DEPLOYMENT OF CHEMICAL EXTRACTION SOIL TREATMENT ON URANIUM CONTAMINATED SOIL

Jeffrey P. Kulpa [1]

ABSTRACT: The significant contributor to the cost of completing D&D activities at most Department of Energy (DOE) sites is the remediation of contaminated soil. The traditional approach of excavation, packaging, transportation, and burial at an approved disposal site can be the major contributor to overall project cost. At the Ashtabula Environmental Management Project (AEMP) in Ashtabula, Ohio, soil remediation in the approved project baseline accounted for over $45 Million of a total project cost of $165 Million. To reduce project costs and shorten the project schedule, Earthline Technologies has designed, built and is operating a chemical extraction soil washing facility. The facility has successfully processed over 14,000 tons of contaminated soil to date. An additional 50,000 tons of uranium contaminated soil will be processed through project completion resulting in overall project savings of approximately $15 Million. The Earthline chemical extraction process has achieved uranium removal efficiencies of 85% and can control secondary waste stream volumes to <2% of feed volume. The process uses a 0.2M carbonate solution that is heated to approximately 115^{o}F and contacts the soil for approximately 90 minutes to leach the uranium from the soil.

The RMI Extrusion Site in Ashtabula, Ohio operated from 1962 through 1990 as part of the U.S. Department of Energy (DOE) weapons production program. Depleted, normal, and slightly enriched (up to 2.1% weight percent U-235) was extruded as part of the DOE production reactor fuels manufacturing process. Since plant shutdown, the remediation effort has been governed by guidance and regulations promulgated by the NRC for site decommissioning and license termination. The primary practice that contributed to soil contamination at the RMI Site was uranium extrusion manufacturing which resulted in particulate deposition from the exhaust system contaminated the surrounding soils with uranium. The soil at the site is predominantly clay (>80%) with a small sand fraction and some non-native gravel that was used for plant service roads. Average uranium contamination levels in the AEMP soils are approximately 100 pCi/gm. The total amount of soil contaminated with uranium at the AEMP is approximately 64,000 tons. In addition to uranium contamination, the soil is also contaminated with Technetium-99 (Tc-99), a byproduct of uranium recycling. The cleanup levels established by the U.S. Nuclear Regulatory Commission are 30 pCi/gm for total uranium and 65 pCi/gm for Tc-99. The unity rule for contamination levels for free release of the soil also exists. Tc-99 impacts approximately 10,000 tons of the total volume of soil. Technetium-99 presents different technical challenges than uranium with respect to extraction chemistry. Earthline has developed a process modification that allows for efficient extraction of the Tc-99. This process will be used during the next campaign of soil washing.

Bench scale testing showed that the Ashtabula soils could be treated effectively using a 0.2 M sodium bicarbonate solution at a temperature of approximately 115^{o}F and a retention time of 1.5 hours. Treatability testing showed that chemical treatment using carbonate extraction achieved removal efficiencies of up to 90% and was effective in meeting the treatment standard of 30

---

[1] Jeff Kulpa, Director, Technical Projects, Earthline Technologies, Ashtabula, OH, (440) 993-2804, jeff_kulpa@earthlinetech.com

pCi/gm for most of the site soils. A pilot plant designed to process 2-ton batches of contaminated soil. The plant was operated on 38 batches in early 1998 to test various feed conditions. The results of pilot plant operations indicated that chemical extraction soil washing would result in contaminant removal efficiencies of approximately 82% and volume reductions of 95% (i.e., <5% residual waste requiring off-site disposal). Based on the successful pilot plant operations, Earthline commenced design and construction of a 10 ton per hour production soil washing facility. A block diagram of the process is illustrated in Figure 1.

In the chemical extraction process, uranium in the contaminated soil is converted into a water-soluble form and extracted from the soil. This process which uses a relatively mild concentration of sodium carbonate to form a carbonate complex with uranium, is approximately 85% to 95% effective depending on properties of the soil and source term of the uranium material contained in the soil. Processed soils however, do contain trace levels of water-soluble uranium. This is largely due to levels of water-soluble carbonate complexed uranium contained in the interstitial soil water and uranium sorbed on clay and silt soil particles due to ion exchange reactions. Earthline devoted substantial research, design, and modeling efforts to ensure that processed soil would not have a negative impact on the long term environmental quality.

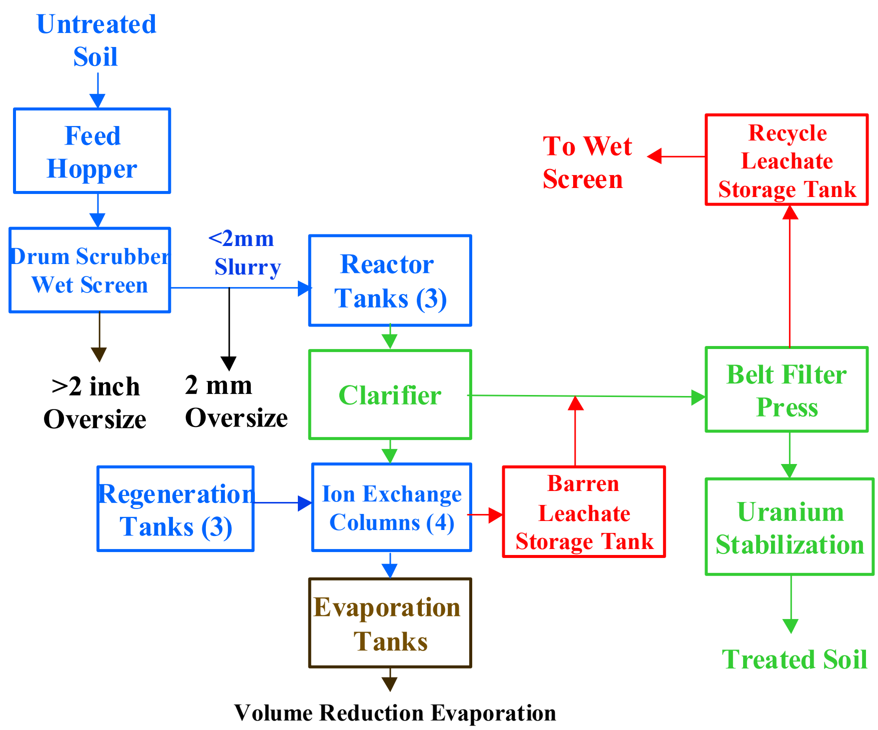

Figure 1: Soil Washing Process Simplified Flow Diagram

Contaminated feed material is introduced into the plant using a front end loader to dump soil into the feed hopper. The feed hopper is equipped with the conveyor that passes the feed materials through a clod breaker to size reduce large chunks of soil. At the drum scrubber water is introduced to the feed stream to the further reduce the size of the feed materials. The drum scrubber rotates on a slanted axis causing materials to travel toward the open end of the drum scrubber. A trommel screen in this portion of the drum scrubber allows materials that are less than 2 inches in size to drop onto the vibrating wet screen below. The fraction of the feed materials that is greater than 2 inches in size drops out the open end of the drum scrubber (this fraction usually consists of rocks, large organic matter, debris and balls of clay). Material that falls to the wet screen is further segregated into greater and less than 2mm sizes. The fraction that is greater than 2mm is conveyed out of the plant for later processing, that which is 2mm or less in size is slurried and pumped to the Reactor Tanks. In Reactor Tank #1 the slurry is mixed with the sodium carbonate to produce a 0.2M solution. The solution is heated approximately 115 degrees F. The solution is gravity fed through the three reactor tanks and then into the Reactor Overflow Tank. From the Reactor Overflow Tank the leachate is pumped to the Lamella Clarifier. At the Lamella Clarifier, a polymer flocculant is added to the solution to allow the solids to settle out of solution. Solids are pumped to a belt filter press for de-watering, and liquids pump to the pregnant leachate tanks. Solids drop from the belt into the screw conveyor below. The screw conveyor transfers the processed soil into the mixing conveyor where stabilization and fertilization additives are mixed into the soil. The soil is then conveyed, via a radial stacker, to the clean soil pad. A pile on the clean soil pad consists of 80 to 100 tons, the amount processed in a usual day. The clean processed soil remains on the clean soil pad until analytical results confirm that the soil meets free release standards.

Liquids from the Pregnant Leachate Tanks are pumped through a series of resin columns. The fluid passes through three of the four columns in a sequence designed to maximize resin efficiency and on line use. The first column that the fluid is introduced to will be the most heavily loaded with uranium. The second column will have the next highest loading value and the third the least uranium loading. When the resin in the first column is saturated with uranium it is taken off line and the fourth column is placed in service. The column that was second is now the first column in series and so on The column taken off line will be regenerated using a sodium chloride solution. Regeneration of each column requires approximately 24 hours.

With the completion of processing 14,200 tons of contaminated soil, the cost of building and operating the soil washing plant is summarized below:

Cost Element	Cost
Operations – Labor cost for plant manager, shift supervisor, 8 operators, 3 treatability laboratory chemists, plus front end loader rental, dump truck rental, maintenance parts and labor.	$169 per ton
Capital Investment Cost - $4.3 Million construction cost plus $700K startup and permitting cost amortized over 60,000 tons.	$83 per ton
Sampling – all required in process and confirmatory laboratory analysis both on site and off site to support plant operations.	$16 per ton
Residuals Management – evaporation of residual water from ion exchange resin regeneration and off site disposal of residues.	$18 per ton
Utilities – natural gas, electricity, and water	$6 per ton
Consumables – Plant operating chemicals, replacement resin, and other consumables such as PPE and other supplies.	$17 per ton

The total life cycle cost per ton of soil processed sums to $309. This compares very favorably with the total cost for shipment and disposal of $550 per ton. The estimated cost savings if 64,000 tons of soil are processed in lieu of off site shipment for burial is $15.4 Million.