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Our ref: HEM-12-73
Date: July 3, 2012

Subject: REQUEST FOR APPROVAL OF THE HEMATITE FINAL STATUS SURVEY PLAN FOR PIPING REMAINING AFTER DECOMMISSIONING (License No. SNM-00033, Docket No. 070-00036)

Reference: 1) Westinghouse (Hackmann) Letter to NRC (Document Control Desk) HEM-10-80, dated July 30, 2010, "Response to Request for Additional Information Concerning Hematite Decommissioning Plan: Chapter 14, Characterization Report and Surrogates Report (License No. SNM-00033, Docket No. 070-00036)"

The purpose of this letter is to submit for approval the Final Status Survey Plan for Piping (FSSPP) for piping that will remain in place at the Hematite Site following its decommissioning.

In Reference 1, Westinghouse Electric Company LLC (Westinghouse) submitted a response to the Request for Additional Information (RAI) designated as HDPC-14-Q6. This response established a commitment for Westinghouse to submit an FSSPP for piping that will remain in place at Hematite Site following its decommissioning. Attachment 1 contains the FSSPP for piping meeting this commitment which has been approved by HDP; however, NRC approval of Attachment 1 is requested. Upon receipt of NRC's approval, the "Final Approved Date" will be inserted on the title sheet of the policy.

Please contact Kevin Davis of my staff at 314-810-3348 should you have questions or need any additional information.

Respectfully,

Robert D. Copp, Project Director
Hematite Decommissioning Project

Attachment: 1) HDP-PO-FSS-800, Final Status Survey Plan for Piping

cc: J. J. Hayes, NRC/FSME/DWMRP/DURLD
J. W. Smetanka, Westinghouse
M. LaFranzo, NRC Region III/DNMS/MCID

Attachment

HDP-PO-FSS-800, Final Status Survey Plan for Piping

(42 Pages)

Westinghouse

Hematite Decommissioning Project

NUMBER: **HDP-PO-FSS-800**

TITLE: **Final Status Survey Plan for Piping**

REVISION: **0**

EFFECTIVE DATE: **See Final Approved Date Below**

QUALITY-RELATED

Approvals:

Author: Allison K. Wilding*

Owner / Manager: Gerald J. Rood *

Project Director: Robert D. Copp*

*Electronically approved records are authenticated in the electronic document management system

REVISION LOG	
Revision No. Effect. Date	Change(s)
0 See Cover Page	This is a new Policy (Plan) that provides the requirements for the planning, designing, implementing, evaluating and reporting activities associated with final status surveys of piping at the Hematite Decommissioning Project. This Plan is based on the commitments specified in the Final Status Survey (FSS) Plan contained in Chapter 14 of the Hematite Decommissioning Plan (DP, Reference 5.1). This policy document also implements as applicable the U.S. Nuclear Regulatory Commission (NRC) regulations and guidance documents and applicable commitments of License SNM-33 (Reference 5.2).

Are Quality Records generated? **NO**.

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1.0 PURPOSE

This Plan describes the processes used in planning, designing, implementing, evaluating and reporting the results of final status surveys performed of piping at the Hematite Decommissioning Project (HDP).

This includes the proper selection of instrumentation and the survey protocols that demonstrate the final radiological status of piping remaining in place at the time of license termination meets the derived concentration guideline levels (DCGL).

2.0 POLICY

Final status surveys (FSS) are conducted to compile data of adequate quantity and quality to demonstrate the annual dose associated with residual activity in piping meet the dose criterion for license termination specified in the Code of Federal Regulations (CFR) Title 10, Part 20.1402, "Radiological Criteria for Unrestricted Use" (Reference 5.5).

3.0 APPLICABILITY

This Plan applies to survey planning and design, data collection and data evaluation and data reporting of final status surveys for piping.

This Plan does not apply to FSS of the soil surrounding piping. That soil is addressed by other procedures contained in the final status survey program. However, the information collected through the implementation of this Plan and associated implementation procedures may be useful to support the final evaluation of surrounding soil.

4.0 DEFINITIONS/ACRONYMS

4.1 Definitions

4.1.1 Data Quality Assessment (DQA) – Scientific and statistical evaluation of data to determine if the data are of the right type, quantity and quality to support their intended use.

4.1.2 Data Quality Objectives (DQO) – Qualitative and quantitative statements derived from the DQO process that clarify study 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.

4.1.3 Derived Concentration Guideline Level (DCGL) – A derived radionuclide-specific activity concentration within a survey unit corresponding to the release criterion.

4.1.4 Derived Concentration Guideline Level ($DCGL_{EMC}$) – An acceptable radionuclide-specific activity concentration within a small area of elevated activity when limited to a specified size.

4.1.5 Derived Concentration Guideline Level for Piping ($DCGL_{PD}$) – An acceptable radionuclide-specific activity concentration within piping based on the specific diameter of the piping.

4.1.6 Derived Concentration Guideline Level for Small Office ($DCGL_{SO}$) – An acceptable radionuclide-specific activity concentration for an exposure scenario based on occupancy within a small office.

4.1.7 Derived Concentration Guideline Level (DCGLw) – An acceptable radionuclide-specific activity concentration when present over wide area.

4.1.8 Final Status Survey (FSS) – Measurements and sampling to describe the radiological conditions of a site following completion of decontamination activities (if any) in preparation for release.

4.1.9 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. The upper bound of the gray region in the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM, Reference 5.7) is set equal to the $DCGL_W$, and the lower bound of the gray region (LBGR) is a site-specific value.

4.1.10 Gross Activity DCGL – Numerical value for the detector response during field measurements of alpha and/or beta radiation that relate to the DCGL established for the isotopic distribution.

4.1.11 Impacted Area – An area with a possibility of containing residual radioactivity from license activities in excess of natural background or fallout levels.

4.1.12 Investigation Level – A threshold concentration or activity level that is based on a fraction of the release criterion, and if exceeded, serves to initiate an investigation that may include additional measurements and/or decontamination.

4.1.13 Judgmental (Biased) Measurements – Measurements performed at locations of elevated count rate or at locations containing residual piping sediment/scale.

4.2 Acronyms

ALARA	As Low As Reasonably Achievable
Am-241	Americium-241
CFR	Code of Federal Regulations
CoC	Chain of Custody
cpm	Counts per Minute
CSM	Conceptual Site Model
DCGL	Derived Concentration Guideline Level
$DCGL_{EMC}$	Derived Concentration Guideline Level (area of elevated activity)
$DCGL_{PD}$	Derived Concentration Guideline Level for Piping
$DCGL_{SO}$	Derived Concentration Guideline Level for Small Office
DCGLw	Derived Concentration Guideline Level (average over wide area)
DP	Decommissioning Plan
DQA	Data Quality Assessment

DQO	Data Quality Objectives
EMC	Elevated Measurement Comparison
FSS	Final Status Survey
HDP	Hematite Decommissioning Project
HP	Health Physics
HPT	Health Physics Technician
HRCR	Hematite Radiological Characterization Report
HSA	Historical Site Assessment
LBGR	Lower Boundary of the Gray Region
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
mrem	Millirem
NIST	National Institute of Standards and Technology
Np-237	Neptunium-237
NRC	U.S. Nuclear Regulatory Commission
Pu-239/240	Plutonium 239/240
QA/QC	Quality Assurance / Quality Control
ROC	Radionuclide(s) of Concern
RPP	Radiation Protection Program
RSO	Radiation Safety Officer
Sr/Y-90	Strontium-90/Yttrium-90
TEDE	Total Effective Dose Equivalent
Tc-99	Technetium-99
Th-230	Thorium-230
Th-232	Thorium-232
U-234	Uranium-234
U-235	Uranium-235
U-238	Uranium-238

5.0 REFERENCES

5.1 Westinghouse, Hematite Decommissioning Project (DP) as amended by Westinghouse Electric Company (Westinghouse) Response to NRC Requests for Information

5.2 U.S. Nuclear Regulatory Commission, License No. SNM-33 (Docket No. 70-36)

5.3 Westinghouse Electric Company Document No. DO-08-005, "Historical Site Assessment"

5.4 Westinghouse Electric Company Document No. DO-08-003, "Hematite Radiological Characterization Report."

5.5 U.S. Nuclear Regulatory Commission Code of Federal Regulations, Title 10, Part 20.1402, Radiological Criteria for Unrestricted Use.

5.6 U.S. Nuclear Regulatory Commission, NUREG-1507, Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions.

5.7 U.S. Nuclear Regulatory Commission, NUREG-1575, Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM).

5.8 U.S. Nuclear Regulatory Commission, NUREG-1757, Consolidated Decommissioning Guidance, Volumes 1 and 2.

5.9 International Organization for Standardization, ISO 7503-1, Evaluation of Surface Contamination – Part 1: Beta Emitters (Maximum Beta Energy Greater than 0.15 MeV) and Alpha Emitters, 1998.

5.10 Hematite Decommissioning Project Policy, HDP-PO-FSS-700, Final Status Survey Program.

5.11 Hematite Decommissioning Project Procedure, HDP-PR-GM-020, Training Material Development and Documentation of Training.

5.12 Hematite Decommissioning Project Procedure, HDP-PR-HP-102, Health Physics Technician Training.

5.13 Hematite Decommissioning Project Procedure, HDP-PR-QA-009, Records Management.

5.14 Hematite Decommissioning Project Procedure, HDP-PR-QA-010, Purchasing and QA Supplier Evaluation.

5.15 Hematite Decommissioning Project Procedure, HDP-PR-QA-013, Software/Calculation Validation.

5.16 Hematite Decommissioning Project Procedure, HDP-PR-QA-007, Quality Assurance Inspections.

5.17 Hematite Decommissioning Project Policy, HDP-PO-GM-007, Project Management Plan.

5.18 HEM-10-85, Response to Request for Additional Information Concerning Hematite Decommissioning Plan: Chapter 5, Dose Modeling (License No. SNM-00033, Docket No. 070-00036).

6.0 RESPONSIBILITIES

6.1 Project Director

6.1.1 Ensuring the safety of project personnel, members of the public, and the environment.

6.2 Radiation Safety Officer (RSO)

6.2.1 Providing technical support for development and implementation of the FSS program and implementing procedures.

6.2.2 Ensuring compliance with the Radiation Protection Program (RPP), the FSS Plan and implementing procedures.

6.2.3 Providing direction to the Health Physics (HP) Staff and the HP Supervisor.

6.2.4 Reviewing and approving FSS plans, Survey Unit Release Records and FSS Reports.

6.2.5 Reviewing and approving the qualifications and selection of Health Physics (HP) Staff.

6.3 The HP Professional Staff

6.3.1 Coordinating the development of a training qualification program for FSS.

6.3.2 Preparing FSS survey and samplings plans, including coordinating the preparation of survey maps, layout diagrams or other graphics necessary.

6.3.3 Monitoring and assisting field survey crews.

6.3.4 Reviewing survey packages and data collected in support of the FSS.

6.3.5 Preparing Survey Unit Release Records and FSS Reports.

6.3.6 Maintaining the FSS data records in electronic formats and hardcopy files.

6.4 HP Supervision

6.4.1 Coordinating the preparation of piping for survey, including access locations and piping cleaning.

6.4.2 Establishing survey unit isolation and control measures to prevent re-contamination.

6.4.3 Ensuring instrumentation and other equipment is available to support the piping surveys.

6.4.4 Coordinating and scheduling HP Technicians to support the FSS schedule.

6.4.5 Overseeing the implementation of approved procedures and survey package instructions during field activities.

6.4.6 Overseeing the transfer of samples that may be collected to the off-site laboratory.

6.5 Heath Physics Technicians (HPT)

6.5.1 Ensuring proper operation of the survey instrumentation by implementing the procedural requirements for calibration, maintenance and daily source checks.

6.5.2 Conducting surveys of piping and documenting the survey results.

6.5.3 Informing supervisory personnel of unexpected conditions or anomalies as they are encountered.

6.5.4 Supporting NRC and Contractor personnel during confirmatory measurements, as requested.

7.0 QUALIFICATIONS AND TRAINING

Qualifications and training are vital to ensuring compliant and consistent performance. Sufficient management and technical resources are available to the FSS organization to ensure the project objectives are achieved.

7.1 Qualifications

7.1.1 The requirements for education, experience and specialized knowledge for the RSO are listed in the HDP-PO-GM-007, Project Management Plan (Reference 5.17).

7.1.2 The general requirements for education, experience and specialized knowledge for the HP Technicians are listed in HDP-PR-HP-102, Health Physics Technician Training (Reference 5.12).

7.1.3 The RSO will determine an individual's suitability to fulfill a specific position and to perform specific tasks.

7.2 Training

7.2.1 HP Technicians and HP Staff involved in FSS activities receive training commensurate with their duties.

7.2.2 HP Technicians attend formal classroom training; and demonstrate proficiency through the completion of practical evaluations, and/or through reading of certain required procedures.

7.2.3 Completion of formal training is documented in accordance with HDP-PR-GM-020, Training Material Development and Documentation of Training (Reference 5.11). Training records are maintained in accordance with HDP-PR-QA-009, Records Management (Reference 5.13).

8.0 FINAL STATUS OVERVIEW

The piping sections that are expected to be removed; expected to be decontaminated and subjected to FSS; or simply subjected to FSS and remain at the time of license termination are summarized in Appendix A Table 1. The piping identified as Class 1 is illustrated in Appendix B Figure 1, and the piping identified as Class 3 is illustrated in Appendix B Figure 2. The objectives of the FSS are to obtain data of adequate quantity and quality to demonstrate that the dose contribution from residual activity remaining in the piping does not exceed the annual dose criterion for license termination specified in 10 CFR 20.1402 (Reference 5.5); and to document that the levels of residual radioactivity are as low as reasonably achievable (ALARA).

The guidance contained in the following regulatory documents was used in the development of this program document.

- Hematite Decommissioning Plan (Reference 5.1),
- NUREG-1507, Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions (Reference 5.6),
- NUREG-1575, Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM), (Reference 5.7),
- NUREG-1757, Vol. 2, Rev. 1, Appendix O, (Reference 5.8),
- ISO Standard 7503-1 Evaluation of Surface Contamination – Part 1: Beta Emitters (Maximum Beta Energy Greater than 0.15 MeV) and Alpha Emitters, (Reference 5.9).

9.0 DATA QUALITY OBJECTIVES

The FSS process consists of the following principal elements to which the DQO are applied:

- Planning and Design (Section 10.0),
- Implementation (Section 11.0), and
- Data Assessment (Section 12.0).

DQO allow for systematic planning, address situations that require a decision to be made, and provide a framework for selecting actions that result in obtaining data of sufficient quantity and quality. The DQO process is iterative and allows for incorporation of newly gained knowledge to enhance the effectiveness of subsequent actions. The seven steps of the DQO process are as follows:

- State the problem,
- Identify the decision,
- Identify inputs to the decision,
- Define the study boundaries,
- Develop a decision rule,
- Specify limits on decision errors, and
- Optimize the design for obtaining data.

The DQO process is described below as it applies to the HDP.

9.1 State the Problem

The problem is the potential presence of residual radioactivity associated with licensed activities within piping. The primary radionuclides of concern (ROC) and the extent of contamination were assessed in the Historical Site Assessment (HSA), (Reference 5.3) and the Hematite Radiological Characterization Report (HRCR), (Reference 5.4). The primary ROC are uranium-234 (U-234), uranium-235 (U-235+D), uranium-238 (U-238+D), technetium-99 (Tc-99), and thorium-232 (Th-232+C). Additionally, trace amounts of americium-241 (Am-241), neptunium-237 (Np-237+D) and plutonium-239/240 (Pu-239/240) may be present, however the latter are insignificant contributors to potential dose.

Although Radium-226 (Ra-226+C) was identified as an ROC site-wide, it was not identified as an ROC in the buildings and associated piping.

NOTE: The nomenclature “+D” above indicates that the dose contribution of short-lived progeny is accounted for by the parent nuclide and “+C” indicates that the dose contribution of the entire decay chain (progeny) in secular equilibrium is accounted for by the parent nuclide.

9.2 Identify the Decision

This Plan, in conjunction with the associated implementing procedures will be used to demonstrate that the piping meets the criteria for unrestricted release, (25 millirem (mrem) per year total effective dose equivalent (TEDE)) as specified in 10 CFR 20.1402 (Reference 5.5). Compliance with the release criteria will be satisfied using the guidance provided in MARSSIM (Reference 5.7) and this Plan.

9.2.1 Derived Concentration Guideline Levels (DCGL)

Radionuclide-specific DCGL for residual surface contamination on buildings, structural surfaces and piping were developed as described in Chapter 5 of the DP (Reference 5.1) using the RESRAD-BUILD computer code, Version 3.4. The exposure scenarios included building occupancy under two conceptual site models (CSM) having different room sizes (i.e., Small Offices and Large Warehouse). Piping DCGL ($DCGL_{PD}$) were also derived using RESRAD, version 6.4 for a range of pipe diameters.

For simplicity and conservatism, the small office DCGL ($DCGL_{SO}$) will be initially applied to piping as the release criteria. A summary of the $DCGL_{SO}$ from DP Table 5-19 (Reference 5.1) is provided as Table 2 of Appendix A. Since these values are radionuclide-specific release criterion, the values cannot be applied directly to field measurements of gross activity. To account for this, gross activity limits (alpha-plus-beta, or beta only depending upon the detector) have been derived based on the isotopic distribution of radionuclides that can be measured using field instrumentation, and accounting for the distribution of all other undetected radionuclides that may be present.

DP Table 4-1 (Reference 5.1) provides the initial isotopic distribution based on samples of pipe scale and debris. This distribution is reproduced in Table 3 of Appendix A of this Plan. These initial isotopic distributions were used to determine a gross activity value that is equivalent to the $DCGL_{SO}$ using Equation

4-4 of MARSSIM, Reference 5.7. The resultant gross activity $DCGL_{SO}$ is provided in Appendix A, Table 4.

Additionally, a gross activity DCGL ($DCGL_{PD}$) was developed for piping as a function of pipe diameter, discussed in Chapter 5 of the DP (Reference 5.1). The $DCGL_{PD}$ from DP Table 5-22 (Reference 5.1) is summarized in Appendix A, Table 5. In the event that levels of residual contamination are found to exceed the $DCGL_{SO}$, the $DCGL_{PD}$ for the specific pipe diameter will serve as the comparator for individual measurement results to determine if the piping may be grouted in-situ and meet the dose-based criterion rather than excavate the piping.

9.3 Identify Inputs to the Decision

Decision inputs determine the acceptable risk of a decision error in the release of piping systems onsite. To minimize risk, the MARSSIM process applies the graded approach that places greater survey efforts on areas with the highest potential of contamination. Inputs to the decision process will be based on:

- A comparison of scanning surveys (gross activity, alpha + beta, or beta depending on the detector) to the $DCGL_{SO}$ or $DCGL_{PD}$,
- Results from statistical testing of data obtained by static measurements measuring total activity including fixed and removable contamination, and
- A determination of whether data are of sufficient quality and quantity.

The appropriate DCGL is used as the comparator to the data collected by these activities in the decision making process.

9.4 Define the Study Boundaries

The study boundaries consist of piping that may remain at the time of license termination. This may include sections of the piping indicated in Appendix A Table 1 dependent upon results of visual inspection, attempts to decontaminate the piping, and results of post-decontamination surveys.

9.4.1 Initial System Designation

Not all piping systems have the same potential for contamination and therefore do not require the same level of survey coverage to achieve an acceptable level of confidence that it meets the release criteria. The piping systems have been sub-divided based on potential for contamination and identified as either Class 1 or Class 3 as indicated in Appendix A Table 1.

9.4.2 Survey Units

The piping has been further sub-divided into three survey units based on physical arrangement. These survey units are comprised of the storm drain system, sanitary and building drain systems and the public water system as indicated in Appendix A Table 1. Based upon the amount and size of the piping, the total estimated surface area inside the piping is well within the suggested survey unit maximum sizes by classification as recommended by MARSSIM. Note that the number of survey units may be increased (i.e., existing survey units sub-divided) as necessary based upon the discretion of the HP Staff.

9.4.3 Survey Unit Classification

Survey classifications of the piping systems are based upon potential for contamination, and are defined in Appendix A Table 1 for each of the three systems identified. The storm drains and sanitary and building drain systems are identified as Class 1 survey units, while the public water system is a considered Class 3 survey unit.

9.5 Develop a Decision Rule

The decision rule is the determination of whether residual activity exceeds the DCGL.

- If all measurements are less than the gross activity $DCGL_{SO}$ and the DQO have been met, then no additional investigation is required and the survey unit is recommended for unrestricted release.
- If any individual measurement exceeds the gross activity $DCGL_{SO}$ but does not exceed gross activity piping $DCGL_{PD}$, an investigation is performed and documented.
    - If the average gross activity level within a section(s) of piping containing the elevated result(s) does not exceed the $DCGL_{SO}$, the survey unit is recommended for unrestricted release.
    - In the unlikely event buried piping to remain exceeds $DCGL_{SO}$ and cannot be practically decontaminated or removed, HDP will verify the piping meets $DCGL_{PD}$ and grout the piping in place. HDP will evaluate the specific dose from piping to be left and account for this dose in the affected survey unit. The specific dose from piping to be left will be determined on a case-by-case basis using specific piping characteristics and a modeling program (e.g., MicroShield®).
- If any individual measurement exceeds the gross activity $DCGL_{PD}$, the section of piping containing individual measurements exceeding the piping $DCGL_{PD}$ will be further decontaminated and re-surveyed, or excavated and removed.

For piping surveys, the Sign test will be applied using a direct comparison to the $DCGL_{SO}$. In the event that a survey unit does not meet the release criterion, a retrospective power analysis can be used to determine if this is due to excess residual radioactivity or if it is due to an inadequate sample size. Retrospective power analyses, if necessary, will be performed following the methods of MARSSIM Sections I.9 (Reference 5.7).

9.6 Specify Limits on Decision Errors

The probability of making decision errors is part of the DQO process in establishing performance goals for the data collection design and can be controlled by adopting a scientific approach through hypothesis testing. In this approach, the survey results are used to select between the null hypothesis or the alternate condition (the alternative hypothesis) as defined and shown below:

- Null Hypothesis (H_o) – The survey unit does not meet the release criterion; and,
- Alternate Hypothesis (H_a) – The survey unit does meet the release criterion. The Type I decision error (α) would result in the release of a survey unit containing residual radioactivity above the release criterion or a false negative. This occurs when the null hypothesis is rejected when in fact it is true.

9.6.1 The Type II decision error (β) would result in the failure to release a survey unit when the residual activity is below the release criterion or a false positive. This occurs when the null hypothesis is accepted when in fact it is not true.

9.6.2 The index of sensitivity (d') represents the distance between the means of the background and background plus signal.

9.6.3 Following the guidance in NUREG-1757 (Reference 5.8), the decision error rates for FSSs designed at the HDP are established as follows:

- The α value will be set at 0.05 unless prior NRC approval is granted for using a less restrictive value; and,
- The β value is nominally set at 0.10, but may be modified, as necessary, after weighing the resulting change in the number of required sampling and measurement locations against the risk of unnecessarily investigating and/or remediating survey units that are truly below the release criterion.
- For surface scanning, 1.38 will be used as the value for d' based on a true positive proportion of 0.95 and a false positive proportion of 0.60. This value is based on data contained in Table 6.5 of MARSSIM (Reference 5.7).

9.7 Optimize the Design for Obtaining Data

The first six steps of the DQO process are used to develop the performance goals of the FSS. The final step in the process leads to the development of an adequate survey design. In order to optimize the survey and to meet the DQOs, any available information is reviewed. This may include previous characterization surveys or preliminary survey data collected near the onset of the FSS. In the absence of data, assumptions are made in accordance with the guidance as provided in MARSSIM (Reference 5.7). This allows for proper survey planning and design as well as aids in ensuring survey units are established properly and that adequate data are collected.

10.0 FINAL STATUS SURVEY PLANNING AND DESIGN

The output for the planning and design phase is the FSS sampling plan. The general approach prescribed by MARSSIM for FSS requires that a minimum number of measurements or samples be collected within a survey unit so that statistical tests can be applied with adequate

confidence. Decisions regarding whether a survey unit meets the applicable release criterion are described in the following sections..

10.1 Sample Size Determination

The level of survey effort required for a given survey unit is determined by the potential for contamination as indicated by its classification. The number of measurement locations is dependent upon the anticipated statistical variation of the final data set such as the standard deviation, the decision errors, and a function of the gray region as well as the statistical tests to be applied.

The number of measurements is determined, using the sign test sample size values, (Table I.2 of MARSSIM, (Reference 5.7)) to establish the relative shift using the decision errors as specified in Section 9.6.4.

10.1.1 Gray Region

The gray region is established by setting an upper and lower boundary. Values for the specified parameter above and below these boundaries usually result in a "black and white" or "go or no go" decision. Values between the upper and lower boundary are within the "gray region" where decision errors apply most. By establishing the decision errors as specified on acceptable risks, the number of measurement location are controlled within reason.

10.1.2 Upper Boundary of the Gray Region

For the purposes of the FSS, release parameters at or near the release guidelines typically result in a decision that the survey unit does not meet the requirements for release, with the exception of evaluating elevated areas. As a result, the upper boundary of the gray region is defined as the $DCGL_{SO}$.

10.1.3 Lower Boundary of the Gray Region (LBGR)

The lower boundary of the gray region is the point at which the Type II error (β), or false positive applies. The LBGR will initially be set at the mean level of residual contamination in the survey unit, if available; otherwise, per MARSSIM (Reference 5.7), the initial value for the LBGR will be set to one-half of the $DCGL_{SO}$. This value may be adjusted as necessary and may be set as low as the MDC for the specific analytical technique.

10.1.4 Relative Shift

The shift (Δ) is defined as the upper boundary of the gray region, of the $DCGL_{SO}$, minus the LBGR. Sigma (σ) is defined as the standard deviation of the data set. For preliminary planning σ will be set as the standard deviation of the preliminary survey data. The relative shift is defined as the shift divided by the standard deviation (Δ/σ).

10.2 Scan Coverage

The purpose of scan measurements is to confirm that an area was properly classified, and that any areas of elevated activity are identified. Depending upon the sensitivity of the scanning method used, the number of static surface contamination measurements is increased if the scanning sensitivity is greater than the $DCGL_{SO}$. The scan coverage also

depends upon the survey unit classification; areas of higher risk will require a higher degree of coverage.

10.2.1 Class 1

For Class 1 survey units, surface scans are performed within the accessible piping to the maximum extent practical. Due to the remote nature of the piping surveys, 100 percent scan coverage is difficult, particularly at greater distances from the access locations. The goal for FSS is to ensure that all accessible piping is subjected to scan coverage. An evaluation is conducted for sections of piping between access locations where full coverage is not achieved. The evaluation considers the results of scans and static measurements performed within the accessible portions of the piping, and the information obtained from the visual inspections to determine if the type and number of measurements are adequate.

10.2.2 Class 3

Class 3 survey units are subjected to judgmental or biased surface scan coverage at access locations identified by the HP Staff. Given the very low probability of the public water supply containing licensed radioactivity, approximately 11 locations will be selected for survey. This value is based on the sign test with a predicted relative shift of 3.

10.3 Reference Grid

A one-dimensional reference grid will be used within the piping. The measurement spacing within each Class 1 survey unit is established by dividing the overall length of the pipe to be surveyed as part of the survey unit by the number of measurements required as determine using the guidance in Section 10.1. This results in a static measurement frequency per unit length of piping.

A reference grid will not be established for the Class 3 survey units.

11.0 FINAL STATUS SURVEY IMPLEMENTATION

11.1 Piping Access and Control

Prior to performing piping surveys, Class 1 (only) piping is accessed to the extent practical for visual inspection. This identifies the location of residual deposits of sediment/scale, breaks or cracks, and aids in ensuring the piping can be adequately accessed for survey.

Piping access locations such as floor drains, storm drains, manholes, clean-outs and discharge locations are identified in the survey record. Any charged systems are isolated and drained prior to accessing.

11.1.1 Piping Inspection

The accessible portions of the piping in each Class 1 (only) piping survey unit are visually inspected using a remote camera to document the integrity of the piping. This also enables the HP Staff to assess the condition of the piping, identify any sediment buildups or piping failures and to identify any additional piping connections that were not previously identified.

11.1.2 Piping Access and Preparation

Access to the piping may be gained at drain openings, manhole covers, and piping clean-outs. Access may also require partial excavation of the piping systems at select locations in order to open the piping at straight sections. This will allow for surveys to be performed to the maximum extent practical. Survey and inspection equipment is inserted and positioned by using a flexible rod or a tether (or equivalent) to push or pull the equipment through the piping. Due to the limitations of the electronic components of the instrumentation, the maximum length of piping that can be surveyed is about 50 feet from each access location.

Based upon visual inspection, piping may require cleaning in order to remove build up of sediment and materials. Once accessed and cleaned as appropriate, the piping is controlled (e.g., sealed or demarcated) to prevent the introduction of contamination. The piping may also be ventilated as necessary in order to dry surfaces prior to survey.

11.2 Piping Scale/Sediment Sampling

Scale or sediment samples are collected from drain traps, manholes and piping systems for sample analysis. The laboratory analyses of these samples are used to confirm, or to update the isotopic distributions. In the event that the results (expressed as a fraction of the $DCGL_{SO}$) indicate a non-conservative isotopic ratio, the isotopic ratio and $DCGL_{SO}$ will be adjusted.

11.3 Instrument Selection

Instrumentation is selected based upon the pipe diameter to be surveyed, with the intent to position the face of the detector as close to the piping surface as possible. A summary of the three primary detectors that will be typically used is provided in Appendix A Table 1. The Ludlum Model 43-98 is a 1.5-inch diameter cylindrical gas flow proportional detector for use in 2-inch piping. The Ludlum Model 43-68 is a 126 cm^2 flat gas flow proportional detector for use in pipe with a diameter 8-inches or larger. An assessment will be performed to determine if the Ludlum Model 43-68 may be used for the survey of 6-inch piping.. The Ludlum Model SN-175-3M detector is a multi-detector system using three standard 15.5 cm^2 GM detectors for use in 4- and 6- inch piping.

The reference to instrumentation above is not intended to be all-inclusive. Additional instrumentation may be used, provided that the equivalency is documented and approved by the RSO.

11.3.1 Instrument Calibration and Efficiency Calculation

Each instrument is calibrated prior to use with sources traceable to the National Institute of Standards and Technology (NIST), and representative of the type and energy of the radiations emitted by the ROC. Multiple calibration sources are used as applicable. The instruments will be operated in the alpha-plus-beta mode, with the exception of the SN-175-3M detector which is sensitive only to beta emissions. A weighted detection efficiency is calculated depending upon the number of sources used during calibration and the type and energy of the emissions. Examples of an efficiency calculation for the Ludlum Model 43-68 is provided in Tables 6 thru 8 of Appendix A for the current isotopic distribution. The data in the described tables,

assume a 5 weight-percent enrichment in U-235, and use radioactive sources containing Tc-99, Sr/Y-90, Th-230 and Pu-239.

The detectors are calibrated in a similar geometry, with a similar cable length, and with the source presented at a distance that approximates the distance to the surface of the piping that will be used during the survey. In the event that the measurement geometries are not similar to the geometries used for calibration, the efficiencies will be modified. Modification is performed using the guidance as provided in NUREG-1507 (Reference 5.6) and summarized in Tables 9 and 10 of Appendix A.

11.3.2 Instrument Detection Sensitivity

Instrument detection sensitivities depend upon the measurement geometry, instrument efficiencies, count times and scan speeds. Both scan and static measurement sensitivities for the various piping detectors are determined using the guidance in Chapter 14 of the DP (Reference 5.1).

The calculations for detection sensitivity assume background count rates of 200 to 300 cpm for the gas flow proportional detectors, and 100 cpm for the G-M detector. Actual instrument sensitivities are documented based upon the measured background in the field. A summary of the detection sensitivities of the three different detectors as listed are provided in Appendix A Table 11 and Figures 3 thru 8 of Appendix B.

11.4 Preliminary Surveys

During survey preparation, preliminary surveys such as static measurements, surface scans and smear samples may be obtained at piping access locations. Any data collected may be used to aid in survey design and to determine the number of measurements and measurement frequencies.

11.5 Survey Methods

The survey methods employed by the FSS for piping consist of a combination of interior surface scans, static measurements and an interior visual inspection. Smear samples and/or sediment and scale samples will be collected to confirm, or update the isotopic distribution.

11.5.1 Scan Surveys

Scan surveys are performed to the maximum extent practical over the length of piping within Class 1 survey units. Due to the remote nature of the surveys, it is difficult to obtain full 100% scan coverage for Class 1 surveys as discussed in Section 10.2.1. Surface scans are performed either by pushing the detector into the piping or by pulling the detector through the piping from the opposite end. Scan speeds are controlled to ensure detection sensitivities below the $DCGL_{SO}$.

Scan surveys are performed only within the immediate vicinity of the access locations within the Class 3 survey units.

11.5.2 Static Measurements

Static measurements are performed at systematic locations along the length of the piping. The measurement frequency is determined by the overall length of the piping within the survey unit and the number of measurements required in accordance with Section 10.1. Additional static measurements are performed at

locations of elevated count rate (biased) that are observed during the scan survey. The biased measurement results are not included in the statistical evaluation, but are directly compared to the DCGL Visual Inspection

As part of the FSS within Class 1 survey units, a visual inspection is performed of the piping interior. This is typically performed prior to radiological surveys; however, additional inspections may be performed following a review of the survey results. The visual inspections are used to supplement scan surveys, to document the condition of the piping and to ensure the absence of sediment/scale in significant amounts where 100% scan coverage cannot be achieved.

A visual inspection is not performed within the Class 3 survey unit.

11.5.3 Smears and Sediment Samples

Smear and sediment samples may be collected as part of the FSS for supporting information as directed by the HP staff.

12.0 FINAL STATUS SURVEY DATA ASSESSMENT

The Data Quality Assessment (DQA) process is used during the evaluation phase of the FSS to ensure the validity of results and to demonstrate the survey plan objectives have been achieved. The DQA process includes a review of the DQOs, the adequacy of the survey plan, assumptions regarding the isotopic distribution and associated gross activity limit, assumptions regarding the required number of measurement, and the appropriateness of the statistical testing. A summary of the DQA process is provided in the following sections.

12.1 Review of the DQOs and Survey Design

Prior to subjecting the data to statistical tests and comparing it to the release criterion, the data is confirmed to have been collected in accordance with applicable procedures, survey plan and QA/QC requirements. This evaluation includes a confirmation, by review of the daily instrument response checks that the instrumentation was operating properly. The survey documentation is reviewed to ensure the prescribed number of measurements was collected, and that the detection sensitivity met the DQO. Any discrepancies between data quality or the data collection process and applicable survey requirements are resolved and documented during data analysis.

12.2 Data Review

The net results are then converted to standard units of reporting for comparison to the DCGL by applying the weighted detection efficiency and any correction for the surface area of the detector.

Basic statistical quantities are calculated for the sample data set from systematic static measurements including the maximum, mean, median and standard deviation. An initial assessment of the measurement results and any sample data is used to determine whether the survey unit met the release criteria. Interpreting the results for the piping surveys is straightforward with an initial comparison to the $DCGL_{SO}$ or the $DCGL_{PD}$.

- Any individual measurement exceeding the $DCGL_{SO}$ is further evaluated against the piping $DCGL_{PD}$.

- Sections of piping containing individual measurements that exceed the $DCGL_{SO}$, but are less than the $DCGL_{PD}$ are evaluated to determine the need for further decontamination and re-survey, or grouting the portion of the piping containing elevated activity in preparation for leaving in place.
- Sections of piping containing individual measurements exceeding the piping $DCGL_{PD}$ will be further decontaminated and re-surveyed, or excavated and removed.

12.3 Sign Test

The Sign Test is applied using the systematic measurements obtained from within piping using the guidance in Section 8.3 of MARSSIM (Reference 5.7). The Sign Test is a non-parametric statistical evaluation typically used in situations when evaluating sample analyses where the radionuclides of concern are not present in background.

12.4 Survey Unit Dose Contribution Assessment

Any piping that may be grouted in place is further evaluated using MicroShield® modeling as described in Attachment 4 to HEM-10-85, Response to Request for Additional Information Concerning Hematite Decommissioning Plan: Chapter 5, Dose Modeling (Reference 5.18) to assess any potential exposure to the public in the event that piping is removed following license termination. This dose contribution is then summed with the contribution to dose from the soil within the applicable survey unit.

12.5 Elevated Measurement Comparison

The Elevated Measurement Comparison (EMC) is not applied to the results of piping surveys.

12.6 Data Conclusions

The data evaluation results in one of three conclusions consistent with the decision rules discussed in Section 9.5

- If all measurements are less than the gross activity $DCGL_{SO}$ and the DQO have been met, then no additional investigation is required and the survey unit is recommended for unrestricted release.
- In the event buried piping to remain exceeds $DCGL_{SO}$ and cannot be practically decontaminated or removed, HDP will verify the piping meets $DCGL_{PD}$ and grout the piping in place. HDP will evaluate the specific dose from piping to be left and account for the dose in the affected survey unit.
- If any individual measurement exceeds the gross activity $DCGL_{PD}$, the section of piping containing individual measurements exceeding the piping $DCGL_{PD}$ will be further decontaminated and re-surveyed, or excavated and removed.

The Sign test will be applied to the static measurements obtained at systematic location and compared to the $DCGL_{SO}$. In the event that a survey unit does not meet the release criterion, a retrospective power analysis can be used to determine if this is due to excess residual radioactivity or if it is due to an inadequate sample size. Retrospective power analyses, if necessary, will be performed following the methods of MARSSIM Sections I.9 (Reference 5.7). In the event that the survey unit meets the release criterion, the dose contribution to the associated soil survey unit(s) is assessed. The release criterion is met provided the sum of the dose contribution from both the piping survey unit and the soil survey unit(s) that it transverses is less than the release criteria as established by 10 CFR 20.1402 (Reference 5.5).

13.0 FINAL STATUS SURVEY REPORTING

A FSS Survey Unit release record is prepared to include a complete record of the final radiological status of the piping for each survey unit. All records are available to the NRC for inspection upon request. Additionally, the results of the piping FSS are compiled into a FSS Final Report that summarizes the survey results and provides a conclusion regarding suitability for release. This report is submitted to the NRC for review.

14.0 QUALITY ASSURANCE AND QUALITY CONTROL MEASURES

FSS Quality Assurance / Quality Control (QA/QC) measures are implemented during the FSS of the piping in accordance with the QA/QC measures as outlined in the Final Status Survey Program, Reference 5.10. To ensure survey data collected are of the type, quantity and quality to demonstrate the unrestricted release of the site with sufficient confidence, surveys are performed following the guidance of this Plan and approved implementing procedures.

FSS activities are performed by trained individuals using properly calibrated instruments that are sensitive to the radionuclides of concern. The FSS process, including training, instrument calibration, daily instrument checks, surveys, sampling and the review of survey and sampling results are documented. Records are maintained in accordance with the records management requirements as specified in Reference 5.13.

Effective implementation of QA/QC measures is verified through audit activities, with corrective actions being prescribed, implemented and verified in the event any deficiencies are identified. The following sections describe the basic QA/QC elements of the FSS approach.

14.1 Selection of Personnel

Personnel performing the FSS of piping meet the training and qualification requirements of Section 7.0 of this Plan.

14.2 Written Procedures

FSS activities essential to data quality are performed in accordance with approved procedures that implement the requirements of this Plan.

14.3 Survey Records and Documentation

FSS records are designated as quality records and are controlled and retained in accordance with Reference 5.13. Examples of quality records associated with the FSS include:

- Training records;
- Procedures;
- Survey packages and sampling plans;
- Instrument calibration and response test records;
- Survey Unit release records and FSS Final Reports; and
- Sample analysis results.

14.4 Final Status Survey Instrumentation

The survey plan design prescribes measurement techniques for scanning and static survey measurements. The DQO process for instrument selection was used during the planning phase for piping surveys. This included consideration of the type of radiation, spatial distribution of activity within the piping, detection capabilities of the instrumentation, and the size and interior condition of the piping. To ensure the quality of the survey records and FSS data, the instrument program is implemented through approved procedures. The instrumentation program includes the following considerations:

14.4.1 Selection

The proper selection of instrumentation ensures reliability under the environmental and physical conditions that are encountered, and ensures that instrumentation is capable of measuring radionuclides of concern at the detection levels needed to meet the DQO.

14.4.2 Calibration and Maintenance

Instrumentation is calibrated for the radiation types and energies to be measured, or to a source of radiation that results in a conservative response. Calibrations are performed annually or after maintenance that could affect operability using HDP approved procedures. Instrument calibrations will be performed by an approved vendor. The geometries used during calibration replicate, to the extent practical, the survey conditions inside the piping. Instrument calibrations are documented and maintained with the project records. Labels are affixed to portable survey instrumentation to identify the calibration status. Prior to using instrumentation, response checks are performed to verify operability.

Radioactive sources used for calibration are traceable to the National Institute of Standards and Technology (NIST).

14.4.3 Operation and Daily QC

Following calibration and prior to use, instrumentation initial response data are recorded. The initial response data are used to establish performance standards (response ranges) for comparison to daily response tests.

Daily response tests are performed in accordance with approved procedures prior to, and following use. The results of the response tests are documented and compared to performance standards to verify operability. If an instrument fails a pre-use response test, it is removed from service until the cause is identified and corrected, and operability is restored. If an instrument fails a post-use response test, data collected during that time period is evaluated and either accepted, or discarded depending upon the cause of failure. In the event that data is accepted, the evaluation and basis for acceptance will be documented.

14.4.4 MDC Calculations

Equations and details pertaining to the detection sensitivities for instrumentation used for piping surveys are summarized in Section 11.3.2 of this plan and Section 14.4 of the DP, Reference 5.1. Before any measurements are performed, the instrumentation and techniques to be used other than those summarized in this plan will be shown to have sufficient detection capabilities relative to the applicable DCGL.

14.5 Field and Laboratory QC Measures

14.5.1 QC Replicate Surveys of Piping

Following the completion of the piping FSS, replicate surveys are performed at approximately 5 percent of the measurement locations identified within piping. The replicate survey (including both static measurements and scanning surveys) is performed independently of the initial survey (i.e., performed by another HP Technician using the same, or similar instrumentation). In the event that the same instrumentation is used, independent response testing is also performed. The replicate survey should result in the same decision that was reached during the original FSS survey. If the same decision is not reached, an investigation will be conducted to determine the cause of the difference. The result of this investigation will be documented.

14.5.2 Sample Chain-of-Custody

A chain-of-custody (CoC) is completed to ensure sample integrity for those samples requiring analysis at an approved offsite laboratory. The CoC provides a record of the sample location and the type of analysis requested. It is used as a comparator to ensure the data specified by the DQO are returned from the laboratory.

14.6 Software Configuration Control

Data collected during the FSS is archived, analyzed and reported using algorithms that are compatible with commercially available computer software. The initial validation

of an algorithm and subsequent modifications to an algorithm are documented in accordance with HDP-PR-QA-013, Software/Calculation Validation (Reference 5.15)

14.7 Control of Vendor-Supplied Services

Vendor supplied-services, such as instrument calibration and laboratory analyses are procured from approved vendors in accordance with HDP-PR-QA-010, Purchasing and QA Supplier Evaluation (Reference 5.14). Specialty services such as piping visual inspection and cleaning do not require similar approval.

14.8 Surveillances and Assessments

Surveillances and assessments are performed periodically throughout the performance of the piping FSS in accordance with the HDP-PR-QA-007, Quality Assurance Inspections (Reference 5.16). This includes surveillances by project personnel to ensure this Plan and implementing procedures are being properly implemented. This will include a review of the quality records as well as FSS fieldwork activities.

14.9 Data Verification and Validation (V&V)

Survey and laboratory analytical data are reviewed to ensure the requirements specified by the DQO have been met. This review includes verification that the number and type of analysis were collected, the instrumentation was operating properly with the acceptance standards, and that the detection sensitivity was sufficiently low to ensure the release criterion was met. Individual measurements are compared to the $DCGL_{SO}$ and an investigation is conducted in the event that the DCGL is exceeded. Calculations used to support the statistical evaluation are independently validated to ensure correctness of the method.

14.10 FSSP Change Control

Changes to this FSSP are governed by the same allowances and restrictions established in Section 1.8 of the License Applicable Request (Attachment 18 to Westinghouse letter HEM-11-96) approved in Amendment 57 to SNM-33.

15.0 APPENDICES

Appendix A: Tables

Appendix B: Figures

Appendix A

Table 1 – Piping Inventory

System	Figure Reference ID#	Depth BGS (inches)	Cover	Length (feet)	Diameter (inches)	Surface Area (m^2)
Storm Drain(s) – Class 1 Survey Unit #1						
Building 110 SE	STM-1	60	asphalt	172	12	50.2
Building 110 NW and West	STM-2	60	soil/asphalt	209	15	76.2
Building 230 SE	STM-3	60	concrete	237	18	103.8
Building 230 South	STM-4	60	asphalt/soil	235	18	102.9
Building 230 North Corner	STM-5	60	asphalt	26	30	19
Building 230 NW	STM-6	60	asphalt	249	36	218
Building 230 – 101 Leg	STM-7	60	soil/asphalt	71	15	25.9
Building 240 North Corner	STM-8	60	asphalt	22	18	9.6
Building 240 NW	STM-9	60	asphalt	140	24	81.7
Building 230 South Interior Drains	STM-10	36	concrete	155	4	15.1
Building 230 NE	STM-11	60	soil	58	24	33.9
Building 230 NE	STM-12	60	soil	15	18	6.6
Discharge Leg	STM-13	60	soil	59	36	51.7
Discharge Leg Outlet	STM-14	60	soil	59	42	60.3
Survey Unit #1 Totals:				**1,707**	**NA**	**854.9**
Sanitary / Gray Drains – Class 1 Survey Unit #2						
Building 110 Sanitary	SAN-1	48	concrete/asphalt	124	4	12.1
Building 230 north Sanitary	SAN-2	36	concrete/soil	130	4	12.6
Building 230 north Gray	SAN-3	36	concrete/soil	155	4	15.1
Building 230 south Sanitary	SAN-4	60	concrete/soil	80	4	7.8
Building 240 NW – Gray	SAN-5	48	asphalt	297	8	57.8
Building 240 NW – Sanitary	SAN-6	60	asphalt	291	8	56.6
Building 240 south – Gray to Sanitary connection	SAN-7	48	asphalt	207	8	40.3
Building 240 south – Sanitary to Treatment Plant	SAN-8	60	asphalt	301	8	58.6
Survey Unit #2 Totals:				**1,585**	**NA**	**260.9**

Appendix A

Table 1 – Piping Inventory (cont.)

Public Water System (County Water District) and Raw Water System - Class 3 Survey Unit #3						
to Building 110	WAT-1	36	soil	266	2	12.9
to Building 230	WAT-2	48	asphalt	252	2	12.2
to Building 231	WAT-3	60	concrete/soil	355	8	69.0
to Building 115	WAT-4	48	soil	94	10	23.0
to Hydrants	WAT-5	60	soil/asphalt	1761	8	342.6
Main along Hwy P, within right-of-way	WAT-6	60	soil	2733	6	398.9
Old Main along Hwy P, north parking lot	WAT-7	60	soil	1034	10	251.6
Raw Water	WAT-8	60	soil	639	10	155.4
Survey Unit #3 Totals:				7,133	NA	1265

Appendix A

Table 2 – Building and Structural $DCGL_{SO}$ for Small Offices

Radionuclide	Occupancy $DCGL_{SO}$ (dpm/100 cm^2) [a]
U-234	20,000
U-235 + D [b]	19,000
U-238 + D [b]	21,000
Tc-99	13,000,000
Th-232 + C [c]	1,200
Np-237 + D [b]	2,700
Pu-239/240	3,500
Am-241	3,400

[a] The reported building DCGL are in gross radioactivity limits rounded down (truncated) to two significant figures as provided in Table 14-1 of the DP, Reference 5.1.
[b] "+ D" = plus short-lived decay products.
[c] "+ C" = plus the entire decay chain (progeny) in secular equilibrium.

Table 3 – Initial Isotopic Distribution

Radionuclide	Radioactivity Fraction [a]
U-234	8.27E-01
U-235 + D [b]	3.72E-02
U-238 + D [b]	1.27E-01
Tc-99	2.83E-03
Th-232 + C [c]	3.21E-03
Np-237 + D [b]	5.57E-05
Pu-239/240	2.03E-06
Am-241	2.68E-03
Sum of fractions for Uranium Only	**9.91E-01**
Sum of fractions for all Radionuclides	**1.00E+00**

[a] Values are as reported in Table 4-2 of the DP, Reference 5.1.

Appendix A

Table 4 - Gross Activity $DCGL_{SO}$ for Small Offices

Radionuclide	$DCGL_{SO}$ (dpm/100 cm^2)	f_i	f_i / $DCGL_{SO}$ [a]
U-234	20,000	8.27E-01	4.14E-05
U-235 + D	19,000	3.72E-02	1.96E-06
U-238 + D	21,000	1.27E-01	6.05E-06
Tc-99	13,000,000	2.83E-03	2.18E-10
Th-232 + C	1,200	3.21E-03	2.68E-06
Np-237 + D	2,700	5.57E-05	2.06E-08
Pu-239/240	3,500	2.03E-06	5.80E-10
Am-241	3,400	2.68E-03	7.88E-07
Σ f_i / $DCGL_{SO}$ [a]			**5.28E-05**
Gross DCGL (1 / (Σ f_i / $DCGL_{SO}$)) [a] (dpm/100 cm^2)			**18,925**

a Values are calculated using Equation 4-4 of MARSSIM, Reference 5.7, as presented below:

$$Gross\ \ Activity\ \ \ DCGL = \frac{1}{\sum_{i=1}^{n}\left(\frac{f_i}{DCGL_{SO,i}}\right)}$$

Appendix A

Table 5 - Gross Activity DCGL for Piping Based on Diameter ($DCGL_{PD}$)

Piping Diameter (inches)	Gross Activity $DCGL_{PD}$ (dpm/100cm^2)[a]
2	81,086
4	162,172
6	243,258
8	324,344
10	405,430
12	486,516
14	567,602
16	648,689
18	729,775
20	810,861
22	891,947
24	973,033
26	1,054,119
28	1,135,205
30	1,216,291
32	1,297,377
34	1,378,463
36	1,459,549
38	1,540,635
40	1,621,721
48	1,946,066

[a] Values are as reported in Table 14-3 of the DP, Reference 5.1.

Appendix A

Table 6 – LMI 43-68 Total Weighted Efficiency (DP Distribution Using Multi-Energy Calibration)

Radionuclide	Emission and Max Energy (MeV) [a]	Calibration Source Basis	Instrument Efficiency [b]	Surface Efficiency [c]	Yield	Activity Fraction [d]	Weighted Efficiency
Am-241	Alpha/5.6	Pu-239	26.10%	25.00%	100%	2.682E-03	1.75E-04
Np-237	Alpha/5.0	Th-230	18.90%	25.00%	100%	5.573E-05	2.63E-06
Pu-239	Alpha/5.2	Pu-239	26.10%	25.00%	100%	2.027E-06	1.32E-07
Tc-99	Beta/0.294	Tc-99	48.90%	25.00%	100%	2.829E-03	3.46E-04
Th-232	Alpha/4.1	Th-230	18.90%	25.00%	100%	3.214E-03	1.52E-04
Ra-228 [e]	Beta/0.046	NA	0.00%	0.00%	100%	3.214E-03	0.00E+00
Ac-228 [e]	Beta/2.13	Sr/Y-90	45.50%	50.00%	100%	3.214E-03	7.31E-04
Th-228 [e]	Alpha/5.5	Pu-239	26.10%	25.00%	100%	3.214E-03	2.10E-04
Ra-224 [e]	Alpha/5.8	Pu-239	26.10%	25.00%	100%	3.214E-03	2.10E-04
U-234	Alpha/4.9	Th-230	18.90%	25.00%	100%	8.270E-01	3.91E-02
U-235	Alpha/4.7	Th-230	18.90%	25.00%	100%	3.720E-02	1.76E-03
Th-231 [f]	Beta/0.390	Tc-99	48.90%	25.00%	100%	3.720E-02	4.55E-03
U-238	Alpha/4.3	Th-230	18.90%	25.00%	100%	1.270E-01	6.00E-03
Th-234 [f]	Beta/0.270	Tc-99	48.90%	25.00%	100%	1.270E-01	1.55E-02
Pa-234m [f]	Beta/2.20	Sr/Y-90	45.50%	50.00%	100%	1.270E-01	2.89E-02
Total Weighted Efficiency:							**9.76%**

[a] Emission data taken from http://www.nndc.bnl.gov/chart/.
[b] Nominal 2π efficiency values for a 126 cm^2 gas flow proportional detector with a 0.8 mg/cm2 window in the $\alpha + \beta$ mode.
[c] Surface efficiencies are based upon the guidance provided in ISO 7503-1, Reference 5.9.
[d] Radionuclide distribution is based upon the DP distribution presented in Table 4.
[e] Progeny from Th-232 decay assuming complete radon emanation.
[f] Progeny from Uranium decay

Appendix A

Table 7 – LMI 43-68 Total Weighted Efficiency (5% EU Using Multi-Energy Calibration)

Radionuclide	Emission and Max Energy (MeV) [a]	Calibration Source Basis	Instrument Efficiency [b]	Surface Efficiency [c]	Yield	Activity Fraction [d]	Weighted Efficiency
Am-241	Alpha/5.6	Pu-239	26.10%	0.25	100%	0.000E+00	0.00E+00
Np-237	Alpha/5.0	Th-230	18.0%	0.25	100%	0.000E+00	0.00E+00
Pu-239	Alpha/5.2	Pu-239	26.10%	0.25	100%	0.000E+00	0.00E+00
Tc-99	Beta/0.294	Tc-99	48.90%	0.25	100%	0.000E+00	0.00E+00
Th-232	Alpha/4.1	Th-230	18.90%	0.25	100%	0.000E+00	0.00E+00
Ra-228 [e]	Beta/0.046	NA	0.00%	0.00	100%	0.000E+00	0.00E+00
Ac-228 [e]	Beta/2.13	Sr/Y-90	45.50%	0.50	100%	0.000E+00	0.00E+00
Th-228 [e]	Alpha/5.5	Pu-239	26.10%	0.25	100%	0.000E+00	0.00E+00
Ra-224 [e]	Alpha/5.8	Pu-239	26.10%	0.25	100%	0.000E+00	0.00E+00
U-234	Alpha/4.9	Th-230	18.90%	0.25	100%	8.209E-01	3.88E-02
U-235	Alpha/4.7	Th-230	18.90%	0.25	100%	4.530E-02	2.14E-03
Th-231 [f]	Beta/0.390	Tc-99	48.90%	0.25	100%	4.530E-02	5.54E-03
U-238	Alpha/4.3	Th-230	18.90%	0.25	100%	1.338E-01	6.32E-03
Th-234 [f]	Beta/0.270	Tc-99	48.90%	0.25	100%	1.338E-01	1.64E-02
Pa-234m [f]	Beta/2.20	Sr/Y-90	45.50%	0.50	100%	1.338E-01	3.04E-02
Total Weighted Efficiency:							**9.96%**

[a] Emission data taken from http://www.nndc.bnl.gov/chart/.
[b] Nominal 2π efficiency values for a 126 cm^2 gas flow proportional detector with a 0.8 mg/cm2 window in the α + β mode.
[c] Surface efficiencies are based upon the guidance provided in ISO 7503-1, Reference 5.9.
[d] Radionuclide distribution is based upon the Enriched Uranium distribution as presented in Table 14-5 of the DP, Reference 5.1, for 5% EU.
[e] Progeny from Th-232 decay assuming complete radon emanation.
[f] Progeny from Uranium decay.

Appendix A

Table 8 – LMI 43-68 Total Weighted Efficiency (DP Distribution Using Simple Tc-99/Th-230 Calibration)

Radionuclide	Emission and Max Energy (MeV) [a]	Calibration Source Basis	Instrument Efficiency [b]	Surface Efficiency [c]	Yield	Activity Fraction [d]	Weighted Efficiency
Am-241	Alpha/5.6	Th-230	18.90%	0.25	100%	2.682E-03	1.27E-04
Np-237	Alpha/5.0	Th-230	18.90%	0.25	100%	5.573E-05	2.63E-06
Pu-239	Alpha/5.2	Th-230	18.90%	0.25	100%	2.027E-06	9.58E-08
Tc-99	Beta/0.294	Tc-99	48.90%	0.25	100%	2.829E-03	3.46E-04
Th-232	Alpha/4.1	Th-230	18.90%	0.25	100%	3.214E-03	1.52E-04
Ra-228 [e]	Beta/0.046	NA	0.00%	0.00	100%	3.214E-03	0.00E+00
Ac-228 [e]	Beta/2.13	Tc-99	48.90%	0.50	100%	3.214E-03	7.86E-04
Th-228 [e]	Alpha/5.5	Th-230	18.90%	0.25	100%	3.214E-03	1.52E-04
Ra-224 [e]	Alpha/5.8	Th-230	18.90%	0.25	100%	3.214E-03	1.52E-04
U-234	Alpha/4.9	Th-230	18.90%	0.25	100%	8.270E-01	3.91E-02
U-235	Alpha/4.7	Th-230	18.90%	0.25	100%	3.720E-02	1.76E-03
Th-231 [f]	Beta/0.390	Tc-99	48.90%	0.25	100%	3.720E-02	4.55E-03
U-238	Alpha/4.3	Th-230	18.90%	0.25	100%	1.270E-01	6.00E-03
Th-234 [f]	Beta/0.270	Tc-99	48.90%	0.25	100%	1.270E-01	1.55E-02
Pa-234m [f]	Beta/2.20	Tc-99	48.90%	0.50	100%	1.270E-01	3.11E-02
Total Weighted Efficiency:							**9.97%**

[a] Emission data taken from http://www.nndc.bnl.gov/chart/.
[b] Nominal 2π efficiency values for a 126 cm^2 gas flow proportional detector with a 0.8 mg/cm2 window in the α + β mode.
[c] Surface efficiencies are based upon the guidance provided in ISO 7503-1, Reference 5.9.
[d] Radionuclide distribution is based upon the DP distribution presented in Table 4.
[e] Progeny from Th-232 decay assuming complete radon emanation.
[f] Progeny from Uranium decay.

Appendix A

Table 9 - Source to Detector Distance Effects for βeta Emitters [a]

Distance from Source (cm)	Normalized Net Count Rate					
	Ni-63 (Disc)	C-14 (Disc)	Tc-99 (Disc)	Tc-99 (Distributed)	Tl-204 (Disc)	Sr/Y-90 (Disc)
Contact	1	1	1	1	1	1
0.5	0.381 ± 0.064	0.786 ± 0.047	0.864 ± 0.016	0.803 ± 0.015	0.910 ± 0.024	0.9189 ± 0.0065
1	0.196 ± 0.053	0.648 ± 0.048	0.7779 ± 0.0085	0.701 ± 0.023	0.836 ± 0.026	0.8534 ± 0.0088
2	0.038 ± 0.041	0.431 ± 0.034	0.5920 ± 0.0090	0.503 ± 0.014	0.645 ± 0.033	0.6995 ± 0.0063

[a] Normalized instrument response as provided in Table 4-5 of NUREG-1507, Reference 5.6.

Table 10 - Source to Detector Distance Effects for Alpha Emitters [a]

Distance from Source (cm)	Normalized Net Count Rate		
	Pu-239 (Disc)	Th-230 (Disc)	Th-230 (Distributed)
Contact	1	1	1
0.5	0.808 ± 0.013	0.812 ± 0.010	0.761 ± 0.026
1	0.656 ± 0.015	0.606 ± 0.012	0.579 ± 0.021
2	0.1974 ± 0.0046	0.0423 ± 0.0027	0.0990 ± 0.0093

[a] Normalized instrument response as provided in Table 4-6 of NUREG-1507, Reference 5.6.

Appendix A

Table 11 - Estimated Piping Detection Sensitivities [a]

Detector / Instrument	Piping Size	DP Nuclide Mix [b]		U-235 5% Enrichment [b]		Tc-99 [b]	
		Scan [c]	Static [d]	Scan [c]	Static [d]	Scan [c]	Static [d]
LMI 43-98	2	1,958.4	1,537.3	1,930.7	1,515.5	2,142.9	1,682.1
SP-175-3M	4	15,624.0	6,731.9	15,004.9	6,465.2	19,907.5	8,577.5
SP-175-3M	6	15,624.0	6,731.9	15,004.9	6,465.2	19,907.5	8,577.5
LMI 43-68	8	834.9	677.2	818.5	663.9	817.7	663.2
LMI 43-68	10 [e]	834.9	677.2	818.5	663.9	817.7	663.2
LMI 43-68	12 [e]	834.9	677.2	818.5	663.9	817.7	663.2
LMI 43-68	15 [e]	834.9	677.2	818.5	663.9	817.7	663.2
LMI 43-68	18 [e]	834.9	677.2	818.5	663.9	817.7	663.2
LMI 43-68	24 [e]	834.9	677.2	818.5	663.9	817.7	663.2
LMI 43-68	30 [e]	834.9	677.2	818.5	663.9	817.7	663.2
LMI 43-68	36 [e]	834.9	677.2	818.5	663.9	817.7	663.2
LMI 43-68	42 [e]	834.9	677.2	818.5	663.9	817.7	663.2

[a] Detection sensitivities as presented in the Table are estimates calculated using nominal instrument efficiencies based upon experience, published documentation and prior detector calibrations as applicable. Detection sensitivities will be revised and documented based upon actual detector calibrations.

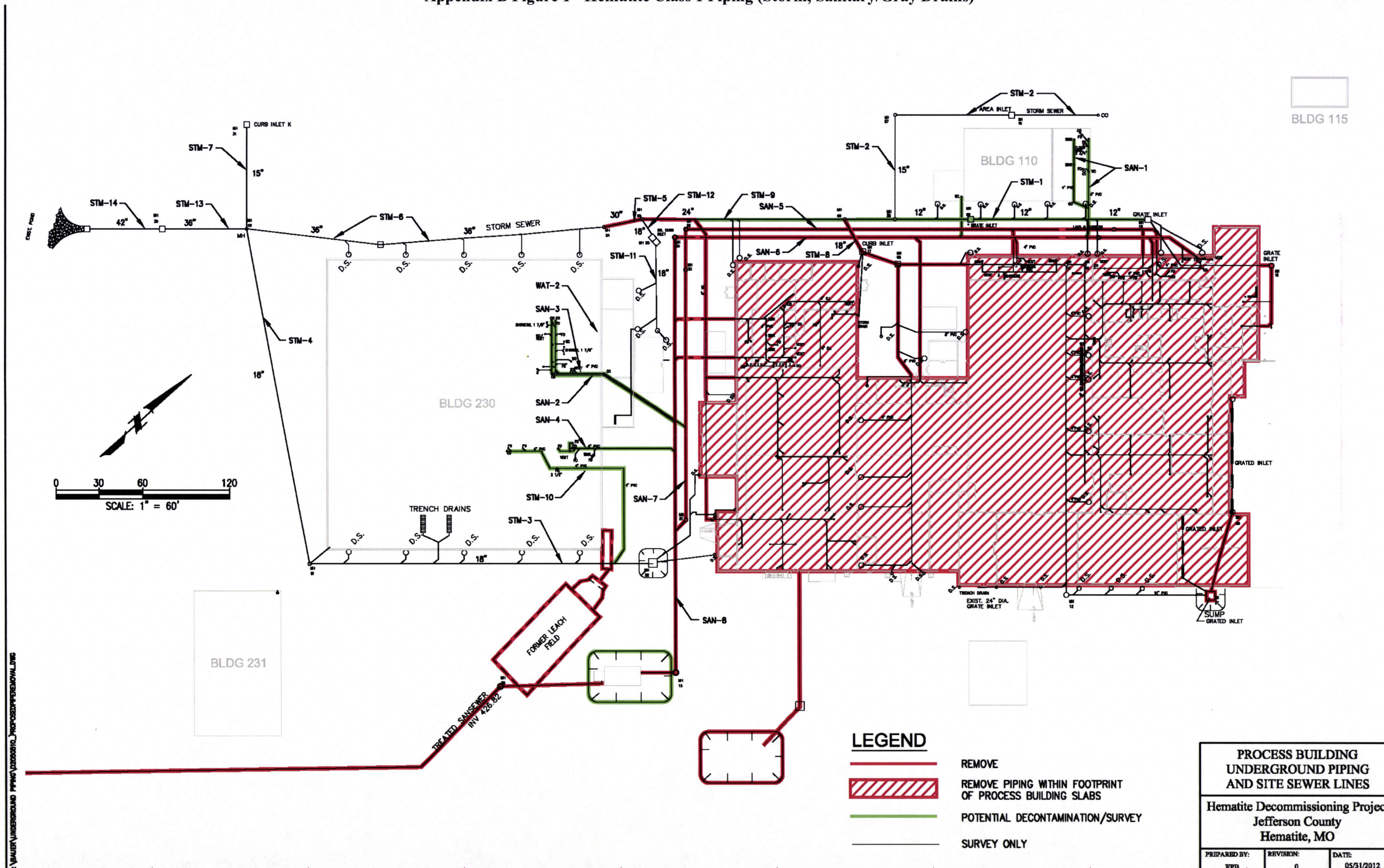
[b] Detection sensitivities are based upon the appropriate weighted efficiencies. Examples of the weighted efficiency calculations are provided in Tables 6, 7 and 8.

[c] Scan sensitivities are based upon a scan speed of 1 inch per second for the specified geometry.

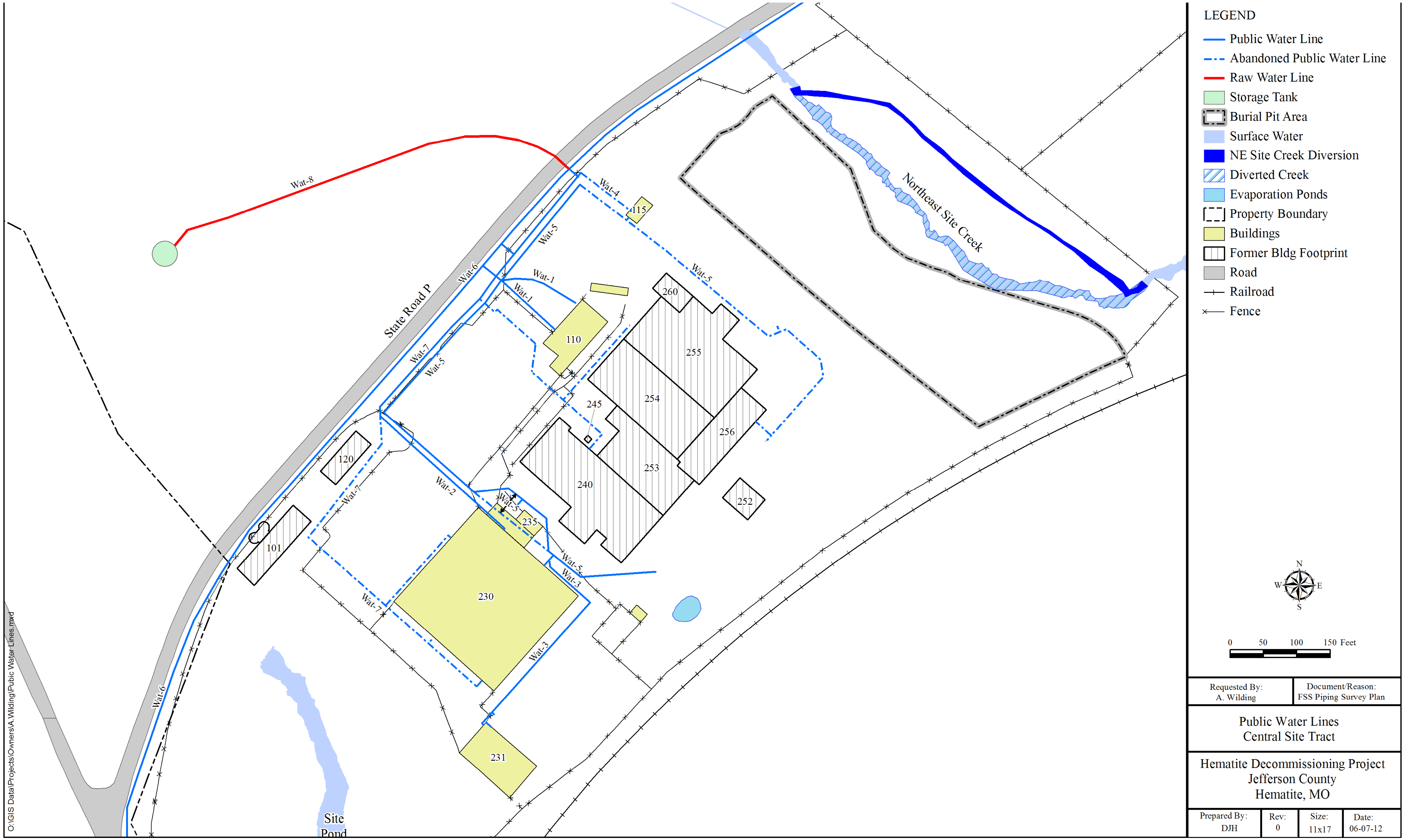
[d] Static measurement sensitivities are based upon a 1 minute scalar count for the specified geometry.

[e] The 43-68 calibration used for the calculations was calibrated at 5/8 inches from the source similar to the distance observed for the 8-inch piping. All piping sizes greater than 8-inches would have a higher efficiency as the detector would be closer to the piping wall. The same efficiency was used for all larger piping sizes; however, the efficiencies can be corrected using Tables 9 and 10 as necessary.

Appendix B Figure 1 - Hematite Class 1 Piping (Storm, Sanitary/Gray Drains)



Appendix B Figure 2 - Hematite Class 3 Piping (Public and Raw Water)



Requested By: A. Wilding	Document/Reason: FSS Piping Survey Plan

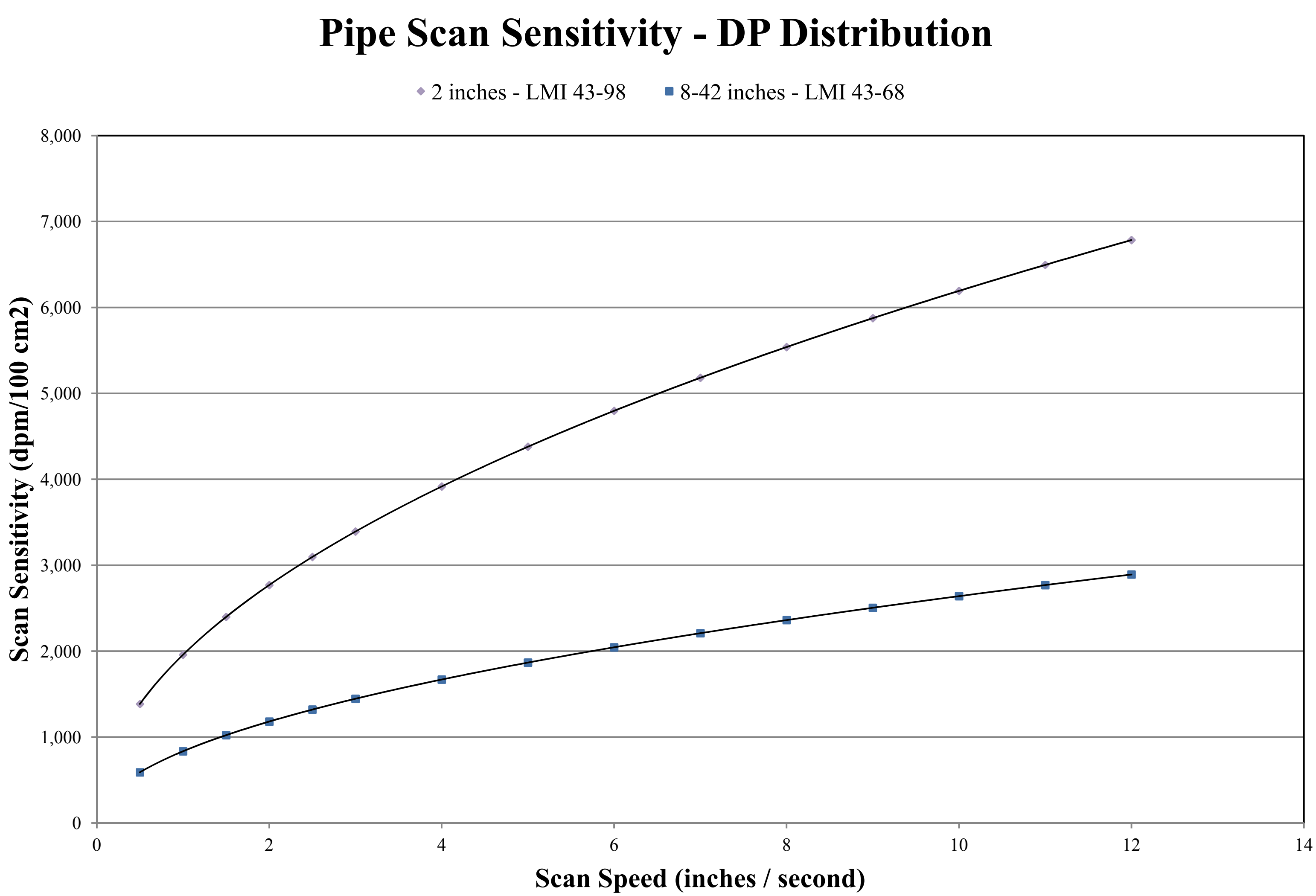
Public Water Lines
Central Site Tract

Hematite Decommissioning Project
Jefferson County
Hematite, MO

Prepared By:	Rev:	Size:	Date:
DJH	0	11x17	06-07-12

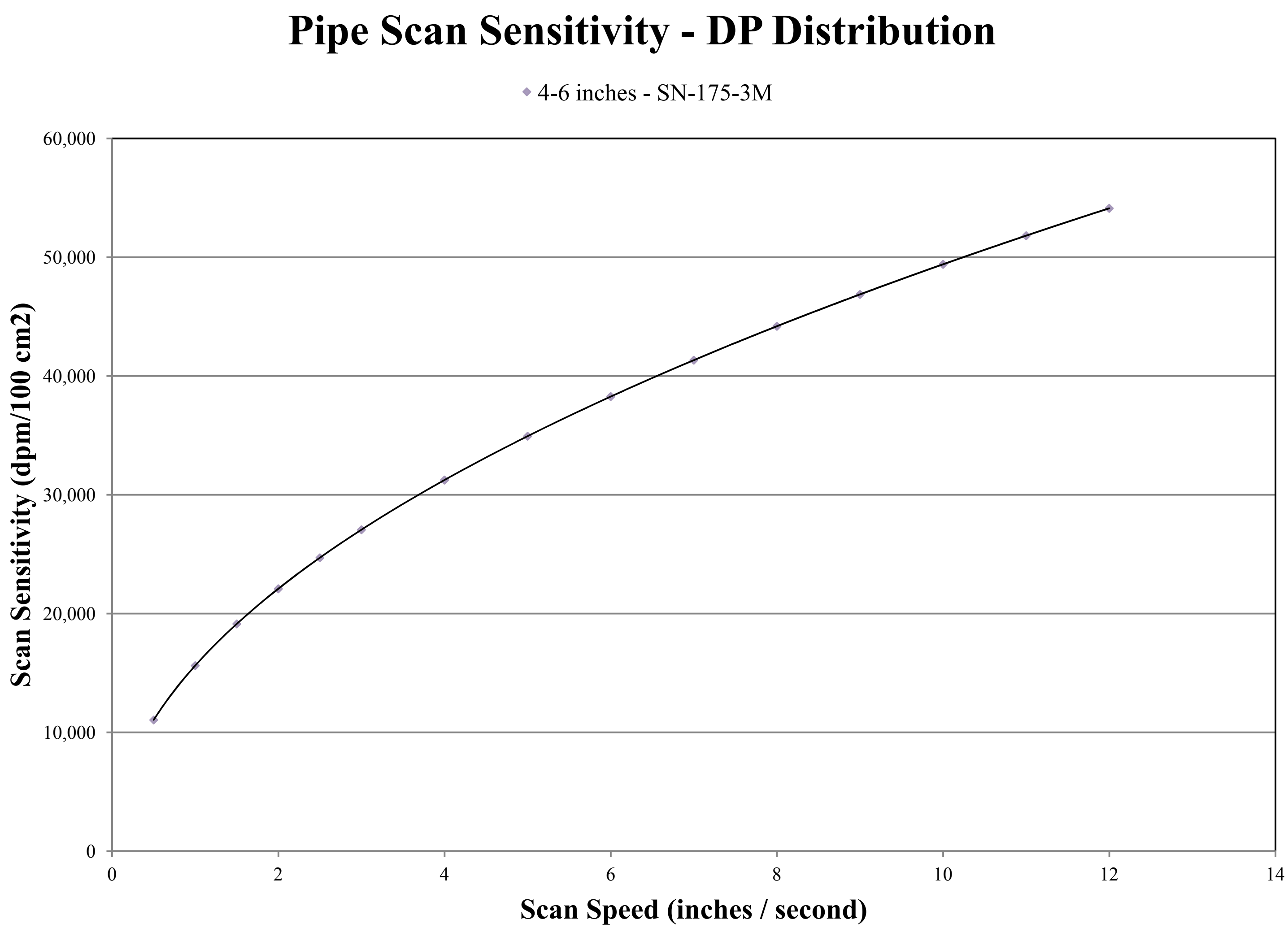
Appendix B

Figure 3 – LMI 43-98 and 43-68 Scan Sensitivities (DP Distribution)



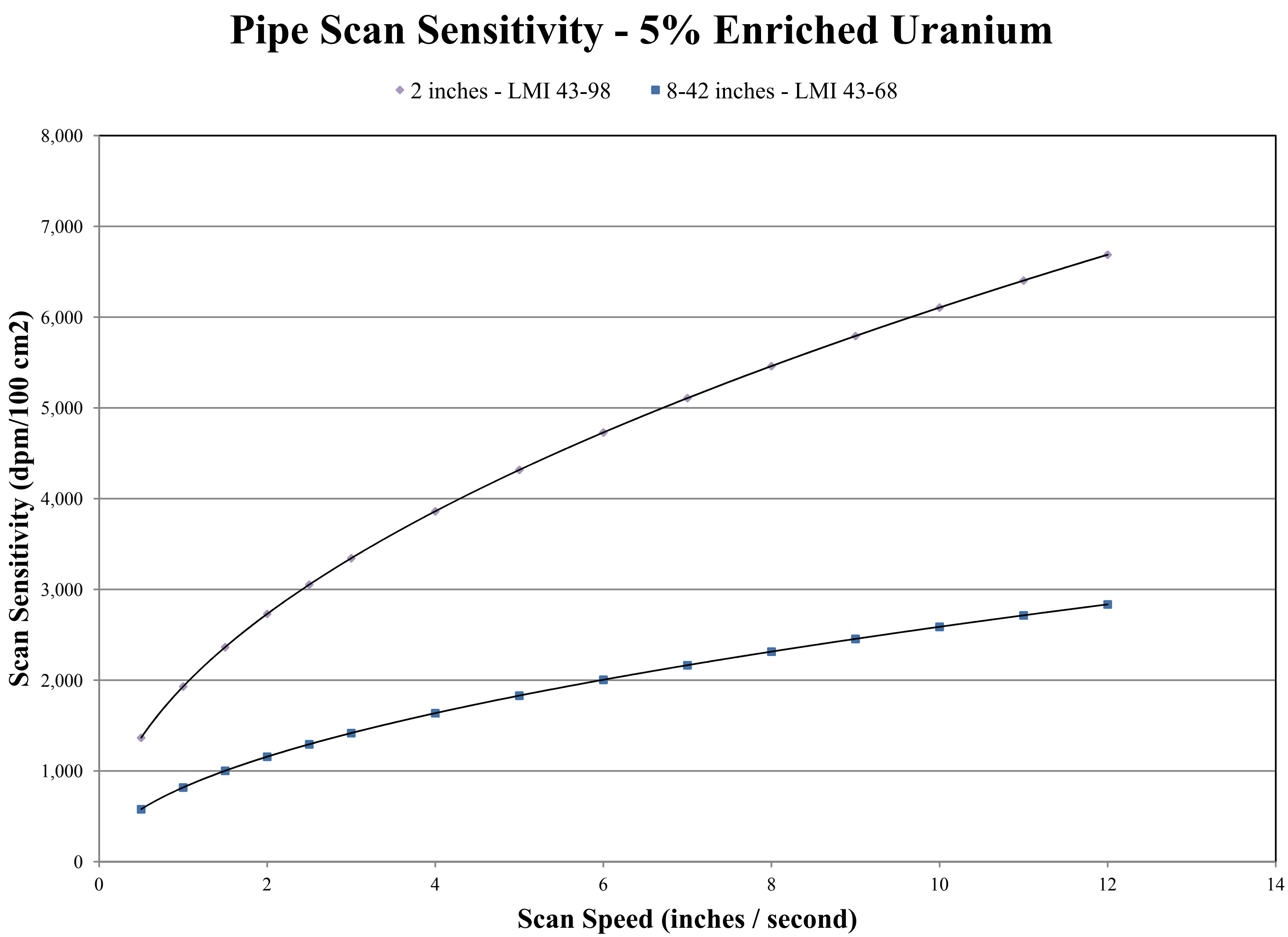
Appendix B

Figure 4 – SP-175-3m Scan Sensitivity (DP Distribution)



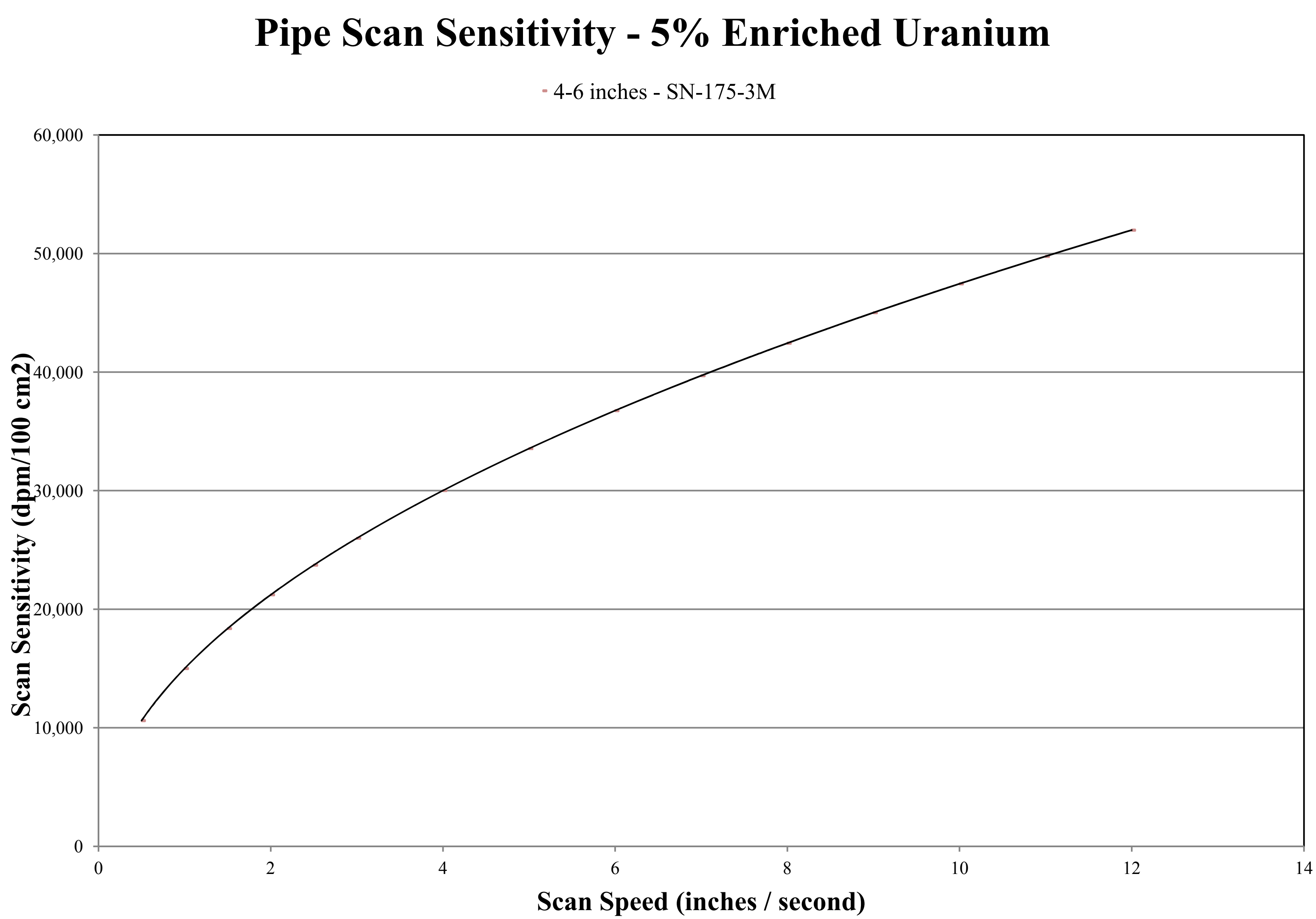
Appendix B

Figure 5 – LMI 43-98 and 43-68 Scan Sensitivities (5% Enriched Uranium)



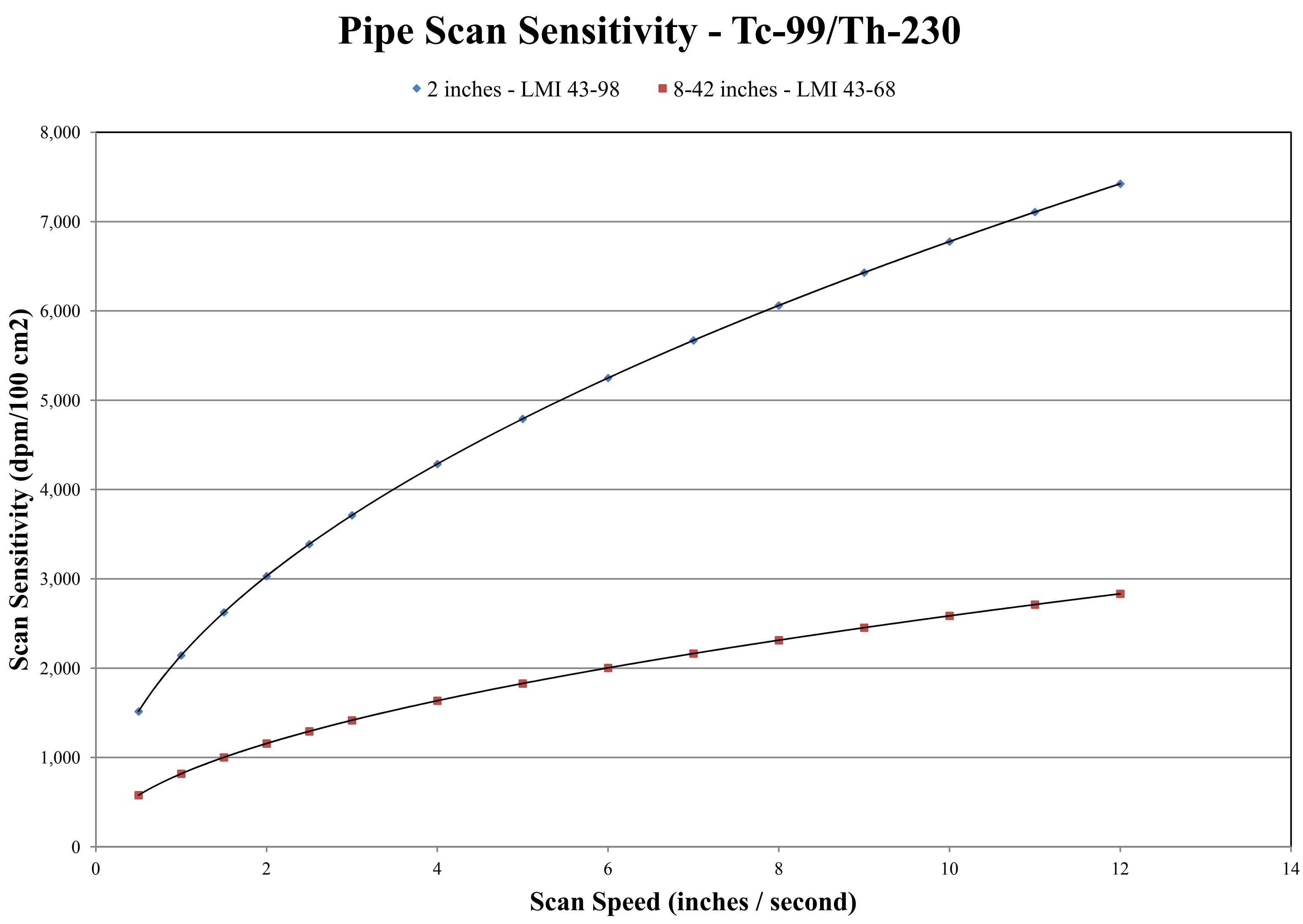
Appendix B

Figure 6 – SP-175-3M Scan Sensitivity (5% Enriched Uranium)



Appendix B

Figure 7 – LMI 43-98 and 43-68 Scan Sensitivities (Tc-99/Th-230 simple Calibration)



Appendix B

Figure 8 – SN-175-3M Scan Sensitivity (Tc-99 simple Calibration)