Waste Management Systems for the 21st Century at Oak Ridge National Laboratory - 9112

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ABSTRACT

Since the Manhattan Project, Oak Ridge National Laboratory (ORNL) has been engaged in developing processes for implementation in the Department of Energy (DOE) production facilities and in producing radioisotopes for medical and industrial applications. The waste management systems designed to support these operations are +30 years old. The systems are reaching the end of their design life and will require replacement and/or significant upgrades in order to meet the future needs for DOE Office of Science (SC) research and development and DOE Environmental Management (EM) programs. This paper describes the planning efforts undertaken to update the ORNL waste management systems to meet future waste treatment needs at ORNL.

INTRODUCTION

ORNL is one of the nation's largest and most diverse energy research and development (R&D) institutions in the U.S. DOE laboratory complex. The infrastructure consists of specialized experimental laboratories, user facilities, hot cells, and nuclear reactors, and their associated waste collection and treatment systems. Much of this infrastructure is aging, and facility revitalization is a key ORNL initiative. The modernization strategy for ORNL replaces or recapitalizes mission-critical buildings, consolidates and co-locates similar research activities, and prepares the ORNL Campus for future DOE program challenges [1]. Key components of the revitalization strategy are (1) to consolidate highly radioactive R&D activities in the Melton Valley Nuclear Facility Complex (MVNFC), away from the main campus where the majority of the ORNL staff and guest scientists are located, and (2) to clean up the Central Campus, the oldest part of ORNL where isotopes production was performed, and make the real estate available for a new Science and Technology Park.

In parallel with the DOE-SC landlord revitalization effort, The Integrated Facility Disposition Project (IFDP) has been established to complete the DOE-EM cleanup mission at ORNL [2].

IFDP is a collaborative proposal developed by the DOE EM, SC, Office of Nuclear Energy (NE) and National Nuclear Security Administration (NNSA) that will complete the cleanup of the DOE Oak Ridge Reservation (ORR) and at the same time enable ongoing modernization efforts at ORNL and the Y-12 National Security Complex (Y-12). The project is expected to be completed within the next 25–35 years.

The existing aging waste management systems are not expected to meet the waste treatment needs of IFDP or ORNL's future scientific missions without significant upgrade or replacement. This paper describes the efforts that have been undertaken to estimate future waste generation, define efficient waste treatment and disposal options, and develop a strategy for implementing them in a cost-effective manner. It also discusses the challenges of providing a waste treatment infrastructure that will not only meet the needs of the IFDP project but will also be suitable for transfer to the site landlord for long-term waste management operations and stewardship at the end of IFDP.

EXISTING WASTE TREATMENT SYSTEMS

ORNL currently has three radioactive liquid waste treatment facilities in operation:

- Process Waste Treatment Complex (PWTC) for treatment of process wastewater and groundwater,
- Liquid Low-Level Waste System (LLLW System) for collection, concentration, and storage of radioactive liquid low-level waste, and
- Transuranic Waste Processing Center (TWPC) for solidification of liquid low-level waste.

Liquid waste is generated and collected throughout the ORNL site within a complex array of building drains, piping, manholes, pump stations, and tanks, as shown in Figure 1. The PWTC treats wastewater for radionuclides (primarily Sr-90), heavy metals, and organics and discharges it to the environment via National Pollutant Discharge Elimination Systems (NPDES)–permitted discharge points. The LLLW System treats waste via evaporation, and the concentrate is ultimately sent to storage in one of many large on-site tanks. The TWPC further processes the concentrated liquids (and resultant sludges) for eventual disposal as a solid waste.

ORNL has a large and complex gaseous collection, treatment, and disposal system, the Central Gaseous System (CGS), which supports facilities in the ORNL Central Campus. The central gaseous waste system was built in the 1950s and consists of a 76.2-meter-high (250 feet), unreinforced radial brick masonry chimney that is connected to waste-generating buildings by a series of below-grade concrete and above-grade stainless steel ducts.

As shown in Figure 1, the ORNL liquid and gaseous waste collection and treatment systems were primarily constructed between 1950 and 1989 and are reaching the end of their safe operating life. Figure 1 also shows the interconnections between the CGS, PWTC, the LLLW System, and the TWPC. The facilities receive waste from each other; they cannot be operated independently. The aging centralized treatment systems are also connected to generating facilities by miles of deteriorating underground piping, both of which are primarily located in the Central Campus, the main location of the IFDP remediation zone. The majority of the facilities

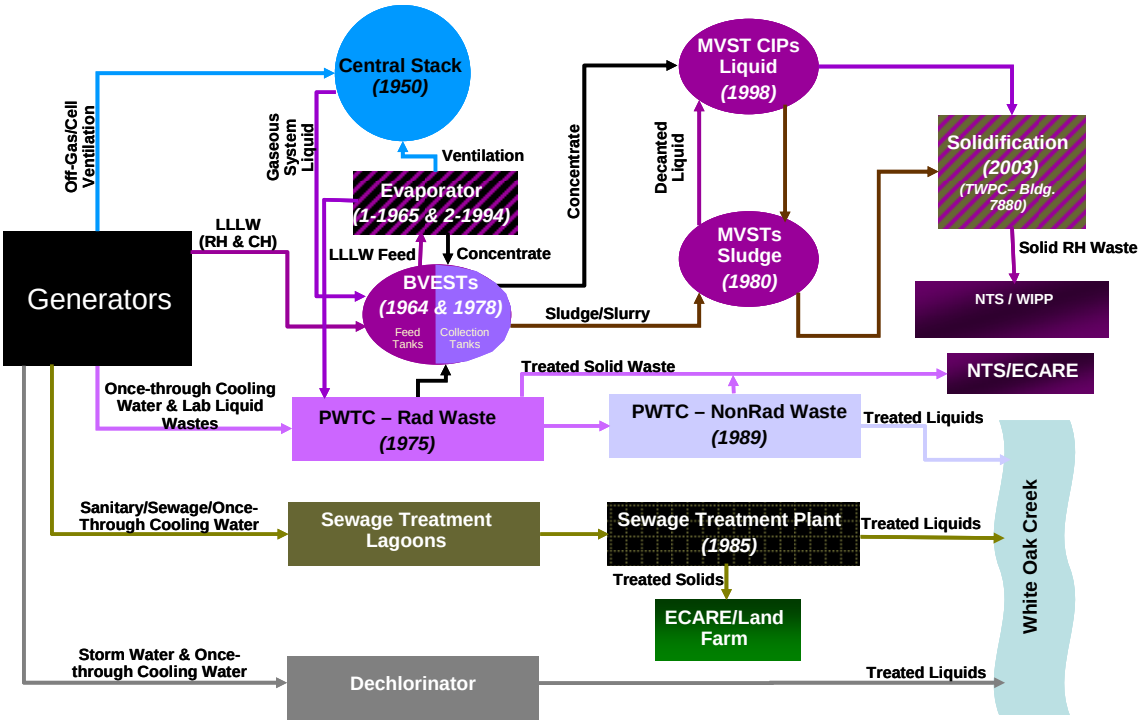


Fig. 1. Schematic of the existing liquid and gaseous waste treatment system.

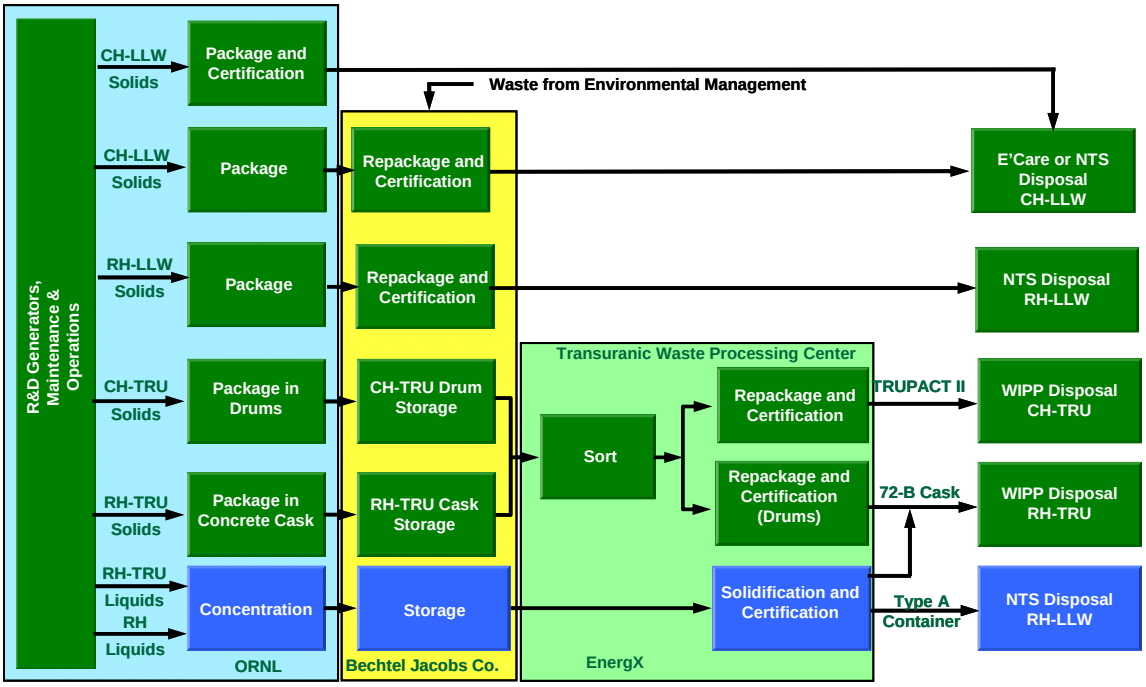


Fig. 2. Current pathways for management of ORNL liquid low-level and solid wastes.

supported by the CGS are located in the remediation zone and will be decontaminated and decommissioned (D&D) and remediated by IFDP, thus eliminating the need for the system.

The process for handling LLLW and radioactive solid waste is shown in Figure 2. The solid waste has historically been packaged at the generator site, put into storage, and then retrieved, sorted, repackaged, and certified for shipment to disposal sites.

The existing solid waste staging and storage facilities are old and deteriorating, were not designed for repackaging and frequent package retrieval, do not accommodate many of the casks/containers expected during IFDP and beyond, and are located at sites which require additional remediation. The TWPC is the only dedicated facility at ORNL with capabilities for processing remote-handled solid and LLLW streams for disposal. It is a Category II nuclear hot cell facility specifically designed as a temporary facility to treat a fixed quantity of legacy waste accumulated at ORNL over the past 60 years in a short time period for disposition at the Nevada Test Site (NTS) and Waste Isolation Pilot Plant (WIPP). It began operation in fiscal year (FY) 2003 and has a 15-year design life. This facility was not designed to accommodate the range of materials expected to be processed from IFDP and future ORNL missions.

The present waste systems are scattered throughout the ORNL site. They are interconnected by miles of underground piping and are extremely complicated to operate. By the end of IFDP, many of the existing waste treatment facilities will be 50–80 years old and well past their design lives. Several of these facilities present environmental, safety, and health (ES&H) risks due to their age and/or location. Facility operating costs are high and, in many cases, fixed. These aging systems are not expected to meet the waste treatment needs of IFDP or ORNL's future missions, and they must be reconfigured to meet future needs.

FUTURE WASTE GENERATION ESTIMATES

Future generation rates have been estimated based on impacts expected from IFDP and predicted changes in R&D missions. They are summarized in Table I.

Table I. Estimated Waste Generation Rates for ORNL

Waste Stream	Present Generation	Future Generation during IFDP	Future Generation after IFDP
Process Wastewater	435 lpm	435 lpm	60 lpm
Groundwater	450 lpm	500 lpm	230-500 lpm
LLLW	760,000 lpy	1,350,000 lpy (peak)	100,000 lpy
Remote-Handled Solids (Requiring Treatment Prior to Disposal)	10 m^3/yr	60 m^3/yr	10 m^3/yr

Waste generation rates for process wastewater and groundwater are expected to be fairly constant until the end of IFDP, at which time they are expected to drop significantly. The process wastewater generated in the Central Campus area will be eliminated by planned IFDP and DOE-SC activities. The majority of the process wastewater will be generated in the MVNFC in the future, and the volume and composition is expected to remain fairly constant over time. The majority of the groundwater will be generated in the Central Campus area, and the groundwater will have the potential of being reduced, or even eliminated,

over time. In addition, the compositions of these two streams are expected to be significantly different in the future.

Since 2000, the LLLW generation rates have been ~760,000 l/yr, with approximately 10–15% of the waste coming from R&D operations located in the MVNFC and the remainder being generated by DOE-EM activities primarily in the IFDP remediation zone. LLLW generated by DOE-EM operations are expected to decrease and eventually be eliminated by the IFDP project. Future LLLW generation rates are expected to be ~100,000 l/yr. The generators are expected to be located primarily in the MVNFC when waste management and mission critical capabilities in remediation zone are relocated to facilitate IFDP remediation.

A significant amount of solid waste is destined for on-site disposal facilities. It is estimated that ~15,800 m^3 will be shipped off-site to Envirocare, NTS, and WIPP. It is estimated that more than 90% of this waste can be packaged at the site of generation and shipped directly to the off-site disposal facility, and less than 10% (1170 m^3) will require additional treatment prior to disposal. An average throughput of ~60 m^3/yr is expected for the remote-handled solids waste processing facilities. Prior to and after IFDP, the estimated waste generation rate from ongoing operations located primarily in the MVNFC is ~10 m^3/yr.

FUTURE WASTE TREATMENT SYSTEM PLANNING

Studies conducted to support waste management planning at ORNL evaluated the cost-effectiveness of upgrading existing facilities versus replacing them. In general, replacement, rather than upgrade of the facilities, is the preferred option considering the age, legacy contamination, size of facilities, physical location (generally far away from generator buildings and/or located in the IFDP remediation zone), the high costs to retrofit contaminated facilities, and the operating costs of the existing facilities.

As mentioned previously, the ORNL strategic plan is to consolidate similar research activities into research complexes on the ORNL site. Waste management evaluations concluded that it would be advantageous to install local radioactive liquid and gaseous treatment systems tailor designed for the major research complexes rather than to continue to use centralized waste treatment systems connected to generating facilities by miles of piping and/or transport significant volumes of wastewater by tanker truck. The exceptions include groundwater and sanitary waste; they will continue with pipeline collection and centralized treatment. Co-locating remote-handled solid waste treatment and storage facilities with the major waste generators and the remote-handed liquid waste treatment systems also creates synergies that would reduce operational complexities and costs.

It has, therefore, been recommended that the existing waste treatment systems, primarily located in the heart of the IFDP remediation zone, be replaced with more efficient systems sized to treat future-generated waste. System interconnections should be minimized, eliminating much of the operating complications associated with the present systems. This is expected to lead to reduced operating costs.

Treatment systems should be sized for real-time processing to eliminate the need for long-term storage of waste. Evaluations indicated that it would be possible to size the remote-handled LLLW and solid waste treatment facilities to operate on one 8-hr shift per day for ongoing operations, and additional shifts could be added to handle peak loads during IFPD D&D operations. The new process waste treatment system should be sized for the capacity required after IFDP is completed, and the high-volume streams should continue to be treated in existing facilities until these streams are eliminated.

A schematic of the new liquid/gaseous waste treatment systems is shown in Figure 3, and the solid waste system is shown in Figure 4. The plan includes (1) installing new local gaseous waste treatment systems

for nuclear facilities planned to be operated well into the future after IFDP is complete, (2) constructing process waste, liquid low-level waste, and remote-handled solid waste treatment plants located in the MVNFC near the major waste generators, and (3) locating a groundwater treatment system near the largest source and pipe/truck groundwater from other sites to this location.

Figure 3 shows liquid and gaseous waste treatment systems that are much more streamlined than the existing system shown in Figure 1. The interconnections between treatment systems have been eliminated, and collection and storage systems have been minimized. Figure 4 shows that the existing packaging, storage, retrieval, and repackaging steps in the existing solids handling flow sheet (Figure 2) will be eliminated by the proposed upgrades.

The treatment system replacement schedule must be integrated with the planned shutdown of existing waste treatment facilities and the IFDP project. The existing waste treatment systems will remain operational as needed to support facility consolidation and initial IFDP legacy waste treatment/remediation efforts; they will then be remediated and closed as part of the IFDP project. The new facilities will process all the remaining waste generated by IFDP, including materials that currently have no treatment pathway at ORNL. At the end of IFDP, it is envisioned that the DOE-EM mission at ORNL will end. If the new treatment facilities are designed as proposed, they can be transitioned to the site landlord for future operation.

SUMMARY

This document outlines a strategy for replacing the existing Cold War Era waste treatment systems with efficient, right-sized waste management facilities specifically designed to support the state-of-the-art research facilities for the "21st Century" ORNL and IFDP needs. When fully implemented, the strategy will

- eliminate ~80% of the process wastewater and LLLW generation;
- eliminate the use of over 15,000 m of contaminated underground piping and ductwork; and
- eliminate the use of over 3,000,000 l of high-activity underground storage tank volume (i.e., 98% of the ORNL inventory).

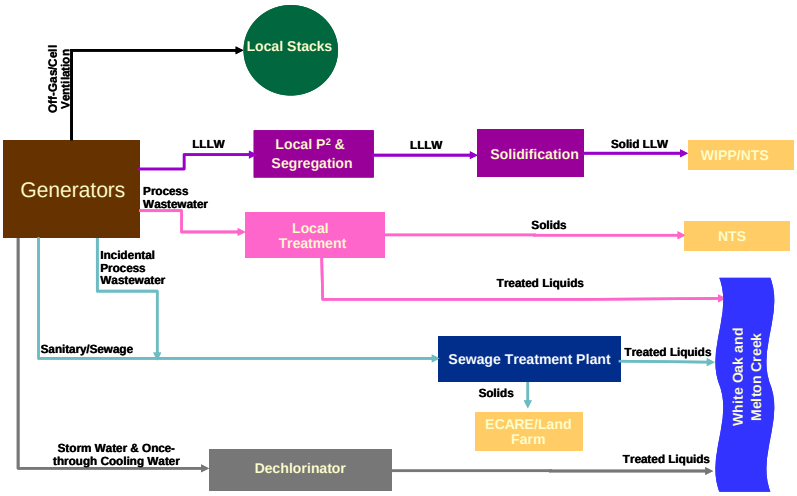
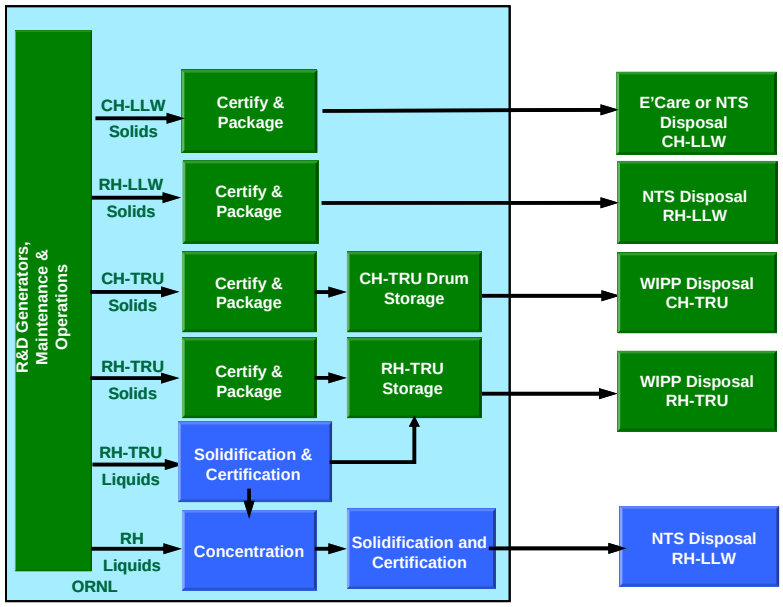


Fig. 3. Proposed liquid and gaseous waste systems designed to maximize treatment efficiency for future wastes, reduce costs, and improve effluent quality.

Fig. 4. Proposed solid waste systems designed to maximize treatment efficiency for future wastes,



reduce costs, and improve effluent quality.

This strategy consolidates the majority of the treatment systems for radiologically contaminated wastes in MVNFC, reducing security and exposure risks for the majority of ORNL employees and increasing visitor population. ES&H and related risks will be further reduced by eliminating the use of underground piping for waste collection (except for the sanitary/sewage waste and groundwater treatment systems) and minimizing the long-term storage of liquid waste in underground storage tanks. Efficient system designs and reduced surveillance and maintenance costs will lower ORNL's annual waste management operating costs.

REFERENCES

1. "10-Year Site Plan FY2009 to FY2018," ORNL/TM-2007/15/R3, Oak Ridge National Laboratory (2007).
2. "Oak Ridge Integrated Facility Disposition Project Critical Decision-1 Approve Alternative Selection and Cost Range Preliminary Project Execution Plan," DOE/OR/2282&D0 (2008).