL treated the river water cooling system to control the zebra mussel population within the river water piping system. This methodology was approved by the NYSDEC via an authorized change to the site SPDES permit (Reference 6). During the treatment process, outfall 002B and outfall 003B exceeded the permit limit as explained in Footnote (16) of Table 2. When identified, the treatment process was stopped and the exceedance was of short duration. The process was effective in controlling the zebra mussel population within the river water piping system.

The radioactivity released in effluent water during 1993 consisted of: (1) less than 0.001 curie of fission and activation products with half lives greater than three hours including those listed under Effluent Analyses, and (2) less than one microcurie each of uranium and plutonium. The radioactivity was contained in approximately 5.6×10^9 liters of water released from the site and was further diluted by mixing in river water following release. The annual average radioactivity concentration in that effluent, prior to additional dilution in Mohawk River water, corresponded to less than 0.1 percent of the DOE derived concentration guide for effluent released to unrestricted areas (Reference 2) for the mixture of radionuclides present.

Liquid effluent monitoring data are reported as required in References (1) and (6).

AIRBORNE EFFLUENT MONITORING

Origins

The principal source of industrial gaseous effluent is the Knolls Site steam-generating boiler system. Number 6 fuel oil with less than 1.5 percent sulfur content is utilized in boiler operation, and the combustion gas products are released through elevated stacks. Other operations at the site such as a paint spray booth, parts cleaning, carpenter shop and welding operations also constitute point sources of airborne effluents. Numerous non-radiological analytical chemistry laboratory hoods comprise another source of air emissions.

Laboratory operations involving radioactive materials result in a small amount of airborne radioactivity being released. Operations capable of generating airborne radioactivity are serviced by controlled exhaust systems that discharge through elevated stacks. To minimize radioactivity content, the exhaust air is passed through appropriate air cleaning devices, such as high efficiency particulate air (HEPA) filters and activated carbon filters, prior to release.

Effluent Monitoring

The stacks for the boiler plants are equipped with photoelectric sensors. These sensors continuously monitor and record the opacity of the stack emissions. The other industrial emission points do not require monitoring under terms of the current New York State permits due to the very low levels of the emissions and the air emissions control equipment specified in some of the various permits. At present the Knolls Site has 16 air emission permits as specified in Table 46. The NYSDEC regulations do not require air emission permits for laboratory hoods used for normal analytical operations.

Airborne effluents from radiological emission points are continuously sampled for particulate radioactivity with particulate filter samplers and with activated charcoal cartridge samplers where iodine may be present. In addition, exhaust systems servicing major facilities are continuously monitored for particulate, iodine, and noble gas radioactivity, as appropriate. The monitors continuously record radioactivity levels in the effluents and are equipped with alarm functions to provide an alert should an abnormal level ever occur.

**TABLE 1 - CHEMICAL CONSTITUENTS AND TEMPERATURE
IN KNOLLS SITE SEWAGE TREATMENT PLANT EFFLUENT, 1993**

Parameter (Units)	Number of Samples	Value ⁽¹⁾ Discharge Point 001			Permit Limit	Percent of Limit ⁽³⁾
		Minimum	Maximum	Average ⁽²⁾		
Discharge Permit Requirements (Reference 6)						
Flow (GPD) *	364	4,307	40,280	15,800 ± 719	30,000 ⁽⁴⁾	53
Biochemical Oxygen ⁽⁵⁾ Demand (mg/l)	51	<2	17	<7.0 ± 2.8	30 ⁽⁶⁾	<8
Fecal Coliform (mpn/100 ml) **	51	<2	116	<2.5 ⁽¹¹⁾ ± 0.3	200 ⁽⁷⁾	<1
Suspended Solids (mg/l) ⁽⁵⁾	53	<1.1	<4.4	<2.5 ± 0.6	30 ⁽⁸⁾	<8
Settleable Solids (ml/l)	12	<0.1	<0.1	<0.1 ± 0.0	0.3 ⁽⁸⁾	<33 ⁽⁸⁾
Total Residual Chlorine (mg/l)	51	1.0	1.6	1.4 ± 0.04	0.5-2.0 ⁽¹⁰⁾	--
Temperature (°F)	251	37	77	56.6 ± 1.4	No Limit ⁽⁹⁾	--
pH (SU) ***	494	6.7	8.1	7.3 ± 0.02	6.5-8.5 ⁽¹⁰⁾	--
Ammonia (mg/l) (as N)	52	0.2	27	8.8 ± 1.8	40 ⁽¹²⁾	22
Nitrate (mg/l) (as N)	52	0.22	83	42.3 ± 4.3	No Limit ⁽⁹⁾	--
Total Kjeldahl Nitrogen (as N) (mg/l)	52	0.3	23	5.3 ± 1.3	No Limit ⁽⁹⁾	--
Nitrite (mg/l) (as N)	52	<0.02	2.8	<0.50 ± 0.14	No Limit ⁽⁹⁾	--
Total Nitrogen (mg/l) (as N)	52	24	86	48.1 ± 3.4	125 ⁽¹³⁾	38
Additional Parameters Monitored						
Phosphate as P (mg/l)	51	4.2	11.0	7.9 ± 0.4	No Limit ⁽⁹⁾	--
Chemical Oxygen Demand (mg/l)	52	<5	86	52 ± 3.8	No Limit ⁽⁹⁾	--

*GPD = Gallons per day

**mpn/100 ml = most probable number (of coliform bacteria) per 100 milliliters

***SU = Standard units

Notes:

- (1) A value preceded by < is less than the minimum detection level.
- (2) Average values preceded by < contain at least one less than minimum detection level value in the average. The (±) value represents the statistical error at two standard deviations.
- (3) Percent of limit for the average value, unless otherwise noted.
- (4) 30 day average. The maximum 1993 30 day flow occurred during April and was 24,514 GPD.
- (5) The average treatment plant removal efficiency was 99% for TSS & for 98% for BOD, Reference (6) requires 85% minimum efficiency.
- (6) 30 day calculated flow-weighted average. The 7 day maximum permit limit is 45 mg/l. The loading limits are 7.5 and 11.25 lbs/day for 30 day average and 7 day maximum, respectively.
- (7) 30 day geometric mean. The 7 day maximum geometric mean limit is 400 mpn/100 ml.
- (8) Maximum daily value; percent of limit based on maximum value.
- (9) Monitor only.
- (10) All values are required to be within this range.
- (11) This is an arithmetic mean of the weekly geometric mean.
- (12) Daily average limit.
- (13) Daily average limit; calculated as the sum of nitrate + nitrite + total Kjeldahl nitrogen.

**TABLE 2 - CHEMICAL CONSTITUENTS AND TEMPERATURE
IN KNOLLS SITE LIQUID EFFLUENT, 1993**

Parameter (Units)	Number of Samples	Value ⁽¹⁾ Discharge Points 002, 002A and 003				Permit Limit	Percent of Limit ⁽³⁾
		Minimum	Maximum	Average ⁽²⁾			
Discharge Permit Requirements (Reference 6)							
Discharge Point 002B							
Intake pH (SU) *	53	7.3	8.6	8.0	± 0.06	No Limit ⁽⁹⁾	--
pH (SU) *	54	7.6	8.4	8.0	± 0.05	6.5-8.5 ⁽⁵⁾	--
Flow (GPD) **	Continuous	731,747	3,762,440	2,438,085	± 39,978	No Limit ⁽⁹⁾	--
Temperature (°F)	54	34	81	56.5	± 4.1	90 ⁽⁴⁾	86 ⁽⁴⁾
Total Residual Chlorine (mg/l)	53	<0.02	0.02	<0.02	± 0.0	0.1 ^(4,7)	<20
Iron (mg/l)	56	<0.05	1.93	<0.33	± 0.01	4.0 ^(6,10)	<39 ⁽⁴⁾
Manganese (mg/l)	8	<0.02	0.03	<0.03	± 0.0	0.35 ⁽¹²⁾	<23 ⁽¹²⁾
Dissolved Sulfide (mg/l)	56	<0.1	<0.1	<0.1	± 0.0	2.0 ⁽¹¹⁾	<40 ⁽⁴⁾
Surfactants (mg/l)	8	<0.02	0.02	<0.02	± 0.0	0.4 ⁽¹²⁾	<12 ⁽¹²⁾
Bromide (mg/l)	8	<1	1.0	<1.0	± 0.0	1.4 ⁽¹²⁾	<71 ⁽¹²⁾
Discharge Point 002A ⁽⁸⁾							
Oil & Grease (mg/l)	24	<5	13	<5.3	± 0.7	15 ⁽⁴⁾	<33 ⁽⁴⁾
Discharge Point 003A-E							
Flow (MGD) ***	365	0.00	2.42	1.68 ⁽¹³⁾	± 0.03	No Limit ⁽⁹⁾	--
Temperature (°F)	300	33	82	55	± 1.9	90 ⁽⁴⁾	86 ⁽⁴⁾
Discharge Point 002B, 003B, and 003D ⁽¹⁴⁾							
Clam-Trol CT-1	11	<0.2	1.2 ⁽¹⁶⁾	NA		0.2 ⁽¹⁵⁾	600 ⁽⁴⁾
Discharge Point 003X							
pH (SU) *	4	7.7	8.2	8.0	± 0.4	No Limit ⁽⁹⁾	--
Oil & Grease (mg/l)	6	<5.0	<5.0	<5.0	± 0.0	No Limit ⁽⁹⁾	--
Suspended Solids (mg/l)	6	11	30	22	± 6.6	No Limit ⁽⁹⁾	--
Flow (GPD) **	43	0	2550	1250 ⁽¹⁷⁾	± 82.4	No Limit ⁽⁹⁾	--
Additional 003X Monitoring							
Temperature (°F)	4	35.1	77.4	58.5	± 27.8	No Limit ⁽⁹⁾	--

Notes:

- (1) A value preceded by < is less than the minimum detection level.
- (2) Average values preceded by < contain at least one less than minimum detection level value in the average. The (±) value represents the statistical error at two standard deviations.
- (3) Percent of limit for the average value, unless otherwise noted.
- (4) Daily maximum limit; Percent of limit for the daily maximum value.
- (5) If intake pH is greater than or equal to 8.2, the upper pH limit is increased to 9.0 but in no case can the effluent pH exceed intake pH by more than 0.5 SU.
- (6) Iron mass loading limit of 20 lbs./day was exceeded for the following dates: 01/06/93- 35 lbs./day (1.93 mg/l), 03/31/93- 33 lbs./day (1.61 mg/l), and 04/28/93- 27 lbs./day (1.31 mg/l). The subject out-of-specification conditions were attributed to iron concentrations naturally present in river water used for non-contact cooling and the large volume of river water used.
- (7) Daily average value shall not exceed 0.1 mg/l. Daily maximum total residual chlorine value shall not exceed 0.2 mg/l.
- (8) Outfall 002A is monitored separately, upstream of where it joins the Outfall 002B effluent as required by Reference (6).
- (9) Monitored only.
- (10) Daily maximum limit; the loading limit is 20.0 pounds per day as required by Reference (6).
- (11) Daily maximum limit; the loading limit is 10.0 pounds per day as required by Reference (6).
- (12) Action level specified by Reference (6); percent of limit based on maximum value.
- (13) Data calculated with combination of actual and estimated flow readings.
- (14) On 08/19/93 chemical addition was performed for zebra mussel control using Betz Clam-Trol CT-1 and Betz DTS detoxifying agent.
- (15) Daily maximum value. Monitoring is required during chemical application and discharge.
- (16) Inadequate mixing at the sampling locations occurred. Additional mixing prior to discharge to the river likely reduced the concentration to <0.2 mg/l.
- (17) Average flow was based on 43 days when backwash system was used.

*SU = Standard Units

**GPD = Gallons per day

***MGD = Million gallons per day

Effluent Analyses

Particulate filters and activated charcoal cartridges are changed and analyzed on a routine basis. Particulate filters are analyzed by direct counting for gross alpha and beta radioactivity using a sensitive low-background gas proportional counting system. The system provides minimum detectable concentrations for alpha and beta radioactivity of approximately 1×10^{-16} $\mu\text{Ci/ml}$ and 5×10^{-16} $\mu\text{Ci/ml}$, respectively. The activated charcoal cartridges are analyzed for iodine by gamma spectrometry, which provides a minimum detectable concentration of approximately 3×10^{-14} $\mu\text{Ci/ml}$. Noble gas radioactivity released is calculated based on operating parameters and integration of recorded data from continuous gas monitors.

Assessment

The New York State emission standards for stationary combustion installations are listed in Reference (14). Standards applicable to boiler operations at the Knolls Site are as follows:

1. *Smoke Emissions* - Opacity is not to exceed 40 percent (#2 on Ringlemann Scale) for any time period or 20 percent (#1 on Ringlemann Scale) for three or more minutes during any 60 minute period.
2. *Sulfur* - Fuel oil is to contain less than 1.5 percent sulfur by weight.

Particle emission standards are specified in the air emission permits listed in Table 46.

The recorded data from the photoelectric sensors installed in the boiler stacks show that smoke emissions during 1993 averaged below the 20 percent opacity level. Maximum values occurred during tube blowdown operations, which are required for efficient boiler operation. Boiler tube blowdowns were performed six times daily for durations of less than 40 seconds during the heating season.

Delivery records and fuel analyses confirm that the number 6 fuel oil used at the Knolls Site for boiler operations contained less than 1.5 percent sulfur by weight. Therefore, the sulfur loading in the stack emissions conformed to the state standard.

The radioactivity released in exhaust air during 1993 consisted of: (1) less than 0.00001 curie of

uranium, (2) less than 0.000001 curie of plutonium, (3) less than 0.0001 curie each of particulate fission and activation products with half lives greater than 3 hours, (4) approximately 0.73 curie of krypton-85 and (5) less than 0.1 curie of other noble gases with half lives of 12 days or less.

The airborne radioactivity was contained in a total air exhaust volume of 1.66×10^{12} liters. The average radioactivity concentration in the exhaust air was well below the applicable standards listed in Reference (2). The radioactivity concentration for the year at the nearest site boundary, based on the annual diffusion parameters, averaged less than 0.01 percent of the DOE derived concentration guide for effluent released to unrestricted areas (Reference 2) for the mixture of radionuclides present. Airborne effluent monitoring data are reported as required in References (1) and (3).

All other point source emissions are operated with the appropriate air emissions control equipment as designated in the air emission permit.

ENVIRONMENTAL MONITORING

Scope

The Knolls Site environmental monitoring program includes: a) the routine collection and analysis of samples of Mohawk River water, sediment, and fish; groundwater; and local municipal waters; b) continuous monitoring of radiation levels off-site and at the perimeter of the site. Air is also sampled continuously at stations located in the upwind and downwind directions from the Knolls Site.

Mohawk River water and bottom sediment samples were collected for radioactivity analyses at locations upriver and downriver from the main Knolls Site outfall as shown in Figure 1. Samples were collected during each of three calendar quarters; ice coverage prevents access to the sampling locations during the first calendar quarter. A Birge-Ekman dredge, which samples an area of approximately 15 cm $\times$ 15 cm to an average depth of 2.5 cm, was used for the collection of sediment samples. In addition, bottom feeding fish and recreational sport fish were collected from the Mohawk River upriver and downriver from the Knolls Site outfall for spectrometric and radiochemical analyses.

The municipal water systems servicing the area surrounding the Knolls Site are those of Schenec-

tady, Niskayuna and Latham/Colonie, New York. Supply wells for the Schenectady and Niskayuna systems are located upriver and downriver, respectively, from the Knolls Site. Although there is no direct mechanism for Knolls Site effluent to enter the water supplies, samples normally are collected monthly from the Schenectady and Niskayuna municipal water systems. A monthly sample also is collected from the Colonie/Latham municipal water system which obtains a portion of its water from the Mohawk River approximately five miles downriver from the Knolls Site. Monthly samples are composited quarterly and analyzed for radioactivity.

Surface water was sampled quarterly for water quality and monthly for radioactivity as follows: Mohawk River upriver and downriver from the Knolls Site outfall, the West Boundary and Midline Streams near the point of entry to the Mohawk River, and the East Boundary Stream upstream and downstream of the landfill. The Midline Stream sample point is near the point of entry to the Mohawk River. Stream sample points are shown on Figure 3.

Radiation levels at the boundary of the Knolls Site were monitored with thermoluminescent dosimeters (TLDs) at the 16 locations shown in Figure 2. Six lithium fluoride TLD chips, selected for uniform sensitivity, were placed at each monitoring location and the dosimeters were changed and processed quarterly. Dosimeters were also placed at off-site locations to determine typical background radiation levels.

Environmental air samplers are operated in upwind and downwind directions from the site to measure normal background airborne radioactivity, and to confirm that Knolls Site effluents have no measurable effect on normal background airborne radioactivity levels.

The Knolls Site contains a landfill that covers an area of approximately 3.7 acres on the east side of the Site. The groundwater surrounding the landfill is routinely monitored and the results are reported quarterly in compliance with Reference (21). The landfill was officially closed on October 25, 1993. Non-hazardous solid waste, including cafeteria waste, was disposed at the Niskayuna Town Landfill. The Knolls Site will continue to monitor the groundwater during the post landfill closure period. Groundwater data are presented in Tables 13 to 19 and will be discussed separately.

Analyses

The individual quarterly samples of Mohawk River water and quarterly composite samples of Schenectady, Niskayuna and Latham/Colonie municipal waters were analyzed for alpha and gross beta radioactivity. The boundary stream samples were analyzed for alpha and gross beta radioactivity, and for other radionuclides as appropriate. The methods used are described under Effluent Analyses, page 9.

The Mohawk River sediment samples were analyzed for alpha radioactivity by chemical extraction with subsequent alpha counting and mass and alpha spectrometry, for gross beta radioactivity by direct counting of a dried sample, and for cesium-137 and other gamma-emitting radionuclides with a gamma spectrometer system. Selected samples collected at seven locations upriver, opposite and downriver from the Knolls Site outfall were also analyzed for strontium-90 by chemical extraction and beta counting. The downriver samples for strontium analysis were selected from locations that previous monitoring had indicated would be locations of highest concentrations. In addition, detailed gamma spectrum analyses were performed with a more sensitive gamma spectrometer system on some of the sediment samples. This type of analysis is intended to fully characterize the naturally and non-naturally occurring gamma-emitting radionuclides in the sediment.

Edible portions of the fish collected from the Mohawk River were analyzed for gamma-emitting radionuclides with a high purity germanium spectrometer system, for strontium-90 by chemical extraction and beta counting and for plutonium by chemical separation followed by alpha and mass spectrometry.

The water samples collected from the Mohawk River and the three streams listed under program Scope for chemical analyses were analyzed for the constituents listed in Tables 3, 4 and 5 plus additional baseline parameters listed in Reference (21). The analyses were performed using the procedures provided in Standard Methods, Reference (20) or other EPA approved methods.

The environmental air sample filters were changed and analyzed on a routine basis by direct counting for gross alpha and gross beta radioactivity using the method described under Effluent Analyses, page 13.

Assessment

The results of the analysis of Mohawk River water for chemical quality are summarized in Table 3. The results show no significant difference between the average values for chemical constituents upriver and downriver from the Knolls Site. Results of routine analyses for chemical constituents, radioactivity and temperature in the East and West Boundary and Midline Streams are summarized in Tables 4 and 5. In most cases analyzed parameters were well below comparable standards for Class A waters such as that section of the Mohawk River which borders the Knolls Site. The surface water data base shows that there is no water quality degradation attributable to the Knolls Site.

The New York State surface water quality standard for iron was exceeded in both Mohawk River and East Boundary Stream upstream and downstream samples and in a West Boundary Stream sample. Also, the State standard for manganese was exceeded in certain East Boundary Stream upstream samples. These results are attributable to variations in water quality chemistry caused by naturally occurring metals, either dissolved or suspended in the samples.

The State pH standard was occasionally exceeded in the Mohawk River upstream, Midline Stream and West Boundary Stream samples but not in the corresponding Mohawk River downstream or East Boundary Stream samples. The exceedances are attributed to natural pH variations that compare with historical results observed in these surface waters. East Boundary Stream dissolved oxygen results for August exceeded the State standard in both upstream and downstream samples. The low results were caused by summer drought conditions and resultant lack of stream flow and related stagnant conditions. Other State standards (phenol, magnesium and sulfate) were exceeded only in the East Boundary Stream upstream data set. Also, the East Boundary Stream upstream data shows that a number of parameters (e.g., oil and grease, suspended solids, surfactants) usually exceed downstream sample results. These upstream elevated results are not related to KAPL and represent off-site water quality.

Results of the radioactivity analyses performed on samples of Mohawk River and municipal waters are summarized in Table 6. The results show no significant difference between alpha and gross beta radioactivity concentrations in river

water upstream and downstream from the Knolls Site or in Schenectady, Niskayuna and Latham/Colonie municipal waters.

The results of radioactivity measurements for alpha, gross beta, strontium-90, cesium-137, plutonium, and uranium in Mohawk River bottom sediment samples are summarized in Table 7. The 1993 data show no significant differences between upstream and downstream radioactivity concentrations, although cesium-137 downstream concentrations measured in the recent past routinely have been slightly higher than those measured upstream. The higher concentrations of cesium-137 have been measured in samples collected from locations within one thousand feet downriver from the site outfall. This localized concentration of cesium-137 activity is attributable to operations conducted prior to 1964, when, subject to applicable federal regulations and state and local agreements through the Mohawk River Advisory Committee, limited amounts of radioactivity were released to the Mohawk River. These low levels of radioactivity in the river sediment do not present a health risk since the radioactivity is deposited as bottom sediment, which is not subject to becoming airborne and is unlikely to interact with the aquatic environment.

The results of the detailed gamma spectrum analyses performed on Mohawk River bottom sediment samples also indicated low levels of potassium-40 and daughters of uranium and thorium. The potassium-40 and the daughters of uranium and thorium are naturally occurring radionuclides. No detectable cobalt-60 was found in any sample. However, localized low levels of cobalt-60, which are attributable to operations prior to 1964, have been observed occasionally in past river sediment samples.

The analytical results for the fish collected from the Mohawk River are summarized in Table 8 and Table 9. The results indicate the presence of naturally occurring potassium-40. The results of sensitive analyses for strontium-90 and plutonium indicate no detectable strontium-90 or plutonium in either upriver or downriver fish. The measured concentrations of radioactivity indicate no effect from site operations. In addition, the results of a previous biological survey (Reference (42)) confirm that the low levels of radioactivity in the Mohawk River bottom sediment near the Knolls Site outfall are not taken up and propagated through the food chain.

Knolls Site, Niskayuna, New York
Mohawk River Sampling Locations

Figure 1

Figure 2

Knolls Site, Niskayuna, New York
Perimeter Monitoring Locations

TABLE 3 - CHEMICAL CONSTITUENTS AND TEMPERATURE IN MOHAWK RIVER WATER, 1993

Parameter ^(1a) (Units)	No. of Samples Upstream/ Downstream	Value ⁽¹⁾									Standard ⁽²⁾	Percent of Standard ⁽⁴⁾
		Upstream			Downstream							
		Minimum	Maximum	Average ⁽²⁾	Minimum	Maximum	Average ⁽²⁾					
pH (SU) *	53/4	7.3	8.6 ⁽⁶⁾	8.0 ± 0.1	7.3	8.3	7.9 ± 0.7	6.5-8.5				
Cadmium (mg/l)	4/4	<0.005	<0.005	<0.005 ± 0.000	<0.005	<0.005	<0.005 ± 0.000	0.01		<50		
Ammonia (as N) (mg/l)	4/4	0.3	0.4	0.35 ± 0.09	<0.1	0.6	<0.33 ± 0.35	2.0 ⁽¹³⁾		<17		
Temperature (°C)	53/4	0.0	24.5	10.9 ± 2.3	5	24	15.6 ± 13.7	See Note ⁽⁷⁾		--		
Oil & Grease (mg/l)	4/4	<5	<5	<5.0 ± 0.0	<5	<5	<5.0 ± 0.0	See Note ⁽⁸⁾		--		
Phosphorus (as P) (mg/l)	4/4	0.05	0.36	0.14 ± 0.23	0.05	0.30	0.17 ± 0.21	See Note ⁽¹⁴⁾		--		
Suspended Solids (mg/l)	4/4	1.5	368	107 ± 280	1.5	289	84 ± 218	See Note ⁽¹⁰⁾		--		
Iron (mg/l)	56/4	<0.05	3.38 ⁽¹¹⁾	<0.37 ± 0.15	0.12	2.60 ⁽¹¹⁾	0.87 ± 1.8	0.3		290 ⁽¹¹⁾		
Manganese (mg/l)	4/4	0.02	0.25	<0.08 ± 0.18	0.03	0.23	0.09 ± 0.15	0.3		30		
Chemical Oxygen Demand (mg/l)	4/4	7.5	32	18.4 ± 16.3	<5	26	<14.3 ± 14.1	No Standard		--		
Surfactants (mg/l)	4/4	<0.02	0.03	<0.02 ± 0.01	<0.02	0.04	<0.02 ± 0.02	No Standard		--		
Bromide (mg/l)	4/4	<1	1.1	<1.0 ± 0.1	<1	1.3	<1.1 ± 0.2	2.0 ⁽⁹⁾		<55		
Dissolved Oxygen (mg/l)	4/4	7.2	13.8	9.7 ± 4.8	7.6	13.5	9.8 ± 4.2	See Note ⁽¹⁶⁾		--		
Eh (mv) **	4/4	296	426	366 ± 85	354	435	403 ± 55	No Standard		--		
Turbidity (ntu) ***	4/4	1.6	220	59 ± 171	2	190	53.3 ± 145	See Note ⁽¹⁷⁾		--		
Specific Conductance (µmhos/cm) ****	4/4	192	357	290 ± 114	253	461	340 ± 139	No Standard		--		
Total Dissolved Solids (mg/l)	4/4	128	192	155 ± 43	153	250	203 ± 66	500 ⁽¹⁸⁾		41		
Total Organic Carbon (mg/l)	4/4	3.6	12	8.6 ± 5.7	6.8	13.0	9.6 ± 4.6	No Standard		--		
Sulfate (S, mg/l)	4/4	13	27	22 ± 10	21	50	33.8 ± 19.8	250		14		
Alkalinity (CaCO ₃ , mg/l)	4/4	68	86	79 ± 13	78	96	88.5 ± 12.0	No Standard		--		
Chloride (mg/l)	4/4	13	22	19 ± 7	19	24	22.0 ± 3.4	250		9		
Total Hardness (CaCO ₃ , mg/l)	4/4	109	129	122 ± 15	124	133	129 ± 6	No Standard		--		
Nitrate (N, mg/l)	4/4	0.39	0.61	0.53 ± 0.16	0.38	0.99	0.61 ± 0.42	10		6		
Total Phenols (mg/l)	4/4	<0.002	<0.002	<0.002 ± 0.000	<0.002	<0.002	<0.002 ± 0.000	0.001		⁽⁶⁾		
Calcium (mg/l)	4/4	33.2	39.7	37.4 ± 4.6	36.7	40.5	39.0 ± 2.7	No Standard		--		
Lead (mg/l)	4/4	<0.005	<0.01	<0.009 ± 0.004	<0.005	<0.01	<0.009 ± 0.004	0.05		<18		
Magnesium (mg/l)	4/4	6.3	7.6	7.0 ± 0.9	7.2	8.1	7.6 ± 0.6	35		22		
Potassium (mg/l)	4/4	1.1	3.9	2.4 ± 2.1	0.06	2.7	1.6 ± 1.4	No Standard		--		
Sodium (mg/l)	4/4	7.8	16.5	12.1 ± 5.7	13.8	16.5	15.1 ± 2.0	No Standard		--		
Dissolved Sulfide (mg/l)	4/4	<0.1	<0.1	<0.10 ± 0.00	<0.1	<0.1	<0.10 ± 0.00	0.05 ⁽¹²⁾		⁽⁶⁾		

TABLE 3 - Continued

Notes:

- (1) A value preceded by < is less than the minimum detection level.
- (2) Average values preceded by < contain at least one less than minimum detection level value in the average. The ($\pm$) value represents the statistical error at two standard deviations.
- (3) Per Reference (10), New York State Quality Standards for Class A Waters: source of water supply for drinking, culinary or food processing purposes; primary and secondary contact recreation; and fishing. The waters shall be suitable for fish propagation and survival.
- (4) Percent of standard for the average value of downriver samples.
- (5) Maximum values for pH, which exceed water quality standards were observed at the upriver sampling location.
- (6) The minimum detection value for that parameter is higher than the reference standard. That does not mean that the actual level of the contaminant exceeded the standard.
- (7) Per Reference (10), the thermal discharge limits relating to site operations are as follows:
 - (a) The water temperature at the surface shall not be raised to more than 32.2°C (90°F) at any point.
 - (b) At least 50% of the cross-sectional area and/or volume of flow of the stream including a minimum of one-third of the surface as measured from shore to shore shall not be raised by more than 2.8°C (5°F), over the temperature that existed before the addition of heat of artificial origin or to a maximum of 30°C (86°F), whichever is less.
 - (c) At least 50 percent of the cross-sectional area and/or volume of flow of the stream including a minimum of one-third of the surface as measured from shore to shore shall not be lowered more than five Fahrenheit degrees from the temperature that existed immediately prior to such lowering.
- (8) No residue attributable to sewage, industrial wastes or other wastes, nor visible oil film nor globules of grease.
- (9) Guidance value.
- (10) None from sewage, industrial wastes or other wastes that will cause deposition or impair the waters for their best usages.
- (11) Maximum values for iron, which exceed water quality standards were observed in Mohawk River on numerous occasions. If only the 4 corresponding upriver iron concentrations were used, the average upriver iron concentration would be 0.93 mg/l as compared to 0.87 mg/l for the downriver sampling location. These iron values are attributable to naturally occurring iron in the river water.
- (12) Guidance value for total sulfides expressed as hydrogen sulfide.
- (13) $\text{NH}_3 + \text{NH}_4^+$ as N.
- (14) None in amounts that will result in growths of algae, weeds and slimes that will impair the waters for their best usages.
- (15) The Knolls Site also performed sampling and analyses of 51 additional baseline parameters as listed in Reference (21) during March 1993. All results were within any existing water quality standards as specified by Reference (10). Table 11 lists the parameters included in the baseline scan.
- (16) For non-trout waters, the minimum daily average shall not be less than 5.0 mg/l, and at no time shall the DO concentration be less than 4.0 mg/l.
- (17) No increase that will cause a substantial visible contrast to natural conditions.
- (18) Shall be kept as low as practicable to maintain the best usage of waters but in no case shall it exceed 500 mg/l.

*SU = Standard Units.

**mv = millivolts.

***ntu = nephelometric turbidity units.

**** $\mu\text{mhos/cm}$ = micromhos per centimeter.

TABLE 4 - CHEMICAL CONSTITUENTS, RADIOACTIVITY AND TEMPERATURE IN WEST BOUNDARY AND MIDLINE STREAMS, 1993

Parameter ^(1a) (Units)	No. of Samples West Boundary/ Midline Streams	Value ⁽¹¹⁾									Percent of Standard ⁽¹⁴⁾ West Boundary/ Midline Streams
		West Boundary Stream			Midline Stream			Standard ^(3,8)			
		Minimum	Maximum	Average ⁽²⁾	Minimum	Maximum	Average ⁽²⁾				
pH (SU)	4/4	7.9	8.9 ⁽⁷⁾	8.3 ± 0.7	7.1	8.6 ⁽⁷⁾	8.0 ± 1.0	6.5-8.5	--		
Cadmium (mg/l)	4/4	<0.005	<0.005	<0.005 ± 0.000	<0.005	<0.005	<0.005 ± 0.000	0.01	<50/<50		
Ammonia (N, mg/l)	4/4	<0.1	0.5	<0.20 ± 0.32	<0.1	0.3	<0.15 ± 0.16	2.0 ⁽⁶⁾	<10/<8		
Temperature (°C)	4/4	0	19	10.6 ± 14.9	0	18	9.5 ± 13.7	See Note ⁽¹⁰⁾	--		
Oil & Grease (mg/l)	4/4	<5	<5	<5.0 ± 0.0	<5	<5	<5.0 ± 0.0	See Note ⁽¹¹⁾	--		
Phosphorus (P, mg/l)	4/4	<0.02	0.24	<0.08 ± 0.17	0.05	0.07	0.06 ± 0.01	See Note ⁽¹²⁾	--		
Suspended Solids (mg/l)	4/4	4.0	1800	454 ±1428	1.5	22	12.4 ± 14.9	See Note ⁽¹³⁾	--		
Iron (mg/l)	4/4	0.08	2.85 ⁽²⁰⁾	0.80 ± 2.2	0.06	0.26	0.14 ± 0.16	0.3	267/47		
Manganese (mg/l)	4/4	<0.02	2.77 ⁽²⁰⁾	<0.71 ± 2.2	<0.02	0.06	<0.03 ± 0.03	0.3	<23/<10		
Chemical Oxygen Demand (mg/l)	4/4	<5	69	<27.8 ± 45.1	<5	19	<11.0 ± 11.3	No Standard	--		
Surfactants (mg/l)	4/4	<0.02	0.03	<0.02 ± 0.01	<0.02	0.02	<0.02 ± 0.00	No Standard	--		
Bromide (mg/l)	4/4	<1	1.2	<1.0 ± 0.2	<1	1.3	<1.1 ± 0.2	2.0 ⁽⁸⁾	<50/<55		
Dissolved Oxygen (mg/l)	4/4	8.9	14.1	11.4 ± 4.0	9.2	13.3	11.2 ± 3.6	See Note ⁽¹⁴⁾	--		
Eh (mv)	4/4	304	438	378 ± 89	415	470	436 ± 38	No Standard	--		
Turbidity (ntu)	4/4	2.6	770	195 ± 610	1.7	17	6.3 ± 11.4	See Note ⁽¹⁵⁾	--		
Specific Conductance (µmhos/cm)	4/4	203	1070	636 ± 659	958	1070	1015 ± 73	No Standard	--		
Total Dissolved Solids (mg/l)	4/4	138	605 ⁽¹⁷⁾	417 ± 317	292	553 ⁽¹⁷⁾	465 ± 190	500 ⁽¹⁶⁾	83/93		
Total Organic Carbon (mg/l)	4/4	4.6	13	8.2 ± 5.8	4.4	22	15.6 ± 12.2	No Standard	--		
Sulfate (S, mg/l)	4/4	20	51	41.5 ± 23.0	46	55	50.0 ± 6.0	250	17/20		
Alkalinity (CaCO ₃ , mg/l)	4/4	38	190	137 ± 110	131	290	219 ± 105	No Standard	--		
Chloride (mg/l)	4/4	40	184	125 ± 97	103	228	147 ± 90	250	50/59		
Total Hardness (CaCO ₃ , mg/l)	4/4	130	356	281 ± 165	258	381	319 ± 80	No Standard	--		
Nitrate (N, mg/l)	4/4	0.05	0.54	0.22 ± 0.35	<0.02	0.19	<0.12 ± 0.11	10	2/<1 ⁽⁹⁾		
Total Phenols (mg/l)	4/4	<0.002	<0.002	<0.002 ± 0.000	<0.002	<0.002	<0.002 ± 0.000	0.001	--		
Calcium (mg/l)	4/4	38.0	102	81.4 ± 47.8	74.5	105	90.1 ± 19.8	No Standard	--		
Lead (mg/l)	4/4	<0.005	0.01	<0.009 ± 0.004	<0.005	<0.01	<0.009 ± 0.004	0.05	<18/<18		
Magnesium (mg/l)	4/4	8.4	25.3	18.9 ± 11.6	17.6	29	22.9 ± 7.5	35	54/65		
Potassium (mg/l)	4/4	1.4	6.5	3.2 ± 3.8	<0.5	1.6	<1.2 ± 0.8	No Standard	--		
Sodium (mg/l)	4/4	22.3	76.9	58.4 ± 39.2	64.3	125	84.1 ± 44.3	No Standard	--		
Dissolved Sulfide (mg/l)	4/4	<0.1	<0.1	<0.1 ± 0.00	<0.1	<0.1	<0.1 ± 0.00	0.05 ⁽¹⁸⁾	-- ⁽¹⁹⁾		
Radioactivity											
(10 ⁻⁹ µCi/ml)											
Alpha	12/11	0.64	0.92	0.78 ± 0.25	0.55	0.78	0.69 ± 0.16	30	3/2		
Beta	12/11	3.58	6.17	4.79 ± 2.05	2.22	3.62	2.94 ± 0.94	1000	0.5/0.3		
Strontium-90	12/11	0.26	0.42	0.35 ± 0.11	0.30	0.67	0.45 ± 0.28	1000	<0.1/<0.1		
Cesium-137	12/11	<0.19	<0.21	<0.20 ± 0.01	<0.21	<0.29	<0.23 ± 0.06	3000	<0.1/<0.1		

TABLE 4 - Continued

Notes:

- (1) A value preceded by < is less than the minimum detection level.
- (2) Average values preceded by < contain at least one less than minimum detection level value in the average. The ($\pm$) value represents the statistical error at two standard deviations.
- (3) New York State Quality Standards for Class A Waters: source of water supply for drinking, culinary or food processing purposes; primary and secondary contact recreation; and fishing. The waters shall be suitable for fish propagation and survival. West Boundary and Midline Streams join the Mohawk River, which is a Class A water.
- (4) Percent of standard for the average value.
- (5) $\text{NH}_3 + \text{NH}_4^+$ as N.
- (6) Guidance value.
- (7) The pH exceeded the standard in West Boundary Stream and Midline Stream during October.
- (8) The radioactivity standard is the derived concentration guide (DCG) listed in DOE Order 5400.5, Reference (2). The DCG for unidentified alpha and beta radioactivity is based on the most restrictive radionuclide possibly present in measurable quantities as a result of KAPL operations.
- (9) The minimum detection value for that parameter is higher than the reference standard. That does not mean that the actual level of the contaminant exceeded the standard.
- (10) Per Reference (10), the thermal discharge limits relating to site operations are as follows:
 - (a) The water temperature at the surface shall not be raised to more than 32.2°C (90°F) at any point.
 - (b) At least 50% of the cross-sectional area and/or volume of flow of the stream including a minimum of one-third of the surface as measured from shore to shore shall not be raised by more than 2.8°C (5°F), over the temperature that existed before the addition of heat of artificial origin or to a maximum of 30°C (86°F), whichever is less.
 - (c) At least 50 percent of the cross-sectional area and/or volume of flow of the stream including a minimum of one-third of the surface as measured from shore to shore shall not be lowered more than five Fahrenheit degrees from the temperature that existed immediately prior to such lowering.
- (11) No residue attributable to sewage, industrial wastes or other wastes, nor visible oil film nor globules of grease.
- (12) None in amounts that will result in growths of algae, weeds and slimes that will impair the waters for their best usages.
- (13) None from sewage, industrial wastes or other wastes that will cause deposition or impair the waters for their best usages.
- (14) For non-trout waters, the minimum daily average shall not be less than 5.0 mg/l, and at no time shall the DO concentration be less than 4.0 mg/l.
- (15) No increase that will cause a substantial visible contrast to natural conditions.
- (16) Shall be kept as low as practicable to maintain the best usage of waters but in no case shall it exceed 500 mg/l.
- (17) Elevated levels of total dissolved solids were seen in the Midline Stream during March and June and in the West Boundary Stream during March.
- (18) Guidance value for total sulfides expressed as hydrogen sulfide.
- (19) The Knolls Site also performed sampling and analysis of 51 additional baseline parameters as listed in Reference (21) during March 1993. All results were within any existing water quality standards as specified by Reference (10). Table 11 lists the parameters included in the baseline scan.
- (20) Iron and manganese exceeded the standard in West Boundary Stream during March. This is attributable to iron and manganese naturally present in groundwater and the surface runoff.

TABLE 5 - CHEMICAL CONSTITUENTS, RADIOACTIVITY AND TEMPERATURE IN EAST BOUNDARY STREAM, 1993

Parameter ⁽²¹⁾ (Units)	No. of Samples Upstream/ Downstream	Value ⁽¹¹⁾									Percent of Standard ⁽¹⁴⁾ Upstream/ Downstream
		Upstream			Downstream						
		Minimum	Maximum	Average ⁽²⁾	Minimum	Maximum	Average ⁽²⁾	Standard ^(3,8)			
pH (SU)	7/5	6.7	8.4	7.7 ± 0.6	7.1	8.1	7.5 ± 0.6	6.5-8.5	--		
Cadmium (mg/l)	7/5	<0.005	0.009	<0.006 ± 0.002	<0.005	0.006	<0.005 ± 0.001	0.01	<60/<50		
Ammonia (N, mg/l)	7/5	<0.1	0.5	<0.23 ± 0.15	<0.1	0.4	<0.18 ± 0.16	2.0 ⁽⁹⁾	<12/<9		
Temperature (°C)	7/5	1.0	20	12.3 ± 7.9	1.5	18	8.4 ± 10.0	See Note ⁽¹⁰⁾	--		
Oil & Grease (mg/l)	7/5	<5	16	<6.6 ± 3.8	<5	<5	<5.0 ± 0.0	See Note ⁽¹¹⁾	--		
Phosphorus (P, mg/l)	7/5	<0.02	0.11	<0.05 ± 0.03	0.03	0.08	0.05 ± 0.03	See Note ⁽¹³⁾	--		
Suspended Solids (mg/l)	7/5	4.0	322	79.6 ± 108	5.0	36	21.6 ± 14.9	See Note ⁽¹⁴⁾	--		
Iron (mg/l)	7/5	0.24	0.75 ⁽⁷⁾	0.49 ± 0.18	0.19	0.95 ⁽⁷⁾	0.50 ± 0.38	0.3	163/167		
Manganese (mg/l)	7/5	0.22	0.76 ⁽⁶⁾	0.40 ± 0.22	<0.02	3.21 ⁽⁶⁾	<0.68 ± 1.8	0.3	133/<227		
Chemical Oxygen Demand (mg/l)	7/5	<5	47	<28.7 ± 13.1	<5	38	<18.1 ± 18.1	No Standard	--		
Surfactants (mg/l)	7/5	<0.02	0.13	<0.09 ± 0.04	<0.02	0.07	<0.04 ± 0.03	No Standard	--		
Bromide (mg/l)	7/5	<1	1.9	<1.1 ± 0.31	<1	<1	<1.0 ± 0.0	2.0 ⁽⁵⁾	<55/<50		
Dissolved Oxygen (mg/l)	7/5	3.0 ⁽¹²⁾	12.8	8.0 ± 3.6	1.3 ⁽¹²⁾	14.6	9.6 ± 6.5	See Note ⁽¹⁵⁾	--		
Eh (mv)	7/5	384	447	415 ± 22	368	447	415 ± 40	No Standard	--		
Turbidity (ntu)	7/5	4.7	81	17.3 ± 26	4.8	39	18.2 ± 20	See Note ⁽¹⁶⁾	--		
Specific Conductance (µmhos/cm)	7/5	530	1900	1294 ± 443	670	1390	931 ± 366	No Standard	--		
Total Dissolved Solids (mg/l)	7/5	250	1230 ⁽¹⁹⁾	796 ± 313	305	742 ⁽¹⁹⁾	516 ± 255	500 ⁽¹⁷⁾	159/103		
Total Organic Carbon (mg/l)	7/5	5.9	31	19.8 ± 9.4	4.9	26	12.5 ± 11.1	No Standard	--		
Sulfate (S, mg/l)	7/5	20	534	254 ± 176	36	234	102 ± 100	250	102/41		
Alkalinity (CaCO ₃ , mg/l)	7/5	74	313	246 ± 78	106	275	185 ± 100	No Standard	--		
Chloride (mg/l)	7/5	21	137	97 ± 36	50	128	86 ± 35	250	39/34		
Total Hardness (CaCO ₃ , mg/l)	7/5	121	744	530 ± 192	179	464	340 ± 182	No Standard	--		
Nitrate (N, mg/l)	7/5	<0.02	0.35	<0.15 ± 0.15	0.03	0.59	0.26 ± 0.36	10	<2/4 ⁽²²⁾		
Total Phenols (mg/l)	7/5	<0.002	0.002 ⁽¹⁸⁾	<0.002 ± 0.000	<0.002	<0.002	<0.002 ± 0.000	0.001	--		
Calcium (mg/l)	7/5	34.9	205	144 ± 52.4	52.0	130	95.2 ± 49.1	No Standard	--		
Lead (mg/l)	7/5	<0.005	<0.01	<0.009 ± 0.002	<0.005	<0.01	<0.009 ± 0.003	0.05	--		
Magnesium (mg/l)	7/5	8.2	56.4 ⁽²³⁾	41.6 ± 14.9	12.0	34.8	24.9 ± 14.6	35	119/71		
Potassium (mg/l)	7/5	<0.5	1.7	<1.0 ± 0.5	<0.5	3.9	<1.8 ± 1.6	No Standard	--		
Sodium (mg/l)	7/5	59.7	110	78.7 ± 20.2	42.1	72.6	57.0 ± 18.0	No Standard	--		
Dissolved Sulfide (mg/l)	7/5	<0.1	<0.1	<0.10 ± 0.00	<0.1	<0.1	<0.10 ± 0.00	0.05 ⁽²⁰⁾	-- ⁽²²⁾		
Radioactivity (10 ⁻⁹ µCi/ml)											
Alpha	12/11	0.35	2.61	1.56 ± 1.49	0.73	1.27	1.08 ± 0.38	30	5/4		
Beta	12/11	3.17	9.50	5.58 ± 4.46	3.23	7.66	5.14 ± 3.00	1000	0.6/0.5		
Strontium-90	12/11	0.11	0.51	0.35 ± 0.29	0.28	0.65	0.51 ± 0.26	1000	<0.1/<0.1		
Cesium-137	12/11	<0.21	<0.24	<0.22 ± 0.02	<0.22	<0.31	<0.25 ± 0.07	3000	<0.1/<0.1		

TABLE 5 - Continued

Notes:

- (1) A value preceded by < is less than the minimum detection level.
- (2) Average values preceded by < contain at least one less than minimum detection level value in the average. The ($\pm$) value represents the statistical error at two standard deviations.
- (3) New York State Quality Standards for Class A Waters: source of water supply for drinking, culinary or food processing purposes; primary and secondary contact recreation; and fishing. The waters shall be suitable for fish propagation and survival. East Boundary Stream joins Mohawk River, which is a Class A water.
- (4) Percent of standard for the average value.
- (5) Guidance value.
- (6) Manganese exceeded the standard in East Boundary Upstream during March and August and East Boundary Downstream during August. This is attributable to naturally manganese naturally present in the groundwater and the surface runoff.
- (7) Iron exceeded the standard in East Boundary Upstream during March, June and August and East Boundary Downstream during March and August.
- (8) The radioactivity standard is the derived concentration guide (DCG) listed in DOE Order 5400.5, Reference (2). The DCG for unidentified alpha and beta radioactivity is based on the most restrictive radionuclide possibly present in measurable quantities as a result of KAPL operations.
- (9) $\text{NH}_3 + \text{NH}_4^+$ as N.
- (10) Per Reference (10), the thermal discharge limits relating to site operations are as follows:
 - (a) The water temperature at the surface shall not be raised to more than 32.2°C (90°F) at any point.
 - (b) At least 50% of the cross-sectional area and/or volume of flow of the stream including a minimum of one-third of the surface as measured from shore to shore shall not be raised by more than 2.8°C (5°F), over the temperature that existed before the addition of heat of artificial origin or to a maximum of 30°C (86°F), whichever is less.
 - (c) At least 50 percent of the cross-sectional area and/or volume of flow of the stream including a minimum of one-third of the surface as measured from shore to shore shall not be lowered more than five Fahrenheit degrees from the temperature that existed immediately prior to such lowering.
- (11) No residue attributable to sewage, industrial wastes or other wastes, nor visible oil film nor globules of grease.
- (12) The dissolved oxygen concentrations for both East Boundary Upstream and Downstream during August were less than the minimum standard. This was likely due to very low flow during the summer.
- (13) None in amounts that will result in growths of algae, weeds and slimes that will impair the waters for their best usages.
- (14) None from sewage, industrial wastes or other wastes that will cause deposition or impair the waters for their best usages.
- (15) For non-trout waters, the minimum daily average shall not be less than 5.0 mg/l, and at no time shall the DO concentration be less than 4.0 mg/l.
- (16) No increase that will cause a substantial visible contrast to natural conditions.
- (17) Shall be kept as low as practicable to maintain the best usage of waters but in no case shall it exceed 500 mg/l.
- (18) Phenol was reported at the minimum detection limit in East Boundary Upstream during June.
- (19) Total dissolved solids frequently (8 samples) exceeded the standard in both East Boundary Upstream and Downstream samples.
- (20) The standard listed is as hydrogen sulfide in the undissociated form.
- (21) The Knolls Site also performed sampling and analysis of 51 additional baseline parameters as listed in Reference (21) during March 1993. All results were within any existing water quality standards as specified by Reference (10). Table 11 list the parameters included in the baseline scan.
- (22) The minimum detection value for that parameter is higher than the reference standard. That does not mean that the actual level of the contaminant exceeded the standard.
- (23) Magnesium exceeded the standard in East Boundary Upstream during June, August and October.

**TABLE 6 - RESULTS OF MONITORING MOHAWK RIVER
WATER AND MUNICIPAL WATER, 1993**

Location and Source of Water Samples	Number of Samples	Radioactivity Concentrations (10^{-9} μ Ci/ml)					
		Gross Beta Values ⁽¹⁾			Alpha Values ^(1,2)		
		Minimum	Maximum	Average	Minimum	Maximum	Average ⁽³⁾
Mohawk River Water							
Upstream	6	1.6 $\pm$ 0.6	2.4 $\pm$ 0.6	1.9 $\pm$ 0.4	<0.1	0.2 $\pm$ 0.2	<0.15 $\pm$ 0.05
Downstream	6	1.8 $\pm$ 0.6	2.6 $\pm$ 0.6	2.2 $\pm$ 0.3	0.1 $\pm$ 0.2 ⁽⁴⁾	0.2 $\pm$ 0.2	<0.14 $\pm$ 0.01
Schenectady Municipal Water	12	1.4 $\pm$ 0.6	2.1 $\pm$ 0.6	1.9 $\pm$ 0.5	0.1 $\pm$ 0.2 ⁽⁴⁾	0.3 $\pm$ 0.2	0.19 $\pm$ 0.12
Niskayuna Municipal Water	12	1.4 $\pm$ 0.6	2.2 $\pm$ 0.7	1.8 $\pm$ 0.5	<0.1	0.3 $\pm$ 0.2	<0.18 $\pm$ 0.15
Latham/Colonia Water	12	1.5 $\pm$ 0.6	2.9 $\pm$ 0.7	2.4 $\pm$ 1.0	<0.1	0.1 $\pm$ 0.2 ⁽⁴⁾	<0.11 $\pm$ 0.02

Notes:

- (1) The ($\pm$) value represents the statistical error at two standard deviations.
- (2) A value preceded by < is less than the minimum detection level for that sample and parameter.
- (3) Average values preceded by < contain at least one less than minimum detection level value in the average.
- (4) The lowest possible value for any parameter is zero.

TABLE 7 - RESULTS OF ANALYSES OF MOHAWK RIVER SEDIMENT, 1993

Number of Samples and Type of Results	Radioactivity Concentration		
	(pCi/g, dry wt.) ⁽¹⁾		
	Area Sampled Relative to Effluent Point		
	Upstream	Opposite	Downstream
Alpha Concentration ⁽²⁾			
Number of Samples	12	3	23
Average Concentration	0.71 ± 0.12	0.57 ± 0.46	0.69 ± 0.09
Minimum Concentration	0.42 ± 0.06	0.36 ± 0.05	0.38 ± 0.05
Maximum Concentration	1.10 ± 0.09	0.71 ± 0.07	1.18 ± 0.09
Gross Beta Concentration ⁽³⁾			
Number of Samples	12	3	23
Average Concentration	24.4 ± 3.0	21.9 ± 2.8	24.0 ± 1.3
Minimum Concentration	17.6 ± 3.8	20.6 ± 4.1	18.8 ± 3.9
Maximum Concentration	32.8 ± 5.1	22.8 ± 4.3	30.9 ± 5.0
Strontium-90 Concentration ⁽⁴⁾			
Number of Samples	12	3	6
Average Concentration	<0.02 ± 0.01	<0.01 ± 0.01 ⁽⁸⁾	0.03 ± 0.01
Minimum Concentration	<0.01	0.01 ± 0.01	0.02 ± 0.01
Maximum Concentration	0.06 ± 0.02	<0.013	0.05 ± 0.02
Cesium-137 Concentration ⁽⁵⁾			
Number of Samples	12	3	23
Average Concentration	<0.17 ± 0.05	<0.12 ± 0.16 ⁽⁸⁾	<0.17 ± 0.04
Minimum Concentration	0.06 ± 0.01	0.05 ± 0.01	0.05 ± 0.01
Maximum Concentration	0.34 ± 0.13	<0.18	0.35 ± 0.13
Plutonium Concentration ⁽⁶⁾			
Number of Samples	6	3	6
Average Concentration	<0.036 ± 0.010	<0.027 ± 0.012	<0.038 ± 0.016
Minimum Concentration	<0.023	<0.024	<0.021
Maximum Concentration	<0.052	<0.033	<0.067
Uranium Concentration ⁽⁷⁾			
Number of Samples	6	3	6
Average Concentration	0.84 ± 0.07	0.36 ± 0.03	0.89 ± 0.10
Minimum Concentration	0.77 ± 0.01	0.34 ± 0.01	0.79 ± 0.01
Maximum Concentration	0.92 ± 0.01	0.37 ± 0.01	1.04 ± 0.02

Notes:

- (1) The sediment is sampled to a depth of approximately 2.5 cm. The (±) values represent the statistical error at two standard deviations. A value preceded by < is less than the minimum detectable activity. Average values preceded by < contain at least one less than minimum detectable activity value in the average.
- (2) The minimum detectable activity was 0.01 pCi/gm.
- (3) Radioactivity was primarily potassium-40 and members of the natural uranium and thorium series. The minimum detectable activity was 10 pCi/gm.
- (4) The minimum detectable activity was 0.01 pCi/gm.
- (5) The minimum detectable activity level varies with the sample contents. The minimum detectable activity level is approximately 0.1 pCi/gm.
- (6) Plutonium concentration values are the sum of results for Pu-238, Pu-239 and Pu-240. Less than values indicate that the analysis for one or more of the plutonium radioisotopes was less than the minimum detectable level.
- (7) The minimum detectable radioactivity level is estimated as approximately 0.001 pCi/gm.
- (8) The lowest possible value for any parameter is zero.

Knolls Site, Niskayuna, New York
Groundwater, Stream and Outfall
Monitoring Locations

Figure 3

TABLE 8 - GAMMA SPECTRUM ANALYSIS RESULTS FOR MOHAWK RIVER FISH, 1993

Sample ⁽²⁾ Location	Fish (#)	No. of Samples	Radioactivity Concentrations (pCi/g. wet weight) ⁽¹⁾			
			K-40		Cs-137	
			Maximum	Average	Maximum	Average
Upriver	White Sucker (4) Carp (2)	4	2.98 ± 0.55	2.26 ± 1.17	<0.022	<0.015
Upriver	Minnows (58)	2	5.61 ± 0.87	4.98 ± 1.80	<0.037	<0.035
Upriver	Smallmouth Bass (6)	2	2.68 ± 0.41	2.46 ± 0.62	<0.015	<0.013
Upriver	Tiger Muskellunge (2)	2	1.91 ± 0.29	1.89 ± 0.07	<0.012	<0.012
Downriver	White Sucker (6) Carp (4)	4	2.32 ± 0.35	2.20 ± 0.25	<0.012	<0.010
Downriver	Golden Shiner (6)	2	3.20 ± 0.54	2.76 ± 1.24	<0.023	<0.022
Downriver	Pumpkinseed (10) Yellow Perch (11)	4	3.56 ± 0.59	3.16 ± 0.75	<0.024	<0.021
Downriver	Rock Bass (6)	2	3.11 ± 0.60	2.69 ± 1.20	<0.029	<0.026
Downriver	Smallmouth Bass (5)	2	3.77 ± 0.65	3.37 ± 1.15	<0.028	<0.021
Downriver	Largemouth Bass (4)	2	2.85 ± 0.48	2.57 ± 0.79	<0.019	<0.016

Notes:

- (1) A value preceded by < is less than the minimum detection level for that sample and parameter. Average values preceded by < contain at least one less than minimum detection level value in the average. The (±) value represents the statistical error at two standard deviations.
- (2) Upriver samples were obtained on August 10, 1993 above Lock 8 and below Lock 9. (Lock 8 and Lock 9 are located approximately 9 miles and 14 miles, respectively, of the Knolls Site outfall. Downriver samples were obtained on August 11, 1993 below the Knolls Site outfall and above the dam at Lock 7.

TABLE 9 - RADIOCHEMICAL ANALYSIS RESULTS FOR MOHAWK RIVER FISH, 1993

Sample Location ⁽²⁾	Fish Type	Radioactivity Concentration ⁽¹⁾ (pCi/g, wet weight)	
		Sr-90	Plutonium ⁽³⁾
Upriver	Carp	<0.007	<0.004
Upriver	Smallmouth Bass	<0.007	<0.005
Upriver	Red Horse Sucker	<0.004	<0.004
	Average	<0.006	<0.004
Downriver	Carp	<0.004	<0.003
Downriver	Smallmouth Bass	<0.005	<0.003
Downriver	White Sucker	<0.005	<0.004
	Average	<0.005	<0.003

Notes:

- (1) A value preceded by < is less than the minimum detection level for that sample and parameter.
- (2) Upriver fish were collected on August 10, 1993 upriver of Lock 8. Downriver fish were collected on August 11, 1993 below the Knolls Site Outfall and above the dam at Lock 7.
- (3) Plutonium concentration values are the sum of results for Pu-238, Pu-239 and Pu-240. Less than values (<) indicate that the analysis for one or more of the plutonium radioisotopes was less than the minimum detectable level.

TABLE 10 - PERIMETER AND OFF-SITE RADIATION MONITORING RESULTS, KNOLLS SITE, 1993

Monitoring Location No. ⁽¹⁾	Total Annual Exposure, ⁽²⁾ (millirem)
1	73 ± 2
2	68 ± 2
3	65 ± 2
4	75 ± 2
5	69 ± 1
6	70 ± 2
7	67 ± 2
8	64 ± 2
9	67 ± 2
10	69 ± 2
11	71 ± 2
12	68 ± 2
13	62 ± 2
14	66 ± 2
15	73 ± 3
16	69 ± 2
Off Site locations	63 ± 12 ⁽³⁾

Notes:

- (1) See Figure 2 for monitoring locations.
- (2) The (±) values for individual locations are expressed at the 2 σ confidence level based on the calculated measurement error.
- (3) Approximately 95% of the natural background measurements are expected to be within this range.

The results for the Knolls Site perimeter and off-site radiation monitoring locations are summarized in Table 10. There is no statistically significant difference between the perimeter and the off-site measurements. This shows that Knolls Site operations in 1993 had no measurable effect on natural background radiation levels at the site perimeter.

The analytical results for the environmental air samples indicate that there were no significant differences between the average upwind and downwind radioactivity concentrations. Gamma spectrum analyses performed on groups of environmental samples indicated only background quantities of naturally occurring radionuclides.

GROUNDWATER MONITORING

Scope

The Knolls Site groundwater monitoring network consists of 57 wells as follows: (1) three Niskayuna test holes (NTH-A), located around the Knolls Site Landfill to assess any potential impact of the landfill on groundwater quality, (2) 13 groundwater assessment wells (W and MW) installed to assess any effect of previous waste handling and disposal practices on groundwater quality, (3) 17 hillside wells (B), which are used to establish hydraulic gradients for the determination of the direction of groundwater flow around a former radioactive material processing facility and determine water quality parameters, (4) a dug well (Shugg), (5) 20 wells (KH) installed to evaluate site-wide hydrogeological conditions, and (6) three original (1978) landfill monitoring wells (NTH). Groundwater from 33 of the 57 wells is sampled and analyzed for either chemical quality or radioactivity. As a result of Knolls Site landfill closure in 1993, wells NTH-2, NTH-5, NTH-6 and NTH-7 were removed. The remaining original wells, NTH-1, NTH-3 and NTH-4, are no longer used for water quality monitoring because well construction is not consistent with NYSDEC landfill monitoring well construction requirements, which became effective December 1988. Only the landfill groundwater monitoring portion of the program is a regulatory agency requirement; the remainder of the program is voluntary. Figure 3 is a map showing the location of the Knolls Site monitoring wells.

Origin

Generally, groundwater underlying the Knolls Site is contained in highly impermeable soil and

bedrock. As a consequence there is only slight movement of the water, generally believed to be toward the northeast, to the Mohawk River. Because of the impermeable nature of the soil and bedrock, there is no commercial or public development of the groundwater in the vicinity of the site. Groundwater contaminants can be introduced through two possible routes. The first route, surface recharging, carries atmospheric contaminants such as acid rain and airborne radioactivity from natural and manmade sources (such as past nuclear weapons testing), and surface contaminants such as deicing compounds, fertilizers, and pesticides. The second route is leaching of shallow non-radioactive buried wastes in the Knolls Site sanitary landfill and other burial areas in the vicinity of the landfill where small amounts of waste chemicals from laboratory operations were buried many years ago, consistent with common industrial practices at the time. Also, in parts of the Knolls Site, soil contains low levels of radioactivity from operations over 30 years ago which are detectable above background levels. There are no radioactive waste burial grounds at the Knolls Site, and therefore there is no groundwater contamination from such a source.

Analyses

During 1993 KAPL conducted quarterly radiological and chemical monitoring of the 5 landfill wells plus annual monitoring for selected other on-site wells to ensure that KAPL operations do not have any adverse effect on the groundwater quality in the area. As part of the continuing groundwater monitoring program, Knolls Site conducted sampling for leachate indicators, volatile organics and metals, per Reference (21), from the landfill wells, and select W, MW, B and KH wells, as designated in Table 12. All B, W, MW and KH wells were selected based on their locations and consideration of subsurface hydrogeologic conditions.

As part of the Knolls Site Landfill post-closure monitoring program approved by the NYSDEC, KAPL monitors 5 wells, one up-gradient and four down-gradient wells. The wells NTH-1A (up-gradient), NTH-2A, NTH-5A, W-11 and W-12 are monitored annually for the baseline scan parameters and quarterly for the routine scan parameters listed in Table 11.

When all monitoring wells are sampled, groundwater elevation, temperature, pH, Eh and specific conductivity are measured in the field. Samples are analyzed for radiological parameters using the methods described under Effluent Analyses, page

9. Chemical parameters are analyzed by a vendor laboratory using procedures provided in Standard Methods, Reference (20), or other EPA approved methods. The vendor analytical laboratory is required to be State certified in potable water analyses and wastewater chemical analyses.

Assessment

Results of the groundwater monitoring for radioactivity are summarized in Table 13. Some wells had slightly higher gross beta and/or alpha radioactivity than the background wells. This is attributed to slightly higher levels of dissolved naturally occurring uranium, thorium and their respective daughter products. Naturally occurring potassium-40, which would contribute to the beta radioactivity, is present in all samples. Strontium-90 was detected in wells W-12, B-15, and KH-21 at levels slightly above background. Strontium-90 and its daughter product, yttrium-90, also contribute to the gross beta radioactivity.

All gross beta, alpha and strontium-90 results were within the range of previously reported values. The maximum concentration of strontium-90, which has the most restrictive derived concentration guide of any radionuclide, measured in any well was less than three percent of the DOE derived concentration guide (Reference 2).

Tables 14, 15, 16, 17, 18 and 19 summarize the results of the groundwater monitoring for routine and baseline chemical parameters. Generally, the majority of analytical results are indicative of natural groundwater quality. Most variations in the data are attributable to natural water quality, variability in laboratory results at or near the minimum detection limit or interferences associated with groundwater turbidity. The turbidity is the result of natural particulate materials entering the well from the surrounding clay and silt-rich geologic materials. Turbid water samples can show elevated metal results that are not indicative of dissolved, mobile metals. Also, monitoring wells in proximity to roadways and parking lots commonly show elevated salt parameters (e.g., total dissolved solids, sodium, chlorides, specific conductivity) related to winter road maintenance operations.

The standards and guidance values used to compare groundwater monitoring results are those in 6 NYCRR Part 703.5, quality standards for class GA groundwater, Water Quality Standards in 6 NYCRR Part 703.3 and the standards and

guidance values in the Technical and Operational Guidance Series (1.1.1) Water Quality Standards and Guidance Values.

Tables 18 and 19 summarize the results of the baseline volatile organic and the toxic metals analyses well samples. Only the constituents that were reported by the analytical subcontractor as present at or above the analytical laboratory's minimum detectable level are listed.

Knolls Site Landfill results (Tables 14, 18 and 19) for some parameters (such as specific conductivity, nitrate, TOC, TDS, alkalinity, chloride, hardness, sodium, calcium, potassium, magnesium, boron and TKN) were elevated in most down-gradient wells compared to the up-gradient well, NTH-1A. The pH, TDS, color, turbidity, iron, manganese, sodium and magnesium results of several wells exceeded NYSDEC groundwater quality standards and guidance values. The pH, color and in part the iron results in NTH-1A samples indicate that such exceedances are attributable to natural groundwater quality. Also, filtered iron results show that elevated results are caused by sample turbidity. Overall, results for the landfill wells are within representative ranges for inorganic constituents typical of leachate from sanitary landfills per Reference (38).

Other than the natural water quality variations, the turbidity/metal relationship and road salt effects, the groundwater assessment well (W and MW) data (Tables 14, 18 and 19) show some minor impact associated with the former land disposal areas. In down-gradient well W-3 volatile organic compounds (i.e., trichloroethylene and tetrachloroethylene) were detected. This is consistent with previously reported data. This well is in the vicinity of an area where small amounts of laboratory chemicals were buried years ago. Migration of these compounds is believed to be limited since results from a monitoring well (i.e., W-4) down-gradient of W-3 are less than the minimum detection limit. Low concentrations of antimony were detected in most groundwater assessment well samples and compare with the KH-1S result. Monitoring well KH-1S is located in an area with no site operations or disposal history, suggesting that the antimony results could be attributed to natural groundwater conditions. However, lack of detectable antimony in the site landfill's March data versus the assessment wells' August data indicates that results may be attributed to analytical laboratory variability at these very low levels. Also, the 1992 and 1991 assessment well data show no detectable antimony.

The Hillside well (B) data (Tables 16 and 19) also shows the effects of road salting and the sample turbidity/elevated metals relationship. Volatile organic compound results for monitoring wells B-5 and B-15 are consistent with previous years. The origin of these compounds is attributed to historical solvent storage and dispensing operations and not to waste burial. In 1993 an investigation in the vicinity of B-5 and B-6 was initiated, in part, to assess the potential migration mechanism for solvent migration beneath this portion of the site. No volatile organic compounds are detected in monitoring wells down-gradient of B-5 and B-15. The benzene, toluene and xylenes results for the B-15 (DUP) and blank samples are not representative of groundwater quality. These gasoline compounds have not been detected historically nor has there been any gasoline spills in this portion of the site. The results are likely caused by sample cross-contamination from vehicular traffic.

Tables 17 and 18 show the sample results for the KH-wells. No volatile organic compounds were detected, and, therefore, results are not listed in Table 19. The data show the effects of turbidity road salting and natural groundwater compositional variations. Arsenic was detected in the KH-15 sample above the State standard and compares with the 1992 data. However, results from well samples downgradient of KH-15 (e.g., KH-21 and 22) show no detectable arsenic, which suggest the arsenic distribution is limited. There is no known use or burial of arsenic in this portion of the site. KAPL will continue to monitor these wells to further assess the significance of arsenic.

The overall conclusion of the groundwater monitoring program is that previous operations and waste disposal practices have resulted in some small, although measurable, effects on the groundwater quality in localized areas of the Knolls Site. Based on upstream and downstream monitoring of the Mohawk River, there is no detectable effect on river water quality as a result of past or current Knolls Site operations. The groundwater is limited in quantity and is not used as a drinking water supply. In addition, the Knolls Site is not located over any principal or primary bed-rock or overburden aquifers. Therefore, the groundwater associated with the Knolls Site does not pose a threat to public health.

CONTROL OF CHEMICALLY HAZARDOUS SUBSTANCES

Origins

Chemicals are not manufactured at the Knolls Site. Minimal quantities of hazardous wastes do result from the necessary use of chemicals in site operations. To ensure the safe use of chemicals and disposal of the resulting wastes, Knolls Site maintains a hazardous waste control program. Hazardous wastes are not disposed of through any KAPL sewer systems or disposed of on-site.

Control Program

The control program minimizes the quantity of waste material generated, ensures safe use and storage of the materials on site and provides for proper disposal of the wastes by vendors that operate under permits issued by state and federal agencies.

A principal part of the waste minimization program is the control of acquisition of hazardous substances for use at the Knolls Site. Purchase orders for chemicals are reviewed to ensure that the materials are actually necessary for site operations, that the amount ordered is not excessive, and that methods for proper disposal are in place before the material is ordered. Additionally, in the past few years, many hazardous substances have been replaced by non-hazardous substitutes. KAPL also formally evaluates over 90% of the hazardous waste produced on a biennial basis and provides the NYSDEC with an annual Hazardous Waste Reduction Plan. Progress in reducing waste at the Knolls Site is tracked in this plan.

All personnel are provided with general information on Knolls Site policies for the procurement, use and disposal of hazardous substances. For individuals who use hazardous substances in operations, specific training is provided to ensure that they are knowledgeable of safe handling techniques and emergency response procedures. After chemicals are used and no longer needed, they are accumulated in designated staging and storage areas where they are segregated and packaged for shipment. Waste is temporarily stored only as necessary to accumulate sufficient volume for economical shipment to a waste disposal ven-

dor. The Knolls Site has an inspection program to routinely verify that hazardous substances are properly stored and controlled in accordance with approved procedures. In addition, the Knolls Site hazardous waste control program is subject to annual independent oversight by NYSDEC.

Disposal

Disposal of hazardous waste is in compliance with the Resource Conservation and Recovery Act (RCRA). The small quantities of waste generated are transported by vendors to treatment/storage/disposal facilities for final disposition. The transportation vendors and the treatment/storage/disposal facilities operate under permits issued by the cognizant state and federal regulatory agencies. KAPL requires the disposal facility to provide itemized written verification that the waste was actually received. During 1993 the Knolls Site shipped approximately 44 tons of RCRA and New York State hazardous waste for off-site disposal. Twenty-seven tons of this waste consisted of 4 PCB transformer carcasses and associated PCB oil/cleanup debris. The remaining total chemical hazardous waste sent for disposal was 17 tons. This includes the weight of the shipping containers. The Knolls Site reduces the potential environmental impact of the waste by selecting the ultimate disposal methods that minimize or eliminate future environmental intrusion. At present, most chemical waste is incinerated.

Elementary neutralization of small volume laboratory waste and the boiler house blowdown and acid regeneration wastewater also occur on site. This process is exempt from regulation as a RCRA treatment process. The neutralized discharge is controlled under the Knolls Site wastewater discharge permit. The boiler house is the primary source of wastewater with a pH prior to neutralization of less than 2 or greater than 12.5.

TRANSPORTATION OF RADIOACTIVE MATERIALS

Operation of the Knolls Site results in the generation of various types of radioactive materials that require detailed procedures for handling, packaging, transportation, and, if necessary, disposal at a government operated burial site.

Radioactive materials that do not require disposal are handled and transferred in accordance with detailed material control and accountability procedures. Internal reviews are made prior to the shipment of any radioactive material from the

Knolls Site, to ensure that the material is properly identified, surveyed, and packaged in accordance with federal requirements.

Low level radioactive solid waste materials that require disposal include filters, metal scrap, rags, resin, paper, and plastic materials. The volume of this waste is minimized through the use of special work procedures that limit the amount of materials that become contaminated during work on radioactive systems and components. In addition, loose waste is mechanically compacted to minimize the volume being disposed. Radioactive liquids are solidified in cement prior to shipment. All radioactive wastes are packaged in accordance with written procedures to meet applicable regulations of the DOT given in Reference (18). The waste packages also comply with all applicable requirements of the NRC, the DOE, and the burial sites.

The shipments of low level radioactive solid wastes were made by authorized common carriers to government owned burial sites located outside New York State. During 1993, approximately 122 cubic meters (160 cubic yards) of low level radioactive waste containing approximately 0.9 curie were shipped from the site for disposal.

RADIATION DOSE ASSESSMENT

The effluent and environmental monitoring results show that radioactivity present in liquid and gaseous effluents from 1993 operations at the Knolls Site had no measurable effect on normal background radioactivity levels. Therefore, any radiation doses from site operations to off-site individuals were too small to be measured and must be calculated using conservative methods. Estimates of: (1) the radiation dose to the maximally exposed individual in the vicinity of the Knolls Site, (2) the average dose to members of the public residing in the 80 kilometer (50 mile) radius assessment area surrounding the Site and (3) the collective dose to the population residing in the assessment area are summarized in Tables 42 and 43. See Figure 12 for a map of the assessment area surrounding the Knolls Site.

The results show that the estimated doses were less than 0.1 percent of that permitted by the radiation protection standards of the DOE listed in Reference (2) and that the estimated dose to the population residing within 80 kilometers (50 miles) of the Knolls Site was less than 0.001 percent of the natural background radiation dose to the population. In addition, the

estimated doses were less than one percent of that permitted by the NRC numerical guide listed in Reference (4) for whole-body dose, demonstrating that doses are as low as is reasonably achievable. The dose attributed to radioactive air emissions was less than one percent of the EPA standard in Reference (3).

The collective radiation dose to the public along the travel route from Knolls Site shipments of

radioactive materials during 1993 was calculated using data given by the NRC in Reference (22). Based on the type and number of shipments made, the collective annual radiation dose to the public along the transportation routes, including transportation workers, was less than one person-rem. This is less than 0.001 percent of the dose received by the same population from natural background radiation.

TABLE 11 - GROUNDWATER MONITORING PARAMETERS

Parameters Tested

A Baseline Scan	B Routine Scan
Static Water Level ⁽¹⁾	Static Water Level ⁽¹⁾
Specific Conductance ⁽¹⁾	Specific Conductance ⁽¹⁾
Temperature ⁽¹⁾	Temperature ⁽¹⁾
pH ⁽¹⁾	pH ⁽¹⁾
Eh ⁽¹⁾	Eh ⁽¹⁾
Total Kjeldahl Nitrogen (TKN)	Ammonia
Ammonia	Nitrate
Nitrate	COD
Chemical Oxygen Demand (COD)	TOC
Biochemical Oxygen Demand (BOD)	TDS
Total Organic Carbon (TOC)	Sulfate
Total Dissolved Solids (TDS)	Alkalinity
Sulfate	Phenols
Alkalinity	Chloride
Phenols	Hardness
Chloride	Turbidity
Hardness	Potassium
Turbidity	Sodium
Color	Iron
Boron	Manganese
Potassium	Magnesium
Sodium	Lead
Iron	Cadmium
Manganese	Calcium
Magnesium	
Calcium	
Aluminum	
Cyanide	
Toxic Metals:	
Antimony	
Arsenic	
Beryllium	
Barium	
Cadmium	
Chromium (total and hexavalent)	
Copper	
Lead	
Mercury	
Nickel	
Selenium	
Silver	
Thallium	
Zinc	
	Volatile Organics
	(EPA Method 601 and 602)
	Chloromethane
	Bromomethane
	Dichlorodifluoromethane
	Vinyl Chloride
	Chloroethane
	Methylene Chloride
	Trichlorofluoromethane
	1,1 Dichloroethane
	1,1 Dichloroethene
	t-1,2 Dichloroethene
	Chloroform
	1,2 Dichloroethane
	1,1,1 Trichloroethane
	Carbon Tetrachloride
	Bromodichloromethane
	1,2 Dichloropropane
	t-1,3 Dichloropropene
	Trichloroethylene
	Dibromochloromethane
	1,1,2 Trichloroethane
	cis-1,3-Dichloropropene
	2-Chloroethylvinylether
	Bromoform
	1,1,2,2-Tetrachloroethane
	Tetrachloroethylene
	Benzene
	Toluene
	Ethylbenzene
	Chlorobenzene
	p-Dichlorobenzene
	m-Dichlorobenzene
	o-Dichlorobenzene
	Xylenes

(1) Measured in the field.

TABLE 12 - KNOLLS SITE GROUNDWATER SAMPLING PLAN - 1993

WELL ID	Radioactivity	Routine	Baseline	Volatile Organics
NTH-1A	Q	Q	A	
NTH-2A	Q	Q	A	
NTH-5A	Q	Q	A	
W-1	Q		A	
W-2	A		A	
W-3	A		A	
W-4	A		A	
W-8	A		A	
W-10	A		A	
W-11	Q	Q	A	
W-12	Q	Q	A	
MW-2	A		A	
MW-3	A		A	
B-5	A	A		A
B-6	A	A		A
B-15	A	A		A
B-16	A	A		A
B-26	A	A		A
KH-1S	A		A	
KH-6	A		A	
KH-9S	A		A	
KH-15	A		A	
KH-16	A		A	
KH-17	A		A	
KH-18	A		A	
KH-19	A		A	
KH-20	A		A	
KH-21	A		A	
KH-22	A		A	
KH-23	A		A	
KH-2	A			
KH-3S	A			
SHUGG	A			

Note: A = Annually

Q = Quarterly

**TABLE 13 - RESULTS OF KNOLLS SITE GROUNDWATER MONITORING
FOR RADIOACTIVITY, 1993**

Locations		Radioactivity Concentrations ⁽¹⁾					
		Gross Beta	Alpha	Sr-90	Cs-137	H-3	
		(× 10 ⁻⁹ uCi/ml)			(× 10 ⁻⁷ uCi/ml)		
Landfill Area							
March	NTH-1A	0.5 ± 0.5	0.2 ± 0.2	0.2 ± 0.2	<0.6	<0.9	
	NTH-2A	5.9 ± 1.1	2.4 ± 0.5	0.5 ± 0.2	<0.6	<0.9	
	NTH-5A	1.2 ± 0.6	0.2 ± 0.2	0.3 ± 0.2	<0.6	<0.9	
	W-11	3.3 ± 0.8	0.2 ± 0.2	<0.1	<0.7	<0.9	
	W-12	36.0 ± 2.0	3.6 ± 0.6	0.4 ± 0.2	<0.6	<0.9	
June	NTH-1A	0.9 ± 0.5	0.6 ± 0.3	0.3 ± 0.2	<0.6	<0.8	
	NTH-2A	5.9 ± 1.2	2.2 ± 0.5	0.4 ± 0.2	<0.6	<0.8	
	NTH-5A	1.5 ± 0.7	0.6 ± 0.3	<0.2	<0.6	<0.8	
	W-11	2.9 ± 0.7	<0.1	<0.2	<0.6	<0.8	
	W-12	19.3 ± 1.5	1.1 ± 0.4	0.9 ± 0.3	<0.6	<0.8	
August	NTH-1A	0.8 ± 0.6	0.2 ± 0.3	<0.6	<0.7	<0.7	
	NTH-2A	7.5 ± 1.4	1.4 ± 0.4	0.8 ± 0.9	<0.7	<0.7	
	NTH-5A	3.2 ± 1.0	0.6 ± 0.3	<0.5	<0.7	<0.7	
	W-11	4.3 ± 1.0	<0.2	<0.5	<0.7	<0.7	
	W-12	26.2 ± 2.0	1.4 ± 0.4	0.7 ± 0.9	<0.7	<0.7	
	W-2	7.3 ± 1.1	0.6 ± 0.3	<0.5	<0.7	<0.7	
	W-3	7.7 ± 1.3	0.4 ± 0.3	0.7 ± 0.8	<0.7	<0.7	
	W-4	2.5 ± 0.8	0.2 ± 0.3	<0.5	<0.7	<0.7	
	W-8	4.2 ± 0.8	<0.2	<0.6	<0.7	<0.7	
	W-10	7.4 ± 1.2	4.0 ± 0.7	<0.4	<0.7	<0.7	
	MW-2	1.3 ± 0.7	0.3 ± 0.3	<0.5	<0.7	<0.7	
	MW-3	1.7 ± 0.7	1.1 ± 0.4	<0.5	<0.8	<0.7	
October	NTH-1A	0.8 ± 0.6	0.6 ± 0.3	<0.2	<0.6	<0.9	
	NTH-2A	6.7 ± 1.2	3.4 ± 0.6	0.4 ± 0.2	<0.7	<0.9	
	NTH-5A	2.3 ± 0.9	0.4 ± 0.3	<0.2	<0.7	<0.9	
	W-11	5.1 ± 1.1	0.3 ± 0.3	0.3 ± 0.2	<0.7	<0.9	
	W-12	17.1 ± 1.6	1.0 ± 0.4	0.6 ± 0.3	<0.6	<0.9	
Hillside Area							
July	B-5	5.2 ± 3.3	1.3 ± 0.4	<0.2	<0.6	<0.9	
	B-6	15.3 ± 4.8	2.8 ± 0.6	0.3 ± 0.2	<0.7	<0.9	
	B-15	14.4 ± 4.0	2.4 ± 0.5	2.4 ± 0.4	<0.7	<0.9	
	B-16	5.7 ± 1.2	2.5 ± 0.6	<0.2	<0.7	<0.9	
	B-26	3.1 ± 0.9	0.7 ± 0.3	<0.2	<0.6	<0.9	
KH Wells							
September	KH-6	1.9 ± 1.0	1.2 ± 0.4	<0.2	<0.7	<0.9	
	KH-9S	2.4 ± 2.5	1.6 ± 0.4	<0.2	<0.7	<0.9	
	KH-15	2.6 ± 0.9	0.3 ± 0.2	<0.2	<0.6	<0.9	
	KH-16	5.6 ± 1.3	2.5 ± 0.5	<0.2	<0.7	<0.9	
	KH-17	2.9 ± 1.0	1.6 ± 0.4	<0.2	<0.7	<2.2	
	KH-18	9.5 ± 1.5	2.9 ± 0.6	<0.3	<0.8	<0.9	
	KH-19	4.1 ± 1.0	4.2 ± 0.7	<0.2	<0.7	<0.9	
	KH-20	9.2 ± 1.3	<0.1	0.2 ± 0.2	<0.7	<0.9	
	KH-21	55.2 ± 6.1	3.3 ± 0.6	20.3 ± 0.9	<0.7	<0.9	
	KH-22	6.2 ± 1.2	0.5 ± 0.3	0.7 ± 0.3	<0.6	<0.9	
	KH-23	9.0 ± 1.5	0.3 ± 0.2	<0.2	<0.6	<0.9	
	Background Wells - for comparison						
	March	W-1	1.7 ± 0.6	0.3 ± 0.2	0.4 ± 0.3	<0.7	<1.6
June	W-1	2.3 ± 0.7	0.3 ± 0.2	<0.2	<0.7	<0.8	
August	W-1	3.2 ± 0.8	0.3 ± 0.3	<0.5	<0.8	<0.7	
July	KH-1S	1.6 ± 0.7	0.8 ± 0.3	<0.2	<0.7	<0.9	
	KH-2	36.9 ± 4.9	1.1 ± 0.4	<0.2	<0.6	<0.9	
	KH-3S	2.8 ± 0.7	3.4 ± 0.6	<0.2	<0.7	<0.9	
October	W-1	3.1 ± 0.8	0.3 ± 0.3	<0.2	<0.6	<0.9	
	Shugg	2.1 ± 0.6	0.5 ± 0.3	0.3 ± 0.2	<0.7	<1.7	

Notes:

- (1) A value preceded by < is less than the minimum detection level for that sample and parameter. The (±) value represents the statistical error at two standard deviations.

**TABLE 14 - RESULTS OF KNOLLS SITE GROUNDWATER MONITORING,
BASELINE/ROUTINE SCAN OF LANDFILL WELLS, 1993**

Parameter (all units are mg/l except where indicated) ^(1,2)																				
Well	Sample Date	Elev. (Feet)	Temp. (C)	pH (SU)	Specific Conductivity (umhos/cm)	Eh (mV)	Ammonia	Nitrate	COD	TOC	TDS	Sulfate	Alkalinity	Chloride	Hardness	Turbidity (NTU) ⁽²⁾	Phenols	Color (cpu) ⁽³⁾	BOD	
NTH-1A	03/25/93	316.50	5.5	6.0	171	456	0.3	0.24	<5	1.6	120	48	97	2.6	77	25	<0.002	15	<2	
DUP	03/25/93	NA	5.5	6.2	168	452	0.4	0.24	<5	2.5	105	44	80	2.1	86	29	<0.002	20	<2	
BLANK	03/25/93	NA	7.0	7.3	5	438	0.2	0.02	19	2.3	5	<2	1	<1	<5	0.22	<0.002	<5	<2	
	06/14/93	315.50	17	7.1	634	346	0.3	<0.02	<5	<1	365	56	207	2.9	292	22	<0.002	--	--	
	08/09/93	312.52	14	6.7	525	468	0.1	<0.02	11	16	258	58	203	2.9	298	32	<0.002	--	--	
	10/15/93	310.77	11.5	7.3	542	453	<0.1	0.03	<5	22	382	57	205	3.1	298	4.6	<0.002	--	--	
NTH-2A	03/25/93	232.92	5	7.0	936	456	0.6	0.09	<5	3.4	570	105	536	2.6	617	22	<0.002	10	<2	
	06/14/93	232.65	17	6.4	1570	376	0.4	0.07	<5	3.7	738	81	570	27	652	12	<0.002	--	--	
DUP	06/14/93	NA	17.0	6.3	1550	382	0.4	0.08	<5	40	730	57	548	28	664	7.5	<0.002	--	--	
	08/09/93	233.16	13	6.6	1340	492	0.1	0.32	19	38	708	127	507	30	653	17	<0.002	--	--	
DUP	08/09/93	NA	13.0	6.6	1350	284	0.1	0.30	22	42	708	123	533	32	679	17	<0.002	--	--	
	10/15/93	233.14	12	7.0	1254	367	0.2	0.18	7.5	70	893	217	525	35	693	4.4	<0.002	--	--	
DUP	10/15/93	NA	12.0	6.9	1278	368	0.1	0.21	<5	29	902	231	530	28	691	3.2	<0.002	--	--	
NTH-5A	03/25/93	268.09	3	6.2	216	445	0.5	0.33	7.5	2.8	100	37	72	3.6	108	33	<0.002	20	<2	
	06/14/93	266.53	17	6.4	1100	345	0.3	<0.02	<5	12	600	81	352	26	549	8.1	<0.002	--	--	
	08/09/93	264.31	13	6.8	916	391	0.1	<0.02	11	13	503	76	427	26	542	4.9	<0.002	--	--	
	10/15/93	263.60	11.5	7.3	921	256	0.2	0.03	<5	28	682	84	450	34	561	5.7	<0.002	--	--	
W-11	03/25/93	257.85	4	6.7	849	457	1.2	<0.02	<5	<1	458	47	362	47	448	12	<0.002	10	<2	
	06/14/93	257.83	19	7.1	956	359	1.1	<0.02	<5	3.2	530	42	388	48	467	12	<0.002	--	--	
	08/09/93	257.44	19	7.2	884	456	0.5	0.08	<5	7.1	445	41	337	42	447	9.1	<0.002	--	--	
	10/15/93	257.64	12.5	7.3	882	378	0.4	0.07	<5	10	590	45	340	48	453	8.4	<0.002	--	--	
W-12	03/25/93	238.91	2	8.1	785	467	1.1	<0.02	<5	6.7	418	127	127	185	266	49	<0.002	20	<2	
	06/14/93	240.21	17	7.2	965	356	0.9	<0.02	7.5	18	582	161	288	34	410	97	<0.002	--	--	
	08/09/93	240.06	17	6.9	969	469	<0.1	0.36	119	6.8	565	199	315	22	469	310	<0.002	--	--	
	10/15/93	239.96	11.5	7.3	826	420	<0.1	0.30	22	14	603	155	305	28	396	300	<0.002	--	--	
Standards ⁽⁴⁾																				
		(5)	(5)	(5)	6.5-8.5 ⁽⁶⁾	(5)	(5)	2	10.0	(5)	(5)	500 ⁽⁶⁾	250	(5)	250	(5)	5 ⁽⁶⁾	0.001	15 ⁽⁶⁾	(5)

Notes:

- (1) A value preceded by < is less than the minimum detection level.
- (2) Nephelometric Turbidity Unit
- (3) Cobalt Platinum Unit
- (4) Water Quality Standards, 6 NYCRR 703.5
- (5) No Groundwater Standards/Guidance Value.

(6) Water Quality Standards, 6 NYCRR 703.3

(7) Technical and Operational Guidance Series (TOGS) 1.1.1, Guidance Values

(8) Unfiltered/filtered metal results.

(9) See Tables 18 and 19 for additional parameters.

**TABLE 14 - RESULTS OF KNOLLS SITE GROUNDWATER MONITORING,
BASELINE/ROUTINE SCAN OF LANDFILL WELLS, 1993 (continued)**

Parameter (all units are mg/l except where indicated) ^(1,8)													
Well	Sample Date	Iron ⁽⁸⁾	Lead	Manganese ⁽⁸⁾	Sodium	Calcium	Potassium	Magnesium	Cadmium	Aluminum	Boron	TKN	Cyanide
NTH-1A	03/25/93	0.28/0.20	<0.01	<0.02/<0.02	7.6	19.1	1.0	7.1	<0.005	0.2	<0.05	<0.3	<0.01
DUP	03/25/93	0.49/0.19	<0.01	0.02/<0.02	8.0	21.4	0.7	7.9	<0.005	<0.2	<0.05	<0.3	<0.01
BLANK	03/25/93	<.05/<.05	<0.01	<0.02/<0.02	<0.5	<0.5	<0.5	<0.5	<0.005	<0.2	<0.05	<0.3	<0.01
	06/14/93	1.38	0.01	0.33	5.2	79.5	<0.5	22.7	<0.005	--	--	--	--
	08/09/93	1.29	0.019	0.29	10.3	81.1	0.5	23.4	<0.005	--	--	--	--
	10/15/93	0.83	<0.005	0.19	9.3	80.7	0.6	23.6	<0.005	--	--	--	--
NTH-2A	03/25/93	2.27/0.09	<0.01	0.91/1.45	39.4	167	2.9	48.5	<0.005	<0.2	0.17	<0.3	<0.01
	06/14/93	0.80	<0.01	1.73	31.2	175	2.9	52.3	<0.005	--	--	--	--
DUP	06/14/93	1.55	<0.01	2.01	30.8	179	2.0	52.8	<0.005	--	--	--	--
	08/09/93	1.45	<0.005	2.21	0.9	176	3.1	52.0	<0.005	--	--	--	--
DUP	08/09/93	1.49	0.016	2.07	1.5	184	3.3	53.5	<0.005	--	--	--	--
	10/15/93	1.53	<0.005	1.09	42.3	191	3.4	52.5	<0.005	--	--	--	--
DUP	10/15/93	2.12	<0.005	0.93	42.7	191	3.2	51.9	<0.005	--	--	--	--
NTH-5A	03/25/93	0.19/0.07	<0.01	0.02/<0.20	6.4	29.8	3.3	8.2	<0.005	<0.2	<0.05	<0.3	<0.01
	06/14/93	0.55	<0.01	0.34	19.8	147	1.6	44.3	<0.005	--	--	--	--
	08/09/93	0.64	<0.005	0.28	8.3	145	0.9	43.8	<0.005	--	--	--	--
	10/15/93	0.41	<0.005	0.21	25.0	149	1.3	45.9	<0.005	--	--	--	--
W-11	03/25/93	0.26/0.19	<0.01	0.11/0.08	24.5	115	2.9	38.9	<0.005	<0.2	0.16	0.3	<0.01
	06/14/93	0.32	<0.01	0.11	21.8	121	3.5	40.0	<0.005	--	--	--	--
	08/09/93	0.30	<0.005	0.06	8.0	115	2.9	38.8	<0.005	--	--	--	--
	10/15/93	0.29	<0.005	0.11	26.0	116	3.1	39.7	<0.005	--	--	--	--
W-12	03/25/93	0.42/<0.05	<0.01	0.29/0.18	41.4	74.5	23.2	19.4	<0.005	<0.2	0.17	1.4	<0.01
	06/14/93	0.80	<0.01	0.51	43.3	117	18.7	28.6	<0.005	--	--	--	--
	08/09/93	1.50	<0.005	0.39	5.1	138	16.6	30.4	<0.005	--	--	--	--
	10/15/93	0.45	<0.005	0.10	42.8	113	11.6	27.6	<0.005	--	--	--	--
Standards ⁽⁴⁾		0.3	0.025	0.3	20	(5)	(5)	35 ⁽⁷⁾	0.01	(5)	1.0	(5)	0.1

See notes on previous page.

**TABLE 15 - RESULTS OF KNOLLS SITE GROUNDWATER MONITORING,
BASELINE SCAN OF GROUNDWATER ASSESSMENT WELLS, 1993**

Parameter (all units are mg/l except where indicated)^{(1),(8)}

Well	Sample Date	Elev. (Feet)	Temp. (C)	pH (SU)	Specific Conductivity (umhos/cm)	Eh (mV)	Ammonia	Nitrate	COD	BOD	TOC	TDS	Color (cpu) ⁽²⁾	Sulfate	Alkalinity	Chloride	Hardness	Turbidity (NTU) ⁽³⁾	Phenols
W-1	08/09/93	302.33	14.0	7.5	645	432	0.3	<0.02	11	5	20	333	5	51	254	13	124	19	<0.002
W-2	08/09/93	301.79	14.0	6.6	938	478	0.1	0.61	8	<2	13	540	<5	213	304	4.8	461	1.5	<0.002
W-3	08/09/93	298.37	14.0	6.6	1005	463	0.2	0.16	8	<2	27	593	<5	213	364	3.8	490	4.2	<0.002
W-3 Dup.	08/09/93	NA	14.0	6.7	1002	464	0.2	0.14	11	<2	23	555	<5	190	370	3.4	485	3.1	<0.002
W-4	08/09/93	282.50	20.0	7.2	878	460	<0.1	0.03	<5	<2	18	498	5	184	270	5.8	497	35	<0.002
W-8	08/09/93	301.82	17.0	7.1	501	444	0.3	0.25	<5	<2	17	253	<5	51	192	2.9	497	1.6	<0.002
W-10	08/09/93	284.59	14.0	7.1	1748	483	0.2	0.96	8	<2	33	1240	5	590	307	20	743	66	<0.002
MW-2	08/09/93	310.57	12.5	6.2	716	475	0.1	0.07	15	<2	5.0	373	5	64	237	32	364	60	<0.002
MW-3	08/09/93	306.01	13.0	6.2	817	455	0.1	0.11	15	<2	5.0	415	15	68	267	58	441	17	<0.002
Blank	08/09/93	NA	25.0	7.2	8	210	<0.1	0.02	<5	<2	<1	<5	<5	<2	2.0	<1	<5	0.34	<0.002
Standards ⁽⁴⁾		(7)	(7)	6.5-8.5 ⁽⁵⁾	(7)	(7)	2	10.0	(7)	(7)	(7)	500 ⁽⁶⁾	15 ⁽⁶⁾	250	(7)	250	(7)	5 ⁽⁶⁾	0.001

Well	Sample Date	Iron	Lead	Manganese	Sodium	Calcium	Potassium	Magnesium	Cadmium	Aluminum	Boron	TKN	Cyanide
W-1	08/09/93	0.65	<0.005	0.05	103	33.7	2.4	9.6	<0.005	1.4	0.33	1.9	<0.01
Filtered		<0.05	<0.005	0.05	109	33.8	1.6	9.7	<0.005	<0.2			
W-2	08/09/93	0.08	<0.005	0.82	37.5	120	3.4	39.2	<0.005	<0.2	0.44	1.4	<0.01
Filtered		<0.05	<0.005	0.84	42.7	125	4.1	44.6	<0.005	<0.2			
W-3	08/09/93	0.11	<0.005	1.00	42.1	138	3.1	35.4	<0.005	<0.2	0.21	1.4	<0.01
Filtered		0.05	<0.005	1.06	47.9	138	3.9	39.0	<0.005	<0.2			
W-3 Dup.	08/09/93	0.14	<0.005	1.10	40.0	138	2.9	34.1	<0.005	<0.2	0.21	1.4	<0.01
Filtered		0.06	<0.005	1.06	48.0	142	3.9	38.6	<0.005	<0.2			
W-4	08/09/93	0.32	<0.005	0.03	14.7	137	0.9	37.7	<0.005	0.2	0.15	1.1	<0.01
Filtered		0.05	<0.005	0.03	17.5	143	1.0	40.6	<0.005	<0.2			
W-8	08/09/93	0.05	<0.005	0.07	39.6	48.5	1.8	13.5	<0.005	<0.2	0.18	1.1	<0.01
Filtered		<0.05	<0.005	0.07	45.8	51.7	3.6	15.3	<0.005	<0.2			
W-10	08/09/93	0.96	<0.005	0.29	136	204	5.6	56.7	<0.005	0.4	0.21	1.1	<0.01
Filtered		0.06	<0.005	0.13	156	196	6.5	59.3	0.009	0.2			
MW-2	08/09/93	0.57	<0.005	0.24	12.1	114	<0.5	19.2	<0.005	0.3	<0.05	1.1	<0.01
Filtered		<0.05	<0.005	0.13	14.8	127	<0.5	22.9	<0.005	<0.2			
MW-3	08/09/93	1.64	<0.005	0.70	12.8	130	<0.5	28.3	<0.005	<0.2	<0.05	1.4	<0.01
Filtered		0.54	<0.005	0.69	15.4	141	<0.5	32.1	<0.005	<0.2			
Blank	08/09/93	<0.05	<0.005	<0.02	<0.5	<0.5	<0.5	<0.5	<0.005	<0.2	0.05	0.3	<0.01
Filtered		<0.05	<0.005	<0.02	<0.5	<0.5	<0.5	<0.5	<0.005	<0.2			
Standards ⁽⁴⁾		0.3	0.025	0.3	20	(7)	(7)	35 ⁽⁶⁾	0.01	(7)			

Notes:

(1) A value preceded by < is less than the minimum detection level.

(2) Cobalt Platinum Unit.

(3) Nephelometric Turbidity Unit.

(4) Water Quality Standards, 6NYCRR 703.5

(5) Water quality standards, 6NYCRR 703.3

(6) Technical and Operations Guidance Series (TOGS) 1.1.1 Guidance Values.

(7) No Groundwater Standard/Guidance Value.

(8) See Tables 18 and 19 for additional baseline parameters.

**TABLE 16 - RESULTS OF KNOLLS SITE GROUNDWATER MONITORING,
ROUTINE SCAN OF HILLSIDE WELLS, 1993**

Parameter (all units are mg/l except for where indicated) ^(1,8)

Well	Sample Date	Elev. (Feet)	Temp. (C)	pH (SU)	Specific Conductivity (umhos/cm)	Eh (mV)	Ammonia	Nitrate	COD	TOC	TDS	Sulfate	Alkalinity	Chloride	Hardness	Turbidity (NTU) ⁽²⁾	Phenols
B-5	07/15/93	324.58	19	7.0	4770	377	0.4	<0.02	29	7.2	3130	352	255	1550	1190	15	<0.002
B-5DUP	07/15/93	NA	19	7.1	4730	375	0.2	<0.02	7.5	11	2860	376	255	1320	1030	11	<0.002
B-6	07/15/93	323.29	18	7.1	3120	340	0.1	<0.02	41	17	1770	93	580	684	352	12	<0.002
BLANK	07/15/93	NA	22	7.2	5	299	<0.1	<0.02	<5	<1	<1	<2	2	<1	<5	0.63	<0.002
B-15	07/14/93	315.87	15	6.2	3570	336	1.2	<0.02	7.5	19	2200	394	400	743	1490	5.4	<0.002
B-15DUP	07/14/93	NA	15	6.1	3580	342	1.1	<0.02	<5	15	2200	396	390	747	1500	53	<0.002
B-16	07/14/93	268.61	16	6.9	1010	315	0.2	0.02	38	33	643	78	350	49	544	195	<0.002
B-26	07/14/93	290.45	18	7.2	1060	294	0.4	0.04	7.5	20	635	39	315	114	556	56	<0.002
BLANK	07/14/93	NA	28	7.6	3	220	0.2	<0.02	<5	<1	<1	<2	2.0	<1	<5	1.1	<0.002
Standards ⁽³⁾		⁽⁶⁾	⁽⁶⁾	6.5-8.5 ⁽⁴⁾	⁽⁶⁾	⁽⁶⁾	2	10.0	⁽⁶⁾	⁽⁶⁾	500 ⁽⁴⁾	250	⁽⁶⁾	250	⁽⁶⁾	5 ⁽⁴⁾	0.001

Well	Sample Date	Iron ⁽⁷⁾	Lead	Manganese ⁽⁷⁾	Sodium	Calcium	Potassium	Magnesium	Cadmium
B-5	07/15/93	1.08/<0.05	<0.01	0.18/0.19	501	317	4.4	96.8	<0.005
B-5DUP	07/15/93	1.08/<0.05	<0.01	0.27/0.19	374	288	4.7	75.4	<0.005
B-6	07/15/93	2.22/1.49	<0.01	0.43/0.40	514	102	5.2	23.5	<0.005
BLANK	07/15/93	<0.05/<0.05	<0.01	<0.02/<0.02	<0.5	<0.5	0.5	<0.5	<0.005
B-15	07/14/93	<0.05/<0.05	<0.01	3.21/3.07	2160	378	11.7	133	<0.005
B-15DUP	07/14/93	<0.05/<0.05	<0.01	3.09/2.89	231	382	12	134	<0.005
B-16	07/14/93	2.87/0.09	<0.01	0.25/0.09	47.0	129	2.7	53.9	<0.005
B-26	07/14/93	1.09/<0.05	<0.01	0.10/0.02	34.9	104	2.1	71.9	<0.005
BLANK	07/14/93	<0.05/<0.05	<0.01	<0.02/<0.02	<0.5	<0.5	<0.5	<0.5	<0.005
Standards ⁽³⁾		0.3	0.025	0.3	20	⁽⁶⁾	⁽⁶⁾	35 ⁽⁶⁾	0.01

Notes:

- (1) A value preceded by < is less than the minimum detection level for that sample and parameter.
- (2) Nephelometric Turbidity Unit
- (3) Water Quality Standards, 6 NYCRR 703.5
- (4) Water Quality Standards, 6 NYCRR 703.3
- (5) Technical and Operational Guidance Series (TOGS) 1.1.1 Guidance Values
- (6) No Groundwater Standard/Guidance Value
- (7) Unfiltered/filtered metal results
- (8) See Table 19 for additional baseline parameters.

**TABLE 17 - RESULTS OF KNOLLS SITE GROUNDWATER MONITORING,
BASELINE SCAN OF KH WELLS, 1993**

Parameter (all units are mg/l except where indicated)^(1,6)

Well	Sample Date	Elev. (Feet)	Temp. (C)	pH (SU)	Specific Conductivity (umhos/cm)	Eh (mV)	Ammonia	Nitrate	COD	BOD	TOC	TDS	Color (cpu) ⁽²⁾	Sulfate	Alkalinity	Chloride	Hardness	Turbidity (NTU) ⁽³⁾	Phenols
KH-15	07/14/93	280.46	14	6.7	970	345	0.5	<0.02	61	<2	50	588	5	48	450	58	816	>1000	<0.002
KH-15DUP	07/14/93	NA	14	6.5	964	340	0.6	<0.02	86	<2	45	615	5	63	450	54	649	>1000	<0.002
KH-9S	07/14/93	324.38	14	6.7	1970	373	0.4	0.43	76	3	13	1510	5	90	315	413	1020	>1000	<0.002
KH-16	07/14/93	316.76	15	7.3	1180	328	0.4	<0.02	35	<2	21	740	<5	56	305	157	696	470	<0.002
KH-17	07/14/93	321.25	16	7.0	1050	312	0.4	0.12	11	<2	24	630	5	81	340	80	559	410	<0.002
BLANK	07/14/93	NA	28	7.6	3	220	0.2	<0.02	<5	<2	<1	<1	<5	<2	2.0	<1	<5	1.1	<0.002
KH-22	07/15/93	220.66	18	6.9	862	223	0.1	0.72	<5	<2	7.8	510	<5	41	160	139	491	46	<0.002
KH-21	07/15/93	239.55	14	6.7	2720	356	0.4	<0.02	<5	<2	8.3	1590	<5	113	215	876	827	91	<0.002
KH-20	07/15/93	231.72	14	7.1	840	337	0.8	0.08	<5	<2	4.2	505	10	86	370	36	3160	220	<0.002
KH-23	07/15/93	241.86	14	7.4	1020	324	2.2	0.04	<5	4	8.6	493	5	40	190	150	374	120	<0.002
KH-6	07/15/93	313.52	16	6.9	1020	323	0.3	0.06	<5	<2	5.4	573	5	42	400	70	516	650	<0.002
KH-1S	07/15/93	330.99	13	7.2	497	411	0.3	0.30	<5	2	7.1	280	5	34	220	1.2	392	>1000	<0.002
KH-19	07/15/93	235.56	16	8.9	1150	312	1.5	<0.02	<5	20	2.1	675	5	3.1	525	46	41	90	0.004
KH-18	07/15/93	275.87	(7)	(7)	(7)	(7)	(7)	(7)	(7)	(7)	(7)	(7)	(7)	(7)	(7)	(7)	(7)	(7)	(7)
BLANK	07/15/93	NA	22	7.2	5	299	<0.1	<0.02	<5	<2	<1	<1	<5	<2	2.0	<1	<5	0.63	<0.002
Standards ⁽⁴⁾		(6)	(6)	6.5-8.5 ⁽⁵⁾	(6)	(6)	2	10.0	(6)	(6)	(6)	500 ⁽⁵⁾	15 ⁽⁵⁾	250	(6)	250	(6)	5 ⁽⁵⁾	0.001

Notes:

- (1) A value preceded by < is less than the minimum detection level for that sample and parameter.
- (2) Cobalt Platinum Unit
- (3) Nephelometric Turbidity Unit
- (4) Water Quality Standards, 6 NYCRR 703.5
- (5) Water Quality Standards, 6 NYCRR 703.3
- (6) No Groundwater Standard/Guidance Value.
- (7) Analysis not performed due to limited insufficient sample volume.
- (8) See Tables 18 and 19 for additional baseline parameters.

**TABLE 17 - RESULTS OF KNOLLS SITE GROUNDWATER MONITORING,
BASELINE SCAN OF KH WELLS, 1993 (Continued)**

Parameter (all units are mg/l except where indicated)^{(1),(6)}

Well	Sample Date	Iron	Lead	Manganese	Sodium	Calcium	Potassium	Magnesium	Cadmium	Aluminum	Boron	TKN	Cyanide
KH-9S	07/14/93	21.7	<0.01	7.69	108	282	1.9	77.1	<0.005	1.9	0.06	3.4	<0.01
Filtered		<0.05	<0.01	0.05	107	200	1.5	60.9	<0.005	<0.2			
KH-15	07/14/93	14.5	<0.01	1.08	27.8	205	2.5	73.8	<0.005	2.3	0.12	5.6	<0.01
Filtered		0.28	<0.01	0.04	29.4	108	2.2	63.1	<0.005	<0.2			
KH-15DUP	07/14/93	10.5	<0.01	0.50	26.4	153	2.7	64.9	<0.005	1.5	0.11	5.0	<0.01
Filtered		0.14	<0.01	0.04	27.5	105	1.9	60.1	<0.005	<0.2			
KH-16	07/14/93	8.48	<0.01	0.79	53	166	1.0	68.4	<0.005	1.9	0.08	7.8	<0.01
Filtered		<0.05	<0.01	<0.02	56	120	2.0	57.5	<0.005	<0.2			
KH-17	07/14/93	1.28	<0.01	0.93	26.9	155	1.6	43.7	<0.005	0.3	0.08	4.5	<0.01
Filtered		<0.05	<0.01	<0.02	27.5	155	1.9	47.4	<0.005	<0.2			
BLANK	07/15/93	<0.05	<0.01	<0.02	<0.5	<0.5	<0.5	<0.5	<0.005	<0.2	<0.05	<0.3	<0.01
Filtered		<0.05	<0.01	<0.02	<0.5	<0.5	<0.5	<0.5	<0.005	<0.2			
KH-1S	07/15/93	10.9	<0.01	1.91	6.7	107	2.0	30.4	<0.005	4.19	0.05	4.5	<0.01
Filtered		<0.05	<0.01	<0.02	36	76.2	1.7	24.4	<0.005	<0.2			
KH-6	07/15/93	1.18	<0.01	0.16	15.6	144	0.9	38	<0.005	0.4	<0.05	1.1	<0.01
Filtered		<0.05	<0.01	<0.02	<0.5	153	0.8	44	<0.005	<0.2			
KH-18	07/15/93	66.7	0.03	3.54	22.1	353	8.1	135	<0.005	31.5	0.30	(5)	(5)
Filtered		(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)			
KH-19	07/15/93	5.01	0.01	0.11	231	14.2	1.7	1.5	<0.005	2.5	1.1	1.7	<0.01
Filtered		<0.05	0.02	<0.02	<0.5	2.7	2.2	<0.5	<0.005	<0.2			
KH-20	07/15/93	1.71	<0.01	12.2	19.9	117	4.3	58.8	<0.005	<0.2	0.07	1.1	<0.01
Filtered		<0.05	<0.01	<0.02	<0.5	24.8	3.4	72.3	<0.005	<0.2			
KH-21	07/15/93	17.7	<0.01	18.3	299	233	2.5	59.6	<0.005	16.0	0.10	0.6	<0.01
Filtered		<0.05	<0.01	4.9	<0.5	194	2.2	56.8	<0.005	<0.2			
KH-22	07/15/93	5.73	<0.01	6.76	137	147	3.7	30.1	0.018	1.1	<0.05	4.5	<0.01
Filtered		<0.05	<0.01	<0.02	52.5	97.2	2.7	18.7	<0.005	<0.2			
KH-23	07/15/93	3.97	<0.01	1.64	78.5	116	3.6	20.5	<0.005	1.1	0.24	2.8	<0.01
Filtered		<0.05	<0.01	0.16	64.0	87.4	4.5	19.5	<0.005	<0.2			
BLANK	07/15/93	<0.05	<0.01	<0.02	<0.5	<0.5	<0.5	<0.5	<0.005	<0.2	<0.05	0.3	<0.01
Filtered		<0.05	<0.01	<0.02	<0.5	<0.5	0.5	<0.5	<0.005	<0.2			
Standards ⁽²⁾		0.3	0.025	0.3	20	(4)	(4)	35 ⁽³⁾	0.01	(4)	1.0	(4)	0.1

Notes:

- (1) A value preceded by < is less than the minimum detection level for that sample and parameter.
- (2) Water Quality Standards, 6 NYCRR 703.5
- (3) Technical and Operational Guidance Series (TOGS) 1.1.1 Guidance Values.
- (4) No Groundwater Standard/Guidance Value
- (5) Analysis was not performed due to insufficient sample volume.
- (6) See Tables 18 and 19 for additional baseline parameters.

**TABLE 18 - RESULTS OF KNOLLS SITE GROUNDWATER MONITORING,
LANDFILL, GROUNDWATER ASSESSMENT AND KH WELLS,
BASELINE TOXIC METALS, 1993**

Parameter (all units are mg/l except where indicated) ^(1,2,5)							
Well	Sample Date	Antimony	Arsenic	Barium	Copper	Total Chromium	Zinc
NTH-1A	03/25/93	<0.06	<0.005	0.01	<0.05	<0.005	<0.01
NTH-1A DUP	03/25/93	<0.06	<0.005	0.01	<0.05	<0.005	<0.01
NTH-2A	03/25/93	<0.06	<0.005	0.08	<0.05	<0.005	<0.01
NTH-5A	03/25/93	<0.06	<0.005	0.02	<0.05	<0.005	<0.01
W-11	03/25/93	<0.06	<0.005	0.21	<0.05	<0.005	<0.01
W-12	03/25/93	<0.06	<0.005	0.05	<0.05	<0.005	<0.01
W-1	08/09/93	<0.06	<0.005	0.10	<0.05	0.007	0.02
W-2	08/09/93	0.16	<0.005	0.05	<0.05	<0.005	<0.01
W-3	08/09/93	0.11	<0.005	0.06	<0.05	<0.005	0.01
W-3 DUP	08/09/93	0.10	<0.005	0.06	<0.05	<0.005	<0.01
W-4	08/09/93	0.17	<0.005	0.05	<0.05	<0.005	<0.01
W-8	08/09/93	0.06	<0.005	0.05	<0.05	0.011	0.01
W-10	08/09/93	0.24	<0.005	0.05	<0.05	<0.005	0.03
MW-2	08/09/93	0.09	<0.005	0.02	<0.05	<0.005	0.02
MW-3	08/09/93	0.11	<0.005	0.02	<0.05	<0.005	<0.01
KH-21	07/15/93	0.21	<0.005	0.38	<0.05	0.018	0.04
KH-22	07/15/93	<0.06	<0.005	0.11	<0.05	<0.005	0.01
KH-23	07/15/93	0.08	<0.005	0.94	<0.05	<0.005	0.01
KH-1S	07/15/93	0.12	<0.005	0.17	<0.05	<0.005	<0.01
KH-6	07/15/93	0.16	<0.005	0.05	<0.05	<0.005	<0.01
KH-15	07/14/93	<0.06	0.053	0.09	<0.05	<0.005	0.04
KH-15 DUP	07/14/93	<0.06	0.044	0.08	<0.05	<0.005	0.01
KH-18	07/15/93	0.51	0.016	0.17	0.06	0.055	0.34
KH-19	07/15/93	<0.06	<0.005	0.21	<0.05	<0.005	0.02
KH-9S	07/14/93	<0.06	0.010	0.22	<0.05	<0.005	0.06
KH-16	07/14/93	<0.06	0.01	0.11	<0.05	<0.005	0.03
KH-17	07/14/93	<0.06	0.005	0.05	<0.05	<0.005	<0.01
KH-20	07/15/93	0.24	<0.005	2.4	<0.05	<0.005	<0.01
Standards ⁽³⁾		0.003 ⁽⁴⁾	0.025	1.0	0.2	0.05	0.3

Notes:

- (1) A value preceded by < is less than the minimum detection level.
- (2) The only parameters listed are those for which any of the Knolls Site wells exceeded the minimum detection level for that parameter.
- (3) Groundwater Standards, 6 NYCRR 703.5.
- (4) Technical and Operational Guidance Series (1.1.1) Guidance Values.
- (5) In addition to the parameters listed in table, mercury, beryllium, nickel, thallium, cadmium, silver, hexavalent chromium and selenium were also analyzed. The results were less than the MDL.

**TABLE 19 - RESULTS OF KNOLLS SITE GROUNDWATER MONITORING,
LANDFILL, HILLSIDE AND GROUNDWATER ASSESSMENT WELLS,
VOLATILE ORGANIC ANALYSES, 1993**

Parameter (all units are $\mu\text{g/l}$ except where indicated)⁽¹⁾

Well ⁽⁴⁾	Sample Date	Chloroform	Carbon Tetrachloride	Trichloroethylene	Tetrachloroethylene	Xylenes	Benzene	Toluene
B-5 ⁽⁵⁾	07/15/93	120	<100	4200	<100	<100	<100	<100
B-5 (DUP)	07/15/93	120	<100	3900	<100	<100	<100	<100
B-6	07/15/93	<1	<1	8	<1	<1	<1	<1
B-15 ⁽⁵⁾	07/14/93	290	270	1200	<50	<50	<50	<50
B-15 (DUP)	07/14/93	260	280	1100	<50	<50	58	<50
B-16	07/14/93	<1	<1	<1	<1	<1	<1	<1
B-26	07/14/93	<1	<1	<1	<1	<1	<1	<1
KH-1S	07/15/93	<1	<1	<1	<1	<1	<1	<1
BLANK	07/14/93	<1	<1	<1	<1	3	<1	4
BLANK	07/15/93	<1	<1	<1	<1	<1	<1	<1
W-1	08/09/93	<1	<1	<1	<1	<1	<1	<1
W-2	08/09/93	<1	<1	<1	<1	<1	<1	<1
W-3	08/09/93	<1	<1	4	140	<1	<1	<1
W-3 (DUP)	08/09/93	<1	<1	4	130	<1	<1	<1
W-4	08/09/93	<1	<1	<1	<1	<1	<1	<1
W-8	08/09/93	<1	<1	<1	<1	<1	<1	<1
W-10	08/09/93	<1	<1	<1	<1	<1	<1	<1
MW-2	08/09/93	<1	<1	<1	<1	<1	<1	<1
MW-3	08/09/93	<1	<1	<1	<1	<1	<1	<1
NTH-1A	03/25/93	<1	<1	<1	<1	<1	<1	<1
NTH-1A (DUP)	03/25/93	<1	<1	<1	<1	<1	<1	<1
NTH-2A	03/25/93	<1	<1	<1	<1	<1	<1	<1
NTH-5A	03/25/93	<1	<1	<1	<1	<1	<1	<1
W-11	03/25/93	<1	<1	<1	<1	<1	<1	<1
W-12	03/25/93	<1	<1	<1	<1	<1	<1	<1
Standards ⁽³⁾		7	5	5	0.7	5	0.7	5

Notes:

- (1) A value preceded by < is less than the minimum detection level.
- (2) The only parameters reported are those for which any of the Knolls Site wells exceeded the minimum detection level (MDL) for that parameter. An additional 26 volatile organic compounds were analyzed and were less than MDL. Table 11 lists the names of all compounds analyzed.
- (3) Groundwater Standards, 6 NYCRR 703.5.
- (4) The KH wells were analyzed for volatile organics also. All results were less than the minimum detection level.
- (5) The minimum detection limits (MDL) were affected by the high level of trichloroethylene in these samples.

KESSELRING SITE EFFLUENT AND ENVIRONMENTAL MONITORING

SITE DESCRIPTION

The Kesselring Site (Figure 12) consists of 3900 acres on which are located four pressurized-water naval nuclear propulsion plants and support facilities, including administrative offices, machine shops, waste storage facilities, oil storage facilities, training facilities, equipment service buildings, chemistry laboratories, a boiler house, cooling towers, and wastewater treatment facilities. One of the four nuclear propulsion plants is permanently shut down. The Site is located near West Milton, New York, approximately 17 miles (27.4 kilometers) north of the City of Schenectady, 9 miles (14.5 kilometers) southwest of Saratoga Springs. The surrounding area is a rural, sparsely populated region of wooded lands through which flow the Glowegee Creek and several small streams that empty into the Kayaderosseras Creek.

The climate in the region of the Kesselring Site is primarily continental in character, but is subjected to some modification from the maritime climate which prevails in the extreme southeastern portion of New York State. Winters are usually cold and occasionally fairly severe. Maximum temperatures during the colder winter months often are below freezing and nighttime low temperatures frequently drop to 10°F or lower. Subzero temperatures occur rather infrequently, about a dozen times a year. Snowfall in the area is quite variable, averaging approximately 65 inches per year. Over some of the higher elevation areas nearby, snow fall ranges up to 75 inches or more for a season. The mean annual precipitation for the area is approximately 40 inches per year. The prevailing winds are from the west.

The area surrounding the Kesselring Site has a complex geological history due to the processes of erosion, glaciation, folding and faulting. The geological formations of the West Milton area are comprised of two major types; bedrock, which ranges in age from Precambrian to Ordovician, and unconsolidated deposits of Pleistocene and Recent age. Bedrock underlying the area crop out only on some steep hillsides and in some stream valleys. They are covered by the unconsolidated deposits in the remainder of the area. These unconsolidated deposits range in thickness from 0 to 200 feet with an average thickness of 50 feet. Bedrock underlying the West Milton area may be

divided into two groups; (1) metamorphosed rocks of Precambrian age, and (2) sedimentary rocks of Paleozoic age. The older metamorphosed rocks consist of gneiss, schist, quartzite, and limestone (marble) of sedimentary origin; and syenite and granite of igneous origin. These rocks are referred to as crystalline rocks. The Paleozoic rocks likewise consist of several types including sandstone, dolomite, limestone and shale. The unconsolidated deposits can be subdivided into four groups: (1) till - an unstratified, dense heterogeneous mixture of glacially deposited rock particles ranging in size from clay to gravel, (2) ice-contact deposits - kames and eskers composed of stratified sand and gravel, (3) glaciolacustrine deposits - homogeneous stratified layer of sand silt and clay, and (4) recent fluvial deposits consisting of sand and gravel.

Generally, the coarser grained, stratified, unconsolidated deposits form better aquifers than the fine grained and unstratified unconsolidated deposits or bedrock foundations. Only small areas are underlain by these coarse grained deposits. Percolating water from rainfall and snow-melt recharge the shallow, unconfined aquifers beneath the site and in turn, the various site streams are recharged by shallow groundwater. The Kayaderosseras Creek valley is underlain by coarse grained glacial and fluvial deposits from which all site service water is produced. The site well-field is located near the eastern boundary of the site within the creek's floodplain.

The Kesselring Site is located in the transition zone between the Adirondack Mountains and the Hudson-Mohawk Valley lowland. The Kayaderosseras Creek forms the main drainage system in the vicinity of the Site. The average flow in the Kayaderosseras Creek is 137 cubic feet per second (cfs) and the minimum recorded 7 day average flow for a 10 year period is 17 cfs.

Three small creeks drain the Site, these are the Glowegee Creek, Crook Brook and Hogback Brook. Crook Brook directly joins the Kayaderosseras. Hogback Brook is a tributary to the Glowegee which is the receiving waters for site drainage. The average flow in the Glowegee is 35.7 cfs and the minimum recorded 7 day average flow for a 10 year period is 0.92 cfs. The Glowegee Creek joins with the Kayaderosseras approximately one mile east of West Milton.

The Glowegee Creek is classified under New York State Codes, Rules and Regulations as a Class C - Trout Stream. Under this classification the waters are suitable for fishing and fish propagation. Additionally the water quality shall be suitable for primary and secondary contact recreation, even though other factors may limit the use for that purpose. The New York State Department of Environmental Conservation (NYSDEC) has permitted the Site to discharge effluent from various site operations to the Glowegee Creek as specified in the Site State Pollution Discharge Elimination System (SPDES) permit. Environmental monitoring has shown no measurable water quality degradation in the Glowegee Creek due to Site Operations. The Kayaderosseras Creek also has a Class C - Trout Stream classification. The Kesselring Site obtains all water for its operation from on-site production wells.

LIQUID EFFLUENT MONITORING

Origins

Liquid effluents from the Kesselring Site are derived from several sources: site boiler blowdown water, sewage treatment plant effluent, cooling tower blowdown and overflow, retention basin discharges, storm water, groundwater and site service cooling water.

Some of the liquid effluents contain low levels of radioactivity. The source of this radioactivity is small quantities of activation products. The activation products may include tritium, radionuclides of corrosion and wear products, carbon-14 and argon-41.

Tritium is present in the reactor coolant as the result of neutron interaction with naturally occurring deuterium present in the water. Corrosion and wear activation products are present as small insoluble metal oxide particles, with cobalt-60 the predominant radionuclide. Carbon-14 and argon-41 are the result of neutron interaction with isotopes of dissolved oxygen, nitrogen, and argon in the coolant. Other radioactive gases such as xenon and krypton are produced by neutron interaction with trace quantities of uranium impurities in structural members within the reactor.

To minimize releases of radioactivity to the environment, a water reuse system is employed. Water is collected and processed through the process system described below. After purification, the majority of water is reused as reactor coolant make-up and in other radioactive systems,

thereby reducing the amount of radioactivity that could be released as liquid effluent.

Liquids that may contain radioactivity are collected in holdup tanks and processed in batches. The processing system consists of a series of filters and demineralizers. Each batch of processed liquid is held in tanks and analyzed to ensure that the radioactivity content is minimal and is in compliance with applicable standards. In addition, each tank of processed water is sampled to provide a sensitive determination of the radioactivity actually present. The samples are combined into a monthly composite, which is analyzed to determine the quantity and identity of radionuclides present.

Liquid discharges that might contain tritium are either sampled and analyzed individually, or sampled and combined into a monthly composite which is then analyzed for tritium.

The low concentrations of radioactivity in the liquids released from the Kesselring Site have always been below all applicable state and federal limits and have not resulted in any detectable radioactivity in the Glowegee Creek.

The primary sources of the effluent water at the Kesselring Site are:

1. *Site Boiler Discharges* - Site boiler water is treated demineralized water. Operations that result in releases are (1) periodic blowdowns to control the concentration of solids and (2) neutralization of ion exchange resin regeneration effluent. The blowdown waters are neutralized before discharge.
2. *Sewage Treatment Plant* - The plant is a tertiary treatment facility employing extended aeration/contact stabilization of activated sludge and chemical precipitation of phosphorous followed by sand filtration. Waste sludge is stored in a holding tank and is periodically removed by a licensed subcontractor for disposal at a state-approved facility.
3. *Cooling Tower Water* - Cooling water is treated to minimize scale formation, to prevent corrosion of system materials and to inhibit the growth of algae and slime. The pH is maintained in the range of 7.0 to 8.4.

4. *Retention Basin Liquids* - The retention basins receive wastewater from reactor plant facilities including blowdown water from steam generators and drainage water from the engine rooms.
5. *Site Drainage Water* - Storm water also makes up a portion of the liquid effluent.
6. *Site Service Water* - Site service water is used for drinking water and non-contact cooling purposes. Chlorine is added to the site service water system as a drinking water disinfectant.
7. *Groundwater* - Groundwater which enters the liners of in-ground tanks is discharged to prevent damage to the tanks.

Approximate flows and chemical characteristics of these discharges were incorporated in the Reference (7) State Pollutant Discharge Elimination System (SPDES) permit application.

Effluent Monitoring

Liquid effluents from the Kesselring Site enter the Glowegee Creek through two surface channels (discharges 001 and 002), a submerged drain line from the sewage treatment plant (discharge 003) and a storm water runoff (discharge 004) shown in Figure 4.

With the exception of the sewage treatment plant, intermittent cooling tower blowdowns, and once-through cooling systems that operate continuously, all effluents are released in batches. Control of effluent concentrations is achieved by the analysis of liquid collected from the continuous flow systems and from the collection tanks prior to each release from the batch systems.

A series of gates are located in discharge channels 001, 002 and the lagoon to provide a means to contain effluent if concentrations should ever exceed applicable discharge limits. In addition, continuous pH and temperature monitoring systems are installed in discharge channels 001, 002 and the lagoon. These systems automatically control the gates and provide an alarm if there is ever an out of specification pH or temperature level.

Periodic samples collected from the effluent channels are analyzed for chemical constituents to demonstrate conformance with the applicable standards listed in References (7) and (10).

Effluent samples from the sewage treatment plant are collected and analyzed daily or weekly as required. Temperature and pH measurements are based on continuous monitoring and/or daily analyses of samples.

Effluent Analyses

The analyses performed for chemical constituents on effluent samples from each discharge channel and the sewage treatment plant are listed in Tables 20 and 21, respectively. Analyses for chemical constituents are performed using procedures described in Standard Methods, Reference (20) or other EPA approved procedures.

The samples collected during the release of each batch of processed radioactive liquid from the collection tanks are combined into separate monthly composite samples. Each composite sample is analyzed for radioactivity by gamma spectrometry. The monthly composite samples are also analyzed for tritium, nickel-63, and iron-55 by liquid scintillation counting.

Each liquid discharge that might contain tritium is sampled. The samples are combined into a monthly composite for each frequently used release point. Samples from other tritium release points are analyzed individually. Tritium analyses are performed by liquid scintillation counting.

Assessment

The analytical results for the measurements of chemical constituents summarized in Tables 20 and 21 and temperature in the Kesselring Site liquid effluents show that all average values are within the applicable effluent standards.

During 1993, site effluents had no adverse effect on the Glowegee Creek ecosystem. This conclusion is substantiated by the results of the aquatic life sampling program discussed in the environmental monitoring section.

The radioactivity released in Kesselring Site liquid effluent during 1993 totaled less than 0.001 curie of activation products with half lives greater than three hours, including those listed under Effluent Analyses, and approximately 0.01 curie of tritium. The activity was contained in approximately 1.6×10^9 liters of water. The resulting annual average radioactivity concentration in the effluent corresponded to less than 0.1 percent

**Kesselring Site, Near West Milton, New York Glowegee Creek
Sampling Locations and Discharge Points**

Figure 4

**TABLE 20 - CHEMICAL CONSTITUENTS AND TEMPERATURE IN KESSELRING SITE
LIQUID EFFLUENT, 1993**

Parameters/Units	Number of Samples	Permit Limit	Discharge Point 001 ⁽¹⁾				Percent of Limit ⁽³⁾	Discharge Point 002 ⁽¹⁾				Percent of Limit ⁽³⁾	
			Minimum	Maximum	Average ⁽²⁾			Minimum	Maximum	Average ⁽²⁾			
Discharge Requirements (Ref. 7)													
Flow (MGD) *	350	Report ⁽¹⁰⁾	0.05	6.50	0.61	± 0.05	--	0.1	3.5	0.58	± 0.04	--	
Temperature (°F)	350	(5)	33.0	72.0	52.7	± 1.0	70%	37.0	72.0	52.7	± 1.0	--	
pH (SU) **	144	6.0-9.0	6.74	8.78	7.73	± 0.07	--	6.86	8.67	7.73	± 0.07	--	
Suspended Solids (mg/l)	12	10 ⁽⁴⁾	2.0	8.5	5.6	± 1.1	56%	<1.0	9.0	<5.4	± 1.6	<54%	
Grease and Oil (mg/l)	52	15	<5.0	<5.0	<5.0	± 0.0	<33%	<5.0	<5.0	<5.0	± 0.0	<33%	
Residual Chlorine (mg/l)	350	0.02 ⁽¹¹⁾	<0.02	<0.02	<0.02	± 0.00	<100%	<0.02	<0.02	<0.02	± 0.00	<100%	
Total Phosphorus concentration (mg/l)	12	Report ⁽¹⁰⁾	0.06	0.28	0.14	± 0.04	--	0.05	0.21	0.14	± 0.04	--	
mass (Kg/month)	12	(6)	2.9	23.8	10.4	± 3.8	--	2.7	21.0	9.3	± 3.1	--	
Nitrite-N (mg/l)	12	Report ⁽⁸⁾	0.01	0.50	<0.077	± 0.086	--	0.01	0.60	<0.083	± 0.105	--	
Zinc concentration (mg/l)	12	Report ⁽¹⁰⁾	0.006	0.02	<0.014	± 0.003	--	0.005	0.03	<0.015	± 0.005	--	
mass (lbs/day)	12	(8)	0.029	0.12	<0.069	± 0.017	--	<0.021	0.18	<0.074	± 0.033	--	
Iron (mg/l)	12	0.40	0.05	0.2	<0.11	± 0.03	<28%	0.05	0.20	<0.11	± 0.04	<28%	
Boron (mg/l)	7	0.50	<0.05	<0.5	<0.12	± 0.16	<24%	<0.05	<0.5	<0.12	± 0.16	<24%	
Additional Parameters Monitored													
Ammonia-N (mg/l)	12	(7)	<0.1	1.4	<0.68	± 0.31	--	<0.10	1.1	<0.67	± 0.28	--	
Copper (mg/l)	12	(7)	0.01	<0.05	<0.035	± 0.008	--	0.005	<0.05	<0.035	± 0.009	--	
Cadmium (mg/l)	12	(7)	<0.005	<0.020	<0.014	± 0.005	--	<0.005	<0.02	<0.014	± 0.005	--	
Specific Conductance (umhos/cm)	12	(7)	309	709	448	± 71	--	204	694	436	± 75	--	
Total Chromium (mg/l)	12	(7)	<0.005	<0.050	<0.032	± 0.014	--	<0.005	<0.050	<0.031	± 0.015	--	
Detergent (MBAS) (mg/l)	12	(7)	0.01	0.08	<0.030	± 0.014	--	<0.02	0.05	<0.026	± 0.006	--	

Notes:

- (1) A value preceded by < is less than the minimum detection level for that sample and parameter.
 - (2) Average values preceded by < contain at least one less than minimum detection level value in the average. The (±) value represents the statistical variation of the results at two standard deviations.
 - (3) Percent of limit for the average value.
 - (4) 30-day average value. The daily maximum for suspended solids is 20 mg/l.
 - (5) (a) During the period from May through October, the temperature of discharges from site operations shall not exceed 23.9°C (75°F) except that if the ambient stream temperature exceeds 23.9°C (75°F), the temperature of the discharge shall be equal to the stream temperature, to a maximum of 25.6°C (78°F).
(b) During the period from November through April, the temperature of the discharge from site operations shall not exceed 23.9°C (75°F). In addition, no discharges will occur which will raise the temperature of the stream by more than 2.8°C (5°F), or to a maximum of 12.8°C (55°F), whichever is less, except that if the upstream temperature is >12.8°C (55°F), the discharge to the stream shall be such that the downstream temperature is ≤ to the upstream temperature.
 - (6) An action level of 50 kg/month has been assigned for the total mass discharged from outfalls 001, 002 and 003 (Table 21). An action level is not a limit but a specified effluent level, exceedance of which requires additional short term monitoring.
 - (7) Permit does not specify limits for the additional parameters monitored.
 - (8) Total site mass discharge limit of 0.5 lbs/day for discharge points 001, 002 and 003.
 - (9) Flow-weighted average limit of 0.40 mg/l for all three outfalls (001, 002 and 003).
 - (10) The Reference 7 permit requires the data to be reported but does not specify a limit for this discharge point.
 - (11) The limit is expressed as non-detectable by amperometric titration (<0.02 mg/l).
- * MGD = Million gallons per day.
 ** SU = Standard Units.

**TABLE 21 - CHEMICAL CONSTITUENTS IN KESSELRING SITE
SEWAGE TREATMENT PLANT EFFLUENTS, 1993**

Parameters/Units	Number of Samples	Permit Limit	Discharge Point 003 ⁽¹⁾			Percent of Limit ⁽³⁾
			Minimum	Maximum	Average ⁽²⁾	
Discharge Requirements (Ref. 7)						
Flow (MGD) *	365	0.09 ⁽¹²⁾	0.006	0.048	0.021 ± 0.001	23%
pH (SU) **	365	6.0-9.0	6.65	7.67	7.14 ± 0.02	--
BOD5 (mg/l)	52	30 ⁽⁵⁾	<1.0	7.0	<2.6 ± 0.38	<9%
Suspended Solids (mg/l)	52	30 ⁽⁵⁾	<1.0	4.5	<1.4 ± 0.22	<5%
Settleable Solids (ml/l)	365	<0.1	<0.1	<0.1	<0.10 ± 0.00	<100%
Dissolved Oxygen (mg/l)	251	5.0 (minimum)	6.8	13.3	9.0 ± 0.2	⁽⁴⁾
Ammonia (mg/l as N)	52	31.8 ⁽¹²⁾	<0.1	1.1	<0.39 ± 0.13	<1%
Total Phosphorus						
concentration (mg/l)	52	Report	0.3	3.1	1.7 ± 0.2	--
mass (Kg/month)	12	(6)	2.8	6.2	4.5 ± 0.7	--
Soluble Phosphorous (mg/l)	12	Report ⁽¹¹⁾	0.6	2.8	1.5 ± 0.4	--
Nitrite-N (mg/l)	13	Report ⁽¹⁰⁾	<0.01	0.6	<0.1 ± 0.1	--
Detergent (MBAS) (mg/l)	13	0.88	<0.02	0.1	<0.04 ± 0.02	<5%
Zinc						
concentration (mg/l)	12	Report ⁽¹¹⁾	0.02	0.2	0.061 ± 0.031	--
mass (lbs/day)	12	(9)	0.002	0.06	0.014 ± 0.01	--
Iron	12	0.30 ⁽⁸⁾	<0.02	0.1	<0.053 ± 0.016	<18%
Boron (mg/l)	12	1.2 ⁽⁸⁾	<0.05	1.1	<0.22 ± 0.19	<18%
Total Copper (lbs/day)	12	0.06	0.002	<0.011	<0.007 ± 0.002	<12%
Dissolved Copper (mg/l)	12	Report ⁽¹¹⁾	<0.005	<0.20	<0.127 ± 0.058	--
Cyanide, Total (mg/l)	13	0.12	<0.01	0.09	<0.025 ± 0.012	<21%

Additional Parameters Monitored

Temperature (°F)	248	(7)	33.0	70.0	52.5 ± 1.3	--
Turbidity (NTU) ***	12	(7)	0.3	16	3.2 ± 3.5	--

Notes:

- (1) A value preceded by < is less than the minimum detection level for that sample and parameter.
- (2) Average values preceded by < contain at least one less than minimum detection level value in the average. The (±) value represents the statistical error at two standard deviations.
- (3) Percent of limit for the average value.
- (4) The average value is well above the limit which is a minimum value.
- (5) The maximum limit for the 30-day arithmetic mean is 30 mg/l, the maximum daily limit is 45 mg/l.
- (6) An action level of 50 kg/month has been assigned for the total mass discharged from outfalls 001, 002 and 003. An action level is not a limit but a specified effluent level, exceedance of which requires additional short term monitoring.
- (7) Permit does not specify limits for the additional parameters monitored.
- (8) Values are Action Levels which are not a limit but a specified effluent level, exceedance of which requires additional short term monitoring.
- (9) Total mass discharge limit of 0.5 lbs/day for Outfalls 001, 002 and 003.
- (10) Flow-weighted average limit of 0.4 mg/l for all three outfalls (001, 002 and 003).
- (11) The Reference 7 permit requires that the data be reported but does not specify a separate limit for this discharge point.
- (12) 30-day average

*MGD = Million gallons per day

**SU = Standard Units

***NTU = Nephelometric turbidity units

of the DOE derived concentration guide for effluent released to unrestricted areas, (Reference 2) for the mixture of radionuclides present.

Liquid effluent monitoring data are reported as required in References (1) and (7).

AIRBORNE EFFLUENT MONITORING

Origins

The principal sources of industrial gaseous effluents are two 21 million, one 30 million and one 110 million Btu/hr steam generating boilers. The Number 2 fuel oil that is used to fire all of the boilers contains less than 0.5 weight percent sulfur. Combustion gases from the boilers are released through three elevated exhaust stacks. Other operations such as Ozalid reproduction, carpenter shops, welding hoods, paint shop and industrial cleaning processes constitute point sources of airborne effluents.

Small quantities of particulate radioactivity, principally cobalt-60, are processed through controlled exhaust systems during reactor coolant sampling, draining, and venting operations. Gaseous radioactivity contained in the exhaust air consists principally of carbon-14, short-lived isotopes of xenon and krypton, argon-41 and tritium. Prior to release from the exhaust stacks, the exhaust air is passed through high efficiency particulate air (HEPA) filter systems to minimize radioactivity content.

Effluent Monitoring

Sulfur emitted from all boiler units is monitored via analysis of fuel sulfur content and reported to the EPA on a quarterly basis in compliance with the EPA's New Source Performance Standards (NSPS). Most other industrial emission points do not require monitoring under terms of the current New York State permits due to the very low levels of the emissions.

The air exhausted from the reactor plants is continuously monitored for particulate radioactivity with monitors that are equipped with alarm functions to provide an alert should an out of specification release occur. The air exhausted from all radiological facilities is continuously sampled for particulate radioactivity. Reactor plant air emissions are also continuously sampled for radioiodine with activated charcoal cartridges. Sampling is performed for tritium and carbon-14 using appropriate absorbers.

Effluent Analyses

The air particulate sample filters are changed routinely and analyzed by direct counting for beta-gamma radioactivity. A minimum detectable concentration of approximately 5×10^{-16} $\mu\text{Ci/ml}$ is achieved for cobalt-60. The activated charcoal cartridges are analyzed for radioiodine by gamma spectrometry to a minimum detection level of approximately 5×10^{-16} $\mu\text{Ci/ml}$ for iodine-131. The tritium and carbon-14 absorbers are analyzed by liquid scintillation spectrometry. The minimum detectable concentrations of tritium and carbon-14 in air are approximately 5×10^{-11} $\mu\text{Ci/ml}$ for typical sampling parameters. The quantity of gaseous radioactivity released is calculated based on reactor plant operating parameters. Periodic noble gas measurements are performed to confirm the calculated values.

Assessment

The New York State emission standards for stationary combustion installations that are summarized on page 13 for the Knolls Site are also applicable for the Kesselring Site.

Sulfur emissions for the boilers are well within the EPA's NSPS emission standard for stationary combustion installations.

The radioactivity contained in exhaust air during 1993 consisted of: (1) less than 0.001 curie each of krypton-85 and particulate fission and activation products having half lives greater than three hours, (2) approximately 1.4 curies of noble gases with half lives of 12 days or less, principally argon-41, xenon-133 and xenon-135, (3) approximately 0.14 curies of tritium and (4) approximately 0.46 curies of carbon-14. Iodine-131 is not normally detectable and none was detected during 1993.

The radioactivity was contained in a total volume of 8.0×10^{11} liters of air. The average radioactivity concentration in the effluent air was well below the applicable standards listed in Reference (2). The average annual radioactivity concentration at the nearest Site boundary, based on average annual diffusion parameters, was less than 0.01 percent of the DOE derived concentration guide for effluent release to unrestricted areas (Reference 2) for the mixture of radionuclides present. Airborne effluent monitoring data are reported as required in References (1) and (3).

All other point source emissions also conform to the applicable state and federal clean air standards.

ENVIRONMENTAL MONITORING

Scope

The environmental monitoring program at the Kesselring Site included: (1) the weekly collection of Glowegee Creek water samples for chemical analyses, (2) the continuous monitoring and recording of water temperature and pH above and below the site discharges to the Glowegee Creek, (3) a survey of the aquatic life upstream, near the discharge channels and downstream in the Glowegee Creek, (4) the collection of fish upstream, between the discharge channels and downstream in the Glowegee Creek, (5) the collection of quarterly samples of Glowegee Creek water and sediment at five locations, (6) the continuous monitoring of radiation levels at perimeter and off-site locations and (7) the operation of continuous air samplers at stations located in the primary upwind and downwind directions from the site.

Grab samples of Glowegee Creek water are collected weekly upstream and downstream of the discharge outfalls for chemical analysis. In addition, continuous monitoring and recording of the creek temperature are conducted upstream of the site, between the discharge channels and downstream of the site. pH is monitored and recorded continuously above and below the site. Flow measuring equipment is installed in both discharge channels. In addition, flow is monitored by the U.S. Geological Survey (USGS) one half mile downstream of the Site at the West Milton Road gaging station (USGS No. 01330000).

An annual aquatic life sampling and evaluation program is conducted in the Glowegee Creek. This survey includes the identification and population assessment of periphyton, benthic macroinvertebrates, and fish. The periphyton samples are collected from rocks located along the stream bottom and the benthic macroinvertebrates are collected using a Surber bottom sampler and kick sampling techniques. Chain electro-fishing techniques are used to collect the fish, which are identified, measured, and returned to the creek unharmed. Only a few of the fish from each location are retained for radioanalysis.

Three samples of sediment and one composite water sample are collected quarterly for radioanalysis across the creek at the five locations shown

in Figure 4.

Radiation levels at the eight site perimeter locations shown in Figure 5 and four off-site locations are monitored with sensitive, thermoluminescent dosimeters (TLDs).

Environmental air samplers are operated in the primary upwind and downwind directions from the site to measure normal background airborne radioactivity and to confirm that Kesselring Site effluents have no measurable effect on normal background levels.

The Kesselring Site operated its own sanitary landfill for the disposal of non-radioactive and non-hazardous solid wastes until October 1993, when landfill operations were permanently ceased. Up to that time, the NYSDEC performed periodic inspections of the landfill area for compliance with New York State regulations given in Reference (21). Since the end of landfill operations, efforts have been underway to close the landfill in accordance with the same New York State regulations (Reference 21). The NYSDEC has approved the final Landfill Closure Plan, pending submittal of a Post Closure Monitoring and Maintenance manual.

Analyses

The routine quarterly samples of Glowegee Creek water and bottom sediment samples are analyzed with a high resolution gamma spectrometer system. In addition, detailed evaluations of the fish and some of the water and sediment samples collected from the Glowegee Creek are performed with a more sensitive high purity germanium gamma spectrometer system. This type of analysis is intended to fully characterize the naturally and non-naturally occurring gamma-emitting radionuclides. Creek water samples are also analyzed for the chemical constituents listed in Table 22 using the analytical techniques described in Standard Methods, Reference (20) or other EPA approved methods.

The environmental air particulate sample filters are changed and analyzed routinely by direct counting for beta-gamma radioactivity and by gamma spectrum analysis.

Kesselring Site, Near West Milton, New York
Perimeter Monitoring Locations

Figure 5

Assessment

The analytical results for the Glowegee Creek water samples for chemical constituents, pH, and temperature and the fish survey made during 1993 are summarized in Tables 22 and 23, respectively. The concentrations of chemical constituents in liquid effluent from the Kesselring Site resulted in no adverse effect on the quality of Glowegee Creek aquatic life. This is substantiated by results of the fish and aquatic life surveys that confirmed the existence of a diverse and healthy aquatic community in the creek water. The biological monitoring data were assessed using the NYSDEC "Proposed Biological Criteria for New York State Streams", and indicated that the creek was "nonimpacted" to "slightly impacted", both upstream and downstream. The different relative abundances of fish at each sampling location reflect their different preferred habitats.

Only naturally occurring radionuclides were detected in the Glowegee Creek water samples. The gamma spectrum analysis results for fish collected from the Glowegee Creek are shown in Table 24. The results show no radioactivity attributable to site operations. The only radionuclide observed in all fish was potassium-40. Low levels of uranium daughters were observed in several fish samples. These naturally occurring radionuclides are frequently observed in fish.

Results of the gamma analysis of sediment samples are shown in Table 25. The data show that there is no significant difference between radioactivity concentrations measured upstream and downstream. Results of the detailed gamma spectrum analyses performed on sediment samples also indicate low concentrations of potassium-40, cesium-137, and daughters of uranium and thorium. Potassium-40 and the daughters of uranium and thorium are naturally occurring radionuclides and are not associated with site operations. The EPA has attributed similar low levels of cesium-137 to fallout from low yield atmospheric nuclear weapon tests. (References 25 and 26). Since the beginning of prototype operations more than 35 years ago, the release of radioactivity into the Glowegee Creek has been small and has had no significant effect on the natural background radioactivity in the sediment.

The total annual radiation exposures measured with TLDs at the boundary of the Kesselring Site and at remote, off-site monitoring locations are summarized in Table 26. There is no statistically significant difference between the perimeter and the off-site measurements. This shows that Kes-

selring Site operations in 1993 had no measurable effect on natural background radiation levels at the Site perimeter.

The results for the environmental air samples show that there was no significant difference between the average upwind and downwind radioactivity concentrations. Gamma spectrum analyses indicated the presence of small quantities of radium-226, thorium-232 and their daughter products. Also present were small quantities of beryllium-7 and potassium-40. These radionuclides are all naturally occurring.

GROUNDWATER MONITORING

Scope

The Kesselring Site groundwater monitoring program focuses on the Site landfill, inactive solid waste disposal sites and the security area. Several groundwater monitoring wells (the KTH series wells and a number of LMW series wells installed in 1991 during the Phase 1 landfill closure investigation) were abandoned in 1993 as part of the Phase 2 closure investigation. Thirty-two overburden and bedrock monitoring wells (HB-Series) were installed as part of the Phase 2 closure investigation. The location of all existing monitoring wells are shown in Figure 6. The following HB-Series monitoring wells are used in conjunction with remaining LMW wells for current landfill monitoring; HB-2A, HB-3A, HB-5A2, and HB-7A. There are an additional 14 monitoring wells at 4 inactive (former) disposal sites located within the reservation, as shown in Figure 7. Nineteen monitoring wells are currently in place within the Kesselring Site security area to monitor groundwater quality in the areas of active site facilities (Figure 8).

Origin

The potential source of contaminants in the landfill wells is past disposal practices. The landfill, operated since 1951, has been used as a sanitary landfill. Prior to enactments of state and federal regulations for solid waste disposal activities which banned disposal of hazardous material in such facilities, the landfill was used to dispose of asbestos scraps, scrap metal including lead, and some oil and oily water, solvents, paint and chemicals.

The inactive disposal sites at the Kesselring Site were used for construction and demolition wastes, and limited amounts of acid waste. These disposal practices were conducted prior to

TABLE 22 - CHEMICAL CONSTITUENTS AND TEMPERATURE IN GLOWEGEE CREEK WATER,⁽³⁾ 1993

Parameters/Units	Number of Samples Upstream/Downstream	Upstream ⁽¹⁾			Downstream ⁽¹⁾			Standard	Percent of Standard ⁽⁴⁾	
		Minimum	Maximum	Average ⁽²⁾	Minimum	Maximum	Average ⁽²⁾			
New York State DEC Water Quality Standard (Ref. 10)										
pH (SU) *	216/215	6.8	8.8	8.0 ± 0.04	7.1	8.6	7.9 ± 0.03	6.5-8.5	--	
Grease and Oil (mg/l)	12/12	<5	<5	<5 ± 0	<5	<5	<5 ± 0	See Note ⁽⁵⁾	--	
Dissolved Oxygen (mg/l)	13/13	7.8	14.6	11.7 ± 1.6	7.2	14.9	11.6 ± 1.8	6.0 (Avg. Min)	See Note ⁽⁶⁾	
Ammonia-N (mg/l)	12/12	<0.1	<1.0	<0.6 ± 0.3	<0.1	<1.0	<0.6 ± 0.3	0.02 ⁽⁶⁾	See Note ⁽⁶⁾	
Total Copper (mg/l)	12/12	<0.005	<0.05	<0.035 ± 0.009	<0.005	<0.05	<0.035 ± 0.009	No Standard	--	
Total Zinc (mg/l)	12/12	<0.002	0.02	<0.010 ± 0.003	0.002	0.09	<0.019 ± 0.015	No Standard	--	
Total Cadmium (mg/l)	12/12	<0.005	0.02	<0.014 ± 0.005	<0.005	<0.02	<0.014 ± 0.005	No Standard	--	
Color (cpu) **	12/12	5	30	17 ± 4	7	25	15 ± 4	See Note ⁽⁷⁾	--	
Residual Chlorine (mg/l)	48/47	<0.02	<0.02	<0.02 ± 0.0	<0.02	<0.02	<0.02 ± 0.0	<0.02 ⁽¹⁰⁾	<100%	
Specific Conductance (umhos/cm)	12/12	199	300	270 ± 21	210	370	302 ± 34	No Standard	--	
Total Phosphorus (mg/l)	12/12	<0.01	0.04	<0.02 ± 0.01	0.01	0.09	<0.04 ± 0.01	No Standard	--	
Hardness (mg/l as CaCO3)	12/12	72	175	130 ± 18	80	198	137 ± 22	No Standard	--	
Total Chromium (mg/l)	12/12	<0.005	0.06	<0.032 ± 0.015	<0.005	0.05	<0.031 ± 0.015	No Standard	--	
Temperature (°F)	228/233	31	64	40 ± 1.2	31	65	41 ± 1.2	See Note ⁽⁹⁾	--	
Total Organic Carbon (mg/l)	11/11	2.1	27.7	7.4 ± 6.5	1.8	26.8	7.1 ± 6.4	No Standard	--	

Notes:

- (1) A value preceded by < is less than the minimum detection level for that sample and parameter.
- (2) Average values preceded by < contain at least one less than minimum detection level value in the average. The (±) value represents the statistical variation of the results at two standard deviations.
- (3) New York State Class C water: suitable for fishing and all other uses except as a source of water supply for drinking, and culinary or food processing purposes.
- (4) Comparison of downstream average data with standard, Reference (10).
- (5) No residue attributable to sewage, industrial wastes or other wastes, nor visible oil film nor globules of grease.
- (6) The average value is well above the standard which is a minimum value.
- (7) None in the amounts that will adversely affect the color thereof, or impair the waters for their best usage.
- (8) The standard is a calculated value for unionized ammonia, based on water temperature and pH. The standard expressed in terms of total ammonia at the given temperature and pH is 0.02 mg/l. On the average, no measurable increases were observed.
- (9) During the winter months (November-April) no increase > 5°F (2.8°C) shall occur up to 55°F (12.8°C), unless stream temperature is 55°F; if so, downstream temperature must be ≤ upstream temperature. There is no limit on summer Creek temperature.
- (10) Kesseling Site State Pollutant Discharge Elimination System Permit #NY-0005843 limit is non-detectable by amperometric titration (0.02 mg/l).

*SU = Standard Units

**cpu = Cobalt Platinum Units

TABLE 23 - GLOWEGEE CREEK FISH SURVEY - 1993

Station Location	Fish Species	Number Collected	Length (mm)
400 ft. Upstream of Discharge Channel 001	Blacknose Dace	546	36-81
	Brook Trout	4	75-80
	Brook Stickleback	9	38-40
	Brown Trout	2	186-226
	Common Shiner	181	30-97
	Creek Chub	224	28-149
	Cutlips Minnow	44	43-117
	Fathead Minnow	6	47-62
	Longnose Dace	46	52-108
	Tessellated Darter	46	55-81
	White Sucker	84	31-204
20 ft. Upstream of Discharge Channel 001	Blacknose Dace	629	25-72
	Brook Trout	1	59
	Brook Stickleback	22	29-41
	Brown Trout	7	59-200
	Common Shiner	500	28-99
	Creek Chub	188	26-109
	Cutlips Minnow	37	44-107
	Fathead Minnow	39	54-66
	Longnose Dace	14	44-93
	Pumpkinseed	4	76-110
	Tessellated Darter	41	54-77
	White Sucker	108	29-164
Between Discharge Channels 001 and 002	Blacknose Dace	550	19-65
	Brook Stickleback	9	23-39
	Brown Trout	6	70-205
	Common Shiner	377	32-114
	Creek Chub	162	28-145
	Cutlips Minnow	20	42-95
	Fathead Minnow	7	45-69
	Golden Shiner	6	57-89
	Longnose Dace	17	39-82
	Tessellated Darter	22	30-80
2900 ft. Downstream from Discharge Channel 002	White Sucker	87	32-166
	Blacknose Dace	482	24-95
	Brook Trout	2	67-73
	Bluegill	1	103
	Bluntnose Minnow	1	60
	Common Shiner	130	43-96
	Creek Chub	35	26-114
	Cutlips Minnow	13	45-116
	Fathead Minnow	6	52-64
	Longnose Dace	169	53-98
	Tessellated Darter	17	26-74
	White Sucker	119	42-172
3200 ft. Downstream from Discharge Channel 002	Blacknose Dace	302	26-70
	Brook Stickleback	1	35
	Brown Trout	1	62
	Bluntnose Minnow	24	50-75
	Common Shiner	367	28-109
	Creek Chub	169	21-158
	Cutlips Minnow	42	43-112
	Fathead Minnow	9	51-65
	Longnose Dace	18	23-88
	Pumpkinseed	1	95
	Tessellated Darter	63	27-70
	White Sucker	373	32-177

TABLE 23 - GLOWEGEE CREEK FISH SURVEY - 1993

Station Location	Fish Species	Number Collected	Length (mm)
5500 ft. Downstream from Discharge Channel 002	Blacknose Dace	1381	26-80
	Bluntnose Minnow	1	63
	Brown Trout	10	64-213
	Common Shiner	172	22-108
	Creek Chub	97	24-173
	Cutlips Minnow	111	38-124
	Fathead Minnow	1	56
	Largemouth Bass	1	50
	Longnose Dace	379	38-109
	Tessellated Darter	13	54-81
	White Sucker	124	39-226

TABLE 24 - RESULTS OF ANALYSES OF GLOWEGEE CREEK FISH, 1993

Sample Location	Radioactivity Concentration (pCi/g wet wt.) ⁽¹⁾		
	K-40	Cs-137	Co-60
400 ft. Upstream of Discharge Channel 001	1.47 ± 0.22	<0.01	<0.01
20 ft. Upstream of Discharge Channel 001	1.39 ± 0.21	<0.01	<0.01
Between Discharge Channels 001 and 002	1.27 ± 0.20	<0.01	<0.01
2900 ft. Downstream from Discharge Channel 002	1.17 ± 0.19	<0.01	<0.01
3200 ft. Downstream from Discharge Channel 002	1.42 ± 0.21	<0.01	<0.01
5500 ft. Downstream from Discharge Channel 002	1.91 ± 0.26	<0.01	<0.01

Note:

- (1) A value preceded by < is less than the minimum detection level for that sample and parameter. The (±) value represents the statistical error at two standard deviations.

TABLE 25 - RESULTS OF ANALYSES OF GLOWEGEE CREEK SEDIMENT, 1993

Sample Location	No. of Samples	Radioactivity Concentration (pCi/g, dry wt.) ^(1,2) Cobalt-60		
		Minimum	Maximum	Average
Upstream of Discharge Channel 001	12	<0.06	<0.10	<0.08 ± 0.01
Opposite Discharge Channel 001	12	<0.07	<0.12	<0.09 ± 0.01
Between Discharge Channels 001 and 002	12	<0.06	<0.10	<0.08 ± 0.01
Opposite Discharge Channel 002	12	<0.06	<0.15	<0.09 ± 0.01
Downstream of Discharge Channel 003	12	<0.06	<0.11	<0.09 ± 0.01

Notes:

- (1) Dry weight is based on sample weight with free water removed.
 (2) A value preceded by < is less than the minimum detection level for that sample and parameter. The (±) value represents the statistical error at two standard deviations.

TABLE 26 - PERIMETER AND OFF-SITE RADIATION MONITORING RESULTS, KESSELRING SITE, 1993

Perimeter Location No. ⁽¹⁾	Total Annual Exposure, ⁽²⁾ (millirem)
1	73 ± 5
2	65 ± 4
3	72 ± 5
4	75 ± 3
5	75 ± 3
6	76 ± 5
7	78 ± 3
8	78 ± 2
Off-Site locations	74 ± 8 ⁽³⁾

Notes:

- (1) See Figure 5 for monitoring locations.
 (2) The (±) values for individual locations are expressed at the 2 σ confidence level based on the calculated measurement error.
 (3) Approximately 95% of natural background radiation measurements are expected to be within this range.

enactment of state and federal regulations governing the disposal of these materials.

The sources of groundwater contaminants and elevated parameters in and adjacent to the security area are the result of historical and present activities. Identified potential sources are historical material handling practices, construction, and the use of deicing materials (i.e., road salt, calcium chloride).

Analyses

Analyses are performed on all groundwater samples in accordance with standard analytical methods as described in Reference (20) or other EPA approved methods and are performed by a NYSDOH Certified laboratory. The groundwater monitoring plan shown in Table 27 identifies the monitoring wells and summarizes the frequency of analysis. The results for all samples taken are presented in Table 28, Table 29, and Table 30.

As required by the New York State regulations of Reference (21), the landfill monitoring wells are sampled on a quarterly basis. These wells were sampled and analyzed for baseline parameters as defined in Reference (21). The 14 wells associated with the former disposal sites were also analyzed for baseline parameters. The results are presented in Table 29. The monitoring program for these wells is currently focused on site assessment. These wells are sampled annually. Within the security area, a total of nineteen monitoring wells exist. These wells are currently sampled once annually. During 1993, all wells were sampled for baseline parameters per Reference (21). The results are shown in Table 30.

The Kesselring Site has conducted radiological monitoring on the groundwater monitoring wells at the landfill area, the four former disposal sites and the security area. The monitoring well locations are shown in Figures 6, 7, and 8. The results of the analyses are shown in Table 31.

Site service water is monitored to assess conformance with the applicable drinking water standards defined in Reference (23). Those parameters are monitored on weekly and monthly bases, as appropriate, and results are given in Table 32. The annual analysis required by Reference (23), is shown in Table 33.

Assessment

Landfill:

Landfill monitoring well sample analytical results shown in Table 28 indicate that certain parameters are elevated in downgradient wells compared to upgradient wells. These parameters include: specific conductivity, alkalinity, hardness,

total dissolved solids, chloride, sulfate, boron, iron, manganese, sodium, calcium, magnesium, TOC, and several volatile chlorinated organic compounds.

Groundwater quality standards per Reference (10) or guidance values per Reference (24) were exceeded for a number of parameters. Standards for turbidity, manganese and iron were exceeded in both upgradient and downgradient wells. Other parameters which exceeded standards only in downgradient wells included: total dissolved solids, sodium, magnesium, chloride, sulfate and dichlorodifluoromethane.

A number of detected metals, including arsenic, beryllium, iron, manganese, lead and chromium are associated with suspended solids in the samples. Filtered sample analyses typically show either non-detectable results or significantly lower levels of these metals.

The groundwater contaminants observed in downgradient wells are predominantly inorganic. In addition, the observed levels of these parameters are within representative ranges for inorganic constituents typical of leachate from sanitary landfills per Reference (38).

Total phenols were detected in the upgradient and some downgradient wells. The results are consistent with previous sampling data. Data from wells that show phenols at or below levels detected in upgradient wells are attributed to natural origins. Data from the existing landfill wells that show phenols elevated above levels detected in upgradient wells are attributed to leachate.

A small number of volatile organic compounds at low parts per billion concentrations were detected in samples collected in 1993. Consistent with historical monitoring results, only volatile chlorinated hydrocarbons were detected in downgradient monitoring well samples. Levels were in the low ppb range (less than 20 ppb) for all detected compounds. Those wells showing the presence of volatile compounds during 1993 are HB-2A (replacement well for LMW-2), LMW-5B, LMW-6, and HB-7A (replacement well for LMW-7). Fewer compounds were detected during 1993, with only dichloroethane (detected in LMW-6 on 9/3/93), trichloroethylene, 1,1,1-trichloroethane, and dichlorodifluoromethane being detected.

Inactive Disposal Sites:

The groundwater analysis results for samples collected at the four inactive disposal sites are shown in Table 29. In general, the data from 1993 is consistent with previous analytical results. Several wells sampled in 1993 (e.g., KBH-3 and KBH-7) show some differences, due to

elevated sample turbidities, in the concentrations or detection of certain metals. These metals typically include aluminum, iron, manganese, and calcium, which can exhibit large variations in concentration based on sample turbidity. In addition, unfiltered samples for arsenic, chromium, lead and occasionally beryllium or mercury are detected at low levels at high sample turbidities. Analysis of filtered samples will consistently show lower levels or be less than detectable, indicating a bias. Based on comparison to historical data since 1988, current data continues to indicate no significant impact of these sites on local groundwater quality.

Security Area:

The following parameters were found to be elevated in most of the nineteen security area monitoring wells sampled (Table 30): turbidity, conductivity, total dissolved solids, chloride, sulfate, ammonia, total kjeldahl nitrogen, sodium, zinc, iron, manganese and magnesium. A number of the elevated metals, including iron and manganese, and the low levels of lead, cadmium, and chromium detected in whole samples, are associated with suspended solids in the samples. Filtered samples analyzed for these metals demonstrate levels significantly lower, often at or near the minimum detection limit. As a result of the high turbidity of most of the samples, filtered results are reported in Table 30.

Several volatile chlorinated organic compounds were detected at low concentrations in four of the nineteen security area monitoring wells. The detected compounds include trichloroethylene, tetrachloroethylene, trichlorofluoromethane and dichlorodifluoromethane. Results are consistent with data from 1990 and 1992.

The cause of the observed elevated inorganic parameters is assumed to be the application of de-icing materials, including urea, rock salt and calcium chloride. Elevated levels of BOD₅, TKN and ammonia are attributable to urea application. The source of the chlorinated organics is likely to be past incidental spills of chlorinated solvents on site, because such solvents were not disposed within the security area.

Radioactivity:

Results of groundwater monitoring for radioactivity are summarized in Table 31. Within expected analysis variability the alpha and gross beta radioactivity levels are consistent with radioactivity levels in background wells. The higher gross beta and alpha radioactivity levels in some of the security area wells, which are within previously observed values, are attributed to higher levels of dissolved solids including naturally occurring radionuclides and their daughter products.

Previous analyses of well water from this area has shown this radioactivity to include natural uranium and naturally occurring potassium-40. In addition, considerably higher amounts of suspended solids are visible in water samples from these wells than in water samples from the other wells. The levels of cesium-137, cobalt-60 and tritium were below the detection limit in all wells. The detection limit concentrations for these radionuclides were less than 0.1 percent of the respective Reference (2) derived concentration guide values.

Site Service Water:

The results of routine site service water monitoring are shown in Table 32. The results of the annual analysis are presented in Table 33. All measured chemical constituents measured have been within the New York State drinking water standards of Reference (23). The site service water well field is hydrologically independent from the site landfill and inactive disposal sites, and is consequently not influenced by materials at those locations.

Conclusion:

It is concluded that past waste disposal practices at the landfill have resulted in observable effects on groundwater quality downgradient of the landfill. Based on monitoring results, disposal at the four inactive areas has resulted in no apparent impact on groundwater quality. Monitoring results within the security area indicate some elevated parameters. These are the combined results of current winter de-icing operations and other past practices.

CONTROL OF CHEMICALLY HAZARDOUS SUBSTANCES

Chemicals are not manufactured or disposed of at the Kesselring Site. Minimal quantities of hazardous wastes do result from the necessary use of chemicals in site operations. To ensure the safe use of chemicals and disposal of the resulting wastes, Kesselring Site maintains hazardous substance control and waste minimization programs similar to those at the Knolls Site. During 1993 the Kesselring Site shipped approximately 104 tons of RCRA and New York State hazardous waste offsite for disposal.

Elementary neutralization of small volume laboratory waste and the boiler house blowdown and acid regeneration wastewater also occur on site. This process is exempt from regulation as a RCRA treatment process. The neutralized discharge is controlled under the Kesselring Site wastewater discharge permit. The boiler house is the primary source of wastewater with a pH prior to neutralization of less than 2 or greater than 12.5.

TRANSPORTATION OF RADIOACTIVE MATERIALS

Operation of the Kesselring Site results in the generation of various types of radioactive materials that require detailed procedures for handling, packaging, transportation, and, if necessary, disposal at a government operated burial site.

Radioactive materials that do not require disposal are handled and transferred in accordance with detailed material control and accountability procedures. Internal reviews are made prior to the shipment of any radioactive material from the Site, to ensure that the material is properly identified, surveyed and packaged in accordance with federal, state and local requirements.

Low level radioactive solid waste material that requires disposal includes filters, metal scrap, resin, rags, paper, and plastic materials. The volume of waste contaminated with radioactivity that is generated and shipped is minimized through the use of special work procedures that limit the amount of material that becomes contaminated during work on radioactive systems and reactor components. In addition, compressible wastes are compacted in order to further reduce the volume of waste to be buried. Radioactive liquids are solidified prior to shipment. All radioactive wastes are packaged to meet applicable regulations of the DOT given in Reference (18). The waste packages also comply with all applicable requirements of the NRC, the DOE, and the burial sites.

The shipments of low level radioactive solid wastes were made by authorized common carriers to government owned burial sites located outside of New York State. During 1993, approximately 200 cubic meters (262 cubic yards) of routine low level radioactive waste containing 25,300 curies were shipped from the site for burial. This included the shipment of a single reactor component which accounted for 99.8% of the total radioactivity.

RADIATION DOSE ASSESSMENT

The effluent and environmental monitoring results show that the radioactivity in liquid and gaseous effluents from 1993 operations at the Kesselring Site had no measurable effect on background radioactivity levels. Therefore, any radiation doses from site operations to off-site individuals were too small to be measured and must be calculated using conservative methods. Estimates of: (1) the radiation dose to the maximally exposed individual in the vicinity of the Kesselring Site, (2) the average dose to members of the public residing in the 80 kilometer (50 mile) radius assessment area surrounding the Site and (3) the collective dose to the population residing in the assessment area are summarized in Tables 43 and 44. See Figure 12 for a map of the assessment area surrounding the Kesselring Site.

The results show that the estimated doses were less than 0.1 percent of that permitted by the DOE radiation protection standards listed in Reference (2) and that the estimated dose to the population residing within 80 kilometers (50 miles) of the Kesselring Site was less than 0.001 percent of the natural background radiation dose to the population. In addition, the estimated doses were less than one percent of that permitted by the NRC numerical guide listed in Reference (4) for whole-body dose demonstrating that doses are as low as is reasonably achievable. The dose attributed to radioactive air emissions was less than one percent of the EPA standard in Reference (3).

The collective radiation dose to the public along travel routes from Kesselring Site shipments of radioactive materials during 1993 was calculated using data given by the NRC in Reference (22). Based on the type and number of shipments made, the collective annual radiation dose to the public along the transportation routes, including transportation workers, was approximately one person-rem. This is less than 0.001 percent of the dose received by the same population from natural background radiation.

Figure 6

Kesselring Site, Near West Milton, New York
Landfill Groundwater Monitoring Wells

**Kesselring Site, Near West Milton, New York
Disposal Areas - Groundwater Monitoring Wells
Figure 7**

Kesselring Site, Near West Milton, New York
Security Area Groundwater Monitoring Wells
Figure 8

TABLE 27 - KESSELRING SITE GROUNDWATER MONITORING PLAN - 1993

Well ID	Radioactivity	Baseline ⁽¹⁾	Other ⁽³⁾
MW-1 ⁽²⁾	A	A	
MW-2 to MW-20	A	A	
KBH-1 ⁽²⁾	A	A	
KBH-2	A	A	
KBH-3	A	A	
KBH-4	A	A	
KBH-5	(WELL SCREEN COLLAPSED - NO SAMPLING POSSIBLE)		
KBH-6 ⁽²⁾	A	A	
KBH-7	A	A	
KBH-8	A	A	
KBH-9	A	A	
KBH-10	A	A	
T-3 ⁽²⁾	A	A	
KBH-11 ⁽²⁾	A	A	
KBH-12	A	A	
KBH-13	A	A	
KTH-1 ⁽²⁾⁽⁴⁾			
KTH-1A ⁽²⁾⁽⁴⁾	(KTH SERIES WELLS ABANDONED)		
KTH-2 ⁽⁴⁾			
KTH-3 ⁽⁴⁾			
KTH-5 ⁽⁴⁾			
KTH-7 ⁽⁴⁾			
LMW-1 ⁽²⁾	A	Q	Q
LMW-2 ⁽⁵⁾ (HB-2A)	A	Q	Q
LMW-3 ⁽⁵⁾ (HB-3A)	A	Q	Q
LMW-4	A	Q	Q
LMW-5B ⁽⁵⁾ (HB-5A2)	A	Q	Q
LMW-6	A	Q	Q
LMW-7 ⁽⁵⁾ (HB-7A)	A	Q	Q

Notes: A = Annual
Q = Quarterly

(1) Parameters defined in 6 NYCRR Part 360-2.11(c).

(2) Background well.

(3) Filtered metals are performed as necessary for verification of elevated metals as attributable to silt or suspended solids in the sample.

(4) These wells were abandoned in 1993 under the second phase of the landfill hydrogeologic investigation.

(5) The indicated LMW monitoring wells were abandoned as part of the second phase of the landfill hydrogeologic investigation. The HB-A series monitoring wells which were installed during the same work effort have replaced the LMW wells for routine monitoring as of the 2nd quarter 1993.

TABLE 28 - RESULTS OF KESSELLING SITE GROUNDWATER MONITORING, LANDFILL WELLS, 1993

WELL NUMBER	Sampling Date	Elev. ft.	Temp. F.	pH (SU)	EH (mv)	Turbidity (NTU)	Color (cpu)	Specific Conductivity (umhos/cm)	TDS	COD	BOD ₅	TOC	Alkalinity mg CaCO ₃ /l	Hardness	Sulfate	Chloride
LMW-1	1/25/93	483.48	42	8.6	278	330	1	188	130	83	2	1.4	84	136	15.0	4.0
LMW-2 (upgradient)	1/25/93	468.01	44	7.2	274	260	5	780	454	83	6	4.6	214	356	11.0	58.0
	5/05/93	472.33	60	7.7	196	700	5	728	490	34	4	4.6	312	296	25.0	67.0
	8/03/93	469.88	58	6.9	111	540	10	890	653	61	2	5.0	305	671	44.0	154
HB-2A ^(m) (downgradient)	10/15/93	470.15	44	7.5	233	> 1000	<5	688	480	21	<2	28.0	310	616	38.0	155
	9/03/93	470.15	44	7.5	233	> 1000	<5	688	480	21	<2	28.0	310	616	38.0	155
	10/15/93	470.15	44	7.5	233	> 1000	<5	688	480	21	<2	28.0	310	616	38.0	155
LMW-3	1/25/93	464.27	42	7.1	283	11	8	1264	805	33	3	4.5	308	528	24.0	126
LMW-3A ^(m) (downgradient)	1/25/93	468.88	64	6.8	303	12	6	1308	821	15	3	4.4	325	640	180	128
	5/05/93	468.62	53	6.6	198	650	8	618	400	11	3	7.2	167	224	25.0	72
	10/15/93	460.10	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
LMW-4	1/25/93	462.85	40	7.1	293	1260	2	2320	1469	219	10	8.9	455	516	260	411
(downgradient)	5/05/93	468.62	53	6.6	198	650	8	618	400	11	3	7.2	167	224	25.0	72
	9/03/93	480.55	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/15/93	460.10	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
LMW-5B	1/25/93	449.00	45	6.7	281	270	5	1920	1055	103	10	11.0	579	760	8.2	284
(downgradient)	5/05/93	454.88	52	6.7	201	1150	6	1087	660	39	4	5.4	455	332	12.0	74
	9/03/93	450.85	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/15/93	450.60	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
LMW-6	1/25/93	455.93	45	7.0	288	85	<1	1331	810	51	3	4.1	389	558	150	129
(downgradient)	5/05/93	451.59	53	6.8	206	70	5	1530	860	13	3	5.4	384	702	104	188
	9/03/93	455.63	58	6.6	94	55	10	1120	868	<5	<2	24.0	473	702	104	178
	10/15/93	455.23	54	7.0	219	120	<5	1580	1040	11	11	28.0	460	667	175	106
LMW-7	1/25/93	460.38	46	7.5	292	280	<1	1638	1301	40	2	2.0	323	1040	700	30.0
(downgradient)	5/05/93	466.41	58	7.6	210	4400	1	746	470	7	4	4.3	219	284	68	37.0
	9/05/93	462.26	64	7.4	143	> 1000	5	1080	578	<5	<2	17.0	765	1140	118	27.0
	10/15/93	462.41	51	7.9	213	380	<5	935	773	<5	<2	17.0	530	1040	700	30.0
HB-7A ^(m)	5/05/93	466.41	58	7.6	210	4400	1	746	470	7	4	4.3	219	284	68	37.0
QA	5/05/93	462.26	64	7.4	143	> 1000	5	1080	578	<5	<2	17.0	765	1140	118	27.0
10/15/93	462.41	51	7.9	213	380	<5	<5	935	773	<5	<2	17.0	530	1040	700	30.0

Notes:

(1) A value preceded by < is the minimum detectable level for that sample and parameter.

(2)

Groundwater standards and guidance values taken from 6 NYCRR Part 703.

(3)

No groundwater standards or guidance values per 6 NYCRR Part 703 or TOGS 1.1.1.

(4)

Samples analyzed by different vendor laboratory.

(5)

Samples for metals are whole (unfiltered) unless indicated.

(6)

The indicated LMW monitoring wells were abandoned as part of the 2nd quarter 1993.

(7)

All other organic compounds listed in 40 CFR, Part 136, Appendix A, Methods 601 and 602 were not detected above the analytical subcontractor's minimum detectable level for that compound.

(8)

Wells for routine monitoring as of the 2nd quarter 1993.

(9)

QA = quality assurance sample, NA = not applicable, R = Rejected Data, -- = analysis not performed, G = Groundwater Guidance Value, NS = well dry; no sample taken.

(10)

**TABLE 28 - RESULTS OF KESSELRING SITE GROUNDWATER MONITORING,
LANDFILL WELLS, 1993 (continued)**

Parameter (all units are mg/l except where indicated) ^(1,5)														
WELL NUMBER	Sampling Date	TKN	Ammonia-N	Nitrate-N	Phenols	Cyanide	Aluminum	Filtered Aluminum	Antimony	Arsenic	Filtered Arsenic	Barium	Filtered Barium	Beryllium
LMW-1 (upgradient)	⁽⁴⁾ 1/25/93	4.3	<1.0	<0.10	0.015	<0.02	6.63	<0.20	<0.003	0.0022	<0.001	0.175	0.01	<0.0005
	⁽⁴⁾ 5/05/93	1.3	<1.0	<0.10	0.0053	<0.02	4.45	<0.30	<0.003	<0.001	<0.001	0.022	0.016	<0.0005
	9/03/93	2.2	0.1	0.11	<0.002	<0.01	0.90	<0.10	<0.06	<0.005	<0.005	0.06	<0.01	<0.005
	10/15/93	1.7	0.2	0.04	<0.002	<0.01	0.90	<0.10	<0.06	<0.005	<0.005	0.05	<0.01	<0.005
	QA 10/15/93	2.5	<0.1	0.03	<0.002	<0.01	0.90	<0.10	<0.06	<0.005	<0.005	0.06	<0.01	<0.005
LMW-2 (downgradient) HB-2A ⁽⁶⁾	⁽⁴⁾ 1/25/93	<1.0	<1.0	<0.10	<0.005	<0.02	4.58	<0.20	<0.003	0.0054	0.0026	0.213	0.129	0.009
	⁽⁴⁾ 5/05/93	3.4	<1.0	<0.10	0.012	<0.02	17.8	<0.30	<0.003	0.010	<0.001	0.33	0.063	0.0019
	9/03/93	3.1	0.1	0.03	<0.002	<0.01	1.1	0.40	<0.06	<0.005	<0.005	0.26	0.14	<0.005
	QA 9/03/93	2.8	0.2	0.02	<0.002	<0.01	2.7	0.40	<0.06	<0.005	<0.005	0.24	0.14	<0.005
	10/15/93	16.0	0.3	0.39	<0.002	<0.01	2.0	0.10	<0.06	<0.005	<0.005	0.48	0.06	<0.005
LMW-3 (downgradient) HB-3A ⁽⁶⁾	⁽⁴⁾ 1/25/93	<1.0	<1.0	0.20	<0.005	<0.02	<0.20	<0.20	<0.003	<0.001	<0.001	0.074	0.060	<0.0005
	QA ⁽⁴⁾ 1/25/93	1.5	<1.0	0.20	<0.005	<0.02	0.21	<0.20	<0.003	<0.001	<0.001	0.075	0.046	<0.0005
	5/05/93	9.3	<1.0	2.6	0.0085	<0.02	40.6	<0.30	<0.003	0.025	<0.001	0.61	0.071	0.00053
	9/03/93	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/15/93	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
LMW-4 (downgradient)	⁽⁴⁾ 1/25/93	10.0	2.2	0.10	<0.005	<0.02	1.02	<0.20	<0.003	<0.001	<0.001	0.172	0.263	<0.0005
	⁽⁴⁾ 5/05/93	40.0	<1.0	<0.10	<0.005	<0.02	28.3	<0.30	<0.003	0.014	<0.001	0.450	0.055	0.0033
	9/03/93	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/15/93	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
LMW-5B (downgradient) HB-5A2 ⁽⁶⁾	⁽⁴⁾ 1/25/93	2.5	<1.0	<0.10	<0.005	<0.02	2.34	<0.20	<0.003	0.0066	0.0061	0.244	0.410	<0.0005
	⁽⁴⁾ 5/05/93	2.0	<1.0	<0.10	<0.005	<0.02	52.2	<0.30	<0.003	0.027	<0.001	0.87	0.073	0.0053
	9/03/93	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/15/93	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
LMW-6 (downgradient)	⁽⁴⁾ 1/25/93	2.0	<1.0	0.20	<0.005	<0.02	17.8	<0.20	<0.003	0.010	<0.001	0.202	0.072	0.0019
	⁽⁴⁾ 5/05/93	1.8	<1.0	<0.10	0.0076	<0.02	2.5	<0.30	<0.003	<0.001	<0.001	0.220	0.061	<0.0005
	9/03/93	1.1	0.2	0.03	<0.002	<0.01	0.7	0.20	<0.06	<0.005	<0.005	0.11	0.070	<0.005
	10/15/93	0.8	0.2	0.25	<0.002	<0.01	<0.1	<0.10	<0.06	<0.005	<0.005	0.10	0.070	<0.005
LMW-7 (downgradient) HB-7A ⁽⁶⁾	⁽⁴⁾ 1/25/93	1.2	<1.0	0.60	<0.005	<0.02	12.9	<0.20	<0.003	<0.001	<0.001	0.181	0.044	0.0012
	QA ⁽⁴⁾ 5/05/93	4.0	<1.0	<0.10	<0.005	<0.02	141	<0.30	<0.003	0.012	<0.001	1.45	0.024	0.037
	5/05/93	2.4	<1.0	<0.10	0.011	<0.02	103	<0.30	<0.003	0.021	<0.001	1.10	0.024	0.0083
	9/03/93	3.6	0.1	0.05	<0.002	<0.01	1.60	0.30	<0.06	<0.005	<0.005	0.26	0.040	<0.005
	10/15/93	0.8	0.2	0.20	<0.002	<0.01	0.60	<0.10	<0.06	<0.005	<0.005	0.09	0.050	<0.005
Standards	⁽²⁾	⁽³⁾	2.0	10.0	0.001	0.1	⁽³⁾	⁽³⁾	0.003G	0.025		1.0		0.003G

*See previous page for table notations.

TABLE 28 - RESULTS OF KESSELRING SITE GROUNDWATER MONITORING,
LANDFILL WELLS, 1993 (continued)

Parameter (all units are mg/l except where indicated) ^(1,4)															
WELL NUMBER	Sampling Date	Boron	Filtered Boron	Cadmium	Calcium	Filtered Calcium	Chromium	Chromium	Hexavalent Chromium	Copper	Iron	Filtered Iron	Lead	Magnesium	Filtered Magnesium
LMW-1 (upgradient)	⁽⁴⁾ 1/25/93	0.08	<0.05	<0.0005	59.5	28.8	0.031	0.0053	<0.01	<0.03	9.51	<0.10	0.0044	13.4	7.0
	⁽⁴⁾ 5/05/93	0.50	1.10 ^R	<0.0005	45.2	26.4	0.0098	0.093 ^R	<0.01	<0.03	5.65	<0.05	0.0032	9.0	6.2
	9/03/93	<0.05	<0.05	<0.005	96.6	33.8	<0.005	<0.005	<0.02	<0.05	1.71	<0.05	<0.01	19.5	8.2
	10/15/93	<0.05	<0.05	<0.005	94.4	30.8	<0.005	<0.005	<0.02	<0.05	1.84	<0.05	<0.005	18.5	7.3
	QA 10/15/93	<0.05	<0.05	<0.005	114	30.9	<0.005	<0.005	<0.02	<0.05	2.02	<0.05	<0.005	23.7	7.3
LMW-2 (downgradient) HB-2A ⁽⁶⁾	⁽⁴⁾ 1/25/93	0.12	0.07	<0.0005	101	93.0	0.021	0.0043	<0.01	<0.03	15.0	2.25	0.0046	17.6	15.4
	⁽⁴⁾ 5/05/93	1.10	1.00	0.0006	129	84.9	0.039	0.0030	<0.01	0.04	36.0	0.11	0.0088	26.6	19.2
	9/03/93	0.05	0.06	<0.005	212	154	<0.005	<0.005	<0.02	<0.05	5.94	3.41	<0.01	34.6	25.5
	QA 9/03/93	0.05	0.08	<0.005	189	156	<0.005	<0.005	<0.02	<0.05	9.55	3.47	<0.01	34.9	26.0
	10/15/93	<0.05	<0.05	<0.005	301	84.9	<0.005	<0.005	<0.02	<0.05	22.4	1.98	<0.005	38.1	15.1
LMW-3 (downgradient) HB-3A ⁽⁶⁾	⁽⁴⁾ 1/25/93	0.09	0.09	<0.0005	134	144	0.0053	0.0043	<0.01	<0.03	0.36	<0.10	<0.001	32.2	31.9
	QA ⁽⁴⁾ 1/25/93	0.09	0.08	<0.0005	138	141	0.0048	0.0057	<0.01	<0.03	0.31	<0.10	<0.001	32.6	31.8
	5/05/93	1.30	1.00	0.0012	396	152	0.060	0.0037	<0.01	0.11	114	<0.05	0.027	48.3	38.2
	9/03/93	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/15/93	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
LMW-4 (downgradient)	⁽⁴⁾ 1/25/93	0.87	0.92	<0.0005	276	274	0.0061	0.0043	<0.01	<0.03	8.00	0.60	0.0019	43.3	41.5
	⁽⁴⁾ 5/05/93	1.30	1.20	0.0008	170	93.2	0.029	0.0029	<0.01	0.04	42.0	0.27	0.0096	30.2	17.6
	9/03/93	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/15/93	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
LMW-5B (downgradient) HB-5A2 ⁽⁶⁾	⁽⁴⁾ 1/25/93	0.26	0.30	<0.0005	215	209	0.0093	0.005	<0.01	0.05	24.3	14.9	0.0018	44.6	42.8
	⁽⁴⁾ 5/05/93	1.20	0.97	0.0015	412	131	0.039	0.0027	<0.01	0.13	125	0.35	0.034	92.9	35.9
	9/03/93	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/15/93	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
LMW-6 (downgradient)	⁽⁴⁾ 1/25/93	0.18	<0.05	<0.0005	195	170	0.0045	0.0042	<0.01	0.05	28.7	<0.10	0.018	39.5	25.8
	⁽⁴⁾ 5/05/93	0.96	1.00	<0.0005	154	156	0.0074	0.0028	<0.01	<0.03	3.05	<0.05	0.0074	33.9	3.1
	9/03/93	0.07	0.05	<0.005	219	198	<0.005	<0.005	NS	<0.05	0.55	0.07	<0.01	37.8	35.4
	10/15/93	<0.05	<0.05	<0.005	207	191	<0.005	<0.005	<0.02	<0.05	0.29	<0.05	<0.005	36.5	35.4
LMW-7 (downgradient) HB-7A ⁽⁶⁾	⁽⁴⁾ 1/25/93	0.11	0.08	<0.0005	292	252	0.033	0.0049	<0.01	<0.03	17.1	<0.10	0.0042	111	95.9
	⁽⁴⁾ 5/05/93	1.20	1.00	0.0030	567	88.8	0.270	0.0023	<0.01	0.20	264	<0.05	0.020	154	26.4
	QA 5/05/93	1.20	0.94	0.0021	458	90.3	0.193	0.0025	<0.01	0.14	177	0.07	0.013	106	25.6
	9/03/93	0.05	<0.05	<0.005	376	139	<0.005	<0.005	<0.02	<0.05	4.78	0.10	<0.01	47.9	37.0
	10/15/93	<0.05	<0.05	<0.005	220	146	<0.005	<0.005	<0.02	<0.05	1.64	<0.05	<0.005	51.6	38.3
Standards	⁽²⁾	1.00		0.01	⁽³⁾	⁽³⁾	0.05	0.05	0.05	0.20	0.30		0.025		35G

*See first page for table notations.

**TABLE 28 - RESULTS OF KESSELRING SITE GROUNDWATER MONITORING,
LANDFILL WELLS, 1993 (continued)**

Parameter (all units are mg/l except where indicated) ^(1,6)													
WELL NUMBER	Sampling Date	Manganese	Filtered Manganese	Mercury	Nickel	Filtered Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Zinc	Filtered Zinc
LMW-1 (upgradient)	⁽⁴⁾ 1/25/93	0.22	<0.02	<0.001	<0.10	<0.10	1.70	<0.002	<0.02	3.20	<0.001	<0.01	<0.01
	⁽⁴⁾ 5/05/93	0.08	<0.02	<0.001	<0.05	<0.05	1.40	<0.002	<0.02	4.80	<0.001	0.02	<0.01
	9/03/93	0.28	<0.02	0.0011	<0.05	<0.05	<0.50	<0.005	<0.02	2.80	<0.01	0.01	0.012
	10/15/93	0.26	<0.02	<0.0004	<0.05	<0.05	0.80	<0.005	<0.02	2.20	<0.01	0.03	0.01
	QA 10/15/93	0.34	<0.02	<0.0004	<0.05	<0.05	0.70	<0.005	<0.02	2.80	<0.01	0.01	<0.01
LMW-2 (downgradient) HB-2A ⁽⁶⁾	⁽⁴⁾ 1/25/93	3.90	3.90	<0.001	<0.10	<0.10	2.70	<0.002	<0.02	33.8	<0.001	<0.01	<0.01
	⁽⁴⁾ 5/05/93	2.36	1.53	<0.001	0.075	<0.05	9.00	<0.002	<0.02	33.8	<0.001	0.09	0.01
	9/03/93	2.40	2.20	<0.0004	<0.05	<0.05	<0.50	<0.005	<0.02	54.0	<0.01	0.012	0.02
	QA 9/03/93	2.23	2.25	<0.0004	<0.05	<0.05	<0.50	<0.005	<0.02	52.9	<0.01	0.02	0.015
	10/15/93	3.04	1.05	<0.0004	<0.05	<0.05	2.20	<0.005	<0.02	41.9	<0.01	0.07	0.01
LMW-3 (downgradient) HB-3A ⁽⁶⁾	⁽⁴⁾ 1/25/93	6.30	0.70	<0.001	<0.10	<0.10	1.70	<0.002	<0.02	74.0	<0.001	<0.01	<0.01
	QA ⁽⁴⁾ 1/25/93	5.50	0.69	<0.001	<0.10	<0.10	1.80	<0.002	<0.02	74.0	<0.001	<0.01	<0.01
	5/05/93	1.77	0.06	<0.001	0.205	<0.05	16.0	<0.002	<0.02	179	0.002	0.305	0.015
	9/03/93	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/15/93	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
LMW-4 (downgradient)	⁽⁴⁾ 1/25/93	0.65	0.60	<0.001	<0.10	<0.10	5.50	<0.002	<0.02	192	<0.001	<0.01	<0.01
	⁽⁴⁾ 5/05/93	0.72	0.27	<0.001	0.07	<0.05	12.0	<0.002	<0.02	75.0	<0.001	0.10	0.15
	9/03/93	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/15/93	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
LMW-5B (downgradient) HB-5A2 ⁽⁶⁾	⁽⁴⁾ 1/25/93	0.74	0.68	<0.001	<0.10	<0.10	2.80	<0.002	<0.02	113	<0.001	<0.01	0.03
	⁽⁴⁾ 5/05/93	1.92	0.41	<0.001	0.15	<0.05	17.0	<0.002	<0.02	38.0	0.002	0.60	0.02
	9/03/93	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/15/93	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
LMW-6 (downgradient)	⁽⁴⁾ 1/25/93	27.0	0.58	<0.001	<0.10	<0.10	5.90	<0.002	<0.02	74.2	<0.001	0.01	<0.01
	⁽⁴⁾ 5/05/93	2.27	0.75	<0.001	<0.05	<0.05	6.00	<0.002	<0.02	103	<0.001	0.04	0.01
	9/03/93	1.72	1.24	<0.0004	<0.05	<0.05	3.10	<0.005	<0.02	110	<0.01	<0.005	<0.005
	10/15/93	1.70	0.03	<0.0004	<0.05	<0.05	1.90	<0.005	<0.02	109	<0.01	0.01	0.01
LMW-7 (downgradient) HB-7A ⁽⁶⁾	⁽⁴⁾ 1/25/93	0.46	0.02	<0.001	<0.10	<0.10	4.60	<0.002	<0.02	22.4	<0.001	<0.01	<0.01
	QA ⁽⁴⁾ 5/05/93	4.89	0.56	<0.001	0.21	<0.05	32.0	<0.002	0.02	24.0	0.0028	0.62	<0.01
	5/05/93	3.47	0.55	<0.001	0.14	<0.05	26.0	<0.002	<0.02	21.9	0.0027	0.40	<0.01
	9/03/93	1.71	0.25	<0.0004	<0.05	<0.05	<0.50	<0.005	<0.02	16.8	<0.01	0.016	<0.005
	10/15/93	0.45	0.09	<0.0004	<0.05	<0.05	1.90	<0.005	<0.02	20.6	<0.01	0.01	<0.01
Standards	⁽²⁾	0.30	0.30	0.002	⁽³⁾	⁽³⁾	⁽³⁾	0.01	0.05	20.0	0.004G	0.3	

*See first page for table notations.

**TABLE 28 - RESULTS OF KESSELRING SITE GROUNDWATER MONITORING,
LANDFILL WELLS, 1993 (continued)**

		Parameter ^(1,7)			
WELL NUMBER	Sampling Date	[1,1 Dichloroethane]	[Trichloroethylene]	[1,1,1 Trichloroethane]	[Dichloro-Difluoromethane]
		-----ug/l-----			
LMW-1	⁽⁴⁾	1/25/93	<0.5	<0.5	<0.5
(upgradient)	⁽⁴⁾	5/05/93	<0.5	<0.5	<0.5
		9/03/93	<1	<1	<1
		10/15/93	<1	<1	<1
	QA	10/15/93	<1	<1	<1
LMW-2	⁽⁴⁾	1/25/93	<0.5	<0.5	<0.5
(downgradient)	⁽⁴⁾	5/05/93	<0.5	<0.5	<0.5
HB-2A ⁽⁶⁾		9/03/93	<1	<1	18
	QA	9/03/93	<1	<1	<1
		10/15/93	<1	<1	<1
LMW-3	⁽⁴⁾	1/25/93	<0.5	<0.5	<0.5
(downgradient)	QA ⁽⁴⁾	1/25/93	<0.5	<0.5	<0.5
HB-3A ⁽⁶⁾		5/05/93	<0.5	<0.5	<0.5
		9/03/93	NS	NS	NS
		10/15/93	NS	NS	NS
LMW-4	⁽⁴⁾	1/25/93	<0.5	<0.5	<0.5
(downgradient)	⁽⁴⁾	5/05/93	<0.5	<0.5	<0.5
		9/03/93	NS	NS	NS
		10/15/93	NS	NS	NS
LMW-5B	⁽⁴⁾	1/25/93	<0.5	1.6	<0.5
(downgradient)	⁽⁴⁾	5/05/93	<0.5	<0.5	<0.5
HB-5A2 ⁽⁶⁾		9/03/93	NS	NS	NS
		10/15/93	NS	NS	NS
LMW-6	⁽⁴⁾	1/25/93	<0.5	1.2	<0.5
(downgradient)	⁽⁴⁾	5/05/93	<0.5	<0.5	<0.5
		9/03/93	2	1	5
		10/15/93	<1	1	<1
LMW-7	⁽⁴⁾	1/25/93	<0.5	<0.5	<0.5
(downgradient)	⁽⁴⁾	5/05/93	<0.5	<0.5	<0.5
HB-7A ⁽⁶⁾	QA	5/05/93	<0.5	<0.5	<0.5
		9/03/93	<1	<1	<1
		10/15/93	<1	2	<1
Standards	⁽²⁾	5	5	5	5

*See first page for table notations.

TABLE 29 - RESULTS OF KESSELRING SITE GROUNDWATER MONITORING, INACTIVE DISPOSAL SITES, 1993

Parameter (all units are mg/l except where indicated) ^(1,6)															
	MONITORING WELL NUMBER	Sampling Date	Temp. F	pH (SU)	EH (mv)	Turbidity (NTU)	Color (cpu)	Specific Conductivity (umhos/cm)	TDS	COD	BOD5	TOC	Alkalinity ----mg CaCo3/l ----	Hardness	
BAPTIST HILL ROAD LANDFILL	KBH-1 ⁽⁷⁾	7/09/93	49.5	8.1	152	86	2	520	291	22	<1	2.0	240	264	
	KBH-2	7/09/93	52.3	8.4	180	165	2	269	161	15	2	0.8	136	124	
	QA	7/09/93	--	--	211	175	4	272	150	21	1	0.7	128	88	
	KBH-3	7/09/93	49.5	9.3	196	1250	5	265	210	57	1	1.4	122	72	
	KBH-4	7/09/93	50.9	8.4	208	175	1	229	141	35	<1	0.7	104	96	
	KBH-5	----- WELL SCREEN COLLAPSED, NO SAMPLE AVAILABLE -----													
SILO AREA	KBH-6 ⁽⁷⁾	7/15/93	53.9	8.3	203	410	1	249	195	47	<1	1.3	128	164	
	KBH-7	7/15/93	51.4	8.0	194	4800	6	223	171	380	<1	3.0	95	100	
	KBH-8	7/15/93	----- WELL DRY, NO SAMPLE AVAILABLE -----												
SWAN SCHOOL ROAD CELLAR	T-3 ⁽⁷⁾	7/09/93	50.4	8.2	190	380	11	181	124	57	16	6.5	82	100	
	KBH-9	7/09/93	50.2	8.4	221	580	12	111	74	42	<1	0.8	50	60	
	KBH-10	7/09/93	48.9	8.3	222	225	3	339	204	22	2	1.2	150	188	
PARKIS MILLS ROAD CELLAR	KBH-11 ⁽⁷⁾	7/15/93	57.9	7.7	180	970	5	379	270	106	<1	2.2	168	208	
	KBH-12	7/15/93	55.2	8.1	177	170	5	221	175	73	<1	1.4	90	124	
	KBH-13	7/15/93	56.8	7.8	176	4	6	278	192	70	<1	1.1	136	164	
Standards		⁽²⁾	NA	6.5-8.5	⁽⁴⁾	5	15	⁽⁴⁾	500	⁽⁴⁾	⁽⁴⁾	⁽⁴⁾	⁽⁴⁾	⁽⁴⁾	

Notes:

- (1) A value preceded by < is the minimum detectable level for that sample and parameter.
- (2) Groundwater standards, 6 NYCRR 703.5.
- (3) Analysis no performed.
- (4) No groundwater standard.
- (5) Samples for metals are unfiltered.
- (6) All other organic compounds listed in 40 CFR, Part 136, Appendix A, Methods 601 and 602 were not detected above the analytical subcontractors minimum detectable level for that compound.
- (7) Background well.

NA = not applicable, QA = quality assurance sample, R = Rejected Data, -- = analysis not performed, G = Groundwater Guidance Value per NYSDEC TOGS 1.1.1.

TABLE 29 - RESULTS OF KESSELRING SITE GROUNDWATER MONITORING, INACTIVE DISPOSAL SITES, 1993 (continued)

Parameter (all units are mg/l except where indicated) ^(1,5,6)												
	WELL NUMBER	Sampling Date	Sulfate	Chloride	TKN	Ammonia	Nitrate-N	Phenols	Cyanide	Aluminum	Antimony	Arsenic
BAPTIST HILL ROAD LANDFILL	KBH-1 ⁽⁷⁾	7/09/93	14	<1.0	1.7	<1.0	4.30	<0.005	<0.02	3.1	<0.003	0.0015
	KBH-2	7/09/93	15	<1.0	2.0	<1.0	0.50	<0.005	<0.02	8.7	<0.003	0.014
	QA	7/09/93	11	<1.0	<1.0	<1.0	<0.10	<0.005	<0.02	9.1	<0.003	0.012
	KBH-3	7/09/93	14	<1.0	2.5	<1.0	<0.10	<0.005	<0.02	38.1	<0.003	0.005
	KBH-4	7/09/93	17	<1.0	<1.0	<1.0	<0.10	<0.005	<0.02	20.7	<0.003	<0.001
	KBH-5	WELL SCREEN COLLAPSED, NO SAMPLE AVAILABLE										
SILO AREA	KBH-6 ⁽⁷⁾	7/15/93	9.3	2.3	2.5	<1.0	<0.1	<0.005	<0.02	11.6	<0.003	<0.001
	KBH-7	7/15/93	9.3	1.4	1.4	<1.0	<0.1	<0.005	<0.02	72.8	<0.003	0.013
	KBH-8	7/15/93	WELL DRY, NO SAMPLE AVAILABLE									
SWAN SCHOOL ROAD CELLAR	T-3 ⁽⁷⁾	7/09/93	15	<1.0	1.7	<1.0	<0.10	<0.005	<0.02	22.7	<0.003	0.002
	KBH-9	7/09/93	7.0	<1.0	<1.0	<1.0	<0.10	<0.005	<0.02	20.5	<0.003	<0.001
	KBH-10	7/09/93	34	<1.0	<1.0	<1.0	<0.10	<0.005	<0.02	15.3	<0.003	0.002
PARKIS MILLS ROAD CELLAR	KBH-11 ⁽⁷⁾	7/15/93	26	1.4	3.1	<1.0	<0.10	<0.005	<0.02	58.3	<0.003	0.009
	KBH-12	7/15/93	18	2.3	1.7	<1.0	<0.10	<0.005	<0.02	24.6	<0.003	0.008
	KBH-13	7/15/93	14	2.3	2.5	<1.0	<0.10	<0.005	<0.02	14.3	<0.003	0.005
Standards		⁽²⁾	250	250	⁽⁴⁾	2.0	10.0	0.001	0.1	⁽⁴⁾	0.003G	0.025

*See first page for table notations.

TABLE 29 - RESULTS OF KESSELRING SITE GROUNDWATER MONITORING, INACTIVE DISPOSAL SITES, 1993 (continued)

Parameter (all units are mg/l except where indicated) ^(1,5,6)													
	WELL NUMBER	Sampling Date	Barium	Beryllium	Boron	Cadmium	Calcium	Chromium	Hexavalent Chromium	Copper	Iron	Lead	Magnesium
BAPTIST HILL ROAD LANDFILL	KBH-1 ⁽⁷⁾	7/09/93	<0.20	<0.0005	0.10	<0.001	91.0	<0.005	<0.01	<0.03	6.90	0.003	28.2
	KBH-2	7/09/93	<0.20	0.0005	0.10	<0.001	44.6	0.011	<0.01	<0.03	12.6	0.005	19.4
		QA 7/09/93	0.20	0.0006	0.14	<0.001	41.3	0.010	<0.01	<0.03	13.4	0.008	19.5
	KBH-3	7/09/93	0.35	0.003	0.17	<0.001	82.1	0.061	<0.01	0.05	62.8	0.027	25.5
	KBH-4	7/09/93	<0.20	0.002	0.10	<0.001	73.7	0.033	<0.01	<0.03	36.7	0.012	25.3
	KBH-5	----- WELL SCREEN COLLAPSED, NO SAMPLE AVAILABLE -----											
SILO AREA	KBH-6 ⁽⁷⁾	7/15/93	<0.20	<0.0005	<0.10	0.001	97.9	0.055	<0.01	0.03	22.5	0.018	34.4
	KBH-7	7/15/93	<0.20	0.0083	0.25	0.001	123	0.113	<0.01	0.10	133	0.048	56.1
	KBH-8	7/15/93	----- WELL DRY, NO SAMPLE AVAILABLE -----										
SWAN SCHOOL ROAD CELLAR	T-3 ⁽⁷⁾	7/09/93	<0.20	0.0018	<0.10	0.001	99.2	0.032	<0.01	0.04	50.0	0.029	26.2
	KBH-9	7/09/93	<0.20	0.0017	<0.10	<0.001	56.2	<0.005	<0.01	0.03	42.2	0.015	22.3
	KBH-10	7/09/92	<0.20	0.0010	0.10	<0.001	98.9	0.045	<0.01	<0.03	23.3	0.010	34.8
PARKIS MILLS ROAD CELLAR	KBH-11 ⁽⁷⁾	7/15/93	0.38	0.0053	0.10	0.001	292	0.135	<0.01	0.10	121	0.034	90.9
	KBH-12	7/15/93	0.43	0.0019	<0.10	<0.001	69.9	0.052	<0.01	0.03	38.2	0.017	25.8
	KBH-13	7/15/93	0.23	0.0012	0.10	0.001	93.9	0.029	<0.01	<0.03	23.7	0.084	26.5
Standards		⁽²⁾	1.0	0.003G	1.00	0.01	⁽⁴⁾	0.05	0.05	0.2	0.30	0.025	35G

*See first page for table notations.

TABLE 29 - RESULTS OF KESSELRING SITE GROUNDWATER MONITORING, INACTIVE DISPOSAL SITES, 1993 (continued)

Parameter (all units are mg/l except where indicated) ^(1,5,6)											
	WELL NUMBER	Sampling Date	Manganese	Mercury	Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Zinc
BAPTIST HILL ROAD LANDFILL	KBH-1 ⁽⁷⁾	7/09/93	0.21	<0.001	<0.05	6.2	<0.002	<0.02	2.7	<0.001	0.02
	KBH-2	7/09/93	0.20	<0.001	0.05	4.8	<0.002	<0.02	9.6	<0.001	0.06
		QA 7/09/93	0.21	<0.001	<0.05	4.2	<0.002	<0.02	9.5	<0.001	0.03
	KBH-3	7/09/93	1.05	<0.001	0.10	15.0	<0.002	<0.02	44.6	<0.001	0.14
	KBH-4	7/09/93	0.64	<0.001	0.05	9.0	<0.002	<0.02	16.9	<0.001	0.07
	KBH-5	----- WELL SCREEN COLLAPSED, NO SAMPLE AVAILABLE -----									
SILO AREA	KBH-6 ⁽⁷⁾	7/15/93	0.70	<0.001	<0.05	3.1	<0.002	<0.02	4.2	<0.001	0.09
	KBH-7	7/15/93	3.97	0.006	0.11	15.0	<0.002	<0.02	5.7	0.001	0.27
	KBH-8	7/15/93	----- WELL DRY, NO SAMPLE AVAILABLE -----								
SWAN SCHOOL ROAD CELLAR	T-3 ⁽⁷⁾	7/09/93	0.81	<0.001	<0.05	6.1	<0.002	<0.02	5.0	<0.001	0.13
	KBH-9	7/09/93	0.95	<0.001	<0.05	9.0	<0.002	<0.02	3.9	<0.001	0.08
	KBH-10	7/09/93	0.53	<0.001	<0.05	3.6	<0.002	<0.02	4.3	<0.001	0.05
PARKIS MILLS ROAD CELLAR	KBH-11 ⁽⁷⁾	7/15/93	2.17	0.002	0.12	18.0	<0.002	<0.02	10.2	<0.001	0.20
	KBH-12	7/15/93	0.88	0.001	<0.05	5.7	<0.002	<0.02	4.0	<0.001	0.08
	KBH-13	7/15/93	0.50	0.002	<0.05	5.7	<0.002	<0.02	4.3	<0.001	0.06
Standards		⁽²⁾	0.30	0.002	⁽⁴⁾	⁽⁴⁾	0.01	0.05	20.0	0.004G	0.3

*See first page for table notations.

**TABLE 30 - RESULTS OF KESSELRING SITE GROUNDWATER MONITORING,
SECURITY AREA WELLS, 1993**

Parameter (all units are mg/l except where indicated)⁽¹⁾

MONITORING WELL NUMBER	Sampling Date	pH (SU)	Temp. F	EH (mv)	Turbidity (NTU)	Color (cpu)	Specific	TDS	COD	BOD5	TOC	Alkalinity	Hardness
							Conductivity (umhos/cm)					--- mg CaCO3/l ---	---
MW-1 ⁽⁷⁾	12/7/93	7.4	54.3	142	810	10	3620	2160	50	<2	21.0	195	519
MW-2	12/7/93	8.1	51.6	115	>1000	5	1270	715	32	10	45.0	625	1700
MW-3	12/7/93	7.0	51.4	177	>1000	40	7730	4910	79	26	55.0	500	1200
MW-4	12/7/93	7.7	49.6	149	>1000	15	4420	2490	76	5	43.0	420	591
MW-5	----- MONITORING WELL REMOVED, NO SAMPLE -----												
MW-6	12/7/93	8.1	52.0	149	>1000	15	1290	720	74	7	25.0	500	1860
MW-7	12/7/93	7.9	48.4	147	>1000	35	2540	1470	32	11	11.0	800	7960
MW-8	12/7/93	7.7	53.8	143	>1000	20	414	300	388	3	9.7	240	615
MW-9	12/7/93	7.3	51.1	162	280	25	1900	922	119	15	14.0	470	322
	QA 12/7/93	-	-	222	460	20	2120	4820	119	8	12.0	450	305
MW-10	12/7/93	6.7	49.5	193	>1000	10	7500	5220	7.5	<2	14.0	36	1250
MW-11	12/7/93	7.2	54.7	195	680	15	1100	3920	63	4	38.0	520	1000
MW-12	12/7/93	7.8	53.1	189	>1000	5	541	390	15	<2	16.0	295	467
MW-13	12/7/93	7.9	50.4	167	730	5	883	718	11	<2	16.0	260	484
MW-14	12/7/93	7.8	50.5	199	210	10	1550	1010	<5	<2	1.6	305	769
MW-15	12/7/93	7.4	45.5	164	>1000	25	1550	928	121	4	21.0	480	592
MW-16	12/7/93	7.4	52.9	221	200	20	2790	1620	38	2	11.0	470	592
MW-17	12/7/93	7.5	53.8	195	480	10	1170	918	19	<2	6.0	425	616
MW-18	12/7/93	7.5	49.6	176	500	25	2300	1870	74	2	12.0	455	305
MW-19	12/7/93	7.3	48.7	235	610	20	3970	2220	74	5	12.0	370	458
	QA 12/7/93	-	-	251	740	15	3860	2010	81	5	15.0	375	435
MW-20	12/7/93	7.6	50.5	187	>1000	15	7950	2180	50	<2	4.1	600	1591
Standards	(2)	6.5-8.5	NA	(4)	5	15	(4)	500	(4)	(4)	(4)	(4)	(4)

Notes:

- (1) A value preceded by < is the minimum detectable level for that sample and parameter.
- (2) Groundwater standards, 6 NYCRR 703.5.
- (3) Analysis not performed.
- (4) No groundwater standard.
- (5) Analysis for metals are reported for filtered samples due to high sample turbidity and its bias on analysis.
- (6) All other organic compounds listed in 40 CFR, Part 136, Appendix A, Methods 601 and 602 were not detected above the analytical subcontractor's minimum detectable level for that compound.
- (7) Background well.

NA = not applicable, QA = quality assurance sample, G = Groundwater Guidance Value per NYSDEC TOGS 1.1.1.

**TABLE 30 - RESULTS OF KESSELRING SITE GROUNDWATER MONITORING,
SECURITY AREA WELLS, 1993 (continued)**

Parameter (all units are mg/l except where indicated) ^(1,6)											
WELL NUMBER	Sampling Date	Sulfate	Chloride	TKN	Ammonia	Nitrate-N	Phenols	Cyanide	Aluminum	Antimony	Arsenic
MW-1 ⁽⁷⁾	12/7/93	49	795	2.0	<0.1	1.4	<0.002	<0.01	2.3	<0.06	<0.005
MW-2	12/7/93	51	237	8.1	3.1	0.47	<0.002	<0.01	2.2	<0.06	<0.005
MW-3	12/7/93	62	2320	55.0	57.0	0.25	<0.002	<0.01	4.3	<0.06	<0.005
MW-4	12/7/93	104	1200	25.0	28.0	33.0	<0.002	0.01	2.6	<0.06	<0.005
MW-5	----- MONITORING WELL REMOVED, NO SAMPLE -----										
MW-6	12/7/93	47	255	12.0	6.5	0.55	<0.002	<0.01	1.5	<0.06	<0.005
MW-7	12/7/93	66	710	10.0	2.3	1.6	<0.002	<0.01	2.4	0.07	<0.005
MW-8	12/7/93	19	10	5.3	0.1	2.2	<0.002	<0.01	2.1	<0.06	<0.005
MW-9 QA	12/7/93	100	267	23.0	12.0	0.81	<0.002	0.04	2.2	<0.06	<0.005
	12/7/93	118	305	24.0	8.3	1.7	<0.002	0.03	1.8	<0.06	<0.005
MW-10	12/7/93	385	2440	4.2	<0.1	81.0	<0.002	0.04	4.2	<0.06	<0.005
MW-11	12/7/93	164	3750	5.6	4.9	1.1	<0.002	<0.01	4.8	<0.06	<0.005
MW-12	12/7/93	55	170	1.7	<0.1	5.7	<0.002	<0.01	2.3	<0.06	<0.005
MW-13	12/7/93	275	21	2.0	0.1	2.7	<0.002	<0.01	2.6	<0.06	<0.005
MW-14	12/7/93	130	180	2.5	0.1	0.27	<0.002	<0.01	2.9	<0.06	<0.005
MW-15	12/7/93	138	230	24.0	24.0	0.31	<0.002	<0.01	2.8	<0.06	<0.005
MW-16	12/7/93	148	565	5.0	3.8	3.6	<0.002	<0.01	3.4	<0.06	<0.005
MW-17	12/7/93	284	37	1.4	<0.1	0.14	<0.002	<0.01	3.1	<0.06	<0.005
MW-18	12/7/93	164	760	2.5	1.1	0.31	<0.002	<0.01	1.8	0.10	<0.005
MW-19 QA	12/7/93	90	1090	71.0	52.0	0.43	<0.002	<0.01	2.4	0.13	<0.005
	12/7/93	67	1050	66.0	40.0	0.53	<0.002	<0.01	2.6	<0.06	<0.005
MW-20	12/7/93	125	2300	5.6	5.4	2.5	<0.002	<0.01	4.4	<0.06	<0.005
Standards	⁽²⁾	250	250	⁽⁴⁾	2.0	10.0	0.001	0.1	⁽⁴⁾	0.003G	0.025

*See first page for table notations.

**TABLE 30 - RESULTS OF KESSELRING SITE GROUNDWATER MONITORING,
SECURITY AREA WELLS, 1993 (Continued)**

Parameter (all units are mg/l except where indicated) ^(1,6)												
WELL NUMBER	Sampling Date	Barium	Beryllium	Boron	Cadmium	Calcium	Chromium	Hexavalent Chromium	Copper	Iron	Lead	Magnesium
MW-1 ⁽⁷⁾	12/7/93	0.14	<0.005	0.09	<0.005	145	<0.005	<0.02	<0.05	0.08	<0.005	24.2
MW-2	12/7/93	0.10	<0.005	0.23	<0.005	120	<0.005	<0.02	<0.05	0.48	<0.005	52.1
MW-3	12/7/93	0.74	<0.005	0.30	<0.005	340	0.009	<0.02	<0.05	24.2	<0.005	123
MW-4	12/7/93	0.32	<0.005	0.27	<0.005	142	<0.005	<0.02	<0.05	0.25	<0.005	25.0
MW-5	----- MONITORING WELL REMOVED, NO SAMPLE -----											
MW-6	12/7/93	0.14	<0.005	0.34	<0.005	36.8	<0.005	<0.02	<0.05	0.53	<0.005	11.3
MW-7	12/7/93	0.13	<0.005	0.29	<0.005	46.0	0.012	<0.02	0.06	0.89	<0.005	8.5
MW-8	12/7/93	0.11	<0.005	0.30	<0.005	74.8	<0.005	<0.02	<0.05	0.45	<0.005	10.7
MW-9	12/7/93	0.23	<0.005	0.33	<0.005	105	<0.005	<0.02	<0.05	0.76	<0.005	21.2
	QA 12/7/93	0.21	<0.005	0.24	<0.005	92.6	<0.005	<0.02	<0.05	0.74	<0.005	18.4
MW-10	12/7/93	0.23	<0.005	0.27	<0.005	297	<0.005	<0.02	<0.05	0.25	<0.005	66.2
MW-11	12/7/93	0.99	<0.005	0.31	<0.005	394	<0.005	<0.02	<0.05	4.0	<0.005	52.5
MW-12	12/7/93	0.08	<0.005	0.26	<0.005	108	<0.005	<0.02	<0.05	0.21	<0.005	21.6
MW-13	12/7/93	0.09	<0.005	0.27	<0.005	143	<0.005	<0.02	<0.05	0.22	<0.005	28.9
MW-14	12/7/93	0.09	<0.005	0.27	<0.005	169	<0.005	<0.02	<0.05	0.22	<0.005	73.6
MW-15	12/7/93	0.17	<0.005	0.30	<0.005	169	<0.005	<0.02	<0.05	4.6	<0.005	33.6
MW-16	12/7/93	0.27	<0.005	0.26	0.009	234	0.09	<0.02	0.10	4.5	<0.005	52.8
MW-17	12/7/93	0.15	<0.005	0.17	<0.005	212	<0.005	<0.02	<0.05	0.17	<0.005	40.0
MW-18	12/7/93	0.12	<0.005	0.24	<0.005	96.0	0.015	<0.02	<0.05	3.9	<0.005	19.6
MW-19	12/7/93	0.62	<0.005	0.23	<0.005	138	0.012	<0.02	<0.05	11.7	<0.005	32.7
	QA 12/7/93	0.65	<0.005	0.26	<0.005	146	<0.005	<0.02	<0.05	17.3	<0.005	34.5
MW-20	12/7/93	0.35	<0.005	0.23	<0.005	344	<0.005	<0.02	<0.05	0.25	<0.005	39.7
Standards	⁽²⁾	1.0	0.003G	1.00	0.01	⁽⁴⁾	0.05	0.05	0.20	0.30	0.025	35G

*See first page for table notations.

**TABLE 30 - RESULTS OF KESSELRING SITE GROUNDWATER MONITORING,
SECURITY AREA WELLS, 1993 (Continued)**

Parameter (all units are mg/l except where indicated) ^(1,5)										
WELL NUMBER	Sampling Date	Manganese	Mercury	Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Zinc
MW-1 ⁽⁷⁾	12/7/93	<0.02	<0.0004	<0.05	<0.5	<0.005	<0.02	484	<0.01	<0.01
MW-2	12/7/93	0.10	<0.0004	<0.05	<0.5	<0.005	<0.02	44	<0.01	<0.01
MW-3	12/7/93	5.60	<0.0004	<0.05	<0.5	<0.005	<0.02	961	<0.01	0.04
MW-4	12/7/93	0.12	<0.0004	<0.05	<0.5	<0.005	<0.02	651	<0.01	0.01
MW-5	----- MONITORING WELL REMOVED, NO SAMPLE -----									
MW-6	12/7/93	0.41	<0.0004	<0.05	<0.5	<0.005	<0.02	212	<0.01	<0.01
MW-7	12/7/93	0.26	<0.0004	<0.05	54.7	<0.005	<0.02	507	<0.01	0.02
MW-8	12/7/93	0.02	<0.0004	<0.05	22.7	<0.005	<0.02	29.6	<0.01	0.01
MW-9	12/7/93	1.60	<0.0004	<0.05	9.0	<0.005	<0.02	208	<0.01	0.39
QA	12/7/93	1.50	<0.0004	<0.05	<0.5	<0.005	<0.02	206	<0.01	0.29
MW-10	12/7/93	0.70	<0.0004	<0.05	3.9	<0.005	<0.02	1570	<0.01	0.10
MW-11	12/7/93	8.3	<0.0004	<0.05	<0.5	<0.005	<0.02	2600	<0.01	<0.01
MW-12	12/7/93	<0.02	<0.0004	<0.05	<0.5	<0.005	<0.02	15.9	<0.01	<0.01
MW-13	12/7/93	<0.02	<0.0004	<0.05	<0.5	<0.005	<0.02	55.4	<0.01	<0.01
MW-14	12/7/93	<0.02	<0.0004	<0.05	<0.5	<0.005	<0.02	76.7	<0.01	<0.01
MW-15	12/7/93	3.2	<0.0004	<0.05	<0.5	<0.005	<0.02	121	<0.01	<0.01
MW-16	12/7/93	2.7	<0.0004	<0.05	<0.5	<0.005	<0.02	280	<0.01	0.03
MW-17	12/7/93	<0.02	<0.0004	<0.05	<0.5	<0.005	<0.02	24.0	<0.01	<0.01
MW-18	12/7/93	0.42	<0.0004	<0.05	<0.5	<0.005	<0.02	542	<0.01	<0.01
MW-19	12/7/93	4.95	<0.0004	<0.05	<0.5	<0.005	<0.02	487	<0.01	<0.01
QA	12/7/93	5.10	<0.0004	<0.05	<0.5	<0.005	<0.02	494	<0.01	0.04
MW-20	12/7/93	0.06	<0.0004	<0.05	<0.5	<0.005	<0.02	1490	<0.01	<0.01
Standards	⁽²⁾	0.30	0.002	⁽⁴⁾	⁽⁴⁾	0.01	0.05	20.0	0.004(G)	0.3

*See first page for table notations.

**TABLE 30 - RESULTS OF KESSELRING SITE GROUNDWATER MONITORING,
SECURITY AREA WELLS, 1993 (Continued)**

WELL NUMBER	Sampling Date	Parameter (all units are ug/l) ^(1,6)				
		Dichloro-Difluoromethane	Trichloro-ethylene	Tetrachloro-ethylene	1,1,1-Tri-chloroethane	Trichloro-fluoromethane
MW-1 ⁽⁷⁾	12/7/93	<1	<1	<1	<1	<1
MW-2	12/7/93	<1	<1	<1	<1	<1
MW-3	12/7/93	<1	<1	<1	<1	<1
MW-4	12/7/93	11	9	<1	<1	<1
MW-5	----- MONITORING WELL REMOVED, NO SAMPLE -----					
MW-6	12/7/93	<1	1	7	<1	<1
MW-7	12/7/93	<1	<1	<1	<1	<1
MW-8	12/7/93	<1	<1	<1	<1	<1
MW-9 QA	12/7/93	<1	<1	<1	<1	<1
	12/7/93	<1	<1	<1	<1	<1
MW-10	12/7/93	<1	<1	<1	<1	<1
MW-11	12/7/93	<1	<1	<1	<1	<1
MW-12	12/7/93	<1	<1	<1	<1	<1
MW-13	12/7/93	<1	<1	<1	<1	<1
MW-14	12/7/93	<1	<1	<1	<1	<1
MW-15	12/7/93	<1	<1	<1	<1	<1
MW-16	12/7/93	2	2	<1	<1	4
MW-17	12/7/93	<1	<1	<1	<1	<1
MW-18	12/7/93	<1	<1	<1	<1	<1
MW-19 QA	12/7/93	2	<1	<1	<1	<1
	12/7/93	1	<1	<1	<1	<1
MW-20	12/7/93	<1	<1	<1	<1	<1
Standards	⁽²⁾	5	5	5	5	5

*See first page for table notations.

**TABLE 31 - RESULTS OF KESSELRING SITE GROUNDWATER MONITORING
FOR RADIOACTIVITY, 1993**

Location	Radioactivity Concentration ⁽¹⁾				
	Gross Beta	Alpha	Cs-137	Co-60	Tritium
	(× 10 ⁻⁹ μCi/ml)			(× 10 ⁻⁷ μCi/ml)	
LANDFILL AREA					
LMW-1 ⁽²⁾	0.8 ± 0.5	<0.2	<0.7	<0.8	<2.6
HB-2A	5.2 ± 1.1	0.9 ± 0.4	<0.6	<0.8	<2.6
HB-3A	WELL IS DRY				
LMW-4	WELL IS DRY				
HB-5A	WELL IS DRY				
LMW-6	5.9 ± 1.3	0.2 ± 0.3	<0.7	<0.7	<2.6
HB-7A	3.5 ± 0.9	0.4 ± 0.3	<0.7	<0.7	<2.6
SECURITY AREA					
MW-1 ⁽²⁾	4.7 ± 1.5	0.4 ± 0.2	<0.6	<0.8	<2.6
MW-2	4.4 ± 1.3	0.8 ± 0.3	<0.6	<0.7	<2.6
MW-3	24.2 ± 6.0	0.6 ± 0.3	<0.6	<0.7	<2.6
MW-4	15.9 ± 2.5	1.2 ± 0.4	<0.6	<0.7	<2.6
MW-6	3.7 ± 1.2	1.8 ± 0.5	<0.6	<0.8	<2.6
MW-7	10.3 ± 2.1	1.6 ± 0.5	<0.7	<0.8	<2.6
MW-8	19.0 ± 1.9	1.0 ± 0.4	<0.7	<0.8	<2.6
MW-9	27.6 ± 2.7	1.9 ± 0.5	<0.6	<0.8	<2.6
MW-10	18.4 ± 3.1	0.3 ± 0.2	<0.7	<0.8	<2.6
MW-11	25.4 ± 6.3	3.9 ± 0.7	<0.7	<0.8	<2.6
MW-12	2.0 ± 0.9	0.7 ± 0.3	<0.7	<0.8	<2.6
MW-13	3.9 ± 1.1	1.2 ± 0.4	<0.7	<0.8	<2.6
MW-14	0.9 ± 0.9	0.5 ± 0.3	<0.6	<0.9	<2.6
MW-15	10.9 ± 1.9	2.8 ± 0.6	<0.7	<0.8	<2.6
MW-16	12.3 ± 2.3	0.8 ± 0.3	<0.6	<0.7	<2.6
MW-17	3.8 ± 1.1	1.6 ± 0.5	<0.5	<0.6	<2.6
MW-18	6.6 ± 1.6	1.7 ± 0.5	<0.6	<0.7	<2.6
MW-19	14.0 ± 2.4	0.4 ± 0.3	<0.6	<0.7	<2.6
MW-20	20.0 ± 5.7	3.2 ± 0.6	<0.6	<0.8	<2.6
BAPTIST HILL ROAD LANDFILL					
KBH-1 ⁽²⁾	7.7 ± 1.1	0.3 ± 0.3	<0.6	<0.8	3.9 ± 3.5
KBH-2	3.6 ± 0.8	0.6 ± 0.3	<0.7	<0.8	<2.9
KBH-3	1.8 ± 0.6	0.7 ± 0.3	<0.7	<0.8	<2.9
KBH-4	1.8 ± 0.6	1.0 ± 0.4	<0.6	<0.8	<2.9
SILO AREA					
KBH-6 ⁽²⁾	1.4 ± 0.6	0.4 ± 0.3	<0.7	<0.8	<2.9
KBH-7	1.5 ± 0.6	<0.2	<0.7	<0.8	<2.9
SWAN SCHOOL ROAD CELLAR					
T-3 ⁽²⁾	1.2 ± 0.5	0.2 ± 0.2	<0.6	<0.8	<2.9
KBH-9	3.9 ± 0.7	<0.2	<0.6	<0.8	2.9 ± 3.5
KBH-10	1.6 ± 0.6	<0.2	<0.6	<0.8	<2.9
PARKIS MILLS ROAD CELLAR					
KBH-11 ⁽²⁾	0.7 ± 0.6	<0.2	<0.7	<0.7	<2.9
KBH-12	1.4 ± 0.6	<0.2	<0.7	<0.8	<2.9
KBH-13	3.0 ± 0.7	<0.2	<0.7	<0.7	<2.9

Notes:

- (1) A value preceded by < is less than the minimum detection level for that sample and parameter. The (±) value represents the statistical error at two standard deviations.
- (2) Background well for comparison purposes.

TABLE 32 - CHEMICAL CONSTITUENTS IN KESSELRING SITE SERVICE WATER, 1993

Parameters/Units	Number of Samples	Value ⁽¹⁾			Standard	Percent of Standard ⁽³⁾
		Minimum	Maximum	Average ⁽²⁾		
Drinking Water Standards (Reference 23)						
Nitrates (mg/l as N)	14	0.11	0.4	0.29 ± 0.05	10	2.9
Total Coliform ⁽⁴⁾	69	<1	18	<1 ± .668	None Detectable	--
Residual Chlorine (mg/l)	484	<0.001	0.023	<0.004 ± 0.0003	Detectable	--
Turbidity (NTU)*	13	0.1	1.9	<0.7 ± 0.34	5	14

Notes:

- (1) A value preceded by < is less than the minimum detection level for that sample and parameter.
- (2) Average values preceded by < contain at least one less than minimum detection level value in the average. The (±) value represents the statistical error at two standard deviations.
- (3) Percent of standard for the average value.
- (4) The minimum detectable concentration by the membrane filter method is one colony per 100 ml (N/100 ml).

*NTU = Nephelometric turbidity units

**TABLE 33 - RESULTS OF KESSELRING SITE GROUNDWATER MONITORING,
ANNUAL SITE SERVICE WATER ANALYSES, 1993**

Parameter	(Units)	Value ⁽¹⁾	Standard ⁽²⁾
Color	(cpu) ⁽³⁾	<5	15
Odor	(TON)	None detected	3
Fluoride	(mg/l)	0.4	2.2
Sulfate	(mg/l)	12	250
Arsenic	(mg/l)	<0.005	0.05
Barium	(mg/l)	0.01	2.00
Cadmium	(mg/l)	<0.005	0.005
Chromium	(mg/l)	<0.005	0.10
Iron	(mg/l)	0.06	0.3
Manganese	(mg/l)	<0.02	0.3
Mercury	(mg/l)	<0.0004	0.002
Selenium	(mg/l)	<0.005	0.01
Sodium	(mg/l)	5.9	---
Zinc	(mg/l)	<0.01	5
Lindane	(ug/l)	<0.05	0.2
Methoxychlor	(ug/l)	<0.5	40
Toxaphene	(ug/l)	<1	3
Endrin	(ug/l)	<0.1	0.2
2,4-D	(ug/l)	<0.5	50
2,4,5-TP Silvex	(ug/l)	<0.1	10

Notes:

- (1) A value preceded by < is less than the minimum detection level for that sample and parameter.
- (2) Maximum Contaminant Level per 10 NYCRR 5.
- (3) cpu = Cobalt platinum units

WINDSOR SITE EFFLUENT AND ENVIRONMENTAL MONITORING

SITE DESCRIPTION

The Windsor Site (Figure 9) is situated on 10.8 acres of land near Windsor, Connecticut, approximately five miles (eight kilometers) north of the City of Hartford. Facilities at the Windsor Site include a naval propulsion plant prototype, administrative offices, machine shops, wastewater treatment facilities, training facilities, a boiler house, waste storage facilities, oil storage facilities, sanitary waste septic system, a cooling tower, a chemistry laboratory and an equipment service building. In March 1993, the nuclear propulsion plant completed its final shutdown. The area surrounding the Windsor Site is a mixture of open land, industrial regions, tobacco and shrub farms, and suburban residential areas. The Windsor Site lies in a broad basin of gently rolling terrain called the Connecticut River Valley. The valley begins well to the north, in Massachusetts, and follows the Connecticut River to Long Island Sound. The valley is bordered on the east by the Green Mountains and on the west by the Berkshire Mountains. The Farmington River turns to within a half mile of the Windsor Site to the north and joins the Connecticut River about 5 miles east of the site.

The climate in the region of the Windsor Site is typical for a northern temperate climate zone. The prevailing west to east movement of air in the region carries the majority of weather systems into the area from the west. The location of the site, relative to the continent and ocean is significant in that rapid weather changes can result when storms move northward along the Mid-Atlantic coast. Seasonally, weather characteristics vary from the cold and dry continental-polar air of winter to the warm, maritime air of summer. Typical minimum and maximum temperatures are 18°F and 83°F respectively and the average temperature is approximately 50°F. Annual snowfall is 50-55 inches per year and precipitation averages approximately 43 inches per year. Prevailing winds are north to northwest during the winter and south to southwest during the rest of the year.

The topography in the area of the Windsor Site exhibits moderate relief due to the erosion of the hills formed during the Jurassic period. Most areas within two miles of the site lie between 150 and 250 feet above sea level. A few hills to the west

reach 400 feet. The site elevation is approximately 180 feet.

The bedrock geology in the vicinity of the Windsor Site is quite simple. Portland arkose lies in a broad belt at a depth of 90-150 feet. Successive layers under this arkose are as follows: (1) the Hampden basalt layer, which is about 100 to 150 feet thick, (2) the East Berline formation that is a gray to reddish-brown siltstone about 500 feet thick, (3) Holyoke basalt about 300 feet thick, and (4) the lowest level which is New Haven arkose. The combined layers comprise the Newark Group of the Triassic age.

The surficial makeup is primarily composed of Deltaic deposits of sand, silt, and gravel. Its origin is probably the western highlands and its accumulation resulted from glaciation. Surface drainage is good, and permeability varies with silt content. Terrace deposits occur immediately north of the site, and the nearby creek banks are composed largely of till. Both contain varying amount of clay in addition to the components found in the Deltaic deposits. These surficial deposits are mixed and layered in a complex manner.

Drainage water from the site enters the Farmington River by a drainage brook. The length of the drainage path from the site to the river is approximately three-quarters of a mile. The flow rate in the Farmington River, which has been monitored since August 1928 at Rainbow, Connecticut, located downstream from the Windsor Site, averages approximately 1000 cubic feet per second (cfs). The Connecticut River is gauged upriver and downriver from its confluence with the Farmington River just east of the Town of Windsor. The average flow rate past the upriver station is approximately 16,270 cfs.

Ground water is an important resource for the area in industrial usage. Three high priority aquifers are designated within ten miles of the Windsor Site. They are at Bradley Airport, at Windsor Locks, and near Broad Brook in East Windsor. The valley of the Farmington River across the Talcott Mountains is also designated a high priority aquifer by the State of Connecticut Water Resources Planning Program of the Department of Environmental Protection. The "high priority" designation is explained as being a "large deposit of permeable rock, sand or gravel within which significant amounts of ground water may be found". The

Windsor Site obtains all water for its operations from two on-site production wells. The well water is chlorinated to ensure potability.

LIQUID EFFLUENT MONITORING

Origins

Liquid effluent at the Windsor Site originates from cooling tower water, boiler blowdown water, storm drainage water, retention tank discharges, and site service water.

Liquids that may contain radioactivity are collected in holdup tanks and processed through a series of filters and demineralizers to reduce the radioactivity concentration. The majority of the water is then reused in certain plant operations. This minimizes the amount of radioactivity that could be released in liquid effluents. The sources of radioactivity in liquids and the radionuclides associated with Windsor Site operations are the same as those described for the Kesselring Site.

The principal sources of effluent water at the Windsor Site are:

1. *Cooling Tower Water* - Cooling water is treated to minimize scale formation, to prevent corrosion of system materials, and to inhibit the growth of algae and slime. The pH is maintained in the range of 7.5 to 8.2.
2. *Site Boiler Discharge* - Site boiler water is treated demineralized water. Operations that result in releases are (1) periodic blowdowns to control the solids in the boiler water and (2) neutralization of ion exchange resin regeneration effluent. The blowdown waters are neutralized before being discharged.
3. *Site Drainage Water* - Storm drainage water also makes up a portion of the liquid effluent. Those sections of the site drainage system that receive only stormwater are permitted under a State of Connecticut Department of Environmental Protection General Stormwater Discharge Permit.
4. *Retention Tank Liquids* - The retention tanks receive wastewater from plant facilities including blowdown water from steam generators and drainage water from the engine room. This water is collected and analyzed before being discharged.

5. *Site Service Water* - Site service water is used for drinking and non-contact cooling purposes. Chlorine compounds are added to the site service water system as a drinking water disinfectant.

Approximate flows and chemical characteristics, as applicable, of these discharges were incorporated in the Reference (8) National Pollutant Discharge Elimination System permit application and the Reference (43) State of Connecticut Department of Environmental Protection General Stormwater Discharge Permit Application. Effluent from the sanitary sewer is not discharged from the Windsor Site but is treated in an anaerobic septic tank with an auxiliary clarification chamber and is released below ground through seepage trenches.

Effluent Monitoring

The liquid effluent from the Windsor Site is released through a section of the Site storm drain system to a drainage brook that flows into the Farmington River as shown in Figure 9. Stormwater discharges are sampled annually in accordance with Reference (43). With the exception of cooling tower blowdowns and once-through cooling systems that operate semi-continuously, all effluents are released in batches. Control of effluent concentrations is achieved by the collection and analysis of samples prior to discharge. Samples are routinely collected for analysis to ensure that the chemical constituents conform to applicable state and federal standards and that the radioactivity concentration complies with release limits.

Effluent Analyses

The analyses currently performed for chemical constituents in Site effluent samples are listed in Table 35. The analyses are performed using procedures described in Reference (20) or other EPA approved methods. Site effluent samples are also analyzed for alpha and gross beta radioactivity, for tritium by liquid scintillation counting and for gamma radioactivity by gamma spectrometry.

Assessment

The analytical results for the chemical constituents present in the Windsor Site liquid effluent during 1993 are summarized in Table 34. These results indicate that the average values for all of the constituents were within the applicable standards at the industrial wastewater outfall.

Windsor Site, Windsor, Connecticut

Figure 9

**TABLE 34 - CHEMICAL CONSTITUENTS, RADIOACTIVITY AND TEMPERATURE IN
WINDSOR SITE LIQUID EFFLUENT, 1993**

Parameter/Units	Number of Samples	Value ⁽¹⁾			Limit or Standard	Percent of Limit or Standard ⁽²⁾
		Minimum	Maximum	Average		
Discharge Permit Requirements (Reference 8)						
Temperature °C	241	3.3	24.4 ⁽⁴⁾	15.2 ± 0.5	(3)	52 ⁽³⁾
Oil/Grease/Discoloration	241	(6)	(6)	(6)	(5)	--
pH (SU) *	52	7.40	8.33	7.99 ± 0.03	6.0-9.0	--
Flow (MGD) **	347	0.003	0.090	0.024 ± 0.001	0.147	16
Additional Connecticut Water Quality Analyses (Reference 11)						
Total Suspended Solids (mg/l)	52	<1.0	5.8 ⁽⁸⁾	<1.5 ± 0.3	20	<8
Copper (mg/l)	12	<0.05	0.08	<0.055 ± 0.007	1.0	<6
Iron (mg/l)	12	<0.06	0.58	<0.18 ± 0.12	1.0	<18
Radioactivity ⁽⁷⁾ (μCi/ml)						
Alpha (× 10 ⁻⁹)	4	<1.0	<1.6	<1.3 ± 1.4	500	<0.3
Gross Beta (× 10 ⁻⁹)	4	<0.8	3.5	<1.9 ± 1.6	5,000	<0.04
Gamma (× 10 ⁻⁹)	50	<19	<22	<20 ± 0.2	5,000	<0.5
Tritium (× 10 ⁻⁷)	12	<0.68	8.1	<1.5 ± 0.1	20,000	<0.01

Notes:

- (1) A value preceded by < is less than the minimum detection level for that sample and parameter. Average values preceded by < contain at least one less than minimum detection level value in the average. The (±) value represents the statistical error at two standard deviations.
- (2) Percent of limit or standard for the average.
- (3) Discharge shall not increase the temperature of the receiving stream above 85 °F (29.4 °C) or raise the normal temperature of the receiving stream more than 4 °F.
- (4) On March 3, 1993, the Windsor Site had a temporary permit exceedance beyond the reasonable control of the permittee per State of Connecticut Water Discharge Permit Regulations, Section 22a-430-3(m)(1). This condition increased the temperature of the receiving stream by 9 °F. This exceedance occurred during a normal daily discharge and was caused by low flow from the downstream tributary to the drainage brook, due to icing conditions.
- (5) Defined by Reference (8) as no visible sheen.
- (6) No visible sheen occurrences were reported for 1993.
- (7) The radioactivity standards are the derived concentration guides (DCGs) listed in DOE Order 5400.5, Reference (2). The DCG for alpha radioactivity is based on uranium-234. The beta and gamma radioactivity DCG are based on cobalt-60.
- (8) On 3/25/93 a Total Suspended Solids of 74 mg/l was analyzed on a non-routine sample during a heavy snow melt condition. Discharge was visually inspected and no discoloration of the receiving stream was noted. Condition was caused by snow melt run-off carrying dirt to storm drains.

*SU = Standard Units.

**MGD = Million gallons per day.

During 1993, less than 0.001 curie of radioactivity consisting of activation products with half lives greater than three hours and less than 0.02 curie of tritium were released from the Site in a total volume of 3.3×10^7 liters of water. The resulting annual average radioactivity concentration in the effluent corresponded to less than 0.1 percent of the DOE derived concentration guide listed in Reference (2) for the mixture of radionuclides present.

Liquid effluent monitoring data are reported as required in References (1) and (8).

AIRBORNE EFFLUENT MONITORING

Origins

The principal source of industrial gaseous effluent at the Windsor Site is the operation of the two steam generating boilers. Number 4 fuel oil is utilized in boiler operation, and the resulting combustion gas products are released through elevated exhaust stacks. Other operations at the site such as emergency power diesel generators that burn diesel fuel also constitute point sources of airborne effluents.

Operations having a potential for the release of airborne radioactivity are serviced by controlled exhaust systems that discharge through elevated stacks. Prior to release, the exhaust air is passed through high efficiency particulate air (HEPA) filters, to minimize radioactivity content. The sources of airborne radioactivity and the radionuclides associated with Windsor Site operations are the same as those described for the Kesselring Site, however those sources attributable to propulsion plant operations ceased to be a factor after March 1993 when the propulsion plant was permanently shutdown.

Effluent Monitoring

The exhaust air from the Site boilers is monitored with a photoelectric optical density system that provides for the continuous recording of the intensity of smoke emissions. The other industrial emission points do not require monitoring under terms of the current State of Connecticut permits due to the very low levels of the emissions.

The air exhausted from all radiological air emission points is continuously sampled for particulate radioactivity. The reactor plant exhaust stack was sampled for radioiodine with activated charcoal

cartridges until the propulsion plant was permanently shutdown in March 1993. Sampling for tritium and carbon-14 was also performed using appropriate absorbers until no longer required due to the propulsion plant shutdown. While the propulsion plant was operating in 1993, the reactor plant exhaust stack was monitored with instrumentation which recorded radioactivity levels and also had alarm functions to provide an alert should an out-of-specification release occur. Air samples are collected for routine analysis using beta counting and gamma spectrometry techniques.

Effluent Analyses

The air particulate sample filters are analyzed for radioactivity on a routine basis. The filters are analyzed for beta-gamma radioactivity by direct counting with a system that provides a minimum detectable concentration for cobalt-60 of approximately 3×10^{-16} $\mu\text{Ci/ml}$. The activated charcoal cartridges used for radioiodine sampling are analyzed by gamma spectrometry to a minimum detectable concentration of approximately 5×10^{-16} $\mu\text{Ci/ml}$ for iodine-131. The tritium and carbon-14 absorbers are analyzed by liquid scintillation spectrometry. The minimum detectable concentrations of tritium and carbon-14 in air are approximately 5×10^{-11} $\mu\text{Ci/ml}$ for typical sampling parameters.

The quantities of gaseous radioactivity in the effluent air were calculated based on reactor plant operating parameters.

Assessment

The site boilers and emergency diesels were operated in compliance with applicable State of Connecticut standards set forth in Reference (12).

The sulfur content of the Number 4 fuel oil and diesel fuel used in boiler and diesel operations during 1993 was less than 1.0 percent and 0.5 percent by weight, respectively, based on vendor supplied analysis reports of fuel supplied and, therefore, conformed to the Connecticut standard.

The radioactivity contained in exhaust air during 1993 consisted of: (1) less than 0.001 curie each of krypton-85 and particulate fission and activation products having half lives greater than three hours, (2) less than 0.1 curie of noble gases with half lives of 12 days or less, principally argon-41, xenon-133 and xenon-135, (3) less than 0.005 curie of tritium, and (4) approximately

0.012 curie of carbon-14. Iodine-131 is not normally detectable and none was detected during 1993.

The airborne radioactivity was contained in a total air exhaust volume of approximately 1.0×10^{11} liters. The average radioactivity concentration in the exhaust air was well below the applicable standards listed in Reference (2). The annual radioactivity concentration at the nearest Site boundary, allowing for typical diffusion conditions, was less than 0.01 percent of the DOE derived concentration guide for effluent released to unrestricted areas (Reference 2) for the mixture of radionuclides present. Airborne effluent monitoring data are reported as required in References (1) and (3).

ENVIRONMENTAL MONITORING

Scope

The environmental monitoring program for the Windsor Site includes the routine collection and radioanalysis of water and sediment samples from the drainage brook and the Farmington River, fish from the Farmington River, periodic radiation surveys of the drainage brook, the continuous monitoring of radiation levels at twelve perimeter locations and at off-site locations ranging from 7.2 to 16.3 kilometers (4.5 to 10.1 miles) from the site, and the routine monitoring of the site service water.

Quarterly, samples of water and sediment are collected from the drainage brook and Goodwin Pond which is the source of the brook. Sediment samples are obtained from 15 locations along the approximately three-quarters of a mile length of the brook. Water samples are taken at five of these locations. Sediment samples are scooped from the top two centimeters of sediment. Three additional sediment samples are taken in the mouth of the brook when accessible from the Farmington River. The Goodwin Pond samples are taken near the discharge point of an abandoned storm drain line which had discharged from the site to the pond. This pipe was sealed in the early 1960's. Semiannually, direct radiation measurements are made at the same 15 locations along the brook.

Farmington River water and sediment samples were collected at three locations across the river at locations upstream, opposite, and downstream

from the release point, as shown in Figure 10. Samples were collected during the last three calendar quarters of 1993; ice coverage on the river prevented collection during the first quarter. Sediment samples were collected with a Birge-Ekman dredge that samples a 15 cm x 15 cm area to a depth of approximately 2.5 cm. In addition, fish were collected from the Farmington River upstream and downstream from the release point and analyzed for radioactivity.

Environmental air samplers are operated in the primary upwind and downwind directions from the site to measure normal background airborne radioactivity and to confirm that Windsor Site effluents have no measurable effect on normal background levels.

Radiation levels at the 12 site perimeter locations shown in Figure 11 and at several off-site locations are monitored with sensitive, thermoluminescent dosimeters (TLDs).

Analyses

The routine quarterly samples of the water and bottom sediment are analyzed with a high resolution gamma spectrometer system. In addition, detailed evaluations of the fish and some of the water and sediment samples collected from the river were performed with a more sensitive gamma spectrometer system. This type of analysis is intended to fully characterize the naturally and non-naturally occurring gamma-emitting radionuclides. The environmental air sample filters are analyzed routinely by direct counting for beta-gamma radioactivity and by gamma spectrum analysis.

Assessment

Low levels of cobalt-60 ranging from less than 0.05 to 0.7 picocuries per gram, with an average concentration of <0.25 picocuries per gram, were measured in brook sediment during 1993. This level of cobalt-60, which is similar to previously measured values, is attributable to operations conducted prior to 1979. No cobalt-60 was detected in Goodwin Pond sediment and no gamma emitting radionuclides were detected in the brook or Goodwin Pond water samples. The radiation measurements were typical of normal background. The drainage brook flows through the property of ABB Combustion Engineering Systems, Inc. and is not readily accessible to the public.

Figure 10

Windsor Site, Windsor, Connecticut
Farmington River Sampling Locations

Figure 11

TABLE 35 - RESULTS OF ANALYSES OF FARMINGTON RIVER SEDIMENT, 1993

Sample Location	Number of Samples	Radioactivity Concentration (pCi/g, dry wt.) ^(1,2)		
		Cobalt-60		
		Minimum	Maximum	Average
Upriver of Site Release Location	9	<0.03	<0.13	<0.07 ± 0.03
Opposite Site Release Location	9	<0.03	<0.20	<0.09 ± 0.06
Downriver from Site Release Location	9	<0.03	<0.15	<0.09 ± 0.04

Notes:

- (1) A value preceded by < is less than the minimum detection level for that sample and parameter. Average values preceded by < contain at least one less than minimum detection level value in the average.
- (2) Dry weight is based on sample weight with free water removed.

TABLE 36 - RESULTS OF ANALYSES OF FARMINGTON RIVER FISH, 1993

Sample Location	Sample Number	Radioactivity Concentration ⁽¹⁾ (pCi/g, wet wt.)		
		K-40	Cs-137	Co-60
Upriver of Site	1	2.40 ± 0.31	<0.009	<0.009
Release Location	2	2.38 ± 0.31	<0.010	<0.009
Downriver from Site	1	2.42 ± 0.31	<0.009	<0.010
Release Location	2	2.10 ± 0.28	<0.010	<0.008

Notes:

- (1) A value preceded by < is less than the minimum detection level for that sample and parameter. The (±) value represents the statistical error at two standard deviations.

TABLE 37 - PERIMETER AND OFF-SITE RADIATION MONITORING RESULTS, WINDSOR SITE, 1993

Perimeter Location No. ⁽¹⁾	Total Annual Exposure ⁽²⁾ (millirem)
1	74 ± 3
2	76 ± 1
3	63 ± 4
4	69 ± 1
5	64 ± 2
6	70 ± 2
7	73 ± 1
8	72 ± 1
9	69 ± 1
10	74 ± 3
11	72 ± 3
12	66 ± 5
Off-Site locations	70 ± 13 ⁽³⁾

Notes:

- (1) Refer to Figure 11.
- (2) The (±) value for individual locations are expressed at the 2 σ confidence level based on the calculated measurement error.
- (3) Approximately 95% of natural background radiation measurements are expected to be within this range.

The results for the Farmington River sediment analyses are shown in Table 35. The data show that there is no significant difference between radioactivity concentrations measured upriver and downriver except for one localized area directly opposite the brook outfall. The low levels of cobalt-60 present at this location are attributable to operations in previous years and are similar to previously observed values. Results of the detailed gamma spectrum analysis performed on the sediment samples indicated no radionuclides attributable to site operations other than cobalt-60. Low levels of cesium-137, which are attributable to

radioactive fallout from nuclear weapons tests, naturally occurring potassium-40 and daughters of uranium and thorium were also detected. No gamma emitting radionuclides were detected in the Farmington River water samples.

In addition, uranium-235 was measured in some of the brook sediment samples at a maximum concentration of approximately 1.7 picocuries per gram. The uranium-235 is not found at the brook locations closest to the Windsor Site outfall and is not a result of Windsor Site operations.

TABLE 38 - WINDSOR SITE GROUNDWATER MONITORING - 1993

Parameter (All Results are mg/l unless noted)	Production Well	14S	14D	15S	15D
pH (Standard Units) ⁽¹⁾	S	S	S	S	S
TDS ⁽²⁾	S	S	S	S	S
Sodium	S	S	S	S	S
Nitrate	S	S	S	S	S
Sulfate	S	S	S	S	S
Cyanide	S	S	S	S	S
Chloride	S	S	S	S	S
ADA ⁽³⁾	S	S	S	S	S
Vanadium	S	S	S	S	S
Conductivity (μ mhos/cm) ⁽¹⁾	S	S	S	S	S
Manganese	S	S	S	S	S
Calcium Hardness	S	S	S	S	S
Total Hardness	S	S	S	S	S
Manganese	S	S	S	S	S
COD ⁽⁴⁾	S	S	S	S	S
Phosphorus	S	S	S	S	S
Iron	S	S	S	S	S
Silica	S	S	S	S	S
TOC ⁽⁵⁾	S	S	S	S	S
MOA ⁽⁶⁾	S	S	S	S	S
POA ⁽⁷⁾	S	S	S	S	S
Temp ($^{\circ}$ F) ⁽¹⁾	S	S	S	S	S
Hexavalent Chromium	S	S	S	S	S

Notes: S = Semi-Annually

(1) Determined in the field.

(2) TDS = Total Dissolved Solids

(3) ADA = Anthraquinone Disulfonic Acid

(4) COD = Chemical Oxygen Demand

(5) TOC = Total Organic Carbon

(6) MOA = Methyl Orange Alkalinity

(7) POA = Phenolphthalein Alkalinity

TABLE 39 - RESULTS OF WINDSOR SITE GROUNDWATER MONITORING, MONITORING WELLS, 1993

Parameter (all units are mg/l except where noted) ⁽¹⁾																								
Well	Sample Date	pH (SU)	^m TDS	(N) Sodium Nitrate	Sulfate	Cyanide	Chloride	^m ADA	Vanadium	Specific Conductivity (µmhos/cm)	Manganese	Ca Hardness	Total Hardness	Magnesium	^m COD	^m MOA	^m POA	Phosphorus	Iron	Silica	^m TOC	Hexavalent Chromium	Temp. (°F)	
14S	4/21/93	7.61	713 ⁽²⁾	10.4	3.0	33	<0.01	25	<0.01	<0.02	450	<0.01	150	217	14.5	<5.0	181	0	<0.02	0.14	17	<0.1	<0.05	55
	10/14/93	7.58	326	9.0	3.6	31	<0.01	20	<0.01	<0.02	490	<0.01	153	253	17.8	<5.0	220	0	0.04	<0.06	21.4	1.4	<0.05	55
14D	4/21/93	8.14	430 ⁽²⁾	8.3	0.6	22	<0.01	40	<0.01	<0.02	322	<0.01	97	157	9.8	<5.0	101	0	<0.02	0.06	28	<0.1	<0.05	54
	10/14/93	8.10	241	7.8	0.54	22	<0.01	35	<0.01	<0.02	330	<0.01	100	140	10.4	<5.0	110	0	0.03	<0.06	15	<0.1	<0.05	54
15S	4/21/93	8.08	543 ⁽²⁾	8.4	0.8	22	<0.01	41	<0.01	<0.02	368	<0.01	112	172	11.2	<5.0	124	0	<0.02	<0.06	28	<0.1	<0.05	55
	10/14/93	8.03	287	8.2	0.68	20	<0.01	40	<0.01	<0.02	385	<0.01	119	171	12.6	<5.0	130	0	0.23	0.06	17.1	<0.1	<0.05	54
15D	4/21/93	8.18	549 ⁽²⁾	10.9	0.7	22	<0.01	48	<0.01	<0.02	368	<0.01	112	165	10.7	<5.0	121	0	<0.02	0.08	21	<0.1	<0.05	55
	10/14/93	8.20	249	10.8	0.54	<5.0	<0.01	40	<0.01	<0.02	370	<0.01	115	160	11.6	<5.0	130	0	0.10	0.06	19.3	<0.1	<0.05	52
Standards ⁽²⁾		5.0-9.0	500 ⁽²⁾	20	10	250	0.2 ⁽⁴⁾	250	0.1 ⁽⁵⁾	0.1	—	0.05 ⁽²⁾	—	—	—	—	—	—	0.3	—	—	0.05	—	

Notes:

- (1) A value preceded by < is less than the minimum detection level for that sample and parameter.
 (2) State of Connecticut public health standards for drinking water, Reference 27.
 (3) USEPA Water Quality Standards.
 (4) CT-DEP Action level is any detectable.
 (5) Action level established by CT-DEP.
 (6) See Table 38 notes for definition.
 (7) These results are considered anomalous when compared with previous and subsequent samples and therefore invalid.

**TABLE 40 - RESULTS OF WINDSOR SITE GROUNDWATER MONITORING,
PRODUCTION WELL, 1993**

Parameter	Sample Date		Standards ⁽²⁾
(all units mg/l except where noted) ⁽¹⁾	4/21/93	10/14/93	
pH (SU) *	7.49	7.62	5.0-9.0
TDS ⁽⁶⁾	461 ⁽⁸⁾	237	500 ⁽³⁾
Sodium	13.3	13.9	20
Nitrate (N)	0.64	0.29	10
Sulfate	14	16	250
Cyanide	<0.01	<0.01	0.2 ⁽⁴⁾
Chloride	40	40	250
ADA ⁽⁶⁾	<0.01	<0.01	0.1 ⁽⁵⁾
Vanadium	<0.02	<0.02	0.1
Specific Conductivity (μ mhos/cm)	355	410	—
Manganese	<0.01	<0.01	0.05 ⁽³⁾
Calcium Hardness	101	108	—
Total Hardness	172	156	—
Magnesium	9.9	12.2	—
COD ⁽⁶⁾	<5.0	<5.0	—
Phosphorus	<0.02	0.02	—
Iron	0.06	<0.06	0.3
Silica	11	17.1	—
TOC ⁽⁶⁾	<0.1	<0.1	—
MOA ⁽⁶⁾	114	120	—
POA ⁽⁶⁾	0	0	—
Temp (°F)	56	58	—
Hexavalent Chromium	<0.05	<0.05	0.05

Notes:

- (1) A value preceded by < is less than the minimum detection level for that sample and parameter.
- (2) State of Connecticut public health standards for drinking water, Reference 27.
- (3) USEPA Water Quality Standard.
- (4) CT-DEP action level is any detectable.
- (5) Action level established by CT-DEP for the Stretford solution spill discussed in groundwater monitoring section.
- (6) See Table 38 notes for definition.

*SU = Standard Units.

**TABLE 41 - CHEMICAL CONSTITUENTS, RADIOACTIVITY AND TEMPERATURE IN
WINDSOR SITE SERVICE WATER, 1993**

Parameter/Units	Number of Samples	Value ⁽¹⁾			Standard	Percent of Standard ⁽²⁾
		Minimum	Maximum	Average		
SITE SERVICE WATER Standards (Reference 27)						
Temperature °C	13	11	17	13.2 ± 1.1	None	--
pH (SU)*	13	6.66	7.58	7.36 ± 0.13	None	--
Nitrates (mg/l as N) ⁽⁶⁾	8	<0.23	1.2	<0.60 ± 0.3	10	<6
Nitrate Nitrogen (mg/l as N) ⁽⁷⁾	1	0.6	0.6	0.6 ± 0.0	10	6
Nitrite Nitrogen (mg/l as N) ⁽⁷⁾	1	<0.2	<0.2	<0.2 ± 0	1	<20
Nitrate + Nitrite Nitrogen (mg/l as N) ⁽⁷⁾	1	0.6	0.6	0.6 ± 0.0	10	6
Residual Chlorine (mg/l)	221	0.10 ⁽⁴⁾	0.50	0.21 ± 0.01	0.2 ⁽³⁾	--
Total Coliform (N/100ml) * * ⁽⁶⁾	12	<1	<1	<1 ± 0	4	<25
Total Coliform (N/100ml) * * ⁽⁷⁾	4	<1	<1	<1 ± 0	4	<25
Suspended Solids (mg/l)	7	<1.0	<1.0	<1.0 ± 0.0	None	--
Radioactivity ⁽⁵⁾ (μCi/ml)						
Gross Alpha (× 10 ⁻⁹)	4	<1.0	<1.6	<1.3 ± 0.3	15	<9
Gross Beta (× 10 ⁻⁹)	4	<0.8	<3.5	<1.9 ± 1.7	50	<4
Tritium (× 10 ⁻⁷)	11	<0.7	<1.5	<0.9 ± 0.1	20,000	<0.02

Notes:

- (1) A value preceded by < is less than the minimum detection level for that sample and parameter. Average values preceded by < contain at least one less than minimum detection level value in the average. The (±) value represents the statistical error at two standard deviations.
- (2) Percent of standard for the average.
- (3) Minimum standard - after 10 minutes contact time or equivalent. State of Connecticut standard for quality of public drinking water specifies that when well-supplied water is chlorinated, a free chlorine residual of at least 0.2 mg/l after ten minutes contact, or the equivalent thereof, shall be maintained.
- (4) The contact time at the sample point is much longer than 10 minutes, Note (3), resulting in a lower residual concentration value. The sample point was selected to provide assurance that the entire system is protected, which is confirmed by the total coliform results. Therefore, the minimum tabulated value is considered acceptable.
- (5) Radioactivity standards are from the Reference (27) drinking water standard.
- (6) Samples taken at on site sample locations.
- (7) Samples taken at entry point to water distribution system per Reference 27.

*SU = Standard Units.

**N/100 ml = number of colonies per 100 ml.

The results of analyses of fish collected from the river are shown in Table 36. There were no radionuclides attributable to Windsor Site operations observed in the fish.

The results for the environmental air samples show that there was no significant difference between the average upwind and downwind radioactivity concentrations.

The results for the perimeter and off-site radiation monitoring program are summarized in Table 37. Radiation levels at the perimeter locations ranged from 63 to 76 mrem, with an average of 70 mrem for the year. There is no statistically significant difference between the perimeter and the off-site measurements. This shows that Windsor Site operations in 1993 had no measurable effect on natural background radiation levels at the Site perimeter.

GROUNDWATER MONITORING

There are no radioactive or chemical waste disposal sites at the Windsor Site. Accordingly, the groundwater monitoring program consists of sampling the groundwater for evidence of Stretford solution, a chemical used to remove sulfur from combustion gases. The source of the Stretford solution is a spill which occurred at a non-KAPL facility which was located adjacent to the Windsor Site. An interceptor well, installed at the spill location by the owner, has been successful in removing a significant portion of the contamination. Two pairs of monitoring wells, each pair consisting of one deep and one shallow well, were installed on the Windsor Site to provide an early indication of any potential threat to the site production well, which serves as the drinking water source for the site. The location of these wells is shown in Figure 11. The 1993 groundwater monitoring program at the Windsor Site is summarized in Table 38. It consisted of two sampling evolutions at the production well and the 4 monitoring wells with corresponding analyses for 23 organic and inorganic parameters.

Samples from the four monitoring wells have been taken by KAPL personnel and the owner of the adjacent facility since 1984. During 1993, results from these wells, as presented in Table 39, indicate that the groundwater in the vicinity of the site production well is not being influenced by the plume of contamination. For 1993, all results from on-site well monitoring except as noted on Table 39 were below the State of Connecticut public

health standards for drinking water.

The production well is sampled by KAPL personnel semi-annually. The results of analyses for 1993 are shown in Table 40. The results of analyses of Windsor Site service water samples collected from the site service water system are shown in Table 41. For 1993 all parameters meet the State of Connecticut public health standards for drinking water.

CONTROL OF CHEMICALLY HAZARDOUS SUBSTANCES

Chemicals are not manufactured or disposed of at the Windsor Site. Minimal quantities of hazardous wastes do result from the necessary use of chemicals in site operations. To ensure the safe use of chemicals and disposal of the resulting wastes, Windsor Site maintains a hazardous substance control program similar to that at the Knolls Site. During 1993 the Windsor Site shipped approximately 55 tons of RCRA hazardous waste offsite for disposal. Approximately 51 tons of this amount was due to large lead-acid batteries sent off-site for recycling as part of the nuclear power plant inactivation.

Elementary neutralization of small volume laboratory waste and the boiler house blowdown and acid regeneration wastewater also occur on site. This process is exempt from regulation as a RCRA treatment process. The neutralized discharge is controlled under the Windsor Site wastewater discharge permit. The boiler house is the primary source of wastewater with a pH prior to neutralization of less than 2 or greater than 12.5.

TRANSPORTATION OF RADIOACTIVE MATERIALS

Various types of radioactive materials are generated at the Windsor Site that require detailed procedures for handling, packaging, transportation, and, if necessary, disposal at a government operated burial site.

Radioactive materials are handled and transferred in accordance with detailed material control and accountability procedures. Internal reviews are made prior to the shipment of any radioactive materials from the Windsor Site, to ensure that the material is properly identified, surveyed, and packaged in accordance with federal, state, and local requirements.

Low level radioactive solid waste materials contaminated with radioactivity that require disposal include filters, metal scrap, rags, paper, resin and plastic. The Site minimizes the volume of solid waste that must be disposed of as radioactive through the use of special work procedures that limit the amount of material that becomes contaminated. To further reduce the volume, the Site compacts all compressible waste material such as rags, paper, and plastic material. All radioactive wastes are packaged in accordance with written site procedures to ensure that all applicable regulations of the DOT are met, Reference (18). The waste packages also comply with all applicable requirements of the NRC, the DOE, and the burial sites.

Shipments of low level radioactive solid wastes are made by authorized common carriers to government owned burial sites located outside the State of Connecticut. During 1993, approximately 16 cubic meters (21 cubic yards) of routine low level waste containing 5.7 curies were shipped from the site for burial.

RADIATION DOSE ASSESSMENT

The effluent and environmental monitoring results show that radioactivity released in liquid and gaseous effluents from 1993 operations at the Windsor Site had no discernible effect on normal background radioactivity levels. Therefore, radiation doses from Windsor Site operations to off-site individuals were too small to be measured and must be calculated using conservative methods.

Estimates of: (1) the radiation dose to the maximally exposed individual in the vicinity of the Windsor Site, (2) the average dose to members of the public residing in the 80 kilometer (50 mile) radius assessment area surrounding the Site and (3) the collective dose to the population residing in the assessment area are summarized in Tables 42 and 43. See Figure 13 for a map of the assessment area surrounding the Windsor Site.

The results show that the estimated doses were less than 0.1 percent of that permitted by the DOE radiation protection standards listed in Reference (2), and that the estimated dose to the population residing within 80 kilometers (50 miles) of the Windsor Site was less than 0.001 percent of the natural background radiation dose to the population. In addition, the estimated doses were less than one percent of that permitted by the NRC numerical guide listed in Reference (4) for whole-body dose demonstrating that doses are as low as is reasonably achievable. The dose attributed to radioactive air emissions was less than one percent of the EPA standard in Reference (3).

The collective radiation dose to the public along travel routes from Windsor Site shipments of radioactive materials during 1993 was calculated using data given by the NRC in Reference (22). Based on the type and number of shipments made, the collective annual radiation dose to the public along the transportation routes, including transportation workers, was less than one person-rem. This is approximately 0.001 percent of the dose received by the same population from natural background radiation.

RADIATION DOSE ASSESSMENT AND METHODOLOGY

Measurements for radioactivity in environmental media representing an exposure pathway to man indicated no radioactivity attributable to operations at any of the three sites that comprise the Knolls Atomic Power Laboratory. Therefore, potential doses to the general public from liquid and airborne effluents were too small to be measured and are estimated using conservative calculational techniques based on assumed pathways for releases to return to man.

The exposure pathways via air and water considered for purposes of estimating radiation exposures were:

1. Air Pathways

- a. External exposure from airborne radioactivity and radioactivity deposited on the ground.
- b. Ingestion of food products.
- c. Inhalation of airborne radioactivity.

2. Water Pathways

- a. Ingestion of water and fish
- b. Ingestion of food products grown on irrigated land.
- c. External exposure from irrigated land.
- d. Boating, swimming and shoreline recreation.

For each KAPL site, calculations were made to estimate: (1) the radiation dose to the maximally exposed individual in the vicinity of the site, (2) the average dose to members of the public residing in the 80 kilometer (50 mile) radius assessment area surrounding the site and (3) the collective dose to the population residing in the assessment area. See Figures 12 and 13 for maps of the 80 kilometer (50 mile) assessment areas surrounding the KAPL sites.

The fundamental equation for calculation of the annual dose from a single radionuclide is:

$$D = XUK \text{ where:}$$

D = annual dose

X = the concentration of the radionuclide in the media of the exposure pathway of interest

U = the annual exposure time (hours) or intake (ml or kg) associated with the exposure pathway of interest

K = The annual dose factor for external exposure to a radionuclide or the dose commitment for a 50 year period from the current year's intake of a radionuclide

In estimating potential doses via the water pathway, the contribution from each radionuclide present in the liquid effluents to the effective dose equivalent was calculated using DOE dose conversion factors from References (28) and (29) and the Reference (30) liquid pathway model.

Estimates of potential doses via air pathways were calculated using CAP-88, the EPA approved computer code package provided in Reference (31). The code package was prepared to implement the dose assessment required to demonstrate compliance with Reference (3). It includes the computer code AIRDOS2 and a file of the 50-year committed effective dose equivalent conversion factors calculated by the computer code RADRISK using weighting factors from ICRP-26. AIRDOS2 is an updated version of AIRDOS-EPA that was used previously.

In AIRDOS2 the area surrounding the site is divided into a circular grid defined by 16 pie-shaped segments, which are subdivided into sectors by annular rings out to 80 kilometers (50 miles). The computer code calculates the air concentration and surface deposition in each sector for each radionuclide released from the site using site specific average atmospheric dispersion parameters. Dispersion parameters for each site are based on 1993 on-site meteorological data summarized in accordance with Reference (32). Next the radionuclide concentrations in meat, milk and fresh vegetables produced in each sector are estimated using the terrestrial food chain models given in Reference (30). The code then calculates the effective dose equivalent to persons residing in each sector through the following exposure modes: (1) immersion in air containing radionuclides, (2) exposure to radionuclides deposited on ground surfaces, (3) inhalation of radionuclides in air and (4) ingestion of food produced in the sector. The collective (population) effective dose equivalent is obtained by summing the product of the dose and

population for each sector. The population residing within 80 kilometers (50 miles) of each site is based on the 1990 census data as reported in Reference (34).

The calculated doses are summarized in Tables 42 and 43. Inhalation of airborne radioactivity was the calculated principal exposure pathway for the hypothetical maximally exposed individual at the Knolls site. At the Windsor and Kesselring Sites the calculated principal exposure pathway for this hypothetical person was the ingestion of foodstuffs.

A comparison of the estimated (calculated) radiation dose to the maximum individual from KAPL operations with the average radiation dose received from other sources is shown in Figure 14. Data in Figure 14 show that the maximum radiation dose that may have been received as a result of KAPL operations is much lower than the DOE radiation protection standard and the drinking water and air emission standards established by the EPA, and considerably lower than the average dose received from other sources (natural and man-made) of radiation.

TABLE 42 - ESTIMATED ANNUAL DOSE TO THE MAXIMUM INDIVIDUAL AND AVERAGE MEMBERS OF THE ASSESSMENT AREA POPULATIONS, 1993

KAPL Site	All Pathways		Air Pathways Only		Effective Dose Equivalent From Natural Background Radiation (mrem) ⁽⁴⁾
	Effective Dose Equivalent Maximum Individual/Average Member (mrem)	Percent of Standard ^(1,2)	Effective Dose Equivalent Maximum Individual/Average Member (mrem)	Percent of Standard ⁽³⁾	
Knolls Site	<0.1/<0.001	<0.1/<0.001	<0.1/<0.001	<1.0/<0.01	63
Kesselring Site	<0.1/<0.001	<0.1/<0.001	<0.1/<0.001	<1.0/<0.01	74
Windsor Site	<0.1/<0.001	<0.1/<0.001	<0.1/<0.001	<1.0/<0.01	70

Notes:

- (1) Based on the DOE radiation protection standard for individuals in off-site areas of 100 mrem/yr effective dose equivalent as given in Reference (2).
- (2) The maximum annual dose to an individual at each site did not exceed 1% of the NRC's guide for demonstrating that radioactive materials in effluents are "as low as is reasonably achievable," given in Reference (4).
- (3) Based on the EPA national air emission standard for radionuclide emissions of 10 mrem/yr effective dose equivalent as given in Reference (3).
- (4) Dose based on average off-site background radiation level determined for each site with TLDs as reported in prior sections for the respective sites. It does not include the estimated average annual effective dose equivalent of 39 mrem that a member of the population receives from naturally occurring radionuclides in the human body or the 200 mrem received from exposure to radon and its decay products as reported in Reference 39.

TABLE 43 - ESTIMATED ANNUAL COLLECTIVE (POPULATION) DOSES FOR RESIDENTS WITHIN 80 KILOMETERS OF KAPL SITES, 1993

KAPL Site	Population ⁽¹⁾ (Millions)	Effective Dose Equivalent From KAPL Operations (Person-Rem)	Effective Dose Equivalent From Natural Background Radiation ⁽²⁾ (Person-Rem)
Knolls Site	1.29	<0.1	81,000
Kesselring Site	1.15	<0.1	85,000
Windsor Site	3.43	<0.1	240,000
		<0.3	406,000

Notes:

- (1) Total population residing within 80 kilometers (50 miles) of each site based on 1990 census data as reported in Reference (34).
- (2) Person-Rem estimate based on average off-site radiation level determined for each site with TLDs as reported in prior sections for the respective sites.

Eighty Kilometer (50 mile) Assessment Area Map for Knolls and Kesselring Sites

Figure 12

Eighty Kilometer (50 mile) Assessment Area
Map for Windsor Site

Figure 13

Figure 14

Comparison of the Estimated Radiation Dose From KAPL Operations With Doses From Other Sources

QUALITY ASSURANCE PROGRAM

This section contains a description of the KAPL Quality Assurance Program conducted to ensure the accuracy and precision of effluent and environmental sampling, analysis, and reporting. The program is based on the guidance contained in several DOE, EPA, and NRC documents on the subject. (References 35, 36 and 37 respectively)

The program consists of the following elements:

1. Internal quality assurance procedures
 - a. Personnel training and qualification
 - b. Written procedures for sampling, sample analysis, and computation methods
 - c. Calibration of sampling and sample analysis equipment
 - d. Internal quality assurance sample analyses
 - e. Data review and computation check
2. Participation in interlaboratory quality assurance programs
 - a. DOE Environmental Measurements Laboratory Quality Assurance Program
 - b. EPA Environmental Monitoring Systems Laboratory Intercomparison Studies Program
3. Subcontractor quality assurance procedures
4. Program audits

The internal quality assurance procedures start with the training and qualification of all personnel involved in the collection and analysis of samples, in accordance with established KAPL policies. Personnel are not permitted to perform sampling and sample analysis until they are trained and have demonstrated the ability to properly perform their duties. Written procedures, based on the methods recommended in References (35) and (37), cover

collection and analysis of samples, the computation of results, and the calibration of sampling and analytical equipment, as required. Radioactivity counting equipment is, whenever possible, calibrated using standards that are traceable to the National Institute of Standards and Technology. Internal quality assurance procedures also provide for a system of duplicate (or replicate) analyses of the same sample and the analyses of spiked samples to demonstrate precision and accuracy. All measurement data are assessed to detect anomalies, unusual results and trends.

KAPL participates in interlaboratory quality assurance programs, conducted by the DOE Environmental Measurements Laboratory and the EPA Environmental Monitoring Systems Laboratory. This provides an independent verification of the accuracy and precision of KAPL analyses of effluent and environmental monitoring samples. The results of KAPL participation in the DOE and EPA quality assurance programs are summarized in Tables 44 and 45, respectively. The data demonstrate satisfactory KAPL performance.

Nonradioactive effluent and environmental sample analyses are performed by vendor subcontractor laboratories. KAPL maintains a quality assurance program to ensure the accuracy and precision of the subcontractor analytical results. This includes submitting known standards, blanks and replicate samples along with routine samples for analysis. If unsatisfactory results are obtained, follow-up investigations are performed to correct the problems. KAPL also requires that vendor laboratories performing analyses for the Knolls and Kesselring Sites be certified by the New York State Department of Health under the Environmental Laboratory Approval Program (ELAP) and that vendor laboratories performing effluent and environmental analyses for the Windsor Site be certified by Connecticut Department of Health Services.

Periodic audits are conducted that examine all phases of the effluent and environmental monitoring programs to ensure compliance with all KAPL procedures and applicable state and federal regulations.

**TABLE 44 - KAPL PERFORMANCE IN DOE ENVIRONMENTAL MEASUREMENTS
LABORATORY (EML) QUALITY ASSURANCE PROGRAM, 1993**

Sample Date ⁽¹⁾	Sample Type	Analysis	KAPL Result ⁽²⁾	EML Result ⁽²⁾⁽³⁾	Normalized Deviation ⁽⁴⁾
3/93	Soil	Potassium-40	8.6 ± 0.3	8.7	-0.1
		Strontium-90	1.0 ± 0.1	1.1	-1.2
		Cesium-137	27.6 ± 0.3	24.9	1.1
		Plutonium-239	0.31 ± 0.05	0.31	-0.3
3/93	Water	Tritium	2.7 ± 0.5	2.6	0.4
		Manganese-54	3.1 ± 0.2	2.8	0.9
		Iron-55	0.64 ± 0.08	0.64	0.0
		Cobalt-60	1.4 ± 0.03	1.2	1.0
		Strontium-90	0.033 ± 0.004	0.028	1.9
		Cesium-134	1.2 ± 0.1	1.1	0.8
		Cesium-137	1.5 ± 0.1	1.4	0.6
		Cerium-144	2.4 ± 0.2	2.3	0.7
		Plutonium-238	0.013 ± 0.001	0.013	-0.3
		Plutonium-239	0.024 ± 0.001	0.022	0.5
		Uranium-total	0.012 ± 0.001	0.012	0.2
9/93	Soil	Potassium-40	0.85 ± 0.7	0.78	1.0
		Strontium-90	0.12 ± 0.2	0.15	-1.5
		Cesium-137	0.34 ± 0.01	0.31	1.1
		Plutonium-239	0.041 ± 0.008	0.041	0.0
9/93	Water	Tritium	7.7 ± 0.3	7.3	0.6
		Manganese-54	3.3 ± 0.3	2.9	1.2
		Iron-55	3.2 ± 0.3	3.6	-1.1
		Cobalt-60	3.1 ± 0.2	2.7	1.3
		Strontium-90	0.070 ± 0.01	0.068	0.5
		Cesium-134	1.6 ± 0.1	1.5	0.6
		Cesium-137	2.3 ± 0.2	2.0	1.4
		Cerium-144	5.1 ± 0.2	4.7	0.9
		Plutonium-238	0.030 ± 0.003	0.031	-0.2
		Plutonium-239	0.0089 ± 0.0002	0.0091	-0.2
		Uranium-total	0.0866 ± 0.0003	0.0842	0.2

Notes:

- (1) The sample date is assigned by EML.
- (2) The results are expressed in pCi/ml of water, or pCi/g of soil, except for uranium where the units are µg/ml.
- (3) The expected result is that reported by EML.
- (4) The normalized deviation from the EML known value is determined as described in EML-454, May 1, 1986. The control limit is ± 3.0.

**TABLE 45 - KAPL PERFORMANCE IN EPA ENVIRONMENTAL MONITORING SYSTEMS
LABORATORY (EMSL) QUALITY ASSURANCE PROGRAM, 1993**

Sample Date ⁽¹⁾	Sample Type	Analysis	KAPL Result ⁽²⁾	EMSL Result ⁽²⁾⁽³⁾	Normalized Deviation ⁽⁴⁾
6/04/93	Water	Tritium	9488 ± 400	9844	-0.6
11/05/93	Water	Tritium	7946 ± 300	7398	1.3
1/29/93	Water	Gross Alpha	16.7 ± 3.1	34.0	-3.3 ⁽⁵⁾
		Gross Beta	40.7 ± 2.6	44.0	-1.2
7/23/93	Water	Gross Alpha	15.7 ± 5.6	15.0	0.2
		Gross Beta	34.7 ± 5.0	43.0	-2.1
10/29/93	Water	Gross Alpha	19.3 ± 7.0	20.0	-0.2
		Gross Beta	17.0 ± 4.4	15.0	0.7
9/27/93	Air Filter	Gross Alpha	22.7 ± 2.5	19.0	1.3
		Gross Beta	51.0 ± 2.9	47.0	1.4
		Strontium-90	19.3 ± 3.0	19.0	0.1
		Cesium-137	9.7 ± 2.0	9.0	0.2
6/11/93	Water	Cobalt-60	15.7 ± 1.2	15.0	0.2
		Zinc-65	120.3 ± 12.0	103.0	3.0
		Ruthenium-106	105.0 ± 11.0	119.0	-2.0
		Barium-133	106.7 ± 8.0	99.0	1.3
		Cesium-134	6.0 ± 1.0	5.0	0.4
		Cesium-137	5.0 ± 1.0	5.0	0.0
11/12/93	Water	Cobalt-60	32.0 ± 1.2	30.0	0.7
		Zinc-65	152.0 ± 9.6	150.0	0.2
		Ruthenium-106	178.3 ± 8.4	201.0	-2.0
		Barium-133	81.3 ± 3.0	79.0	0.5
		Cesium-134	63.3 ± 2.0	59.0	1.5
		Cesium-137	43.0 ± 2.2	40.0	1.0

Notes:

- (1) The sample date is assigned by EMSL.
- (2) The results are expressed in pCi/liter for water samples and pCi/filter for air sample filters.
- (3) The expected result is that reported by EMSL.
- (4) The normalized deviation from the EMSL known value is as reported by EMSL for each sample. The control limit is ±3.0.
- (5) KAPL's result was within 0.1 as a normalized deviation of the average of the participating laboratories (excluding outliers). KAPL performed extensive analyses of a backup sample provided by EPA. KAPL's results all agreed with each other and the all-laboratory average of 17.1 pCi/liter. Sample results for the July and October samples show good agreement with EPA results.

TABLE 46 - ENVIRONMENTAL PERMITS

Permit Number	Permit Type	Issuing Agency	In Compliance	Expiration Date	Other Information
KNOLLS SITE					
NY0005851	SPDES ⁽¹⁾	NYSDEC ⁽²⁾	Yes ⁽³⁾	11/1/94	Site Outfalls
NY6890008992	RCRA ⁽⁴⁾	NYSDEC	Yes	(5)	RCRA waste
0774	SWMF ⁽⁶⁾	NYSDEC	Yes	(14)	Landfill
EP-00001	AE ⁽⁸⁾	NYSDEC	Yes	2/28/97	Heating boiler
EP-00002	AE	NYSDEC	Yes	2/28/97	Heating boiler
EP-00003	AE	NYSDEC	Yes	2/28/97	Heating boiler
EP-00004	AE	NYSDEC	Yes	2/28/97	Heating boiler
EP-00010	AE	NYSDEC	Yes	2/28/97	Shop Exhaust
EP-00011	AE	NYSDEC	Yes	2/28/97	Shop Exhaust
EP-00012	AE	NYSDEC	Yes	2/28/97	Welding Exhaust
EP-00018	AE	NYSDEC	Yes	2/28/97	Spray paint booth
EP-00019	AE	NYSDEC	Yes	2/28/97	Cutoff Wheel/Sander
EP-00020	AE	NYSDEC	Yes	2/28/97	Welding Exhaust
EP-00021	AE	NYSDEC	Yes	2/28/97	Welding Exhaust
EP-00022	AE	NYSDEC	Yes	2/28/97	Glass Shop
EP-00023	AE	NYSDEC	Yes	2/28/97	Welding Exhaust
EP-00028	AE	NYSDEC	Yes	2/28/97	Parts Cleaning
EP-00029	AE	NYSDEC	Yes	2/28/97	Parts Cleaning
EP-TWBC1	AE	NYSDEC	Yes	2/28/97	Portable Welding Exhaust
443417	PBSF ⁽⁹⁾	NYSDEC	Yes	8/23/98	Oil Storage
4-000020	BCSF ⁽¹⁰⁾	NYSDEC	Yes	3/10/95	Freon-114 storage
KESSELRING SITE					
NY 00 5843	SPDES ⁽¹⁾	NYSDEC ⁽²⁾	Yes ⁽³⁾	9/1/98	Site Outfalls
NY5890008993	RCRA ⁽⁴⁾	NYSDEC	Yes	(5)	RCRA waste
(7)	SWMF ⁽⁶⁾	NYSDEC	(7)	(7)	Landfill
006	AE ⁽⁸⁾	NYSDEC	Yes	5/31/96	Shop exhaust
05A01	AE	NYSDEC	Yes	5/31/96	Spray paint booth
05B01	AE	NYSDEC	Yes	3/21/96	Welding hood
07401	AE	NYSDEC	Yes	5/1/96	Welding hood
07402	AE	NYSDEC	Yes	5/1/96	Welding hood
01801	AE	NYSDEC	Yes	7/23/94	Duplicating machine
86G01	AE	NYSDEC	Yes	11/21/98	Welding Hood
86D01	AE	NYSDEC	Yes	7/2/94	Carpentry Shop
86D02	AE	NYSDEC	Yes	3/14/95	Lagging Shop

Notes:

- (1) State Pollutant Discharge Elimination System
- (2) New York State Department of Environmental Conservation
- (3) Occasional excursions beyond permit limits identified and satisfactorily explained in periodic discharge monitoring reports issued in accordance with permit requirements.
- (4) Resource Conservation and Recovery Act.
- (5) Interim Status (Interim permission to operate authorized by cognizant agency.) The permit number listed is the EPA identification number.
- (6) Solid Waste Management Facility.
- (7) Landfill closure operations have been initiated.
- (8) Air Emission
- (9) Petroleum Bulk Storage Facility
- (10) Bulk Chemical Storage Facility
- (11) National Pollutant Discharge Elimination System
- (12) State of Connecticut, Department of Environmental Protection
- (13) Currently operating under authorization to discharge beyond expiration date based on permit renewal application submitted on 10/1/86.
- (14) Landfill officially closed on 10/25/93
- (15) Stormwater
- (16) Air permit was limited to 448 hours of total production for the specific process.
- (17) Windsor Site RCRA "Part B" authorization granted effective 11/30/90.
- (18) State of Connecticut, Department of Environmental Protection Air Emission Registration

TABLE 46 - ENVIRONMENTAL PERMITS (Continued)

Permit Number	Permit Type	Issuing Agency	In Compliance	Expiration Date	Other Information
<u>KESSELRING SITE (Continued)</u>					
09201	AE	NYSDEC	Yes	9/26/95	Welding Hood
TGC01	AE	NYSDEC	Yes	2/28/94	Cleaning Process
WBC01	AE	NYSDEC	Yes	8/20/94	Welding Hood
GRB01	AE	NYSDEC	Yes	4/5/97	Grit Blasting
GRB02	AE	NYSDEC	Yes	4/5/97	Grit Blasting
GRB03	AE	NYSDEC	Yes	4/5/97	Grit Blasting
WFE01-05	AE	NYSDEC	Yes	5/12/98	Portable Welding Operations
WFE06	AE	NYSDEC	Yes	1/31/93 ⁽¹⁸⁾	Thermal Metal Spray
5-000070	BCSF ⁽¹⁰⁾	NYSDEC	Yes	7/19/95	Chemical Storage
414506	PBSF ⁽⁹⁾	NYSDEC	Yes	8/17/97	Oil Storage
<u>WINDSOR SITE</u>					
CT 000 2020	NPDES ⁽¹¹⁾	CT-DEP ⁽¹²⁾	Yes	2/24/87 ⁽¹³⁾	Site Outfall
HWM 164-021	RCRA ⁽¹⁷⁾	CT-DEP	Yes	11/30/95	RCRA waste EPA-ID CT 6890113792
0212-0049-01	AE ⁽¹⁸⁾	CT-DEP	Yes	None	Heating boiler
0212-0049-02	AE ⁽¹⁸⁾	CT-DEP	Yes	None	Heating boiler
0212-0058-03	AE	CT-DEP	Yes	None	Emergency Diesel
0212-0059-04	AE	CT-DEP	Yes	None	Emergency Diesel
CT GSW000407	SW ⁽¹⁵⁾	CT-DEP	Yes	10/1/97	Stormwater Discharge

Notes: See first part of table on previous page.

APPENDIX

RADIATION AND RADIOACTIVITY - GENERAL INFORMATION

This section provides general information on radiation and radioactivity for those who may not be familiar with the terms and concepts.

Man has always lived in a sea of natural background radiation. This background radiation was and is as much a part of the earth's environment as the light and heat from the sun's rays. There are three principal sources of natural background radiation: cosmic radiation from the sun and outer space, radiation from the natural radioactivity in soil and rocks (called 'terrestrial radiation'), and internal radiation from the naturally radioactive elements that are part of our bodies. A basic knowledge of the concepts of radiation and radioactivity is important in understanding how effective control programs are in reducing radiation exposures and radioactivity releases to levels that are as low as is reasonably achievable.

RADIATION

In simple terms, radiation is a form of energy. Microwaves, radio waves, x-rays, light, and heat are all common forms of radiation. The radiation from radioactive materials (radionuclides) is in the form of particles or rays. During the decay of radionuclides, alpha, beta and gamma radiation are emitted.

Alpha radiation consists of small, positively charged particles of low penetrating power that can be stopped by a sheet of paper. Radionuclides that emit alpha particles include radium, uranium, and thorium.

Beta radiation consists of negatively charged particles that are smaller than alpha particles but are generally more penetrating and may require up to an inch of wood or other light material to be stopped. Examples of beta emitters are strontium-90, cesium-137, and cobalt-60.

Gamma radiation is an energy emission like an x-ray. Gamma rays have great penetrating power but are stopped by up to several feet of concrete or several inches of lead. The actual thickness of a particular shielding material required depends on the quantity and energy of

the gamma rays to be stopped. Most radionuclides emit gamma rays along with beta or alpha particles.

Each radionuclide emits a unique combination of radiations that is like a "finger print" of that radionuclide. Alpha or beta particles and/or gamma rays are emitted in various combinations and energies. Radionuclides may be identified by measuring the type, relative amounts, and energy of the radiations emitted. Measurement of half-life and chemical properties may also be used to help identify radionuclides.

Radiation Dose Assessment

Body tissue can be damaged if enough energy from radiation is absorbed. The amount of energy absorbed by body tissue during radiation exposure is called "absorbed dose". The potential biological effect resulting from a particular dose is based on a technically defined quantity called "dose equivalent." The unit of dose equivalent is called the rem. Another quantity called "effective dose equivalent" is a dose summation that is used to estimate health-effects risk when the dose is received from sources that are external to the body and from radioactive materials that are within the various body tissues. The unit of effective dose equivalent is also the rem. As will be seen from the following discussion, the rem unit is relatively large compared with the level of doses received from natural background radiation or projected as a result of releases of radioactivity to the environment. The millirem (mrem), which is one thousandth of a rem, is frequently used instead of the rem. The rem and mrem are better understood by relating to concepts that are more familiar.

Radiation comes from both natural and man-made sources. Natural background radiation includes cosmic radiation from the sun and outer-space, terrestrial radiation from radioactivity in soil, radioactivity in the body and inhaled radioactivity.

The National Council on Radiation Protection and Measurements estimates that the average member of the population of the United States

receives an annual effective dose equivalent of approximately 300 mrem from natural background radiation. This is composed of approximately 28 mrem from cosmic radiation, 28 mrem from terrestrial radiation, 39 mrem from radioactivity within the body and 200 mrem from inhaled radon and its decay products. The cosmic radiation component varies from 26 mrem at sea level to 50 mrem in Denver (at 1600 meters). The terrestrial component varies from 16 mrem on the Atlantic and Gulf coastal plain to 63 mrem in the Rockies. The dose from inhaled radon and its decay products is the most variable.

The average natural background radiation level measured in the vicinity of the KAPL sites is approximately 70 mrem per year. Individual locations will vary based on soil composition, soil moisture content and snow cover.

In addition to natural background radiation, people are also exposed to man-made sources of radiation, such as medical and dental x-rays. The average radiation dose from these sources is about 53 mrem per year. Other man-made sources include consumer products, such as color television sets. An individual's radiation exposure from color television averages 0.3 mrem per year. An airplane trip results in increased radiation exposure. A round-trip flight between Los Angeles and New York results in a dose of about 5 mrem.

RADIOACTIVITY

All materials are made up of atoms. In the case of a radioactive material, these atoms are unstable and give off energy in the form of rays or tiny particles in order to reach a stable state. Each type of radioactive atom is called a radionuclide. Each radionuclide emits a characteristic form of radiation as it gives off energy. Radionuclides change as radiation occurs, and this transition is called radioactive decay. The rate at which a particular radionuclide decays is measured by its half-life. Half-life is the time required for one-half the radioactive atoms in a given amount of material to decay. For example, the half-life of the man-made radionuclide cobalt-60 is 5.3 years. This means that during a 5.3-year period, half of the cobalt-60 atoms initially present will have decayed. In the next 5.3 year period, half the remaining cobalt-60 atoms will have decayed, and so on.

The half-lives of radionuclides differ greatly. The half-life of naturally occurring radon-220, for instance, is only 55 seconds. In contrast, uranium-238, another naturally occurring radionuclide

has a half life of 4.5 billion years.

Through the decay process, each radionuclide changes into a different nuclide or atom - often becoming a different chemical element. For example, naturally occurring radioactive thorium-232, after emitting its radiation, leads to a second radionuclide, which leads to a third, and so on. Thus, a chain of eleven radionuclides is formed including radon-220, before nonradioactive lead-208 is formed. Each of the radionuclides in the series has its own characteristic half-life and type of radiation. The chain finally ends when the newest nuclide is not radioactive. The uranium chain starts with uranium-238 and proceeds through 13 radionuclides, ending with stable lead-206. All of these naturally occurring radionuclides are present in trace amounts in the soil in your backyard as well as in many other environmental media.

Measuring Radioactivity

The curie (Ci) is the common unit used for expressing the magnitude of radioactive decay in a sample containing radioactive material. Specifically, the curie is that amount of radioactivity equal to 3.7×10^{10} (37 billion) disintegrations per second. For environmental monitoring purposes, the curie is usually too large a unit to work with conveniently and is broken down into smaller values such as the microcurie (μCi), which is one millionth of a curie (10^{-6} curie) and the pico-curie (pCi), which is one trillionth of a curie (10^{-12} curie). The typical radium dial wrist watch has about one microcurie (μCi) of radium on the dial. The average person has about one tenth (0.1) microcurie of naturally occurring potassium-40 in his body. Typical soil and sediment samples contain about one pico-curie of natural uranium per gram.

Sources of Radioactivity

Of the radioactive atoms that exist in nature, some have always existed and others are continually formed by natural processes. For example, uranium has always existed, is radioactive, and occurs in small but variable concentrations throughout the earth. Radioactive carbon and tritium, on the other hand, are formed by cosmic radiation striking atoms in the atmosphere. Radionuclides can also be created by man. For example, they are created in nuclear reactors and consist of fission products and activation products. The fission products are the residue of the uranium fission process that produces the energy

within the reactor. The fission process also produces neutrons that interact with structural and other materials in the reactor to form activation products. Because of the nature of the fission process, many fission products are unstable and, hence, radioactive. Most fission products have short lives and are retained within the nuclear fuel itself; however, trace natural uranium impurities in reactor structural materials release small quantities of fission products to the reactor coolant.

It should be noted that a certain level of "background" fission-product radioactivity also exists in the environment, primarily due to atmospheric nuclear weapons testing. Although the level is very low, these fission products are routinely detected in air, food and water when analyzed with extremely sensitive instruments and techniques.

CONTROL OF RADIATION AND RADIOACTIVITY

To reduce to as low as is reasonably achievable the exposure of persons to ionizing radiation, controls on the use and disposal of radioactive materials and comprehensive monitoring programs to measure the effectiveness of these controls are required. Effluent streams that may contain radioactive materials must be treated by appropriate methods to remove the radioactive materials and the effluent monitored to ensure that these materials have been reduced to concentrations that are as low as is reasonably achievable and are well within all applicable guidelines and requirements.

GLOSSARY

Activation Products - As cooling water circulates through the reactor, certain impurities present in the water and even components of the water itself can be converted to radioactive nuclides (they become "activated"). Important activation products present in reactor coolant water include radionuclides of corrosion and wear products (cobalt-60, iron-59, cobalt-58, chromium-51), of impurities dissolved in the water (argon-41, sodium-24, carbon-14) and of atoms present in the water molecules (tritium). Of these, the predominant radionuclide and also the one with the most restrictive limits is cobalt-60.

Alpha Radioactivity - A form of radioactivity exhibited by certain radionuclides characterized by emission of an alpha particle. Many naturally occurring radionuclides including radium, uranium and thorium decay in this manner.

Benthic Macroinvertebrates - Small organisms inhabiting the bottom of lakes and streams or attached to stones or other submersed objects. The study of macroinvertebrate communities gives an indication of the overall quality of the body of water from which they are taken.

Beta-Gamma Radioactivity - A form of radioactivity characterized by emission of a beta particle and/or gamma rays. Many naturally occurring radionuclides such as lead-212, bismuth-212 and bismuth-214 decay in this manner.

Biochemical Oxygen Demand (BOD) - The BOD test is used to measure the content of organic material in both wastewater and natural waters. BOD is an important parameter for stream and industrial waste studies and control of waste treatment plants because it measures the amount of oxygen consumed in the biological process of breaking down organic materials in the water.

Birge-Ekman Dredge - A device used for sampling the bottom sediment in rivers, streams, lakes, etc. The Birge-Ekman dredge is lowered to the bottom on a line and its spring-loaded "jaws" are remotely tripped from the surface. It samples an area of approximately 230 cm² to an average depth of 2.5 cm.

BTU (British Thermal Unit) - A unit commonly used to quantify the heat output of boilers, furnaces, etc. Specifically, the amount of heat necessary to raise 1 lb. of water one degree Fahrenheit.

Chain Electro-Fishing Techniques - A technique of collecting samples of fish from a body of water whereby the fish are stunned with an electric current, categorized, and returned to the water unharmed.

Collective Dose Equivalent and Collective Effective Dose Equivalent* - Are the sums of the dose equivalents or effective dose equivalents of all individuals in an exposed population within an 80-km radius, for the purposes of this Order, and they are expressed in units of person-rem.

Committed Dose Equivalent* - Is the predicted total dose equivalent to a tissue or organ over a 50-year period after a known intake of a radionuclide into the body. It does not include contributions from external dose. Committed dose equivalent is expressed in units of rem.

Committed Effective Dose Equivalent* - Is the sum of the committed dose equivalents to various tissues in the body, each multiplied by the appropriate weighting factor. Committed effective dose equivalent is expressed in units of rem.

Confidence Interval - Statistical terminology for the error interval ($\pm$) assigned to numerical data. A 2σ (σ , the lower case Greek letter "Sigma") confidence interval means there is 95% confidence that the true value (as opposed to the measured one) lies within the ($\pm$) interval. The 95% is the confidence level. (See ($\pm$) value, Standard Deviation of the Average.)

*Note: Definitions are from DOE 5400.5.

Corrosion and Wear Products - Piping and components used in construction of a nuclear reactor are fabricated from extremely durable, corrosion and wear resistant materials. Even under the best circumstances, however, small amounts of these materials enter the reactor cooling water due to wear of moving parts and corrosion of the water contact surfaces of reactor plant components. While in no way affecting operational characteristics or reactor plant integrity, some of these corrosion and wear products may become activated as they pass through the reactor core. This necessitates that the reactor coolant be processed by filtration or other methods of purification before it is discharged or reused. (See Activation Products).

Curie (Ci) - The curie is the common unit used for expressing the magnitude of radioactive decay in a sample containing radioactive material. Specifically, the curie is that amount of radioactivity equal to 3.7×10^{10} (37 billion) disintegrations per second. For environmental monitoring purposes, the curie is usually too large a unit to conveniently work with and is broken down to smaller values. (See Microcurie and Pico-curie.)

Dendy Multiple Plate Samplers - A device for collecting bottom dwelling organisms (mostly larvae) by providing an artificial substrate on which these organisms can colonize.

Derived Concentration Guide (DCG) - is the concentration of a radionuclide in air or water that, under conditions of continuous exposure for one year by one exposure mode (i.e., ingestion of water, submersion in air, or inhalation), would result in an effective dose equivalent of 100 mrem (0.1 rem).

Dose Equivalent - The quantity that expresses the biological effects of radiation doses from all types (alpha, beta-gamma) of radiation on a common scale. The unit of dose equivalent is the rem.

Ecosystem - The integrated, interdependent system of plant and animal life existing in an environmental framework. Understanding of an entire ecosystem is important because changes or damage to one component of the system may have effects on others.

Effective Dose Equivalent - The effective dose equivalent is the sum of the dose equivalent to the whole body from external sources plus the dose equivalents to specific organs times a weighting factor appropriate for each organ. The weighting factor relates the effect of individual organ exposure relative to the effect of exposure to the whole body. The unit of effective dose equivalent is the rem.

Fission Products - During operation of a nuclear reactor, heat is produced by the fission (splitting) of "heavy" atoms, such as uranium, plutonium or thorium. The residue left after the splitting of these "heavy" atoms is a series of intermediate weight atoms generally termed "fission products." Because of the nature of the fission process, many fission products are unstable and, hence, radioactive. Most fission products have short lives and are retained within the nuclear fuel itself; however, trace natural uranium impurities in reactor structural materials release small quantities of fission products to the reactor coolant.

It should be noted that a certain level of "background" fission product radioactivity exists in the environment, primarily due to atmospheric nuclear weapons testing. The level is very low, but may be detectable when environmental samples are analyzed with extremely sensitive instruments and techniques such as those used by the Knolls Atomic Power Laboratory.

Half Life - A value assigned to a radionuclide that specifies how long it takes for one half of a given quantity of radioactivity to decay away. Half lives may range from fractions of a second to millions of years.

High Purity Germanium Gamma Spectrometer System - A High Purity Germanium gamma spectrometer system is a sophisticated set of components designed for characterizing and quantifying the radionuclides present in a sample. This system makes use of the fact that during the decay of most radionuclides, one or more gamma rays are emitted at energy levels characteristic of the individual radionuclide. For example, during the decay of cobalt-60, two gamma rays of 1.17 and 1.33 million electron volts (MeV) are emitted while the decay of argon-41 produces one gamma ray of 1.29 MeV. The high purity germanium detector used in this system is capable of detecting and very precisely resolving differences in gamma ray energy levels and sending this information along to electronic components where it is processed and evaluated.

Long-Lived Gamma Radioactivity - Two very important characteristics of radionuclides are the length of time it takes for a given amount to decay away and the type of radiation emitted during decay. From an environmental standpoint, some of the most significant radionuclides are those whose "life" is relatively long and that also emit penetrating gamma radiation during decay. Two radionuclides of concern in these respects are cobalt-60 (a corrosion and wear activation product) and cesium-137 (a fission product). (See Half-Life, Beta-Gamma Radioactivity.)

mg/l (Milligrams per liter) - A unit of concentration commonly used to express the levels of impurities present in a water sample. A milligram is a thousandth of a gram. A milligram per liter is equal to a part per million.

Microcurie (μCi) - One millionth of a curie (10^{-6} curie). The typical radium dial watch might contain $1\mu\text{Ci}$ of radioactive material. (See Curie and Pico-curie.)

Millirem (mrem) - One thousandth of a rem (10^{-3} rem).

Minimum Detectable Concentration (MDC) - For an observed value equal to the MDC there is 95% confidence that the true concentration is greater than zero; i.e., there is really something there. Analytical techniques and sampling and instrumentation errors all effect the MDC. (See $(\pm)$ Value, Confidence Interval.)

Parshall Flume Outfall - A specially constructed channel designed such that discharge water flow rate can be accurately measured. The Parshall Flume may also be instrumented to record the total volume of flow over long periods of time.

Pasquill Stability Class - A classification that defines the relative stability and dispersive capability of the atmosphere. Classification is highly dependent upon the change in temperature with height.

Periphyton - Communities of microorganisms growing on stones, sticks and other submerged surfaces. The quantities and types of periphyton present are very useful in assessing the effects of pollutants on lakes and streams.

Person-Rem - The sum of the individual dose equivalents or effective dose equivalents received by each member of a certain group or population. It is calculated by multiplying the average dose per person by the number of persons within a specific geographic area. For example, a thousand people each exposed to 0.001 rem would have a collective dose of one person-rem.

Photoelectric Optical Density System - A system used to determine the density of smoke emissions. A beam of light is passed through the smoke and measured with a photoelectric cell. As smoke density increases, the amount of light measured by the cell decreases. This effect can be quantified and read out using appropriate electronic devices.

Pico-curie (pCi) - One trillionth of a curie (10^{-12} curie). Typical soil and sediment samples contain approximately one pCi of natural uranium per gram. (See Curie and Millicurie.)

$\pm$ Value (plus or minus value) - The $(\pm)$ value is an expression of the error in sample results. The magnitude of the $(\pm)$ value depends on the number of samples, the size of the sample, intrinsic analytical errors and the degree of confidence required. The $(\pm)$ value assigned to data in this report is for the 95% confidence level. (See Confidence Interval.)

Priority Pollutant - This term refers to the list of chemicals in Tables II and III, 40 CFR 122, Appendix D. The EPA requires that discharges from facilities be evaluated for these chemicals.

Radionuclides - Atoms that exhibit radioactive properties. Standard practice for naming radionuclides is to use the name or atomic symbol of an element followed by its atomic weight (e.g., cobalt-60 or Co-60, a radionuclide of cobalt). There are several hundred known radionuclides, some of which are man-made and some of which are naturally occurring. Radionuclides can be differentiated by the types of radiation they emit, the energy of the radiation and the rate at which a known amount of the radionuclide decays away. (See Half Life.)

Rem - The unit of dose equivalent and effective dose equivalent.

Settleable Solids - A measurement of the amount of solids that will settle out of a sample of water in a certain interval of time. This parameter commonly applies to water being processed in sewage treatment plants and is used to control the operation and evaluate the performance of these plants.

Short-Lived Gamma Radioactivity - Radioactive material of relatively short life that decays with the emission of gamma rays. It is generally not important with respect to environmental discharges because of the short life span. Some examples of short-lived gamma emitting radionuclides are argon-41 (an activation product gas), krypton-88 (a fission product gas), and xenon-138 (a fission product gas).

Spiked Sample - A sample to which a known quantity of the material that is being analyzed for has been added for quality assurance testing.

Standard Deviation of the Average - A term used to characterize the error assigned to the mean of a set of analyzed data. (See Confidence Interval, ($\pm$) Value).

Suspended Solids - Particulate matter, both organic and inorganic suspended in water. High levels of suspended solids not only affect the aesthetic quality of water by reducing clarity, but may also indirectly indicate other undesirable conditions present. The analysis for suspended solids is performed by passing a sample of water through a filter and weighing the residue.

Surber Bottom Sampler - A device for collecting samples of benthic macroinvertebrates from the bottom of relatively shallow, fast moving streams.

Thermoluminescent Dosimeters (TLDs) - TLDs are sensitive monitoring devices that record accumulated dose due to radiation. The TLDs used by the Knolls Atomic Power Laboratory for environmental monitoring consist of small chips of calcium fluoride (CaF_2) or lithium fluoride (LiF) encased in appropriate materials and strategically located at site perimeter and off-site locations. Thermoluminescent Dosimeters derive their name from a property that CaF_2 and LiF crystals exhibit when exposed to radiation and subsequently heated-that of emitting light proportional to the amount of radiation exposure received (thermoluminescence). The emitted light can then be read out on special instrumentation and correlated to the amount of radiation dose accumulated. The TLDs used by the Knolls Atomic Power Laboratory for environmental monitoring are specially selected for their accuracy and consistency of results.

Weight Percent - A term commonly used to describe the amount of a substance in a material. For example, oil containing 0.5 lb. sulfur per 100 lb. oil would contain 0.5 percent by weight sulfur.

Weighting Factor - Is tissue-specific and represents the fraction of the total health risk resulting from uniform, whole-body irradiation that could be contributed to that particular tissue.

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