# REMEDIATION OF TRANSURANIC-CONTAMINATED CORAL SOIL AT JOHNSTON ATOLL USING THE SEGMENTED GATE SYSTEM

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## ABSTRACT

An effective method for removing mixed plutonium and americium contamination from coral soil matrix at the Defense Nuclear Agency's Johnston Atoll site has been developed by DNA's contractor, TMA/Eberline. The system uses arrays of sensitive radiation detectors coupled with sophisticated computer software designed by Eberline Instrument Corporation. The software controls TMA's unique Segmented Gate System for removing contaminated soil from a moving feed supply on conveyor belts. Contaminated soil is diverted to either a metal drum for collecting larger sized "hot" particles ( > 5000 Becquerels), or to a supplementary soil washing process designed to remove dispersed low level contamination from a soil fraction consisting of very small particles. Low to intermediate levels of contamination are removed from the soil to meet DNA's criteria for release for unrestricted use based on EPA guidelines. The innovative process has achieved a 98 percent volume reduction of contaminated soil that would otherwise require special handling and packaging for off-site disposal.

## INTRODUCTION

TMA/Eberline is conducting a radiologically-contaminated coral cleanup project on Johnston Atoll (JA) as prime contractor to the Defense Nuclear Agency (DNA). This paper describes TMA's Segmented Gate System methodology for removing mixed plutonium and americium contamination from the coral soil matrix, and presents operational experience gained from using the system at JA.

JA is an unincorporated territory of the United States. It is located approximately 825 miles WSW of Honolulu near the center of the North Pacific between the Hawaiian and Marshall Islands. It is the only land area in approximately 800,000 square miles of open ocean, and supports breeding of twelve species of seabirds. JA was first protected as a Bird Refuge in 1926, and has been a military reservation since 1939. The lagoon supports diverse marine life. Two unique forms of sea life found at JA, including green sea turtles, are protected under Federal laws controlling threatened and endangered species.(1) The atoll is now designated as the JA National Wildlife Refuge. The refuge is managed by the Department of the Interior, U.S. Fish and Wildlife Service, cooperatively with the Defense Nuclear Agency (DNA).(2) JA is one of a small group of remote protected habitats in the Pacific Ocean.

JA is comprised of four small islands, two of which are entirely human-made. The largest, Johnston Island (JI), is approximately 2.0 miles long and 0.5 mile wide, covering about 650 acres (slightly over one square mile). JI includes the main original land mass in the atoll, and has been extensively enlarged by coral dredge-and-fill from the lagoon. The atoll was not historically inhabited until 1936, when the Navy began extensive reef blasting, dredging, landfilling, grading, and construction on the islands.(3) Current atoll population is approximately 1300 persons, including both military and civilian personnel. JA is administered by DNA.

In the late 1950's and early 1960's, a series of high altitude atmospheric nuclear tests brought new activity and attention to JA. In 1962, a nuclear device-carrying Thor missile was intentionally destroyed on the launch pad during an aborted launch attempt. Radiological contamination was dispersed over the land area, and was especially concentrated in the area of the missile launch emplacement. Two additional aborts at high altitude took place, but the main source of contamination was the launch pad occurrence. Radiological evaluations were subsequently performed and contaminated coral soil was relocated to a single controlled area. However, a significant portion of island land remained under radiological control.

Later, identification and removal of radioactive material were begun on a small scale using manual methods, but large scale remediation was deferred. The JA Radiological Control Area (RCA) currently encloses 27 acres. For planning purposes, the RCA has been estimated to contain approximately 100,000 cubic yards of coral soil matrix contaminated with low levels of transuranic elements, chiefly plutonium-239 and americium-241.

## PROJECT OBJECTIVE

The primary objective of DNA's JA Plutonium Soil Cleanup Project is to effectively decontaminate the coral soil inside a 24 acre Radiological Controlled Area (RCA) on Johnston Island and release it for unrestricted use. The continuing cleanup project is eliminating a radiological hindrance to the beneficial use of JA land and a potential health hazard to personnel and the environment. The project uses innovative technology to significantly reduce the volume of contaminated soil requiring offsite disposal. The processed "clean" soil is made suitable for use at JA without radiological restriction.

All material for construction or landfill must be conveyed to JA using expensive barge transportation. After decontamination, the soil from inside the RCA becomes a valuable

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on-island resource. In addition, the land area of the RCA will become available for use to support future missions.

## THE SOIL PROCESSING PLANT

TMA/Eberline has made important changes to a former cleanup demonstration plant to facilitate decontamination of approximately 100,000 cubic yards of low level transuranic-contaminated coral soil remaining inside the RCA. Initial plant modifications were planned to be able to utilize some existing items of conventional material-handling equipment (of the type used in "sand and gravel" operations) that were already on-site. For example, a vibrating screen separates and excludes larger pieces of coral from the feed material, and motor-driven conveyor belts move soil through the plant.

Radioactive material is diverted from the flow of feed material through the plant using a new mechanical soil sorting method - TMA's Segmented Gate System. This plant is the first to utilize this unique and effective technology. A series of eight diversion chutes operate independently to divert only the smallest portion of contaminated feed material in order to achieve a maximum mass reduction of contaminant. A minimum diversion of contaminated feed contains only about one pint of material. Results of soil sorting on JA using the Segmented Gate System were highly satisfactory during an operational base period, with an overall contaminated soil volume reduction of 98 percent. DNA therefore decided to initiate additional modifications to the plant to further increase production throughput by utilizing a second Segmented Gate System for front end soil sorting.

Principal mechanical areas of the plant include the soil feed and preparation area, the detection and counting system, the Segmented Gate System for soil sorting, belt weigh scales to track material balance, and the control station. A supplementary soil washing mechanism removes distributed contamination consisting of very small particles from the total soil mass as fractionated fines. Clean material is stored in a segregated area inside the RCA pending release for use elsewhere on-island. Concentrated plutonium- and americium-containing material that has been diverted by the plant is expected to be packaged and shipped to an approved defense waste disposal facility for disposal as low level waste (LLW).

## CLEAN SOIL CRITERIA

DNA has set two criteria for processed coral soil to be considered radiologically "clean" and suitable for release for unrestricted use:

1. Alpha radioactivity from plutonium and americium must be less than 500 Becquerels (Bq) per kilogram (kg) of soil; and,
2. All radioactive particles with activities greater than 5000 Bq must be removed from the soil.

The < 500 Bq/kg criteria addresses dispersed radioactive material consisting of very small particles in the soil. DNA based the criteria on a draft Environmental Protection Agency (EPA) guideline.(4) The second criteria prohibits release for unrestricted use of soil that contains much larger "hot" particles, and is based on expected processing capabilities of the single channel analyzer counting system. Specifically, the counting system can detect, at a 95% confidence level, a single 5000 Bq particle located at the bottom of the soil layer as it passes under a single detector at a rate of 30 feet per minute.

## MATERIAL PROCESSING AND HANDLING

Contaminated soil within the RCA is excavated with standard heavy equipment and relocated to the feed point of the processing plant. DNA staff determine precise locations warranting excavation by in situ radiological surveys in conjunction with Global Positioning System (GPS) receivers. The GPS receivers calculate locations by analyzing signals emitted from satellites. The emitted signals contain satellite positions in reference to the earth. The GPS receiver calculates its position by triangulation between it and four satellites.

Metal debris is extracted from the feed material flow by a large magnet permanently mounted over the feed conveyor belt. Feed material is sized to less than 0.5 inch by a vibrating screen, and layered across the 3-foot width of one of two flat feed conveyor belts to a depth of 0.75 inch and width of approximately 31 inches. Care is taken to maintain a uniform thickness and width of feed material on the moving belt.

The belts convey material under an array of sodium iodide (NaI) FIDLER-type detectors at a rate of 30 feet per minute. A sophisticated motor speed controller is used to maintain a constant belt speed. The thin-window NaI detectors are sensitive to the low energy 60 keV gamma radiation emitted by americium-241, a decay product of plutonium-241. The radiation detectors are linked with new microprocessors and computer software developed for the project by Eberline Instrument Corporation. The new microprocessors and software identify radioactive material as it passes under detector arrays, track it through the system, and generate and archive data files of monitoring, assay, and sorting transactions. Direct measurement of americium allows a calculation to be performed to determine total transuranic contamination, since the ratio of americium to plutonium is known.

## CORAL COUNTING SYSTEM

The fifteen NaI detectors in each monitoring unit are arranged in two overlapping rows of 7 and 8 detectors, respectively. Each detector has an active area measuring 100 by 100 millimeters and is encased in an aluminum housing with a thin end window. The second row of 7 detectors is offset from the first row to prevent "hot" particles from passing undetected between adjacent detectors.

Each detector electronically reports to an individual microprocessor board that calculates amounts of radioactivity and determines whether a "hot" particle has been detected. Each detector microprocessor board then electronically reports to a master control board that collects data, determines whether dispersed radioactivity has been detected, and selects and actuates one of the eight diversion chutes of the Segmented Gate System as required. The master control board tracks diversion gate movement by monitoring changes in electrical position switches.

The master control board utilizes a fiber optic system to communicate with the personal computer (PC) that is used to operate the Plant from the central Control Room. A portable laptop computer can be directly connected to the master control board at the detector box itself to allow local entry and editing of operator selected system parameters or to perform system maintenance and calibration functions. The control room PC enters changes in operating parameters, logs and archives data, and requests and displays information from the master control board. The PC can direct and monitor the operation of up to 4 Segmented Gate Systems at once (i.e., four arrays of 15 detectors each, on 4 different conveyor belts, with associated diversion chutes).

When "hot" particles or distributed contamination above release criteria are detected, one or more of the eight diversion segmented gates located at the end of the sorter conveyor is electronically directed by the master control board to divert the contaminated material. "Hot" particles are diverted to a steel drum. Dispersed radioactivity is diverted to the supplementary soil washing path. The minimum amount of diverted soil is approximately 36 cubic inches (about 1 pint). Material diverted to the soil washing path is agitated with water to remove contamination in the form of very small particles. Material is then re-assayed by the system to verify that it meets release criteria. Contaminated fines are diverted to holding ponds.

It is expected that plant throughput can be maintained at approximately 800 metric tons per week with the current two Segmented Gate Systems running. Planned parallel installation of two additional systems are underway to further increase soil processing throughput. Soil processing operations at this site are expected to continue until 1998.

## SOIL PROCESSING RESULTS

Figure 1 shows the cumulative processed soil mass in metric tons and recovered radioactivity for soil processing operations through September 30, 1992. One metric ton is equal to 2200 pounds. At that time, over 4500 metric tons had been processed, and nearly 400,000 kiloBecquerels of transuranic contamination had been removed from the feed material.

Although volume reduction of contaminated soil depends upon the amount of radioactivity initially present in each batch of feed material, design expectations were to reduce the total volume of contaminated material at the JA site by 95%. Current typical day to day operational data demonstrates volume reduction from 93-99%, with cumulative operational results of over 98% (50:1) reduction.

Figure 2 displays a combination chart of the activity recovered in thousands of Becquerels (plotted line) and the percent weight reduction achieved on a daily basis (columns). Results are routinely in the >95% range. As shown, a notable exception occurred on February 19, when atypical feed material containing much higher than usual amounts of radioactivity was processed through the plant. On that day, over 56,000 kiloBecquerels of radioactivity was removed from the feed material, resulting in a volume reduction of approximately 75 percent.

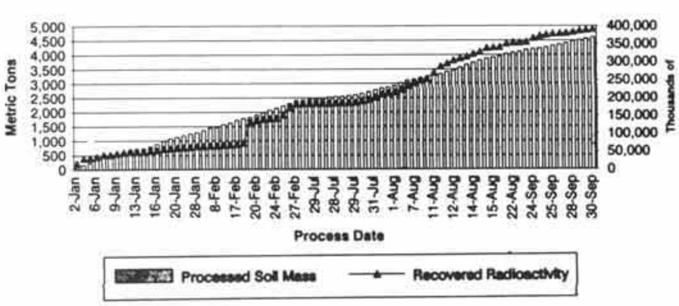


Fig. 1. Cumulative processed soil mass and recovered radioactivity, Jan. 1-Sept. 30, 1992.

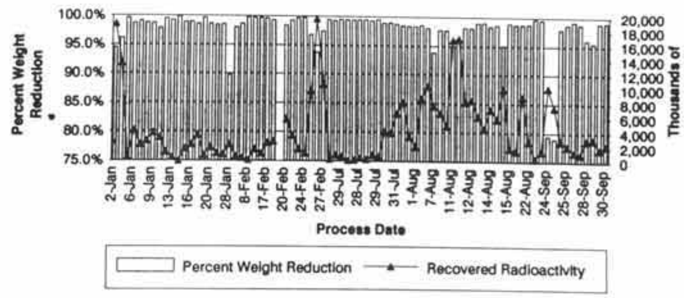


Fig. 2. Daily activity recovered and percent weight reduction.

Figure 3 displays data previously presented in Fig. 2, with the results of soil processing on February 19 deleted and results for other days replotted to an expanded scale for increased clarity. The recovered radioactivity is presented in thousands of Becquerels (plotted line) and the weight reduction (columns) is shown as a percentage of the total mass processed. Recovered radioactivity ranged from less than 2000 to nearly 20,000 kiloBecquerels per day of soil processing.

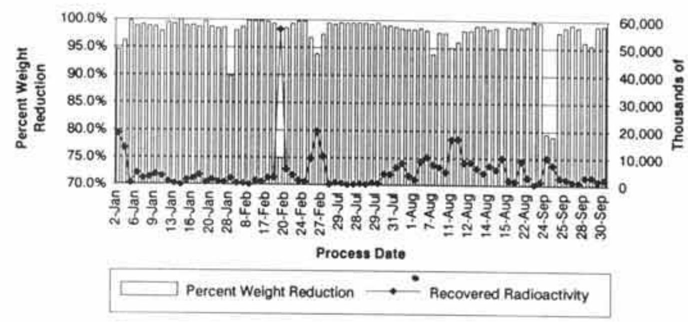


Fig. 3. Daily activity recovered and percent weight reduction, replotted.

Figure 4 shows activity recovered per process ton of feed material. Soil processed on February 19 is shown to have exceptionally elevated activity compared to other process days. Figure 5 displays data previously presented in Figure 4, again deleting data for February 19, and replotted to an expanded scale for increased clarity. Radioactivity per process ton ranged from less than 50 to nearly 500 kiloBecquerels.

Quality control sampling and independent confirmatory measurements performed by DNA verified that the Segmented Gate System is effective in processing contaminated JA soil for release for unrestricted use. Figure 6 shows the results TMA's of quality control sample analysis for the operational period of July 25 through September 30, 1992. Analysis was performed in an on-site count laboratory at JA using a shielded FIDLER calibrated with a narrow window around the 60 keV americium gamma coupled to an Eberline Model MS-2 Miniscalar. All results are well below DNA's clean soil release criteria of 500 Becquerels per kilogram.

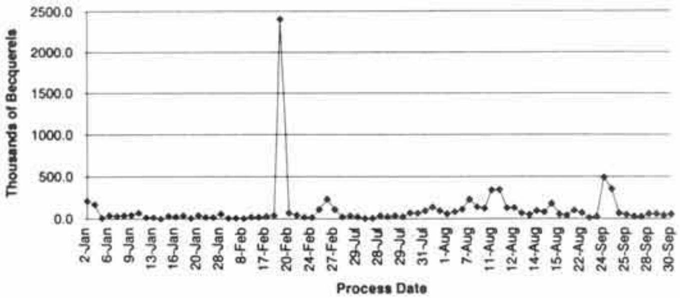


Fig. 4. Activity recovered per process ton.

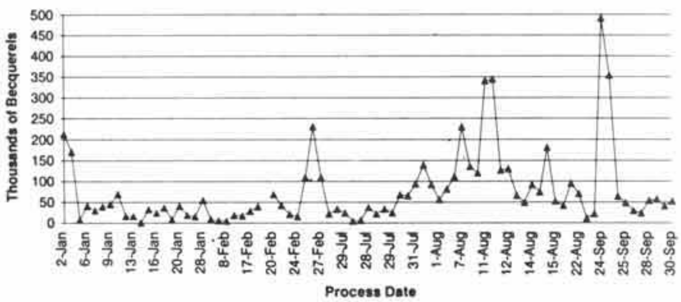


Fig. 5. Activity recovered per process ton, replotted.

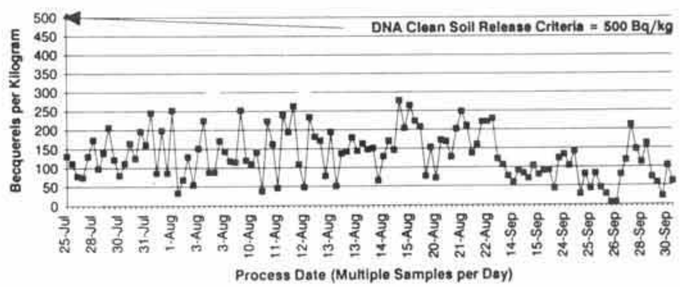


Fig. 6. Results of "Clean" pile quality control sample analysis, 25 July-30 September, 1992.

## REFERENCES


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