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RESULTS OF THE MOBILE GAMMA SCANNING ACTIVITIES IN WAYNE AND PEQUANNOCK TOWNSHIPS, NEW JERSEY

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MARTIN MARIETTA ENERGY SYSTEMS, INC.
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Results of the Mobile Gamma Scanning Activities In Wayne and Pequannock Townships, New Jersey

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EXECUTIVE SUMMARY

During the early 1980s the W. R. Grace site and the adjacent area were the focus of several radiological investigations. Radiological surveys revealed surface radionuclide concentrations greater than those acceptable under U.S. Department of Energy (DOE) remedial action guidelines. In 1984, Congress assigned responsibility for cleanup of the W.R. Grace site to the Department of Energy. The property was redesignated as the Wayne Interim Storage Site (WISS) and in 1985 DOE began plans for survey/monitoring, and remedial action of nearby vicinity properties and the interim storage site. Evaluations of the radiological survey data in 1986 indicated radioactive contamination above current DOE guidelines at the off-site areas of parts of Township Park southwest of WISS, and parts of the Sheffield Brook area and railroad siding in Pequannock Township. Remedial action was conducted over several years of most of these areas and independent verification of remedial action was performed.

At the request of the U.S. Department of Energy (DOE), a team from Oak Ridge National Laboratory conducted a mobile radiological scanning survey of a portion of the Wayne and Pequannock Townships, New Jersey. Under the Formerly Utilized Sites Remedial Action Program (FUSRAP), the Wayne vicinity properties have been previously investigated to determine the extent of on-site radiological contamination migrating from WISS in Wayne, New Jersey. This mobile scan, requested for the Townships of Wayne and Pequannock, was performed by ORNL in May 1993 on specific streets in both townships. The route of the survey was selected by local officials and supplemented with additional streets in Pequannock by DOE. The purpose of the survey was to determine if residual radioactive materials from former thorium processing activities at the former W. R. Grace facility could be detected along the routes. It should be noted, however, that a mobile scan can only highlight an increase in radiation levels above background that are scanned in passing an area (a "hit"). It cannot pinpoint the source nor define what contributed to the rise in activity. The only way to identify the exact location of any radioactive contamination is to conduct a walk-on survey of each area that resulted in an unidentified hit during the mobile scan.

The survey encompassed a stretch of public roadway in the immediate vicinity south of the WISS, extending northwest to the Pompton turnpike. A mobile gamma scanning van with an on-board computer system was used to identify possible anomalies (i.e., those areas highlighted by the computer system when the preset hit criteria were exceeded during the scan), and three biased soil samples were taken where slightly elevated surface radiation levels were measured in a small area of the ballpark in the Sheffield Brook area.

The instrumentation highlighted at least 24 anomalous areas, some attributable to the naturally elevated levels in concrete, asphalt, and natural granite found in streets, driveways and landscaping materials in the area. Analyses of the biased soil samples taken in the ballpark also revealed slightly elevated thorium concentrations. However, based on analyses of the samples, and past results of data from this area, soil concentration measurements when averaged over 100 m^2 fall below the limits prescribed by DOE radiological guidelines established for this site. Furthermore, the anomalies found in this survey may result from a wide range of sources, such as ash, granite, and fertilizer as well as materials from the former Grace facility.

Therefore, it is recommended that the locations of unidentified hits found in this mobile survey of the Wayne and Pequannock Townships be further investigated to determine and/or confirm the source and nature of the elevated gamma radiation levels.

RESULTS OF THE MOBILE GAMMA SCANNING ACTIVITIES IN WAYNE AND PEQUANNOCK TOWNSHIPS, NEW JERSEY*

INTRODUCTION

The Davison Chemical Division of W. R. Grace and Co. continued thorium ore processing begun in 1948 by Rare Earths Inc. until plant closure in July 1971. Waste products from these activities included radionuclides of the thorium and uranium decay series, some of which were buried on-site. At the time of closure, W. R. Grace amended its Atomic Energy Commission (AEC) license for storage only. Decontamination of the buildings was performed in 1974[1], and in 1975 the storage license was terminated and the property was released by the Nuclear Regulatory Commission (NRC) for unrestricted use, with the provision that the land deed indicate that radioactive material is buried on the property.

In May 1981 an aerial radiological survey, requested by the state of New Jersey, was conducted by EG&G.[2] This survey identified elevated radiation levels on the W.R. Grace site and along Sheffield Brook, a small drainage stream west of the site. A second aerial survey, performed in September 1982 and covering a larger area, reached the same conclusions.[3] In order to further define the thorium anomalies found on the EG&G aerial survey, a mobile gamma scanning survey was conducted by personnel from ORNL during the period of November 11-13, 1982.[4]

During the early 1980s the W. R. Grace site and the adjacent area were the focus of several on-site investigations.[5-8] These surveys indicated surface radionuclide concentrations greater than those acceptable under U.S. Department of Energy (DOE) remedial action guidelines.

In 1984, Congress, under the Energy and Water Appropriations act, directed the DOE to undertake a research and development decontamination project at the former W. R. Grace facility and vicinity properties. DOE assigned this operation to the Formerly Utilized Sites Remedial Action Program (FUSRAP) and redesignated the former W.R. Grace site as the Wayne Interim Storage Site (WISS). The WISS property was acquired by DOE from W.R. Grace in 1984 to serve as a storage site for contaminated material resulting from cleanup of the site itself and of several vicinity properties. Figure 1 shows the location of WISS in relation to the Wayne and Pequannock Townships.

In 1985 DOE prepared the engineering design, radiological survey/monitoring, and associated plans for Phase I remedial action of the vicinity properties and the interim storage site[9]. Evaluations of the radiological survey data in 1986[10] indicated radioactive contamination above current DOE guidelines[11] at off-site areas that included parts of Township Park southwest of WISS, the school bus maintenance facility immediately south of WISS, undeveloped property west of WISS at the intersection of Pompton Plains Cross Road and Black Oak Ridge Road, parts of the Sheffield Brook area, and a railroad

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* The survey was performed by the Measurement Applications and Development Group of the Health Sciences Research Division of Oak Ridge National Laboratory under DOE contract DE-AC05-84OR2100

siding in Pequannock Township. Remedial action in most of these areas was conducted over several years and some of the reports describing the remediation and the verification of remedial action are described in Refs. 12-14.

In February 1993, the Township of Wayne, New Jersey requested a mobile scanning survey of specific streets in the township. Based on site history, additional streets in the Pequannock Township were added to the scanning area by DOE. The purpose of the survey was to assess whether any residual radioactive material could be detected along any of the routes. The survey was conducted by ORNL on May 10 and 11, 1993, and encompassed a stretch of public roadway in the immediate vicinity south of WISS, extending northwest to the Pompton Turnpike. The scanning areas included approximately 19 streets in surrounding residential areas including sections of two major public roadways in Wayne, and approximately 10 streets and two major roadways in Pequannock Township. The following is a brief description of the results of this mobile scan of the Wayne and Pequannock Township areas designated by the request. Figure 2 shows the route investigated by ORNL in this mobile scan.

SURVEY METHODS

A brief description of the methods and instrumentation used for the mobile scanning of the described areas follows. Standard operating procedures for the mobile gamma scanning van were used to conduct the survey. [15] A more detailed description of the system and operation is provided in Myrick et al.[16] Anomalies (locations where the mobile scanner revealed the presence of radiological materials above normal background levels for the area) were verified in the system's identification mode. The scoping approach used in this scanning method is described in *Procedures Manual for the ORNL Radiological Survey Activities (RASA) Program*, Oak Ridge National Laboratory, ORNL/TM-8600 (April 1987).[17]

MOBILE SCANNING METHOD

The initial step in searching for gamma radiation anomalies with the scanning van is to obtain the baseline (background) data with which to compare measurements taken in the relevant areas. Background exposure rates were measured along thoroughfares in similar areas in the vicinity. Scans were then performed of the suspect areas at a slow speed (<5 mph), minimizing the distance between the detectors and the properties. All accessible areas were scanned in both directions to maximize the number of views obtained for each surveyed property. Anomalous locations were highlighted by the computer system when the preset "hit" criteria were exceeded during the scan (a "hit" is simply a way of saying the instrument detects and registers a measurement that exceeds the preset baseline level).

While the mobile scanning method is a very efficient means to cover large areas accessible by road, the equipment cannot make definitive decisions regarding the location and magnitude of radiation anomalies (hits). Therefore, if possible, hits are immediately investigated using hand-held survey instrumentation. In many instances, the surveyor can determine if the hit is from changes in road materials, nearby buildings, etc., and these hits are not included in a proposed investigation. The criteria, derived mathematically, are described as follows.

INSTRUMENTATION

The gamma radiation detection system employed in the ORNL scanning van is operator-controlled through keyboard instructions to an on-board computer where data output is displayed. The data can be simultaneously printed and is stored on a dual floppy disk drive. The system consists of three 4 x 4 x 16-in. NaI(Tl) log crystals housed in a lead-shielded steel frame that is mounted on the right side of the van to provide two detector surface areas for measuring gamma radiation. A 12 x 16-in. surface measures radiation coming from sources on the right side of the van. The second surface is 4 x 12 in. in size and detects radiation from directly beneath the van. The detector and shield height can be varied with a hydraulic lift mechanism to optimize the detector field-of-view. The detector output is transferred to a computer-controlled eight channel discriminator and interface that provides for continuous analysis of data inputs for correlation of system location with count rate information. Separate energy regions-of-interest are analyzed and a radionuclide-specific algorithm is used to identify locations containing residual thorium materials. Multichannel analysis capabilities are included in the system for additional qualitative radionuclide identification.

The algorithm used for data analysis compares the observed count rates arising from certain naturally occurring radionuclides to those produced by residual radioactive materials. Three regions of interest for ^{226}Ra (609 keV, 1120 keV, and 1764 keV energy peaks from ^{214}Bi) and one for ^{232}Th (2614 keV from ^{208}Tl) are analyzed. A Ra/Th ratio is computed from the observed background (bkg) observations and this ratio is used for comparison with scan data obtained from the suspect areas. In identifying locations containing residual ^{226}Ra-and/or ^{232}Th-bearing material, the system utilizes criteria (to derive the minimum level exceeding the background level) based on the observed background Ra and Th count rates and the computed Ra/Th ratio. The criteria used are the following:

(1) a minimum count rate that results in a change in the background Ra/Th ratio; and

(2) an observed Ra/Th ratio that is less than the background Ra/Th ratio, since thorium is the contaminant of interest.

DETECTOR SENSITIVITY

The sensitivity of the detectors had been determined by comparing the detector system response to its position at various distances from a point source and to different radionuclide concentrations in surface soil.[17] Exposure rates versus distance for these particular sources were well documented. The 1.0 mg ^{226}Ra point source, placed at 2 m above the ground surface (detector height), could be statistically detected at a distance of 65 m. This corresponds to an ~2% (0.25 μR/h) increase in normal background radiation levels. The system was also sufficiently sensitive to detect 35 pCi/gm of ^{226}Ra in a 23 kg soil sample at ground level at 3 m distance from the detectors. Obviously, ease of detection increases with increase in total area and volume of ^{226}Ra-contaminated soil. Since ^{232}Th and ^{226}Ra emit gamma-rays at energies which are closely spaced (i.e., <100 KeV apart), sensitivity for ^{232}Th can be considered to be essentially the same as that for

^{226}Ra when using NaI detectors. However, the instrumentation cannot provide information regarding mass or quantity of contamination. Thus, a hit from a large area of elevated radiation levels at some distance from the detector will appear to be the same as a very small spot of highly radioactive material directly beneath the detector. It should be noted that no attempt has been made to establish a calibration factor for the scanning system since, during actual application, several factors are site-dependent. These include the source-to-detector distance, the counting geometry, and the potential for significant shielding caused by structures or buried material between the contamination and the detectors.

SURVEY RESULTS

Analysis of the mobile scan data indicated the presence of anomalies (locations registering above normal background levels) on many of the streets surveyed, and involved houses and municipal properties as well as intersections and lawns (Fig. 3). Some anomalies detected were attributable to the naturally elevated levels in concrete, asphalt, and natural granite materials found in this area as determined by manual surveying with hand-held radiation detection equipment.

While a mobile scan can highlight a slight increase in radiation levels above background that are scanned in passing an area, it cannot pinpoint the source nor define what contributed to the rise in activity. Thus, a hit from a large area of elevated radiation levels at some distance from the detector will appear to be the same as a very small spot of highly radioactive material directly beneath the detector. The only way to identify the exact location of any radioactive contamination is to conduct a walk-on survey of each area that resulted in an unidentified hit during the mobile scan.

However, some elevated levels could be associated with past operations of W. R. Grace as found in other surveys (see references). As the result of one hit, biased soil samples (samples collected in areas of elevated gamma exposure rates) were taken from a small area on the ballpark in the Sheffield Brook area and analyzed for radium, thorium, and uranium. Results of the analysis showed concentrations of ^{232}Th ranging from 4.8 to 8.4 pCi/g. While the DOE guideline for these radionuclides in surface soil is 5 pCi/g above background averaged over 100 m^2, and the background for the northern New Jersey area is ~1 pCi/g, the average soil concentration for this area is below DOE guidelines[12] (see below).

According to the history of this area, the remedial actions on the Sheffield Brook floodplain were conducted in 1985 and 1987 by Bechtel National, Inc. (BNI), project management contractor designated by DOE . This area includes the ballpark where remedial action was completed in 1985. Remedial action of the Sheffield Brook area from Farmingdale Road to the Pompton River was completed in 1987. A post-remedial radiological survey was conducted by BNI to ensure compliance with DOE remedial action guidelines[12]. Verification surveys were conducted in 1986 and 1987 by ORNL along the lower Sheffield Brook floodplain (i.e., generally west of Farmingdale Road between Pompton Plains Crossroads and the Pompton River).[18] It was concluded in this report that although a few transitory, localized spots of elevated gamma levels were measured in the ballpark, soil analyses showed that all concentration measurements were

within DOE radiological guidelines. Based on the results of all remedial action and verification data, soil concentration measurements fell, (as stated in the report), "well below the limits prescribed by DOE radiological guidelines established for this site".

SIGNIFICANCE OF FINDINGS

The results of these mobile scanning activities along specified roadways in the Wayne and Pequannock Townships revealed the presence of radioactive residuals above background levels for the area. While the anomalies detected at some locations may be attributable to road-based gravel, asphalt, concrete, and other natural materials found in drives, streets, etc., other anomalies found in this survey could not be readily identified. When anomalies cannot be readily identified by hand-held instruments from the roadside, it typically means that conclusions cannot be made regarding the magnitude of the radiation source. However, based on past surveys of this type, this kind of hit is generally due to low concentration diffuse sources rather than large point sources.

It is therefore recommended that the locations of otherwise identified hits found in this mobile survey of the Wayne and Pequannock Townships be further investigated to determine the source and nature of the elevated gamma radiation levels.

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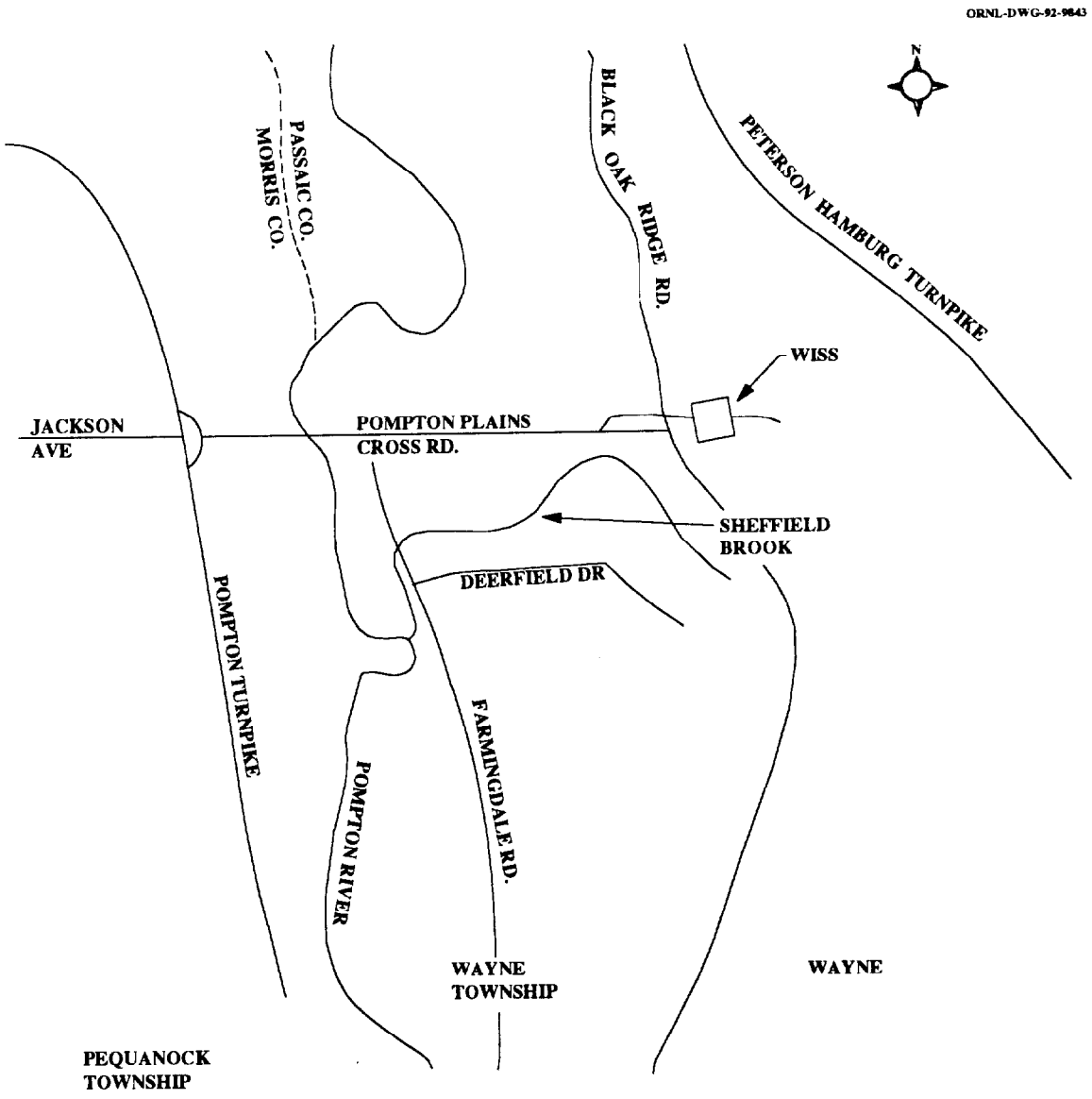

Fig. 1. Diagram showing general location of the Wayne Interim Storage Site relative to the Wayne and Pequannock Townships, New Jersey.

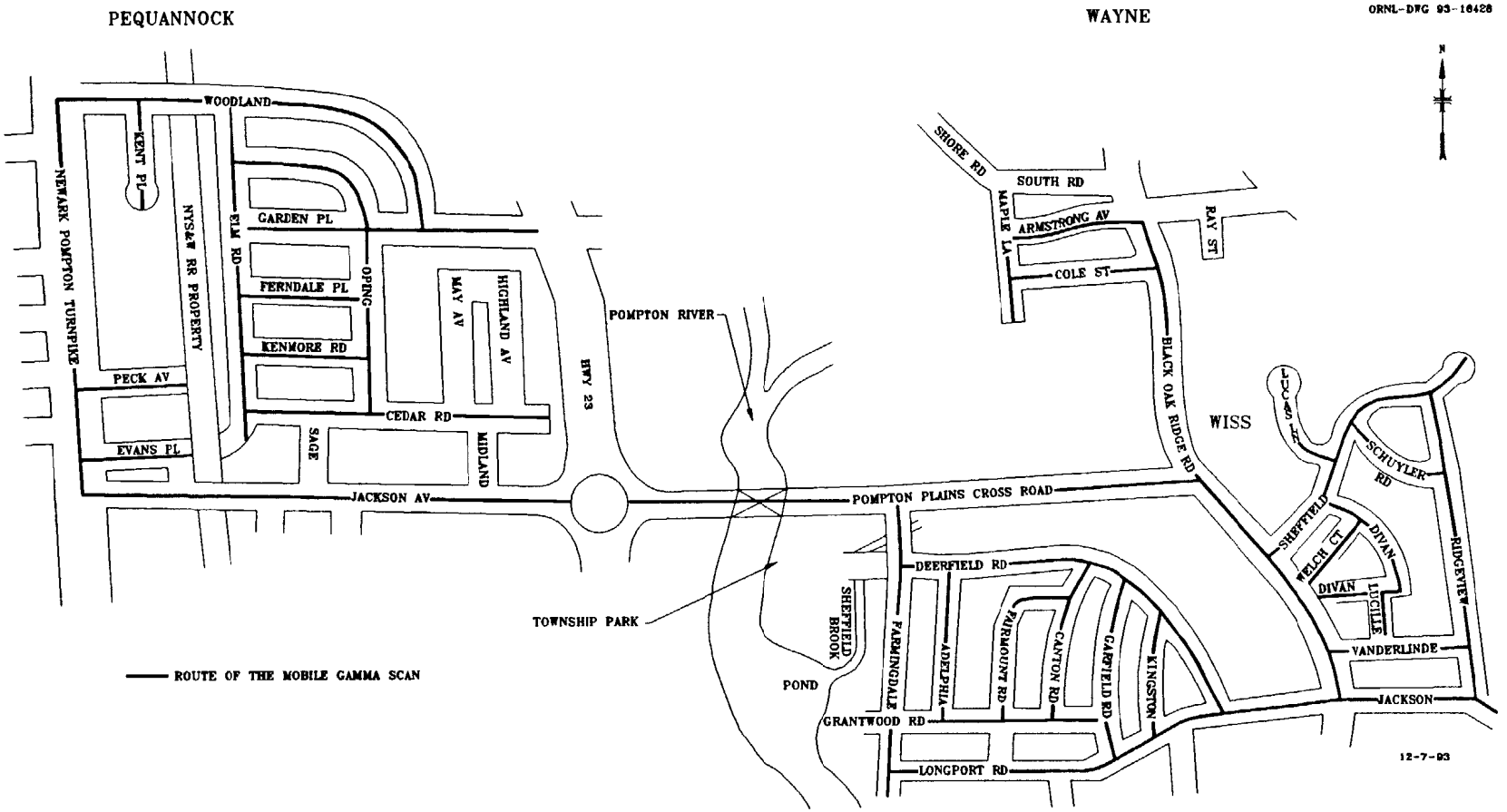

Fig. 2. Diagram showing the route surveyed during the mobile gamma scan of the Wayne and Pequannock Townships, New Jersey.

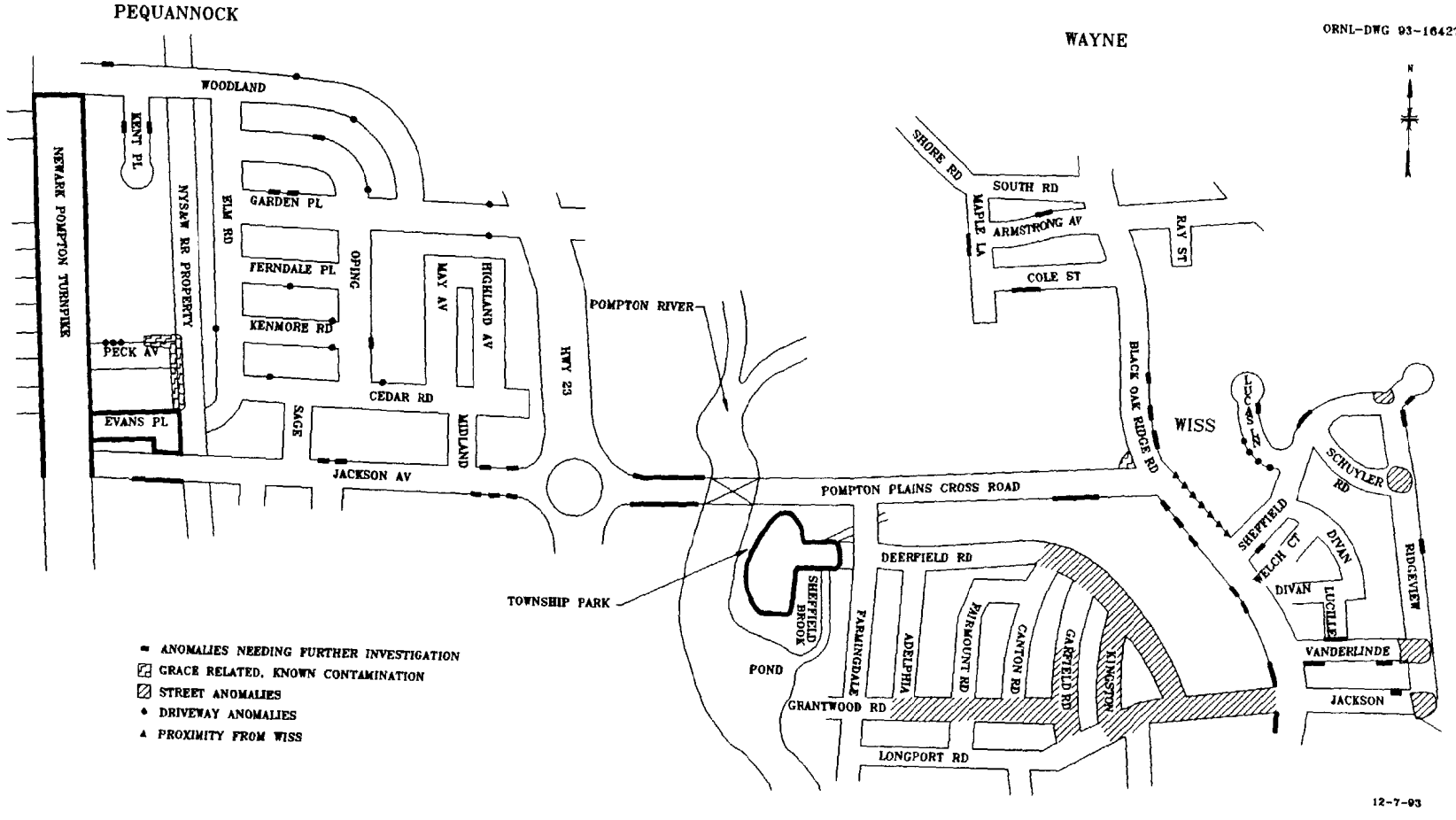

Fig. 3. Diagram showing the anomalies found during the mobile gamma scan of the Wayne and Pequannock Townships, New Jersey.

Table 1. Concentrations of radionuclides in soil from Township Park, Wayne, New Jersey (WJ03V)

Sample number[a]	Radionuclide concentration (pCi/g)[b]		
	^{226}Ra	^{232}Th	^{238}U
	Biased soil samples		
WJ003VB025	0.87 ± 0.04	5.10 ± 0.2	2.7 ± 0.5
WJ003VB026	1.00 ± 0.06	8.40 ± 0.8	3.5 ± 0.5
WJ003VB027	0.78 ± 0.04	4.80 ± 0.3	2.2 ± 0.5

[a]Locations of surface soil samples are from a small area of the ballpark (Township Park) shown in Fig. 3.

[b]Indicated counting error is at the 95% confidence level (± 2σ).

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