05/15/92

ATTACHMENT 1

VERMONT YANKEE NUCLEAR POWER CORPORATION

APPLICATION TO DISPOSE IN PLACE CONTAMINATED SOIL

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1.0 Introduction

Vermont Yankee Nuclear Power Corporation (Vermont Yankee) requests approval, pursuant to 10CFR20.302(a) to dispose of radioactively contaminated soil located beneath the plant Chemistry Laboratory floor, by leaving that material in place.

A leak in a Chemistry Laboratory sink drain inside the Radiation Control Area (RCA), was discovered early in 1991. It had led to contamination of soil beneath the laboratory floor. It was found at the time of discovery that a portion of the drain line between the sink and the floor had developed a leak. Upon detailed investigation it was determined that portions of the buried drain line had failed. This included an elbow connecting the vertical drain line to horizontal piping, approximately 15 inches below the concrete floor, allowing liquids poured down the sink to go into the soil below the laboratory floor rather than the intended 4,000 gallon capacity Chemical Drain Tank (TK-19A). Wastes from this drain tank are processed for chemical as well as radionuclide content along with other plant liquid wastes.

As soon as it was determined that the pipe had failed, the pipeline was isolated from the laboratory sink such that no further contamination could be released via this pathway. The end of the pipe has been capped and the area of excavation has been backfilled with concrete to the original floor line so that the line is now inaccessible. Appropriate notations will be placed on building prints warning of the material beneath the floor and referencing the file number where documentation of these activities are kept.

New piping for the sink has been run above the floor to the collection tank. This new piping is accessible over its full length for periodic inspection to preclude a repeat of this event.

The length of time this condition has existed is not known and cannot be determined exactly, however, for purpose of this submittal, an extended time period of ten years is assumed in order to bound the potential impacts associated with the drain line leakage. It is estimated that 10 liters per week of reactor water have been routinely discharged to this sink as a result of chemistry

sampling activities. Other non-radioactive liquids and chemicals were also disposed of utilizing this sink. The results of radiological analyses of reactor water samples were reviewed for recent years to calculate an estimate of the concentration and total activity that may have been discharged to this sink over time. Samples of soil from grade to bedrock were obtained from a split-spoon boring through the Chemistry Laboratory floor. Samples were subsequently analyzed for chemical and radionuclide distribution and concentration.

The Chemistry Laboratory is located in the lower level of the office building at the north end of the turbine building complex. During plant construction, this area was excavated to bedrock at a depth of approximately 15 feet below the Chemistry Laboratory floor (El. 233'±). The area under the laboratory was then filled to its current grade and the concrete laboratory floor poured. Removal of this contaminated material is impractical due to the fact that it is located underneath existing building structures. Furthermore, concentrations of contaminants are very low and pose no significant risk to the health and safety of plant workers or the general public.

2.0 Waste Stream Description

2.1 Physical Properties

Discharge from the Chemistry Laboratory sink seeped directly into the structural fill beneath the building floor slab. The contaminated material consists of approximately a 15 foot thickness of structural fill placed during plant construction. The fill itself is a uniform fine-grained sand with some silt and minor gravel. This is a well defined volume, confined on three sides by existing foundations and on the bottom by bedrock. If it is assumed the soil volume under the entire 150 foot length of buried pipe has become contaminated, the total volume as estimated by projecting a cone shaped spread of activity downward and laterally away from the horizontal pipe, is about 58,500 cubic feet. If it is assumed the leak was local in nature, the zone of contamination may be represented by a 120° cone extending down 15 ft., and would contain approximately 10,600 ft^3. The larger, more conservative value was selected for this evaluation

to emphasize the limited extent of the contamination. It is believed, because of uncertainty about the zone of contamination, the best estimate of the total activity can best be made from historical records of sink discharges.

A compilation was made of the constituents used in the lab. In addition it was determined that a volume of distilled and tap water mixed with or separately disposed of in the same drain was on the order of 200 liters per day. A sample testing program, described below, was then designed to assess the character of the chemicals added to the soil.

2.2 Sampling Procedures

Samples of contaminated soil were obtained through a hole cut into the laboratory floor. Both block samples from immediately beneath the floor, and split spoon soil boring samples at various depths were taken. Samples were taken under controlled conditions, in conformance with written procedures and with direct inspection by personnel familiar with such activities. Three samples analyzed for chemical contaminants included a sample (SS-2) from the most contaminated zone near the Chemistry Laboratory floor surface, a sample (SS-3) from an intermediate depth and a sample (SS-5) from a wet zone, possibly the capillary fringe located at the bedrock interface. Nine samples from the boring were analyzed for radionuclide content and distribution as described in Section 2.4.

2.3 Chemical Properties

Samples of the soil were analyzed for chemical constituents that would be characterized as hazardous by the EPA. The results of the sample analysis did not indicate the presence of any hazardous chemical constituents.

Analyses were performed on soil samples from the boring (MW-1) for volatile organic compounds (VOC EPA Method 8240), semi-volatile organic compounds (SVOC EPA Method 8270), 24 metals (EPA Method 6010), 4 other metals, and ammonia, chloride, nitrate and pH. The sample with the highest level of radioactive

contamination, (SS-2), was also analyzed by toxicity characteristic leaching procedure (TCLP) including TCLP metals, TCLP semi-volatiles, and TCLP zero headspace extraction (ZHE) volatile organics. In addition an organic vapor meter (OVM) was used to test samples as they were withdrawn from sampling equipment.

OVM analysis used to screen samples during sampling operations detected no organic vapors from any of the samples taken. Laboratory analyses showed neither TCLP ZHE volatile organics nor TCLP semi-volatiles to be present above detection limits. TCLP metals were found to be below EPA regulatory limits. Volatile, semi-volatile and metal test results for all three samples are below regulatory limits. The ammonia, chloride, nitrate and Ih parameters are also well within normal ranges. These tests support the conclusion made by ENSR (Ref. 1) that the soil beneath the Chemistry Laboratory is <u>not</u> a RCRA characteristic hazardous waste.

2.4 Radiological Properties

A continuous 3" diameter split-spoon boring, (MW-1), was taken from the Chemistry Laboratory floor elevation down approximately 15 feet to bedrock. It was not possible to take this core sample directly adjacent to the pipe at the location of the failed elbow between the transition from vertical to horizontal pipe runs. This was due to the presence of a concrete electrical duct bank buried just below the horizontal run of the drain pipe from the Chemistry Laboratory to the chemical drain tank. The boring was thus located approximately 4 feet from the vertical portion of the drain line inside the Chemistry Laboratory. At approximate 1 vertical foot intervals, three inch samples of the removed soil were retained and analyzed for radionuclide distribution and concentration. The environmental Technical Specification lower limit of detection (LLD), as specified in Technical Specifications, Table 4.9.3 for sediments, were applied to the analyses. The samples were analyzed in the "as found" moist condition without oven drying and are reported as "wet", which is the standard environmental laboratory practice for "in-situ" sample reporting (for other than sediment samples). The moisture content of these samples was estimated not to exceed 10-20%, by weight, thus density correction would not greatly affect the reported results, given other uncertainties in the collection and measurement

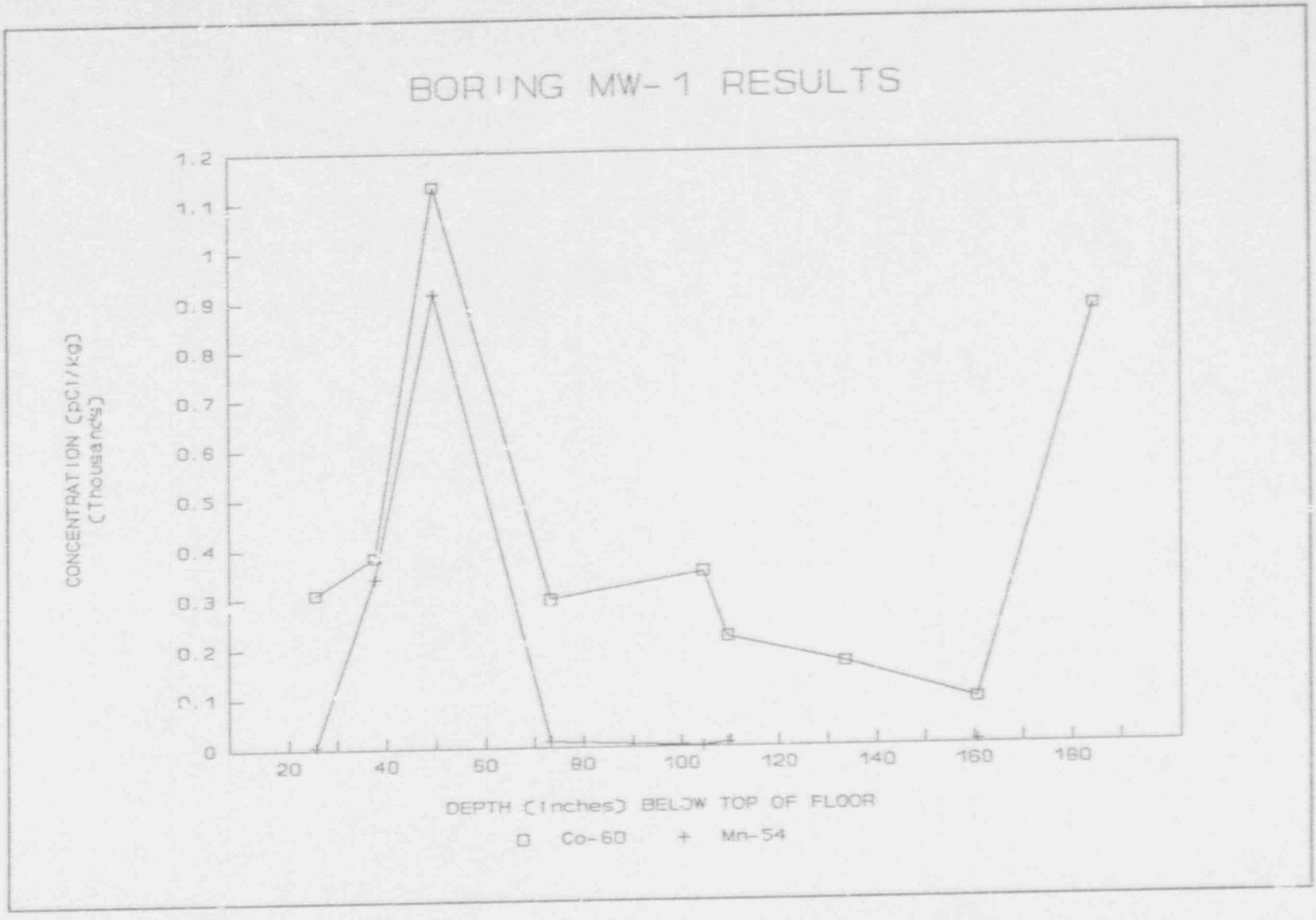
program. Co-60 and Mn-54 were the only two radionuclides of plant origin detected.

TABLE 1 (Revised)

SOIL BORING SAMPLE RESULTS (Boring MW-1)

DEPTH BELOW TOP OF FLOOR (inches)	Co-60 (pCi/Kg, wet)	Mn-54 (pCi/Kg, wet)
25.5	308	5
37.5	383	339
49.5	1131	914
73.5	296	12
104.5	351	1
109.5	221	7
133.5	166	<MDA
160.5	90	5
184.5	879	<MDA
AVERAGE CONCENTRATION	425	183

Block samples taken at the point immediately below where the pipe penetrates the floor had a Co-60 concentration that peaked at 1.1E+05 picocurie/kg. It should be noted that several short lived plant related radionuclides were detected in this sample, indicating recent leakage, but were not detected in samples taken at depth. Table 1 presents the results of analysis of the core boring with respect to depth below the laboratory concrete floor. It might be expected, had the boring been able to be taken in close proximity to the vertical pipe, the measured values would reflect the higher values measured in the block samples. Assuming this were to be the case, it would be indicative that the activity has not moved laterally to any great extent and that an estimate of total activity based upon one boring or the block sample, would result in an overestimation of total activity.


BORING MW-1 RESULTS
CONCENTRATION (pCi/kg)
(Thousands)
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
20
40
60
80
100
120
140
160
180
DEPTH (Inches) BELOW TOP OF FLOOR
□ Co-60 + Mn-54

Sampling in the boring was done using a split-spoon sampler 3 ft long and 2" in diameter. The penetration depth used for each sample attempt was only 2 ft. Due to the nature of the soil, a relatively dry, fine to medium-grained sand, recovery of samples averaged about 60% (of the 2 ft attempted for each split-spoon sample). The recovered portion of each sample represents about the top 60% of the soil depths penetrated in each attempt; the bottom portion of sample sloughed out of the sampler.

Approximate 2-3 inch segments of each split-spoon sample were selected and analyzed, one for radioactive and one for chemical constituents. Samples to be analyzed were selected from the recovered material in each split-spoon based upon judgement of the representative nature of the sample as well as the spacing. For example, material such as loose gravel wash typically found at the top of such split-spoon samples was not selected for testing. As a result of the limited recovery and the nature of such a boring operation, the accuracy of the sample depths may vary as much as +/- 2 to 3 inches from the reported values.

Results of radiological analysis of soil boring samples indicate the presence of materials in the soil which could only have come from plant operation. Concentrations are highest beneath the pipe (1.125E+05 pCi/kg for Co-60), but considerably lower with depth (90 pCi/kg Co-60 at 12 ft below the floor). The distribution of radionuclides suggests that the movement of these radionuclides is, as expected, greatly restricted in the soil. Cobalt-60 was the principle radionuclide detected, and the only plant nuclide found below a depth of 4.2 feet below the Chemistry Laboratory floor.

While radionuclide measurements done on the soil boring samples indicate that the higher values near the top of the soil column (in close proximity to the leakage) and a decrease with depth, a relatively high value (879 pCi/kg) was obtained from the bottom sample of boring in comparison with the sample taken just above it (90 pCi/kg at 13 feet). The core boring data in total suggests the following:

a. Migration of radionuclides does appear to be retarded by sorption of ions onto soil particles. There was some doubt about the degree to which this would occur due to the use of drains for disposal of chemicals.

b. The concentration of radionuclides in the bottom sample of the boring could be the result of the introduction of a relatively large quantity of activity put into the sink drain at some time in the past, or more likely, could also result from "ponding" of activity at a low point at the top bedrock, as a result of lower vertical water velocity and longer contact time for ion exchange to take place.

c. Cobalt-60 (and we assume Tritium) may have approached or crossed into the ground water regime, and may be subject to present or future movement through ground water, although no sample of water was obtainable from the screened well placed in the chemistry laboratory floor.

2.5 Estimate of Total Activity

Given the data from the soil boring, it is felt that a conservative estimate of the total activity present in both the soil zone immediately below the laboratory floor and above the ground water table, as well as any fraction which might have entered the ground water zone, could best be determined by assuming a 10 liter per week quantity of reactor water, at a conservative concentration of radionuclides of concern, was disposed of through the sink drain over an extended period of time. This value is believed representative of the quantity of liquid released to the ground based upon the following:

Vermont Yankee Technical Specification 4.6.B.1.a. states "a sample of reactor coolant shall be taken at least every 96 hours and analyzed for radioactive iodines of I-131 through I-135 during power operation". Section 4.6.B.1.b, states "an isotopic analysis of reactor coolant sample shall be made at least once per month".

Conversation with plant chemistry personnel and review of completed plant chemistry procedures indicates 1 liter samples are collected and brought to the Laboratory for analysis on a daily basis.

The basic assumption is that these samples were disposed in the laboratory

sink, under the assumption the contents was going to the Chemistry Drain Tank.

One sample per day equates to 7 liters per week. This value is rounded up to 10 liters per week, for purpose of this evaluation.

It is reasonable to assume that the drain leak began as a small corrosion hole in the drain line near the elbow. This allowed small quantities of liquids to leak into the soil. As time progressed, the corrosion continued and the leak increased in magnitude and an increasing fraction of the material discharged to the drain sink leaked. It is unlikely that the entire volume of water leaked out of the pipe. Undoubtedly a significant percentage of water followed the path of least resistance, down the open pipe. Neither the exact time, nor magnitude of leakage is precisely known, therefore it is assumed conservatively assumed that all of the estimated liquid discharged to the sink for the previous 10 year period resulted in leakage. It is believed this approach has results in a conservative estimation of the total activity that may have been discharged to the sink and the calculated radiological impact represents the upper bound of exposure.

It is assumed that 100% of the associated activity put down the drain is released to the soil. A 100 ml aliquot of the monthly sample is analyzed for gamma emitters. A review of reactor water analysis results for the period from 1987 through 1990, indicated that the fifteen month period from May, 1988 through July, 1989 represented conservatively high values for reactor water activity. These more recent results are used to estimate the radionuclide concentration of gamma emitters. Table 2 lists the monthly concentrations of Co-60, Mn-54, Cs-134 and Cs-137 measured in reactor water.

It is known from analyses of other waste streams that nuclides important to 10CFR61, which are not gamma emitters, are also present. In order to account for those radionuclides, whose half lives are of an order of 1 year or longer, a representative reactor water sample previously analyzed for Part 61 nuclides was reviewed for applicability to this situation.

TABLE 2

REACTOR WATER ANALYSIS SUMMARY DATA

DATE	Co-60 (uCi/ml)	Mn-54 (uCi/ml)	Cs-134 (uCi/ml)	Cs-137 (uCi/ml)
5/88	9.05E-05	5.23E-05	9.11E-06	1.49E-05
6/88	8.38E-05	5.45E-05	1.50E-05	8.08E-05
7/88	5.35E-05	3.96E-05	1.48E-05	1.50E-05
8/88	4.49E-05	3.45E-05	No Data	7.32E-06
9/88	5.47E-05	3.96E-05	4.19E-06	4.33E-06
10/88	5.99E-05	3.85E-05	1.89E-06	4.08E-06
11/88	3.96E-05	5.88E-05	5.40E-06	7.35E-06
12/88	8.38E-05	5.52E-05	5.25E-06	5.92E-06
1/89	1.88E-04	1.36E-04	1.65E-05	2.43E-05
3/89	1.03E-03	4.71E-04	2.37E-04	2.11E-04
4/89	4.87E-05	5.04E-05	1.22E-05	2.48E-05
5/89	5.82E-05	4.44E-05	9.90E-06	9.31E-06
6/89	6.06E-05	4.34E-05	6.01E-06	5.15E-06
7/89	8.04E-05	4.29E-05	2.77E-06	3.28E-06
AVERAGE	1.42E-04	8.31E-05	2.62E-05	2.98E-05

Table 3 lists radionuclides and their relative concentrations with no decay and also the concentration with a decay period of 2.5 years. 2.5 years represents a very conservative travel time to the river and neglecting soil retardation effects. We have determined, for a conservative evaluation, that seven radionuclides, H-3, Mn-54, Fe-55, Co-60, Cs-134, Cs-137, and Sr-90 should be considered as present. These seven radionuclides represent 99.9% of the total reactor coolant activity present after 2.5 years.

TABLE 3

TYPICAL REACTOR WATER RADIONUCLIDES

Nuclide	Half-life (Years)	No Decay (uCi/ml)	2.5 Yr Decay (uCi/ml)
H-3	12.2	2.0E-02	1.8E-02
Co-60	5.272	1.4E-04	1.0E-04
Fe-55	2.70	2.4E-04	1.3E-04
Mn-54	0.855	8.3E-05	1.1E-05
Zn-65	0.667	1.7E-04	1.3E-05
Sb-125	2.77	2.3E-05	1.2E-05
Ce-144	0.778	8.0E-06	8.6E-07
Cs-134	2.065	2.6E-05	1.1E-05
Cs-137	30.17	3.0E-05	2.8E-05
Sr-90	28.6	6.9E-08	6.5E-08
Zr-95	0.175	3.9E-04	2.0E-08
Co-58	0.194	7.1E-05	9.4E-09
Fe-59	0.122	1.6E-04	1.1E-10
Cr-51	0.076	1.7E-04	2.0E-14

The concentrations of radionuclides not measured in the monthly samples were based upon the relative abundance of radionuclides in the previously mentioned laboratory analysis of a reactor water sample.

For purposes of bounding the potential impact, it is assumed that 10 liters of reactor water per week, at the "batch" values of Table 4, have been disposed in the sink over an arbitrarily long 10 year period, and that 100% of this water has

TABLE 4

RADIONUCLIDE DISTRIBUTION

Radionuclide	Concentration (uCi/ml)	"Batch" Activity* (uCi)
H-3	2.0E-02	2.0E+02
Mn-54	8.3E-05	8.3E-01
Fe-55	2.4E-04	2.4E+00
Co-60	1.4E-04	1.4E+00
Cs-134	2.6E-05	2.6E-01
Cs-137	3.0E-05	3.0E-01
Sr-90	6.9E-08	6.9E-04

* Activity in a 10 liter "batch"

TABLE 5

ACTIVITY BUILDUP BELOW THE CHEM LAB FLOOR WITH TIME

Radionuclide	Half-life (Years)	Q_o (uCi/Batch)	Q_s * (Total uCi)
H-3	12.2	2.0E+02	8.0E+04
Mn-54	0.85476	8.3E-01	5.4E+01
Fe-55	2.7	2.4E+00	4.4E+02
Co-60	5.272	1.4E+00	4.1E+02
Cs-134	2.065	2.6E-01	3.9E+01
Cs-137	30.17	3.0E-01	1.4E+02
Sr-90	28.6	6.9E-04	3.2E-01
Total Activity		2.1E+02	8.1E+04

* Total activity present after 10 yrs of weekly "batch" releases

gone directly to the soil underlying the Chemistry Laboratory. With a constant input and considering decay, it is mathematically possible to calculate a total inventory at any point in time. This analysis assumes a ten year period of weekly Table 4 "batch" releases. Table 5 tabulates the postulated total inventory present at the end of an arbitrary 10 year period of weekly "batch" releases.

3.0 Description of Proposed Disposal Method

It is proposed to dispose of the activity by leaving it in place where it currently resides. By terminating the release of liquids into the failed drain line, there is no significant driving force to cause any further movement of the activity now in the soil below the Chemistry Laboratory floor any deeper toward the ground water regime. The total quantity of activity is sufficiently small that it does not currently present a direct radiation exposure hazard to the Chemistry Laboratory. To remove the material would, however, require a major excavation effort under the laboratory floor and in proximity to the reactor building foundation, and other critical structures, as well as exposure to the workers performing the excavation. The direct exposure as well as potential airborne exposure to current workers performing remediation would be far greater than the potential for exposure to a future population. In fact, there is no practical way for this material to be removed from under the plant at this time.

4.0 Geology and Hydrology Considerations

Natural soils at the site were removed at the time of plant construction so that major plant structures could be founded on bedrock. Structural fill replacing soils consists of fine uniform sand with some silt and minor gravel. Natural soils remain around the periphery of the site. These natural soils consist of a loose silty fine-grained sand 5 to 15 ft thick underlain by medium dense, glacio-fluvial, silty fine-grained sand 10 to 20 ft thick. Where bedrock surface elevation is below + 220 ft (msl) there also exists deposits of varied fine sand and silt with a few thin clay layers. Thickness of these varied deposits ranges

up to 12 ft. They are typically underlain by a few feet of sand and gravel.

Bedrock under these soils is hard, fresh massive gneiss. The bedrock surface is undulatory, varying in elevation from about +190 ft to +230 ft (msl), in the vicinity of the major plant structures. The bedrock surface rises to elevations of +250 ft to the west side of the plant site, and drops well below +200 ft to the east beneath the Connecticut River. Grade in the vicinity of plant structures is about +250 ft. The top of the Chemistry Laboratory floor (12" concrete) is +248'6".

Ground water depth in the vicinity of plant structures is about +230 ft. Average elevation of the Connecticut River is +220 ft. The building housing the Chemistry Laboratory is about 300 ft from the river. Hydraulic gradient is thus rather high at 0.05 ft/ft. Ground water flow rates have been estimated at about 32 feet/year, through natural soils, and may be a factor of two or higher through the fill materials. For this reason, only 2.5 years is assumed for travel time to the river.

Bedrock was encountered in the soil boring MW-1 at an elevation of about +233 ft. The bottom 1.5 to 2 feet of soil encountered in the boring just above the bedrock surface was damp and a well screen was installed in the hole to attempt to measure water levels upon completion of sampling. However, since the well installation no water has accumulated in the hole. The damp soil encountered thus may have been a capillary fringe, but more likely was the remnants of water leaked from the subject pipe. Thus the natural ground water surface appears to be below the bedrock surface beneath the Chemistry Laboratory. Original site drawings show ground water elevation in natural soils to be at about elevation +235 in this area. The present ground water table may be lower than when original soils were present due to the somewhat lower permeability of those soils compared with the structural fill and the possible alteration of ground water flow regime due the construction of building foundations.

The alteration of ground water due to floods was considered and dismissed as insignificant. The 100-year flood on the Connecticut River reaches an elevation of only +[illegible] just below the typical current level of ground water. The 500-year

flood reaches an elevation of only 4 feet higher at +232, but has a very short duration of only a few hours.

Ground water flow across the entire site is directly toward the Connecticut River (Vernon Pond). Two possible paths to the river appear to exist for ground water in the vicinity of the Chemistry Laboratory. It either flows northeast following the path of a bedrock depression and former gully (filled in during construction), or it flows east, perhaps intercepting fill along the 126 inch diameter circulating water intake pipe trench.

Four potable water wells exist on site. All of these wells are either up-gradient or decidedly away from any potential ground water path from the Chemistry Laboratory to the Connecticut River.

In general, bedrock permeability is very low. Studies have identified photo lineaments which appear to be some long, narrow fracture zones on the site. However, none of these zones are located where they might influence flow of ground water from the Chemistry Laboratory area to the river. Thus, the bedrock is considered an aquiclude and infiltration of the radioactivity into the bedrock is not considered probable.

Major plant structures as well as adjoining residential properties are depicted on FSAR figure 2.2.4, Station Plan. This figure is included as Appendix 1 to this submittal. In general, the residences located on the west of the site on Gov. Hunt road have individual shallow wells as potable water supplies. As mentioned previously, the ground water flow is from west to east to the Connecticut River, and away from the residences. The Chemistry Laboratory, the source of the leakage is located in the lower level of the "Offices Bldg", adjacent the "Turbine Bldg". The grid scale of the plan is 500'. The main potable water supply for the site is provided by the "West Well", whose location is shown near the 345 KV switchyard.

5.0 Environmental Sampling Program

5.1 Water Sampling Description

In accordance with Technical Specification 3.9.C.1 (and Table 3.9.3), river water is sampled at two locations on a monthly basis. The sample locations and descriptions are presented in Table 4.1 of the Off Site Dose Calculation Manual (ODCM). At the upstream control location (WR-21), a grab sample is collected monthly. At the downstream location (WR-11), aliquots of water are collected automatically, approximately every two hours, by a compositing sampler. The composited sample is picked up monthly. Each sample is analyzed for gamma-emitting radionuclides. On a quarterly basis, the three monthly samples are composited by sampling location and are then analyzed for Tritium (H-3).

Also in accordance with Technical Specification 3.9.C.1, sediment samples are collected semi-annually from two (2) shoreline locations. A single grab sample is collected from the first location (SE-11), downstream of the plant discharge on the west shore of the Connecticut River. Multiple grab samples are collected from the second location (SE-12), upstream of the discharge point where the North Storm Drain empties into the west side of the Connecticut River. Grab samples collected at these two locations are analyzed by gamma spectroscopy.

Grab samples of ground water are collected quarterly from three well locations. These are WG-11 on the plant site, WG-12 in the SSE sector at 2.0 km, and WG-22 (the control) in the N sector at 14.3 km. (WG-22 replaced WG-21 as a control during the first quarter of 1991, when Station WG-21 became inaccessible.) Each sample is analyzed for gamma-emitting radionuclides and tritium (H-3).

Technical Specification 4.9.C.1 (and Table 4.9.3) provides the minimum detection capabilities (Lower Limits of Detection, or LLDs) for each required sample analysis. The LLDs for C-60 and H-3 in river or ground water are 15 and 3000 pCi/l, respectively. There is no LLD specified for Co-60 in sediment, although it is specified for Cs-134 and Cs-137. LLDs are typically achieved at levels one-half or better than the values noted above.

Technical Specification Table 3.9.4 provides the Reporting Levels for river water and sediment samples. The Reporting Levels for Co-60 and H-3 in river water (i.e. non-drinking water pathway) are 300 and 30,000 pCi/l, respectively. For ground water (the drinking water pathway), the Reporting Levels are 300 and 20,000 pCi/l, respectively. For Co-60 in sediment (only applicable to individual grab samples at the North Storm Drain Outfall), the Reporting Level is 3000 pCi/kg(dry).

5.2 Sampling Program Results

The presence of Co-60 or H-3 in river water and of Co-60 in sediment were investigated for a 13-year period (3rd Quarter 1977 through 1st Quarter 1991 - i.e. dating back to the time the Yankee Environmental Laboratory began operation). Over that period, Co-60 was detected in many samples from Station SE-12 (North Storm Drain Outfall), with a maximum concentration of 490 pCi/kg (dry). No Co-60 was detected in sediment from the downstream sampling location, SE-11. Likewise, no Co-60 was detected in river water during that period, either at the upstream location or at the downstream compositing location. The presence of Co-60 in sediment near the North Storm Drain outfall has been attributed in the past to rain water runoff from the Turbine Building roof carrying low levels of deposited Co-60 from Turbine Building roof vent releases.

Tritium (H-3) has been detected during the above period on several occasions at Station WR-11. The occurrence of tritium in river water there during 1977 and 1978 may have been due to nuclear weapons testing fallout, as the same levels were detected in Station WR-21 (the control) as at WR-11. Tritium was also detected in river water at WR-11 on one occasion in 1982 and on one occasion in 1984.

6.0 Radiological Considerations

Scenarios that have the potential for radiological impacts to members of the public have been postulated for the purpose of determining maximum possible

doses. One scenario assumes the contamination migrates off site to Vernon Pond on the Connecticut River where it becomes the source term for subsequent direct uptake as drinking water, indirect uptake after concentration in fish and subsequent consumption by man, use of the water for crop irrigation, and direct exposure from standing on the shoreline of the pond. A second scenario assumes the material remains in place until the plant is decommissioned and control over the site is no longer maintained. At that time an intruder arrives on site, drills a well into the soil containing the activity, and/or exhumes the material and spreads the activity over the ground, grows crops, feeds a dairy cow, and supports a family on the site. These scenarios are mutually exclusive, i.e., one or the other may occur, but both cannot occur. Neither can the intruder be exposed via the drinking water pathway with the crop production/ingestion pathway simultaneously. The radiological evaluation has considered all scenarios and assumes the higher radiological impact case takes place.

Another scenario considered is that the radioactivity reaches the on site potable well used by the plant, during the current period of plant operation. This potential exposure pathway does not include members of the public but is restricted to plant employees. The previously described environmental monitoring program (Section 5.1) is designed to detect any increase in activity in environmental media due to plant operations. The principle on site potable drinking water well is also included in this program. To date, no plant related radioactivity has been determined to be present in any well water sample. None the less, a potential exposure is calculated for this pathway.

6.1 Potential Off Site Exposure Pathways

In this scenario it is assumed the activity moves at the rate of ground water and arrives at Vernon Pond. With a distance of approximately 300 ft and an estimated groundwater velocity of 32 ft/yr, it is expected to take 9+ years to arrive at the pond. Because of the uncertainty over the possible start time of any migration, it is assumed that 100% of the estimated activity in each weekly "batch" arrives at the river 2.5 years after its release. It is assumed a continuous release exists and the annual release consists of the sum of 52 weekly

"batch" releases. Effects of retardation by the soil are neglected. Table 6 presents the activity assumed to reach the river on an annual basis. It is assumed this release rate continues for 10 years.

TABLE 6

ANNUAL ACTIVITY RELEASE ASSUMING
2.5 YEARS OF DECAY

Radionuclide	Half-Life (Years)	Q_o (uCi/Batch)	Q_d * (Total uCi)	Annual Release ** (Total uCi)
H-3	12.2	2.0E+02	1.8E+02	9.1E+03
Mn-54	0.85476	8.3E-01	1.1E-01	5.7E+00
Fe-55	2.7	2.4E+00	1.2E+00	6.5E+01
Co-60	5.272	1.4E+00	1.0E+00	5.3E+01
Cs-134	2.065	2.6E-01	1.1E-01	5.9E+00
Cs-137	30.17	3.0E-01	2.8E-01	1.5E+01
Sr-90	28.6	6.9E-04	6.5E-04	3.4E-02

* Weekly batch activity released to river, after 2.5 year decay.

** Annual release, 52 times the weekly batch release.

6.1.1 Approach to Analysis

The methods described in Regulatory Guide 1.109 (Ref. 2) are generally applicable to analysis of the radiological impact of off site releases. The dose model used for estimation of total exposure is IDLE (Ref. 5) and is based upon Regulatory Guide 1.109. The entire inventory of activity is assumed to be continuously released via a liquid effluent pathway to the river. The release flow rate is assumed to be small and the activity remains undiluted as it moves to the river. Credit for 2.5 years decay is taken.

6.1.2 Description of Scenario

The scenario assumes an essentially constant release rate over a ten year period, such that the activities listed in Table 6 reach Vernon Pond annually. Dilution is assumed in Connecticut River water flowing by the plant. The FSAR (Ref. 3), states the river flow is typically 10,000 cfs, with no less than 1,200 cfs during the dry season. For purpose of this evaluation, a conservatively low value of 100 cfs is assumed for the entire year, as the dilution flow.

Pathways considered in this evaluation include consumption of fish, use of the water to irrigate leafy and stored vegetables, and sediment irradiation to recreational users of the shoreline. Regulatory Guide 1.109 (Ref. 2) bioaccumulation factors, consumption rates, and shoreline activity times are used in the calculation of the radiological impact to man over a one year period. The time period selected is the tenth year, which calculates the annual dose in the tenth year, from releases that year as well as dose resulting from residual activity from the previous nine years of releases.

6.2 Potential On Site Exposure Pathways

Another hypothetical scenario is that activity reaches the on site potable well; with subsequent consumption of the water by plant employees. Monitoring of the water supply will ensure this will not constitute an exposure pathway.

The Draft Environmental Impact Statement for 10CFR61 (Ref. 4) also considered several potential exposure pathways in its radiological analysis, among them was an intruder settling on a site once institutional control was lost.

The scenario considered for this application, to demonstrate the extreme case and the insignificance of the total exposure, consists of an intruder settling on the plant site after termination of the plant license and decommissioning and dismantling of all buildings. It is assumed this intruder arrives 20 years from now and either sinks a well into an aquifer containing the residual activity, or unearths all of the activity present at that time, spreads it about, plants and

harvests crops, and raises a milk cow on the land. (These two scenarios are mutually exclusive).

6.2.1 Approach to Analysis

In general, the dose model used for estimation the total exposure is from Regulatory guide 1.109. For the ingestion pathway resulting from the intruder settling on the site 20 years in the future, it is assumed that the decayed activity is spread over a sufficiently large area to support the growing of crops as well as the grazing requirements of one cow, in accordance with the values suggested in Regulatory Guide 1.109. This total area is calculated to be 4,086 sq. meters.

Doses were calculated for the intruder scenario in which food crops, grazing requirements for a milk cow, and inhalation of resuspended material were considered, for the whole body and seven organs to each of four age groups; infants, children, teens, and adults, using the consumption rates, or usage factors as listed in Reg. Guide 1.109.

The following two scenarios use analysis techniques that differ from a strict Regulatory Guide 1.109 type of analysis. Differences in the scenarios are such that they do not lend themselves to a direct application of R.G. 1.109. One is the direct ground plane from a finite size source and the other is a well water ingestion pathway in which the activity is assumed to be below the ground level. The direct ground plane exposure component is determined by the DIDOS computer program (Ref. 6), which calculates doses from a cylindrical source of stated density, and is applicable to this assumed scenario consisting of a ground plane source. The whole body ground plane direct exposure fraction, after exhumation is calculated assuming the decayed activity is exhumed and spread in a layer equivalent to the plow depth (15 cm.) used in Reg. Guide 1.109. This equates to a circular area of 59 meters radius, based upon the previously estimated 58,500 cubic feet of contaminated soil. It is assumed the receptor stands at the center of this circle for 8760 hours per year

TABLE 7

ACTIVITY AFTER 10 YEARS OF WEEKLY RELEASES,
FOLLOWED BY 20 YEARS OF DECAY

Radionuclide	Half-life (Years)	Q_o (uCi/Batch)	Q_s * (Total uCi)	Q_d ** (Total uCi)
H-3	12.2	2.0E+02	8.0E+04	2.6E+04
Mn-54	0.85476	8.3E-01	5.4E+01	4.9E-06
Fe-55	2.7	2.4E+00	4.4E+02	2.6E+00
Co-60	5.272	1.4E+00	4.1E+02	3.0E+01
Cs-134	2.065	2.6E-01	3.9E+01	4.8E-02
Cs-137	30.17	3.0E-01	1.4E+02	8.7E+01
Sr-90	28.6	6.9E-04	3.2E-01	2.0E-01

* Total activity present after 10 yrs of weekly "batch" releases
** That activity after a 20 year decay period

The radiological impact of the on site drinking water scenario has been evaluated using three approaches. It is postulated that a small family settles on the site 20 years in the future after plant closure and digs a shallow well to obtain its drinking water needs.

The activity in Table 7 is that activity remaining after 10 years of continuous releases followed by a 20 year decay period and is that which serves as the source term for the calculating of the intruder scenario exposures.

Approach 1

The total activity in the right hand column of Table 7, Q_d, forms the activity source term. It is assumed that migration away from the area has not occurred, nor is any activity retarded it its movement to an "underground pool", which is the source of drinking water. Applying the assumptions presented in Ref. 4, for

natural percolation of precipitation a into groundwater system, the measured precipitation for the site, and assuming a small area of recharge, a conservative value of total dilution water volume (and hence specific activity) can be postulated for the scenario. The methodology presented in Ref. 2 can then be applied to calculate radiological impacts.

The average precipitation for Vermont Yankee for the period 1981-1990 was 40" per year. Ref. 4 lists an annual precipitation rate of 41" and a percolation rate of 2.9", for a NE site. A recharge area consisting of a circle of 500 ft radius (7.85E+05 sq. ft.), representing a small fraction of the site area upgradient of the Chemistry Laboratory, is assumed. The volume of water percolating to the "underground pool" at a rate of 2.9" per year for 20 years is equivalent to 1.075E+11 ml. Using this volume and the activity from Table 7 results in the specific activities in the drinking water "pool: as listed in Table 8, below.

Table 8

Radionuclide Activity and Concentration in Drinking Water

Nuclide	Total Activity μCi	Concentration μCi/ml
H-3	2.6E+04	2.4E-07
Mn-54	4.9E-06	4.6E-17
Fe-55	2.6E+00	2.4E-11
Co-60	3.0E+01	2.8E-10
Cs-134	4.8E-02	4.5E-13
Cs-137	8.7E+01	8.1E-10
Sr-90	1.9E-01	1.8E-12

Approach 2

An evaluation using the RESRAD code (Ref. 7) with the following assumptions:

Zone of contamination consisting of a cube with sides equal to the depth to bedrock, 4.7 meters.

Source term consisting of the activity present after 10 years of weekly discharges, Table 5, Q_e, time since spill, 10 years

Hydraulic conductivity, 1.42E-02 cm/sec.

Groundwater velocity, 2.6E-02 meters/day

Effective soil porosity, 0.33 (dimensionless)

Approach 3

NUREG/CR-3332 (Ref. 8), provides a relatively simple approach to ground water transport of radionuclides. The same assumptions as were used in the above approach were used. The results are expressed as a radionuclide concentration in the aquifer at the well location. The well is assumed to be located next to the failed elbow in order to get the maximum aquifer concentration and resultant radiological impact. The methodology of Ref. 2 is then applied to determine the dose.

7.0 Radiological Impacts

7.1 Potential Off-Site Exposures

The maximum radiological impact due to the sum of off site pathways is 9.8E-04 MREM to an adult whole body, and 1.5E-03 MREM child organ dose (liver). These exposures are subdivided into the following individual pathways.

7.1.1 Drinking Water Ingestion

Consumption of drinking water from contamination that has traveled undiminished though the soil, except for a 2.5 year decay during travel, diluted in the minimum flow of the Connecticut River, and consumed at the rates specified in Reg. Guide 1.109 (Ref. 2) for the four age groups (infant, child, teen, and adult), results in a maximum whole body dose to an adult from drinking water ingestion of 2.5E-05 MREM. The maximum organ dose is to an infant liver of 6.3E-05 MREM. The methodology used for analysis is that described in Regulatory Guide 1.109 (Ref. 2).

7.1.2 Fish Ingestion Pathway

Bioaccumulation factors and consumption rates from Reg. Guide 1.109 (Ref. 2) are applied to fish ingestion. The maximum whole body dose is to an adult and is estimated to be 8.3E-04 MREM. The maximum organ dose is to a teen liver and is 1.2E-03 MREM.

7.1.3 Irrigation Exposure Pathway

The diluted water in Vernon Pond is used as crop irrigation water in accordance with Reg. Guide 1.109 (Ref. 2) for a 8760 hour period. The maximum whole body annual dose is to a child and is estimated to be 1.2E-04 MREM. The maximum organ dose is to a child liver and is 4.0E-04 MREM.

7.1.4 Shoreline Direct Exposure

As above, using Reg. Guide 1.109 guidance (Ref. 2) results in a maximum whole body dose of a teen of 2.2E-05 MREM from standing on the shoreline.

7.2 On Site Exposure Pathways

7.2.1 On Site Potable Well

For the on site well during plant operation (next 20 years) it is assumed that the sampling program will detect any significant increase in activity and that corrective actions will be implemented before any individual receives a significant dose.

For the on site well intruder scenario, the 3 approaches result in similar results. Approach 1 calculates a maximum whole body dose of 6.4E-02 Mrem/yr to an adult and a maximum organ dose of 1.9E-01 mRem/yr to the infant liver. Approach 2 calculates a whole body dose of 4.6E-02 mRem/yr. (Organ dose not calculated.) Approach 3 calculates in a whole body dose of 3.8E-01 mRem/yr and serves to provide an upper bound to the radiological impact.

7.2.2 Direct Ground Plane Exposure

At year 20 in the future (Table 7 activity), exhumation of the 58,500 ft^3 (1.657E+03 M^3) of material and spreading in a layer equivalent to the plow depth (15 cm), results in an continuous annual exposure of 2.7E-01 MREM, as calculated by DIDOS, a small fraction of exposure due to natural background.

7.2.3 Intruder Surface Related Exposure

Using the methodology of Reg. Guide 1.109 (Ref. 2), and the activities from Table 7, results in the maximum calculated pathway exposures as listed in Table 9. The assumptions used include intruders consisting of a couple with an infant, child, and teen all getting 100% of their food from crops grown on contaminated ground and milk from a cow whose entire food supply was also grown on this land. This represents an extreme case that while not necessarily credible, does represent an upper bound on what the potential radiological impact might be.

TABLE 9

INTRUDER EXPOSURES, BY PATHWAYS

Pathway	Max Whole Body Dose (MREM)	Max Organ Dose Child-Lung (MREM)
Inhalation (resuspension)	1.1E-01	6.5E-01
ored Vegetables	4.9E-01	4.8E-01
afy Vegetables	2.5E-02	2.4E-02
Cow Milk	1.6E-01	1.5E-01
rinking Water	3.8E-01	
Direct Ground plane (from 6.2.2 above)	2.7E-01	2.7E-01
Totals	1.5E+00	1.6E+00

8.0 Conclusions

The total activity calculated to have been released over a ten year period and remaining now, is of the order of 81.3 millicuries, 80 millicuries of which is calculated to be Tritium, based upon its concentration in reactor water. Dilution with the estimated 200 liters per day of other non-radioactive liquids discharged through this sink over the same time period, results in a tritium concentration, discounting any decay or further dilution, of the order of 1.0E-03 uCi/ml. The 10CFR20 Appendix B, Table II allowable release concentration for Tritium is 3E-03 uCi/ml., thus, the current estimated inventory, at its present estimated concentration, could be released under current regulation. No other radionuclide under consideration approaches the limits specified in 10CFR20. The alternative to in-place disposal is exhumation of this material and possible disposal as radioactive waste, or the subject of an additional application for disposal by alternate means, at a great increase in cost with no associated significant increase in benefit. The material, being located under plant

TABLE 10

SUMMARY OF EXPOSURES

OFF-SITE PATHWAYS	WB (MREM)	ORGAN (MREM)
Drinking Water Ingestion	2.5E-05	6.3E-05
Fish Ingestion	8.3E-04	1.2E-03
Irrigation Exposure Pathway	1.2E-04	4.0E-04
Shoreline Direct Exposure	2.2E-05	-
ON-SITE PATHWAYS		
Well Water Ingestion	3.8E-01	1.9E-01
Direct Ground Plane	2.7E-01	-
Inhalation (Resuspension)	1.1E-01	6.5E-01
Stored Vegetables	4.9E-01	4.8E-01
Leafy Vegetables	2.5E-02	2.4E-02
Cow Milk	1.6E-01	1.5E-01

structures, is impossible to safely remove without essentially decommissioning a large portion of the plant.

In the past the NRC staff has considered the potential effects on the environment of licensed material from operation of nuclear power plants, and in the evaluation of radiological impacts, generally conclude that operation of plants will contribute only a small increment of the radiation dose that persons living in the area normally receive from background radiation, and fluctuations of the natural background dose may be expected to exceed the small dose increment contributed by the operation of the power plant.

Since the disposal herein proposed involves licensed material containing a small fraction of the radioactivity already considered acceptable under the Radiological Effluent Technical Specifications (RETS), and involves pathways much less significant, and in a radiochemical form much less mobile than those

considered in the RETS, it is concluded that this application has an insignificant radiological impact.

In reality it is not expected that loss of control over the Vermont Yankee site will occur in the near term time frame, however, even should an intruder settle atop the disposed material, the radiological consequences would remain minimal.

Vermont Yankee, therefore requests approval from the commission to dispose of an existing quantity of radioactively contaminated material containing an estimated total of 82 mCi, (80 mCi of which is tritium), by leaving the material in place in its current location under the floor of the plant Chemistry Laboratory.

9.0 References

1. ENSR Consulting and Engineering, Environmental Site Assessment of Chemical Laboratory Subsurface, Vermont Yankee Nuclear Power Corp., Vernon, VT., April 1991.

2. USNRC Regulatory Guide 1.109, Calculation of Annual Dose to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10CFR50, Appendix I, rev.1, October, 1977.

3. Vermont Yankee Final Safety Analysis Report, Section 2.4.3 and Table 2.4.3.

4. NUREG-0782 Draft Environmental Impact Statement on 10CFR Part61 "Licensing Requirements for Land Disposal of Radioactive Waste", USNRC, September, 1981.

5. IDLE, A computer program used to calculate receptor doses from routine liquid effluent releases in accordance with Regulatory Guide 1.109, Rev 8, Yankee Atomic Electric Company, August, 1987.

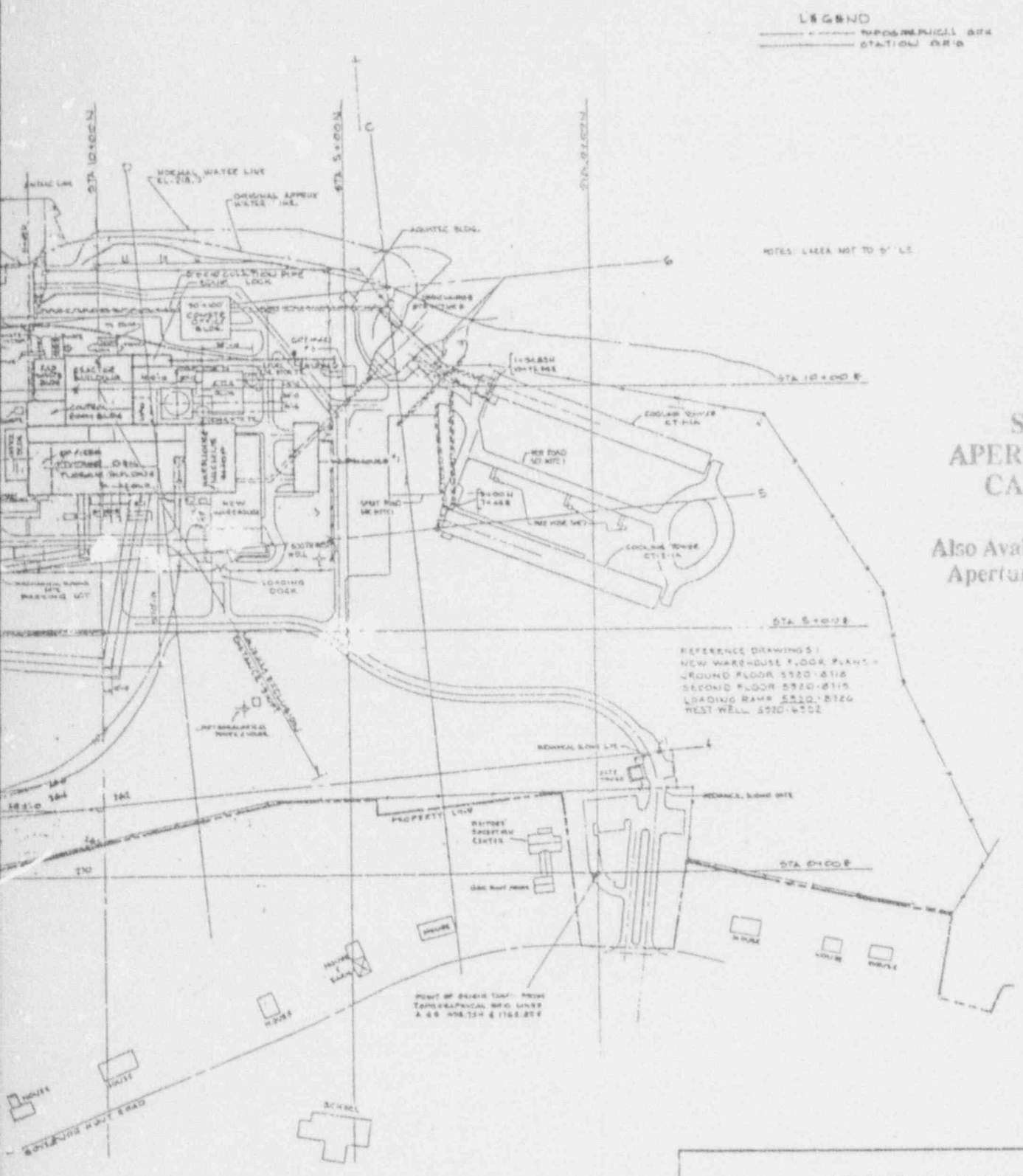
6. DIDOS-IV A computer program that calculates direct gamma dose rates from cylindrical sources, Yankee Atomic Electric Company, November, 1988.

7. RESRAD, ver. 4.3, USDOE, Methodology Description for Compliance with DOE Order 54005, Chapter IV, in press.

8. NUREG/CR-3332, Radiological Assessment, Chapter 4, U.S. Nuclear Regulatory Commission, September, 1983.

Appendix 1 Vermont Yankee Site Plan


TRUE NORTH
PLANT NORTH
MAX WATER ELEVATION
EL 336.0
NORMAL WATER ELEVATION
EL 330.0
CONNECTICUT RIVER
INTAKE
L.L. RAD. WASTE SITE
SEPTIC TANK
345 KV SWITCHYARD
WEST WELL
MET TOWER
BARN
GARAGE
HOUSE



VERMONT YANKEE
NUCLEAR POWER STATION

Station Plan

Figure 2.2.4

REV #6

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