Zion*Solutions*, Inc.

PROJECT PLAN

CHARACTERIZATION SURVEY PLAN

ZS-LT-02

Revision 03

STOP THINK ACT REVIEW

Originator:	David Wojtkowiak, Radiological Consultant	Date:	05/06/15
Reviewer:	Robert Yetter, Characterization/License Termination Manager	Date:	7/6/15
Approval:	Donald E Williams, Vice President, Radiological and Environmental Controls	Date:	7/6/15

Summary of Changes in this Revision:

- Rev. 3 – Rewritten to reflect and comply with terminology, approaches and commitments presented in *"Zion Station Restoration Project License Termination Plan"* – December 2014.

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1. INTRODUCTION

The characterization of the Zion Nuclear Power Station (ZNPS) site commenced on November 2, 2011. Characterization of the impacted and non-impacted open land survey units, as well as the structural building basements that would remain at license termination, was accomplished in the following 23 months with the initial site characterization campaign concluding in October of 2013. During this period, 145,730 m^2 of surface soil was scanned, 1,037 surface soil samples and 699 subsurface samples were acquired and analyzed, 282 static measurements were taken on surface soils using a Canberra *In Situ* Object Counting System (ISOCS), direct scans were performed over approximately 17,700 m^2 of basement structures below the 588 foot elevation, 109 concrete core samples were acquired from subsurface basement structures, and samples and measurements were taken inside building drain systems.

Throughout the initial characterization effort, survey activities were performed in parallel with radioactive commodity removal and radioactive waste shipment activities at ZNPS. Consequently, the removal and movement of radioactive material directly impacted access to certain structural survey units and open land areas to obtain meaningful characterization survey data. In these cases, characterization was deferred until radiological or physical conditions would allow access to these survey units. The characterization will continue throughout the decommissioning process, including following the submittal of the License Termination Plan (LTP) (Reference 1) and up to the time when surveys are performed to demonstrate compliance with the unrestricted release criterion.

This revision of the Characterization Survey Plan presents the approach and process to continue the characterization of ZNPS. It provides guidance and direction to personnel responsible for implementing and executing characterization survey activities. The revised Characterization Survey Plan works in conjunction with the LTP, implementing procedures, and survey unit specific survey instructions (sample plans) developed to safely and effectively acquire any requisite characterization data.

Characterization data acquired through the execution of this plan is used to meet three primary objectives:

- Ensure Final Radiation Survey (FRS) provides the expected results.
- Ensure radiological conditions and assumptions used in the LTP to derive site specific unrestricted release criterion for ZNPS remains valid.
- Continue the evaluation of remediation alternatives and technologies.

The term "Final Radiation Survey" (FRS) is from 10 CFR 50.82(9)(ii)(D) and is used in the LTP to acknowledge the distinction between the two types of compliance surveys to be performed by the Zion Station Restoration Project (ZSRP). These surveys are; (1) Final Status Survey (FSS) to be conducted in accordance with NUREG-1575, *"Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM)*"* (Reference 2) on soil, buried piping and groundwater to demonstrate that residual radionuclide concentrations are equal to or below site-specific concentration-based Derived Concentration Guideline Levels (DCGL), and (2) a "Source Term Survey" (STS) to be conducted to demonstrate that the inventory of residual radioactivity in building basements, embedded piping and penetrations is below a source term inventory commensurate with the dose criterion in 10 CFR 20.1402.1.

Section 8.5 of Exhibit C, Lease Agreement, titled "Removal of Improvements; Site Restoration" integral to the *"Zion Nuclear Power Station, Units 1 and 2 Asset Sale Agreement"* (Reference 3) requires the demolition and removal of all on-site buildings, structures, and components to a depth of at least three feet below grade. Several minor structures, such as the Switchyard, the Independent Spent Fuel Storage Installation (ISFSI), the ISFSI Warehouse, the microwave tower, and the Sewage Lift Station, as well as all roadways and rail lines, will remain at license termination as requested by Exelon. The major structures to remain at license termination and be subjected to STS include the following; basements of the Unit 1 and Unit 2 Containment Buildings, Auxiliary Building, Turbine Building, Waste Water Treatment Facility (WWTF), the lower portion of the Spent Fuel Pool (SFP), the Fuel Transfer Canal, Crib House and Forebay, Unit 1 and Unit 2 Steam Tunnels and the Circulating Water Intake, and Discharge Tunnels below the 588 foot elevation (3 feet below grade). All systems, components, and structures above the 588 foot elevation (with the exception of the minor structures previously noted) will be removed during decommissioning and disposed of as a waste stream.

In both Containment basements, all concrete will be removed from the interior side of the steel liner, leaving only the remaining exposed liner below the 588 foot elevation and the structural concrete outside of the liner. In the Auxiliary Building, all interior walls and floors will be removed, leaving only the exterior walls and basement floor. In the Turbine Building basement, the remaining structures will consist of reinforced concrete floors and exterior foundation walls and the sub-grade portions of the pedestals below the 588 foot elevation. For the Fuel Handling Building, the only portion of the structure to remain is the lower 12 feet of the SFP below 588 foot elevation and the concrete structure of the Fuel Transfer Canals, once the steel liner has been removed. Other below ground structures to remain are the lower concrete portions of the WWTF, Main Steam Tunnels, and Circulating Water Inlet Piping and Discharge Tunnels. The current decommissioning approach for ZSRP also calls for the beneficial reuse of concrete from building demolition as clean fill. Concrete that meets the non-radiological definition of clean concrete demolition debris and where radiological surveys demonstrate that the concrete is free of plant derived radionuclides above background will be used. Radiological surveys will be performed in accordance with the guidance of NUREG-1575, Supplement 1, *"Multi-Agency Radiation Survey and Assessment of Materials and Equipment Manual"* (MARSAME) (Reference 4).

2. DEFINITIONS AND ACRONYMS

2.1. Definitions

2.1.1. Action Levels - A derived media-specific, radionuclide-specific concentration or gross activity level of radioactivity that triggers a response, such as further investigation or remediation, if exceeded.

2.1.2. Biased Measurements - Measurements performed at locations selected using professional judgment based on unusual appearance, location relative to known contamination areas, high potential for residual radioactivity or other general supplemental information.

2.1.3. Data Quality Assessment (DQA) - The scientific and statistical evaluation of data to determine if the data are of the right type, quantity, and quality to support their intended use.

2.1.4. Data Quality Objectives (DQO) - Qualitative and quantitative statements derived from the DQO process that clarify technical and quality objectives, define the appropriate type of data, and specify tolerable levels of potential decision errors that will be used as the basis for establishing the quality and quantity of data needed to support decisions.

2.1.5. Derived Concentration Guideline Level (DCGL) - A derived, radionuclide-specific activity concentration within a survey unit corresponding to the release criterion. DCGLs are derived from activity/dose relationships through various exposure pathway scenarios.

2.1.6. Final Radiation Survey (FRS) - Measurements and sampling to describe the radiological conditions of a site, following completion of decontamination activities (if any) in preparation for release.

2.1.7. Final Status Survey (FSS) - Surveys conducted on soil, buried piping and groundwater to demonstrate that residual radionuclide concentrations are equal to or below site-specific DCGLs.

2.1.8. Gray Region - A range of values of the parameter of interest for a survey unit where the consequences of making a decision error are relatively minor.

2.1.9. Impacted Area - An area with a possibility of containing residual radioactivity from licensed activities in excess of natural background or fallout levels.

2.1.10. Mean - The average value obtained when the sum of individual values is divided by the number of values.

2.1.11. Measurement - For the purpose of characterization, it is used interchangeably to mean: 1) the act of using a detector to determine the level or quantity of radioactivity on a surface or in a sample of material from a media being evaluated, or 2) the quantity obtained by the act of measuring.

2.1.12. Median - The center of the data set when data points are ranked in order from smallest to largest.

2.1.13. Minimum Detectable Concentration (MDC) - The minimum detectable concentration is the *a priori* activity level that a specific instrument and technique can be expected to detect 95% of the time. When stating the detection capability of an instrument, this value should be used. The MDC is the Detection Limit (L_D), multiplied by an appropriate conversion factor to give units of activity concentration.

2.1.14. Non-impacted Area - Area where there is no reasonable possibility (extremely low probability) of residual contamination from licensed activities.

2.1.15. Outlier - A measurement that is unusually large or small relative to the sample population and therefore is suspected of misrepresenting the population from which it was collected.

2.1.16. Range - The measure of difference between the largest and smallest values in a data set.

2.1.17. Reference Area - Geographical area from which representative reference measurements are performed for comparison with measurements performed in a specific survey unit at remediation site. A site radiological reference area (background area) is defined as an area that has similar physical and radiological characteristics as the site area being remediated, but which has not been contaminated by site activities.

2.1.18. Site - The land area and buildings comprising the ZNPS.

2.1.19. Source Term Survey - Surveys conducted to demonstrate that the inventory of residual radioactivity in building basements, embedded piping and penetrations is below a source term inventory commensurate with the dose criterion in 10 CFR 20.1402.

2.1.20. Survey Area - Survey areas are established based on logical physical boundaries and site landmarks for the purpose of documenting and conveying radiological information, and in order to facilitate the scheduling, management and reporting of characterization data. The survey areas may be sub-divided into one or more survey units.

2.1.21. Survey Unit - A contiguous unit within a survey area of similar use history and the same classification of contamination potential.

2.1.22. Type I Error - A decision error that occurs when the null hypothesis is rejected when it is true for the scenario used. This would result in incorrectly releasing an area that does not meet the release criteria.

2.1.23. Type II Error - A decision error that occurs when the null hypothesis is not rejected when it is false for the scenario used. This would result in failing to release an area that meets the release criteria.

2.1.24. Unity Rule - A rule applied when more than one radionuclide is present at a concentration that is distinguishable from background and where a single concentration comparison does not apply. In this case, the mixture of radionuclides is compared against default concentrations by applying the unity rule. This is accomplished by determining: the fraction between the concentration of each radionuclide in the mixture, and the concentration for that radionuclide in an appropriate listing of default values. The Sum of Fractions (SOF) for all radionuclides in the mixture should not exceed 1.

2.2. Acronyms

ALARA	As Low As Reasonably Achievable
AMCG	Average Member of the Critical Group
C/LT	Characterization/License Termination
CsI	Cesium Iodide
DQA	Data Quality Assessment
DQO	Data Quality Objectives
DCGL	Derived Concentration Guideline Level
FOV	Field of View
FRS	Final Radiation Survey
FSS	Final Status Survey
GPS	Global Positioning System
HASP	Health and Safety Plan
HTD	Hard-to-Detect
HSA	Historical Site Assessment
ISFSI	Independent Spent Fuel Storage Installation
ISOCS	*In Situ* Object Counting System
JHA	Job Hazard Analysis
LBGR	Lower Bound of the Grey Region
L_D	Detection Limit
LTP	License Termination Plan
MARSAME	Multi-Agency Radiation Survey and Assessment of Materials and Equipment
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MW	Megawatts
MDC	Minimum Detectable Concentration
NAD	North American Datum
NaI	Sodium Iodide
NIST	National Institute of Standards and Technology

NRC	Nuclear Regulatory Commission
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RA	Radiological Assessments
RASS	Remedial Action Support Surveys
RE	Radiological Engineer
RRA	Radiological Restricted Area
ROC	Radionuclides of Concern
RWP	Radiation Work Permit
SFP	Spent Fuel Pool
SOF	Sum of Fractions
STS	Source Term Survey
TEDE	Total Effective Dose Equivalent
THA	Task Hazard Assessment
TSD	Technical Support Document
VSP	Visual Sample Plan
WWTF	Waste Water Treatment Facility
ZNPS	Zion Nuclear Power Station
ZSRP	Zion Station Restoration Project

3. SCOPE OF THE CHARACTERIZATION PLAN

Characterization incorporates the results of investigations and surveys conducted to quantify the extent and nature of contamination at the ZNPS site. The results of site characterization surveys and analyses will continue to be used to identify areas of the site that require remediation, as well as to plan remediation methodologies, develop waste classification and volumes, and estimate costs.

During the initial site characterization, the surveys of many inaccessible or not readily accessible subsurface soils and structural surfaces were deferred. Examples of these areas include soils under structures, concrete, or asphalt coverings, underlying concrete of the SFP and Transfer Canal, interiors of embedded and/or buried pipe that may remain, and interior and exterior of both Containment domes. Deferring characterization in these areas was based on one or more of the following conditions:

- ALARA considerations (e.g., the area was either a high radiation or high contamination area and additional data would likely not change the survey area or area classification of the location or surrounding areas).

- Safety considerations (e.g., difficulty of access to the upper reaches of the Containments due to height).
- Historical data shows that the area could be classified without further characterization.
- Access for characterization would require significant deconstruction of adjacent systems, structures or other obstacles where the removal could result in an unsafe condition or interfere with continued operation of operating systems.
- The ability to use engineering judgment in assigning the area a classification based on physical relationship to surrounding areas and the likelihood of the area to have radiological conditions represented by the conditions in these adjacent areas.

As access is gained to these areas, additional characterization data will be collected, evaluated, and stored with previous radiological survey data in a survey history file for the survey unit. This data will supplement existing data to update both the types of radionuclides present and the variability in the radionuclide mix for both gamma-emitting and Hard-to-Detect (HTD) radionuclides. As decommissioning progresses, data from operational events caused by equipment failures or personnel errors, which may affect the radiological status of a survey unit(s), will also be captured, evaluated, and when appropriate, stored in the survey history file. This additional characterization data may be used in validating the classification of a survey unit and in planning for FRS.

Characterization surveys are designed and executed using the guidance provided in MARSSIM and NUREG-1757, Volume 2, Revision 1, *"Consolidated Decommissioning Guidance - Characterization, Survey, and Determination of Radiological Criteria, Final Report"*, (Reference 5). In addition, surveys are designed and executed in accordance with the Zion*Solutions* ZS-LT-01, "*Quality Assurance Project Plan (for Characterization and FSS)*" (QAPP) (Reference 6) which describes policy, organization, functional activities, the DQO process, and measures necessary to achieve quality data. The information obtained from performing characterization provides guidance for decontamination and remediation planning. Materials contaminated with radioactive material at concentrations greater than the unrestricted release criteria will continue to be removed and properly packaged for shipment and disposal.

The characterization survey process incorporates survey data from initial site characterization, historical information from the *"Zion Station Historical Site Assessment"* (HSA), (Reference 7) as well as static measurements, scan measurements and/or sampling and analyses taken to adequately present the current radiological condition of each survey unit.

Radiological characterization provides reliable information for the quantity and type of radionuclides, their distribution, and their physical state. This information provides decommissioning planning personnel the ability to assess various options and their consequences, considering:

- Operating techniques, decontamination processes, dismantling procedures (hands on, semi-remote, or fully remote working), and the tools required.
- The protection for workers, the general public, and the environment.

- Waste classification.
- Resulting costs.

The objectives for characterization surveys at ZNPS are as follows:

- Validate and verify the full nature and extent of the final suite of dose significant Radionuclides-of-Concern (ROC), including HTD radionuclides specified in the LTP.
- Validate and verify that the radionuclide mixture derived for the Auxiliary Building is applicable to all structures and open land areas that will be subjected to FRS as specified in the LTP.
- Identify any additional structures that may be candidates for the beneficial reuse of concrete as hard fill.
- Determine or verify the lateral/vertical extent of radioactive contamination in basement concrete and sub-slab soils.
- Obtain additional data to provide guidance to decontamination personnel for waste management planning and decontamination/remediation activities planning.

If contamination from hazardous material other than radioactive material is identified during the performance of characterization, the Zion*Solutions* Environmental Group will be notified. The evaluation and determination of the need for further surveys, sampling, and analyses to identify and quantify non-radiological contaminants that may be present at ZNPS will be performed by the Zion*Solutions* Environmental Group.

4. BRIEF SITE DESCRIPTION

The ZNPS is located in Northeast Illinois on the west shore of Lake Michigan. The site is approximately 40 miles north of Chicago, Illinois, and 42 miles south of Milwaukee, Wisconsin. The site is in the extreme eastern portion of the city of Zion, (Lake County) Illinois, on the west shore of Lake Michigan approximately 6 miles NNE of the center of the city of Waukegan, Illinois, and 8 miles south of the center of the city of Kenosha, Wisconsin.

The station is comprised of two essentially identical pressurized water reactors with supporting facilities. Each unit's primary coolant system consists of a pressurized water reactor system designed by the Westinghouse Corporation and is comprised of the reactor vessel and four heat transfer loops. Each loop contains a reactor coolant pump, steam generator, and associated piping and valves. In addition, each unit includes a pressurizer, a pressurizer relief tank, interconnecting piping, and the instrumentation necessary for operational control. All major components of each unit's reactor coolant system are located in their respective containment building. The design reactor thermal power level was 3250 Megawatts thermal (MWth). The corresponding electrical output was approximately 1,085 Megawatts electric (MWe) for both Units 1 and 2.

The initial construction of the station was authorized on December 26, 1968. Unit 1 and Unit 2 achieved initial criticality on June 19, 1973 and December 24, 1973 respectively. Next, Unit 1 was synchronized to the grid for the first time on June 28, 1973 and Unit 2 on December 26, 1973. Finally, Unit 1 and Unit 2 began commercial operation on

December 31, 1973 and September 19, 1974 respectively. Between the two units, Zion operated for approximately 248,238,983 Megawatt hours (MWhrs) over the course of its operating lifetime.

On January 15, 1998, Commonwealth Edison (ComEd) announced the permanent shutdown of both Zion reactors. The shutdown decision was based on the corporation's economic determination that neither Zion reactor would be able to produce competitively priced electricity in a deregulated marketplace over the facility's remaining useful life.

On February 13, 1998, ComEd certified the permanent cessation of operation of ZNPS Units 1 and 2 to the Nuclear Regulatory Commission (NRC). On March 9, 1998, ComEd certified to the NRC that all fuel assemblies had been permanently removed from both ZNPS reactor vessels and placed in the SFP. Both units at ZNPS were subsequently placed in a SAFSTOR condition (a period of safe storage of the stabilized and defueled facility) until eventual final decommissioning and dismantlement.

Upon docketing of the certification for permanent cessation of operation and permanent removal of fuel from the reactor vessels, the 10 CFR Part 50 license no longer authorizes operation of the reactors or emplacement or retention of fuel in the reactor vessels. In addition, the operating licenses scheduled to expire in April 2013 for Unit 1 and November 2013 for Unit 2 continue to remain in effect until the NRC notifies Zion*Solutions* that the licenses have been terminated.

The reactors at Zion remained in a SAFSTOR condition until September of 2010. At this point, the license for the facility was transferred from Exelon Generation Company (Exelon) (the licensee at that time) to Zion*Solutions* LLC. This was accomplished to allow Zion*Solutions* to begin the process of the physical decommissioning of the ZNPS.

5. MANAGEMENT

Zion*Solutions* will provide the necessary personnel, materials and subcontractors to perform all phases of the ZNPS decommissioning, including performance of the characterization surveys described in this plan. Trained and experienced Zion*Solutions* and/or contractor personnel perform characterization surveys in accordance with this plan, using survey instructions and approved procedures.

5.1. Characterization Organization and Responsibilities

The duties and responsibilities of the various positions within the Radiological and Environmental Controls organization as they pertain to the implementation of this revised Characterization Plan are described below. Responsibilities for each position described may be assigned to a designee, as appropriate.

5.1.1. Vice President, Radiological and Environmental Controls

The Vice President, Radiological and Environmental Controls is responsible for the overall management and oversight for characterization activities, including staffing and resources to execute the sample plans.

5.1.2. Characterization/License Termination (C/LT) Manager

The C/LT Manager is responsible for the implementation of this Characterization Plan, as well as approving survey methodology, performance, and evaluation and analysis of resulting data. The C/LT Manager is also responsible for the control of samples and the review and approval of all characterization sample plans prior to implementation in the field.

5.1.3. Radiological Engineer (RE)

Radiological Engineers are responsible for the technical direction, development, and implementation of each characterization survey. This includes the preparation of survey designs (sample plans) and schedules, oversight for data collection, and supporting data evaluations. As part of the survey development, REs are responsible for approving the survey techniques and instrumentation, sampling locations and reference areas, and determining whether the acquired data supports the survey objectives.

5.1.4. Characterization/Final Radiation Survey (C/FRS) Supervisor/Engineer

The C/FRS Supervisor/Engineer is responsible for the control and implementation of characterization sample plans received from the RE and to ensure that all survey objectives are achieved. The C/FRS Supervisor/Engineer can also assist with the development of sample plans.

5.1.5. Radiochemist

The Radiochemist provides direction and support for project sampling activities, including sample collection, preparation, handling, storage, and shipment and ensures that all requisite instrument Quality Control (QC) and Minimum Detectable Concentration (MDC) criteria are met.

5.1.6. Laboratory Technician

The Laboratory Technicians perform radiological sample analysis of volumetric material and swipe samples obtained for characterization. They also operate radiological laboratory instrumentation in accordance with approved procedures and manufacturers' recommendations and ensure that all requisite instrument Quality Control (QC) and MDC criteria are met.

5.1.7. Characterization/Final Radiation Survey (C/FRS) Technician (Radiation Protection Technician)

C/FRS Technicians are responsible for collecting samples and obtaining and documenting survey measurements in accordance with the characterization sample plan instructions and approved procedures.

5.2. Training

Specific training for this Characterization Plan is provided to personnel who take measurements and/or collect samples for characterization. Training ensures that personnel performing characterization will have sufficient knowledge to perform work activities in accordance with this plan, the survey instructions, and approved procedures.

5.3. Procedures

Characterization is conducted in accordance with written procedures approved for use by Zion*Solutions* management. Procedures are implemented and controlled to ensure that operations are performed in a safe and technically correct manner.

6. SURVEY UNITS AND CLASSIFICATION

The size of the entire ZNPS site is approximately 331 acres. Structures and open land classified as "impacted" by the operation of the facility are defined by a surrounding single-security fence line that has been designated as the "Radiologically Restricted Area" (RRA). The approximate area of the footprint is 87 acres. The area that was previously defined by the double-security fence line designated as the "Security Restricted Area" that contains all structures and open land areas initially classified as Class 1 is now considered part of the RRA.

In addition to the area within the RRA, several additional areas have been deemed as "impacted". These include the site parking lot, the open land area directly north of the site and the area along Shiloh Boulevard designated as the West Training Area. The parking lot and north field were designated as impacted as they represent the major path for material egress on and off the site. The West Training Area was once the location of the Training Building which housed a Westinghouse Nuclear Training Reactor. The training reactor was decommissioned and the license terminated by the NRC in 1988 and the structure was demolished in 2003.

The impacted ZNPS facilities and grounds were divided into survey units and assigned initial area classifications based on the operational history and the incidents and processes documented for that survey unit. The impacted open land survey areas at ZNPS have been subdivided into Class 1, Class 2, or Class 3 survey units. The initial classifications and survey unit boundaries for open land survey units were specified in the HSA. The initial classifications and STS survey unit boundaries for structural survey units are specified in LTP Chapter 5.

Characterization of the impacted survey units began in November 2011 with the characterization of the Class 3 open land survey units encompassing the proposed site for the future ISFSI facility, the "non-impacted" location where the Vertical Concrete Cask Construction Area was to be located and the pathway for the new rail tracks. The remaining balance of the "impacted" survey units were surveyed between November 2012 and October 2013.

For the characterization surveys of open land, survey unit size was determined based upon the guidance provided in MARSSIM, section 4.6, which states the following suggested physical area sizes for survey units for FSS as follows:

Table 6-1 Suggested Area Size for FSS Survey Units

Classification	Suggested Area
Class 1	
Land Areas	up to 2,000 m^2
Class 2	
Land Areas	2,000 m^2 to 10,000 m^2
Class 3	
Land Areas	No Limit

Open land survey units may be increased up to 10 percent in size to account for the impact of physical conditions. As an example, if an isolated Class 1 open land area has a size of 2,200 m^2, the area is considered only one survey unit.

With the exception of the Auxiliary Building, where the walls and floor are separate survey units, the STS survey units are comprised of the combined wall and floor surfaces of each remaining building basement (i.e. Unit 1 Containment, Unit 2 Containment, Turbine Building, Crib House/Forebay, WWTF and remnants of the SFP/Fuel Transfer Canal, and the Circulating Water Intake and Circulating Water Discharge Tunnels). Contamination potential was the prime consideration for grouping STS survey units. Contiguous surface areas with the same contamination potential will minimize uncertainty in the estimate of the mean inventory and ensure the appropriate level of areal coverage. Characterization data, radiological surveys performed to support commodity removal, and surveys performed to support structural remediation for open air demolition will be used to verify that the contamination potential within each STS survey unit is reasonably uniform throughout all walls and floor surfaces.

Survey units have not been established for systems (e.g. embedded or buried piping). If the DQOs developed for the characterization of a structural or open land survey unit require the acquisition of radiological survey data on systems, then the survey will be designed and documented in the structural or open land survey unit in which it resides.

Although it is expected that the classification of existing areas and conceptual survey units will require little modification the characterization process is iterative. When additional characterization data is obtained during the decommissioning process, the DQO process will be used to verify that the initial classification is appropriate, to guide reclassification of the survey unit, and/or to guide the design of subsequent surveys, if necessary.

Initial survey area numbers, survey unit numbers and survey unit classifications in accordance with the HSA and characterization surveys performed to date are presented in Table 6-2, “Survey Units for Open Land Areas” and Table 6-3, which presents the STS survey units and the initial survey unit classifications for each from LTP Chapter 5.

Throughout the decommissioning process, these survey units may be altered by changing the boundaries, adjusting the survey unit areas, breaking the survey unit into one or multiple smaller survey units. Tables 6-2 and 6-3 will not be revised to reflect these changes. A master copy of the survey units is maintained by the C/LT Manager. As changes are made to the physical boundaries of survey units and, as survey unit classifications change due to the results of characterization, Remedial Action Support Surveys (RASS) and Radiological Assessments (RA), the master copy is updated by the C/LT Manager until final classification for FRS is performed. This Characterization Plan will not be revised to reflect these changes.

Table 6-2 Survey Units for Open Land Areas

Survey Unit No	Survey Unit Description	Survey Unit Area (m^2)	Current Classification	Date of Last Change
12101	WWTF Sludge Drying Bed Area	2,036	Class 1	HSA
12102	Waste Water Treatment Facility (WWTF)	2,024	Class 1	HSA
12103	Unit 2 PWST/SST Area	2,034	Class 1	HSA
12104	North Half of Unit 2 Containment	1,940	Class 1	HSA
12105	South Half of Unit 2 Containment	1,938	Class 1	HSA
12106	North Half of Fuel & Auxiliary Buildings	1,936	Class 1	HSA
12107	South Half of Fuel & Auxiliary Buildings	1,935	Class 1	09/11/12
12108	North Half of Unit 1 Containment	1,933	Class 1	09/11/12
12109	South Half of Unit 1 Containment	1,931	Class 1	HSA
12110	Yard Between Unit 1 Containment and Turbine	1,740	Class 1	HSA
12111	South Yard Area Northeast of Gate House	1,964	Class 1	09/11/12
12112	Unit 1 PWST/SST Area West	1,693	Class 1	07/31/12
12113	Unit 1 PWST/SST Area East	1,658	Class 1	07/31/12
12201	North Protected Area Yard	9,610	Class 2	HSA
12202	Gate House and Southwest Yard	7,574	Class 2	04/17/13
12203	Under Service Building and South East Yard	7,569	Class 2	HSA
12204	Crib House Area	5,909	Class 2	HSA
12205	Area Under the Turbine Building	9,085	Class 2	HSA
10201A	NE Corner of Restricted Area -	6,028	Class 3	09/10/13

Survey Unit No	Survey Unit Description	Survey Unit Area (m^2)	Current Classification	Date of Last Change
	Lakeshore			
10202A	IRSF/Fire Training Area	6,844	Class 3	09/10/13
10203	East Training Area	9,998	Class 3	04/19/13
10204	North Gate Area	7,228	Class 3	04/19/13
10205	Switchyard	54,573	Class 3	02/04/13
10206	Station Construction Area	10,529	Class 3	04/19/13
10207	North Warehouse Area	10,274	Class 3	04/16/13
10208	South Warehouse Area	11,821	Class 3	04/18/13
10209	Restricted Area South of Gate House	5,971	Class 3	04/19/13
10210	Restricted Area South of Turbine Building	5,594	Class 3	04/19/13
10211	Southeast Corner of Restricted Area - Lakeshore	3,199	Class 3	04/19/13
10212A	NE Corner of Exclusion Area - Lakeshore	12,256	Class 3	06/03/13
10212B	VCC Construction Area	15,364	Class 3	10/06/11
10213A	NE Corner of Exclusion Area	12,255	Class 3	06/05/13
10214	Construction Parking Area	33,551	Class 3	10/14/13
10218A	ISFSI Area East	11,559	Class 3	07/30/12
10218B	ISFSI Area East	11,559	Class 3	07/30/12
10218F	Area Near South of Switchyard	3,152	Class 3	07/24/13
10219A	Area Far South of Switchyard (Part A)	2,433	Class 3	06/03/13
10219B	Area Far South of Switchyard (Part B)	7,516	Class 3	06/05/13
10220A	SE Corner of Exclusion Area – Lake Shore	8,192	Class 3	10/10/13

Survey Unit No	Survey Unit Description	Survey Unit Area (m^2)	Current Classification	Date of Last Change
10220B	SE Corner of Exclusion Area – Inland	8,271	Class 3	10/10/13
10220C	SE Corner of Exclusion Area – Inland	25,560	Class 3	10/10/13
10221A	South of Protected Area - Lakeshore	6,274	Class 3	10/10/13
10221B	South of Protected Area - Inland	6,374	Class 3	09/03/13
10222	North Beach Area	21,778	Class 3	09/25/13
10223	Power Block Beach Area	12,371	Class 3	09/25/13
10224	South Beach Area	14,608	Class 3	10/10/13
10301	West Training Area	55,942	Class 3	09/19/13

Table 6-3 Survey Units for Structures

Survey Unit No.	Survey Unit Description	Area (m2)	Classification	Date of Last Change
05100	Auxiliary Building 542 foot Floor	2,591	Class 1	LTP
05119	Auxiliary Building Basement Walls	3,912	Class 2	LTP
01100	Unit 1 Containment Basement	2,759	Class 2	LTP
02100	Unit 2 Containment Basement	2,759	Class 2	LTP
03201	SFP/Transfer Canal	780	Class 1	LTP
06100	Turbine Building Basement	14,679	Class 3	LTP
08100	Crib House/Forebay	6,940	Class 3	LTP
09200	Circulating Water Discharge Tunnels	4,871	Class 3	LTP
09100	WWTF	1,124	Class 3	LTP

6.1. Radionuclides of Concern

Zion*Solutions* Technical Support Document (TSD) 11-001, *"Potential Radionuclides of Concern during the Decommissioning of Zion Station"* (Reference 8) was prepared and approved in November 2011. The purpose of this document was to establish the basis for an initial suite of potential ROC for the decommissioning. Zion*Solutions* TSD 14-019, *"Radionuclides of Concern for Soil and Basement Fill Model Source Terms"* (Reference 9) evaluated the results of concrete core sample analysis data from the Containments and Auxiliary Building and refined the initial suite of potential ROC by evaluating the dose significance of each radionuclide. Insignificant dose contributors were determined consistent with the guidance contained in section 3.3 of NUREG-1757. Based upon the analysis, it was determined that Co-60, Ni-63, Sr-90, Cs-134 and Cs-137 accounted for 99.5% of all dose in the contaminated concrete mixes. For activated concrete, H-3, Eu-152, and Eu-154, in addition to the five aforementioned nuclides, accounted for 99% of the dose. Table 6-4 presents the final suite of ROC for the decommissioning of ZNPS and the normalized mixture fractions based on the radionuclide distribution presented for the Auxiliary Building in TSD 14-019.

Table 6-4 Dose Significant Radionuclides and Mixture

Radionuclide(2)	% of Total Activity (normalized)(1)
Co-60	0.92%
Cs-134	0.01%
Cs-137	75.32%
Ni-63	23.71%
Sr-90	0.05%

(1) Based on maximum percent of total activity from Table 20 of TSD 14-019, normalized to one for the dose significant radionuclides.

(2) Does not include dose significant radionuclides for activated concrete (H-3, Eu-152, Eu-154) under the assumption that all activated concrete will be removed and disposed of as waste.

The results of surface and subsurface soil characterization performed to date in the impacted area surrounding ZNPS indicate that there is minimal residual radioactivity in soil. Consequently, ZSRP does not anticipate the presence of significant soil contamination in any remaining subsurface soil that has not yet been characterized. In addition, based on process knowledge, minimal contamination is expected in any of the buried piping that ZSRP plans to abandon in place. Accordingly, due to the absence of any significant source term in soil or in buried piping, the suite of ROC and radionuclide mixture derived for the Auxiliary Building concrete was considered as a reasonably conservative mixture to apply to soils and buried piping for FSS planning and implementation.

As the characterization survey of many inaccessible or not readily accessible subsurface soils or structural surfaces have been deferred, as characterization surveys are performed, the survey results will be reviewed to ensure that the suite of ROC and radionuclide mixture derived for the Auxiliary Building and presented in Table 6-4 continues to be applicable. In addition, any concrete samples taken for characterization from the underlying concrete of the SFP and Transfer Canal will be analyzed for the presence of HTD radionuclides. For other structural surfaces, embedded piping and penetrations, if characterization surveys indicate that the potential dose from residual radioactivity in a structure could exceed 10% of a dose limit (2.5 mrem/yr), then the samples will also be analyzed for the presence of HTD radionuclides. For soils and buried pipe, if characterization surveys indicate the presence of gamma-emitting radionuclides at concentrations greater than 50% of a DCGL, then the samples will be analyzed for the presence of HTD radionuclides.

6.2. Action Levels

The overall objective for the decommissioning of the ZNPS is to sufficiently remediate all remaining structures and soil to a condition that corresponds to a calculated dose to the an average member of the critical group (AMCG) of less than 25 mrem/year Total Effective Dose Equivalent (TEDE) from residual radioactivity distinguishable from background from all applicable pathways plus ALARA. The remaining structures and land may then be released for unrestricted use. This is the decommissioning rule in accordance with 10 CFR 20.1402.

The DCGLs and Basement Dose Factors that will be used to demonstrate compliance with the 25 mrem/yr unrestricted release criterion have been established by the LTP. The DCGLs and Basement Dose Factors are calculated by analysis of various pathways (direct radiation, inhalation, ingestion, etc.), media (concrete, soils, and groundwater) and scenarios through which exposures could occur.

For characterization, the primary DQO is whether or not a survey unit is classified correctly. The appropriate classification of a survey unit is critical to the basis of survey design during FRS. A classification which underestimates the potential for contamination could result in a survey design that does not obtain adequate information to demonstrate that the survey unit meets the release criteria. Initial and subsequent classifications for STS and open land survey units at ZNPS have been established by the HSA and by the initial characterization surveys. For characterization, the DCGLs and Basement Dose Factors will be used as the action levels to determine the correct classification of a survey unit.

For soil and buried pipe, each radionuclide-specific DCGL is equivalent to the level of residual radioactivity (above background levels) that could, when considered independently, result in a TEDE of 25 mrem per year to an AMCG. When applied to soil, the DCGLs are expressed in units of activity per unit of mass (pCi/g). For buried piping, DCGLs are calculated and expressed in units of activity per surface area (dpm/100 cm^2). The surface and subsurface soil DCGLs for the unrestricted release of open land survey units are provided in Tables 6-5 and 6-6, respectively.

Table 6-5 DCGLs for Surface Soils (ρCi/g)

Radionuclide	Surface Soil DCGL (pCi/g)
Co-60	4.7
Cs-134	7.5
Cs-137	15.7
Ni-63	3998
Sr-90	14.3

Table 6-6 DCGLs for Subsurface Soils (ρCi/g)

Radionuclide	Subsurface Soil DCGL (pCi/g)
Co-60	3.8
Cs-134	4.9
Cs-137	8.5
Ni-63	847
Sr-90	1.8

Site-specific DCGLs were developed based on a reasonable exposure scenario for a range of buried pipe diameters. Table 6-7 presents the buried piping DCGLs based upon the most conservative values for each ROC.

Table 6-7 DCGLs for Buried Piping (ρCi/g)

Radio nuclide	Buried Piping DCGL (dpm/100 cm^2)
Co-60	3.60E+04
Cs-134	6.33E+04
Cs-137	1.50E+05
Ni-63	1.31E+08
Sr-90	3.49E+05

For basements/structures below 588 foot elevation, building-specific Basement Dose Factors are calculated in units of mrem/yr per mCi. The total inventory remaining for each ROC will be multiplied by the Basement Dose Factors for each radionuclide to calculate the actual dose from the remaining basement source term. These Basement Dose Factors are radionuclide-specific values that are determined for each ROC. The Basement Dose Factors from the LTP are reproduced in Table 6-8.

Table 6-8 Basement Dose Factors (mrem/yr per mCi)

Nuclide	Auxiliary	Containment	Turbine	SFP	Crib House/Forebay	WWTF
Co-60	1.10E-02	4.13E-02	1.26E-02	1.20E+00	2.05E-02	7.57E-01
Cs-134	1.57E-02	2.16E-01	5.56E-02	7.15E-01	5.31E-02	9.27E+00
Cs-137	3.00E-02	1.65E-01	4.21E-02	3.67E-01	3.83E-02	7.31E+00
Eu-152	5.14E-03	1.77E-02	5.48E-03	5.66E-01	9.18E-03	2.83E-01
Eu-154	5.70E-03	2.04E-02	6.21E-03	6.26E-01	1.01E-02	3.73E-01
H-3	6.28E-03	2.73E-02	6.88E-03	1.10E-08	5.87E-03	1.25E+00
Ni-63	2.89E-04	1.61E-03	4.06E-04	2.85E-06	3.48E-04	7.40E-02
Sr-90	3.33E-01	4.54E+00	1.15E+00	5.83E-04	9.78E-01	2.09E+02

Multiple ROC are known to be present at ZNPS. For both STS and FSS, the dose contribution from each ROC is accounted for using the SOF to ensure that the total dose from all ROC does not exceed the dose criterion.

7. DESCRIPTION OF PLANNED CHARACTERIZATION ACTIVITIES

As with the initial characterization process, the characterization process will consist of four principal elements:

- Planning
- Designing
- Implementation and,
- Data Assessment

The DQO and Data Quality Assessment (DQA) processes are applied to these four principal elements. DQOs allow for systematic planning and are specifically designed to address problems that require a decision to be made and provide alternate actions. The DQA process is an evaluation method used during the assessment phase to ensure the validity of survey results and demonstrate achievement of the sampling plan objectives.

Survey planning includes a review of the HSA, any previous characterization survey results and any other pertinent information specific to the survey area that will be characterized.

Before the characterization process can proceed to the implementation phase, the survey unit must be prepared. Survey unit preparation for characterization mostly pertains to housekeeping and the establishment of a reference grid system as necessary to allow for the reproducibility of sample and/or static measurement locations.

Survey implementation is the process of carrying out the survey plan for a given survey unit. This consists of performing the appropriate scan measurements, static measurements and collection and analysis of samples.

Quality assurance and control measures will be employed in accordance with the QAPP to ensure that subsequent decisions are made on the basis of data of acceptable quality. Quality assurance and control measures are applied to ensure:

- DQOs are properly defined and derived.
- The plan is correctly implemented as prescribed.
- Data and samples are collected by individuals with the proper training using approved procedures.
- Instruments are properly calibrated and source checked.
- Collected data are validated, recorded, and stored in accordance with approved procedures.
- Documents are properly maintained.
- Corrective actions are prescribed, implemented, and followed up on.

The DQA approach is applied to characterization survey results to ensure the population of the data is complete, valid, and the objectives of the survey have been met. The data quality assessment verifies that:

- The measurements were obtained using approved methods.
- The quality requirements for the methods were met.
- The appropriate corrections were made to the gross measurements and the data are expressed in proper reporting units.
- The measurements required by the survey design and any investigations have been included.
- The classification and associated survey unit design remain appropriate based on a preliminary review of the data.

7.1. Scope of Characterization

Areas where characterization was deferred during the initial site characterization of ZNPS include the characterization of subsurface soils under Class 1 structures, the characterization of subsurface soils under concrete or asphalt coverings, the assessment of the underlying concrete below the steel liner in the SFP/Transfer Canal, the assessment of structural wall and floor surfaces in the Auxiliary Building below the 588 foot elevation that were obstructed by systems or components, the characterization of the Forebay and the relevant portions of the Circulating Water Intake and Discharge Tunnels that are currently under water, the assessment of the steel liner below the 568 foot and 541 foot elevations of both Containment basements, an assessment of the interior and exterior of the upper concrete surfaces of both Containment domes and the assessment of the interiors of embedded and/or buried pipe that may remain. As access is gained to these areas during the decommissioning process, characterization surveys will be performed and the survey results evaluated in accordance with the relevant DQOs applicable to the survey unit. This list of areas that will undergo characterization is not all-inclusive and additional areas may be added as necessary. For example, if a previously characterized Class 2 or Class 3 survey unit is potentially impacted by radiological contamination by ongoing or future decommissioning activities, then additional characterization surveys will be performed to define the nature and extent of the radiological contamination and verify that the classification of the survey unit is valid.

7.1.1. Subsurface Soils Under Class 1 Structures

During the initial site characterization, 283 subsurface soil samples were taken around building footprints in Class 1 open land survey units. Cs-137 was positively identified in concentrations greater than the instrument MDC in 14 samples and Co-60 was positively identified in concentrations greater than the instrument MDC in one (1) sample. No other potential plant-derived gamma-emitting radionuclides were positively identified. The average Cs-137 concentration observed in the analysis of all the subsurface soil samples taken in Class 1 survey units was 0.18 pCi/g with a maximum observed concentration of 0.70 pCi/g. The one sample where Co-60 was positively identified had a concentration of 0.10 pCi/g. In addition, a single soil sample was acquired from the soil under the Turbine Building 560 foot floor slab. A hole was drilled through the concrete floor slab, exposing the underlying soil. The soil consistency found was hard-packed clay. A single sample of the soil was acquired, representing a depth of approximately 38 feet below grade. The sample was analyzed on the on-site gamma spectroscopy system. No plant-derived radionuclides at concentrations greater than the instrument MDC were detected.

Based upon the results of the initial characterization surveys, as well as the historical process information presented in the HSA, the contamination of sub-slab soils under the building foundations of the Containment Buildings, Turbine Building and Crib House/Forebay is highly unlikely. Any radiological contamination in the Containment Buildings would be contained within the contiguous steel liner. At this time, there are no indications that the liner has been breached in either structure. In the Turbine Building and Crib House/Forebay, characterization surveys performed to date indicate that the source term in these two structures is minimal. Consequently, the characterization of subsurface soils under the foundation slabs of building basements that will remain will focus on the subsurface soils under the Auxiliary Building, SFP/Transfer Canal and the WWTF.

As decommissioning progresses and as the opportunity arises, efforts will be made to sample the subsurface soils under the Auxiliary Building, SFP/Transfer Canal and the WWTF. In the case of the Auxiliary Building, samples of the underlying soils may be taken by drilling through the 542 foot elevation concrete floor to expose the soils, or by using the GeoProbe technology to drill adjacent to the foundation at an angle which will penetrate the soils under the foundation. In order to accomplish this task, commodity removal in the 542 foot elevation basement must first occur as to allow access for the concrete core drilling and GeoProbe equipment or, the upper structures of the Turbine Building and Fuel Handling Building must be removed to expose the area adjacent to the Auxiliary Building foundation. In the case of the SFP/Transfer Canal, the underlying soils may be sampled following the completion of the movement of all spent fuel in the SFP to the ISFSI, the completion of all commodity removal in the Fuel Handling Building, the removal of the steel pool liner and the demolition and removal of the upper structure of the building. In the case of the WWTF, the underlying soils may be sampled once the structure has been demolished and prior to backfill.

7.1.2. Subsurface Soils Under Concrete or Asphalt Coverings

Within the "Security Restricted Area", a majority of the ground surface is covered by concrete or asphalt roads and walkways. As decommissioning progresses, these roads and walkways will be excavated, removed and disposed of as waste. In addition, there are several subsurface structures that will be exposed by removing the overburden soils. Of most interest are the Unit 1 and Unit 2 Steam Tunnels. When the concrete or asphalt roads and walkways are removed and the upper portions of the Steam Tunnels are exposed, an opportunity will exist to characterize the underlying soils. This is of particular interest in the areas adjacent to the Unit 1 and Unit 2 Auxiliary Building "trackways". The HSA states that these two areas, both referred to as the "keyway" areas have the highest potential for the radiological contamination of soils at ZNPS due to the spills of resins and radioactive liquids during operations. The accessible surface and subsurface soils in these two locations were sampled during initial characterization and the analysis of the soil samples indicated minimal contamination. However, the soils sampled represented a very small percentage of the total volume of soil in these areas.

Based upon the history of radioactive material spills in these two areas, the additional characterization of soils as they are exposed during decommissioning is prudent.

7.1.3. Forebay, Circulating Water Intakes and Circulating Water Discharge Tunnels

At the time that initial characterization was performed, the systems that used the Forebay, Circulating Water Intakes and Circulating Water Discharge Tunnels for cooling water and as an effluent release pathway for treated liquid waste water discharge were still operational. Consequently, the Forebay and connected Circulating Water system were completely underwater.

During decommissioning, the Forebay walls will be demolished to elevation 588 foot. The circulating water suction piping that runs from the Forebay to the Main Condenser will be isolated and drained. The Circulating Water Discharge Piping is a tunnel that runs under the Forebay and discharges to Lake Michigan approximately 870 feet from the lakeshore. The current decommissioning approach is to leave the Circulating Water Discharge Piping in place.

Due to the fact that these systems, particularly the Circulating Water Discharge Tunnels were exposed to low level radioactive liquids throughout the operating history of ZNPS, it is a relevant question to determine the extent of any radiological contamination of the interior surfaces of these structures once the water has been drained and the interior surfaces are accessible. This may be accomplished by direct survey or remotely using instruments on long-handled tools or transport sleds.

As it is difficult to isolate the majority of the tunnel from Lake Michigan, the tunnel may be characterized by collecting a series of sediment samples from the lake bottom at the tunnel discharge location and extrapolating the results to the activity inside the tunnel. Another option is to perform underwater surveys or sampling of the tunnel by diver or remote methods.

7.1.4. SFP/Transfer Canal Concrete

When initial characterization was performed, spent nuclear fuel was stored in the SFP. The fuel has since been moved to the ISFSI. The SFP will then be drained down and the steel liner removed. Once that is complete, the removal of the systems and components can commence.

All systems, components and materials located in the Fuel Handling Building will be removed and dispositioned as radioactive or non-radioactive waste as appropriate. A majority of the Fuel Handling Building structure is located above the 588 foot elevation. Consequently, the basic decommissioning end-state for the Fuel Handling Building is the complete removal of the current accessible structure. The only portion of the building that resides below the 588 foot elevation is the bottom 12 feet of the SFP and adjoining Transfer Canal. As part of the building demolition, the steel liner will be removed from the SFP and Transfer Canal. Once the liner is removed and the underlying concrete is exposed, additional characterization surveys will be performed to assess the radiological condition of the underlying concrete pad and remaining pool walls. A DQO for this assessment will be to provide the requisite survey information to perform a cost benefit analysis to determine if the remaining concrete will be remediated and abandoned in place or removed and disposed of as waste. In addition, the concrete samples taken from the underlying concrete of the SFP and Transfer Canal will be analyzed for the presence of HTD radionuclides.

7.1.5. Auxiliary Building Wall and Floor Surfaces

When initial characterization was performed, all radioactive systems and components were still located inside the Auxiliary Building. Consequently, ambient radiation dose rates inside most of the cubicles on the 542 foot elevation prohibited the direct assessment of concrete surfaces by scanning or direct measurement. Once commodity removal is complete, additional characterization will be performed by scan and/or direct measurement to identify the lateral and vertical extent of surficial contamination of the concrete surfaces and the extent of any remediation of concrete that will be necessary.

7.1.6. Containment Building Steel Liner

The basic decommissioning end-state for each Containment building will consist of the walls and floors below 588 foot elevation. Interior concrete walls and floors except for the 568 foot elevation floor and the under-vessel incore walls and floor will be removed. In addition, the 3 feet of concrete on the 568 foot elevation floor will be removed to expose the metal liner. Once the concrete is removed and the underlying steel liner is exposed, additional characterization surveys will be performed to assess the radiological condition of the liner to determine the extent of any radiological contamination.

7.1.7. Containment Dome Concrete

The outer containment shells above the 588 foot elevation will be surveyed and demolished. However, if the exterior concrete is free of detectable plant-derived radioactive material, it may be used as clean hard fill or disposed of as clean demolition debris. When initial characterization was performed, all radioactive systems and components were still located inside each Containment Building. Consequently, ambient radiation dose rates inside each Containment prohibited the direct assessment of concrete surfaces by scanning or direct measurement with sufficient sensitivity to determine if the concrete is suitable for use as fill.

In order to assess if this concrete is suitable for use as fill, characterization will be performed on this concrete once it becomes accessible, both physically and radiologically. Once commodity removal is complete and all large components have been removed from each containment, including the reactor vessel, then physical access can be permitted for the characterization of the upper walls on the interior. On the exterior, once physical access is possible, then the characterization of the exterior dome concrete can commence. It is also possible that these surveys could be performed remotely. For example, an ISOCS detector could be suspended from a crane to take the requisite measurements.

7.1.8. Embedded and Buried Piping

The vast majority of embedded and buried piping will be removed during decommissioning. However, several sections of embedded and buried piping located below the 588 foot elevation have been designated to remain following demolition as part of the end-state condition for the structures in which they reside. At the time of initial characterization, the interior surfaces of most of these sections of pipe were not accessible. As decommissioning progresses and access is achieved, radiological surveys will be performed to assess if any remediation is necessary, to confirm the radiological distribution inside of the pipe, and to assess the dose from residual radioactivity remaining in the pipes.

For pipe embedded in concrete, the pipe interiors will be remediated to levels commensurate with inventory limits that represent the dose criterion for unrestricted release specified in 10 CFR 20.1402. In most cases, these sections of pipe will consist of mostly penetrations through the remaining concrete walls of the structure. The majority of the penetrations are located in the concrete walls between the Auxiliary Building and the two Containments.

For pipe buried in soil, the pipe interiors will be remediated to levels less than the site-specific DCGLs presented in Table 6-7.

The residual radioactivity remaining in each section of embedded and/or piping will be assessed and quantified by direct survey. Shallow penetrations or short lengths of embedded pipe that are directly accessible will be surveyed using hand-held portable detectors, such as a gas-flow proportional or scintillation detector. Lengths of embedded pipe or penetrations that cannot be directly accessed by hand-held portable detectors will be surveyed using applicable sized Sodium Iodide (NaI) and Cesium Iodide (CsI) detectors that will be inserted and transported through the pipe using flexible fiber-composite rods. The ISOCS may also be used to assess hard-to-access piping and sleeves.

The interior of embedded and/or buried pipe or penetration sections that cannot be accessed directly will be inspected prior to survey using a miniature video camera designed to assess the physical condition of the pipe interior surfaces. The miniature camera with supporting lighting components, as well as the subsequent detectors that will be used to survey the pipe interior surfaces, will be maneuvered through the pipe by the manipulation of fiber-composite rods which will be manually pushed or pulled to provide locomotion. A static measurement will be acquired at a specified distance traversed into the pipe. This distance will be determined as a DQO based on the contamination potential in the pipe. The detector output will represent the gamma activity in gross cpm. This gamma measurement value in cpm will then be converted to dpm using an efficiency factor based on the calibration source. The total activity in dpm will adjusted for the assumed total effective surface area commensurate with the pipe diameter, resulting in measurement results in units of dpm/100 cm^2. This measurement result will then represent a commensurate and conservative gamma surface activity. Using the appropriate surrogate ratio, the gamma surface activity will then be modified to account for all applicable HTD radionuclides present in the radionuclide distribution applicable to the system.

7.2. Overall Characterization Data Quality Objectives

As with initial characterization, the DQO process will be incorporated as an integral component of the planning and survey design steps of any characterization. Complex characterization survey designs that have a higher level of risk associated with an incorrect decision require significantly more effort than a survey plan used to simply verify known conditions. The seven steps of the DQO process are outlined in the following sections.

7.2.1. State the Problem

The first step of the planning process consists of defining the problem. This step provides a clear description of the problem and a conceptual model of the hazard to be investigated. In all cases, the problem associated with radiological characterization is to "perform characterization inspections and surveys of sufficient quality and quantity to determine the nature, extent and range of radioactive contamination in the survey unit".

7.2.2. Identify the Decision

For radiological characterization, the most important step in the DQO process is decision identification. This step consists of developing a decision statement, or in most cases, several decision statements, based on a principal study question (i.e., the stated problem) and determining alternative actions that may be taken based on the answers. For characterization, the possible decisions and the objectives are one and the same. For each survey unit, each of the characterization objectives must be assessed as to their applicability to the end state of each specific survey unit. These objectives include, but are not limited to:

- Providing a basis for classifications (Class 2 or 3).
- Providing a basis for identification and distribution of ROC.
- Providing a basis for surrogate relationships for HTD ROC.
- Providing a basis for the lateral extent of remediation of surface soils.
- Providing a basis for the lateral and vertical extent of remediation of subsurface soils.
- Evaluating the variability of existing radioactivity to support FRS survey design.
- Evaluating neutron activation of concrete that is intended for use as fill.
- Evaluating residual radioactivity of concrete that is intended for use as fill.
- Evaluating if unrestricted release as non-radioactive is a viable disposition path for certain materials
- Providing sufficient radiological data to determine waste streams.
- Providing sufficient data to guide remediation planning and the selection of the appropriate decontamination technology.

7.2.3. Identify Inputs to the Decision

This step in the DQO process identifies the types and quantity of information necessary to address the different decisions which are identified in the previous steps. The information required depends on the type of media under consideration (e.g., soil, water, concrete) and the adequacy of existing data. If a decision can be made based on the existing data, then the source(s) will be documented and evaluated to ensure reasonable confidence that the data are acceptable. If new data are needed, then the type of measurement (e.g., scan, static measurement and sampling) will be determined in the next step.

The following types of information can be utilized to determine the necessary inputs:

- Historical incidents or accidents involving radioactive materials (HSA).
- Evidence of previous radioactive material storage or the burial of radioactive material (HSA).
- Anticipated ROC (HSA and LTP).
- Initial survey unit classification and basis for classification.
- Action levels.
- Instrumentation and sensitivity (MDC).
- Analytical requirements.
- QC sample requirements.

7.2.4. Define the Study Boundaries

This step of the DQO process includes identification of the target population of interest, the spatial and temporal features of the population pertinent to the decision, a time frame for collecting the data, practical constraints, and the scale of decision making. Sampling methods, sample quantities, sample matrices, type(s) of analyses, and analytic and measurement process performance criteria, including detection limits, are established to ensure adequate sensitivity relative to the decision and/or action level.

For characterization, the target population is the set of samples or static measurements that constitute the area of interest (i.e., the survey unit). The medium of interest is the type of materials that will be sampled or surveyed (e.g., soil, water, concrete, and steel). The spatial boundaries include the entire area of interest, including soil depth, area dimensions, contained water bodies, and natural boundaries, as needed. Temporal boundaries include those activities impacted by time-related events such as weather conditions, seasons (i.e., more daylight available in the summer), operation of equipment under different environmental conditions, resource loading, and work schedule.

7.2.5. Develop a Decision Rule

This step of the DQO process develops the binary statement that defines a logical process for choosing among alternative actions. The decision rule is a clear statement using the "If...then..." format; it includes action level conditions and the statistical parameter of interest (e.g., mean of data). Decision statements can become complex depending on the objectives of the survey and the radiological character of the affected area.

For example, the decision rule could be based on if the radioactivity concentrations of residual radioactivity exceed the established action level values. Subsequently, the decision rule could be established as follows.

- For a Class 2 open land survey unit, if the SOF is less than unity (1), then the basis for the initial classification is verified as valid.
- If the SOF is greater than or equal to unity (1), then the survey unit will be reclassified as a Class 1 open land survey unit.

7.2.6. Specify Limits on Decision Errors

This step of the DQO process incorporates hypothesis testing and probabilistic sampling distributions to control decision errors during data analysis. Hypothesis testing is a process, based on the scientific method that compares a baseline condition to an alternate condition. The baseline condition is technically known as the null hypothesis. Hypothesis testing rests on the premise that the null hypothesis is true and that sufficient evidence must be provided for rejection.

While the MARSSIM guidance for acquiring FSS data is based on non-parametric statistics, site characterization surveys are more of an exploratory nature verses the verification phase of the FSS. Therefore, decision errors are more subjective during the characterization process and the use of descriptive statistics is more appropriate.

Characterization data has to have statistical quality to support decision making and to provide input to FSS design. Subsequently, the decision errors should be established to ensure that the type, quantity, and quality of data used in decision making are appropriate for the intended application.

7.2.7. Optimize the Design for Obtaining Data

The first six steps of the DQO process develop the performance goals of the survey. This final step in the DQO process leads to the development of an adequate survey design. For characterization, this step incorporates the data acquired and the analytical results to further refine inputs into the decision.

For example, scan measurements may indicate the presence of an area of elevated activity in an open land survey unit. That will prompt the acquisition of additional biased soil samples to act as additional inputs into the decision regarding the lateral and vertical extent of soil contamination. This data will be evaluated and used to refine the scope of field activities to optimize implementation of the characterization design and ensure the DQOs are met.

7.3. Survey Unit Preparation for Characterization

Preparation for characterization will be performed in all survey units as deemed appropriate. Prior to performing characterization surveys, the survey units should be cleared of all loose equipment and materials to the extent possible. Appropriate staging or mechanical devices shall be used in accordance with the *"Zion Restoration Project*

Health and Safety Plan" (HASP) (Reference 10) to safely access structural surfaces greater than 6 feet above a normal walking surface.

Prior to performing characterization surveys in open land survey units, it may be necessary to clear the area of debris and/or vegetation to the extent possible, to eliminate physical obstructions. In this case, the vegetation should be cut as close to the ground surface as possible. All physical hazards in the survey unit should be either identified and removed or marked, as appropriate.

In order to facilitate the selection of systematic survey locations, a reference coordinate or grid should be established. Reference grids provide a mechanism for identifying the location of a static measurement or sample and ensuring that the location can be reproduced.

For structural survey units, the reference coordinate system may consist of a grid of intersecting lines which reference a fixed site location. The lines will be arranged in a perpendicular pattern, dividing the survey unit into grid squares depending upon its classification.

For open land survey units, reference coordinates may be acquired using a Global Positioning System (GPS) coupled with a standard topographical grid coordinate system such as the North American Datum (NAD) system.

7.4. Survey Packages and Sample Plans

Sample plans will be prepared by or under the direct supervision of a RE. A Characterization Survey Package will be developed for each STS survey unit and open land survey unit designated in Tables 6-2 and 6-3. A folder designated as the characterization survey package should be utilized to keep sample plans and survey results. The folder shall be controlled in accordance with the record quality requirements of the QAPP.

Multiple sample plans may be generated for a survey unit when performing characterization in phases. Sample plans contain survey instructions that describe the number, type, and location of static measurements and material samples with the type of analyses to be performed. Direction will also be provided for selection of instruments, count times, instrument modes, survey methods, required documentation, action levels, investigation actions, background requirements and other appropriate instructions. In conjunction with the survey instructions, survey data forms, indicating desired measurements, are prepared to assist in survey documentation. The survey package will become the primary method of controlling and tracking survey results.

A sample plan should contain sections for the following types of information:

- Detailed description of the survey unit
- Photographs, maps, and/or drawings of the survey unit
- A summary of the operational history from the HSA pertinent to the survey unit and summary data from any previous radiological surveys if available
- The specific DQOs for the characterization surveys performed in the survey unit

- Types and number of survey measurements and/or samples prescribed for the survey
- Specific survey instructions
- Sample designation codes and locations,
- Quality assurance measures in accordance with the QAPP,
- Any additional pertinent information such as support from others, health and safety information and necessary Work Orders (e.g. for coring, drilling, excavation activities, as required), permits (e.g. Excavation Permit, Radiation Work Permit, etc.)

When a sample plan is ready for implementation, a separate RE will perform a peer review of the plan, including a review of the survey design, instructions, and calculations. The peer review will also ensure that appropriate instruments, survey methods, and sample locations have been properly identified. When the peer review is complete, sample plans will be reviewed and approved by the C/LT Manager or designee prior to implementation.

7.5. Survey Unit Walk-down

Sample plan development will begin with the performance of a walk-down of the survey unit. During the walk-down, details regarding the physical survey area will be compiled such as the surfaces in the unit (wall, floor, ceiling, surface soil, etc.,) and metric dimensions in meters. Data from available operational surveys will be reviewed and utilized as appropriate.

Significant health and safety concerns include the potential industrial hazards commonly found at a construction site, such as exposed electrical circuitry, excavations, enclosed work spaces, hazardous atmospheres, insects, poisonous snakes, plants, and animals, unstable surfaces, heat and cold, sharp objects or surfaces, falling objects, tripping hazards, and working at heights. The pre-survey walk-down will identify potential industrial safety hazards specific to the survey unit. This inspection is intended to identify general safety hazards, as well as significant industrial safety hazards, that may or may not impact the performance of the survey.

Each hazard identified will be evaluated to determine if the hazard can be eliminated, avoided, or minimized, as well as to determine if the need for additional outside support/expertise is necessary to complete further evaluation. If at any time during the inspection or the subsequent survey, a serious hazard is identified that requires immediate action (i.e., cannot be immediately eliminated, avoided, or minimized), the area will be isolated until an acceptable remedy has been implemented.

7.6. Survey Design

Characterization surveys will be designed and performed in accordance with all applicable approved procedures and this characterization survey plan. Survey design will incorporate a graded approach based upon the DQOs for the survey unit.

There are two approaches that can be used for survey design, biased and systematic sampling. Biased survey designs use known information to select locations for static measurements and/or samples. Systematic survey design selects static measurement and/or sample locations at random or by using a systematic sampling design with a random start. The decision of whether to perform survey design using a biased or systematic approach should be addressed by the DQO process. A biased approach would be warranted when the characterization effort is designed to delineate the extent of an area that requires remediation. Alternatively, a systematic approach would be warranted if the characterization effort is designed to verify the basis for classification.

7.6.1. Number of Static Measurements and/or Samples

The number of measurements and/or samples that will be taken in each survey unit will be determined by assessing the population size necessary to satisfy the DQOs.

For the characterization of Class 1 survey units, the number of static measurements and/or samples will be of sufficient quantity to satisfy the DQO decision in the professional judgment of the responsible RE.

For the characterization of Class 2 survey units, the minimum number of systematic static measurements and/or samples that should be taken in the survey unit should be commensurate with the probability of the presence of residual radioactive contamination in the survey unit. The sample size selected should be sufficiently robust to provide a statistically defensible mean and assessment of variability.

For Class 3 survey units, the primary characterization DQO is to establish the basis for the Class 3 classification. Consequently, the population of systematic static measurements and/or samples should be sufficiently robust so that the basis for the classification will present a high degree of confidence that no licensee-generated radioactive material resides in these areas. Since the recommended survey unit size for a Class 3 survey unit is unlimited, additional systematic static measurements and/or samples above the minimum population calculated may be necessary to address this DQO.

7.6.2. Determination of Static Measurement or Sample Locations

The location of biased measurements and/or samples to be taken in each survey unit will be determined by the professional judgment of the responsible RE during the survey design process. Consideration should be given to locations that exhibit measurable radioactivity, depressions, discolored areas, cracks, low point gravity drain points, actual and potential spill locations, or areas where the ground has been disturbed. Historical information found in the HSA can aid in biased location selection.

The location of systematic measurements and/or samples will be chosen at random. Sample locations should be determined by generating random pairs of coordinates that correspond to specific locations within a survey unit. This can be accomplished through the use of a random number generator or through the use of computer software such as Visual Sample Plan (VSP).

A combination of photographs, maps, and drawings should be developed for each sample plan depicting each survey unit. The survey unit maps should be annotated with the grid reference system and the location of the characterization survey measurement locations. The sample locations and/or the reference grid should be superimposed on the map to provide an (x,y) coordinate for each location.

7.6.3. Scan Coverage

Survey units are scanned in accordance with their classification. The area to be scanned in each survey unit will be determined by the professional judgment of the responsible RE during the survey design process. The following is a list of recommended scan coverage guidelines that may be used.

Area Classification	Recommended Characterization Scan Coverage
Class 1	No scanning required unless compelled by a specific survey objective.
Class 2	50% to 100%, concentrating on areas with an increased probability of exhibiting elevated activity (such as Class 1 boundaries, vehicle transit routes, etc.).
Class 3	10% to 50%, with emphasis on areas that were used for plant activities during operation and areas downwind or downstream of known effluent release points.

7.6.4. Types of Measurements or Samples

The characterization survey of building surfaces may consist of surface scans (beta and gamma); gamma spectroscopy measurements using the ISOCS, static beta measurements, material samples and smears. The characterization survey of any concrete and/or asphalt-paved open land area may consist of surface scans (beta and gamma), gamma spectroscopy measurements using the ISOCS, static beta measurements, and volumetric samples. The survey of the open land areas will consist of gamma scans and the sampling of surface and subsurface soil, sediment, and surface water for isotopic analysis. The following is a description of the different types of measurements and samples that may be utilized.

7.6.4.1. Static Measurements

Static measurements are performed to detect direct levels on structural surfaces of the buildings or on concrete or asphalt paved areas. These measurements are typically performed using ~126 cm^2 scintillation or gas-flow proportional detectors. Smaller detectors may be used as accessibility requires.

Static measurements are conducted by placing the detector on or very near the surface to be counted and acquiring data over a pre-determined count time. A count time of one minute is typically used for surface measurements and generally provides detection levels well below the action level. (The count time may be varied provided the required detection level is achieved).

Instrument count times will be adjusted, as appropriate, to achieve an acceptable MDC for static measurements.

7.6.4.2.Canberra In Situ Object Counting System (ISOCS)

Static measurements may be taken using the ISOCS, primarily in open land survey units and in building basements. The ISOCS has been selected as the primary instrument to be used to perform STS. Static measurements using the ISOCS detector are typically taken with the detector oriented perpendicular to the surface under assessment. In most cases, the exposed face of the detector may be positioned at a distance of one (1) to three (3) meters above the surface; however, some measurements may be taken at a closer distance to avoid obstructions. With the 90-degree collimation shield installed, an orientation at a height of three (3) meters from a surface corresponds to a nominal Field-of-View (FOV) of 28 m^2.

Typically, the measurements acquired using ISOCS are taken with a geometry that evaluates activity to a depth of 15 cm (6 inches below grade) over the geometric FOV. Measurement count times are adjusted to achieve an acceptable MDC.

7.6.4.3.Beta Surface Scans

Scanning is performed in order to locate areas of residual activity above the investigation level. Beta scans are performed over accessible structural surfaces including, but not limited to; floors, walls, ceilings, roofs, asphalt and concrete paved areas. Floor monitors using large area gas-flow proportional detectors (typically with 584 cm^2) may be used for floor and other larger accessible horizontal and vertical surfaces. Hand-held beta scintillation and/or gas-flow proportional detectors (typically 126 cm^2) may be used for surfaces not accessible by a floor monitor.

Beta scanning will typically be performed with the detector position maintained within 1.27 cm (0.5 inch) of the surface and with a scanning speed of one detector active window per second. If surface conditions prevent scanning at the specified distance, the detection sensitivity for an alternate distance can be determined, and the scanning technique adjusted accordingly. Scanning speed is calculated *a priori* to assure the MDC for scanning is appropriate for the stated objective of the survey. Adjustments to scan speed and distance may be made when necessary.

Whenever possible, technicians should monitor the audible response to identify locations of elevated activity that require further investigation and/or evaluation. All areas of elevated contamination should be identified for further investigation and potential decontamination.

7.6.4.4.Gamma Surface Scans

Gamma scans are performed over land surfaces to identify locations of residual surface activity. Sodium iodide (NaI) gamma scintillation detectors (typically 2” x 2”) are typically used for these scans. Scanning may be performed by moving the detector in a serpentine pattern, while advancing at a rate not to exceed 0.5 m (20 in) per second. The distance between the detector and the surface should be maintained within two to three inches. Audible and visual signals should be monitored; and, locations of elevated direct levels should be flagged for further investigation and/or sampling.

The percentage of the surface area to be scanned during characterization will be determined by the professional judgment of the responsible RE during the survey design process.

7.6.4.5.Removable Surface Contamination

Removable beta and/or alpha contamination or smear surveys are performed to verify loose surface contamination is less than the action level. A smear for removable activity is usually taken at each static measurement location. A 100 cm^2 surface area will be wiped with a circular cloth or paper filter, using moderate pressure. Smears are then analyzed for the presence of gross beta and/or gross alpha activity, as appropriate. This is typically performed using a proportional counting system or equivalent.

7.6.4.6.Concrete Core Sampling

Concrete core boring and the sampling of concrete, as opposed to static measurements, may be necessary if gross static measurements are not sufficient to address the survey unit specific DQOs. Core bore sampling of concrete typically involves the use of a diamond bit core drill. Sampling in asphalt covered surfaces may involve the use of an electric powered jackhammer.

The material (asphalt or concrete) sample produced by the coring is typically sliced into ½-inch wide "pucks", representing a certain depth into the surface. Static measurements are performed on the top and bottom of the pucks to determine contaminant intrusion depth and/or the activation of the concrete matrix. Concrete pucks can also be pulverized and analyzed for isotopic content. On asphalt, subsequent layers may be separated to reveal and measure contamination between the layers.

7.6.4.7.Material Sampling

Samples of soil, sediment, and sludge will be obtained from designed judgmental and systematic sample locations, as well as other biased locations in areas exhibiting elevated activity that were identified by scanning. Surface soil is defined as the top 15 cm (6 inch) layer of soil while subsurface soil is defined as soil below the top 15 cm layer in 1 meter increments. Surface soil can be collected using a split spoon sampling system or, by using hand trowels, bucket augers, or other suitable sampling tools.

Subsurface soil is typically sampled by direct push sampling systems (e.g. GeoProbe®) or by the excavation of test pits. Subsurface soil sampling is performed, as necessary, to address the DQOs for the survey unit.

An adequate amount of material (may range from 0.5 liters up to two liters) will be collected at each location. Sample preparation may include the removal of extraneous material and the homogenization and drying of the soil for analysis. Separate containers will be used for each sample and accountability for each container will be throughout the analysis process as specified in the QAPP. Samples will be split when required as specified in the QAPP.

7.7. Survey Implementation

When a sample plan has been approved and prior to implementation, the responsible RE will conduct a pre-survey briefing with the C/FRS Supervisors and Technicians who will perform the survey. During the briefing, the survey instructions will be reviewed. Subsequently, Technicians will gather and stage all equipment and instruments required to perform the survey in accordance with the survey instructions.

Sample plan implementation may include the following:

- The set-up of the survey instrumentation.
- Checking source and background radiation before and after each shift to ensure proper operation.
- Performing preliminary inspections of the areas to identify additional specific survey requirements.
- Locating and marking static measurement and/or sample locations using the coordinates provided in the survey instructions.
- Taking survey measurements and the analysis of samples using appropriate calibrated instruments.
- Documentation of survey measurements and sample analysis data collected during the characterization and placed in the survey package.
- The review of the completed sample pans to ensure that all required surveys have been performed.
- The review of the survey results to identify any areas exceeding the specified action levels.

7.8. Survey Measurement Location Codes

To facilitate data queries and reporting, each characterization survey measurement and sample collected will be assigned a unique survey measurement location code. Table 7-1 presents the sample and measurement unique identification designation system used to identify sample and measurement types and locations.

Table 7-1, Sample & Measurement Unique Identification Designation

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)

Classification & Survey Area

1st digit indicates type of Survey Area

L = Open Land Area
B = Structural Survey Area
S = System

2nd digit indicates Classification

1 = Class 1
2 = Class 2
3 = Class 3
4 = Non-impacted
5 = Unassigned

3rd, 4th and 5th digits indicate the Survey Area Number

(from Tables 6-1 and 6-2)

Survey Unit Number & Sequence Indicator

6th and 7th digits indicate the Survey Unit Number

(from Tables 6-1 and 6-2)

The 8th digit indicates alphanumeric sequence

(Sequence A-J) allows the survey unit to be divided into 10 smaller survey units.

(Sequence K-Z) allows for up to 16 different survey instructions for a single survey unit.

Survey and Measurement Type

The 9th digit indicates the type of survey.

B = Background
S = **Scoping**
C= **Characterization**
R =**Remedial** Action
F = FSS
I = **Investigation**
V = **Verification**
Q = QA/QC

The 10th digit indicates the type of measurement.

B = Background
R = Random
S = Systematic
J = Judgmental
I = Investigation
V = Verification
Q = QA/QC

Surface Type

The 11th digit indicates the type of surface where the measurement was taken.

F = Floor
W = Wall
C = Ceiling
S = System
R = Roof
P = Paved Road
G = Ground
L = Water

The 12th digit indicates the material composition of the surface where the measurement was taken.

C = Concrete
M = Metal
W = Wood
B =Cinder Block
K = Brick
A =Asphalt
S = Soil
T = Tar
L = Liquid

Sample or Measurement No.

The 13th, 14th and 15th digits indicate the alphanumeric measurement number

Sequentially, 001 through 999

Media Type

The 16th and 17th digits indicate the type of media that was sampled.

SS = Surface Soil
SB = Subsurface Soil
SM =Sediment
WT = Water
LQ = Other liquids besides water
OL = Oil
CV = Volumetric Concrete
AV = Volumetric Asphalt
MT = Metal
PT = Paint
SW = Smear Sample
BD = Beta Direct
AD = Alpha Direct
GD = Static Gamma measurement
BS = Beta Scan
GS = Gamma Scan
JS = Juncture Scan
JD = Juncture Direct
PS = Penetration Scan
PD = Penetration Direct

7.9. Quality Assurance

This characterization plan was developed according to the essential elements of the quality assurance and quality control (QA/QC) program for the decommissioning of ZNPS and is subject to the QAPP. The QA/QC program elements applicable to characterization are as follows:

- Establishment/implementation of plans, procedures, and protocols for the field operations.
- Actions to ensure that the procedures are understood and followed by the implementing staff.
- Documentation of the data collected.

Details of the QA/QC elements specific to characterization are presented in the QAPP, as well as the procedures and survey package instructions. The characterization operations and the associated data acquisition and recording will be guided and conducted in compliance with these QA/QC requirements. The specific QA/QC program components for the characterization are as follows:

- Personnel qualifications, experience, and training.
- Execution in accordance with approved procedures.
- Proper documentation of survey data and sample analyses.
- Selection of appropriate instruments to perform the surveys.
- Proper instrument calibration and daily functional checks.
- Management oversight of characterization activities relative to the adherence to procedures, protocols, and documentation requirements.

All characterization activities are conducted in accordance with this plan, the QAPP, all applicable implementing procedures, and approved survey package instructions.

7.10. Instrumentation and Selection

Radiation detection and measurement instrumentation for characterization are selected to provide both reliable operation and adequate sensitivity to detect the ROC identified for the decommissioning of ZNPS at levels sufficiently below the established action levels. Detector selection is based on detection sensitivity, operating characteristics, and expected performance in the field.

Commercially available portable and laboratory instruments and detectors are typically used to perform the three basic survey measurements: 1) surface scanning; 2) static measurements; and 3) analysis of material samples.

The instruments and detectors selected for static measurements and scanning should be capable of detecting the gross beta-gamma activity to a MDC of 50% of the applicable DCGL for soil or, the action level corresponding to the remediation criteria for structures. This is an administrative guideline only and not necessarily a limit.

Instrumentation and nominal MDC values currently proposed for use during characterization are listed in Table 7-2.

Table 7-2 Instrument Types and Nominal MDC

Detector Model [2]	Meter Model	Application	Nominal Detection Sensitivity MDCscan (dpm/100cm2)	MDCstatic1 (dpm/100cm2)
Ludlum 44-9	Ludlum 2350-1	β static & scan	2900	985
Ludlum 43-5	Ludlum 2350-1	α static & scan	150	75
Ludlum 43-68 β mode	Ludlum 2350-1	β static & scan	1050	330
Ludlum 43-68 α mode	Ludlum 2350-1	α static & scan	170	70
Ludlum 44-116	Ludlum 2350-1	β static & scan	1300	415
Ludlum 43-90	Ludlum 2350-1	α static & scan	130	55
Ludlum 44-10	Ludlum 2350-1	γ scan	3.5 pCi/g Co-60 6.5 pCi/g Cs-137	N/A
Ludlum 43-37	Ludlum 2350-1	β scan	1000	N/A
Tennelec LB5100 proportional counting system	N/A	α and/or β smear	N/A	18
HPGe Gamma Spectroscopy System [3]	N/A	γ Analysis	N/A	~0.15 pCi/g for Co-60 and Cs-137

1. Based on 1-minute count time; and default values for surface efficiencies, $\in_S$, as specified in International Standard, ISO 7503-1 (Reference 11).
2. Functional equivalent instrumentation may be used.
3. MDC Requirements per Regulatory Guide 4.8 (Reference 12)

7.10.1. Instrument Calibration

All data loggers, associated detectors, and all other portable instrumentation that will be used for characterization are calibrated on an annual basis using National Institute of Standards and Technology (NIST) traceable sources and calibration equipment. The calibration of instruments used for characterization is addressed in section 5.2 of the QAPP.

7.10.2. Instrument Use and Control

The receipt, inspection, issue, control, and accountability of portable radiological instrumentation used for characterization is performed in accordance with the procedure that governs the issue, control and accountability of characterization and FRS portable radiological instrumentation. The issue and control of instruments used for characterization is addressed in section 5.1 of the QAPP.

8. SURVEY DOCUMENTATION

Records of characterization surveys are maintained in the survey packages for each survey unit. The survey package could include the following records depending upon the survey design and DQOs.

- Survey Unit Diagram or drawing which includes depictions of boundaries, landmarks, and measurement and/or sample locations.
- Photographs of the survey area, as necessary, to show special or unique conditions.
- Printout of laboratory analysis results reported in appropriate units.
- Hand-logged or downloaded data files with measurement results converted to appropriate units for all static surface contamination measurements.
- Alpha/beta smear counter logged results or data files with measurement results converted to appropriate units for all removable surface contamination measurements.

Digital cameras may be employed to provide a more permanent record of survey locations within a survey unit. When used, these photographic records should be linked to landmark and directional information to ensure reproducibility.

9. DATA VALIDATION

Characterization survey measurement and/or analysis results are reviewed to ensure that the survey is complete, fully documented, and technically acceptable. Validation ensures that the data set is comprised of qualified measurement results collected in accordance with the survey design, which accurately reflects the radiological status of the survey unit. The review criterion for data acceptability includes the following items as a minimum.

- Compliance with survey instructions as specified in the survey package.
- Showing that MDCs were appropriate for the instruments and techniques used to perform the survey.
- The instrument calibration was current and traceable to NIST standards.

- The field instruments were source checked with satisfactory results before and after use each day that the data was collected or, if unsatisfactory, data obtained with that instrument since its previous acceptable performance check was evaluated for acceptability.
- The survey methods used to collect data were proper for the types of radiation involved and for the media being surveyed.
- The data set is comprised of qualified measurement results collected in accordance with the survey design, which accurately reflects the radiological status of the survey unit.
- The data has been properly recorded.
- If the data review criteria are not met, then the C/LT Manager is informed. The discrepancy is then reviewed and the decision to accept or reject the data is documented in the survey package.

10. DATA EVALUATION AND REVIEW

Static beta-gamma and/or alpha measurements collected during the characterization surveys are compared against the action levels (section 6.2). Material sample analysis results are also compared against the volumetric action level values. If multiple ROC are identified in concentrations greater than MDC, then the sum of the fraction rule applies. In Class 3 survey units, individual survey results exceeding 50% of the action level are identified. Survey results that approach or exceed the action level are considered cause for additional investigation or possible reclassification. In addition, the mean activity and the standard deviation should be calculated for the survey population.

At the completion of the surveys conducted in each survey unit, measurement results are assessed and evaluated according to the DQOs. If the lateral extent of contaminated areas has not been determined by the measurements prescribed in the survey package instructions, more measurements may be prescribed to delineate where surface contamination is no longer present. If the vertical extent of contaminated areas has not been determined, subsequent at depth samples will be prescribed to delineate where subsurface contamination is no longer present. The guidance provided in MARSSIM for survey, measurement, data analysis and data evaluation according to the survey DQOs process is repeated during the data evaluation. Once all DQOs have been attained, the characterization is considered complete.

11. HEALTH AND SAFETY CONSIDERATIONS

The Zion Nuclear Station HASP was developed to identify health and safety features to be used while performing characterization, deconstruction, and support activities at ZSRP. The HASP and implementing procedures for job safety analysis meet the MARSSIM section 4.10, Health and Safety, recommendation for health and safety evaluation prior to commencement of work.

All sampling and surveys described in this plan are performed in accordance with the HASP. All sampling and surveys are also conducted safely, addressing hazards and applicable health and safety requirements as identified through Task Hazard Assessments

(THA), Job Hazard Analysis (JHA), and pre-job briefings, as required. For entry and work in posted radiologically controlled areas, characterization activities are also conducted under an approved Radiation Work Permit (RWP). The characterization activities are described in sufficient detail to identify any applicable radiation protection and ALARA requirements.

12. REFERENCES

1 Zion*Solutions* License Termination Plan (LTP) – December 2014

2 NUREG-1575, "Multi-Agency Radiation Survey and Site Investigation Manual" (MARSSIM) – August 2000

3 "Zion Nuclear Power Station, Units 1 and 2 Asset Sale Agreement" – December 2007

4 NUREG-1575, Supplement 1, "Multi-Agency Radiation Survey and Assessment of Materials and Equipment Manual" (MARSAME) – December 2006

5 NUREG-1757, "Consolidated NMSS Decommissioning Guidance - Characterization, Survey, and Determination of Radiological Criteria" Volume 2, Revision 1 – September 2002

6 "Zion Restoration Project Quality Assurance Project Plan for Characterization and FSS" (QAPP)

7 Zion Station Historical Site Assessment (HSA) – September 2006

8 ZionSolutions TSD 11-001, "Potential Radionuclides of Concern during the Decommissioning of Zion Station"

9 ZionSolutions TSD 14-019, "Radionuclides of Concern for Soil and Basement Fill Model Source Terms"

10 ZA-SA-01, Rev. 1, "Zion Restoration Project Health and Safety Plan" (HASP)

11 International Standard ISO 7503-1, Part 1, "Evaluation of Surface Contamination, Beta-Emitters (maximum beta energy greater than 0.15 MeV) and Alpha-Emitters" – August 1998

12 Regulatory Guide 4.8, "Environmental Technical Specifications for Nuclear Power Plants" – December 1975