ENVIRONMENTAL CHARACTERIZATION OF THE WEST VALLEY SITE

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ABSTRACT

In March 1982, on-site work officially began to develop and implement a program to solidify the high-level liquid radioactive waste stored at the former nuclear fuel reprocessing facility located at West Valley, New York for future disposal at a federal high-level waste repository.

A comprehensive pre-solidification environmental characterization of the site was undertaken to provide baseline information prior to solidification activities. Ground-level measurements of aerial radiation survey areas were performed and a permanent grid set up for detailed site surveys. Core sampling methods for waste water holding pond sludge and surface soil were adapted to the site needs. The principles used to establish correlation between ground level and aerial measurements are discussed, and the methods used for site gamma surveys and sample collection are presented.

INTRODUCTION

In March 1982, the former nuclear fuel reprocessing plant facilities located at West Valley, New York, were officially placed under Department of Energy (DOE) control, marking the operational start of the West Valley Demonstration Project. The project was authorized by Public Law 96-368 to solidify the high-level liquid radioactive waste stored at the site. Neither detailed preoperational measurements (pre-construction data) nor comprehensive on-site radiological measurement data were available at the time of facility management transfer; collection and documentation of these data was considered to be a priority item. The purpose of the characterization effort discussed in this report was to establish clearly the radiological status of the on-site environment as a reference point for both the continuing monitoring program and future post-solidification measurements. A major environmental baselining effort was initiated in mid-May with the majority of the data collected being completed by August 1982. Several different measurement techniques were employed in the characterization program, some of which were developed specifically for this purpose.

The program focused on environmental measurements of three types of media: soil, vegetation, and water.

A direct gamma radiation survey of the ground surface was performed to identify both the general background as well as to characterize specific contaminated areas within the protected area fence. This survey was designed to detect and delineate areas containing radioactive contamination greater than 10 pCi Cs-137 per gram of soil in the surface layer. The measurements were keyed to a grid system which was referenced to the New York State land survey grid and plant construction benchmarks. In drainage channels both on and off site, the measurements were taken along parallel lines on either side of the stream bed centerline. Other areas were measured using a combination of these techniques to characterize the gamma radiation levels associated with specific locations.

Soil samples were taken from the surface layer (0 to 5 cm depth) and from selected shallow borings and test holes at contaminated and uncontaminated locations using gamma radiation survey results to direct the effort. Sediment samples from stream and drainage ditch bottoms were also collected.

Forage vegetation was collected from points coinciding with soil sampling locations when possible. The collection included several background samples, with the remainder taken from suspected or potentially contaminated areas.

Groundwater samples were taken from the existing shallow well network, with additional off-site collection from privately owned water wells providing background data. Samples from over 50 separate monitoring points were analyzed for tritium, gross alpha-beta and for specific gamma-emitting radionuclides.

Sludge samples were obtained from the open water treatment holding lagoons. Special sampling techniques were developed to collect and handle the radioactive cores safely.

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METHODOLOGY

Although the overall scope of work encompassed more than surface radiation surveys and sludge sampling, these aspects of the characterization merit discussion because of their unique application.

GENERAL SITE CHARACTERIZATION

Gamma Survey

The site survey was performed using portable gamma-sensitive scintillation (NaI-Tl) detectors (Figure 1). The instruments have a maximum range of 5 milliroentgen (5 mr) per hour or 5,000 microroentgen per hour (μR/hr). The minimum detection level is about 2 μR/hr (0.002 mR/hr) in a background field of 11 μR/hr typical for this area (Reference 1). Two general survey methodologies were used; the standard grid pattern, and a parallel-transverse method.

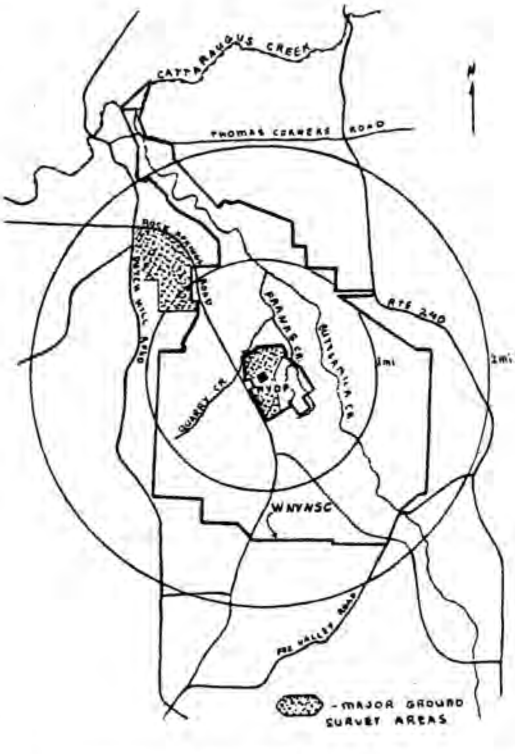

Fig. 1. Environs of the West Valley Demonstration Project.

A standard square grid pattern was used for the area immediately around the plant facilities (Figure 2). In order to provide an accurate, permanent plan or reference system for future measurements, a registered land surveyor emplaced grid stakes, including seven permanent markers referenced to the New York State land survey system within the plant protected area fence. Using the stakes as a visual reference, the gamma survey points were measured at one meter above the ground surface on a 10-meter grid spacing. A Brunton-type pocket transit and surveyor's tape were used to maintain true direction and distance where the visual markers were hidden by buildings or heavy foliage. Around gullies and other high relief areas, two-meter tall stakes painted fluorescent orange were used as temporary markers to locate specific grid intersections while that section was being surveyed.

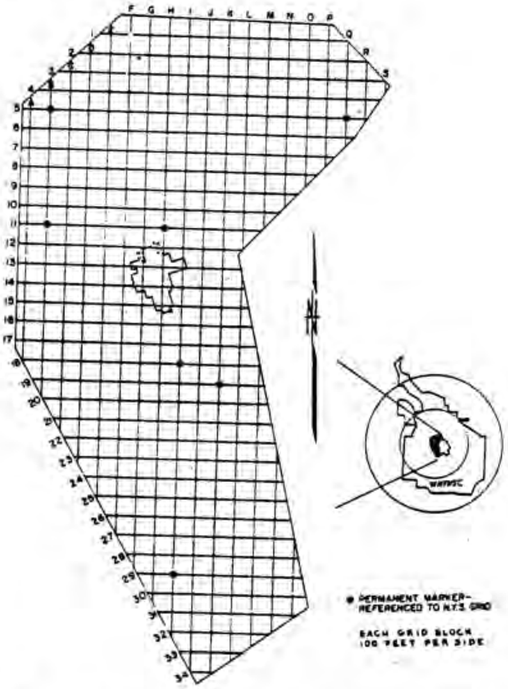

Fig. 2. Western New York Nuclear Service Center Facility Site Grid Plan.

The grid system (based on a 100-foot spacing) was alpha-numerically coded for a three-character identification and reference to an individual grid area. Each grid square code is referenced to the intersect point in the upper left (northwest) corner of each square. Nine sub-squares in each grid (each sub-square 33.3 ft or 10.2 m on a side) are each coded for the intersect at the respective top left corner by adding a single digit. A radiation measurement was taken at nine points in each 100-foot grid or each 33 1/3 feet (10 meters). Use of this system can accurately locate any point on the site within five meters by using a four-character code. The readings in microroentgen per hour were taken at the sub-square points and recorded on a plan map of the site. Over 3,000 discrete readings were taken on the site grid system using this method.

The other method used was a parallel-transverse system in which readings were taken across a stream bed at intervals of about ten meters. The major difference from the grid system is that the longitudinal pattern followed the stream bed direction with each cross-sectional (transverse) reading about five meters apart and the cross-sections taken at ten-meter intervals along the drainage channels. Depending on the width of the stream bed, one or two readings were recorded on each bank of the drainage channel. The gamma survey path of travel was along two or more parallel lines five meters apart and along, the length of each stream bed. This method proved quite effective in detecting localized areas of radioactive contamination deposited along the on-site stream banks. This technique was used in collecting data from off-site streams as well, using an appropriately larger spacing of 30-meter intervals between cross-sections to cover the greater distances involved.

Soil Sampling

Soil was sampled at locations on site where contaminated areas were indicated by the gamma survey or were suspected. A standard procedure employing specially fabricated sampling tools to assure repeatability was used to collect the surface soil samples from an area centered on the highest gamma radiation reading.

Samples were collected in seal-strip plastic bags, labeled, and screened for gross beta-gamma contamination with an HP-260 G-M probe and ratemeter. An average activity of 50 pCi/g of Cs-137 contamination was found to be the lower detectable limit for bagged samples using this method; the screening was used to segregate samples for laboratory routing and storage. After screening, the bagged samples were logged into the environmental monitoring record system and packaged in individually labeled, airtight steel cans for archive storage or shipment to off-site laboratories for analysis.

Vegetation Sampling

Forage vegetation was collected from soil sample locations wherever possible, and additional non-forage vegetation was collected from various ponds and marshy areas as well. Where the vegetation was short, it was collected by first mowing with a power mower, then collecting the cuttings. For thicker vegetation, a knife or machete was used to sample along the transect of the soil sample pattern or from a similarly sized area. The vegetation was put in two four-liter plastic bags, averaging about 500 grams per sample. The sealed and labeled bags were then screened for gross contamination (using an HP-260 G-M probe) and logged in as were the soil samples. After sealing the bags in steel cans, they were either archived or shipped to a laboratory for analysis.

SPECIAL SURVEYS

Several investigative surveys were performed either to define further a contaminated area or to assess a specific source term. When measurements were taken or samples collected, written procedures were used to standardize the sampling for future reproducibility and representativeness. Two surveys requiring special methodology are described below:

The "Cesium Prong"

High sensitivity, aircraft-mounted radiation detection systems were used at the Western New York Nuclear Service Center in 1968 and 1969 to define the contribution to environmental gamma radiation levels from ground level sources located within the reservation boundaries (Reference 2). A remonitoring flight was performed ten years later in 1979 using more sophisticated equipment, lower elevation, reduced flight speed, and a tighter flight pattern (Reference 1). Additionally, computer-assisted separation of the detected gamma rays into discrete energy levels allowed identification of specific isotopes. Cesium-137 constituted a measurable fraction of the general gamma-emitting activity around the plant site. Detectable cesium-137 was also noted to extend about 900 yards northwest of the site (Figure 3) in the shape of a "prong". The elevated gamma radiation exposure rates within this off-site area were comparable to natural backgrounds in some other parts of the United States, for example up to 23 μR/hr on the Colorado plateau (Reference 3), but could be distinguished from the natural gamma background in the local area. A program of ground-level radiation measurement and soil sampling was designed and implemented to define the limits and concentration of the man-made component and to determine its vertical distribution. The pattern of vertical deposition was important in showing that the source of the contaminants was not from the groundwater under the adjacent West Valley site.

The purpose of the ground-level survey was to define more accurately, by an independent ground survey method, the findings of the 1979 aerial survey. Relatively few but accurately measured ground control points were required to achieve the desired accuracy for the aerial survey interpretation (Reference 4). For a previously undefined area, the NCRP 50 method (Reference 5) suggests a five-meter radius of detection at one meter above the ground surface for environmental level surveys. Since 100 percent coverage was not necessary to locate accurately specific areas of interest, a pattern similar to that used for constructing bathymetric cross-sectional models of lake bottoms was used (Reference 6). North-south lines were measured by pacing (the pace length was periodically calibrated by the surveyor against known distances) north from the reference line using a hand-held compass to maintain direction. An arbitrary landmark feature (an old bridge near the site boundary) served as a starting point for the survey. Gamma radiation was measured at one meter from the ground surface at intervals of ten meters along the lines; every 500 feet or less, flagging tape was used to temporarily mark both the distance north from the reference point and the number of lines west of that point. Distance measurements between survey lines were also taken at these points to keep the east-west intervals consistent. The individual north-south lines represented total gamma survey coverage along their length; however, since the spacing for most of the survey was 30 meters between lines, alternating areas about 20 meters wide between survey lines were not measured with the same level of sensitivity. Where elevated readings were noted, additional survey lines were added on 15 meter

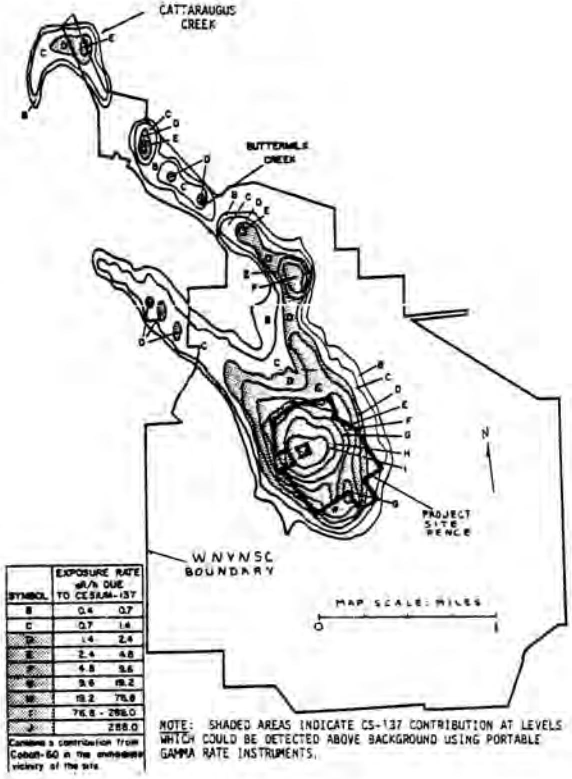

Fig. 3. Cesium-137 Isoexposure Map 1979 Aerial Survey.

spacing to increase the detection probability and more accurately define the area of potential contamination.

Soil samples were collected from areas previously measured for ambient gamma radiation. The sampling was designed to detect radioactive contaminants in soil in a vertical profile from the surface down to a point at which contamination was no longer measurable (Reference 7 and 8). The original intent was to collect multiple subsamples in an area at discrete depths in order to determine the average radionuclide concentration at any given level. Several samples were collected using a three and one-quarter inch diameter sampler designed to maintain a consistent surface to volume ratio (Figure 4). Samples from the most active areas were screened by gamma spectroscopy and found to have substantially different levels of contaminants between subsamples taken within six inches of each other at the same depth. Since this method of sampling essentially presupposes a uniform deposition of contaminants, an alternate method was developed. Screening of another set of samples from a larger area indicated that a much better representation of the detectable contamination could be achieved (Figure 5). The remaining samples were collected in the following manner:

Depth		Area		Total Volume	
Inches	(cm)	Inches	(cm)	Cubic Inches	(cm^3)
0–4	(0–10)	12x12	(30x30)	576	9400
4–10	(10–25)	10x10	(25x25)	600	9800
10–16	(25–41)	10x10	(25x25)	600	9800

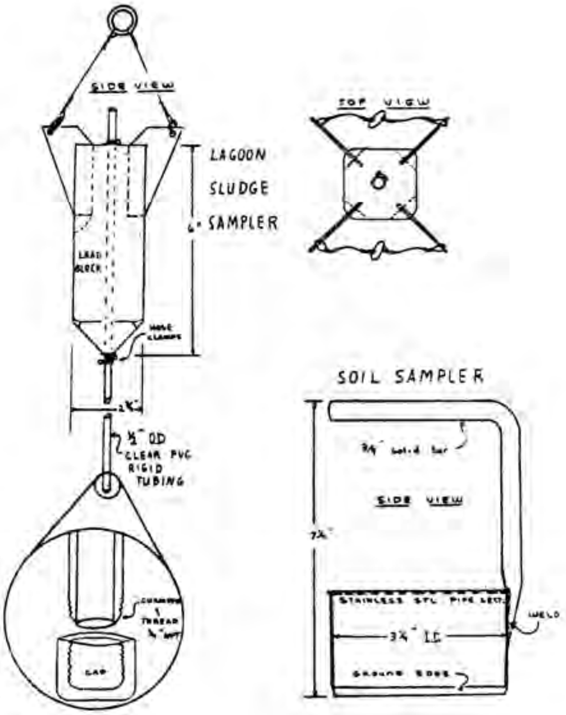

Fig. 4. Special Sampling Tools.

The screening measurement method used to compare the levels of contaminants in various samples is similar to re-entrant beaker geometry (Reference 5). The original sample at ambient moisture was collected in a large plastic bag. A sodium iodide detector wrapped in several layers of plastic was inserted into the sample such that the detector was completely contained within the soil volume (Figure 6). The entire configuration was placed in a five-gallon plastic pail and counted for 1000 seconds. The set of samples showing the highest concentration, and a low background area sample set were sent immediately to an off-site laboratory for positive isotope identification and concentration measurements. The laboratory procedures required mixing the soil and counting several subsamples from each 14 kg sample to ascertain the degree of homogeneity obtained by mixing (Reference 9). This was necessary, since one particle of contaminant could bias an entire sample using a single aliquot count; the radioactive contaminant might or might not be included were a single subsample analyzed. Most of the split sample results agreed within 10 percent

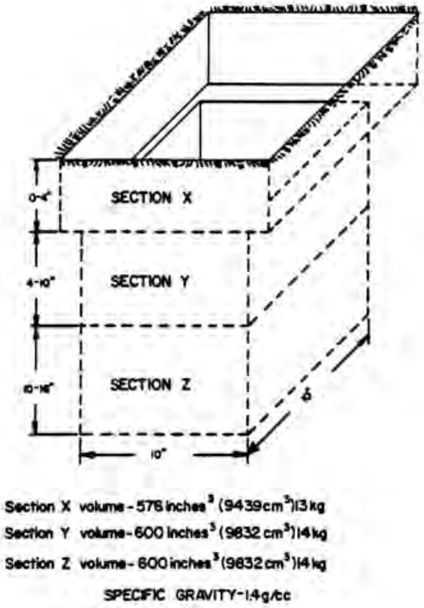

Fig. 5. Soil Sampling Profile.

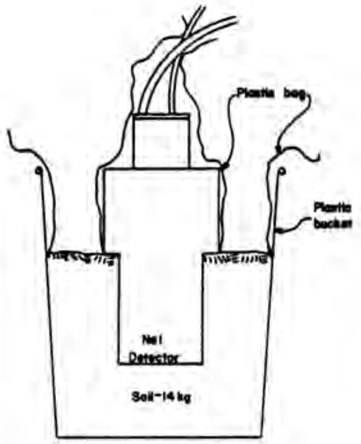

Fig. 6. Soil Screening Method.

indicating good mixing and representation for each large sample. These parameters were then used for estimating the concentrations of other similarly sampled soils.

These samples were collected at four different locations exhibiting a gradient of direct gamma readings at the surface (Figure 3). This pattern, deliberately keyed to specific aboveground readings, would indicate the depth and concentration of any surface deposited radioactive contamination, while maintaining consistent surface-to-volume ratios for each sample set (Figure 5). Using depth and soil concentration data, the average gamma radiation level at one meter could be mathematically determined (Reference 10) and compared to the measured rate.

Lagoon Sludge Sampling

The existing water treatment system includes several open holding lagoons which function as raw feed receiving and storage, and treated effluent holding reservoirs (Figure 7). Although the radionuclides in the water were routinely measuured, the bottom sludge depth and characteristics were unknown. A technique for extracting a sample of the bottom sludge from various points in the lagoons was developed.

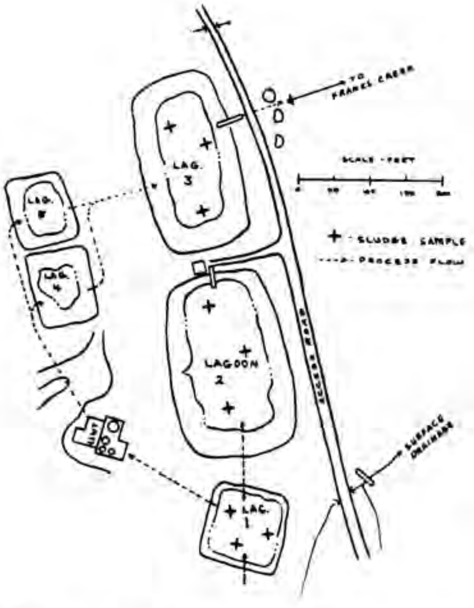

Fig. 7. Low-Level Waste Water Treatment Holding Pond Flow Plan.

The basic problem was to avoid personnel exposure while obtaining a core sample of unknown activity from specific points in each impoundment. A "high-line" system was developed with the sampler being positioned on a double pulley by operators at each end of the suspension line. To lower the core sampler, tension on the sampler line was released while maintaining position with the pulley tag line, allowing the sampler to drop vertically from a desired point along the transect (Figure 8). The sampler itself consisted of a clear 3/8-inch inside diameter PVC tube between two and three feet long, chamfered at the bottom to penetrate the sludge and clay lining; a removable float valve was fitted at the top to prevent drainage during lifting. A driving weight was constructed by drilling a hole through a shaped block of lead, installing fins, and fixing the PVC tube in place using hose clamps. The fins and the vertically trailing sampler line kept the dropping assembly vertical, forcing the tube into the bottom by the weight of the lead block on the upper end (Figure 4). To extract the sampler, tension was put on the pulley tag line and sampler line upward. The assembly was

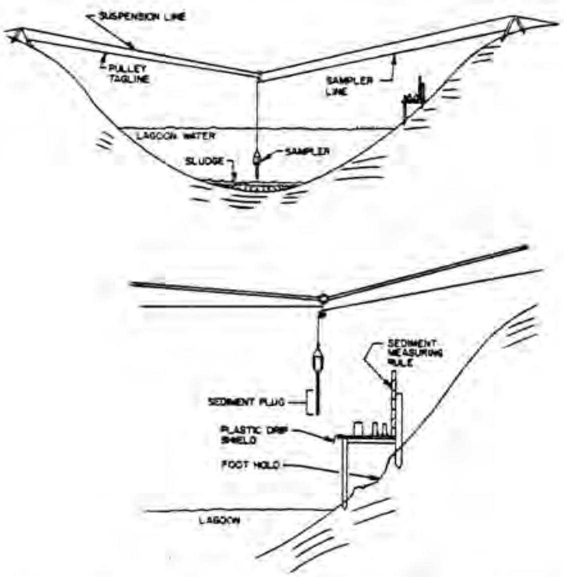

Fig. 8. Lagoon Sampling High-Line Configuration.

lifted clear of the water and visually checked to ascertain that a sample was obtained, then moved along the suspension line to the edge of the lagoon. A measurement was performed to determine exposure rates, and the bottom of the sampler was secured with a threaded cap. The sampler assembly was then moved to the prepositioned measurement table, where the valve and top clamp were loosened, allowing the tube to slip out of the weight. The tube sediment height was measured against a vertical ruler, then the contents were decanted and rinsed into a tared container using a preweighed wash bottle. The empty tubing above the clay plug at the bottom was cut off with a tubing cutter and the solid core retained for separate analysis.

RESULTS

The environmental characterization of the site revealed no previously undocumented conditions requiring protective action or immediate corrective action. Those aspects of the survey such as the presence of contaminated flora or contaminated soil areas within the plant exclusion boundary are not without precedent (References 11 and 12) and were expected to some degree in view of the operating history of the plant.

GAMMA SURVEY RESULTS

Anomalous readings with more than 150 percent the value of surrounding readings were interpreted as showing either the likelihood of ground surface contamination or a local subsurface source (such as a waste transfer line). Several such readings, as were found in the waste burial area or the sewage outfall drainage channel, were confirmed to result from operations or incidents in the past which deposited surface contamination. Other readings, such as a general elevation of gamma radiation found in the northwest corner of the site, did not appear to be entirely attributable to radiation from the process building but exhibited no discernable contamination zone boundaries. This latter set of data may indicate the on-site residue of the deposition noted by the 1979 ARMS Report (Reference 1) and the previous NYSDEC soil sampling (Reference 11).

The entire site drainage downstream of the facility buildings had spots of detectable stream bed contamination evidenced by direct gamma radiation measurements along the 3,800 linear feet of the surveyed surface water drainage system. Levels of 10 to 20 times the adjacent bank radiation levels were found from the Lagoon 3 release weir to the security fence discharge point. Quarry Creek on the north did not show evidence of radioactive contamination based on the direct gamma survey method but the entire Frank's Creek stream bed outside the security fence contained varying amounts of detectable deposits of radionuclides contributed by previous operations.

Within the 3.3 million square foot gridded survey area, 69,000 square feet (2 percent) showed evidence of previously undefined surficial contamination. Of the gridded area, approximately 600,000 square feet surrounding the facility Process Building is so heavily influenced by gamma radiation sources contained in the reprocessing plant that positive low-level surface contamination detection was not possible using the direct low-level gamma radiation survey method.

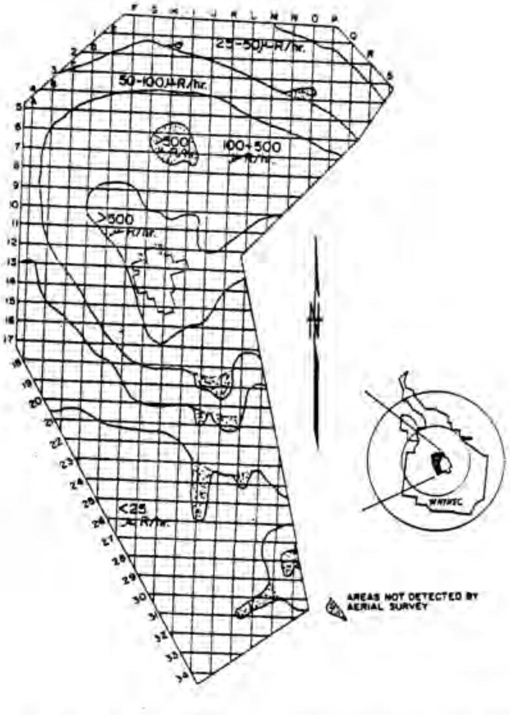

Fig. 9. Gamma Radiation Isopleth for Site Gridded Area.

The isoexposure patterns for the fenced protected area closely paralleled those of the 1979 aerial survey confirming the efficiacy of the aerial survey method (Figure 9). Some localized areas such as a contaminated equipment laydown pad and the sewer outfall were not distinguishable from the rest of the plant because the aerial survey tends to average the detected radiation over a large surface area as well as suffer loss of resolution in the presence of an interfering source such as the Process Building. The sections of Frank's Creek and Buttermilk Creek which showed elevated readings on the aerial survey were generally verified by the direct stream surveys.

SOIL SAMPLING RESULTS

A background sample analysis for Cs-137 indicated a small but detectable amount of activity (0.7 pCi/g) in the surface soil. Two Quarry Creek bed sediments northwest of the plant also indicated the same range of activity. Background sediments in this region are typically 0.7 to 2 pCi/g Cs-137 (Reference 13).

Soil samples from the contaminated spots of the plant site varied widely in concentration, but typical values ranged from 100 to 800 pCi/g of dry soil, easily detected with a portable scintillation detector but not presenting a personnel exposure concern.

VEGETATION SAMPLE RESULTS

Background forage vegetation samples from the Quarry Creek area indicated no detectable Cs-137 or H-3 activity. Gross alpha and beta activity levels were also near the lower limit of detection. One moss sample from a log was taken for comparison with data obtained in a West Coast survey. The 13 pCi/g of Cs-137 in the Quarry Creek background moss sample compared favorably with Cascade Mountain moss measured at 20 to 60 pCi/g Cs-137 from worldwide fallout in the mid-1960's (Reference 14).

Generally, vegetation samples from the area around Lagoon 1 and Lagoon 2 (Figure 7) showed tritium uptake, strengthening the conclusions of a previous monitoring well evaluation that Lagoon 1 is a significant source of tritium. Positive uptake of other radionuclides, including some Sr-90 and Cs-137, was detected in vegetation from areas with higher soil contamination levels.

CESIUM PRONG RESULTS

The ground level survey of the areas identified by the 1979 Aerial Radiological Measurement System survey (Reference 1) confirmed the presence of cesium-137 at concentrations above world fallout levels for this region. The areas of measurably elevated radiation (about 9 μR/hr above the general background of 11 μR/hr) were statistically consistent with the aerial survey data from the 1979 measurements. The detectably elevated gamma radiation levels (not statistically quantifiable, but detectably present at 3 to 4 μR/hr above background) found during the ground survey indicate a general gamma radiation field in agreement with the pattern of the aerial measurements. The ground level survey confirmed the aerial survey with respect to relative ambient radiation levels and varying concentrations within the survey area.

The intensity of radiation above background at the highest measured point (9 μR/hr) is within the calculated range of gamma radiation due to soil contamination levels at about 35 pCi/g of Cs-137 to a depth of 11 cm or 4 inches (Reference 9). The soil samples taken from zero to four inches were measured by gamma spectroscopy to be 30 pCi/g of Cs-137, a value quite close to the calculated concentration. The conclusion is that no additional contributions to radiation above background other than low-level surficial contamination exists in the off-site area northwest of the WNYNSC.

LAGOON SAMPLING RESULTS

The measurements provided several important parameters. Radiological analyses made on the decanted fluid gave the specific activity of the dried sludge solids; a rough wet specific activity was also calculated, factoring in the known volume of rinse water. The important facet of this information is that the amount and activity of free sludge could be calculated, providing information needed in safety and cleanup disposal evaluations.

Concentrations of gross beta activity ranged from less than 300 pCi/g at the bottom of Lagoon 3 to over 1 μCi/g in Lagoon 1. Alpha components constituted about 10 percent the value of the beta-emitting nuclides. Over the bottom of any given lagoon, the three sludge samples, analyzed in duplicate sets, showed very good agreement, indicating a generally uniform deposition of radionuclides.

SUMMARY

The results showed that the desired sample representativeness and detection levels were consistent with the isolated data sets available from previous surveys. As noted above, the "Cesium Prong" investigation demonstrated the efficacy of aerial radiation measurements for detecting contamination at near natural background levels, and the limitations of this type of survey for detailed analysis, especially in the presence of a strong masking source. The lagoon sampling effort resulted in credible data sets based on internal agreement, yet required little in the way of exotic equipment or personnel exposure. The establishment of a site radiation map keyed to a grid system reproducible by accurate land surveying methods will be invaluable not only during the project, but in the future when decommissioning activities are commenced.

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