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EFFECTIVENESS OF INTERIM REMEDIAL ACTIONS AT A RADIOACTIVE WASTE FACILITY*

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ABSTRACT

Over the past eight years, several interim remedial actions have been taken at the Niagara Falls Storage Site (NFSS), primarily to reduce radon and gamma radiation exposures and to consolidate radioactive waste into a waste containment facility. Interim remedial actions have included capping of vents, sealing of pipes, relocation of the perimeter fence (to limit radon risk), transfer and consolidation of waste, upgrading of storage buildings, construction of a clay cutoff wall (to limit the potential groundwater transport of contaminants), treatment and release of contaminated water, interim use of a synthetic liner, and emplacement of an interim clay cap. An interim waste containment facility was completed in 1986. Monitoring results have shown a noticeable decrease in radon levels and a sharp decrease in average external gamma radiation levels from 1982 to 1986; these levels have remained stable since 1986. Uranium and radium concentrations in surface water have decreased, and only low concentrations have been detected in stream sediment samples. Concentrations in

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groundwater have remained stable. Recent monitoring data have shown that NFSS is in compliance with U.S. Department of Energy radiation protection standards. This paper discusses the results of the environmental monitoring program at NFSS and presents an analysis of the effectiveness of the interim remedial actions taken at the site.

SITE BACKGROUND

The Niagara Falls Storage Site (NFSS) is located in northwestern New York within the Township of Lewiston in Niagara County, approximately 6.4 km south of Lake Ontario and 16 km north of the city of Niagara Falls. The site occupies approximately 77.4 ha and is located in a generally rural setting. The current configuration of NFSS is shown in Figure 1 (the locations of storage buildings no longer in existence are marked as "old buildings"). The site is bordered by a hazardous waste disposal site, a sanitary landfill, and land that is currently vacant. The nearest permanent residence is 1.1 km southwest of the site.

The climate of the NFSS area is classified as humid continental; normal temperatures range from -3.9 to 24.4°C during the year and the mean annual precipitation is 80 cm. Wind is predominantly from the southwest, with an average monthly wind speed ranging from 15.9 to 23 km/h. The site is generally level, sloping gently to the northwest. Soils at NFSS are predominantly silty loams underlain by clayey glacial till and lacustrine clay. All surface water from the site discharges via the Central Drainage Ditch and its tributary ditches into Four Mile Creek, located northwest of the site (Bechtel National, Inc. 1989).

The NFSS is a remnant of the original 612-ha site that was used during World War II by the Manhattan Engineer District (MED) project and was a portion of the U.S. Department of the Army's Lake Ontario Ordnance Works (LOOW). Except for enriching operations involving nonradioactive boron-10 during the periods 1954 to 1958 and 1964 to 1971, the site's major use from 1944 to the present has been for the storage and transhipment of radioactive residues produced as by-products of uranium processing

DISCLAIMER

FIGURE 1

during the MED project and subsequent Atomic Energy Commission (AEC) projects. The site is currently managed by the U.S. Department of Energy (DOE) under its Surplus Facilities Management Program.

The composition of residues and waste materials at NFSS has been reported in a 1986 document (U.S. Department of Energy 1986). The primary radionuclides are radium-226, uranium-238, and associated radioactive decay products. The major contaminant is radium-226. Materials stored at the site consist of low-grade residues and by-products from the Linde Air Products Division of the Union Carbide Corporation in Tonawanda, New York (L-30, L-50, and R-10 residues) and from the Middlesex Sampling Plant in Middlesex, New Jersey (F-32 residues). The L-30 and L-50 residues were stored in Buildings 411, 413, and 414, and the F-32 residues were stored in the recarbonation pit directly west of Building 411. The R-10 residues and associated iron cake were stored in an open area north of Building 411. The small quantity of Middlesex sands resulting from decontamination activities at the Middlesex Sampling Plant was stored in Building 410. In 1949, pitchblende residues (K-65 residues) resulting from uranium extraction conducted at a St. Louis, Missouri, plant were transported to the LOOW in drums. Some of these were stored outdoors along existing roads and rail lines; others were stored in Building 410. From 1950 to 1952, the K-65 residues were transferred to a renovated concrete water tower (Building 434).

About 190,000 m^3 of contaminated soils, wastes, and residues are stored at NFSS. The inventory of residues stored at the site is as follows (Battelle Columbus Laboratories 1981): 3,891 t K-65, 8,227 t L-30, 1,878 t L-50, 138 t F-32, and 8,235 t R-10. About 2 t of Middlesex sands are also stored at the site. The residues, with a volume of about 18,000 m^3, account for the bulk of the radioactivity, which is primarily radium-226. The K-65 residues, which account for about 95% of the radium-226 content in the residues, are estimated to contain about 1,830 Ci of radium-226 based on the most recent concentration data available (Turi 1987). The amount of uranium remaining in the residues and wastes after extraction of uranium from the ores is quite low, <30 Ci in the residues and <1 Ci in wastes (U.S. Department of Energy 1986).

INTERIM REMEDIAL ACTIONS AND THEIR EFFECTIVENESS

Over the past eight years, several interim remedial actions have been taken at the NFSS. The overall effects of these actions have been to reduce the radon release levels from above DOE guidelines to near background levels. In 1984, work began on consolidation of the waste; following this activity, gamma exposure rates declined sharply to stable, low levels after 1986 when the Interim Waste Containment Facility (IWCF) was completed.

Gamma exposure and inhalation of radon are considered the only plausibly significant exposure pathways for an individual at or near the NFSS. Figures 2 and 3 show the decline in radon exposures and gamma exposure rates, respectively, during the years when the interim remedial actions were taken, eventually culminating in waste consolidation in the IWCF. The data in these figures are annual average values, and only data for representative boundary locations are shown. The radon data include background levels, which have ranged from 0.3 to 1 pCi/L over the past several years. The gamma exposure rate data reflect values that can be attributed to NFSS, i.e., the background levels (ranging from 64 to 91 mR/yr) have been subtracted from the measured readings. The monitoring network currently consists of 35 radon detectors and 33 thermoluminescent dosimeters for measuring gamma radiation levels. Average annual concentrations of total uranium in surface water samples taken at a location where the Central Drainage Ditch exits NFSS have decreased from 108 pCi/L in 1982 to stable values after 1986 (10 pCi/L in 1988). Radium concentrations at the same location have remained low, ranging from 1.5 pCi/L in 1982 to 1.0 pCi/L in 1988. In sediment samples taken in 1988, the average concentrations were 2 pCi/g (dry) for uranium and 0.9 pCi/g for radium, which are near background levels. Groundwater concentrations of

FIGURE 2

FIGURE 3

total uranium and radium have generally remained stable; for example, along the eastern and western edges of the northern boundary of NFSS, the concentration of uranium is about 4 pCi/L and that of radium about 0.4 pCi/L. Only one well located on the western perimeter of the IWCF has shown elevated uranium concentrations (about 55 pCi/L). An investigation conducted in 1988 (Bechtel National, Inc. 1989) has shown that the well is located in a sand lens and that the radioactive contamination is possibly associated with contaminated solids in or near the well. The current groundwater monitoring network consists of 48 on-site wells. The interim remedial actions from 1980 to the present are explained below.

Battelle Columbus Laboratories conducted a radiological survey of NFSS in 1979. The report of this survey (Battelle Columbus Laboratories 1981) served as a basis for initial interim remedial action planning for the site. Bechtel National, Inc. (BNI), has acted as DOE's project management contractor and implemented interim remedial actions at the site since 1981. BNI currently maintains the site and conducts environmental monitoring (Bechtel National, Inc. 1989). Access to the site is restricted by a 2.1-m high fence that encloses the DOE property.

Since 1980, various steps have been taken at the NFSS to minimize potential radiological risks and prevent migration of residues. In the fall of 1980, the vent at the top of Building 434 (the former water tower in which the K-65 residues were stored) was capped to reduce radon emissions to the environment. Also during 1980, pipes penetrating the walls of the residue storage buildings were sealed or resealed, as necessary, to prevent radionuclide migration.

Because radon levels at the site's western boundary, average concentrations in the range of 5 to 7 pCi/L (NLO, Inc. 1981), were exceeding the DOE limit of 3 pCi/L (U.S. Department of Energy 1987), the site fence was relocated approximately 152.4 m to the west in mid-1981, creating an exclusion area to protect the public from exposure to higher radon levels. Radon levels at the new boundary were well below applicable guidelines. In 1981, remedial action was performed on a triangular-shaped vicinity property adjacent to NFSS, and approximately 342 m^3 of excavated contaminated material was placed in storage at NFSS.

To further reduce the levels of radon emanating from the site, Buildings 413 and 414 (used for storing the L-50 residues) were upgraded and sealed in 1982. Also in 1982, to prevent further migration of residues, contaminated soil near the R-10 pile was moved onto the pile, and a dike and cutoff wall were constructed around the R-10 area. The R-10 pile was then covered with an ethylene propylene diene monomer (EPDM) liner, which markedly reduced radon emanation from the R-10 area. This action effectively reduced radon concentrations at the old site boundary (along Lutts Road) to levels that were below DOE guidelines.

In 1983 and 1984, the EPDM liner was removed, additional contaminated soils and rubble from on-site and off-site areas were placed on the pile, and the pile was covered with the first layer of the interim clay cap. These actions constituted the origin of the IWCF. In 1984, 93% of the K-65 residues were transferred from Building 434 to Building 411.

During 1985, transfer of the K-65 residues from Building 434 to the IWCF was completed. Activities during 1985 also included demolition of Building 434, completion of remedial action on vicinity properties near the site, and continuation of the installation of the cap over the waste in the IWCF. These activities involved excavating approximately 10,640 m^3 of contaminated materials from on-site and off-site areas, transferring 1,102 m^3 of building rubble to the IWCF, and discharging 12 million liters of treated, impounded water in accordance with New York State Department of Environmental Conservation (NYSDEC) permit requirements. In 1986, another 25.8 million liters of contaminated water were treated and released, and four of the six water treatment ponds were reduced to grade.

The cap over the IWCF was completed in late 1986. The facility covers an area of 4 ha and is enclosed within a dike and cutoff wall, each constructed of compacted clay. The cutoff wall extends a minimum of 45 cm into an underlying gray clay unit. The dike and cutoff wall, in conjunction with the engineered earthen cap, enclose the waste in a clay envelope that provides a barrier to migration of waste constituents. Pollution control measures were applied during construction of the IWCF. These included the use of prudent engineering controls, e.g., use of sedimentation barriers in excavation areas and batch discharges of treated, impounded surface water in accordance with NYSDEC requirements. In 1987, the impounded water in the remaining two ponds (38.8 million liters) was treated and released. These two ponds were reduced to grade, and the NFSS was closed. The site is currently inactive, except for environmental monitoring and surveillance and maintenance of the IWCF.

In 1988, several isolated areas of residual radioactivity were excavated and placed in temporary storage. This material will remain in temporary storage until the IWCF is reopened so that additional material can be added. At the present time, all of the residual radioactivity on-site has been remediated, with the exception of one localized area suspected to be both radioactively and chemically contaminated. This remaining area will be remediated in the future (Bechtel National, Inc. 1989).

CONCLUSIONS

Interim remedial actions taken over the past eight years at the NFSS have been effective in reducing radon exposures and gamma exposure rates. Since the IWCF was completed in 1986, the exposure levels have remained stable and close to background levels. Remedial actions have also been successful in limiting any potential migration of radionuclides via the water pathways. Monitoring results show that the site is in compliance with DOE's radiation protection standards.

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LIST OF FIGURES

Figure 1. Configuration of the Niagara Falls Storage Site

Figure 2. Radon Levels at Representative Boundary Locations

Figure 3. Gamma Exposure Rates at Representative Boundary Locations

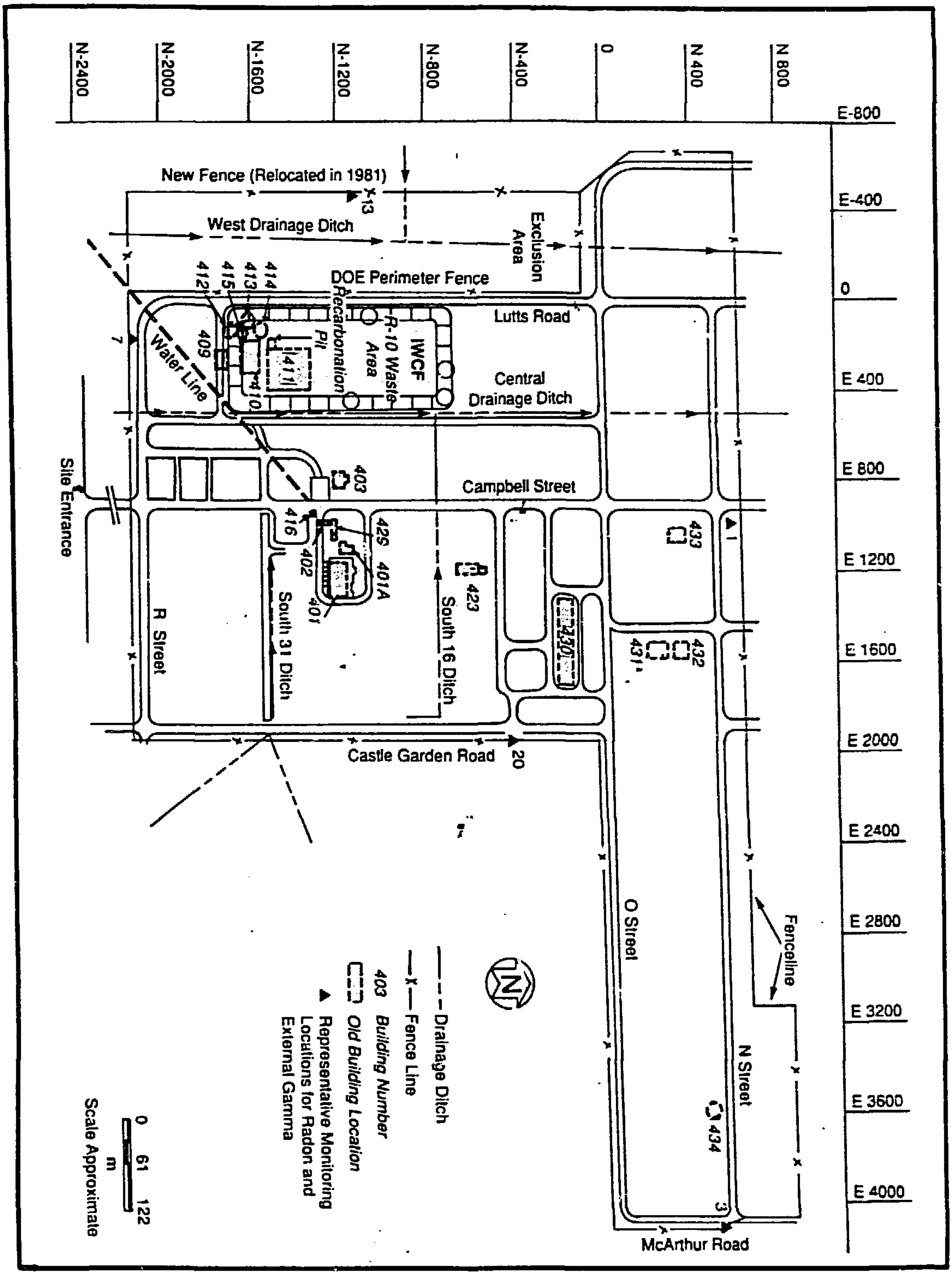
N-2400
N-2000
N-1600
N-1200
N-800
N-400
0
N 400
N 800
E-800
E-400
0
E 400
E 800
E 1200
E 1600
E 2000
E 2400
E 2800
E 3200
E 3600
E 4000
New Fence (Relocated in 1981)
West Drainage Ditch
Exclusion Area
DOE Perimeter Fence
Lutts Road
IWCF
R-10 Waste Area
Recarbonation Pit
Central Drainage Ditch
Water Line
Campbell Street
Site Entrance
R Street
South 31 Ditch
South 16 Ditch
Castle Garden Road
O Street
N Street
Fenceline
McArthur Road
Drainage Ditch
Fence Line
403 Building Number
Old Building Location
Representative Monitoring Locations for Radon and External Gamma
0 61 122
m
Scale Approximate

Figure 1

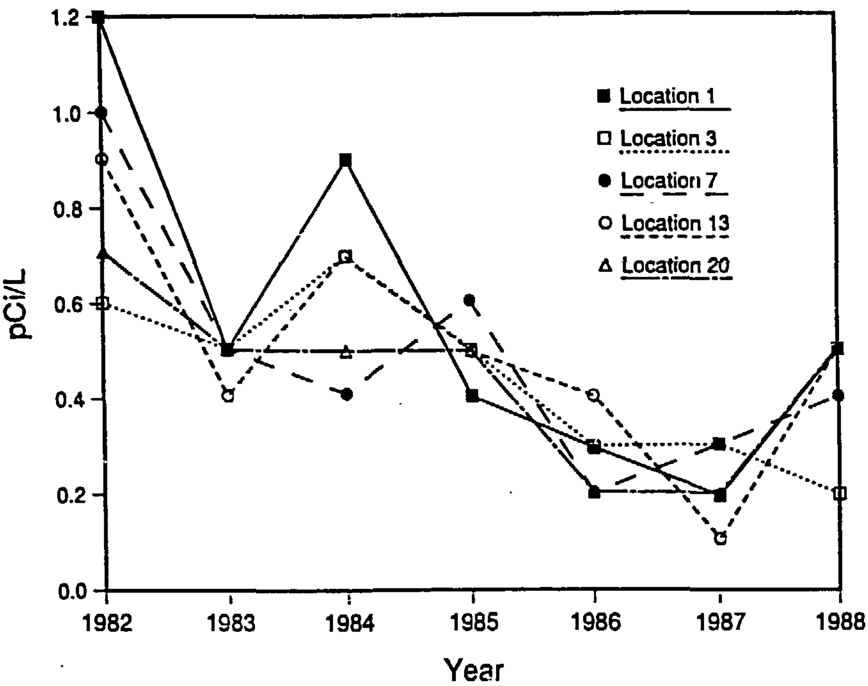

Figure 2

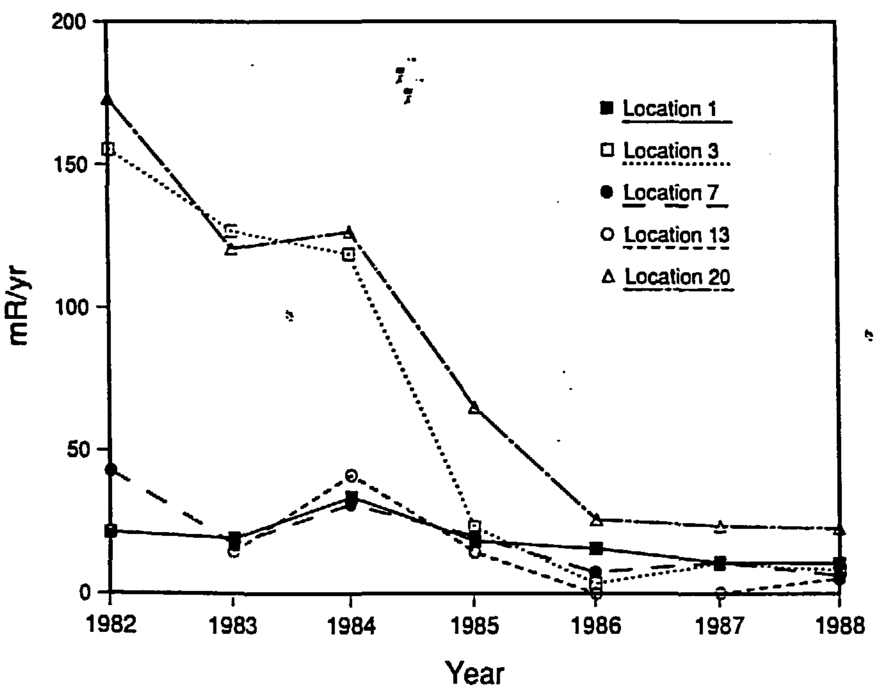

Figure 3