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Texas Instruments Incorporated
Attleboro, Massachusetts

Remediation
of the
Former Radioactive Waste Burial Site
(NRC License SNM-23)

Final Report

Prepared by

Creative Pollution Solutions, Inc.
September 1993

SECTION COPY

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TEXAS INSTRUMENTS INCORPORATED
FINAL REPORT: REMEDIATION OF THE FORMER RADIOACTIVE WASTE BURIAL SITE

License: SNM-23
Docket No: 70-33

Date: September 1993
Version: 1.0

1.0 BACKGROUND INFORMATION

1.1 Nuclear Operations

The Texas Instruments Incorporated (TI), Attleboro, Massachusetts site was owned and operated by Metals & Controls, Inc. (M & C) until 1959, at which time M & C merged with TI. The General Plate Division of M & C began processing nuclear materials in 1952, and between 1952 and 1959 fabricated uranium foils for reactor experiments and fuel components and complete reactor fuel cores for the U.S. Navy. Source material license D-549 was issued permitting acquisition and title to refined source material for use in the production of the uranium foils; and special nuclear materials license No. SNM-23 was issued, permitting acquisition and title to enriched uranium for fabrication of the fuel components and cores. After the merger in 1959, TI continued fabricating reactor fuel cores, for government research and production reactors in addition to the nuclear Navy program. Also, source materials (e.g., natural uranium and thorium) were used under the same programs. TI's involvement in the nuclear Navy business continued into 1966. The final chapter of TI's nuclear business involved the fabrication of High Flux Isotope Reactor fuels (HFIR). The HFIR project extended for approximately thirteen years between 1968 - 1981.

On-site burials of scrap materials contaminated with uranium were conducted at the Texas Instruments Incorporated site in accordance with 10 CFR 20.304. The former radioactive waste burial site was believed to have operated from approximately 1958 through 1961, however materials found during the 1992 excavation suggest the first burials may have occurred in the early 1950's.

Work with nuclear materials was gradually reduced beginning in 1968 and was terminated in 1974. The interior of the facility (buildings 3, 4 and 10) was decontaminated and released for unrestricted use by the Nuclear Regulatory Commission (NRC) in 1983.

1.2 Summary of Radiological Surveys

In 1982 and 1983, TI conducted two radiological surveys in and around the location of the former radioactive waste burial site. Both studies indicated that residual levels were within regulatory guidance established by the NRC, Option 1-4 of the Branch Technical Position (Federal Register v.46,n.205, 23 October, 1981, pg 52061-52063, "Disposal or On-Site Storage of Thorium or Uranium Wastes from past Operations.") The second study further recommended that the former burial site should remain intact and undisturbed as all contaminated material was buried and reasonably inaccessible.

A follow-up verification study by the NRC (1985) identified some "isolated" pockets of surface and sub-surface contamination. The Oak Ridge Associated Universities (ORAU) study[1] reiterated much of what was already known from the TI radiological surveys. Data from the ORAU study suggested that the majority of the residual radioactivity was associated with small fragments of metal and other scrap material discernable from the surrounding soil particles. Furthermore, most of the contamination was found within the first few feet of the surface. Radioactivity was not found to be migrating with the groundwater flow. The report concluded, however, that there were isolated pockets of surface and subsurface contamination that exceeded the limits allowed by the NRC under Option 1 of the Branch Technical Position (BTP). Option 1 prescribes levels acceptable for release with no restrictions. As a result of these findings, the ORAU study virtually eliminated the possibility of terminating the SNM license without some degree of remediation.

In the summer of 1992 additional surveys of the burial site were performed by Creative Pollution Solutions, Inc. (CPS), a radiological consulting firm, to better determine the levels of residual activity and the extent of contamination in preparation for remediation within the burial area.

The results of the ORAU survey along with the CPS survey results were the basis for estimating areas requiring remediation and projecting volumes of soil for disposition. Remediation of the burial area began on August 31, 1992.

Radiological surveys were performed to demonstrate that Option 1 of the BTP had been achieved. These surveys were initiated in November 1992. Following submittal of the results of these surveys, on-site verification surveys were performed by both the NRC and Oak Ridge Institute for Science and Education (ORISE).

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1 Radiological Survey of the Texas Instruments Site, Attleboro, Massachusetts, Final Report, January 1985, Oak Ridge Associated Universities, Report Number RSAP/ SMPB-8

This report describes the results of these surveys and demonstrates that the former radioactive waste burial site now satisfies the NRC guidelines for release for unrestricted use. These surveys are detailed in this report.

2.0 SITE DESCRIPTION

2.1 General Description

The Texas Instruments Incorporated, Attleboro, Massachusetts, site is located approximately 48 kilometers south of Boston on Route 123. The area of concern was the area between buildings 11 and 12, to the southwest of building 12 (see Figure 2.1).

The area of concern for remediation activities was believed to be within an area previously defined as the burial area (see Figure 2.2). This defined boundary covers an area of approximately 10,000 m^2. This was the area within which the burials described in section 1.1 of this report took place. The actual excavation covered an area of approximately 2500 to 3000 m^2.

The burials were believed to be at least 1.2 m deep and covered with a soil cap of unknown thickness. There is no indication that any liner material was used. The site was disturbed during construction of Building 12, and contaminated soil from the original burial trenches was apparently distributed over a larger area. For this reason, the area of concern was the larger burial area (approximately 10,000 m^2). This area was fairly level and clear of obstructions, with the exception of some landscaping details and a five foot wide concrete sidewalk located parallel and along the 170 North gridline. The area was bounded by a bog on the north northeast side (see Figure 2.2) and by buildings and paved areas for the remaining areas. For this report "burial area" refers to this larger area, and "burial site" refers to the smaller area requiring excavation.

The underground utilities between buildings 11 and 12 were of concern since excavation affected that area. The utilities in the area included a 8 inch gas line, three air lines, a 12 inch water main, a sewer main, a telephone cable, and a communication duct.

The site hydrogeology has been well documented by subsurface investigations initiated for concerns over non radiological groundwater contaminants elsewhere at the Attleboro site. The burial area is located at a groundwater flow divide and thus the hydraulic gradient is relatively flat. As a result of this condition the groundwater flow rates at this location are extremely slow. Further discussion of the hydrogeology and other water sampling are found in Appendix F.

2.2 Survey Findings

2.2.1 Background Levels and Baseline Concentrations

The ORAU survey reported background exposure rates and dose rates along with baseline radionuclide concentrations in soil and water for five locations, from the Attleboro area (but not on or near TI property). The reported exposure rates ranged from 10-11 μR/h, both at contact and at 1 meter above the surface. Dose rates measured at the surface ranged from 21 to 31 μrad/h.

Soil samples were obtained and analyzed isotopically. The soil concentration ranges for the radionuclides of interest were: U-235, <0.11 to <0.34 pCi/g (picocuries per gram); U-238, <0.78 to 2.74 pCi/g; Th-232, 0.54 to 1.23 pCi/g; and Ra-226, 0.41 to 0.84 pCi/g.

Ground water samples were analyzed for gross alpha and beta concentrations. These samples ranged from <0.32 to 0.59 pCi/l (picocuries per liter) and 1.42 to 3.07 pCi/l, respectively.

These levels and concentrations are typical of those normally occurring in nature. As part of the remedial activities CPS also collected a background soil sample from an area in Attleboro (but not on or near TI property). This sample was submitted for alpha spectrographic analysis. Concentrations of radionuclides in this background soil sample were: U-235 - 0.025 pCi/g, U-238 - 0.7 pCi/g and U-234 - 0.7 pCi/g .

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2.2.2 *Burial Area Findings -- ORAU Survey (1984)*

During the ORAU survey, direct radiation levels were measured at grid line intersections throughout the burial area (see Figure 2.3). The gamma exposure rates measured at 1 m above the surface ranged from 10 to 13 μR/h. At surface contact, the exposure rates ranged from 10 to 14 μR/h. In addition to the grid line measurements ORAU also identified numerous small areas with slightly elevated surface radiation levels. Contact gamma exposure rates ranged from 16 to 200 μR/h.

Surface soil samples were taken at alternate grid line intersections. These samples contained U-235 and U-238 soil concentrations ranging from <0.11 to 8.15 pCi/g and <0.38 to 44.9 pCi/g respectively. The highest value of U-235 and U-238 were identified at locations 235N x 165E and 165N x 125E respectively.

Surface soil samples were also taken in the areas identified as having elevated contact radiation levels. Concentrations of U-235 ranged from <1.78 to 590 pCi/g. The maximum level was in the sample collected at 185N x 149E. Concentrations of U-238 ranged from <46.6 to 887 pCi/g. The maximum level was found in the sample collected at 154N x 111E.

Radionuclide concentrations in subsurface soils were determined by taking samples from several boreholes within the burial area. Elevated concentrations of U-235 were determined ranging from 6.03 pCi/g to 20.6 pCi/g. Elevated concentrations of U-238 were determined ranging from 5.48 pCi/g to 680 pCi/g.

U-238
5.48
680
pC

U-235
6 - 20.6

Subsurface water samples were also taken from the boreholes. At seven locations outside of the burial area, gross alpha and beta concentrations were slightly elevated above baseline concentrations. Gross alpha concentrations ranged from 1.36 to 8.66 pCi/l, and gross beta concentrations ranged from 3.03 to 14.0 pCi/l. Additionally, water samples were collected from four locations in the burial area. The gross alpha concentrations ranged from 1.21 to 101 pCi/l and the gross beta concentrations ranged from 6.20 to 251 pCi/l. Though these levels appear to be elevated compared to other samples taken, the aqueous samples were not filtered prior to analysis. Subsequent sampling in 1993 provides a better characterization of groundwater quality. (see Appendix F)

2.2.3 *Burial Area Findings -- CPS Surveys (1992)*

The pre-excavation surveys performed by CPS, Inc. included a pilot study ("Radiological Characterization of Texas Instruments Incorporated", 7/92 Appendix G) and a subsurface sampling study ("Supplemental Subsurface soil sampling ...", 8/92 Appendix I). These surveys did not include walkover surveys, water sampling or ground water sampling since the ORAU study appeared to adequately cover these aspects of the survey.

In the pilot study a trenching scheme was used in an attempt to better determine the extent and depth of contamination. The trenches along with a few test pits were excavated in the areas shown in Figure 2.4. The concentration of total uranium in soil samples obtained during the pilot study, based on alpha screening results, ranged from 8.22 to 3349 pCi/g total uranium. Specifically the concentrations of total uranium in samples from trench A, B, C and D ranged from 9.06 to 44.88 pCi/g , 8.22 to 27.99 pCi/g , 20.34 to 84.66 pCi/g , and 14.18 to 3349 pCi/g respectively. The concentrations in samples from the test pits ranged from 11.24 to 117.63 pCi/g total uranium. The highest concentration identified was found in the "D trench" at 170N x 130E. This sample was found at approximately 3 - 4 feet depth. The high end concentrations were found in only a few samples.

The subsurface sampling survey included selected sample locations based on previous elevated samples and random sample locations selected within the burial area. The concentration of total uranium in soil, based on alpha screening results, ranged from 8 pCi/g total uranium to 227 pCi/g total uranium. Thirty one samples, from nineteen locations, were identified above the 30 pCi/g criteria however, only four showed concentrations greater than 200 pCi/g total uranium. The results of this subsurface soil sampling are detailed in Appendix I.

3.0 MANAGEMENT COMMITMENT AND PROJECT ORGANIZATION

3.1 Management Policy

From the outset of the project, TI established the goal to remediate the former radioactive waste burial site to the levels prescribed in Option 1 of the BTP. Originally, initial estimates, in the most optimistic scenario, projected the volume of soil and debris requiring disposal would not exceed 10,000 cubic feet. In the end, the actual volume of soil disposed proved to be approximately 63,000 cubic feet. Though the scope of the project expanded to this degree, TI remained committed to achieving Option 1 criteria within the burial area.

The health and safety procedures and policies implemented during the site operations took priority over all other site operations. A conservative approach was always exercised with regard to personnel and environmental monitoring. During the site excavation, twenty-four hour security was maintained to protect the public from the physical dangers of an excavation site. After the excavation process was complete and prior to backfilling, a temporary, six foot high chain link fence was erected to prevent unauthorized access to the burial area.

In order to provide positive public relations, TI proactively disseminated information to the media, public officials and the site workforce. Prior to the physical excavation TI issued a press release which explained exactly what contaminants were involved on the site and what measures were being taken to rectify the problem. As the time period over which the physical excavation took place was extended, TI issued periodic updates. The Environmental Department of TI routinely conducted management and supervisor briefings to update site personnel on the status of the project.

To assist in all of the above, TI established a Task Force which met on a weekly basis to oversee the physical actions on the site. The Task Force was a multi-disciplinary committee consisting of TI personnel from: Environmental Engineering, Health and Safety, Facilities, Transportation, Purchasing, Security, and Human Resources. The committee also included representatives from the two primary contractors on the site: Creative Pollution Solutions (CPS) and Franklin Environmental Services (FES). This task force assisted in making all decisions involving health and safety, remediation, human relations, waste disposal, transportation, and security.

3.2 Project Organization

TI contracted with two companies to perform the majority of the work on site. CPS was contracted for the radiological support for site operations. This included advising TI on areas requiring excavation as well as providing radiological health and safety support on site. FES was contracted for the excavation portion of the site work. In addition, FES provided all non-radiological health and safety support. Two other contractors for TI, Bartlett Nuclear and Guild Drilling, were asked to work under the supervision of CPS. The oversite of all site operations was the responsibility of TI. Figure 3.1 shows an organizational chart for the project.

During the backfill and restoration of the site, TI contracted with four additional contractors to perform backfilling of the excavated area, asphalt paving of the parking lot, restoration landscaping, and topographic surveying of the excavated area. The contractors used for these operations were Walsh Construction, Narrangansett Improvement, Old Farm Nurseries, and E. Otis Dyer, respectively.

4.0 REMEDIATION ACTIVITIES

4.1 Remediation Criteria

The purpose of the remediation of the burial area was to excavate contaminated soil to the extent necessary to achieve clean-up criteria prescribed in Option 1 of the BTP. For processed uranium (uranium without daughter products) the criteria for surface contamination or contamination of soil in areas without use restriction are 35 pCi/g for depleted uranium and 30 pCi/g for enriched uranium. The acceptable exposure rate at one meter above the surface as determined by the NRC is 10 μR/h above background or 21 μR/h total for this location (i.e., approximately 2 times background). This goal was to be achieved by using the approach outlined in the "Remediation Plan" in Appendix J.

4.2 Contaminants Identified

The primary contaminants of interest for the remediation of the burial area were: U-234, U-235 and U-238. Prior to remediation of the site, surveys indicated that the contaminated soil concentrations in the burial area were believed to be slightly greater then the Option 1 criteria of 30 pCi/g total uranium. There was some indication that some of the metal debris in the burial area was contaminated to a greater extent than the soil.

While a few areas were found to have elevated levels of Thorium-232 it was determined that elevated thorium levels were associated with elevated uranium levels. Remediation controlled on the basis of uranium exclusively, resulted in a proportional reduction of thorium to below its acceptable levels and therefore thorium was not of significant concern. For this reason the focus of the remediation was on the level of total uranium activity in soil.

4.3 Previous Radiological Surveys

Previous radiological surveys included surveys performed by TI, ORAU, and CPS. These surveys were performed between 1982 and 1992. The surveys were used to determine the extent and depth of contamination within the burial area. These surveys indicated that the major area of contamination was between 160N - 190N x 110E - 140E. Some of the initial survey data provided by ORAU indicated that isolated debris might be more of a problem than the surrounding soils.

4.4 Chronology of Site Operations

This section outlines the chronology of site operations involved in the remediation of the former radioactive waste burial site at TI. The operations described below took place between July 1992 and September 1993. Figure 4.1 shows a timeline of the entire process.

4.4.1 Pilot Study

In July, 1992 TI retained CPS to perform a pilot study to better determine the extent of the contaminants within the burial area. A series of parallel trenches were excavated. The trenches were approximately 30 meters long and 2-3 feet deep. Composite samples were taken from the trenches.

Soil samples were analyzed using a gross alpha screening method to allow for rapid field assessment of the contaminants (see Appendix C). Four composite samples were sent to a certified laboratory for analysis by both alpha and gamma spectroscopy. A correlation was established between the gross alpha screening method and the alpha spectroscopy data. The gross alpha screening was also shown to have very good correlation with gamma spectroscopy data (see Appendix C). Once characterized, isotopic information was no longer necessary for comparison with the total uranium criteria. The results of the pilot survey can be found in Appendix G.

During the pilot study, the health and safety requirements of the site included: level C protection (full face respirators and tyvek suits) within the exclusion zone (see Figure 4.2), Breathing Zone Air (BZA) sampling, personal Thermoluminescent Dosimeters (TLDs), and Area Air (AA) sampling. This level of protection was selected as a conservative measure. For the actual remediation of the site, the level of protection was downgraded to level D (no respiratory protection).

The pilot study successfully identified one highly elevated sample. This sample was obtained at a depth of approximately 4-5 feet. One conclusion from the pilot excavation was that the contaminants may have been deeper than initially expected.

4.4.2 *Initial Remediation Estimates*

Initial remediation estimates were provided based on the limited information available from the ORAU survey and the CPS pilot study. The remediation option report, as provided in Appendix H, presented several options ranging from further characterization to the removal of a limited number of elevated locations. In the most optimistic scenario, it was estimated that the remediation would generate approximately 6,000 ft^3 of soil and debris for disposal. On the conservative side, the remediation options presented indicated volumes in excess of 30,400 ft^3.

After review of radiological characteristics, debris content, anticipated volumes, modes of transportation, and financial objectives, available disposal options were evaluated. Based on these criterion, the most viable disposal option was determined to be EnviroCare of Utah. This decision was facilitated by the sites ability to handle uranium contaminated materials and to receive bulk rail shipments.

Due to the large variation in the volume estimates additional subsurface sampling was performed to aid in the selection of the appropriate remediation option.

4.4.3 Pre Excavation Survey

With the identification of contamination at a depth greater than one meter, identified in the CPS pilot study, further selected split spoon samples were taken. The sampling protocol for this exercise was to sample the burial area to a greater depth and over a larger area than in the pilot study. This survey was designed in an attempt to bound the extent of the contamination.

This survey focused specific attention in the area of 160N - 190N x 110E - 140E due to the results of the CPS pilot study and the ORAU survey. Exclusive of this sampling, random samples were also collected within the larger defined burial area.

The results of this survey indicated contamination, at concentrations greater than 30 pCi/g of total uranium, was not limited to isolated locations. Based upon these results, revised estimates for remediation were generated.

4.4.4 Revised Remediation Estimates

After the pre-excavation survey CPS provided revised remediation estimates incorporating the additional subsurface sampling results. These estimates concluded that larger areas might require remediation.

A remediation plan was developed to minimize total volumes. The remediation plan outlined a two phase approach. The first phase was to remediate isolated elevated locations. The second phase was to excavate remaining areas identified in the plan for removal of debris and disposition of materials. This plan (Appendix J) was submitted and approved by the NRC on August 26, 1992, as Amendment No. 16 to License No. SNM-23 (Appendix K).

4.4.5 Initial Excavation

The initial excavation of the burial area started on August 31, 1992. Initially, the excavation was performed using a small backhoe. Excavated materials were transferred directly to a front end loader for transport to a mechanical screener to separate potentially contaminated debris and aggregate from the soils. GM monitoring and alpha screening techniques were employed to determine extent of excavation and disposition of soils. The sampling method is included within Appendix C.

The excavation began at 170N x 130E, the location where the most elevated sample had been previously identified. The first day of excavation identified a large pocket of debris at a depth of approximately 4 - 6 feet. Some of the debris indicated surface readings with a pancake GM detector of greater than 20,000 counts per minute (cpm). The surrounding soil had concentrations ranging from 100 pCi/g to > 5000 pCi/g total uranium based on gross alpha screening results.

The debris consisted of laboratory bottles, graphite crucibles, extruded uranium/ zirconium tubes, mounted uranium samples, 55 gallon drums, partial mock fuel elements, metal fines, uranium ingots, ductwork, uranium/aluminum plates, etc. Some of the debris could be directly associated with contract work performed under the direction of the Schenectedy Naval Reactor Office.

Due to the volume of debris excavated, five specimens were assayed to determine isotopic enrichments. These specimens were determined to have either natural or depleted abundancies of U-235. This assay information was later used for determining activities for shipment and is provided in Appendix B, Attachment 3.

The volume of debris and levels of contamination were greater than anticipated. These findings dictated an adjustment in the approach to remediation.

4.4.6 Adjustment in approach to remediation

Since the levels of soil contamination and debris were higher than expected, an adjustment in the remediation approach was implemented. This adjustment would allow for the separation of highly contaminated soil / debris from soils with moderate levels of contamination (between 30 pCi/g and 500 pCi/g), and soils which may be suitable for backfill.

As of September 10, 1992, the total volume of contaminated soil / debris staged for disposal was approximately 10,000 ft^3. The excavation continued on the south side of the burial area at 160N - 165N x 135E - 150E. It appeared that a trench of contaminated material exhibiting elevated levels of radioactivity, easily identifiable by both radiation levels and a characteristic dark gray color, cut diagonally through these grid points. This trench was at a depth of approximately 4 to 6 feet. In many areas the contaminated soils extended approximately 1 to 2 feet below existing groundwater elevations.

Field observations indicated that the contamination did not extend far below the ground water levels. Since the volume of wet soils was relatively small, and pumping to locations outside the excavation presented regulatory obstacles, no mechanical dewatering was performed. Rather, the wet soils were staged and allowed to drain back into the excavation prior to further processing.

As the excavation proceeded the increased volumes mandated a change in the methods for processing and staging soils. On September 15, 1992 larger excavation equipment was brought on site in order to remove identified volumes more efficiently. An additional mechanical screener was brought on site to facilitate soil processing. Rather than attempting to stage all soils in roll-off containers, soils were staged in piles within the exclusion zone. Wet soils were staged near the excavated area as previously discussed. Even after air drying some of the wet soils required stabilization prior to ultimate disposition.

Shipment of contaminated soils for disposal to EnviroCare of Utah began in early October of 1992. The higher activity soil / debris was packaged in B-25 boxes and loaded on rail cars for shipment. The remaining soils were acceptable in bulk load form and therefore were loaded directly in rail cars for shipment (See Appendix B).

On September 26, 1992, the excavation of the north side of the burial area was initiated. The remediation approach was modified by first excavating the top 1 to 2 feet of soil, which was usually determined to be below BTP Option 1 criteria, then excavating the remaining area to acceptable levels. Samples were taken from the floor of the excavation, prior to the infiltration of ground water and rain water into the area. These samples were used as part of a site survey subsequently submitted to the NRC. This survey is included in Appendix E.

On November 28, 1992, TI submitted a survey of the burial area to the NRC. This survey consisted of alpha screening results for soil samples from the floor of the excavated area and a gamma exposure rate walkover survey for the remaining areas within the defined burial area. Figure 4.3 shows the extent of the excavated area at this point.

4.4.7 Initial NRC / ORISE Site Visit

The NRC and ORISE arrived at TI on December 15, 1992, to perform a verification survey of the burial area. ORISE performed a gamma exposure rate walkover survey in the burial area and along the bounds of the excavated area. With the assistance of CPS, ORISE took a limited number of soil samples from the floor of the excavation (through several feet of standing water) and from the overburden piles. At the time of the site visit, the NRC raised concerns with levels found on some walls of the excavation. NRC recommended that the bounds of the excavation be extended in certain areas and that the extent of the excavation be verified.

4.4.8 Extending the Bounds of the Excavation

From December 15, 1992 to January 5, 1993, the bounds of the excavation were extended in accordance with the NRC recommendations. The bounds of the excavation were extended in locations where the NaI readings, on the accessible portion of the wall, were greater than two times background. Subsurface split spoon soil samples were taken to demonstrate that the excavation had been appropriately extended. As shown in Figure 4.4, the excavation extended beyond the original exclusion zone and into the building 11 parking lot.

The excavation in this area was in close proximity to a 12 inch water main providing the only service for fire protection and all other uses within two buildings. In order to prevent freezing or physical damage to the exposed water main, this area was immediately backfilled after removal of contaminated soils and confirmatory sampling. Prior to the backfilling, TI notified the NRC of its intent and obtained their concurrence.

On January 8 1993, a revised final survey report was submitted to the NRC.

4.4.9 Scraping the Floor of the Excavation

The NRC reviewed the TI "Revised Final Survey Report", dated January 8, 1993 along with the ORISE verification survey results of December 15, 1992, and recommended that TI address two elevated locations on the floor of the excavated area. To address these locations it was necessary to dewater the excavated area.

Dewatering involved pumping the water out of the excavated area, filtering the water and discharging the effluent. Discussions between TI and the NRC concerning the dewatering operation concluded that this operation, and its subsequent discharge, was consistent with the existing requirements of TIs license. In order to meet Environmental Protection Agency (EPA) requirements, TI obtained a National Pollution Discharge Elimination System (NPDES) permit exclusion for the discharge of the effluent. Approval from the EPA was received on May 3, 1993. Discussion of radiological aspects of the water pumped and site hydrogeology is found in Appendix F.

The pumping process began on May 14, 1993. Since there was continuous groundwater infiltration, the floor of the excavation was never completely dry however, continuous pumping allowed for access with excavation equipment. Pumping was concluded on June 9, 1993.

CPS performed a walkover survey within the excavated area to identify any areas greater than two times background on the NaI survey meter. In addition to the two locations identified in the NRC inspection report, several other isolated locations were identified during this walkover. In most cases, these isolated locations were due to a small amount of debris and were remediated by hand digging. The two locations identified by the NRC required more extensive scraping which was achieved through the use of conventional excavation equipment. The scraping in these regions involved excavation to depths ranging from 2 to 12 inches.

4.4.10 NRC survey

On June 2, 1993, the NRC conducted a site inspection. During the inspection the NRC performed a walkover survey within the excavated area. All areas within the excavated area were determined to be between 1 and 1.5 times background (using NaI survey meter) except for two locations (185N x 157E and 177.5N x 122E) which showed levels of 3 times background. These locations were remediated during the day of the NRC survey.

The NRC also performed a walkover with a Micro-R meter within the excavated area. The exposure rates at one meter above the floor of the excavation ranged from 11 μR/hr to 15 μR/hr.

The NRC obtained four soil samples from the areas scraped. The concentrations of these samples ranged from 16 pCi/g to 58 pCi/g based on gross alpha screening.

4.4.11 Topographical Survey

On June 3, 1993, prior to the backfilling operation, TI retained the services of E. Otis Dyer, a Registered Professional Engineer and Land Surveyor, to develop a topographical map of the excavation area and its environs. This map recorded the horizontal and vertical extent of the excavation at the point in time when all field work ceased as the project objectives had been achieved. This map is provided as a size "D" print located at the end of this report.

4.4.12 Backfilling

After the NRC inspection was complete, backfilling of the excavated area began. The overburden piles were used as backfill material. During the backfill operation CPS conducted quality assurance walkover surveys.

5.0 FINAL SURVEY

5.1 Introduction

The final survey was conducted to demonstrate that the criteria outlined in Option 1 of the BTP was achieved. It included three main components: **split spoon samples** taken around the perimeter of the excavated area, **soil samples** collected from the floor of the excavation, and a **walkover survey** which assessed exposure rates. These surveys were performed in accordance with the remediation plan.

This final survey report includes data collected during the post excavation survey report (November 28, 1992), the revised final survey (January 8, 1993), data collected after the final scraping of the floor of the area (June 3, 1993), and final walkover results after backfilling was completed in late June 1993. A description of the methodology and results from these surveys are included in Appendix E. A summary of the findings is included below.

5.2 Perimeter Split Spoon Sampling

The perimeter split spoon sampling demonstrated that the excavation addressed the appropriate areas. The split spoon sample locations are shown in Figure 5.1. The average concentration over the total depth of each borehole (0 to 6 feet) ranged from 7.0 to 27.7 pCi/g. The concentrations of individual split spoon samples ranged from 4 pCi/g to 37 pCi/g. These results are tabulated in Appendix E.

5.3 Surface soil sampling within the excavated area

Surface soil sampling of the floor of the excavation consisted of samples at each corner, and in the middle of each 10 meter x 10 meter grid cell. These locations are shown in Figure 5.2. The concentrations of the soil samples ranged from 4 pCi/g to 55 pCi/g. The 10 meter x 10 meter grid cell averages, within the excavated area, ranged from 18.2 pCi/g to 31.6 pCi/g. While two grid cells averaged slightly over the 30 pCi/g criteria, these averages are conservative by virtue of the analytical technique. As demonstrated in the alpha screening correlation in Appendix C and ORISE's independent analysis of split samples taken during the initial NRC / ORISE site visit, alpha screening results at concentrations less than 20 pCi/g are conservative. This conservatism is documented in correspondence between ORISE and NRC of January 25, 1993 included in Appendix K. Details of the surface soil sampling results are tabulated in Appendix E.

5.4 Walkover surveys of the Burial Area

After the backfilling operation was completed, and prior to landscaping, CPS conducted an extensive walkover survey of the burial area. Results of a near surface walkover survey, using a NaI survey meter, identified four locations in excess of one and one half times background. No areas were identified greater than two times background. Results of the one meter survey, at all 10 meter x 10 meter grid locations within the burial area, indicated results between one and one and one half times background. The results of these surveys are further discussed in Appendix E.

6.0 CONCLUSIONS

Between July 1992 and July 1993, the former radioactive waste burial site at TI was successfully remediated. The final volume of soil and debris requiring disposal was approximately 63,000 cubic feet. Radiological surveys conducted between November 1992 and July 1993 demonstrate that the remediation efforts were effective in reducing residual activity within the burial site to meet NRC Option 1 BTP criteria for release.

Figure 2.1
Map of Massachusetts and Attleboro Showing Location and Plan View of the Texas Instruments Site.

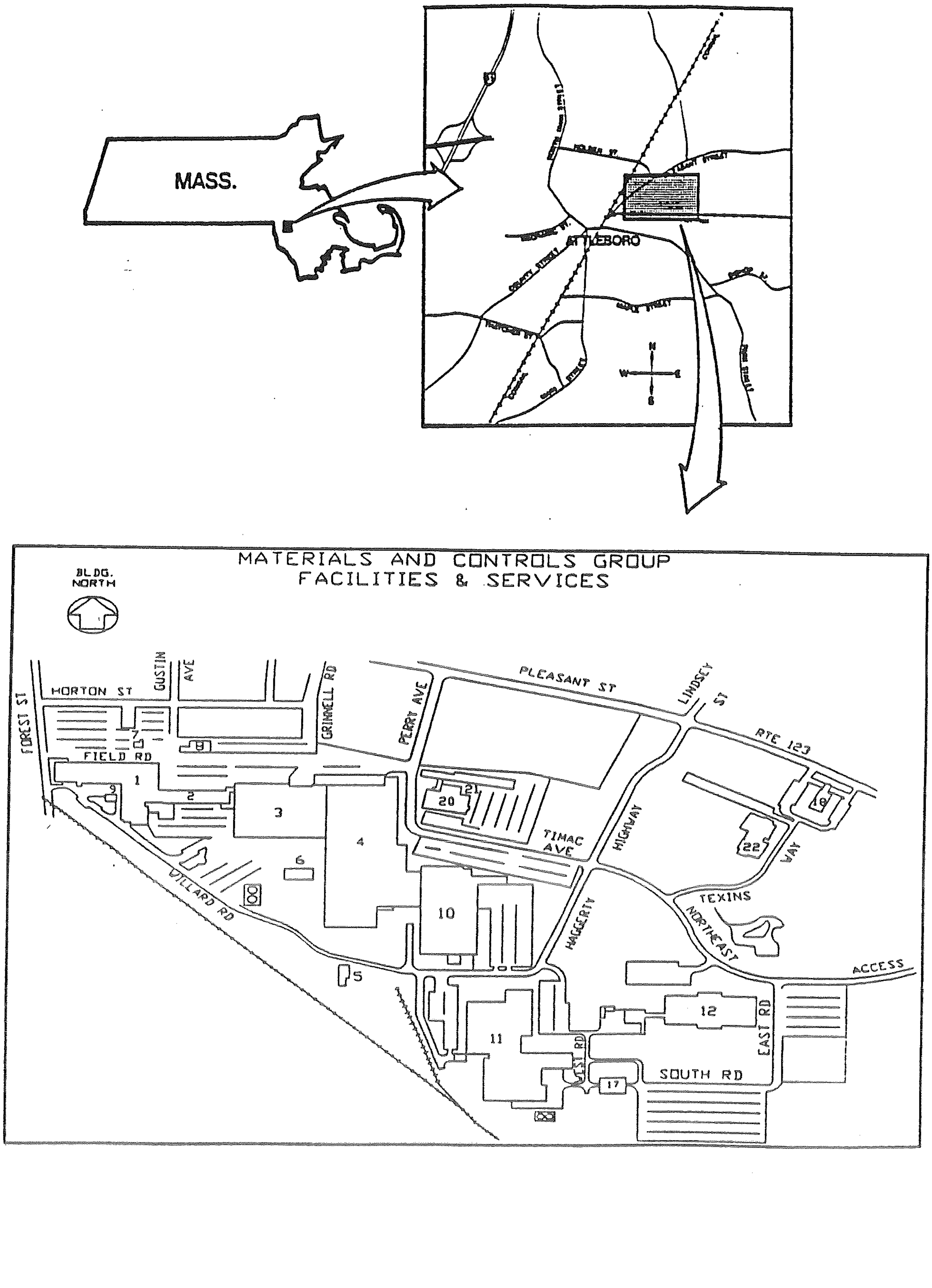


Figure 2.2
Defined Burial Area

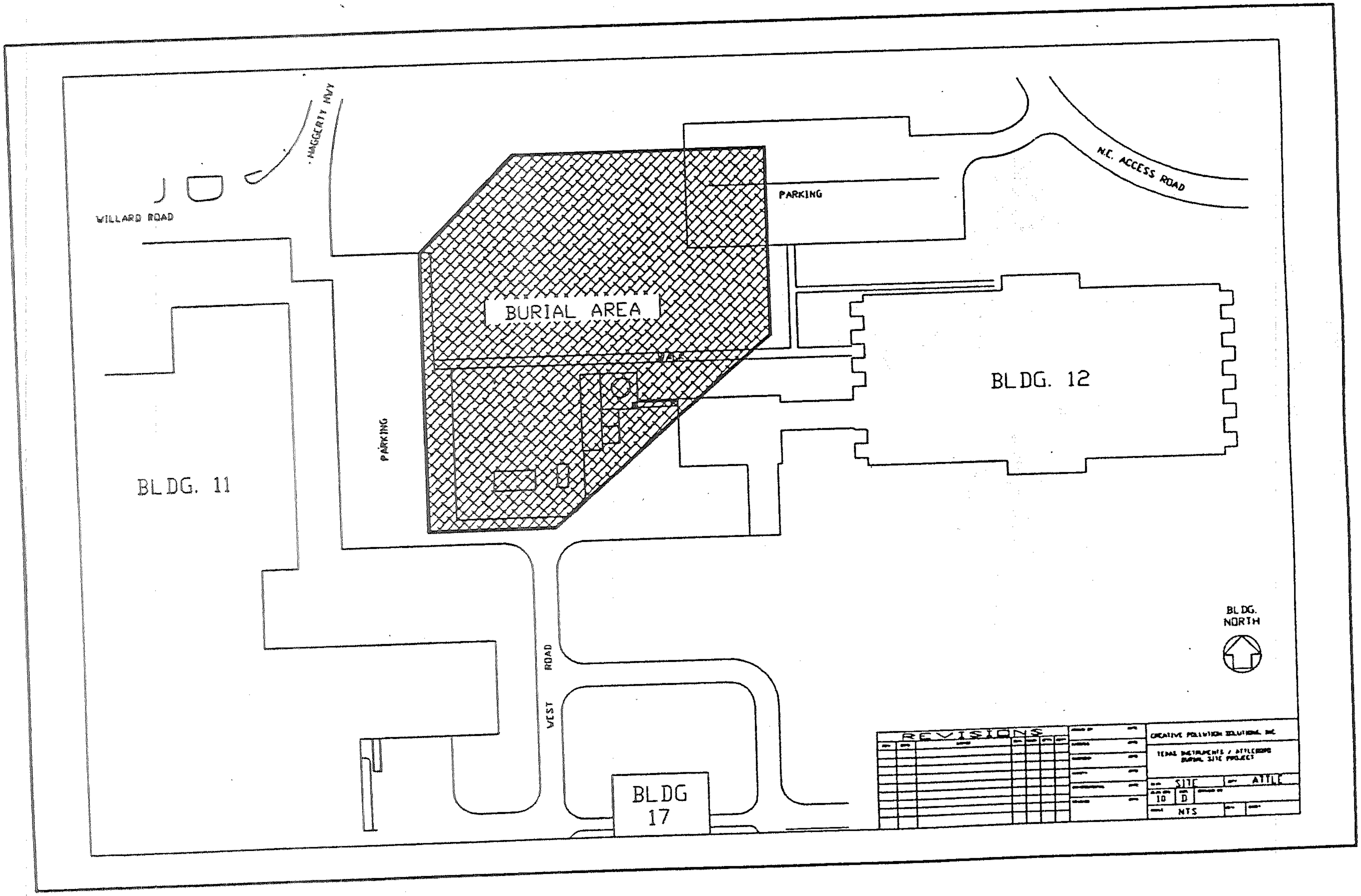


Figure 2.3
Burial Area with Grid Layout

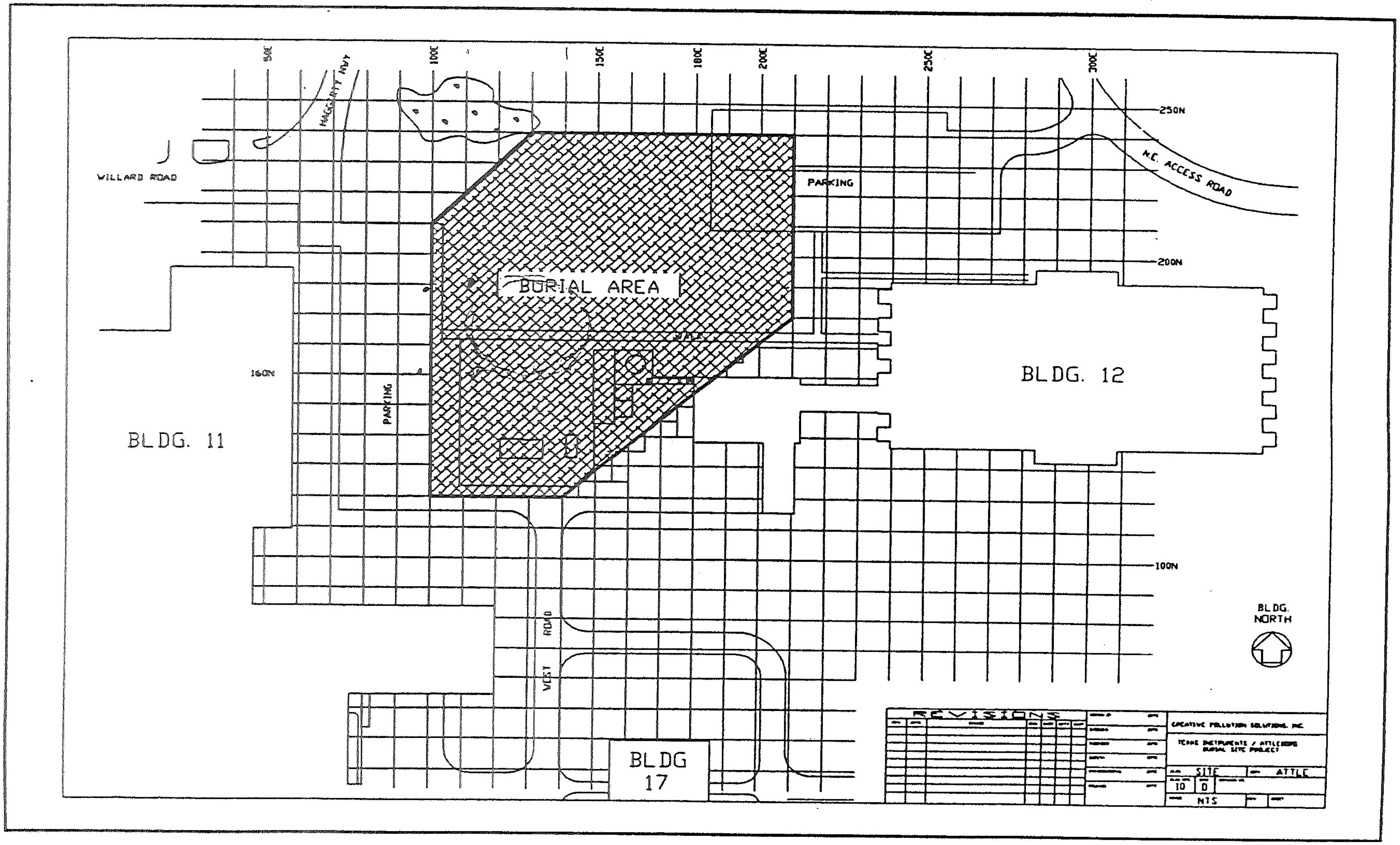


Figure 2.4
Pilot Survey Site Layout

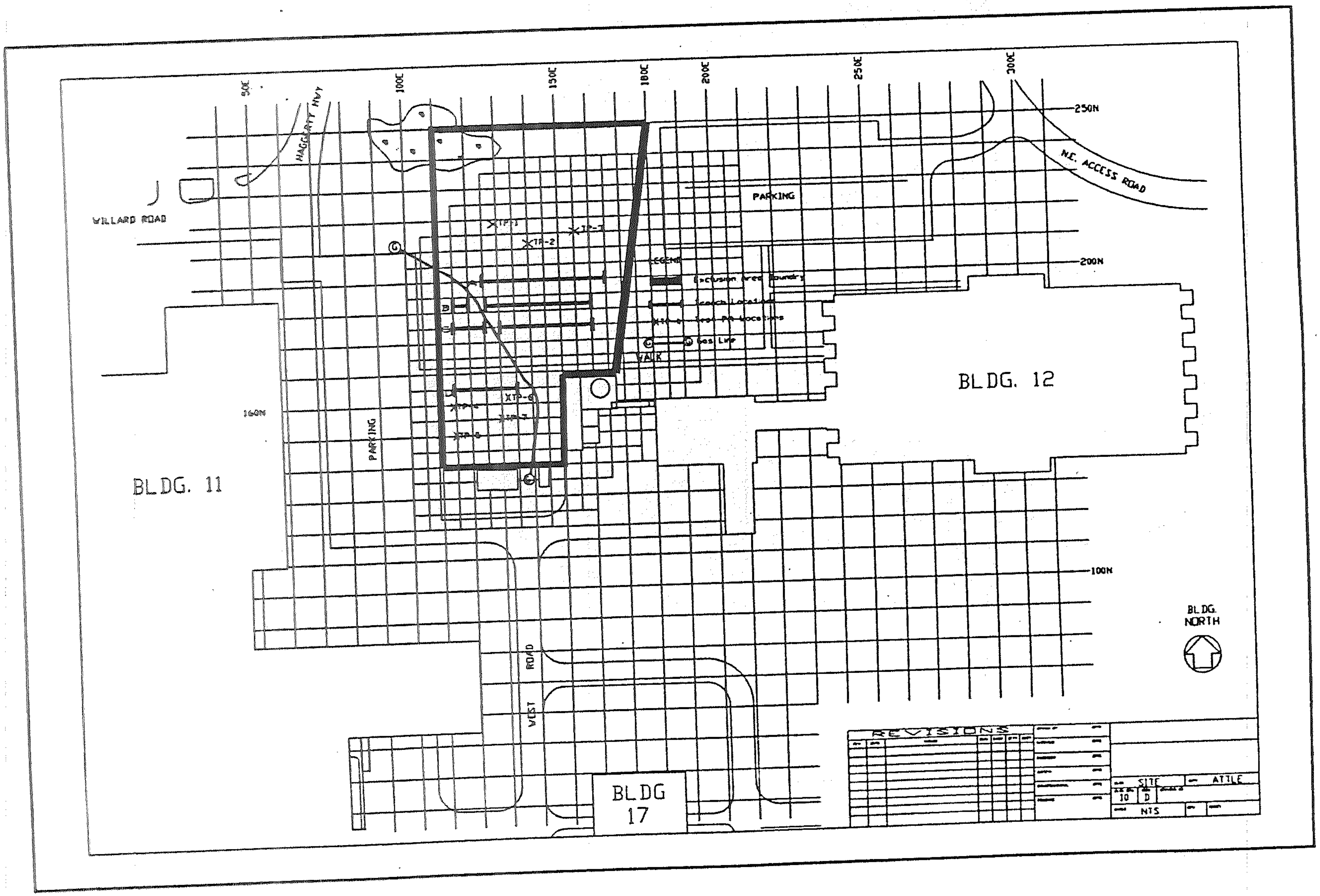


Figure 3.1
Organizational Chart

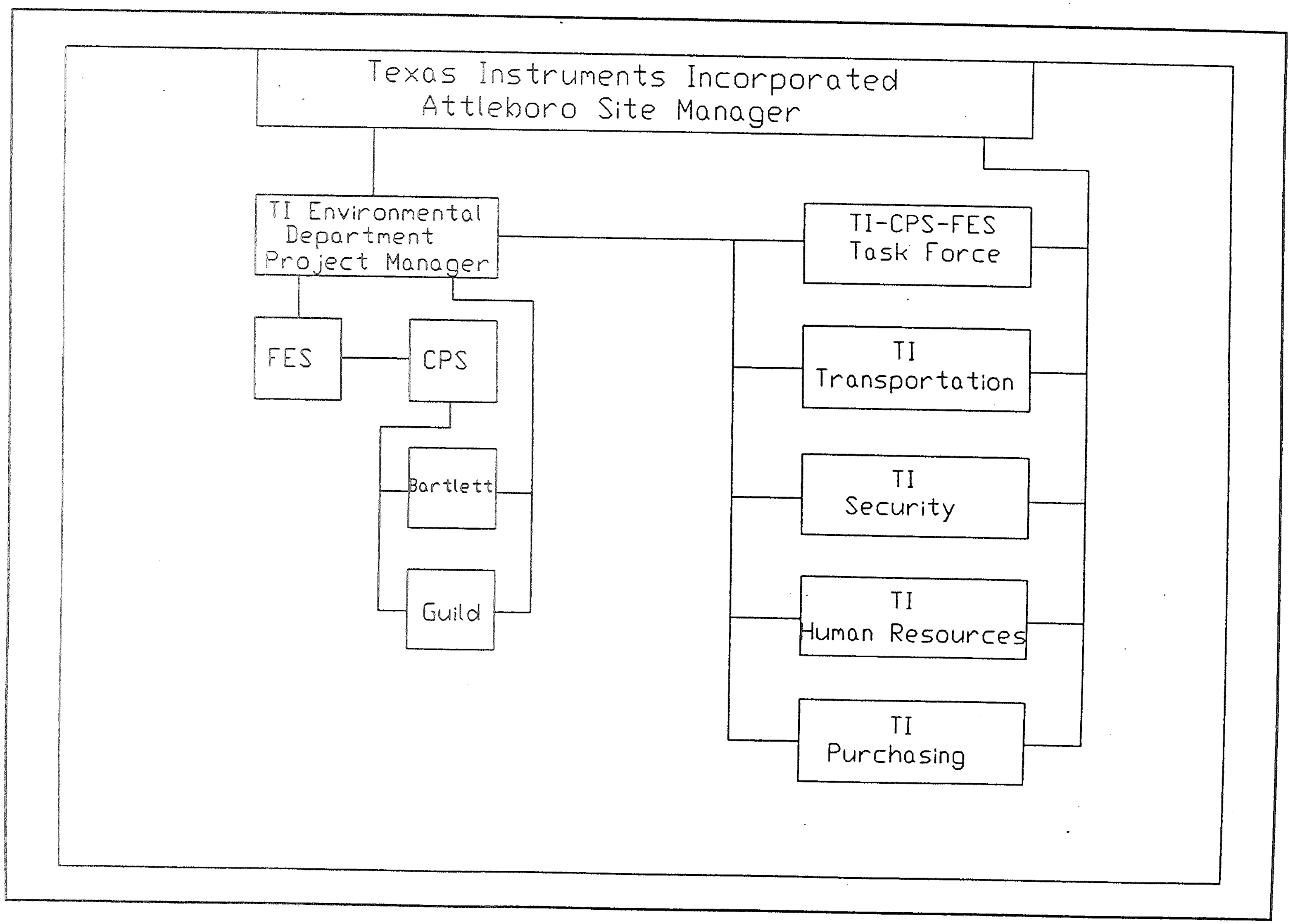


Figure 4.1
Schedule for Texas Instruments Incorporated Soil Remediation

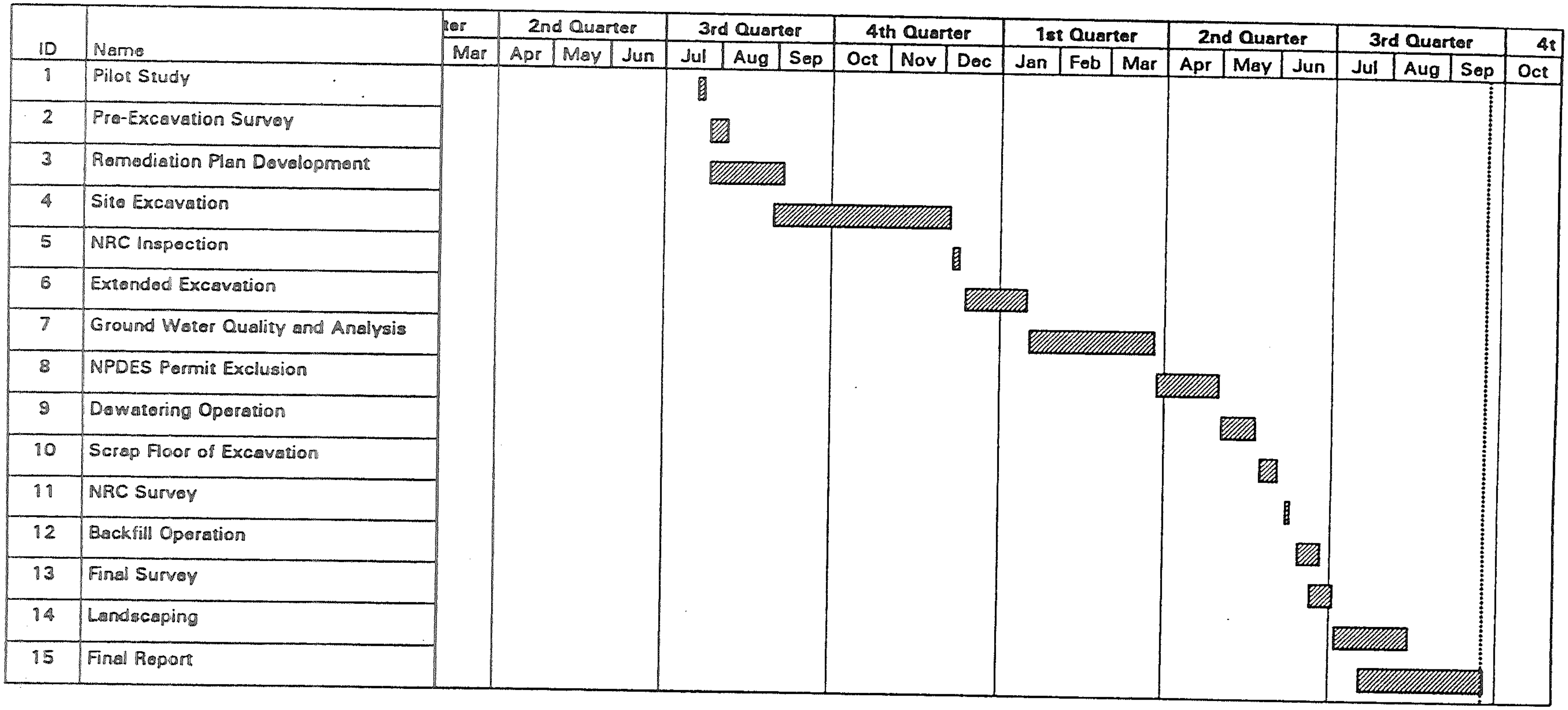


Figure 4.2
Control Zone Layout

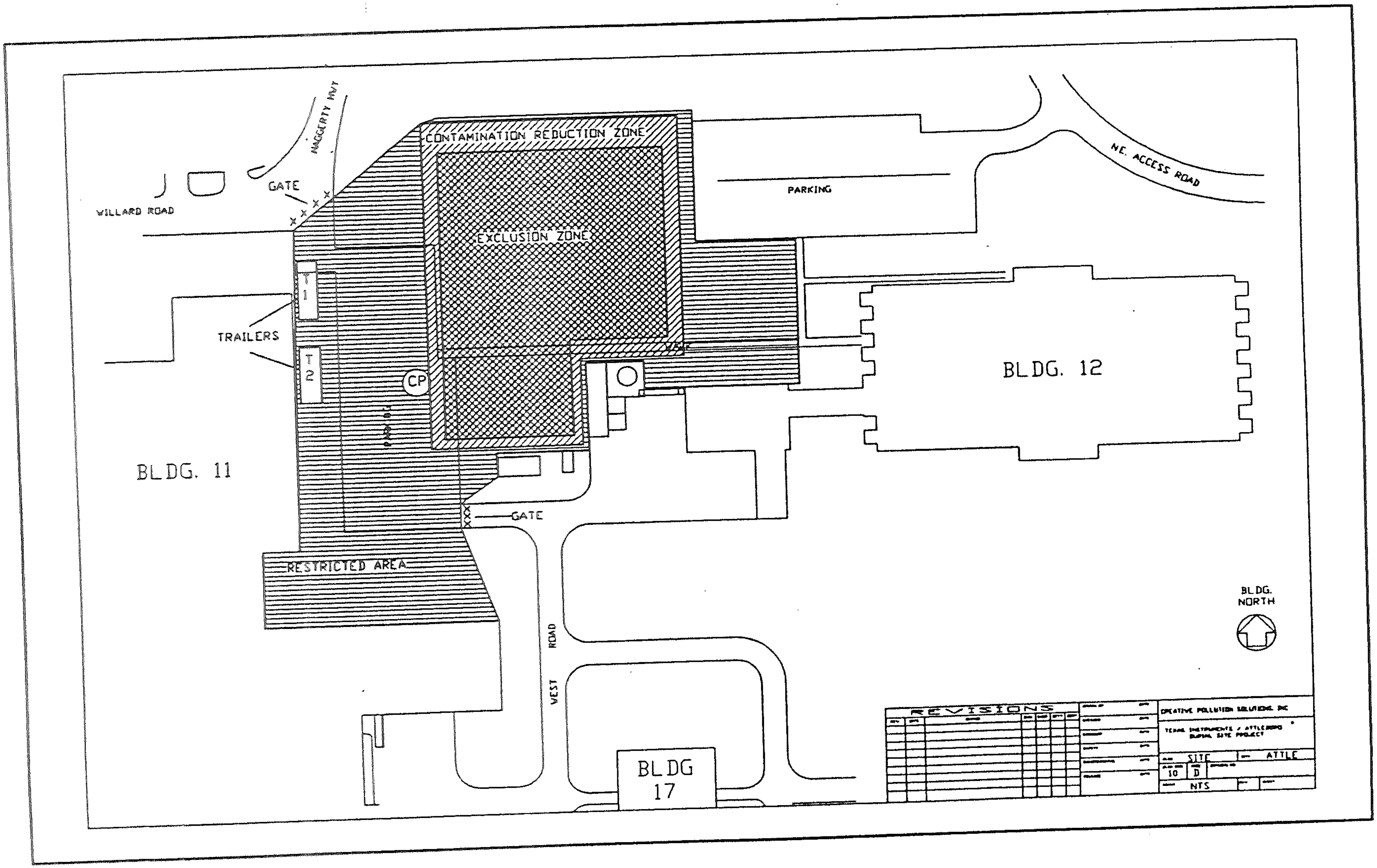


Figure 4.3
Extent of Excavation as of November 28, 1992.

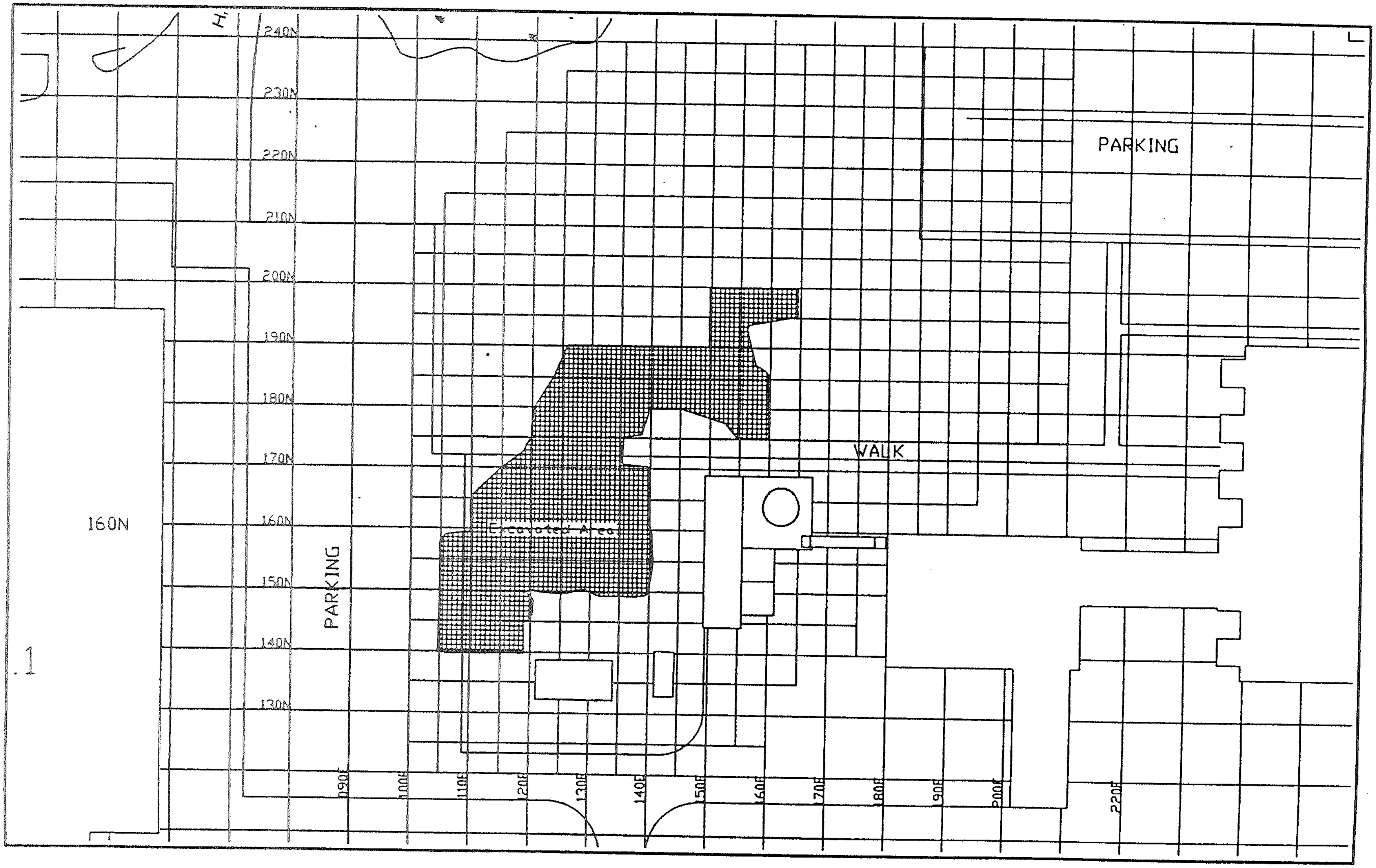


Figure 4.4
Final Site Excavation

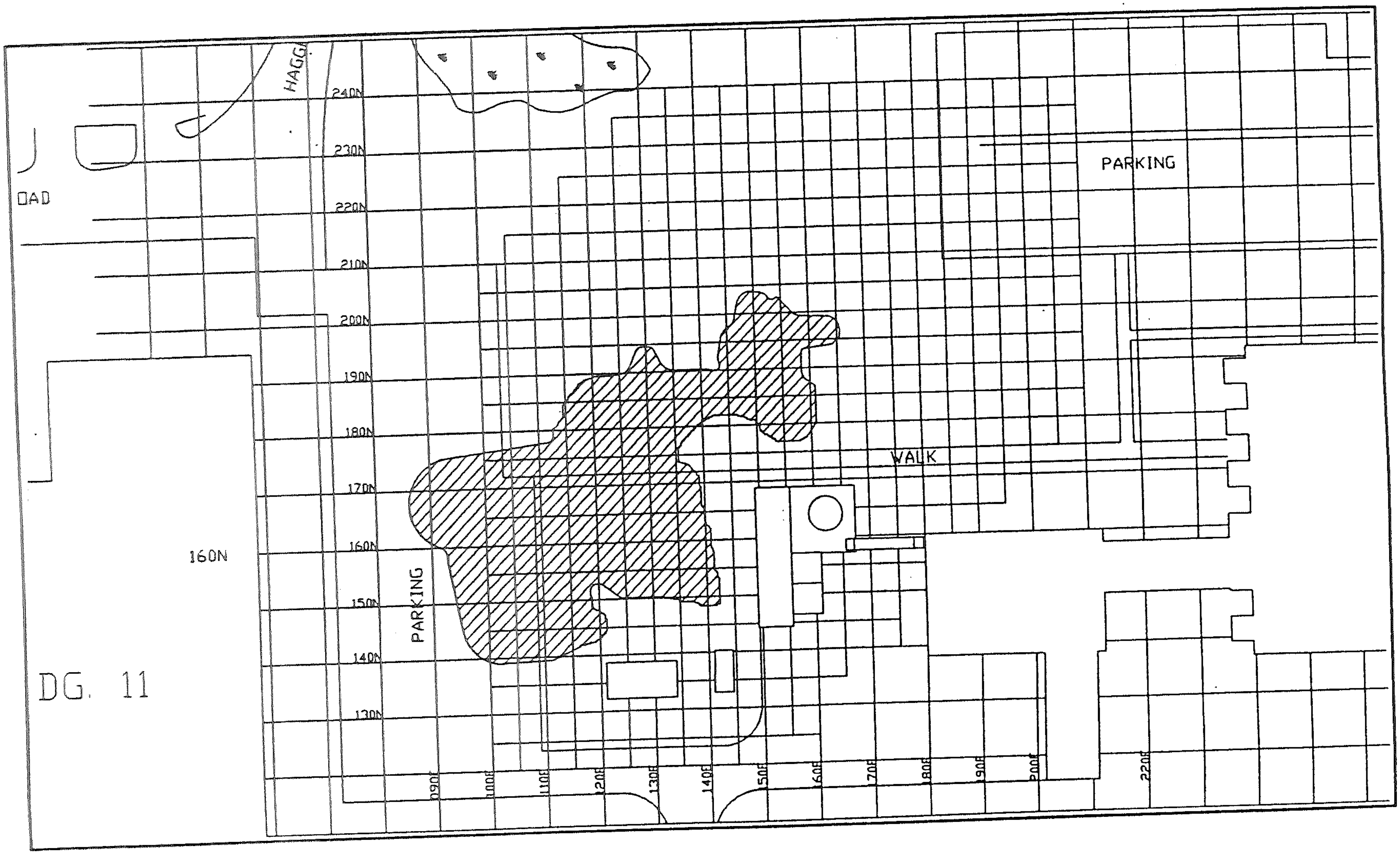


Figure 5.1
Split Spoon Sample Locations

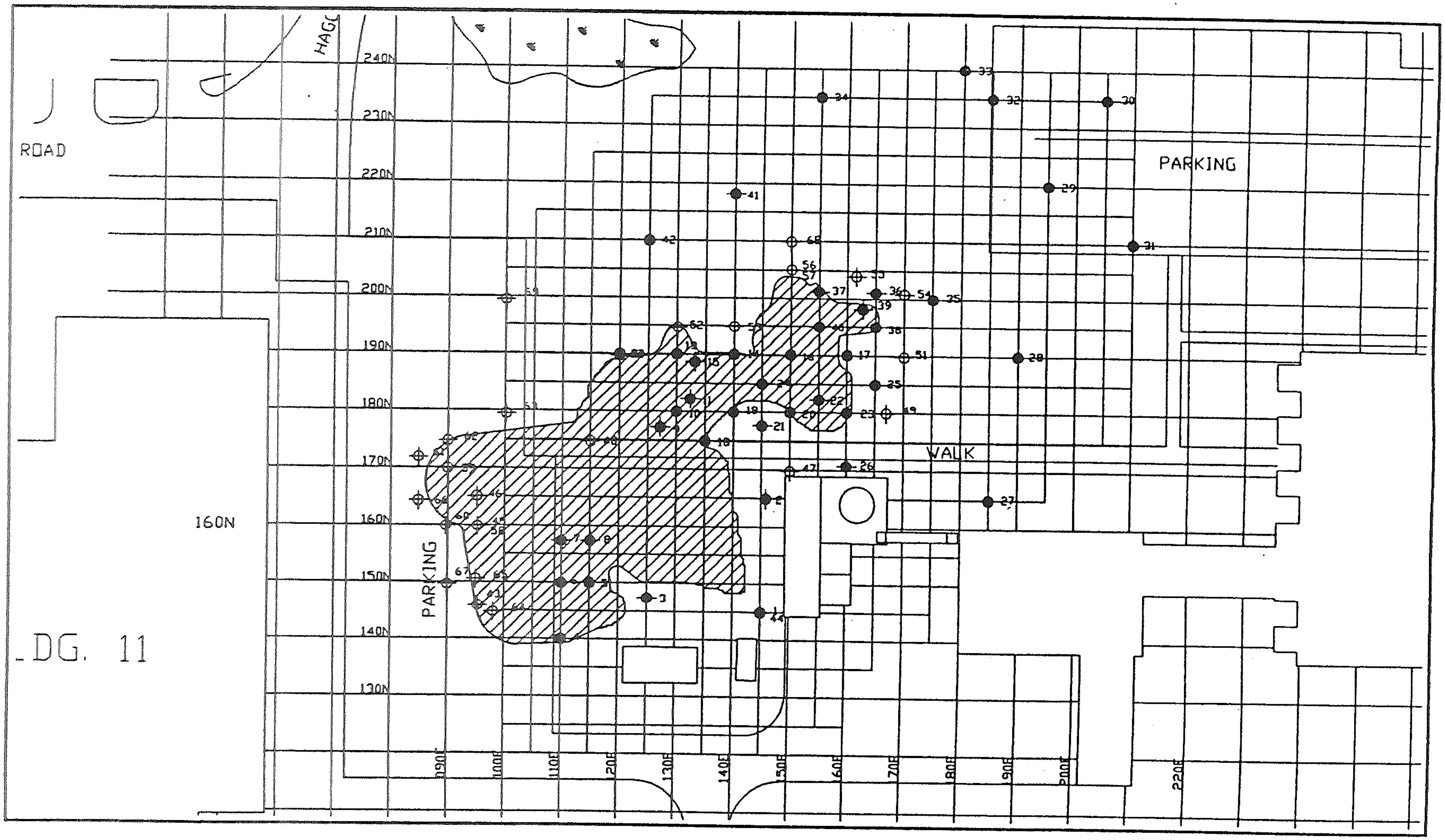
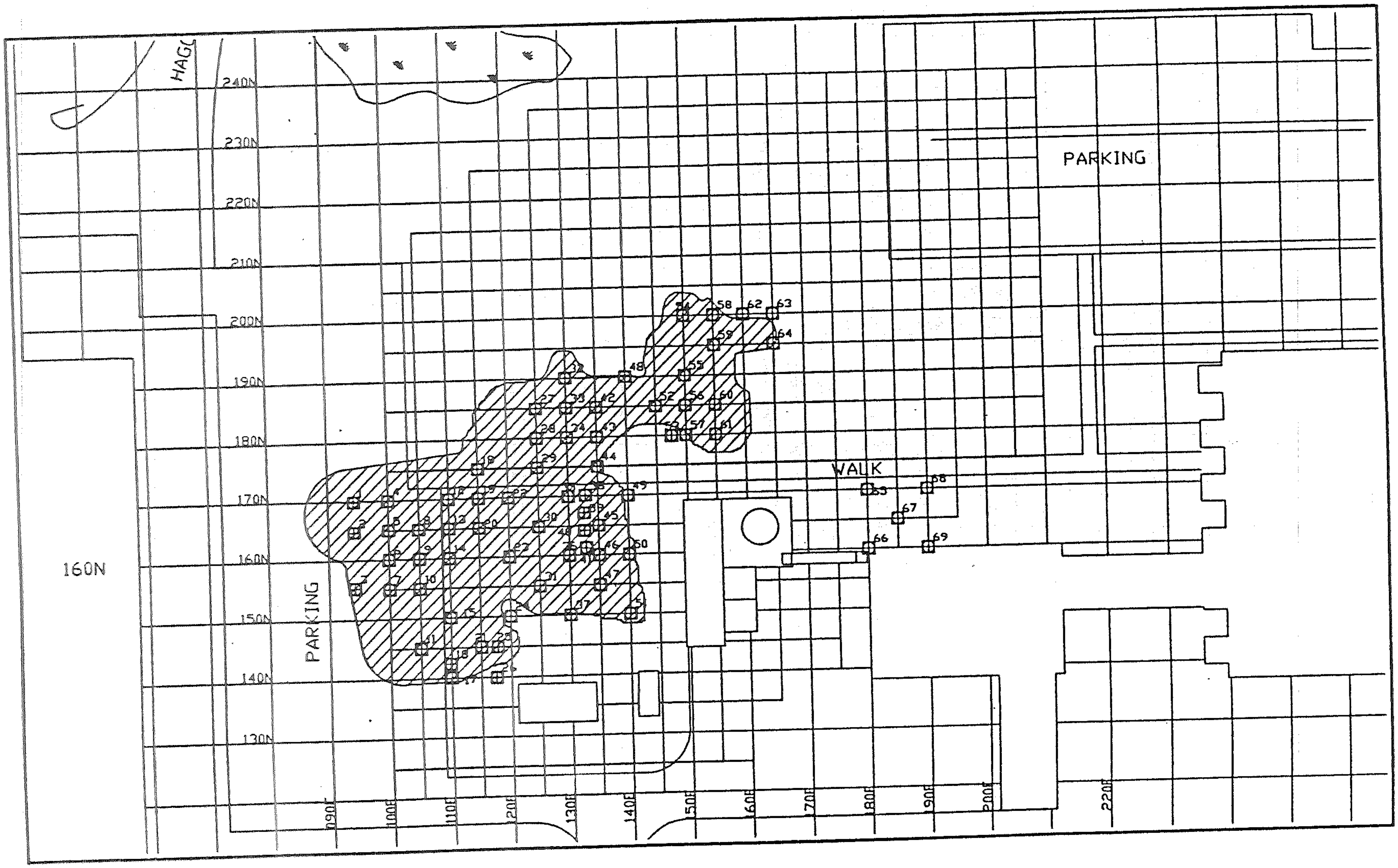


Figure 5.2
Location of Samples from the Floor of Excavated Area



Appendix C

Radiological Field Screening for Uranium in Soil

RADIOLOGICAL FIELD SCREENING TECHNIQUES FOR URANIUM IN SOIL

1.0 INTRODUCTION

For the determination of uranium concentrations in soil two methods are commonly employed: gamma spectroscopy and alpha spectroscopy.

The use of alpha spectroscopy for the determination of total uranium in soil involves the chemical separation of the uranium from the soil and the direct measurement of the alpha particles associated with each radionuclide: U-235, U-234, and U-238.

The use of gamma spectroscopy for the determination of total uranium involves determination of U-235 concentration directly, although radium (186 keV) can cause some interference, and by inference and/or scaling factors, the concentrations of Uranium-238 and Uranium-234 respectively. The scaling factors for the estimation of the U-234 concentrations are often based upon a U-234 to U-235 ratio. Industry experiences have generally found a ratio of 22 to be representative. This scaling factor, however, may vary significantly depending upon previous site specific activities. It is therefore more reasonable to base the isotopic uranium distribution on alpha spectroscopy data obtained from representative samples on site.

The analytical results of the samples provided herein indicated a scaling factor disparate from industry norm in representing a value of approximately 11 - 13 for the ratio of U-234 to U-235. This discrepancy could be related to either the use of natural and depleted uranium in the early fabrication and experimentation prior to the production of products requiring enriched uranium or earlier naval fuel activities where reprocessed uranium may have been introduced thereby generated different isotopic ratios.

Regardless, routine use of gamma spectroscopy and alpha spectroscopy is time consuming, requires extensive experience, sample preparation, analysis and interpretation, and requires the use of independent laboratories or extensive capital outlay. It was therefore desirable to develop methodologies which could be used in the field to assess the extent of remediation activities and to provide a reasonable and accurate estimation of contaminants (uranium) for final determinations.

Two such methodologies are presented: GM screening and gross alpha screening. GM screening uses a pancake type GM probes placed in close proximity to the soil matrix of interest. It has been determined from experimentation and practice that this technique is limited to concentration values in excess of 100 pCi/g uranium in soil. Nonetheless this does not detract from its utility within field application during physical excavation. Gross Alpha Screening provides for estimation of total uranium activity at levels well below the action limits specified for remediation. This appendix presents the basis for the use of GM and gross alpha screening techniques.

2.0 GM SCREENING TECHNIQUE.

A technique for the use of a hand held GM survey meter is desirable for quick determinations of remediation attainment. With the emission of alpha, beta and gamma radiations from uranium and its' progeny, the use of a GM detector becomes a desirable option for gross screening of materials for contamination in levels which exceed natural abundances.

To quantify levels and extent of contamination in the TI soil which can be identified by a conventional hand held GM survey meter, a simple response determination was done. One composite sample analyzed by LAL and determined to contain 4700 pCi/gram of uranium, was prepared in an infinitely thick geometry for the detection of beta. The thickness of soil required to obtain "infinitely thick" was based on a Sargents Rule calculation for beta energies over 0.8 MeV.

SARGENTS RULE
E > 0.8 Mev

$$R = 0.526\,E\,(-0.094)$$

Where R is the range in grams/cm^2

$$R = 0.526\,(2.3)^{-0.094}$$

$$R = 0.486 \text{ grams/cm}^2$$

for a soil density of 2.0 grams/cm^3

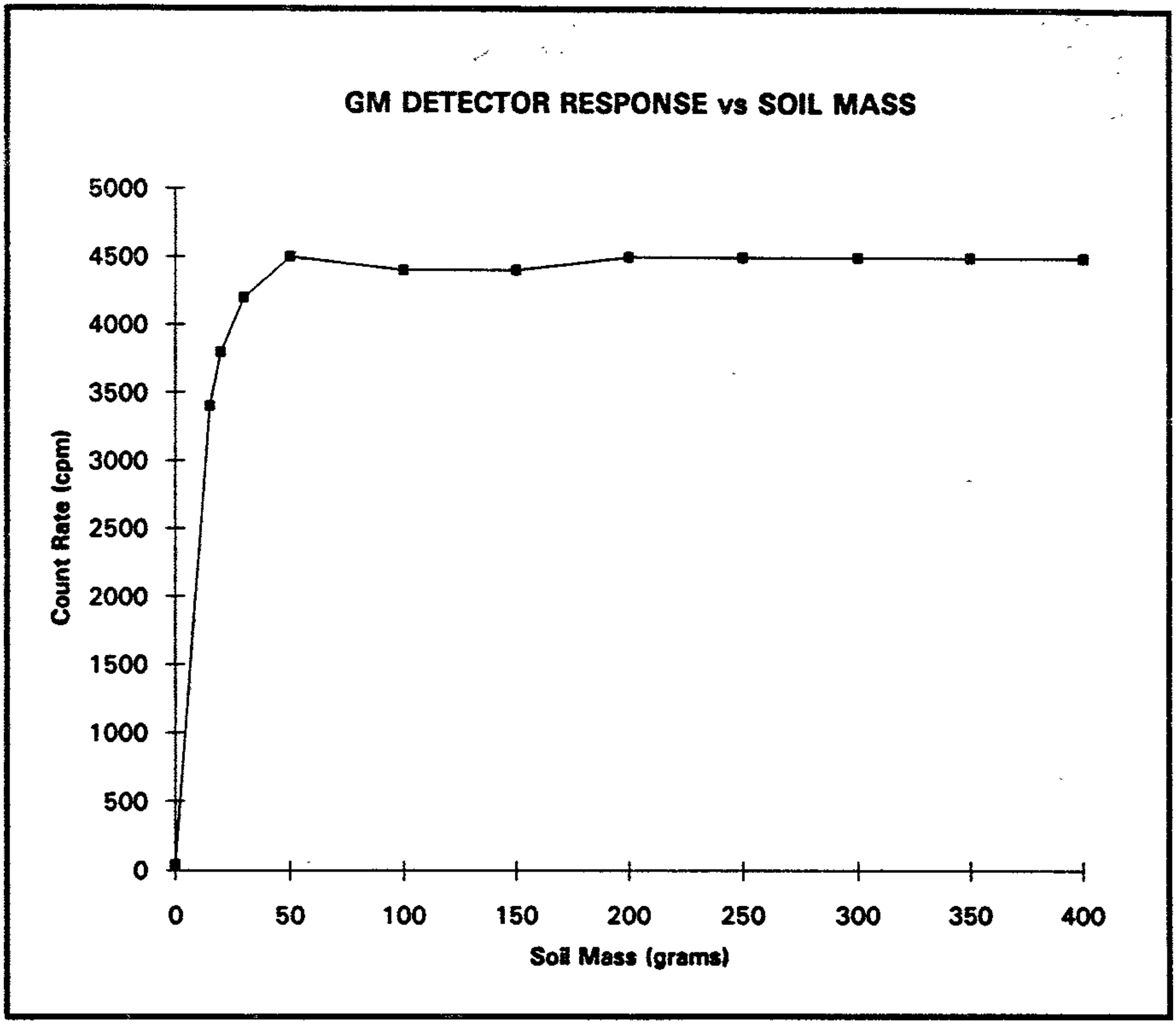
$$R = 0.243 \text{ cm or } 0.618 \text{ inches}$$

A GM detector was placed in direct contact with the soil of known uranium content, 4700 pCi/gm, and the detector response was recorded. A single sheet of mylar was used to prevent detector contamination. To establish the condition of equilibrium detector response the sample volume (thickness) was incrementally reduced while recording the detector response. The results of this exercise are plotted and provided in Figure C-1.

The uniformity in the GM detector response at sample down to thicknesses of only a few centimeters indicates the ability to achieve equilibrium conditions within a sample volume of 100 cm^3 (50 grams). Based on the detector surface area and the sample volume at which non equilibrium conditions were observed, the approximate range or thickness of soil in this sample, necessary to achieve equilibrium conditions, was experimentally determined to be less than 1.0 centimeters. This experimental conclusion is consistent with the theoretical calculation shown above.

Figure C-1
Analysis of GM Detector Response to Varying Soil Mass

Mass of Soil	0	15	20	30	50	100	150	200	250	300	350	400
Detector Response	40	3400	3800	4200	4500	4400	4400	4500	4500	4500	4500	4500



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Using the known sample concentration of 4700 pCi/gm (LAL); an approximate effective sample volume (based on the detector window area); and the experimentally determined effective range; the resulting mass of soil is calculated at approximately 20 grams. The sample concentration, 4700 pCi/gram, multiplied by the sample mass of 20 grams provides the total effective sample activity of 9.4E4 pCi or 2.08E5 disintegrations per minute (dpm). With the detector response of 4500 counts per minute (cpm) the effective detector efficiency is calculated.

4500 cpm / 2.08E5 dpm = 2.15E-2 c/d
or
An effective GM detector efficiency of 2.15%

This demonstrates the sensitivity of the GM to small sample volumes and low concentrations. If a criteria of 2 times background is applied as a field screening action point an effective sample concentration can be calculated.

GM background = 50 cpm
2 x 50 cpm = 100 cpm or 50 cpm net

50 cpm(net) / 0.0215 cpm/dpm = 2.32E3 dpm

applying an effective sample mass of 20 grams

1.05E3 pCi / 20 grams = 52.4 pCi/gram

If the conservative assumption is made that the gross GM screening could effectively see contamination in excess of twice background then the application of "no detectable" would result in a contamination level of 52 pCi/gm. Therefore, results at or below twice background could be instituted as a technique for determining when to suspend remediation and apply the more sensitive technique like alpha screening to determine actual contamination levels. This screening technique will eliminate excessive delays in the determination of the extent to which each location should be mitigated. The cost savings in laboratory sample analysis alone justifies the use of such a technique not to mention the costs associated with delays in site excavation.

3.0 GROSS ALPHA SCREENING TECHNIQUE.

3.1 Introduction.

The gross alpha screening technique used during the excavation involved direct counting of alpha particles within a soil matrix. The use of direct counting of alpha particle for the detection of radiological constituents mixed within a sample matrix has been discounted as a viable technique mainly due to the concerns over self absorption of the alpha particle within the sample matrix itself. The common industry method of quantifying alpha activity, alpha spectroscopy, involves minimizing any self absorption by means of chemical preparation such as ion exchange or microwave dissolution of a sample aliquot and subsequent plating onto a surface in an infinitely thin layer. The sample is then evaluated in a similar manner as in gamma spectroscopy where the detection of the radiation within the detector results in proportional counts to appear on the channels of the analyzer. The resolution and peak fitting difficulties with this technique requires careful and precise analytical preparation as well as detailed calibration. Even when these factors are adequately addressed sample count times can be very long. The cost of alpha spectrographic analysis can be on the order of $200 to $500 per sample with turn around times ranging from 7 to 60 days.

The desire to quantify alpha emitting nuclide concentrations such as uranium and plutonium within various environmental media because of there extensive uses over the past forty plus years has brought on the need to further evaluate a direct, quick and inexpensive technique for the quantification of alpha emitters.

One such technique was developed from the work published by K.W. Skrable and K.A. Pheonix in Health Physics, Volume 60, Number 3, March 1991 "Theoretical Response of a ZnS(Ag) Scintillation Detector to Alpha emitting Sources and Suggested Applications". This approach derives an expected count rate from an infinitely thick source of alpha emitting material using Zeigler's theoretical ranges of alpha particle based on energy and the elemental make up of the sample matrix. Early trials of this technique indicated a correlation between the gross alpha counts and the isotopic alpha concentrations determined by alpha spectroscopy.

The expected results (pCi/gm), however, did not yield the values determined by alpha spectroscopy. With the strong correlation of the total alpha counts to the alpha (uranium) concentration determined by the certified lab a cross calibration using a range of samples was pursued. In addition, field portable counting systems and standard sample collection and preparation techniques had to be developed.

3.2 Sample Counting Equipment.

The theory of counting alphas with a phosphor such as ZnS(Ag) is to have intimate contact between the alpha emitting material and the phosphor. This was achieved by using 2 inch disks of ZnS(Ag) on the bottom (phosphor side up) of a 2 inch clear plastic culture dish. The soils could then be placed within the dish directly on top of the phosphor disk. The dish with the soil phosphor sandwich is then placed on a conventional photo multiplier tube (pmt). The PMT is housed inside a light tight container with a removable lid.

One tremendous advantage to this PMT arrangement is that the detector background count rate is very near zero for the intended count time of 10 minutes. Typical count rates have been 0.01 to 0.05 counts per minute over extended count times.

3.3 Sample Preparation.

With the sample in a fixed configuration within the dish the only other factors which need to be standardized were (1) the water content of the soil and (2) the particle size of the soil.

The easiest approach to standardizing the moisture content of the soil samples which may be experienced in the field for counting was to dry them in a small oven to eliminate the moisture inconsistencies. A simple set of experiments was undertaken to determine what combination of temperature and drying time was optimum. It was experimentally determined that a 15 to 20 gram samples of soil with varying moisture contents could be heated in the oven within a small tin dish for 15 minutes at 100 degrees centigrade and result in consistent moisture removal on soils typically found insitu.

The particle size of the soil was important to insure the most intimate contact between soil and phosphor was achieved. Experiments sieving dried soils were done to evaluate the effects of sieve size to the sample counts. It was obvious that all aggregate such as small rocks should be removed as they would preclude the soils from touching the ZnS(Ag). Various sieves were used to determine an acceptable sieve size to maximize counter response. It was determined that once below a sieve size of about 0.125 inches consistent response on the detector is achieved. Based on this determination the use of a common kitchen strainer (sieve size about 0.0625 inches) was employed.

3.4 Sample Counting and System Evaluation.

In addition to standard chi-square tests of the counter to determine the reliability and stability of the counting system daily source checks and background checks were performed. Routine samples were also split and run as well as independent splits using gamma spectroscopy and alpha spectroscopy. Information relating to individual sample counts on a single sample was desirable to insure reproducibility of the results for a single sample. A prepared dish, phosphor and soil configuration was repeatedly put onto the counter, counted and taken off. This procedure was followed for ten iterations and the results are tabulated in Table C-1. The results show that the system experienced a smaller sample deviation that theoretically expected.

With a background count rate at or near zero, the calculation of an MDA is simplified. Assuming a background of zero the MDA would be 2.7 pCi/g. However, "background" soil, free of any alpha emitters other than those provided by nature would present additional counts and therefore a different MDA. These background counts would not only arise from the three Uraniums of interest but any other natural occurring alpha emitting species and therefore confounds the interpretation of low count samples. The results of alpha screening on background soils yielded 10 counts per ten minutes. Alpha specectroscopy correlated this sample to approximately 2.5 pCi/g of total uranium. Therefore any sample with a count of less than this, could be interpreted as background soil at 2.5 pCi/g. Nonetheless, the ability to determine soil concentrations at less than 30 pCi/g is established.

TABLE C-1

REPETITIVE COUNTS ON SINGLE SAMPLE
Test #1 High Sample Activity
(COUNTS PER 10 MINUTES)
90
97
99
88
89
95
92
90
99
90
MEAN = 92.90
EXPERIMENTAL STANDARD DEVIATION = 4.23
THEORETICAL STANDARD DEVIATION = 9.64

REPETITIVE COUNTS ON SINGLE SAMPLE
Test #2 Low Sample Activity
(COUNTS PER 10 MINUTES)
23
24
16
23
17
20
16
22
22
21
MEAN = 20.40
EXPERIMENTAL STANDARD DEVIATION = 3.03
THEORETICAL STANDARD DEVIATION = 4.52

TABLE C-2

INDEPENDENT PROGENY COUNTS FROM PARENT SAMPLE
Test #1 High Sample Activity (RS 414)
(Each Individual Sample Counted 10 Minutes)
97
88
90
95
99
92
90
99
90
99
MEAN = 93.90
EXPERIMENTAL STANDARD DEVIATION = 4.38
THEORETICAL STANDARD DEVIATION = 9.69

INDEPENDENT PROGENY COUNTS FROM PARENT SAMPLE
Test #2 Low Sample Activity (MP 5)
(Each Individual Sample Counted 10 Minutes)
23
26
22
18
21
18
20
20
23
15
MEAN = 20.6
EXPERIMENTAL STANDARD DEVIATION = 3.12
THEORETICAL STANDARD DEVIATION = 4.54

TABLE C-3

INDIVIDUAL PROGENY SAMPLES FROM PROCESS PILE
Ten Samples Cored At Random From Reed Screened Process Pile
Reed Screened Process Pile Volume: 200 Cubic Feet
Each Individual Sample (10 - 20 grams) Counted 10 Minutes

RS 277 - 1	47
RS 277 - 2	62
RS 277 - 3	37
RS 277 - 4	49
RS 277 - 5	61
RS 277 - 6	40
RS 277 - 7	70
RS 277 - 8	55
RS 277 - 9	87
RS 277 - 10	52

MEAN = 56.00
EXPERIMENTAL STANDARD DEVIATION = 14.84
THEORETICAL STANDARD DEVIATION = 7.48

3.5 Sample Variability.

Due to the small sample volume needed with this technique an evaluation of sample variability was prudent. In the field a one liter sample is extracted under standard protocols. From two such sample volumes of different activity concentrations multiple counting samples were prepared. The tabulation of these repetitive counts and the resulting statistics are provided in Table C-2. This data set also shows the statistics which complement this technique. The actual observed deviation about the mean is less than expected by theoretical calculation.

3.6 Sample Collection In The Field.

The process of soil excavation followed by reed screening for the removal of aggregate and contaminated debris resulted in the continuous generation of piles of screened soils. These piles were estimated at 200 cubic feet each and were staged separate for each reed screen load. These piles were analyzed by alpha screening to determine their disposition. To insure adequate sampling as many as ten coring were taken in each pile. The individual coring were composited and homogenized within a larger container. From this composite a one liter aliquot is drawn for analysis. In support of this sampling procedure each individual coring has been analyzed for selected piles and the individual counts with the resulting statistics are provided in Table C-3. In this case of random sampling from a large volume of soil the resulting deviation about the sample mean is larger that expected by theoretical calculation. In almost all cases where samples were taken a one liter composite sample was taken, mixed and an aliquot sample of 20 grams, from the larger initial sample, taken for alpha screening.

3.7 Initial Alpha Screening Correlation.

The initial sampling done prior to the excavation of soils for disposal provided for the analysis of five unique samples by a certified laboratory. The samples were analyzed by gamma spectroscopy and plotted against alpha screening (Figure C-2) and analyzed by alpha spectroscopy and plotted against alpha screening (Figure C-3). The combined data is plotted in Figure C-4. From this data plot the relationship between alpha screening counts observed in a 10 minute count and the laboratory alpha spectrographic results was determined to be a stronger correlation. The gamma spectrographic results which, due to it's inherent difficulty in resolving low yield gamma peaks from progeny of the isotopes of primary interest, has less of an observable correlation. These plots also raise concerns over the use of gamma spectroscopy for the detection of low yield, low activity, progeny born photons in the determination of their parent activities. It is from these plots that the verification and justification of the alpha screening technique as a fast, cheap and reliable measurement method was based.

FIGURE C-2

TOTAL URANIUM COMPARISON	
Alpha Screening (counts/10 Min.)	LAL Gamma Spec. (pCi/gm)
135	211.51
94	115.87
54	109.48
17	19.41
10	2.95

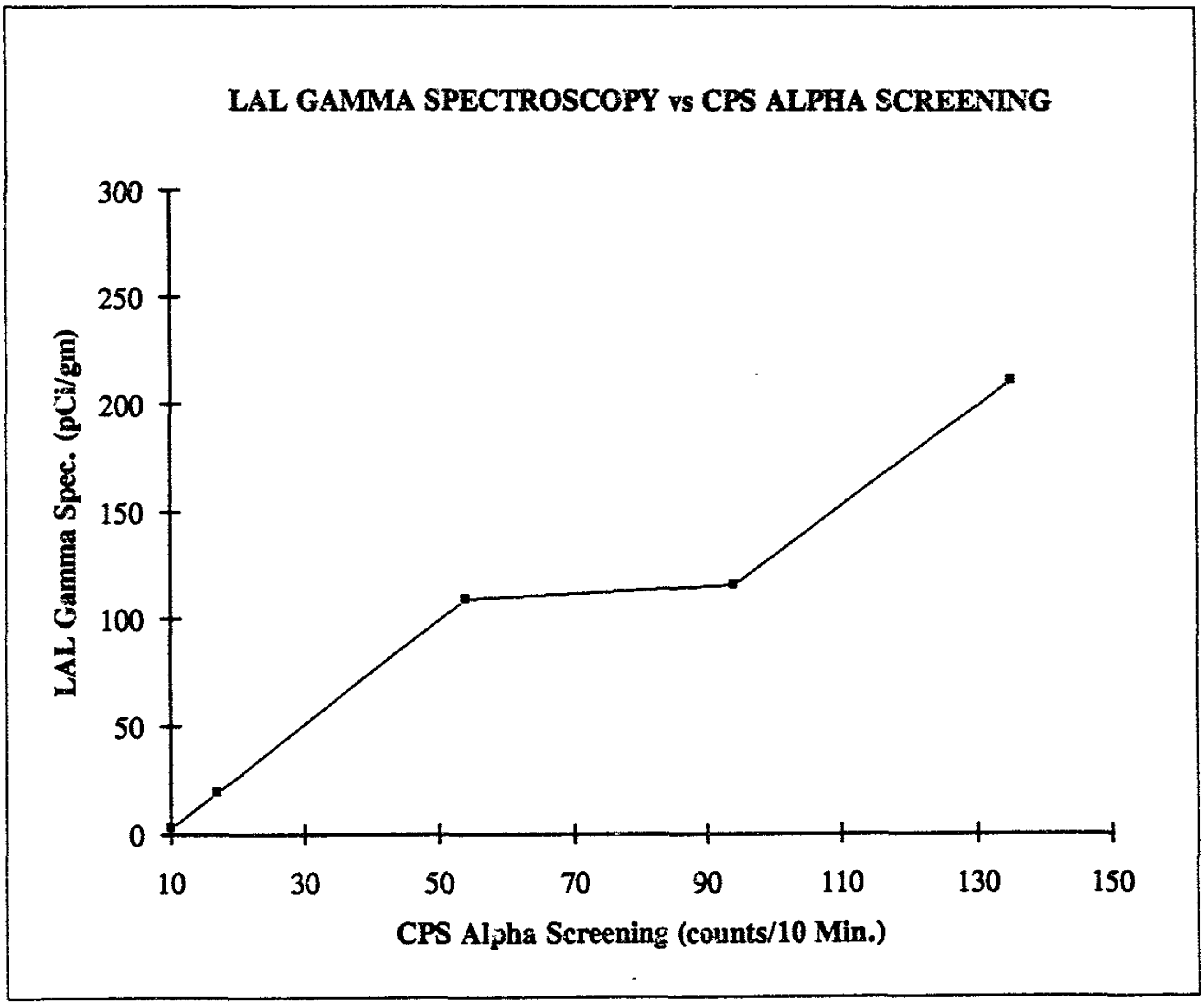

FIGURE C-3

TOTAL URANIUM COMPARISON	
Alpha Screening (counts/10 Min.)	LAL Alpha Spec. (pCi/gm)
135	166.9
94	121.17
54	77.37
17	17.98
10	2.13

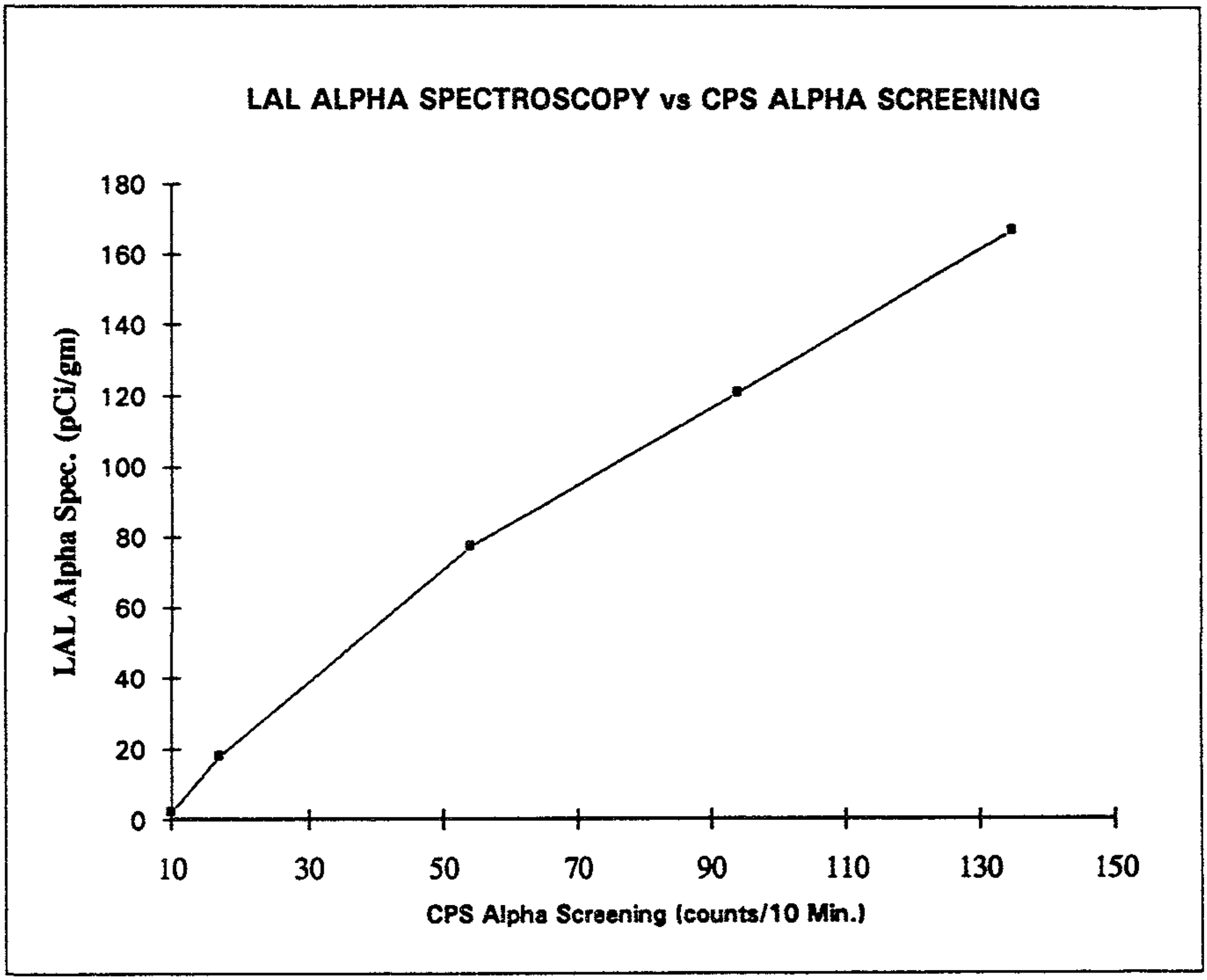

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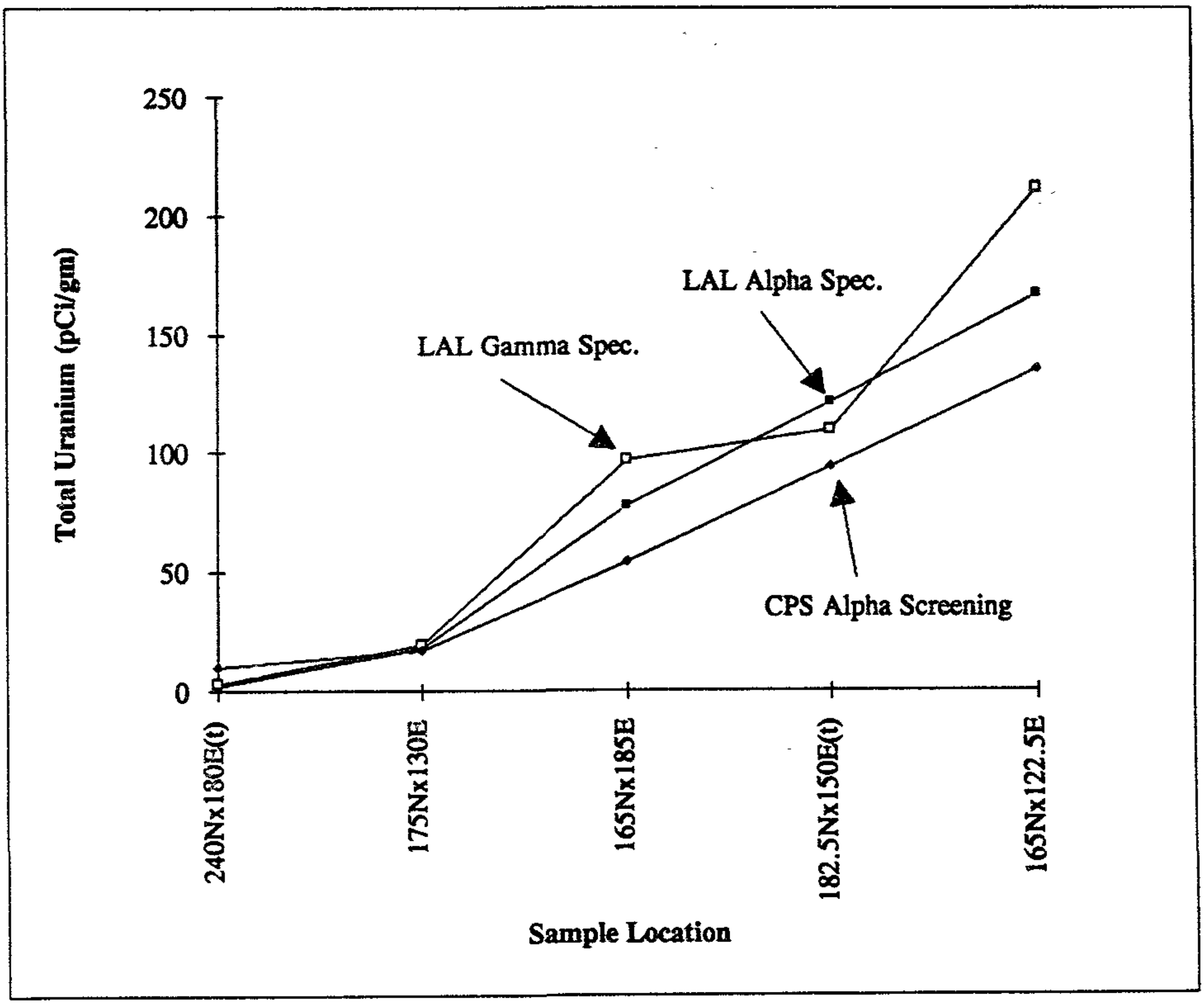
FIGURE C-4

ALPHA SCREENING CORRELATION WITH URANIUM IN SOIL			
LOCATION	LAL ALPHA SPEC.	LAL GAMMA SPEC.	CPS ALPHA SCREENING
	Total U (pCi/gm)	Total U (pCi/gm)	Total U (pCi/gm)
240Nx180E(t)	2.13	2.95	10
175Nx130E	17.96	19.41	17
165Nx185E	77.37	96.91	54
182.5Nx150E(t)	121.17	109.46	94
165Nx122.5E	166.9	211.51	135



3.8 Additional Alpha Screening Correlations.

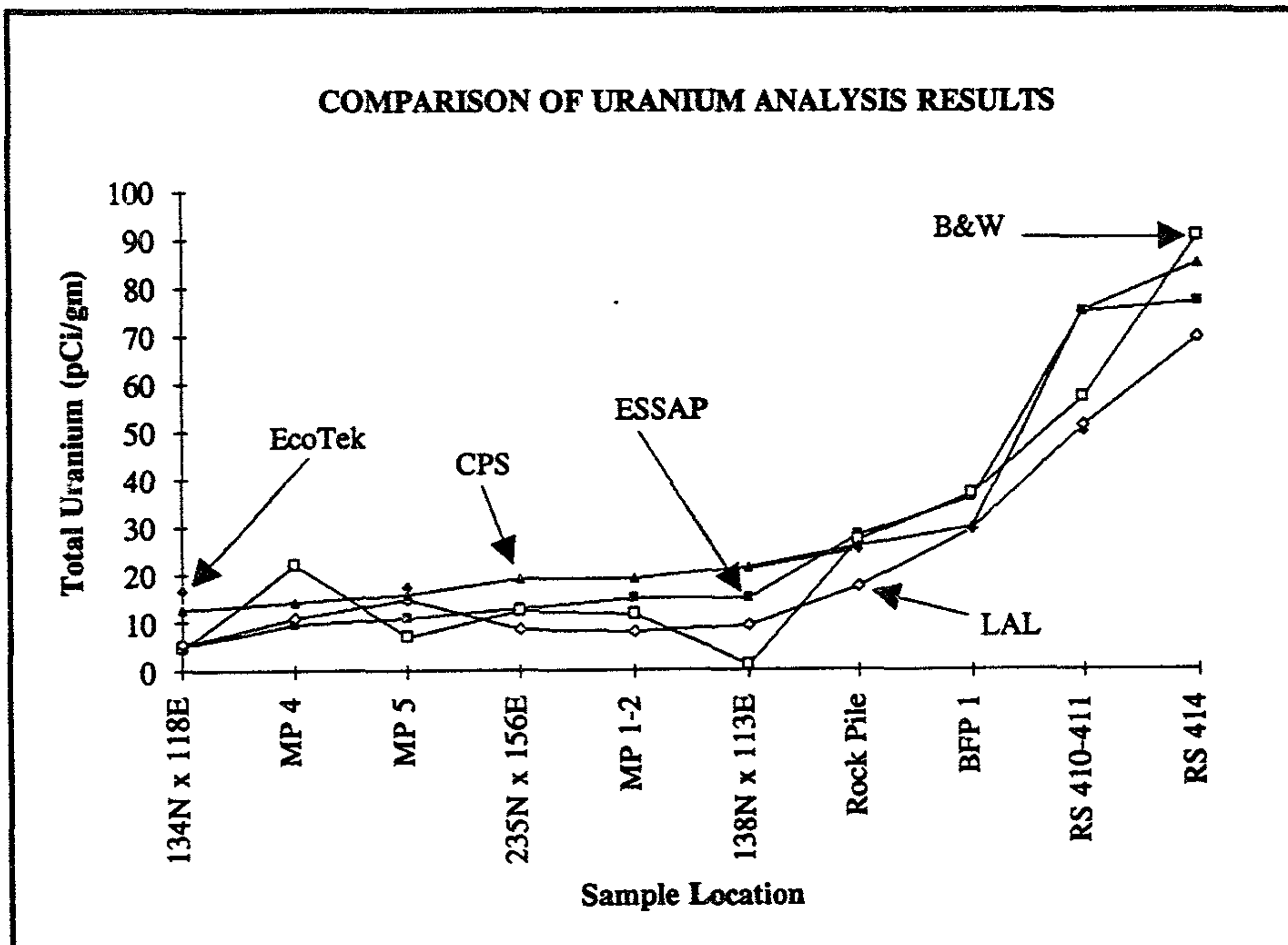
The quality control and quality assurance aspects of the sampling and analysis program provided for further split sample opportunities. The ten ORISE ESSAP samples taken during a survey exercise were split with: (1) B&W Nuclear Environmental Services, Inc.; (2) EcoTek; (3) Lockheed Analytical Laboratory and (4) CPS, Inc. All samples except CPS, Inc. were analyzed by gamma spectroscopy. The comparison of this data is presented in Figure C-5. It is apparent that there is variability between sample results, however, these variations do not appear to be of a magnitude that is of concern or deviates from expected variations in sample results normally encountered with gamma spectroscopy for uranium-238 and uranium-235 and uranium-234 by inference from uranium-235.

4.0 CONCLUSIONS.

The use of gross counting of alpha emissions from infinitely thick sources of soil has proven through correlation to both alpha spectroscopy and gamma spectroscopy to by a viable method for the rapid, inexpensive and economical determination of soil activities. It provided for precise and cost effective mitigation of uranium contaminated soils and resulted in no loss time in waiting for results of samples taken. The cost savings just in sample analysis alone justifies it's usefulness. With over 2000 samples analyzed by alpha screening a cost saving can be estimated to be in the order of $500,000.00 (based on $300.00 per sample by alpha spectroscopy). The ability to know sample results within tens of minutes resulted in the tight control in the disposition of soil volumes. This control provided unprecedented minimization of soils requiring ultimate disposal as radioactive waste, again saving hundreds of thousands of dollars.

FIGURE C-5

COMPARISON OF TOTAL URANIUM ANALYSIS RESULTS					
Sample Locations	Total Uranium Concentration (pCi/gm)				
	Gamma Spectroscopy				Alpha Screening
	ESSAP	B&W	EcoTek	LAL	CPS
134N x 118E	5.3	4.65	16.5	5.44	12.8
MP 4	9.6	21.82		10.96	14.2
MP 5	11	7.1	17.34	14.8	15.9
235N x 156E	13	12.49		8.62	18
MP 1-2	15	11.65		7.96	19.2
138N x 113E	15	1.25	21.18	9.31	21.4
Rock Pile	28	26.96	25.12	17.24	25.8
BFP 1	36	36.76		29.4	29.9
RS 410-411	75	56.99	49.86	51.11	75.3
RS 414	77	90.77		69.74	85



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Appendix E

Final Survey Methods
and
Results

APPENDIX E: FINAL SURVEY METHODS AND RESULTS

Introduction

The final survey consisted of walk over near surface surveys and one-meter gamma surveys; floor soil samples from excavated area; and split spoon samples around the perimeter of the excavation. The walk over surveys were conducted to verify that exposure rates were below the acceptable levels outlined in the option 1 criteria of the NRC branch technical position. The excavation floor soil samples were taken in accordance with the remediation plan to assure that grid cell averages meet the 30 pCi/g limit established in the option 1 criteria. The split spoon samples were taken to verify the excavation area extended to the appropriate bounds.

Walk Over Survey

After the backfilling operation was completed, and prior final landscaping, CPS conducted an extensive walkover survey of the area previously defined as the burial area. This survey was conducted using a Ludlum model 3 survey meter with a Ludlum model 44-2 one inch x one inch sodium iodide scintillation detector. All readings for this portion of the survey were taken within two inches of the surface. Prior to the survey, the instrument background was determined to be about 2500 counts per minute. Radiation levels in the burial area were found to be between one and one and one-half times background except in four distinct locations. These areas are shown in Table 1 of this appendix. Of the areas greater than one and one-half times background all were less than two times background.

One-Meter Gamma Survey

In addition to the sodium iodide walkover survey a one meter gamma survey was conducted at appropriate grid intersections within the defined burial area. These measurements were performed using Ludlum model 3 survey meter with a Ludlum model 44-2 one inch x one inch sodium iodide scintillation detector. The response of the instrument is measured in counts per minute. Nominal background as determined in previous reports (ORAU, 1983) was between 10 - 11 μR/hr (based on measurements with a pressurized ion chamber). This corresponds to a count rate on the sodium iodide detector of approximately 2500 cpm. According to Option 1 of the NRC branch technical position (BTP) an acceptable exposure level is 10 μR/hr above background. In this case, 10μR/hr above background is equivalent to two times background. With this criteria, measurements equal to or less than two times background on the sodium iodide detector would meet the BTP criteria. In this one-meter gamma survey no areas were determined to have exposure rates greater than one and one-half times background. The results of this one-meter grid intersection survey are shown in Table 2 of this appendix.

Surface Soil Sampling

The soil sampling plan for the excavated area consisted of surface soil samples at each corner and in the middle of each 10 meter x 10 meter grid cell. Wherever possible surface (0-15cm) soil samples of approximately 1 kg each were collected at these points. A map showing the sample locations is shown in Figure 1 of this appendix. Table 3 of this appendix shows the gross alpha screening results (in pCi/g total uranium) for the floor soil samples (see Appendix C for discussion of the gross alpha screening method). The average concentration for all samples taken from the floor of the excavation is 23.7 pCi/g. The minimum and maximum values are 4 and 55 pCi/g respectively. Table 4 shows the 10 meter x 10 meter grid cell averages. Two grid cells (170 - 180N x 110 - 120E, and 180 -190N x 150 - 160E) are slightly above the 30 pCi/g criteria however, when taking the average of those cells with adjacent cells the averages are 25.6 and 24.9 pCi/g respectively.

Split Spoon Sampling

Initially, the bounds of the excavation were surveyed to determine that the exposed surfaces (above the water level) were at background levels using a NaI meter. In areas where greater than background levels were found the excavation was extended. When all of the surfaces at the bounds of the excavation were determined to be at background levels, split spoon samples were taken as a means of demonstrating that the bounds of the excavation were at or below the approved guidance. The split spoon samples were taken around the perimeter of the excavated area to a depth of approximately six feet. These samples were taken approximately 1 to 5 meters back from the bounds of the excavation and approximately every 5 to 10 meters around the entire excavated area where practical. Sampling locations for the split spoon samples are shown in Figure 2 of this appendix. In locations where split spoon samples had been previously taken, the locations were not resampled and the previous data was used.

The soil samples which were collected during the split spoon sampling were analyzed using the gross alpha screening technique. The results show that the average concentration over the total depth of each borehole (approximately 0 - 6 feet) range from 7.0 to 27.7 pCi/g. These results demonstrate that the boundaries of the burial site had been reached. The results are shown in Table 5 of this appendix.

TABLE 1

WALKOVER SURVEY RESULTS OF AREAS GREATER THAN BACKGROUND

Location	Sodium Iodide Response (cpm)
185 -190N x 170 -175E	3000 - 4000*
190 - 195N x 175 - 180E	3000 - 4000
195 - 197.5N x 177.5 - 180E	4000
182.5 - 185N x 180 - 182.5E	4000

* Background levels were determined to be approximately 2500 counts per minute.

TABLE 2: ONE-METER EXPOSURE RATE MEASUREMENTS AT GRID INTERSECTIONS

LOCATION	SURFACE (NaI reading in cpm)*	1 METER (NaI reading in cpm)*
160N x 180E	2800	2500
170N x 180E	2450	2300
180N x 180E	2250	2250
190N x 180E	2250	2050
200N x 180E	2200	2100
210N x 180E	2150	2150
220N x 180E	2100	2100
230N x 180E	2200	2200
240N x 180E	2250	2250
240N x 190E	2400	2300
230N x 190E	2400	2350
220N x 190E	2450	2300
210N x 190E	2500	2350
200N x 190E	2250	2150
190N x 190E	2200	2200
180N x 190E	2000	2000
170N x 190E	2500	2150
160N x 190E	2500	2250
160N x 200E	2750	2600
170N x 200E	2350	2350
180N x 200E	2200	2200
160N x 170E	2450	2400
170N x 170E	2400	2400
180N x 170E	2650	2300
190N x 170E	2250	2250
200N x 170E	2100	2250
210N x 170E	2150	2150
220N x 170E	2150	2150
230N x 170E	2150	2050
240N x 170E	2200	2150
240N x 160E	2250	2250
230N x 160E	2450	2150
220N x 160E	2150	2150
210N x 160E	2200	2000
200N x 160E	2300	2250
190N x 160E	2050	2050
180N x 160E	2100	2100
170N x 160E	2700	2200
145N x 150E	2450	2300
150N x 150E	2300	2300
160N x 150E	2300	2300
170N x 150E	2300	2300
180N x 150E	2000	1900
190N x 150E	2100	2150
200N x 150E	2050	2050
210N x 150E	2150	2150

TABLE 2: ONE-METER EXPOSURE RATE MEASUREMENTS AT GRID INTERSECTIONS

LOCATION	SURFACE (NaI reading in cpm)*	1 METER (NaI reading in cpm)*
220N x 150E	2500	2300
230N x 150E	2400	2250
145N x 140E	2300	2200
150N x 140E	2100	2200
160N x 140E	2200	2100
170N x 140E	2100	2100
180N x 140E	2050	1900
190N x 140E	2150	2100
200N x 140E	2100	2150
210N x 140E	2200	2250
220N x 140E	2300	2400
145N x 130E	2200	2200
150N x 130E	2300	2200
160N x 130E	2150	1950
170N x 130E	1950	2000
180N x 130E	2050	2050
190N x 130E	2100	2050
200N x 130E	2400	2150
210N x 130E	2200	2200
220N x 130E	2300	2200
220N x 120E	2300	2200
210N x 120E	2500	2200
200N x 120E	2400	2300
190N x 120E	2350	2350
180N x 120E	2300	2100
170N x 120E	2150	2150
160N x 120E	2300	2100
150N x 120E	2100	2150
140N x 120E	2300	2150
140N x 110E	2400	2400
150N x 110E	2600	2500
160N x 110E	2500	2500
170N x 110E	2600	2500
180N x 110E	2350	2300
180N x 100E	2400	2300
170N x 100E	2500	2350
160N x 100E	2450	2300
150N x 100E	2400	2300
140N x 100E	2450	2400

* Background = 2500 cpm

Figure 1
Surface Soil Sample Locations Within Excavated Area

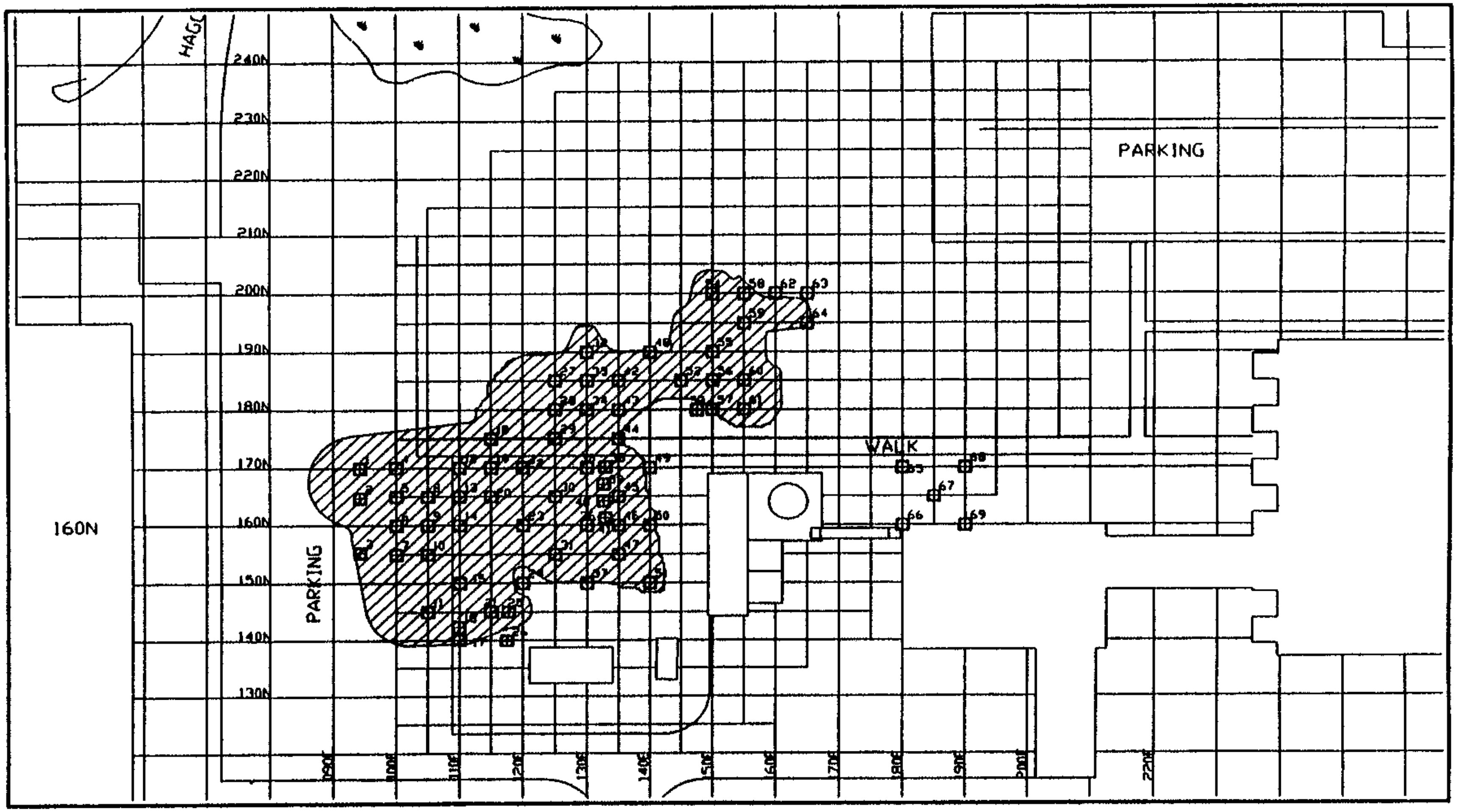

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Table 3: Excavated Area Soil Sample Results

Floor Sample Location Reference # (Figure 1)	Floor Sample Location	Date	Uranium (pCi/g) Gross Alpha Screen
1	170N x 95E	Dec-92	21
2	165N x 95E	Dec-92	31
3	155N x 95E	Dec-92	37
4	170N x 100E	Dec-92	16
5	165N x 100E	Dec-92	24
6	160N x 100E	Dec-92	28
7	155N x 100E	Dec-92	24
8	165N x 105E	Dec-92	24
9	160N x 105E	Dec-92	24
10	155N x 105E	Dec-92	24
11	145N x 105E	Nov-92	9
12	170N x 110E	Nov-92	53
13	165N x 110E	Nov-92	34
14	160N x 110E	Nov-92	22
15	150N x 110E	Nov-92	26
16	142.5N x 110E	Nov-92	24
17	140N x 110E	Nov-92	42
18	175N x 115E	Nov-92	14
19	170N x 115E	Nov-92	22
20	165N x 115E	Nov-92	18
21	145N x 115E	Nov-92	18
22	170N x 120E	Nov-92	34
23	160N x 120E	Nov-92	17
24	150N x 120E	Nov-92	27
25	145N x 117.5E	Nov-92	17
26	140N x 117.5E	Nov-92	9
27	185N x 125E	Feb-93	25
28	180N x 125E	Nov-92	15
29	175N x 125E	Nov-92	12
30	165N x 125E	Nov-92	11
31	155N x 125E	Nov-92	12
32	190N x 130E	Nov-92	17
33	185N x 130E	Feb-93	35
34	180N x 130E	Feb-93	23
35	170N x 130E	Nov-92	15
36	160N x 130E	Nov-92	27
37	150N x 130E	Nov-92	21
38	170N x 132.5E	Feb-93	32
39	167.5N x 132.5E	Feb-93	23
40	165N x 132.5E	Feb-93	33
41	162.5N x 132.5E	Feb-93	26
42	185N x 135E	Nov-92	50
43	180N x 135E	Feb-93	28
44	175N x 135E	Nov-92	14
45	165N x 135E	Nov-92	26
46	160N x 135E	Feb-93	24

Table 3: Excavated Area Soil Sample Results

Floor Sample Location Reference # (Figure 1)	Floor Sample Location	Date	Uranium (pCi/g) Gross Alpha Screen
47	155N x 135E	Feb-93	22
48	190N x 140E	Nov-92	12
49	170N x 140E	Nov-92	16
50	160N x 140E	Nov-92	24
51	150N x 140E	Nov-92	55
52	185N x 145E	Nov-92	8
53	180N x 147.5E	Nov-92	4
54	200N x 150E	Nov-92	29
55	190N x 150E	Nov-92	28
56	185N x 150E	Nov-92	50
57	180N x 150E	Nov-92	48
58	200N x 155E	Nov-92	7
59	195N x 155E	Nov-92	11
60	185N x 155E	Nov-92	21
61	180N x 155E	Nov-92	11
62	200N x 160E	Nov-92	16
63	200N x 165E	Nov-92	19
64	195N x 165E	Nov-92	10
65	170N x 180E	Nov-92	22
66	160N x 180E	Nov-92	33
67	165N x 185E	Nov-92	30
68	170N x 190E	Nov-92	46
69	160N x 190E	Nov-92	23
70	150N x 97.5E	Nov-92	19
71	145N x 100E	Nov-92	10

TABLE 4: GRID CELL AVERAGES OF GROSS ALPHA SCREENING DATA

GRID CELL LOCATION	GROSS ALPHA DATA (pCi/g)	GRID AVERAGE (pCi/g)
190 - 200N x 150 - 160E	29, 28, 7, 11, 16	18.2
180 -190N x 150 - 160E	50, 48, 21, 11, 28	31.6
180 - 190N x 140 - 150E	50, 48, 28, 12, 8, 4	25
180 - 190N x 130 - 140E	12, 17, 50, 28, 12, 8, 4	27.5
180 - 190N x 120 - 130E	15, 23, 35, 25, 17	23
170 - 180N x 130 - 140E	16, 14, 28, 23, 15, 32	21.3
170 --180N x 120 - 130E	12, 15, 23, 34, 15	19.8
170 - 180N x 110 - 120E	53, 22, 34, 14	30.8
160 - 170N x 130 - 140E	6, 24, 22, 24, 32, 23, 26, 33, 15, 2	24.2
160 - 170N x 120 - 130E	15, 27, 11, 34, 17	20.8
160 - 170N x 110 - 120E	34, 17, 22, 18, 53, 34, 22	28.6
160 - 170N x 100 - 110E	53, 34, 22, 24, 24, 24, 16, 28	28.1
160 - 170N x 90 - 100E	16, 24, 28, 21, 31	24
150 - 160N x 130 - 140E	24, 55, 24, 22, 27, 21	28.8
150 - 160N x 120 - 130E	27, 21, 12, 17, 27	20.8
150 - 160N x 110 - 120E	17, 27, 22, 26	23
150 - 160N x 100 - 110E	22, 26, 28, 24, 24, 24	24.7
150 - 160N x 90 - 100E	28, 24, 37, 19	27
140 - 150N x 110 - 120E	27, 17, 9, 18, 24, 42	22.8
140 - 150N x 100 - 110E	26, 24, 42, 9, 10	22.2

Figure 2
Split Spoon Sampling Locations

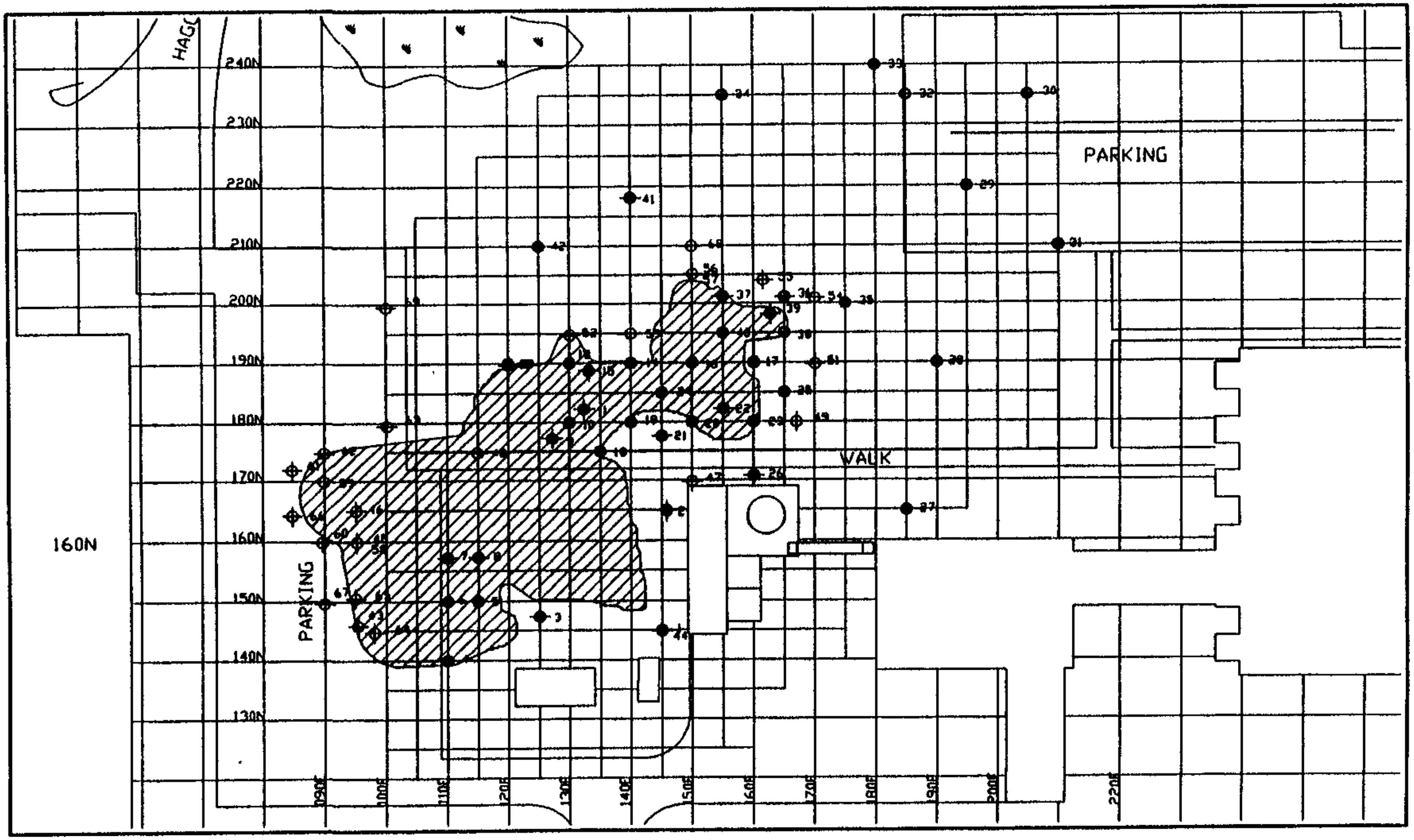

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TABLE 5: PERIMETER SPLIT SPOON SAMPLE RESULTS

LOCATION	DATE	0-2' pCi/g	2'-4' pCi/g	4'-6' pCi/g	0-6' AVERAGE pCi/g
200N X 125E	Dec-92	12	10	11	11
206N X 130E	Dec-92	14	24	10	16
200N X 135E	Dec-92	15	9	14	12.7
200N X 140E	Dec-92	29	14	8	17
200N X 145E	Dec-92	12	15	5	10.7
205N X 145E	Dec-92	21	16	9	15.3
210N X 165E	Dec-92	11	21	13	15
205N X 153E	Dec-92	8	12	23	14.3
195N X 135E	Dec-92	25	11	REF	18
175N X 185E	Dec-92	18	21	10	16.3
190N X 174E	Dec-92	32	5	8	15
175N X 163E	Dec-92	9	5	8	7.3
175N X 165E	Dec-92	17	4	6	9
180N X 175E	Dec-92	13	10	5	9.3
175N X 168E	Dec-92	13	15	37	21.7
145N X 135E	Dec-92	33	23	18	24.7
155N X 145E	Dec-92	9	18	13	10
175N X 175E	Dec-92	7	5	9	7
185N X 162E	Dec-92	.7	5	11	7.7
140N X 125E	Dec-92	29	20	18	22.3
140N X 103E	Dec-92	17	13	16	15.3
178N X 98E	Dec-92	19	7	REF	13
135N X 115E	Dec-92	17	18	15	16.7
130N X 110E	Dec-92	13	18	10	13.7
165N X 85E	Dec-92	15	18	25	19.3
150N X 90E	Dec-92	8	8	REF	8
210N X 150E	Dec-92	34	25	24	27.7
172.5N X 85E	Dec-92	12	13	15	13.3
175N X 90E	Dec-92	16	13	REF	14.5

TABLE 5: PERIMETER SPLIT SPOON SAMPLE RESULTS

LOCATION	DATE	0-1'	1-2'	2-3' (pCi/g)	3-4'	4-5'	0-6' AVERAGE
145N X 95E	Nov-92	10	31	17		22	20
145N X 140E	Nov-92	27	34	10	10	9	18
190N X 120E	Nov-92	18	21	15		15	17.3
202N X 170E	Nov-92	11	16			12	13
170N X 150E	Nov-92	9	12	6	5	7	7.8

LOCATION	DATE	.5 meter pCi/g	1 meter pCi/g	1.5 meter pCi/g	2 meter pCi/g	0-2 meter AVG. pCi/g
145N X 145E	Jul-92	12	10			11
175N X 105E	Jul-92	9	9			9
190N X 115E	Jul-92	15	11			13
210N X 130E	Jul-92	11	5			8
202N X 160E	Jul-92	16	11			13.5
200N X 170E	Jul-92	9	6			7.5
172.5N X 160E	Jul-92	8	8			8
177.5N X 140E	Jul-92	20	9	6	13	12
147.5N X 125E	Jul-92	10	6			8

Attachment 1

Post Excavation Radiological Survey Report

POST EXCAVATION RADIOLOGICAL SURVEY REPORT

TEXAS INSTRUMENTS INCORPORATED
BURIAL SITE
Attleboro, Massachusetts

Prepared by

Creative Pollution Solutions, Inc.

11/28/92

INTRODUCTION

The post excavation survey for the Texas Instruments Incorporated Building 12 Burial Site was designed in accordance with the Remediation Plan (approved 8/29/92). The remediation of the site included at least all areas outlined in the initial plan. When necessary, additional areas were excavated. The average depth of the excavated area is approximately 1.5 meters. In many areas groundwater was reached. Excavated material was either processed to remove aggregate and/or staged for disposition. A volume of approximately 90,000 ft^3 of material was excavated of which approximately 58,000 ft^3 was sent to EnviroCare of Utah via rail for final disposition. Figure 1 in Appendix A in this report shows the area of excavation. The excavated area will not be backfilled (except around an exposed fire hydrant) until after ORISE completes necessary sampling to confirm the post excavation survey.

The post excavation survey consists of two parts: a walkover surface scan of the affected area and surface soil sampling of the excavated area.

SURFACE SOIL SAMPLING WITHIN THE EXCAVATED AREA

The soil sampling plan for the excavated area consisted of surface soil samples at each corner and in the middle of each 10 meter x 10 meter grid cell. Wherever possible surface (0-15cm) soil samples of approximately 1 kg each were collected at these points. In some cases excavation equipment had to be used to extract a sample from beneath the standing water. A map of sample locations along with sample results are shown in Appendix A. All of the samples from the excavated area were analyzed using gross alpha screening. The average of all gross alpha screening samples within the excavated area is less than 30 pCi/g (Note: 30 counts/10 min approximately equals 30 pCi/g as correlated with Babcock and Wilcox gamma spectroscopy data -- see Appendix C). The gross alpha screening methodology is described in Appendix B.

SURVEY OF AFFECTED AREA

A walkover surface scan using portable NaI(Tl) gamma scintillation detectors was conducted at 1 meter intervals over the entire affected area. The affected areas consist of any areas in the defined exclusion area (see Health and Safety Plan, 8/92). The grid system established in the ORAU Radiological Survey (1985) was used. A walkover of the excavated area was not possible because of the elevated water table and accumulation of surface water run-off in this area. The walkover survey data is provided in Appendix D.

These surveys were conducted with a Ludlum model 44-2 1" by 1" NaI(Tl) probe coupled to a Ludlum model 2221 Portable Scaler/ratemeter. The purpose of these surveys was to determine and locate any radiological anomalies. The NaI type detectors are inherently highly energy dependent, but are useful due to its general greater sensitivity. The use of such instruments are well suited for the identification of anomalies, however, care must be given when interpreting the response in terms of exposure rates (μR/h). In this regard, a linear response check was performed using a ^{60}Co Source, the results of which are included within Appendix D. The energy distribution of photons encountered in field are characterized by a much lower photon energy distribution which is further confounded by a large degradation of this spectral distribution due to the source incorporation in a soil matrix. The interpretation of exposure rate from this instrument, short of an exhaustive study, is to assume from previous studies (ORAU) that a nominal background exposure rate of 11 μR/h exists and that a the NaI(Tl) background response correlates to this value. Even under this presumption certain errors will exist such as variation of background with time. Not withstanding a response factor from 0.0039 to 0.0034 with an average of 0.0037 is established.

APPENDIX A

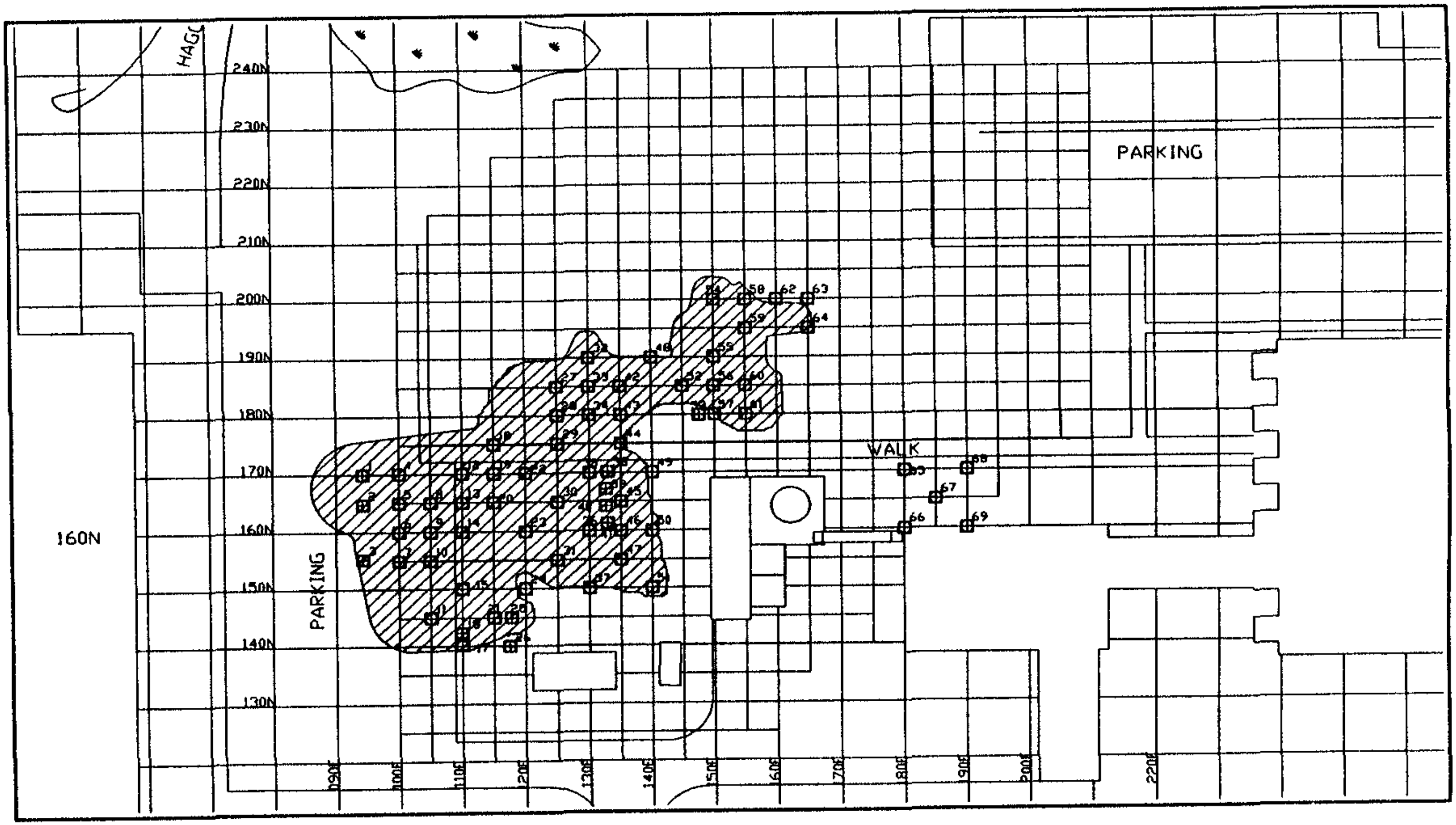
EXCAVATION FLOOR SAMPLING
ALPHA SCREENING RESULTS

North	East	Alpha Screen (pCi/g)
200	150	29
200	155	7
200	160	16
200	165	19
195	155	11
195	165	10
190	130	17
190	140	12
190	150	28
185	125	45
185	135	50
185	145	8
185	152	50
185	155	21
180	125	15
180	130	14
180	150	4
180	152	48
180	155	11
175	115	14
175	125	12
175	135	14
170	110	53
170	115	22
170	120	34
170	130	7
170	140	16
170	180	22
170	190	46

North	East	Alpha Screen (pCi/g)
165	110	34
165	115	18
165	125	11
165	135	22
165	185	30
160	110	22
160	120	17
160	130	27
160	140	24
160	180	33
160	190	23
155	125	12
155	135	25
150	110	26
150	120	27
150	130	21
150	140	55
145	105	9
145	115	18
145	120	17
142	110	24
140	110	42
140	120	9

Average of values = 23.10 pCi/g
Standard deviation = 13.23

Figure 1
Surface Soil Sample Locations Within Excavated Area



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APPENDIX B

ALPHA SCREENING METHODOLOGY

The alpha screening technique employed was gross alpha counting of a soil sample in intimate contact with a ZnS(Ag) detector. Using this method the ZnS(Ag) disc is disposable.

The method employed in the field was as follows:

1) Approximately 1 kg soil sample obtained

2) Sample homogenized by mixing (in larger container if necessary)

3) An aliquot of the homogenized sample is then (approximately 20-40 grams) dried in an oven at about 100° C for approximately 10 minutes. The sample is then allowed to cool.

4) The sample is then sieved and placed in direct contact with the phosphor side of the ZnS dish assembly.

5) The sample is then place in direct contact with a photomultiplier tube and counted for 10 minutes.

The counts obtained have been correlated to both alpha spectroscopy and gamma spectroscopy. The correlation to gamma spectroscopy is attached in Appendix C and the correlation to alpha spectroscopy has been demonstrated in previous reports.

APPENDIX C

COMPARISON OF ALPHA SCREENING AND GAMMA SPECTROSCOPY

Since the post excavation survey results were obtained using alpha screening 10 split samples were sent to both ORISE and an outside laboratory to establish a correlation between the gamma spectroscopy data and the alpha screening data. The comparison with one set of gamma spectroscopy results are shown below.

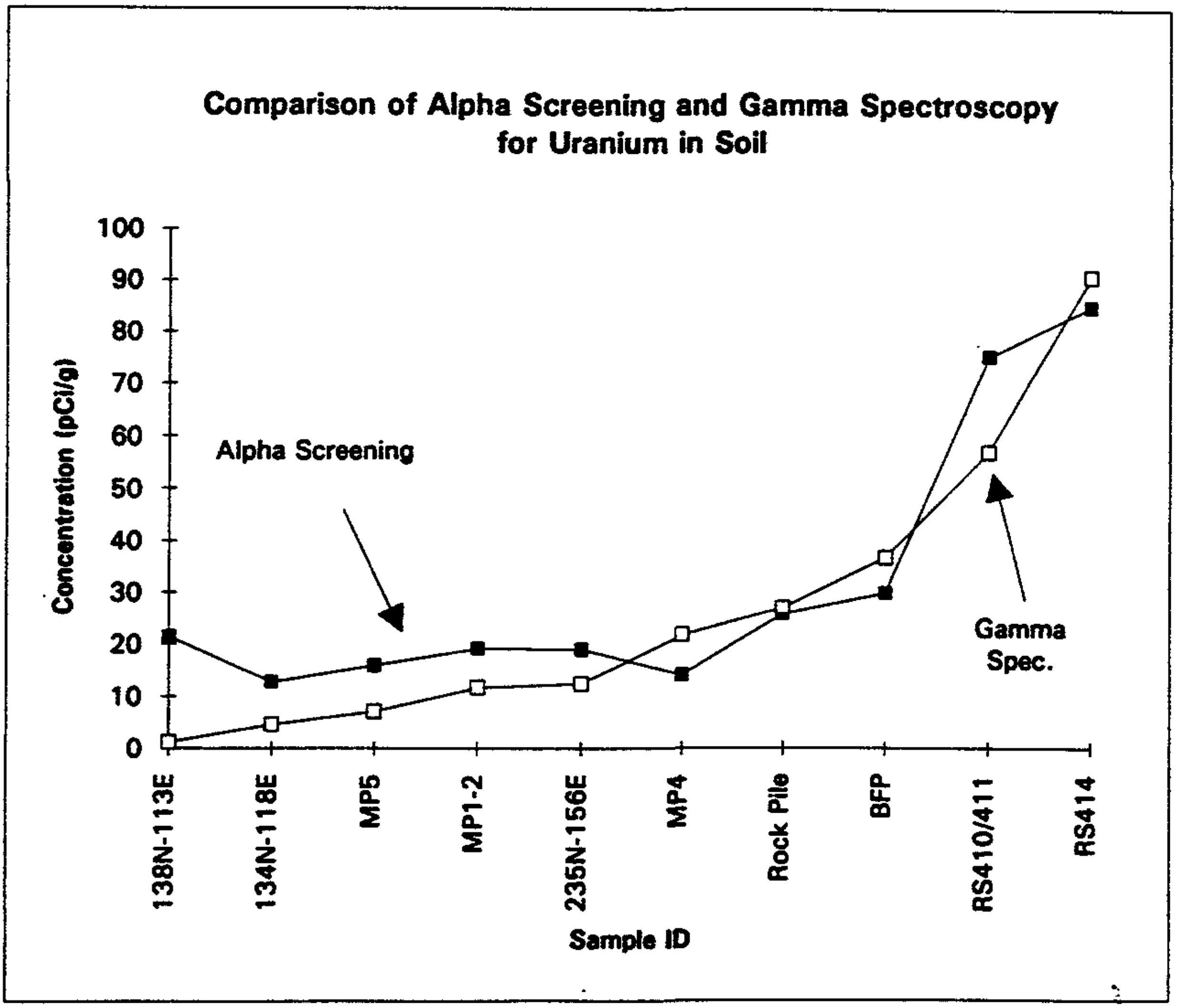
Notes regarding attached graph:

1) alpha screening result is based on an average of 5-10 samples

2) gamma spec data assumed an activity ratio (U-234/U-235) of 22.

Comparison of Alpha Screening and Gamma Spectroscopy for Uranium in Soil

SAMPLE ID	ALPHA SCREEN (TOTAL U pCi/g)	GAMMA SPEC (TOTAL U pCi/g)
138N-113E	21.4	1.25
134N-118E	12.8	4.65
MP5	15.9	7.1
MP1-2	19.2	11.65
235N-156E	19	12.49
MP4	14.2	21.82
Rock Pile	25.8	26.96
BFP	29.9	36.76
RS410/411	75.3	56.99
RS414	85	90.77



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APPENDIX D

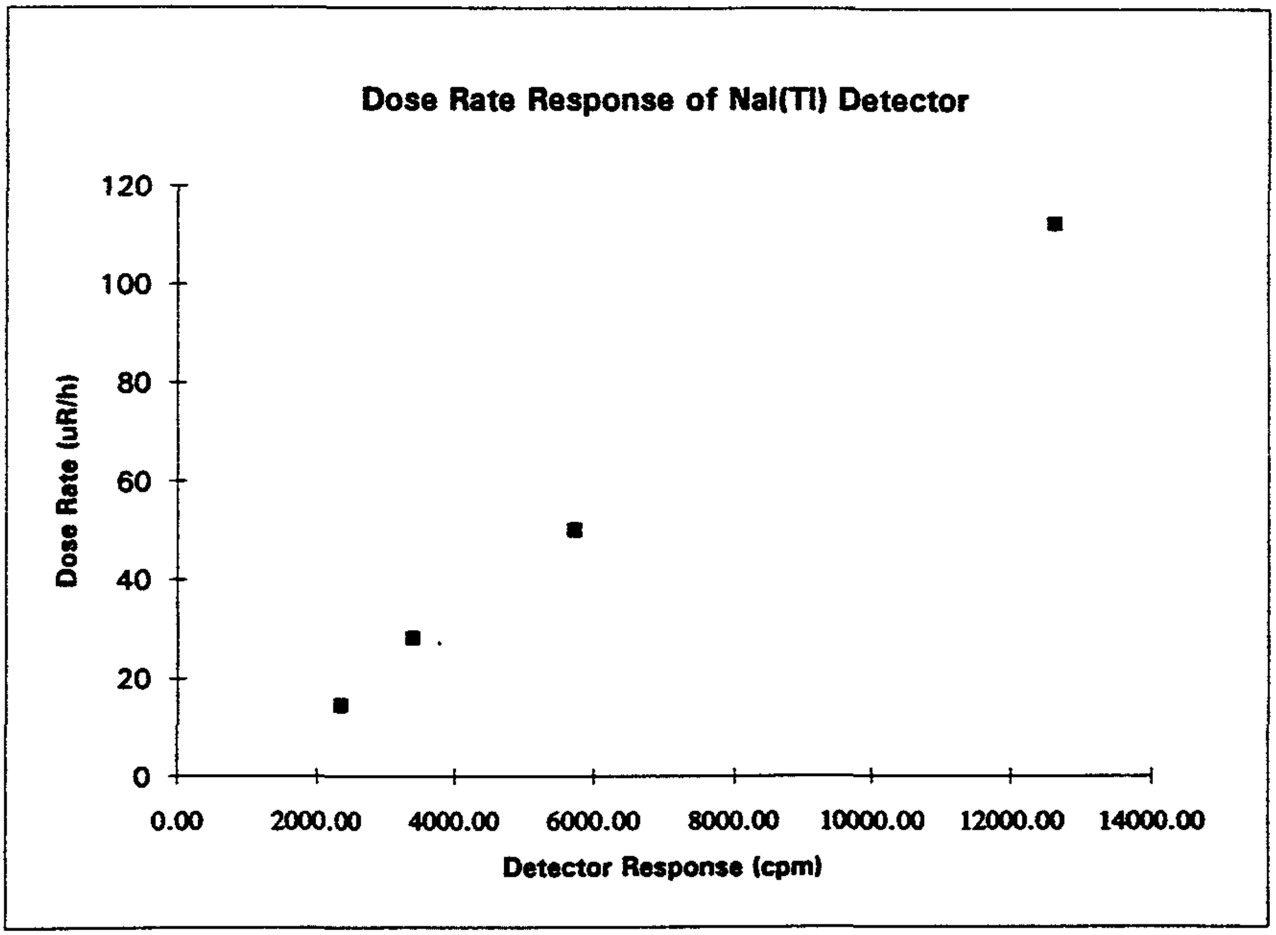
WALKOVER SURVEY RESULTS

NOTE: The attached represents the results of the walk over survey. The results presented are in the units of counts per minute (cpm)

Determination of the Response of the NaI(Tl) Detector for Radiological Field Surveys

	Bkg	2.5 meter	2.0 meter	1.5 meter	1.0 meter
1.00	5206.00	7455.00	8444.00	10938.00	17472.00
2.00	5283.00	7277.00	8564.00	10835.00	17646.00
3.00	5143.00	7441.00	8751.00	11107.00	17738.00
4.00	4959.00	7489.00	8552.00	10797.00	17744.00
5.00	5056.00	7589.00	8418.00	10864.00	17790.00
6.00	5105.00	7602.00	8334.00	10542.00	18064.00
Average	5125.33	7475.50	8510.50	10847.17	17742.33
Exp. Err	113.64	118.39	145.98	185.39	193.97
Th. Err.	71.59	86.46	92.25	104.15	133.20
Chi. Sq.	2.52	1.87	2.50	3.17	2.12

Net Response, cpm	2350.17	3385.17	5721.83	12617.00
Dose Rate, uR/h	14.58	28.13	50	112.5
Calibration Factor, uR/h/cpm	0.0062038	0.0083083	0.0087385	0.0089165



Regression Statistics	
Multiple R	0.9962444
R Square	0.9925029
Adjusted R Square	-1.333333
Standard Error	3.7517943
Observations	1

Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*
Regression	4	5590.341138	1397.58528	397.16
Residual	3	42.22788077	14.0759603	
Total	7	5632.569019		

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0					
Slope	0.0087835	0.000259572	33.8385201	5E-09	0.0079575	0.00961

Walk Over Surface Scan

Coordinates East North	105	106	107	108	109	110	111	112	113
120									
121									
122									
123									
124									
125									
126									
127									
128							3200	3200	2500
129						2600	2800	2800	2500
130						2700	2600	2700	3500
131						3000	2800	2800	2900
132				2800	2500	2500	2500	2500	2500
133				2500	2600	3100	3100	3200	2900
134	tar	tar	tar	3000	3000	2800	3000	2800	2800
135	tar	3200	2500	3200	3100	3000	3100	3200	3000
136	tar	2900	3000	3300	3000	3000	3300	3100	3100
137	tar	3000	2900	3000	3100	3000	2900	3300	3200
138	2900	2900	3100	3100	3200	3100	3000	3000	3100
139	3500	3200	3000	3300	3000	3200	3000	3200	3200
140	3300	2800	3600	3900	3300	3300	3200	3300	3300
141	3300	3500	3500	3500	3700	3300	3800	3700	3700
142	tar	3300	3500	4000	3300	3000	3200	3100	3200
143	tar								
144	tar								
145	tar								
146	tar								
147	tar								
148	tar								
149	tar								
150	tar								
151	tar								
152	tar								
153	tar								
154	tar								
155	tar								
156	tar								
157	tar								
158	tar								
159	3200	3500	4000	3200	5500	5000			
160		3600	3900	4000	3900	3500			
161		3700	3800	4000	4000				
162		4100	4500	4000	3900				
163		3500	4000	3700	4000				
164		3900	3900	3900	3800				
165		3500	4000	3900	4100				
166		4000	3900	3500	3800				
167		3500	4200	3800	4000	3800			
168		3700	3800	3700	3800	3200			

Walk Over Surface Scan

Coordinates East / North	105	106	107	108	109	110	111	112	113
169				4100	4200	4100			
170				3900	3900	3900			
171				3400	3500	3700			
172				3600	3900	3700			
173				3400	3500	3600			
174				3300	3400	3500			
175				3200	3300	3400			
176				3100	3200	3200			
177				3300	3500	3500	3200		
178				3500	3500	3300	3500	3500	
179				3400	3200	3100	3300	3300	3200
180						3000	3600	3500	3400
181						3200	3200	3100	3700
182							3300	3400	3400
183									4000
184									
185									
186									
187									
188									
189									
190									
191									
192									
193									
194									
195									
196									
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217									

218										
219										
220										

Walk Over Surface Scan

Coordinates East / North	114	115	116	117	118	119	120	121	122
120									
121									
122									
123									
124									
125									
126									
127									
128	2500	2400	2500	2500					
129	2500	2900	2500	2800					
130	2600	2600	2500	2500	2500	2500	2400		
131	2500	2800	2500	2500	2400	2300	3000		
132	2500	2800	2800	2600	2500	2500	2500		
133	2900	3000	3100	2900	2500	2500	2500		
134	2700	2500	2700	2500	2500	2500	2500		
135	2800	3000	3000	3000	2900	2800	2800		
136	3300	3100	rock	rock	3200	2900	2900		
137	3200	3500	rock	rock	3100	3200	3000		
138	3100	3200	3100	2900	3000	3000	2900		
139	3100	3200	3100	3200	2500	3000	3000		
140	3500	3400	3400	3100	3000	3000	3000		
141	3800	3600	3300	3200	3500	3200	3300		
142	3400	3300	3000	3200	2900	2900			
143					2800	2800			
144						2900	2900	2700	2800
145						2800	3000	3100	3000
146						2900	3200	3000	3200
147							3000	3000	3100
148									
149									
150									
151									
152									
153									
154									
155									
156									
157									
158									
159									
160									
161									
162									
163									
164									
165									
166									
167									
168									

Walk Over Surface Scan

Coordinates East / North	114	115	116	117	118	119	120	121	122
169									
170									
171									
172									
173									
174									
175									
176									
177									
178									
179	3200	3200	3300	3500	3500	3300	3400		
180	3400	3400	3000	3000	3000	3300	3500	3400	
181	3300	3200	3600	3200	3200	3000	3500	3600	3400
182	3300	3400	3400	3100	3000	3000	3200	3500	3200
183	3300	3300	3100	3200	3100	3000	3100	3300	3200
184	3100	3400	3000	3100	3200	3100	3100	3300	3200
185		3500	3200	3100	3300	3000	3200	3500	3200
186		3400	3100	3200	3300	3200	2900	3500	3500
187		3400	3200	3100	3500	3000	3000	3500	3200
188		3200	3100	3300	3500	3200	3000	3200	3400
189		3300	3200	3100	3000	3200	3200	3200	3200
190		3500	3200	3100	3000	3200	3000	3200	3700
191		3500	3200	3100	3200	3100	3500	3200	3700
192		3400	3200	3000	3500	3200	3200	3500	3700
193		3300	3400	3200	3500	3100	3200	3500	3700
194		3400	3400	3100	3200	3200	3400	3500	3400
195		3400	3400	3100	3000	3200	3500	3300	3300
196		3400	3200	3000	3100	3300	3500	3000	3500
197		3400	3400	3100	3100	3600	3500	3100	3500
198		3200	3300	3300	3400	3000	3100	3100	3300
199		3300	3300	3200	3300	3100	3100	3000	3300
200		3400	3100	3000	3000	3100	3300	3300	3400
201							3300	3400	3300
202							3200	3100	3400
203							3100	3200	3200
204							3200	3200	3100
205							3200	3100	3400
206							3100	3100	3200
207							3000	3100	3500
208							3000	3300	3500
209							3000	3200	3600
210							3500	3300	3200
211							3400	3200	3200
212		3300	3200	4400	3600	3400	3400	3500	3200
213		3200	3200	3700	3600	3300	3400	3300	3100
214		3400	3100	3600	3700	3500	3300	3200	3100
215		3300	3800	3600	4600	3400	3300	3300	3400
216		3300	3500	3800	3600	3800	3400	3400	3600
217		3900	4100	3900	3600	4000	4000	3800	3600

218		4100	4300	4100	4000	3800	3800	4000	3600
219		4000	3800	4200	4100	3800	3900	3800	3600
220		4000	4200	4600	4100	3800	3900	3600	3700

Walk Over Surface Scan

Coordinates East / North	123	124	125	126	127	128	129	130	131
120									
121									
122									
123									
124									
125									
126									
127									
128									
129									
130									
131									
132									
133									
134									
135									
136									
137									
138									
139									
140									
141									
142									
143									
144	2900	3000	3000	3000	3000	3000	3000	2900	
145	3000	3200	3200						3000
146	3400	3400	3500						
147	3000	3100							
148									
149									
150									
151									
152									
153									
154									
155									
156									
157									
158									
159									
160									
161									
162									
163									
164									
165									
166									
167									
168									

Walk Over Surface Scan

Coordinates East / North	123	124	125	126	127	128	129	130	131
169									
170									
171									
172									
173									
174									
175									
176									
177									
178									
179									
180									
181									
182	3100								
183	3400								
184	3500	3200							
185	3700	3200							
186	3400	3600							
187	3500	3700	3400						
188	3500	3200	3400						
189	3400	3400	3700	3200					
190	3700	3400	3200	3600	3600				
191	3600	3600	3200	3700	3800	3700	3600	3700	4500
192	3500	3600	3600	3700	4300	3800	4000	5000	6500
193	3500	3900	3700	3600	4100	3800	4000	4500	3700
194	3300	3700	3600	3600	3600	3600	3500	4000	3600
195	3200	3500	3600	3300	3400	3600	3500	3700	3700
196	3500	3300	3100	3300	3400	3600	3400	3500	3700
197	3500	3700	3500	3300	3200	3700	3100	3500	3600
198	3500	3600	3400	3500	3400	3200	3100	3700	3600
199	3200	3200	3000	3300	3300	3200	3100	3600	3500
200	3300	3400	3200	3500	3300	3400	3400	3600	3400
201	3200	3400	3200	3400	3500	3400	3400	3700	3200
202	3300	3300	3800	3100	3600	3200	3200	3900	3100
203	3500	3100	3400	3200	3300	3000	3400	3300	3000
204	3300	3100	3500	3300	3400	3000	3500	3300	3400
205	3200	3200	3500	3400	3600	3200	3500	3600	3500
206	3100	3500	3400	3400	3100	3700	3400	3400	3600
207	3400	3300	3300	3400	3300	3500	3500	3600	3600
208	3400	3200	3400	3200	3700	3400	3400	3400	3200
209	3200	3300	3400	3300	3200	3500	3300	3200	3100
210	3300	3300	3400	3500	3200	3300	3200	3200	3100
211	3200	3200	3100	3200	3500	3600	3200	3300	3100
212	3200	3200	3300	3300	3300	3500	3100	3400	3200
213	3300	3300	3300	3200	3700	3500	3500	3300	3200
214	3300	3600	3300	3500	3200	3400	3500	3200	3400
215	3300	3700	3600	3700	3500	3600	3600	3600	3500
216	3800	3800	3500	3600	3500	3800	3600	3800	3500
217	4200	4000	3800	4000	3800	4000	4100	3800	3500

218	4000	3600	4000	3900	3600	3800	4000	3700	3500
219	4000	3600	3800	4200	3600	3800	3700	4600	3600
220	3600	3800	3600	3400	3600	3400	3600	3300	3100

Walk Over Surface Scan

Coordinates East / North	132	133	134	135	136	137	138	139	140
120									
121									
122									
123									
124									
125									
126									
127									
128									
129									
130									
131									
132									
133									
134									
135									
136									
137									
138									
139									
140									
141									
142									
143									
144									
145	3000	3000	2900	2900	3000	3000	3000	2900	3000
146	3000	3000	3000	2900	2900	3000	3000	2800	3000
147	3000	3000	2800	3000	3000	3000	3000	3000	3000
148	3000	3000	3000	3000	3100	3000	3200	2900	3000
149	3200						3200	3000	3000
150							3300	3200	3200
151									
152									
153									
154									
155									
156									
157									
158									
159									
160									
161									
162									
163									
164									
165									
166									
167									
168									

Walk Over Surface Scan

Coordinates East / North	132	133	134	135	136	137	138	139	140
169									
170									4100
171									4200
172						sw	sw	sw	sw
173						sw	sw	sw	sw
174						sw	sw	sw	sw
175								3500	3400
176								3200	3400
177								3200	3500
178								3400	3500
179								3500	3600
180								3500	3700
181									
182									
183									
184									
185									
186									
187									
188									
189									
190			3800	4300	5500	3900	3700	4000	3700
191	4500	5500	3800	5500	4800	3400	3700	3900	4000
192	6100	5000	4100	3500	3800	3200	3700	3500	4000
193	5700	10000	3800	3400	3200	3400	3400	3500	3400
194	4400	4100	3700	3300	3200	3200	3200	3300	3500
195	3300	3400	3700	3200	3000	3300	3200	3400	3500
196	3200	3500	3500	3300	3000	3100	3100	3400	3400
197	3200	3100	3300	3500	3000	3200	3200	3300	3200
198	3500	3300	3400	3600	3200	3200	3300	3100	3300
199	3600	3300	3400	3500	3000	3900	3200	3200	3500
200	3500	3400	3400	3800	3700	3500	3200	3400	3200
201	3400	3400	3000	4000	3500	3300	3400	3100	3300
202	3600	3700	3400	3800	3400	3500	3400	3400	3300
203	3500	3600	3700	3900	3700	3200	3400	3400	3500
204	3500	3600	3800	4400	3500	3300	5800	3200	3400
205	3500	3600	4100	3600	3900	3500	3400	3500	3400
206	3700	3500	3800	3500	3700	3100	3100	3600	3500
207	3800	3700	3500	3400	3500	3200	3100	3400	3500
208	3400	3100	3200	3300	3200	3100	3300	3300	3300
209	3100	3200	3300	3500	3400	3300	3500	3400	3400
210	3300	3300	3400	3500	3300	3100	3300	3500	3500
211	3100	3100	3100	3200	3200	3200	3200	3200	3300
212	3100	3100	3300	3400	3300	3400	3600	3200	3400
213	3600	3200	3500	3600	3600	3400	3600	3300	3600
214	3500	3200	4000	3500	3800	3800	3800	3300	3600
215	3600	3400	4000	3600	3800	4000	3800	3500	3600
216	3700	4100	3700	4000	3900	4400	4100	3800	3800
217	3800	3800	3700	3900	3800	4200	4300	4000	

218	3500	3600	3400	3900	3200	4200	4200		
219	3600	3400	3200	3400	3000	3600			
220	3300	3100	3300	3100					

Walk Over Surface Scan

Coordinates East / North	141	142	143	144	145	146	147	148	149
120									
121									
122									
123									
124									
125									
126									
127									
128									
129									
130									
131									
132									
133									
134									
135									
136									
137									
138									
139									
140									
141									
142									
143									
144									
145	2800	2900	3100	3100	3100	3000	3300	3200	3100
146	2700	3000	3300	3400	2900	3200	3700	3000	3200
147	2800	3000	3400	3500	2800	3400	3800	3300	3200
148	2800	3200	3300	3300	3100	3900	3700	3400	3300
149	2900	3000	3200	3300	3100	3500	3200	3500	3200
150	3200	3400	3200	3100	3000	3500	3500	3200	3000
151			3200	3200	3200	3000	2900	3200	3100
152			3000	3400	3200	3100	3000	3400	3100
153			3200	3200	3200	3100	3000	3200	3000
154			3500	3200	3300	3200	3400	3100	3900
155			3400	3200	3000	3200	3400	3100	3000
156			3300	3100	2700	3100	3200	3000	3000
157			3200	3200	2900	3100	3000	3000	3100
158			3400	3000	3000	3000	3000	3000	3200
159			3300	3000	3000	3000	3000	3100	3000
160			3200	3000	3200	3200	3100	3000	3900
161			3400	2900	3000	3100	3000	2900	3000
162			3500	3000	2900	3200	3000	3000	3000
163			3400	3000	3100	3200	3200	2900	3000
164			3500	3100	3000	3300	3400	3000	3200
165			3500	3300	3000	3300	3300	3200	3300
166			3200	3200	3000	3400	3200	3000	3300
167			3200	3300	3300	3200	3100	3000	3200
168			3000	3100	3200	3200	3200	3200	3000

Walk Over Surface Scan

Coordinates East / North	141	142	143	144	145	146	147	148	149
169			3000	3000	3100	3200	3300	3400	3300
170	3400	3300	3500	3200	3000	3100	3200	3000	2500
171	3800	3600	3500	3500	3000	3000	3200	3000	2900
172	sw	sw	sw	sw	sw	sw	sw	sw	sw
173	sw	sw	sw	sw	sw	sw	sw	sw	sw
174	sw	sw	sw	sw	sw	sw	sw	sw	sw
175	3400	3500	3400	4000	3400	3700	3500	3500	3400
176	3400	3500	3700	3500	3300	3500	3500	3400	3400
177	3500	3500	3600	3500	3300	3800	3500	4000	3900
178	3200	3700	3500	3800	9300	4000	3500	3800	3900
179	3700	3800	3500	3800	6500	4000	4200	3600	3500
180	3800	4000							
181									
182									
183									
184									
185									
186									
187									
188									
189									
190	3400	3600	3600	3600	3300	3200	3400		
191	3600	3700	3800	3400	3300	3400	3600		
192	3400	3600	3400	3600	3500	3500	3600		
193	3700	3600	3200	3500	3700	3700	3500		
194	3600	3600	3500	3600	3600	3400	3900		
195	3200	3700	3500	3500	3800	3600	4700		
196	3300	3500	5700	3500	3900	4200	3800		
197	3400	3300	3200	3600	3700	4800	3600		
198	3500	3300	3200	3400	3300	3700	3500	3600	3500
199	3500	3500	3300	3400	3400	3800	3200	3400	3400
200	3200	3200	3000	3300	3500	3200	3200	3400	3500
201	3200	3300	3200	3200	3500	3100	3500	3500	3300
202	3000	3400	3200	3100	3400	3200	3400	3300	3600
203	3300	3000	3200	3100	3300	3000	3400	3400	3500
204	3300	3300	3300	3100	3300	3200	3400	3600	3500
205	3400	3400	3400	3400	3400	3500	3700	3400	3000
206	3400	3500	3300	3400	3500	4500	3600	3500	3500
207	3300	3400	3500	3400	3500	3400	3600	3600	3500
208	3500	3400	3600	3600	3300	3200	3700	3600	3500
209	3600	3600	4200	3600	3500	3400	3700	3500	3400
210	3400	3600	3400	3700	3500	3700	3700	3500	3500
211	3200	3500	3400	3500	3500	3500	3400	3200	3300
212	3200	3300	3600	3600	3400	3400	3400		
213	3400	3300	3500	3400	3300	3600			
214	3200	3500	3600						
215	3300	3600							
216	3600								
217									

218									
219									
220									

Walk Over Surface Scan

Coordinates East North	150	151	152	153	154	155	156	157	158
120									
121									
122									
123									
124									
125									
126									
127									
128									
129									
130									
131									
132									
133									
134									
135									
136									
137									
138									
139									
140									
141									
142									
143									
144									
145	drive	drive	drive	drive	drive	drive	drive	bldg	bldg
146	drive	drive	drive	drive	drive	drive	drive	bldg	bldg
147	drive	drive	drive	drive	drive	drive	drive	bldg	bldg
148	drive	drive	drive	drive	drive	drive	drive	bldg	bldg
149	drive	drive	drive	drive	drive	drive	drive	bldg	bldg
150	drive	drive	drive	drive	drive	drive	drive	bldg	bldg
151	drive	drive	drive	drive	drive	drive	drive	bldg	bldg
152	drive	drive	drive	drive	drive	drive	drive	bldg	bldg
153	drive	drive	drive	drive	drive	drive	drive	bldg	bldg
154	drive	drive	drive	drive	drive	drive	drive	bldg	bldg
155	drive	drive	drive	drive	drive	drive	drive	bldg	bldg
156	drive	drive	drive	drive	drive	drive	drive	tank	tank
157	drive	drive	drive	drive	drive	drive	drive	tank	tank
158	drive	drive	drive	drive	drive	drive	drive	tank	tank
159	drive	drive	drive	drive	drive	drive	drive	tank	tank
160	drive	drive	drive	drive	drive	drive	drive	tank	tank
161	drive	drive	drive	drive	drive	drive	drive	tank	tank
162	drive	drive	drive	drive	drive	drive	drive	tank	tank
163	drive	drive	drive	drive	drive	drive	drive	tank	tank
164	drive	drive	drive	drive	drive	drive	drive	tank	tank
165	drive	drive	drive	drive	drive	drive	drive	tank	tank
166	drive	drive	drive	drive	drive	drive	drive	tank	tank
167	drive	drive	drive	drive	drive	drive	drive	tank	tank
168	drive	drive	drive	drive	drive	drive	drive	tank	tank

Walk Over Surface Scan

Coordinates East / North	150	151	152	153	154	155	156	157	158
169	drive	drive	drive	drive	drive	drive	drive	tank	tank
170	2800	2800	2900	2900	3000	3300	3300	3200	3200
171	2900	3000	3100	3000	3200	3200	3200	3000	3000
172	sw	sw	sw	sw	sw	sw	sw	sw	sw
173	sw	sw	sw	sw	sw	sw	sw	sw	sw
174	sw	sw	sw	sw	sw	sw	sw	sw	sw
175	3600	3400	3300	3500	3700	3800	3300	3200	3300
176	3300	3600	3400	3500	3500	3500			
177	3400	3900	3400	3700	3500	3500			
178	3700	3700	3500	3600					
179	3600								
180									
181									
182									
183									
184									
185									
186									
187									
188									
189									
190									
191									
192									
193									
194									
195									
196									
197									
198									
199	3500	3700					4500	4300	
200	3700	3800	3600	7000	3800	5500	4600	4100	4200
201	3700	4500	4000	3700	4000	4100	4900	4200	4400
202	3500	3900	4100	3700	4100	4100	3500	4000	4200
203	3800	4200	4000	4100	3600	4200	3800	3600	4200
204	3900	3900	3900	5100	3800	4000	3900	3600	3600
205	3700	3600	3700	4000	4000	3900	3600	3700	3900
206	3500	3600	4200	3600	4000	3800	3600	3400	3600
207	3200	3800	3600	3600	3900	3400	4100	3300	3900
208	3200	3400	3600	3700	4000	3500	4100	3700	
209	3400	3600	3700	3700	3900	rockpile			
210	3200	3300	3700	3900	rockpile				
211	3200	3600	4000						
212									
213									
214									
215									
216									
217									

218										
219										
220										

Walk Over Surface Scan

Coordinates East / North	159	160	161	162	163	164	165	166	167
120									
121									
122									
123									
124									
125									
126									
127									
128									
129									
130									
131									
132									
133									
134									
135									
136									
137									
138									
139									
140									
141									
142									
143									
144									
145	bldg	bldg	bldg	bldg	bldg	bldg	bldg	bldg	
146	bldg	bldg	bldg	bldg	bldg	bldg	bldg	bldg	
147	bldg	bldg	bldg	bldg	bldg	bldg	bldg	bldg	
148	bldg	bldg	bldg	bldg	bldg	bldg	bldg	bldg	
149	bldg	bldg	bldg	bldg	bldg	bldg	bldg	bldg	
150	bldg	bldg	bldg	bldg	bldg	bldg	bldg	bldg	
151	bldg	bldg	bldg	bldg	bldg	bldg	bldg	bldg	
152	bldg	bldg	bldg	bldg	bldg	bldg	bldg	bldg	
153	bldg	bldg	bldg	bldg	bldg	bldg	bldg	bldg	
154	bldg	bldg	bldg	bldg	bldg	bldg	bldg	bldg	
155	bldg	bldg	bldg	bldg	bldg	bldg	bldg	bldg	
156	tank	tank	tank	tank	tank	tank	tank	tank	
157	tank	tank	tank	tank	tank	tank	tank	tank	
158	tank	tank	tank	tank	tank	tank	tank	tank	
159	tank	tank	tank	tank	tank	tank	tank	tank	
160	tank	tank	tank	tank	tank	tank	tank	tank	tar
161	tank	tank	tank	tank	tank	tank	tank	tank	3700
162	tank	tank	tank	tank	tank	tank	tank	tank	3900
163	tank	tank	tank	tank	tank	tank	tank	tank	4400
164	tank	tank	tank	tank	tank	tank	tank	tank	5500
165	tank	tank	tank	tank	tank	tank	tank	tank	8200
166	tank	tank	tank	tank	tank	tank	tank	tank	4700
167	tank	tank	tank	tank	tank	tank	tank	tank	4000
168	tank	tank	tank	tank	tank	tank	tank	tank	4000

Walk Over Surface Scan

Coordinates East North	159	160	161	162	163	164	165	166	167
169	tank	tank	tank	tank	tank	tank	tank	tank	4700
170	3500	3300	3300	3400	3800	3500	3500	3500	3500
171	3500	3400	3400	3200	3800	3300	3400	3600	3200
172	sw	sw	sw	sw	sw	sw	sw	sw	sw
173	sw	sw	sw	sw	sw	sw	sw	sw	sw
174	sw	sw	sw	sw	sw	sw	sw	sw	sw
175	3500	3200	3500	3400	3200	3200	3200	3600	3200
176	3600	3500	3700	3200	3000	2200	3300	3400	3200
177	3300	3500	3400	3400	3000	3300	3300	3500	3500
178	3500	3700	3300	3500	3300	3400	3400	3500	3900
179	3200	3500	3500	3800	3300	3400	3400	3500	4100
180	3200	3400	3600	3400	3300	3500	3500	4200	3800
181	3200	3500	3300	3400	3300	3500	3500	3600	3700
182	3400	3500	3500	3300	3400	3500	3500	3700	3500
183	3500	3400	3400	3800	3400	3400	3500	3500	3500
184	3500	3400	3500	3500	3500	3700	3500	3500	3500
185	3400	3400	3400	3500	3600	3500	3400	3500	3500
186	3300	3300	3700	4000	3700	3600	3500	3600	3700
187	3200	3500	3800	4000	3500	3700	3400	3700	3700
188	3200	4000	3700	4000	4000	3700	3300	3800	4000
189	3400	3900	4000	4100	3500	3800	3500	3800	3500
190	4000	3600	3500	3600	4000	3800	4100	3900	4100
191							4200	4100	4100
192							3800	4100	4100
193							3800	3800	4000
194							3400	3700	4200
195							3800	4100	4100
196							4300	3900	4200
197							4600	4000	4900
198							4100	3900	4300
199							3800	3900	4100
200	4600	4200	4100	4000	4100	3800	4100	3600	4200
201	4500	5000	3700	3200	3700	3500	3500	3000	3500
202	4300	4200	3700	3200	3600	3500	3500	3500	3700
203	3800	3400	3500	3300	3300	3500	3300	3300	
204	3600	3600	3600	3300	3300	3400	3400		
205	3600	3300	3400	3300	3400	3500			
206	3500	3600	3300	3500	3400	3600			
207	3500	3800			3500	3400			
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Walk Over Surface Scan

Coordinates East / North	168	169	170	171	172	173	174	175	176
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159									
160	tar	tar	tar	tar	tar	tar	sw	sw	sw
161	3200	3200	3000	3000	3200	3000	sw	sw	sw
162	3400	3500	3200	3200	3500	3100	sw	sw	sw
163	3400	3500	3700	3400	3500	3200	sw	sw	sw
164	3300	3700	3200	3500	3500	3000	sw	sw	sw
165	3500	3600	3200	3400	3600	3500	sw	sw	sw
166	3800	3600	3500	3600	4000	3800	sw	sw	sw
167	3600	3600	3400	3800	3600	3800	sw	sw	sw
168	3600	3600	3200	3700	3900	3300	sw	sw	sw

Walk Over Surface Scan

Coordinates East / North	168	169	170	171	172	173	174	175	176
169	3500	3500	3200	3200	3500	3200	sw	sw	sw
170	3200	3400	3400	3000	3200	3200	sw	sw	sw
171	3200	3100	3500	3100	3300	3000	sw	sw	sw
172	sw	sw	sw	sw	sw	sw	sw	sw	sw
173	sw	sw	sw	sw	sw	sw	sw	sw	sw
174	sw	sw	sw	sw	sw	sw	sw	sw	sw
175	3000	3000	3000	2900	3100	3000	3200	3700	3000
176	2900	3000	3000	2900	3200	3000	3300	3200	3000
177	3000	3500	3000	3200	3200	3200	3200	3300	3400
178	3000	3700	3000	3200	3200	3800	3300	3700	4000
179	3200	3800	3200	3300	3400	3900	3700	3500	3400
180	4000	4500	3900	4000	3200	3400	3400	3500	3800
181	3500	4000	3700	3600	3200	3600	3700	4000	3900
182	3500	4000	3700	4000	3400	3600	3500	3600	4000
183	3500	4000	3500	3500	3400	3800	4000	4000	3800
184	3700	3600	3400	3400	3700	4200	3900	4100	3700
185	3900	3500	3500	3400	3900	3900	3800	4100	3900
186	4000	3600	3400	3800	5300	3800	4000	3800	3700
187	4100	3700	3300	3800	4000	3800	3800	3600	3500
188	4000	3700	4000	4000	4000	4000	3500	3700	4400
189	4200	3800	3900	3800	3900	3800	5500	3800	7500
190	3800	4400	3900	4100	3800	3900	3800	4000	3700
191	8000	4000	4000	3900	3900	3900	3800	3900	3900
192	4400	3900	3800	3700	3800	3800	3900	4100	4100
193	4000	3900	3900	3700	3800	3900	4200	4200	3800
194	4100	4000	4000	3400	3700	3800	3900	4000	3900
195	3800	3900	4000	3500	3700	3400	3700	3700	3800
196	3900	4200	3900	3400	3600	3900	3600	3600	4100
197	3900	4000	3600	3400	3400	3400	3800	3400	3800
198	3300	3500	3300	3900	3800	3600	3800	3600	rockpile
199	3400	3300	3100	rockpile	3700	3600	rockpile	rockpile	rockpile
200	3300	3200	3300	rockpile	4000	rockpile	rockpile	rockpile	
201	3700			rockpile	rockpile	rockpile			
202	3800								
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Walk Over Surface Scan

Coordinates East / North	177	178	179	180	181	182	183	184	185
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160	3000	3200	3400	3300	3400	3500	3300	3500	3500
161	3300	3100	3200	3200	3300	3300	3400	3700	3600
162	3000	3000	pit	pit	pit	pit	pit	pit	pit
163	3200	3000	pit	pit	pit	pit	pit	pit	pit
164	3000	3000	pit	pit	pit	pit	pit	pit	pit
165	3200	3000	pit	pit	pit	pit	pit	pit	pit
166	3200	3200	pit	pit	pit	pit	pit	pit	pit
167	3400	3200	pit	pit	pit	pit	pit	pit	pit
168	3000	3000	pit	pit	pit	pit	pit	pit	pit

Walk Over Surface Scan

Coordinates East / North	177	178	179	180	181	182	183	184	185
169	3000	3000	pit	pit	pit	pit	pit	pit	pit
170	3100	3500	pit	pit	pit	pit	pit	pit	pit
171	3000	3400	pit	pit	pit	pit	pit	pit	pit
172	sw	sw	sw	sw	sw	sw	sw	sw	sw
173	sw	sw	sw	sw	sw	sw	sw	sw	sw
174	sw	sw	sw	sw	sw	sw	sw	sw	sw
175	3000	3000	3200	3000	3100	3200	3000	3200	3200
176	3000	3000	3300	3100	3100	3000	3000	3400	3100
177	3000	3300	3000	3200	3200	3200	3100	3500	3000
178	3100	3500	3500	3200	3300	3500	3100	3300	3200
179	3100	3500	3500	3400	3200	3400	3000	3500	3300
180	3800	4100	3600	3400	3400	3500	3400	3400	3700
181	4100	4200	4000	4000	3400	3300	3500	3400	3200
182	3700	4100	4400	4400	3500	3300	3500	3500	3200
183	3900	4100	4200	4200	3800	3300	3400	3400	3200
184	3900	3800	3800	4000	3700	3300	3400	3000	3300
185	4200	3800	3700	3800	3200	3500	3300	3200	3200
186	3800	3800	3800	3700	3300	3300	3300	3400	3300
187	3900	3800	3800	3900	3500	3400	3300	3600	3200
188	4200	4100	4000	4100	3500	3500	3400	3600	3200
189	4400	4400	4100	4000	3500	3600	3200	3500	3200
190	4000	4200	4400	4200	3500	3400	3400	3300	3300
191	4000	4100	3800	4000	3700	3500	3500	3300	3200
192	4000	4100	4000	4600	3700	3500	3200	3500	
193	4400	4000	3800	4100	3400	3500	3200	3500	
194	4200	3800	4200	3800	3500	3500			
195	3900	3900	4500	3500	3700				
196	3600	3700	3900	3700					
197	3700	3600	rockpile	rockpile					
198	rockpile	rockpile	rockpile	rockpile					
199	rockpile								
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Walk Over Surface Scan

Coordinates East / North	186	187	188	189	190	191	192	193	194
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160	3300	3200	3300	3700	4400	3200	3200	3200	3200
161	3400	3200	3100	3000	3200	3100	3300	3300	3100
162	pit	pit	pit	3000	3200	3000	3400	3400	3000
163	pit	pit	pit	3000	3300	3200	3400	3400	3000
164	pit	pit	pit	3200	3500	3200	3000	3500	3400
165	pit	pit	pit	3300	3300	3200	3100	3500	3300
166	pit	pit	pit	3200	3400	3400	3200	3100	3400
167	pit	pit	pit	3100	3400	3700	3400	3200	3400
168	pit	pit	pit	3200	3300	3400	3300	3200	3300

Walk Over Surface Scan

Coordinates East / North	186	187	188	189	190	191	192	193	194
169	pit	pit	pit	3200	3300	3400	3300	3300	3200
170	pit	pit	pit	3400	3000	3400	3200	3300	3100
171	pit	pit	pit	3200	3200	3000	3500	3400	3300
172	sw	sw	sw	sw	sw	sw	sw	sw	sw
173	sw	sw	sw	sw	sw	sw	sw	sw	sw
174	sw	sw	sw	sw	sw	sw	sw	sw	sw
175	3000	3000	3000	3000	3200	3000	3000	3300	3000
176	3000	3000	3200	3000	3000	3300	3200	3400	3000
177	3000	3000	3200	3000	3000	2900	3300	3700	3000
178	3200	3000	3000	3000	3100	2900	3400	3400	3200
179	3300	3100	3000	3000	3000	3000	3300	3300	3100
180	3500	3200	3100	3000	3000	3000	3000	3500	3200
181	3900	3000	3000	3000	3100	2900	3000	3500	3200
182	3900	3100	3300	2900	3000	2800	3000	3300	3300
183	3500	3200	3200	2900	3000	3000	3000	3000	3000
184	3200	4500	3400	3000	3000	3000	3200	3000	3000
185	3300	3900	3500	3000	3000	3100	3100	3000	2800
186	3500	3900	3400	3000	3200	3200	3200	3000	2800
187	3000	3500	3100	3200	3200	3200	3400	3000	3200
188	3000	3200	3200	3200	3000	3200	3300	3100	
189	3200	3000	3300	3300					
190	3200	3200	3000						
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Walk Over Surface Scan

Coordinates East / North	195	196	197	198	199	200	201	202	203
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159									
160	3200	3500	3500	4200	3800	4000			
161	3500	3500	3500	3500	3700	3700	3700		
162	3500	3300	3400	3500	3200	3500	4000	4000	
163	3200	3400	3500	3400	3400	4000	3900	3500	3500
164	3000	3500	3500	3300	3500	4000	3500	3500	3800
165	3000	3400	3400	3300	3400	3900	3500	3500	3800
166	3200	3300	3300	3400	3300	3500	3500	3600	3500
167	3100	3500	3800	3300	3300	3500	3600	3300	3300
168	3200	3500	3400	3100	3200	3000	3200	3400	3400

Walk Over Surface Scan

Coordinates East / North	195	196	197	198	199	200	201	202	203
169	3000	3500	3300	3000	3200	3400	3000	3400	3200
170	3100	3400	3300	3300	3100	3200	3100	3300	3200
171	3200	3200	3300	3200	3000	3200	3200	3100	3200
172	sw	sw	sw	sw	sw	sw	sw	sw	sw
173	sw	sw	sw	sw	sw	sw	sw	sw	sw
174	sw	sw	sw	sw	sw	sw	sw	sw	sw
175	3200	3000	3100	3000	3100		163000	3000	
176	3000	3000	3200	3000	3100		3000	3000	
177	3100	2800	3000	3200	3200		3100	4000	
178	3100	3000	3000	3000	3200		3100		
179	3200	3000	3000	3100	3000		3200		
180	3200	3200	3200	3000	3000	3100	3200	3200	
181	3200	3300	3100	3400	2800	3200	3100		
182	3200	3500	3300	3300	3000	3200			
183	3100	3400	3200	3200	3300				
184	3100	3400	3200	3500					
185	3200	3200	3200						
186	3200	3200							
187	3200								
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Walk Over Surface Scan

Coordinates East / North	204	205
169	3300	3000
170	3200	3200
171	3200	3300
172	sw	sw
173	sw	sw
174	sw	sw
175		
176		
177		
178		
179		
180		
181		
182		
183		
184		
185		
186		
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ME-024228

Attachment 2

Revised Final Survey Report

ME-024229

REVISED FINAL SURVEY REPORT

TEXAS INSTRUMENTS INCORPORATED
BURIAL SITE
Attleboro, Massachusetts

Prepared by

Creative Pollution Solutions, Inc.

1/8/93

revision 1.0

INTRODUCTION

This revised post excavation survey report is intended as an addendum to the initial "Post Excavation Radiological Survey Report" submitted by Texas Instruments Incorporated to the NRC on 12/1/92. This report shows the areas where additional excavation took place on the site and the method for defining the extent of the excavation. This report does not include a walk-over survey of the entire affected area, however, this will be included in a later report to the NRC.

The conclusion of the survey conducted by ORISE for the NRC, on December 14-16 1992, was that the bottom of the excavation was at acceptable levels, however, there was some question on areas around the wall of the excavation. NRC requested that Texas Instruments continue to excavate in certain areas and that Texas Instruments demonstrate that the extent of the excavation is appropriate.

To address these issues Texas Instruments Incorporated (TI) performed additional excavation in areas where the walls of the excavation were above background radiation levels (using NaI measurements). In addition, to demonstrate that the excavation had been extended far enough TI performed split spoon sampling around the perimeter of the excavation (see Appendix A).

While a complete walk-over survey has not yet been completed all elevated areas identified during the ORISE survey or identified in the initial Post Excavation Survey report were addressed. In some cases the entire excavation area was extended while in other cases the surface of the area was scraped to removed the contaminated material. A complete walk-over survey will be included in a final report to the NRC.

PERIMETER SPLIT SPOON SAMPLING

As a means of demonstrating that the walls of the excavated area were at or below the approved guidance levels of 30 picocuries total uranium per gram of soil (pCi/g), a perimeter split spoon sampling plan was implemented. Initially, the walls of the excavation were surveyed to determine that the exposed wall (above the water) was at background levels (on the NaI meter). In areas where greater than background levels were found the excavation was extended. When all of the walls were found to be at background levels split spoon samples were taken to a depth of 6 feet. These samples were taken approximately 1-5 meters back from the wall of the excavation and were spaced approximately every 5-10 meters around the entire excavated area. Sampling results are included in Appendix A and locations are shown on the map in figure 1. In cases where past data was available the area was not resampled but, rather, the previous data was used as documentation.

SURFACE SOIL SAMPLING WITHIN THE EXCAVATED AREA

In areas where significant additional excavation took place, whenever possible, surface soil samples were taken on the floor of the excavation. In many locations these samples were composites, taken from the floor of the excavation, through the water, with a backhoe. These results are shown in Appendix B and sample locations are shown on the map in figure 1.

Appendix A

Split Spoon Samples
Excavation Perimeter

		Alpha screen (pCi/g)		
North	East	0-2'	2-4'	4-6'
200	125	12	10	11
206	130	14	24	10
200	135	15	9	14
200	140	29	14	8
200	145	12	15	5
205	145	21	16	9
210	165	11	21	13
205	153	8	12	23
195	135	25	11	refusal
175	185	18	21	10
190	174	32	5	8
175	163	9	5	8
175	165	17	4	6
180	175	13	10	5
175	168	13	15	37
145	135	33	23	18
155	145	9	18	13

Alpha screen (pCi/g)

North	East	0-2'	2-4'	4-6'
175	175	7	5	9
185	162	7	5	11
140	125	29	20	18
140	103	17	13	16
178	98	19	7	refusal
135	115	17	18	15
130	110	13	18	10
165	85	15	18	25
150	90	8	8	refusal
210	150	34	25	24
172.5	85	12	13	15
175	90	16	13	no sample (water line)

Split spoon results from prior sampling (11/6/92)

Alpha screening (pCi/g)

North	East	0-1'	1-2'	2-3'	3-4'	4-5'	5-6'
145	95	10	31	17		22	
145	140	27	34	10	10	9	
190	120	18	21	15		15	
202	170	11	16			12	
170	150	9	12	6	5	7	

Split spoon results from prior sampling (7/25/92)

		Alpha screening (pCi/g)			
North	East	.5 meter	1 meter	1.5 meter	2 meter
145	145	12	10		
175	105	9	9		
190	115	15	11		
210	130	11	5		
202	160	16	11		
200	170	9	6		
172.5	160	8	8		
177.5	140	20	9	6	13
147.5	125	10	6		

Appendix B

Additional soil samples from Excavated Area

North	East	Alpha screening (pCi/g)
170	95	21
165	95	31
155	95	37
165	105	24
155	105	24
145	100	10
150	97.5	19