CONSTRUCTION OF A MIXED-WASTE FACILITY A CASE STUDY IN QUALITY ASSURANCE/QUALITY CONTROL

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ABSTRACT

The purpose of this case study is to show how Quality Assurance (QA) and Quality Control (QC) were used to demonstrate to the Utah Department of Environmental Quality (UDEQ), the United States Environmental Protection Agency (EPA), and other interested parties that Envirocare's Mixed-Waste Facility was constructed to the required specifications. This case study covers the construction of the liner system and the disposal of waste. Covering of the waste will occur sometime in the future.

BACKGROUND

In 1988, the State of Utah Division of Radiation Control issued Envirocare of Utah, Inc., (Envirocare) a license to store and dispose of naturally occurring radioactive materials (NORM) at a site located 129 kilometers (80 miles) to the west of Salt Lake City, Utah. In August 1989, the Division of Radiation Control amended this license to include limited concentrations of low level radioactive waste.

In November 1990, after two (2) years of permit application review, the State of Utah Division of Solid and Hazardous Waste issued Envirocare a permit to treat, store and dispose of hazardous waste. This permit, in conjunction with a permit issued by the State of Utah Division of Radiation Control, allowed Envirocare to store and dispose of mixed-waste (radioactive and hazardous waste).

In April 1991, Envirocare began the construction of the mixed-waste disposal embankment. Approximately one year later, on April 7, 1992, Envirocare completed the construction of the mixed-waste liner system. Envirocare subsequently received approval from the State of Utah to begin disposal of mixed-waste.

The purpose of this case study is to show how Quality Assurance (QA) and Quality Control (QC) were used to demonstrate to the Utah Department of Environmental Quality (UDEQ), the United States Environmental Protection Agency (EPA), and other interested parties that Envirocare's Mixed-Waste Facility was constructed to the required specifications. This case study covers the construction of the liner system and the disposal of mixed waste.

EMBANKMENT DESIGN

In order to operate a facility for the permanent disposal of waste which is both radioactive and hazardous, Envirocare designed and permitted a disposal embankment which combined the features of a RCRA Subtitle C embankment with the features of a Uranium Mill Tailings Remedial Action (UMTRA) embankment. The embankment design incorporates:

- the RCRA requirements of a liner system with two synthetic liners and leachate detection and collection system and a cap with a synthetic liner
- DOE's UMTRA requirements for a radon-elimination-barrier cap designed to withstand flooding and erosion for 1,000 years with design features to withstand the probable maximum precipitation (PMP) and probable maximum flood (PMF)

Because of its unique design, approved permits and licenses, Envirocare may dispose of such mixed wastes as: CERCLA wastes, DOE wastes, characteristic wastes, and many F-, K-, P-, and U-listed mixed wastes.

Envirocare's permit and licenses specifically prohibit the disposal of the following wastes: wastes with free liquids, wastes which do not meet the land disposal prohibition treatment standards, dioxin-related wastes, air- or water-reactive wastes, pyrophoric wastes, DOT forbidden class wastes, Class A and Class B explosives, shock-sensitive wastes, non-empty gas cylinders, and nerve-agent-related wastes.

The design of the liner system includes four liners, two leachate detection systems, and a leachate collection system. The design of the liner system from bottom to top is as follows:

1. A 0.91-meter (three-foot) clay liner with a permeability of 10^{-7} cm/sec (3.28×10^{-9} feet/sec) or less
2. A 1.5-mm (60-mil) high density polyethylene (HDPE) liner
3. A drainage net
4. A 1.5-mm (60-mil) HDPE liner
5. A drainage net
6. An 230-gram (eight-ounce), non-woven geotextile fabric
7. A 0.61-meter (two-foot) layer of soil to protect the liner system
8. An 2.0-mm (80-mil) HDPE liner
9. A drainage net
10. An 230-gram (eight-ounce), non-woven geotextile fabric, and
11. A 0.61-meter (two-foot) layer of soil to protect the liner system

A compression fit between the clay liner and the lower HDPE liner merges them into a composite liner. The HDPE liners of the cell bottom were sloped (from 2 to 33 percent) to allow any liquid which may collect above the liners to drain towards a sump. Pipe and gravel sumps are located at the lowest points of each of the HDPE liners to serve as collection points. The lower two drainage nets and sumps serve as a leachate detection system, and the upper drainage net and sump serve as a leachate collection system.

The design of the cap includes the following components:

1. A 1.7-meter (5.5)-foot layer of clay
2. An HDPE liner
3. A 15-cm (six-inch) filter zone, and

4. An 46-cm (18-inch) layer of rock erosion barrier (rip-rap).

The layer of clay and HDPE liner are designed to limit both the release of radon gas and infiltration from precipitation. The filter zone and rock erosion barrier are designed to permanently protect the HDPE liner and clay liner from erosion and from the PMP and PMF.

A variety of support facilities have been constructed to support the operation of the mixed-waste embankment.

The embankment is surrounded by a 0.61-meter-high (two-foot-high) berm to contain precipitation inside the embankment until it can be collected and handled in an appropriate manner. The facility is surrounded by a 0.91-meter-high (three-foot-high) berm to prevent water from leaving or entering the facility.

The facility includes indoor and outdoor decontamination facilities which allow for year-round decontamination of equipment leaving the facility.

The leachate and water from the embankment from decontamination operations are treated in two permitted 76,000-liter (20,000 gallon) evaporation tanks.

The facility includes indoor and outdoor storage area for storage of containerized waste with a combined capacity of 7,646 cubic meters (10,000 cubic yards).

The facility includes a comprehensive ground-water monitoring system with 13 detection monitoring wells, 21 exploratory bore-holes and other piezometers.

The State of Utah Department of Environmental Quality was involved with approving the proposed design for the embankment throughout the permitting process. The design was submitted to the State with the original application. The approved final design was issued as part of the hazardous waste permit. Envirocare's hazardous waste permit required Envirocare to revise the Construction Quality Assurance Plan (CQAP). After working with the State for seven months, Envirocare received approval for the revised CQAP and began construction on the clay liner.

During construction of the embankment, construction was halted for four months to add a construction detail to the drawings and address some minor errors in the drawings. During this time, Envirocare worked closely with the State to expedite the review and design modification.

ORGANIZATION

The QA and QC for the construction were performed by two separate groups, the QA group and the QC group. These groups functioned independently of each other. Each group was directed by an officer (QA officer and QC officer) who was responsible for the work of the group. The QA officer was isolated from production schedules by reporting directly to the President of Envirocare.

The QA group was responsible for insuring the QA requirements outlined in the CQAP were implemented. The QA group was responsible for reviewing and accepting all work and documentation produced by the QC group. During construction the QA group was required by the State to submit a monthly review of all non-conforming work.

The QC group was responsible for performing observation and testing required by the CQAP, documenting the tests and observation, and reporting the results to the QA group. During construction, the State required the QC Group to submit: 1) Weekly schedules detailing the construction progress and anticipated construction schedule for the following two weeks, and 2) Weekly non-conformance reports which identified all non-conforming work, the steps taken to correct such work, and what non-conforming work had been corrected during the week.

Besides reviewing the schedules and reports submitted by Envirocare, the State regularly inspected the site. During the time the clay liner was being finished in preparation for the placement of HDPE liner, the State had at least one full-time inspector present at the site during construction.

FOUNDATION AND CLAY LINER

Quality Assurance for the clay liner was performed by the QA group. Quality Control for the clay liner was performed by an independent testing contractor under the direction of the QC officer.

The CQAP required that the foundation be scarified and recompacted to 95% of a standard proctor (ASTM D 698) within 3% of optimum moisture content prior to placement of the clay. To obtain representative samples for control determinations, the foundation was divided into 26 lots of 743 square meters (8,000 square feet) or less. Samples were taken at random from among the 26 lots and tested. The QA officer was required to accept the foundation prior to placement of clay liner.

Prior to construction of the clay liner, Envirocare conducted a test fill to demonstrate that clay with a permeability of 1×10^{-7} cm/s ($3.28\ 10^{-9}$ feet/sec) or less could be obtained. A 18-meter (60-foot) by 21-meter (70-foot) by 0.61-meter (2-foot) test fill was constructed using the same type of equipment that was used in construction of the clay liner. The test fill was tested for moisture content, compaction, and permeability. Both field (sealed single-ring infiltrometer) and laboratory testing for permeability were included. These permeability results were similar.

In addition to the test fill, Envirocare performed a demonstration test between a sealed double-ring infiltrometer test (ASTM D 5093) and the sealed single-ring infiltrometer test used by Envirocare's testing contractor. As a result of a statistical evaluation of the demonstration test, the two tests were shown to produce the same average measurements.

Borrow materials for liner construction were required to be classified as CL soils with 90 percent passing the number 200 sieve. Classification tests were performed on lots of less than 2,293 cubic meters (3,000 cubic yards). Clays not meeting this specification were rejected and not used to construct the clay liner. Standard proctor tests were performed on 7,646-cubic-meter (10,000-cubic-yards) lots. All borrow was inspected for moisture content and suitability by QC prior to use in the clay liner.

The clay liner was placed in 15-cm (six-inch) lifts and compacted with a Caterpillar 815 B soil compactor with 20 cm (8 inch) feet. The soil compactor was used to knead the lifts together.

The CQAP required that the clay liner be compacted to 95% of a standard proctor within three percent of optimum moisture. The clay liner was divided into 261 lots with the largest lot being less than 743 square meters (8,000 square feet). Moisture-density tests were performed in each lot. The acceptance of a lot was based on the results of the test. The test locations were chosen by random numbers. An additional 29 moisture-density tests were performed beside the permeability test. During the placement of the clay liner only one moisture-density test failed. The failure was due to a high moisture content.

During placement of the clay, Envirocare directly measured the permeability of the clay liner using the sealed single-ring infiltrometer test. The clay liner was divided into 31 lots for permeability. The location of the permeability tests were chosen by random numbers. Forty-one infiltrometer tests, including 10 duplicates, were performed on approximately 12,200 cubic meters (16,000 cubic yards) of clay liner. All of the tests demonstrated that the clay liners met or exceeded the permeability requirement of 10^{-7} cm/s (3.28×10^{-9} feet/sec) or less.

The final surface of the clay liner was cut back to within a maximum 6.1 cm/sec (0.2 feet) above the specified grade. The clay liner was then rolled with a smooth drum to provide a compression fit between the clay liner and the synthetic liner. The moisture content of the clay liner was maintained until the liner was covered by synthetic liner. The State inspected the clay liner surface after its completion.

SYNTHETIC LINER SYSTEM

The QC for the synthetic liner system was performed by the liner installer. The QA for the synthetic liner system was performed by Envirocare employees assisted by a independent engineering firm.

The manufacturer of the synthetic materials were required to submit QC certifications for materials delivered to the site. These QC certifications were required to be accepted by QA officer before The material was used in the cell liner.

The HDPE was required to comply the NSF Standard 54. The manufacturer of the HDPE liner was required to submit a QC certification indicating that the liner had been tested at a rate of one test per 2,323 square meters (25,000 square feet) and meet specification for thickness, tensile strength at break, tensile strength at yield, elongation at break, and elongation at yield. The manufacture of the HDPE welding rod had to certify that the rod was the same polymer as the liner.

The HDPE liner could only be placed at temperatures above 1°C or 34°F. As the liner unrolled, the liner was inspected by both QC and QA personnel for holes, blisters, thin spots, undispersed raw material, or other defects. Defective materials were replaced or repaired by patch.

Prior to allowing welding technicians to weld on the HDPE liners, the welding technician had to qualify by demonstrating that he could produce an acceptable seam with the welding machine to be used. This qualification consisted of welding a test seam and then testing the seam in peel and shear. To qualify, five of five peel tests and five of five shear tests had to meet specification. The welding technician had to qualify twice a day and after the welding machine sat idle for 30 minutes. Quality assurance personnel observed all of the qualifying tests.

The QA personnel visually inspected every foot of seam, looking for defects or improper welding. All defects found were repaired or patched.

The QC performed on the liner included both non-destructive and destructive testing. Every foot of seam was non-destructively tested. The seams welded by the double wedge fusion method were tested by air testing the channel between the welds. The seams welded by the extrusion method were tested using the vacuum box method. All non-destructive testing was observed by QA personnel. Any defects found were repaired or patched.

A destructive sample or coupon was taken at a frequency of one sample per 122 meters (400 feet) of seam. The destructive sample was divided into three pieces. The first piece of the sample was used in field peel and shear tests. The second piece sample was turned over to QA to be sent out for laboratory testing. The third piece was archived. Quality assurance personnel observed all field testing and compared the laboratory data with the field data. If the seam failed either the field or laboratory destructive testing, the seam was repaired to the nearest passing test. All sample holes were patched and the patch was non-destructively tested.

The manufacturer of the drainage net was required to submit a QC certification indicating that the net had been tested at a rate of one test per 4,645 square meters (50,000 square feet) and met specification for specific gravity and thickness.

The drainage net was placed by hand to prevent damage to the HDPE liner. The drainage net was overlapped at least 10 cm (four inches) and placed with the up-slope drainage net overlapping the down-slope drainage net. The drainage net was tied with polymer ties at a maximum spacing of 1.5 meters (five feet) on the sides and 0.61 meters (two feet) on the end of the rolls. The drainage net was inspected by both QA and QC for damage, proper spacing of the ties, and proper overlap. Any damaged areas were replaced or repaired.

The manufacture of the filter fabric was required to submit a QC certification indicating that the net had been tested at a rate of one test per 4,645 square meters (50,000 square feet) and met specifications for mass per unit area, tensile strength, mullen burst equivalent opening.

The filter fabric was placed by hand to prevent damage to the HDPE liner and drainage net. The filter fabric was overlapped at least 0.30 cm (12 inches) and placed with the up-slope drainage net overlapping the down-slope drainage net. The filter fabric was inspected by both QA and QC for damage and proper overlap. Any damaged areas were replaced or repaired.

In addition to reviewing the schedules and reports submitted by Envirocare, the State had at least one and as many as three full-time inspectors on site during construction of the synthetic liner system.

SOIL PROTECTIVE LAYER

Soil used to protect the liner was required to be classified as CL, ML, SM or SC by the Unified Soil Classification System. All borrow material were required to be classified at a rate of one test per 7,646 cubic meters (10,000 cubic yards). The size of the equipment used to place the soil cover was limited to prevent damage to the liner.

WASTE PLACEMENT

For waste disposal, Envirocare places waste in 0.30 meter (12-inch) uncompacted lifts. The lifts are then compacted to 90 percent of a standard proctor (ASTM D 698) with a maximum moisture content of 3 percent over optimum moisture. Debris placed in the lift is limited to 10 to 25 percent of the lift depending on the type of debris. All debris must be less than 2.44 meters (8 feet) by 2.44 meters (8 feet) by 0.25 meters (10 inches).

When the waste is placed in the embankment, they are kept separate from wastes from other generators. The location of the waste is also recorded. Wastes which are determined to be incompatible (e.g. wastes that would react with each other) are separated by a barrier of at least 0.61 meters (2 feet).