# Radiochemical Analysis

## Pfohl Brothers Landfill
## Cheektowaga, N.Y. Erie County
## Site No. 09-15-043

## October 1989



**Reported By:**

**New York State Department of Environmental Conservation**
**Division of Hazardous Waste Remediation/**
**Hazardous Substances Regulation**

**New York State Department of Health**
**Bureau of Environmental Exposure Investigation**
**Bureau of Environmental Radiation Protection**

TRANSMITTAL MEMO

TO: Distribution

FROM: Robert W. Schick, Chief, Remedial Action Section A, BWRA

SITE NAME: PFOHL BROTHERS LANDFILL
CHEEKTOWAGA, ERIE CO., N.Y.
SITE 09-15-043

MUNICIPALITY / COUNTY:

SITE NO:

DATE: 10/17/89

Attached for your action as indicated please find the following documents related to the above referenced site:

/ ☐ / Review ☒ Information / ☐ / Approval

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DIV. ENVIRONMENTAL ENFORCEMENT
BUFFALO FIELD UNIT

/ ☐ / Work Plan

/ ☐ / Health and Safety Plan

/ ☐ / QA/QC Plan

/ ☐ / Public Participation Plan

/ ☐ / Temporary Use and Occupancy Agreement/Easement

/ ☐ / Remedial Investigation

/ ☐ / Feasibility Study

/ ☐ / Design Documents:

/ ☒ / Phase I Walk-Over Gamma Radiation Survey + Radiochemical Analysis Report

Please review the attached documents(s) and provide any comments, in writing, to me by _____. If no comments are received by this date, it will be assumed you have no comments relative to the attached documents. If you have any questions on any of the above, please contact Joseph White at (518) 457-4343.

DISTRIBUTION: Jaspal Walia, Reg 9
S. Stanish, NYSDOH
Ed Johnson, Radiation Bureau
Martha McCabe, Attny Gen. Office

cc: Project File
Joe Ryan (Steering Committee Copy
Rick Kennedy Copy)

## OBJECTIVE

As a result of the discovery of localized areas with elevated radiation readings, identified during the course of the remedial investigation of this site, it was decided to investigate possible pathways for migration of this radiation off the site. The perimeter of Pfohl Brothers Landfill was sampled during April of 1989 at seep locations where water trickled or flowed out of the landfill to off-site locations. These samples were taken to determine if radionuclides were contained in the water or sediments that could possibly be migrating off site. Additional information regarding the elevated radiation readings and their investigation is contained in the Phase I Radiation Walkover Survey Report.

## RESULTS

Seventeen seep water samples and 18 seep sediment samples were collected by Camp Dresser and McKee at the site's seeps. The analysis of the samples performed by Clean Harbors Analytical Services and reported to the NYSDEC Bureau of Radiation. The findings were as follows:

1. The concentrations of the radionuclides of interest are close to, or below, naturally occurring levels.

2. The water analysis confirms that there is no evidence of radioactive contamination migration from the seeps at the site.

3. The water samples showed low levels of radioactivity with gross alpha values below the 15 pCi/l maximum contaminant level specified by Part 5 of the State Sanitary Code for drinking water; and these samples are not drinking water.

4. The sediment samples show naturally occurring radionuclides in concentrations typical for soils or sediments in New York State.

## SAMPLE LOCATIONS

Table number 1 shows the sample number, date sampled, site locations, and the media sampled. The site locations can be referenced to Figure 1 which shows the general location of each seep at the site perimeter. Samples on Table 1 labeled "SS" are seep sediments and "SP" are the seep water sample locations.

For example, the sediment sample at seep number 1 is labeled SS-1 and the water sample at seep number 1 is labeled SP-1. The location on the map for seep number 1 is labeled SP-1.

The locations on Figure 1 labeled SE/SW were not sampled for analysis of radionuclides. These locations were sampled for chemical analysis and will be addressed in a separate report.

SAMPLING METHOD

Water samples were collected unfiltered into one liter plastic bottles directly from the seeps. The sediments samples were collected by scooping sediments with a clean trowel where accessible or by using a clean coring device which was pushed into a sedimentation area adjacent to the seep. Each core of material was segmented into pieces and a part of each segment was placed into the sample jar.

DISCUSSION - BACKGROUND

It is fundamental in the assessment of potential environmental radioactive contamination to understand that radioactive materials exist in the environment even where there are not radioactive wastes. This presence of radioactive materials constitutes a measurable level of background radioactivity. The radioactive materials comprising background radioactivity belong to one of two general categories, naturally-occurring and man-made. Radioactive materials occur naturally in ground waters, surface waters, soils, and air. In fact, naturally-occurring radioactive materials are common in the environment and in all living species, having existed on the earth since its formation. A small but detectable amount of radioactivity in practically any environmental medium is expected to be present as a naturally-occurring background radioactivity concentration.

The radioactive materials present in waters and soils which contribute to natural background radioactivity consists of a variety of naturally-occurring radionuclides. Examples are the radionuclides composing the Uranium, Actinium and Thorium Series. These natural series are chains of radionuclides which are produced by the transformation (radioactive decay) of one radionuclide, such as uranium-238, into another radionuclide, such as thorium-234. There are also non-series naturally-occurring radionuclides present in the environment, such as potassium-40 and hydrogen-3 (tritium).

The other general category of radioactive materials contributing to background radiation is composed of man-made radionuclides. Man-made radionuclides are also widespread in the environment. While these radionuclides exist purely as environmental contaminants, they nonetheless compose a "non-natural" background of radioactivity. Examples of man-made background radionuclides are nuclear fission products, such as cesium-137 and strontium-90, and to a much lesser degree activation products, such as cobalt-60 and plutonium-239. These materials are produced in nuclear reactors operated for electrical power production, radiopharmaceutical production, and defense purposes, and from the detonation of nuclear weapons. As a result of extensive atmospheric nuclear weapons testing throughout the world, man-made radionuclides exist as background radioactive contaminants at very low concentrations in soils, surface waters, and some ground waters.

00-17-1 (5/76)
Formerly GA-4

NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION

# TRANSMITTAL SLIP

TO: Joseph Ryan, DEE, Reg 9

FROM: Joe White, Western Remedial Action

DATE: 10/17/89

RE: FROHL BROTHERS LANDFILL
CHEEKTOWAGA, ERIE CO., N.Y.
SITE 09-15-043

Attached is the Phase I Walk
and the DEC Radiochemical

Tech
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FOR ACTION AS INDICATED:

- ☐ Please Handle
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- ☐ Prepare Reply for _____ Signature
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- ☐ Comments
- ☐ Signature
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The typical background concentrations of both the natural and non-natural radionuclides in surface and ground waters varies from one locale to another. This variation is due to many factors including non-uniform deposition of radioactive material in soils, meteorologic differences, variations of water chemistry, and variations of soil adsorption coefficients for different elements. Thus, a background level of dissolved total alpha particle-emitting radionuclide concentration for ground water in one location may be 2 pCi/l (picocuries per liter) while 50 meters downgradient it may be higher by a factor of five or more.

Radioanalyses conducted on environmental samples are designed to detect quantities above background levels of both naturally occurring and man-made radionuclides which may occur as wastes in the environment. Man-made radionuclide wastes are of the types described above. Naturally-occurring radioactive materials (NORM) wastes occur as one of two basic types: 1) as a consequence of the natural presence of NORM in building materials, or 2) by deliberate enhancement of the concentration of NORM for use in an industrial or consumer product. An example of the latter is thorium, which materially exhibits ceramic properties and is included in products such as metal alloys, optical lenses, and incandescent mantles.

**Discussion - Results**

The radioanalyses performed on the Pfohl Brothers site water samples included gross alpha and gross beta radioactivity, total uranium (by flourometry), and gamma-ray spectroscopy. Sediment samples were analyzed via total uranium and gamma-ray spectroscopy. To interpret radioanalyses results for water samples it is essential to understand that the gross alpha and gross beta analyses are the primary indicators of all radionuclides that may be present. That is, the gross alpha and gross beta radioactivity concentrations are the sums of all alpha and beta particle-emitting radionuclide concentrations that are present. Therefore, if the gross alpha activity is 3 pCi/l, then the sum of all alpha particle-emitting radionuclide activities, such as uranium-238 and thorium-232, is no greater than 3 pCi/l. In addition, the gross beta analysis indicates the presence of virtually all of the gamma-ray emitting radionuclides. For samples yielding gross alph/beta activities greater than typical background levels, one must apply caution before concluding that the radioactivity is due to the presence of an industrial contaminant. Occasionally, unfiltered samples of turbid water may exhibit alpha/beta activity concentrations that are higher than one would typically expect. This would not necessarily indicate the presence of dissolved radioactive materials, however, since an excess of suspended solids (soil particles) , containing naturally-occurring radioactive materials, could yield greater than typical gross alpha/beta activity levels. One way to eliminate this possible interference is to filter the sample and reanalyze.

All other water analyses results, except total uranium, are a result of a separate analytical method called gamma-ray spectroscopy. This method identifies specific radionuclides by the detection of the gamma-rays emitted with beta particles by radionuclides that undergo beta particle decay. Due to laboratory constraints (i.e. a moderate length of counting time) the laboratory could only report the gamma-ray spectroscopy analyses with detection limits that appear high when compared to the gross alpha/beta analyses detection limits. The gamma spectroscopy detection limits also appear to be high when compared to typical background concentrations for those gamma-ray emitting radionuclides. In other words, the gamma-ray spectroscopy analysis is not sensitive enough to identify the concentrations of specific radionuclides that contributed to the reported gross alpha/beta activities, without conducting a very long counting time (e.g. 14 hours) on each sample.

This constraint was not an impediment to the interpretation of the results for the Pfohl Brothers site water samples. Recall that the gross alpha/beta analyses are the primary indicators of radioactivity in the samples. Referring to the attached analytical reports, one observes that all samples exhibited typical background levels of gross alpha/beta activity. This also means that the levels of individual alpha/beta emitting radionuclides in the samples are no greater than the gross alpha/beta activity concentrations. For example, the gross alpha activity concentration for sample number 18 was reported as 6 $\pm$4 pCi/l, typical of background. Even though the uranium-238 detection limit was 2,000 pCi/l, the actual uranium-238 concentration could be no greater than 6 $\pm$4 pCi/l, since uranium-238 emits an alpha particle in 100% of its radioactive decays.

Based on the results of the radioanalyses conducted on the Pfohl Brothers site seep water and seep sediment samples collected to date, the New York State Department of Environmental Conservation (NYSDEC) concludes that there are no off-site environmental hazards resulting from the radioactive materials known to be present on the site. Table 2 compares the minimum and maximum concentrations of gross alpha/beta activities in the Pfohl Brothers site seep water samples with the acceptable New York Sate standards for surface waters and with background radioactivity concentrations typical of surface waters in the Buffalo area. The maximum site water gross alpha/beta activity concentrations are comparable to the background concentrations in Niagara River samples collected and analyzed routinely by the NYS Department of Health.

Previous direct gamma radiation surveys of the site and preliminary gamma-ray spectroscopic analyses of collected waste materials have established that there are several different types of thorium bearing wastes and a few discrete sources of radium scattered across the site. Most of these materials are submerged under the surface of the landfill. Minor excavation is required to perform surveys and extensive sample collection. With the exception of some thoriated wastes exposed on the surface of the landfill, removal of radioactive materials from the site requires a radiation detector and a shovel. Therefore, at this time, the likely radiation exposure pathway existing at the site is through direct external exposure to materials emitting gamma-rays. However, none of the gamma-ray surface exposure levels observed thus far exceed State standards for uncontrolled areas. Therefore, no member of the public could receive a radiation dose in excess of the allowable State standard from this pathway.

While there are suspected sources of alpha particle emitting radioactive materials present (e.g. thorium), the alpha particles do not have the ability to penetrate through clothing or the dead layer of skin. The critical exposure pathways for exposure to alpha particle emitting materials are inhalation and ingestion. Exposure to alpha emitting materials at this site is considered unlikely for several reasons. First, the site is designated for restricted access. Second, it is heavily vegetated and wet in many areas. Finally, as previously stated, much of the radioactive materials appear to be located under the surface soils. Therefore, significant airborne resuspension of wastes is not expected. The radioactive materials that are visible on the surface of the site resemble industrial wastes and require radiation detectors to identify. Under most circumstances these material are not considered ingestible.

Due to the limited intrusive investigations of wastes conducted thus far and the lack of identifying information on any of the radioactive materials discovered, it is imprudent to speculate on the specific origin of the wastes. To date, the radioactive industrial waste materials studied indicate that they contain concentrated amounts of various thorium isotopes. Thorium is used in many industrial products including metal alloys, ceramics, and optical devices. The materials studied do not contain levels of uranium above natural background. In addition to the thorium wastes, several small sources of concentrated radium, of the type used for self-illumination have been discovered under the surface soils.

The NYSDEC and NYSDOH will continue to investigate the presence of these materials and provide more detailed characterization of their radioactive material constituents.

References:

1. Interoffice Memorandum, New York State Department of Health, dated August 4, 1989 from William J. Condon, CHP, Chief, Environmental Radiation Section to Sandra M. Stanish, Bureau of Environmental Exposure Investigation.

2. Pfohl Brothers Landfill Site Radiological Analysis Report, issued by New York State Department of Environmental Conservation, Bureau of Radiation on September 14, 1989.

RADIONUCLIDE ANALYSIS
SAMPLE NO., TYPE, LOCATION
PFOHL BROTHERS LANDFILL 09-15-043
TABLE NO. 1

| SAMPLE NUMBER | MONTH | DAY | YEAR | LOCATION | | MEDIA SAMPLED |
|---|---|---|---|---|---|---|
| 4 | 4 | 25 | 89 | SP | 5 | WATER |
| 5 | 4 | 24 | 89 | SP | 8 | WATER |
| 6 | 4 | 25 | 89 | SP | 18 | WATER |
| 7 | 4 | 24 | 89 | SP | 15 | WATER |
| 8 | 4 | 24 | 89 | SP | 16 | WATER |
| 9 | 4 | 24 | 89 | SP | 17 | WATER |
| 10 | 4 | 20 | 89 | SP | 1 | WATER |
| 11 | 4 | 20 | 89 | SP | 2 | WATER |
| 12 | 4 | 20 | 89 | SP | 3 | WATER |
| 13 | 4 | 25 | 89 | SP | 10 | WATER |
| 14 | 4 | 25 | 89 | SP | 11 | WATER |
| 15 | 4 | 25 | 89 | SP | 14 | WATER |
| 16 | 4 | 19 | 89 | SP | 4 | WATER |
| 17 | 4 | 19 | 89 | SP | 7 | WATER |
| 18 | 4 | 19 | 89 | SP | 9 | WATER |
| 19 | 4 | 25 | 89 | SP | 12 | WATER |
| 20 | 4 | 25 | 89 | SP | 13 | WATER |
| 21 | 4 | 20 | 89 | SS | 1 | SEDIMENT |
| 22 | 4 | 20 | 89 | SS | 2 | SEDIMENT |
| 23 | 4 | 20 | 89 | SS | 3 | SEDIMENT |
| 24 | 4 | 19 | 89 | SS | 4 | SEDIMENT |
| 25 | 4 | 19 | 89 | SS | 6 | SEDIMENT |
| 26 | 4 | 19 | 89 | SS | 7 | SEDIMENT |
| 27 | 4 | 19 | 89 | SS | 9 | SEDIMENT |

RADIONUCLIDE ANALYSIS
SAMPLE NO., TYPE, LOCATION
PFOHL BROTHERS LANDFILL 09-15-043
TABLE NO. 1

| SAMPLE NUMBER | MONTH | DAY | YEAR | LOCATION | | MEDIA SAMPLED |
|---|---|---|---|---|---|---|
| 28 | 4 | 21 | 89 | SS | 10 | SEDIMENT |
| 29 | 4 | 20 | 89 | SS | 11 | SEDIMENT |
| 30 | 4 | 21 | 89 | SS | 12 | SEDIMENT |
| 31 | 4 | 21 | 89 | SS | 13 | SEDIMENT |
| 32 | 4 | 21 | 89 | SS | 14 | SEDIMENT |
| 33 | 4 | 25 | 89 | SS | 5 | SEDIMENT |
| 34 | 4 | 24 | 89 | SS | 8 | SEDIMENT |
| 35 | 4 | 24 | 89 | SS | 15 | SEDIMENT |
| 36 | 4 | 24 | 89 | SS | 16 | SEDIMENT |
| 37 | 4 | 24 | 89 | SS | 17 | SEDIMENT |
| 38 | 4 | 25 | 89 | SS | 18 | SEDIMENT |

TABLE 2

Pfohl Brothers Site Surface Water Sample
Radioactivity Comparison

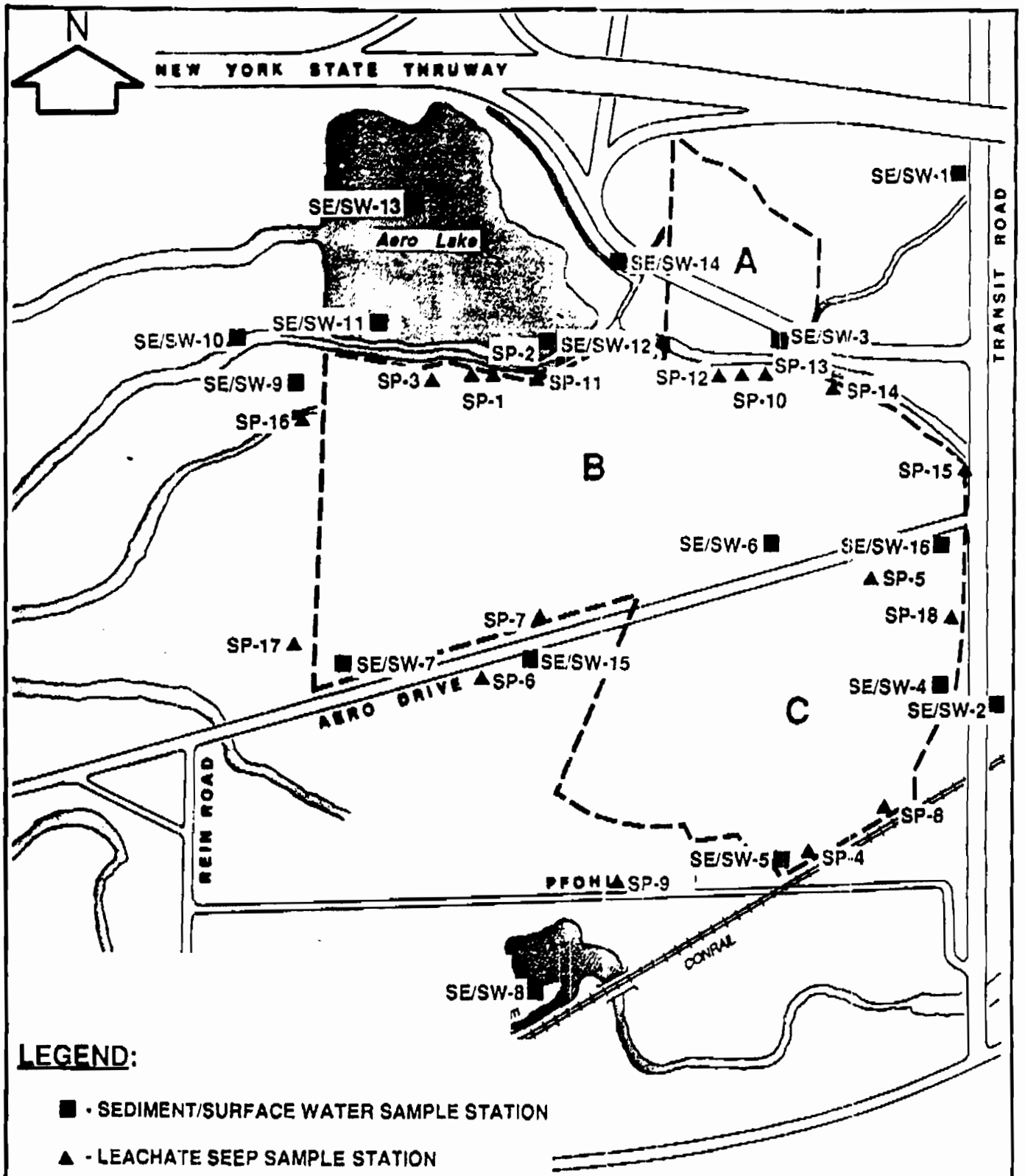
All Units in pCi/l

| | Background (1) | Site (2) | Standard (3) |
|---|---|---|---|
| Gross Alpha | | | |
| Min | <1 | <2 | |
| Max | 6 ±4 | 11 ±8 | 15 |
| Gross Beta | | | |
| Min | <1.4 | 4 ±3 | |
| Max | 5 ±2 | 24 ±5 | 1000 |

(1) Minimum and maximum values of routine samples of Niagara River water collected for background determination between 1982 and 1986 by the NYSDOH. Samples were collected from a location not expected to be influenced by discharges of man-made radionuclides. Source: "Environmental Radiation in New York State 1986 Annual Report" and "Environmental Radiation in New York State 1982-1985 Annual Reports, Volumes I and II"; NYSDOH, February, 1989.

(2) Minimum and maximum values of all samples collected from Ellicott Creek and Pfohl Brothers site seeps on April 19, 1989.

(3) New York State gross alpha (excluding radon and uranium) and gross beta (excluding strontium-90 and alpha emitters) radioactivity standards applicable to Class "AA" surface waters, for which the best usage is as a drinking water supply and any other usage. Source: NYSDEC 6NYCRR Part 701 Appendix 31, March 1986.




**CDM**

*environmental engineers, scientists planners & management consultants*

FIGURE 1

Field Activity Locations

Pfohl Brothers Landfill, Cheektowaga, New York

# Summary of Analytical Results

## ABBREVIATION KEY

| | |
|---|---|
| LT | Less than 2 standard deviations in the net count rate or the procedure detection limit. |
| +/- | Plus or Minus the uncertainity in the analytical results |
| pCi/g | Picorcuries per gram |
| pCi/l | Picocuries per liter |
| U-235 | Uranium-235 |
| U-238 | Uranium-238 |
| RA-226 | Radium-226 |
| TL-210 | Thallium-210 |
| ACT-228 | Actinium-228 |
| PB-212 | Lead 212 |
| TL-208 | Thallium-208 |
| CO-60 | Cobalt-60 |
| K-40 | Potassium-40 |
| CS-137 | Cesium-137 |

RADIONUCLIDE ANALYSIS RESULTS
PFOHL BROTHERS LANDFILL 09-15-043
CHEEKTOWAGA N.Y., ERIE CO.

| SAMPLE NUMBER | SEEP | UNITS | GROSS ALPHA | GROSS BETA |
|---|---|---|---|---|
| 4 | SP-5 | (pCi/l) | LT 2 | 7 +/- 3 |
| 5 | SP-8 | (pCi/l) | LT 4 | 10 +/- 5 |
| 6 | SP-18 | (pCi/l) | LT 2 | 7 +/- 3 |
| 7 | SP-15 | (pCi/l) | LT 3 | LT 9 |
| 8 | SP-16 | (pCi/l) | LT 3 | 16 +/- 5 |
| 9 | SP-17 | (pCi/l) | LT 2 | 4 +/- 3 |
| 10 | SP-1 | (pCi/l) | LT 3 | 21 +/- 5 |
| 11 | SP-2 | (pCi/l) | LT 3 | 24 +/- 5 |
| 12 | SP-3 | (pCi/l) | LT 3 | 16 +/- 3 |
| 13 | SP-10 | (pCi/l) | LT 5 | 14 +/- 6 |
| 14 | SP-11 | (pCi/l) | LT 4 | 19 +/- 4 |
| 15 | SP-14 | (pCi/l) | LT 2 | 10 +/- 2 |
| 16 | SP-4 | (pCi/l) | LT 5 | 20 +/- 5 |
| 17 | SP-7 | (pCi/l) | LT 4 | 16 +/- 6 |
| 18 | SP-9 | (pCi/l) | 6 +/- 4 | 18 +/- 4 |
| 19 | SP-12 | (pCi/l) | LT 5 | 8 +/- 6 |
| 20 | SP-13 | (pCi/l) | 11 +/- 8 | 19 +/- 7 |

RADIONUCLIDE ANALYSIS RESULTS
PFOHL BROTHERS LANDFILL 09-15-043
CHEEKTOWAGA N.Y., ERIE CO.
URANIUM SERIES

| SAMPLE NUMBER | SEEP | UNITS | TOTAL URANIUM | U-235 | U-238 | RA-226 | TL-210 |
|---|---|---|---|---|---|---|---|
| 4 | SP-5 | (pCi/l) | | LT 13 | LT 2000 | LT 20 | LT 10 |
| 5 | SP-8 | (pCi/l) | | 14 +/-10 | LT 2000 | LT 20 | LT 8 |
| 6 | SP-18 | (pCi/l) | 2.6+/-.5 | LT 14 | LT 2000 | LT 30 | LT 10 |
| 7 | SP-15 | (pCi/l) | 8 +/- 2 | LT 14 | LT 2000 | LT 20 | LT 11 |
| 8 | SP-16 | (pCi/l) | 1.7+/-.3 | LT 14 | LT 2000 | 30 +/-20 | LT 13 |
| 9 | SP-17 | (pCi/l) | 1.2+/-.3 | LT 13 | LT 2000 | LT 20 | LT 11 |
| 10 | SP-1 | (pCi/l) | LT .3 | LT 14 | LT 2000 | LT 20 | LT 10 |
| 11 | SP-2 | (pCi/l) | 2.5+/- 5 | 20 +/-15 | LT 2000 | LT 30 | LT 12 |
| 12 | SP-3 | (pCi/l) | 8 +/- 2 | LT 13 | LT 2000 | LT 20 | LT 11 |
| 13 | SP-10 | (pCi/l) | 1.2+/-.3 | LT 13 | LT 2000 | LT 30 | LT 11 |
| 14 | SP-11 | (pCi/l) | | LT 20 | LT 3000 | LT 30 | LT 12 |
| 15 | SP-14 | (pCi/l) | | LT 11 | LT 2000 | LT 20 | LT 9 |
| 16 | SP-4 | (pCi/l) | | LT 14 | LT 2000 | LT 20 | LT 9 |
| 17 | SP-7 | (pCi/l) | | LT 12 | LT 2000 | LT 20 | LT 11 |
| 18 | SP-9 | (pCi/l) | | LT 10 | LT 2000 | LT 20 | LT 9 |
| 19 | SP-12 | (pCi/l) | | LT 12 | LT 2000 | LT 20 | LT 9 |
| 20 | SP-13 | (pCi/l) | | LT 11 | LT 1400 | LT 20 | LT 10 |
| 21 | SS-1 | (pCi/g) | LT 0.3 | LT 0.09 | LT 13 | .7 +/-.2 | LT 0.07 |
| 22 | SS-2 | (pCi/g) | .4 +/-.3 | LT 0.20 | LT 20 | .7 +/-.3 | LT 0.14 |
| 23 | SS-3 | (pCi/g) | LT 0.3 | LT 0.11 | LT 15 | LT 0.2 | LT 0.09 |
| 24 | SS-4 | (pCi/g) | .5 +/-.3 | LT 0.20 | LT 30 | 1 +/-.4 | LT 0.15 |
| 25 | SS-6 | (pCi/g) | 3.8+/-.8 | LT 0.14 | LT 20 | .5+/-.3 | LT 0.10 |
| 26 | SS-7 | (pCi/g) | 0.6+/-.3 | LT 0.08 | LT 10 | .5+/-.2 | LT 0.07 |
| 27 | SS-9 | (pCi/g) | 0.8+/-.3 | LT 0.1 | LT 11 | .3+/-.2 | LT 0.07 |

RADIONUCLIDE ANALYSIS RESULTS
PFOHL BROTHERS LANDFILL 09-15-043
CHEEKTOWAGA N.Y., ERIE CO.
URANIUM SERIES

| SAMPLE NUMBER | SEEP | UNITS | TOTAL URANIUM | U-235 | U-238 | RA-226 | TL-210 |
|---|---|---|---|---|---|---|---|
| 28 | SS-10 | (pCi/g) | 1.6+/-.3 | LT 0.1 | LT 15 | .6+/-.2 | LT 0.08 |
| 29 | SS-11 | (pCi/g) | .8+/-.3 | LT 0.08 | LT 11 | .5+/-.2 | LT 0.06 |
| 30 | SS-12 | (pCi/g) | .4 +/-.3 | LT 0.09 | LT 14 | .4+/-.2 | LT 0.07 |
| 31 | SS-13 | (pCi/g) | 3.8+/-.8 | LT 0.09 | LT 15 | LT 0.2 | LT 0.08 |
| 32 | SS-14 | (pCi/g) | .5 +/-.3 | LT 0.08 | LT 13 | .2 +/-.2 | LT 0.07 |
| 33 | SS-5 | (pCi/g) | 2.2+/-.4 | LT 0.20 | LT 14 | .2 +/-.2 | LT 0.07 |
| 34 | SS-8 | (pCi/g) | 1.6+/-.3 | LT 0.20 | LT 30 | .7 +/-.4 | LT 0.20 |
| 35 | SS-15 | (pCi/g) | 7.6+-1.5 | LT 0.50 | LT 70 | LT .8 | LT 0.40 |
| 36 | SS-16 | (pCi/g) | LT 0.3 | LT 0.08 | LT 10 | .22+-.15 | LT 0.07 |
| 37 | SS-17 | (pCi/g) | LT 0.3 | LT 0.06 | LT 10 | .2+/-.13 | LT 0.05 |
| 38 | SS-18 | (pCi/g) | .4 +/-.3 | LT 0.08 | LT 10 | .5+/-.2 | LT 0.07 |

RADIONUCLIDE ANALYSIS RESULTS
PFOHL BROTHERS LANDFILL 09-15-043
CHEEKTOWAGA N.Y., ERIE CO.
THORIUM SERIES

| SAMPLE NUMBER | SEEP | UNITS | ACT-228 | PB-212 | TL-208 |
|---|---|---|---|---|---|
| 4 | SP-5 | (pCi/l) | LT 50 | LT 20 | LT 30 |
| 5 | SP-8 | (pCi/l) | LT 50 | LT 20 | LT 30 |
| 6 | SP-18 | (pCi/l) | LT 50 | LT 20 | LT 40 |
| 7 | SP-15 | (pCi/l) | LT 50 | LT 20 | LT 40 |
| 8 | SP-16 | (pCi/l) | LT 60 | LT 20 | LT 40 |
| 9 | SP-17 | (pCi/l) | LT 40 | 20 +/-20 | LT 30 |
| 10 | SP-1 | (pCi/l) | LT 50 | LT 20 | LT 40 |
| 11 | SP-2 | (pCi/l) | 50+/- 50 | LT 20 | LT 40 |
| 12 | SP-3 | (pCi/l) | LT 50 | LT 20 | LT 40 |
| 13 | SP-10 | (pCi/l) | LT 50 | LT 20 | LT 40 |
| 14 | SP-11 | (pCi/l) | LT 60 | LT 20 | LT 40 |
| 15 | SP-14 | (pCi/l) | LT 40 | LT 20 | 30 +/-30 |
| 16 | SP-4 | (pCi/l) | LT 40 | LT 20 | LT 30 |
| 17 | SP-7 | (pCi/l) | LT 50 | LT 20 | LT 30 |
| 18 | SP-9 | (pCi/l) | LT 30 | LT 20 | LT 30 |
| 19 | SP-12 | (pCi/l) | LT 40 | LT 20 | LT 30 |
| 20 | SP-13 | (pCi/l) | LT 40 | LT 20 | LT 30 |
| 21 | SS-1 | (pCi/g) | .7 +/-.4 | .8 +/-.2 | .5 +/-.3 |
| 22 | SS-2 | (pCi/g) | LT 0.7 | LT 0.3 | LT 0.5 |
| 23 | SS-3 | (pCi/g) | LT 0.4 | .5 +/-.2 | .8 +/-.3 |
| 24 | SS-4 | (pCi/g) | 1.5+/-.8 | .9 +/-.3 | 1.1+/-.5 |
| 25 | SS-6 | (pCi/g) | LT 0.6 | .6 +/-.2 | LT 0.4 |
| 26 | SS-7 | (pCi/g) | .5 +/-.4 | .49+/-.1 | LT 0.3 |
| 27 | SS-9 | (pCi/g) | .6 +/-.3 | .6 +/-.2 | .5 +/-.3 |

RADIONUCLIDE ANALYSIS RESULTS
PFOHL BROTHERS LANDFILL 09-15-043
CHEEKTOWAGA N.Y., ERIE CO.
THORIUM SERIES

| SAMPLE NUMBER | SEEP | UNITS | ACT-228 | PB-212 | TL-208 |
|---|---|---|---|---|---|
| 28 | SS-10 | (pCi/g) | .7 +/-.4 | .6 +/-.2 | .4 +/-.3 |
| 29 | SS-11 | (pCi/g) | .4 +/-.3 | .52+-.14 | .3 +/-.2 |
| 30 | SS-12 | (pCi/g) | LT 0.3 | .28+-.15 | LT .3 |
| 31 | SS-13 | (pCi/g) | LT 0.3 | .23+-.14 | .4+/-.3 |
| 32 | SS-14 | (pCi/g) | LT 0.4 | .52+-.15 | .3+/-.2 |
| 33 | SS-5 | (pCi/g) | LT 0.3 | LT .2 | LT .2 |
| 34 | SS-8 | (pCi/g) | LT 0.9 | .4 +/-.3 | LT .6 |
| 35 | SS-15 | (pCi/g) | 2 +/- 2 | 1.2+/-.7 | LT 1.4 |
| 36 | SS-16 | (pCi/g) | LT 0.3 | LT 12 | LT 0.2 |
| 37 | SS-17 | (pCi/g) | .4+/-.3 | .32+-.11 | .4 +/-.2 |
| 38 | SS-18 | (pCi/g) | .6+/-.3 | .45+-.14 | .6 +/-.2 |

RADIONUCLIDE ANALYSIS RESULTS
PFOHL BROTHERS LANDFILL 09-15-043
CHEEKTOWAGA N.Y., ERIE CO.

| SAMPLE NUMBER | SEEP | UNITS | CO-60 | K-40 | CS-137 |
|---|---|---|---|---|---|
| 4 | SP-5 | (pCi/l) | LT 11 | LT 200 | LT 10 |
| 5 | SP-8 | (pCi/l) | LT 9 | LT 200 | LT 9 |
| 6 | SP-18 | (pCi/l) | LT 12 | 300+-300 | LT 12 |
| 7 | SP-15 | (pCi/l) | LT 13 | LT 300 | LT 10 |
| 8 | SP-16 | (pCi/l) | LT 14 | LT 300 | LT 14 |
| 9 | SP-17 | (pCi/l) | LT 13 | LT 300 | LT 11 |
| 10 | SP-1 | (pCi/l) | LT 14 | LT 300 | LT 12 |
| 11 | SP-2 | (pCi/l) | LT 15 | LT 300 | LT 14 |
| 12 | SP-3 | (pCi/l) | LT 13 | LT 300 | LT 13 |
| 13 | SP-10 | (pCi/l) | LT 13 | LT 300 | LT 12 |
| 14 | SP-11 | (pCi/l) | LT 20 | LT 300 | LT 14 |
| 15 | SP-14 | (pCi/l) | LT 11 | LT 200 | LT 9 |
| 16 | SP-4 | (pCi/l) | LT 12 | LT 200 | LT 10 |
| 17 | SP-7 | (pCi/l) | LT 12 | LT 200 | LT 10 |
| 18 | SP-9 | (pCi/l) | LT 10 | LT 200 | LT 9 |
| 19 | SP-12 | (pCi/l) | LT 11 | LT 200 | LT 11 |
| 20 | SP-13 | (pCi/l) | LT 10 | LT 200 | LT 10 |
| 21 | SS-1 | (pCi/g) | LT 0.08 | 12 +/- 2 | .23 +-10 |
| 22 | SS-2 | (pCi/g) | LT 0.14 | LT 3 | LT 13 |
| 23 | SS-3 | (pCi/g) | LT 0.10 | 3 +/- 2 | LT 0.1 |
| 24 | SS-4 | (pCi/g) | LT 0.20 | 25 +/- 5 | LT 0.2 |
| 25 | SS-6 | (pCi/g) | LT 0.20 | 8 +/- 3 | LT 14 |
| 26 | SS-7 | (pCi/g) | LT 0.09 | 7 +/- 2 | .25+-.09 |
| 27 | SS-9 | (pCi/g) | LT 0.09 | 13+/- 2 | .39 +-10 |

RADIONUCLIDE ANALYSIS RESULTS
PFOHL BROTHERS LANDFILL 09-15-043
CHEEKTOWAGA N.Y., ERIE CO.

| SAMPLE NUMBER | SEEP | UNITS | CO-60 | K-40 | CS-137 |
|---|---|---|---|---|---|
| 28 | SS-10 | (pCi/g) | LT 0.10 | 9 +/- 2 | .17+-.11 |
| 29 | SS-11 | (pCi/g) | LT 0.08 | 4 +/- 2 | .18+-.08 |
| 30 | SS-12 | (pCi/g) | LT 0.08 | 3 +/- 2 | .2 +-.10 |
| 31 | SS-13 | (pCi/g) | LT 0.08 | LT 2 | LT 0.08 |
| 32 | SS-14 | (pCi/g) | LT 0.08 | 6 +/- 2 | .15+-.09 |
| 33 | SS-5 | (pCi/g) | LT 0.08 | 2 +/- 2 | .11+-.08 |
| 34 | SS-8 | (pCi/g) | LT 0.28 | LT 4 | LT .2 |
| 35 | SS-15 | (pCi/g) | LT 0.50 | 15 +/-11 | 1.1+/-.5 |
| 36 | SS-16 | (pCi/g) | LT 0.06 | 1.7+-1.5 | LT 0.07 |
| 37 | SS-17 | (pCi/g) | LT 0.06 | 3.1+-1.5 | .08+-.07 |
| 38 | SS-18 | (pCi/g) | LT 0.07 | 5 +/- 2 | .25+/-.1 |