THE TECHNICAL BASIS FOR THE "NON-IMPACTED AREA" CLASSIFICATION ASSOCIATED WITH THE DECOMMISSIONING OF THE YANKEE NUCLEAR POWER STATION

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ABSTRACT

As part of the decommissioning process for the Yankee Nuclear Power Station, the property was classified into one of three designations: Affected, Unaffected, and Non-Impacted. Of the 2200 acres owned by Yankee Atomic Electric Company at the Rowe power station, only about 30 acres have a reasonable potential for rad contamination and have been classified as Affected or Unaffected for the Final Status Survey (FSS) following the guidance of NUREG/CR-5849. This includes the Owner Controlled Area (i.e., all-principal plant building and facilities), a 20-meter wide buffer zone surrounding the Owner Controlled Area, and other routinely utilized plant areas. During the FSS, the Affected and Unaffected areas will be extensively surveyed and evaluated for residual radioactivity in order to demonstrate compliance with the site release criteria for unrestricted access. Most of the site property, however, has no significant potential for radiological contamination. Taking guidance from MARSSIM, this area has been classified as "Non-Impacted" with the resulting reduction in the extent of survey efforts needed over this substantial land area. This will allow for early release of the land and cost savings in maintaining the focus of the FSS on those sections of the site that have potentially been impacted by plant operations. The justification for classifying over 98% of the site property as Non-Impacted is based on a documented evaluation, which includes: (1) review of operational Radiological Environmental Monitoring Program (REMP) reports; (2) review of historical records for identification of past sites uses, including review of aerial photographs; (3) projection of expected residual soil radionuclide concentrations based on 32+ years of permitted plant effluents; and (4) review of soil characterization sample data taken as part of the site area classification assessment.

INTRODUCTION

The Yankee Nuclear Power Station (YNPS) is located on a 2200-acre site along the Deerfield River in the towns of Rowe and Monroe Bridge, Massachusetts. Only about 10 acres of the site was developed for plant structures. The major plant facilities are located at the bottom of a deep river valley at the corner of a small hydroelectric dam and reservoir on the Deerfield River. The vast majority of the site property surrounding the facility structures is mostly wooded with very steep slopes on both sides of the river. The hills surrounding the plant rise about 1000 feet above the river level within one mile and extend from 10 miles north to 8 miles south southeast of the site.

YNPS achieved initial criticality in 1960. The Nuclear Steam Supply System (NSSS) was a four loop pressurized water reactor with a thermal power design limit of 600 Mwt and electric output of 185 Mwe. In February 1992, Yankee Atomic Electric decided to cease power generation

after more than 32 years of operation and begin the decommissioning process. The Decommissioning Plan was filed with the NRC in late 1993 and approved in February 1995. To-date, spent fuel remains in storage in the Spent Fuel Pool, which has been isolated from the balance of plant. All other major components of the NSSS have been removed and shipped offsite for disposal. The final objective of the decommissioning project is to remove all structures and return the site to a "green field".

AREA CLASSIFICATIONS

Within the scope of the approved Decommissioning Plan, commitments were made to conduct the required Final Status Survey (FSS) following the guidance provided in NUREG/CR-5849 [(1)]. Under the NUREG/CR-5849 classification system, the site is divided into "Affected" and "Unaffected" areas based on the expectation and potential for radiological contamination being present. The classification of areas as Affected or Unaffected dictates the level of survey coverage necessary to achieve an acceptable level of confidence that an area satisfies the established release limits. The "Affected" area of the site is limited to about 10 acres. This includes areas locations of known radioactive contamination and the immediate surrounding areas (based on past or preliminary radiological surveys) due to one or more of the following activities in the area: 1) the use or storage of radioactive materials; 2) spills or other unusual occurrences that could have resulted in the spread of contamination; or 3) the burial of radioactive material. Areas which are expected to have contamination existing at average levels in excess of 25% of the average total surface contamination or soil guideline values, or greater than the Minimum Detectable Concentration (MDC) for the equipment used to perform the survey, which ever is larger.

"Unaffected" Areas have a low potential for radioactive contamination, based on knowledge of site history and previous survey information. Average measurements for total surface contamination and radionuclide concentrations in soil or asphalt are expected to be less than 25% of the applicable GuideLine Value (GLV) or less than the MDC for equipment used to perform the survey, whichever is larger. The designation of Unaffected areas includes sufficient space to act as a buffer around Affected areas such that it would be highly unlikely that the spread of contamination beyond the outer boundary of the Unaffected area could occur, and therefore go undetected. This includes about 20 additional acres of land surrounding the "Affected Area".

The balance of the site property owned or controlled by YNPS includes approximately 2170 acres, or about 98% of the total site area. Under the guidance provided in NUREG/CR-5849, there is no FSS classification that would be designated for this area. However, since this extended land area is owned by the company, it was felt that additional evaluations should be conducted to demonstrate that it was appropriate not to have included this outer property within one of the NUREG/CR-5849 area definitions. If the "Unaffected Area" classification were to be extended beyond the existing 20 acre buffer, an additional 7000 soil samples would be required along with about 217 acres of surface scans over very difficult or inaccessible terrain. The effort needed to accomplish this level of survey would have substantially increased the cost of the FSS while diverting resources from areas that had already been determined to have some potential of have radioactive contamination. In order to determine if the "Unaffected Area" designation needed to be extended over the entire site, the following evaluation steps were implemented: (1) review of operational Radiological Environmental Monitoring Program (REMP) reports; (2)

review of historical records for identification of past sites uses, including review of aerial photographs; (3) projection of expected residual soil radionuclide concentrations based on 32+ years of permitted plant effluents; and (4) review of soil characterization sample data taken as part of the site area classification assessment. Guidance and terminology was taken from MARRSIM [(2)] for the designation of this outer property as an "Non-Impacted Area", though it should be noted that a minimal number of soil concentration measurements and exposure rate surveys were performed in this area during the Final Status Survey in order to further support the "Non-Impacted" area classification, and allow for a logical presentation of the data to NRC in a format resembling a Final Status Survey package. This goes beyond the definition of "Non-Impacted Area" since no survey or sample collection / analysis requirements exist in MARRSIM for this designation. In order to capture this area within the FSS process and to facilitate NRC review, the entire 2170 acres were treated as a single FSS survey unit.

The results of the evaluations that were performed to assess the "Non-Impacted Area" designation follow:

Radiological Environmental Monitoring Program (REMP) Review

A review was conducted of the Radiological Environmental Operating Reports for the operational and post operational periods of the plant (i.e., from 1961 through 1997). The review was conducted to search for evidence of detectable plant related contamination, or the demonstrated lack of such contamination, in open land areas of the site or in areas adjacent to it that might have been subject to plant effluents. Included in the review were those airborne pathway sample media that have been collected and monitored at various times throughout the plant's history. These included air particulate and charcoal filter results from air monitoring, soil sample collection and laboratory gamma analyses, *in situ* gamma spectroscopy of land survey areas, mixed vegetation, food crops and cattle feed.

Each of the evaluated sample media had naturally occurring radioactivity, as well as radioactivity from nuclear weapons testing fallout deposited during the 1960's, 70's, and early 80's. There were, however, several suspected positive measurements of YNPS-related radioactivity in air particulate and vegetation samples taken during the mid-1970's. Each of these was followed, in subsequent years, by two or three soil and *in situ* surveys that detected no plant-related contamination in the surrounding soil, thereby demonstrating that these occurrences were either statistical anomalies, or had no lasting or significant impact on the surrounding soil.

This review of airborne pathway data from annual REMP reports did not lead to the identification of any outer property or nearby off-site areas that would have a significant chance of contamination due to YNPS operations. This conclusion supports the "Non-Impacted Area" classification for open land areas outside of the designated Unaffected Area of the site.

Historical Record Review for Past Site Uses

A review of historical land use patterns across the site area was performed based on several sources of information. Plant construction records and interviews with plant personnel and retirees whose experience cover the operating life of the plant were reviewed for possible identification of plant activities that may have extended into land areas currently not considered

part of the facility proper. In addition, a time series of aerial photography of the site (i.e., 1951, 1958, 1966, 1970, 1974, 1980, 1981, 1982, 1989 and 1990) were utilized to document past land use and housekeeping practices in the site area. The primary objective of the photographic review was to locate past activities directly related to plant operations, which may not be easily determined or located from the written records. Photos were found available from various government agencies and were typically in 9- inch-by-9-inch, black and white stereo pairs. Enlargements of some area were also available, as well as some color photos, although the resolution of these photos were not necessarily an improvement over that provided by the stereoscopic pairs.

Historical record review shows that areas beyond those already designated as either "Affected" or "Unaffected" are heavily wooded and over very hilly terrain. Parts of the site property that had been used for construction material disposal, or contained structures such as the septic leach fields, were not included in the "Non-Impacted Area" designation. The only human activity visible from the photos across the "Non-Impacted Area" relates to the construction and maintenance of the electric transmission right-of-ways, local roadways, and some lumbering operations. None of these activities involved any plant interfaces that could have created the potential for the spread of radioactive contamination. This review, therefore, supported the conclusion that the "Non-Impacted Area" designation for the open land outside the "Unaffected Area" is appropriate.

Projection of Expected Residual Soil Radioactivity from Plant Effluents:

A separate evaluation of the long term impact that plant effluent releases over its operating history may have had on deposited radioactivity in the designated "Non-Impacted Areas" of the site property. The method applied in this bounding calculation followed these primary steps:

(1) A tabulation of all gaseous effluent releases by year from 1960 through 1992 was complied from plant effluent records. Each radionuclide was then decay corrected from the time of release to January 1, 1998 as a measure of the quantity of radioactivity still present in the environment.

(2) A conservative atmospheric deposition factor (D/Q) was calculated using NRC standard modeling approaches as discussed in Regulatory Guide 1.111 [3]. This modeling was run with a long-term record (5 years) of site meteorological data taken from the plant's met tower as the primary input. This met history input was also combined with site parameter information such as effluent stack height, surrounding building cross sectional areas, and terrain height changes with distance and direction from the release point in order to reflect site conditions. The point of maximum air deposition was then determined by calculating deposition values across a matrix of points that covered the surrounding property, with the selection of the single maximum value as a conservative representation of all areas with the property boundary. The maximum long-term time averaged D/Q value was set at 8.79E-08 m^{-2}.

(3) The maximum soil concentration of each surviving radionuclide was then calculated following assumptions taken from Regulatory Guide 1.109 [(4)]. It was assumed that deposited activity is retained in the top 15-cm soil depth, which has an effective surface density of 240 kg/m^2. The soil depth is considered appropriate for this application given that the deposition occurred over a thirty-year period, with snow and rain serving to disperse the activity. In addition, this depth estimate is supported by surface contamination measurements taken within the Affected Area as a result of past operational events which also shows that the vertical migration down into the soil is essentially retained in the top 6 inches.

The four particulate radionuclides released in gaseous effluents that were found to have the highest potential of remaining in soil are listed in Table 1.

Table1
Maximum Expected Soil Concentration in the Non-Impacted Area
Based on YNPS Effluent History

Radionuclide	Projected Soil Concentration (pCi/g)
Sr-90	2.6E-04
Cs-134	4.9E-07
Cs-137	1.0E-04
Co-60	1.3E-04

NUREG-1301 [(5)] provides guidance for environmental lower limits of detection (LLD's) which are 0.15 and 0.18 pCi/g for Cesium-134 and Cesium-137, respectively. The soil concentration values determined for Table 1 are several orders of magnitude below the NRC requirements for routine environmental analysis detectability. This assessment of projected residual activity from past effluent releases supports the "Non-Impacted Area" classification since any residual radioactivity would not be expected to result in measurable quantities for areas beyond the "Unaffected Area" buffer zone located outside the protected area fence. It is recognized that this analysis does not account for localized concentration of these materials in the environment. Such an affect would be countered by the conservatism built into the D/Q value and the large margin between the calculated levels and the LLD requirements.

Soil Characterization Data Assessment

As part of the initial site classification effort, numerous survey measurements, including soil sample analyses, were performed. This initial characterization task generated 29 gamma isotopic soil analyses over the property, which has now been designated as "Non-Impacted". No plant related radionuclides, other than Cesium-137, were found in the samples. Since Cesium-137 in the environment is primarily the result of past weapons testing fallout, a statistical comparison of the sample data with a background set of Cesium-137 concentrations in soil was performed to determine if the observed concentrations on the plant property were the same as, or indistinguishable, from background levels. The observed Cesium-137 soil concentrations ranged from less than the MDC (Minimum Detectable Concentration) of typically 0.1 pCi/g to a high

value of 1.64 pCi/g, with a mean value of 0.64 pCi/g and standard deviation of 0.498 pCi/g. The soil background determination was derived from 60 sample measurements with a mean value of 0.971 pCi/g (ranged from 0.292 to 2.16 pCi/g (dry) for undisturbed soils. When tested at a 95% confidence level (t-test), no significant difference was found between the two data sets.

The review of REMP and initial characterization soil data coverage of the outer plant property resulted in a decision to take a second set of 39 soil samples from an approximate 70-acre area east-southeast of the plant and outside the owner-controlled area fence. The primary reason for this second set was to provide characterization data over an area where limited information previously existed. The actual size and specific locations of this sampling were based on matching terrain height with the maximum effective plume height above plant grade for releases from the YNPS primary ventilation stack during plant operations. As with the initial characterization soil samples, no plant-related radionuclides, with the exception of Cesium-137, were detected. The upper 95% confidence level of the mean Cesium-137 concentration was less than the established background concentration, and similar to the value found in the first characterization set. The conclusion is that the Cesium-137 found on plant property beyond the owner-controlled area is the result of weapons fallout and not plant operations.

In addition to soil sample collection and analyses, an NRC sponsored aerial radiological survey of the site and local environment was performed in 1989. This aerial survey was flown at an altitude of 300 feet using a grid pattern composed of parallel flight lines spaced 500 feet apart. The aerial pattern covered an 87 square-mile area centered over the plant property. The aerial data were used to derive exposure rates at one meter above ground level. In support of the aerial measurements, ground-based exposure rates and soil samples were also obtained from various benchmark sites identified by the aerial survey. Radionuclide assay of the soil samples was performed to determine radioisotopic concentrations. The typical terrestrial gamma radiation exposure rates outside the owner-controlled area varied from 6 to 10 μR/hr. This was typical of background exposure rate measurements and demonstrated that at the time of the survey, observed exposure rates over the property area of concern were attributable to naturally-occurring radioactivity.

All information and evaluations (i.e., lack of plant use of the land, REMP history, aerial photographs and exposure rate measurements, projected residual soil concentrations from plant operations, and characterization soil sample analyses and surveys) formed the technical basis for the “Non-Impacted Area” classification of approximately 98% of the site property.

SOIL CONCENTRATION AND EXPOSURE RATE MEASUREMENTS UNDER FSS

The above evaluations were used to justify the classification of 2170 acres of plant property as “Non-Impacted”. Under the commitments in the License Termination Plan to treat the “Non-Impacted Area” as one survey unit, the FSS included 30 more distributed soil samples and exposure rate measurements taken from locations within the designated survey area. As applied in MARSSIM, “Non-Impacted Areas” do not require any radiation surveys or sample analyses. However, a minimal number of soil concentration measurements and exposure rate surveys were performed in this area in order to further support the "Non-Impacted" area classification, and allow for a logical presentation of the data to NRC in a format resembling a Final Status Survey package.

The results of the FSS showed that gross Cesium-137 values for all soil samples collected in the "Non-Impacted Area" are consistent with those found in control samples (background) taken during the site characterization phase, and the Radiological Environmental Monitoring Program. As such, this radioactivity is attributed to global fallout from atmospheric nuclear weapons testing. Other than Cesium-137, no other plant related radionuclides were detected in the soils. All exposure rate measurements also were found to have fallen within the expected range for natural-occurring radiation. Tables 2 and 3 summarize the results of the FSS surveys in the "Non-Impacted Area".

Table 2
Final Status Survey for "Non-Impacted Area"
Gamma Exposure Rate Results (net of Background)
(μR/hr)

No. of Measurements	Minimum	Maximum	Mean	Std. Dev.	GLV
30	-1.8	1.3	-0.5	0.9	5

Table 3
Final Status Survey for "Non-Impacted Area"
Gross Cesium-137 Soil Results
(pCi/g)

No. of Samples	Minimum	Maximum	Mean*	Std. Dev.	GLV
30	0.007	1.643	0.695	0.404	7.8

* The average background Cs-137 concentration for undisturbed areas is 0.971 pCi/g.

CONCLUSION

The "Non-Impacted Area" designation of the site open land area beyond the "Unaffected Area" buffer zone surrounding plant facilities is supported by the determinations that there were no past plant activities which could have lead to the potential for significant or measurable contamination of the property. This is confirmed by sample analyses and area survey results taken under the FSS.

REFERENCES

(1) NUREG/CR-5849, "Manual for Conducting Radiological Surveys in Support of License Termination", Draft Report for Comment, Oak Ridge Associated Universities, June 1992.

(2) NUREG-1575, "Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)", December 1997.

(3) USNRC Regulatory Guide 1.111, Rev. 1, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors"' July 1977.

(4) USNRC Regulatory Guide 1.109, Rev.1, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10CFR50, Appendix I", October 1977.

(5) NUREG-1301, "Offsite Dose Calculation Manual Guidance: Standard Radiological Effluent Controls for Pressurized Water Reactors", Generic Letter 89-01, Supplement No. 1, April 1991.