STATUS OF THE DESIGN AND CONSTRUCTION OF THE NIAGARA FALLS STORAGE SITE

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ABSTRACT

The U.S. Department of Energy established the Niagara Falls Storage Site near Lewiston, New York for the shortterm storage of lowlevel radioactive wastes and residues. The facility was constructed to provide interim storage for these waste materials for a period of 25 to 50 years, but can be upgraded to provide a service life of 200 to 1000 years. In this paper, the processes by which the facility was designed and constructed are described. In addition, the technical "lessons learned" in relation to each of these processes are summarized. Finally, the programs for maintenance and surveillance, environmental monitoring, and performance monitoring at the NFSS are described.

INTRODUCTION

The Niagara Falls Storage Site (NFSS) is a U.S. Department of Energy (DOE) surplus facility that lies approximately 16 km north of the City of Niagara Falls and within the Town of Lewiston, New York (Fig. 1). It is approximately 6.5 km south of Lake Ontario. The 77ha site is a remnant of the original 612 ha site that was used during World War II by the Manhattan Engineer District (MED) and was a portion of the U.S. Army's Lake Ontario Ordnance Works (LOOW). Since 1944, the site has been used primarily for the storage of radioactive residues produced as byproducts of uranium production during the MED project and subsequent Atomic Energy Commission (AEC) projects. As a result of these operations, the NFSS and various vicinity properties became radioactively contaminated. Remedial action has been conducted at the NFSS and vicinity properties under DOE's Surplus Facilities Management Program (SFMP) and Formerly Utilized Sites Remedial Action Program (FUSRAP), respectively. Bechtel National, Inc. (BNI) was selected by DOE as the Project Management Contractor for this work.

Remedial actions commenced in 1982; by October 1986 all vicinity properties had been decontaminated and construction of the interim waste containment facility (IWCF) completed.

Radioactive residues of various compositions (codenamed K-65, L-30, L-50, F-32, and R-10 during wartime activities) and sands contaminated with radium were stored at the NFSS. Although the residues comprised only a small percentage of the contaminated materials stored at the NFSS, they accounted for 99 percent of the radioactivity, primarily because of the high specific activity of the K-65 residues (averaging 520,000 pCi/g). These residues resulted from the processing of highgrade pitchblende ore (containing 35 to 60 percent uranium oxide) by a St. Louis processing plant. In 1949 they were brought to the NFSS and placed in drums. Between 1950 and 1952 the K-65 residues were placed inside a 60m high concrete water tower. Because of the location and high specific activity of these residues, it was necessary to develop innovative remedial action techniques.

The L-30, L-50, F-32, and R-10 residues originated from various processing and extraction operations conducted at the nearby Linde Ceramics Plant in Tonawanda, New York. All of these materials were stored in various buildings and on the grounds of the NFSS, with the result

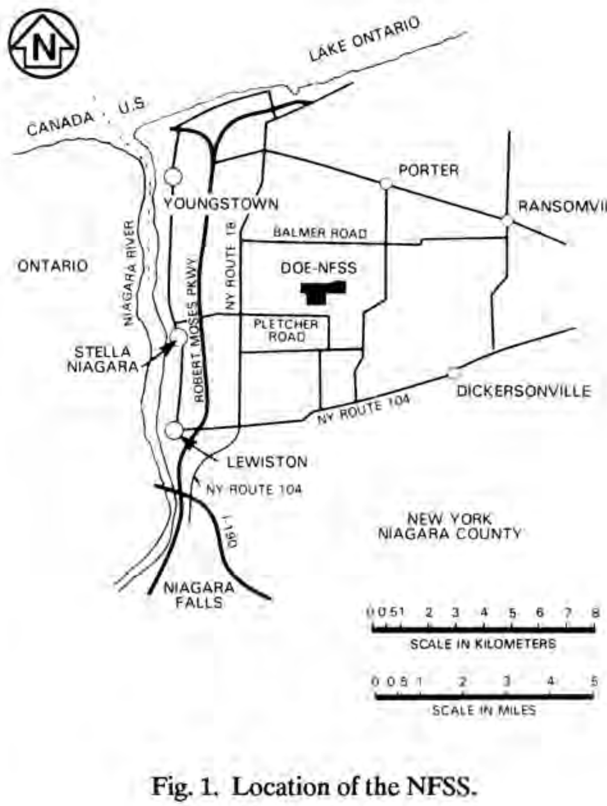

Fig. 1. Location of the NFSS.

that several areas of the site became contaminated. In addition, surface erosion of contaminated areas on the NFSS (particularly the R-10 area) resulted in contamination of two major drainage ditches that carried water offsite. The larger Central Drainage Ditch begins on the site and slopes northward for a distance of approximately 6 km to its confluence with Fourmile Creek northwest of the site. The West Ditch begins at a point west and south of the site and slopes northward for approximately 1400 m, intersecting the Central Drainage Ditch north of the site. The NFSS now covers only 77 ha of the approximately 600 ha originally used for shipment, storage, and burial of radioactive materials and wastes. This is because several segments of the original site were released for unrestricted use and have been sold.

Site Geology and Hydrology

The NFSS is located on a terrace of glacial Lake Iroquois, the predecessor of Lake Ontario. The site stratigraphy comprises 12.4 to 15.5 m of unconsolidated, glacially derived sediments overlying a thick sequence of sedimentary rock (1). Six major stratigraphic units lie beneath the ground surface. In descending order, these units are: surficial soils and fill, brown clay, gray clay, sand and gravel, red silt, and sedimentary rock of the Queenston Formation. The top layer consists primarily of silty clay, but also contains sand lenses and sandfilled channels. The lacustrine clay directly below the surface material is an aquitard that hydraulically separates the shallow groundwater found in the sand lenses from an underlying aquifer at the top of bedrock. The Queenston Formation bedrock is a redbrown siltstone/shale with fractures near its upper surface, which forms an aquifer in conjunction with the overlying sand/gravel zone. The groundwater hydrology consists of two waterbearing zones; the shallower zone is approximately 1.5 m below the ground surface.

DESIGN AND CONSTRUCTION OF THE IWCF

Design Features

The waste containment facility at the NFSS was designed and constructed to store radioactively contaminated material removed from the site itself and from other properties in its vicinity. A design requiring minimal maintenance was used in constructing the facility. The service life of the existing interim facility is 25 to 50 years; however, with design modifications, the facility could be upgraded to provide a service life of 200 to 1,000 years to accommodate longterm disposal of the waste. In its Record of Decision (ROD)(issued in August 1986), DOE announced its selection of longterm, inplace management of the contaminated waste materials as the preferred disposal alternative, consistent with the guidance provided in the U.S. Environmental Protection Agency (EPA) regulations governing uranium mill tailings. For the residues, it is the DOE intent to provide for longterm, inplace management consistent with future applicable EPA guidance. If future analyses show that inplace management cannot meet EPA guidance, another option will be selected that meets EPA guidance and is environmentally acceptable.

The waste containment structure is approximately 325 m long by 165 m wide and covers roughly 4 ha. It encapsulates approximately 190,000 m^3 of contaminated materials. The consolidated residues are enclosed in a concrete vault that was used by the MED for wartime operations; this vault is itself buried within the waste containment facility. A natural layer of gray, highly impermeable lacustrine clay forms the bottom of the containment facility; a cutoff wall keyed into the gray clay unit and a clay dike atop the cutoff wall form the perimeter of the cell. The structure is covered by an engineered, multilayered clay cap that extends beyond the perimeter dike. The clay cap is itself covered with a 46cm layer of soil and topsoil, which is planted with shallow-rooted grass. Figure 2 shows the configuration of the cap on the existing short-term facility, and also illustrates the design of the cap that would be constructed for long-term use. Additional information about the design of the containment facility is available in Refs. 1-6.

Schedule

An environmental monitoring program was already in progress when interim remedial action began at the NFSS in 1982. Field work was performed in discrete packages according to the schedule shown in Fig. 3. Also shown in Fig. 3 are the annual costs associated with remedial action and with the design of the waste containment facility. Finally, Fig. 3 shows the volume of contaminated material excavated each year. Work was generally performed during the construction season, with the exception of the removal of the K-65 residues from the concrete water tower, which continued into the winter of 1984 until weather conditions caused a temporary halt in February 1985. Interim remedial actions at NFSS were completed in 1987.

Various activities were conducted in preparation for remedial action. Radiological characterizations and field surveys were conducted to determine the locations and depths of contamination. Related engineering tasks included determining volumes of soil to be excavated, preparing location drawings to guide the excavation subcontractor, and establishing the configuration of the waste pile. In addition, specifications and subcontract documents were provided to support the procurement process for this work, which also included analytical services, demolition of onsite buildings, and miscellaneous support services such as the performance of civil surveys.

Local contractors performed all work at the site. Most of the contractors had not previously worked at radioactively contaminated sites, and had to be trained in proper health and safety measures as well as in construction procedures designed to prevent the spread of contamination to radiologically clean areas. A site field office was staffed

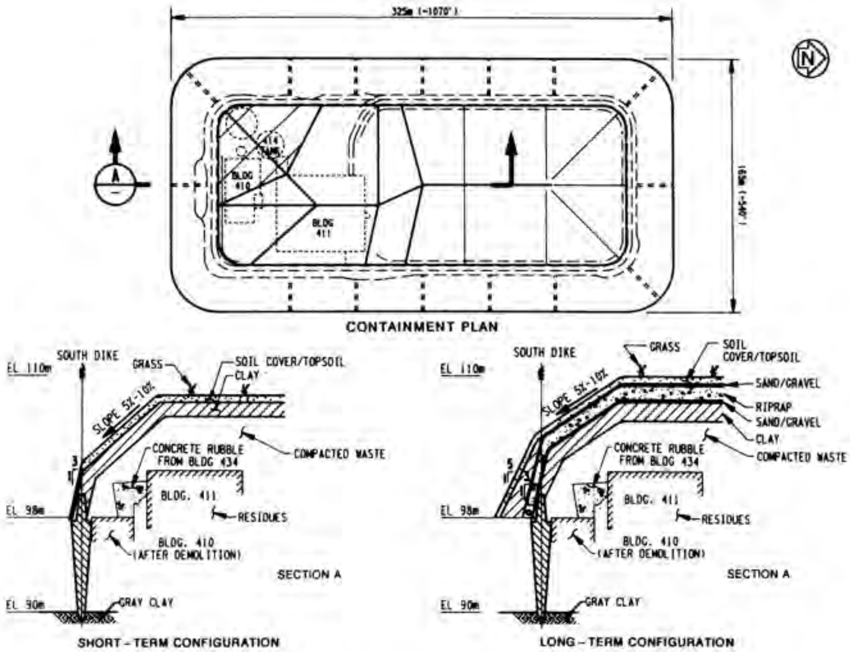

Fig. 2. Waste Containment Facility Plan and Sections.

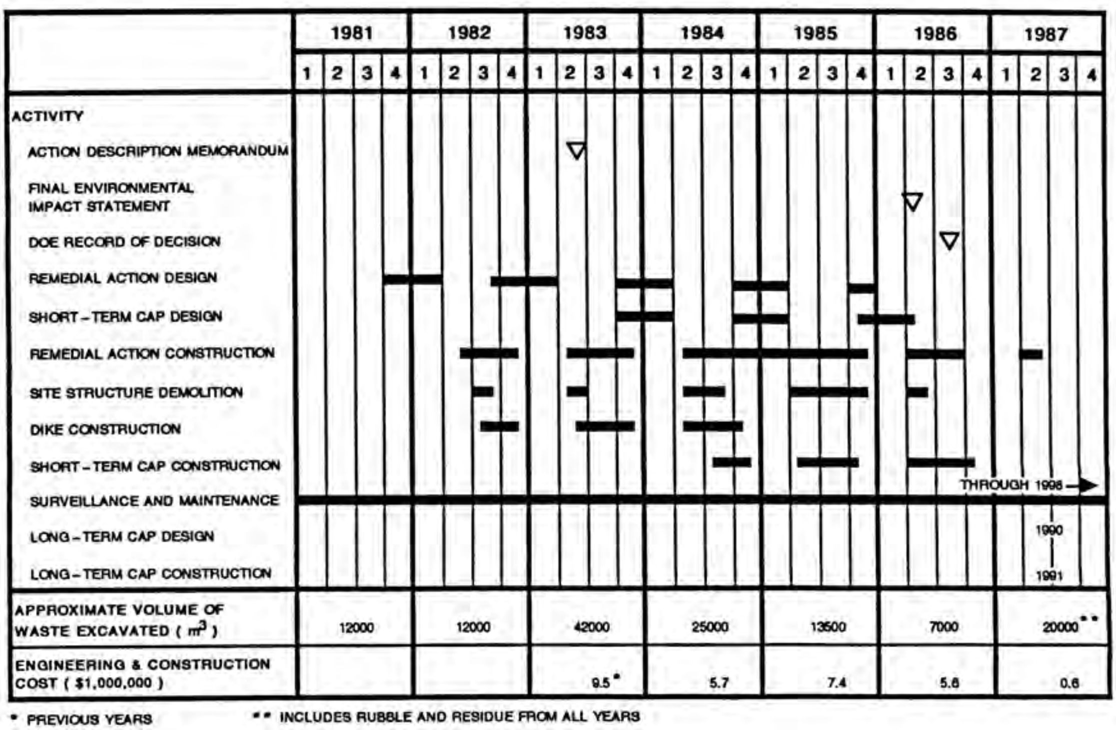

Fig. 3. Schedule for Design and Construction of the NFSS Waste Containment Facility.

during the 6-year construction period. The BNI staff generally consisted of five people during the construction season and two people during the off-season.

Construction Methods

Selection of construction methods and equipment was based in part on the physical properties (particularly moisture content) of the soil to be excavated. Additional considerations included requirements to avoid excavating larger areas or volumes than was necessary and to prevent the spread of contamination to radiologically clean areas as a result of erosion, contamination of the groundwater, or transport via radioactively contaminated equipment or dust. Other factors in the selection process were the requirements to thoroughly compact the contaminated soil after placement in the storage pile and to decontaminate equipment before it could be released for unrestricted use.

A large (1.5- or 2.3-m^3), tracked backhoe with a "toothless" bucket proved most efficient for excavating soil. Use of this type of backhoe permitted the haul trucks to remain on radiologically clean ground, provided for controlled-depth excavation for the 8- to 60-cm excavation depths typically required; enabled operators to remove soil near trees, structures, and utilities; prevented the mixing of contaminated soil with underlying clean soil during excavation; and provided the most efficient loading rate possible. Haul trucks were 10-wheel dump trucks with covers and tail gates that could be sealed when wet soil was hauled.

Temporary haul roads surfaced with crushed stone were constructed so that trucks hauling contaminated soil could drive directly onto the waste storage pile without becoming contaminated. Where appropriate, ramps were used instead of roads. The soil was discharged from the back end of the truck to avoid contaminating parts of the vehicle other than the waste receptacle. After the soil was discharged from the truck, it was cleared away from the dumping point by bulldozers. Two or three bulldozers (Caterpillar D6 or equivalent) serviced the dumping points and spread the soil for compaction. Vibrating sheepsfoot (Ingersoll-Rand SPF56) or flat-drum (Raygo Rascal 400) rollers were used to compact the soil in 20-cm (loose measure) lifts. Three bulldozers and two roller compactors could place and compact 450 m^3 of soil on an average day. Smooth-faced, flat-drum rollers were used to seal the surface of the soil on days when rainfall was expected.

When the moisture content of contaminated soil was too great to permit proper compaction, the soil was spread out in the open air to promote drying and was pulverized with an agricultural disc as required. After grading of surfaces was completed, the surfaces were sloped to promote runoff of water. Sedimentation barriers constructed with bales of hay or straw were used to control and direct runoff. Contaminated rainwater runoff was collected with sumps and pumped to lined ponds for treatment.

For construction of the cap on the waste containment facility, only clay that was compactible to a Modified Procter density of 95 percent to achieve a maximum permeability of 10^{-7} cm/sec was used. The clay was transported to the site in 8-m^3 dump trucks. Clay was placed in 15-cm-thick lifts at an average rate of 550 m^3/day. Each lift was spread so as to achieve the required thickness and was then compacted. The cap was graded and leveled using a Caterpillar 12G motor grader. The soil layer and the final topsoil layer were placed in a similar fashion.

Completion

The waste storage pile was covered with clay at the end of the 1985 construction season. In the spring of 1986 the pile was opened to permit placement of contaminated soil removed from the water treatment ponds during closure activities and from contaminated areas (on- and off-site) identified in late 1985. The pile was subsequently closed and regraded and its slopes restored as required. The cap was seeded with grass and fertilized late in 1986; areas in which growth was poor were again seeded and fertilized in the spring of 1987.

Lessons Learned

During the course of the activities conducted at the NFSS, the technical suitability of a number of concepts and practices has been confirmed. In addition, new information has been gained with regard to the design and construction of this type of waste containment facility and the associated remedial action techniques. These "lessons learned" include the following:

- A thorough initial characterization, though more costly than a quick "walk-over" scan, is cost-effective for several reasons. First, it eliminates the need to perform supplemental remedial action in cases where walk-over scans have provided incomplete definition of the horizontal and vertical limits of contamination. Second, it simplifies engineering and scheduling activities. Finally, it permits development of more accurate budgets and storage space requirements.
- A thorough topographical survey should be performed and a grid with 30-m spacing established across the site prior to characterization. This provides for better controls during engineering, characterization, and excavation activities.
- Equipment to be used for excavation and hauling in contaminated areas should be precleaned to remove accumulations of oil, grease, asphalt, and other adhering materials. This simplifies subsequent decontamination of the equipment.
- Because of the manner in which radioactive materials migrate, contaminated soil often accumulates in low-lying areas, swales, ditches, and

swamps. Soil removed from those areas is likely to be wet, and considerable effort is necessary to dry the soil sufficiently to permit proper compaction. A 10 percent reduction in moisture content is routinely required.

- There should be sufficient planning for the temporary storage and disposal of large quantities of construction water, runoff from the waste pile, decontamination water, and rainwater pumped from the contaminated soil. Holding ponds may be required for chemical treatment of the water or installation of evaporation equipment.
- It was demonstrated on the basis of an in-situ, large-scale cap permeability test that the 10^{-7}-cm/sec permeability specified for the clay used to construct the cap can be achieved with the standard construction methods used at NFSS.
- Experienced field engineers should be available on-site to assist in implementing engineering designs and in processing design changes.
- Adequate time must be allowed for site-specific and OSHA-required training.
- On-site laboratory facilities for the radiological analysis of soil and the determination of its physical properties were found to be essential in minimizing delays in the excavation and soil placement processes.
- Special care is needed in selecting topsoil material for use on the cover of the facility; e.g., low-plasticity material should be used to minimize the potential for the development of minor surface cracks.

MAINTENANCE AND SURVEILLANCE

Turf Establishment

Performance of the activities required to establish a turf cover occupied most of the 1987 growing season. These activities included the application of weed killers, fertilizer, and lime; the filling of channels created by erosion; the installation of a mobile irrigation system; and the establishment of a regular mowing program. A severe mid-summer drought inhibited growth in 1987, as did other factors such as weed growth and erosion.

It is apparent that extensive efforts will be required for a period of several years to develop and maintain turf on the slopes of the waste containment facility. A detailed maintenance and surveillance program has been developed to guide the two-member site operations staff in monitoring and maintaining the cap to ensure its integrity. Mowing of the cover is scheduled so as to maintain the height of the grass at less than 11 cm. The cover is inspected during mowing activities to ensure early detection of the growth of deep-rooted or woody vegetation and of excessive drying, which can inhibit grass growth or lead to cracking of the soil cover and subsequent erosion. Such early detection allows for prompt implementation of corrective measures.

Intruder Protection

A 2-m-high woven wire fence was installed along the site perimeter to prevent intrusion by humans and large animals such as deer. The fence is inspected regularly and is kept in good repair. In addition, if the waste containment facility is upgraded to provide for long-term disposition of the wastes, a 1-m-thick layer of riprap will be inserted below the sand-and-gravel layer (Fig. 2) to prevent intrusion by humans, animals, and the roots of plants.

Performance Monitoring Activities

Various activities are conducted to monitor the performance of the waste containment structure. A double ring of monitoring wells was installed around the waste containment facility as one means of providing information on system performance. One ring of wells lies 6 to 15 m outside the outer limits of the waste, and the second ring is 60 m outside the waste boundary. The monitoring wells were positioned to permit a determination based on analysis of groundwater samples from the wells as to whether contaminants had escaped from the waste containment facility. The wells are installed in pairs consisting of a shallow well screened within the materials above the aquitard forming the bottom of the disposal structure, and a deeper well screened in the sand and gravel/top-of-bedrock zone that constitutes an aquifer. Water samples are collected from these wells and analyzed on a quarterly basis. In addition, the water level in each monitoring well is measured each quarter to permit early detection of gradient changes. In this way, the movement of any contaminants detected by analysis of groundwater samples can be better defined.

A "walk-over survey" of the site is performed twice a year: once in the spring soon after the final thaw, and once in the fall after the first frost. The cap of the waste containment facility is examined by a team consisting of a geologist, a soils engineer, a civil engineer, and a site maintenance foreman. The surveyors look for indications of cracking, disturbance, subsidence, erosion damage, and loss of ground cover. The field examination is performed in conjunction with a grid survey to detect anomalous vertical or horizontal movement of established markers. Aerial photographs of the facility are taken twice annually and reviewed to assist in the early detection of conditions requiring corrective action. The schedule for these monitoring activities is designed to detect damage caused by seasonal factors such as freezing, thawing, and heavy rains. To maximize the visibility of surface defects, aerial photographs are taken in early spring when plant cover is limited to newly grown turf, and in the late fall after the trees have lost their foliage.

As an additional monitoring measure, a system of pressure transducers has been installed inside the containment structure to detect accumulation of water before the opportunity for discharge develops. The devices for measuring the internal water level are read automatically on a daily basis to permit early detection of changes in the water level.

CONCLUSION

The short-term waste containment facility at the NFSS has been successfully completed and serves as a model for the design and construction of a facility of this type. The continuing development and implementation of environmental and performance monitoring programs at the NFSS will serve to ensure the integrity of the waste containment facility and the continuing protection of public health and the environment.

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