



E. I. DU PONT DE NEMOURS & COMPANY
INCORPORATED
WILMINGTON 98, DELAWARE

DOCKET NO. 40-6664

LAR FILE COPY

PURCHASING DEPARTMENT

July 20, 1962

Mr. J. C. Delaney, Acting Chief (4)
Source and Special Nuclear Materials Branch
Division of Licensing and Regulation
United States Atomic Energy Commission
Washington 25, D. C.

LICENSE NO. STB-489

Dear Sir:

This license authorizes the use of Thorium as outlined in my letters of October 16, 1961, and November 20, 1961. The current possession limit is 300 pounds.

In line with the expansion of our Dispersion Modified Metals Program, we desire increased authorization for quantity on hand. It is requested that the limitation be changed from 300 pounds to 2,000 pounds. Of the 2,000 pounds which could possibly be on hand at one time, approximately 1,000 pounds would be in the form of raw material (i.e. Thorium Salts as procured from salt producers), 500 pounds in process and 500 pounds in finished material.

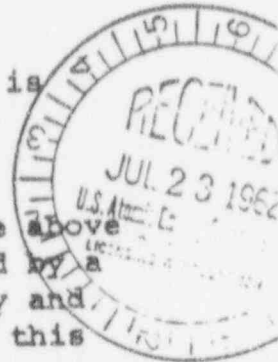
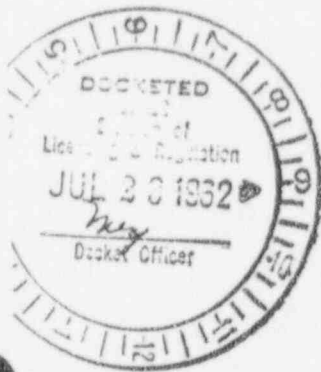
In line with this request certain changes will be made in the information presented in the above mentioned letters.

The reference to maximum Thorium used per year is to be deleted.

Facilities used will consist of:

1. The original installation described in the above mentioned letters. This area will be increased by a section of approximately 20' x 25'. All safety and handling precautions in effect will be used in this new area.

2. A second building for somewhat larger scale operation will be used. This building has two levels and is approximately 25' x 42'. All precautions used in the current building will be used in the new building. The ventilation will be increased to 10,000 cubic feet per minute.



Copy Supplied
Public Information Branch
Dir. of Compliance 7/24/62
ARR

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C PDR

July 20, 1962

Mr. J. C. Delaney, Acting Chief (4)

3. Supporting research is done in laboratories. The work is limited to small samples. Precautions of working in hoods and maintaining clean conditions are observed. Ventilation in the laboratories is equal to or in excess of that in the original building.

Waste- There will be no changes in the method of waste disposal outlined in the October 16th letter. Processing of additional quantities will result in a higher quantity of waste. It is expected that up to 2,000 pounds may be disposed of in a year by burying.

There are no other changes.

Experience to date has confirmed our ability to keep radiation hazards extremely low. The same procedures will continue to be followed and all AEC regulations will be adhered to.

Your prompt attention to this request will be appreciated.

Very truly yours,



H. J. Gorman, Jr.
Asst. Purchasing Agent
Chemicals & Containers Div.

HJG/dat

400154
Volume 1
1163

**Work Plan
Remedial Investigation / Feasibility Study
DuPont - Newport Site
Newport, Delaware
July 28, 1988**

for
U.S. Environmental Protection Agency
Region 3
841 Chestnut Street
Philadelphia, Pa. 19107

Prepared for

E.I. du Pont de Nemours & Co., Inc.
Brandywine Building
Wilmington, Delaware 19898

Woodward-Clyde Consultants



Consulting Engineers, Geologists and Environmental Scientists
5120 Butler Pike, Plymouth Meeting, Pennsylvania 19462

a field operable gas chromatograph (GC) located on-site and equipped specifically for TCE and PCE analysis. Details on the method of soil gas sample collection and analysis used at the Newport Site are described in Appendix G and presented in Section 6 of QAPP.

The samples were analyzed within one-half hour of sample collection by injecting the sample directly into the gas chromatograph (GC). The GC used, a Varian 3400 series equipped with dual electron capture detectors (ECD), affords the most sensitive analysis for the chlorinated organic compounds of interest (TCE and PCE). Detection limits achieved during this survey were approximately 10 parts per billion (ppb) for the two compounds of interest (see Appendix G). The soil gas survey results are shown in Table 1-6 and discussed in Section 1.2.2.4.

1.1.6.5 GROUND RADIOMETRIC SURVEY

From 1961 to 1968, the Newport plant manufactured a thoriated nickel alloy that was used in the manufacture of supersonic jet engines. The alloy consisted mostly of nickel, some chromium and molybdenum, and small quantities of thorium (2 to 5 percent).

Solid and semi-solid waste material from this process (reportedly about 20 tons) was buried in the North Disposal site in accordance with federal regulations in effect at that time. The estimated weight of thorium dioxide disposed is between 0.4 and 1 ton. According the Du Pont records, the thorium waste was placed in jars that were subsequently placed in 55 gallon barrels together with disposable protective clothing and debris from the waste handling operations. The barrels were placed in "holes" or small excavations which were nominally at depths up to 10 feet below the clay-capped present land surface of the landfill.

The exact number and locations of disposal "holes" at the North Disposal site are unknown. Based on existing plant records, the thorium waste was apparently buried within the area shown on Figure 1-12.

ATTACHMENT B

**Data Sufficiency Memorandum
Remedial Investigation - Phase 2
DuPont - Newport Site
Newport, Delaware
April 27, 1989**

for:

U.S. Environmental Protection Agency
Region 3
841 Chestnut Street
Philadelphia, Pa. 19107

Prepared for:

E. I. du Pont de Nemours & Co., Inc.
Brandywine Building
Wilmington, Delaware 19898

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the particle surface have a possibility of releasing the Ra-228 daughter atom to the pore space.

Question 4
Ra-228 Available to Groundwater. Of the total Ra-228 activity, only that portion from Th-232 near the surface of the solid matrix will be potentially available to the groundwater. This percent can be calculated by subtracting the volume of the 100 angstrom thick surface skin from the total volume of soil matrix and calculating a ratio of the volume of this surface skin to the total volume. The matrix is assumed to consist of spherical particles of average diameter of 0.25 mm.

$$\text{Total particle volume} = \frac{4}{3} \pi r^3$$

$$V \text{ (total)} = \frac{4}{3} \pi \left(\frac{.25}{2} \text{ mm} \right)^3 = 8.18123 \times 10^{-3} \text{ mm}^3$$

Subtract 100 angstrom shell

$$V = \frac{4}{3} \pi \left(\frac{.25}{2} \text{ mm} - 100 \text{ angstroms} \right)^3 = \frac{8.17927 \times 10^{-3} \text{ mm}^3}{2 \times 10^{-6} \text{ mm}^3}$$

$$\frac{\text{Available Volume}}{\text{Total Volume}} = \frac{2 \times 10^{-6} \text{ mm}^3}{8.2 \times 10^{-3} \text{ mm}^3} = 2.4 \times 10^{-4}$$

Maximum Available Ra-228:

$$90 \text{ mCi} \frac{10^9 \text{ pCi}}{\text{mCi}} \cdot 2.4 \times 10^{-4} = 2.2 \times 10^7 \text{ pCi}$$

Using alpha recoil will theory, about one-half of the decays will result in an emission further into the solid matrix and one-half into the pore spaces. The theoretical volume is reduced by one-half because there is an equal probability for a newly-formed Ra-228 atom or the simultaneously emitted alpha particle to move into the pore space or to stay in the solid matrix. Thus the Ra-228 theoretical activity is 1.1×10^7 pCi.

contaminants reported for the fill material samples suggest that the previously reported quantities and characteristics of wastes disposal at the North Disposal site were both accurate and complete. In conjunction with the groundwater analytical data, there are no new parameters of concern.

Based on the horizontal and vertical distribution of the sampling locations, these analytical data are considered sufficient to adequately characterize the TCL chemistry of the North Disposal site fill materials.

2.2 RADIOLOGICAL INVESTIGATION

In response to EPA's modification to this section of the Work Plan, a subsurface radiological investigation was conducted at the North Disposal site to characterize the potential activity levels. The soil and fill boring operations for waste characterization (Section 2.1) on the North Disposal site included the collection of three fill material samples from boring SBND-5 in what was previously considered the presumed thorium disposal area. More recent information suggests that the disposal area was about 500 feet further northeast, closer to well SM-1 (personal communication with former Du Pont employee involved with thoriated waste disposal operations). These three fill material samples were analyzed by Teledyne Isotopes for thorium-232 (Th-232) and its daughter products. In addition, a groundwater sample was collected from monitoring well SM-4 and analyzed for radium-228 (Ra-228). The results of these radioactivity analyses, along with detailed activity calculations, are presented in Attachment 3.

Based on the Th-232 activity levels reported by Teledyne Isotopes for the fill material samples along with the radioactivity analyses from groundwater collected from monitoring well SM-4, an evaluation of the impact of Th-232 and Ra-228, its primary daughter product, in the groundwater medium was conducted. Relevant detailed calculations are presented in Attachment 3. Part of this discussion includes summarization of communications with Dr. J.K. Osmond, noted isotope geochemist at Florida State University.

*2/27/83
3
C. SM-104 k) Response*

Based on available plant records, the total activity of the buried Th-232 is 90 mCi (see Attachment 3). The primary daughter product of concern from decay of Th-232 is Ra-228. Because the half-life of Th-232 (1.4×10^{10} year) is very long compared with the half-life of Ra-228 (5.7 year), in a closed system the activity of Th-232 is equal to the activity of Ra-228. The total activity of Ra-228 would, therefore, be 90 mCi in the source. In reality, Th-232 is insoluble in water and is found on and in the solid phase matrix. Further, as reported in the Work Plan (WCC, 1988), the thorium wastes were mainly in the form of a thoriated nickel, which contained a range of 2 percent to 5 percent ThO_2 . This ThO_2 , which is dispersed in the solid phase nickel alloy, is also insoluble in water.

In contrast, Ra-228 is generally soluble in groundwater. Consequently, the amount of Ra-228 in solution at the source is a function of the physical potential for the Ra-228 to move from the solid matrix to the solution-filled pores of the shallow zone. This will be a function of the alpha-recoil potential of the decay of Th-232 as documented by Kigoshi (Science, 1971). He calculated a recoil distance of about 200 angstroms for alpha particles of this energy. Assuming that the average particle size of the fill material and soils adjacent to the buried thorium waste is a fine to medium sand and that only the outer rind of about 100 angstroms in thickness is a potential source of Ra-228 to the pore space of the shallow zone, the potential total activity of the groundwater near the source is calculated to be 4.5×10^6 pCi Ra-228 (see Attachment 3).

Available records suggest that the waste was contained in an area about 130 feet by 35 feet by 5 feet in thickness, located between wells SM-3 and SM-1. The maximum Ra-228 activity in groundwater at the source based on the above assumptions is calculated to be 17 pCi/l. Because the buried source is entirely above the water table, any part of the 17 pCi/l Ra-228 that may be recoiled out of the solid matrix will be in unsaturated or capillary fringe pore space. These atoms will potentially reach the water table only as a result of periodic rainfall and subsequent infiltration down to the water table. Due to these hydrologic constraints, it is estimated that no more than one-half of the available Ra-228 will actually reach the water table via infiltration through interconnected pores. The remainder will likely be detained in the capillary fringe long enough for the Ra-228 to further decay.

Consequently, the maximum potential activity of Ra-228 in groundwater at the source is calculated to be about 9 pCi/l. If the average particle size of the soils associated with the buried waste is larger than estimated, or the residence time of Ra-228 in the capillary zone is longer than estimated, or the original source is 3 percent ThO₂ rather than the 5 percent used in these calculations, then, maximum potential activity could be even lower. If the source is closer to 2 percent ThO₂, the theoretical activity of Ra-228 in groundwater near the source would be 7 pCi/l, rather than 17 pCi/l, and the maximum potential activity of Ra-228 in the shallow groundwater at the source would be about 4 pCi/l after taking the hydrologic constraints discussed above into account.

In fact, groundwater in well SM-4 had a measured Ra-228 activity of 5.0 and 5.6 pCi/l (November 8, 1988). This well, although believed to be about 700 feet from the source, had measurable activity of Th-232 in the groundwater. Th-232 would generally be expected to have zero activity in groundwater. Thus, either an additional source of Th-232 is nearby or particles from the source were in the sample of SM-4 groundwater analyzed. The former possibility is considered unlikely. Although the source is about 700 feet from well SM-4, it is possible that surface conduits during the period of active fill operation (progressively away from the river) could have been pathways for migration of Th-232 particulate waste. Well SM-4 is at the mouth of a drainageway leading directly from the operations area as well as downgradient during landfilling operations in the 1960's. As an alternative, if groundwater gradients were parallel to the river during the landfilling period a hypothetical gradient of about one-half the present gradient can be assumed, and the Ra-228 in well SM-4 assumed residual from the source. Then a source activity of 160 pCi/l is calculated. This activity is much larger than the maximum calculated source activity. Consequently, this option is considered unrealistic and other alternative pathways (surface migration) need be considered more likely.

Although the available data do not provide a clear choice between either flow in the shallow zone or surface drainage from the buried area for the possible source of Ra-228 at well SM-4, several observations are worth noting:

- o gross alpha and gross beta measurements in 1980 and 1987 indicate more activity at well SM-4 than well SM-3. If groundwater were the source of Ra-228 in water from well SM-4, well SM-3 should indicate larger activity levels.

- o Groundwater flow could still be a source for activity in SM-4 if some thoriated metal alloy were colloidal and some particles have migrated through the porous medium. A colloid is a finely dispersed phase having at least one dimension in the range of 1 to 10^3 nanometers. Because of their extremely large specific surface areas, colloids are efficient scavengers of metals. Movement of colloidal particles is controlled by the physical properties of the colloid rather than by the hydrologic properties of the system or the chemistry of the unadsorbed material.

In this case, rates of groundwater movement would not be related to activity levels. The Th-232 activity measured in well SM-4 could then be a result of Th-232 residing on colloidal particles in the vicinity of well SM-4. That no significant gross alpha or beta activity is measured at SM-3 supports the random distribution of colloids in the shallow zone and suggests that dissolved Ra-228 is not the primary source of Ra-228 activity at well SM-4.

In summary, the measured activity of Ra-228 in well SM-4 of 5.6 pCi/l is comparable with maximum potential activity near the source. Consequently, soil samples from additional borings or groundwater samples from additional monitoring wells would be unlikely to alter the characterization of the potential Ra-228 activity levels. Because the existing data are considered sufficient for the objectives of the RI/FS, additional drilling and sampling are, therefore, unnecessary.

2.3 RESIDENTIAL WELL SAMPLING

During Phase II, groundwater samples from 10 residential/private wells located southwest of the Site along Old Airport Road were collected to provide additional data on the

ATTACHMENT 3

Question 2

Source strength calculation. Radioactive ThO₂ was deposited in the North Disposal site. Of 20 tons of total waste (primarily off-grade thoriated nickel), 2 to 5 percent by weight is ThO₂. The part of the specific activity of this material derived from Th-232 decay to Ra-228 is calculated to be:

$$\begin{aligned}
 A &= \lambda N \\
 &= \frac{\ln 2 \text{ disin.}}{1.4 \times 10^{10} \text{ yr}} \frac{6 \times 10^{23}}{264 \text{ g}} \frac{454 \text{ g}}{\text{lb}} \frac{2000 \text{ lb}}{\text{ton}} \frac{\text{yr}}{3.1 \times 10^7 \text{ sec}} \text{ }^A \\
 &\quad \frac{10^{12} \text{ pCi}}{3.7 \times 10^{10} \text{ dps}} \frac{\text{mCi}}{10^9 \text{ pCi}} \\
 &= 90 \text{ mCi/ton}
 \end{aligned}$$

Because there are 20 tons of waste buried on-site, with a ThO₂ content between 2 and 5 percent, the total activity of Th-232 is between

$$\begin{aligned}
 A &= (90 \text{ mCi/ton}) (20 \text{ tons}) (0.05) = 90 \text{ mCi and} \\
 A &= (90 \text{ mCi/ton}) (20 \text{ tons}) (0.02) = 36 \text{ mCi}
 \end{aligned}$$

Theoretical Activity of Ra-228. Because the half-life of Th-232 (1.4×10^{10} yr) is much longer than the half-life of Ra-228 (5.7 yr), in a closed system the activity of Th-232 equals the activity of Ra-228. Therefore,

$$A (\text{Ra-228}) = 36 \text{ to } 90 \text{ mCi at the source.}$$

Only part of the activity of Ra-228 will be available to the groundwater because most of the Th-232 is within the solid matrix. According to alpha-recoil theory (Kigoshi, Science, 1971), Ra-228 will be recoiled into solution only from Th-232 atoms located within recoil distance of the particle surface. Recoil distance for an alpha decay of this energy is about 200 angstroms, suggesting that Th-232 atoms within about 100 angstroms of

The volume estimated for the solid waste is;

$$130 \text{ ft} \times 35 \text{ ft} \times 5 \text{ ft} \times \frac{7.5 \text{ gal}}{\text{ft}^3} \times \frac{3.8 \text{ l}}{\text{gal}} = 6.5 \times 10^5 \text{ l}$$

This would correspond to a maximum potential activity for Ra-228 in groundwater near the source, based on 5 percent ThO₂ in the waste, of

$$\frac{1.1 \times 10^7 \text{ pCi}}{6.5 \times 10^5 \text{ l}} = 17 \frac{\text{pCi}}{\text{l}}$$

Minimum available Ra-228.

Similarly, calculating Ra-228 activity based on a theoretical source of 36 mCi/l, a minimum potential activity of 7 pCi/l Ra-228 in groundwater near the source, based on 2 percent ThO₂ in the waste, is calculated.

Hydrologic Constraints. These calculations assume the Ra-228 is recoiled into a saturated porous medium. In reality, the buried wastes are in an unsaturated zone situated a few feet above the local water table. Depending on infiltration rates and percolation characteristics of the capillary zone, the full range of Ra-228 (7 to 17 pCi/l) may not migrate to the saturated zone. Rather, some may be detained in the capillary fringe long enough for the Ra-228 to further decay. A qualitative estimate of about one-half of the Ra-228 may reach the water table, suggesting a range of Ra-228 activity of between 4 and 9 pCi/l in groundwater near the source.

Geochemical Constraints. Radium solubility is a function of redox conditions and water salinity. Oxygenated waters, such as are likely in the infiltration zone, are expected to result in reduced radium solubility relative to more reducing environments. Waters of low salt content, again comparable to waters in the shallow zone, also tend to limit radium solubility (J.K. Osmond, Florida State University, oral communication). Geochemical conditions thus favor further qualitative limitations on radium solubility.

Groundwater Velocity Calculation. The groundwater velocity in the saturated part of the shallow zone is a function of:

- o hydraulic conductivity $K = 40 \text{ gpd/ft}^2$ (more likely estimate -- see Section 2.6.1)
- o hydraulic gradient between SM-4 and the burial site near SM-1. Although present gradient is zero (parallel to contour lines) the historical evidence of landfilling operations seen on aerial photography supports a possible gradient toward SM-4. A gradient of about one-half present day gradient to the river is estimated.
- o porosity of the shallow zone, estimated at $= 0.25$

$$\begin{aligned} \text{Velocity } v &= KI/n \\ &= 40 \frac{\text{gpd}}{\text{ft}^2} \times 0.01 \times \frac{\text{ft}^3}{7.5 \text{ gal}} \times \frac{1}{0.25} \\ &= 0.2 \text{ ft/d.} \end{aligned}$$

Well SM-4 is believed to be about 700 feet from the source. The calculated travel time for a dissolved constituent such as Ra-228 would be:

$$\begin{aligned} T &= \text{distance/velocity} \\ &= 700 \text{ ft}/0.2 \text{ ft/d} \\ &= 3,500 \text{ d} = 9.6 \text{ yr} \end{aligned}$$

This travel time does not fully account for the relevant site history of landfilling. For this calculation, it is assumed that:

- o dissolved components in groundwater are the only source of activity;

- o the 5.6 pCi/l Ra-228 activity measured in 1988 has been out of contact with source material since landfilling stopped in about 1970 (18 years); and
- o that during the length of active landfilling the source was continuously available to the groundwater.

Back calculating using the decay equation for the past 18 years, the theoretical activity of Ra-228 in groundwater from well SM-4 in 1970 would have been;

$$\begin{aligned}
 A &= A_{\text{measured}} \exp(\lambda t) \\
 &= 5.6 \frac{\text{pCi}}{\text{l}} \exp\left(\frac{\ln 2}{5.7 \text{ yr}} \times 18 \text{ yr}\right) \\
 &= 50 \frac{\text{pCi}}{\text{l}}
 \end{aligned}$$

Then considering the travel time from the source during the active landfilling period, the theoretical activity of groundwater near the source would have been;

$$A_{\text{source}} = 50 \frac{\text{pCi}}{\text{l}} \exp\left(\frac{\ln 2}{5.7 \text{ yr}} \times 9.6 \text{ yr}\right) = 160 \frac{\text{pCi}}{\text{l}}$$

This value is well above the maximum activity of 17 pCi/l calculated based on known characteristics of the waste and hydrologic constraints. It is concluded that measured Ra-228 activity in water from well SM-4 is probably not a result of dissolved Ra-228 in the groundwater flow path of the shallow zone.

Background and Field Data. Part of the measured Ra-228 is a result of naturally occurring background Ra-228 activity in the shallow zone. Background radium activity in groundwater is highly localized and variable, but a typical range is between 0.1 and 4.0 pCi/l for total radium activity (Dragun, 1988, Soil Chemistry of Hazardous Materials). Because the measured activity of 5.6 pCi/l (Table 1) is within the calculated range of source

concentrations, it is reasonable to conclude that the local background activity of Ra-228 in the shallow zone is relatively small, that water from well SM-4 is very near the buried source, and that the measured activity of Ra-228 in groundwater is comparable to the likely maximum at the source.

Background Th-232 activity in groundwater would be expected to be zero. Because of the measured activity of Th-232 of 0.25 pCi/l in well SM-4, one of two conclusions is appropriate. Either the well is at the source, or suspended colloidal sediment from the source has been transported a short distance through the shallow zone and been pumped with the well water. In either case, it is reasonable to conclude that the source is nearby.

Background data on Th-232 in soils is sparse, but available data (Hansen and Stout, 1968, Soil Science) report a range between 0.2 and 2.0 pCi/g for Th-232 in sandy and silty loam (topsoil). Measured soil concentrations in boring SBND-5 (Table 1) are within this range. Because this boring attempted to core the buried waste, and is believed near the waste source, the background thorium levels support the idea that the buried thoriated nickel waste is immobile in the shallow zone.

The soil boring activities of Th-228 and Ra-228 are identical within analytical error for each depth. This is because of expected equilibrium in the soil between the parent and daughter isotopes, and supports the idea of a closed system behavior resulting from hydrologic constraints. That is, the unsaturated nature of the buried waste area and the insoluble nature of the thoriated metal waste limit the potential mobility of Ra-228 from the source.

Ra-224 is also a daughter product of Th-232. Because of its very short half-life of 3.6 days, there is sparse background information available on Ra-224 activity. It is reasonable to assume that Ra-224 activity can be estimated to be equal to Ra-228 activity after the approximate 5 half lives of Ra-228 the waste has been buried. Therefore, the maximum source activity of Ra-224 would also be expected to fall in the range of 4 to 9 pCi/l in the shallow zone at the source.

TABL. P.

TELETYPE ISOTOPIES

REPORT OF ANALYSIS

REVISED 04/24/89
 NUM DATE 11/16/88

MR ROGER GRESH
 WOODWARD-CLYDE CONSULTANTS
 5120 BUTLER PIKE
 PLYMOUTH MEETING PA 19442

WORK ORDER NUMBER
 3-0845

CUSTOMER P.O. NUMBER

DATE RECEIVED 10/14/88
 DELIVERY DATE 11/16/88

PAGE 1

SOIL

TELETYPE SAMPLE NUMBER	CUSTOMER'S IDENTIFICATION	STA NUM	COLLECTION-DATE START DATE	STOP DATE	ACTIVITY (PCI/GM DRY)	MUCL-UNIT-Z U/R	MID-COUNTY DATE TIME	VOLUME - UNITS ASH-WGT-Z	LAB.
48980	B7C2076-4F 5 1 58ND-5		10/13 1605		4.7 ±-0.5 0.084 ±-0.040 0.58 ±-0.09 0.45 ±-0.05		11/10 10/24 11/10 11/10		4 6 4 4
48981	B7C2076-4C 5 2 58ND-5		10/13 1605		2.4 ±-0.3 0.15 ±-0.03 0.93 ±-0.10 0.74 ±-0.07		11/13 10/24 11/13 11/13		4 6 4 4
48982	B7C2076-4C 5 3 58ND-5		10/13 1605		1.9 ±-0.2 0.081 ±-0.026 0.42 ±-0.08 0.36 ±-0.04		11/15 10/24 11/15 11/15		4 6 4 4
52000	WELL SM-4 THORNTON-DAU		11/08		1.1, 70 0.75 ±-0.11 1.1, 7 0.96 ±-0.24	PCI/L PCI/L PCI/L PCI/L	12/01 12/12 12/01 12/12		4 4 6 6 6
52001	WELL SM-4 RA-228		11/08		5.6 ±-0.9	PCI/L	12/06		3
52002	WELL SM-4 RA-228 DUP		11/08		5.0 ±-0.8	PCI/L	12/04		3
52003	WELL SM-4 EXTRA		11/08		NOT ANALYZED				3

LAST PAGE OF REPORT

APPROVED BY *B Campbell* CAMPBELL 12/20/88

SEND 3 COPIES TO DUS725 MS CATHERINE BARTON

2 - GAS LAB. 3 - RADIO CHEMISTRY LAB. 4 - GELI) GAMMA SPEC LAB. 5 - IODINE CAS/L.S. LAB. 6 - ALPHA SPEC LAB.

3.2.5 - RESEARCH METALS

Four specific metals were worked with at the research level, zirconium, hafnium, niobium (Columbium), and tantalum. These metals were worked with during the period from approximately 1950 to 1965. The only one of these metals that was produced in any significant amount was niobium (total of several hundred pounds per day). These metals were very valuable and were handled in a manner as to prevent any loss due to carelessness. The only waste materials from the manufacturing of these metals were incompletely reacted chlorides.

3.2.6 THORIA DISPERSED/MODIFIED NICKEL

Thorium-232 was used at the Site during the period from 1961 to 1966 as part of Du Pont's Dispersion Modified Metals program to impart improved high temperature properties to metals such as nickel. Thoria Dispersed Nickel (TD Nickel) was the only material of this type to be produced at the Newport Plant in pilot unit quantities (several hundred pounds per day). The process operations, licensing, and waste disposal for the TD Nickel program are described below:

Process Operations: The TD Nickel process consisted of the preparation of a colloidal suspension (a sol) of the thorium oxide (thoria), mixing with a solution of nickel salt (generally nickel nitrate), co-precipitation and filtration of the mixture, and finally drying and then calcining of the precipitate. The nickel oxide in calcined material was, in turn, reduced to elemental nickel with hydrogen. The thoria remained unchanged. The levels of thoria were generally in the range of 2 to 5 percent in the finished material.

The TD Nickel operations were performed in only two buildings at the Site. Small scale operations were conducted in Building 23 and somewhat larger operations were performed in Building 72.

The initial thorium for this process was purchased as either thorium nitrate or oxalate. Thorium nitrate is water soluble. Thorium oxalate is insoluble. When the thorium

nitrate was used as the starting material, it was converted to the insoluble oxalate by mixing with oxalic acid. Then the thorium oxalate crystals were heated to form thorium oxide. From that point on in the process, the thorium was only present as the insoluble oxide and was generally in a homogeneous mixture with the nickel in the 2 percent to 5 percent range as a dispersed metal oxide.

Licensing Licenses were obtained from the Atomic Energy Commission (AEC) to handle materials containing thorium. The first license was issued by the AEC in December, 1961 and permitted a maximum of only 300 pounds of thorium at any one time. This was renewed in 1965, extending to 1968. The renewal license permitted an increase in the maximum usage to 5000 pounds. However, during the period of greatest activity, the license not only still restricted the total amount of thorium at any one time to 300 pounds, but also placed restrictions on the amount on hand in each stage of the process:

Raw Materials - 150 lbs.

In Process - 20 lbs.

Semi-finished product - 50 lbs.

Product - 150 lbs.

Waste Disposal The AEC license application described the two means of disposal and the methods to be used to handle spills. ~~In general, waste solids containing thorium were to be accumulated, stored and periodically buried in the plant landfill (North Disposal site).~~

~~All waste solutions or suspensions containing thorium were to be treated to precipitate the thorium. The precipitate would be accumulated with the solid waste and ultimately buried and the thorium-free liquid would be discharged to the plant sanitary sewerage~~

An excerpt from operating instructions in the AEC license application is included here, which provides guidance on burial procedures and also discusses how liquids contaminated with radioactive materials were to be treated:

Solids: "All waste process material, towels, etc., which show a beta plus gamma count on the Geiger Muller counter of over twice background 1-inch from the surface will be regarded as radioactive and placed in a container labeled "Thorium Wastes." When full, this container will be buried. The AEC specifies burial of not over 450kg of thorium metal per burial. Each burial is to be at least 4 feet deep and 6 feet from the nearest previous burial. Not over 12 burials are to be made per year. L. Hovis will be responsible for these burials, for notifying H.F. Barfelo in writing of the quantity of source material buried, and for making entry of the burial in the log."

Liquids: "All liquid which may be contaminated with radioactive materials will be dumped in a drum located in "A" line. An attempt should be made to precipitate the radioactive material when possible. When the drum is full, it will be carefully decanted (by siphon) to the sewer using care not to disturb solid material which has settled to the bottom. Occasionally the solids collected in the bottom of the drum will be removed, filtered, and added to the storage drum for solid waste. Mr. West will be responsible for liquid waste disposal."

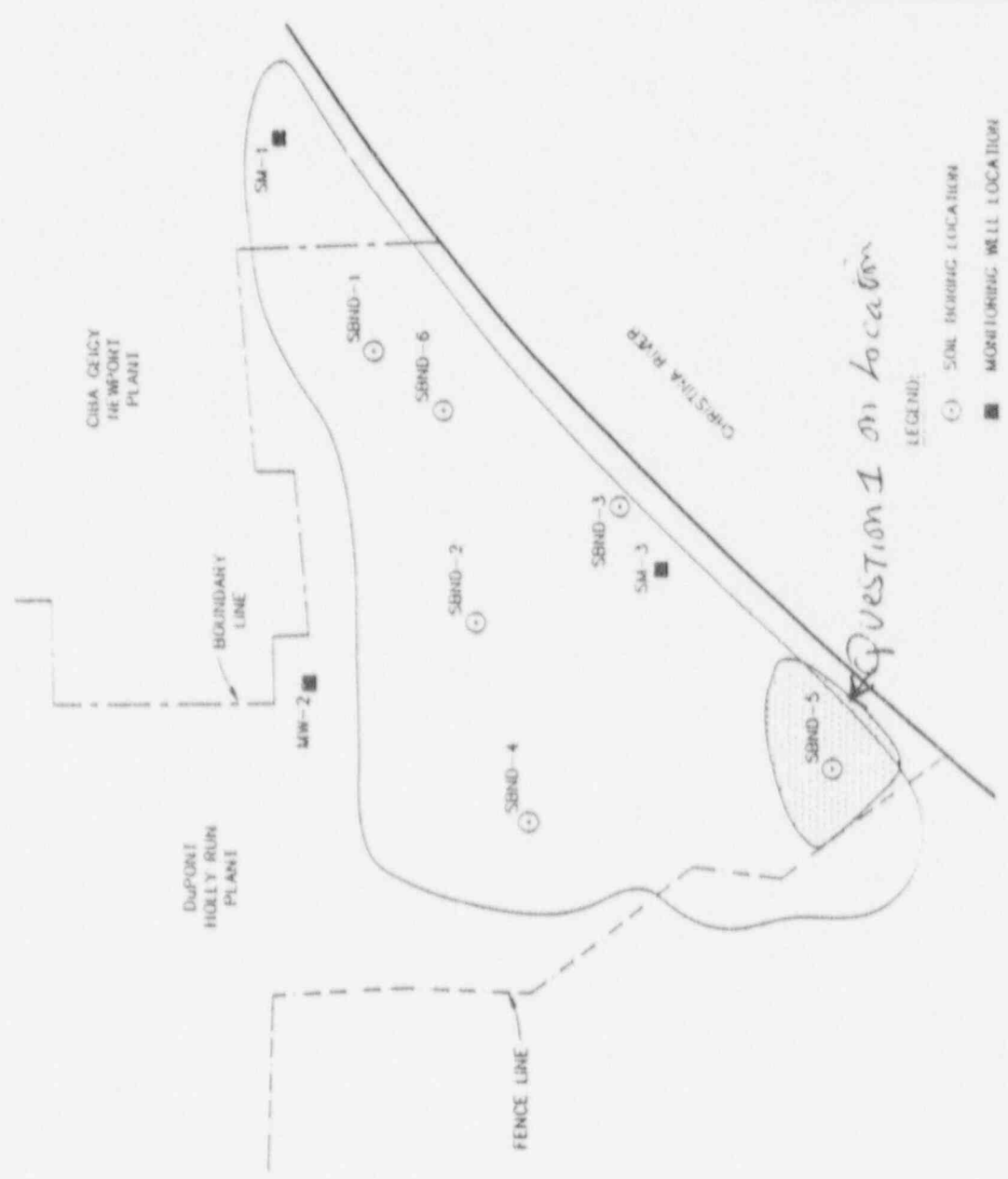
Ground water from SM-4 and upgradient monitoring wells NW-1A: V

From discussions with Du Pont pensioners who had worked on the process, the solid wastes were normally paper towels, gloves, filter cloths, etc., which had been used in the process. By far, however, the largest amount of solid waste was material found to be out of specification after the calcining step and before reduction. Due to the strict AEC regulations, it is very unlikely that the cleanup and disposal of any spilled materials was not handled properly. Consequently, it is concluded that due to the stringent materials handling procedures, the operations area is not a likely source of radiological contamination. This has been confirmed by the background levels of alpha and beta activity in wells SM-5 and DM-8, adjacent to the former TD Nickel operations main building (Building 72).

These results are presented in a report prepared by Du Pont (see Appendix 7).

Discussions with pensioners also confirmed that an estimated 20 tons of waste containing a maximum of 2 percent to 5 percent thorium oxide were buried in the North Disposal site. Based on these discussions and a review of extant maps and drawings, it is concluded with a high degree of certainty that the burial location was restricted to the area shown on Figure 4. According to the pensioners the waste materials were transported from Buildings 73 and 72 to the burial area and the burial location of the drums was recorded on a burial log. Except for a small amount of material buried slightly east of the Sodium Burning Pad that existed in 1957, all of the wastes were buried immediately to the southwest of this pad in an area about 35 feet wide and 130 feet long, parallel to the river, as schematically shown in the burial log on Figure 5. (Figure 5 is a reproduction of the Du Pont

file burial log required by the AEC license; as excerpted above in the operating instructions.)
No additional investigation or documentation of the thoriated waste burial location or handling
practices is considered necessary.



LEGEND:
 (○) SOIL BORING LOCATION
 (■) MONITORING WELL LOCATION

DuPont - Newport Site Newport, Delaware	
WOODWARD-CLYDE CONSULTANTS Consulting Engineers, Geologists and Environmental Scientists	
SOIL COVER SAMPLING LOCATIONS NORTH DISPOSAL SITE DuPont - Newport Site	
Job No. 80C2078-4	Drawing No. 807301-00
Checked by R.T.G.	Rev. No.:
Date: 2/7/88	Scale: 1" = 150 Feet
FIGURE 3	



LEGEND:

Phase I Monitoring Wells

MW-7A Shallow Zone

MW-7B Intermediate Zone

MW-7C Deep Zone

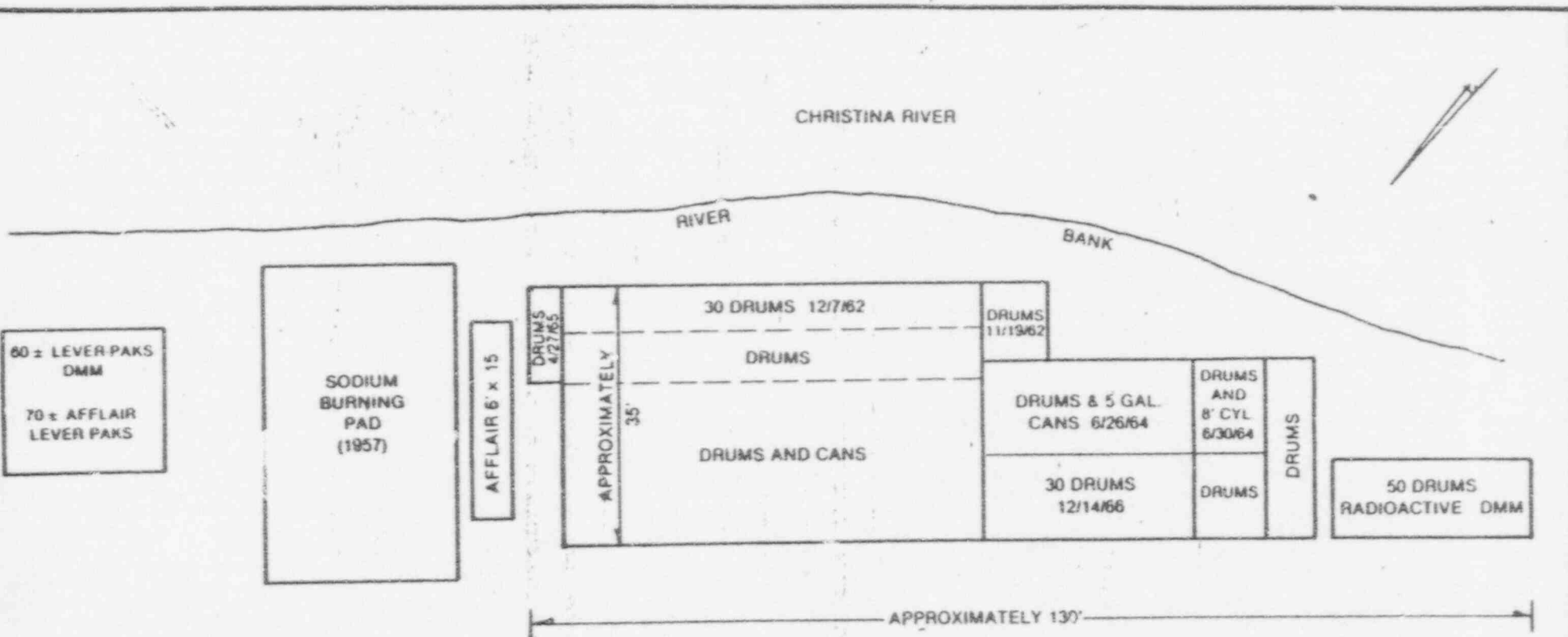
Phase II Monitoring Wells

MW-10A Shallow Zone

MW-10B Intermediate Zone

Existing Monitoring Wells

DUPONT - NEWPORT SITE NEWPORT, DELAWARE	
WOODWARD-CLYDE CONSULTANTS Consulting Engineers, Geologists and Environmental Scientists	
MONITORING WELL LOCATION PLAN PHASE I AND PHASE II	
Job No. BAC2016-NC	Drawing No. 80780110
Checked by R.T.C.	Date 3/7/88
Scale 1" = 400'	Rev. No.
FIGURE 1	



CHRISTINA RIVER

RIVER

BANK

60 ± LEVER PAKS
DMM
70 ± AFFLAIR
LEVER PAKS

SODIUM
BURNING
PAD
(1957)

AFFLAIR 6' x 15'

DRUMS
4/27/65

APPROXIMATELY
35'

30 DRUMS 12/7/62

DRUMS

DRUMS
11/19/62

DRUMS AND CANS

DRUMS & 5 GAL.
CANS 6/26/64

DRUMS
AND
8' CYL.
6/30/64

DRUMS


30 DRUMS
12/14/66

DRUMS

50 DRUMS
RADIOACTIVE DMM

APPROXIMATELY 130'

Source: DuPont

DuPONT-NEWPORT SITE NEWPORT, DELAWARE		
 WOODWARD-CLYDE CONSULTANTS <small>Consulting Engineers, Geologists and Environmental Scientists</small>		
THORIA WASTE BURIAL LAYOUT		
Job No. 88C2076-000	Drawing No.	Date: 10/8/89
Checked by: R.T.G.	Rev. No.	
Scale:	NOT TO SCALE	
		FIGURE 5

ATTACHMENT C

DRAFT

TECHNICAL REVIEW AND COMMENTS

By Douglas Gonzales, Ph.D.

RADIOLOGICAL INVESTIGATION DATA FOR THE DUPONT NEWPORT SITE

JACOBS ENGINEERING GROUP, INC.

TES IV, WA 05-B877-00

12 MAY, 1989

A brief review of Radiological Investigation Data for the North Disposal site of the Dupont Newport facilities was made relative to the adequacy of this limited field study to provide an assessment of the radiological health and environmental impacts associated with buried Thorium-232 contamination. The following comments and observations are provided.

GENERAL

o The overall conclusions are inconsistent and appear contradictory with the analysis presented. Analysis of soil samples are correlated with water analysis in a location where the thoriated nickel is now presumed not to exist (SBND-5 and SM-4, respectively). The arguments presented to link the source presumed to be near the shallow well SM-3, with this single soil/water sampling point via the ground-water pathway is tenuous since presently there is no hydraulic gradient in that direction and no piezometric data to support the notion of a gradient during the time of active landfill operations. Historical data, including aerial photographs were not presented nor an analysis stemming from such material to confirm or deny the gradient estimates used. Direct conduit flow between the SM-3 and SM-4 appears to be unsupported conjecture.

o The analysis concludes that the thorium source cannot be near SM-3 since the water quality in this well is incompatible with the worst-case modeling used to characterize the thoriated nickel source, as well as back-calculated Ra-228 concentrations from well SM-4. The limited data is then interpreted to imply that the source must be near SM-4 without considering whether the worst-case modeling may not apply and other thorium sources may be responsible for the elevated Ra-228 and Th-232 concentrations detected in SM-4. It should be noted that the thorium series soil concentrations extracted from SMND-5 do not correspond to a high activity, local thorium source.

o Since the SM-4 well was noted to be in the drainage from the plant operations area an analysis of plant operations that may have produced leachable thorium wastes should be considered as well as potential contamination of the drainage channel. Another possible source that has not been characterized is the several thousand tons of acid leached zinc barite ore that may contain natural thorium and uranium chain radionuclides: no information has been viewed to exclude this material from consideration.

o The analysis tends one to the conclusion that the location of the thoriated nickel source and other potential thorium sources are still unknown and that a characterization plant based on a single borehole and two wells sampling is inadequate to test a model of the present source and fully assess its current impact on human health and the environment.

o It should be noted that drinking water standards for radium are 5 pCi/l for combined Ra-226 and Ra-228. The values measured during a single sampling episode indicate that Ra-228 alone may be above these standards: the SM-4 water samples should have been analyzed for other radionuclides in the U-238 decay chain, as well, particularly Ra-226. Furthermore, there does not appear to be any site-specific background radionuclide measurements for soil and groundwater on which to scale these SM-4 and SBND-5 results. Also upgradient and downgradient river water quality or river sediments have not been analyzed for radionuclides to delineate existing impacts on these media.

o The general groundwater regime consists of upward movement of groundwater from lower hydrological units into the shallow zone underlying and partially wetting the North Disposal site, and finally discharging into the Christina River. The off-site, public use of the shallow groundwater zone that may be impacted by disposal site derived contaminants does not seem likely, and the potential contamination of the lower water units has been excluded by on-site hydrological measurements. Off-site well monitoring data should be compiled or collected from background and domestic wells to gauge the radionuclide contamination of the water in SM-4 relative to background and demonstrate that off-site wells are not being contaminated.

o Contaminants entering the Christina River will be diluted through mixing and dispersion and continual flushing of any contaminated sediments should reduce their potential as sources of dissolved hazardous constituents. The contaminant loading of the Christina River due to the disposal sites and the associated current impact on humans and environmental could be estimated by sediment and river water sampling, as well as water quality data from wells SM-1, 2 and 3 or other wells installed along the disposal cell/river boundary.

o In lieu of a more detailed source characterization through additional borehole exploration, an estimate of the future impact on domestic well and the Christina River could be constructed using the worst-case model developed in the report and a realistic water pathway analysis employing site-specific transport and geochemical parameters.

SPECIFIC COMMENTS

o Secular equilibrium of Ra-228 with Th-232 depends on the age of thorium liquid source at time of usage by Dupont. If the original thorium feed material was processed to extract only thorium, say by ion exchange and nitric acid stripping, only Th-232 and Th-228 may have been present in the solutions used by Dupont. Since a condition of partial secular equilibrium between Th-232 and Ra-228 may have existed since the waste material was placed in the landfill from 1950 to 1960, the available Ra-228 activity calculated represents a conservative upper limit for a worst-case situation in which complete loss of protective packaging has occurred.

o The Ra-228 concentration estimates in groundwater near the source appears to be incorrectly modeled for the worst-case scenario. The volume of thorium contaminated landfill material is estimated at 6.5×10^5 liters based on the assumed landfill area and depth of the deposit, but incorrectly assumes that this also corresponds to the volume of water receiving the Ra-228 from the decay of thorium in the solid waste material. Assuming a porosity of 0.25, a recalculated estimate of the Ra-228 concentration in the vicinity of a 2% and 5% thorium source would be 27 and 68 pCi/l, respectively. If all the pathway assumptions can be supported and no geochemical attenuation between source and well SM-4 occurs, then using the calculation methods presented in the report, the source would be on the order of 300 feet away from SM-4 in the direction of SM-3.

o The solubility of thorium in groundwater depends on the complexing ligands available and the pH of the water. Thorium mobility would be expected to be higher at pH values below about 4.5 for inorganic complexing in natural waters. However, its solubility is dominated by organic complexes at higher pH values. If all the available thorium were locked up in an alloyed nickel metal placed in a saturated neutral groundwater environment, one would expect that the thorium would be essentially insoluble. Groundwater data presented in the RI/FS Work Plan indicates that the shallow groundwater at the North Disposal site is slightly acidic, pH in the range of 4 to 6. The potential leachability of thorium from the nickel alloy metal by existing groundwater has not been fully analyzed and excluded from further consideration. The draft Ground Radiometric Report for the North Disposal site refers to the existence of "semi-solid waste material from the process" as well, and may include radionuclide contaminated process residuals and solution associated with the thoriated nickel metal production. The relative volume, disposal methods employed and characteristics of this material relative to leachability, by prevailing groundwater and geochemical transport are unknown, and may be a contributing source to relatively elevated Ra-226 and Th-232 concentrations in well SM-4. Surface transport of colloidal thorium during landfill operations seems questionable, since the off-grade thoriated nickel wastes were presumed to be placed in jars and packed in drums prior to burial.

ATTACHMENT D