March 4, 1999

Docket No. 030-20934

License No. 37-23341-01

Michael Fuller
Manger, Health Physics and Engineering
Interstate Nuclear Services
295 Parker Street
P.O. Box 51957
Springfield, MA 01151

SUBJECT: REPORT NO. 99990001/97-015

Dear Mr. Fuller:

Betsy Ullrich of this office has reviewed the data accumulated by the NRC from 1986 to 1997 regarding the radioactive material present at the Royersford Wastewater Treatment Facility in Royersford, Pennsylvania. Data reviewed included measurements made by NRC and our contractors and information submitted to the NRC by Interstate Nuclear Services Corporation. The review is documented in the enclosed NRC report.

No violations of NRC requirements were identified during the review.

As stated in the Executive Summary of the enclosed report, we plan to continue sampling of processes and the monitoring of dose rates and doses at the Royersford Wastewater Treatment Facility. If you have any questions, corrections or comments regarding the report, please contact Ms. Ullrich at (610) 337-5040.

In accordance with Section 2.790 of the NRC's "Rules of Practice," Part 2, Title 10, Code of Federal Regulations, a copy of this letter and the enclosed report will be placed in the Public Document Room. No reply to this letter is required.

Thank you for your cooperation.

Sincerely,

Original signed by John D. Kinneman, Acting Deputy Director
John D. Kinneman, Acting Deputy Director
Division of Nuclear Materials Safety

Enclosure: Report No. 99990001/97-015

IE07

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U.S. NUCLEAR REGULATORY COMMISSION
REGION I

INSPECTION REPORT

Report No.	99990001/97-015
Associated Docket No.	030-20934
Associated License No.	37-23341-01
Associated Licensee:	Interstate Nuclear Services Corporation 401 North Third Avenue Royersford, Pennsylvania 19468
Facility Name:	Royersford Wastewater Treatment Facility First Avenue Royersford, Pennsylvania 19468
Review Conducted:	June 1996 through February 1999

Inspector: Betsy Ullrich (signature) 3/2/99 (date)

Betsy Ullrich
Senior Health Physicist

Approved By: John D. Kinneman (signature) 3/2/99 (date)

John D. Kinneman, Chief
Nuclear Materials Safety Branch 2
Division of Nuclear Materials Safety

Executive Summary

Report No. 99990001/97-015

This inspection was a review and evaluation of the data from 1986 to 1997 concerning releases made to the Royersford Wastewater Treatment Facility (RWTF) by the Interstate Nuclear Services Corporation (INS) facility in Royersford, Pennsylvania (NRC License Number 37-23341-01, Docket Number 030-20934) and the data from 1986 to 1997 concerning the resulting radioactivity and radiation levels at the RWTF. The review was conducted to summarize available data, provide a basis for NRC actions and decisions and to document the cause of increases in dose rates at the RWTF.

No violations were identified.

Radioactive material from the INS facility is present in all processes at the RWTF. Dose rates at the RWTF have increased, but doses to the public, including the workers at the RWTF, are not in excess of NRC limits.

Radioactive material at the RWTF is readily detected due to the RWTF's very small operational volume of 400,000 gallons per day compared to the 5000 to 30,000 gallons per day of wastewater released by the INS laundry. From 50 to 70 millicuries of gamma-emitters are released by INS each year. Cesium-137 is the gamma-emitting radionuclide present in the largest quantity (20-30 millicuries per year) in releases from INS. While most of this isotope remains in the liquid phase at the RWTF and is released to the Schuylkill River in the cleaned and treated water, about 4 millicuries has accumulated in the reed bed. By contrast, most of the cobalt-60, the gamma-emitting radionuclide of second greatest abundance in the releases (10-20 millicuries per year), accumulates in the reed bed at the RWTF or in the final sludge cake which is disposed at other locations. About 26 millicuries of cobalt-60 has accumulated in the reed bed. Radiation levels in and around the reed beds at the RWTF are directly related to the accumulated activity of these two isotopes in the reed beds.

Region I conducted additional sampling of the material in the reed beds, plans to continue TLD monitoring of the RWTF and plans to continue sample collection and analysis to track the effect of the re-concentration of radionuclides from INS at the RWTF. Emphasis will be placed on collecting samples from processes at the RWTF where few samples have been collected, such as samples of effluent released to the river. Personnel at the RWTF will be requested to wear personnel monitoring devices to better estimate their exposure. Evaluation of all data collected to determine if any person is likely to receive doses in excess of the public dose limits will also continue.

1. Background Information

The Interstate Nuclear Services (INS) Corporation nuclear laundry in Royersford, PA has released effluent water containing radioactive material to the Royersford Wastewater Treatment Facility (RWTF), the municipal sewerage treatment plant also in Royersford, from 1986 until the present. Based on inspection of their records and comparison of analyses of split samples, INS releases are in compliance with NRC requirements for solubility and allowable concentrations of radioactive material which may be released to the sanitary sewerage system as described in 10 CFR 20.2003. Based on studies performed for the NRC by Oak Ridge Associated Universities (ORAU) from 1986 through 1989, radioactive material released from INS is reconcentrated during the treatment of sewage at the RWTF. More recent measurements by and for NRC confirm that the reconcentration continues. Radioactive material can be detected throughout all processes at the RWTF, with the highest concentrations of activity found in the sludge produced by the facility.

2. Purpose of Review

Since 1990 NRC has measured radiation levels at the RWTF using TLDs (discussed in detail in Section 6 of this report). Annual doses measured by the TLDs in the two cells of the reed bed at RWTF were about 600 and 700 millirem in 1991, 1992 and 1993; in 1994 the annual doses approached 800 and 900 millirem. The 1995, 1996, and 1997 annual doses in the reed bed continued to increase, respectively exceeding 800 and 1100 millirem, 700 and 1300 millirem, and 1000 and 1400 millirem. The increase in radiation levels beginning in 1994 was not expected, and data from 1986 to 1997 were reviewed to determine if a particular cause of the increase could be identified.

3. Facilities

3.a INS Facility

The site at 401 North Third Avenue, Royersford, Pennsylvania was first purchased for use as a nuclear laundry by Tri-State Industrial Laundries, the parent company of Environmental Laundries, on April 27, 1982. Tri-State Environmental Laundries' home office was in Utica, New York, and the laundry operated under License No. 31-21168-01 from April 1983 until January 1984. On February 17, 1984, Environmental Laundries was purchased by Interstate Nuclear Services Corporation (INS Corporation), a subsidiary of Interstate Uniform Services, Incorporated (now Unifirst Corporation). The facility continued to operate under License No. 31-21168-01 until September 13, 1984 when License No. 37-23341-01 was issued to reflect the INS Corporation as the licensee. The current license expires on August 31, 2005.

The Royersford facility includes a building of approximately 40,000 square feet and 1 ½ stories high on 12 acres of ground. An addition to the building was completed in spring 1987 to house a new waste water filtration system.

License No. 37-23341-01 authorizes the collection, laundering and decontamination of contaminated clothing and other launderable non-apparel items; the collection and decontamination of respirators and other such non-launderable non-apparel items that are used in conjunction with a protective clothing program; and the possession of contaminated equipment in the licensee's portable laundry unit. INS Corporation employs 25-40 individuals, most of whom handle contaminated items on a daily basis. The majority of the work is done during the day, although second and third shifts are used if necessary to respond to customer needs. Incoming shipments, which come primarily from nuclear power plants, are monitored to verify agreement with shipping documents. Each item is monitored for alpha and beta/gamma activity after laundering, either by hand or with an automated system, according to the customer's contract specifications.

Wastewater from the washers is pumped through a shaker screen which removes coarse particles, then through a lamella phase separator which includes chemical treatment to remove suspended solids. Solid material collected in the lamella phase separator is transferred to a filter press system which collects and dries the solids into a sludge which is disposed of by INS as radioactive waste. Supernatant liquid from the lamella phase separator passes through polishing filters into the hold-up tanks. Two 5000-gallon hold-up tanks are used alternately to collect treated effluent water prior to release to the sanitary sewerage system. A third 5000-gallon tank is available if necessary.

A continuous drip sample of wastewater is collected from the piping in the filtration room, at a point after all treatment and filtration is completed but before it passes to a hold-up tank. A 500-milliliter sample is removed from the sample collection container, of which a 50-milliliter aliquot is analyzed for gross alpha and gross beta concentration to determine if the hold-up tank contents are suitable for release of the contents of a hold-up tank to the sewer. The remainder is added to the monthly composite sample container. Results of gamma spectroscopy analyses and beta analyses of the monthly composite samples are reported each quarter to the Region I office.

3.b <u>RWTF</u>

The RWTF, located on First Avenue in Royersford, has a design peak capacity of 540,000 gallons per day, but normally receives about 400,000 gallons of influent per day, and releases about the same volume of treated liquid effluent to the Schuylkill River. The most significant factor in the determining the concentrations of radioactive material appears to be the relatively small size of the RWTF compared to the amount of effluent it receives from INS, which ranges from 5000 gallons per day (the capacity of one holding tank at INS) to 30,000 gallons per day. A simplified description of the RWTF process is as follows: Influent goes first to settling tanks, where grit and other bulk solids are removed and then to skimmers where some greases and oils are removed. Sewage is then pumped from the settling tanks to the primary anaerobic digester where the organic content is stabilized. Supernatant liquid from the settling tanks and the primary digester is treated through biofilters, chlorinated and released to the river.

Thickened sludge from the primary digester is transferred to the secondary digester for further treatment and storage. Sludge in the secondary digester is a liquid containing about 3 to 6% solids.

Sludge from the secondary digester has been disposed of in several ways. Until 1989 sludge from the secondary digester was used as fertilizer on non-human food producing farmland. Since 1989 most sludge has been mechanically dewatered to produce a sludge cake containing about 20% solids and a filtrate which is returned either to the RWTF influent or to the secondary digester. Currently, about 90% of the sludge is treated by mechanical dewatering with transfer of the resulting sludge cake to a landfill. The remainder is applied to an on-site reed bed where the growth of reeds dries the sludge and promotes additional breakdown of the solid material. While no sludge material has yet been removed from the reed bed, it is expected to contain about 40% solids when removed and completely dried.

The reed bed was built in 1990 as an alternative to mechanical dewatering and immediate off site disposal of sludge. The expectation, which has been realized, was that sludge from the secondary digester will be dewatered by application to growing reeds in an enclosed area. The reed bed is 72 feet long by 50 feet wide and has concrete walls approximately 6 feet high. A wall about 30 feet from one end of the reed bed divides it into two cells. Cell A is the smaller of the two cells. The front of the reed bed is a long wall nearest the facility fence, which has an entrance opening for each cell. The reed bed base is marine macadam to contain the liquid sludge, overlain by layers of gravel and sand to provide an initial growing base for the reeds.

Sludge is dewatered as the reeds take up liquid for growth, and bacteria surrounding the reed root system decompose the solids. Personnel at the RWTF monitor the solids content of the secondary digester sludge (typically 4-6% solids) and control the amount of sludge that is applied to the growing reeds. As the depth of the dried sludge increases in the reed bed, the reeds send out new roots and continue to grow. Most of the year, the reed bed is moist from repeated applications of secondary digester sludge. During the winter, when the reeds are dormant and when the sludge is frozen, the reeds are cut back to promote new growth in the spring. When the depth of the sludge approaches the height of the surrounding walls, the dried sludge will be removed for disposal. Initial estimates expected the useful life of the reed bed to be 5 to 10 years, however, after 8 years of use, the depth of sludge is about half the wall height. Therefore, current estimates are that removal of sludge will not be necessary prior to 2003.

Reeds must be harvested each year in order to promote growth the following season. From 1990 through 1996, reeds were cut down after the sludge had frozen in the winter, and composted on site. In 1997 and 1998, the reeds were burned in place in the reed beds. Analysis by Region I indicates that burning of the reeds results in very small releases of radioactive material, well below NRC limits.

4. Trends in Releases of Radioactive Material by INS to the RWTF

Identifying trends in the amount of radioactive material released from INS is complicated by the changes in the types of analyses on which INS based its estimate of total activity released over the years. From 1986 though the first quarter of 1988, INS estimated the total activity released from gross beta analyses of water samples from the holdup tanks in the Royersford laundry. The ORAU study discussed in Section 1 included comparative analysis of holdup tank samples, and concluded that the total activity reported by INS using gross beta analysis was overestimated by a factor of 2.9. Between 1988 and 1992, the total activity reported by INS as released was based on the sum of the activities of radionuclides identified by gamma spectroscopy analysis. From 1993 through 1996, the total activity reported by INS as released was based on the sum of the results of gamma spectroscopy analysis and the results of analyses for beta-emitting radionuclides including tritium. Unless corrections are made for these differences, the INS reported total activity cannot be used to determine trends in the amount of radioactive materials released from the INS Royersford laundry.

INS submitted corrected reports for the period 1990 through 1996 in a letter dated March 21, 1997, and this data is incorporated in Table 4.A. NRC staff corrections to the total gamma activity discharged, based on licensee-reported data, are shown in Table 4.B. The total gamma activity released annually by INS has decreased slightly since 1986, from about 80 millicuries to about 60 millicuries. The highest total gamma activity (175 millicuries) was released in 1989 and the lowest total gamma activity (48 millicuries) was released in 1992.

As mentioned in Section 2 and discussed in detail in Section 6 of this report, radiation levels measured by the TLD monitoring in the reed bed increased beginning in about 1994. Therefore, six gamma-emitting radionuclides were evaluated to identify trends to see if they provided an explanation for the increase: manganese-54, cobalt-58, cobalt-60, zinc-65, cesium-134 and cesium-137. These radionuclides are identified in nearly all samples of INS releases and samples from the RWTF. Other gamma-emitting radionuclides are sometimes identified, but in insufficient quantities or frequencies to contribute significantly to the dose rate measured in the reed bed. Beta-emitting radionuclides, of which tritium is by far the largest, are also identified by INS in their releases, but due to the low beta energies and/or small quantities released, are unlikely to be detected by the TLDs and so were not included in this review.

INS began isotopic analyses of releases in 1989. The activity of the six selected gamma-emitting radionuclides released, their concentrations, and the total volume of effluent released by INS each year were reviewed. Table 4.C. shows the total activity of each of these radionuclides, as well as tritium and other beta-emitters, for 1990 through 1997. There is a slight decrease in the total quantity of each radionuclide except tritium over the period 1989 through 1997, as shown in Graph 4.A, but the total gamma activity discharged by INS each year does not correspond to the increase in TLD readings at the reed bed. The total activity released by INS for each of the six gamma-emitters is shown in Graph 4.B. There appears to be some correlation with the total activity of cesium-137 released.

Review of the annual average concentrations of each of the six selected gamma-emitting radionuclides does not identify any significant trend. There may have been some decrease in concentrations over the period of 1990 through 1997, but there is considerable variation among the concentrations of individual releases. All releases of the six selected gamma-emitting radionuclides are within the regulatory limits. There is no obvious relationship between the concentration of radionuclides released and the increased dose measured in the reed bed, as shown in Graph 4.C.

The total volume of effluent released by INS to the RWTF has varied by a factor of about three over the period of 1986 through 1997, with the lowest release being about 8 million liters in 1990 and the highest about 29 million liters in 1997. There is some correspondence between the volume released and the increase in radiation levels in the reed bed as shown in Graph 4.D, but an increase in volume alone does not seem reasonable as a cause of the increase in radiation levels.

The use of the reed bed and TLD monitoring began at the RWTF in July 1990, following the year which INS had the highest annual average concentration for releases since 1986: about 175 millicuries total gamma activity in about 11 million liters of effluent, with a resulting concentration of 1.6 E-5 millicuries per liter. There is no consistent change in annual activity released or the annual concentration released in subsequent years, although the volume of effluent generally increased. INS anticipates continued releases of this volume and total activity of effluent, based on continued contracts with in customers to whom they provide service.

TABLE 4.A.

INS REPORTED ANNUAL EFFLUENT RELEASES

UNCORRECTED

Year	total activity reported (millicuries)	total activity, less H-3 and C-14 (millicuries)	total volume released (gallons)
1986	242.1	242.1	3,958,400
1987	178.2	178.2	5,004,075
1988	271.3	271.3	5,804,658
1989	174.9	174.9	3,211,818
1990	154.6	120.0	2,095,000
1991	311.5	99.1	4,155,000
1992	397.0	65.8	5,140,000
1993	473.1	97.2	5,030,000
1994	451.5	93.8	7,135,000
1995	832.8	188.0	6,735,000
1996	593.7	180.0	6,950,000
1997	879.3	151.5	7,692,500

TABLE 4.B.

INS ANNUAL EFFLUENT RELEASES

NRC CORRECTED[1] TOTAL GAMMA ACTIVITY

Year	corrected total activity (millicuries)	total volume released (liters)	average concentration (millicuries/liter)
1986	83.4	1.499 E+7	5.56 E-6
1987	61.4	1.866 E+7	3.29 E-6
1988	93.6	2.197 E+7	4.26 E-6
1989	174.9	1.123 E+7	1.56 E-5
1990	70.1	7.930 E+6	8.83 E-6
1991	61.6	1.573 E+7	3.92 E-6
1992	47.7	1.946 E+7	2.45 E-6
1993	69.6	1.904 E+7	3.66 E-6
1994	72.5	2.701 E+7	2.68 E-6
1995	54.3	2.549 E+7	2.13 E-6
1996	62.9	2.631 E+7	2.39 E-6
1997	61.5	2.912 E+7	2.11 E-6

[1] The reported total activity released was corrected as follows:

For 1986, 1987, and 1988 data by dividing the total activity by 2.9 in accordance with ORAU comparative measurements.
For 1990 through 1997 by subtracting the total beta activity.
No correction to 1989 data due to change in analytical methods.

TABLE 4.C.

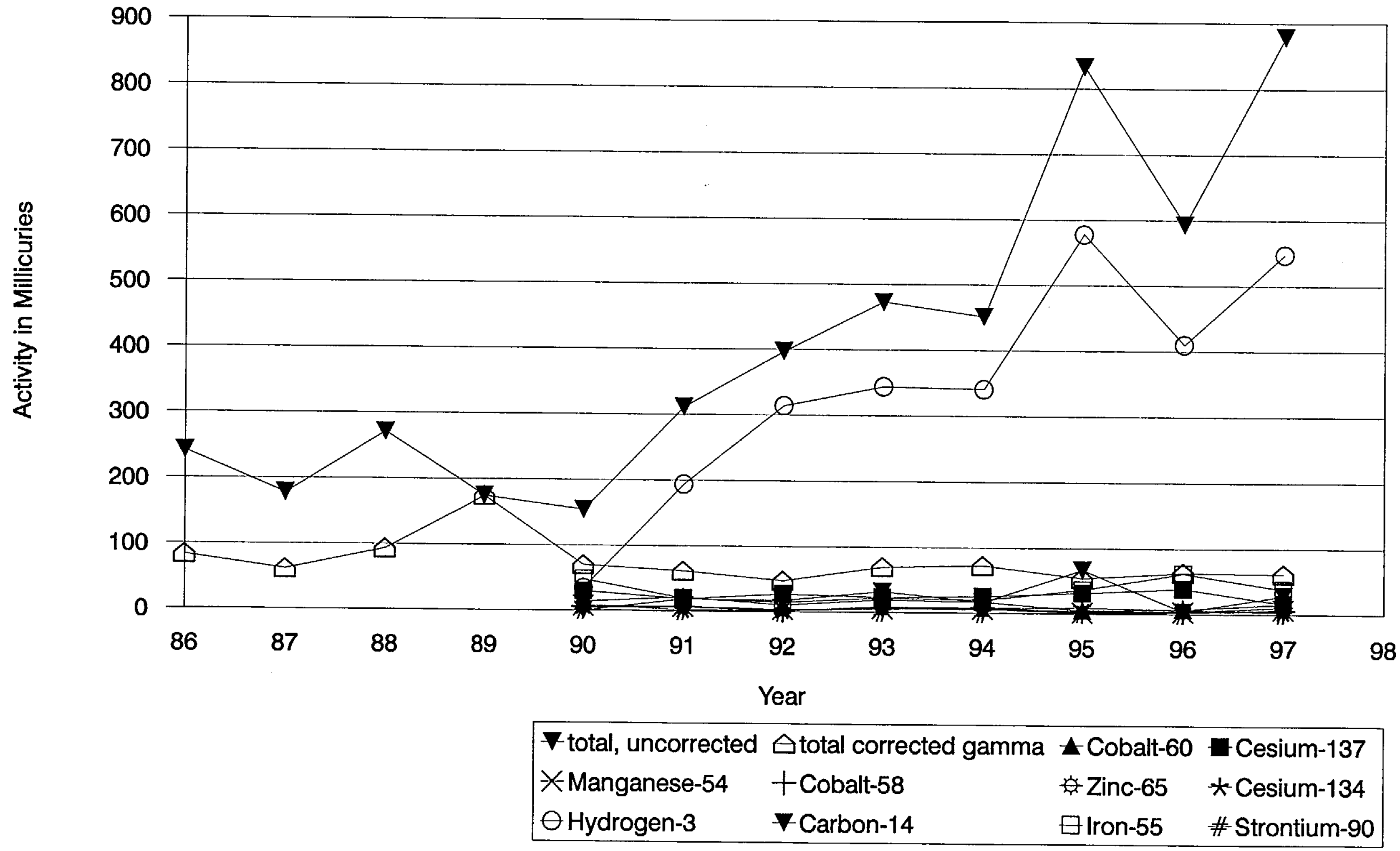
TOTAL ACTIVITY RELEASED FOR SELECTED RADIONUCLIDES
1990 THROUGH 1997
(millicuries)

Year	Mn-54	Co-58	Co-60	Zn-65	Cs-134	Cs-137	Total
1990	7.44	5.75	14.1	4.58	8.23	30.2	70.3
1991	6.98	6.61	21.6	6.04	2.07	18.8	62.1
1992	3.81	1.79	10.3	2.72	1.70	27.3	47.6
1993	5.68	7.49	19.5	5.45	8.54	23.0	69.7
1994	6.02	8.00	16.9	6.53	7.84	25.5	70.8
1995	1.76	3.77	5.19	2.90	9.04	31.6	54.3
1996	3.06	3.70	6.89	3.96	6.62	38.5	62.7
1997	6.96	5.23	15.8	10.8	3.24	16.2	58.2

Year	H-3	C-14	Fe-55	Ni-63	Sr-89	Sr-90
1990	34.6	NR	48.1	0.178	0.258	0.814
1991	194	18.4	19.9	NR	0.095	0.608
1992	314	17.2	14.3	NR	NR	0.275
1993	344	31.9	22.2	0.929	NR	0.727
1994	341	16.7	19.8	0.690	NR	0.139
1995	578	66.8	36.5	86.8	NR	1.130
1996	410	3.68	62.1	40.4	0.578	0.143
1997	548	28.4	37.7	7.49	NR	6.658

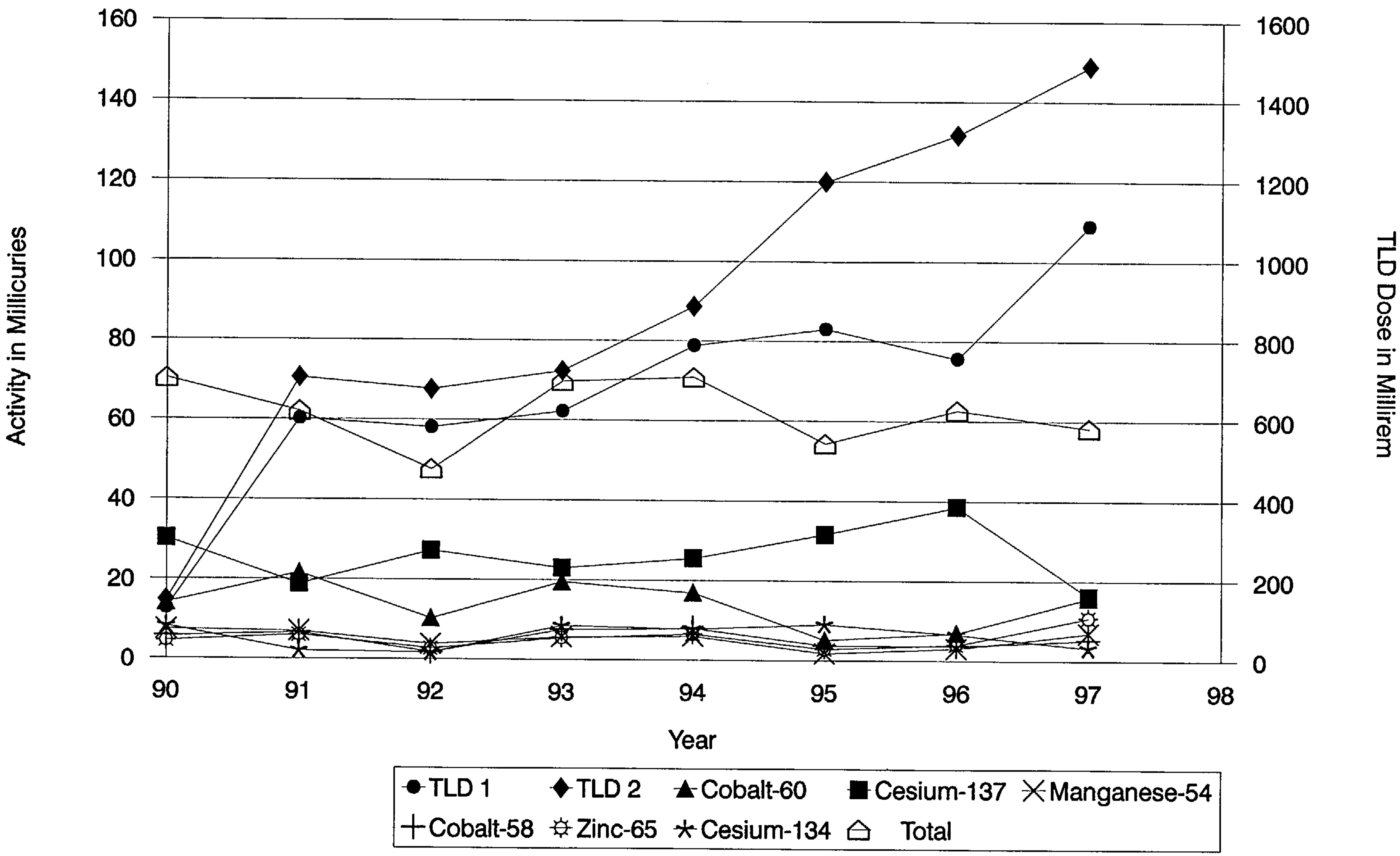
NR = not identified during that year

Annual Total Activity of Selected Radionuclides Reported as Released by INS to the RWTF



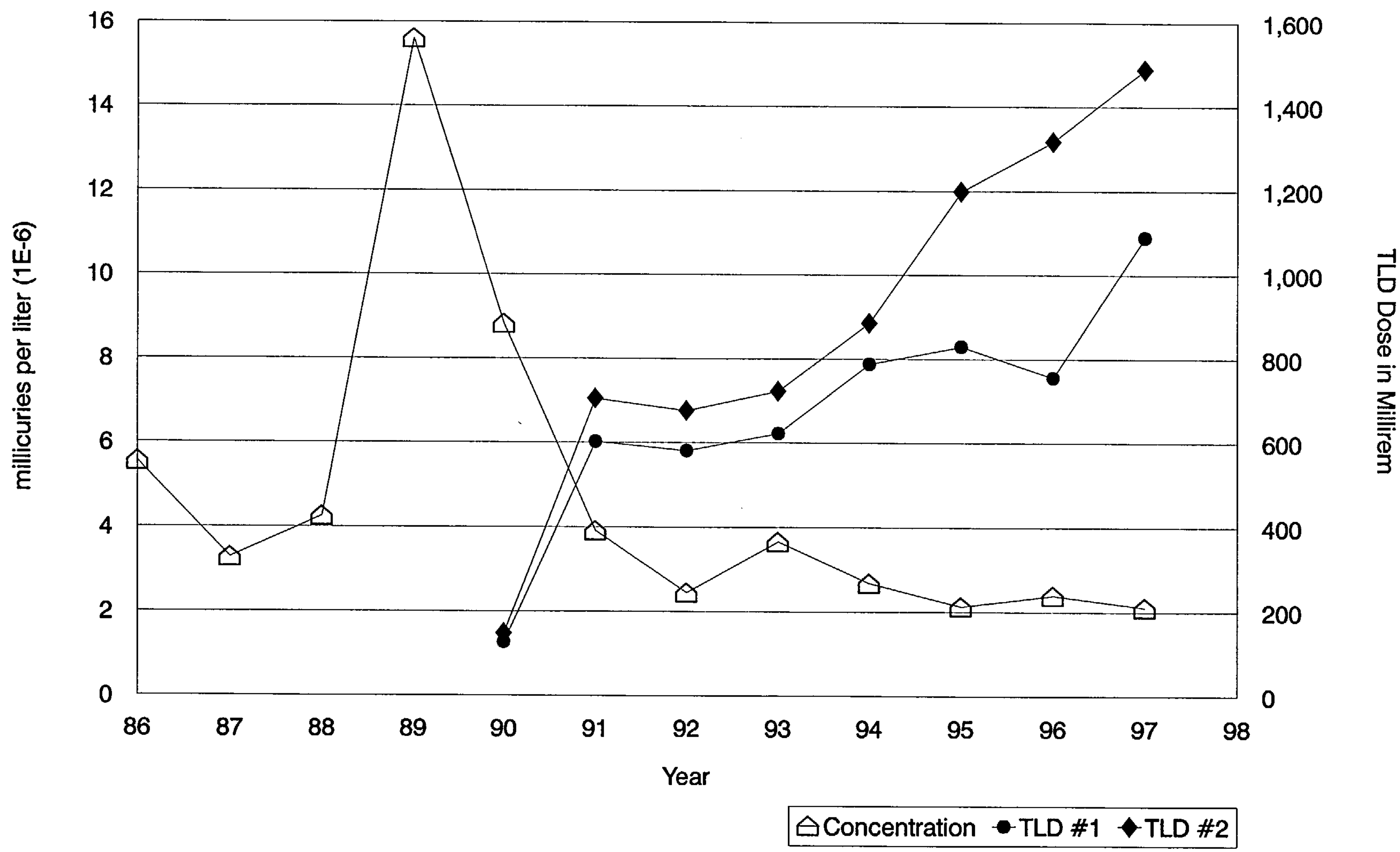
Report No. 99990001/97-015 Graph 4.A.

Annual Reedbed TLD Measurements and Annual Activity of Six Radionuclides Released by INS to the RWTF



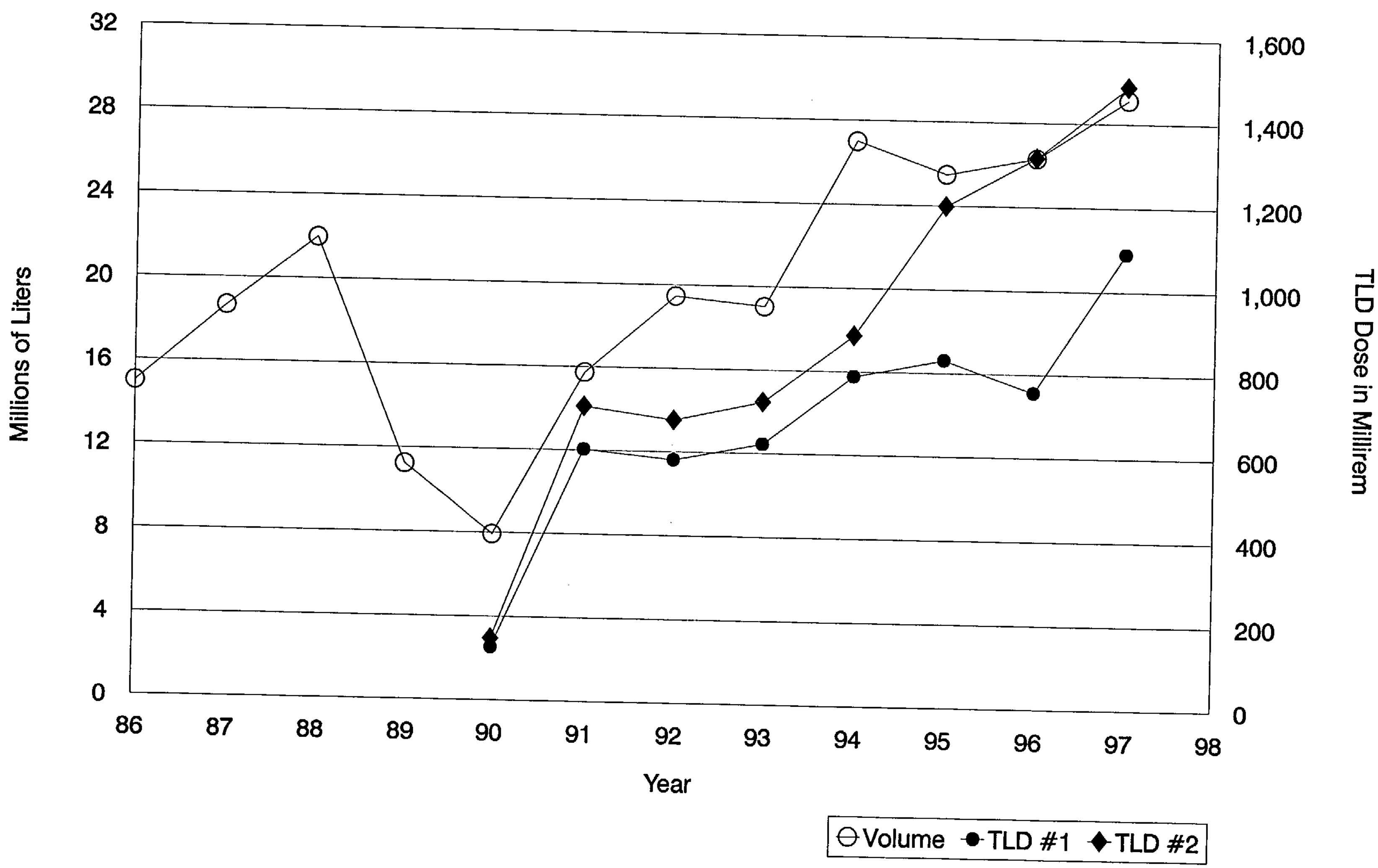
Report No. 99990001/97-015 Graph 4.B.

Annual Reedbed TLD Measurements and INS Annual Corrected Gamma Concentrations Released to the RWTF



Report No. 99990001/97-001 Graph 4.C.

Annual Reedbed TLD Measurements and Annual Volume Released by INS to the RWTF



Report No. 99990001/97-015 Graph 4.D.

5. Radioactivity in Samples from Processes at the RWTF

Sampling of material from a variety of processes at the Royersford Wastewater Treatment Facility (RWTF) began in 1986 to determine the types, quantities, and concentrations of radioactive material at the RWTF. From 1986 through 1989, Oak Ridge Associated Universities (ORAU) reviewed releases from INS to the RWTF, performed sampling and analysis at INS and the RWTF, and evaluated the dose to the maximally exposed person from the processing and disposal of radioactive sewage at the RWTF. At that time, the RWTF disposed of sludge by application to farmland as fertilizer. The maximally exposed individual was calculated to be the farmer eating produce from the land, who received an estimated 3.4 millirem per year.

Since that time, the NRC has had RWTF personnel collect samples for analysis by the Oak Ridge Institute for Science and Education (ORISE), the successor to ORAU. Samples of sludge from the secondary digester, and sludge cake and filtrate, are collected when mechanical dewatering takes place. Samples have also been collected intermittently from the primary digester, secondary digester, reed bed, and reeds. In addition, the NRC placed thermoluminescent dosimeters (TLDs) at the RWTF beginning in July 1990, when use of the reed bed began.

As previously discussed in Section 4, manganese-54, cobalt-58, cobalt-60, zinc-65, cesium-134, and cesium-137 are found in samples of effluent released by INS to the RWTF as well as in all phases of processing at the RWTF. While most of the cesium-134 and cesium-137 is released in the RWTF effluent to the river, most of the other gamma-emitters stay with the sludge. This can be shown by the following comparison of the relative amounts of the two gamma-emitters of primary concern, cesium-137 and cobalt-60, found in various stages of sewage processing (although a mass-balance evaluation would be preferred, insufficient information regarding flow-through volumes is available): Cesium-137 makes up about 30-60% of the activity of the six gamma-emitters in effluent released from INS; 70-90% of the six gamma-emitters present in the effluent from the RWTF to the river; and only 5-10% of the six gamma-emitters present in secondary digester sludge, filtercake from dewatering, and reed bed sludge. This indicates that cesium-137 tends to stay in the liquid processing phase. By contrast, cobalt-60 makes up 9-36% of the six gamma-emitters present in effluent released from INS; 3-19% of the six gamma-emitters released in the effluent from the RWTF to the river; and 40-60% of the six gamma-emitters present in secondary digester sludge, filtercake from dewatering, and reed bed sludge. This indicates that cobalt-60 tends to be re-concentrated with the solid processing phase.

Very small amounts of radioactive material are also taken up in the reeds, but no consistent trend is seen in analyses of reed samples. A comparison of materials sampled from various processes at the RWTF, and their concentrations and relative total gamma-emitters percentages are shown in Tables 5.A. through 5.G.

Based on the review of the number of each type of sample collected from the RWTF for analysis, additional samples of sludge from the reed bed, reeds, and clean water released by the RWTF to the river are needed to properly characterize the cycle of radionuclides through the

RWTF. RWTF staff have been requested to take samples of the clean water discharge and forward them to ORISE for analysis. Region I staff will continue to provide oversight, and assistance where needed, of sample collection.

The time for influent material to reach the secondary digester is on the order of hours to days. Sludge from the secondary digester is applied to the reeds weekly during the growing season, approximately 8 or 9 months each year, depending on reed growth and weather conditions. Since the reed bed is not sufficient in size to dry all the sludge from the secondary digester, only about 10% of the sludge produced annually is placed on the reed bed. Mechanical dewatering of sludge occurs about once each year for disposal of sludge that cannot be handled by the on-site reed bed. Recent changes in sewage treatment processing may result in less frequent need to perform mechanical dewatering. In the past, the dewatered sludge was sent to the Pottstown Landfill with the approval of the Pennsylvania Department of Environmental Protection (PADEP). This is necessary because landfills are prohibited by state law from disposing of radioactive material. The Borough of Royersford's contract with the Pottstown Landfill expired in 1996, and a new contract was issued to a landfill in the Reading area. Special permission to dispose of material to this landfill was again granted. When the reed bed is full (NRC estimates this will not occur prior to 2003), the dried sludge will also require final removal and disposal.

The RWTF provided the volumes of sludge applied to the reed beds, and the volumes mechanically dewatered (see Table 5.I). No sludge was applied to the reed bed in 1993 while the primary digester needed repair, because raw sewage was pumped directly from the settling tanks to the secondary digester which then acted as the primary digester. During this period, material from the secondary digester was sent offsite for secondary treatment and disposal. Since there was no accumulation of secondary digester sludge during 1993, no mechanical dewatering occurred in 1994. This alteration may have affected the concentrations of radioactive material in the secondary digester in 1995 and 1996, but too little data is available to make a firm conclusion.

The accumulation of radioactive material in the reed bed was estimated by calculating the amount of each of the six selected radionuclides applied to the reed bed, using available data and accounting for decay annually. It was assumed that the average concentration of each radionuclide found in the secondary digester sludge at the time of mechanical dewatering, is representative of the concentration during the entire time during the year when sludge was applied to the reed bed. This average concentration was multiplied by the volume of sludge reported by the RWTF as applied to the reed bed and the resulting value corrected for decay.

The resulting accumulated activities in the reed bed are shown in Table 5.H. The shorter half-lives of manganese-54 (0.830 years), cobalt-58 (0.195 years), zinc-65 (0.671 years) and cesium-134 (2.05 years) result in little or no difference in the total activity present in the reed bed at any one time. The amount of cobalt-60 (half-life 5.26 years) steadily increases until 1995 and 1996, years in which an unusually low amount of cobalt-60 was reported as released by INS compared to previous years. (Comparable reductions were noted in releases for other

activation products.) The total accumulated activity of cesium-137, which is present in the reed bed sludge in a relatively low proportion, steadily increases because of its long half-life (30.0 years). The estimated annual accumulated activity is compared to the TLD annual doses in the reed bed in Graph 5.A.

TABLE 5.A
RELEASES OF SIX GAMMA-EMITTERS FROM INS TO THE RWTF
(BASED ON MONTHLY DATA, 1990 TO 1995)

Radionuclide released	range of concentrations (picocuries/liter)	percent of total gamma (typical range)
Mn-54	50 to 1,800	2.7 to 15.8%
Co-58	30 to 1,800	4.6 to 11.3%
Co-60	90 to 5,000	9.2 to 36.4%
Zn-65	90 to 4,000	3.0 to 15.2%
Cs-134	100 to 4,500	3.5 to 17.4%
Cs-137	300 to 8,000	29.2 to 57.7%

TABLE 5.B.

SIX GAMMA-EMITTERS IN RWTF EFFLUENT TO RIVER
(4 SAMPLES, 1988)

Radionuclide in liquid effluent	range of concentrations (picocuries/liter)	percent of total gamma (typical range)
Mn-54	<MDA to 3.6	0 to 3.5%
Co-58	<MDA to 9.1	0 to 7.5%
Co-60	3.3 to 16.9	3.7 to 19.0%
Zn-65	<MDA	0%
Cs-134	<MDA to 18.0	0 to 14.9%
Cs-137	25.4 to 94.6	72.8 to 90.8%

TABLE 5.C.

SIX GAMMA-EMITTERS IN RWTF SECONDARY DIGESTER
(MULTIPLE SAMPLES, 1989 TO 1997)

Radionuclide in secondary digester	range of concentrations (picocuries/liter)			percent of total gamma (typical range)		
Mn-54	3650	to	13,720	16.1	to	27.1%
Co-58	772	to	2231	1.3	to	5.4%
Co-60	9200	to	31,530	42.2	to	60.1%
Zn-65	1825	to	14,720	13.4	to	30.3%
Cs-134	270	to	505	0.6	to	1.8%
Cs-137	1476	to	3606	5.4	to	9.3%

TABLE 5.D.

SIX GAMMA-EMITTERS IN MECHANICALLY DEWATERED SLUDGE CAKE
(MULTIPLE SAMPLES, 1989 TO 1997)

Radionuclide in sludge cake	range of concentrations (picocuries/gram)			percent of total gamma (typical range)		
Mn-54	4.5	to	487	12.7	to	31.4%
Co-58	0.17	to	50.4	0.4	to	4.2%
Co-60	21.8	to	954	41.8	to	62.4%
Zn-65	0.4	to	314	10.0	to	31.4%
Cs-134	1.6	to	14.0	0.5	to	2.3%
Cs-137	8.3	to	112	5.5	to	8.8%

TABLE 5.E.

SIX GAMMA-EMITTERS IN FILTRATE
FROM MECHANICALLY DEWATERED SLUDGE

(4 SAMPLES, 1996; 4 SAMPLES, 1997)

Radionuclide in filtrate	range of concentrations (picocuries/liter)			percent of total gamma (typical range)		
Mn-54	73.5	to	491	13.4	to	19.9%
Co-58	27.3	to	37.8	3.8	to	4.1%
Co-60	188	to	1286	37.3	to	57.1%
Zn-65	39.1	to	385	7.9	to	15.7%
Cs-134	31.1	to	40.5	4.1	to	6.8%
Cs-137	139	to	301	10.6	to	28.8%

TABLE 5.F.1

SIX GAMMA-EMITTERS IN REED BED SLUDGE
(2 SAMPLES, 1992)

Radionuclide in Reed bed Sludge	concentration (picocuries/gram)		percent of total gamma	
	Cell A	Cell B	Cell A	Cell B
Mn-54	39.5	65.4	14.3%	14.2%
Co-58	1.3	2.1	0.5%	0.5%
Co-60	178	295	64.6%	64.0%
Zn-65	25.1	47.5	9.1%	10.3%
Cs-134	2.1	4.3	0.8%	0.9%
Cs-137	29.6	46.3	10.7%	10.1%
Total	275.6	463.6	100.0	100.0

TABLE 5.F.2

SIX GAMMA-EMITTERS IN REED BED SLUDGE
(8 SAMPLES, 1997)

Radionuclide in Reed bed Sludge	concentration (picocuries/gram)		percent of total gamma	
	Cell A	Cell B	Cell A	Cell B
Mn-54	14 to 37	24 to 30	16 to 18%	13 to 15%
Co-58	-----	-----	----- %	----- %
Co-60	85 to 146	117 to 136	63 to 69%	65 to 67%
Zn-65	7 to 23	14 to 20	6 to 10%	8 to 9%
Cs-134	-----	-----	----- %	----- %
Cs-137	15 to 26	21 to 22	11 to 18%	11 to 12%

----- Results for these isotopes were less than MDA

TABLE 5.G.

SIX GAMMA-EMITTERS IN REEDS GROWN IN THE RWTF REED BED

(6 ASHED SAMPLES, 1990 TO 1994; TWO "WET" SAMPLES, 1996)

Radionuclide	range of concentrations (picocuries/gram)	percent of total gamma (typical range)
Mn-54	0.56 and 1.79 wet <MDA to 6.6 ash	22.8 and 11.4% 0 to 70.7%
Co-58	<MDA wet <MDA to 0.9 ash	0% 0 to 1.2%
Co-60	0.06 and 10.6 wet 0.9 to 73.7 ash	0.17 and 30.1% 0 to 71.2%
Zn-65	0.27 and 1.19 wet <MDA to 12.0 ash	11.0 and 7.5% 0 to 40.2%
Cs-134	0.21 and 0.29 wet <MDA to 1.8 ash	8.5 and 1.8% 0 to 5.5%
Cs-137	1.36 and 1.87 wet <MDA to 18.9 ash	55.0 and 11.9% 0 to 45.9%

TABLE 5.H.

ESTIMATED ACCUMULATED ACTIVITY IN THE REED BED
DECAY-CORRECTED
(millicuries)

Year	Mn-54	Co-58	Co-60	Radionuclide Zn-65	Cs-134	Cs-137	Total
1990	0.728	0.172	1.677	1.407	0.0389	0.273	4.296
1991	2.030	0.410	5.418	0.382	0.1194	0.908	9.268
1992	2.721	0.446	8.987	0.499	0.1835	1.576	14.41
1993	0.581	0.013	7.878	0.238	0.1309	1.540	10.38
1994	2.335	0.234	13.87	1.603	0.2024	2.226	20.47
1995	1.013	0.096	14.73	1.123	0.1443	2.441	19.54
1996	1.771	1.130	13.66	1.402	0.2250	2.875	21.06
1997	7.074	0.038	26.27	8.198	0.1604	4.427	46.17

Assumptions:

1. Secondary digester concentrations from samples collected during mechanical dewatering in a given year are representative of the concentrations applied to the reedbeds during that year, without regard to the actual time period that sludge accumulated in the secondary digester between mechanical dewatering.

2. Secondary digester concentrations for 1990 are used for 1991 and 1992, when no samples were collected. The releases from INS, averaged over the three-year period, are similar to the releases in 1990, so the use of 1990 concentrations is acceptable.

3. Secondary digester concentrations for 1995 are used for 1994 (the year use of the secondary digester sludge in the reed bed resumed). Although only one sample was collected in 1995, no mechanical dewatering was performed in 1994 because of operation of the secondary digester for primary treatment during 1993.

TABLE 5.I.

VOLUME OF SECONDARY DIGESTER CONTENTS RELEASED FOR TREATMENT

Year	Reed Bed (liters)	(liters)	Other Treatment Method	Dates
1986	NA	713,000	fertilizer	May-September
1987	NA	805,000	fertilizer	Mar and May-Sept
1988	NA	529,000	fertilizer	Apr-Jul and Sept
1989	NA	1,962,400	mechanical	March 1989
1990	77,101	unknown	mechanical	May 1990
1991	181,465	unknown	mechanical	May 1991
1992	194,790	unknown	mechanical	September 1992
1993	-- 0 --	-- 0 --	See note below	
1994	198,280	-- 0 --		
1995	73,043	1,542,555	mechanical	March/April 1995
1996	234,643	1,655,581	mechanical	Jan/Feb 1996
1997	492,050	1,677,524	mechanical	April/May 1997

Note: In 1993, the primary digester was undergoing repair. The secondary digester was then used for primary treatment, and 1,550,505 gallons of the primary-treated sludge was shipped to another facility for secondary treatment.

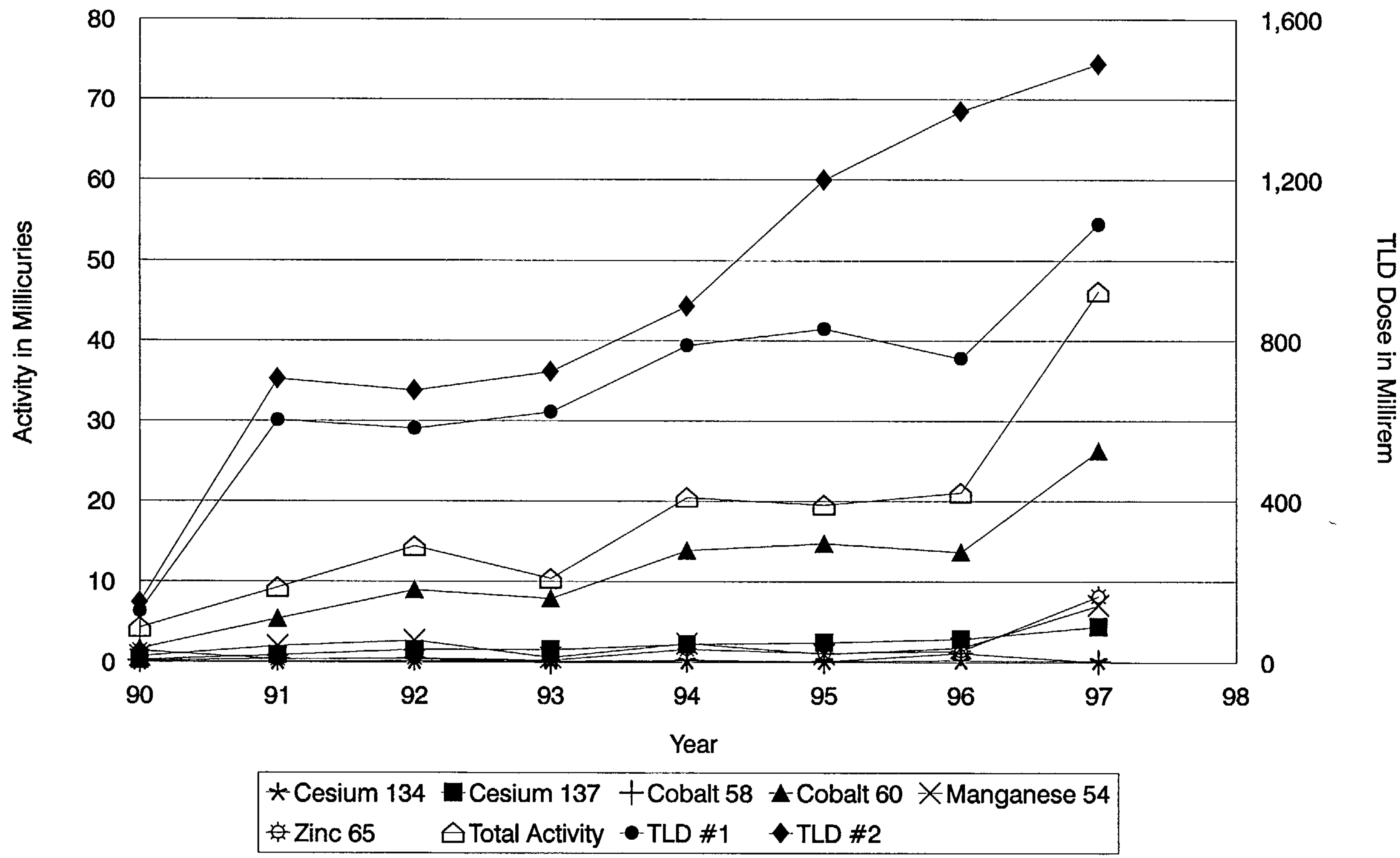
TABLE 5.J.

ANNUAL AVERAGE CONCENTRATION OF SIX RADIONUCLIDES IN SECONDARY DIGESTER SLUDGE SAMPLES (picocuries/liter)

Year	No. of Samples	Mn-54	Co-58	Co-60	Zn-65	Cs-134	Cs-137
1986	31	-----	-----	55,000	-----	-----	15,000
1987	35	-----	-----	55,000	-----	-----	18,000
1988	23	-----	-----	24,000	-----	-----	6,900
1989	33	2,955	-----	32,182	1,591	447	6,170
1990	15	9,447	2,231	21,755	1,825	505	3,535
1995	1	9,190	770	35,140	7,650	550	3,640
1996	4	4,433	4,742	3,180	4,270	398	2,086
1997	2	12,815	-----	29,055	13,610	-----	3,286

---- no analysis performed for these radionuclides

Annual Reedbed TLD Measurements and Estimated Annual Accumulated Gamma Activity in Reedbed



Report No. 99990001/97-015 Graph 5.A.

6. Environmental TLD Measurements at the RWTF

The NRC began monitoring the RWTF using environmental thermoluminescent dosimeters (TLDs) in July 1990, just prior to the use of the on-site reed bed for drying of sludge from the secondary digester. The locations of the TLDs are described in Table 6.A and are shown on the diagram attached to that table. The radiation levels measured by the TLDs result from the accumulation of radioactive material in the RWTF sludge. Radiation levels above background are measured in a number of locations at RWTF including in and near the reed bed.

Graphs 6.A and 6.B show the quarterly TLD results since July 1990. From 1991 through early 1994, the radiation levels measured by the TLDs in the reed bed show seasonal variations, with a maximum level of about 200 millirem per quarter during the growing season. The minimum radiation levels measured occur during winter months when little or no new sludge is applied to the reedbeds and when snow cover is frequently present. Calculations were performed in 1993 using the computer code "Microshield" to predict the radiation levels resulting from continuing application of sludge, at a constant radioactive materials concentration, to the reed bed. The model used predicted that a maximum radiation level would be reached as underlying layers became shielded by new sludge. As predicted by computer modeling, the radiation levels detected by the TLDs after a year-long accumulation of sludge plateaued and did not increase for three years. The initial plateau was at 200 millirem, much lower than predicted by the model. However, in the second quarter of 1994, the radiation levels measured by the TLDs in the reed bed increased, exceeding 300 millirem per quarter, and the measured levels in Cell B had not returned to the previous levels as of the end of 1997. An increase in radiation levels was not predicted by the model assuming that the sludge had a uniform concentration of radioactivity. Therefore, it seems reasonable to conclude that if radiation levels are increasing, the amount or concentration of radioactive material in the sludge is also increasing. One of the purposes of this review was to evaluate this potential conclusion.

Graphs 4.A through 4.D compare the reed bed TLD measurements to the total activity released by INS and other variables based on the INS releases. These graphs do not indicate any clear relationship between the material released by INS, and the changing radiation levels measured by the TLDs in the reed bed. This is most likely because the TLD measurements include any radiation from accumulated material, not from that year alone, and from variations in the rate at which material is placed in the reed bed. Using data from sampling of the secondary digester and the volumes of secondary digester sludge applied to the reed bed, the total amount of radioactive material in the reed bed was estimated, tabulated in Table 5.H. and compared to the annual doses measured by TLDs 1 and 2 in Graph 5.A. There is some correspondence between the increase in total activity and the increase in dose measured by the TLDs. The only radionuclide which has continually increased in quantity in the reed bed sludge is cesium-137, due to its long half-life. NRC estimates that, as of December 1997, about 4 millicuries of cesium-137 have accumulated in the reed bed sludge, compared to 26 millicuries of cobalt-60 and a total of 46 millicuries for the six gamma-emitting radionuclides.

A notable difference between the doses measured by TLD 1 in Cell A and TLD 2 in Cell B also was observed beginning about 1994. This change is thought to be primarily caused by the fact

that a lesser amount of sludge, and, therefore, total radioactivity, has been applied to Cell A compared to Cell B. There are several other possible causes. The leachate from the reed bed and the decanted liquid from the secondary digester is applied to Cell B, but not to Cell A; therefore, Cell B may receive a higher fraction of the radioactivity. In 1994, snails removed from the cleaning of a large pipeline at the RWTF were placed in Cell A, forming a layer about a foot deep in the portion of the reed bed nearest the vent pipe on which the TLD is located. This caused a temporary reduction in the reed growth in that area; therefore, less sludge was applied to Cell A until the reeds had recovered. The snail layer also reduced the volume of sludge near the TLD. Also, Cell A is smaller than Cell B.

A general increase of the radiation levels measured by the TLDs in other areas at the RWTF has also been noted, which is most likely due to increases in "shine" as the height of sludge in the reed bed has increased. The reed bed walls are 6 feet tall; however, the property is sloped so that the ground is level with the top of the two walls (north and west). The ground is level with the bottom of the front (east) wall of the reed bed and sloped along the fourth (south) wall. Sludge in the reed bed is now about 2.5 feet deep. The TLDs which show general increases are those located in areas which are physically above the height of the reed bed walls and within about ten meters of the reed bed. They are TLD #4 (from 50 to about 70 millirem per quarter), located on the railing of the settling tanks nearest the reed bed; TLD #13 (from 30 to about 50 millirem per quarter), located on the ladder support rail on top of the primary digester; and TLD #14 (from 30 to about 40 millirem per quarter), located on the west wall of the secondary digester facing the reed bed.

It can be seen on Graph 6.B that the radiation level measured by TLD 13 varies more irregularly than the others. This is due to the TLD having been removed from its location on occasion, either purposefully or by accident, when work was done on the primary digester. TLD 13 was not in place most of 1993. Radiation levels of about 30 millirem per quarter are measured by TLD 12, located on the Chlorine Contact Building. This is generally higher than the 20 millirem per quarter measured by most of the other TLDs, and does not show any increase over time. The slightly elevated radiation levels measured are most likely due to the brick walls of the building on which the TLD is located, which were found to have elevated radiation levels compared to background during early surveys using a microR survey meter at the facility.

Table 6.A.

TLD LOCATIONS AT THE RWTF

TLD Number	Location Description
1	Cell A of reed bed
2	Cell B of reed bed
3	east fence
4	rail of settling tanks, overlooking reed bed
5	rail of settling tanks, facing secondary digester
6	north fence
7	west fence
8	storage shed
9	west side of secondary digester
10	flag pole
11	south fence
12	side of chlorine contact building, facing secondary digester
13	top of ladder on the primary digester building, overlooking reed bed
14	east side of secondary digester
15	rail of settling tanks, along path to Main Office building
16	inside Main Office

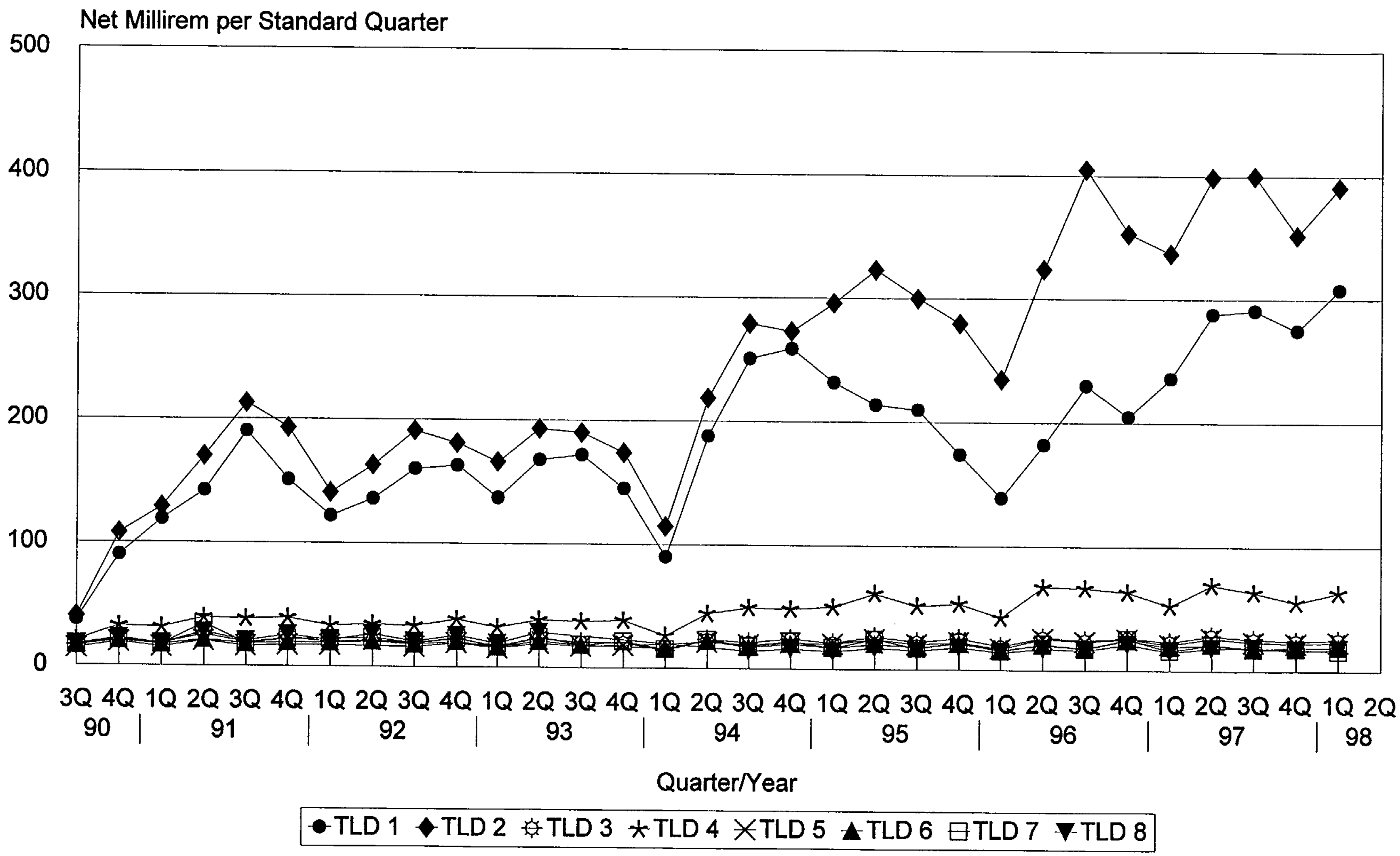
Note 1: All TLDs are located at a height of about 1 meter above the ground surface except TLD #13. The reed bed TLD #1 and #2 are raised as the level of sludge in the reed bed increases.

Note 2: The RWTF is located on a slope towards the Schuylkill River, with the north fence being along the highest side of the slope. The Main Office building, the settling tank rails, and the storage shed are at elevations above the reed bed walls. The top of the 6-foot walls of the reed bed are at the ground level of the secondary digester, the chlorine contact building, and the primary digester. The east and west fences travel along the slope and the portion of these fences on which TLDs are located are at about the same ground level as the reed bed. The ground level of the south fence is below the ground level of the reed bed.

Note 3: See the attached diagram of the RWTF showing TLD locations.

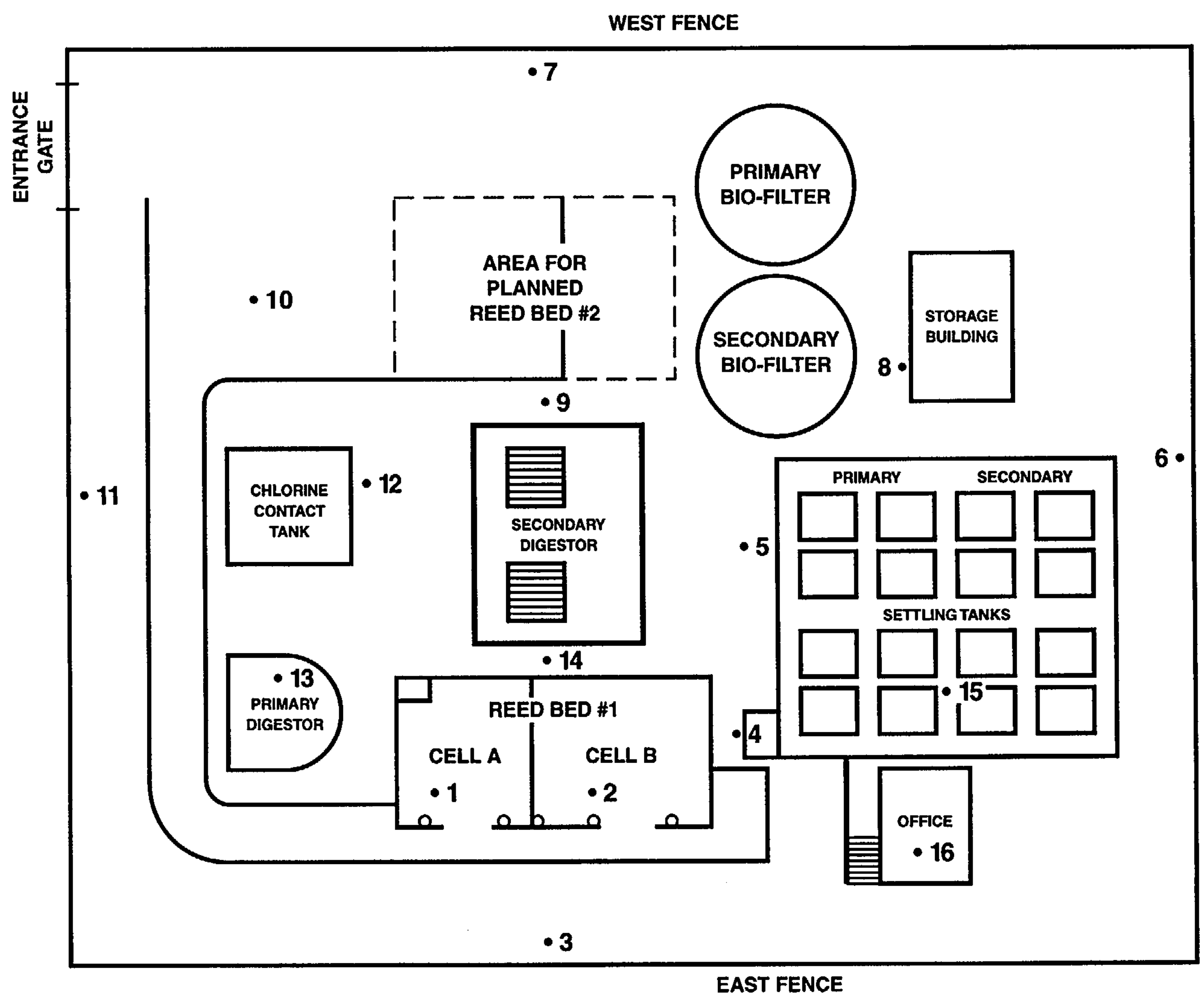
RWTF Standard Quarter TLD Results

Locations 1 through 8



Report No. 99990001/97-015, Graph 6.A.

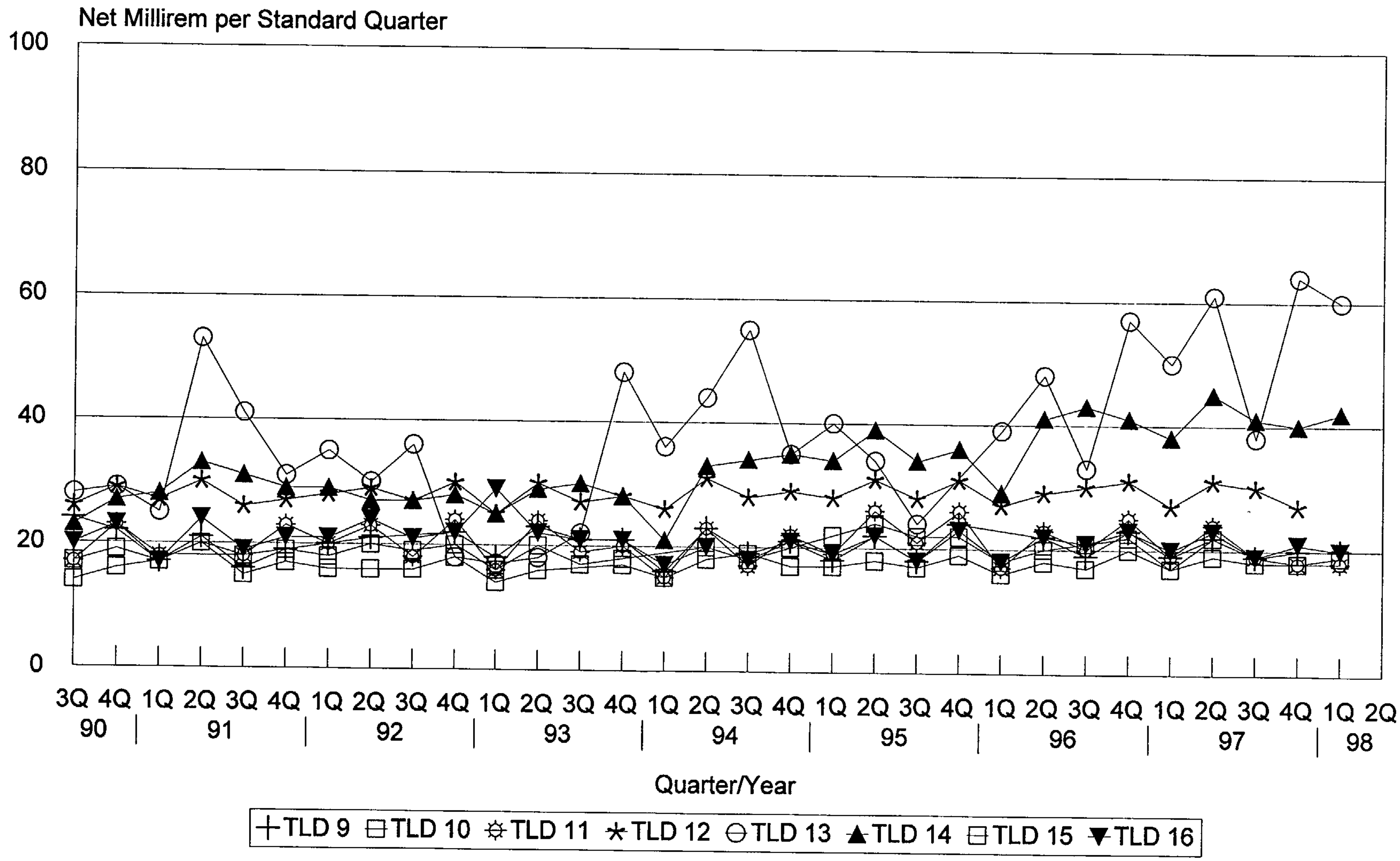
SITE PLAN OF THE WASTEWATER TREATMENT FACILITY



ATTACHMENT TO TABLE 6.A:
DIAGRAM OF ENVIRONMENTAL TLD LOCATIONS AT THE RWTF

RWTF Standard Quarter TLD Results

Locations 9 through 16



Report No. 99990001/97-015, Graph 6.B.

7. Calculation of Doses to the RWTF Workers

INS issued the document "Radiological Impacts of Effluent Releases to the Atmosphere and Sanitary Sewer from Interstate Nuclear Services, Royersford, Pennsylvania" in August 1993. INS used information regarding INS releases to the RWTF, as well as ORAU, ORISE and NRC data from sampling at the RWTF, in calculational models from Regulatory Guide 1.109 "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR 50, Appendix I" and NUREG/CR-3332 "Radiological Assessment - A Textbook on Environmental Dose Analysis" to determine that the maximum dose to a member of the public from the INS Royersford laundry was 0.286 millirem per year, and the dose to the RWTF personnel was 18.58 millirem per year. The dose to the workers at the RWTF was assessed by INS from three sources: Case 6.10, "Dose from Direct Exposure to Contaminated Reed Bed Sludge"; Case 6.11, "Dose from Inhalation of and Direct Exposure to Contaminated Reed Bed Sludge During Sludge Removal"; and Case 6.12, "Dose from Direct Exposure to Mechanical Dewatered Sludge". These cases were updated by the inspector using more recent data to estimate the current dose to the RWTF workers, who are members of the general public.

For Case 6.10, direct exposure to reed bed sludge, INS assumed that workers at the RWTF spend 20 hours per year in the reed bed for sludge application and receive 1.57 millirem. This was based on the average annual net exposure rate of 0.0785 millirem per hour which INS calculated from 1992 TLD measurements. Using 1997 TLD net measurements of 1090 millirem for TLD 1 located in Cell A and 1488 millirem for TLD 2 located in Cell B, an average net exposure rate of 0.147 millirem per hour is calculated in the reed bed. For 20 hours spent per year in or near the reed bed applying sludge, the resultant annual dose is 2.94 millirem. In addition, the RWTF worker is assumed to spend 20 hours each year in the reed bed harvesting reeds, which doubles the annual external dose from the reed bed to 5.88 millirem.

For Case 6.11, INS assumed that reed bed sludge requires removal every 5 years and the activity takes 10 working days, and calculated a dose of 0.3 millirem from external exposure and 7.83 E-5 millirem committed effective dose from inhalation for this activity. INS assumptions were conservative, and the calculations do not require any revision at this time. No removal of the reed bed sludge has yet occurred, and the dose from this activity is not included in the total dose to RWTF personnel in this report.

For Case 6.12, INS defined mechanical dewatering to include all those activities required for the processing of influent at the RWTF, and assumed that RWTF employees spend 4 hours per week near dewatered sludge (dose rate 0.0114 millirem per hour based on 1992 TLD data) and 35 hours per week in the general areas (dose rate 0.00865 millirem per hour based on 1992 TLD data), for 48 weeks per year. INS calculated the dose from working in the vicinity of dewatered sludge to be 2.18 millirem and from working in the general area to be 14.54 millirem. Using 1997 TLD net measurements, an average dose rate of 0.0255 millirem per hour is calculated for work in the vicinity of sludge processing activities from the annual dose in millirem shown in Table 7.A. At 4 hours per week, 48 weeks per year, a net dose of 4.90 millirem is calculated for work around sludge processing areas during 1997.

Using 1997 TLD data, an average dose rate of 0.00983 millirem per hour is calculated for work in all other general areas at the RWTF shown in Table 7.B. At 35 hours per week for 48 weeks, a worker would receive a net dose of 16.5 millirem at the RWTF in 1997 from working in the general areas. Summing this with the external doses of 5.88 millirem received from work in the reed bed and 4.90 millirem from work near sludge processing activities results in a total net exposure of 27.3 millirem in 1997. This is less than the NRC limit of 100 millirem per year to members of the general public from licensed activities, but is an increase from the dose of 18.3 millirem calculated using 1992 data, and 22.8 millirem calculated using 1995 data, as shown below.

ANNUAL CALCULATED DOSE TO WORKERS AT THE RWTF

Case	1992 (millirem)	1995 (millirem)	1997 (millirem)
6.10 (reed bed)	1.57	4.64	5.88
6.12 (sludge areas)	2.18	2.57	4.90
6.12 (general areas)	14.5	15.6	16.5
TOTAL	18.3	22.8	27.3

TABLE 7.A.

TLD MEASUREMENTS IN SLUDGE PROCESSING AREAS AT RWTF

TLD	1997 dose (mrem)	location description
4	239	rail of settling tanks, overlooking reed bed
5	92	rail of settling tanks, facing secondary digester
9	80	west side of secondary digester, overlooking area where mechanical dewatering occurs
10	80	flag pole, closest TLD to location where contracted mechanical dewatering occurs about once each year
12	115	side of chlorine contact building, facing secondary digester and overlooking mechanical dewatering area
13	213	top of ladder on the primary digester building, overlooking reed bed
14	164	east side of secondary digester, overlooking reed bed
15	72	rail of settling tanks, along path to Main Office building

TABLE 7.B.

TLD MEASUREMENTS IN GENERAL AREAS AT RWTF

TLD	1997 dose (mrem)	location description
3	100	east fence, facing reed bed
6	77	north fence
7	109	west fence
8	68	storage shed
11	80	south fence
16	83	inside Main Office

8. Dose from Release of INS Effluent to the Schuylkill River

INS is considering direct release of their effluent water to the Schuylkill River, instead of release to the RWTF. The data reported by for 1995 releases were used in the computer code "PCDose" to calculate the dose to an adult downstream of the release if INS had released to the river that year. A river flow rate of 100 cubic feet per second was assumed and the resulting total body dose is 1.652 millirem. In 1997 the total activities of manganese-54, cobalt-58, cobalt-60, and zinc-65 released were larger than in 1995, but these isotope have little impact on the calculated total dose. The total activities released in 1997 of cesium-134 and cesium-137, the isotopes which produce most of the dose from release to the river were less than released in 1995.

TABLE 8.A

ESTIMATED PUBLIC DOSE FROM DIRECT RELEASE TO RIVER

Based on 1997 Data

Radionuclide	INPUT Activity (microcuries)	RESULTS Dose to total body (millirem for the year)
Mn-54	1,523	0.000136
Co-58	4,504	0.000149
Co-60	5,166	0.000486
Zn-65	2,712	0.00901
Cs-134	8,822	0.510
Cs-137	30,793	1.05
H-3	561,677	0.000495
C-14	62,169	0.0385
Fe-55	35,210	0.000494
Ni-63	80,230	0.0114
Sr-90	1,118	0.0317
Nb-95	162	0.00000215
Total		1.652

VIII. Comparison of Split Samples by INS and NRC/ORISE

During an inspection May 15, 1996, at the INS Royersford facility the wastewater treatment system and the sampling and analysis procedures used by INS were reviewed and found to be

appropriate and as described in the license application. As part of the review, the NRC collected a split sample from the May 15 effluent release sample. INS forwarded their portion of the split sample to the INS laboratory in Springfield, Massachusetts. The NRC sample was forwarded to ORISE for analysis. Analysis of a daily effluent water sample for gross alpha, gross beta, and gamma spectrometry was performed in the Region I laboratory in May. Results of the analyses were received from ORISE in a letter dated December 12, 1996. Results were received from INS in a letter dated March 21, 1997. Results of the gamma spectrum analysis were in agreement. See Table 9.A.

INS also provided a split of their May 1996 liquid effluent composite sample. INS results were provided in the quarterly report of effluent releases and are shown in Table 9.B. NRC and INS gamma spectrum analyses for the May composite sample were in agreement except for cobalt-60. However, the disagreement in the cobalt-60 values is acceptable given the difficulty in assuring that the samples were identical, considering surface plate-out and other factors which could affect cobalt-60 concentrations during sample collection and storage. Although analyses of beta-emitters were performed, the results reported by INS were for a quarterly composite sample composed of three months (April, May and June) and could not be directly compared to the ORISE results for the May composite. Even though not comparable, the results are shown in Table 9.B

Table 9.A

COMPARISON OF MAY 15, 1996 SPLIT SAMPLE ANALYSES BY INS AND ORISE

Nuclide	ORISE Results (uCi/ml)	INS Results (uCi/ml)	R	Ratio	Result
Mn-54	7.85 ± 1.29 E-8	5.326 ± 2.759 E-8	6.09	0.678	A
Co-58	8.16 ± 0.489 E-7	7.887 ± 1.464 E-7	16.7	0.967	A
Co-60	2.345 ± 0.147 E-7	3.108 ± 0.8192 E-7	16.0	1.325	A
Zn-65	ND	ND			
Cs-134	4.628 ± 0.175 E-7	4.202 ± 0.9793 E-7	26.4	0.897	A
Cs-137	2.125 ± 0.0295 E-6	2.639 ± 1.039 E-6	72.0	1.242	A
Tc-99	1.96 ± 0.56 E-8	ND			
Zr-95	ND	1.096 ± 0.5165 E-7			
Nb-95	ND	2.232 ± 0.5331 E-7			
I-125	2.581 ± 0.618 E-6	ND/NR			
H-3	1.0440 ± 0.571 E-5	NR			
Sr-89	1.47 ± 0.42 E-7	NR			
Sr-90	<5.6 E-9	NR			

NR = not reported/not evaluated
ND = not detected
R = Resolution = ORISE value/ORISE uncertainty
Ratio = INS value/ORISE value
A = Agreement
D = Disagreement

Resolution Range	Ratio for Agreement
< 3	0.4 - 2.5
4 - 7	0.5 - 2.0
8 - 15	0.6 - 1.66
16 - 50	0.75 - 1.33
51 - 200	0.8 - 1.25
> 200	0.85 - 1.18

Table 9.B

COMPARISON OF MAY 1996 MONTHLY COMPOSITE SPLIT SAMPLE ANALYSES
BY INS AND ORISE

Nuclide	ORISE Results (uCi/ml)	INS Results (uCi/ml)	R	Ratio	Result
Mn-54	3.57 ± 1.85 E-8	2.99 E-8	1.93	0.838	A
Co-58	5.089± 0.669 E-7	6.25 E-8	7.49	0.123	D
Co-60	1.604 ± 0.219 E-7	3.84 E-8	7.32	0.239	D
Zn-65	ND	ND			
Cs-134	4.105 ± 0.284 E-7	3.85 E-7	14.5	0.938	A
Cs-137	1.901 ± 0.0441 E-6	2.44 E-6	43.1	1.282	A
Zr-95	ND	ND			
Nb-95	ND	ND			
I-125	ND	ND/NR			
H-3	NR	2.64 E-5 *			
Sr-89	1.47 ± 0.42 E-7	3.21 E-8 *	1.19	1.04	A
Sr-90	ND	ND *			
Tc-99	1.44 ± 0.73 E-8	9.9 E-8 *	1.97	6.88	

* These results are averaged over three months (April-May-June) and should not be used for formal comparison.

See text for discussion of cobalt-60 results.

NR = not reported/not evaluated
ND = not detected
R = Resolution = ORISE value/ORISE uncertainty
Ratio = INS value/ORISE value
A = Agreement
D = Disagreement

Resolution Range	Ratio for Agreement
< 3	0.4 - 2.5
4 - 7	0.5 - 2.0
8 - 15	0.6 - 1.66
16 - 50	0.75 - 1.33
51 - 200	0.8 - 1.25
> 200	0.85 - 1.18

10. Conclusions

INS releases to the RWTF have been in compliance with NRC regulations. However, the radioactive materials released reconcentrate in measurable amounts at the RWTF. The process of laundering results in release of radioactive materials in a soluble form; after release from INS, a portion of the gamma emitting radioactive material is removed from the waste water during the sewage treatment process and remains with the sludge produced by the RWTF. The accumulation of radioactive material in an onsite reed bed at RWTF has resulted in exposure rates above normal background in some areas at the RWTF. The gamma-emitting radionuclide of greatest abundance in the reed bed is cobalt-60 with an increasing contribution to the dose rate from cesium-137. Other gamma emitting radionuclides in the reed bed contribute little to the dose rate.

Early measurements indicated that dose rates in the RWTF increased following initiation of use of the reed bed and then became relatively stable. This stability was explained by self shielding and it was expected that dose rates would not change markedly at RWTF as sludge was added to the reedbeed. However, in 1994 dose rates began to increase near the reed bed. The increase is continuing and is best explained by the continual, although small, increase in total activity accumulating in the reed bed. While there has been no significant increase in the amount of activity received by the RWTF from INS, and roughly the same fraction of the RWTF output is going to the reed bed as prior to 1994, less solid material has accumulated than expected, resulting in less shielding for lower layers. The depth of sludge in the reed bed is about half that which was expected when the reed bed was first used. Since the relative fraction of cesium-137 present in the reed bed is continuing to increase because of its half-life of 30 years, it will likely account for a greater fraction of the dose rate in the future.

In March 1997 eight samples were collected in from the reedbed of material accumulated since 1990. The sample results confirm that cobalt-60, although present in the highest concentration, is present in about the same concentration as in sludge produced by mechanical dewatering, indicating that the cobalt-60 concentration in the reed bed is approximately steady, given decay of older material and application of new material (Table 5.F.2). Therefore, the increase in the radiation levels from the reed bed is unlikely to be due to cobalt-60 in the reed bed. However, the cesium-137 concentration in the reed bed sludge is higher than that in sludge from mechanical dewatering, indicating that the increase in the radiation levels from the reed bed is most likely due to the slow accumulation of cesium-137.

The increased dose rate results in increased doses to the RWTF workers. While the annual dose to the RWTF workers is increasing, these doses do not exceed the annual public dose limit of 100 millirem (the doses are estimated to have been about 27 mrem in 1997) and it is not expected that they will reach the 100 millirem level in the near future. Monitoring using the TLDs should continue in order to identify if radiation levels continue to increase with additional sludge accumulation. In addition, personnel monitoring badges have been provided to the RWTF workers to better assess their actual exposure.

Collection of samples of clean water released to the river is expected to occur before the end of 1998. Review of the analysis of these samples, as well as samples from the secondary digester collected each year, will be used to determine if additional samples should be collected from the reed bed or other areas of the RWTF. Due to the public, state and local government interest, sampling will continue during future dewatering operations. The next dewatering is currently expected in 1999.

11. Persons Contacted

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