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**Remedial Actions of Nuclear Safety Shot Sites:
Double Tracks and Clean Slates**

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ABSTRACT

Remedial actions of plutonium (Pu) -contaminated soils are in the preliminary stages of development at the Nevada Test Site (NTS). Interim clean-up actions were completed at the Double Tracks and Clean Slate 1 safety shot sites in 1996 and 1997, respectively. Soil at both sites, with a total transuranic activity greater than 200 picoCuries per gram (pCi/g), was excavated and shipped to the NTS for disposal.

Characterization and assessment efforts were initiated at the Double Tracks site in 1995, and the clean-up of this site as an interim action was completed in 1996. Clean-up of this site consisted of taking site-specific data and applying rationale for dose and risk calculations in selecting parameter values for the interim corrective action level. The remediation process included excavating and stockpiling the contaminated soil and loading the soil into supersacks with approximately 1,513 cubic meters (m^3) (53,500 cubic feet [ft^3]) being shipped to the NTS for disposal. In 1997, remediation began on the Clean Slate 1 site on which characterization had already been completed using a very similar approach; however, the site incorporated lessons learned, cost efficiencies, and significant improvements to the process. This paper focuses on those factors and the progress that has been made in cleaning up the sites. The application of a technically reasonable remediation method, as well as the cost factors that supported transport and disposal of the low-level waste in bulk are discussed.

INTRODUCTION

Remedial actions of plutonium (Pu) -contaminated soils are in the preliminary stages of development at the Nevada Test Site (NTS). Interim clean-up actions were completed at the Double Tracks and Clean Slate 1 safety shot sites in 1996 and 1997, respectively. Soil at both sites, with a total transuranic activity greater than 200 picoCuries per gram (pCi/g), was excavated and shipped to the NTS for disposal.

The Operation Roller Coaster safety shots were a series of four non-nuclear destruction experiments conducted on nuclear devices detonated on the Nellis Air Force Range in 1963. These four tests, conducted at Double Tracks and Clean Slates I, II, and III, were part of a joint exercise among the United Kingdom, the U.S. Department of Defense (DOE), and the U.S. Atomic Energy Commission (now the DOE). The contamination at these sites consisted primarily of soils containing plutonium (Pu) and depleted uranium materials. The sites are located approximately 209 kilometers (km) (130 miles) northwest of Las Vegas, Nevada, (see Figure 1).

Clean Slates I, II, and III are identified in the Federal Facility Agreement and Consent Order (FFACO) for the NTS (1). In anticipation of the FFACO being signed, an interim corrective action was conducted to evaluate the technical and economic feasibility of remediating a soil corrective action unit. In April 1994, Double Tracks was selected for the initial interim corrective action based on its relatively small size and similarity in site characteristics to other Roller Coaster sites.

STAKEHOLDER INVOLVEMENT

The process began by following formal National Environmental Policy Act requirements for an Environmental Assessment to identify and address the concerns of the public regarding the remedial actions at the Double Tracks site. Public meetings were held with the local communities as well as county officials and regulatory representatives. Their major concern was the transportation of low-level waste through their communities and emergency response capabilities. Once these concerns were addressed through additional meetings and training, the public was supportive in pursuing the remedial action of the site. Building confidence with stakeholders was a key element for completing these projects.

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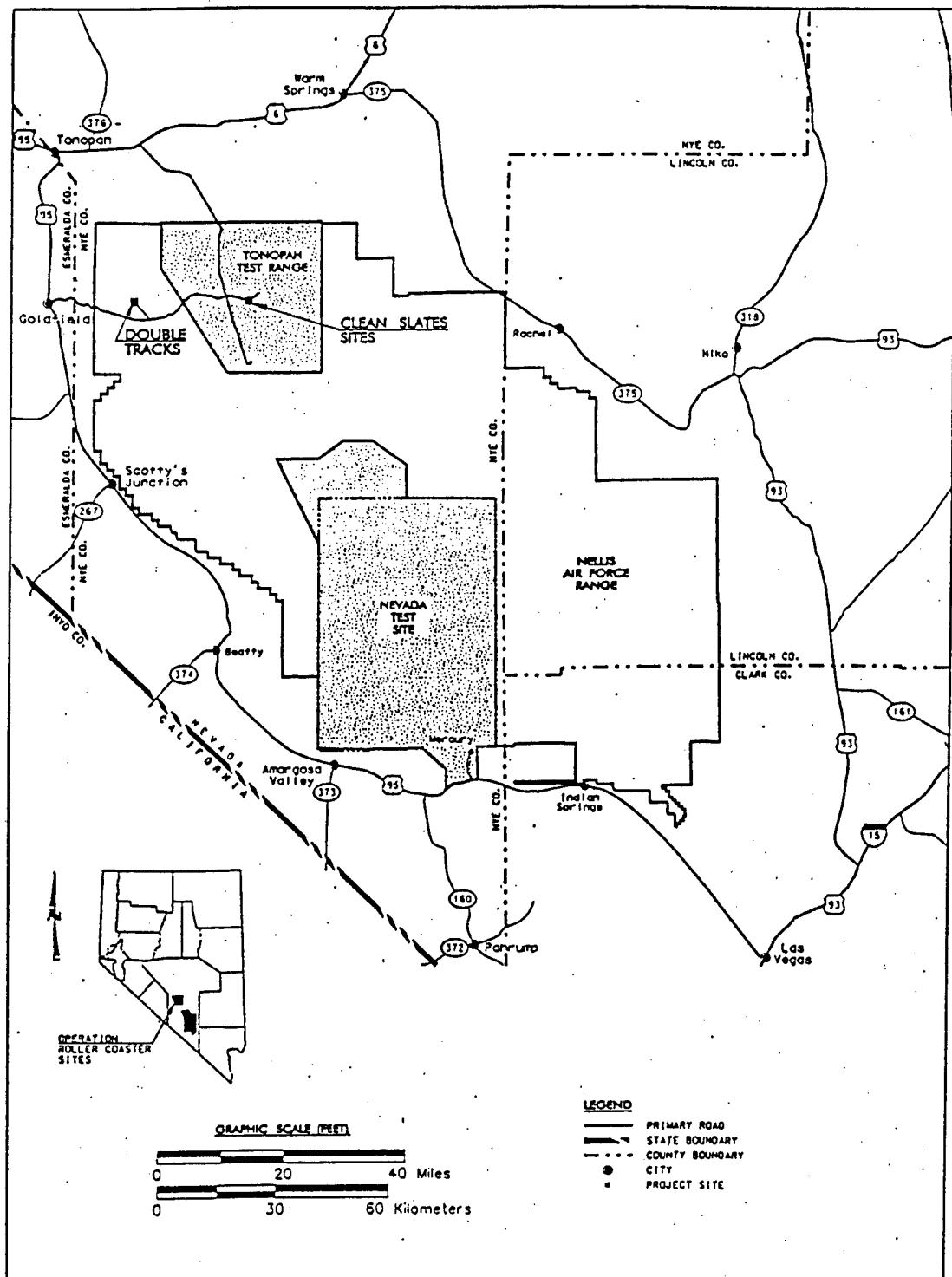


Figure 1 Operation Roller Coaster Sites - General Location Map

The Double Tracks site was located on an active portion of the Nellis Air Force bombing range. Very intricate logistics were required to successfully complete the field operations. Numerous meetings were held with the Air Force officials regarding the necessary scheduling, security, housing, lodging, and overall project implementation.

SITE CHARACTERIZATION

The objectives of characterization activities included determining the nature and extent of contamination, estimating the volume of contaminated soil and debris, and adequately characterizing the soil to meet disposal criteria. Historical data consisted primarily of aerial americium-241 (Am-241) gamma surveys and soil sample analyses. The review of this data revealed two major inadequacies. Soil sample analyses gave soil concentration numbers for very small areas within the site with variations approaching four orders of magnitude for adjacent sites. Because of this variation in sample results and the very large number of samples needed to produce an accurate soil activity contour map of the site, this traditional radiological characterization technique was discarded for these sites. Soil activity contour maps were produced from the aerial data, but the resolution was poor. Because of the 30-meter (100-foot) altitude at which the aerial survey was flown and the 43-meter (140-foot) spacing of flight lines, the detector field of view was very large (over 1,000 square meters [m^2]). The ground zero areas with high activity caused an overestimation of the actual contaminated area when this data was mapped (⁴). This did not meet the criteria of Radiation Protection of the Public and the Environment, DOE Order 5400.5, Chapter IV, which states, "Residual concentrations of radioactive material in soil are defined as those in excess of background concentrations averaged over an area of 100 square meters (m^2)."

To provide the data quality necessary for site characterization over large areas, it was decided to install the aerial-based sodium iodide (NaI) detector system into a ground vehicle. The new system was nicknamed the Kiwi (flightless bird). The Kiwi provides many advantages for characterization of large sites. Using a combination of one-second counting intervals for Am-241 gamma activity and a differential Global Positioning System unit, the Kiwi measures a footprint area of approximately 10 m^2 and has a vehicle position uncertainty of less than 1 meter as it travels at 2.2 meters per second (m/s) (5 miles per hour [mph]). The data is used for two purposes. A map showing the Kiwi's "flight" lines documents coverage of the entire site for soil activity measurements. A second map with the soil activity contour overlays is used to establish the boundaries of the clean-up area as well as assist in disposal volume estimates. After excavation is completed, the Kiwi is used to provide real-time verification that the clean-up criteria has been met and provides accurate location information on "hot-spots" requiring additional excavation while the equipment is still mobilized.

To adequately characterize the soil for low-level waste disposal criteria, a limited number of soil samples were required. These were taken within the soil activity contours slated for excavation. The analysis was primarily for Resource Conservation and Recovery Act (RCRA) constituents and characteristics tests with limited radiological analysis.

CLEAN-UP CRITERIA

A radiological dose assessment was conducted for these sites using the DOE residual radioactive material guideline (RESRAD) computer code. For hypothetical individuals who may work or reside at the sites, the calculated dose does not exceed the limits established in Radiation Protection of the Public and the Environment, DOE Order 5400.5 for protection of members of the public and the environment. The RESRAD model was run assuming a resident rancher scenario. A soil activity concentration of 200 pCi/g was conservatively selected assuming that all areas of the Double Tracks and Clean Slate 1 sites with Pu-239/240 concentrations in soil exceeding 200 pCi/g would be remediated (⁵). The estimated dose for the areas remediated to below 200 pCi/g is 47 millirems per year for the resident rancher scenario.

OPERATIONAL ASPECTS

Inhalation of resuspended Pu is the primary dose pathway to workers. Numerous engineering controls were considered for the excavation equipment, but wetting the ground surface of the contaminated plume and the ground zero areas prior to beginning excavation was adopted as the best engineering control. Because the excavation equipment had air conditioning and only three units operated in close proximity to each other, the operators wore full-face respirators to keep doses as low as reasonably achievable (ALARA) without increasing other safety hazards. At Double Tracks only

water was used for wetting and some excavated areas showed little moisture penetration below the first 5 centimeters (cm) (2 inches [in]). At Clean Slate 1, a surfactant was mixed with the water to improve moisture penetration and the water was applied two days in advance instead of the previous day only. Additional water was applied, during the excavation and periodically, to the stockpiled soil at both sites.

Application of new technology for excavation was evaluated. Available technology included water sprays on equipment, modified pavement profilers, and laser guidance. A critical path analysis revealed, however, that the excavation phase of the project would have little impact to the overall schedule. The decision was made to use conventional construction equipment with skilled operators for the two sites. The performance using this equipment would provide the benchmark to assess future applications of technology. The contaminated soil at both sites was excavated in layers approximately 3.8 cm (1.5 in) thick using a motor grader. A 23.7-cubic meter (m^3) (31-cubic yard [yd^3]) paddle-wheel scraper picked up the soil windrowed by the motor grader and trammed it to the stockpile area. The soil was mounded into a stockpile with the assistance of a front-end loader (4,5).

At the Double Tracks site, preliminary radiological verification surveys of the excavated areas were conducted using a germanium (Ge) mast detector to determine if the 200 pCi/g clean-up level had been met. At Clean Slate 1, "hot-spot" surveys were conducted after areas were excavated using field instruments for detection of low-energy radiation (FIDLER) followed by random location surveys using the Ge mast detector. The use of the FIDLERs provided real-time information to the excavation crew and ensured that the final Kiwi verification survey would not identify additional areas requiring excavation.

A front-end loader was used to move soil from the stockpile to the feed hopper of the soil processing system. From the feed hopper, the soil was conveyed to a vibrating shaker screen where material with a diameter greater than 3.8 cm (1.5 in) (oversize) was removed (see Figure 2). The oversize was removed so that all soil loaded for transport would pass beneath a scree bar mounted 3.8 cm (1.5 in) above the conveyor belt. A NaI detector was mounted above the conveyor belt to measure the total activity in the soil. The scree bar ensured that a consistent 3.8-cm thickness of soil was maintained and evenly distributed on the conveyor to minimize counting error.

The NaI detector measured the total activity in each package shipped for disposal. The package activity information was needed to comply with U.S. Department of Transportation low-level waste shipping regulations and the NTS low-level waste acceptance criteria. The NaI detector system recorded the Am-241 gamma activity level from which the various Pu isotope activities were calculated based on the Pu-239/240:Am-241 ratio which had been measured during site characterization. In addition, historical documents provided isotopic percentages for the weapon's grade mix of Pu. At Double Tracks, the total transuranic activity ranged from 200 to 5000 pCi/g per package (supersack). At Clean Slate 1, the total activity per package (side-dump trailer) generally ranged from 1,100 pCi/g to 1,300 pCi/g, with a maximum activity of 1,590 pCi/g.

The front-end loader mixed the soil at the stockpile to achieve an optimal moisture content to minimize clogging in the hoppers of the soil-processing system. Additional mixing of the stockpile was also required at Double Tracks site to ensure that the project-specific 5,000-pCi/g upper limit per package was not exceeded. This limit had been negotiated with the NTS radiological waste acceptance program to obtain approval for using the NaI conveyor detector system and isotopic ratios to quantify waste packages. As another condition for NTS disposal, approximately 18.2 kilograms (kg) (40 pounds [lbs]) of bentonite was added to the each 0.85- m^3 (30- ft^3) supersack of soil to lower the moisture content and assure that free liquids would not occur in the supersack packages.

The contaminated soil from the Double Tracks site was loaded into supersacks constructed of woven polypropylene fabric with an inner 6-millimeter-thick polyethylene bag. Double bagging was an NTS disposal requirement for material suspected of containing more than 1 percent by weight of \leq 1 micron or more than 15 percent by weight of \leq 2 micron particulates. Documentation of the total radioactivity level and weight of each supersack was prepared by Bechtel Nevada waste control personnel and reviewed by an autonomous waste certification official. The intermodal transportainers used for shipping contained ten supersacks each.

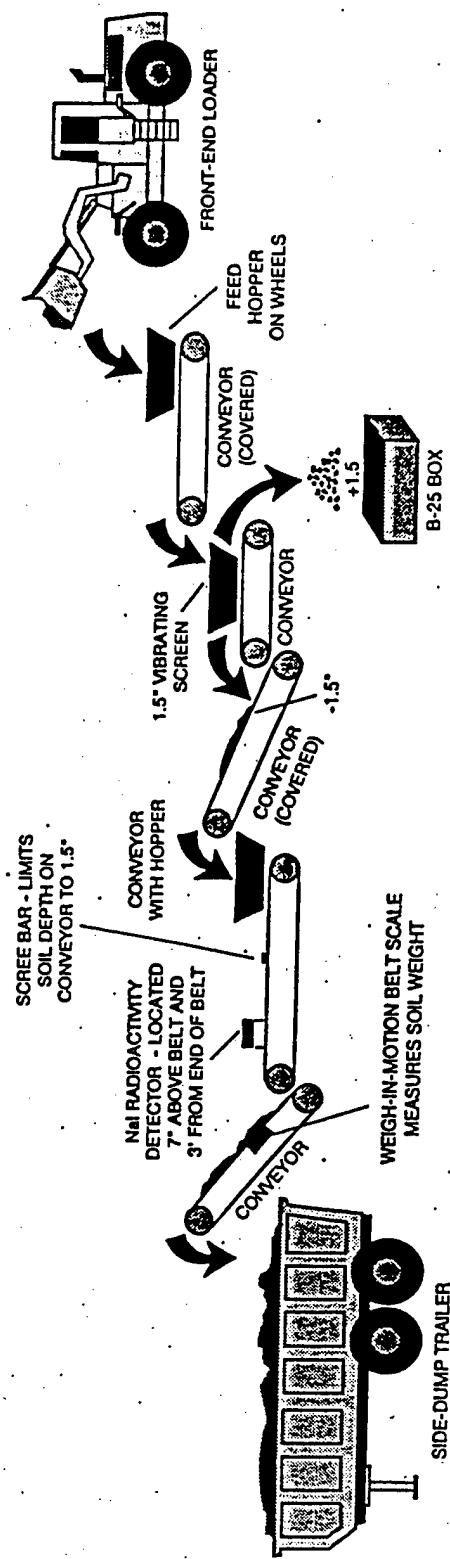


Figure 2 Soil Processing and Loading Schematic

This method of packaging was slow and labor intensive. A crew of 15 personnel working inside the exclusion zone (EZ) were needed for the packaging operation. Four personnel needed respiratory protection (full-face respirators) - the front-end loader operator, an equipment operator stationed where the soil was spread evenly across the conveyor belt by the scree bar, and two laborers located at the soil discharge spout to fill the supersacks. The two laborers at the discharge spout prepared the supersack for filling, monitored the bag-filling progress, and stopped the soil discharge when a digital readout scale indicated that the capacity of the bag had been reached. After filling, the top was closed, secured with a seal, and moved from the fill area using a fork-lift. An average of only 81.2 m³ (2868 ft³) of contaminated soil could be packaged and prepared for shipping in a 10-hour workday.

A number of significant changes occurred in the waste-packaging and disposal process between projects. Based on operational lessons learned, bulk packaging, transport, and disposal were required to remediate Clean Slates 1 safely and efficiently. Changes in the waste acceptance approval process and the opening of a bulk disposal cell at the NTS reduced packaging and transport requirements. The credibility established with stakeholders from previous meetings allowed acceptance of bulk transport without the use of intermodal transportainers.

The contaminated soil at Clean Slate 1 was packaged and shipped as bulk material. Soil was loaded into side-dump trailers lined with 18- to 20-millimeter thickness polypropylene liners (nicknamed burrito wrappers) that matched the dimensions of trailers. The flaps of the liner overlapped so that the wrapper completely enclosed the soil. Once the trailer had been filled and the wrapper closed, the trailer was covered with a tarp. The same soil processing conveyor system that was used at Double Tracks was used at Clean Slate 1. The only change was that an additional conveyor with a digital weigh-in-motion belt scale was used to load the soil into the transport trailers. Using this method, an average of 178.4 m³ (6300 ft³) of soil was packaged and shipped in a 10-hour workday.

A total of only nine personnel were required in the EZ for the packaging operation and only two personnel needed respiratory protection - the front-end loader operator and the equipment operator stationed by the scree bar.

TRANSPORTATION

The Double Tracks soil was transported to the NTS Area 3 Radioactive Waste Management Site (RWMS) by a subcontract carrier. Each shipment consisted of two intermodal transportainer containers on a 48-ft flat-bed trailer with a total of 10 supersacks in each container. The average weight of soil shipped per trailer was 17,324 kg (38,200 lbs - approximately 478 ft³). The maximum net weight per trailer was 18,141 kg (40,000 lbs). Five trucks (ten sealands) per day transported soil from the Double Tracks site to the NTS.

At Clean Slate 1, efficiencies in transportation were achieved using the side-dump trailers provided by the subcontract carrier (the same carrier was used for Double Tracks and Clean Slate 1). The three-axel trailer pulled by a four-axel tractor was permitted for a gross vehicle weight of 42,177 kg (93,000 lbs) which allowed shipment of up to 25,397 kg (56,000 lbs) of soil per trip, a 7,256 kg (16,000 lbs - approximately 200 ft³) improvement over the Double Tracks shipments. Nine trucks per day transported soil from Clean Slate 1 to the NTS.

DISPOSAL

The soil from both sites was disposed at the NTS Area 3 RWMS. At the disposal site, the Double Tracks supersacks were removed from the intermodal transportainer containers using boom fork-lifts. They were then placed on the ground, inspected, and stacked in the disposal pit. This resulted in double handling of the bag. This process was time consuming and required a crew of five in the disposal cell.

The soil from Clean Slate 1 was disposed in a dedicated bulk disposal crater within the Area 3 RWMS. Emptying the trailer was accomplished within a few minutes. The trailer was driven into the disposal crater, directed to the discharge point, and the side-dump trailer rotated using the hydraulic system of the tractor/trailer rig to discharge the load. Once the load has been discharged, the truck and trailer could exit the crater immediately. This required a crew of two in the disposal crater.

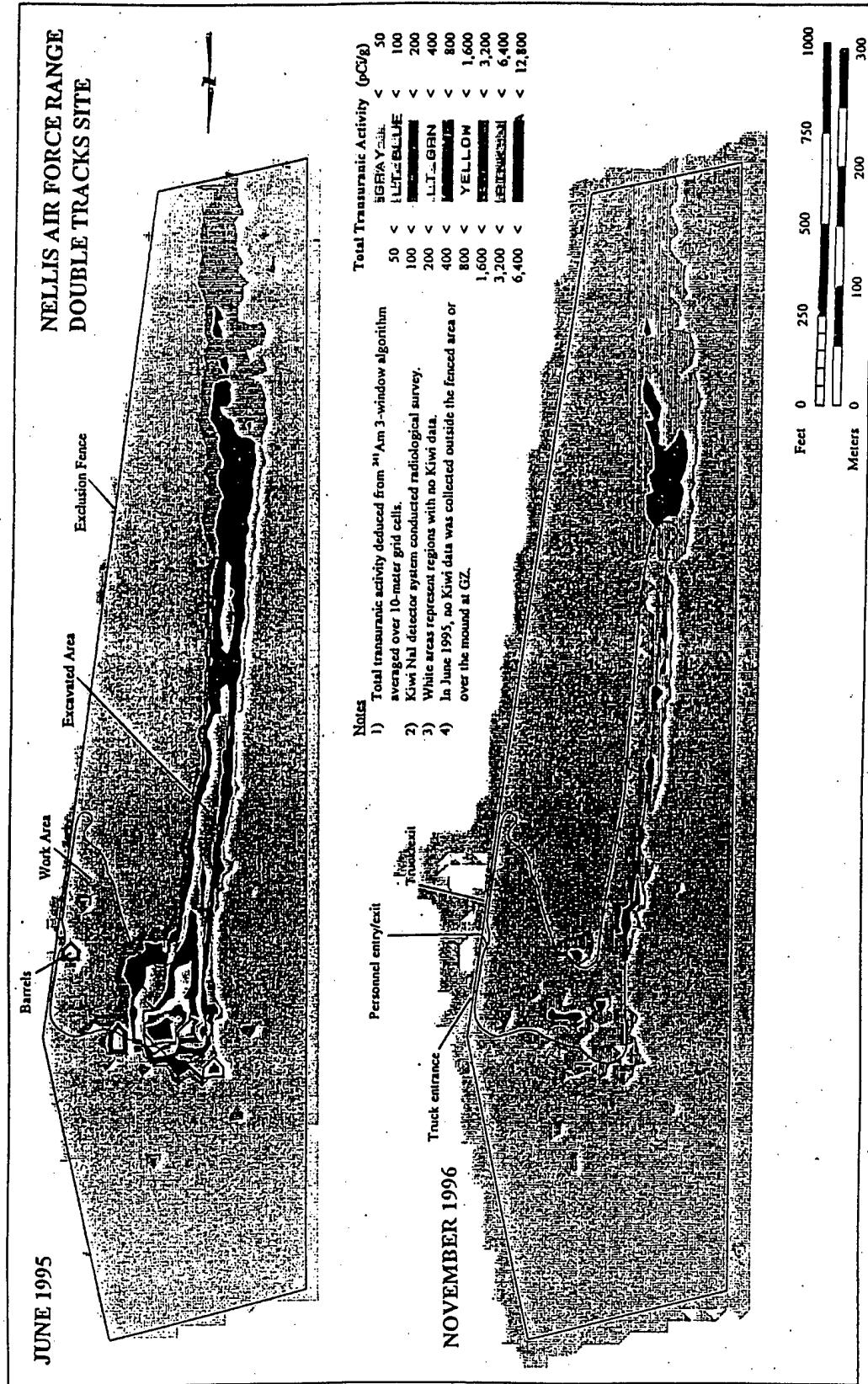
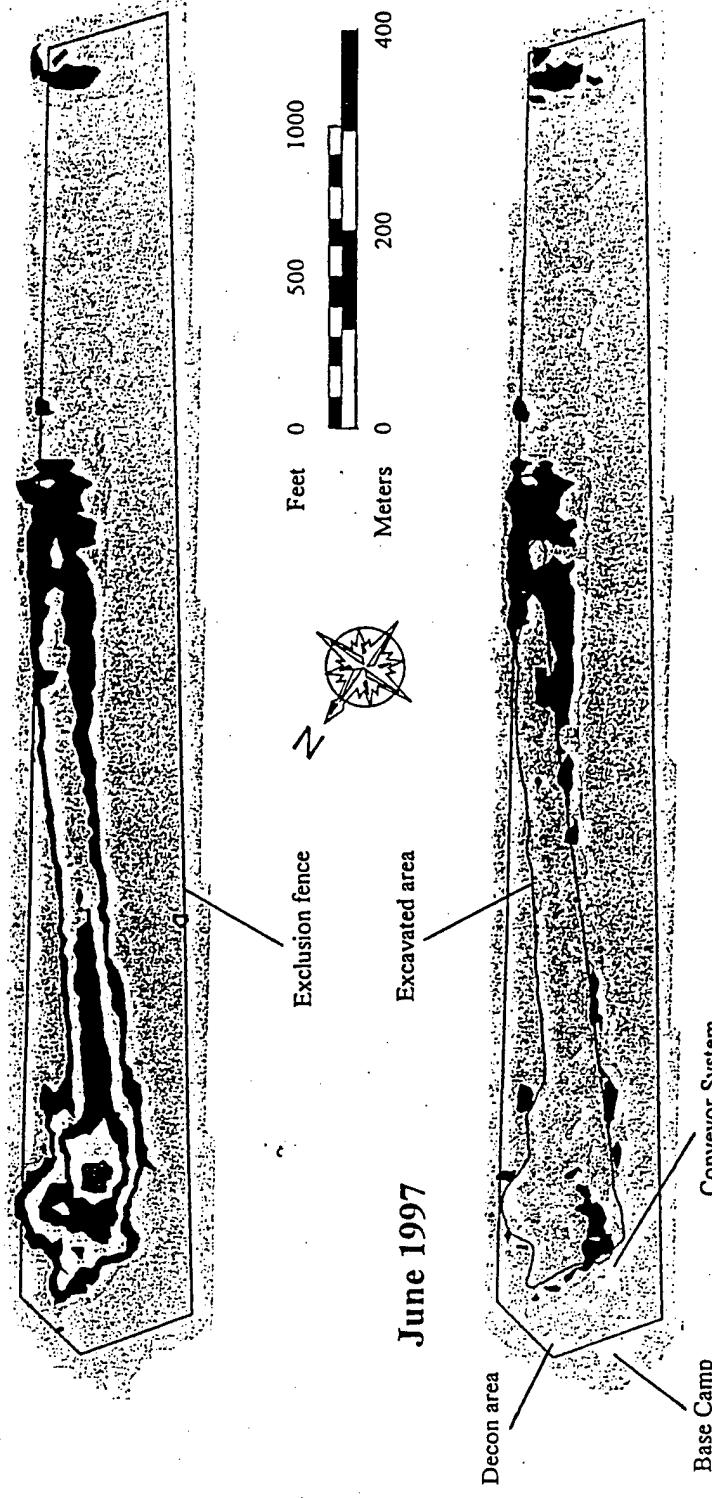


Figure 3 Double Tracks - Total Transuranic Activity

April 1996

Clean Slate 1 Site



Total Transuranic Activity Range (pCi/g)

GRAY	\leq	50
LT BLUE	\leq	100
100	<	200
LT GRN	\leq	400
200	<	800
400	<	1,600
800	<	3,200
1,600	<	6,400
PINK	\leq	

Notes:

1. Total transuranic activity deduced from ^{210}Am 3-window algorithm averaged over 10-m grid cells.
2. Radiological survey conducted with Kiwi NaI detector system.
3. White areas represent grid cells having no Kiwi data.

Figure 4 Clean Slate 1 - Total Transuranic Activity

VERIFICATION SURVEYS

The Kiwi surveyed each site to document that the corrective action objective of 200 pCi/g had been achieved. The entire fenced area of the sites was surveyed and the data evaluated and plotted before the excavation equipment was demobilized from the exclusion zone. Figures 3 and 4 are contour maps of the total transuranic activity before and after remediation at Double Tracks and Clean Slate 1, respectively.

COSTS

The cost per cubic foot to process, package, and transport Pu-contaminated soil was significantly reduced by packaging and transporting in bulk. This method resulted in fewer workers in the EZ and fewer workers wearing respiratory protection. There was less potential for heat stress and less potential radiation exposure. Approximately three times as much soil was processed and shipped at Clean Slate 1 in 22 days compared to 31 days at Double Tracks. Table 1 is a comparison of the two sites.

Table 1
Comparison of Double Tracks and Clean Slate 1 Sites

	Double Tracks	Clean Slate 1
Acres Remediated	2.5	9
Clean-up Level	200 pCi/g	200 pCi/g
Soil Volume Disposed	53,500 ft ³	146,400 ft ³
Estimated Activity Disposed	5.12 Curies	5.65 Curies
Estimated Grams of Pu Disposed	52.3	56
Average Activity per Disposal Package	2500 pCi/g	1100 pCi/g
Total Personnel in EZ	15	9
Personnel Wearing Respiratory Protection	4	2
Days to Complete Packaging and Disposal	31	22
Packaging and Loading Cost	\$36.46 /ft ³	\$12.80/ft ³
Transportation Cost	\$8.00 /ft ³	\$5.12 /ft ³
Total Project Cost	\$3,988,753	\$4,584,000

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