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June 30, 2006

Kenneth L. Kalman
Decommissioning Branch
Division of Waste Management
Office of Nuclear Materials Safety and Safeguards
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555

Re: Follow-up to the March 9, 2006 Meeting and Response to USNRC Letter of January 26, 2006

Dear Mr. Kalman:

Consistent with 10 C.F.R. § 40.42(g)(2), the U. S. Nuclear Regulatory Commission (USNRC) authorized Shieldalloy Metallurgical Corporation (SMC) to submit a revised "Decommissioning Plan for the Newfield Facility" (Report No. 94005/G-28247, Rev. 1), hereinafter referred to as the "DP" by June 30, 2006. By the submission of this letter, the current version of the DP, hereinafter referred to as Rev. 1a, supersedes all previous versions.[1]

On March 9, 2006, representatives of SMC met with USNRC to discuss a path forward after receiving the USNRC's letter of January 26, 2006. In that letter, the USNRC refused to docket and submit for technical review the, even though SMC firmly believes that the document, as submitted, met *all* of the USNRC's criteria for acceptability.[2,3,4]

The purpose of this letter is to respond to the issues raised in the USNRC's January 26th letter (see Attachment 1), during the March 9th meeting, and during an April 11, 2006 technical meeting at the Newfield site. Specifically, this letter transmits modifications to Rev. 1 of the DP to document discussions on dose modeling, hydrology and erosion protection; to resolve financial assurance concerns; and to confirm eligibility for the proposed institutional control methodology.

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[1] The entirety of this letter, plus Rev. 1a of the DP, will be published shortly on SMC's web site (http://www.shieldalloy.com/decommissioning/index.html) for public review.

[2] U. S. Nuclear Regulatory Commission, NUREG-1757, Volume 1, Rev. 1, "Consolidated NMSS Decommissioning Guidance; Decommissioning Process for Materials Licensees", Chapter 16, Appendix D, September, 2003.

[3] Supplemental guidance in the form of "draft for comment" revisions to NUREG-1757, released by the USNRC shortly before the October 24, 2005 submission date of this Plan (70 FR 56940-56941, "Draft Report for Comment: Office of Nuclear Material Safety and Safeguards Consolidated Decommissioning Guidance: Updates to Implement the License Termination Rule", September 29, 2005), was captured in the checklists.

[4] Bellamy, R. R., U. S. Nuclear Regulatory Commission, letter to D. R. Smith, Shieldalloy Metallurgical Corporation, "Rejection of Decommissioning Plan for the Newfield Facility and Denial of the Exemption Request to Postpone Initiation of Decommissioning Process, Control No. 132074", February 28, 2003.

SMC understands that the process of approving a decommissioning plan under restricted release conditions that includes a Long Term Control (LTC) license is unique to both SMC and the USNRC. We also understand that the approval process may not be as straight-forward as would be the case for conventional decommissioning (i.e., unrestricted release). In its January 26, 2006, letter, the USNRC stated that it was not accepting the DP at that time because acceptance then "would likely require multiple rounds of requests for additional information (RAIs) from the NRC staff." Because there is no published requirements restricting the number of RAIs, and because Rev. 1 of the DP met all of the USNRC's published requirements for acceptability, we hope that the decision to docket Rev. 1a will not be adversely influenced by unpublished administrative guidance.

Once Rev. 1a of the DP has been docketed, we look forward to continuing our productive dialogue with the USNRC on the most efficient and cost-effective means of achieving the regulatory objectives for decommissioning the site, including public participation in accordance with 10 C.F.R. § 20.1405 and 10 C.F.R. Part 51. In accordance with 10 C.F.R. § 40.42(d), SMC is ready to begin decommissioning upon USNRC approval of the DP. In the meantime, I can be reached at (856) 692-4205, ext. 226 if you have any questions.

Sincerely,

David R. Smith,
Radiation Safety Officer

cc: Eric Jackson
Joseph Diegel
David White
Robert Haemer, Esq. - Pillsbury Winthrop Shaw Pittman
Charles L. Harp, Esq. - Archer & Greiner
Carol D. Berger, CHP - Integrated Environmental Management, Inc.
Jean Oliva, PE - TRC
Michael Turner - MMW Group
Marjorie M. McLaughlin - USNRC Region I

cc w/o enc: Commissioner Lisa Jackson - NJDEP
Donna Gaffigan - NJDEP
Mayor Richard Westergaard
Assm. David Mayer
Assm. Paul Moriarity
Assm Fred Madden
Congressman Frank LoBiondo
Congressman Robert Andrews

ATTACHMENT 1
SMC Response to the USNRC's letter of January 26, 2006

USNRC Issue No. 1: During numerous meetings with SMC, the NRC staff stressed the importance of identifying and justifying the chosen value for parameters determined to be important to the estimated dose. For most of the scenarios evaluated for the restricted area, assuming that institutional controls fail, key parameters are not identified. For example, in Chapter 17, SMC discussed how parameter values were derived, but no justification was provided. In fact, some significantly important parameters (e.g., shielding factor) are not even included in the list.

> **SMC Response:** SMC maintains that all of the key parameters used as input to the dose modeling were identified and justified in Rev. 1 of the DP. SMC described and presented the justification for each of the RESRAD input parameters of significance in Chapters 5 and 17 of the DP. The USNRC agreed during previous meetings and teleconferences with SMC that it would *not* be necessary to provide justification for generic or widely-accepted parameters (i.e., breathing rates) and those that would have marginal impact on the resulting dose. Because many of the parameters are common to all scenarios, a collective discussion of these appeared in Section 5.2, thus they were omitted from the scenario-specific discussions in Section 5.3.
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> In regard to the shielding factor issue, the following quote from the RESRAD Manual is pertinent: "*The occupancy factor (OF) and shielding factor account for the fraction of a year that an individual is located on the site and the reduction in external exposure rate afforded by onsite buildings or other structures while the individual is indoors.*" (Yu, C. Et al, ANL/EAD-4). Because none of the exposure scenarios applicable to the Newfield site involve the placement of any sort of building on top of the engineered barrier in the Storage Yard, the application of a shielding factor is not only unnecessary, it would degrade the element of conservatism built into SMC's assessments.
>
> It is important to note that the USNRC was provided with preliminary drafts of Chapters 5 and 17 in advance of submission of Rev. 1 of the DP. At no time during the information exchanges was SMC told that the contents would not pass the acceptability review.
>
> In follow-up information exchanges with the USNRC, SMC asked the Staff to provide one or two examples of dose modeling for decommissioning that they would deem acceptable for technical review.[5] SMC was referred to the DPs for the Michigan Department of Natural Resources (MDNR) and Whittaker sites, accessible on the ADAMS data base.[6] SMC researched ADAMS and identified only two documents that appeared relevant:[7]

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[5] Berger, C. D., Integrated Environmental Management, Inc., e-mail communication to Mark Thaggard, U. S. Nuclear Regulatory Commission, March 29, 2006, 8:51 a.m.

[6] Kalman, Kenneth, U. S. Nuclear Regulatory Commission, e-mail communication to David Smith, Shieldalloy Metallurgical Corporation, April 5, 2006, 2:57 p.m.

[7] The USNRC did not give SMC the ADAMS accession numbers or specific references to the MDNR or Whittaker documents that they would consider to be model documents.

- Michigan Department of Natural Resources, "Decommissioning Plan; Tobico Marsh SGA Site, Kawkawlin, Michigan", February, 2003.

- Whittaker Corporation, "Dose Assessment in Support of Establishing Derived Concentration Guideline Levels for the Whittaker Decommissioning Site", August, 2004.

The approach these licensees used to justify dose modeling input parameters, in both cases, is significantly less comprehensive than the approach put forth by SMC in Rev. 1 of the DP. Consequently, SMC remains unclear with respect to the USNRC's additional requirements regarding parameter justification necessary for the DP forward for technical review.

Action to be Taken: SMC has modified the individual exposure scenarios described in Sections 5.3.1 and 5.3.2 of the DP to add the following specific sub-sections: Description of the Critical Group; Pathways included in the Trespasser Scenario; and Justification for the Key Parameters Used in the Analysis. The basis for selecting the referenced values in those subsections, if more than one value in a reference is applicable, has been clearly stated.

Appendix A of this attachment contains Chapter 5 of the DP, which has been revised. The Chapter 5 that currently exists in all USNRC copies of Rev. 1 of the DP should be removed and replaced with the pages in the Appendix in order to upgrade them to Rev. 1a..

The Chapter 17 tables that list the various RESRAD input parameters have also been modified to show the justification and/or source for each selection (e.g., RESRAD default, site-specific information, referenced information, etc.). Appendix B of this attachment contains the revised tables, which should replace those that currently exist in all USNRC copies of Rev. 1 of the DP in order to upgrade the DP to Rev. 1a.

Appendix 19.5 of Rev. 1 of the DP contains the summary reports from the dose modeling. As a result of parameter modifications agreed to herein, new summary reports are necessary. In order to keep from generating and transmitting the large volumes of paper associated with those reports SMC would be pleased to transmit them to the staff under separate cover and electronically. Once agreement between SMC and the USNRC on the applicable input parameters is reached, Appendix 19.5 replacement pages for all USNRC copies of Rev. 1 of the DP will be provided in order to upgrade them to Rev. 1a.

USNRC Issue No. 2: It should be noted that the greatest expected risk associated with the site is expected to be associated with the radioactivity in the controlled area once controls have failed. However, more discussion is provided for chosen parameter values for situations at the site where the radiological risk is expected to be much less (e.g., scenarios associated unrestricted release). In some of these situations, the justification for chosen parameter values is minimal. For example, for the industrial scenario, SMC noted that the fraction of time spent outdoors and the shielding factor are two of the most sensitive parameters. However, the reference cited as a basis for the chosen value for the fraction of time spent outdoors would suggest that the selected value is likely to result in a lower than actual dose.

SMC Response: See response to USNRC Issue No. 1.

Action to be Taken: See actions taken in response to USNRC Issue No. 1.

USNRC Issue No. 3: The value selected for the shielding factor is not even listed. In other cases, a reference is cited. However, it is not clear how the chosen value was derived from the reference (e.g., the fraction of the time that a trespasser is assumed to spend at the site in the unrestricted release area) or the basis for selecting the value (e.g., why it is considered to be either acceptable or conservative).

SMC Response: See response to USNRC Issue No. 1.

Action to be Taken: See actions taken in response to USNRC Issue No. 1.

USNRC Issue No. 4: In considering multiple land-use scenarios, SMC needs to provide more information used in defining the scenarios and developing appropriate exposure pathways. For example, the justification for excluding the groundwater as an exposure pathway is lacking in that it amounts to assuming that the current water supply will always be available.

SMC Response: See response to USNRC Issue No. 1. SMC maintains that there is sufficient justification for excluding the groundwater exposure pathway from the various dose assessments performed in Chapter 5 of the DP, not the least of which is that the groundwater at the site is not potable.[8]

Action to be Taken: See actions taken in response to USNRC Issue No. 1. The exposure scenarios outlined in Sections 5.3.1 and 5.3.2 of the DP will be modified to include expanded justifications for excluding the drinking water pathway from the analysis. Also, as suggested in Appendix M (section M.5.2.1) of NUREG-1757, Vol. 2, an independent consultant report that compares the quality of the groundwater in the vicinity of the site to the Primary and Secondary Drinking Water standards has been prepared and referenced in the revised Chapter 5. A copy of the consultant's report is included herein as Appendix C.

USNRC Issue No. 5: During a June 14, 2005 telephone conference, NRC staff advised SMC to evaluate the potential impacts associated with including the groundwater pathway before attempting to justify its exclusion. This comment was also reiterated in our June 24, 2005, letter to SMC (ML051680544). It is not clear if this was done in the DP.

SMC Response: SMC did indeed take the USNRC's advice and performed site-specific groundwater modeling to confirm whether there would be any impact of significance on the resulting dose if a hypothetical manufacturing facility opted to obtain its drinking water from an on-site well rather than Borough-supplied water. That effort, initiated prior to the submission of Rev. 1 of the DP to the USNRC, showed that the groundwater pathway, even if enabled, would have no significant radiological impact on hypothetical receptors.

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[8] The groundwater at the SMC site contains hexavalent chromium, trichloroethylene and other constituents which, when compared to the National Primary Drinking Water standards defined in 40 CFR 141 and as referenced in Table M.8 and M.11 of NUREG-1757, Vol. 2, shows that it is not a potable water supply.

Action to be Taken: See actions taken in response to USNRC Issue No. 4. Appendix D contains a copy of the groundwater modeling analysis that was performed in response to the USNRC's request. It is being provided for staff information only and *is not* a part of Rev. 1a of the DP.

USNRC Issue No. 6: SMC was also advised to consider a scenario of a recreational user being exposed to a previously excavated portion of the pile when the land-use restriction fails. However, there is no discussion of this scenario in the DP.

SMC Response: One of the exposure scenarios evaluated in the DP (see Section 5.3.3.3) was an excavation scenario wherein the exposure potential for an intruder who attempts to excavate slag from under the engineered barrier is assessed. With that trigger in place, the dose potential to a resident living in the line of sight of the spot where the slag was excavated was also assessed as part of the excavation scenario. This was a scenario of interest to the New Jersey Department of Environmental Protection (NJDEP) staff.

The input parameters for modeling the dose to both the "nearby suburban resident" and the "recreational user" show that the former is limiting due, primarily, to the longer exposure duration. Since the total dose is directly proportional to the exposure duration, the nearby "suburban resident" and not the "recreational user" would have the greatest dose potential.

Action to be Taken: The dose to a hypothetical "recreational hunter" from a previously-excavated portion of the engineered barrier when land-use restrictions fail has been assessed and is included in Section 5.3.3.3 of Rev. 1 of the DP (see Appendix A of this attachment).

USNRC Issue No. 7: SMC failed to produce sufficient information showing that it met the regulatory requirements regarding the use of engineered barriers. (For one acceptable approach, see Guidance in NUREG-1623). Many of the technical analyses were incorrect and incomplete relative to surface water hydrology and design of erosion protection. For example, the Probable Maximum Precipitation and resulting Probable Maximum Flood runoff rates were incorrectly determined.

SMC Response: Appendix 19.3 of the DP included an evaluation of the worst-case maximum flow velocity based on the Probable Maximum Precipitation (PMP), using standard calculation methodologies that include those referenced in NUREG-1623. As the standards of 10 CFR Part 20, Subpart E are more performance-based than prescriptive, existing uranium mill guidance (e.g. NUREG-1623) is worthy of consideration for the analysis, but SMC maintains that it is not necessarily directly applicable to it. However, based on further discussions with the USNRC (see below), SMC understands that the USNRC is nonetheless requiring the use of more conservative parameters and methodologies in conducting the necessary analyses than those used by SMC in Appendix 19.3.

With respect to the Probable Maximum Flood (PMF) evaluation, based on the site's location near the headwaters of the Hudson Branch, flooding was not considered to be an issue with respect to the long-term integrity of the engineered barrier. Based on further discussions with the USNRC, SMC understands that a specific evaluation of the potential impact of flooding on the engineered barrier is nonetheless required.

Action to be Taken: SMC, SMC's consultant (TRC Environmental Corporation) and representatives of the USNRC had a technical meeting at the Newfield facility on April 11, 2006 to review existing site conditions and the required hydrologic evaluations. Representatives of NJDEP were also in attendance. Based on discussions held at that meeting, the PMP analysis has been re-evaluated using more stringent parameters and methodologies, as prescribed in NUREG-1623 and other associated reference documents. The design of the engineered barrier has been modified, as necessary, to provide the necessary protection against the erosive forces of the PMP and now incorporates a rock cover on the top slope, side slopes and apron at the toe of the side slopes. In addition, the geomembrane has been removed.[9] An evaluation of the potential impact of flooding on the engineered barrier under PMF conditions was also conducted.

The new engineering evaluations are attached hereto as Appendix E. As the estimated soil loss evaluation and erosion protection calculations of Rev. 1 of the DP are no longer applicable to a stone-covered barrier, all information currently present in Appendix 19.3 of all USNRC copies of the DP should be removed and replaced with the pages in Appendix E in order to upgrade the DP to Rev. 1a.

Similarly, selected sections in Chapter 8 have been revised to reflect the new engineered barrier design. Appendix F of this document contains the revised sections that should take the place of those that currently exist in all USNRC copies of Rev. 1 of the DP in order to upgrade it to Rev. 1a.

Figures 18.6, 18.7, 18.8 and 18.9 also required revision to reflect the new engineered barrier design. Appendix G of this document contains the revised figures. Figures 18.6 through 18.9 that currently exist in all USNRC copies of the DP should be removed and replaced with the figures in Appendix G in order to upgrade them to Rev. 1a.

USNRC Issue No. 8: The determinations of actual runoff velocities, relative to the permissible velocities, were not appropriate, based on inappropriate use of Manning's 'n' value, rainfall intensity, slope lengths, and flow concentration factors. Insufficient information was provided to address the flow velocities on the top slopes as well as the likely need for rock to be placed on the side slopes and on the toe of the side slopes.

SMC Response: See response to Issue No. 7.

Action to be Taken: See action to be taken with respect to Issue No. 7. The need for rock to be placed on the side slopes has been evaluated within the new analyses and more conservative design factors have been incorporated. Rock has been incorporated into the new engineered barrier design and separate evaluations are presented for the top slope, the side slope and the toe of the side slopes. See the Appendices referenced in the response to Issue No. 7 above for the revised evaluations.

USNRC Issue No. 9: Chapter 16 on restricted use includes very limited information about the proposed use of the long-term control (LTC) possession-only license and a supporting deed notice. Although the proposed LTC license could resolve one of the most significant issues that caused rejection of the first DP, SMC did

[9] Based on risk insights and because no credit can be taken for the features afforded by the geomembrane in the dose modeling, the geomembrane was deemed unessential and removed from the barrier design. The addition of the rock layer effectively retards erosion of the engineered barrier.

not provide important information about the LTC approach and restricting future site use that was described in NRC's interim guidance developed for this site and discussed with SMC.

SMC Response: Section 16.3.1 of the DP specifies that future use of the property will be that which is authorized by USNRC in the LTC license only. Section 16.3.2 states that the conditions of the LTC license will be specified in part, by the LTC Plan, to be submitted to the USNRC with the final decommissioning report. Restricting future site use, as outlined in Section 16.3.2 of the DP, will be accomplished by controlling access to the licensed materials through the use of an engineered barrier, a fence, warning signs, periodic surveillance, adverse event surveillance, maintaining a visitor log for access to the restricted area and periodic program reviews.

Action to be Taken: Section 16.3.1 has been modified to incorporate information about the LTC approach as described in the USNRC's interim guidance. Appendix H of this attachment contains a copy of the revised section. The Section 16.3.1 text that currently exists in all USNRC copies of the DP should be removed and replaced with the text in Appendix H in order to upgrade them to Rev. 1a.

USNRC Issue No. 10: Major areas with either missing or insufficient information include: (1) Eligibility for the LTC license option, including a demonstration that SMC was unable to arrange other types of institutional controls and independent third party arrangements, such as a letter from the State rejecting responsibility for ownership, control, or independent third party oversight (interim guidance, p. 4).

SMC Response: Concur.

Action to be Taken: On May 24, 2006, SMC forwarded a letter to the State of New Jersey asking if the State would accept responsibility for ownership, control or independent third-party oversight of the Newfield site. Appendix I contains a copy of that letter. To date SMC has received no response from the State.[10]

Section 16.2 has been revised (see Appendix H) to include a stronger justification of eligibility based upon SMC's inability to arrange for a viable independent third-party to serve as the institutional control. The Chapter 16.2 text that currently exists in all USNRC copies of the DP should be removed and replaced with the text in Appendix H in order to upgrade them to Rev. 1a.

USNRC Issue No. 11: Major areas with either missing or insufficient information include: (2) Although restrictions were simply listed, there was no justification given based on risk insights from dose assessments, such as specific access and land use scenarios that could lead to non-compliance with the dose criteria (interim guidance, p. 9).

SMC Response: Concur.

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[10] On June 21, 2006, Nancy Wittenberg, Assistant Commissioner for the NJDEP, forwarded a letter of inquiry to Jack Strosnider, USNRC, wherein additional information on the role of the State as trustee for the funds set aside for long-term monitoring and maintenance. The NJDEP asked that a written response to the inquiries be provided before they would consider SMC's request.

Action to be Taken: Section 16.2 of Rev. 1 of the DP has been revised to link restrictions needed with the dose modeling results, and to show that the engineering components of the long term control license must be maintained and that they are sufficiently robust to remain protective over the long-term. Appendix H contains the revision to Section 16.2, which has been captured in Rev. 1a of the DP.

USNRC Issue No. 12: Major areas with either missing or insufficient information include: (3) Detriments to using the LTC license including stakeholder input (interim guidance, p. 11).

SMC Response: As described in section 16.5 of the DP, the SSAB was given multiple opportunities and methods for providing input to the decommissioning process, with emphasis on the specific lines of inquiry required in 10 CFR 20.1403(d).

Action to be Taken: The final paragraph in Section 16.5.4 (see Appendix H) has been revised to include a listing of detriments to using the LTC license based upon stakeholder input, summarized from elsewhere in section 16.5.4 of the DP (see Pg. 166 through 168). The Chapter 16.5.4 text that currently exists in all USNRC copies of the DP should be removed and replaced with the text in Appendix H in order to upgrade the DP to Rev. 1a.

USNRC Issue No. 13: Major areas with either missing or insufficient information include: (4) Demonstration that the engineered cap has been designed to be sufficiently robust to remain effective even assuming loss of monitoring and maintenance (interim guidance, p. 11) (see also comment above on erosion control).

SMC Response: See response to Issues No. 7 and No. 8.

Action to be Taken: See actions to be taken with respect to Issues No. 7 and 8. With the incorporation of a new engineered barrier design that includes the placement of rock on the top and side slopes as well as the toe of the side slopes, the accompanying engineering evaluations conducted in accordance with NUREG-1623 guidance demonstrate the protectiveness of these features, even without continued monitoring and maintenance. These revised evaluations clearly demonstrate the robustness of the engineered barrier.

USNRC Issue No. 14: NRC recognizes that SMC proposes to release the unrestricted use portion of the site rather than maintain it with the restricted use portion under the LTC license. NRC notes that SMC justified its position in response to the Site-Specific Advisory Board (SSAB) comments on this question, stating its position is based on sufficient financial assurance to pay for long-term monitoring and maintenance of the restricted area. NRC's interim guidance developed for this site and draft guidance in NUREG-1757 Supplement 1 were written to provide both protection and beneficial reuse of the total site. Both guidance documents explain that the LTC license would specify safe, and therefore, permitted uses of all parts of the site so there would be no uncertainty regarding safe use of the site by parties interested in leasing or purchasing the site in the future. Thus, there might be no restrictions on future use for the majority of the site area outside of the restricted area with the disposal cell. To help resolve this issue, SMC should describe the potential for reuse of the site as a whole under the LTC license.

SMC Response: In Section 16.5.4 of the DP (pages 166 and 167), the issue of potential re-use of the site under the LTC license if the license applied to the entirety of the site was addressed by both the SSAB and by SMC. Stakeholders and SMC are equally concerned about (1) whether anyone other than SMC would consider building a business on the site if faced with the need to become a USNRC licensee, and (2) the reduced tax revenue for the Borough if the property in its entirety remained underutilized for being subject to the LTC license. The radiological impacts on the "unrestricted" portion of the property, whether there is dual ownership or not would not change from that presented in Chapter 5 of the DP.

During multiple meetings with the SSAB, SMC listened to their concerns about permitted uses of all parts of the site and remains convinced that they believe the ability to subdivide and sell the unrestricted portions of property unencumbered by a radioactive materials license is critical to future redevelopment. Furthermore, sustaining the terms and conditions of the LTC license is independent of whether the property is subdivided or not because there will be sufficient financial assurance in place to enforce the LTC Plan.[11] Both the SSAB and SMC are convinced that future commercial interest in purchasing or developing property that would require the owner to maintain and pay for a USNRC license in perpetuity would be small, at best.

Action to be Taken: None.[12]

USNRC Issue No. 15: SMC should work with the SSAB to clearly discuss the pros and cons of this approach given in the NRC's draft guidance on page II-57, to ensure common understanding, as well as to identify how the whole site could be reused under the LTC license, real or perceived barriers to reuse, and, ways to resolve these barriers.

SMC Response: See response to USNRC Issue No. 14.

Action to be Taken: See actions taken in response to USNRC Issue No. 14.

USNRC Issue No. 16: SMC should also discuss how site ownership of the restricted use portion of the site would be sustained over the long-term, if it were separate from the rest of the site, to avoid gaps in ownership, and control, and to minimize NRC's active involvement to take actions if there is a gap.

SMC Response: See response to USNRC Issue No. 14. The licensee remains obliged to fulfill the terms and conditions of the LTC license, regardless of the property size. If that licensee fails to honor those terms and conditions, the USNRC would have enforcement options up to and including the use of funds from the trust to hire a contractor to fulfil license conditions. An LTC licensee that defaults would relinquish funds set aside in trust in the same way as any other USNRC licensee.

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[11] Under an LTC license, the important financial consideration is the economic viability of the licensee which is not necessarily the site owner. To the extent subdividing the property provides increased economic return, the economic viability of the licensee is maximized.

[12] During the March 9, 2006 meeting, both the USNRC and SMC agreed to consider this issue further. In addition, USNRC Staff stated that input from USNRC has been solicited and will presumably be forwarded to SMC.

Action to be Taken: See actions taken in response to USNRC Issue No. 14.

USNRC Issue No. 17: SMC should further explore both approaches with the SSAB and provide this additional information for NRC review.

SMC Response: See response to USNRC Issue No. 14 and 18.

Action to be Taken: See actions taken in response to USNRC Issue No. 14 and 18.

USNRC Issue No. 18: Although SMC provided information on use of institutional controls that it received from the SSAB, NRC recognizes that there was a general concern that not enough information was provided to the SSAB. SMC should take this opportunity to enhance its interactions with the SSAB, as it noted in responses to the SSAB input.

SMC Response: The SSAB did indeed state that they could not provide input in certain of the 10 CFR 20.1403(d) questions posed to them because they did not have an opportunity to review Rev. 1 of the DP. Because the SSAB's involvement in the planning process was necessary *before* the release of Rev. 1, SMC could not possibly comply with their request. However, SMC did provide the SSAB with a copy of Rev. 0 of the DP so that they could review the general approach and learn about the radiological and environmental conditions at the site, which remained relatively unchanged from Rev. 0 to Rev. 1. Rev. 1 of the DP was immediately posted on the SMC web site after its submission to the USNRC and has been available to the SSAB and other interested parties ever since.

During the last meeting of the SSAB, SMC asked whether the group was interested in meeting again. The response was a unanimous "no". Since then, however, SMC has received inquiries regarding future meetings of the SSAB, and has stated that it would be pleased to meet whenever the SSAB feels there is something to meet about. In the interim, SMC has been meeting with local legislators and officials to exchange information about the DP's objectives and to ensure as many stakeholders as possible are given an opportunity to participate in the process.

Action to be Taken: A follow-on meeting with the SSAB will be scheduled as soon as there is sufficient SSAB interest.

USNRC Issue No. 19: The staff is concerned that SMC did not provide sufficient rationale for it's alternative approach to meet the regulatory requirements for financial assurance. Specifically, SMC assumes a greater return on investment (ROI) than appears appropriate for the long-term surveillance and monitoring fund. The NRC's interim guidance (which represents one approach for meeting the regulations) applies a 1% ROI for the LTC license. However SMC used a 3% ROI. The higher ROI assumed by SMC reduces the amount placed in trust to cover long-term surveillance and monitoring costs, which increases the potential for inadequate funding in the event a string of losses occurs in the funds investments.

SMC Response: Because the return on investment primarily impacts the long-term maintenance fund, and because that fund is relatively small, the assumption of either a 1% or 3% ROI is not of major significance.

Action to be Taken: Attached to the USNRC's May 12, 2006 letter to SMC summarizing the March 9, 2006 meeting, the USNRC provides a staff assessment of the ROI issue, concluding that "to be acceptable, SMC's revised Decommissioning Plan must calculate the contribution to the decommissioning trust fund using a one percent rate of return." Based on that directive, a 1% ROI has been incorporated into the revised Decommissioning Plan cost estimates. New cost estimates (i.e., Tables 17.14, 17.15 and 17.16) have been prepared that reflect both the revised engineered barrier design and the 1% ROI. An adjustment to reflect increases in unit costs incurred between 2005 and 2006 has also been incorporated in the revised cost estimates.

As a change in the ROI only impacts cost estimates with long-term surveillance and monitoring components, only Tables 17.14 and 17.16 are impacted by the revised ROI. The new cost estimates are presented in Appendix B. The copies of Tables 17.14, 17.15 and 17.16 currently present in all USNRC copies of the DP should be removed and replaced with those in Appendix B in order to upgrade the DP to Rev. 1a.

Selected sections of Chapter 15 have also been revised to reflect the change in the ROI. The revised sections are attached hereto as Appendix J and should replace those in all USNRC copies of Rev. 1 of the DP in order to upgrade it to Rev. 1a.

USNRC Issue No. 20: Also, SMC did not specify whether it would include a 25%contingency in the long-term surveillance and monitoring fund.

SMC Response: As stated on page 151 of the DP, a 25% contingency was added to the total cost of all alternatives. Therefore, the 25% contingency was indeed added to *both* the capital cost and the long-term surveillance and monitoring costs components for the LTC Alternative. This is also indicated in the cost table (Table 17.14).

Action to be Taken: Existing text on the last bullet of page 151 of the DP has been reworded to read as follows: "In accordance with USNRC guidance, a 25% contingency has been added to the capital and long-term surveillance and monitoring costs of all alternatives." To clarify that the 25% contingency is added to both the capital costs and long-term maintenance and monitoring present worth costs, the cost estimates now include it as a separate line item under both the capital and long-term surveillance and monitoring sections, rather than as an individual line item applied to the total combined cost. The revisions to the cost estimate tables and the associated text of Section 15 are incorporated into the revised pages of Appendix B and J referenced in the response to Issue No. 19 in Rev. 1a of the DP.

USNRC Issue No. 21: The tables of decommissioning costs do not present sufficient detail to permit the NRC to assess the adequacy of the cost. The unit costs combine labor, material, equipment, and overhead and profit costs. NUREG-1757, Vol. 3 and the interim guidance developed for this site asks the licensee to present the cost elements separately.

SMC Response: NUREG-1757, Vol. 3 provides cost estimating tables that represent an action involving the decontamination/demolition of radioactive facility components, which is not always representative of the activities/costs involved in the proposed decommissioning of the SMC facility. For example, off-site disposal costs are not available to the level of detail requested. However, those costs that are not based on lump sums or other information for which detail cannot be obtained can be presented in terms of labor, material, equipment and overhead and profit costs.

Action to be Taken: Revised cost tables that include the necessary breakdown, for those costs not based on lump sums or other information for which detail cannot be obtained, have been prepared. This additional information has been incorporated into the revised cost tables presented in Appendix B of this document, as previously referenced in the response to Issue No. 19, above.

USNRC Issue No. 22: The NRC staff also notes that the DP did not include a Certification Statement or an originally signed financial instrument to cover the decommissioning costs. The Certification is required as an affirmation that financial assurance has been provided, even though the licensee plans to pay for decommissioning out of operating funds. The Certification and originally signed financial instrument will be required before final approval of the DP.

SMC Response: Concur.

Action to be Taken: Section 15.2 of the DP has been modified to incorporate a Certification Statement. Appendix J shows the modification as it appears in Section 15.2 of the DP. Appendix K contains the signed original of the Certification Statement. A copy of the most recent statement from the trust showing its balance as of that date, as well as language from the Bankruptcy Settlement Agreement are also included in Appendix K for USNRC reference.

Appendix A - Revised Chapter 5

[Chapter 5 of Rev. 1 of the DP has been revised in its entirety as follows, and has been captured in Rev. 1a of the DP.]

5 DOSE MODELING EVALUATIONS

A critical aspect of this decommissioning plan is an assessment of the potential radiation dose that could result from the residual radioactivity at the Newfield site after all decommissioning activities are completed. However, an important point is that the Newfield site is actually treated as two separate land areas for dose modeling purposes. This is because SMC proposes to release the majority of the property for unrestricted use. A much small portion of the property will be placed under a LTC license where its use will be restricted for radiation safety purposes. Therefore, the dose modeling must demonstrate that both of the following limits will be met once n decommissioning is complete:[70,71]

> *"A site will be considered acceptable for unrestricted use if the residual radioactivity that is distinguishable from background radiation results in a total effective dose equivalent (TEDE) to an average member of the critical group that does not exceed 25 millirem (0.25 mSv) per year, including that from groundwater sources of drinking water, and the residual radioactivity has been reduced to levels that are As Low As Reasonably Achievable (ALARA). Determination of the levels which are ALARA must take into account consideration of any detriments, such as deaths from transportation accidents, expected to potentially result from decontamination and waste disposal."*

and:

> *"A site will be considered acceptable for license termination under restricted conditions if: ... (e) Residual radioactivity at the site has been reduced so that if the institutional controls were no longer in effect, there is reasonable assurance that the TEDE from residual radioactivity distinguishable from background to the average member of the critical group is as low as reasonably achievable and would not exceed either– (e)(1) 100 millirem (1 mSv) per year–, . . ."*

To decommission the majority of the SMC site, excluding approximately eight (8) acres within the Storage Yard, a radiation dose objective of 25 millirem above background is applicable and is therefore used as the basis for demonstrating that this portion may be released for unrestricted use. A radiation dose objective of less than 100 millirem per year is applicable to the portion of the property subject to the terms/conditions of the LTC license (i.e., the Storage Yard) in the unlikely event that all controls fail. However, with controls in place, even the restricted portion must meet the 25 millirem criterion.

[70] US Nuclear Regulatory Commission, *Radiological Criteria for Unrestricted Use*, Title 10 CFR 20.1402, July 21, 1997.

[71] US Nuclear Regulatory Commission, *Criteria For License Termination Under Restricted Conditions*, Title 10 CFR 20.1403, July 21, 1997.

The U. S. Nuclear Regulatory Commission (USNRC) has developed guidance on acceptable approaches and methodologies for radiation dose modeling to demonstrate compliance with the aforementioned dose limits. In addition, the USNRC has offered examples of acceptable dose modeling that could be used as a guide.[72] As recommended , SMC has selected the scenarios and critical population groups, developed the source term, selected exposure pathways and calculated DCGLs in accordance with NUREG-1757 and Staff recommendations.[73]

The following subsections of this chapter contain this information. Included herein is a brief description of the methodology used to perform the dose assessments, a detailed description of the site conceptual model which includes the source term used as input to the assessment, the exposure scenarios deemed reasonably likely under LTC conditions, less likely exposure scenarios if the controls specified as part of the terms of the LTC license should fail, a presentation of the uncertainty associated with the input parameters, and the findings (results) of the assessment. Included as well is a statement as to whether the requirements for unrestricted release of most of the property have been met, and whether the portion of the site to be subject to the terms and conditions of the LTC license meets the applicable dose criteria.

5.1 Assessment Methodology

The process of assessing the radiation dose potential for SMC's decommissioned Newfield site involves defining the source(s), preparing a site conceptual model, identifying the likely pathways for potential human exposure, and assessing the availability of a receptor to receive a dose. However, the relationships between these factors are complex and often interdependent. Therefore, a computer program to model the plausible human exposure scenarios and to perform the complex sets of computations was employed.

The computer code, RESRAD (Version 6.22) was used to model radionuclide fate and transport of residual radioactivity at the site and to assess the radiation dose incurred by hypothetical receptors who may be impacted by the site after decommissioning is complete.[74] This code provides an estimate of the annual radiation dose beginning immediately after decommissioning is complete and extending for 1,000 years into the future.[75] It is widely-accepted as an industry-standard tool for

[72] Kalman, Kenneth, U. S. Nuclear Regulatory Commission, in an e-mail communication to David Smith, Shieldalloy Metallurgical Corporation, April 5, 2006, 2:57 p.m., referred SMC to the DPs for the Michigan Department of Natural Resource (MDNR) and Whittaker sites, accessible on the ADAMS data base. A search of the data base identified the only following documents with apparent relevance: (1) Michigan Department of Natural Resources, "Decommissioning Plan; Tobico Marsh SGA Site, Kawkawlin, Michigan", February, 2003; and (2) Whittaker Corporation, "Dose Assessment in Support of Establishing Derived Concentration Guideline Levels for the Whittaker Decommissioning Site", August, 2004.

[73] U.S. Nuclear Regulatory Commission, *Consolidated NMSS Decommissioning Guidance-Decommissioning Process for Materials Licensees*, NUREG-1757, Volume 1, September, 2003.

[74] Yu, C, Zielen, A.J, et al, *User's Manual for RESRAD Version 6*, ANL/EAD-4, Argonne National Laboratory, Argonne, Illinois, July, 2001.

[75] The RESRAD code was chosen primarily because it can adequately depict the key site-specific features of SMC's site. It is also able to derive values for exposure parameters based on built-in fate and transport computations using well-defined site-specific data. In addition, the code is able to integrate radiation dose projections over time taking into account transient conditions that may occur.

performing radiological dose assessments and for deriving DCGLs. However, there are several important features of the code that should be taken into account in interpreting any results that are generated. These include the following:

- The radiation dose conversion factors (DCFs) used in RESRAD 6.22 are taken from Federal Guidance Reports (FGRs) No. 11 and 12, which are derived from outdated dosimetry model promulgated by the International Commission on Radiation Protection (ICRP);[76,77,78,79]

- Short-lived radioactive progeny (e.g. half-life less than 180 days) are accounted for using the "parent+D" DCFs;

- RESRAD integrates and normalizes exposure factors based on the fraction of time a receptor is exposed over the exposure period;[80] and

- RESRAD uses single-point estimates for values of every parameter to evaluate complete pathways in the deterministic module of the code.

Another feature of the RESRAD code is that the user may select from two types of risk assessment methods, deterministic and probabilistic.[81] Most professionals are familiar with the deterministic approach because it has been, until recently, the most widely used of the two. It is designed to capture the reasonable maximum exposure (RME) condition for a receptor using single point estimates of parameter values used to calculate dose. Such a calculation provides a single point estimate of radiation dose that could result from a given concentration of radioactivity. For the purposes of modeling radiation doses for the Newfield site, a deterministic approach was used to establish the acceptable concentrations of uranium and thorium in the surface soil in that portion of the property to be released for unrestricted use (i.e., DCGLs).

Few of the parameters used to calculate deterministic dose potentials at long times into the future are so well known that they can be described by a single value. Therefore, a reasonable alternative is to use unrealistically-conservative input parameters in order to bound the inherent uncertainty in

[76] U.S. Environmental Protection Agency, *Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion*, Federal Guidance Report Number 11, EPA 520/1-88-20, September, 1988.
[77] U.S. Environmental Protection Agency, *External Exposure to Radionuclides in Air, Water and Soil*, Federal Guidance Report Number 12, EPA 402 R-93-081, September, 1993.
[78] International Council on Radiation Protection, *Report of the Task Force on Reference Man*, ICRP Report 23, 1981.
[79] The bio-kinetic dosimetry model accounts for particle fractioning that might occur following exposure. For example, the DCFs for particle inhalation account for the dose to the GI tract from the fraction of respired particles that are ingested. As a result, there is no need to independently account for biological fractioning in the dose calculations.
[80] For example, a soil ingestion rate of 100 mg/d for a receptor who is exposed on Site for only 50-percent of one day would result in an ingestion intake of 50 mg.
[81] Table 5.1 summarizes the principal differences that exist between the deterministic and probabilistic methods.

the deterministic approach. However, this often leads to gross over-estimation of the radiological impact of the site.[82]

Another approach is the probabilistic methodology for risk assessment, which addresses the potential for exposure through what is essentially an uncertainty analysis, taking both the range and distribution of individual input parameters into consideration.[83] The probabilistic method provides a substantially clearer picture of what the dosimetric impacts of a decommissioning method might be and it is a useful tool for risk managers.

Because the USNRC has established its decision-making criteria on the use of probabilistic assessment methods and the resulting mean or "reasonably foreseeable" exposure to an average member of the critical exposure group, and because it is a required assessment methodology in NUREG-1757, this is the approach that was used by SMC in its assessment of the dose potential for the two areas at the decommissioned Newfield site (i.e., the restricted and the unrestricted areas).[84,85,86,87] It was used to evaluate the range of the radiation dose potentials associated with the restricted area, and those associated with the DCGLs for the unrestricted portion of the site. The remaining sections of this Chapter are organized as follows:

- Section 5.2 describes the site conceptual model, the radioactive source term and the physical parameters of the SMC site that are used as input to the computer modeling;

- Section 5.3 describes "reasonably likely" exposure scenarios for both the unrestricted and restricted areas of the site, and the "less likely" scenarios for the restricted area in the event that all protective controls fail;

- Section 5.4 describes the uncertainty associated with the various input parameters and the dose modeling results; and

- Section 5.5 presents the results of dose modeling for the decommissioned SMC site for comparison to applicable requirements.[88,89]

[82] This difficulty was acknowledged by the USNRC in recent guidance specific to SMC and in supplemental information to accompany NUREG-1757.
[83] U.S. Nuclear Regulatory Commission, *Consolidated NMSS Decommissioning Guidance, Decommissioning Process for Materials Licensees*, NUREG 1757, Vol. 1, Rev. 1, September, 2003.
[84] The average member of the critical group is used rather than using the RME for the entire population. In a typical deterministic risk, the RME is used for the entire population.
[85] As defined in 10 CFR 20.1003, the critical group is a group of individuals expected to receive the greatest exposure to residual radioactivity for any applicable set of conditions.
[86] U.S. Nuclear Regulatory Commission, *Radiological Criteria for License Termination*, Volume 62, Federal Register, page 39058, July 21, 1997.
[87] NUREG-1757, Vol. 2, Section 2.1, September, 2003.
[88] US Nuclear Regulatory Commission, *Radiological Criteria for Unrestricted Use*, Title 10 CFR 20.1402, July 21, 1997.
[89] US Nuclear Regulatory Commission, *Criteria For License Termination Under Restricted Conditions*, Title 10 CFR 20.1403, July 21, 1997.

5.2 Site Conceptual Model

A site conceptual model has three fundamental components that must be described in order to calculate (or model) the potential future dose to a receptor on or near the decommissioned SMC site. The first component is the source term itself.[90] The second is the physical characteristics of the site.[91] The third is the range of realistic (plausible) human exposure scenarios, described primarily by factors that are associated with human behavior and metabolic physics. Each of these fundamental components is described briefly in the subsections that follow.

5.2.1 Source Term

The source term abstraction used by the RESRAD code to project potential future dose is derived from knowledge about the source material itself, and previously completed radiological assessments of the residual radioactivity at the Newfield site. The source term is defined by its radionuclide composition, as well as its lateral and vertical extent (spatial configuration).

5.2.1.1 Values Used to Describe the Unrestricted Area Source Term

The source term for the unrestricted area of the property is the residual concentrations of radioactive materials that will be allowed to remain after remediation is complete. That concentration is bounded by an upper limit on radiation dose of 25 millirem, TEDE, and applies only to the unrestricted portion of the site (i.e., the preponderance of the total property area).

In describing the source term for input to RESRAD, the area (size) of the unrestricted contaminated zone parameter is equal to the area of the SMC property, excluding the planned restricted area that will be in the current Storage Yard. The minimum unrestricted area is represented by a triangular distribution with a minimum value of 244,000 m^2 and a maximum value of 295,000 m^2. The maximum area is established by the property boundary but includes the Storage Yard. The minimum value is considered to be the most likely value.

The use of the loguniform distribution provides a realistic, yet conservative, description of the lateral variability in the size of the source term in that it assigns the most likely size (244,000 m^2) as the minimum size and allows for the possibility (albeit with lower probability of occurrence) of larger sizes up to the entirety of the property. Vertically, the radiologically significant material is assumed to be located in the top six (6) inches of soil (e.g. 0.15 meters), with no cover. The thickness of the contaminated zone parameter is represented by a triangular distribution, with the central tendency (CT) value conservatively set to a thickness of 0.5 feet (0.15 meters). Tables 17.3.1 through 17.3.12 contain a summary of these parameters as they apply to the unrestricted portion of the property.

5.2.1.2 Values Used to Describe the Restricted Area Source Term

The source term in the restricted portion of the Newfield site has a variety of components, including the engineered barrier, boulders of vitreous, radionuclide-bearing slag, a baghouse dust pile with

[90] The size, thickness, and radiological composition of the source must be conceptualized in the source term abstraction.
[91] The site must be described in a physical abstraction that includes physical and hydraulic characteristics of the site and its potentially impacted environment.

exempt source material concentrations, contaminated soil and surface-contaminated building rubble. The radionuclide content of each was described in Section 4.4, above, and summarized as the effective single, consolidated volume shown in Table 17.7. SMC intends to establish a boundary around the restricted area such that the applicable dose limits for both the restricted and unrestricted portions of the property are satisfied separately for each area.

In describing the restricted area source term for input to RESRAD, the area (size) of the consolidated contaminated zone parameter is represented by a loguniform distribution with a minimum value of 18,228 m^2 and a maximum value of 28,767 m^2. The minimum size is equal to the footprint of the proposed engineered barrier and represents the area currently occupied by the Storage Yard. The use of the loguniform distribution provides a realistic, yet conservative, description of the lateral variability in the size of the source term in that it assigns the most likely size (28,767 m^2) as the minimum size. Vertically, the radiologically-significant material is assumed to be located beneath the cover.

The thickness of the contaminated zone is represented by a triangular distribution, with the central tendency (CT) value conservatively set to a thickness of nine (9) feet. The capped material in the Storage Yard will be shaped more like a pyramid than a cylinder, thus the actual thickness, on average, will exceed the CT value. The thickness of the engineered barrier has a central tendency value of four (4) feet.

The radionuclide composition of the materials to be consolidated under the engineered barrier is defined by both measured isotopic ratios in samples collected from within the contaminated volume and by historical knowledge of the origin of the radioactivity found within the volume (see Chapter 4). The relatively longer-lived progeny of ^{232}Th and ^{238}U are in secular equilibrium with their parent, an assumption that is not only conservative but supported by the results of analytical testing. The source term used as input to the RESRAD computer code includes all of the isotopes in the ^{238}U and ^{232}Th decay series with half-lives longer than 180 days, in the concentrations shown in Table 17.7.[92]

5.2.2 Site Physical Parameters

The second major conceptual component of a dose assessment is the physical abstraction of the site, which must capture and express its important physical, hydraulic, and geological conditions. It is also used to place the source term in the context of the environment and systems that surround it.[93]

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[92] Isotopes with half-lives shorter than 180 days are assumed to be in equilibrium with their first parent with a half-life greater than 180 days and a re accounted for in dose calculations through the use of "parent+D" dose conversion factors.

[93] The physical, hydraulic, and geologic conditions must be described and input into RESRAD. RESRAD is not a comprehensive model for the fate and transport of groundwater and surface water. It does, however, model the vertical migration of radiological contaminants from the surface or near surface soils to ground water sources of drinking water and surface water bodies for the purpose of calculating the potential exposure to human receptors who may use such water.

5.2.2.1 Unrestricted Area Physical Parameters

The RESRAD computer model uses information about the physical characteristics of the site to estimate the migration potential for radionuclides and the ultimate distribution of the radioactive materials in the receptor exposure pathways over the course of 1,000 years. For the unrestricted area, the three layers defined in Section 5.2.2.2 were used as input to the RESRAD model. For the "contaminated zone", it was assumed that the radioactivity is present in the top 6 inches (0.15 meters) of the ground surface and no cover was applied to limit direct contact with the radioactivity. Thus, the surface soil is the contaminated zone and the surface soil erosion rate is captured in the RESRAD model as the contaminated zone erosion rate (VCZ).

In recognition of the relatively flat topographic features of the site, the general meteorological signature for the area, and the non-invasive nature of all reasonably foreseeable exposure scenarios, lower than average soil erosion potential exists. Therefore, the contaminated zone erosion rate in the unrestricted portion of the property was conservatively modeled with a deterministic value of 0.001 m/yr (1 m/1,000 years), equivalent to the RESRAD default value.[94] Annual dose estimates are not particularly sensitive to this parameter since the peak annual dose occurs in the first year after deposition, and decreases each year thereafter, regardless of the surface soil erosion rate used. The other layers (i.e., the unsaturated zone and the saturated zone) exhibited the same characteristics as those described for the restricted area. The input parameters used for the unrestricted area physical characteristics are described in Section 5.7, below.

5.2.2.2 Restricted Area Physical Parameters

Conceptually, the restricted area of the Newfield property after decommissioning is complete will be composed of four "layers", all of which are important to the dose modeling process. These are:

- Engineered Barrier Layer - a thick layer of unimpacted native soil, topsoil, rock and vegetation brought onto the site to form a cap over the contaminated zone and underlying waste layer;
- Contaminated Zone Layer - a layer generally lying just beneath the engineered barrier in which radionuclide-bearing materials are consolidated;
- Undisturbed Surface Layer - a relatively thick, dense, undisturbed native deposit of gravel/sands of the Bridgeton Formation (thickness ranging from 8 to 10 feet), underlain by the fine- to coarse-grained sands of the Cohansey Sand; and
- Saturated Zone Layer - the saturated Cohansey Sand to the depth of the confining Kirkwood formation (i.e., 120 feet or more).

[94] This may not be true as described for the excavation scenario, where some of the radioactive materials could be exposed.

The various parameters used to describe the composition of each "layer" are defined within RESRAD with probabilistic variables. These, which account for the variability and uncertainty inherent in hydrogeological features, are described in detail in the subsections that follow.

5.2.2.2.1 Engineered Barrier Layer

The engineered barrier overlies the radionuclide-bearing consolidated material. It is comprised of a geomembrane and soil (native materials brought onto the site) and a rock cover for intruder and erosion protection installed pursuant to strict specifications. The thickness of the engineered barrier is modeled as a triangular distribution with a central tendency value of one (1) meter and a minimum and maximum of 0.9 and 1.2 meters, respectively. This thickness, while not expected to vary greatly over the area of the Storage Yard, will be an important consideration in the construction of the engineered barrier and will thus be confirmed routinely during construction to verify is remains uniform.

When modeling the subsurface-soil source term in RESRAD, the engineered barrier is identified as the "cover layer" since it overlies the contamination zone. Cover degradation is accounted for in RESRAD by a surface soil erosion rate parameter. The value used as input to the code was derived using the Revised Universal Soil Loss Equation computer program, version 2 (RUSLE 2), the MPV method (as recommended in NUREG-1623) and conservative input parameters.[95] Appendix 19.3 contains the findings of these analyses.

From assessment and calculation, the engineered barrier comprised only of a soil layer is clearly sufficiently robust to maintain its ability to shield the consolidated material under it from the population even if all controls for its maintenance and care should fail. Nonetheless, and in response to concerns raised by the USNRC, a redundant layer of protection in the form of a rock covering to further reduce the erosion rate and serve as an intruder barrier, is included in the design (see Section 8.3, below). However, no shielding credit for the presence of the rock cover is taken in the dose modeling described herein.

5.2.2.2.2 Contaminated Zone Layer

Residual radioactivity in the form of ferrocolumbium slag, baghouse dust, soil and contaminated building rubble will be consolidated within a portion of the existing Storage Yard and then capped with the engineered barrier. The contaminated zone will consist of 65,800 cubic meters of material, with a mean density of 2.8 g/cm^3 and a hydraulic conductivity of 2,000 meters per year.[96] These data were measured during the remedial investigation of the site and represent an average of the results from the multiple samples that were collected.[97]

Information regarding the partition coefficients (K_d) is provided in Section 5.4.3 and 5.24. Testing indicates that the radionuclides are tightly bound in the slag matrix and do not leach into water.

[95] TRC Environmental Corporation, *Estimated Soil Loss from Soil Cap*, Project Number 26770-0000, January, 2005.
[96] Table 17.1 provides a physical inventory of the materials to be consolidated in the restricted area.
[97] "Remedial Investigation Technical Report", TRC Environmental Consultants, Inc., 1992; Draft Final Feasibility Study Report, TRC Environmental Corporation, April 1995.

The contaminated zone and the engineered barrier have a total volume of approximately 76,870 m^3. As described in Section 5.2.1.2 of this report, the use of a loguniform distribution provides a realistic, yet conservative, description of the lateral variability in the size of the contaminated zone in that it assigns the most likely size (18,228 m^2) as the minimum size and allows for the possibility (albeit with lower probability of occurrence) of larger sizes up to the entire area currently covered by the Storage Yard.

5.2.2.2.3 Undisturbed Surface Layer

The third layer is the undisturbed native deposits of gravel/sand layer of the Bridgeton Formation, underlain by coarse-grained sands of the Cohansey Sand. There is little to a trace of silt found in the Cohansey Sand. This layer is estimated to range in thickness between 8 and 10 feet (2.5 to 3.1 meters) with a nominal or typical thickness of approximately 8 ft.(2.5 meter).

RESRAD identifies this layer as the "unsaturated layer" when modeling the source term. The thickness of this zone is bounded with a triangular distribution, having a central tendency value of 2.5 meter bounded and a maximum of 3.1 meters. Measured soil density is 1.3 g/cm^3 and measured hydraulic conductivity is 0.017 m/yr. The radionuclide distribution coefficients described in Section 5.4.3.3 were used for all isotopes.[98]

5.2.2.2.4 Saturated Zone Layer

The lower-most (deepest) layer is described as the deep aquifer layer. The geology beneath the Storage Yard is characterized by brown sand and gravel representative of the Bridgeton Formation that extends in depth to 8.5 meters (28 feet) (well SC-12D) below the ground surface.[99] The Cohansey Sand lies beneath the Bridgeton Formation and is composed of coarse sands and little to trace silt in the upper 12 meters (40 feet), and generally finer sand and some silt, with some clay and silt stringers in the lower 18 to 24 meters (60 to 80 feet). As described in Section 5.3, below, groundwater is not potable and not likely to be ingested by anyone at the site.

5.3 Exposure Scenarios

In order to demonstrate compliance with applicable requirements for both the restricted and unrestricted portions of the SMC site, and to ensure a realistic correlation between radiation dose and residual radioactivity, it is critical that the model portrayed in the RESRAD code be sufficiently representative of actual (site-specific) cases. To determine the setup of the RESRAD code, SMC first envisioned and then characterized the most realistic exposure scenarios applicable to future (post-decommissioning) receptors.

A number of physical and demographic properties pertinent to the site contribute to the conception of plausible and realistic conditions under which an individual might be exposed. In addition, the

[98] Berger, C. (IEM), written communication to D. R. Smith (SMC), *Radionuclide Leachability from Newfield Slag*, September 16, 2005.
[99] "Remedial Investigation Technical Report", TRC Environmental Consultants, Inc., 1992; Draft Final Feasibility Study Report, TRC Environmental Corporation, April 1995.

future use of the property as described in Chapter 3, above, was also taken into account. For the foreseeable future (100 years), the following is deemed reasonably likely for the SMC property:

- The property will retain industrial (light industry) zoning.
- Residential encroachment up to the property boundary is possible but not likely because of the restrictions established by the requirements of the LTC license held by the property owner, and anticipated land use factors.[100]
- Farming encroachment up to the property boundary is not likely due anticipated land use factors in areas that border the deed-noticed SMC property.
- The property will remain intact (i.e.,. will not be subdivided), such that the "releasable" portion of the property will remain associated with the restricted area.[101]
- All controls specified in Chapter 16 of this Plan will be implemented as part of the LTC license issued to SMC, and those controls will remain in force in perpetuity.
- If regulatory control fails, it is reasonable to assume that the physical controls do not fail instantly and completely. Instead, if engineered barrier maintenance should cease, the engineered barrier will erode over time.[102]
- Excavating the residual radioactivity from beneath the engineered barrier is considered highly unlikely because the engineered barrier will camouflage its contents, there is no economic value in the materials, and the physical form of the majority of the residual radioactivity (large, vitrified and irregularly-shaped rocks) is unappealing.
- Excavating some or all of the engineered barrier as a source of fill, thus partially exposing the residual radioactivity therein, is not likely due to the relative difficulty of scavenging fill from a sloped, rock-covered surface as compared to a nearby flat surface.

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[100] SMC is committed to documenting the restrictions established in the LTC license in the form of a legal document recognized by and recorded with Gloucester County. Because the restrictions will be in effect for a substantial time period, SMC intends to have a recorded deed notice that addresses site use restrictions. SMC recognizes that the LTC will include a license condition that requires the maintenance of the deed notice in the recorded land records that describes the legal issues associated with the property.

[101] Although this was a recommendation of the USNRC (Kallman, KL (USNRC), letter to D. Smith (SMC), "Nuclear Regulatory Commission Staff Guidance for a Long Term Control Possession Only license at the Shieldalloy Metallurgical Corporation Site in Newfield, New Jersey", May 15, 2004), as described in Chapter 16, this decommissioning plan does not make such a commitment.

[102] The USNRC separates institutional controls from engineered controls. Therefore, institutional controls are assumed to fail instantly, along with any maintenance, but engineered controls would degrade over time without monitoring and maintenance.

- The presence of the institutional controls at the site for a reasonable period of time after decommissioning is complete would create a natural separation that would not be conducive to construction in close proximity to the engineered barrier even if controls should fail.

- The fenced perimeter of the restricted area is positioned such that the applicable dose limits in both the restricted and unrestricted portions of the property are satisfied.

- There are existing site use restrictions due to the natural resource restoration requirements applicable to a large portion of the Newfield site (i.e, required maintenance of tree-planting areas), as well as potential future residential use restrictions due to soil contaminant levels under the CERCLA that would result in a land buffer to prevent construction in close proximity to the engineered barrier. Also, county-sensitive area zoning and the nearby Pinelands would also deter construction near the restricted area.

There is sufficient justification for excluding the groundwater exposure pathway from the dose assessments described in this chapter. The justification for doing so includes the following:

- The engineered barrier is designed to prevent rainwater infiltration into the consolidated material;

- TCLP results and distribution coefficients determined for the residual radioactivity in SMC's slag show that there is marked resistance to leaching;

- The groundwater at the SMC site contains hexavalent chromium, trichloroethylene and other constituents which, when compared to the National Primary Drinking Water standards defined at 40 CFR 141 and as referenced in Table M.12 of NUREG-1757, Vol. 2, shows that it is not a potable water supply;[103] and

- It is unreasonable to assume that future industrial operations on the Newfield site would drill and maintain their own on-site drinking water well when a source of municipal water is readily available.[104]

With these assumptions in mind, the following subsections describe the most realistic (likely) post-decommissioning exposure scenarios assuming all controls remain in place. They also describe the scenarios associated with the unlikely event of all controls failing. In most cases, the parameters used as input to the dose assessments for the various scenarios were selected based upon USNRC

[103] TRC Environmental Corporation, "Groundwater Potability Analysis - Shieldalloy Metallurgical Corporation, Newfield, New Jersey", TRC Project No. 26770-0100-00000, June, 2006.
[104] This assumption was deemed valid by the USNRC recently by the agency's approval of the decommissioning plan for the in-situ disposal of thorium slag in the SCA Hartley & Hartley Landfill (ADAMS Accession No. ML060370014).

recommendations that they be conservative yet realistic to conditions at the site.[105] The exceptions are for scenarios deemed unlikely but evaluated nonetheless in response to regulatory or public input.

5.3.1 Exposure Scenarios For the Unrestricted Portion of the Site

For dose modeling on the unrestricted portion of the Newfield site, the following key assumptions were made:

- The critical groups are industrial workers who work eight (8) hours per day on the site and occasional trespassers.
- Municipal water is used for drinking and irrigation purposes;
- Radioactive materials have been remediated to concentrations below the DCGLs established for this section;
- No water or food grown from the site is consumed;[106]
- A hypothetical industrial worker works at the site or an occasional trespasser visits the site after the decommissioning is complete and the engineered barrier is in place;[107]
- Workers leave the site after their work shift is completed each day and do not work on the weekends.

The following subsections describe scenario-specific assumptions made for assessing the radiation dose potential for the two critical groups.

5.3.1.1 Industrial Worker

The calculation of dose potential using the scenario of an industrial worker is reasonable. The site has access restrictions (i.e., fences, placarding) currently in place which effectively discourages trespassers on the restricted portion of the site. It is anticipated that these access restrictions will remain in place over the near term. Industrial use of the SMC property is a reasonable and likely land use scenario, given the site characteristics. Portions of the site underlain by upland soil may be suitable for light industry, as evidenced by existing light industrial land use at properties abutting the SMC site. Therefore, this scenario was used to establish the DCGLs for residual radioactivity in the unrestricted area.

[105] U.S. Nuclear Regulatory Commission, *Results of the License Termination Rule Analysis*, SECY-03-0069, May 2, 2003.
[106] Yu, C, Zielen, A.J, et al, *User's Manual for RESRAD Version 6*, Table 2.2, ANL/EAD-4, Argonne National Laboratory, Argonne, Illinois, July, 2001.
[107] Although the hypothetical industrial worker can see and approach the engineered cover in the restricted area, access to that area is denied as a result of LTC license conditions.

Description of the Critical Group

To ensure an element of conservatism in the analysis, SMC anticipates that industrial operations will be located on the property immediately adjacent to the fenced Storage Yard. Industrial workers will be present on the property at work each day, but at no time will any workers enter the restricted portion of the property. It is assumed that the industrial worker will work immediately adjacent to the Storage Yard even though it is not likely that the industrial operations will be located close to a fence. It is also assumed that the industrial worker will work at the site eight (8) hours per day, five (5) days per week for fifty (50) weeks per year, which is the duration of a typical working year (i.e., 2,000 hours). During each work day, a fraction of the worker's time is spent out-of doors.

Pathways included in the Industrial Worker Scenario

RESRAD identifies the potential pathways for exposure to the critical group. Three (3) pathways are used for the industrial worker scenario, including:

- direct radiation exposure;
- particulate inhalation; and
- direct ingestion of soil.

Table 17.4.10 lists the pathways that have been retained for the analysis and provides an explanation for those pathways that were not retained. The RESRAD User Manual supports the position that an industrial worker is not likely to drink groundwater.[108] Instead, he/she would drink water supplied to the site by the local drinking water service. Furthermore, the groundwater is not potable (see Section 5.3, above). Consequently, the groundwater pathway in RESRAD is disabled for this analysis because a public water supply is used by industrial workers at the Newfield site.

Table 17.3.2 describes the specific parameters that were used in the RESRAD model for the industrial worker (basis for the DCGL calculation).[109] Table 17.3.1 describes the parameters used in the RESRAD model to depict the physical parameters of the residual radioactivity in the surface soil after decommissioning is complete. These parameters are common to each of the restricted area scenarios analyzed herein.

[108] Argonne National Laboratory, *User's Manual for RESRAD Version 6*, Section 2.4.2, ANL/EAD-4, July, 2001.

[109] A more comprehensive list of the input parameters used in the execution of the RESRAD dose modeling code to evaluate the potential future radiation dose for each scenario is provided in the RESRAD summary reports (see Appendix 19.5).

Justification for the Key Parameters Used in the Analysis

Given the pathways described above, the key parameters for this scenario are identified in Table 17.3.2. Listed below is the justification for each key parameter.

- Indoor Time Fraction - The total time spent at the site is 2,000 hours, with 69% of that spent indoors and the remaining 31% outdoors.[110] This is a conservative assumption as the industrial worker is more likely to be given work assignments inside of the site buildings. The indoor fraction used as input to the RESRAD code, 0.16, is derived by dividing 1,380 hours (69% of 2,000 hours per year) by the total number of hours in a year (8,760 hours). For purposes of the sensitivity analysis, the probabilistic distribution ranges to twice as much as two (2) times the central tendency value (a maximum of 2,000 hours per year spent indoors at the site).

- Outdoor Time Fraction - The total time spent at the site is 2,000 hours, with 69% of that spent indoors and the remaining 31% outdoors.[111] This is a conservative assumption as the worker is assumed to be assigned to work inside the manufacturing building and more likely to be outdoors only to walk to and from their car, located in the parking lot. The outdoor fraction, 0.07, is derived by dividing 620 hours (31% of 2,000 hours per year) by the total number of hours in a year, 8,760 hours. For purposes of the sensitivity analysis, the probabilistic distribution ranges to twice the central tendency value (1,240 hours per year spent outdoors at the site). The radiation dose decreases as the industrial worker spends more time indoors instead of outdoors.

- Inhalation Rate -The inhalation rate for the industrial worker (adult male) is assumed to be 1,848 cubic meters per year. This value is equal to the RESRAD default inhalation rate based on geometric mean rate for short term exposure to adult males and working at the site for 2,000 hours per year or a fraction of 0.22 for the actual duration at the site.[112] It is considered to be conservative in that there is typically little work being performed outdoors by industrial workers, who are also not likely to be involved in heavy work nor in direct contact with the surface soil. As referenced in ICRP 23, Reference Man breathes 9,600 liters (0.96 m^3 of air) of air in an eight (8) hour period or 240 m^3 per year.[113] The radiation dose associated with this value decreases as the inhalation rate drops.

[110] U.S. Nuclear Regulatory Commission, *Development of Probabilistic RESRAD 6.0 and RESRAD-Build 3.0 Computer Codes*, NUREG/CR-6697, Appendix C, Table 7.6-3, November, 2000.

[111] U.S. Nuclear Regulatory Commission, *Development of Probabilistic RESRAD 6.0 and RESRAD-Build 3.0 Computer Codes*, NUREG/CR-6697, Appendix C, Table 7.6-3, November, 2000.

[112] U.S. Environmental Protection Agency, *Exposure Factors Handbook, Volume I, General Factors*, EPA 600/P-95-002Fa, August, 1997.

[113] International Commission on Radiological Protection, *Report of Task Group on Reference Man*, Report Number 23, 1975.

- Mass loading for inhalation - The value selected for the analysis was the default value for the RESRAD code. The mass loading in air describes the airborne dust loading conditions on the site and it is assumed that the industrial worker is located indoors and not exposed to the airborne dust from the surface soil.[114]

- Soil ingestion Rate - The industrial worker may ingest soil as a result of incidental contact with the soil. The value selected, 18.3 grams per year, was greater than the USEPA recommendations of 50 milligrams per day for an adult in an industrial setting.[115,116,117] It is assumed that the industrial worker is engaged in non contact intensive activities. The industrial worker does not enter the fenced restricted area, but may ingest soil from incidental contact with the surface soil in the unrestricted area. The industrial worker does not eat any animals or vegetables from the site, and does not drink any surface water or ground water.[118]

- Cover Depth - The residual activity is assumed to be present in the top 15 centimeters of the soil. It is assumed that residual radioactivity is distributed in a homogeneous manner. This assumption is consistent with the definition of the DCGL.

- Area of the Contaminated Zone - The area of the unrestricted area is represented by the area of the SMC property, less the area of the Storage Yard. The value of 244,000 m^2 refers to the largest portion of the site and the likely area where a manufacturing facility could be built. The area of the unrestricted area is likely to be smaller depending on the final construction of the engineered barrier and the area occupied by the restricted area. The potential radiation dose decreases as the area decreases. In describing the source term for input to RESRAD, the area (size) of the unrestricted contaminated zone parameter (AREA) is equal to the area of the SMC property, excluding the planned restricted area that will be in the current Storage Yard. The minimum unrestricted area is represented by a triangular distribution with a minimum value of 244,000 m^2 and a maximum value of 295,000 m^2. The maximum area is established by the property boundary but includes the Storage Yard. The minimum value is considered to be the most likely value. The use of the loguniform distribution provides a realistic, yet conservative, description of the lateral variability in the size of the source term in that it assigns the most likely size

[114] Argonne National Laboratory, *User's Manual for RESRAD Version 6*, July, 2001.
[115] The value of 18.3 grams of soil per year was calculated as 50% of the RESRAD default. The RESRAD default was based on the average for a residential family.
[116] U.S. Environmental Protection Agency, *Risk Assessment Guidance for Superfund, Volume I - Human Health Evaluation Manual*, Part A, OSWER Directive 9285.6-01, 1990.
[117] An ingestion rate of 50 milligrams per day yields a potential ingestion of 12 grams of soil per year.
[118] Drinking water is provided by a publicly-owned water system where there is testing for compliance with drinking water standards for radionuclides, and there are no potable surface water sources or ground water wells inside of the Storage Yard.

(244,000 m^2) as the minimum size and allows for the possibility (albeit with lower probability of occurrence) of larger sizes up to the entirety of the property.

- Thickness of the Contaminated Zone - The residual activity is present in the top 15 centimeters of the soil. Vertically, the radiologically significant material is assumed to be located in the top six (6) inches of soil (e.g. 0.15 meters), with no cover. The thickness of the contaminated zone parameter (THICKO) is represented by a triangular distribution, with the central tendency (CT) value conservatively set to a thickness of 0.5 feet (0.15 meters). This assumption is consistent with the definition of the DCGL.

5.3.1.2 Occasional Trespasser

Description of the Critical Group

The unrestricted portion of the site will be fenced and signs will be posted that prohibit trespassers from entering the property. SMC will maintain these controls for the foreseeable future, thus the likelihood that a trespasser will enter the property is remote. However, since there are no provisions for round-the-clock security, it is possible, although not likely, that a trespasser might be present on the unrestricted portion of the property.

Pathways included in the Trespasser Scenario

RESRAD identifies the potential pathways for exposure to the critical group. Three (3) pathways are used for the trespasser scenario, including:

- direct radiation exposure;
- particulate inhalation; and
- direct ingestion.

The other pathways are inapplicable and are disabled for the purpose of the RESRAD model. Table 17.4.1 identifies the pathways that have been retained for the analysis and provides an explanation for those pathways that were not retained. Table 17.3.3 describes the specific parameters that were used in the RESRAD model, showing the parameters specifically used in the model for the trespasser.[119] Table 17.3.1 describes the parameters used in the RESRAD model that depict the physical parameters of the unrestricted area.

[119] A comprehensive list of the input parameters used in the execution of the RESRAD dose modeling code to evaluate the potential future radiation dose for each scenario is provided in the RESRAD summary reports (See Appendix 19.5).

Justification for the Key Parameters Used in the Analysis

Given the pathways described above, the key parameters for this scenario are identified in Table 17.3.3. Listed below is the justification for each key parameter.

- Indoor Time Fraction - The total time spent indoors by the trespasser is assumed to be 0 hours. It is assumed that all of the time in the unrestricted area is spent outdoors. This assumption maximizes the radiation dose.

- Outdoor Time Fraction - It is assumed that a hypothetical trespasser spends 2.5 continuous days per year in the unrestricted area.[120] It is assumed that the manufacturing facility will restrict access by trespassers in order to protect their equipment and products. It is assumed that if a trespasser enters the area, employees of the manufacturing facility will identify them and require that they leave the area immediately. The outdoor fraction, 0.007, is derived by dividing the 59 hours per year by the total number of hours in a year, 8,760 hours. For purposes of the sensitivity analysis, the probabilistic distribution ranges to twice as much as two (2) times the central tendency value.

- Inhalation Rate -The inhalation rate for the trespasser is assumed to be a short term exposure for adult males averaging 8,400 cubic meters per year. This value is equal to the RESRAD default inhalation rate based on geometric mean rate for short term exposure to adult males.[121] This value is conservative because it assumed that the trespasser is not likely to be involved in heavy work nor in direct contact with the surface soil. The radiation dose associated with this value decreases as the inhalation rate drops.

- Mass loading for inhalation - The value selected for the analysis was the default value for the RESRAD code.[122] The mass loading in air describes the airborne dust loading conditions on the site and it is assumed that the trespasser is not involved in any intrusive activities that may call attention to the trespasser. It is not likely that the trespasser is exposed to the airborne dust from the surface soil. The radiation dose associated with this value decreases as the mass loading decreases.

- Soil ingestion Rate - The trespasser may ingest soil as a result of incidental contact with the soil. The value selected, 18.3 grams per year, was 50% of the default value for the RESRAD code and likely to be much lower than 18.3 grams per year based on the limited time spent in the Storage Yard. It is assumed that the trespasser is

[120] U. S. Environmental Protection Agency, "Exposure Factors Handbook Volume III - Activity Factors", Table 15-80 (Category - all), EPA/600/P-95/002Fc (August, 1997), the mean number of hours per year in outdoor playing is 592. It is reasonable to assume tht less than 10% of that time is spent trespassing on the Newfield site.

[121] U.S. Environmental Protection Agency, *Exposure Factors Handbook, Volume I, General Factors*, EPA 600/P-95-002Fa, August, 1997.

[122] Argonne National Laboratory, *User's Manual for RESRAD Version 6*, July, 2001.

engaged in non-contact intensive activities. The trespasser does not enter the fenced restricted area, but may ingest soil from incidental contact with the surface soil in the unrestricted area. The trespasser does not eat any animals or vegetables from the site, and does not drink any surface water or ground water.[123] The radiation dose associated with this value decreases as the ingestion of impacted soil decreases.

- Cover Depth - The residual activity is assumed to be present in the top 15 centimeters of the soil. It is assumed that residual radioactivity is distributed in a homogeneous manner. This assumption is consistent with the definition of the DCGL. The presence of any cover soil may attenuate potential external exposure and also reduce the likelihood of airborne dust. The radiation dose associated with this value decreases as the cover depth increases.

- Area of the Contaminated Zone - The area of the unrestricted area is represented by the area of the plant; the area of the Storage Yard is subtracted. The value of 244,000 m^2 refers to the largest portion of the site and the likely area where a manufacturing facility could be built. The area of the unrestricted area is likely to be smaller depending on the final construction of the engineered barrier and the area occupied by the restricted area. The potential radiation dose decreases as the area decreases.

- Thickness of the Contaminated Zone - The residual activity is present in the top 15 centimeters of the soil. This assumption is consistent with the definition of the DCGL.

5.3.2 Exposure Scenarios Involving the Restricted Portion of the Property

Once decommissioning is complete, SMC will be issued a LTC license from the USNRC. The conditions of this license will include a variety of institutional controls as described in Chapter 16, all of which are designed to minimize exposures of population groups.

Under these conditions, the reasonably foreseeable limiting exposure scenario for many years into the future would be for industrial workers who work on the unrestricted portion of the property, and a maintenance worker who is required to periodically traverse the engineered barrier for its inspection and repair (as necessary).[124] In addition, an occasional trespasser may climb the fence and traverse the restricted area for brief periods of time. All other scenarios are considered to be

[123] Drinking water is provided by a publicly-owned water system where there is testing for compliance with drinking water standards for radionuclides, and there are no surface water sources or ground water wells inside of the Storage Yard.

[124] The use of realistic exposure scenarios, rather than those that are unduly conservative, was approved by the Commission in a November 17, 2003 memorandum from A. L. Vietti-Cook to W. D. Travers, "Staff Requirements - SECY-03-069 - Results of the License Termination Rule Analysis". In that memorandum it states in part that "The Commission has approved the staff's recommendation for use of realistic exposure scenarios as described in attachment 6".

unlikely. The following subsections describe scenario-specific assumptions made for assessing the radiation dose potential for the critical groups.

5.3.2.1 Maintenance Worker

Description of the Critical Group

A maintenance worker in the employ of SMC will inspect and maintain the engineered barrier that is installed over consolidated residual radioactivity. The maintenance worker will inspect the barrier by walking or driving over its surface.[125] It is assumed that the maintenance worker will inspect the entire surface and repair any evidence of erosion or intrusion in the barrier.

Pathways included in the Maintenance Worker Scenario

RESRAD identifies the following potential pathways for the maintenance worker scenario:

- direct radiation exposure;
- particulate inhalation; and
- direct ingestion.

The other pathways are inapplicable and are disabled for the purpose of the RESRAD model. Table 17.4.4 identifies the pathways that have been retained for the analysis and provides an explanation for those pathways that were not retained. Table 17.3.6 lists the parameters specifically used in the model for the maintenance worker.[126] The tables are organized such that key parameters common to the assessment of both the surface and subsurface soil source terms are presented first. Subsequent tables present key parameters that are unique to the source term. Table 17.3.7 also describes the parameters used in the RESRAD model that depict the physical parameters of the cover, slag and the undisturbed layer conditions; these parameters are common to each of the scenarios used in restricted area of this chapter.

The exposure pathway for potential exposure to radon gas was eliminated for all potential outdoor exposure scenarios. The USNRC documented their concurrence with this approach in the Statement of Consideration for the License Termination Rule:[127]

> *"Following the approach taken in the proposed rule, this final rule includes radiological criteria for residual radioactivity that is distinguishable from*

[125] Mechanical equipment usage will be limited on the surface of the cover. Mechanized equipment such as a "four wheel ATV" or light tracked equipment may be used. Heavy equipment that may cause damage to the cover and/or the vegetation will be specifically prohibited.
[126] A comprehensive list of the input parameters used in the execution of the RESRAD dose modeling code to evaluate the potential future radiation dose for each scenario is provided in the RESRAD summary reports (see Appendix 19.5).
[127] U.S. Nuclear Regulatory Commission, *Radiological Criteria for License Termination*, Federal Register, Volume 62, Number 139, July 21, 1997.

background. Because of natural transport of radon gas in outdoor areas due to diffusion and air currents, doses from exposure to radon in outside areas due to radium in the soil are negligible... Therefore, in implementing the final rule, licensees will not be expected to demonstrate that radon from licensed activities is indistinguishable from background on a site-specific basis..."

Justification for the Key Parameters Used in the Analysis

Given the pathways described above, the key parameters for this scenario are identified in Table 17.3.6. Listed below is the justification for each key parameter.

- Indoor Time Fraction - The total time spent indoors by the maintenance worker is assumed to be 0 hours. It is assumed that all of the time in the restricted area is spent outdoors. There are no habitable structures on the Storage Yard. This assumption maximizes the radiation dose.

- Outdoor Time Fraction - It is assumed that the inspection and maintenance will require no more than 24 hours per year since the engineered barrier will be installed in a manner that minimizes erosion and enhances the growth of vegetation on its surface. From SMC's experience at its Cambridge, Ohio site, cap inspection and maintenance has been on-going for many years for footprint that is significantly larger than the one proposed for the Newfield site. The more realistic annual average inspection and maintenance duration at that site is one (1) day per month for two (2) hours or 24 hours per year.[128] Once established, the inspection and maintenance efforts are likely to be minimal. The outdoor fraction, 0.003, is derived by dividing 24 hours by the total number of hours in a year, 8,760 hours. For purposes of the sensitivity analysis, the probabilistic distribution ranges to twice as much as two (2) times the central tendency value. The radiation dose decreases as the maintenance worker spends less time on the Storage Yard.

- Inhalation Rate -The inhalation rate for the maintenance worker is assumed to be a short term exposure for adult males averaging 8,400 cubic meters per year. This value is equal to the RESRAD default inhalation rate based on geometric mean rate for short term exposure to adult males.[129] This value is conservative because it assumed that the maintenance worker is assigned to inspect the cover and not likely to be involved in a work intensive activity routinely over the course of the year. The maintenance worker is assumed to walk on the surface of the engineered barrier for purposes of inspection. The radiation dose associated with this value decreases as the inhalation rate drops.

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[128] See the SMC-Cambridge Radiation Protection Program Plan, RSP-001, for specifications on the routine maintenance and inspection activities for the West Pile.

[129] U.S. Environmental Protection Agency, *Exposure Factors Handbook, Volume I, General Factors*, EPA 600/P-95-002Fa, August, 1997.

- Mass loading for inhalation - The value selected for the analysis was the default value for the RESRAD code.[130] The mass loading in air describes the airborne dust loading conditions on the site and it is assumed that the maintenance worker is working on top of the engineered barrier and not exposed to the airborne dust from the slag.

- Soil ingestion Rate - The maintenance worker may ingest soil as a result of incidental contact with the soil. The value selected, 18.3 grams per year, was 50% of the default value for the RESRAD code; this value is expected to be much lower than the value selected. It is assumed that the maintenance worker is engaged in non contact intensive activities. The maintenance worker works on top of the engineered barrier and does not contact slag. The maintenance worker does not eat any animals or vegetables from the site, and does not drink any surface water or ground water.[131]

- Cover Depth - The thickness of the engineered barrier has a central tendency value of four (4) feet. The thickness of the engineered barrier decreases the external radiation levels and minimizes direct contact with the slag.

- Area of the Contaminated Zone - The area (size) of the consolidated contaminated zone parameter is represented by a loguniform distribution with a minimum value of 18,228 m^2 and a maximum value of 28,767 m^2. The minimum size is equal to the footprint of the proposed engineered barrier. The maximum value represents the area currently occupied by the Storage Yard. The use of the loguniform distribution provides a realistic, yet conservative, description of the lateral variability in the size of the source term in that it assigns the most likely size (28,767 m^2) as the minimum size.

- Thickness of the Contaminated Zone - Vertically, the radiologically-significant material is assumed to be located beneath the cover. The thickness of the contaminated zone parameter is represented by a triangular distribution, with the central tendency value conservatively set to a thickness of nine (9) feet.

5.3.2.2 Industrial Worker

Description of the Critical Group

SMC anticipates that industrial operations will be located on the property adjacent to the fenced restricted area. Industrial workers will go to work each day, but at no time will any workers enter the fenced area or walk on the engineered barrier. Although this places the critical group in the unrestricted portion of the property, it is assumed that the industrial worker will work immediately adjacent to the restricted area even though it is not likely that his day-to-day work take place to close

[130] Argonne National Laboratory, *User's Manual for RESRAD Version 6*, July, 2001.

[131] Drinking water is provided by a publicly-owned water system where there is testing for compliance with drinking water standards for radionuclides, and there are no surface water sources or ground water wells inside of the Storage Yard.

to a fenceline. However, his presumed presence at this location means he could be impacted by the presence of the consolidated material nearby. It is also assumed that the industrial worker will work five (5) days per week for fifty (50) weeks per year, and that the work day will last for eight (8) hours, with a fraction of that time spent outdoors.

Pathways Included in the Industrial Worker Scenario

RESRAD identifies the following potential pathways for the industrial worker scenario:

- direct radiation exposure; and
- particulate inhalation.

Table 17.4.5 lists the pathways that have been retained for the analysis and provides an explanation for those that were not. The RESRAD User Manual supports the position that an industrial worker is not likely to drink groundwater.[132] Instead, he/she would drink water supplied to the site by the local drinking water supply. Consequently, the groundwater pathway in RESRAD disabled for this analysis because a public water supply is indeed available to industrial workers at the Newfield site.

Table 17.3.8 describes the specific parameters that were used in the RESRAD model; this table lists the parameters specifically used in the model for the industrial worker.[133] Table 17.3.7 describes the parameters used in the RESRAD model that depict the physical parameters of the restricted area. These parameters are common to each of the scenarios used in this chapter.

Justification for the Key Parameters Used in the Analysis

Given the pathways described above, the key parameters for this scenario are identified in Table 17.3.8. Listed below is the justification for each key parameter.

- Indoor Time Fraction - The total time spent at the site in the unrestricted area is 2,000 hours; it is assumed that the industrial worker spends 69% of his time indoors, and 31% of the time outdoors.[134] This is conservative as the worker is assumed to be assigned to work inside the manufacturing building. The indoor fraction, 0.16, is derived by dividing 1,380 hours (69% of 2,000 hours per year) by the total number of hours in a year, 8,760 hours. For purposes of the sensitivity analysis, the probabilistic distribution ranges to twice as much as two (2) times the central tendency value (a maximum of 2,000 hours per year spent indoors at the site).

- Outdoor Time Fraction - Unrestricted Area - The total time spent at the site in the unrestricted area is 2,000 hours; it is assumed that the industrial worker spends 31%

[132] Argonne National Laboratory, *User's Manual for RESRAD Version 6*, Section 2.4.2, ANL/EAD-4, July, 2001.

[133] A comprehensive list of the input parameters used in the execution of the RESRAD dose modeling code to evaluate the potential future radiation dose for each scenario is provided in the RESRAD summary reports (see Appendix 19.5).

[134] U.S. Nuclear Regulatory Commission, *Development of Probabilistic RESRAD 6.0 and RESRAD-Build 3.0 Computer Codes*, NUREG/CR-6697, Appendix C, Table 7.6-3, November, 2000.

of the time outdoors.[135] This is conservative as the worker is assumed to be assigned to work inside the manufacturing building and more likely to be outdoors to walk to and from their car, located in the parking lot. The outdoor fraction, 0.07, is derived by dividing 620 hours (31% of 2,000 hours per year) by the total number of hours in a year, 8,760 hours. For purposes of the sensitivity analysis, the probabilistic distribution ranges to twice as much as two (2) times the central tendency value (1,240 hours per year spent outdoors at the site). The radiation dose decreases as the industrial worker spends more time indoors instead of outdoors.

- Outdoor Time Fraction - Restricted Area - The industrial worker is exposed to the source term from the restricted area as well as the residual radioactivity in the unrestricted area, however to a significantly lesser degree. For the purposes of this analysis, the contribution from the restricted area (i.e., external exposure from the Storage Yard) to the industrial worker is assumed to be less than 1% of the total effective dose; the dose resulting from the residual radioactivity (e.g, DCGL) in the unrestricted area is assumed to be 99% of the total effective dose.

- Inhalation Rate -The inhalation rate for the industrial worker is assumed to be a short term exposure for adult males averaging 8,400 cubic meters per year. This value is equal to the RESRAD default inhalation rate based on geometric mean rate for short term exposure to adult males.[136] This value is conservative because it assumed that there is no work being performed outdoors and not likely to be involved to be in work intensive activities and not in direct contact with the surface soil. The radiation dose associated with this value decreases as the inhalation rate drops.

- Mass loading for inhalation - The value selected for the analysis was the default value for the RESRAD code. The mass loading in air describes the airborne dust loading conditions on the site and it is assumed that the industrial worker is located indoors and not exposed to the airborne dust from the surface soil.[137]

- Cover Erosion Rate - The cover is assumed to be maintained and dose not erode while institutional controls are in place. The thickness of the cover does not change; the attenuation of external gamma dose rates does not change significantly. The contribution of external gamma exposure from the restricted area is determined to be less than 1% of the total effective dose; the dose resulting from the residual radioactivity (e.g, DCGL) in the unrestricted area is assumed to be 99% of the total effective dose.

[135] U.S. Nuclear Regulatory Commission, *Development of Probabilistic RESRAD 6.0 and RESRAD-Build 3.0 Computer Codes*, NUREG/CR-6697, Appendix C, Table 7.6-3, November, 2000.
[136] U.S. Environmental Protection Agency, *Exposure Factors Handbook, Volume I, General Factors*, EPA 600/P-95-002Fa, August, 1997.
[137] Argonne National Laboratory, *User's Manual for RESRAD Version 6*, July, 2001.

- Soil ingestion Rate - The industrial worker may ingest soil as a result of incidental contact with the soil. The value selected, 18.3 grams per year, was the default value for the RESRAD code. It is assumed that the industrial worker is engaged in non contact intensive activities. The industrial worker does not enter the fenced restricted area, but may ingest soil from incidental contact with the surface soil in the unrestricted area. The industrial worker does not eat any animals or vegetables from the site, and does not drink any surface water or ground water.[138]

- Cover Depth - The residual activity is assumed to be present in the top 15 centimeters of the soil. It is assumed that residual radioactivity is distributed in a homogeneous manner. This assumption is consistent with the definition of the DCGL.

5.3.2.3 Occasional Trespasser

Description of the Critical Group

The Newfield site is fenced and signs are be posted that prohibit trespassers from entering the property. SMC will maintain these conditions at the site in its entirety, and for the fenced restricted area. The likelihood that a trespasser will enter the property when the institutional controls are in place is remote. However, there will not be provision for round-the-clock security at the site, thus it is possible that a trespasser might be present in the restricted area for short durations.

Pathways included in the Trespasser Scenario

RESRAD identifies the following potential pathways for the trespasser scenario:

- direct radiation exposure;
- particulate inhalation; and
- direct ingestion.

The other pathways are inapplicable and are disabled for the purpose of the RESRAD model. Table 17.4.6 identifies the pathways that have been retained and provides an explanation for those pathways that were not retained. Table 17.3.9 describes the specific parameters that were used in the RESRAD model specifically for the trespasser scenario.[139] Table 17.3.7 describes the parameters used to depict the physical parameters of the cover, slag and the undisturbed surface conditions; these parameters are common to each of the scenarios used in this chapter.

[138] Drinking water is provided by a publicly-owned water system where there is testing for compliance with drinking water standards for radionuclides, and there are no surface water sources or ground water wells inside of the Storage Yard.

[139] A comprehensive list of the input parameters used in the execution of the RESRAD dose modeling code to evaluate the potential future radiation dose for each scenario is provided in the RESRAD summary reports (see Appendix 19.5).

Justification for the Key Parameters Used in the Analysis

Given the pathways described above, the key parameters for this scenario are identified in Table 17.3.9. Listed below is the justification for each key parameter.

- Indoor Time Fraction - The total time spent indoors by the trespasser is assumed to be 0 hours. It is assumed that all of the time in the unrestricted area is spent outdoors. This assumption maximizes the radiation dose and provides a conservative (i.e., high) estimate of the potential radiation exposure.

- Outdoor Time Fraction - It is assumed that the trespasser spends one hour per day and no more than one day per month at the site or a total of 59 hours in the restricted area.[140] It is assumed that if a trespasser enters the restricted area, employees of the manufacturing facility will identify them and require that they leave the area immediately. The outdoor fraction, 0.007, is derived by dividing the 59 hours per year by the total number of hours in a year (i.e., 8,760 hours). For purposes of the sensitivity analysis, the probabilistic distribution ranges to twice as much as two (2) times the central tendency value.

- Inhalation Rate -The inhalation rate for the trespasser is assumed to be a short term exposure for adult males averaging 8,400 cubic meters per year. This value is equal to the RESRAD default inhalation rate based on geometric mean rate for short term exposure to adult males.[141] This value is conservative because it assumed that the trespasser is not likely to be involved to be in work intensive activities and in direct contact with the surface soil. The radiation dose associated with this value decreases as the inhalation rate drops.

- Mass loading for inhalation - The value selected for the analysis was the default value for the RESRAD code.[142] The mass loading in air describes the airborne dust loading conditions on the site and it is assumed that the trespasser is not involved in any intrusive activities that may call attention to the trespasser. It is not likely that the trespasser is exposed to the airborne dust from the surface soil. The radiation dose associated with this value decreases as the mass loading decreases.

- Cover Erosion Rate - The cover is assumed to be maintained and dose not erode while institutional controls are in place. The thickness of the cover does not change; the attenuation of external gamma dose rates does not change significantly.

[140] In U. S. Environmental Protection Agency, "Exposure Factors Handbook Volume III - Activity Factors", Table 15-80 EPA/600/P-95/002Fc (August, 1997), the mean number of hours per year spent in outdoor playing for the "All" category is all categories is 592. It is arbitrarily assumed that approximately 10 percent of the total outdoor time is spent trespassing on the SMC property.

[141] U.S. Environmental Protection Agency, *Exposure Factors Handbook, Volume I, General Factors*, EPA 600/P-95-002Fa, August, 1997.

[142] Argonne National Laboratory, *User's Manual for RESRAD Version 6*, July, 2001.

- Soil ingestion Rate - The trespasser may ingest soil as a result of incidental contact with the soil. The value selected, 18.3 grams per year, was the default value for the RESRAD code. It is assumed that the trespasser is engaged in non-contact intensive activities. The trespasser does not enter the fenced restricted area, but may ingest soil from incidental contact with the surface soil in the unrestricted area. The trespasser does not eat any animals or vegetables from the site, and does not drink any surface water or ground water.[143] The radiation dose associated with this value decreases as the ingestion of impacted soil decreases.

5.3.3 Exposure Scenario Involving the Restricted Portion of the Site (Controls Fail)

In the event that all institutional controls fail, it is unreasonable to assume anyone could access the engineered barrier, although taking up residence on it is unlikely because its shape/form would not be conducive to building construction. The engineered barrier is shaped like a chevron and exhibits side slopes that are too steep for construction. On the top surface, there is insufficient area to build a house or install footers for a building foundation. It is equally unreasonable to assume that truck farming or small-scale agriculture would be conducted directly on top or on the sides of the engineered barrier, again because of its configuration and because flat surfaces are readily available in the immediate proximity.

The potential for intruders to excavate the slag was evaluated and rejected by the USNRC during its evaluation of the decommissioning plan prepared for SMC's Cambridge, Ohio facility (with similar radiological constituents and a similar decommissioning alternative) in 1996.[144] The USNRC concluded in the Draft Environmental Impact Statement for that action as follows:

> *"The staff believes, however, that the combined likelihood of the institutional controls failing and a member of the public obtaining slag from the stabilized piles is remote. Assuming that the access controls failed, and in order for an off-site residential use scenario to be occur, a member of the public would have to dig through the caps that will be on the piles to obtain the slag. While this might be possible if the material had some significant value and was known to be beneath the cover by a member of the public, this is or will not be the case. The slag is similar to other readily available and inexpensive sources of fill materials, such as limestone so it is unlikely that an individual would dig into the slag piles to obtain materials which are otherwise easily obtained. Also, if a member of the public knew that the*

[143] Drinking water is provided by a publicly-owned water system where there is testing for compliance with drinking water standards for radionuclides, and there are no surface water sources or ground water wells inside of the Storage Yard.

[144] U.S. Nuclear Regulatory Commission, *Draft Environmental Impact Statement, Decommissioning of the Shieldalloy Metallurgical Corporation, Cambridge, Ohio, Facility*, NUREG-1543, July, 1996.

slag was buried in the piles, he would also likely know that the material was radioactive and would therefore not use it." [145]

Like the limestone mining in Ohio, the principle mineral resource in New Jersey is sand and gravel mining. Therefore, anyone seeking sand or gravel will pursue easier to-process sources than the engineered barrier with its relatively large, impervious igneous slag.

SMC also considered the likelihood of an intruder successfully excavating the slag and removing it from the engineered barrier, and rejected it. The particle size of the slag currently in the storage yard is very large (i.e., dimensions on the order of square feet rather than square inches); it would take a significant effort to excavate it and crush it down to sizes that would be more useful for fill or road bed. And it is not reasonable to assume anyone would pursue the use of slag as a source of fill when other sources of fill that are cheaper to obtain are available. The baghouse dust, on the other hand, does have a smaller particle size, but it will be used to fill void spaces between the large pieces of slag prior to installing the engineered barrier. As such, its retrieval would not be cost-effective in light of the ready availability of similar materials elsewhere.

The only exposure scenarios considered applicable in the unlikely event the institutional controls fail for the restricted area are for: (1) a recreational hunter that would hunt game on the engineered barrier, (2) a family that may live near the engineered barrier, (3) a trespasser that may traverse the engineered barrier where some of the cover has been excavated thus partially exposing the contents, and (4) an industrial worker that may work at a manufacturing facility elsewhere on the property that is in proximity to the restricted area.[146] There was regulatory and public interest in the dose potential for the excavator scenarios, in spite of the fact that they are unlikely. Therefore, they were included in the evaluation as well. The following sections describe the scenario-specific assumptions used as input to the dose modeling.

5.3.3.1 Recreational Hunter Scenario

<u>Description of the Critical Group</u>

The critical exposure group for the recreational hunter scenario is described as a hypothetical subpopulation that hunts for recreation and consumes game meat culled from the restricted portion of the site. This hunter (as conservatively described) would spend a fraction of his available outdoor recreational time engaged in hunting and who goes to the SMC site, where the fencing around the restricted area has failed thus permitting the egress of game. Although not realistic, it is assumed he chooses the SMC site each time rather than visiting other sites in search of prey.

[145] U.S. Nuclear Regulatory Commission, *Draft Environmental Impact Statement, Decommissioning of the Shieldalloy Metallurgical Corporation, Cambridge, Ohio, Facility*, NUREG-1543, Appendix H, July, 1996.

[146] As described in Section 5.3, removing some or all of the engineered barrier as a source of fill, thus partially exposing the residual radioactivity therein, is not likely due to the relative difficulty of scavenging fill a sloped surface as compared to a nearby flat surface. And even if surface mining did occur, the radionuclide concentration in the excavated material would be small since it is comprised of radiologically-inert soil and possibly small amounts of the baghouse dust that was placed below the native soils as void filler. (The baghouse dust contains less than 0.05% source material.) Therefore, this scenario does not present dosimetric significance.

Hunting on the property is not likely, even if institutional controls should fail, because of the lack of shelter in which animals could hide and forage and because hunting is not allowed within Newfield borough limits. Hunters are not likely to use such a small piece of elevated land as a source of game because of the realistically-small animal population in its vicinity. However, this scenario, albeit unlikely, was deemed somewhat more likely than others (i.e., agricultural farm family, resident family, excavator).

Pathways Included in the Recreational Hunter Scenario

RESRAD identifies the following potential pathways for exposure for the trespasser scenario:

- direct radiation exposure;
- particulate inhalation;
- meat ingestion; and
- direct ingestion.

The other pathways are inapplicable and are disabled for the purpose of the RESRAD model. Table 17.4.7 identifies the pathways that have been retained for the analysis and provides an explanation for those pathways that were not retained. Table 17.3.10 describes the specific parameters that were used in the RESRAD model; this table lists the parameters specifically used in the model for the recreational hunter.[147]

Justification for the Key Parameters Used in the Analysis

Given the pathways described above, the key parameters for this scenario are identified in Table 17.3.10. Listed below is the justification for each key parameter.

- Indoor Time Fraction - The total time spent indoors by the recreational hunter is assumed to be 0 hours. It is assumed that all of the time in the unrestricted area is spent outdoors. This assumption maximizes the external radiation dose.
- Outdoor Time Fraction - It is assumed that the recreational hunter spends 75 hours per year in the restricted area.[148] The outdoor fraction, 0.009, is derived by dividing 80 hours per year by the total number of hours in a year, 8,760 hours. For purposes of the sensitivity analysis, the probabilistic distribution ranges to twice as much as

[147] A comprehensive list of the input parameters used in the execution of the RESRAD dose modeling code to evaluate the potential future radiation dose for each scenario is provided in the RESRAD summary reports (see Appendix 19.5).

[148] In U. S. Environmental Protection Agency, "Exposure Factors Handbook Volume III - Activity Factors", Table 15-85 EPA/600/P-95/002Fc (August, 1997), the mean number of hours per year spent in active sports for the "All" category is all categories is 754. It is reasonable to assume that less than 10% of the total time is spent hunting within in the restricted area of the SMC property.

two (2) times the central tendency value. Hunting on the property is not likely even if institutional controls should fail because of the lack of shelter in which animals could hide and forage, the presence of the rock cover, and because hunting is not allowed within Newfield borough limits. Hunters are not likely to use such a small piece of elevated land as a source of game because of the realistically-small animal population in its vicinity and the unsure footing associated with its traversal. The potential radiation exposure decreases as the time decreases.

- Inhalation Rate -The inhalation rate for the recreational hunter is assumed to be a short term exposure for adult males averaging 8,400 cubic meters per year. This value is equal to the RESRAD default inhalation rate based on geometric mean rate for short term exposure to adult males.[149] This value is conservative because it assumed that the recreational hunter is walking on the property and performing tasks that are considered to be "light activity" as defined in the USEPA Exposure Factors Handbook and in direct contact with the surface soil. Moreover, at the rate of 20 liters per minute and present for 80 hours per year, the more likely air volume is more likely to be 98 m^3/year rather than 8,400 m^3/year. The radiation dose associated with this value decreases as the inhalation rate drops.

- Contaminated Fraction of Meat - The fraction of the annual meat diet that is obtained from game harvested from off the site is assumed to be 30%. The number is conservative in that the size of the site is small relative to the grazing land required to support game habitat. The use of the triangular distribution (i.e., 0 to 50%) results in a more conservative estimate than the RESRAD default for this site.[150]

- Mass loading for inhalation - The value selected for the analysis was the default value for the RESRAD code.[151] The mass loading in air describes the airborne dust loading conditions on the site; it is assumed that the recreational hunter is not involved in any intrusive activities. It is not likely that the recreational hunter is exposed to the airborne dust from the surface soil because the engineered barrier eliminates direct contact with the slag. The selected value, 1×10^{-4} g/m^3 is 2-10x greater than the range of observed values summarized in NUREG 5512.[152] The radiation dose associated with this value decreases as the mass loading decreases.

- Cover Erosion Rate - The cover is assumed to be maintained and dose not erode while institutional controls are in place. The thickness of the cover does not change;

[149] U.S. Environmental Protection Agency, *Exposure Factors Handbook, Volume I, General Factors*, EPA 600/P-95-002Fa, August, 1997.
[150] U.S. Environmental Protection Agency, *Exposure Factors Handbook, Food Ingestion Factors*, Volume II, EPA/600/P-95/002Fb, August, 1997.
[151] Argonne National Laboratory, *User's Manual for RESRAD Version 6*, July, 2001.
[152] U.S. Nuclear Regulatory Commission, *Residual Radioactive Contamination from Decommissioning Parameter Analysis*, NUREG/CR-5512, Volume 3, October 31, 1999.

the attenuation of external gamma dose rates does not change significantly. The erosion rate was calculated using the Revised Universal Soil Loss Equation computer program, RULE2 (see Appendix 19.3).

- Soil ingestion Rate - The recreational hunter may ingest soil as a result of incidental contact with the soil. The value selected, 18.3 grams per year, was 50% of the RESRAD default established for a resident farm family who is located on the site for the entire year. The USEPA recommends 50 milligrams per day or less than 1 gram of soil per year.[153] It is assumed that the recreational hunter is engaged in non-contact intensive activities. The recreational hunter may enter the fenced restricted area, but may ingest soil from incidental contact with the surface soil in the unrestricted area. This value is conservative because of the time that the recreational hunter is assumed to on the property. The recreational hunter is assumed to spend no more than 20 days per year on the property; it is predicted that the recreational hunter may ingest no more than 50 milligrams of soil per day or less than one (1) gram of soil per year under these conditions.[154] The likelihood of ingesting soil is greatly reduced because the engineered barrier eliminates direct contact with the slag. The radiation dose associated with this value decreases as the ingestion of impacted soil decreases.

5.3.3.2 Suburban Resident Scenario

Description of the Critical Group

The critical exposure group for the suburban resident scenario is described as a hypothetical family that occupies a house constructed near the restricted area.[155] It is assumed that the house is located 1,000 feet from the restricted area.[156] The family who lives in the house uses water provided by a publicly owned water supply and does not grow food or vegetables near the engineered barrier (i.e., food is purchased at a nearby grocery store). The groundwater pathway was disabled because a suburban resident is most likely to secure water from a public water supply, which is regionally available, rather than drilling and maintaining a well. This is consistent with current conditions for SMC's neighbors, and is thus likely for the foreseeable future.

[153] U.S. Environmental Protection Agency, *Exposure Factors Handbook, Volume I, General Factors*, EPA 600/P-95-002Fa, August, 1997.

[154] U.S. Environmental Protection Agency, *Exposure Factors Handbook, Volume I, General Factors*, EPA 600/P-95-002Fa, August, 1997.

[155] As a result of the design of the engineered barrier, it is not feasible for a house to be built directly on top. The cover is elevated from the ground surface and covers the slag; the presence of the slag within three (3) feet (1 meter) from the surface does not allow excavation or trenching for typical construction of footers or utility trenches, commonly used in the construction of a house. Furthermore, the surface is covered in rock that would present a considerable expense to re-locate in light of the ready availability of nearby, flat, non-rocky property.

[156] The distance from the restricted area to the nearest drinking water well and off-site resident is approximately 1,000 feet. This is consistent with the median distance to the nearest off-site resident from municipal landfills around the country, as determined in a 1988 USEPA Office of Solid Waste survey, of 1,400 feet (U. S. Environmental Protection Agency, Region 6, Multimedia Planning and Permitting Division, "RCRA Delisting Technical Support Document", Chapter 3, Exposure Scenario Selection, May, 2000).

It is important to note that the suburban resident scenario is also unlikely because of the lack of available space to construct a house and parking, and because the majority of the area surrounding the Storage Yard is assigned for natural resource damage mitigation (tree planting) and could only be developed for housing if the controls maintaining the conservation should fail. However, this scenario was nonetheless selected for the dose assessment.

Pathways Included in the Suburban Resident Scenario

RESRAD identifies the potential pathways for exposure to the critical group. Three (3) pathways are used for the suburban resident, including:

- direct radiation exposure;
- particulate inhalation; and
- direct ingestion of soil.

Table 17.4.3 lists the pathways that have been retained for the analysis and provides an explanation for those pathways that were not retained. The RESRAD User Manual supports the position that the suburban resident does not drink groundwater.[157] Instead, he/she would drink water supplied to the site by the local drinking water service. Consequently, the groundwater pathway in RESRAD disabled for this analysis because a public water supply is available to industrial workers at the Newfield site.

Table 17.3.2 describes the specific parameters that were used in the RESRAD model for the suburban resident using the input parameters that were used to develop the DCGLs for the unrestricted area.[158] Table 17.3.1 describes the parameters used in the RESRAD model to depict the physical parameters of the residual radioactivity in the surface soil of the unrestricted area after decommissioning is complete. The computer code Microshield was used to calculate the external exposure stemming from the restricted area after the engineered barrier is completed. The RESRAD code was not used because it requires the receptor to be positioned directly on top of the engineered barrier. The suburban resident is exposed to the external radiation component of the restricted area.

Justification of the Key Parameters Used in the Analysis

Given the pathways described above, the key parameters for this scenario are identified in Table 17.3.5. The suburban resident is assumed to live in the unrestricted area where residual radioactivity exists at concentrations at or below the DCGLs. Listed below is the justification for each key parameter.

[157] Argonne National Laboratory, *User's Manual for RESRAD Version 6*, Section 2.4.2, ANL/EAD-4, July, 2001.
[158] A more comprehensive list of the input parameters used in the execution of the RESRAD dose modeling code to evaluate the potential future radiation dose for each scenario is provided in the RESRAD summary reports (see Appendix 19.5).

- Indoor Time Fraction - The total time spent at the site is 1,920 hours (240 days for 8 hours per day); it is assumed that the suburban resident spends 69% (0.69) of his time indoors, and 31% (0.31) of the time outdoors.[159] This is conservative because the resident is unlikely to spend as many as 240 days at the site. The indoor fraction, 0.15, is derived by dividing 1,920 hours by the total number of hours in a year, 8,760 hours and multiplying the product by 0.69. For purposes of the sensitivity analysis, the probabilistic distribution ranges to twice as much as two (2) times the central tendency value (a maximum of 2,650 hours per year spent indoors at the site). The radiation dose decreases as the fraction indoors increases.

- Outdoor Time Fraction - The total time spent at the site is 8,760 hours; it is assumed that the suburban resident spends 31% of the time outdoors.[160] The outdoor fraction, 0.07, is derived by dividing 595 hours by the total number of hours in a year, 8,760 hours. For purposes of the sensitivity analysis, the probabilistic distribution ranges to twice as much as two (2) times the central tendency value (1,190 hours per year spent outdoors at the site). The radiation dose decreases as the resident spends more time indoors instead of outdoors.

- Inhalation Rate -The inhalation rate for the suburban resident is assumed to be a short term exposure for adult males averaging 8,400 cubic meters per year. This value is equal to the RESRAD default inhalation rate based on geometric mean rate for short term exposure to adult males.[161] This value is conservative because it assumed that the suburban resident is walking on the property and performing tasks that are considered to be "light activity" as defined in the USEPA Exposure Factors Handbook. This volume of air assumes that the resident is on the site 100% of the time. The radiation dose associated with this value decreases as the inhalation rate drops.

- Mass loading for inhalation - The value selected for the analysis was the default value for the RESRAD code. The mass loading in air describes the airborne dust loading conditions on the site and it is assumed that the suburban resident spends some time outdoors in direct contact with the impacted soil.[162]

- Soil ingestion Rate - The suburban resident may ingest soil as a result of incidental contact with the soil. The value selected, 18.3 grams per year, was assumed to be 50 milligrams per day for 365 days per year. It is assumed that the suburban resident

[159] U.S. Nuclear Regulatory Commission, *Development of Probabilistic RESRAD 6.0 and RESRAD-Build 3.0 Computer Codes*, NUREG/CR-6697, Appendix C, Table 7.6-3, November, 2000.
[160] U.S. Nuclear Regulatory Commission, *Development of Probabilistic RESRAD 6.0 and RESRAD-Build 3.0 Computer Codes*, NUREG/CR-6697, Appendix C, Table 7.6-3, November, 2000.
[161] U.S. Environmental Protection Agency, *Exposure Factors Handbook, Volume I, General Factors*, EPA 600/P-95-002Fa, August, 1997.
[162] Argonne National Laboratory, *User's Manual for RESRAD Version 6*, July, 2001.

is engaged in non contact intensive activities. The suburban resident does not enter the fenced restricted area, but may ingest soil from incidental contact with the surface soil in the unrestricted area. The suburban resident does not eat any animals, and does not drink any surface water or ground water.[163]

- Cover Depth - The residual activity is assumed to be present in the top 15 centimeters of the soil. It is assumed that residual radioactivity is distributed in a homogeneous manner. This assumption is consistent with the definition of the DCGL.

- Area of the Contaminated Zone - The area of the unrestricted area is represented by the area of the plant; the area of the Storage Yard is subtracted. The value of 244,000 m^2 refers to the largest portion of the site and the likely area where a manufacturing facility could be built. The area of the unrestricted area is likely to be smaller depending on the final construction of the engineered barrier and the area occupied by the restricted area. The potential radiation dose decreases as the area decreases. In describing the source term for input to RESRAD, the area (size) of the unrestricted contaminated zone parameter (AREA) is equal to the area of the SMC property, excluding the planned restricted area that will be in the current Storage Yard. The minimum unrestricted area is represented by a triangular distribution with a minimum value of 244,000 m^2 and a maximum value of 295,000 m^2. The maximum area is established by the property boundary but includes the Storage Yard. The use of the loguniform distribution provides a realistic, yet conservative, description of the lateral variability in the size of the source term in that it assigns the most likely size (244,000 m^2) as the minimum size and allows for the possibility (albeit with lower probability of occurrence) of larger sizes up to the entirety of the property.

- Thickness of the Contaminated Zone - The residual activity is present in the top 15 centimeters of the soil. Vertically, the radiologically significant material is assumed to be located in the top six (6) inches of soil (e.g. 0.15 meters), with no cover. The thickness of the contaminated zone parameter is represented by a triangular distribution, with the central tendency value conservatively set to a thickness of 0.5 feet (0.15 meters). This assumption is consistent with the definition of the DCGL.

- Ingestion of Water - Surface water and ground water on site is unfit for consumption as drinking water. No on-site sources of groundwater have been developed for drinking water. There are no surface water ponds on the property. It is assumed that the resident does not ingest ground water.

[163] Drinking water is provided by a publicly-owned water system where there is testing for compliance with drinking water standards for radionuclides, and there are no surface water sources or ground water wells inside of the Storage Yard.

- Distance from the Storage Yard - The source term found in the site soils produces penetrating gamma radiation. Exposure from direct penetrating radiation is expected to be a significant contributor to the overall potential dose. External radiation dose was modeled using Microshield; RESRAD does not accurately model a direct exposure at a distance form the source term.

5.3.3.3 Barrier Excavation Scenario

Description of the Critical Group

The critical exposure group for the cover excavation scenario, which is considered to be an unlikely scenario, is described as a hypothetical person who excavates into the engineered barrier and exposes some of the slag.[164] The potential for exposure was evaluated in three different scenarios, including the immediate exposure to the excavator, the potential exposure to a recreational hunter after the cover is breached and the potential exposure to a family living nearby the damaged cap.

Exposure to the Excavator

It is assumed that an excavator climbs the fence surrounding the restricted area after institutional controls fail. The excavator then removes a portion of the engineered barrier to expose the buried slag, at which point he determines there is no further benefit in continuing and exits the area. While there, the excavator is assumed to excavate one (1) square meter ($1m^2$) of the cover, including all its layers. It is assumed that the excavator uses manual excavation methods and that he is somehow able to cut or otherwise breach the geomembrane during the excavation process. The nominal footprint for the excavation (i.e., one square meter) would provide enough space for the excavator to climb down from the surface of the cover and onto the layer of exposed slag in order to confirm that further excavation would not be beneficial.

The person who excavates through the barrier is assumed to spend ten (10) work days at a rate of eight (8) hours per day, for a total of eighty (80) hours for this task.[165] It is assumed that one (1) square meter of the barrier is fully excavated, thus the excavator is exposed to a one (1) square meter surface of slag as he attempts to pulverize or chip the first boulder encountered. When the excavator is unsuccessful in removing the large, heavy pieces of slag using manual methods, excavation discontinues. Once refusal is reached, it is assumed that no slag is removed and that the excavated portion of the cap is not replaced.

Exposure to a Nearby Suburban Resident

Following the attempted excavation, it is assumed that the barrier is not repaired or returned to its original condition. The exposed surface of the slag is thus open to the environment and unshielded. The suburban resident family described in Section 5.3.3.2 lives within the line of sight from the

[164] It assumed that the cover may be excavated after institutional controls fail and that there is no maintenance or inspection of the cover over time. It is assumed that the person excavating the slag is doing so in an attempt to determine the intrinsic value and potential uses of the material. This individual may consider the material to be useful for landscaping or fill at a different location.

[165] A single individual, using hand-held excavating equipment, would be able to remove one square meter of the engineered barrier in this amount of time.

damaged portion of the barrier, which is assumed to be located on one of the side walls of the barrier, and is thus exposed to direct radiation for the durations described in the previous section. This scenario is considered to be highly unlikely because of the difficulty in removing the barrier material using hand excavating equipment, the likelihood that if such a removal campaign did occur, the excavator would excavate the top rather than a side wall of the engineered barrier so as to improve his/her footing.

Exposure to a Recreational Hunter

It is assumed that a hunter climbs the fence surrounding the restricted area after cap is damaged by the excavator. The hunter is assumed to spend 75 hours per year hunting for game inside the fenced area.[166] It is reasonable to assume that approximately one (1) percent of that time is spent within three (3) feet of the one (1) square meter of the engineered barrier that had been fully excavated, for a total of 0.75 hours per year. This scenario is not realistic because of the limited access of game inside of the small fenced area, meaning hunters are not likely to remain for the entire exposure duration, and would likely avoid a six-foot-deep pit.

Pathways Included in the Barrier Excavation Scenario

One pathway, direct radiation exposure, is evaluated for the each of the three scenarios. The slag itself is hard and difficult to chip or pulverize, thus there is no potential for ingestion or inhalation of radioactive materials. The excavator and recreational hunter are exposed to external radiation for the duration described above. The direct radiation exposure assessed for the suburban resident under this scenario is added to the potential exposure calculated for a suburban resident who lives adjacent to the fenced area, as derived in Section 5.3.3.2. The result of the two exposure potentials is added. in order to estimate the total exposure potential to this critical group.

Justification for the Key Parameters Used in the Analysis

Given the pathways described above, the key parameters for this scenario are identified in Table 17.3.11. The suburban resident is assumed to live in the unrestricted area where residual radioactivity exists at concentrations at or below the DCGLs. Listed below is the justification for each key parameter.

- Excavator Exposure Duration - The total time spent in the excavation is 80 hours. The total exposure is calculated by multiplying the exposure rate, calculated with Microshield by the estimated duration. The excavation of the cover requires two (2) days or sixteen hours; the exposure rate is reduced because of the increased distance from the slag, or at least one (1) meter away. The remaining time, 64 hours, is spent in direct contact with the exposed slag attempting to penetrate its surface.[167] These are conservative assumptions in that the excavator is not likely to stay in direct

[166] In U. S. Environmental Protection Agency, "Exposure Factors Handbook Volume III - Activity Factors", Table 15-85 EPA/600/P-95/002Fc (August, 1997), the mean number of hours per year spent in active sports for the "All" category is all categories is 754. It is arbitrarily assumed that approximately 10% of the total time is spent hunting in the restricted area of the SMC property.

[167] The excavator spends 8 days, 8 hours per day, to excavate the slag.

contact after a few attempts to pulverize or remove it are refused. The direct exposure to the excavator is the sum of the two exposure scenarios, the excavation and the direct contact.

- Recreational Hunter Exposure Duration - The total time spent in the fenced area is 75 hours per year. The total exposure is calculated by multiplying the exposure rate, calculated with Microshield by the estimated duration. It is assumed that the hunter spends 0.75 hours in close proximity to the open excavation and approximately one (1) meter from the surface of the exposed slag. This a conservative assumption because the hunter is unlikely to spend so much time inside of the fenced area or near the excavation because of the lack of game inside the fenced area. The direct exposure to the hunter is the sum of the two exposure scenarios, walking over the cover and standing near the open excavation.

- Suburban Resident Exposure Duration - It is assumed that the resident is potentially exposed for 24 hours per day, 365 days per year. The computer code Microshield was used to evaluate the direct exposure potential from the open excavation. It is assumed that the suburban resident is located 300 meters from the open excavation and no additional attenuation of the gamma radiation is provided by the barrier. The total time spent in the house is 6,044 hours per year. The total exposure is calculated by multiplying the exposure rate, calculated with Microshield by the estimated duration. These are conservative assumptions in that the resident is not likely to stay in one location for the entire year and dose not have direct contact with the slag after the engineered barrier is breached.

5.3.3.4 Industrial Worker Scenario

Description of the Critical Group

SMC anticipates that industrial operations will be located on the property adjacent to the restricted area. In the unlikely case that all controls fail, this critical group would be impacted by the presence of the restricted area, either through direct exposure or by accessing the surface of the engineered barrier.

For this scenario, it is assumed that industrial workers travel to the site to work each day, that there are no controls in place, and there are no prohibitions to entering the restricted area (i.e., workers may walk on the engineered barrier). It is assumed that the industrial worker will work immediately adjacent to the restricted area even though it is not likely that the industrial operations will be located in such close proximity to an elevated land area. It is also assumed that the industrial worker will work at the site five (5) days per week for fifty (50) weeks per year, and that the work day will last for eight (8) hours per day.

Pathways included in the Industrial Worker Scenario

RESRAD identifies the potential pathways for exposure to the critical group. Three (3) pathways are used for the industrial worker scenario, including:

- direct radiation exposure;
- direct ingestion; and
- particulate inhalation.

Table 17.4.9 identifies the pathways that have been retained for the analysis and provides explanation for those pathways that were not retained. The other pathways are inapplicable and are disabled for the purpose of the RESRAD model. Table 17.3.12 describes the specific parameters that were used in the RESRAD model; this table lists the parameters specifically used in the model for the industrial worker.[168] Table 17.3.7 describes the parameters used in the RESRAD model that depict the physical parameters of the cover, slag and the subsurface conditions; these parameters are common to each of the scenarios used in this chapter.

Justification of the Key Parameters Used in the Analysis

It is assumed that the industrial worker spends 69% of his time indoors and 31% of the time outdoors.[169] It is assumed that the industrial worker spends time indoors in the unrestricted area (1,324 hours/year)and 100% of their time outdoors walking in the unrestricted area 595 hours/yr). This approach is consistent with a worker who is employed at an industrial facility and is working inside of a building. The outdoor fraction, 0.07, is derived by dividing the 2,000 hours per year by the total number of hours in a year, 8,760 hours. These time fractions, as well as the external gamma shielding factor, are more sensitive parameters in this industrial worker scenario where the institutional controls fail,. The inhalation rate for the industrial worker is assumed to be a short term exposure for adult males averaging 8,400 cubic meters per year.

The industrial worker may enter the restricted area and it is assumed that he may ingest soil from there. However, the worker does not eat any animals or vegetables from the restricted area, and drinking water is provided by a publicly-owned water system because there are no surface water sources or ground water wells inside of the restricted area.

Because failure of institutional controls means cover maintenance may cease, the engineered barrier is likely to erode. As addressed previously in Section 5.2.2.1, the cover design ensures that, without maintenance or care, it will erode by less than six inches (0.015 meters) in 1,000 years. For

[168] A comprehensive list of the input parameters used in the execution of the RESRAD dose modeling code to evaluate the potential future radiation dose for each scenario is provided in the RESRAD summary reports (see Appendix 19.5).
[169] U.S. Nuclear Regulatory Commission, *Development of Probabilistic RESRAD 6.0 and RESRAD-Build 3.0 Computer Codes*, NUREG/CR-6697, Appendix C, Table 7.6-3, November, 2000.

modeling purposes, it is assumed that the engineered barrier maintenance program ceases immediately after the LTC license is issued.[170]

5.4 Uncertainty Analysis

5.4.1 Managing Uncertainty

There is an inherent uncertainty in any projection of a future conditions. Thus, tools were developed to model or project a future condition and to understand the uncertainty associated with such projections.

As described in Section 5.1, above, the alternative to the deterministic approach to dose modeling is the probabilistic approach in which the overall uncertainty in the assessment is evaluated to arrive at a better estimate of the correspondence between residual radioactive concentration and the extent of incremental dose to an exposed receptor. Uncertainty analysis imparts more information to the decision maker than deterministic analysis. It characterizes a range of potential doses and the likelihood that a particular dose would be exceeded. However, regardless of the method, uncertainty is inherent in all dose and risk assessment calculations and should be considered in determining whether a selected release criteria will satisfy the regulatory decision-making criteria.

In general, there are three primary sources of uncertainty in a dose/risk assessment: Uncertainty in the models, uncertainty in the scenarios and uncertainty in the input parameters.[171] Models are simplifications of reality and, in general, several alternative models may be consistent with available data. Computer modeling codes have permitted the analyst to increasingly refine the models they use because the computer is handling the complex calculations that result.

The RESRAD code used in this evaluation has been developed and maintained using a stringent version control process. Its models (or components of them) are tested for mathematical correctness, verified, and benchmarked against comparable models, when available. However, modeling in and of itself implies a degree of uncertainty in that direct measurements or standards are typically not available to compare to modeled results.

Parameter uncertainty results from incomplete knowledge of the coefficients that describe the model. However, with the selection of a suitable model for the site conditions and scenarios to be considered, and configuring the model with realistic and most probable input parameters, one may be reasonably confident in the model's predictions.

The current regulatory philosophy is to evaluate the uncertainty in an estimate along with the severity of consequence and probability of exceeding a deterministic regulatory limit. Such a decision method is termed "risk-informed decision making." The advent of powerful personal

[170] Over the following 1,000-year period, there is insufficient erosion to result in noncompliance with the applicable dose criteria for the industrial worker. In fact, the maximum dose potential occurs at year 1,000 when the engineered barrier is, presumably, at its thinnest.

[171] Bonano, E.J, Davis, P.A., *A Review of Uncertainties Relevant in Performance Assessment of High Level Radioactive Waste Repositories*, NUREG/CR-5211, September, 1988.

computers and increasingly capable software tools coupled with increased knowledge of key physical, behavioral, and metabolic parameters used to make dose/risk assessments, have brought probabilistic analysis to the state of the art. While not all regulating agencies currently expect that assessments will employ the probabilistic approach, with a quantitative assessment of the associated uncertainties, the USNRC has adopted a risk-informed approach to regulatory decision making, suggesting that an assessment of uncertainty be included in dose assessments.[172] The USNRC's Probabilistic Risk Assessment (PRA) Policy Statement states, in part,

> *The use of PRA technology should be increased in all regulatory matters to the extent supported by the state of the art in PRA methods and data, and in a manner that complements the USNRC's deterministic approach.*[173]

Even with the use of probabilistic analyses, it should be recognized that not all sources of uncertainty could be, or need to be, considered in a dose assessment. The primary emphasis in uncertainty analysis is to identify the important assumptions and parameter values that, when altered, could change the decision.

Sensitivity analysis performed in conjunction with the uncertainty analysis is used to identify parameters and assumptions that have the largest effect on the overall result and provides a tool for understanding and explaining the influence of these key assumptions and parameter values on the variability of the estimated dose.

5.4.2 How Sources of Uncertainty are Addressed

An important issue in uncertainty and sensitivity analysis is that not all sources of uncertainty can be easily quantified. Of the three primary sources of uncertainty in dose assessment analyses, parameter uncertainty analysis is most mature and will be dealt with quantitatively in this section. Mathematical approaches for quantifying the uncertainty in the site conceptual models and future use scenarios are not well developed. For example, it is difficult to predict with absolute certainty the characteristics of a future society. For these reasons, no attempt to formally quantify model or scenario uncertainty is made.

To confront these uncertainties a suite of scenarios capturing the plausible range of future uses for this site, given the nature and site-specific impediments to future land development, has been developed and is considered in the assessment. In addition, conceptual site models have been designed and selected to represent the existing features at the site and to conservatively represent the conditions that might be encountered in each scenario. By carefully selecting input parameters as SMC has attempted to do for Chapter 5, the estimates of dose potential using the RESRAD computer code overestimates the dose rather than underestimate the potential dose. In reality, the uncertainties in the conceptual site model and the scenario selections are captured, to a certain extent, in the parameter uncertainty analysis.

[172] NUREG-1757, September, 2003.

[173] U.S. Nuclear Regulatory Commission, *Probabilistic Risk Assessment Policy Statement*, Commission Policy Statement, August, 1995.

5.4.3 Uncertainty Evaluation

SMC has selected the most current version of the RESRAD dose modeling code (version 6.22, February, 2004) to evaluate uncertainty in accordance with USNRC guidance.[174] It contains a probabilistic module that is used to assess the uncertainty in the relationship between a concentration of radioactivity in soil and the dose it might produce. It uses an enhanced random sampling algorithm called Latin Hypercube sampling in which input parameter values are selected randomly from probability distribution functions (PDF).

The uncertainty module in the code permits the analyst to define the PDF for each variable of interest by selecting the distribution and its parameters, and to identify the parameter as either independent or correlated to other input variables. The following describes the process used to evaluate uncertainty:

- Each scenario was evaluated using the deterministic module to identify a concentration in soil corresponding to the deterministic regulatory limits. Additionally, coarse scale sensitivity analysis was performed to zero in on the parameters that had the greatest potential to impact the dose.

- Pathways of interest were identified through preliminary runs of the deterministic module in the code for all the scenarios. These identified the scenario specific pathways that most significantly contributed to dose. The direct exposure pathway, or "ground" pathway was consistently the dominant pathway for exposure to the source term, and by a significant margin.

- Where site-specific knowledge was lacking, where the dose response was not sensitive to variability in a given parameter, or where the default parameter distributions were reasonably representative of site conditions or conditions being portrayed in the exposure scenario, the default was used. Where no default distribution is recommended or where discrete knowledge of site-specific conditions exists, an appropriate distribution considering the degree of knowledge of site-specific conditions was selected.

- The Latin-Hypercube sampling algorithm (a variant of the Monte Carlo sampling technique which has an advantage in that it forces the sampling to occur over the entire range of possible values in the PDF rather than rely on pure random sampling) was set to obtain 1,500 samples (300 samples, repeated five times).

Parameters to which probability density functions were assigned in order to evaluate their impact on uncertainty are listed in the following subsections. They are organized such that the receptor exposure parameters are presented first, followed by the geotechnical parameters describing the various soil layers starting with the cover and concluding with the contaminated zone.

[174] NUREG-1757, September, 2003.

5.4.3.1 Exposure Factors

Outdoor Time Fraction

RESRAD uses fractions of a whole year spent on site to calculate annual dose to a receptor. The total fraction of a year spent on site is divided between two parameters: indoor time fraction (FIND) and outdoor time fraction (FOTD). Fractions of time spent on site are wholly dependent upon the scenario under consideration. The value used to describe the on site, outdoor time fraction for each of the use scenarios is derived from conservative assumptions attributed to members of the critical exposure group and designed to be conservative for the general population of potentially exposed individuals. SMC selected guidance from the USNRC to establish the fraction for both indoor and outdoor durations.[175]

Sensitivity analysis indicates that total annual dose is sensitive to variability in the FOTD parameter as the penetrating gamma (ground) exposure pathway dominates and is strongly dependent on exposure duration. In setting up the uncertainty analysis, the FOTD parameter is represented with a triangular distribution.

Inhalation Rate

Inhalation rate (INHALR) is the air volume inhaled over time and is used to calculate the radiation dose from the inhalation pathway.[176] The parameter represents the annual average breathing rate for a receptor from the critical exposure group subpopulation performing tasks under evaluation in a given scenario.

Population normalized inhalation rates vary depending upon the tasks that are being performed. For the land user, the inhalation rate used is the RESRAD default, which is derived from ICRP and EPA recommendations for adults engaged in short-term (episodic) exposure scenarios.[177,178,179] Sensitivity analysis shows that the total annual dose is not sensitive to this parameter, because the inhalation pathway is not a significant contributor to total annual dose. Inhalation rate is represented with a triangular distribution, using the default provided by RESRAD.

Contaminated Fraction of Meat Diet

The meat ingestion pathway is unique to the recreational hunter scenario. Evaluation of the potential dose from this pathway considers both the annual consumption of meat and poultry, DIET(4) (using the RESRAD default value of 63 kilograms per year), and the fraction of that annual meat diet that is potentially impacted with residual radioactivity from the site (FMEAT). A triangular distribution was selected to represent the range and variability in the fraction of the receptor's meat diet that might have been culled from among game animals that grazed on the site. The mode of the

[175] USNRC, NUREG/CR-6697, Appendix C.
[176] The air volume is measured in cubic meters of air per year.
[177] ICRP Report 23, 1981.
[178] U.S. Environmental Protection Agency, *Development of Statistical Distributions or Ranges of Standard Factors used in Exposure Assessments*, EPA 600/8-85-010, 1985.
[179] U.S. Environmental Protection Agency, *Exposure Factors Handbook, Volume I, General Factors*, EPA 600/P-95-002Fa, August, 1997.

distribution (the most likely value) was selected based upon the typical dressed weight of a white-tail deer (40 pounds or 19 kilograms), the most abundant game species in the area.[180] The contaminated fraction is estimated to be 0.3; the fraction ranges between 0 and 0.5.[181] The fraction modeled is conservative in that the size of the site is small relative to the grazing land required to support game habitat. Sensitivity analysis shows that the total annual dose is not sensitive to this parameter, because the meat ingestion pathway is not a significant contributor to total annual dose for the undisturbed surface soil source terms.

Mass Loading for Inhalation

Mass loading for inhalation (MLINH) is the soil/air concentration ratio. It is used to calculate the dose from the particle inhalation pathway. The parameter represents the dust (mass) loading on site conservatively assuming that all airborne dust is generated on site and is radioactive. Other parameters, derived by the RESRAD code and based upon the site-specific parameters input, are used to modify this assumption, as appropriate. Mass loading does vary from season to season and depends upon the activities that are being performed at the Site. The RESRAD default continuous liner distribution and fit with a central tendency value of 0.00003 g/m^3 (30 micrograms/m^3) and ranging up to 100 micrograms/m^3 are used for each of the scenarios evaluated. The use of the RESRAD default is conservative as PM10 monitoring in Camden, New Jersey indicates annual average dust loading to be approximately 27 micrograms/m^3. In addition, site-specific air modeling as described in the Environmental Report (see Appendix 19.9), gives values of 11 micrograms per cubic meter or less during implementation of the LTC alternative. Sensitivity analysis shows that the inhalation pathway and total annual dose are insensitive to this parameter when the radioactivity is effectively isolated from the receptor by the in-place cover material. However, under the cover excavation scenario, such isolation will not exist.

Soil Ingestion Rate

RESRAD uses the annual average soil ingestion rate (SOIL) to calculate the dose from the direct soil ingestion pathway. The soil ingestion rate used in deriving the soil release criteria for the site is represented by a triangular distribution centered at 18.3 g/yr (50 mg/d) and ranging from 0 to 36.5 g/yr (0 to 100 mg/d), the RESRAD default. Sensitivity analysis for the restricted area shows that neither the soil ingestion pathway nor the annual effective dose equivalent is sensitive to this parameter because the radioactivity is effectively isolated from the receptor by the in place cover material. However, under the unrestricted area and the cover excavation scenario, such isolation will not exist.

5.4.3.2 Geophysical Parameters for the Engineered Barrier

Evapotranspiration Coefficient

The evapotranspiration coefficient (EVAPTR) is the fraction of total precipitation that is released back to the atmosphere via plant "respiration." Evapotranspiration varies with geographic region and to some extent with soil type. Evapotranspiration rates in the Newfield region are estimated to be

[180] RESRAD, ANL/EAD-4, July, 2001.

[181] A contaminated fraction of 0 is defined as no game meat harvested while a contaminated fraction of 0.5 means that 50% of the entire annual meat diet consumed is derived from game grazing on the SMC site,

approximately 24 inches per year, corresponding to a most likely evapotranspiration coefficient of approximately 0.625 (average annual precipitation in the region is 42.05 inches).[182,183]

The evapotranspiration coefficient is conservatively represented with a uniform distribution ranging between 0.3 and 0.9 which is a greater range than recommended by RESRAD. SMC determined that the national average of 0.5 is appropriate for the Newfield site.

Wind Speed

Average annual wind speed is used to calculate the dose from the inhalation pathway. The wind speed is used to transport airborne dust generated on site in a standard air dispersion model. Through the transport calculations, the radioactive fraction of the total dust loading in air is derived. The fraction is then used to calculate particle inhalation intake.

While wind speeds do vary from day-to-day and season-to-season, the annual average wind speed is reasonably steadfast. Data from the National Climate Data Center from Philadelphia, Pennsylvania were reviewed from 1971 through 2000. The mean annual wind speed was reported to be 9.6 miles per hour (4.3 meters/sec). Sensitivity analysis shows that the inhalation pathway is insensitive to this parameter because, the residual radioactivity is effectively isolated by the covering layer such that radioactive particle suspension is minor. As a result, the inhalation pathway is not a significant contributor to total annual dose. Wind speed is represented with the RESRAD default (4.25 m/sec), bounded lognormal-N distribution.

Runoff Coefficient

The runoff coefficient is one of a number of parameters used to calculate the amount of water that is allowed to enter the contaminated zone and ultimately an estimate of the radionuclide leaching from the contaminated zone. It is the fraction of precipitation that does not penetrate the top soil layer; the lower the fraction, the more water is allowed to co-mingle with the contaminated zone. The runoff coefficient (RUNOFF) varies with topography, precipitation patterns in the region, and soil type. The runoff coefficient is 1 when a geomembrane is used.

Runoff coefficient is represented with the RESRAD default parameter distribution, a uniform distribution ranging between 0.1 and 0.8 (10% to 80% of precipitation runs off without penetrating the surface). Considering the mounded topography of the site and the presence of the engineered barrier over the consolidated radioactivity, the true range is likely to be much narrower and near the maximum value (80%) considered in the probability distribution.

Depth of Soil Mixing Layer

This parameter (DM) is used in calculating the depth factor for the dust inhalation and soil ingestion pathways and for foliar deposition for the ingestion pathways. The depth factor is the fraction of resuspendable soil particles at the ground surface that are contaminated, which is calculated by

[182] Yu, C, et al, *Data Collection Handbook to Support Modeling the Impacts of Radioactive Material in Soil*, ANL/EAIS-8, Argonne National Laboratory, Argonne, Illinois, April, 1993.

[183] National Climatological Data Center, 1940 through 2003 (Philadelphia).

assuming that mixing of the soil will occur within a layer of thickness, DM, at the surface. The RESRAD default distribution (triangular) and range (0 to 0.6 m) was used.

Cover Depth (Thickness)

When modeling the source term, the cover depth (thickness) is a key parameter in assessing the protectiveness of the chosen decommissioning alternative as it provides a barrier to potential physical contact with residual radioactivity in the slag materials located within the cell, and a substantial degree of gamma radiation attenuation for the penetrating gamma radiation exposure pathway, the dominant, or critical dose pathway. RESRAD does not suggest a default probability distribution for cover depth (COVERO) as it is dependant upon site-specific conditions and for the unrestricted area, does not exist at all. Thus, SMC has conservatively chosen to represent this parameter with a triangular distribution ranging between 0.5 and 1.2 meters thick and with a most likely value of 1 meters (3.3 ft.). This representation is conservative in that the thickness value used does not include the topsoil layer to support natural succession vegetation as an erosion control mechanism. Sensitivity analysis reveals that the "cover penetrating gamma radiation dose" pathway, and as a result the total annual effective dose equivalent, is sensitive to this parameter.

Cover Soil Density

The engineered cover is comprised of a combination of soil and the geomembrane. The soil density at the site was measured to arrive at a site-specific estimate of the soil density of both the cover material and the undisturbed surface layer. The measured soil density was found to be 1.9 g/cm^3. Sensitivity analysis showed that annual dose was insensitive to a wide range of soil densities. Since site-specific data was available for the materials at the site, these were used to describe the density of the cover soil layer. Cover soil density (DENSCV) was represented with a truncated normal distribution (the RESRAD default). The mean was set equal to the measured density of 1.9 g/cm^3 with a truncated normal distribution and a standard deviation of 0.23; the RESRAD program allows the density of the cover to range between approximately 1.46 to 2.33 g/cm^3.

Surface Soil Erosion Rate

When modeling the engineered barrier, the conceptual site model includes a relatively thick cover layer that is engineered to resist the forces of erosion. In this case, the surface soil layer is the engineered cover layer and the surface soil erosion rate is captured in two important parameters within the RESRAD model. The cover layer erosion rate (VCV) is important because as cover erosion occurs, the underlying contaminated zone is exposed, increasing the potential for human exposure to radiation.[184] Once the cover layer has been eroded, RESRAD further accounts for the effect of surface soil erosion through the contaminated zone erosion rate parameter (VCZ).

[184] It is important to note that once the cover soil is eroded, the underlying contaminated zone will not be immediately exposed because of the geomembrane. And if just a small area of geomembrane were to be exposed, it is unlikely that the protective nature of the geomembrane would be degraded or compromised or a very long time.. However, if a larger area of geomembrane was exposed, it is possible that an edge of the geomembrane could come loose thus exposing the underlying contaminated zone.

An evaluation of the cover erosion rate was completed to estimate the potential for erosion over the 1,000 years exposure period.[185] The Revised Universal Soil Loss Equation computer program, RUSLE2, was used (see Appendix 19.3).[186] The assumptions made include the following:

- Climate based on data for Gloucester County, New Jersey;
- A 3:1 slope with a side slope length of 90 feet;
- Cool grass season grass, applied by hydroseeding, with no harvesting; and
- Sandy loam, providing a moderately low runoff.

Based on the assumptions provided, the RUSLE2 model estimated that the loss of soil from the engineered barrier was 1.2 tons of soil per acre per year. Assuming an average soil density of 120 pounds per cubic foot (1.9 g/cm^3), the average annual erosion rate was estimated to be 4.6×10^{-4} feet per year; the erosion over the 1,000 year period was estimated to be 0.46 feet (0.14 meters). Based on this analysis, the one-meter-thick engineered barrier will not permit any of the slag confined below it to be exposed over the 1,000-year dose assessment period. If a small area of the engineered barrier (i.e., gully) erodes at a rate of six inches in 1,000 years, the dose potential to any recipient will be lower than if the engineered barrier in its entirety erodes at that rate, and the latter is the assumption associated with the RESRAD analysis. (Appendix 19.3 contains a more detailed description of the analysis.)

The cover erosion rate (VCV) has been conservatively estimated with a range of possible values to represent the likely and extreme erosion rates typical for conditions and activities expected at the site. Surface soil erosion is represented with a continuous logarithmic distribution (the RESRAD default) and ranging over approximately four decades from 8×10^{-7} to 0.003 m/yr. The most probable range for a site in a humid climate, with a slope of approximately 30 percent, and natural succession vegetation extends from 1.5×10^{-4} to 4.6×10^{-4} m/yr. Extreme surface soil erosion potential has been accounted for by estimating that there is as much as a 50% probability that the soil erosion rate will exceed this range, with estimates ranging to 0.003 m/yr (the predicted maximum for sites used for permanent pasture).

Sensitivity analysis shows that all pathways are sensitive to this parameter when represented with chronic and extreme erosion values such as those that might be observed in arid climates or where continual loosening of the surface soils occurs, such as might be expected for land used for agricultural purposes. In every scenario, the greatest annual dose occurs in the out years (year 1,000) when the cumulative effect of long-term soil erosion impacts the thickness of the cover layer and thus reducing its shielding affect for direct radiation exposure.

[185] TRC Environmental Corporation, *Estimated Soil Loss from Soil Cap*, Project Number 26770-0000, January, 2005.
[186] U.S. Department of Agriculture, *Revised Universal Soil Loss Equation*, Computer Program Version 2, 2005. Available for download ftp://fargo.nserl.purdue/pub/RUSLE2/RUSLE2_Program _File/..

Weathering Removal Constant

The weathering removal constant is used to account for the natural removal of soil and dust that have been deposited on consumable plants. It is relevant only for the recreational hunter scenarios (scenarios in which the consumption of plants by game animals is considered). Sensitivity analysis showed that annual dose was insensitive to the weathering removal constant (WLAM), thus the RESRAD default distribution (triangular) and range were used when modeling the source term. The RESRAD deterministic default (20/yr) is used when modeling the surface soil source term.

5.4.3.3 Geophysical Parameters for Sub-Barrier Zones

Area of Contaminated Zone

The area of the contaminated zone (AREA) describes the areal size, in square meters, of the region in which elevated concentrations of residual radioactivity are located. As described in Section 5.2.2, the areas describing the source terms are related to one another but they are not necessarily equal to one another. In defining the probability density function for the AREA parameter when modeling the source term for the restricted area, it was conservatively assumed that the contaminated zone area is no smaller than the 18,228 m^2 estimate derived from characterization survey data, but might be as large as the entire area circumscribed by the slag pile 28,767 m^2. RESRAD does not offer a default distribution for this parameter. A loguniform distribution ranging from the most likely value, 18,228 m^2, to a maximum value of 28,767 m^2 was selected to represent the area of the contaminated zone within the probabilistic module of RESRAD. Sensitivity analysis showed that annual dose was insensitive to the area of the contaminated zone.

Contaminated Zone Thickness

Thickness of the contaminated zone (THICKO) describes the depth profile of the residual radioactivity. Vertically, the radiologically significant material associated with the source term is located just beneath the cover (approximately 5 feet below the ground surface) and lies in a lens that is nominally about 9 feet (2.8 meters) thick (see Figure 18.7). The amount of radioactive material deposited rapidly depletes as the depth increases and terminates at a maximum thickness of approximately 30 feet. RESRAD does not offer a recommended (or default) distribution for the thickness of contaminated zone parameter (THICKO).

A triangular distribution best describes the observed variability in the depth profile for the source term and thus the thickness of the contaminated zone. In describing the source term for input to RESRAD, the thickness parameter is represented by a central tendency (CT) value conservatively set to a thickness of 2.8 meters. This thickness is conservative in that the mean source thickness over the entire footprint of the cell, the impacted area, is considerably less than 9 feet. The distribution is bounded at a minimum value of 0.5 feet (0.15 meters), and a maximum value of 10 meters. Sensitivity analysis shows the annual dose is insensitive to the thickness of the contaminated zone because of the self-attenuating effect of source thicknesses greater than approximately 12 inches (0.3 meters) and the attenuating capacity of the engineered cover.

Contaminated Zone Density

The density of the slag has been measured at 2.8 g/cm^3. Sensitivity analysis showed that radiation dose was insensitive to a wide range of soil densities, as low as 1.6 g/cm^3, equivalent to the native soil. Because of the increased volumetric attenuation of emitted radiations with increasing density, a higher dose would result if a lower density was assumed. The contaminated zone density (DENSCZ) was represented with a truncated normal distribution (the RESRAD default). The mean was set equal to the measured density of the slag at the site (2.8 g/cm^3) and allowed to range between approximately 1.6 and 3.0 g/cm^3.

Contaminated Zone Hydraulic Conductivity

RESRAD uses vertical hydraulic conductivity to model the potential vertical movement of water through the contaminated layer and any underlying strata. Hydraulic conductivity is a key parameter used to assess the downward vertical migration potential of radioactivity released from the contaminated zone layer. This allows RESRAD to calculate the potential concentration of residual radioactivity in a useable subsurface saturated zone. Sensitivity analysis showed that annual dose is insensitive to a wide range of hydraulic conductivities in the contaminated zone, largely because the thorium and other radionuclides in the contaminated zone are physically and chemically bound up in the slag and because the slag is very insoluble.

Hydraulic conductivity in the residual radioactivity layer is described with a probabilistic distribution. Hydraulic conductivity was specifically measured for the native sand materials found at the site and was determined to be 6.4 x 10^{-3} cm/s (2,000 m/yr). Hydraulic conductivity in the contaminated zone (HCCZ) and the underlying unsaturated zone 1 (HCUZ(1)) is represented with bounded lognormal-N distributions (the RESRAD default) having central tendency values at 2,000 meters per year and with values conservatively ranging over two decades between 200 and 20,000 meters per year.

Soil Specific b-Parameter

The soil-specific exponential b-parameter is one of several hydrogeologic parameters used to calculate radionuclide transport from the contaminated zone. Sensitivity analysis showed that annual dose was insensitive to both the contaminated zone and saturated zone b-parameters (BCZ and BSZ, respectively), thus, the RESRAD default distribution (bounded lognormal-N) and parameters were used when modeling the source term.

Distribution Coefficient, Contaminated Zone

Distribution coefficients (K_d) describe the partitioning between solid (soil) and liquid phases of soluble concentrations of radionuclides introduced to a soil column. It is a key parameter influencing the migration of radioactivity from contaminated zone soils to groundwater. In the general environment, distribution coefficients for a given chemical species (e.g., uranium) can vary over many orders of magnitude depending on the soil type, pH, redox potential, and presence of other ions. Observed K_d values for thorium are somewhat less subject to extreme variability.

The distribution coefficient, K_d, is the ratio of the mass of solute species adsorbed or precipitated on the solids per unit of dry mass of the soil to the solute concentration in liquids within the pore spaces in the soil. The key component of this definition as it relates to the site-specific conditions at the site and the RESRAD groundwater transport model is that it assumes that the radionuclide is introduced to the soil column as a solute. While this classical approach may be appropriate to describe the retardation of soluble contaminant migration in the soil column beneath the contaminated soil layer, it fails to address the situation encountered for the so-called "contaminated zone."

The site specific condition encountered at the SMC site is that the physical composition of the contaminant is a vitreous slag that is essentially insoluble even under the most extreme in-situ conditions that might reasonably be encountered (see Appendix 19.4). Analysis of the distribution coefficient of the slag, where the greatest radionuclide concentration will reside within the capped pile, results in the values shown in Table 17.5. These are the parameters used as input to the RESRAD code.

Bounds have been established on the range of values sampled during probabilistic analysis (a triangular distribution). The central tendency value for the distribution has been set to match the arithmetic average of the slag samples that were analyzed; the single-point estimate used in the RESRAD deterministic module for thorium was 52,010 cm^3/g.[187] Probabilistic sampling is bounded between 2,900 and 129,000 cm^3/g.

Thickness of the Undisturbed Surface Layer

The thickness of the undisturbed surface layer (unsaturated layer #1 H(1)) varies from eight (8) to 10 feet in the Storage Yard. Sensitivity analysis showed that annual dose equivalent was insensitive to variability in the thickness of the undisturbed surface layer. The thickness is represented with a triangular distribution, with a most likely value (2.5 meters) near the lower end of the range that extends from 2.5 to 4.6 meters.

Density, Undisturbed Surface Layer

As described earlier, the unsaturated zone is comprised of the undisturbed layer underlying the entire area. The measured soil density was found to be 1.65 g/cm^3, a number that is typical of soils. Sensitivity analysis showed that annual dose was insensitive to a wide range of soil densities. Since site-specific data was available for the density of the materials at the site, it was used to describe the density of the undisturbed layer. Unsaturated layer soil density (DENSUZ(1)) was represented with a truncated normal distribution (the RESRAD default). The Mean was set equal to the measured density of 1.97 g/cm^3 and allowed to range between approximately1.6 and 2.4 g/cm^3.

[187] Yu,C., et al, ANL/EAIS-8, April, 1993.

Hydraulic Conductivity, Undisturbed Surface Layer

Hydraulic conductivity was specifically measured for the native materials found at the site and was determined to be 5.4×10^{-8} cm/s (0.017 m/yr).[188] Hydraulic conductivity in undisturbed layer [HCUZ(1)] is represented with a triangular distribution having a central tendency value at 0.017 meters per year and with values conservatively ranging over three decades between 0.001 and 1.7 meters per year. Sensitivity analysis showed that annual dose was insensitive to a wide range of hydraulic conductivities, largely because the radionuclides in the contaminated zone are physically and chemically bound up in the slag and because the slag itself is not readily soluble.

Density, Saturated Zone

The RESRAD default distribution and fit for the saturated zone density is used in the uncertainty analysis because no site-specific data was collected explicitly for this parameter. The truncated normal distribution is centered at the most likely value of 1.52 g/cm^3 and ranges between values of less than 1 and 2.2 g/cm^3. Variability in the saturated zone soil density was shown to have no affect on the projected annual dose in the uncertainty analysis.

Hydraulic Conductivity, Saturated Zone

The saturated zone hydraulic conductivity (HCSZ) for the site is 16,000 m/yr.[189] The bounded lognormal- N distribution is centered at the most likely value of 16,000 m/yr (for the Cohansey Sand) and ranges over more than five decades of possible values between approximately 10 cm/yr and more than 20,000 m/yr.[190] Variability in the saturated zone hydraulic conductivity was shown to have no measurable impact on the projected annual dose in the uncertainty analysis.

Saturated Zone Hydraulic Gradient

The hydraulic gradient is one of several hydrogeologic parameters used to calculate radionuclide transport from the contaminated zone. Sensitivity analysis, again, showed that annual dose was insensitive to the hydraulic gradient parameter (HGWT). A site-specific value of 0.004 is used when modeling the source term. The central tendency value is estimated to be 0.004 (for the Cohansey Sand) and the distribution is allowed to range over approximately 4 decades from 7×10^{-5} to 0.5.[191]

Saturated Zone Thickness

When modeling the surface soil source term, the RESRAD default deterministic value was used. The depth to the Kirkwood Formation clays in the Storage Yard area varies from approximately 121 to 144 feet below the ground surface. Subtracting the depth of the unsaturated zone (about eight to 10 feet), the average thickness of the saturated zone in the Storage Yard area would range from

[188] TRC Environmental Consultants, Inc., *Remedial Investigation Technical Report*, Project Number 7650-N51, Windsor, Connecticut, April, 1992.

[189] TRC Environmental Consultants, Inc., *Remedial Investigation Technical Report*, Project Number 7650-N51, Windsor, Connecticut, April, 1992.

[190] TRC Environmental Consultants, Inc., *Remedial Investigation Technical Report*, Project Number 7650-N51, Windsor, Connecticut, April, 1992.

[191] TRC Environmental Consultants, Inc., *Remedial Investigation Technical Report*, Project Number 7650-N51, Windsor, Connecticut, April, 1992.

about 110 to 135 feet, with 130 to 135 feet being a more typical range for boring locations closest to the storage yard.

5.4.4 Interpreting Uncertainty Analysis Results

Since the results of the uncertainty analyses provide a distribution of annual doses, it must be recognized that some percentage of the calculated doses may exceed the regulatory limit. At the same time, because not all parameter distributions are symmetrical and because some parameters are correlated, the mean dose calculated in the uncertainty analysis is not necessarily equal to a deterministic dose calculated using single point estimates of the various parameters. A further phenomenon observed in the probabilistic modeling is that the mean dose for a particular series of repetitions is frequently higher than the 90th or even the 95th percentile estimates of probable dose. This results when all but the rarest combinations of very conservative estimates of the individual parameters result in little or no dose. In the very few cases in which the Monte Carlo sampling technique selects combinations of values from the outermost extremes of the proposed parameter distributions, projected annual dose is large compared to the majority of cases sampled.

A key issue that must be addressed in the treatment of uncertainty is specifying how to interpret the results from an uncertainty analysis in the context of the deterministic regulatory limit. There is no such thing as absolute assurance that the regulatory limit will be met, so regulatory compliance must be stated in terms of a metric of the distribution. Even for a deterministic analysis, it should be recognized that the reported dose is simply one of a range of possible doses that could be calculated for the site and scenario.

In this analysis, the peak of the mean dose for the critical exposure group (the most exposed subpopulation) is presented for comparison with the deterministic regulatory limit as required by regulation. Since the severely skewed cumulative distribution phenomenon occurs repeatedly in the radiation dose modeled for the Newfield site using the probabilistic approach, a suite of projected annual doses corresponding to the 50th, 90th, 95th, and maximum is reported along with the traditional compliance measure, peak mean annual dose. In addition, the deterministic estimate of projected annual dose is provided for comparison.

The parameters used to perform the assessment were selected to represent the critical exposure group (analogous to the Reasonable Maximum Exposure concept), and as such already overstate the expected dose to the average receptor at the Site. Results of both the deterministic and probabilistic dose modeling including an evaluation of the uncertainty analyses are presented in the sections that follow.

5.5 Results

The RESRAD code was iteratively run for each of the selected scenarios to arrive at the highest uniform concentration of residual radioactivity in soil that results in a peak mean annual dose estimate to a single receptor in the critical exposure group that is equal to the regulatory limit of 25 millirem per year for scenarios where the controls are in intact and less than 100 millirem per year if the controls should fail.[192]

The computer code was set up to model each scenario with the input parameters identified and explained previously in this Chapter. A separate set of soil release criteria are presented for each scenario and for each source term. The following subsections present the results of the dose modeling, relating residual radionuclide concentration to potential future doses in each of the scenarios evaluated.

5.5.1 DCGL for Unrestricted Areas

The DCGLs provided in Table 17.6 reflect the concentration of radionuclides in soil that may be present outside of the restricted area to ensure a maximum exposure of less than 25 millirem per year over background. The presence of these isotopes will be verified after the remediation is completed and the final status survey is implemented. As described in Section 5.3.1, an industrial worker scenario was used to develop the DCGLs. The RESRAD summary report is provided in Appendix 19.5 (NewField 3005006.rad).[193]

The primary isotopes of concern at the SMC site are Thorium-232 in equilibrium with its decay progeny(^{232}Th+D) and Uranium-238 in equilibrium with its decay progeny (^{238}U+D). Thorium-232 reaches secular equilibrium with its decay progeny in approximately ten (10) half lives of the longest lived progeny, ^{228}Th; secular equilibrium is reached in approximately 20 years.[194] The slag is at least 20 years old and assumed to be in secular equilibrium; this assumption is confirmed by analytical data provided in Chapter 4 of this Plan (see Table 17.7). As a result, a DCGL is established for ^{232}Th and the progeny. The concentration of each isotope in the decay chain is assumed to be equal to the greatest concentration reported for any isotope in the decay chain.

Uranium 238 is present in equilibrium with its decay progeny. The DCGL established for ^{238}U applies to any isotope in the decay chain. If analytical data indicates that ^{238}U is not in equilibrium with its decay progeny, a limit of 21 pCi/gram limit applies to ^{238}U and the DCGL for the detected progeny is limited to 9.8 pCi/gram, the limit for ^{238}U+D.

The RESRAD code was used to generate DCGLs in the soil by inputting unit activity concentrations and running the code to determine the resultant dose rate. This dose factor in millirem/year per pCi/g is divided into the release criteria to yield the DCGL. For ^{232}Th+D, the concentration of 1 pCi/g was used for the key isotopes, ^{232}Th, ^{228}Th and ^{228}Ra. For ^{238}U+D, the ratios of the uranium isotopes, ^{238}U, ^{235}U and ^{234}U, were used for the unit activity concentrations. For ^{238}U, the fraction of 0.0.471 was used, 0.044 for ^{235}U and 0.485 for ^{234}U. The slag exhibits concentrations of ^{226}Ra, and ^{210}Pb; the fraction 0.471 was used for each of these isotopes. This fractional source term was

[192] The USNRC separates institutional controls from engineered controls. Therefore, institutional controls are assumed to fail instantly, along with any maintenance, but engineered controls would degrade over time without monitoring and maintenance.
[193] The DCGLs for surfaces are shown in Table 17.11.
[194] The halflife of ^{228}Th is 1.9 years.

entered directly into the RESRAD code; the short-lived progeny were calculated by RESRAD according to their respective parents.

The input parameters for the physical and chemical characteristics, as described in Section 5.3.1 of this Chapter, were used in the RESRAD code and outlined in Tables 17.3.1, 17.3.2 and 17.4.10, including the unit activity concentrations. The unit activity and input parameters associated with the likely exposure scenario resulted in a dose factor for thorium plus progeny of 1.745 pCi/gram and for uranium plus progeny of 0.597 pCi/gram. The $DCGL_W$ for U+D and Th+D was calculated for a dose criterion of 25 millirem per year or as 12.5 millirem per year for each element (above background), as follows:

$$DCGL_{uranium} = \frac{12.5\ mrem/year}{\frac{0.597\ mrem/year}{1\ pCi/g}} = 20.9\ pCi/g$$

$$DCGL_{thorium} = \frac{12.5\ mrem/year}{\frac{1.745\ mrem/year}{1\ pCi/g}} = 7.2\ pCi/g$$

For each uranium isotope, the DCGL was calculated according to the ratio described above. Consequently, the DCGL for ^{238}U is 9.8 and the DCGL for ^{226}Ra and ^{210}Pb is 9.8 pCi/gram.

Background was established during prior site surveys, and summarized in Table 17.2. The DCGLs are based on a maximum dose of 25 millirem per year, the radiation dose is additive and cannot exceed the 25 millirem per year release criteria when combined. Therefore, the unity rule applies and the sum of the ratios of the measured ^{232}Th plus progeny, and ^{238}U plus progeny concentrations in a survey unit to their respective DCGL does not exceed one (1).

5.5.2 Occasional Trespasser Scenario (Unrestricted Area, Controls in Place)

The potential radiation dose was calculated for an occasional trespasser who may enter the unrestricted area. The results of the RESRAD computer code are provided in Table 17.8.1. The peak of the mean annual radiation dose was calculated to be 0.5 millirem per year and the maximum annual dose was calculated to be 3.3 millirem per year. The 50th percentile of the probabilistic radiation exposure was 0.002 millirem per year, the 90th percentile was 1.9 millirem per year and the 95th was 2.2 millirem per year. The principal exposure was external radiation contributing 98% of the dose in Year 0 of the analysis. Two isotopes contributed to the direct exposure, ^{226}Ra and ^{228}Th, 48% and 31% respectively. Appendix 19.5 (Newfield 3005007.rad) provides the output of the RESRAD code.

5.5.3 Suburban Resident Scenario (Unrestricted Area, Controls Fail)

The critical exposure group for the suburban resident scenario is described by hypothetical suburban family occupying a house located in the unrestricted area, outside of the fence of the restricted area. The results of the Microshield computer code are provided in Table 17.8.2. The peak of the mean annual radiation dose was calculated to be less than one (1) millirem per year. The only source of exposure was determined to be the external radiation stemming from the Storage Yard. The exposure rate was calculated to be less than 1×10^{-5} millirem per hour or less than one (1) millirem per year. Appendix 19.5 contains the Microshield summary report.

5.5.4 Maintenance Worker Scenario (Restricted Area, Controls in Place)

A maintenance worker will periodically inspect and maintain the engineered barrier after the decommissioning effort is complete. The results of the RESRAD computer code are provided in Table 17.8.3 The peak of the mean annual radiation dose was calculated to be 0.0006 millirem per year and the maximum annual dose was calculated to be 0.02 millirem per year. The 50^{th} percentile of the probabilistic radiation exposure was 0.00005 millirem per year, the 90^{th} percentile was 0.001 millirem per year and the 95^{th} was 0.003 millirem per year. The principal exposure was external radiation contributing 98% of the dose in Year 0 of the analysis. Two isotopes contributed to the direct exposure, ^{226}Ra and ^{228}Th, 48% and 31% respectively. Appendix 19.5 (Newfield 3004001.rad) provides the output of the RESRAD code.

5.5.5 Industrial Worker Scenario (Impacted by Restricted Area, Controls in Place)

Although this is not a reasonably likely scenario, it is nonetheless assumed that industrial workers will visit the site to work each day; at no time will any workers enter the fenced area or walk on the engineered barrier. The results of the analysis are provided in Table 17.8.4. The peak of the mean annual radiation dose was calculated to be less than 20.8 millirem per year for exposure to the DCGLs in the unrestricted area and less than one (1) millirem for the potential exposure to direct radiation stemming from the covered Storage Yard, the restricted area.[195] The principal exposure was external radiation contributing 100% of the dose in Year 0 of the analysis. Two isotopes contributed to the direct exposure, ^{226}Ra and ^{228}Th, 48% and 31% respectively. Appendix 19.5 (Newfield 3004005.rad) provides the output of the RESRAD and Microshield code.

5.5.6 Trespasser Scenario (Restricted Area, Controls in Place)

The potential radiation dose was calculated for a person who trespasses in the restricted area and traverses the engineered barrier. The results of the RESRAD computer code are provided in Table 17.8.5. The peak of the mean annual radiation dose was calculated to be 0.0006 millirem per year and the maximum annual dose was calculated to be 0.02 millirem per year. The 50^{th} percentile of the probabilistic radiation exposure was 0.00004 millirem per year, the 90^{th} percentile was 0.001 millirem per year and the 95^{th} was 0.003 millirem per year. The radiation exposure was external radiation contributing 100% of the dose in Year 0 of the analysis. Two isotopes contributed to the direct exposure, ^{226}Ra and ^{228}Th, 19% and 77% respectively. Appendix 19.5 (Newfield 3004002.rad) provides the output of the RESRAD code.

[195] Microshield was used to calculate the potential direct radiation exposure at a distance of 100 feet from the fence surrounding the covered Storage Yard.

5.5.7 Recreational Hunter Scenario (Restricted Area, Controls Fail)

The recreational hunter scenario is considered, perhaps, to be the most reasonably foreseeable among the future use scenarios considered for this site. Table 17.8.6 summarizes the results of modeling the projected future exposure potential for the scenario involving exposure while engaged in recreational hunting at the Site.

A review of the RESRAD summary reports for the recreational hunter scenario reveals that exposure from external exposure from Thorium-232 and daughters (^{232}Th, ^{228}Th and ^{228}Ra) dominates the probabilistic estimate of radiation dose where the peak of the mean annual radiation dose was calculated to be 13.6 millirem per year and the maximum annual dose was calculated to be 78.6 millirem per year, which is estimated to occur after 1,000 years. The 50th percentile of the probabilistic radiation exposure was 0.4 millirem per year, the 90th percentile was 47 millirem per year and the 95th percentile was 54 millirem per year. The deterministic radiation exposure, dominated by the consumption of meat after the cover was allowed to erode, was calculated to be 0.3 millirem per year after 558 years. The peak of the mean radiation exposure for the consumption of meat was determined to be 0.2±0.007 millirem per year, with ^{231}Pa and ^{226}Ra isotopes are the most significant contributors to total effective annual dose for meat consumption. Appendix 19.5 (Newfield 3004008.rad) provides RESRAD summary report for this analysis.

5.5.8 Industrial Worker Scenario (Restricted Area, Controls Fail)

In the event that institutional controls fail, the industrial workers may gain access to the restricted area. The results of the RESRAD computer code are provided in Table 17.8.7. The peak of the mean annual radiation dose was calculated to be 0.03 millirem per year and the maximum annual dose was calculated to be 0.4 millirem per year. The 50th percentile of the probabilistic radiation exposure was 0.1 millirem per year, the 90th percentile was 0.2 millirem per year and the 95th percentile was 3.4 millirem per year. The radiation exposure was external radiation contributing 100% of the dose in Year 0 of the analysis. Two isotopes contributed to the direct exposure, ^{226}Ra and ^{228}Th, 19% and 77% respectively. Appendix 19.5 (Newfield 3004004.rad) provides the output of the RESRAD code.

5.5.9 Slag Excavation Scenario (Restricted Area, Controls Fail)

The computer code RESRAD was not adequate to evaluate the potential direct radiation exposure over the exposure period of 10 days or 80 hours. Microshield was used to model the exposed slag as an infinite slab, one (1) meter thick. Table 17.8.9 summarizes the potential exposures; an exposure rate of 0.13 mR per hour was calculated. The results of the Microshield code was compared to existing monitoring data surrounding the Storage Yard, which indicate an external exposure rate of 250 to 300 millirem in the three month period (0.01 mR per hour at approximately 20 feet from the edge of the Storage Yard).[196] The results of the Microshield code verified these results. Therefore, for the excavator, the potential radiation exposure was calculated to be 8.3 millirem for the 80 hour exposure period.

[196] Letter From Carol Berger to David Smith, *Quarter 4, 2004 Perimeter Monitoring Results*, January 3, 2005.

5.5.10 Suburban Resident Scenario (Restricted Area, Controls Fail, Excavation)

In the event that the excavator attempts to excavate the slag, it is assumed that the cover is not repaired and the excavation is abandoned as is. In an effort to provide a conservative estimate of radiation exposure, this scenario assumes that the suburban family lives 1,000 feet directly downrange of the open excavation. The exposures summarized in Table 17.8.2 are added to the calculated direct exposure estimate of 0.002 mR per hour or 17 millirem per year.

5.5.10 Recreational Hunter Scenario (Restricted Area, Controls Fail, Excavation)

In the event that the excavator attempts to excavate the slag, it is assumed that the cover is not repaired and the excavation is abandoned as is. In an effort to provide a conservative estimate of radiation exposure, this scenario assumes that the recreational hunter spends some of his/her time within the Storage Yard at a distance of three (3) feet from the excavation. The remainder of the time is associated with general Storage Yard exposure only. The exposures summarized in Table 17.8.6 are added to the calculated direct exposure estimate of 0.13 mR per hour or 13.7 millirem per year.

5.6 Summary of Dose Modeling and Comparison to Release Criteria

The estimates of peak mean dose to the critical exposure groups in each of the foregoing scenarios have been derived using industry standard modeling tools specifically designed to assess exposures to residual radioactivity. Conservatism has been built into the modeling by conscientiously selecting exposure factor values that err on the side of safety when confronted with uncertainty in the selection of input parameters. In order to provide the risk managers and decision makers with insight as to the degree of conservatism associated with the dose modeling, projected annual doses have been calculated with both deterministic and probabilistic techniques.

Based on the results presented above, the source term in each of the scenarios considered is projected to produce a peak mean annual dose that is well-below the dose limits for unrestricted and restricted release as specified in 10 CFR 20.1402 and 1403, respectively, as shown in the following summary:

Scenario	Area	Status of Controls	Peak of the Mean Dose Estimate (millirem)	Applicable Dose Limit (millirem)
Trespasser	Unrestricted	In Place	<1	25
Suburban Resident	Unrestricted	Fail	<1	25
Maintenance Worker	Restricted	In place	<1	25
Industrial Worker	Restricted	In place	<20.8	25
Trespasser	Restricted	In place	<1	25

Scenario	Area	Status of Controls	Peak of the Mean Dose Estimate (millirem)	Applicable Dose Limit (millirem)
Recreational Hunter	Restricted	Fail	13.6	100
Industrial Worker	Restricted	Fail	<1	100
Slag Excavator	Restricted	Fail	8.3	100
Suburban Resident	Restricted/Excavated	Fail	17	100
Recreational Hunter	Restricted/Excavated	Fail	13.7	100

Once decommissioning pursuant to this Plan is complete, the radiation doses incurred by any of the potentially affected population groups, if any, will be lower than the estimates derived herein. In any case, they will not be discernible from background radiation exposures incurred by these population groups by virtue of being alive.

Appendix B - Revised Chapter 17

[The following selected tables in Chapter 17 of the DP have been revised and have been captured in Rev. 1a of the DP.]

Table 17.3 - RESRAD Input Parameters

17.3.1 - Common Parameters (Unrestricted Area, Controls in Place)

Parameter			Central Tendency Value	Description of Parameter Distribution		Classification (D=RESRAD Default; S-Site-specific; O=Other)	Impact on Resulting Dose (I=Insignificant; S=Significant and requires justification or explanation)	Justification, Source or Other Information
Description	Code	Unit		Distribution	Range & Fit			
Site General and Weather Related Parameters								
Evapotranspiration Coefficient	EVAPTR	Unitless, 0 to 1	0.5	Uniform	Range: 0.3 to 0.9	D	I	No value recommended by USNRC in NUREG 5512. RESRAD Default used for this parameter. Typical values in humid climates east of the Mississippi River are approximately 0.7.[112]
Average Annual Wind Speed	WIND	m/sec	4.25	Bounded Lognormal-N	μNormal: 1.445 σNormal: 0.2419 Min: 1.4 Max: 13.0	D	I	RESRAD Default. The thirty year (1961-1990) site- specific annual average value (4.3 m/s) is nearly equal to the RESRAD default value.[113]
Precipitation Rate	PRECIP	m/year	1.05	Point Estimate		S	S	The annual average given for the Newfield area in the Environmental report is 41 inches per year.[114] Infiltration of water on the surface assumes that there is a potential for contaminated water to leave the Storage Yard.
Irrigation Rate	RI	m/year	0.2	Point Estimate		D	I	No site specific data available. The RESRAD default was determined to be representative to growing conditions sufficient to maintain a grass cover on the barrier.
Runoff Coefficient	RUNOFF	Unitless, 0 to 1	0.45	Uniform	Range: 0.1 to 0.8	S	S	The fraction of total annual precipitation that sheds off the surface and drains to the site watershed. Drainage was not assumed to percolate through the soil. Typical value is approximately 0.3 to 0.5, as shown in the Environmental Report for the SMC site (DP Section 5.4.3.2). The value for this parameter was calculated based on 18" annual average runoff. The contaminated zone and the engineered cover create a "hill". Therefore, runoff is increased by a factor of two.
Watershed Area for Nearby Stream or Pond	WAREA	m^2	273,000	Point Estimate		S	I	Assumed to be 67 acres and represents the low lying areas adjacent to the Storage Yard. The watershed area is used to calculate dilution factors for contaminant concentrations in surface water bodies in the vicinity of the site. The larger watershed area, the greater volume through which dilution is possible. While there is no pathway for humans to drink surface water, animals may use the pond for their water supply. The greater the dilution, the lower the radiation dose.
Depth of Soil Mixing Layer	DM	m	0.15	Triangular	Range: 0 to 0.6	D	I	Value based on conceptual site model for surface soil.[115]

[112] Argonne National Laboratory, *User's Manual for RESRAD Version 6*, July, 2001.
[113] National Climate Data Center, *Local Climatological Data, Annual Summary with Comparative Data for Philadelphia, Pennsylvania*, 2000.
[114] National Climate Data Center.
[115] U.S. Nuclear Regulatory Commission, *Residual Radioactive Contamination from Decommissioning: Parameter Analysis*, NUREG/CR-5512, Vol.3, October 1999.

Parameter			Central Tendency Value	Description of Parameter Distribution		Classification (D=RESRAD Default; S-Site-specific; O=Other)	Impact on Resulting Dose (I=Insignificant; S=Significant and requires justification or explanation)	Justification, Source or Other Information
Description	Code	Unit		Distribution	Range & Fit			
Calculation Times	T(n)	Yrs.	1 10 100 300 500 700 900 1000	NA		--	--	Evaluation at these time segments allows for consideration of the potential for conditions at the Site to evolve from the initial conditions specified (e.g., soil erosion impacts the cover thickness) and projects the changing Site conditions to the required 1000-year outlook.[116,117]
Geotechnical Parameters								
Cover Depth (thickness)	COVER0	m	0	Triangular	Range: 0 to 0.5	S	S	The DCGLs derived for the unrestricted area assume the residual activity is present in the top 6 inches (0.15 m), with no cover. In the restricted area, the thickness of the cover is as shown in the preliminary design.
Depth of Roots	DROOT	m	0.9	Lognormal-N	μNormal: -1.9 σNormal: 0.6	D,S	I	No restrictions are assumed for the unrestricted portion, thus the default values were deemed appropriate. In the restricted area, the degradation of the barrier is assumed to be 0 for the foreseeable future, as long as the cover is maintained. the thickness of the engineered barrier limits depth of root intrusion.
Geotechnical Parameters-Subsurface Soil Contaminated Zone								
Area of Contaminated Zone	AREA	m^2	244,000	Loguniform	Range: 244,000 m^2 to 295,000 m^2	S	S	The area of the unrestricted portion is represented by the area of the site *excluding* the Storage Yard. The area of the restricted portion is the area that comprises the Storage Yard.
Thickness of the contaminated zone	THICK0	m	0.15	Triangular	Min 0.1m Max 0.3 m	S	S	The residual activity of the unrestricted area is assumed to be present in the top 15 cm of soil, pursuant to USEPA guidance on the thickness of surface soil. The thickness of the radioactivity placed into the restricted portion of the site is the thickness of the slag after shaping and placement.
Contaminated Zone Density	DENSCZ	g/cm3	1.3	Triangular	Min 1.2 Max 1.6	S	S	The density of the soil in the unrestricted area is equivalent to the nominal density of soil (i.e., RESRAD default value).[118] The volume-weighted density of the slag and baghouse dust as measured via analytical testing was used for the restricted area.
Contaminated Zone Erosion Rate	VCZ	m/yr	0.001	Continuous Logarithmic	5E-8 0 7E-4 0.22 5E-3 0.95 2E-1 1.0	D (unrestricted area), S (restricted area)	I	For the restricted area, the erosion of the slag was assumed to be 10x less than that of the cover. The boulders located in the Storage Yard are not likely to erode over the 1,000 year period of time (DP Section 5.4.3.2). For the unrestricted area, the RESRAD default erosion of the surface soil is deemed conservative even in cases of significant farming and gardening activities.[119]

[116] U.S. Nuclear Regulatory Commission, *Radiological Criteria for License Termination*, Volume 62, Federal Register, page 39058, July 21, 1997.
[117] U.S. Nuclear Regulatory Commission, *NMSS Decommissioning Standard Review Plan*, NUREG-1727, September, 2000.
[118] TRC Environmental Consultants, Inc., *Remedial Investigation Technical Report*, Project Number 7650-N51, Windsor, Connecticut, April, 1992.
[119] Argonne National Laboratory, *Data Collection Handbook to Support Modeling the Impacts of Radioactive Material in Soil*, ANL/EAIS-8, 1993.

Parameter			Central Tendency Value	Description of Parameter Distribution		Classification (D=RESRAD Default; S-Site-specific; O=Other)	Impact on Resulting Dose (I=Insignificant; S=Significant and requires justification or explanation)	Justification, Source or Other Information
Description	Code	Unit		Distribution	Range & Fit			
Contaminated Zone Total Porosity	TPCZ	Unitless 0 to 1	0.4	Point Estimate		D	I	RESRAD default for silty clay soil was selected. The actual soil type at the site is sandy, with a recommended porosity is 0.34.
Contaminated Zone Field Capacity	FCCZ	Unitless, 0 to 1	0.2	Point Estimate		D	I	This value was calculated in accordance with RESRAD guidance using the total and effective porosity for the site.
Contaminated Zone Hydraulic Conductivity	HCCZ	m/yr	2,000	Bounded Lognormal-N	μNormal: 7.6 σNormal: 0.75 Min: 200 max: 20000	S	I	The central tendency value, 2,000 m/yr (6.4E-3 cm/sec), corresponds to the measured hydraulic conductivity in the sandy soils that are found at the site. This value is ranges over two orders of magnitude from 200 to 20,000 m/yr.[120]
Contaminated Zone ß-Parameter	BCZ	Unitless	2.88	Bounded Lognormal-N	μNormal: 1.06 σNormal 0.66 min: 0.5 Max: 30	D	I	The RESRAD default value for sandy soil was selected.
Kd (Thorium)	DCACT(n)	cm^3/g	52,010	Triangular	Min 2,900 Max 129,000	S	S	The slag was studied to define the site specific leaching properties for thorium, uranium and radium.[121]
Kd (Uranium)	DCACT(n)	cm^3/g	70,355	Triangular	Min 50,000 Max 293,000	S	S	
Kd (Radium)	DCACT(n)	cm^3/g	53	Triangular	Min 35 Max 77	S	S	
Kd (Lead)	DCACT (n)	cm^3/g	100	Point Estimate		D	S	RESRAD Default value was selected.
Geotechnical Parameters- Unsaturated Layer								
Thickness Unsaturated Layer	H1	m	2.5	Triangular	Min 2.5 Max 4.6	S	S	The subsurface geology was measured during the Remedial Investigation of the site.[122]
Density, Unsaturated Layer	DENSUZ	g/cm^3	1.65	Truncated Normal	μNormal: 1.65 σNormal: 0.23 Quantile, min: 0.05 Quantile, max: 0.95	D,S	S	Unsaturated Zone is the sand cover layer placed over the residual radioactivity. The density selected is typical of native sand (RESRAD default). The subsurface geology was measured during the Remedial Investigation of the site.
Total Porosity Unsaturated Layer	TPUZ	Unitless 0 to 1	0.4	Point Estimate		D	I	RESRAD value for silty clay soil selected.

[120] TRC Environmental Consultants, Inc., *Remedial Investigation Technical Report*, Project Number 7650-N51, Windsor, Connecticut, April, 1992.
[121] Berger, C. (IEM), written communication to D. R. Smith (SMC), *Radionuclide Leachability from Newfield Slag*, September 16, 2005.
[122] TRC Environmental Consultants, Inc., *Remedial Investigation Technical Report*, Project Number 7650-N51, Windsor, Connecticut, April, 1992.

Parameter			Central Tendency Value	Description of Parameter Distribution		Classification (D=RESRAD Default; S-Site-specific; O=Other)	Impact on Resulting Dose (I=Insignificant; S=Significant and requires justification or explanation)	Justification, Source or Other Information
Description	Code	Unit		Distribution	Range & Fit			
Effective Porosity of Unsaturated Layer	EPUZ	Unitless, 0 to 1	0.2	Point Estimate		D	I	RESRAD value for silty clay soil selected.
Field Capacity Unsaturated Layer	FCUZ	Unitless, 0 to 1	0.2	Point Estimate		–	I	This value was calculated in accordance with RESRAD guidance using the total and effective porosity for the site
Hydraulic Conductivity Unsaturated Layer	HCUZ	m/yr	0.017	Triangular	Min 0.001 Max 1.7	S	I	The central tendency value, 0.017 m/yr, corresponds to the measured hydraulic conductivity in the sandy soils present at the site. This value was found to range from 0.001 m/yr to 1.7 m/yr.[123]
Unsaturated Layer 1, B-Parameter	BUZ(1)	Unitless	5.3	Point Estimate		D	I	RESRAD value for silty loam soil was selected.
Kd (Thorium)	DCACTU(n)	cm^3/g	52,010	Triangular	Min 2,900 Max 129,000	S	S	Samples of the slag from the site were studied to determine site specific leaching properties.[124]
Kd (Uranium)	DCACTU(n)	cm^3/g	70,355	Triangular	Min 50,000 Max 293,000	S	S	
Kd (Radium)	DCACTU(n)	cm^3/g	53	Triangular	Min 35 Max 77	S	S	
Kd (Lead)	DCACTU(n)	cm^3/g	100	Point Estimate		S	S	RESRAD Default value selected
Geotechnical Parameters-Saturated Zone								
Density, Saturated Zone	DENSAQ	g/cm^3	1.52	Truncated Normal	μNormal: 1.52 σNormal: 0.23 Quantile, min: 0.001 Quantile, max: 0.999	S	I	The subsurface geology was assessed during the Remedial Investigation of the site.[125]
Total Porosity Saturated Zone	TPSZ	Unitless,0 to 1	0.4	Point Estimate		D	I	RESRAD value for silty clay soil was selected.
Effective Porosity, Saturated Zone	EPSZ	Unitless, 0 to 1	0.2	Point Estimate		D	I	RESRAD value for silty clay soil was selected.
Field Capacity, Saturated Zone	FCSZ	Unitless, 0 to 1	0.2	Point Estimate		D	I	RESRAD value for silty clay soil was selected.

[123] TRC Environmental Consultants, Inc., *Remedial Investigation Technical Report*, Project Number 7650-N51, Windsor, Connecticut, April, 1992.
[124] Berger, C. (IEM), written communication to D. R. Smith (SMC), *Radionuclide Leachability from Newfield Slag*, September 16, 2005.
[125] TRC Environmental Consultants, Inc., *Remedial Investigation Technical Report*, Project Number 7650-N51, Windsor, Connecticut, April, 1992.

Parameter			Central Tendency Value	Description of Parameter Distribution		Classification (D=RESRAD Default; S-Site-specific; O=Other)	Impact on Resulting Dose (I=Insignificant; S=Significant and requires justification or explanation)	Justification, Source or Other Information
Description	Code	Unit		Distribution	Range & Fit			
Hydraulic Conductivity, Saturated Zone	HCSZ	m/yr	16,000	Bounded Lognormal-N	μNormal: 2.3 σNormal: 2.11 min: 0.1 max: 20,000	S	I	The subsurface geology was assessed during the Remedial Investigation of the site.[126]
Hydraulic Gradient	HGWT	Unitless	0.004	Bounded Lognormal-N	μNormal: -5.11 σNormal: 1.77 min: 0 .00007 max: 0.5	S	I	The subsurface geology was assessed during the Remedial Investigation report for the site.[127]
Saturated Zone B-Parameter	BSZ	Unitless	2.88	Bounded Lognormal-N	μNormal: 1.06 σNormal: 0.66 Min: 0.5 Max: 30	D	I	RESRAD default value for silty clay soil was used.
Source Term Factors								
Dose Conversion Factors	DCFX(n)	millirem/pCi	All DCFs used are RESRAD defaults			S	S	RESRAD defaults from FGR#11 and FGR#12, derived using ICRP 30 dosimetry model.[128,129] Short-lived (<180 days) radioactive progeny isotopes are accounted for through the use of the "parent+D" DCFs.
Source Isotopes								
Actinium-227	S!(1)	pCi/g	0.044	Point Estimate		--	--	Unit activity used to derive DCGLs
Protactinium-231	S!(2)	pCi/g	0.044	Point Estimate		--	--	Unit activity used to derive DCGLs
Lead-210	S1(3)	pCi/g	0.471	Point Estimate		--	--	Unit activity used to derive DCGLs
Radium-226	S1(4)	pCi/g	0.471	Point Estimate		--	--	Unit activity used to derive DCGLs
Radium-228	S1(5)	pCi/g	1	Point Estimate		--	--	Unit activity used to derive DCGLs
Thorium-228	S1 (6)	pCi/g	1	Point Estimate		--	--	Unit activity used to derive DCGLs
Thorium-230	S1(7)	pCi/g	0.471	Point Estimate		--	--	Unit activity used to derive DCGLs
Thorium-232	S1(8)	pCi/g	1	Point Estimate		--	--	Unit activity used to derive DCGLs
Uranium-234	S1(9)	pCi/g	0.485	Point Estimate		--	--	Unit activity used to derive DCGLs
Uranium-235	S1(10)	pCi/g	0.044	Point Estimate		--	--	Unit activity used to derive DCGLs
Uranium-238	S1(11)	pCi/g	0.471	Point Estimate		--	--	Unit activity used to derive DCGLs

[126] TRC Environmental Consultants, Inc., *Remedial Investigation Technical Report*, Project Number 7650-N51, Windsor, Connecticut, April, 1992.
[127] TRC Environmental Consultants, Inc., *Remedial Investigation Technical Report*, Project Number 7650-N51, Windsor, Connecticut, April, 1992.
[128] U.S. Environmental Protection Agency, *Limiting Values of Radionuclide Intake and Air Concentrations and Dose Conversion Factors for Inhalation, Submersion, and Ingestion*, Federal Guidance Report Number 11, EPA 520/1-88-020, September, 1988.
[129] U.S. Environmental Protection Agency, *External Exposure to Radionuclides in Air, Water and Soil*, Federal Guidance Report Number 12, EPA 402 R-93-081, September, 1993.

17.3.2 - Industrial Workers (Unrestricted Area, Controls In Place, DCGL Basis)

Parameter			Central Tendency Value	Description of Parameter Distribution		Classification (D=RESRAD Default; S=Site-specific; O=Other)	Impact on Resulting Dose (I=Insignificant; S=Significant and requires justification or explanation)	Justification, Source or Other Information
Description	Code	Unit		Distribution	Range & Fit			
Receptor Exposure Factors								
Exposure Frequency (Total)	EF	Days per year	250	EF and ET are not input parameters used by RESRAD. They are presented here to disclose the calculation used to arrive at the parameters RESRAD uses to account for exposure frequency, FIND & FOTD		--	--	Assumes a standard 2,000-hour work year spent on the Newfield site.
Exposure Time	ET	hours per day	8			--	--	Assumes a standard eight-hour work day.
Indoor Time Fraction	FIND	Unitless, 0 to 1	0.15	Point estimate		O	S	The fraction of the total year (8,760hr) that is spent indoors on site, pursuant to NUREG-6697, is 69% of the total exposure duration.[130]
Outdoor Time Fraction	FOTD	Unitless, 0 to 1	0.07	Triangular	Range: 0 to 0.21	O	S	The fraction of a total year (8760hr) that is spent outdoors on Site. Equals 595 hrs outdoors on Site divided by 8760 hours. The probabilistic distribution ranges to twice the CT value (1,920 hrs per year spent on the site).
Inhalation Rate	INHALR	m^3/yr	8400	Triangular	Range: 4380 to 13100	D	I	Inhalation rate based on geometric mean rate for short term exposure to adult males, which is equivalent to that presented in ICRP 23.[131] This pathway has minimal associated dose because of the cover and dense slag, which does not become airborne (DP Section 5.3.2).
Mass Loading for Inhalation	MLINH	g/m^3	0.00003	Continuous Linear	0.000000 - 0.0000 0.000008 - 0.0151 0.000016 - 0.1365 0.000030 - 0.8119 0.000040 - 0.9495 0.000060 - 0.9937 0.000076 - 0.9983 0.000100 - 1.0000	D	I	Mass loading in air describes the airborne dust loading conditions on the site.[132]
Soil Ingestion Rate	SOIL	g/y	18.3	Triangular	Range: 0 to 36.5	D	I	The industrial worker may ingest soil as a result of incidental contact with the soil. RESRAD default for adults engaged in non-contact-intensive activities used.
Cover Depth (thickness)	COVER0	m	0	Point estimate		S	S	The DCGLs derived for the unrestricted area assume the residual activity is present in the top 6 inches (0.15 m), with no cover. In the restricted area, the thickness of the cover is as shown in the preliminary design.

130 U. S. Nuclear Regulatory Commission, Development of probabilistic RESRAD 6.0 and RESRAD-Build 3.0 computer codes, NUREG-6697. December 2000

131 U.S. Environmental Protection Agency, *Exposure Factors Handbook, Volume I, General Factors*, EPA 600/P-95-002Fa, August, 1997.

132 Argonne National Laboratory, *User's Manual for RESRAD Version 6*, July, 2001.

Parameter			Central Tendency Value	Description of Parameter Distribution		Classification (D=RESRAD Default; S-Site-specific; O=Other)	Impact on Resulting Dose (I=Insignificant; S=Significant and requires justification or explanation)	Justification, Source or Other Information
Description	Code	Unit		Distribution	Range & Fit			
Receptor Exposure Factors								
Area of Contaminated Zone	AREA	m^2	244,000	Loguniform	Range: 244,000 m^2 to 295,000 m^2	S	S	The area of the unrestricted portion is represented by the area of the plant *excluding* the Storage Yard. The area of the restricted portion is the area that comprises the existing Storage Yard.
Thickness of the contaminated zone	THICK0	m	0.15	Triangular	Min 0.1m Max 0.3 m	S	S	The residual activity of the unrestricted area is assumed to be present in the top 15 cm of soil, pursuant to USEPA guidance on the thickness of surface soil. The thickness of the radioactivity placed into the restricted portion of the site is the thickness of the slag after shaping and placement.

17.3.3 - Trespasser Scenario (Unrestricted Area, Controls In Place)

Parameter			Central Tendency Value	Description of Parameter Distribution		Classification (D=RESRAD Default; S-Site-specific; O=Other)	Impact on Resulting Dose (I=Insignificant; S=Significant and requires justification or explanation)	Justification, Source or Other Information
Description	Code	Unit		Distribution	Range & Fit			
Receptor Exposure Factors								
Exposure Frequency (Total)	EF	Days per year	2.5	EF and ET are not input parameters used by RESRAD. They are presented here to disclose the calculation used to arrive at the parameters RESRAD uses to account for exposure frequency, FIND & FOTD		--	--	Assumes number of days per year of time working specifically at the SMC site
Exposure Time	ET	hours per day	24			--	--	Conservatively assumes that each day is 24 hours long
Indoor Time Fraction	FIND	Unitless, 0 to 1	0	Point estimate		O	S	The fraction of a total year (8,760 hr) that is spent indoors on site. Assumes that all exposures occur outdoors. It is assumed that the trespasser will not occupy any of the buildings in the unrestricted area.
Outdoor Time Fraction	FOTD	Unitless, 0 to 1	0.007	Triangular	Range: 0 to 0.013	O	S	The fraction of a total year (8760hr) that is spent outdoors on Site is 288 hrs outdoors on Site divided by 8760 hours. The probabilistic distribution ranges to twice the CT value.
Inhalation Rate	INHALR	m³/yr	8400	Triangular	Range: 4380 to 13100	D	I	Inhalation rate based on geometric mean rate for short term exposure to adult males.[133]
Mass Loading for Inhalation	MLINH	g/m3	0.00003	Continuous Linear	0.000000 - 0.0000 0.000008 - 0.0151 0.000016 - 0.1365 0.000030 - 0.8119 0.000040 - 0.9495 0.000060 - 0.9937 0.000076 - 0.9983 0.000100 - 1.0000	D	I	Mass loading in air describes the airborne dust loading conditions on the site.[134]
Soil Ingestion Rate	SOIL	g/y	18.3	Triangular	Range: 0 to 36.5	D	I	The industrial worker may ingest soil as a result of incidental contact with the soil.
Cover Depth (thickness)	COVER0	m	0	Point estimate		S	S	The residual activity is present in the top 15 cm of the soil.
Area of Contaminated Zone	AREA	m²	244,000	Loguniform	Range: 244,000 m² to 295,000 m²	S	S	The area of the unrestricted area is represented by the area of the plant; the area of the Storage Yard is subtracted.
Thickness of the contaminated zone	THICK0	m	0.15	Triangular	Min 0.1m Max 0.3 m	S	S	The residual activity is present in the top 15 cm of the soil.

[133] U.S. Environmental Protection Agency, *Exposure Factors Handbook, Volume I, General Factors*, EPA 600/P-95-002Fa, August, 1997.

[134] Argonne National Laboratory, *User's Manual for RESRAD Version 6*, July, 2001.

17.3.4 - Industrial Worker Scenario (Unrestricted Area, Controls Fail)

Parameter			Central Tendency Value	Description of Parameter Distribution		Classification (D=RESRAD Default; S-Site-specific; O=Other)	Impact on Resulting Dose (I=Insignificant; S=Significant and requires justification or explanation)	Justification, Source or Other Information
Description	Code	Unit		Distribution	Range & Fit			
Receptor Exposure Factors								
Exposure Frequency (Total)	EF	Days per year	240	EF and ET are not input parameters used by RESRAD. They are presented here to disclose the calculation used to arrive at the parameters RESRAD uses to account for exposure frequency, FIND & FOTD		--	--	Assumes number of days per year of time working specifically at the SMC sit.[135]
Exposure Time	ET	hours per day	8			--	--	Conservatively assumes that each day eight (8) hours long.
Indoor Time Fraction	FIND	Unitless, 0 to 1	0.15	Point estimate		O	S	The fraction of a total year (8,760hr) that is spent indoors on site. Assumes that 69% of the exposure occur indoors.
Outdoor Time Fraction	FOTD	Unitless, 0 to 1	0.07	Triangular	Range: 0 to 0.14	O	S	The fraction of a total year (8760hr) that is spent outdoors on Site. Equals 620 hrs outdoors on Site divided by 8760 hours. The probabilistic distribution ranges to twice the CT value.
Inhalation Rate	INHALR	m³/yr	8,400	Triangular	Range: 4,380 to 13,100	D	I	Inhalation rate based on geometric mean rate for short term exposure to adult males.[136]
Mass Loading for Inhalation	MLINH	g/m³	0.00003	Continuous Linear	0.000000 - 0.0000 0.000008 - 0.0151 0.000016 - 0.1365 0.000030 - 0.8119 0.000040 - 0.9495 0.000060 - 0.9937 0.000076 - 0.9983 0.000100 - 1.0000	D	I	Mass loading in air describes the airborne dust loading conditions on the site.[137] Mass loading likely to be lower (i.e. 3x10⁻⁶) according to USNRC guidance.[138]
Soil Ingestion Rate	SOIL	g/y	18.3	Triangular	Range: 0 to 36.5	D	I	The industrial worker may ingest soil as a result of incidental contact with the soil. Uses RESRAD default (i.e. 76 mg/day) for adults engaged in non contact intensive activities.
Cover Depth (thickness)	COVER0	m	0	Point estimate		S	S	The residual activity is present in the top 15 cm of the soil and no cover.
Area of Contaminated Zone	AREA	m²	244,000	Loguniform	Range: 244,000 m² to 295,000 m²	S	S	The area of the unrestricted area is represented by the area of the plant; the area of the Storage Yard is subtracted.

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135 U.S. Nuclear Regulatory Commission, *Development of Probabilistic RESRAD 6.0 and RESRAD-Build 3.0 Computer Codes*, NUREG/CR-6697, November, 2000.

136 U.S. Environmental Protection Agency, *Exposure Factors Handbook, Volume I, General Factors*, EPA 600/P-95-002Fa, August, 1997.

137 Argonne National Laboratory, *User's Manual for RESRAD Version 6*, July, 2001.

138 U.S. Nuclear Regulatory Commission, *Residual Radioactive Contamination from Decommissioning: Parameter Analysis*, NUREG/CR-5512, Vol.3, October 1999.

Parameter			Central Tendency Value	Description of Parameter Distribution		Classification (D=RESRAD Default; S-Site-specific; O=Other)	Impact on Resulting Dose (I=Insignificant; S=Significant and requires justification or explanation)	Justification, Source or Other Information
Description	Code	Unit		Distribution	Range & Fit			
Receptor Exposure Factors								
Thickness of the contaminated zone	THICK0	m	0.15	Triangular	Min 0.1m Max 0.3 m	S	S	The residual activity is present in the top 15 cm of the soil.
Irrigation	RI	m/yr	0.2	Point Estimate		D	I	Uses RESRAD value for humid region where minimal irrigation is required to maintain the cover vegetation, as is the case for New Jersey.

17.3.5 - Suburban Resident Scenario (Unrestricted Area, Controls Fail)

Parameter			Central Tendency Value	Description of Parameter Distribution		Classification (D=RESRAD Default; S-Site-specific; O=Other)	Impact on Resulting Dose (I=Insignificant; S=Significant and requires justification or explanation)	Justification, Source or Other Information
Description	Code	Unit		Distribution	Range & Fit			
Receptor Exposure Factors								
Exposure Frequency (Total)	EF	Days per year	250	EF and ET are not input parameters used by RESRAD. They are presented here to disclose the calculation used to arrive at the parameters RESRAD uses to account for exposure frequency, FIND & FOTD		--	--	Assumes number of days per year of time working specifically at the SMC site
Exposure Time	ET	hours per day	8			--	--	Conservatively assumes that each work day eight (8) hours long.
Indoor Time Fraction	FIND	Unitless, 0 to 1	0.15	Point estimate		O	S	The fraction of a total year (8,760hr) that is spent indoors on site. Assumes that 69% of the exposure occur indoors.[139]
Outdoor Time Fraction	FOTD	Unitless, 0 to 1	0.07	Triangular	Range: 0 to 0.14	O	S	The fraction of a total year (8760hr) that is spent outdoors on Site. Equals 595 hrs outdoors on Site divided by 8760 hours. The probabilistic distribution ranges to twice the CT value (1,190 hrs per year spent on the site).
Inhalation Rate	INHALR	m^3/yr	8,400	Triangular	Range: 4,380 to 13,100	D	I	Inhalation rate based on geometric mean rate for short term exposure to adult males.[140]
Mass Loading for Inhalation	MLINH	g/m3	0.00003	Continuous Linear	0.000000 - 0.0000 0.000008 - 0.0151 0.000016 - 0.1365 0.000030 - 0.8119 0.000040 - 0.9495 0.000060 - 0.9937 0.000076 - 0.9983 0.000100 - 1.0000	D	I	Mass loading in air describes the airborne dust loading conditions on the site.[141]
Soil Ingestion Rate	SOIL	g/y	18.3	Triangular	Range: 0 to 36.5	D	I	The industrial worker may ingest soil as a result of incidental contact with the soil. RESRAD value for adults engaged in non contact intensive activities is 50 mg/day
Cover Depth (thickness)	COVER0	m	0	Point estimate		S	S	The residual activity is present in the top 15 cm of the soil.
Area of Contaminated Zone	AREA	m^2	244,000	Loguniform	Range: 244,000 m^2 to 295,000 m^2	S	S	The area of the unrestricted area is represented by the area of the plant; the area of the Storage Yard is subtracted.
Thickness of the contaminated zone	THICK0	m	0.15	Triangular	Min 0.1m Max 0.3 m	S	S	The residual activity is present in the top 15 cm of the soil.

[139] U.S. Nuclear Regulatory Commission, *Development of Probabilistic RESRAD 6.0 and RESRAD-Build 3.0 Computer Codes*, NUREG/CR-6697, November, 2000.
[140] U.S. Environmental Protection Agency, *Exposure Factors Handbook, Volume I, General Factors*, EPA 600/P-95-002Fa, August, 1997.
[141] Argonne National Laboratory, *User's Manual for RESRAD Version 6*, July, 2001.

Parameter			Central Tendency Value	Description of Parameter Distribution		Classification (D=RESRAD Default; S=Site-specific; O=Other)	Impact on Resulting Dose (I=Insignificant; S=Significant and requires justification or explanation)	Justification, Source or Other Information
Description	Code	Unit		Distribution	Range & Fit			
Receptor Exposure Factors								
Irrigation	RI	m/yr	0.2	Point Estimate		D	I	Uses RESRAD value for humid area where minimal irrigation is required, which is typical for New Jersey

17.3.6 - Maintenance Worker Scenario (Restricted Area, Controls in Place)

Parameter			Central Tendency Value	Description of Parameter Distribution		Classification (D=RESRAD Default; S=Site-specific; O=Other)	Impact on Resulting Dose (I=Insignificant; S=Significant and requires justification or explanation)	Justification, Source or Other Information
Description	Code	Unit		Distribution	Range & Fit			
Receptor Exposure Factors								
Exposure Frequency (Total)	EF	Days per year	4	EF and ET are not input parameters used by RESRAD. They are presented here to disclose the calculation used to arrive at the parameters RESRAD uses to account for exposure frequency, FIND & FOTD		--	--	Assumes four (4) days per year that the maintenance worker inspects the cover, which is consistent with the cover inspection schedule currently in place at SMC's Cambridge facility.
Exposure Time	ET	hours per day	6			--	--	Conservatively assumes that each inspection day extends for six (6) hours.
Indoor Time Fraction	FIND	Unitless, 0 to 1	0	Point estimate		O	S	The fraction of a total year (8,760hr) that is spent indoors on site. Assumes that all exposures occur outdoors. There are no habitable structures on the site.
Outdoor Time Fraction	FOTD	Unitless, 0 to 1	0.003	Triangular	Range: 0 to 0.005	O	S	The fraction of a total year (8760hr) that is spent outdoors on Site. Equals 24 hrs outdoors on Site divided by 8760 hours. The probabilistic distribution ranges to twice the CT value.
Inhalation Rate	INHALR	m^3/yr	8400	Triangular	Range: 4380 to 13,100	D	I	Inhalation rate based on geometric mean rate for short term exposure to adult males.[142]
Mass Loading for Inhalation	MLINH	g/m^3	0.00003	Continuous Linear	0.000000 - 0.0000 0.000008 - 0.0151 0.000016 - 0.1365 0.000030 - 0.8119 0.000040 - 0.9495 0.000060 - 0.9937 0.000076 - 0.9983 0.000100 - 1.0000	D	I	Mass loading in air describes the airborne dust loading conditions on the site.[143]
Soil Ingestion Rate	SOIL	g/y	18.3	Triangular	Range: 0 to 36.5	D	I	USEPA default value for adults engaged in non-contact intensive activities (50 mg/day).[144] (Yu 2001, EPA 1997).
Site General and Weather Related Parameters								
Evapotranspiration Coefficient	EVAPTR	Unitless, 0 to 1	0.625	Uniform	Range: 0.3 to 0.9	D	I	Typical values in humid climates east of the Mississippi River, including New Jersey, are approximately 0.7.[145]

142 U.S. Environmental Protection Agency, *Exposure Factors Handbook, Volume I, General Factors*, EPA 600/P-95-002Fa, August, 1997.
143 Yu, C, Zielen, A.J, et al, *User's Manual for RESRAD Version 6*, ANL/EAD-4, Argonne National Laboratory, Argonne, Illinois, July, 2001.
144 Argonne National Laboratory, *User's Manual for RESRAD Version 6*, July, 2001.
145 Argonne National Laboratory, *User's Manual for RESRAD Version 6*, July, 2001.

Parameter			Central Tendency Value	Description of Parameter Distribution		Classification (D=RESRAD Default; S-Site-specific; O=Other)	Impact on Resulting Dose (I=Insignificant; S=Significant and requires justification or explanation)	Justification, Source or Other Information
Description	Code	Unit		Distribution	Range & Fit			
Receptor Exposure Factors								
Average Annual Wind Speed	WIND	m/sec	4.25	Bounded Lognormal-N	μNormal: 1.445 σNormal: 0.2419 Min: 1.4 Max: 13.0	D	I	The thirty year (1961-1990) site- specific annual average value (4.3 m/s) is nearly equal to the RESRAD default value.[146]
Precipitation Rate	PRECIP	m/year	1.05	Point Estimate		S	S	The annual average given for the Newfield area in the Environmental report is 41 inches per year.[147] Infiltration of water on the surface assumes that there is a potential for contaminated water to leave the Storage yard.
Irrigation Rate	RI	m/year	0	Point Estimate		D	I	No irrigation is considered applicable in the future uses of the site.
Runoff Coefficient	RUNOFF	Unitless, 0 to 1	0.45	Uniform	Range: 0.1 to 0.8	S	S	The fraction of total annual precipitation that sheds off the surface and drains to Site watershed drainage without percolating through the soil. Value selected from the Environmental Report is approximately 0.3 to 0.5 (DP Section 5.4.3.2).
Watershed Area for Nearby Stream or Pond	WAREA	m^2	273,000	Point Estimate		S	I	Value of 67 acres taken from the Environmental Report. The watershed area is used to calculate dilution factors for contaminant concentrations in surface water bodies in the vicinity of the site. While there is no pathway for humans to drink surface water, animals may use the pond for their water supply.
Depth of Soil Mixing Layer	DM	m	0.15	Triangular	Range: 0 to 0.6	D	I	Uses the RESRAD Default.[148]
Calculation Times	T(n)	Yrs.	1 10 100 300 500 700 900 1000	NA		--	--	Evaluation at these time segments allows for consideration of the potential for conditions at the Site to evolve from the initial conditions specified (e.g., soil erosion impacts the cover thickness) and projects the changing Site conditions to the required 1000-year outlook.[149,150]

146 National Climate Data Center, *Local Climatological Data, Annual Summary with Comparative Data for Philadelphia, Pennsylvania*, 2000.
147 National Climate Data Center.
148 Argonne National Laboratory, *User's Manual for RESRAD Version 6*, July, 2001.
149 U.S. Nuclear Regulatory Commission, *Radiological Criteria for License Termination*, Volume 62, Federal Register, page 39058, July 21, 1997.
150 U.S. Nuclear Regulatory Commission, *NMSS Decommissioning Standard Review Plan*, NUREG-1727, September, 2000.

17.3.7 - Common Parameters, Subsurface Soil (Restricted Area, Controls in Place)

Parameter			Central Tendency Value	Description of Parameter Distribution		Classification (D=RESRAD Default; S=Site-specific; O=Other)	Impact on Resulting Dose (I=Insignificant; S=Significant and requires justification or explanation)	Justification, Source or Other Information
Description	Code	Unit		Distribution	Range & Fit			
Site General and Weather Related Parameters								
Evapotranspiration Coefficient	EVAPTR	Unitless, 0 to 1	0.5	Uniform	Range: 0.3 to 0.9	D	I	No value recommended by USNRC in NUREG 5512. RESRAD Default used for this parameter. Typical values in humid climates east of the Mississippi River are approximately 0.7.[151]
Average Annual Wind Speed	WIND	m/sec	4.25	Bounded Lognormal-N	μNormal: 1.445 σNormal: 0.2419 Min: 1.4 Max: 13.0	D	I	RESRAD Default. The thirty year (1961-1990) site-specific annual average value (4.3 m/s) is nearly equal to the RESRAD default value.[152]
Precipitation Rate	PRECIP	m/year	1.05	Point Estimate		S	S	The annual average given for the Newfield area in the Environmental report is 41 inches per year.[153] Infiltration of water on the surface assumes that there is a potential for contaminated water to leave the Storage Yard.
Irrigation Rate	RI	m/year	0.2	Point Estimate		D	I	No site specific data available. The RESRAD default was determined to be representative to growing conditions sufficient to maintain a grass cover on the barrier.
Runoff Coefficient	RUNOFF	Unitless, 0 to 1	0.45	Uniform	Range: 0.1 to 0.8	S	S	The fraction of total annual precipitation that sheds off the surface and drains to the site watershed. Drainage was not assumed to percolate through the soil. Typical value is approximately 0.3 to 0.5, as shown in the Environmental Report for the SMC site (DP Section 5.4.3.2). The value for this parameter was calculated based on 18" annual average runoff. The contaminated zone and the engineered cover create a "hill". Therefore, runoff is increased by a factor of two.
Watershed Area for Nearby Stream or Pond	WAREA	m²	273,000	Point Estimate		S	I	Assumed to be 67 acres and represents the low lying areas adjacent to the Storage Yard. The watershed area is used to calculate dilution factors for contaminant concentrations in surface water bodies in the vicinity of the site. The larger watershed area, the greater volume through which dilution is possible. While there is no pathway for humans to drink surface water, animals may use the pond for their water supply. The greater the dilution, the lower the radiation dose.
Depth of Soil Mixing Layer	DM	m	0.15	Triangular	Range: 0 to 0.6	D	I	Value based on conceptual site model for surface soil.[154]

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151 Argonne National Laboratory, *User's Manual for RESRAD Version 6*, July, 2001.
152 National Climate Data Center, *Local Climatological Data, Annual Summary with Comparative Data for Philadelphia, Pennsylvania*, 2000.
153 National Climate Data Center.
154 U.S. Nuclear Regulatory Commission, *Residual Radioactive Contamination from Decommissioning: Parameter Analysis*, NUREG/CR-5512, Vol.3, October 1999.

Parameter			Central Tendency Value	Description of Parameter Distribution		Classification (D=RESRAD Default; S=Site-specific; O=Other)	Impact on Resulting Dose (I=Insignificant; S=Significant and requires justification or explanation)	Justification, Source or Other Information
Description	Code	Unit		Distribution	Range & Fit			
Site General and Weather Related Parameters								
Calculation Times	T(n)	Yrs.	1 10 100 300 500 700 900 1000	NA		--	--	Evaluation at these time segments allows for consideration of the potential for conditions at the Site to evolve from the initial conditions specified (e.g., soil erosion impacts the cover thickness) and projects the changing Site conditions to the required 1000-year outlook.[155,156]
Geotechnical Parameters-Cover Layer (Engineered Clay Cover)								
Cover Depth (thickness)	COVER0	m	1	Triangular	Range: 0.5 to 1.2	S	S	The engineered barrier will be installed over the slag in the Storage Yard with a thickness of 1.0 meters as shown in the preliminary design.
Cover Density	DENSCV	g/cm³	1.9	Truncated Normal	μNormal 1.9 σNormal: 0.23 Quantile, min;0.05 Quantile,max:0.95	S	S	Measured density for clay-bearing materials provided in the preliminary design.
Cover Erosion Rate	VCV	m/yr	0			S	S	The engineered barrier is maintained during the institutional controls. It is assumed that no erosion occurs due to the presence of the rock cover over the soil layer.
Depth of Roots	DROOT	m	0.9	Lognormal-N	μNormal: -1.9 σNormal: 0.6	D,S	I	The engineered cover is composed of dense clay material that is designed to shed water. It does not readily support a typical plant root zone. The fit of the lognormal-N distribution allows for root depths of up to approximately 1 meter. As long as the cover is maintained, there is no uptake by plants.
Geotechnical Parameters-Subsurface Soil Contaminated Zone								
Area of Contaminated Zone	AREA	m²	18,228	Loguniform	Range: 14,580 to 28,767	S	S	The footprint of the Storage Yard is 18,228 m². The area is assumed to be ±20%; the maximum area is defined by the area of the entire cover.
Thickness of Contaminated Zone	THICK0	m	2.8	Triangular	Min 0.5 Max 3.0	S	S	The Storage Yard volume was measured during the Remedial Investigation and subsequent aerial photography.
Contaminated Zone Density	DENSCZ	g/cm³	2.8	Triangular	Min 1.6 Max 3.0	S	S	The density of the slag and baghouse dust was measured.[157]
Contaminated Zone Erosion Rate	VCZ	m/yr	0	Triangular	Min $8x10^{-8}$ Max $3x10^{-4}$	D (unrestricted area), S (restricted area)	I	The erosion of the slag was assumed to be 10x less than that of the cover. The boulders located in the Storage Yard are not likely to erode over the 1,000 year period of time.

[155] U.S. Nuclear Regulatory Commission, *Radiological Criteria for License Termination*, Volume 62, Federal Register, page 39058, July 21, 1997.
[156] U.S. Nuclear Regulatory Commission, *NMSS Decommissioning Standard Review Plan*, NUREG-1727, September, 2000.
[157] Berger, C. (IEM), written communication to D. R. Smith (SMC), *Radionuclide Leachability from Newfield Slag*, September 16, 2005.

Parameter			Central Tendency Value	Description of Parameter Distribution		Classification (D=RESRAD Default; S-Site-specific; O=Other)	Impact on Resulting Dose (I=Insignificant; S=Significant and requires justification or explanation)	Justification, Source or Other Information
Description	Code	Unit		Distribution	Range & Fit			
Site General and Weather Related Parameters								
Contaminated Zone Total Porosity	TPCZ	Unitless 0 to 1	0.4	Point Estimate		D	I	Site specific parameter measured during the Remedial Investigation[158]
Contaminated Zone Field Capacity	FCCZ	Unitless, 0 to 1	0.2	Point Estimate		D	I	Site specific parameter measured during the Remedial Investigation.
Contaminated Zone Hydraulic Conductivity	HCCZ	m/yr	2,000	Bounded Lognormal-N	μNormal: 7.6 σNormal: 0.75 Min: 200 max: 20000	S	I	The central tendency value, 2000 m/yr (6.4E-3 cm/sec), corresponds to the measured hydraulic conductivity in sandy soils found at the site. The value is assumed to range over two orders of magnitude from 200 to 20,000 m/yr.[159]
Contaminated Zone B-Parameter	BCZ	Unitless	2.88	Bounded Lognormal-N	μNormal: 1.06 σNormal 0.66 min: 0.5 Max: 30	D	I	RESRAD value for sandy soil
Kd (Thorium)	DCACT(n)	cm^3/g	52,010	Triangular	Min 2,900 Max 129,000	S	S	The slag was studied to define the site specific leaching properties.[160]
Kd (Uranium)	DCACT(n)	cm^3/g	70,355	Triangular	Min 50,000 Max 293,000	S	S	
Kd (Radium)	DCACT(n)	cm^3/g	53	Triangular	Min 35 Max 77	S	S	
Kd (Lead)	DCACT (n)	cm3/g	100	Point Estimate		S	S	RESRAD Default.
Geotechnical Parameters- Unsaturated Layer								
Thickness Unsaturated Layer	H1	m	2.5	Triangular	Min 2.5 Max 4.6	S	S	The unsaturated layer was measured during the Remedial Investigation.[161]
Density, Unsaturated Layer	DENSUZ	g/cm3	1.65	Truncated Normal	μNormal: 1.65 σNormal: 0.23 Quantile, min: 0.05 Quantile, max: 0.95	S	S	The unsaturated zone is the layer beneath the Storage Yard. The density of native sand materials present at the site was used.
Total Porosity Unsaturated Layer	TPUZ	Unitless 0 to 1	0.4	Point Estimate		D	I	Site specific parameter measured during the Remedial Investigation

[158] TRC Environmental Consultants, Inc., *Remedial Investigation Technical Report*, Project Number 7650-N51, Windsor, Connecticut, April, 1992.
[159] TRC Environmental Consultants, Inc., *Remedial Investigation Technical Report*, Project Number 7650-N51, Windsor, Connecticut, April, 1992.
[160] Berger, C. (IEM), written communication to D. R. Smith (SMC), *Radionuclide Leachability from Newfield Slag*, September 16, 2005.
[161] TRC Environmental Consultants, Inc., *Remedial Investigation Technical Report*, Project Number 7650-N51, Windsor, Connecticut, April, 1992.

Parameter			Central Tendency Value	Description of Parameter Distribution		Classification (D=RESRAD Default; S-Site-specific; O=Other)	Impact on Resulting Dose (I=Insignificant; S=Significant and requires justification or explanation)	Justification, Source or Other Information
Description	Code	Unit		Distribution	Range & Fit			
Site General and Weather Related Parameters								
Effective Porosity of Unsaturated Layer	EPUZ	Unitless, 0 to 1	0.2	Point Estimate		D	I	Site specific parameter measured during the Remedial Investigation
Field Capacity Unsaturated Layer	FCUZ	Unitless, 0 to 1	0.2	Point Estimate		D	I	RESRAD Default
Hydraulic Conductivity Unsaturated Layer	HCUZ	m/yr	0.017	Triangular	Min 0.001 Max 1.7	S	I	The central tendency value, 0.017 m/yr, corresponds to the measured hydraulic conductivity in sandy soils found at the site. The value was found to range from 0.001 m/yr to 1.7 m/yr.[162]
Unsaturated Layer 1, B-Parameter	BUZ(1)	Unitless	5.3	Point Estimate		D	I	RESRAD value for silty clay
Kd (Thorium)	DCACTU(n)	cm³/g	52,010	Triangular	Min 2,900 Max 129,000	S	S	The slag was studied to define the site specific leaching properties.[163]
Kd (Uranium)	DCACTU(n)	cm³/g	70,355	Triangular	Min 50,000 Max 293,000	S	S	
Kd (Radium)	DCACTU(n)	cm³/g	53	Triangular	Min 35 Max 77	S	S	
Kd (Lead)	DCACTU(n)	cm3/g	100	Point Estimate		S	S	RESRAD Default
Geotechnical Parameters-Saturated Zone								
Density, Saturated Zone	DENSAQ	g/cm³	1.52	Truncated Normal	µNormal: 1.52 σNormal: 0.23 Quantile ,min: 0.001 Quantile, max: 0.999	S	I	Site specific parameter measured during the Remedial Investigation
Total Porosity Saturated Zone	TPSZ	Unitless,0 to 1	0.4	Point Estimate		D	I	RESRAD Default
Effective Porosity, Saturated Zone	EPSZ	Unitless, 0 to 1	0.2	Point Estimate		D	I	RESRAD Default
Field Capacity, Saturated Zone	FCSZ	Unitless, 0 to 1	0.2	Point Estimate		D	I	RESRAD Default
Hydraulic Conductivity, Saturated Zone	HCSZ	m/yr	16,000	Bounded Lognormal-N	µNormal: 2.3 σNormal: 2.11 min: 0.1 max: 20,000	S	I	Site specific parameter measured during the Remedial Investigation

162 TRC Environmental Consultants, Inc., *Remedial Investigation Technical Report*, Project Number 7650-N51, Windsor, Connecticut, April, 1992.
163 Berger, C. (IEM), written communication to D. R. Smith (SMC), *Radionuclide Leachability from Newfield Slag*, September 16, 2005.

Parameter			Central Tendency Value	Description of Parameter Distribution		Classification (D=RESRAD Default; S-Site-specific; O=Other)	Impact on Resulting Dose (I=Insignificant; S=Significant and requires justification or explanation)	Justification, Source or Other Information
Description	Code	Unit		Distribution	Range & Fit			
Site General and Weather Related Parameters								
Hydraulic Gradient	HGWT	Unitless	0.006	Bounded Lognormal-N	μNormal: -5.11 σNormal: 1.77 min: 0 .00007 max: 0.5	S	I	Site specific parameter measured during the Remedial Investigation
Saturated Zone B-Parameter	BSZ	Unitless	2.88	Bounded Lognormal-N	μNormal: 1.06 σNormal: 0.66 Min: 0.5 Max: 30	D	I	RESRAD Default
Source Term Factors								
Dose Conversion Factors	DCFX(n)	millirem/pCi	All DCFs used are RESRAD defaults			D	S	RESRAD defaults from FGR#11 and FGR#12 and are derived using ICRP 30 dosimetry model.[164,165] Short-lived (<180 days) radioactive progeny isotopes are accounted for through the use of the "parent+D" DCFs.
Source Isotopes								
Actinium-227	S!(1)	pCi/g	8	Point Estimate		--	--	Weighted average. See Table 17.7
Protactinium-231	S!(2)	pCi/g	8	Point Estimate		--	--	Weighted average. See Table 17.7
Lead-210	S1(3)	pCi/g	182	Point Estimate		--	--	Weighted average. See Table 17.7
Radium-226	S1(4)	pCi/g	182	Point Estimate		--	--	Weighted average. See Table 17.7
Radium-228	S1(5)	pCi/g	182	Point Estimate		--	--	Weighted average. See Table 17.7
Thorium-228	S1 (6)	pCi/g	182	Point Estimate		--	--	Weighted average. See Table 17.7
Thorium-230	S1(7)	pCi/g	182	Point Estimate		--	--	Weighted average. See Table 17.7
Thorium-232	S1(8)	pCi/g	182	Point Estimate		--	--	Weighted average. See Table 17.7
Uranium-234	S1(9)	pCi/g	182	Point Estimate		--	--	Weighted average. See Table 17.7
Uranium-235	S1(10)	pCi/g	8	Point Estimate		--	--	Weighted average. See Table 17.7
Uranium-238	S1(11)	pCi/g	182	Point Estimate		--	--	Weighted average. See Table 17.7

[164] U.S. Environmental Protection Agency, *Limiting Values of Radionuclide Intake and Air Concentrations and Dose Conversion Factors for Inhalation, Submersion, and Ingestion*, Federal Guidance Report Number 11, EPA 520/1-88-020, September, 1988.
[165] U.S. Environmental Protection Agency, *External Exposure to Radionuclides in Air, Water and Soil*, Federal Guidance Report Number 12, EPA 402 R-93-081, September, 1993.

17.3.8 - Industrial Worker Scenario (Restricted Area, Controls in Place)

Parameter			Central Tendency Value	Description of Parameter Distribution		Classification (D=RESRAD Default; S=Site-specific; O=Other)	Impact on Resulting Dose (I=Insignificant; S=Significant and requires justification or explanation)	Justification, Source or Other Information
Description	Code	Unit		Distribution	Range & Fit			
Receptor Exposure Factors								
Exposure Frequency (Total)	EF	Days per year	250	EF and ET are not input parameters used by RESRAD. They are presented here to disclose the calculation used to arrive at the parameters RESRAD uses to account for exposure frequency, FIND & FOTD		–	--	Assumes number of days per year of time working specifically at the SMC site
Exposure Time	ET	hours per day	8			–	--	Conservatively assumes that each day eight (8) hours long.
Indoor Time Fraction	FIND	Unitless, 0 to 1	0.15	Point estimate		O	S	The fraction of a total year (87860hr) that is spent indoors on site. Assumes that 69% of the exposure occurs indoors on the unrestricted side of the site (NUREG 6697).
Outdoor Time Fraction	FOTD	Unitless, 0 to 1	0.07	Triangular	Range: 0 to 0.14	O	S	The fraction of a total year (8,760hr) that is spent outdoors on Site. Equals 595 hrs outdoors on Site divided by 8,760 hours. The probabilistic distribution ranges to twice the CT value (1,190 hrs per year spent outdoors on the site).
Inhalation Rate	INHALR	m³/yr	8400	Triangular	Range: 4380 to 13100	D	I	Inhalation rate based on geometric mean rate for short term exposure to adult males.[166]
Mass Loading for Inhalation	MLINH	g/m3	0.00003	Continuous Linear	0.000000 - 0.0000 0.000008 - 0.0151 0.000016 - 0.1365 0.000030 - 0.8119 0.000040 - 0.9495 0.000060 - 0.9937 0.000076 - 0.9983 0.000100 - 1.0000	D	I	Mass loading in air describes the airborne dust loading conditions on the site.[167]
Cover Erosion Rate	VCV	m/yr	0			S	S	The cover is assumed to be maintained and does not erode while institutional controls are in place.
Soil Ingestion Rate	SOIL	g/y	0			D	I	The industrial worker does not enter the fenced Storage Yard. There is no direct contact with the soil inside the fence.

166 U.S. Environmental Protection Agency, *Exposure Factors Handbook, Volume I, General Factors*, EPA 600/P-95-002Fa, August, 1997.

167 Argonne National Laboratory, *User's Manual for RESRAD Version 6*, July, 2001.

17.3.9 - Trespasser Scenario (Restricted Area, Controls in Place)

Parameter			Central Tendency Value	Description of Parameter Distribution		Classification (D=RESRAD Default; S-Site-specific; O=Other)	Impact on Resulting Dose (I=Insignificant; S=Significant and requires justification or explanation)	Justification, Source or Other Information
Description	Code	Unit		Distribution	Range & Fit			
Receptor Exposure Factors								
Exposure Frequency (Total)	EF	Days per year	2.5	EF and ET are not input parameters used by RESRAD. They are presented here to disclose the calculation used to arrive at the parameters RESRAD uses to account for exposure frequency, FIND & FOTD		--	--	Scenario-specific values used.
Exposure Time	ET	hours per day	24			--	--	Conservatively assumes that the trespasser spends 24 hours per day on the site before they are discovered and removed by the SMC staff.
Indoor Time Fraction	FIND	Unitless, 0 to 1	0	Point estimate		O	S	The fraction of a total year (8,760hr) that is spent indoors on site. Assumes that all exposures occur outdoors. There are no habitable structures on the site.
Outdoor Time Fraction	FOTD	Unitless, 0 to 1	0.007	Triangular	Range: 0 to 0.013	O	S	The fraction of a total year (8,760hr) that is spent outdoors on Site. Equals 59 hrs outdoors on Site divided by 8760 hours. The probabilistic distribution ranges to twice the CT value.
Inhalation Rate	INHALR	m^3/yr	8400	Triangular	Range: 4380 to 13100	D	I	Inhalation rate based on geometric mean rate for short term exposure to adult males.[168]
Mass Loading for Inhalation	MLINH	g/m3	0.00003	Continuous Linear	0.000000 - 0.0000 0.000008 - 0.0151 0.000016 - 0.1365 0.000030 - 0.8119 0.000040 - 0.9495 0.000060 - 0.9937 0.000076 - 0.9983 0.000100 - 1.0000	D	I	Mass loading in air describes the airborne dust loading conditions on the site[169]
Cover Erosion Rate	VCV	m/yr	0			S	S	The cover is assumed to be maintained and does not erode while institutional controls are in place.
Soil Ingestion Rate	SOIL	g/y	18.3	Triangular	Range: 0 to 36.5	D	I	USEPA default value for adults engaged in non-contact intensive activities (50 mg/day).

[168] Argonne National Laboratory, *User's Manual for RESRAD Version 6*, July, 2001.
[169] U.S. Environmental Protection Agency, *Exposure Factors Handbook, Volume I, General Factors*, EPA 600/P-95-002Fa, August, 1997.

17.3.10 - Recreational Hunter Scenario (Restricted Area, Controls Fail)

Parameter			Central Tendency Value	Description of Parameter Distribution		Classification (D=RESRAD Default; S-Site-specific; O=Other)	Impact on Resulting Dose (I=Insignificant; S=Significant and requires justification or explanation)	Justification, Source or Other Information
Description	Code	Unit		Distribution	Range & Fit			
Receptor Exposure Factors								
Exposure Frequency (Total)	EF	Days per year	3.1	EF and ET are not input parameters used by RESRAD. They are presented here to disclose the calculation used to arrive at the parameters RESRAD uses to account for exposure frequency, FIND & FOTD		--	--	Assumes 75 hours per year of time spent hunting specifically at the SMC site
Exposure Time	ET	hours per day	24			--	--	Conservatively assumes that each day spent hunting on site is 24 hours long.
Indoor Time Fraction	FIND	Unitless, 0 to 1	0	Point estimate		O	S	The fraction of a total year (8,760hr) that is spent indoors on site. Assumes that all exposures occur outdoors. There are no habitable structures on the site.
Outdoor Time Fraction	FOTD	Unitless, 0 to 1	0.009	Triangular	Range: 0 to 0.017	O	S	The fraction of a total year (8760hr) that is spent outdoors on Site. Equals 75 hrs outdoors on Site divided by 8760 hours. The probabilistic distribution ranges to twice the CT value.
Inhalation Rate	INHALR	m^3/yr	8,400	Triangular	Range: 4,380 to 13,100	D	I	Inhalation rate based on geometric mean rate for short term exposure to adult males[170]
Contaminated Fraction of Meat	FMEAT	Unitless, 0 to 1	0.3	Triangular	Range: 0 to 0.5	D	I	The fraction of the annual meat diet that is obtained from game harvested from off the site. The number is conservative in that the size of the site is small relative to the grazing land required to support game habitat. The use of the triangular distribution results in a more conservative estimate than the RESRAD default for this site.[171]
Mass Loading for Inhalation	MLINH	g/m^3	0.00003	Continuous Linear	0.000000 - 0.0000 0.000008 - 0.0151 0.000016 - 0.1365 0.000030 - 0.8119 0.000040 - 0.9495 0.000060 - 0.9937 0.000076 - 0.9983 0.000100 - 1.0000	D	I	Mass loading in air describes the airborne dust loading conditions on the site.[172]
Cover Erosion Rate	VCV	m/yr	0	Continuous Logarithmic	0.0000008 - 0.00 0.00046 - 0.50 0.003 - 1.00	S	S	An erosion rate of zero was justified using the Revised Universal Soil Loss Equation computer program, RULE2 (Appendix 19.3 of the DP)

[170] U.S. Environmental Protection Agency, *Exposure Factors Handbook, Volume I, General Factors*, EPA 600/P-95-002Fa, August, 1997.
[171] U.S. Environmental Protection Agency, *Exposure Factors Handbook, Food Ingestion Factors*, Volume II, EPA/600/P-95/002Fb, August, 1997.
[172] Argonne National Laboratory, *User's Manual for RESRAD Version 6*, July, 2001.

Parameter			Central Tendency Value	Description of Parameter Distribution		Classification (D=RESRAD Default; S-Site-specific; O=Other)	Impact on Resulting Dose (I=Insignificant; S=Significant and requires justification or explanation)	Justification, Source or Other Information
Description	Code	Unit		Distribution	Range & Fit			
Receptor Exposure Factors								
Soil Ingestion Rate	SOIL	g/y	18.3	Triangular	Range: 0 to 36.5	D	I	USEPA default value for adults engaged in non-contact intensive activities (50 mg/day).

17.3.11 - Cover Excavation Scenario (Restricted Area, Controls Fail)

Parameter			Central Tendency Value	Description of Parameter Distribution		Classification (D=RESRAD Default; S-Site-specific; O=Other)	Impact on Resulting Dose (I=Insignificant; S=Significant and requires justification or explanation)	Justification, Source or Other Information
Description	Code	Unit		Distribution	Range & Fit			
Receptor Exposure Factors								
Exposure Frequency (Total)	EF	Days per year	10	EF and ET are not input parameters used by RESRAD. They are presented here to disclose the calculation used to arrive at the parameters RESRAD uses to account for exposure frequency, FIND & FOTD		--	--	Assumes it takes two (2) weeks to attempt to excavate slag from the engineered cover
Exposure Time	ET	hours per day	8			--	--	Conservatively assumes that each day spent digging is 8 hours long.
Indoor Time Fraction	FIND	Unitless, 0 to 1	0	Point estimate		O	S	The fraction of a total year (87860hr) that is spent indoors on site. Assumes that all exposures occur outdoors. There are no habitable structures on the site.
Outdoor Time Fraction	FOTD	Unitless, 0 to 1	0.009	Triangular	Range: 0 to 0.018	O	S	The fraction of a total year (8760hr) that is spent outdoors on Site. Equals 80 hrs outdoors on Site divided by 8760 hours.
Uranium 238 and progeny	Nuclide	µCi/cubic centimeter	0.001	Point estimate		--	--	All progeny in secular equilibrium, including Ra226
Thorium 232 and progeny	Nuclide	µCi/cubic centimeter	0.001	Point estimate		--	--	All progeny in secular equilibrium, including Ac228
Thickness	16 Infinite Slab	m	0.01	Point estimate		S	S	Assume the excavation is 1 m^2 in area and 1 m deep.
Dose Point	Air gap	m	0.92	Point estimate		S	S	Assume the intruder stays within 3 ft (0.92 m) for 64 hours
Density	Concrete	g/cm^3	2.8	Point estimate		S	S	Assume the slag has the same shielding properties as concrete, which was generally confirmed by measurement.[173]

[173] Berger, C. (IEM), written communication to D. R. Smith (SMC), *Radionuclide Leachability from Newfield Slag*, September 16, 2005.

17.3.12 - Industrial Worker Scenario (Restricted Area, Controls Fail)

Parameter			Central Tendency Value	Description of Parameter Distribution		Classification (D=RESRAD Default; S-Site-specific; O=Other)	Impact on Resulting Dose (I=Insignificant; S=Significant and requires justification or explanation)	Justification, Source or Other Information
Description	Code	Unit		Distribution	Range & Fit			
Receptor Exposure Factors								
Exposure Frequency (Total)	EF	Days per year	250	EF and ET are not input parameters used by RESRAD. They are presented here to disclose the calculation used to arrive at the parameters RESRAD uses to account for exposure frequency, FIND & FOTD		--	--	Assumes number of days per year of time working specifically at the SMC site
Exposure Time	ET	hours per day	8			--	--	Conservatively assumes that each day eight (8) hours long.
Indoor Time Fraction	FIND	Unitless, 0 to 1	0.15	Point estimate		O	S	The fraction of a total year (8,760hr) that is spent indoors at the unrestricted area. Assumes that 69% of the time is spent indoors, in the unrestricted area.
Outdoor Time Fraction	FOTD	Unitless, 0 to 1	0.07	Triangular	Range: 0 to 0.14	O	S	The fraction of a total year (8,760hr) that is spent outdoors on the restricted area. Assumes that 31% of the time at the SMC site is spent walking on the cover and in close proximity to the engineered barrier. Equals 595 hrs outdoors on the restricted site, divided by 8,760 hours. The probabilistic distribution ranges to twice the CT value (1,190 hrs per year spent on the restricted site).
Inhalation Rate	INHALR	m^3/yr	8400	Triangular	Range: 4380 to 13100	D	I	Inhalation rate based on geometric mean rate for short term exposure to adult males.[174]
Mass Loading for Inhalation	MLINH	g/m3	0.00003	Continuous Linear	0.000000 - 0.0000 0.000008 - 0.0151 0.000016 - 0.1365 0.000030 - 0.8119 0.000040 - 0.9495 0.000060 - 0.9937 0.000076 - 0.9983 0.000100 - 1.0000	D	I	Mass loading in air describes the airborne dust loading conditions on the site.[175]
Cover Erosion Rate	VCV	m/yr	0	Continuous Logarithmic	0.0000008 - 0.00 0.00046 - 0.50 0.003 - 1.00	S	S	The erosion rate was calculated using the Revised Universal Soil Loss Equation computer program, RULE2 (see Appendix 19.3 of the DP).
Soil Ingestion Rate	SOIL	g/y	18.3	Triangular	Range: 0 to 36.5	D	I	The industrial worker enters the fenced Storage Yard. Ingestion of contaminated soil is incidental to walking in the restricted area. USEPA default value for adults engaged in non-contact intensive activities (50 mg/day).

[174] U.S. Environmental Protection Agency, *Exposure Factors Handbook, Volume I, General Factors*, EPA 600/P-95-002Fa, August, 1997.
[175] Argonne National Laboratory, *User's Manual for RESRAD Version 6*, July, 2001.

* **Table 17.4 - RESRAD Exposure Pathways**

17.4.1 - Trespasser Scenario (Unrestricted Area, Controls in Place)

Pathway	Retained	Comments
Direct Exposure	Yes	The source term found in the site soils produces penetrating gamma radiation. Exposure from direct penetrating radiation is expected to be a significant contributor to the overall potential dose. External radiation dose was modeled using Microshield; RESRAD does not accurately model a direct exposure at a distance form the source term.
Particulate Inhalation	Yes	Allowance is made for soils containing radiological constituents of the source being liberated and suspended in the breathing air of the occasional trespasser.
Radon	No	Radon is specifically excluded from consideration within the framework of the governing regulations. In addition, the source term found is not a significant producer of radon due to the relatively long half-life of the thorium isotopes found in the slag
Plant Ingestion	No	Ingestion of plant foods addresses those plant foods grown in the radioactivity or irrigated with water containing radioactivity from on Site. Since the trespasser does not eat edible plant parts grown on site for food consumption, this pathway is incomplete.
Drinking Water	No	Surface water on site is unfit for consumption as drinking water. No on-site sources of groundwater have been developed for drinking water.
Meat Ingestion	No	The trespasser does not consume meat from animals culled from the site.
Milk Ingestion	No	Milk ingestion pathway is incomplete because milk cows are not allowed to graze in the unrestricted area.
Aquatic Foods Ingestion	No	There are no surface water ponds on the property.
Direct Ingestion	Yes	Trespassers are assumed to spend approximately 100% of their time in the unrestricted area outdoors. They may ingest relatively small amounts of soil through incidental oral contact with their hands.

17.4.2 - Industrial Worker Scenario (Unrestricted Area, Controls Fail)

Pathway	Retained	Comments
Direct Exposure	Yes	The source term found in the site soils produces penetrating gamma radiation. Exposure from direct penetrating radiation is expected to be a significant contributor to the overall potential dose. External radiation dose was modeled using Microshield; RESRAD does not accurately model a direct exposure at a distance form the source term.
Particulate Inhalation	Yes	Allowance is made for soils containing radiological constituents of the source being liberated and suspended in the breathing air of the industrial worker.
Radon	No	Radon is specifically excluded from consideration within the framework of the governing regulations. In addition, the source term found is not a significant producer of radon due to the relatively long half-life of the thorium isotopes found in the slag
Plant Ingestion	No	Ingestion of plant foods addresses those plant foods grown in the radioactivity or irrigated with water containing radioactivity from on Site. Since the industrial worker does not eat edible plant parts grown on site for food consumption, this pathway is incomplete.
Drinking Water	No	Surface water on site is unfit for consumption as drinking water. No on-site sources of groundwater have been developed for drinking water.
Meat Ingestion	No	Site workers do not consume meat from animals culled from the site.
Milk Ingestion	No	Milk ingestion pathway is incomplete because milk cows are not allowed to graze in the unrestricted area.
Aquatic Foods Ingestion	No	There are no surface water ponds on the property.
Direct Ingestion	Yes	Industrial workers are assumed to spend approximately 30% of their time outdoors. They may ingest relatively small amounts of soil through incidental oral contact with their hands.

17.4.3 - Suburban Resident Scenario(Unrestricted Area, Controls Fail)

Pathway	Retained	Comments
Direct Exposure	Yes	The source term found in the site soils produces penetrating gamma radiation. Exposure from direct penetrating radiation is expected to be a significant contributor to the overall potential dose. External radiation dose was modeled using Microshield; RESRAD does not accurately model a direct exposure at a distance form the source term.
Particulate Inhalation	Yes	Allowance is made for soils containing radiological constituents of the source being liberated and suspended in the breathing air of the suburban resident.
Radon	No	Radon is specifically excluded from consideration within the framework of the governing regulations. In addition, the source term found is not a significant producer of radon due to the relatively long half-life of the thorium isotopes found in the slag
Plant Ingestion	Yes	Ingestion of plant foods addresses those plant foods grown in the radioactivity or irrigated with water containing radioactivity from on Site.
Drinking Water	No	Surface water on site is unfit for consumption as drinking water. No on-site sources of groundwater have been developed for drinking water.
Meat Ingestion	Yes	The suburban resident may raise livestock and use water containing radioactivity from onsite to water the animals.
Milk Ingestion	Yes	Milk cows may be allowed to graze in the unrestricted area.
Aquatic Foods Ingestion	No	There are no surface water ponds on the property.
Direct Ingestion	Yes	Suburban residents are assumed to spend approximately 30% of their time outdoors. They may ingest relatively small amounts of soil through incidental oral contact with their hands.

17.4.4 - Maintenance Worker Scenario (Restricted Area, Controls in Place)

Pathway	Retained	Comments
Direct Exposure	Yes	The source term found in the site soils produces penetrating gamma radiation. Exposure from direct penetrating radiation is expected to be a significant contributor to the overall potential dose.
Particulate Inhalation	Yes	Allowance is made for soils containing radiological constituents of the source being liberated and suspended in the breathing air of the maintenance worker.
Radon	No	Radon is specifically excluded from consideration within the framework of the governing regulations. In addition, the source term found is not a significant producer of radon due to the relatively long half-life of the thorium isotopes found in the slag
Plant Ingestion	No	Ingestion of plant foods addresses those plant foods grown in the radioactivity or irrigated with water containing radioactivity from on Site. Since the maintenance worker does not eat edible plant parts grown on site for food consumption, this pathway is incomplete.
Drinking Water	No	Surface water on site is unfit for consumption as drinking water. No on-site sources of groundwater have been developed for drinking water.
Meat Ingestion	No	Site workers do not consume meat from animals culled from the site.
Milk Ingestion	No	Milk ingestion pathway is incomplete because milk cows are not allowed to graze on the storage yard.
Aquatic Foods Ingestion	No	There are no surface water ponds on the property.
Direct Ingestion	Yes	Maintenance workers may ingest relatively small amounts of soil through incidental oral contact with their hands.

17.4.5 - Industrial Worker Scenario (Restricted Area, Controls in Place)

Pathway	Retained	Comments
Direct Exposure	Yes	The source term found in the Site soils produces penetrating gamma radiation. Exposure from direct penetrating radiation is expected to be a significant contributor to the overall potential dose. External radiation dose was modeled using Microshield; RESRAD does not accurately model a direct exposure at a distance form the source term.
Particulate Inhalation	Yes	Allowance is made for soils containing radiological constituents of the source being liberated and suspended in the breathing air of the industrial worker.
Radon	No	Radon is specifically excluded from consideration within the framework of the governing regulations. In addition, the source term found is not a significant producer of radon due to the relatively long half-life of the thorium isotopes found in the slag
Plant Ingestion	No	The industrial workers does not eat plant parts grown on site for food consumption; this pathway is incomplete.
Drinking Water	No	Surface water on site is unfit for consumption as drinking water. No on-site sources of groundwater have been developed for drinking water.
Meat Ingestion	No	Industrial workers do not consume meat from animals culled from the site.
Milk Ingestion	No	Milk ingestion pathway is incomplete. Milk cows do not graze on the site.
Aquatic Foods Ingestion	No	No surface bodies of water are found on the site.
Direct Ingestion	No	Workers at the site do not enter the fenced Storage Yard and there is no direct contact with the soil.

17.4.6 - Trespasser Scenario (Restricted Area, Controls in Place)

Pathway	Retained	Comments
Direct Exposure	Yes	The source term found in the Site soils produces penetrating gamma radiation. Exposure from direct penetrating radiation is expected to be a significant contributor to the overall potential dose.
Particulate Inhalation	Yes	Allowance is made for soils containing radiological constituents of the source being liberated and suspended in the breathing air of the trespasser.
Radon	No	Radon is specifically excluded from consideration within the framework of the governing regulations. In addition, the source term found is not a significant producer of radon due to the relatively long half-life of the thorium isotopes found in the slag
Plant Ingestion	No	Ingestion of plant foods addresses those plant foods grown in the radioactivity or irrigated with water containing radioactivity from on Site. Since trespassers are not expected to glean edible plant parts grown on site for food consumption, this pathway is incomplete.
Drinking Water	No	Surface water on site is unfit for consumption as drinking water. No on-site sources of groundwater have been developed for drinking water.
Meat Ingestion	No	Trespassers are not expected to consume meat from animals culled from the site.
Milk Ingestion	No	Milk ingestion pathway is incomplete because milk cows do not graze at the site.
Aquatic Foods Ingestion	No	Trespassers are not expected to spend time fishing the surface water bodies surrounding the site.
Direct Ingestion	Yes	Trespassers on the site may ingest relatively small amounts of soil through incidental oral contact with their hands.

17.4.7 - Recreational Hunter Scenario (Restricted Area, Controls Fail)

Pathway	Retained	Comments
Direct Exposure	Yes	The source term found in the Site soils produces penetrating gamma radiation. Exposure from direct penetrating radiation is expected to be a significant contributor to the overall potential dose.
Particulate Inhalation	Yes	Allowance is made for soils containing radiological constituents of the source being liberated and suspended in the breathing air of the recreational hunter.
Radon	No	Radon is specifically excluded from consideration within the framework of the governing regulations. In addition, the source term found is not a significant producer of radon due to the relatively long half-life of the thorium isotopes found in the slag
Plant Ingestion	No	Ingestion of plant foods addresses those plant foods grown in the radioactivity or irrigated with water containing radioactivity from on Site. Since recreational hunters are not expected to glean edible plant parts grown on site for food consumption, this pathway is incomplete.
Drinking Water	No	Surface water on site is unfit for consumption as drinking water. No on-site sources of groundwater have been developed for drinking water.
Meat Ingestion	Yes	Recreational hunters are expected to consume meat from animals culled from the site.
Milk Ingestion	No	Milk ingestion pathway is incomplete since it is not credible to consider that recreational hunters would graze milk cows on this site.
Aquatic Foods Ingestion	No	Recreational hunters are not expected to spend time fishing the surface water bodies surrounding the site.
Direct Ingestion	Yes	Hunters on the site may ingest relatively small amounts of soil through incidental oral contact with their hands.

17.4.8 - Cover Excavation Scenario (Restricted Area, Controls Fail)

Pathway	Retained	Comments
Direct Exposure	Yes	The source term found in the Site soils produces penetrating gamma radiation. Exposure from direct penetrating radiation is expected to be a significant contributor to the overall potential dose. External radiation dose was modeled using Microshield; RESRAD does not accurately model a direct exposure with a limited exposure, in direct contact with the engineered cover or the excavation of the cover.
Particulate Inhalation	Yes	Allowance is made for soils containing radiological constituents of the source being liberated and suspended in the breathing air of the excavator excavating to the slag.
Radon	No	Radon is specifically excluded from consideration within the framework of the governing regulations. In addition, the source term found is not a significant producer of radon due to the relatively long half-life of the thorium isotopes found in the slag
Plant Ingestion	No	Ingestion of plant foods addresses those plant foods grown in the radioactivity or irrigated with water containing radioactivity from on Site. Since the excavator and others are not expected to glean edible plant parts grown on site for food consumption, this pathway is incomplete.
Drinking Water	No	Surface water on site is unfit for consumption as drinking water. No on-site sources of groundwater have been developed for drinking water.
Meat Ingestion	Yes	The excavator and others are not anticipated to consume meat from animals culled from the site.
Milk Ingestion	No	Milk ingestion pathway is incomplete since milk cows do not graze on this site.
Aquatic Foods Ingestion	No	The excavator and others does not expected to spend time fishing the surface water bodies surrounding the site.
Direct Ingestion	Yes	The excavator excavating the slag may ingest relatively small amounts of soil through incidental oral contact with their hands.

17.4.9 - Industrial Worker Scenario (Restricted Area, Controls Fail)

Pathway	Retained	Comments
Direct Exposure	Yes	The source term found in the Site soils produces penetrating gamma radiation. Exposure from direct penetrating radiation is expected to be a significant contributor to the overall potential dose. External radiation dose was modeled using Microshield; RESRAD does not accurately model a direct exposure at a distance form the source term.
Particulate Inhalation	Yes	Allowance is made for soils containing radiological constituents of the source being liberated and suspended in the breathing air of the industrial worker.
Radon	No	Radon is specifically excluded from consideration within the framework of the governing regulations. In addition, the source term found is not a significant producer of radon due to the relatively long half-life of the thorium isotopes found in the slag
Plant Ingestion	No	The industrial workers does not eat plant parts grown on site for food consumption; this pathway is incomplete.
Drinking Water	No	Surface water on site is unfit for consumption as drinking water. No on-site sources of groundwater have been developed for drinking water.
Meat Ingestion	No	Industrial workers do not consume meat from animals culled from the site.
Milk Ingestion	No	Milk ingestion pathway is incomplete. Milk cows do not graze on the site.
Aquatic Foods Ingestion	No	No surface bodies of water are found on the site.
Direct Ingestion	Yes	Industrial workers at the site may enter the fenced restricted area and have direct contact with the engineered barrier.

Table 17.4.10 - Industrial Worker (Unrestricted Area, Controls in Place, DCGL Basis)

Pathway	Retained	Comments
Direct Exposure	Yes	The source term found in the site soils produces penetrating gamma radiation. Exposure from direct penetrating radiation is expected to be a significant contributor to the overall potential dose. External radiation dose was modeled using Microshield; RESRAD does not accurately model a direct exposure at a distance form the source term.
Particulate Inhalation	Yes	Allowance is made for soils containing radiological constituents of the source being liberated and suspended in the breathing air of the industrial worker.
Radon	No	Radon is specifically excluded from consideration within the framework of the governing regulations. In addition, the source term found is not a significant producer of radon due to the relatively long half-life of the thorium isotopes found in the slag
Plant Ingestion	No	Ingestion of plant foods addresses those plant foods grown in the radioactivity or irrigated with water containing radioactivity from on Site. Since the industrial worker does not eat edible plant parts grown on site for food consumption, this pathway is incomplete.
Drinking Water	No	Surface water on site is unfit for consumption as drinking water. No on-site sources of groundwater have been developed for drinking water.
Meat Ingestion	No	Industrial workers do not consume meat from animals culled from the site.
Milk Ingestion	No	Milk ingestion pathway is incomplete because milk cows are not allowed to graze on the storage yard.
Aquatic Foods Ingestion	No	There are no surface water ponds on the property.
Direct Ingestion	Yes	Industrial workers are assumed to spend approximately 30% of their time outdoors. They may ingest relatively small amounts of soil through incidental oral contact with their hands.

Table 17.8 - Dose Modeling Results

17.8.1 - Occasional Trespasser (Unrestricted Area, Controls in Place)

Statistic	Projected Annual Dose (millirem/year)
Annual Dose Limit	25.0
Peak Mean Annual Dose	0.5 ± 0.8
50th Percentile	0.002 ± 0.0004
90th Percentile	1.9 ± 0.1
95th Percentile	2.2 ± 0.07
Maximum Annual Radiation Dose	3.3
Deterministic Estimate, Peak Annual Dose	1.3 @ 0 years
Summary reports showing source term, radiation dose, and geophysical parameters are provided in Appendix 19.5 (Newfield 3005007.rad)	

17.8.2 - Suburban Resident (Unrestricted Area, Controls Fail)

Statistic	Projected Annual Dose (millirem/year)
Annual Dose Limit	100
Peak Mean Annual Dose	<1
50th Percentile	<1
90th Percentile	<1
95th Percentile	<1
Maximum Annual Radiation Dose	<1
Deterministic Estimate, Peak Annual Dose	<1 @ 0 years
The suburban resident is exposed to gamma radiation stemming from the engineered barrier in the Storage Yard. The calculated exposure rate is less than $1x10^{-5}$ mR/hr or less than 1 millirem/year.	

17.8.3 - Maintenance Worker (Restricted Area, Controls in Place)

Statistic	Projected Annual Dose (millirem/year)
Annual Dose Limit	25.00
Peak Mean Annual Dose	$6x10^{-4} \pm 1x10^{-4}$
50th Percentile	$4x10^{-5} \pm 6x10^{-6}$
90th Percentile	$1x10^{-3} \pm 2x10^{-4}$
95th Percentile	$3x10^{-3} \pm 4x10^{-4}$
Maximum Annual Radiation Dose	0.02
Deterministic Estimate, Peak Annual Dose	$1x10^{-5}$ @ 0 years
Summary reports showing source term, radiation dose, and geophysical parameters are provided in Appendix 19.5.	

17.8.4 - Industrial Worker (Restricted Area, Controls in Place)

Statistic	Projected Annual Dose (millirem/year)
Annual Dose Limit	25.0
Peak Mean Annual Dose	<20.8
50th Percentile	<20.8
90th Percentile	<20.8
95th Percentile	<20.8
Maximum Annual Radiation Dose	<21
Deterministic Estimate, Peak Annual Dose	0.6 @ 1,000 years
Summary reports showing source term, radiation dose, and geophysical parameters are provided in Appendix 19.5. (Newfield 3005006.rad)	

The industrial worker is exposed to the source term from the Storage Yard with an engineered barrier as well as the residual radioactivity in the unrestricted area. The direct radiation exposure from the covered Storage Yard contributed 0.6 millirem per year (0.001 mR/hr for 595 hours) and the exposure from the residual radioactivity established by the DCGLs was less than $2.94x10^{-5}$ millirem per year.

17.8.5 - Trespasser (Restricted Area, Controls in Place)

Statistic	Projected Annual Dose (millirem/year)
Annual Dose Limit	25.00
Peak Mean Annual Dose	$6x10^{-4} \pm 2x10^{-4}$
50th Percentile	$4x10^{-5} \pm 7x10^{-6}$
90th Percentile	$1x10^{-3} \pm 2x10^{-4}$
95th Percentile	$3x10^{-3} \pm 4x10^{-4}$
Maximum Annual Radiation Dose	0.02
Deterministic Estimate, Peak Annual Dose	$1x10^{-6}$ @ 0 years
Summary reports showing source term, radiation dose, and geophysical parameters are provided in Appendix 19.5.	

17.8.6 - Recreational Hunter (Restricted Area, Controls Fail)

Statistic	Projected Annual Dose (millirem/year)
Annual Dose Limit	100.0
Peak Mean Annual Dose	13.6 ± 0.8
50th Percentile	0.4 ± 0.01
90th Percentile	47 ± 3
95th Percentile	54 ± 1
Maximum Annual Radiation Dose	78.6
Deterministic Estimate, Peak Annual Dose	0.3 @ 558 years
Summary reports showing source term, radiation dose, and geophysical parameters are provided in Appendix 19.5. (Newfield 3004008.rad)	

17.8.7 - Industrial Worker (Restricted Area, Controls Fail)

Statistic	Projected Annual Dose (millirem/year)
Annual Dose Limit	25.0
Peak Mean Annual Dose	0.03 ± 0.06
50th Percentile	0 ± 0
90th Percentile	0.1 ± 0.004
95th Percentile	0.2 ± 0.005
Maximum Annual Radiation Dose	0.4
Deterministic Estimate, Peak Annual Dose	0.0 @ 0 years
Summary reports showing source term, radiation dose, and geophysical parameters are provided in Appendix 19.5. (Newfield 30040004.rad)	

17.8.8 - Excavator (Restricted Area, Controls Fail)

Statistic	Projected Annual Dose (millirem/year)
Annual Dose Limit	100.0
Peak Mean Annual Dose	8.3
Deterministic Estimate, Peak Annual Dose	8.3
Microshield summary report showing source term, radiation dose, and geophysical parameters are provided in Appendix 19.5	

17.8.9 - Suburban Resident (Restricted Area, Controls Fail, Cover Excavated)

Statistic	Projected Annual Dose (millirem/year)
Annual Dose Limit	100
Peak Mean Annual Dose	<17
Deterministic Estimate, Peak Annual Dose	<17 @ 0 years
The suburban resident is exposed to gamma radiation stemming from the excavated area of the engineered barrier or 0.002 mR/hr or less than 17 millirem/year. See Microshield report	

17.8.10 - Recreational Hunter (Restricted Area, Controls Fail, Cover Excavated)

Statistic	Projected Annual Dose (millirem/year)
Annual Dose Limit	100.0
Peak Mean Annual Dose	13.7 ± 0.8
50th Percentile	0.5 ± 0.01
90th Percentile	47 ± 3
95th Percentile	54 ± 1
Maximum Annual Radiation Dose	78.7
Deterministic Estimate, Peak Annual Dose	0.4 @ 558 years
Summary reports showing source term, radiation dose, and geophysical parameters are provided in Appendix 19.5. (Newfield 3004008.rad)	

The recreational hunter is exposed to the source term from the Storage Yard with an engineered barrier as well as the elevated external exposure from the open excavation. The direct radiation exposure rate at three feet from the excavation of 0.13 mR/hr (see Table 17.8.8) is added to the total exposure on the Storage Yard (see Table 17.8.6). The exposure duration within the Storage Yard in general is identical to that in Table 17.8.6 (i.e., 75 hr), and the exposure duration within three feet of the excavation is assumed to be one (1) percent of the Storage Yard duration (i.e., 0.75 hr).

TABLE 17.14 - COST ESTIMATE FOR THE LTC (LONG-TERM CONTROL) ALTERNATIVE

Item	Quantity	Units	Materials	Labor	Equipment	O&P	Total Unit Price Incl. O&P	Base Year	Escalation	2006 Unit Cost	Total 2006 Cost	Present Value
<u>CAPITAL COSTS</u>												
SITE PREPARATION												
Mobilization	1	LS		$27,500.00	$12,500.00	$10,000.00	$20,000.00	1996	1.370	$27,000.00	$27,000	
Construction Surveying	7.1	ACRES	$49.00	$3,500.00	$101.00	$1,050.00	$4,700.00	2005	1.018	$4,785.20	$33,975	
Sediment and Erosion Controls	2,500	L. FT.	$2.40	$1.29	$0.05	$0.64	$4.38	2005	1.018	$4.46	$11,148	
SUBTOTAL												$72,123
ENGINEERED BARRIER CONSTRUCTION												
Dust Suppressant (Haul Roads)	28,000	SY	$0.26	$1.56	$1.05	$0.72	$3.60	2005	1.018	$3.66	$102,519	
Radiological and Air Monitoring	13	WEEKS	$1,653.12	$1,530.91	$171.44	$1,507.49	$4,862.96	2006	1.000	$4,862.96	$63,218	
Consolidation of Slag Piles into Cap Footprint	40,000	CY		$3.95	$3.64	$1.90	$9.48	2005	1.018	$9.65	$386,148	
Rough Grading of Coarse Slag	17,500	SY		$1.76	$3.63	$1.35	$6.74	2005	1.018	$6.86	$120,050	
Grading of Subgrade Cap Materials	17,500	SY		$0.13	$0.08	$0.05	$0.26	2005	1.018	$0.26	$4,616	
Adjacent Soil Characterization	4	DAYS	$3,930.00	$384.00	$100.00	$942.42	$5,356.42	2005	1.018	$5,453.52	$21,814	
Soil Isolation/ Frost Protection Layer	14,700	CY	$6.35	$3.47	$7.16	$4.25	$21.23	2005	1.018	$21.61	$317,714	
Stone Filter Layer	1,550	CY	$25.00	$8.10	$8.75	$10.46	$52.31	2005	1.018	$53.26	$82,554	
1/2" - 1 1/2" Stone on Top Slopes	325	CY	$25.00	$8.10	$8.75	$10.46	$52.31	2005	1.018	$53.26	$17,310	
2" - 4" Stone on Sideslopes	2,250	CY	$25.00	$8.10	$8.75	$10.46	$52.31	2005	1.018	$53.26	$119,837	
4" - 6" Stone at Toe of Sideslopes	525	CY	$25.00	$8.10	$8.75	$10.46	$52.31	2005	1.018	$53.26	$27,962	
Topsoil for NRC Area Outside of Barrier	6,100	CY	$21.00	$7.58	$4.07	$8.16	$40.81	2005	1.018	$41.55	$253,457	
Fine Grade, Seed and Mulch	18,300	SY	$0.35	$1.35	$0.22	$0.80	$2.72	2005	1.018	$2.77	$50,678	
Drainage Improvements	1	LS		$5,700.00	$5,700.00	$3,600.00	$15,000.00	2005	1.018	$15,271.91	$15,272	
SUBTOTAL												$1,583,151
FINAL STATUS SURVEY	30	DAYS	$1,348.00	$955.67	$37.15	$740.00	$3,080.82	2006	1.000	$3,080.82	$92,425	$92,425
DEMOBILIZATION/ DECONTAMINATION/ SITE CLEANUP	1	LS		$11,000.00	$5,000.00	$4,000.00	$20,000.00	1996	1.370	$27,400.68	$27,401	$27,401
CONSTRUCTION SUBTOTAL												$1,775,100
IMPLEMENTATION COSTS												
Administrative Costs (5%)											$88,755	
Project Management During Construction (10%)											$177,510	
Permits and Legal Documentation (10%)											$177,510	
Engineering Design Costs (10%)											$177,510	
IMPLEMENTATION TOTAL												$621,285
SUBTOTAL - CONSTRUCTION AND IMPLEMENTATION												$2,396,385
25% CONTINGENCY ON TOTAL CAPITAL COST												<u>$599,096</u>
<u>CAPITAL COST GRAND TOTAL, INCLUDING CONTINGENCY</u>												$2,995,481

TABLE 17.14 - COST ESTIMATE FOR THE LTC (LONG-TERM CONTROL) ALTERNATIVE

Item	Quantity	Units	Materials	Labor	Equipment	O&P	Total Unit Price Incl. O&P	Base Year	Escalation	2006 Unit Cost	Total 2006 Cost	Present Value
1000-YEAR O&M COSTS												
ANNUAL O&M COSTS												
Visual and Ambient Gamma Radiation Surveys	1	LS	$181.37	$406.30	$111.43	$397.78	$1,096.88	2006	1.000	$1,100.00	$1,100	
Site Security Maintenance	12	MONTHS	$100.00	$384.00	$100.00	$426.00	$1,010.00	2006	1.000	$1,010.00	$12,120	
Cap Maintenance	12	MONTHS	$100.00	$192.00	$100.00	$228.00	$620.00	2006	1.000	$620.00	$7,440	
NRC Fees												
Annual Report Review/Inspection	1	LS					$10,000.00	2005	1.018	$10,181.26	$10,181	
Additional Cost Every 5 Years for License Renewal, Expanded Inspection and Report Review (converted to an annual cost)	1	LS					$20,000.00	2005	1.018	$20,362.55		
1% Discount Rate											$4,195	
Trust Fund Fees & Expenses	1	LS					$5,390.00	2005	1.018	$5,487.71	$5,488	
PRESENT WORTH - 1000-YEAR O&M COSTS (1% DISCOUNT RATE)												
Visual and Ambient Gamma Radiation Surveys												$110,000
Site Security Maintenance												$1,212,000
Cap Maintenance												$744,000
NRC Fees												
Annual Report Review/Inspection												$1,018,128
5-Year License Renewal, Expanded Inspection, Report Review												$419,460
Trust Fund Fees & Expenses												$548,771
SUBTOTAL O&M (1% DISCOUNT RATE)												$4,052,359
25% CONTINGENCY												$1,013,090
SUBTOTAL O&M (1% DISCOUNT RATE) INCLUDING CONTINGENCY												$5,065,449
GRAND TOTAL CAPITAL AND 1,000-YEAR O&M COSTS AT 1% DISCOUNT RATE, INCLUDING CONTINGENCY												$8,060,930

TABLE 17.15 - COST ESTIMATE FOR THE LT (LICENSE TERMINATION) ALTERNATIVE

Item	Quantity	Units	Materials	Labor	Equipment	O&P	Total Unit Price Incl. O&P	Base Year	Escalation	2006 Unit Cost	Total 2006 Cost	Present Value
CAPITAL COSTS												
SITE PREPARATION												
Mobilization	1	LS		$22,500.00	$15,000.00	$12,500.00	$50,000.00	1996	1.370	$69,000.00	$69,000	
Sediment and Erosion Controls	2,500	L. FT.	$2.40	$1.29	$0.05	$0.64	$4.38	2005	1.018	$4.46	$11,148	
Clear and Grub Dense Brush Including Stumps	2.7	AC		$1,525.00	$3,550.00	$1,175.00	$6,250.00	2005	1.018	$6,363.30	$17,181	
Gravel Roadway	3,700	SY	$8.35	$0.80	$0.87	$2.50	$12.52	2005	1.018	$12.75	$47,167	
SUBTOTAL												$144,496
RAILROAD IMPROVEMENTS												
Remove Old Railroad Ties and/or Track	3,000	LF		$4.89	$1.87	$2.79	$9.55	2005	1.018	$9.72	$29,169	
New Crossties with Tie Plates and Spikes	3,000	EA	$44.93	$24.87	$18.92	$13.31	$102.03	2005	1.018	$103.88	$311,633	
New Track	2,400	LF	$13.59	$2.15	$0.27	$2.40	$18.41	2005	1.018	$18.75	$44,989	
Car Bumper	1	EA	$2,525.00	$519.50	$266.38	$496.63	$3,807.51	2005	1.018	$3,876.53	$3,877	
Wheelstops	1	PAIR	$565.00	$74.21	$38.05	$101.59	$778.85	2005	1.018	$792.97	$793	
Railcar Switcher	294	DAYS					$2,000.00	1996	1.370	$2,700.00	$793,800	
SUBTOTAL												$1,184,260
ONSITE SLAG PROCESSING												
Dust Suppressant	76,667	SY	$0.26	$1.56	$1.05	$0.72	$3.60	2005	1.018	$3.66	$280,708	
Radiological and Air Monitoring	21	WEEKS	$1,690.47	$1,523.62	$265.32	$1,541.37	$5,020.78	2006	1.000	$5,020.78	$105,436	
Relocation of Coarse Slag to Staging Area	43,000	CY		$3.95	$3.64	$1.14	$8.72	2005	1.018	$8.88	$381,900	
Relocation of Baghouse Dust, Finer Slag and Soils to Staging Area	33,000	CY		$3.16	$2.87	$0.90	$6.93	2005	1.018	$7.06	$232,999	
Crush Slag Larger Than Disposal Facility Cutoff	81,000	TONS					$43.20	1996	1.370	$59.19	$4,794,022	
Load Slag Materials into Railcars	76,000	CY		$3.16	$2.87	$0.90	$6.93	2005	1.018	$7.05	$536,603	
Adjacent Soil Characterization	8	DAYS	$3,480.00	$384.00	$100.00	$1,017.42	$4,981.42	2005	1.018	$5,071.72	$40,574	
SUBTOTAL.												$6,372,242
OFFSITE SLAG DISPOSAL												
Haul Slag to Envirocare Facility in Utah	2,052,000	CF					$5.38	1994	1.424	$7.66	$15,717,756	
Slag Disposal at Envirocare in Utah	2,052,000	CF					$8.00	1994	1.424	$11.39	$23,372,128	
SUBTOTAL												$39,089,884
FINAL STATUS SURVEY	30	DAYS	$1,348.00	$955.67	$37.15	$740.00	$3,080.82	2006	1.000	$3,080.82	$92,425	$92,425
SITE RESTORATION												
Grading	35,000	SY		$0.12	$0.19	$0.05	$0.36	2005	1.018	$0.36	$12,704	
Topsoil (assume 1 foot of clean soil)	11,500	CY	$21.00	$4.17	$3.05	$4.23	$32.45	2005	1.018	$33.04	$379,975	
Fine Grade and Seed	35,000	SY	$0.35	$1.35	$0.22	$0.29	$2.21	2005	1.018	$2.25	$78,681	
Drainage Improvements	1	LS		$5,700.00	$5,700.00	$3,600.00	$15,000.00	2005	1.018	$15,271.91	$15,272	
SUBTOTAL												$486,631
DEMOBILIZATION/ DECONTAMINATION/ SITE CLEANUP	1	LS	$5,000.00	$22,500.00	$15,000.00	$12,500.00	$55,000.00	1996	1.370	$75,000.00	$75,000	$75,000
CONSTRUCTION TOTAL												$47,444,938
IMPLEMENTATION COSTS												
Administrative Costs (1%)											$474,449	
Project Management During Construction (2%)											$948,899	
Permits and Legal Documentation (1%)											$474,449	
Engineering Design Costs (2%)											$948,899	
IMPLEMENTATION TOTAL												$2,846,696
CAPITAL COST TOTAL												$50,291,635
CONTINGENCY (25%)												$12,572,909
GRAND TOTAL CAPITAL COST (INCLUDING CONTINGENCY)												$62,864,543

TABLE 17.16 - COST ESTIMATE FOR THE LC (LICENSE CONTINUATION) ALTERNATIVE

Item	Quantity	Units	Materials	Labor	Equipment	O&P	Total Unit Price Incl. O&P	Base Year	Escalation	2005 Unit Cost	Total 2005 Cost	Present Value
1000-YEAR SURVEILLANCE AND MONITORING COSTS												
ANNUAL O&M COSTS												
USNRC Fees	1	LS					$62,400.00	2006	1.000	$62,400.00	$62,400	
On-Site Monitoring	1	LS	$362.74	$812.60	$222.86	$795.56	$2,193.76	2006	1.000	$2,200.00	$2,200	
PRESENT WORTH - 1000-YEAR O&M COSTS (1% DISCOUNT RATE)												
USNRC Fees												$6,240,000
On-Site Monitoring												$220,000
SUBTOTAL O&M (1% DISCOUNT RATE)												$6,460,000
CONTINGENGY (25%)												$1,615,000
GRAND TOTAL CAPITAL AND 1,000-YEAR O&M COSTS AT 1% DISCOUNT RATE, INCLUDING CONTINGENCY												**$8,075,000**

Appendix C - Consultant's Report on Groundwater Potability

TRC

GROUND WATER POTABILITY ANALYSIS

Shieldalloy Metallurgical Corporation
Newfield, New Jersey

Prepared for
Shieldalloy Metallurgical Corporation
Newfield, New Jersey

Prepared by
TRC Environmental Corporation
Windsor, Connecticut

TRC Project No. 26770-0100-00000
June 2006

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TABLE OF CONTENTS

TABLE OF CONTENTS
(Continued)

TABLES

FIGURES

1.0 INTRODUCTION

Shieldalloy Metallurgical Corporation (SMC) in Newfield, New Jersey is currently seeking approval from the U.S. Nuclear Regulatory Commission (NRC) for decommissioning under its source material license SMB-743. The purpose of this report is to evaluate the potability of ground water in the vicinity of the SMC. This evaluation has been conducted in accordance with NRC document NUREG-1757, Volume 2 (Sections I.3.3.3.2 and M.5.2.1.4).

This report summarizes and evaluates ground water quality conditions at the SMC facility based on historic and current analytical results of ground water samples. The site has been designated as a Superfund site and, as such, has undergone extensive ground water characterization activities. Numerous ground water monitoring wells are present, as are ground water extraction wells associated with an existing pump-and-treat system implemented to treat chromium and trichloroethylene (TCE) ground water contamination. The monitoring/extraction system extends with the ground water plume to the southwest, to a farm parcel property that SMC purchased to support the implementation of ground water remedial actions. The pump-and-treat system was implemented due to the presence of ground water contaminants at levels exceeding federal drinking water standards. A site plan of the SMC facility, including the locations of all current ground water monitoring and remediation extraction wells, is presented in Figure 1. In addition, water table and piezometric surface contours have been developed for the shallow and deep portions of the underlying Cohansey aquifer, respectively (as presented in Figures 2 and 3), which illustrate a general ground water flow direction from northeast to southwest across the SMC site and adjacent farm parcel.

The evaluation presented herein includes an exploration of volatile organic, semi-volatile organic and inorganic (including unfiltered and filtered metals, major ions and nutrients) parameter results from ground water sampling events conducted between October 1988 and April 2006. The ground water sampling investigations represented here were conducted by both Dan Raviv Associates, Inc. (DRAI) and TRC Environmental Corporation (TRC), with analytical results presented in detail in the April 1990 DRAI report entitled Summary of Geohydrologic Information Collected Since January 1988, as well as in TRC's Remedial Investigation Report (April 1992), Final Focused Feasibility Study Report (February 1994), and a number of quarterly and annual ground water monitoring reports from sampling conducted between July 2001 and April 2006. Additional ground water issues relating to ground water potability in the vicinity of the SMC site (i.e., well restriction area, classification exception area) are also discussed in the report.

2.0 SITE INFORMATION

2.1 Site History

SMC operated a metal specialty plant producing chromium alloys, ferro-alloys, and other specialty metal products at this site since 1952. Production activities included processing ores plus degreasing operations to clean metal work beginning circa 1965 (TRC, 1992). Past disposal practices discharged untreated wastewater to an unlined lagoon circa 1960s to 1971, until being replaced with lined lagoons, which received treated wastewater. Other operational by-products of site operations include materials regulated by the NRC under the facility's source material license (e.g., slag and baghouse dust) which are stored on-site in an area referred to as the Storage Yard. Other historical areas of environmental concern (AOCs) include permanently closed diesel and gasoline underground storage tanks (USTs). Current and historical use of the farm parcel, southwest of the manufacturing facility, remains agricultural.

Environmental investigations at SMC's facility began in 1972, after hexavalent chromium was detected in a nearby newly-installed municipal supply well, which triggered additional studies evaluating the potential environmental impacts associated with SMC's facility operations. Consequently, the site has an extensive history of soil, ground water, sediment and surface water characterization, plus remedial activities, which are summarized chronologically below:

- SMC installed an 80 gallon per minute (gpm) ground water pump and treat remediation system in 1979;
- SMC installed a 400 gpm ground water pump and treat remediation system to control offsite migration of hexavalent chromium under an October 1988, NJDEP Administrative Consent Order (ACO);
- Remedial Investigation (RI) Technical Report (TRC, 1992);
- Final Focused (Ground Water) Feasibility Study (TRC, 1994);
- Characterized, remediated, and closed nine wastewater treatment lagoons from 1994 to 1997;
- Draft Final Feasibility Study Report (Soil, Sediment and Surface Water) (TRC, 1996);

- Record of Decision (ROD) in 1996 for the ground water operable unit; and
- Quarterly/Annual Ground Water Monitoring Reports

Based on these investigations, TCE and chromium have been defined as the primary contaminants of concern (COCs) in ground water and are being remediated by the pump-and-treat system. Both the TCE and chromium plumes have migrated to SMC's farm parcel. Five extraction wells, two on-site in the southwest corner of the manufacturing portion of the facility and three offsite, withdraw ground water at a rate of approximately 400 gpm and hydraulically control migration of the chromium plume.

2.2 Site Geology

Surficial materials at the site are characterized by brown sand that is representative of the Bridgeton Formation. The thickness of the sand ranges from 0 meters (offsite well SC-17D) to 8.5 meters (28 feet) (well SC-12D). The underlying Cohansey Sand is the major geologic formation identified during subsurface investigations at the SMC facility. The Cohansey Sand is composed of coarse sands and little to trace silt in the upper 12 meters (40 feet), and generally finer sand and some silt, with some clay and silt stringers in the lower 18 to 24 meters (60 to 80 feet). Discontinuous silt and clay lenses up to 1.8 meters (6 feet) thick were encountered. The Kirkwood Formation, described as a gray silt and clay layer, has been encountered on-site at depths ranging from 37 meters (121 feet) below grade (on-site well SC-22D) to 46.6 meters (153 feet) bgs (offsite well SC-17D). More information on site geology is presented in the October 2005 Decommissioning Plan (IEM and TRC, 2005).

2.3 Site Hydrogeology

As previously mentioned, the Cohansey Sand below the site is composed of coarse sands and little to trace silt in the upper 12 meters (40 feet), and generally finer sand and some silt, with some clay and silt stringers in the lower 18 to 24 meters (60 to 80 feet). Based on pumping test analyses, the shallow and deep transmissivities vary for the upper and lower Cohansey Sand beneath the SMC facility, with lower transmissivity and specific yield values for the lower Cohansey Sand (due to the smaller grain size sand and increased percentage of silt and clay) than for the upper Cohansey Sand. Based on these differences, historically the ground water data for the shallow wells (screened above 15 meters or 50 feet) have been evaluated separately from the data for the deeper wells (screened below 15 meters). These two zones are referred to herein as the Upper Cohansey Sand and the Lower Cohansey Sand.

The ground water flow directions in both the Upper and Lower Cohansey Sands closely correlate to the general topography of the site, which slopes gently to the southwest, as indicated in Figures 2 and 3. The average horizontal gradient for both the water table and piezometric surface is 0.002 ft/ft. The extraction of ground water as part of SMC's ground water treatment system impacts the contours, especially in the lower Cohansey Sand. A downward hydraulic gradient has been observed at most of the well clusters on-site, consistent with the ground water pumping conditions at and downgradient of the site.

2.4 Ground Water Use

Potable water is provided locally by the Newfield Water Department and the Vineland Water and Sewer Utility. Each utility relies solely on ground water sources for its potable water. The Newfield Water Department serves approximately 1,900 individuals in Newfield Borough and Franklin Township from two wells, one located at Catawba and Hazel (Well 3) and one located at Catawba and Woodlawn (Well 5). These wells are located to the north and northeast of the SMC facility, respectively. The Newfield Water Department also purchases ground water to supplement that produced by the two Newfield wells (NJDEP, 2004a; NJDEP, 2004b).

The Vineland Water and Sewer Utility serve approximately 31,000 individuals in the City of Vineland from 13 wells. The nearest well to the SMC facility is referred to as Well 10, located along Delsea Drive, just north of Burnt Mill Pond.

Due to the presence of chromium and TCE in ground water beneath and downgradient of the SMC facility, the City of Vineland has designated an area of the city downgradient from the SMC facility as a well restriction area, requiring mandatory connection with public water systems. More information on the well restriction area is presented in Section 7.

3.0 METHODOLOGY

Ground water monitoring data for the SMC facility encompass a large number of sampling events, ranging from larger-scale remedial investigations to smaller-scale monthly monitoring, over the course of many years. Similarly, the range of analytes included in the sampling events varies based on the scale of the investigation. Therefore, in an effort to emphasize general ground water conditions, this evaluation focused on select sampling events involving the most comprehensive sets of data dating back to December 1990. Data for both the Upper (represented by shallow monitoring wells) and Lower (represented by deep monitoring wells) Cohansey aquifers were considered, based on the maximum detected concentration of each analyte in each aquifer for each sampling round represented. The majority of these sampling events consisted of quarterly and/or annual ground water monitoring conducted by TRC.

To evaluate the potability of the ground water, analytical results are compared to applicable drinking water standards. Standards considered in this analysis include promulgated federal standards, namely the Federal Primary Maximum Contaminant Levels (MCL), legally enforceable standards that apply to public water systems, and Secondary MCLs, non-enforceable guidelines regulating contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water, were also considered. Lists of Federal Primary and Secondary MCLs are summarized on Tables M.11 and M.12, respectively of the NRC NUREG-1757 document (US NRC, 2003). These lists are not complete, however, when compared to the Primary MCLs defined at 40 CFR 141.11 through 141.16 and 141.61 through 141.66, and the Secondary MCLs defined at 40 CFR 143.3. The currently promulgated values defined at 40 CFR 141 and 40 CFR 143 were used in conducting these analyses.

4.0 HISTORIC ORGANIC GROUND WATER RESULTS

A comparison of the maximum concentrations of VOCs, SVOCs and pesticides/PCBs detected in ground water samples to applicable drinking water standards is presented in Table 1. As indicated, several compounds have historically exceeded their associated drinking water standards. The following eight VOC compounds have been detected at levels exceeding their respective MCLs:

- benzene
- 1,1-dichloroethene
- 1,2-dichloroethene
- 1,1,1-trichloroethane
- trichloroethene (TCE)
- tetrachloroethene (PCE)
- toluene
- vinyl chloride

For the majority of these compounds, MCL exceedances in both the Upper and Lower Cohansey have been sporadic. However, PCE in the deep aquifer and TCE in both the shallow and deep portions of the aquifer have consistently been detected at concentrations exceeding each compound's MCL of 5 µg/L. Current (April 2006) isopleth maps of the shallow and deep TCE plumes are presented in Figures 4 and 5, respectively.

Analysis of ground water samples for SVOCs, pesticides and PCBs has not been regularly conducted at the SMC site. The most recent SVOC results from December 1990 and April 1991 indicated that no SVOCs were present at levels exceeding their applicable drinking water quality standards (Table 1). Furthermore, pesticides/PCBs, which were last included as ground water analytes in December 1990, were not detected at levels exceeding their respective MCLs.

5.0 HISTORIC INORGANIC RESULTS

A comparison of the maximum concentrations of select unfiltered (total) metals detected in ground water to the applicable drinking water standards is presented in Table 2. As indicated there, several analytes have been detected at levels exceeding Primary or Secondary MCLs. These include the following:

- aluminum
- antimony
- arsenic
- beryllium
- cadmium
- chromium (total)
- selenium
- cyanide
- fluoride
- iron
- lead
- manganese
- mercury

Furthermore, two of these metals, aluminum and chromium, have consistently been detected at levels exceeding their associated MCLs in both the shallow and deep portions of the aquifer. Isopleth maps depicting the shallow and deep total chromium plume, created from the most current annual sampling event (April 2006) analytical results, are presented in Figures 6 and 7, respectively. In addition, although there is no federal drinking water quality standard associated with hexavalent chromium, due to its high toxicity and consistently elevated concentrations, isopleth maps of the shallow and deep hexavalent chromium plumes are presented in Figures 8 and 9, respectively.

In addition to metals, several additional inorganic parameters (e.g., major ions, nutrients, pH, etc.) have also historically exhibited maximum concentrations in exceedance of Secondary MCLs, as indicated in Table 2. These include chloride, nitrate, sulfate and pH. Sulfate has historically exceeded the associated MCL (250,000 µg/L) on a regular basis. In addition, the range of ground water pH levels has consistently exceeded (above and below) the range established as the Secondary MCL of 6.50 to 8.50.

Ground water sampling of filtered (dissolved) metals was also conducted for a full list of metals during December 1990 and April 1991, while select filtered metals were analyzed during July 2002. Maximum concentrations of several analytes exceeded their associated Primary MCLs, as indicated in Table 3. The dissolved metals exhibiting exceedances included the following:

- aluminum
- antimony
- arsenic
- beryllium
- cadmium
- chromium (total)
- iron
- lead
- manganese
- mercury
- selenium

Once again, chromium consistently exceeded it associated MCL (100 μg/L) in both the shallow and deep portions of the aquifer.

6.0 GROUND WATER USE RESTRICTIONS

In accordance with NJS 40:63-52, et seq., and due to the presence of contaminants in ground water at levels exceeding MCLs at the SMC site, the City of Vineland in 1986 designated an area of the city (approximately 800 acres or 1.25 square miles), immediately downgradient from the SMC facility, as a well restriction area requiring mandatory connection with public water systems. A figure depicting the well restriction area is presented as Figure 10, and a copy of the legal description of the well restriction area (as provided by the City of Vineland Water-Sewer Utility) is attached to this document.

In addition to the well restriction area, in a letter dated September 18, 2000 (attached) the NJDEP documented its determination that a Classification Exception Area (CEA) would be established for the ground water contamination at and emanating from the SMC site. In accordance with N.J.A.C. 7:9-6.6, NJDEP can establish a CEA when the Department determines that constituent standards for a given ground water classification are not being met or will not be met due to natural quality, localized effects of a NJDEP-permitted discharge, or pollution caused by human activity within a contaminated site as defined by the Department in the context of an applicable regulatory program. A CEA is an institutional control by which NJDEP can protect public health and the environment by suspending the designated uses of the aquifer. The designated use of the ground water in the vicinity of SMC is as potable water and conversion (through conventional water supply treatment, mixing or other similar technique) to potable water, with a secondary designated use that includes agriculture water and industrial water. In accordance with N.J.A.C. 7:9-6.6(d), "all designated uses in each CEA will be suspended during the life of the CEA". Furthermore, the NJDEP "shall restrict or require the restriction of potable ground water uses within any CEA where there is or will be an exceedance of the Primary Drinking Water Quality Standards." Therefore, NJDEP has acknowledged, through its commitment to establish a CEA, that ground water at and in the vicinity of the SMC facility, is not potable.

7.0 CONCLUSIONS

Based on historical results of ground water sampling at the SMC facility it is clear that ground water is not potable. A number of analytes, including organic compounds, total and dissolved metals, major ions, and nutrients have been and/or are currently in exceedance of the federal primary and/or secondary drinking water quality standards (MCLs). Furthermore, PCE, TCE, total and dissolved inorganics (i.e., aluminum and chromium), major ions/nutrients (i.e., sulfate) and pH have consistently been detected at levels exceeding their associated MCLs over an extended period of time. Elevated concentrations of highly toxic hexavalent chromium have also been consistently detected in ground water throughout and downgradient of the site. Extensive TCE and total/hexavalent chromium plumes (1,000 to greater than 4,000 feet in length) exist in the aquifer beneath and emanating from the SMC site. In addition, Ra-226 and Ra-228 combined has historically been detected, albeit inconsistently, at levels exceeding its associated federal drinking water quality standard.

Finally, the City of Vineland has acknowledged that ground water is not potable by establishing a well restriction area immediately downgradient of the SMC site. Similarly, NJDEP has acknowledged that ground water is impaired and not potable through it's determination that a ground water CEA will be established for the site area.

8.0 REFERENCES

Dan Raviv Associates, Inc. (DRAI), Ground Water Remediation Alternatives, Shieldalloy Corporation, Newfield, New Jersey, April 1987, Finalized January 1988.

DRAI, Summary of Geohydrologic Information Collected Since January 1988, April 1990.

Integrated Environmental Management, Inc. (IEM) and TRC Environmental Corporation (TRC), Decommissioning Plan, Volumes I, II and III, Revision 1, October 2005.

New Jersey Department of Environmental Protection, 2004a; Source Water Assessment Report for Newfield Water Department, November 2004.

NJDEP, 2004b. Source Water Assessment Report for Vineland Water and Sewer Utility, November 2004.

TRC Environmental Corporation (TRC), Remedial Investigation Report – Shieldalloy Metallurgical Corporation, April 1992.

TRC Environmental Corporation (TRC), Final Focused Feasibility Study - Ground Water Remediation, Revision 2, February 1994.

TRC, Draft Final Feasibility Study Report, Volumes I, II and III (Background Study, Soil, and Surface Water and Sediment), April 1996.

U.S. Nuclear Regulatory Commission Consolidated NMSS Decommissioning Guidance, Characterization, Survey, and Determination of Radiological Criteria, NUREG 1757, Vol. 2, September 2003.

9.0 REFERENCES

Dan Raviv Associates, Inc. (DRAI), Ground Water Remediation Alternatives, Shieldalloy Corporation, Newfield, New Jersey, April 1987, Finalized January 1988.

DRAI, Summary of Geohydrologic Information Collected Since January 1988, April 1990.

Integrated Environmental Management, Inc. (IEM) and TRC Environmental Corporation (TRC), Decommissioning Plan, Volumes I, II and III, Revision 1, October 2005.

New Jersey Department of Environmental Protection, 2004a; Source Water Assessment Report for Newfield Water Department, November 2004.

NJDEP, 2004b. Source Water Assessment Report for Vineland Water and Sewer Utility, November 2004.

TRC Environmental Corporation (TRC), Remedial Investigation Report – Shieldalloy Metallurgical Corporation, April 1992.

TRC Environmental Corporation (TRC), Final Focused Feasibility Study - Ground Water Remediation, Revision 2, February 1994.

TRC, Draft Final Feasibility Study Report, Volumes I, II and III (Background Study, Soil, and Surface Water and Sediment), April 1996.

U.S. Nuclear Regulatory Commission Consolidated NMSS Decommissioning Guidance, Characterization, Survey, and Determination of Radiological Criteria, NUREG 1757, Vol. 2, September 2003.

TABLE 1
HISTORICAL COMPARISON OF MAXIMUM DETECTED CONCENTRATIONS OF ORGANICS
TO FEDERAL GROUND WATER QUALITY STANDARDS
December 1990 through January 2006
Shieldalloy Metallurgical Corporation

Parameter	December 1990 & April 1991		July 2001		October 2001		January 2002		July 2002		October 2002		MCLs
	Upper Cohansey	Lower Cohansey	Upper Cohansey	Lower Cohansey	Upper Cohansey	Lower Cohansey	Upper Cohansey	Lower Cohansey	Upper Cohansey	Lower Cohansey	Upper Cohansey	Lower Cohansey	Primary[1]
Volatile Organics (ug/L)													
Acetone	170 (W3)	160 (SC5D)	ND	1.3 J (SC28D)	ND	51 (SC22D)	16 (SC21S)	30 (SC22D)	ND	67 (SC22D)	ND	54 (SC22D)	
Benzene	78 (SC23S)	4 (SC5D)	ND	ND	1 (K)	ND	ND	ND	ND	ND	ND	ND	5
Bromodichloromethane	ND	ND	ND	ND	0.6 (K)	ND	ND	ND	ND	ND	ND	ND	80 (a)
Bromomethane	ND	ND	4.1 (K)	ND	ND	0.22 J (SC28D)	ND	ND	ND	ND	ND	ND	
2-Butanone (MEK)	78 (SC6S)	ND	ND	ND	ND	2.4 (SC2DR)	ND	ND	ND	ND	ND	ND	
Carbon Disulfide	2 (SC4S)	2 (SC4D)	ND	ND	9 (SC5S)	6.7 (SC22D)	ND	5 J (SC22D)	ND	ND	ND	ND	
Chlorobenzene	ND	ND	ND	ND	0.9 (K)	ND	ND	ND	ND	ND	ND	ND	
Chloroform	ND	ND	ND	ND	0.8 (K)	ND	ND	ND	ND	0.2 J (SC30D)	ND	0.2 J (SC30D)	80
Chloromethane	ND	ND	ND	ND	ND	0.26 J (SC28D)	ND	ND	ND	ND	ND	ND	
1,4-Dichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	75
1,1-Dichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
1,2-Dichloroethane	ND	ND	ND	ND	1.9 (SC5S)	1.8 (SC2DR)	ND	ND	ND	ND	ND	ND	5
1,1-Dichloroethene	4 (SC6S)	ND	ND	2.6 (IW2)	ND	ND	ND	0.8 J (SC5D)	ND	ND	ND	ND	7
1,2-Dichloroethene (total)	270 (SC20S)	25 (SC5D)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	70(b) 100 (c)
cis-1,2-Dichloroethene	ND	ND	ND	0.66 (SC28D)	1.1 (K)	0.9 (SC2DR)	ND	0.6 (SC24D & SC28D)	ND	1 J (IW2)	ND	2 J (IW2)	70
trans-1,2-Dichloroethene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	100
1,2-Dichloropropane	ND	ND	ND	ND	1.7 (IWC2)	ND	ND	ND	ND	ND	ND	ND	5
Ethylbenzene	630 (SC23S)	ND	120 (SC23S)	ND	6 (SC23S)	ND	ND	ND	230 (SC23S)	ND	35 (SC23S)	ND	700
Methylene Chloride	37 (SC27S)	32 (A)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
4-Methyl-2pentanone	120 (SC18S)	3 (SC18D & SC19D)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
Naphthalene	NA	NA	NA	ND	NA	0.2 J (SC28D)	NA	ND	NA	ND	NA	ND	
Styrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	100
1,2,3-Trichlorobenzene	NA	NA	NA	ND	NA	ND	NA	ND	NA	ND	NA	1 (SC30D)	
1,2,4-Trichlorobenzene	NA	NA	NA	ND	NA	ND	NA	ND	NA	ND	NA	0.6 H (SC30D)	70
1,1,1-Trichloroethane	9 (SC6S)	ND	ND	2.2 (IW2)	ND	ND	ND	2 J (IW2)	ND	2 J (IW2)	ND	ND	200
Trichloroethene	840 (SC20S)	430 (SC5D)	14 (K)	30 (SC24D)	28 (K)	25 (SC24D)	29 (K)	18 (SC28D)	44 (K)	21 (A)	49 (K)	17 (SC22D)	5
1,1,2,2-Tetrachloroethane	ND	ND	ND	ND	0.7 (K)	ND	ND	ND	ND	ND	ND	ND	
Tetrachloroethene	4 (SC19S)	3 (SC19D)	ND	7.7 (IW2)	1 (K)	7.8 (IW2)	ND	1 J (SC2DR)	ND	66 (IW2)	ND	44 (IW2)	5
Toluene	4900 (SC23S)	5 (SC21D)	240 (SC23S)	17 (SC22D)	13 (SC23S)	ND	ND	1 J (SC22D)	190 (SC23S)	12 (SC26D)	13 (SC23S)	ND	1,000
Vinyl Chloride	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.3 J (SC30D)	2
Xylene (total)	2100 (SC23S)	3 (SC21D)	ND	ND	12 (SC23S)	ND	ND	2 J (SC22D)	1,100 (SC23S)	0.2 J (SC30D)	150 (SC23S)	ND	10,000
Semivolatile Organics (ug/L)													
Bis(2-ethylhexyl)phthalate	6 (IWC2)	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	6
Di-n-butylphthalate	ND	1 (SC22D)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Phenol	1 (SCG1S)	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
PCBs (ug/L)	ND	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Pesticides (ug/L)	ND	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	

NOTES:
Shaded results indicate analyte that is in exceedance of Maximum Contaminant Levels (MCLs)
Monitoring well exhibiting the maximum analyte concentration is shown in parentheses.
ND - Not Detected
NA - Not Analyzed
(1) Primary MCL - Primary Maximum Contaminant Level. 40 CFR Part 141
(2) Secondary MCL - Secondary Maximum Contaminant Level, 40 CFR Part 143 - No secondary MCLs are established for organics
(a) 1998 Final Rule for Disinfectants and Disinfection By-products (The total for trihalomethanes is 80 ug/L)
(b) cis-1,2-Dichloroethene
(c) trans-1,2-Dichloroethene

QUALIFIERS:
J - Indicates an estimated value
H - Alternate peak selection upon analytical review
B - The analyte is found in the associated blank as well as in the sample
a - Reported result is from a second laboratory run of the sample

TABLE 1 (continued)
HISTORICAL COMPARISON OF MAXIMUM DETECTED CONCENTRATIONS OF ORGANICS TO FEDERAL GROUND WATER QUALITY STANDARDS
December 1990 through January 2006
Shieldalloy Metallurgical Corporation

Parameter	January 2003		July 2003		October 2003		January 2004		April 2004		July 2004		MCLs
	Upper Cohansey	Lower Cohansey	Upper Cohansey	Lower Cohansey	Upper Cohansey	Lower Cohansey	Upper Cohansey	Lower Cohansey	Upper Cohansey	Lower Cohansey	Upper Cohansey	Lower Cohansey	Primary[1]
Volatile Organics (ug/L)													
Acetone	ND	30 (SC22D)	2 J (B)	41 (SC22D)	ND	53 (SC22D)	ND	55 (SC22D)	4 J (SC22S)	39 (SC22D)	ND	47 B (SC22D)	
Benzene	ND	ND	ND	ND	ND	ND	ND	ND	86 (SC20S)	ND	ND	ND	5
Bromodichloromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	80 (a)
Bromomethane	45 (K)	ND	ND	ND	ND	ND	ND	ND	ND	ND	1 J (K)	ND	
2-Butanone (MEK)	ND	ND	ND	6 J (SC2DR & SC22D)	ND	11 (SC22D)	ND	7 J (SC22D)	ND	3 J (SC20D)	ND	8 J (SC22D)	
Carbon Disulfide	ND	ND	ND	ND	ND	ND	ND	ND	2 J (SC5S)	1 JH (SC19D)	ND	ND	
Chlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
Chloroform	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	80
Chloromethane	6 J (K)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
1,4-Dichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	75
1,1-Dichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
1,2-Dichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	5
1,1-Dichloroethene	ND	ND	ND	3 J (IW2)	ND	ND	ND	4 J (IW2)	74 (SC20S)	5 J (IW2)	ND	3 J (IW2)	7
1,2-Dichloroethene (total)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	70(b) 100 (c)
cis-1,2-Dichloroethene	ND	9 (SC3DR)	ND	5 J (IW2)	ND	1 JH (SC2DR)	ND	4 J (IW2)	18 J (SC20S)	3 J (IW2)	ND	3 J (IW2)	70
trans-1,2-Dichloroethene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	100
1,2-Dichloropropane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	5
Ethylbenzene	410 (SC23S)	ND	280 (SC23S)	ND	420 (SC23S)	ND	220 (SC23S)	ND	580 (SC23S)	ND	640 (SC23S)	ND	700
Methylene Chloride	ND	ND	ND	ND	23 J (SC23S)	ND	ND	ND	ND	ND	ND	0.2 JB (SC28D)	
4-Methyl-2pentanone	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
Naphthalene	NA	ND	NA	ND	NA	ND	NA	ND	NA	ND	NA	ND	
Styrene	13 J (SC23S)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	100
1,2,3-Trichlorobenzene	NA	ND	NA	ND	NA	ND	NA	ND	NA	ND	NA	ND	
1,2,4-Trichlorobenzene	NA	ND	NA	ND	NA	ND	NA	ND	NA	ND	NA	ND	70
1,1,1-Trichloroethane	ND	1 J (SC3DR & IW2)	ND	ND	ND	2 J (IW2)	ND	2 J (IW2)	350 (SC20S)	2 J (IW2)	ND	2 J (IW2)	200
Trichloroethene	32 (K)	18 (SC3DR)	9 (K)	38 (IW2)	16 (K)	27 (IW2)	4 J (K)	27 (IW2)	220 (SC20S)	30 (IW2)	3 J (K)	20 (IW2)	5
1,1,2,2-Tetrachloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
Tetrachloroethene	ND	67 (SC3DR)	ND	12 (IW2)	ND	17 (IW2)	ND	15 (IW2)	ND	5 J (IW2)	ND	4 J (IW2)	5
Toluene	170 (SC23S)	ND	100 (SC23S)	ND	120 (SC23S)	ND	50 (SC23S)	ND	96 J (SC23S)	ND	95 J (SC23S)	ND	1,000
Vinyl Chloride	ND	ND	ND	ND	0.9 J (K)	ND	ND	ND	12 J (SC20S)	ND	2 J (K)	ND	2
Xylene (total)	1,600 (SC23S)	ND	1,200 (SC23S)	ND	1,700 (SC23S)	ND	910 (SC23S)	ND	2,300 (SC23S)	ND	2,600 (SC23S)	ND	10,000
Semivolatile Organics (ug/L)													
Bis(2-ethylhexyl)phthalate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	6
Di-n-butylphthalate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Phenol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
PCBs (ug/L)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Pesticides (ug/L)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	

NOTES:

Shaded results indicate analyte that is in exceedance of Maximum Contaminant Levels (MCLs)
Monitoring well exhibiting the maximum analyte concentration is shown in parentheses.
ND - Not Detected
NA - Not Analyzed
(1) Primary MCL - Primary Maximum Contaminant Level. 40 CFR Part 141
(2) Secondary MCL - Secondary Maximum Contaminant Level, 40 CFR Part 143 - No secondary MCLs are established for organics
(a) 1998 Final Rule for Disinfectants and Disinfection By-products (The total for trihalomethanes is 80 ug/L)
(b) cis-1,2 Dichloroethene
(c) trans 1,2 Dichloroethene

QUALIFIERS.

J - Indicates an estimated value
H - Alternate peak selection upon analytical review.
B - The analyte is found in the associated blank as well as in the sample
- Reported result is from a second laboratory run of the sample.

TABLE 1 (continued)
HISTORICAL COMPARISON OF MAXIMUM DETECTED CONCENTRATIONS OF ORGANICS
TO FEDERAL GROUND WATER QUALITY STANDARDS
December 1990 through January 2006
Shieldalloy Metallurgical Corporation

Parameter	October 2004		January 2005		July 2005		October 2005		January 2006		MCLs
	Upper Cohansey	Lower Cohansey	Upper Cohansey	Lower Cohansey	Upper Cohansey	Lower Cohansey	Upper Cohansey	Lower Cohansey	Upper Cohansey	Lower Cohansey	Primary[1]
Volatile Organics (ug/L)											
Acetone	ND	37 (SC22D)	ND	ND	ND	ND	ND	ND	ND	ND	
Benzene	ND	ND	ND	ND	ND	ND	ND	ND	0.59 J (K)	ND	5
Bromodichloromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	80 (a)
Bromomethane	1 J (K)	ND	ND	ND	ND	ND	ND	ND	ND	ND	
2-Butanone (MEK)	ND	6.1 J (SC22D)	ND	ND	ND	ND	ND	ND	ND	ND	
Carbon Disulfide	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
Chlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
Chloroform	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	80
Chloromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
1,4-Dichlorobenzene	ND	ND	1.8 (K)	ND	2.1 (K)	ND	0.51 J (K)	ND	0.79 J (K)	ND	75
1,1-Dichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	0.33 J (K)	ND	
1,2-Dichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	5
1,1-Dichloroethene	ND	1.8 JH (IW2)	ND	2 (IW2)	ND	2.1 (IW2)	ND	1.8 (IW2)	ND	2.8 (IW2)	7
1,2-Dichloroethene (total)	ND	ND	ND	1.8 (IW2)	0.32 J (K)	1.6 (IW2)	ND	1.5 (IW2)	0.3 J (K)	1.1 (IW2)	70(b) 100 (c)
cis-1,2-Dichloroethene	ND	1.4 J (IW2)	ND	1.3 (SC28D)	ND	3.5 (SC28D)	ND	3.4 (SC28D)	ND	2.6 (SC28D)	70
trans-1,2-Dichloroethene	ND	ND	ND	ND	ND	0.26 J (SC28D)	ND	0.24 J (SC28D)	ND	0.16 J (SC28D)	100
1,2-Dichloropropane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	5
Ethylbenzene	58 (SC23S)	ND	247 (SC23S)	ND	607 (SC23S)	ND	364 (SC23S)	ND	182 a (SC23S)	ND	700
Methylene Chloride	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
4-Methyl-2pentanone	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
Naphthalene	NA	ND	NA	ND	NA	ND	NA	ND	NA	ND	
Styrene	1.4 J (SC23S)	ND	ND	ND	ND	ND	ND	ND	ND	ND	100
1,2,3-Trichlorobenzene	NA	ND	NA	ND	NA	ND	NA	ND	NA	ND	
1,2,4-Trichlorobenzene	NA	ND	NA	ND	NA	ND	NA	ND	NA	ND	70
1,1,1-Trichloroethane	ND	ND	0.34 J (SC1S)	1 (IW2)	ND	1.5 (IW2)	0.19 J (SC5S)	1.7 (IW2)	0.17 J (SC5S)	3.7 (IW2)	200
Trichloroethene	2.8 J (K)	16 (SC22D)	7.1 (K)	15.3 (IW2)	3.8 (K)	29 (SC22D)	1.8 (K)	19.7 (SC31D)	2.2 (K)	22 (IW2)	5
1,1,2,2-Tetrachloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
Tetrachloroethene	ND	4.2 J (IW2)	ND	6.5 (IW2)	ND	2.6 (SC31D)	ND	2.4 (IW2)	ND	2.3 (SC31D & IW2)	5
Toluene	6.0 J (SC23S)	ND	27.3 (SC23S)	ND	34.1 (SC23S)	ND	17.8 (SC23S)	ND	6.6 (SC23S)	ND	1,000
Vinyl Chloride	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2
Xylene (total)	230 (SC23S)	ND	1,100 (SC23S)	ND	2,830 (SC23S)	0.92 J (SC22D)	1,460 (SC23S)	ND	807 a (SC23S)	ND	10,000
Semivolatile Organics (ug/L)											
Bis(2-ethylhexyl)phthalate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	6
Di-n-butylphthalate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Phenol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
PCBs (ug/L)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Pesticides (ug/L)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	

NOTES:
Shaded results indicate analyte that is in exceedance of Maximum Contaminant Levels (MCLs)
Monitoring well exhibiting the maximum analyte concentration is shown in parentheses.
ND - Not Detected
NA - Not Analyzed
(1) Primary MCL - Primary Maximum Contaminant Level. 40 CFR Part 141
(2) Secondary MCL - Secondary Maximum Contaminant Level, 40 CFR Part 143 - No secondary MCLs are established for organics
(a) 1998 Final Rule for Disinfectants and Disinfection By-products (The total for trihalomethanes is 80 ug/l)
(b) cis-1,2-Dichloroethene
(c) trans-1,2-Dichloroethene

QUALIFIERS:
J - Indicates an estimated value
H - Alternate peak selection upon analytical review
B - The analyte is found in the associated blank as well as in the sample.
a - Reported result is from a second laboratory run of the sample.

TABLE 2
HISTORICAL COMPARISON OF MAXIMUM DETECTED CONCENTRATIONS OF INORGANICS (UNFILTERED) TO FEDERAL GROUND WATER QUALITY STANDARDS
December 1990 through January 2006
Shieldalloy Metallurgical Corporation

Parameter	December 1990 & April 1991		July 2001		October 2001		January 2002		July 2002		October 2002		MCLs	
	Upper Cohansey	Lower Cohansey	Upper Cohansey	Lower Cohansey	Upper Cohansey	Lower Cohansey	Upper Cohansey	Lower Cohansey	Upper Cohansey	Lower Cohansey	Upper Cohansey	Lower Cohansey	Primary[1]	Secondary[2]
Inorganics (ug/L)														
Aluminum	70,800 (SC18S)	69,400 (SC22D)	3,660 (W2R)	311 (SC13D)	41,800 (SC12S)	701 (SC13D)	14,100 (SC12S)	297 B (SC13D)	7,830 (SC12S)	833 (SC2DR)	6,420 (W2R)	488 B (SC12D)		50-200
Antimony	673 (W2)	2140 (SC22D)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	6	
Arsenic	748 (SC13S)	382 (SC22D)	ND	29.8 (WC5)	NA	NA	NA	NA	ND	ND	NA	NA	10	
Barium	369 (W3S)	507 (SC22D)	NA	NA	NA	NA	NA	NA	ND	NA	NA	NA	2 000	
Beryllium	870 (SC18S)	11.8 (SC22D)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	4	
Boron	17 600 (SC12S)	699 (W4)	16,200 (SC25S)	62 7 (SC12D)	16,600 (SC12S)	ND	14 200 (SC12S)	61 6 (SC12D)	9,310 (SC25S)	589 (SC13D)	9 970 (SC12S)	ND		
Cadmium	7.7 (SC18S)	8 (SC8D)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	5	
Calcium	116,000 (SC18S)	32,900 (SC17D)	10,900 (SC22S)	43,700 (SC22D)	NA	NA	NA	NA	12 800 (K)	4,850 (SC2DR)	NA	NA		
Chromium (total)	20,800 (L)	102,000 (SC22D)	1,800 (RW2)	8,280 (A)	1,530 (RW2)	10,630 (A)	1,770 (SC12S)	8,080 (SC2DR)	1,810 (K)	84,500 (SC22D)	1,870 (RW2)	42,800 (SC22D)	100	
Chromium (VI)	19 900 (LAYNE)	60 900 (A)	1,800 (RW2)	7 570 (A)	1,210 (RW2)	7,110 (A)	1 620 (SC12S)	7 500 (W9)	1,320 (RW2)	7 600 (SC2DR)	1 410 (RW2)	5 360 (SC6D)		
Cobalt	27 5 (SC15S)	43 8 (SC22D)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
Copper	130 (D)	74 4 (SCG2D)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1,300	1,000
Cyanide	28,400 (SC18S)	81,200 (SC8D)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	200	
Fluoride	30,800 (SC18S)	2,400 (W8)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	4 000	2 000
Iron	164,800 (SC18S)	241,000 (SCG2D)	4,100 (SC18S)	11,000 (WC8)	NA	NA	NA	NA	1,820 (K)	8,080 (SC2DR)	NA	NA		300
Lead	137 (W2S)	282 (SCG2D)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	15	
Magnesium	40 800 (SC18S)	7240 (W3D)	25,700 (SC22S)	735 B (WC5)	NA	NA	NA	NA	10,000 (K)	1 900 (SC30D)	NA	NA		
Manganese	3880 (SCG18S)	848 (SCG2D)	481 (SC22S)	19 7 (SC2DR)	NA	NA	NA	NA	17 8 (K)	91 (SC2DR)	NA	NA		50
Mercury	18.8 (H)	13.8 (SC8D)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2	
Molybdenum	NA	NA	NA	NA	NA	NA	NA	NA	5 8 B (K)	NA	NA	NA		
Nickel	1090 (H)	20 2 (SCG2D)	5 6 (W2R)	2 2 (SC13D)	16 6 B (SC12S)	2 2 B (SC12D)	11 1 (SC25S)	2 5 B (SC12D)	3 6 B (SC12S)	5 9 B (SC13D)	4.5 B (W2R)	2 5 B (SC13D)		
Potassium	346,000 (F)	23,000 (SC17D)	72,100 (WC2)	57 400 (SC22D)	NA	NA	NA	NA	42,000 (K)	17 300 (SC28D)	NA	NA		
Selenium	12.9 (SC8S)	420 (SC8D)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	50	
Silicon	38,600 (SC15S)	13,600 (SC6D)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
Silver	30 3 (SCG1S)	14 3 (W3D)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		100
Sodium	1,790 000 (SC13S)	706 000 (SC22D)	160,000 (SC12S)	613 000 (SC22D)	198,000 (SC12S)	277,000 (SC22D)	231,000 (SC12S)	546,000 (SC22D)	160 000 (LAYNE)	406,000 (SC22D)	204,000 (WC2)	989 000 (W9)		
Strontium	152 (SC20S)	318 (SC22D)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
Titanium	149 (SC22S)	325 (SC22D)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
Vanadium	128,000 (SC13S)	2000 (SC22D)	3,700 (SC13S)	ND	3,710 (SC13S)	ND	1,450 (SC17S)	ND	1,260 (W2R)	1 9 B (SC2DR)	1 400 (W2R)	ND		
Zinc	1130 (SCG1S)	3130 (WC5)	NA	NA	NA	NA			NA	NA	NA	NA		5 000
Additional Parameters (ug/L)*														
Alkalinity (Total as $CaCO_3$)	NA	NA	NA	NA	NA	NA	NA	NA	107,000 (K)	268,000 (SC28D)	NA	NA		
Bicarbonate	549,000 (SC13S)	115,000 (W9)	349,000 (WC2)	578,000 (SC22D)	NA	NA	NA	NA	106,000 (K)	268,000 (SC28D)	NA	NA		
Carbonate	1,180,000 (SC13S)	ND	5,000 (WC2)	164 000 (SC22D)	NA	NA	NA	NA	ND	ND	NA	NA		
Chloride	1,280,000 (LAYNE)	30,200 (W9)	31,600 (SC14S)	494,000 (SC22D)	NA	NA	NA	NA	23 000 (K)	32,000 (SC28D)	NA	NA		250 000
Hydroxide Alkalinity	NA	NA	NA	NA	NA	NA	NA	NA	ND	ND	NA	NA		
pH (Range)	NA	NA	4.44-8.17 (SC24S & SC19S)	4.26-10.71 (SC13D & WC5)	4.17-8.03 (SC24S & SC19S)	4.77-11.82 (SC30R & SC22D)	4.86-8.82 (SC24S & SC21S)	6.04-11.70 (SC30R & SC22D)	4.40-8.38 (SC24S & SC26S)	4.48-12.12 (SC19D & SC22D)	5.80-10.88 (SC24S & SC18)	4.82-11.57 (SC13D & SC22D)		6 50 8 50
Phosphorous (Total as P)	NA	NA	NA	NA	NA	NA	NA	NA	81 8 B (K)	57 9 B (SC2DR)	NA	NA		
Nitrate	34,300 (W8S)	12,800 (W3D)	7 480 (WC2)	4,530 (SC19D)	NA	NA	NA	NA	17,000 (K)	6 400 (SC2DR)	NA	NA	10 000	
Sulfate	4,630,000 (F)	388,000 (SC18D)	438,000 (LAYNE)	478,000 (A)	420,000 (LAYNE)	287,000 (W8)	340,000 (LAYNE)	320,000 (SC28D)	380,000 (LAYNE)	460,000 (A)	280,000 (LAYNE)	320,000 (W8)		250 000
Total Organic Carbon (TOC)	NA	NA	8 650 (W1)	19 100 (SC22D)	NA	NA	NA	NA	3 400 (K)	3,300 (SC5D)	NA	NA		

NOTES:
Shaded results indicate analyte that is in exceedence of Maximum Contaminant Levels (MCLs)
Monitoring well exhibiting the maximum analyte concentration is shown in parentheses.
* - All concentrations in ug/L, except pH in Standard Units.
ND - Not Detected
NA - Not Analyzed
(1) Primary MCL - Primary Maximum Contaminant Level, 40 CFR Part 141
(2) Secondary MCL - Secondary Maximum Contaminant Level, 40 CFR Part 143

QUALIFIERS:
B - The reported value was obtained from a reading that was less than the Contract Required Detection Limit (CRDL) but not greater than or equal to the Instrument Detection Limit (IDL).
H - Alternate peak selection upon analytical review.
E - Serial dilution exceeds the control limits

TABLE 2 (continued)
HISTORICAL COMPARISON OF MAXIMUM DETECTED CONCENTRATIONS OF INORGANICS (UNFILTERED)
TO FEDERAL GROUND WATER QUALITY STANDARDS
December 1990 through January 2006
Shieldalloy Metallurgical Corporation

Parameter	January 2003		July 2003		October 2003		January 2004		April 2004		July 2004		MCLs	
	Upper Cohansey	Lower Cohansey	Upper Cohansey	Lower Cohansey	Upper Cohansey	Lower Cohansey	Upper Cohansey	Lower Cohansey	Upper Cohansey	Lower Cohansey	Upper Cohansey	Lower Cohansey	Primary[1]	Secondary[2]
Inorganics (ug/L)														
Aluminum	3,400 (W2R)	486 B (SC13D)	2,300 (SC12D)	438 B (SC12D)	1,170 (W2R)	434 B (SC13D)	3,540 (W2R)	478 B (SC13D)	NA	NA	1,320 (SC26S)	364 B (SC13D)		50 200
Antimony	NA	NA	NA	NA	NA	NA	NA	NA	ND	ND	NA	NA	6	
Arsenic	NA	NA	NA	NA	NA	NA	NA	NA	7.9 B (SC15S)	748 (SC22D)	NA	NA	10	
Barium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2,000	
Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	ND	0.66 B (WC5)	NA	NA	4	
Boron	8,770 (SC25S)	ND	10,800 (SC25S)	26.9 B (SC12D)	15,800 (SC25S)	ND	11,100 (SC25S)	27.5 B (SC12D)	NA	NA	17,100 (SC25S)	66.9 (SC12D)		
Cadmium	NA	NA	NA	NA	NA	NA	NA	NA	1.7 B (B)	7.2 B (WC8)	NA	NA	5	
Calcium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
Chromium (total)	1,820 (RIW2)	41,800 (SC22D)	1,600 (RIW2)	38,803 (SC22D)	1,800 (WC2)	48,100 (SC22D)	1,790 (WC2)	47,300 (SC22D)	1,720 (RIW2)	40,100 (SC22D)	1,870 (RIW2)	8,300 (SC22D)	100	
Chromium (VI)	1,380 (RIW2)	32,200 (SC22D)	1,490 (RIW2)	32,903 (SC22D)	1,540 (WC2)	6,530 (W9)	1,180 (RIW2)	45,300 (SC22D)	1,440 (RIW2)	13,700 (SC4D)	1,500 (RIW2)	6,700 (W9)		
Cobalt	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
Copper	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1,300	1,000
Cyanide	NA	NA	NA	NA	NA	NA	NA	NA	ND	78.9 (SC22D)	NA	NA	200	
Fluoride	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	4,000	2,000
Iron	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		300
Lead	NA	NA	NA	NA	NA	NA	NA	NA	1,600 (RW6S)	127 (WC8)	NA	NA	15	
Magnesium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
Manganese	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		50
Mercury	NA	NA	NA	NA	NA	NA	NA	NA	1.4 (SC24S)	8.1 (SC1D)	NA	NA	7	
Molybdenum	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
Nickel	ND	ND	2.7 B (SC13S)	3 B (SC13D)	ND	3.0 B (SC13D)	2.6 B (W2R)	2.8 B (SC13D)	23.2 (RW6S)	26.1 (SC6D)	3.8 B (W2R)	3 B (SC12D)		
Potassium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
Selenium	NA	NA	NA	NA	NA	NA	NA	NA	8.5 B (SC12S)	129 B (SC22D)	NA	NA	50	
Silicon	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
Silver	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		100
Sodium	165,000 (WC2)	467,000 (SC22D)	231,000 (WC2)	431,000 (SC22D)	175,000 E (WC2)	511,000 E (SC22D)	184,000 (B)	487,000 (SC22D)	135,000 (B)	454,000 (SC22D)	180,000 (SC13S)	148,000 (SC28D)		
Strontium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
Titanium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
Vanadium	1,180 (SC12S)	ND	1,330 (SC12S)	ND	2,820 (SC12S)	ND	1,490 (SC12S)	ND	NA	NA	4,700 (SC13S)	ND		
Zinc	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		5,000
Additional Parameters (ug/L)*														
Alkalinity (Total as $CaCO_3$)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
Bicarbonate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
Carbonate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
Chloride	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		250,000
Hydroxide Alkalinity	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
pH (Range)	4.86-12.40 (SC1S & SC8S)	4.74-11.80 (SC30R & SC22D)	4.43-8.38 (SC34S & SC29S)	4.46-11.70 (SC10D & SC22D)	4.44-6.34 (SC34S & SC29S)	4.84-11.30 (SC21D & SC22D)	4.79-8.82 (SC34S & SC5S)	5.36-12.13 (SC13D & SC22D)	4.82-10.07 (SC16S & SC21S)	4.34-12.13 (SC13D & SC22D)	5.09-6.62 (SC14S & SC13S)	5.68-11.80 (SC13D & SC22D)		6.50-8.50
Phosphorous (Total as P)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
Nitrate	NA	NA	NA	NA	NA	NA	NA	NA	34,700 (SC24S)	10,300 (SC10D)	NA	NA	10,000	
Sulfate	270,000 (WC2)	380,000 (W8)	430,000 (WC2)	190,000 (W9)	200,000 (B)	200,000 (SC28D)	284,500 (B)	196,000 (SC28D)	322,000 (B)	181,000 (SC28D)	331,000 (B)	212,000 (SC28D)		250,000
Total Organic Carbon (TOC)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		

NOTES:
Shaded results indicate analyte that is in exceedance of Maximum Contaminant Levels (MCLs)
Monitoring well exhibiting the maximum analyte concentration is shown in parentheses
* - All concentrations in ug/L, except pH in Standard Units
ND - Not Detected
NA - Not Analyzed
(1) Primary MCL - Primary Maximum Contaminant Level 40 CFR Part 141
(2) Secondary MCL - Secondary Maximum Contaminant Level, 40 CFR Part 143

QUALIFIERS:
B - The reported value was obtained from a reading that was less than the Contract Required Detection Limit (CRDL) but not greater than or equal to the Instrument Detection Limit (IDL)
H - Alternate peak selection upon analytical review
E - Serial dilution exceeds the control limits

TABLE 2 (continued)
HISTORICAL COMPARISON OF MAXIMUM DETECTED CONCENTRATIONS OF INORGANICS (UNFILTERED)
TO FEDERAL GROUND WATER QUALITY STANDARDS
December 1990 through January 2006
Shieldalloy Metallurgical Corporation

Parameter	October 2004		January 2005		July 2005		October 2005		January 2006		MCLs	
	Upper Cohansey	Lower Cohansey	Upper Cohansey	Lower Cohansey	Upper Cohansey	Lower Cohansey	Upper Cohansey	Lower Cohansey	Upper Cohansey	Lower Cohansey	Primary[1]	Secondary[2]
Inorganics (ug/L)												
Aluminum	1,300 (W2R)	418 B (SC13D)	2,840 (W2R)	433 (SC13D)	823 (SC13S)	386 (SC13D)	2,820 (SC25S)	408 (SC13D)	5,040 (SC12S)	417 (SC13D)		50-200
Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	6	
Arsenic	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	10	
Barium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2,000	
Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	4	
Boron	12,100 (SC25S)	40.7 B (SC12D)	7,960 (SC12S)	ND	6,960 (SC25S)	NA	8,110 (SC25S)	ND	8,250 (SC25S)	ND		
Cadmium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	5	
Calcium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
Chromium (total)	1,700 (RIW2)	49,900 (SC22D)	1,480 (RIW2)	31,900 (SC22D)	1,480 (RIW2)	34,600 (SC22D)	1,360 (RIW2)	30,700 (SC22D)	1,800 (IWC2)	7,810 (SC2DR)	100	
Chromium (VI)	1,470 (RIW2)	6,700 (W9)	1,500 (RIW2)	7,100 (W9)	1,400 (RIW2)	5,700 (W9)	1,400 (RIW2)	16,000 (SC22D)	1,600 (IWC2)	7,600 (SC2DR)		
Cobalt	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
Copper	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1,300	1,000
Cyanide	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	200	
Fluoride	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	4,000	2,000
Iron	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		300
Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	15	
Magnesium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
Manganese	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		50
Mercury	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2	
Molybdenum	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
Nickel	4.5 B (SC13S)	3.7 B (SC13D)	ND	ND	ND	ND	ND	ND	ND	ND		
Potassium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
Selenium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	50	
Silicon	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
Silver	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		100
Sodium	555,000 (SC13S)	566,000 (SC22D)	651,000 (SC13S)	495,000 (SC22D)	213,000 (SC13S)	648,000 (SC22D)	180,000 (B)	506,000 (SC22D)	173,000 (B)	297,000 (SC10D)		
Strontium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
Titanium	NA	NA	NA	NA	NA	AN	NA	NA	NA	NA		
Vanadium	30,900 (SC13S)	2.1 B (SC13D)	37,200 (SC13S)	ND	27,100 (SC13S)	ND	15,600 (SC13S)	ND	7,650 (SC13S)	ND		
Zinc	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		5,000
Additional Parameters (ug/L) *												
Alkalinity (Total as $CaCO_3$)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
Bicarbonate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
Carbonate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
Chloride	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		250,000
Hydroxide Alkalinity	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
pH (Range)	4.31-6.88 (SC18S & SC13S)	4.16-12.10 (SC21D & SC22D)	4.80-8.81 (SC21S & IWC2)	4.26-11.49 (SC19D & SC22D)	4.49-10.08 (SC24S & SC13S)	4.78-12.07 (SC19D & SC22D)	4.60-10.36 (SC24S & SC13S)	4.57-11.91 (SC19D & SC22D)	4.51-8.45 (SC24S & SC13S)	4.21-11.26 (SC24D & IWC5)		6.50-8.50
Phosphorous (Total as P)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
Nitrate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	10,000	
Sulfate	411,000 (B)	200,000 (SC28D)	386,000 (B)	200,000 (SC28D)	207,000 (B)	180,000 (SC28D)	210,000 (B)	178,000 (SC28D)	222,000 (B)	205,000 (SC6D)		250,000
Total Organic Carbon (TOC)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		

NOTES:
Shaded results indicate analyte that is in exceedance of Maximum Contaminant Levels (MCLs)
Monitoring well exhibiting the maximum analyte concentration is shown in parentheses.
* - All concentrations in ug/L, except pH in Standard Units
ND - Not Detected
NA - Not Analyzed
(1) Primary MCL - Primary Maximum Contaminant Level, 40 CFR Part 141
(2) Secondary MCL - Secondary Maximum Contaminant Level, 40 CFR Part 143

QUALIFIERS:
B - The reported value was obtained from a reading that was less than the Contract Required Detection Limit (CRDL) but not greater than or equal to the Instrument Detection Limit (IDL).
N - Alternate peak selection upon analytical review.
E - Serial dilution exceeds the control limits.

TABLE 3
HISTORICAL COMPARISON OF MAXIMUM DETECTED CONCENTRATIONS OF INORGANICS (FILTERED)
TO FEDERAL GROUND WATER QUALITY STANDARDS
December 1990 through July 2002
Shieldalloy Metallurgical Corporation

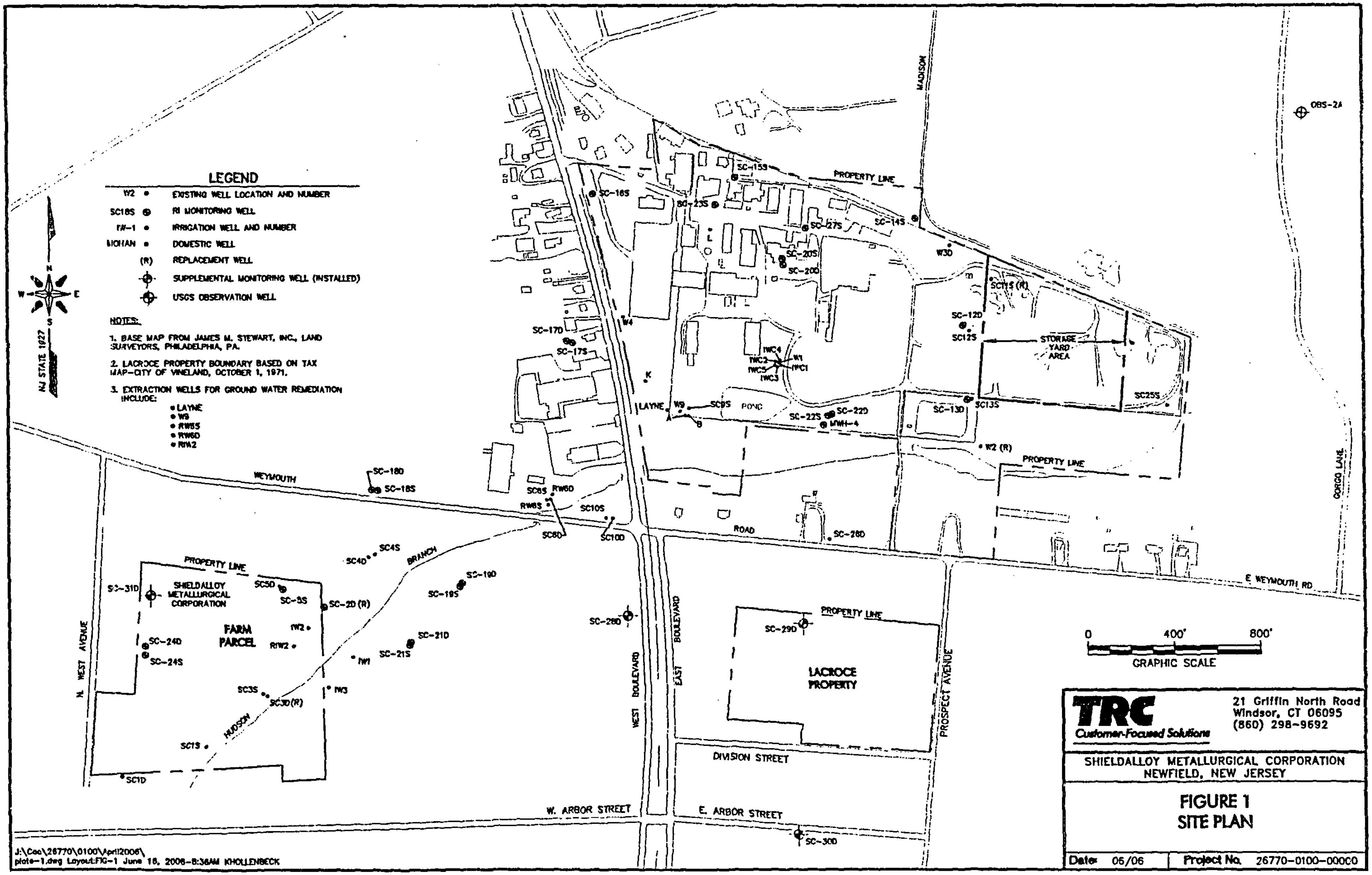
Parameter	December 1990 & April 1991		July 2002		MCLs	
	Upper Cohansey	Lower Cohansey	Upper Cohansey	Lower Cohansey	Primary[1]	Secondary[2]
Inorganics						
Aluminum	40,700 (SC13S)	53,000 (SC22D)	NA	NA		50-200
Antimony	280 (SC6S)	2300 (SC22D)	NA	NA	6	
Arsenic	392 (SC13S)	692 (SC22D)	ND	29.3 B (MWH4)	10	
Barium	493 (L)	654 (A)	NA	NA	2,000	
Beryllium	636 (SC13S)	7.2 (SC22D)	NA	NA	4	
Boron	18,300 (SC13S)	197 (SC22D)	NA	NA		
Cadmium	7.1 (SC13S)	ND	NA	NA	5	
Calcium	111,000 (SC18S)	12,100 (SC17D)	NA	NA		
Chromium (total)	11,700 (SC6S)	108,000 (SC22D)	1,290 (K)	8,280 (SC2DR)	100	
Chromium (VI)	16,600 (LAYNE)	27,400 (A)	1,340 (K)	7,300 (SC2DR)		
Cobalt	14.3 (L)	38.5 (SC22D)	NA	NA		
Copper	32 (W3S)	57.1 (SC22D)	NA	NA	1,300	1,000
Cyanide	ND	ND	NA	NA	200	
Fluoride	ND	ND	NA	NA	4,000	2,000
Iron	77,100 (L)	17,000 (SCG2D)	ND	472 (MWH4)		300
Lead	108 (W3S)	19.6 (SC1D)	NA	NA	15	
Magnesium	39,300 (SC18S)	6800 (W3D)	NA	NA		
Manganese	1160 (SC22S)	257 (SCG2D)	4.4 B (K)	108 (SC2DR)		50
Mercury	1.3 (SC1S)	12.2 (SC5D)	NA	NA	2	
Molybdenum	NA	NA	NA	NA		
Nickel	275 (H)	18.8 (SC10D)	NA	NA		
Potassium	374,000 (F)	17,600 (SC17D)	NA	NA		
Selenium	46.4 (SC13S)	91 (SC22D)	NA	NA	50	
Silicon	4710 (SC15S)	5490 (SC6D)	NA	NA		
Silver	20.8 (L)	11.5 (SCG2D)	NA	NA		100
Sodium	1,940,000 (SC13S)	729,000 (SC22D)	NA	NA		
Strontium	152 (SC20S)	ND	NA	NA		
Titanium	ND	ND	NA	NA		
Vanadium	122,000 (SC13S)	2080 (SC22D)	NA	NA		
Zinc	897 (L)	153 (IWC5)	NA	NA		5,000

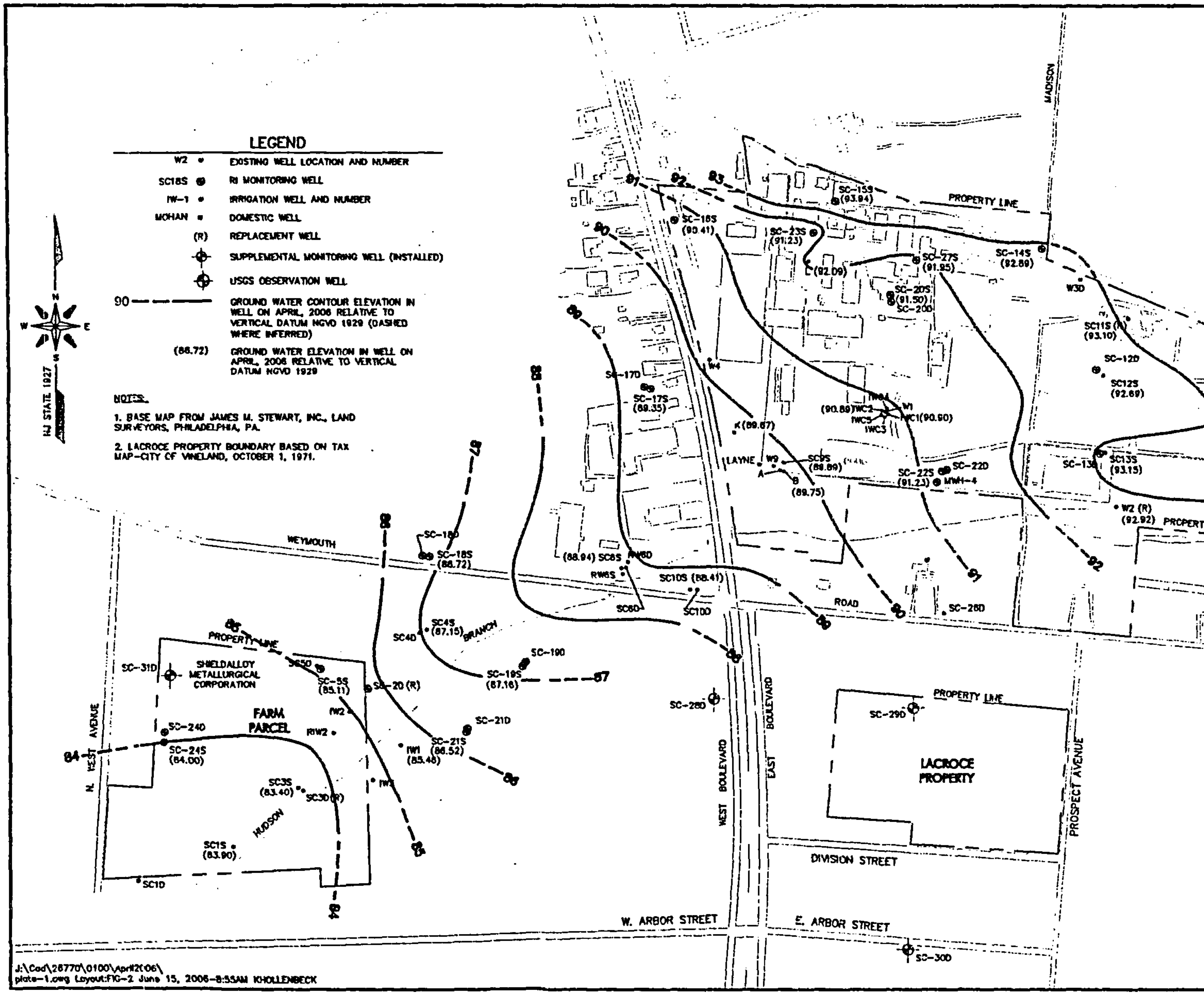
NOTES:

Shaded results indicate analyte that is in exceedance of Maximum Contaminant Levels (MCLs)
Monitoring well K was the only well from the Upper Cohansey analyzed for filtered metals during July 2002.
Monitoring well exhibiting the maximum analyte concentration is shown in parentheses.
* - All concentrations in ug/L, except pH in Standard Units.
ND - Not Detected
NA - Not Analyzed
(1) Primary MCL - Primary Maximum Contaminant Level. 40 CFR Part 141
(2) Secondary MCL - Secondary Maximum Contaminant Level. 40 CFR Part 143

QUALIFIERS:

B - Reported value was obtained from a reading that was less than the Contract Required Detection Limit (CRDL), but not greater than or equal to the Instrument Detection Limit (IDL).


LEGEND
W2 • EXISTING WELL LOCATION AND NUMBER
SC18S ⊛ RI MONITORING WELL
IW-1 • IRRIGATION WELL AND NUMBER
MOHAN • DOMESTIC WELL
(R) REPLACEMENT WELL
SUPPLEMENTAL MONITORING WELL (INSTALLED)
USGS OBSERVATION WELL
NOTES:
1. BASE MAP FROM JAMES M. STEWART, INC., LAND SURVEYORS, PHILADELPHIA, PA.
2. LACROCE PROPERTY BOUNDARY BASED ON TAX MAP-CITY OF VINELAND, OCTOBER 1, 1971.
3. EXTRACTION WELLS FOR GROUND WATER REMEDIATION INCLUDE:
• LAYNE
• W9
• RW5S
• RW6D
• RIW2
NJ STATE 1927
PROPERTY LINE
STORAGE YARD AREA
POND
WEYMOUTH ROAD
E WEYMOUTH RD
BRANCH
HUDSON
SHIELDALLOY METALLURGICAL CORPORATION
FARM PARCEL
LACROCE PROPERTY
N. WEST AVENUE
WEST BOULEVARD
EAST BOULEVARD
PROSPECT AVENUE
DIVISION STREET
W. ARBOR STREET
E. ARBOR STREET
MADISON
GORGO LANE
OBS-2A
0 400' 800'
GRAPHIC SCALE
TRC
Customer-Focused Solutions
21 Griffin North Road
Windsor, CT 06095
(860) 298-9692
SHIELDALLOY METALLURGICAL CORPORATION
NEWFIELD, NEW JERSEY
FIGURE 1
SITE PLAN
Date: 06/06
Project No. 26770-0100-00000
J:\Cad\26770\0100\April2006\plate-1.dwg Layout:FIG-1 June 16, 2006-8:36AM KHOLLENBECK



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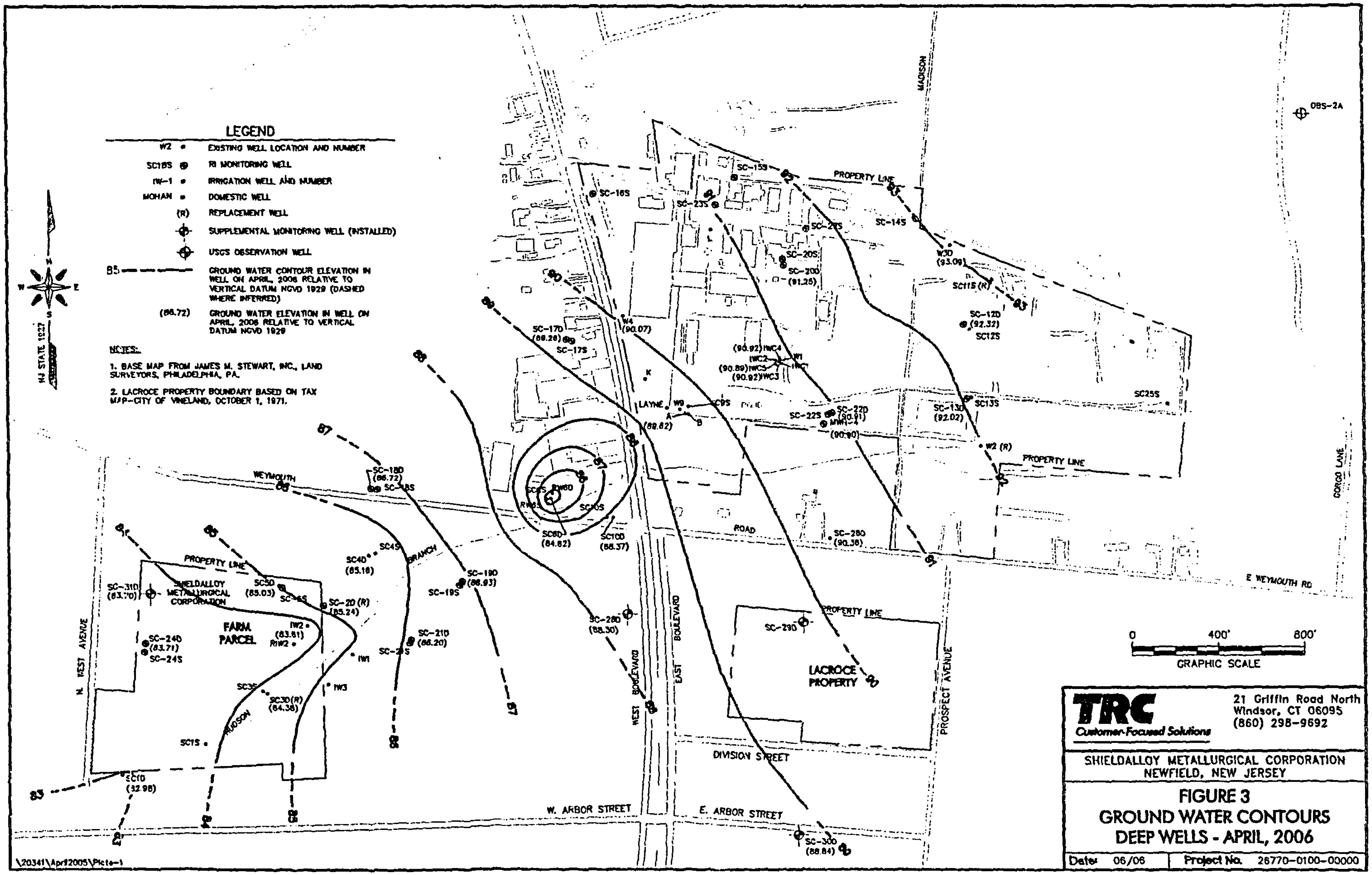
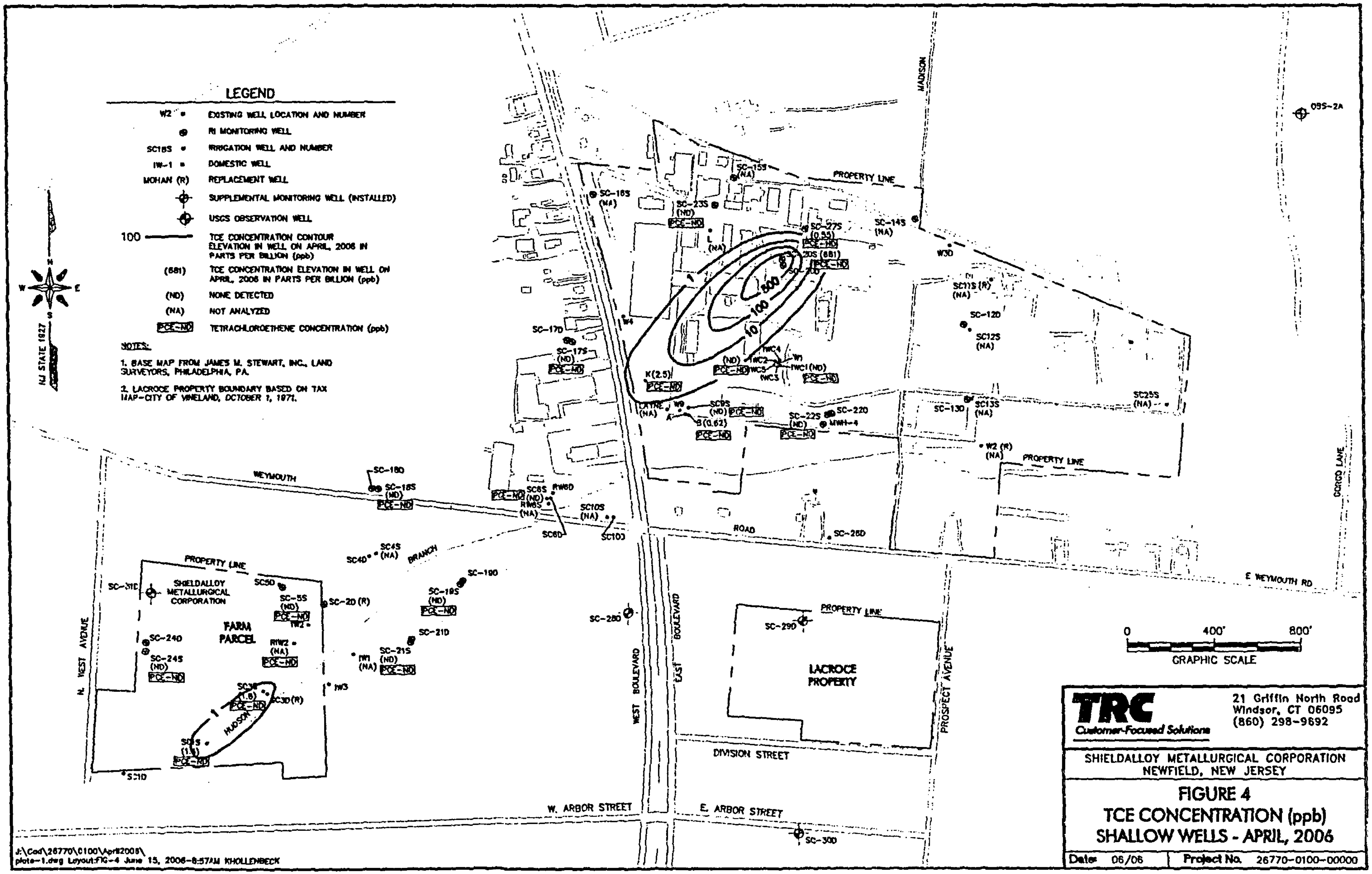
SHIELDALLOY METALLURGICAL CORPORATION
NEWFIELD, NEW JERSEY

FIGURE 2
GROUND WATER CONTOURS
SHALLOW WELLS - APRIL, 2006

Date: 06/06 | Project No. 26770-0100-00000


LEGEND
W2 • EXISTING WELL LOCATION AND NUMBER
SC18S ⊕ RI MONITORING WELL
IW-1 • IRRIGATION WELL AND NUMBER
MOHAN • DOMESTIC WELL
(R) REPLACEMENT WELL
SUPPLEMENTAL MONITORING WELL (INSTALLED)
USGS OBSERVATION WELL
85 GROUND WATER CONTOUR ELEVATION IN WELL ON APRIL, 2006 RELATIVE TO VERTICAL DATUM NGVD 1929 (DASHED WHERE INFERRED)
(86.72) GROUND WATER ELEVATION IN WELL ON APRIL, 2006 RELATIVE TO VERTICAL DATUM NGVD 1929
NOTES:
1. BASE MAP FROM JAMES M. STEWART, INC., LAND SURVEYORS, PHILADELPHIA, PA.
2. LACROCE PROPERTY BOUNDARY BASED ON TAX MAP-CITY OF VINELAND, OCTOBER 1, 1971.
NJ STATE 1927
SHIELDALLOY METALLURGICAL CORPORATION
FARM PARCEL
LACROCE PROPERTY
WEYMOUTH ROAD
E WEYMOUTH RD
WEST BOULEVARD
EAST BOULEVARD
N. WEST AVENUE
PROSPECT AVENUE
MADISON
DIVISION STREET
W. ARBOR STREET
E. ARBOR STREET
PROPERTY LINE
OBS-2A
0 400' 800'
GRAPHIC SCALE
TRC
Customer-Focused Solutions
21 Griffin Road North
Windsor, CT 06095
(860) 298-9692
SHIELDALLOY METALLURGICAL CORPORATION
NEWFIELD, NEW JERSEY
FIGURE 3
GROUND WATER CONTOURS
DEEP WELLS - APRIL, 2006
Date: 06/06
Project No. 26770-0100-00000
\20341\Apr12005\Plcte-1



LEGEND
W2 EXISTING WELL LOCATION AND NUMBER
RI MONITORING WELL
SC18S IRRIGATION WELL AND NUMBER
IW-1 DOMESTIC WELL
MOHAN (R) REPLACEMENT WELL
SUPPLEMENTAL MONITORING WELL (INSTALLED)
USGS OBSERVATION WELL
100 TCE CONCENTRATION CONTOUR ELEVATION IN WELL ON APRIL, 2006 IN PARTS PER BILLION (ppb)
(681) TCE CONCENTRATION ELEVATION IN WELL ON APRIL, 2006 IN PARTS PER BILLION (ppb)
(ND) NONE DETECTED
(NA) NOT ANALYZED
PCE-ND TETRACHLOROETHENE CONCENTRATION (ppb)
NOTES:
1. BASE MAP FROM JAMES M. STEWART, INC., LAND SURVEYORS, PHILADELPHIA, PA.
2. LACROCE PROPERTY BOUNDARY BASED ON TAX MAP-CITY OF VINELAND, OCTOBER 7, 1971.
NJ STATE 1927
PROPERTY LINE
MADISON
WEYMOUTH
ROAD
BRANCH
E WEYMOUTH RD
CORSO LANE
SHIELDALLOY METALLURGICAL CORPORATION
FARM PARCEL
HUDSON
N. WEST AVENUE
WEST BOULEVARD
EAST BOULEVARD
LACROCE PROPERTY
PROSPECT AVENUE
DIVISION STREET
W. ARBOR STREET
E. ARBOR STREET
0 400' 800'
GRAPHIC SCALE
J:\Cad\26770\0100\April2006\plate-1.dwg Layout:FIG-4 June 15, 2006-8:57AM KHOLLENBECK
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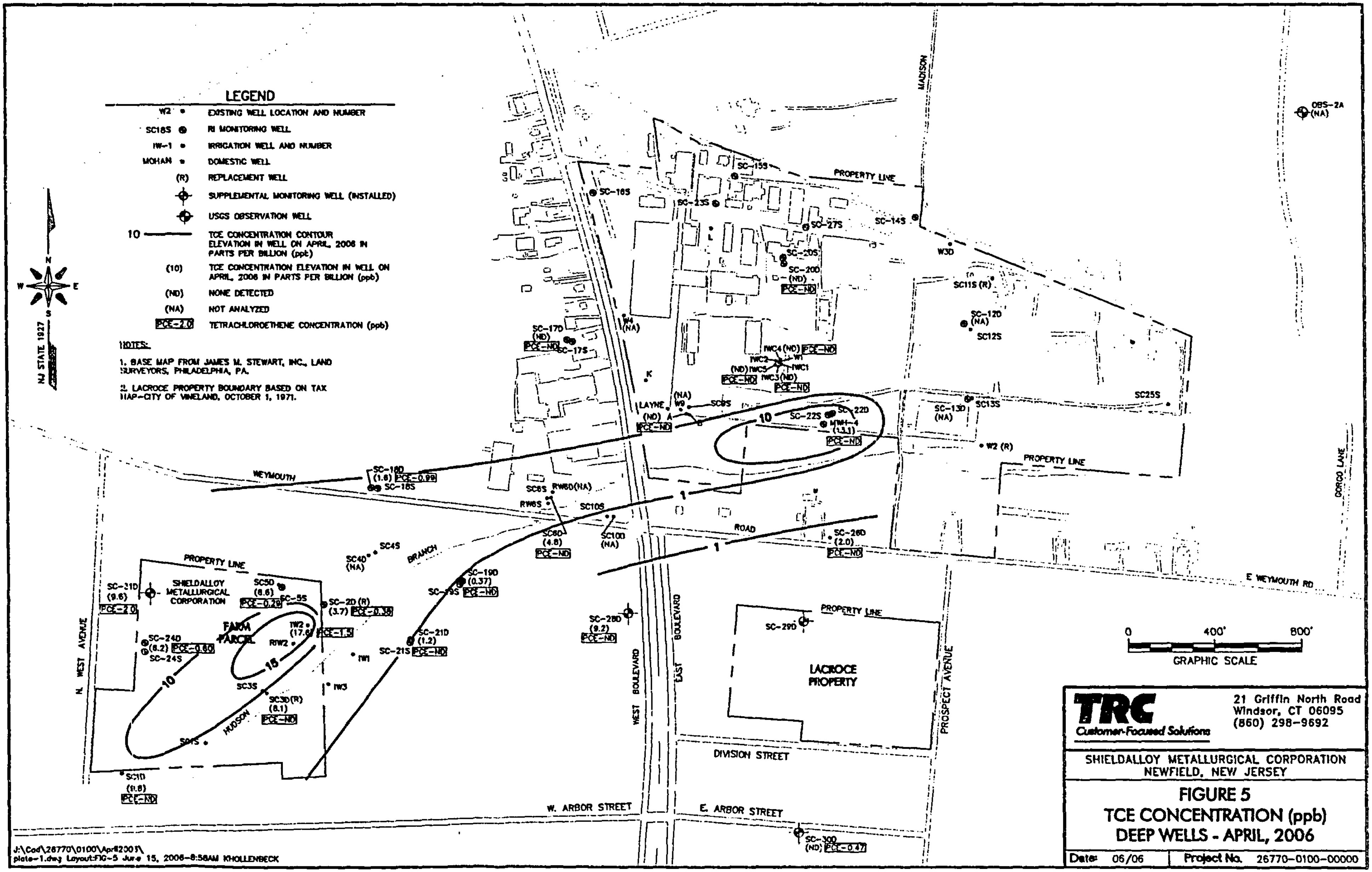
SHIELDALLOY METALLURGICAL CORPORATION
NEWFIELD, NEW JERSEY
FIGURE 4
TCE CONCENTRATION (ppb)
SHALLOW WELLS - APRIL, 2006
Date: 06/06
Project No. 26770-0100-00000


LEGEND
W2 EXISTING WELL LOCATION AND NUMBER
SC18S RI MONITORING WELL
IW-1 IRRIGATION WELL AND NUMBER
MOHAN DOMESTIC WELL
(R) REPLACEMENT WELL
SUPPLEMENTAL MONITORING WELL (INSTALLED)
USGS OBSERVATION WELL
10 TCE CONCENTRATION CONTOUR ELEVATION IN WELL ON APRIL, 2006 IN PARTS PER BILLION (ppb)
(10) TCE CONCENTRATION ELEVATION IN WELL ON APRIL, 2006 IN PARTS PER BILLION (ppb)
(ND) NONE DETECTED
(NA) NOT ANALYZED
PCE-2.0 TETRACHLOROETHENE CONCENTRATION (ppb)
NOTES:
1. BASE MAP FROM JAMES M. STEWART, INC., LAND SURVEYORS, PHILADELPHIA, PA.
2. LACROCE PROPERTY BOUNDARY BASED ON TAX MAP-CITY OF VINELAND, OCTOBER 1, 1971.
NJ STATE 1927
SHIELDALLOY METALLURGICAL CORPORATION
FARM PARCEL
LACROCE PROPERTY
PROPERTY LINE
WEYMOUTH ROAD
E WEYMOUTH RD
BRANCH
HUDSON
N. WEST AVENUE
WEST BOULEVARD
EAST BOULEVARD
PROSPECT AVENUE
MADISON
GORGO LANE
DIVISION STREET
W. ARBOR STREET
E. ARBOR STREET
0 400' 800'
GRAPHIC SCALE
TRC
Customer-Focused Solutions
21 Griffin North Road
Windsor, CT 06095
(860) 298-9692
SHIELDALLOY METALLURGICAL CORPORATION
NEWFIELD, NEW JERSEY
FIGURE 5
TCE CONCENTRATION (ppb)
DEEP WELLS - APRIL, 2006
Date: 06/06
Project No. 26770-0100-00000
J:\Cad\26770\0100\April2006\
plate-1.dwg Layout:FIG-5 June 15, 2006-8:56AM KHOLLENBECK

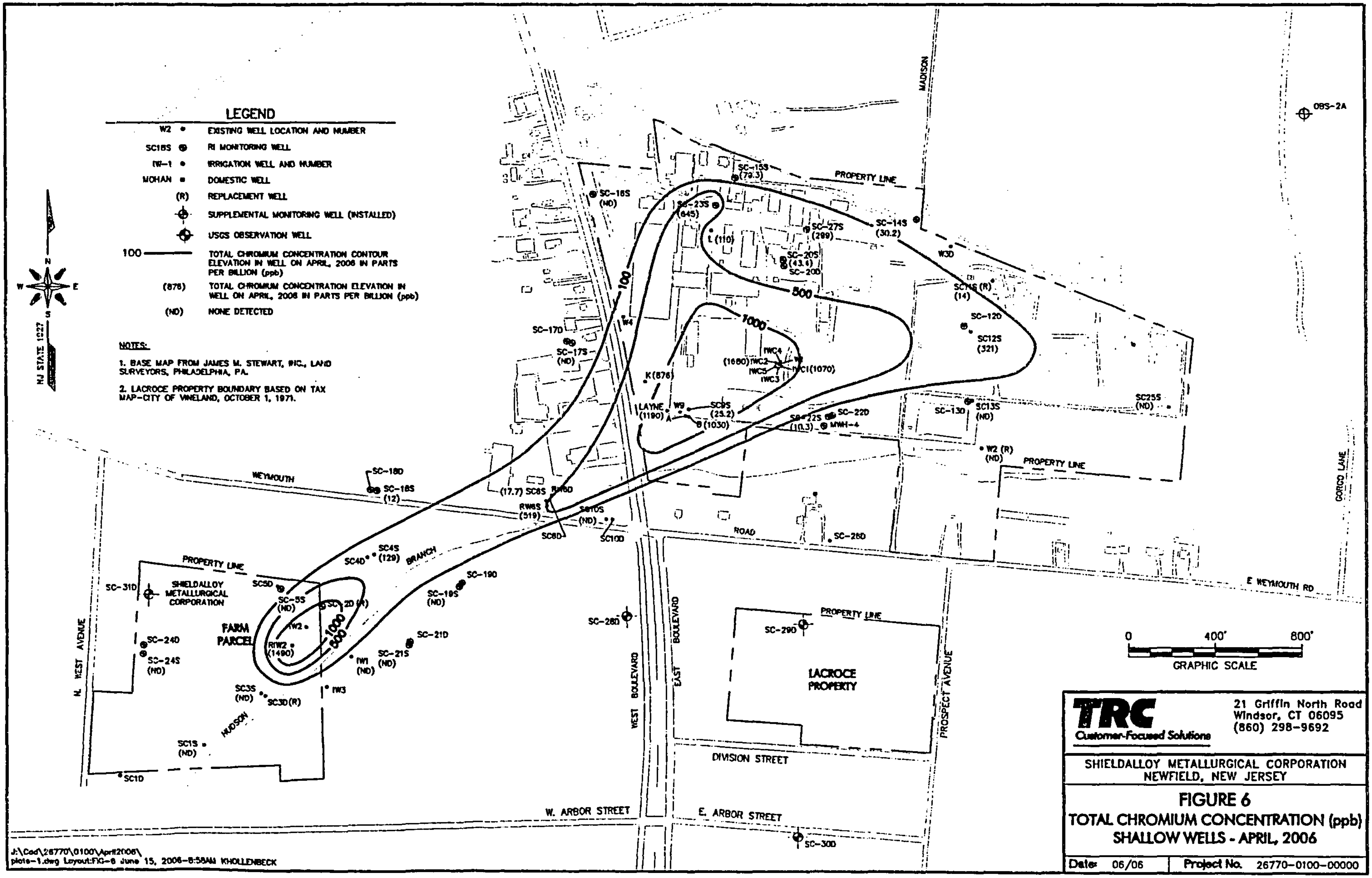


FIGURE 6
TOTAL CHROMIUM CONCENTRATION (ppb)
SHALLOW WELLS - APRIL, 2006

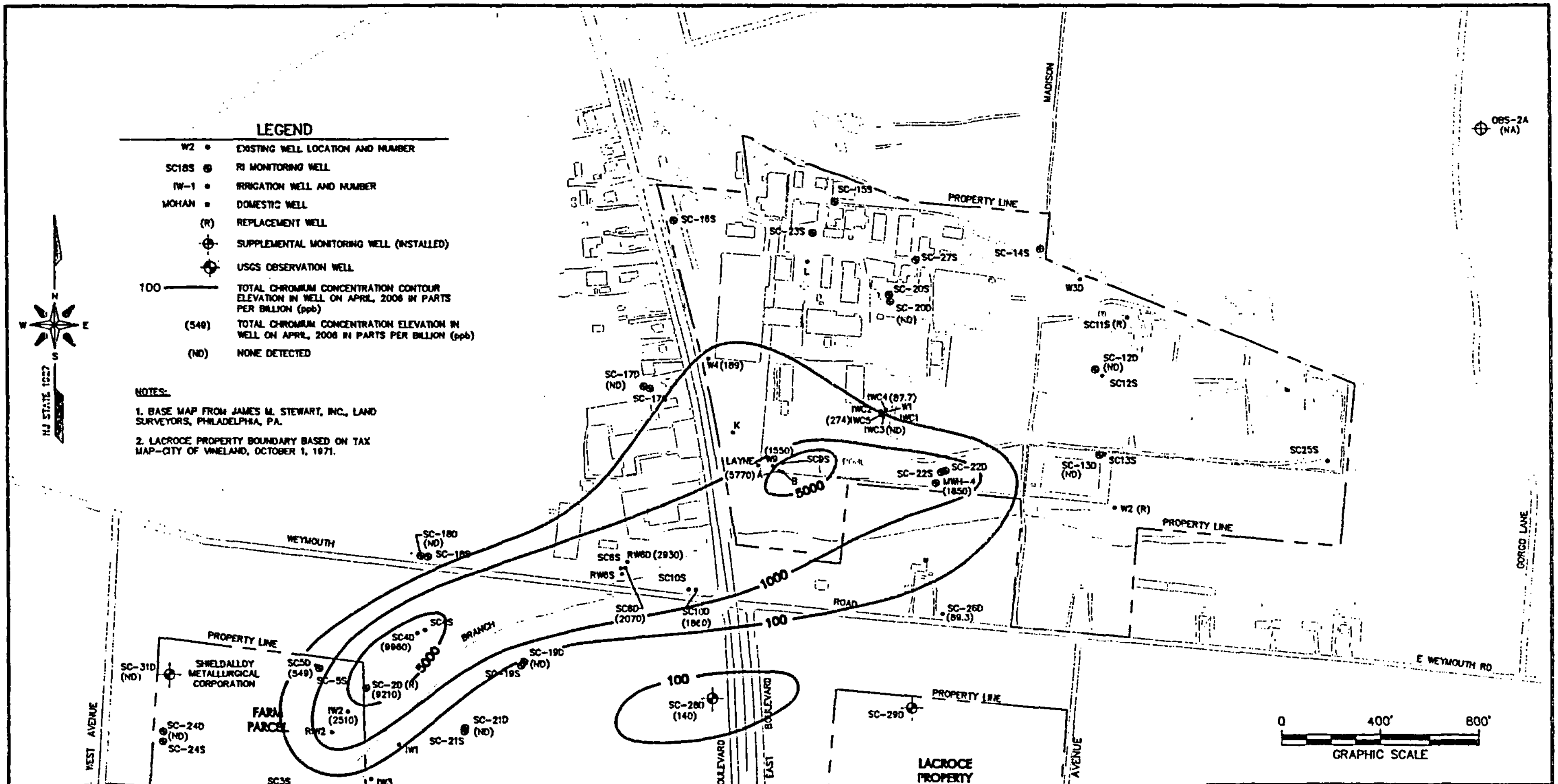


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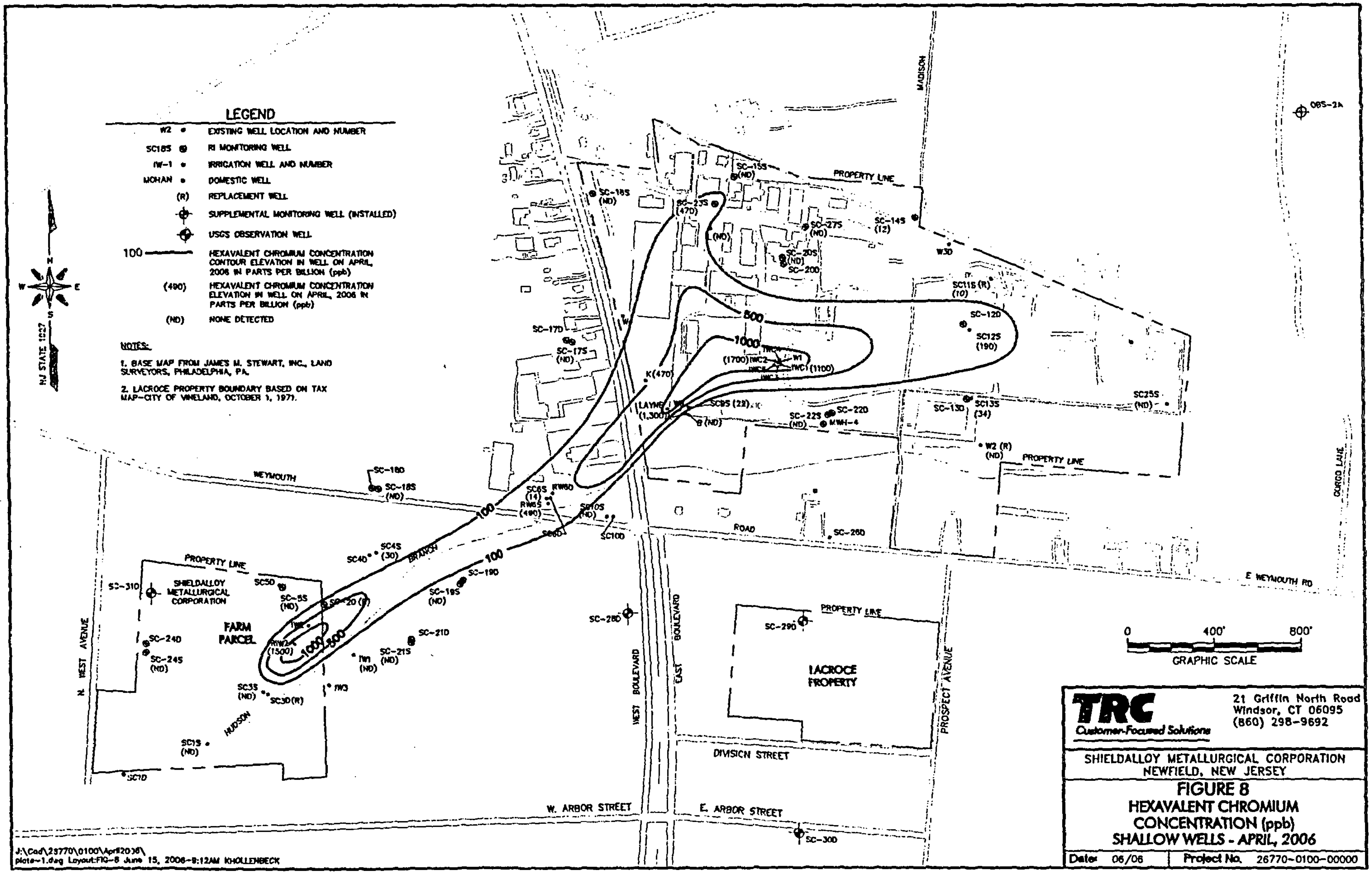
FIGURE 7
TOTAL CHROMIUM CONCENTRATION (ppb) DEEP WELLS - APRIL, 2006

Date: 06/06 | Project No. 26770-0100-00000

J:\Cad\26770\0100\April2006\plate-1.dwg Layout:FIG-7 June 15, 2006-9:10AM KHOLLENBECK


LEGEND
W2 • EXISTING WELL LOCATION AND NUMBER
SC18S RI MONITORING WELL
IW-1 • IRRIGATION WELL AND NUMBER
MOHAN • DOMESTIC WELL
(R) REPLACEMENT WELL
SUPPLEMENTAL MONITORING WELL (INSTALLED)
USGS OBSERVATION WELL
100 HEXAVALENT CHROMIUM CONCENTRATION CONTOUR ELEVATION IN WELL ON APRIL, 2006 IN PARTS PER BILLION (ppb)
(490) HEXAVALENT CHROMIUM CONCENTRATION ELEVATION IN WELL ON APRIL, 2006 IN PARTS PER BILLION (ppb)
(ND) NONE DETECTED
NOTES:
1. BASE MAP FROM JAMES M. STEWART, INC., LAND SURVEYORS, PHILADELPHIA, PA.
2. LACROCE PROPERTY BOUNDARY BASED ON TAX MAP-CITY OF VINELAND, OCTOBER 1, 1971.
NJ STATE 1927
N
S
E
W
PROPERTY LINE
SHIELDALLOY METALLURGICAL CORPORATION
FARM PARCEL
LACROCE PROPERTY
WEYMOUTH
BRANCH
ROAD
E WEYMOUTH RD
HUDSON
N. WEST AVENUE
WEST BOULEVARD
EAST BOULEVARD
PROSPECT AVENUE
MADISON
GORGO LANE
DIVISION STREET
W. ARBOR STREET
E. ARBOR STREET
SC-15S (ND)
SC-18S (ND)
SC-23S (470)
SC-27S (ND)
SC-20S (ND)
SC-20D
SC-14S (12)
W30
SC11S (R) (10)
SC-12D
SC12S (190)
SC-17D
SC-17S (ND)
K(470)
LAYNE (1,300)
SC9S (22)
B (ND)
SC-22S (ND)
SC-22D
MWH-4
SC-13D
SC13S (34)
SC25S (ND)
W2 (R) (ND)
IWC1 (1100)
(1700) IWC2
W1
SC-18D
SC-18S (ND)
SC6S (14)
RW6D
RW6S (490)
SC10S (ND)
SC10D
SC6D
SC-26D
SC4S (30)
SC4D
SC-19D
SC-19S (ND)
SC5D
SC-5S (ND)
SC-20 (R)
RW2-A (1500)
SC-31D
SC-24D
SC-24S (ND)
SC-21D
SC-21S (ND)
IW1 (ND)
IW3
SC3S (ND)
SC3D (R)
SC1S (ND)
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SC-28D
SC-29D
SC-30D
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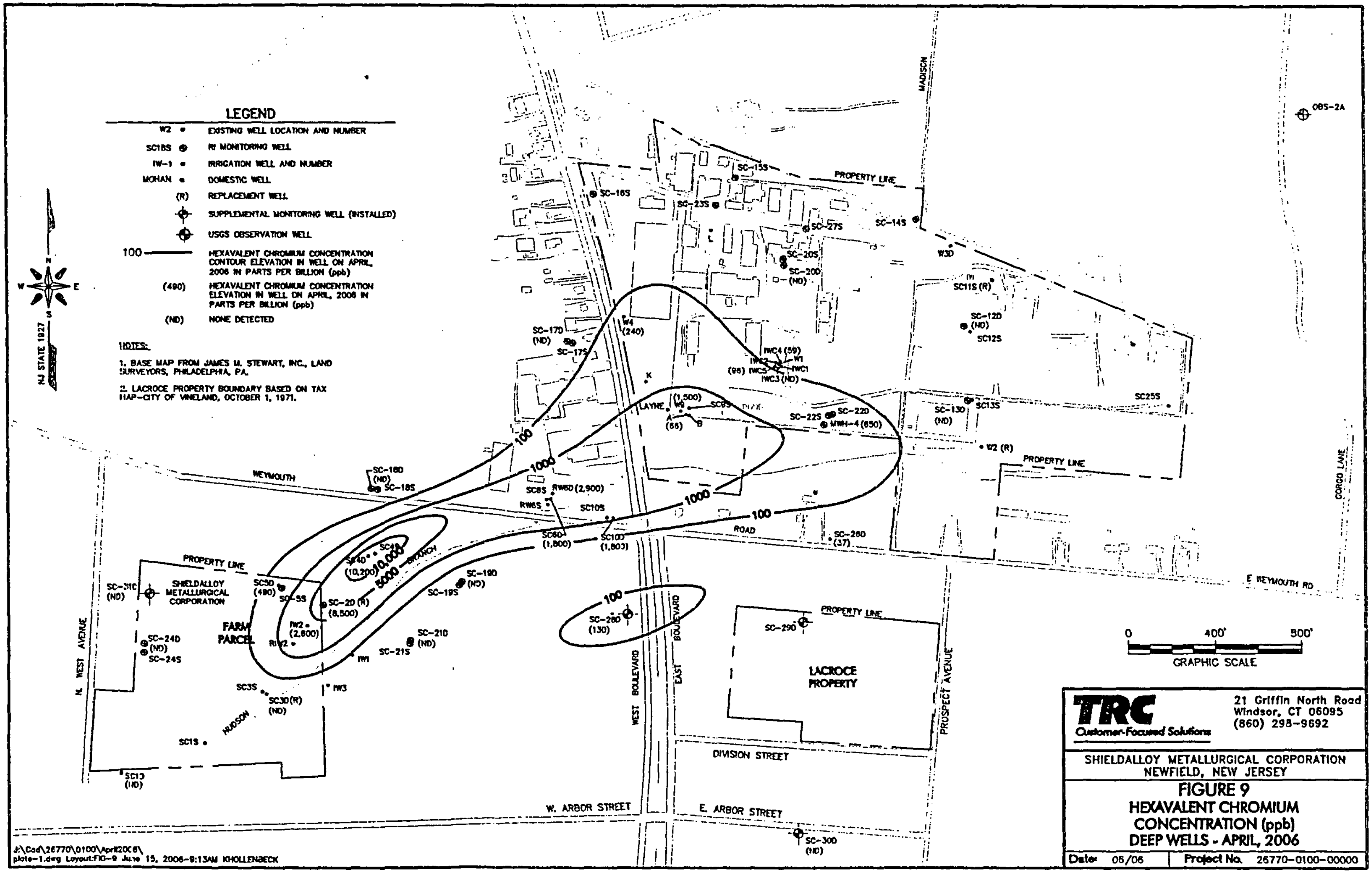
GRAPHIC SCALE
TRC
Customer-Focused Solutions
21 Griffin North Road
Windsor, CT 06095
(860) 298-9692
SHIELDALLOY METALLURGICAL CORPORATION
NEWFIELD, NEW JERSEY
FIGURE 8
HEXAVALENT CHROMIUM CONCENTRATION (ppb)
SHALLOW WELLS - APRIL, 2006
Date: 06/06
Project No. 26770-0100-00000
J:\Cad\26770\0100\April2006\
plate-1.dwg Layout:FIG-8 June 15, 2006-9:12AM KHOLLENBECK


LEGEND
W2 • EXISTING WELL LOCATION AND NUMBER
SC18S RI MONITORING WELL
IW-1 • IRRIGATION WELL AND NUMBER
MOHAN • DOMESTIC WELL
(R) REPLACEMENT WELL
SUPPLEMENTAL MONITORING WELL (INSTALLED)
USGS OBSERVATION WELL
100 HEXAVALENT CHROMIUM CONCENTRATION CONTOUR ELEVATION IN WELL ON APRIL, 2006 IN PARTS PER BILLION (ppb)
(490) HEXAVALENT CHROMIUM CONCENTRATION ELEVATION IN WELL ON APRIL, 2006 IN PARTS PER BILLION (ppb)
(ND) NONE DETECTED
NOTES:
1. BASE MAP FROM JAMES M. STEWART, INC., LAND SURVEYORS, PHILADELPHIA, PA.
2. LACROCE PROPERTY BOUNDARY BASED ON TAX MAP-CITY OF VINELAND, OCTOBER 1, 1971.
NJ STATE 1927
SHIELDALLOY METALLURGICAL CORPORATION
FARM PARCEL
LACROCE PROPERTY
PROPERTY LINE
WEYMOUTH ROAD
E WEYMOUTH RD
WEST BOULEVARD
EAST BOULEVARD
N. WEST AVENUE
PROSPECT AVENUE
DIVISION STREET
W. ARBOR STREET
E. ARBOR STREET
MADISON
CORSO LANE
HUDSON
BRANCH
OBS-2A
SC-15S
SC-16S
SC-23S
SC-27S
SC-14S
SC-20S
SC-20D (ND)
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(96) IWC5
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LAYNE
W9 (1,500)
(66)
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MWH-4 (650)
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SC-18S
SC6S
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RW6S
SC10S
SC6D (1,800)
SC10D (1,800)
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SC4D (10,200)
SC4S
SC5D (490)
SC-5S
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IW2 (2,600)
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SC-19S
SC-21D (ND)
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SC-28D (130)
SC-29D
SC-31C (ND)
SC-24D (ND)
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GRAPHIC SCALE
TRC
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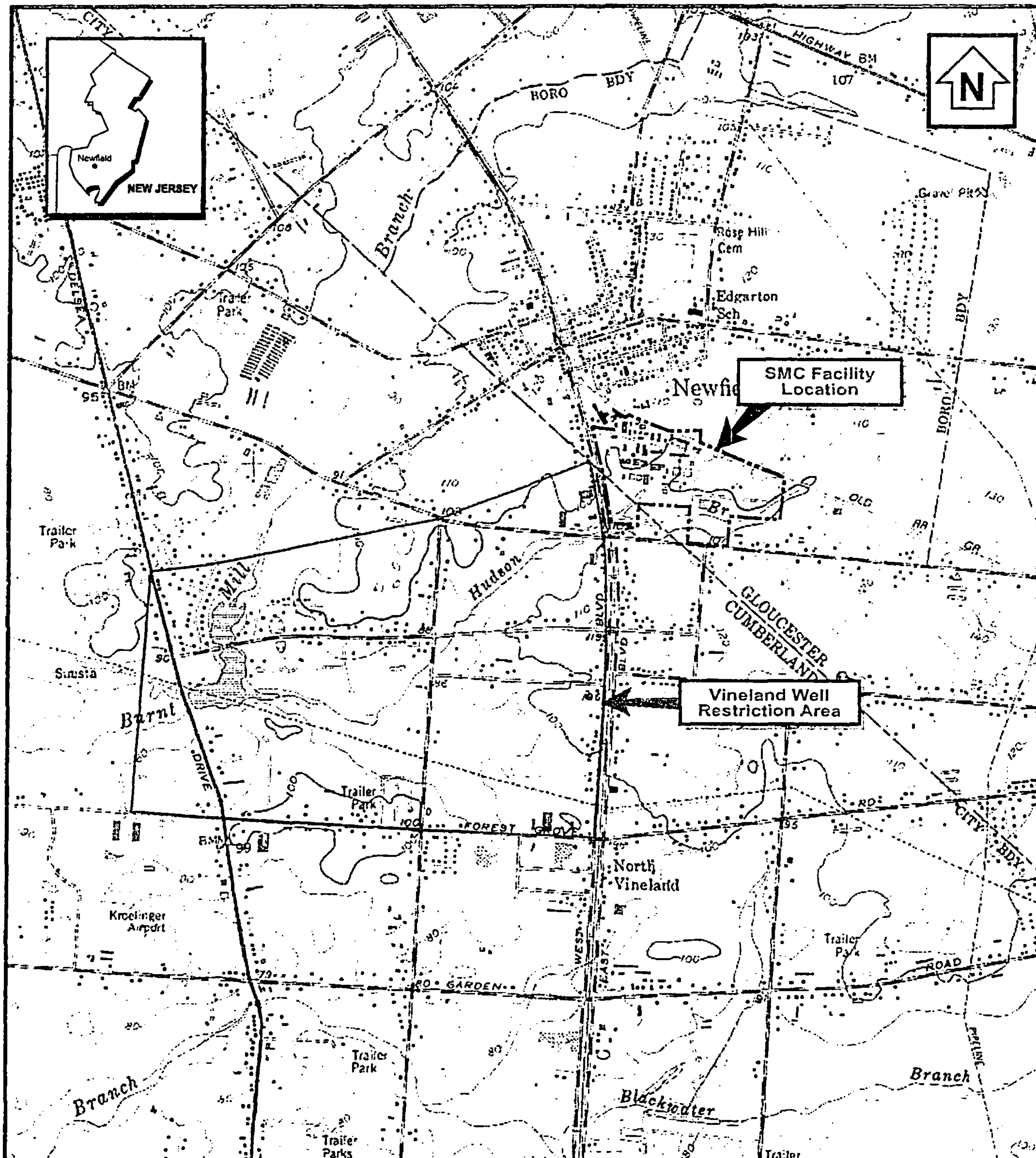
21 Griffin North Road
Windsor, CT 06095
(860) 298-9692
SHIELDALLOY METALLURGICAL CORPORATION
NEWFIELD, NEW JERSEY
FIGURE 9
HEXAVALENT CHROMIUM CONCENTRATION (ppb)
DEEP WELLS - APRIL, 2006
Date: 06/06
Project No. 26770-0100-00000
J:\Cad\26770\0100\April2006\
plate-1.dwg Layout:FIG-9 June 15, 2006-9:13AM KHOLLENBECK



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SCALE FEET

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SCALE 1:24000 MILE

BASE CREATED WITH TOPO™ © 1996 WILDFLOWERS PRODUCTIONS, www.topo.com

7.5' USGS TOPOGRAPHIC MAP

PERS/JW/HAZ/SMC/WELL RESTRICTION.fh10

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Windsor, CT 06095
(860) 298-9692

SHIELDALLOY METALLURGICAL CORPORATION
NEWFIELD, NEW JERSEY

FIGURE 10
LOCATION OF VINELAND WELL RESTRICTION AREA

Date: 06/06	Project No. 26770-0100-00000

June 3, 1991 City of Vineland Water-Sewer Utility Well Restrictions

CITY OF VINELAND
WATER-SEWER UTILITY

FACSIMILE COVER SHEET

DATE: 6-3-91 FAX NO: 697-9025

TO: Shield Alloy

ATTENTION: Mr. Jim Valente

FROM: Paul Hornar

TOTAL NUMBER OF SHEETS INCLUDING COVER SHEET: Ø2

COMMENTS: Description of Well Restriction Area in North Vineland

FAX # 609-794-6181
TEL # 609-794-4056

WHEREAS, the State legislature has provided, in N.J.S. 40:63-52, et seq., for local ordinances requiring mandatory connection with water systems, and the State of New Jersey, Department of Environmental Protection, has ordered mandatory sealing of wells in accordance with N.J.S.A. 58:4A-4.1 et seq., and N.J.S.A. 58:12A-1 et seq.;

NOW, THEREFORE, BE IT ORDAINED by the City Council of the City of Vineland, County of Cumberland, and State of New Jersey, as follows:

1. All buildings located upon a street in which the public water supply main is constructed in the area designated by the State of New Jersey, Department of Environmental Protection, identified in Section 2 of this Ordinance, shall be connected with the public water supply main, and the private water supply well shall be permanently sealed.

2. All private water supply wells in the following area shall be sealed pursuant to mandatory order issued by the State Department of Environmental Protection, and the City of Vineland shall contract therefor upon connection of all properties to the Municipal Water Utility's distribution mains in said area: N. West Avenue, from Weymouth Road to Forest Grove Road; W. Arbor Avenue, from N.J. Route No. 47 (Delsea Drive) to N. West Boulevard; Old Forest Road, from N. West Avenue to N. West Boulevard; W. Forest Grove Road, from 1,225 feet west of N.J. Route No. 47 (Delsea Drive) to N. West Boulevard; N.J. Route No. 47, from W. Forest Grove Road to 1,200 feet north of W. Arbor Avenue; N. West Boulevard, from W. Forest Grove Road to City Limit; W. Weymouth Road, from 210 feet west of N. West Avenue to N. West Boulevard; Gerow Avenue, from W. Arbor Avenue to Elty Avenue; Elty Avenue, from Gerow Avenue to Braun Avenue; Braun Avenue, from Elty Avenue to W. Arbor Avenue; Burnt Mill Road, from W. Arbor Avenue to Regina Elena Avenue; Tess Court, from Burnt Mill Drive to cul-de-sac; Regina Elena Avenue, from Burnt Mill Drive to easterly terminus.

September 18, 2000 NJDEP Letter

State of New Jersey

Department of Environmental Protection

Christine Todd Whitman
Governor

Robert C. Shinn, Jr.
Commissioner

CERTIFIED MAIL,
RETURN RECEIPT REQUESTED
NO. Z 456 933 593

SEP 1 8 2000

David R. Smith, Environmental Manager
Shieldalloy Metallurgical Corporation
P.O. Box 768
Newfield, NJ 08344

Re: Classification Exception Area

Dear Mr. Smith:

This letter is to advise you the NJDEP has made the determination that a Classification Exception Area (CEA) will be established for the ground water contamination at and emanating from the Shieldalloy Metallurgical Corporation (SMC) site. A CEA is an institutional control by which NJDEP can protect public health and the environment by suspending the designated uses of an aquifer, as discussed below.

Pursuant to the New Jersey Ground Water Quality Standards (GWQS), specifically, N.J.A.C. 7:9-6.5, ground water shall be classified according to the hydrogeologic characteristics of the ground water resource and the designated use(s) which are to be maintained, restored and enhanced within the classification area. The ground water in the area of Shieldalloy is classified as Class II-A, which consists of all ground in the State, except for ground water designated in Classes I, IIB or III. The primary uses for Class II-A ground water shall be potable water and conversion (through conventional water supply treatment, mixing or other similar technique) to potable water. Class II-A secondary designated uses include agricultural water and industrial water. Specific Ground Water Quality Criteria for Class II-A ground water is listed in Table 1 of the GWQS.

As you are well aware, the ground water at and emanating from the SMC site is not in compliance with the Ground Water Quality Criteria for Class II-A for a number of constituents, including, but not limited to chromium and trichloroethene.

When NJDEP determines that constituent standards for a given classification are not being met or will not be met in a localized area due to pollution caused by human activity within a contaminated site as defined by NJDEP in the context of an applicable regulatory program (for example, Site Remediation Program Oversight Document), NJDEP may establish a Classification Exception Area (CEA) pursuant to N.J.A.C. 7:9-6.6(a). It has been determined that NJDEP will establish a CEA for the ground water contamination at and emanating from the SMC site. NJDEP recognizes that the full extent of the ground water contamination has not been determined, however, this does not preclude NJDEP for establishing a CEA at this time. The CEA can be modified over time to either reflect a greater area as more data becomes available or a smaller area as the contaminants are remediated to attain the Ground Water Quality Criteria for Class II-A.

When establishing a CEA, the GWQS state that NJDEP shall determine or describe appropriate boundaries for each Classification Exception Area and specify the longevity of the exception, after which the original classification, designated uses and constituent standards shall be applicable. To accomplish this, NJDEP relies on the information and data provided by the responsible parties and has developed a guidance document to assist with the process. A copy of the Final Guidance on Designation of Classification Exception Areas (November 1998) has been enclosed for your convenience. The Guidance is also available online on the NJDEP webpage at WWW.STATE.NJ.US/DEP/SRP under the heading Regulations and Guidance.

Therefore, SMC shall submit to NJDEP, the information required to establish a CEA. This should not be burdensome to SMC since the majority of the information is already available. Information that may not be readily available, but is still required, includes:

- Submittal of a map of the proposed CEA compatible with NJDEP's Geographic Information System,
- Blocks and lots of the site, and
- Blocks and lots of all other properties affected by the CEA.
- Documentation that appropriate municipal authorities, health agencies and individual property owners were notified.

SMC shall submit the required information within thirty (30) calendar days of receipt of this letter. Failure to comply with the requirements of this letter may subject SMC to daily stipulated penalties pursuant to paragraph 57 of the October 5, 1988 Administrative Consent Order.

If you have any questions regarding this letter, please do not hesitate to contact me at (609) 633-1494.

Sincerely,

Donna L Gaffigan

Donna L. Gaffigan, Case Manager
Bureau of Case Management

Enclosure

C: George Nicholas, BGWPA (w/o enclosure)
Trevor Anderson, USEPA (w/o enclosure)

Appendix D - Groundwater Modeling Memo

MEMORANDUM

TO: Larry Butlien, TRC Windsor

FROM: Gastón Leone, TRC Littleton

DATE: November 17, 2005

SUBJECT: **Results of Radiological Flow and Transport Ground Water Modeling to Supplement Chapter 5 of the SMC Decommissioning Plan – Newfield, NJ Facility – Shieldalloy Metallurgical Corporation**

As part of the Decommissioning Plan (Revision 1, October 2005) for the Shieldalloy Metallurgical Corporation (SMC) facility located in Newfield, New Jersey, an On-Site Stabilization and Long-Term Control (LTC) alternative was evaluated for the management of residual radioactive materials. This alternative includes the consolidation and shaping of residual radioactive materials at the SMC facility within a portion of the existing Storage Yard (where the majority of these materials currently reside), the placement of an engineered barrier over the surface of these materials, the establishment of institutional controls, and subsequent long-term maintenance and monitoring of the stabilized materials. The engineered barrier will include soil cover materials, as well as a geomembrane barrier. With on-going maintenance and monitoring, the engineered barrier will prevent precipitation from passing through the cover and underlying radioactive materials, will direct surface runoff away from the capped radioactive materials and will provide a barrier to direct contact with the underlying materials. As a result, no radiological impact on ground water is anticipated.

As part of the dose modeling assessment portion of the Decommissioning Plan, an analysis of radiation doses incurred by hypothetical receptors for a period extending 1,000 years into the future must be assessed. Based on the existing provision of drinking water by a publicly-owned water system, the lack of potable ground water wells within the restricted area of the SMC facility and the long-term effectiveness of the engineered barrier when combined with institutional controls and long-term maintenance and monitoring, ingestion of drinking water was not included as a potential exposure pathway within the Decommissioning Plan's dose modeling assessment. Furthermore, based on existing ground water data collected downgradient of the current Storage Yard (where residual radioactive materials have been stored with no protection against infiltration for over 30 years) licensed radioactivity has not been detected above the USEPA's drinking water standards.

Ground water ingestion is not considered to be a likely or reasonably foreseeable pathway by which hypothetical receptors could incur a radiation dose. Even if all controls fail, negative radiological impacts to ground water quality due to leaching are also unlikely to result in population dose potentials in excess of the USNRC's criteria. To demonstrate this point, TRC developed a numerical ground water flow and transport model to assess a scenario in which the engineered barrier would fail and radionuclides would leach from the stabilized radioactive materials and reach the water table, where they would be subsequently transported by the ground water. The model was primarily used to assess potential impacts to a hypothetical residential water well located approximately 100 feet downgradient of the Storage Yard. Figure 1 presents the facility layout, including the location of the consolidated radioactive material and the hypothetical water supply well.

The ground water model in the RESRAD computer code is not, in and of itself, applicable to assessing site-specific groundwater impacts from the capped SMC Storage Yard. This is because the model assumes the drinking water well is installed directly on top of the engineered barrier, with ground water drawn from immediately below the location of the licensed radioactivity. Therefore, a supplement to the RESRAD analysis was developed in order to include radionuclide transport at a more realistic well location.

The supplemental model was developed using the numerical code *MODFLOW-SURFACT*, Version 2.2 (HydroGeoLogic Inc., 2002), which is a three-dimensional finite difference code that can simulate ground water flow and transport. *MODFLOW-SURFACT* simulates the following processes for the transport of contaminants in ground water: advection, dispersion, equilibrium adsorption and desorption on soil surfaces, and decay due to radiological transformations.

The following conceptual model and parameter values, taken from Rev. 1 of the SMC Decommissioning Plan unless otherwise noted, were assumed for the analysis of impacts to the water supply well:

1. Radionuclides are leached from the consolidated radioactive materials during infiltration of precipitation following failure of the engineered barrier. Concentrations of radionuclides reaching the water table underneath the consolidated radioactive materials were calculated using the RESRAD model. Four radionuclides reach the water table during the 1,000 year period of analysis: Actinium 227 (Ac-227), Protactinium 231 (Pa-231), Lead 210 (Pb-210), and Radium 226 (Rd-226). The time at which these radionuclides reach the water table was also calculated by the RESRAD model. Figure 2 presents the concentrations calculated by RESRAD for these four radionuclides in leachate reaching the water table. These concentrations correspond to the input parameters provided by Integrated Environmental Management, Inc. (input file: Newfield 300308.rad). This RESRAD simulation assumes a precipitation infiltration rate equal to the natural ground water recharge rate of 10.9 inches per year. The ground water recharge for this area was calculated using the methodology provided by the New Jersey Geological Survey in publication DGS99-2. The assumption that infiltration through the consolidated radioactive materials will equal the natural ground water recharge constitutes a worst case scenario, considering that the pile will have at least a partial engineered cover (i.e., it is highly unlikely that the entire cover would fail at once) and surface runoff will be diverted away from the pile.

2. The shallow aquifer underneath the facility is comprised of two main hydrogeologic units, the Upper Cohansey Sand and the Lower Cohansey Sand. Around the vicinity of the Storage Yard, these two units are separated by a low conductivity clay "wedge" unit ranging from 6 feet to 4 inches thick. There is a significant vertical hydraulic gradient of approximately 0.5% between the Cohansey sands. The Upper Cohansey sand is approximately 40 feet thick and has an average hydraulic conductivity of 200 ft/day. The Lower Cohansey sand varies in thickness between 60 and 80 feet, with an average hydraulic conductivity of 70 ft/day.
3. A constant recharge rate of 10.9 inches/year was applied to the entire model domain.
4. The hypothetical water supply well is located 100 feet downgradient of the Storage Yard along the leading edge of a potential plume, has a depth of 40 feet (screened within the Upper Cohansey sand) and an average pumping rate of 328 gal/day. The pumping rate is based on a household of four people, an average water consumption per capita of 75 gal/day (American Water Works, 2005), and an outdoor water use of 28 gal/day (U.S. Geological Survey, 1977).

The model domain is 2,000 feet long, 1,200 feet wide and 110 feet thick. The model grid has 69 rows, 71 columns, 11 layers, and a total of 53,889 cells. Constant head cells were set all around the model perimeter, with specified heads that correspond to the potentiometry and vertical gradients of each sand.

A steady state flow calibration was conducted using water levels measured on October 12, 1992. On this date, ground water remediation pumping was discontinued in order to obtain ambient flow conditions representative of steady state flow within the aquifer. The average hydraulic conductivity values of 200 and 70 ft/day for the Upper and Lower Cohansey sands were used during the steady state calibration. Figures 3 and 4 present the results of the calibrated water levels for the Upper and Lower Cohansey sands. The simulated ground water flow direction is to the southwest with an average gradient of 0.002 ft/ft in both sands. Calibration results indicate a good fit between model simulated and measured ground water levels, with a root mean square (RMS) error of 0.48 feet. The ratio between the RMS and the hydraulic head change across the model domain (3.5 feet) is 13.7%.

After the model calibration was completed, a predictive solute transport simulation was conducted. This predictive simulation consisted of applying the RESRAD transient concentrations presented in Figure 2 at the water table over the entire area underneath the consolidated residual radioactive materials at a leaching rate equal to 10.9 inch/year. Chain decay was not explicitly simulated because the effect of the progeny was considered negligible. Transport of each radionuclide was evaluated independently. This simulation also included pumping from the hypothetical water supply well indicated in Figure 1. Table 1 presents the solute transport parameters used in this simulation.

Table 1 – Solute Transport Parameters

Parameter	Units	Value
Longitudinal Dispersivity	ft	30
Horizontal Dispersivity	ft	3
Vertical Dispersivity	ft	0.3
Effective Porosity	unitless	0.25
Kd – Ac-227	mL/gr	20
Kd- Pa-231	mL/gr	50
Kd – Pb-210	mL/gr	100
Kd – Ra-226	mL/gr	48
Half-life – Ac-227	Year	21.7
Half-life – Pa-231	Year	32,760
Half-life – Pb-210	Year	22.8
Half-life – Ra-226	Year	1,600

The porosity value is the same as the effective porosity used for the RESRAD simulation and is within the range of typical values for this type of aquifer material. Dispersivity values were estimated assuming a 300-foot plume length and following Pickens and Grisak guidelines for dispersivity estimates (Pickens and Grisak, 1981). The 30-foot longitudinal dispersivity value is very conservative given the 100-foot travel distance to the hypothetical water well. The distribution coefficient (Kd) value for Ra-226 is a site-specific value measured for the residual radioactive materials which is not necessarily representative of the Kd value for the aquifer materials. This value was used because it is conservative with respect to the default value of 70 mL/gr that is commonly accepted as applicable for Ra-226. The remaining Kd values are defaults used in RESRAD. Half-life values were obtained from the RESRAD database.

Figure 5 presents the model calculated concentrations of radionuclides at the water supply well located 100 feet downgradient from the Storage Yard. The solute transport modeling results indicate that after 1,000 years the Ra-226 concentration will reach a maximum of 3.43 pCi/L, while Ac-227 will reach 0.22 pCi/L. The Pb-210 and Pc-231 concentrations remain at or below 0.05 pCi/L. Concentrations at this well remain relatively low during the 1,000 year time period due to the dilution that takes places within the aquifer and the significant retardation of these radionuclides. Table 2 presents the maximum annual dose in the hypothetical water supply well at year 1,000 based on the maximum concentrations calculated with the solute transport model. The water consumption rate and dose conversion factors are default values used in RESRAD.

Table 2 – Maximum Annual Dose Associated with a Water Supply Well at Year 1,000

Radionuclide	Water Consumption Rate (L/Year)	Dose Conversion Factor for Ingestion (mrem/pCi)	Maximum Concentration (pCi/L)	Dose (mrem/Year)
Ac-227	410	0.0148	0.22	1.33
Pa-231	410	0.0106	0.05	0.20
Pb-210	410	0.00727	0.00	0.00
Ra-226	410	0.00133	3.43	1.87
			Total Dose	3.40

A sensitivity analysis was conducted to identify the key parameters that control the maximum dose simulated at the hypothetical water supply well. A total of four parameters were considered in this sensitivity analysis: hydraulic conductivity, effective porosity, dispersivity, and distribution coefficients for Ac-227 and Ra-226. Only Ac-227 and Ra-226 were considered as part of the distribution coefficient sensitivity analysis because these two radionuclides provide the majority of the dose at the water supply well. Two sensitivity simulations were conducted for each of the identified parameters. Each parameter value, except for effective porosity, was increased for the first simulation by a factor of 2 (100% increase) and then decreased by a factor of 2 (50% decrease) for the second simulation. A sensitivity factor of 1.5 (50% increase and 33% decrease) was used for effective porosity in order to keep this parameter value within the literature range for the type of materials in the Cohansey sands.

Table 3 presents the results of the sensitivity analysis. This table shows the maximum calculated dose at the water supply well and also the relative percent change with respect to the base case total dose of 3.40 mrem/year presented in Table 2. The maximum calculated dose for all sensitivity scenarios is 17.10 mrem/year. This sensitivity analysis shows that the dose is insensitive to changes in effective porosity and moderately sensitive to dispersivity. The results are highly sensitive to decreases in distribution coefficients and changes in hydraulic conductivity.

Table 3 – Sensitivity Analysis Results

Parameter	Initial Value	Sensitivity Factor (%)	Maximum Dose (mrem/year)	Dose Sensitivity Factor (%)
Hydraulic Conductivity	200 ft/d U Cohansey	100	12.04	254
	70 ft/d L Cohansey	-50	0.51	-85
Effective Porosity	0.25	50	3.38	-1
		-33	3.42	0
Dispersivity (Long., Horiz., Vertical)	30 ft, 3 ft, 0.3 ft	100	5.23	54
		-50	2.27	-33
Kd – Ra-226	48 mL/gr	100	1.62	-52
		-50	17.10	357
Kd – Ac-227	20 mL/gr	100	2.19	-36
		-50	10.21	200

Attachments:

Figure 1 – Site Layout and Model Domain

Figure 2 – Radionuclides in Leachate Reaching the Water Table – RESRAD Model

Figure 3 – Upper Cohansey - Steady State Potentiometry

Figure 4 – Lower Cohansey - Steady State Potentiometry

Figure 5 – Radionuclides in Water Supply Well

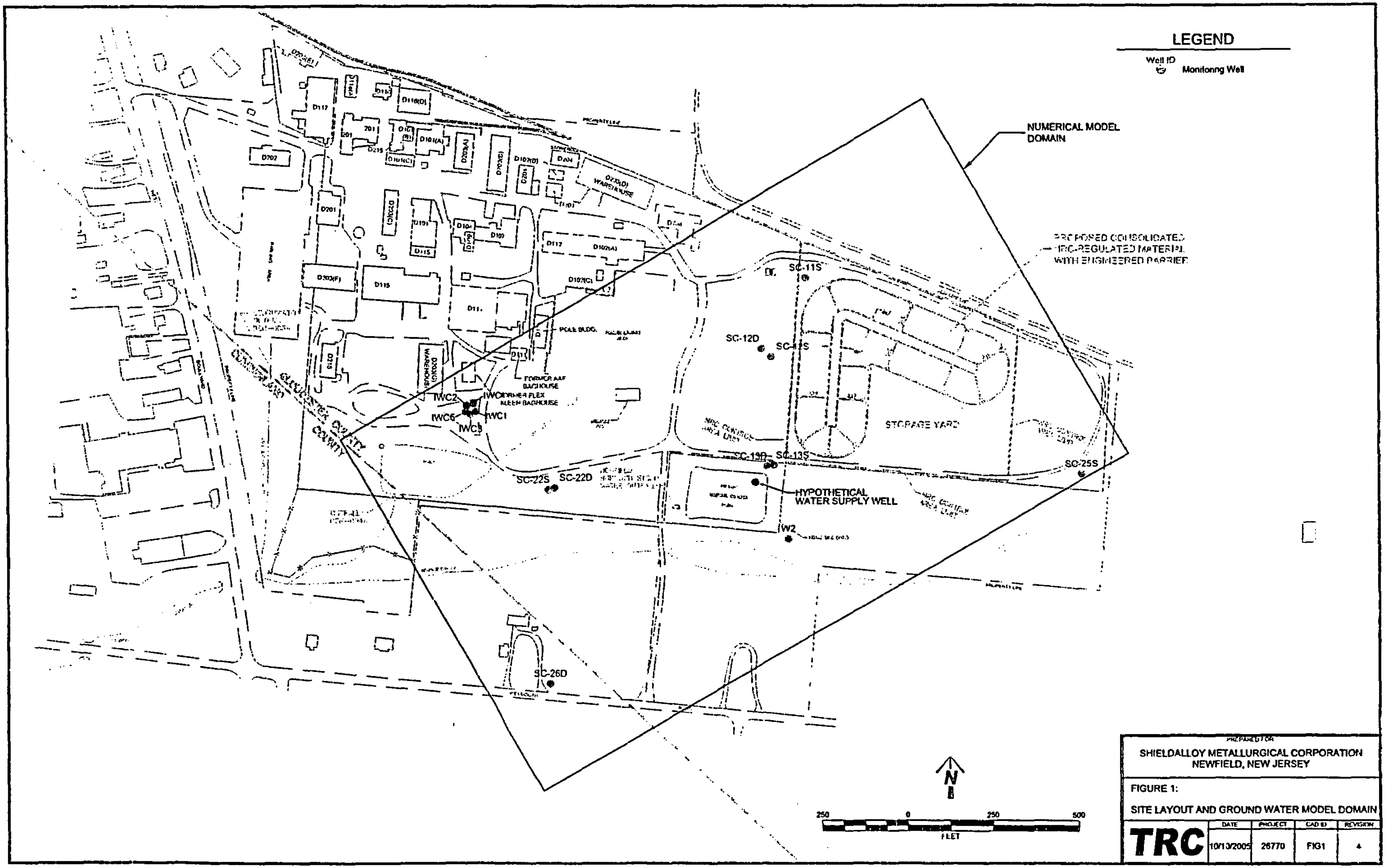
References:

American Water Works, 2005. Stats on Tap. Available online: http://www.awwa.org/Advocacy/pressroom/statswp5.cfm.

HydroGeoLogic Inc., 2002. *MODFLOW-SURFACT*, Code Documentation: Herndon, Virginia.

Pickens, J. F., and G. E. Grisak, 1981. Modeling of scale-dependent dispersion in hydrogeologic systems. Water Resources Res. Vol. 17(6): 1701-1711.

U. S. Geological Survey, 1997. National Handbook of Recommended Methods for Water-Data Acquisition. Available online: http://pubs.usgs.gov/chapter11/chapter11D.html



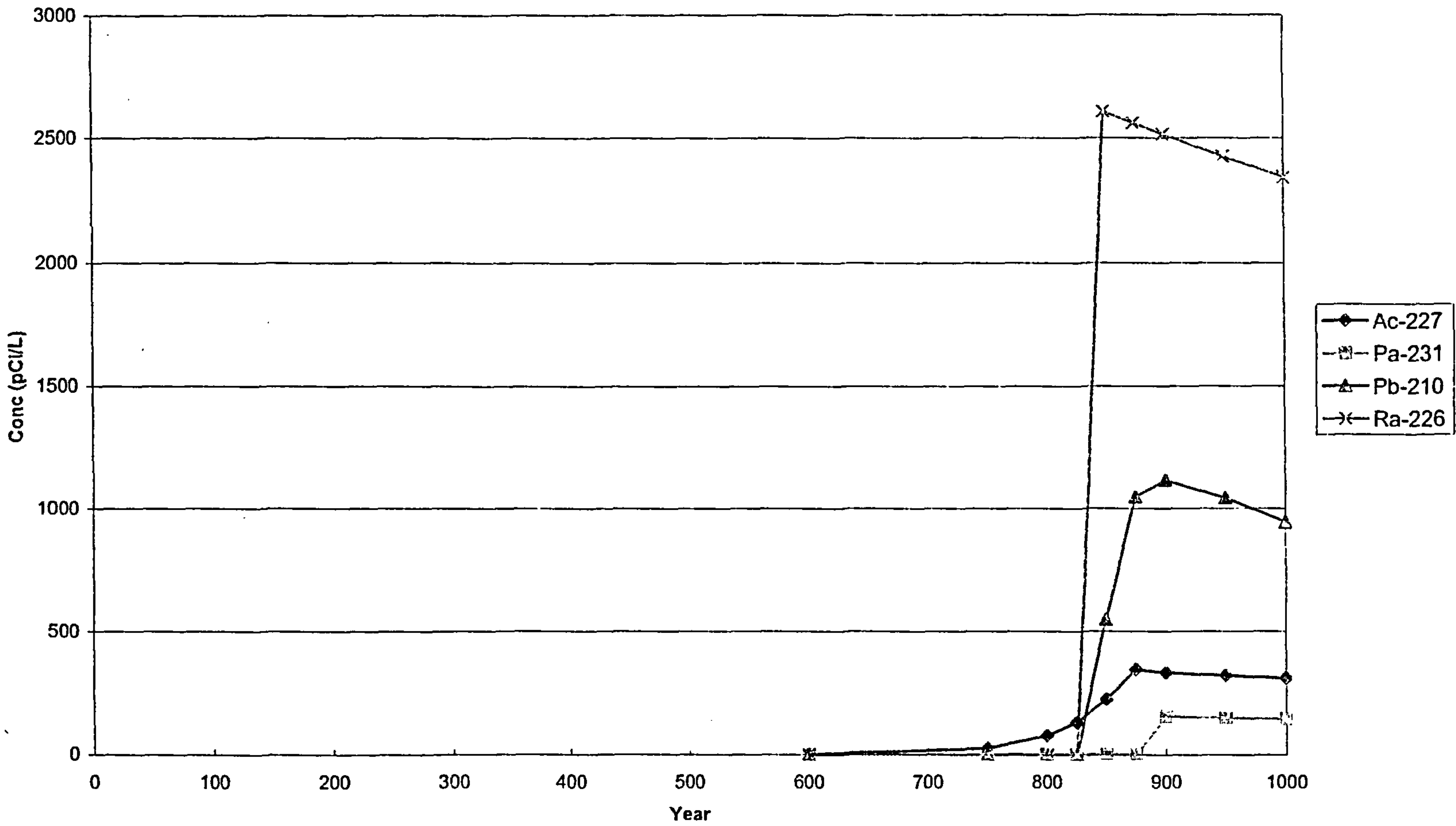
PREPARED FOR

SHIELDALLOY METALLURGICAL CORPORATION
NEWFIELD, NEW JERSEY

FIGURE 1:

SITE LAYOUT AND GROUND WATER MODEL DOMAIN

	DATE	PROJECT	CAD ID	REVISION
TRC	10/13/2005	26770	FIG1	4

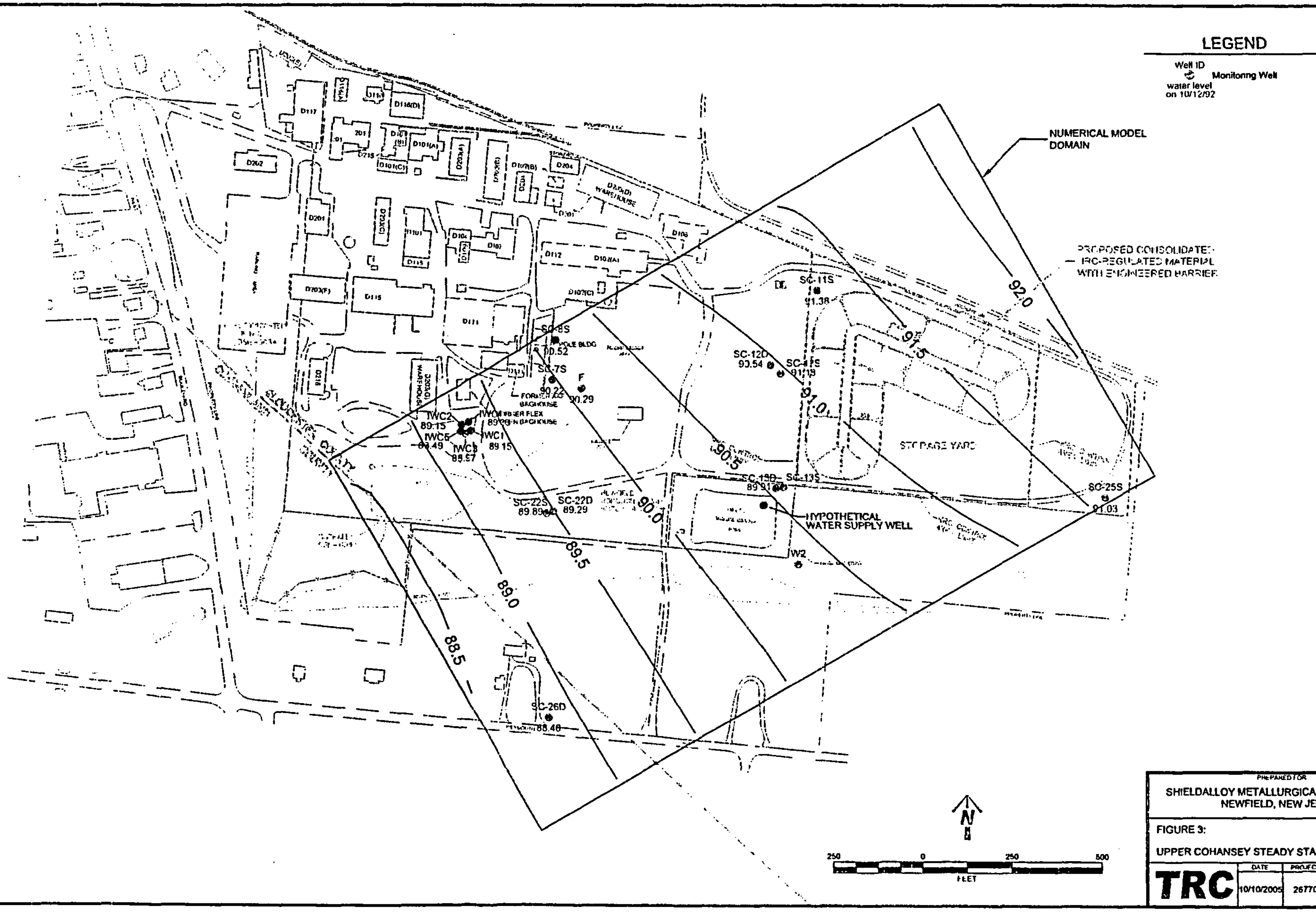


PREPARED FOR:

SHIELDALLOY METALLURGICAL CORPORATION
NEWFIELD, NEW JERSEY

FIGURE 2:
Radionuclides in Leachate Reaching the Water Table
RESRAD Model

TRC	DATE	PROJECT	CAD ID	REVISION
	10/10/2005	26770	MD01	3



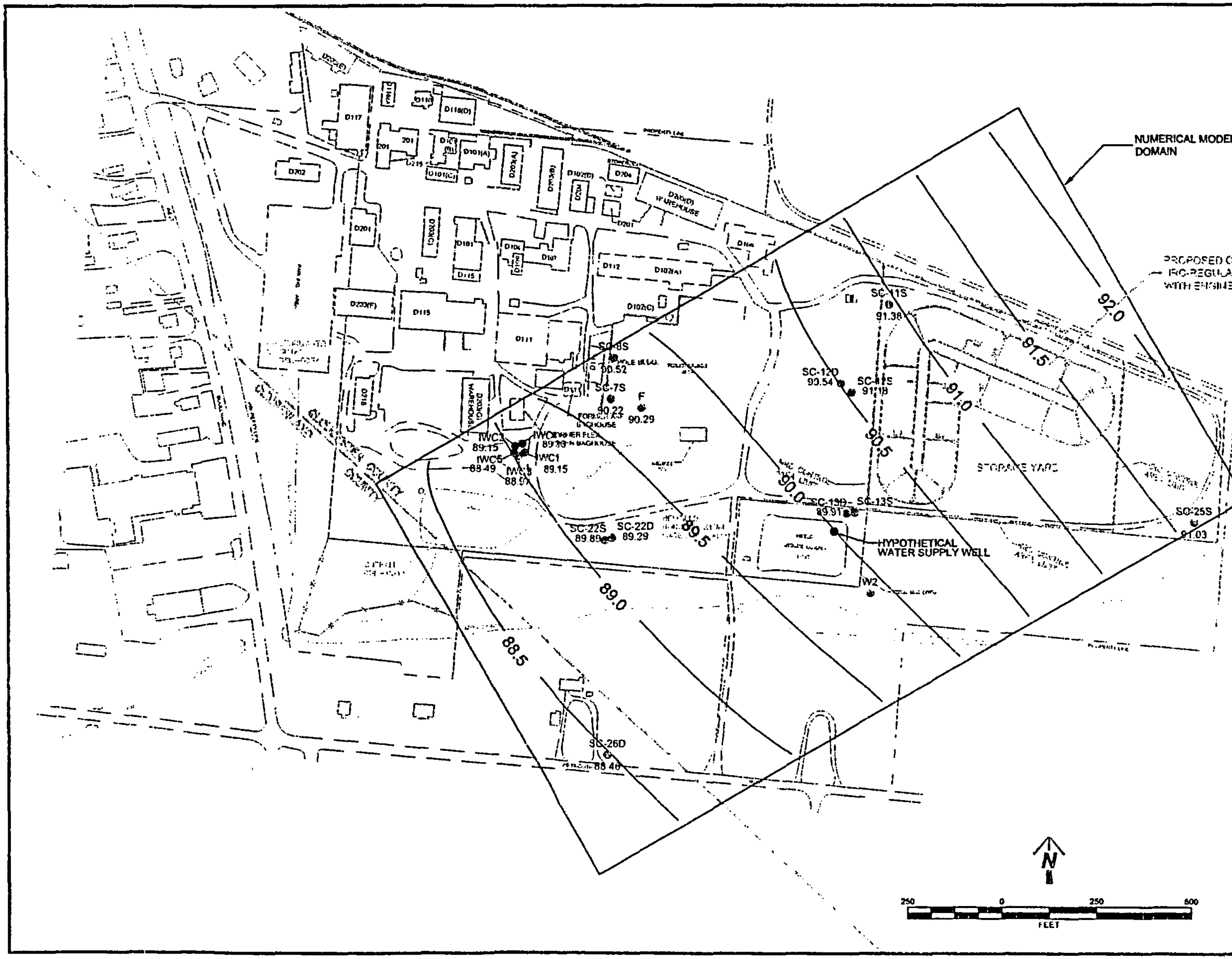
PREPARED FOR

SHIELDALLOY METALLURGICAL CORPORATION
NEWFIELD, NEW JERSEY

FIGURE 3:

UPPER COHANSEY STEADY STATE POTENTIOMETRY

TRC	DATE	PROJECT	CAD ID	REVISION
	10/10/2005	26770	FIG3	4



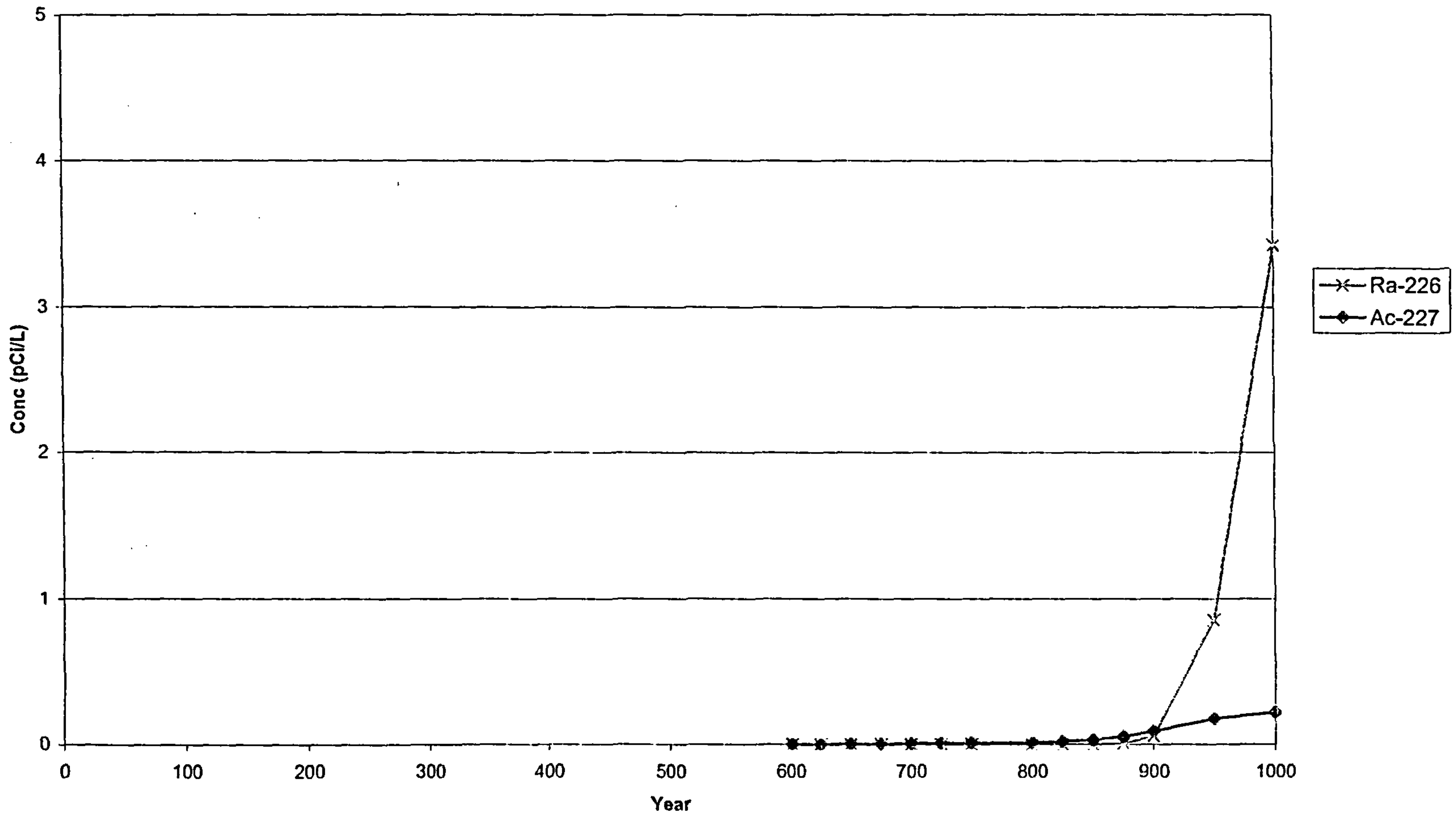
PREPARED FOR

SHIELDALLOY METALLURGICAL CORPORATION
NEWFIELD, NEW JERSEY

FIGURE 4:

LOWER COHANSEY STEADY STATE POTENTIOMETRY

TRC	DATE	PROJECT	CAD ID	REVISION
	10/10/2005	26770	FIG4	4



PREPARED FOR:

SHIELDALLOY METALLURGICAL CORPORATION
NEWFIELD, NEW JERSEY

FIGURE 5:
Radionuclides in Water Supply Well

	DATE	PROJECT	CAD ID	REVISION
TRC	10/10/2005	26770	FIG5	3

Appendix E - Revised Appendix 19.3 (Soil Erosion Rate Calculations)

TRC

ENGINEERED BARRIER DESIGN CALCULATIONS

Prepared for
Shieldalloy Metallurgical Corporation
Newfield, New Jersey

Prepared by
TRC Environmental Corporation
Windsor, Connecticut

Matthew N. Brown, P.E.
Project Engineer

Carl N. Stopper, P.E.
Senior Program Manager

TRC Project No. 26770-0100
June 2006

TRC Environmental Corporation
21 Griffin Road North
Windsor, Connecticut 06095
Telephone 860-298-9692
Facsimile 860-298-6399

ENGINEERED BARRIER DESIGN CALCULATIONS
Shieldalloy Metallurgical Corporation
Newfield, New Jersey

Erosion Protection Design

.The design of the long term erosion protection measures for the engineered barrier was performed using the techniques recommended in US NRC NUREG 1623 – Design of Erosion Protection for Long-Term Stabilization. The design precipitation event utilized as the basis for the engineered barrier design was the Probable Maximum Precipitation (PMP). The PMP design criteria were established by the US Army Corps of Engineers (USACOE), with the PMP defined in NUREG 1623 as "the estimated depth of rainfall for a given duration, drainage area, and time of year for which there is virtually no risk of exceedance." The goal of the design process was to identify appropriate ground cover methods for the engineered barrier to ensure long term stabilization of its surface.

The first step in the design process was to identify the appropriate PMP for the site using USACOE Hydrometeorological Report (HMR) 51 – Probable Maximum Precipitation Estimates, United States East of the 105th Meridian, and HMR 52 – Application of Probable Maximum Precipitation Estimates, United States East of the 105th Meridian. To determine maximum flow rates at various locations on the engineered barrier, the calculated PMP was converted into a rainfall intensity using the methodology prescribed in NUREG 4620 – Methodologies for Evaluating Long Term Stabilization Designs of Uranium Mill Tailings Impoundments. In accordance with NUREG 1623, based upon the calculated rainfall intensity and utilizing the rational method, the maximum flow rates along the top slopes and side slopes were calculated. In order to determine if vegetative cover was suitable to ensure long term stabilization, the maximum runoff flow velocity along the top slopes was calculated using the methodology stipulated in NUREG 1623. The calculations show that a vegetative cover will provide suitable long term erosion protection on the top slopes of the proposed landform. However, in order to provide more substantive erosion protection, stone riprap will be placed on both the top slopes and side slopes.

Calculations were performed, in accordance with the procedures stipulated in NUREG 1623, to determine both the required minimum stone size and minimum stone depth at the following locations on the engineered barrier: top slopes, side slopes, and at the toe of the side slopes. The calculations utilized the Abt and Johnson method, using a conservative flow concentration value of 3. The calculations show the following minimum 50th percentile stone diameters (d_{50}): Top Slopes – 0.45 inches, Side Slopes – 2.23 inches, Toe of Side Slopes – 4.47 inches. The following stone gradations will be utilized: Top Slopes – ½" to 1 ½" (d_{50} = 1"), Side Slopes – 2" to 4" (d_{50} = 3"), Toe of Side Slopes – 4" to 6" (d_{50} = 5"). The required minimum stone layer depth was then calculated in accordance with the procedures stipulated in NUREG 1623 and based upon the proposed d_{50} for each stone size. The calculated minimum stone layer depths are as follows: Top Slope – 2", Side Slopes – 6", Toe of Side Slopes – 15". To facilitate ease of installation, a 3" thickness of stone will be placed on the top of the landform rather than the minimum 2". Finally, the width of the riprap layer at the toe of the side slopes was calculated, in accordance with NUREG 1623, to be 7'.

Several calculations will need to be performed during the final design, after both stone and soil isolation layer sources have been selected. These calculations include stone durability (oversizing) calculations and stone filter layer design calculations. Depending on the physical characteristics of the stone selected for placement on the landform surface, as determined through laboratory testing, the required minimum stone d_{50} may increase slightly. The proposed stone d_{50} values have been selected to account for any oversizing that may be required. Depending on the soil gradation of the underlying soil isolation layer, a filter layer may be required beneath each of the stone layers. The calculations necessary to make this determination will be performed once a source for the soil isolation layer is selected. The filter layers will be added to the final design if necessary based upon the results of these calculations.

Probable Maximum Flood Evaluation

The impact of a probable maximum flood (PMF) event and its impact on the proposed plan for consolidating/capping the NRC regulated material were evaluated. The PMF is defined as the hypothetical flood (peak discharge, volume and hydrograph shape) that is considered to be the most severe reasonably possible, based on hydrometeorological application of the PMP and other hydrologic factors favorable for maximum flood runoff, such as sequential storms and snowmelt.

The Storage Yard area lies in an upland area of the site. The Hudson Branch runs east to west along the southern boundary of the property. Under the LTC Alternative, the Hudson Branch stream is 350 feet from the engineered barrier at its closest point. The Hudson Branch watershed upstream from the Storage Yard area measures approximately 370 acres and is mostly relatively flat undeveloped woodland and farmland. The Hudson Branch has its headwaters immediately upstream of the SMC facility and is a poorly defined stream channel through this reach, dry during several months of the year. A culvert pipe, which carries storm water from the more developed Newfield center north of the facility from north to south beneath the site, discharges into the Hudson Branch downstream of the Storage Yard area. The Hudson Branch leaves the site at the southwest corner of the property, flowing in a culvert pipe beneath the elevated railroad embankment and West Boulevard. The watershed area upstream from the railroad embankment measures approximately 700 acres.

During a PMF storm event, it is anticipated that the culvert pipe carrying the Hudson Branch beneath the railroad embankment and West Boulevard will be significantly obstructed and will pass an insignificant portion of the PMF flow. The result will be the overtopping of the railroad embankment and West Boulevard. The railroad embankment is relatively flat with its low point at the stream crossing over 500 feet long at approximately elevation 100 feet (NAD 83). Within any flood event having broad overbank flow, there is a region at the outer portion that is considered ineffective flow. The outer area of overbank flow is moving so slowly that it only provides dead storage and does not cause erosion. The demarcation between effective and ineffective flow is determined by the stream channel, overbank topography, vegetative cover, obstructions and water depth. The swiftest velocities will predominately be within a relatively narrow zone centered on the main stream channel, with the velocity decreasing further away from the main channel as the depth of flow decreases. A cross-section of the Hudson Branch and the overbank at the proposed capped pile shows the stream bottom elevation at approximately 90 feet. Fifty feet from the edge of the proposed capped pile, approximately 300 feet from the main stream channel, the elevation is 100 feet. The base of the proposed engineered barrier is also at approximately elevation 100 feet at this location. Along the upstream (easterly) facing side of the pile, the base of the proposed engineered barrier ranges from elevation 105 feet to elevation 110 feet. The base of the downstream (westerly) facing side of the proposed engineered barrier ranges from elevation 100 feet to elevation 105 feet.

TRC estimates that a PMF event peak flow could range as high as 4,000 cubic feet per second (cfs) at the point where the stream intersects the railroad embankment. This flow is based upon the Probable Maximum Precipitation (PMP) with a time of concentration of one hour. TRC's PMF estimate conservatively did not take into account any effect that storage and flood routing would have on reducing the peak flow. The depth of flow over the railroad embankment, acting as a broad crested weir (500 feet long), with no conveyance in the pipe culvert is approximately 1.9 feet. Assuming a worst case elevation of 102 feet (weir flow = 4,365 cfs) at the railroad embankment, the water elevation at the proposed engineered barrier 1500 feet upstream from the railroad embankment is anticipated to rise no more than three feet to approximately elevation 105 feet.

This scenario would place the peak water surface elevation along the southerly edge of the pile approximately five feet above the toe of the slope. The upstream (easterly) face of the pile would not be impacted by the maximum flood surface because the elevation of the base of the pile in this area is above elevation 105 feet. The downstream (westerly) face maximum flood surface depth would range from 0 feet at the northerly end to 5 feet at the southerly end. The topography along the base of the upstream face of the pile has the effect of deflecting the slow moving overbank flow away from the pile. This, combined with the fact that the average velocity of the PMF flow in the combined channel and overbank is less than 1 foot per second, and the velocity in the overbank area 350 feet away from the main channel will be negligible, is sufficient to support the conclusion that the protection offered by the riprap cover included in the engineered barrier design will be sufficient to protect the barrier from the effects of the PMF without the need to provide additional stone riprap or other protection below elevation 105 feet.

TRC SUBJECT SMC Erosion Protection Calcs

Determine 5 min Rainfall intensity for PMP (I)

1-Hr - 1 mi^2 PMP for site = 18.0 inches (USACOE HMR 52, Fig. 24)

Per Figure 36 of USACOE HMR-52, multiply 1hr PMP by 0.335 to determine 5 min PMP for site

∴ 5min PMP = 18.0 inches × 0.335 = 6.03 inches

$$I = \frac{6.03 \text{ inches}}{5 \text{ min}} \times \frac{60 \text{ min}}{hr} = \boxed{72.36 \frac{\text{inches}}{hr}}$$ (NUREG 4620 Eq. 2.2)

Determine Maximum Unit Flow from Top of Landform - Assume Grass Surface

$$Q = F \cdot C \cdot I \cdot A$$

F = Flow Concentration Factor = 3 (NUREG 1623 Apendix A, sec 2.2.2)

C = Runoff Coefficient = 0.7 (upper range for steep grass slopes per USDA 2003)

A = Area = 37.5' long × 1' wide = 37.5 ft^2

I = 72.36 inches/hr (see above)

$$Q = (3) \times (0.7) \times 37.5 ft^2 \times \frac{1 \text{ acre}}{43560 ft^2} \times 72.36 = \boxed{0.13 ft^3/sec \text{ per ft}}$$

A

TRC

SUBJECT SMC Erosion Protection Calculations

CHK'D

Determine Depth of Flow on Top of Landform

$$y^{5/3} = \frac{Q\,n}{1.486 \cdot S^{1/2}}$$ (equation A-3 of NUREG 1623)

Q = flow Rate = 0.13 (see previous calc)

n = 0.04 (Chow 1959 and discussions with TED JOHNSON OF NRC)

S = slope = 4% = 0.04

$$y^{5/3} = \frac{0.13 \times 0.04}{1.486 \times (0.04)^{1/2}}$$

$$y^{5/3} = \frac{.0052}{.2972} = 0.0175$$

$y = 0.088$ say **0.09 ft**

Determine Maximum Permissible for vegetative cover

unadjusted maximum permissible velocity (MPV) = 3 ft/s (USACOE EM-1110-2-1601 Table 2-5 and discussions with Ted Johnson of NRC)

Per NUREG 1623 Appendix A, section 2.2.2, Adjustment Factor = 0.5

Adjusted MPV = 3 ft/s × 0.5 = **1.5 ft/s**

Determine Velocity of Flow at Top of Landform

$V = Q/y = 0.13/0.09 =$ **1.44 ft/s**

Actual Velocity < Adjusted MPV

∴ Vegetation is Adequate Erosion Protection

A

TRC

SUBJECT SMC Erosion Protection Calculations

Determine Flow At Toe of Sideslopes - Assume Stone

$Q = C I A \cdot F$ (See calcs on pg 1 of calcs)

$F = 3$

$C = 0.8$ (Per NUREG 1623 Sec D-2.4.1)

$I = 72.36$

$A = [37.53'(\text{Topslope}) + 90.12'(\text{sideslope})] \times 1'$ wide

$= 127.65 \text{ ft}^2$

$$Q = (0.8) \times (72.36) \times \frac{(127.65)}{43560} \times (3) = 0.506 \text{ ft}^3/\text{sec}\cdot\text{ft} \quad \text{say } \boxed{0.51 \text{ ft}^3/\text{sec}\cdot\text{ft}}$$

Determine size of stone on sideslopes

Assume stone meets criteria in section 2.2.2 of Appendix D of NUREG-1623

Per 2.2.2 of Appendix D of NUREG 1623:

$$\min d_{50} = (5.23) \times (\text{Slope})^{0.43} \times (Q)^{0.56}$$

$$= (5.23)(0.33)^{0.43} \times (0.51)^{0.56}$$

$$= \underline{2.23 \text{ inches}}$$

∴ Use 2-4 inch stone with $d_{50} = 3''$

Determine depth of stone on Sideslope

Per Section 2.2.2 of Appendix D of NUREG 1623:

$$\text{Min depth of Stone} = 2 \cdot d_{50}$$

$$= 2 \times 3''$$

$$= \boxed{6''}$$

A

TRC

SUBJECT SMC Erosion Protection Calculations

Determine size of stone for Riprap Apron

Per Section 6.1 of Appendix D of NUREG 1623,

$$d_{50} = 10.46 \times S^{0.43} \times Q^{0.56}$$

$$d_{50} = (10.46) \times (0.33)^{0.43} \times (0.51)^{0.56}$$

$$= 4.47 \text{ inches}$$

∴ use 4"-6" stone with $d_{50} = 5"$

Determine Width of Apron

Per Section 6.3 of Appendix D of NUREG 1623

Min width $= 15 \cdot d_{50}$

$= 15 \times 5" = 75" = 6.25$ feet

∴ Use apron width of 7'

Determine thickness of Riprap Apron

Per Section 6.3 of Appendix D of NUREG 1623

Thickness $= 3 \cdot d_{50}$

$= 3 \times 5"$

$= 15"$

A

Determine Maximum Unit Flow from Top of Landform - Use Stone Surface

$Q = CIA \cdot F$ (see pg 1 of Calcs)

$F = 3$
$C = 0.8$ (Per NUREG 1623 Sec D-2.4.1)
$I = 72.36$
$A = 37.5\ ft^2$

$Q = (3)(0.8)(37.5) \times \frac{1\ acre}{43560\ ft^2} \times 72.36 = $ **0.15 ft^3/sec per ft**

Determine Size of stone on top slopes

Assume stone meets Criteria in Section D-2.2.2 of NUREG 1623

Per D-2.2.2 of NUREG 1623

$$\min d_{50} = 5.23 \times (slope)^{0.43} \times (Q)^{0.56}$$
$$= 5.23 \times (0.04)^{0.43} \times (0.15)^{0.56}$$
$$= 0.45 \text{ inches} \quad \text{say } 0.5 \text{ inches}$$

∴ use ½" to 1½" stone with $d_{50} = 1"$

Determine depth of Stone on top Slopes

Per D-2.2.2 of NUREG 1623

$$\text{min. depth} = 2 \cdot d_{50}$$
$$= 2 \cdot 1"$$
$$= 2"$$

∴ use 3" for ease of installation

A

2.2 Procedures

Procedures have been developed to (a) design a stable unprotected soil cover (or vegetated soil cover with no credit given for vegetation) using the allowable shear stress method, as modified and developed in the Horton/NRC Method and (b) design a stable vegetated section using the permissible velocity method for areas where vegetation can be effective. These procedures provide two acceptable methods for designing stable covers. It is recognized that in many cases, specific values of parameters may be difficult to justify. In those cases where licensees can justify values of individual parameters that depart from the values given by suggested references, the resulting designs will be considered on a case-by-case basis.

2.2.1 Unprotected Soil Cover

Step-by-step procedures for implementing the allowable shear stress method for an unprotected soil cover are presented below:

Step 1. Determine maximum allowable shear stress for bare soil using procedures developed by Temple et al. (1987). The staff considers Temple's method to be an accurate method for determining shear stresses because it is related to the Unified Soil Classification System and can be applied for specific soil types and degrees of cohesiveness. In general, the Temple procedure for determining allowable shear stress is based primarily on the soil particle size and the soil cohesiveness. The amount of resistance for granular non-cohesive soils, including rocky soils, is principally a function of the D_{75} grain size, where the allowable tractive force is equal to 0.4 x D_{75} (Temple et al., 1987). For granular soils, the increase in shear resistance due to cohesiveness is minimal. For cohesive soils where the particle size is smaller, the amount of resistance is principally a function of the soil cohesiveness and not the particle size.

Step 2. Determine slope and slope length to be considered, as developed in the preliminary reclamation design.

Step 3. Determine flow concentration factor (F). Documentation of the occurrence of flow concentrations and the ability of an individual rock or soil particle to resist given flow rates is discussed further by Abt et al. (1987). The actual value of F will depend on several factors, including grading practices during cover construction, cover slope, and potential for differential settlement. The staff recommends a default value of 3, for most soil slopes; other values may be used, if properly justified.

Step 4. Estimate Manning's "n" value using general procedures given by Temple et al. (1987); by Nelson et al. (1986); or by Chow (1959).

Step 5. Determine the rainfall intensity using the procedures given by Nelson et al. (1986) and determine the peak runoff rate using the Rational Formula.

NUREG 1623

Step 6. Solve for stable slope, using the Horton/NRC equation. If the computed slope is different from that assumed, return to Step 2 with new values of slope and/or slope length.

2.2.2 Vegetated Soil Cover

Step 1. Maximum permissible velocities (MPVs) should be estimated using data developed by the U.S. Soil Conservation Service (SCS, 1984); or by Nelson et al., 1986). Based on these data, maximum MPVs should generally range from about 2½ to 3½ ft per second for any vegetation other than dense grasses. These velocities need to be further reduced, as discussed in Step 6.

Step 2. Determine slope and slope length.

Step 3. Determine flow concentration (F). See Step 3 in Section 2.2.1, above for additional information.

Step 4. Estimate Manning's "n" value using procedures recommended by Chow (1959, Table 7.6) for very low vegetal retardance (Fig. 7.14).

Step 5. Determine rainfall intensity and runoff rate using procedures discussed in Step 5 in Section 2.2.1.

Step 6. Determine the flow depth (y) by solving the Manning Equation for normal depth on a one-foot-wide strip. This equation can be solved directly in this case using the following derivation:

$$y^{5/3} = Qn/\ (1.486\ S^{1/2}). \qquad \text{(A-3)}$$

Step 7. Determine the permissible velocity for the slope, based on the computed depth of flow. Chow has developed correction factors that may be applied to determine the permissible velocity. The permissible velocity is multiplied by the following correction factors, depending on the depth of flow.

Depth of Flow (ft)	Correction Factor
3.0 or greater	1.0
1.9	0.9
1.0	0.8
0.65	0.7
0.4	0.6
0.25 or less	0.5

Step 8. For the assumed one-foot-wide strip, determine the actual flow velocity (V_a) by dividing the discharge by the flow depth:

from: Low-Volume Roads Engineering
Best Management Practices Field Guide
By
Gordon Keller & James Sherar
USDA, Forest Service, July 2003

RECOMMENDED PRACTICES

- Use the best available hydrologic methods to determine design flows.
- Where appropriate, use drainage structures that are not sensitive to exact flow predictions, such as low water crossings (fords) and drivable dips versus culvert pipes.
- Add freeboard or extra capacity to structures in drainages with uncertain flow or for debris passage in watersheds with changing land uses, usually on the order of 120% to 150%.
- To minimize risk to structures, the recommended storm frequency (return period) for design of culverts is 20 to 50 years, and 100 to 200 years is recommended for bridges or drainages with sensitive environmental concerns.
- For culverts installed in areas with limited or inadequate hydrologic data or designs, include overflow (overtopping) protection to reduce risk of total failure or stream diversion (see Figure 7.10).
- Involve hydrologists, fisheries biologists and engineers in the process of hydrologic and hydraulic design.

PRACTICES TO AVOID

- Installing drainage structures without some rational or statistical assessment of the expected flow.

Table 5.1

DESIGN FLOW ANALYSIS METHODS FOR VARIOUS WATERSHED SIZES

Watershed Size	Typical Type of Analysis
Small (to 120 ha) (300 acres)	Rational Method, Talbot Method, Local Experience
Medium (to 4,000 ha) (10,000 acres)	Regression Analysis, High Water Marks + Manning, Local Experience
Large (over 4,000 ha)	Gauging Data, High Water Marks, Statistical or Regression Analysis

Table 5.2

RATIONAL METHOD VALUES OF "C"

Land Use or Type	"C" Value
Agriculture	
Bare Soil	0.20-0.60
Cultivated Fields (sandy soil)	0.20-0.40
Cultivated Fields (clay soil)	0.30-0.50
Grass	
Turf, Meadows	0.10-0.40
Steep Grassed Areas	0.50-0.70
Woodland/Forest	
Wooded Areas with Level Ground	0.05-0.25
Forested Areas with Steep Slopes	0.15-0.40
Bare Areas, Steep and Rocky	0.50-0.90
Roads	
Asphalt Pavement	0.80-0.90
Cobblestone or Concrete Pavement	0.60-0.85
Gravel Surface	0.40-0.80
Native Soil Surface	0.30-0.80
Urban Areas	
Residential, Flat	0.40-0.55
Residential, Moderately Steep	0.50-0.65
Commercial or Downtown	0.70-0.95

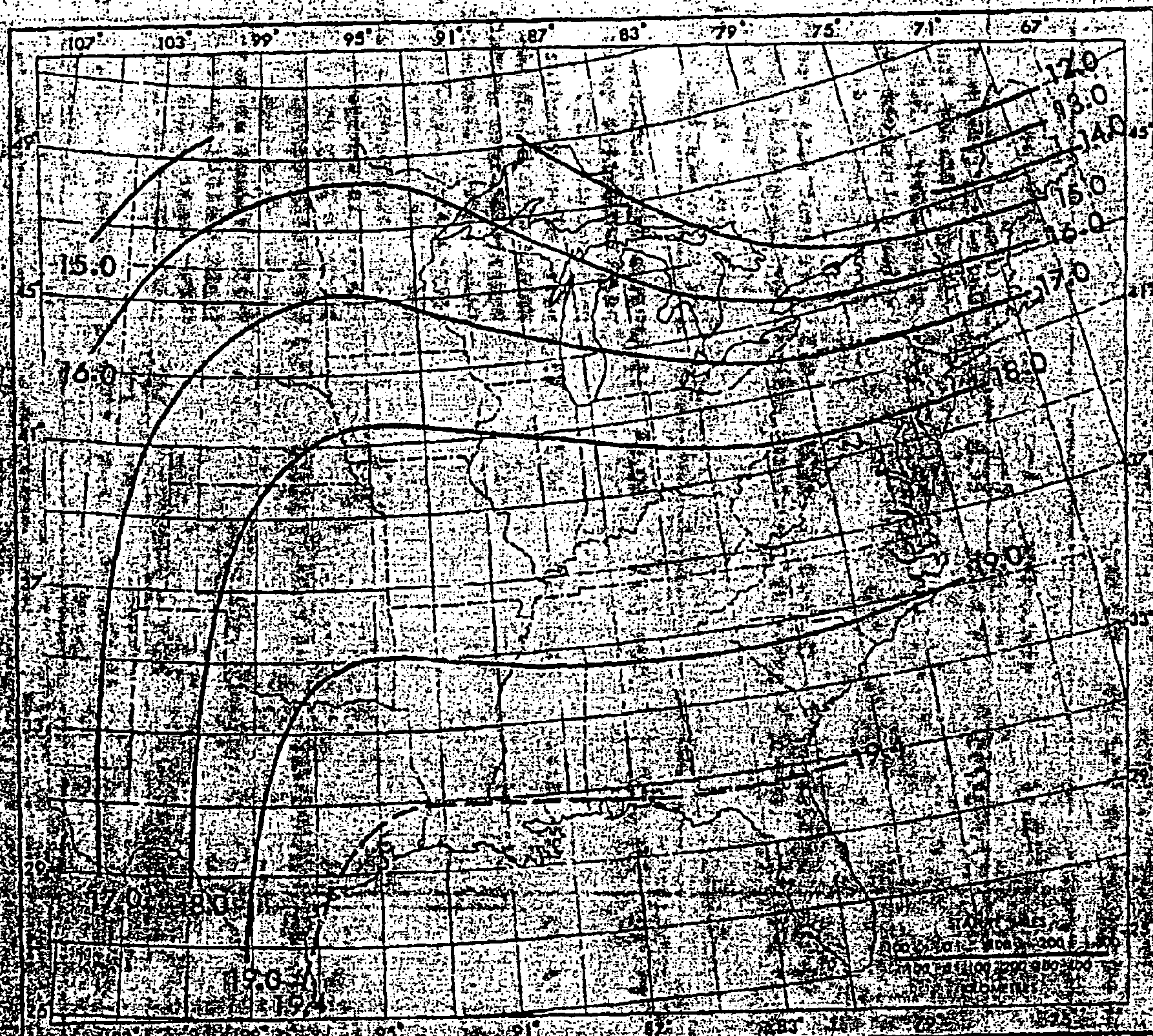


Figure 24.—1-hr, 1-mi² PMP analysis based on figure 23 and 6-hr 10-mi² precipitation from HMR No. 51.

transposition limits. Comparison of this 18.9-in. value with the 1-hr 1-mi² PMP from figure 24 shows a difference of 0.6 in. We consider this a reasonable envelopment of a moisture maximized transposed amount.

6.3.3 Depth-area ratios

Preparation of 1-hr PMP values over the range of area sizes of interest required development of depth-area reduction ratios. A primary basis for such reduction ratios is the list in table 19 of 12 extreme storms (those noted by asterisks) for which point or 1-mi² data are available at 1 hr. A problem with the data from these 12 storms is the limited area of most storms. Nearly 60 percent have an areal extent of less than 240 mi², while one fourth of them

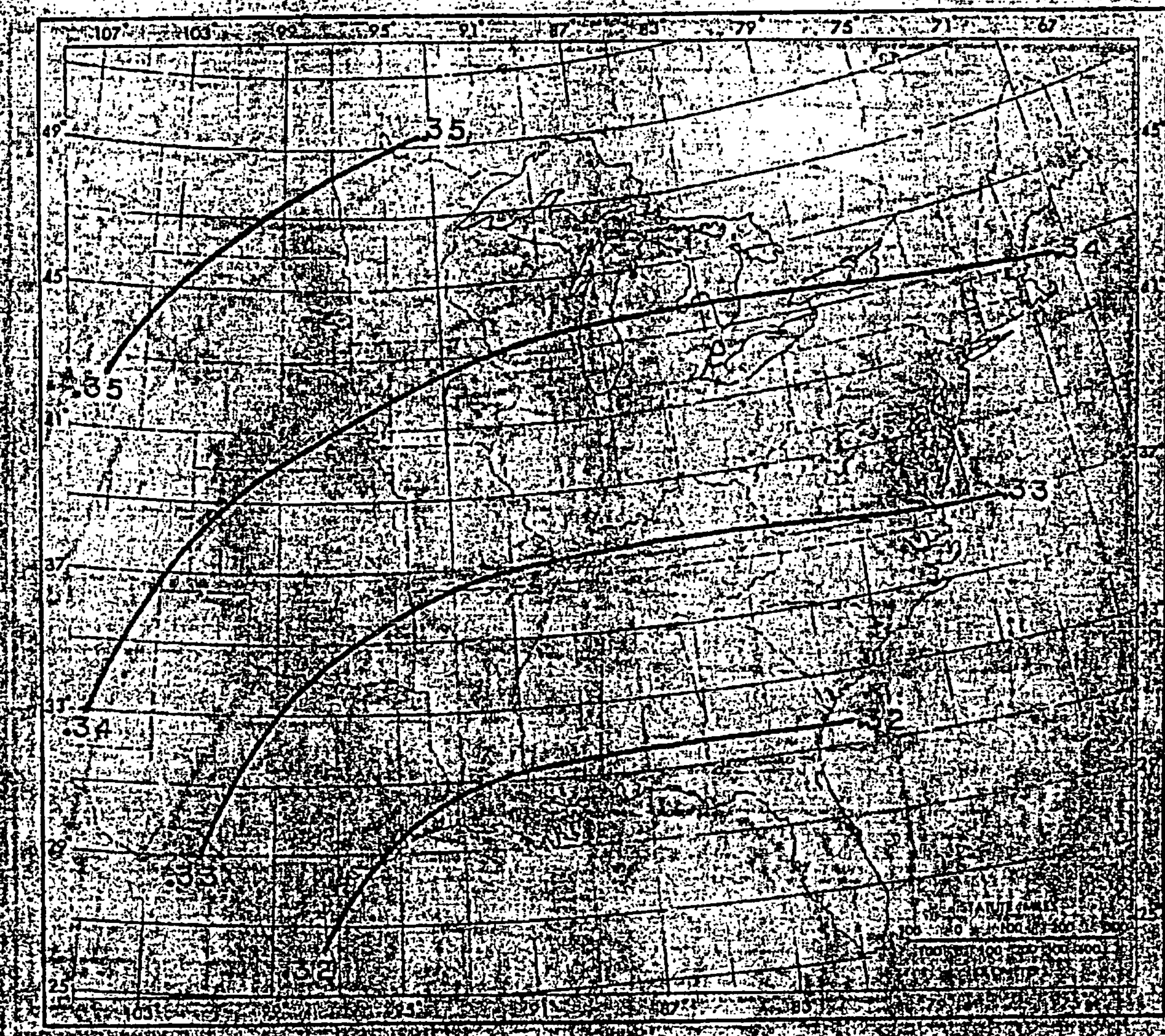


Figure 36.—Ratio analysis of 5- to 60-min precipitation used to obtain 5-min PMP. (Applicable to area sizes < 200 mi².)

The rainfall depth for a specific site is estimated by determining the rainfall duration and/or appropriate time of concentration. The resulting rainfall depth in inches, is

$$\text{PMP rainfall depth} = (\%\ \text{PMP}) \times (\text{PMP}) \qquad (2.1)$$

where the percent PMP is obtained from Table 2.1 and the PMP is obtained from the appropriate PMP design storm presented in Section 2.1.1.

The rainfall intensity, i, in inches per hour can be computed as

$$i = \text{rainfall depth (inches)} \times \frac{60}{\text{rainfall duration (minutes)}} \qquad (2.2)$$

The rainfall intensity determined from Equation 2.2 is generally a conservative value and represents the peak rainfall intensity of the design storm.

To compute the rainfall intensity for any rainfall duration, it is recommended that a rainfall intensity versus rainfall duration curve be plotted on semilogaritnmic paper. Because of the extremely conservative rainfall intensity values obtained for short durations, it is recommended that the minimum rainfall duration be 2.5 minutes. Rainfall depths should be extracted from the appropriate Hydrometeorological Report.

2.2 PMP COMPARISON STORMS

A comparison of estimates of the PMP with greatest observed rainfall and estimates of the 100-year events for areas both east and west of the 105° meridian was prepared (NWS, 1980). Information from 6500 precipitation reporting stations in the eastern U.S. and about 2100 stations in the west was used. Including storm durations of 6 to 72 hours, the study indicated that 177 separate storm events have been recorded in which the rainfall was greater than or equal to 50 percent of the PMP for stations east of the 105° meridian. Only 65 separate storm events were recorded west of the 105° meridian where rainfalls were greater than or equal to 50 percent of the PMP.

The National Weather Service also reported the number of storm events which met or exceeded the 100-year rainfall values and compared them with the regional PMP values (NWS, 1980). Table 2.2 summarizes these rainfall events for 6 and 24-hour storms occurring over a 10 square mile area. It is interesting to note that a storm has not been officially recorded west of the Continental Divide that exceeds 90% of the PMP value. However, it is evident that a number of storms approach the PMP values, thereby substantiating that the prescribed PMP values are not extremely conservative.

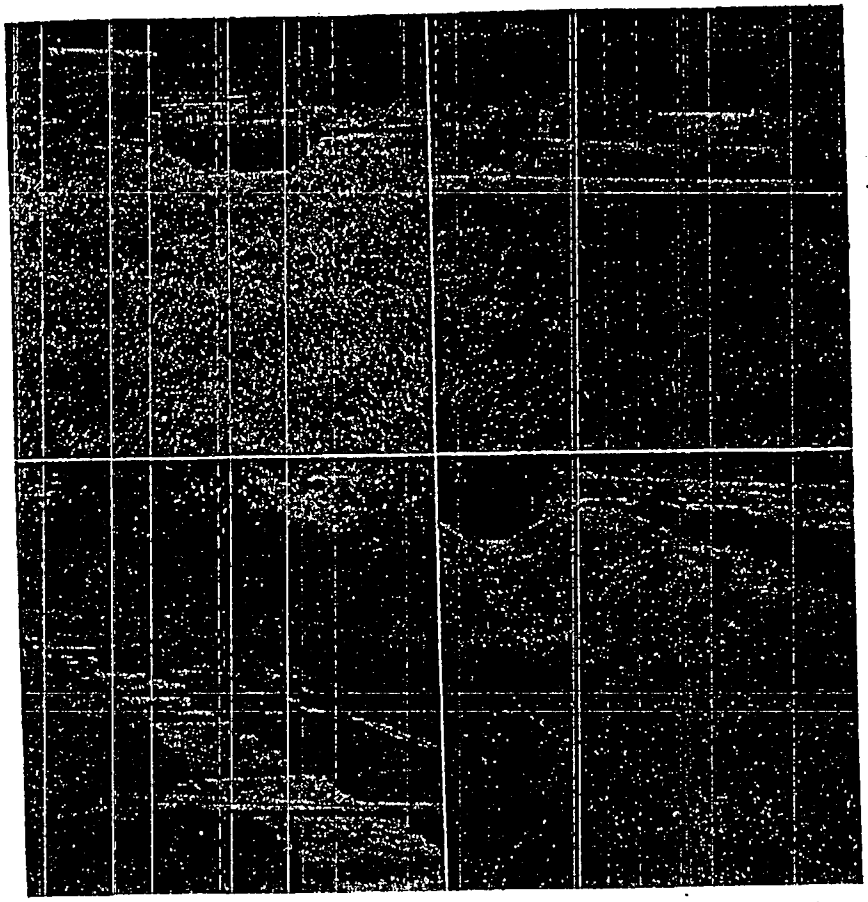


FIG. 7-13. Centipede grassed channel. (*Courtesy of W. O. Ree, U.S. Agricultural Research Service.*) (*A*) Before experiment; (*B*) after test at a flow equal to 15 cfs for 40 min; (*C*) during test at a flow equal to 30 cfs; (*D*) at completion of the whole experiment.

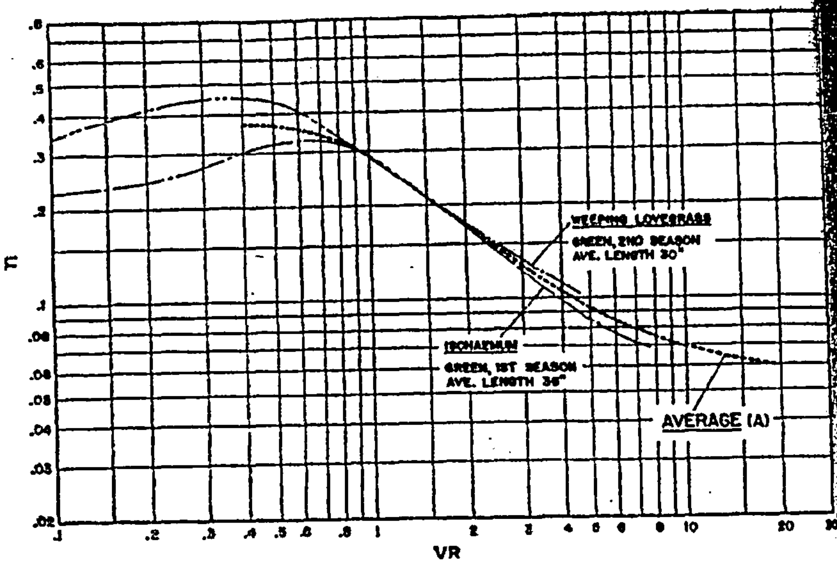
only the average curve is shown, together with the curves for low retardance. The classification of degree of retardance is based on the kind of vegetation and the condition of growth, as described in Table 7-4. The term "stand" used in the table refers to the density of grass, or the count of vegetation, which is sometimes expressed as the number of stems per square foot. The n-VR curves thus developed may also be applied to other kinds of grass, provided that their characteristics and degree of retardance can be identified. For this purpose, Table 7-5 is provided as a guide in the selection of the vegetal retardance for different conditions of stand and average length of the grass.

TABLE 7-4. CLASSIFICATION OF DEGREE OF RETARDANCE FOR VARIOUS KINDS OF GRASS*

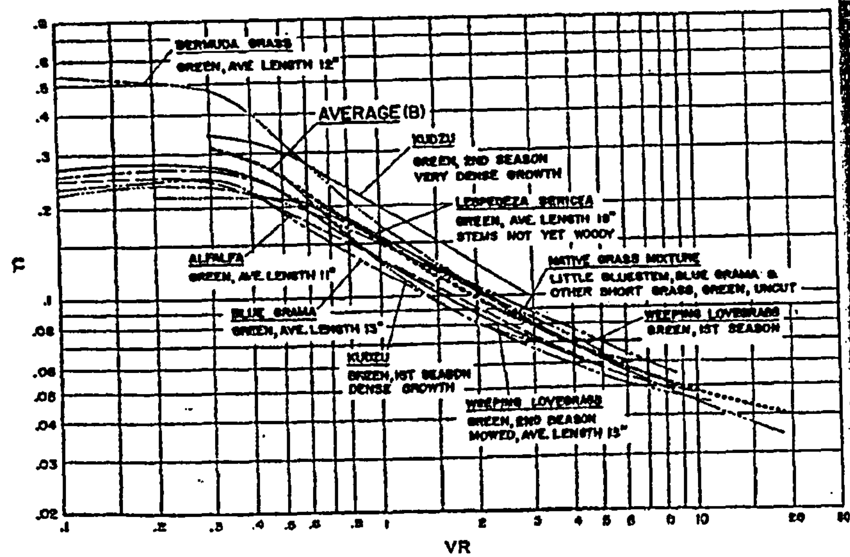
Retardance	Cover	Condition
A Very high	Weeping love grass	Excellent stand, tall (av 30 in.)
	Yellow bluestem ischaemum	Excellent stand, tall (av 36 in.)
B High	Kudzu	Very dense growth, uncut
	Bermuda grass	Good stand, tall (av 12 in.)
	Native grass mixture (little bluestem, blue grama, and other long and short Midwest grasses)	Good stand, unmowed
	Weeping love grass	Good stand, tall (av 24 in.)
	Lespedeza sericea	Good stand, not woody, tall (av. 19 in.)
	Alfalfa	Good stand, uncut (av 11 in.)
	Weeping love grass	Good stand, mowed (av 13 in.)
	Kudzu	Dense growth, uncut
	Blue grama	Good stand, uncut (av 13 in.)
C Moderate	Crab grass	Fair stand, uncut (10 to 48 in.)
	Bermuda grass	Good stand, mowed (av 6 in.)
	Common lespedeza	Good stand, uncut (av 11 in.)
	Grass-legume mixture—summer (orchard grass, redtop, Italian rye grass, and common lespedeza)	Good stand, uncut (6 to 8 in.)
	Centipede grass	Very dense cover (av 6 in.)
	Kentucky bluegrass	Good stand, headed (6 to 12 in.)
D Low	Bermuda grass	Good stand, cut to 2.5 in. height
	Common lespedeza	Excellent stand, uncut (av 4.5 in.)
	Buffalo grass	Good stand, uncut (3 to 6 in.)
	Grass-legume mixture—fall, spring (orchard grass, redtop, Italian rye grass, and common lespedeza)	Good stand, uncut (4 to 5 in.)
	Lespedeza sericea	After cutting to 2 in. height, very good stand before cutting
E Very low	Bermuda grass	Good stand, cut to 1.5 in. height
	Bermuda grass	Burned stubble

* U.S. Soil Conservation Service [41].

Chow (1959)

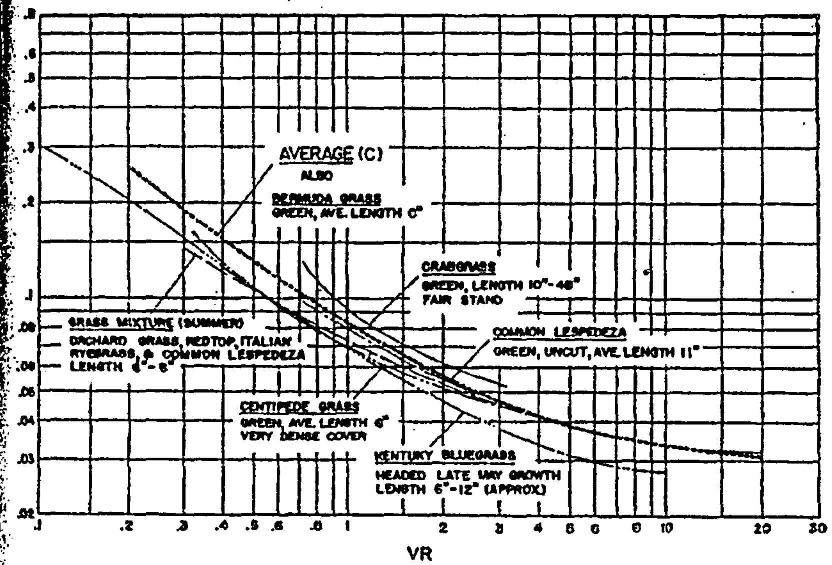


(a) Curves for A or very high vegetal retardance.

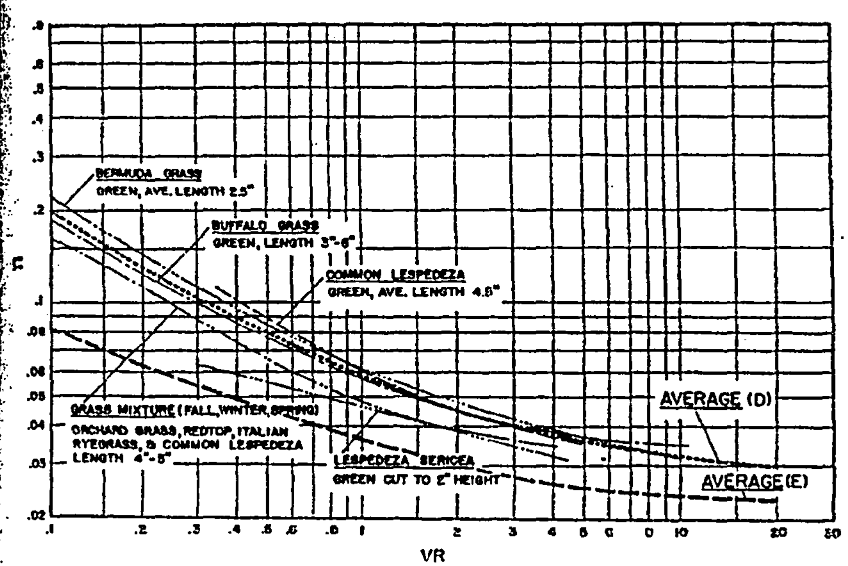


(b) Curves for B or high vegetal retardance.

FIG. 7-14. Experimental n-VR curves. (*U.S. Soil Conservation Service.*)



(c) Curves for C or moderate vegetal retardance.



(d) Curves for D or low vegetal retardance, and an average curve for E or very low vegetal retardance.

FIG. 7-14 (*Continued*).

Chow (1959)

TABLE 7-5. GUIDE IN SELECTION OF VEGETAL RETARDANCE*

Stand	Average length of grass, in.	Degree of retardance
Good	>30	A Very high
	11–24	B High
	6–10	C Moderate
	2–6	D Low
	<2	E Very low
Fair	>30	B High
	11–24	C Moderate
	6–10	D Low
	2–6	D Low
	<2	E Very low

* U.S. Soil Conservation Service [41].

7-18. The Permissible Velocity. The permissible velocity of flow in a grassed channel is the velocity that will prevent severe erosion in the channel for a reasonable length of time. Permissible velocities for different vegetal covers, channel slopes, and soil conditions, recommended on the basis of investigation by the Soil Conservation Service, are shown in Table 7-6.

7-19. Selection of Grass. The selection of grass for the channel lining depends mainly on the climate and soil in which the plant will grow and survive under the given conditions. From the hydraulic viewpoint, stability and other factors should also be considered. In general, a higher discharge requires a stronger or better lining. On steep slopes, bunch grasses, such as alfalfa, lespedeza, and kudzu, will develop channeling of the flow and, hence, are unsatisfactory for lining. For slopes greater than 5%, only fine and uniformly distributed sod-forming grasses, such as Bermuda grass, Kentucky bluegrass, and smooth brome, are recommended for lining where the main flow occurs. Because of the objectionable spreading nature of sod-forming grasses, the top portion of the sides and the berm may be planted with grasses that do not spread easily, such as weeping love grass. For fast establishment of the lining, Bermuda grass and weeping love grass are recommended. Sometimes annuals are used as temporary protection until permanent covers by native grasses are established. Silt deposition in channels may be controlled by lining with bunch grasses, which will develop channeled flow, increase velocity, and thus reduce silting.

7-20. Procedure of Design. After the kind of grass for channel lining is selected, the degree of retardance can be determined from the condition of the stem length and the density of growth. During the period of

establishment, the grass will grow and the channel will be stabilized under a condition of low degree of retardance. The channel will not reach its maximum capacity until the grass cover is fully developed and well established. Therefore, it is suggested that the hydraulic design of a grassed channel consist of two stages. The first stage (*A*) is to design the channel for stability, that is, to determine the channel dimensions under the condition of a *lower* degree of retardance. The second stage

TABLE 7-6. PERMISSIBLE VELOCITIES FOR CHANNELS LINED WITH GRASS*

Cover	Slope range, %	Permissible velocity, fps: Erosion-resistant soils	Permissible velocity, fps: Easily eroded soils
Bermuda grass	0–5	8	6
	5–10	7	5
	>10	6	4
Buffalo grass, Kentucky bluegrass, smooth brome, blue grama	0–5	7	5
	5–10	6	4
	>10	5	3
Grass mixture	0–5	5	4
	5–10	4	3
	Do not use on slopes steeper than 10%		
Lespedeza sericea, weeping love grass, ischaemum (yellow bluestem), kudzu, alfalfa, crabgrass	0–5	3.5	2.5
	Do not use on slopes steeper than 5%, except for side slopes in a combination channel		
Annuals—used on mild slopes or as temporary protection until permanent covers are established, common lespedeza, Sudan grass	0–5	3.5	2.5
	Use on slopes steeper than 5% is not recommended		

REMARKS. The values apply to average, uniform stands of each type of cover. Use velocities exceeding 5 fps only where good covers and proper maintenance can be obtained.

* U.S. Soil Conservation Service [41].

(*B*) is to review the design for maximum capacity, that is, to determine the increase in depth of flow necessary to maintain a maximum capacity under the condition of a *higher* degree of retardance. For instance, if common lespedeza is selected as the grass for lining, the common lespedeza of low vegetal retardance (green, average length 4.5 in.) is used for the first stage in design. Then, in the second stage, the common lespedeza of moderate vegetal retardance (green, uncut, average length 11 in.) should be used. Finally, a proper freeboard is added to the computed

CHOW (1959)

critical scour velocities is given by the Task Committee on Preparation of Sedimentation Manual (1966). Table 2-5 gives a set of permissible velocities that can be used as a guide to design nonscouring flood control channels. Lane (1955) presents curves showing permissible channel shear stress to be used for design, and the Soil Conservation Service (1954) presents information on grass-lined channels. Departures from suggested permissible velocity or shear values should be based on reliable field experience or laboratory tests. Channels whose velocities and/or shear exceed permissible values will require paving or bank revetment. The permissible values of velocity and/or shear should be determined so that damage exceeding normal maintenance will not result from any flood that could be reasonably expected to occur during the service life of the channel.

Table 2-5
Suggested Maximum Permissible Mean Channel Velocities

Channel Material	Mean Channel Velocity, fps
Fine Sand	2.0
Coarse Sand	4.0
Fine Gravel[1]	6.0
Earth	
Sandy Silt	2.0
Silt Clay	3.5
Clay	6.0
Grass-lined Earth (slopes less than 5%)[2]	
Bermuda Grass	
Sandy Silt	6.0
Silt Clay	8.0
Kentucky Blue Grass	
Sandy Silt	5.0
Silt Clay	7.0
Poor Rock (usually sedimentary)	10.0
Soft Sandstone	8.0
Soft Shale	3.5
Good Rock (usually igneous or hard metamorphic)	20.0

Notes:
1. For particles larger than fine gravel (about 20 millimetres (mm) = 3/4 in.), see Plates 29 and 30.
2. Keep velocities less than 5.0 fps unless good cover and proper maintenance can be obtained.

SHEET NO. 1 OF 2
PROJECT NO. 26770-0100
DATE 3/2/06
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SUBJECT SMC

Determine Flow of PMF and depth over Road

Flow Calculations

Rational Method → $Q = CIA$

A = Drainage Area = 30,000,000 sf = 688.7 acres = 1.07 mi²

C = Coefficient of Imperviousness

Assume 75% wooded + Level Ground (C = 0.25 conservatively)
25% Flat Residentia (C = 0.55 conservatively)

$C = (0.75)(0.25) + (0.55)(0.25) = 0.325$

I = intensity, based upon T_c (Assume 60 min conservatively)

1hr - 1 mi² PMP = 18.0 inches (ACOE HMR 52, Figure 24)

$$I = PMP \times \frac{60 min}{duration of PMP} = 18.0 \times \frac{60 min}{60 min} = 18.0 \text{ inches/hr}$$

$Q = CIA = 688.7 \times 0.325 \times 18 = 4029$ cfs

Depth over Road

Assume Railroad/Roadway is acting as a broad crested weir

$$Q = C_W \times 2/3 \times \sqrt{2g} \times B \times H^{3/2}$$ solve for H

C_W = weir discharge coefficient = 0.577 (Daugherty and Franzini 1965)
g = gravity = 32.2
B = width = 500' (conservative estimate)

$4000 \text{ cfs} = 0.577 (2/3) \sqrt{2(32.2)} \cdot 500 \cdot H^{3/2}$

$H^{3/2} = 4000 \div 1543.47$

H = 1.89 ft

A

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SHEET NO. 2 OF 2
PROJECT NO. 26770
DATE 3/2/06
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Determine avg flow velocity of PMF at pile.

Avg Velocity = total Flow ÷ cross Sectional Area of Flow

= 4029* cfs ÷ 5675 sf (see attached figures)

= 0.71 ft/sec

As velocity at outer limits of flow will be significantly less than that in the area of "effective flow" around the center of the channel, the velocity at the pile is expected to be much less than 0.71 ft/sec, well below even the vegetative adjusted MPV of ~~2.5~~ 1.5 ft/sec
MB 6/1/06

* this calculation proves to be extremely conservative, as it assumes all flow crossing road downstream passes by pile. In fact, only approx ½ of the total watershed leading to the roadway crossing lies upgradient of the proposed pile location.

A

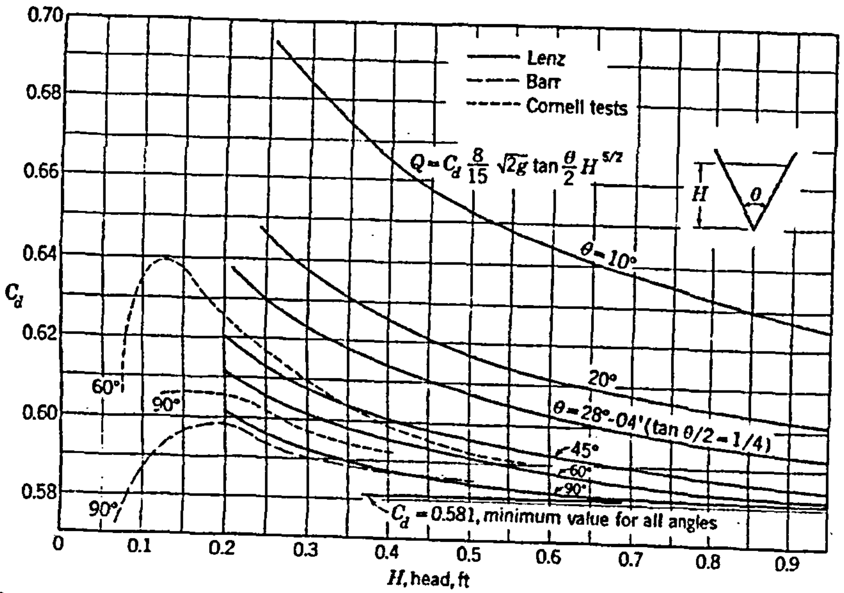


Fig. 11.36. *Coefficients for triangular weirs.*

In Fig. 11.36 are presented experimental values of C_d for water flowing over *V*-notch weirs with central angles varying from 10 to 90°. The solid lines represent tests by Lenz;[1] the dotted lines are from data taken at Cornell University;[2] the dashed line represents a 90° weir with a fine sharp edge, reported by Barr.[3] The rise in C_d at heads less than 0.5 ft is due to incomplete contraction. At lower heads the frictional effects reduce the coefficient. At very low heads, when the nappe clings to the weir plate, the phenomenon can no longer be classed as weir flow and Eq. (11.44) is inapplicable.

11.23. BROAD-CRESTED WEIR

Another type of weir is the broad-crested weir (Fig. 11.37), which is usually built of concrete. One of its advantages is that it is rugged and can stand up well under field conditions.

[1] Arno T. Lenz, Viscosity and Surface Tension Effects on V-notch Weir Coefficients, *Trans. ASCE*, vol. 108, pp. 759–802, 1943.
[2] *Eng. News*, vol. 73, p. 636, 1915.
[3] James Barr, Experiments upon the Flow of Water over Triangular Notches, *Engineering*, Apr. 8–15, 1910.

Daugherty and Franzini 1965

The broad-crested weir, as mentioned in Illustrative Example 10.3, is a critical-depth meter; that is, critical depth occurs on the crest of the weir. In Eq. (10.16) it was shown that, for a rectangular channel, $E = \frac{3}{2}y_c$, while Eq. (10.19) stated that $y_c = (q^2/g)^{1/3}$. Employing these relations, we can write for the flow over a broad-crested weir:

$$Q = B\sqrt{gy_c^3} = B\sqrt{g(\tfrac{2}{3}E)^3} = B(\tfrac{2}{3})^{3/2}\sqrt{g}\,E^{3/2} \qquad (11.46)$$

Let us now substitute this expression into Eq. (11.39), which is applicable to broad-crested weirs as well as sharp-crested ones, since both have rectangular flow cross sections. This yields

$$C_W = \frac{1}{\sqrt{3}}\left(\frac{E}{H}\right)^{3/2} \qquad (11.47)$$

For very high weirs (that is, P/H large) the velocity of approach becomes small, so that $H \rightarrow E$, and thus $C_W \rightarrow 1/\sqrt{3} = 0.577$. Hence it is seen that C_W depends on the P/H ratio. When P/H is small, C_W is large, and vice versa.

11.24. SLUICE GATE

The sluice gate shown in Fig. 11.38 is a device used to control the passage of water in an open channel. When properly calibrated, it may also serve as a means of flow measurement. As the lower edge of the gate opening is flush with the floor of the channel, contraction of the bottom side of the issuing stream is entirely suppressed. Side contractions will of course depend on the extent to which the opening spans the width of the channel. The complete contraction on the top side, however, because of the larger velocity components parallel to the face of the gate, will offset the suppressed bottom contraction, resulting in a coefficient of

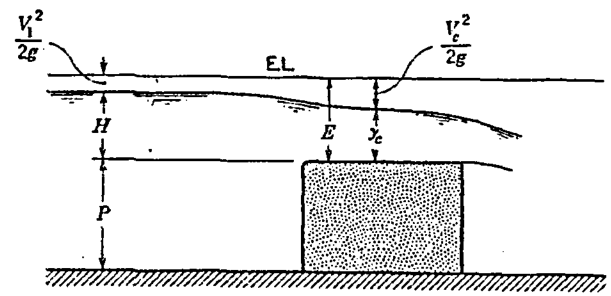
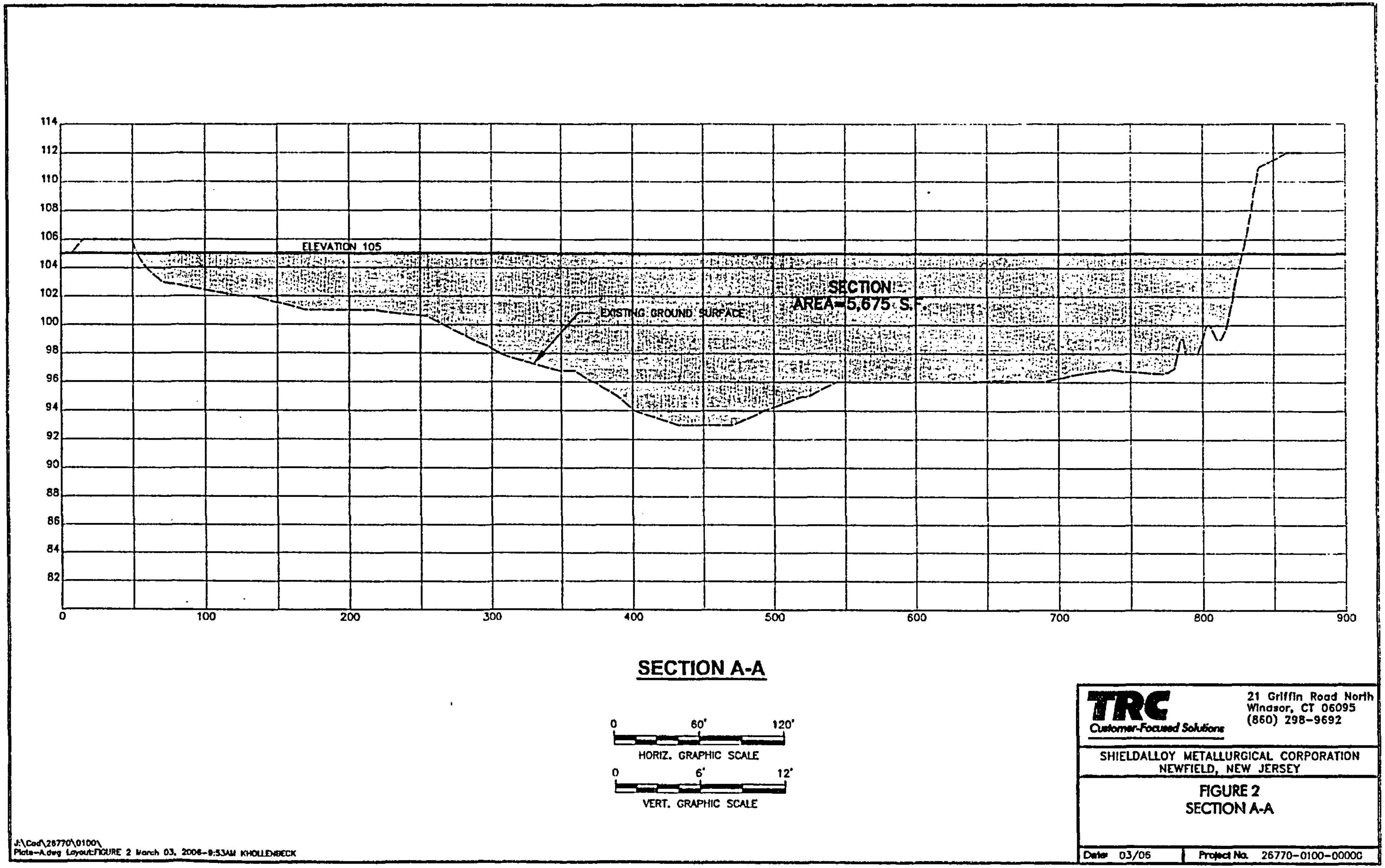


Fig. 11.37. Broad-crested weir.



114
112
110
108
106
104
102
100
98
96
94
92
90
88
86
84
82
0
100
200
300
400
500
600
700
800
900
ELEVATION 105
SECTION
AREA=5,675 S.F.
EXISTING GROUND SURFACE
SECTION A-A
0 60' 120'
HORIZ. GRAPHIC SCALE
0 6' 12'
VERT. GRAPHIC SCALE
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FIGURE 2
SECTION A-A
Date 03/06
Project No. 26770-0100-00000
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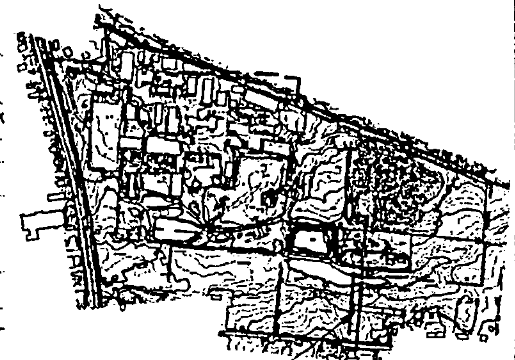
Plate-A.dwg Layout:FIGURE 2 March 03, 2006-9:53AM KHOLLENBECK



SITE PLAN

SCALE: 1"=800'

SOURCE:
PHOTOMETRIC SURVEY BY PROMAPS
DATED JANUARY 18, 2005.

NOTE:
HORIZONTAL DATUM IS NEW JERSEY
STATE PLANE COORDINATES NAD '83.

VERTICAL DATUM IS NAVD 88.

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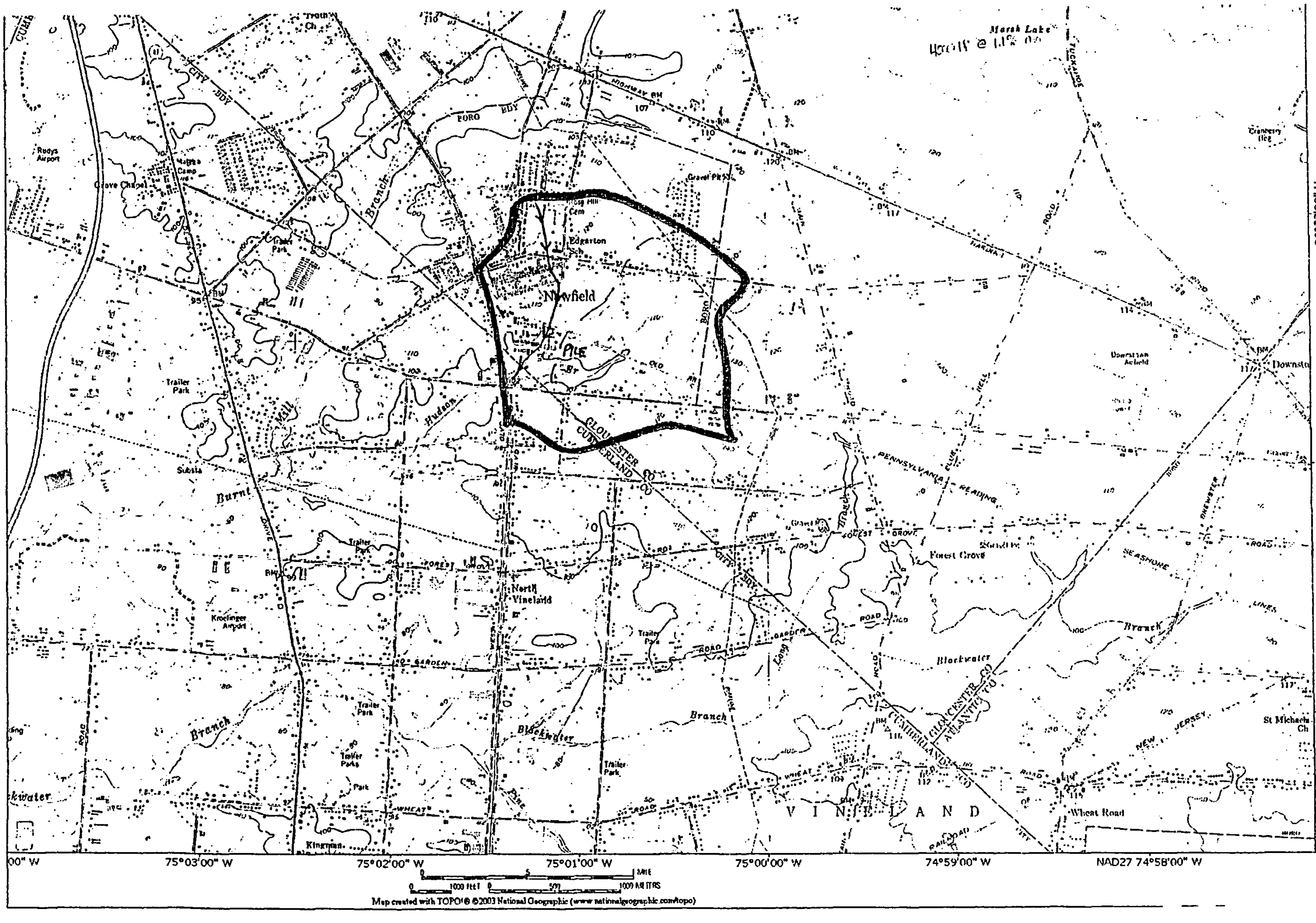
FIGURE 1
SECTION LOCATION PLAN

Date: 03/06 | Project No. 26770-0100-00000



Newfield
Edgarton Sch
Gravel Pit
Rudys Airport
Grove Chapel
Trailer Park
Subsia
Burnt
Hudson
Mill
Branch
North Vineland
Kroelinger Airport
Forest Grove
Blackwater
Branch
Long
Seashore
Lines
Downstown Airfield
St Michaels Ch
Wheat Road
Kingman
Trailer Parks
V I N E L A N D
GLOUCESTER CO
CUMBERLAND CO
ATLANTIC CO
PENNSYLVANIA READING
NEW JERSEY
Marsh Lake
Cranberry Bog
75°03'00" W
75°02'00" W
75°01'00" W
75°00'00" W
74°59'00" W
NAD27 74°58'00" W
39°33'00" N
39°32'00" N
39°31'00" N
1 MILE
1000 FEET
1000 METERS
Map created with TOPO!® ©2003 National Geographic (www.nationalgeographic.com/topo)

Appendix F - Revised Chapter 8 Sections

[The following selected sections of Chapter 8 of the DP have been revised and have been captured in Rev. 1a of the DP.]

8.3 Soil

The focus of this Plan is the consolidation, capping and management of remaining process slag, baghouse dust, contaminated concrete, radiologically-impacted soils and other USNRC-regulated materials into a designated . . . *[text continues]* . . .

Primary design considerations include: (1) physical characteristics of the stockpiled regulated materials (size, density); (2) volumes of the material piles; (3) relative locations of the material piles and (4) long-term durability and robustness of the final engineered barrier. The engineered barrier will be designed and constructed in order to minimize material relocation, while establishing a stable storage system. Specific design considerations include provision for the following:

- Provide required radiological shielding through installation of calculated engineered barrier thickness;
- Maintain engineered barrier thickness over the long-term to preclude the need for repairs and therefore maintain the necessary radiological shielding
- Facilitate drainage off of engineered barrier and away from unit while precluding the occurrence and need for repair of deep erosion gullies;
- Ensure long-term engineered barrier slope stability through appropriate design and construction;
- Install erosion controls for implementation during construction and for long-term engineered barrier maintenance;
- Provide dust control during engineered barrier construction;
- Minimize need for waste material handling (loading, transfer, and installation) to lower construction costs and simplify logistics;
- Utilize baghouse dust, soil and finer slag material as subgrade preparation for the engineered barrier, over the larger size slag material;
- Minimize requirements for off-site cover material to lower construction costs;
- Minimize surface area of engineered barrier while meeting requisite slope stability and other key design objectives to simplify long-term maintenance and lower overall program costs; and

- *Use low maintenance cover materials to minimize long-term active maintenance requirements*

To ensure long-term durability and robustness, design considerations included the probable maximum flood event (PMF), defined as the most severe reasonably possible hypothetical flood, and the probable maximum precipitation (PMP) event, the estimated rainfall depth for a given duration, drainage area and time of year for which there is virtually no risk of exceedance. The PMP approaches and approximates the maximum rainfall that is physically possible within the limits of contemporary hydrometeorological knowledge and techniques. The final engineered barrier design includes a rock cover, USNRC's preferred method for satisfying the long-term stability requirements of 40 CFR 192 and 10 CFR Part 40, Appendix A.

USNRC guidance, provided in NUREG-1623, was used in designing a rock cover that will resist erosion and prevent gullying on the top and side slopes of the pile. The design of the apron or transition area where the side slope of the engineered barrier meets the existing grade was also designed in accordance with NUREG-1623 to address the additional erosive forces that may result from the flow velocities of side slope runoff.

While a specific source of rock for the cover has not yet been identified, it will be selected to meet the durability requirements of NUREG-1623. Similarly, once a rock source as well as a soil source for the underlying engineered barrier material are identified, a more detailed analysis of the need for a filter layer beneath the various rock surfaces will be conducted in accordance with NUREG-1623 and NUREG/CR-4620. If that analysis indicates the need for a filter layer, such a layer will be incorporated into the engineered barrier design, maintaining the overall 1-meter barrier thickness by replacing a portion of the soil thickness with the filter thickness. Between the rock cover material and the underlying filter layer (if determined to be necessary), the engineered barrier design, developed in accordance with NUREG-1623 and NUREG/CR-4620, will be sufficiently robust to provide long-term protection against worst-case erosive forces.

8.3.3 Engineered Barrier Completion

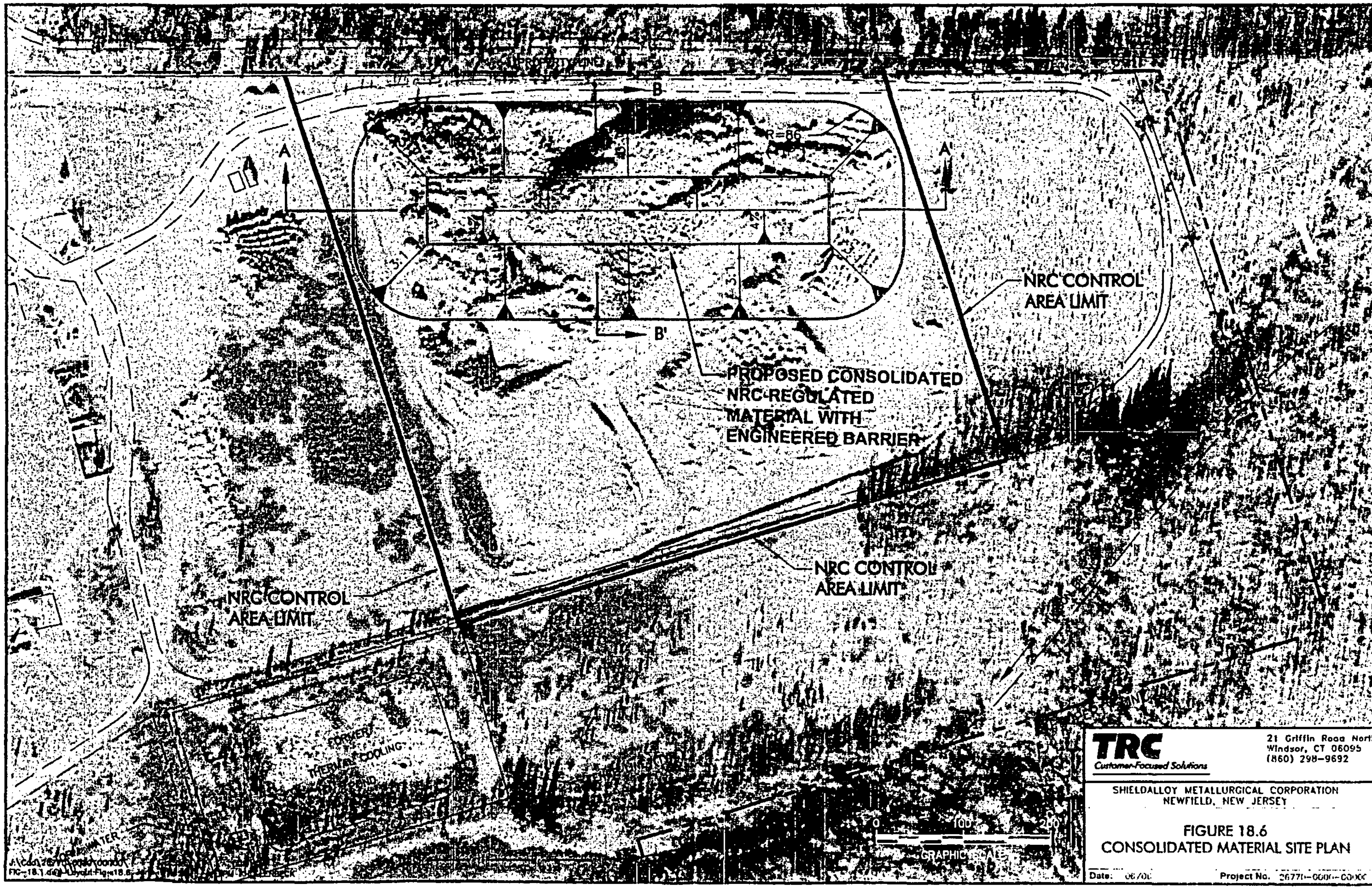
Upon final consolidation of materials, the engineered barrier will be constructed on the prepared subgrade in order to achieve the design criteria described in Section 5.0 and in the introduction of Section 8.3 above. The engineered barrier has been designed in accordance with USNRC specifications. On this basis, the final graded and compacted impoundment will be covered with a one-meter-thick compacted soil shield barrier. The thickness of the soil barrier layer was calculated using a RESRAD computer model, and demonstrates that the potential for radiation exposures from all exposure pathways over the next 1,000 years, even if no barrier maintenance takes place, is less than 100 millirem per year (see Chapter 5, above). The engineered barrier in its entirety will be one (1) meter thick and will consist of compacted suitable soil, topped with a suitable thickness of rock to protect the soil from the forces of erosion. As described above, stone size calculations were made in accordance with USNRC guidance[13], with separate calculations performed for the top slopes, side slopes and toe of side slopes. While erosion calculations indicate that a vegetative cover would provide suitable long-term erosion protection on the top slopes of the proposed landform, the stone riprap proposed for the top slope will provide even more substantive erosion protection. Erosion protection calculations as well as an evaluation of the potential affects of the probable maximum flood are provided in Appendix 19.3.

---

[13] US Nuclear Regulatory Commission, *Design of Erosion Protection for Long-Term Stabilization*, NUREG-1623, September 2002.

Soil material for the engineered barrier will be secured from a certified off-site source, and will be of appropriate grain size and quality to be stable. Similarly, the rock cover materials will be secured from an off-site source that meets the minimum requirements of Sections 2.2.2 and 7 of Appendix D of NUREG-1623 for durability and physical properties as determined by specified laboratory testing. Once the soil and rock sources are identified, an additional evaluation will be conducted to determine the need for a filter layer between the rock surface and the underlying soil layer. If it is determined that a filter layer is required, its thickness will replace a portion of the proposed soil thickness, maintaining the overall 1-meter thickness of the engineered barrier. Proposed location and dimensions of the final engineered barrier are depicted in Figures 18.6 and 18.7; details of design elements are provided in Figure 18.8.

Appendix G - Revised Figures 18.6, 18.7, 18.8 and 18.9



A
A'
B
B'
R=66
NRC CONTROL
AREA LIMIT
PROPOSED CONSOLIDATED
NRC-REGULATED
MATERIAL WITH
ENGINEERED BARRIER
NRC CONTROL
AREA LIMIT
NRC CONTROL
AREA LIMIT
FORMER
THERMAL COOLING
0
100
200
GRAPHIC SCALE
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FIGURE 18.6
CONSOLIDATED MATERIAL SITE PLAN
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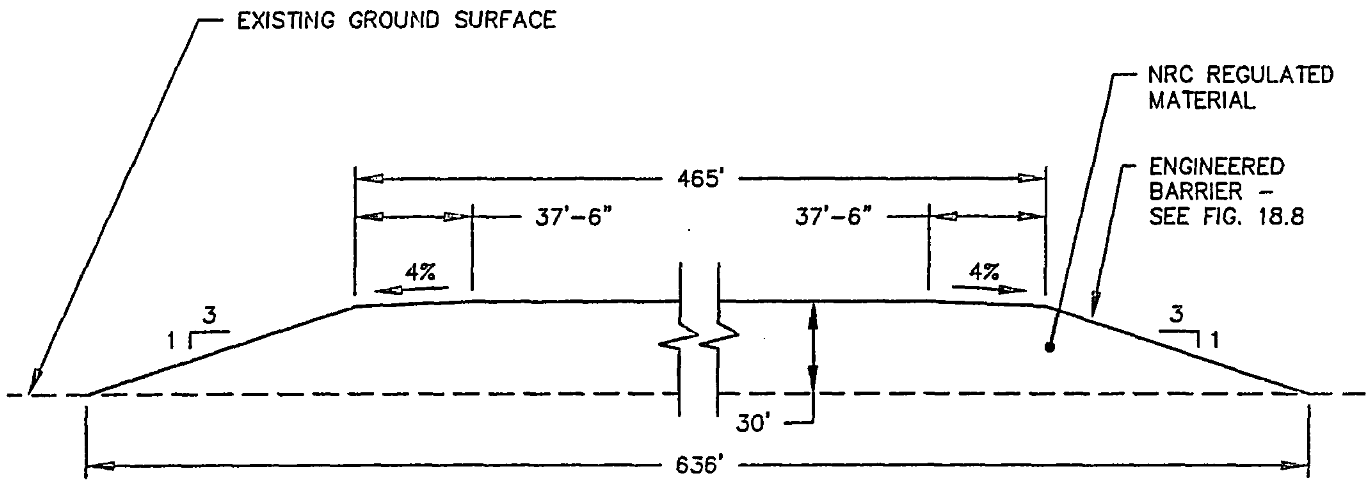
Project No.



SECTION A-A'

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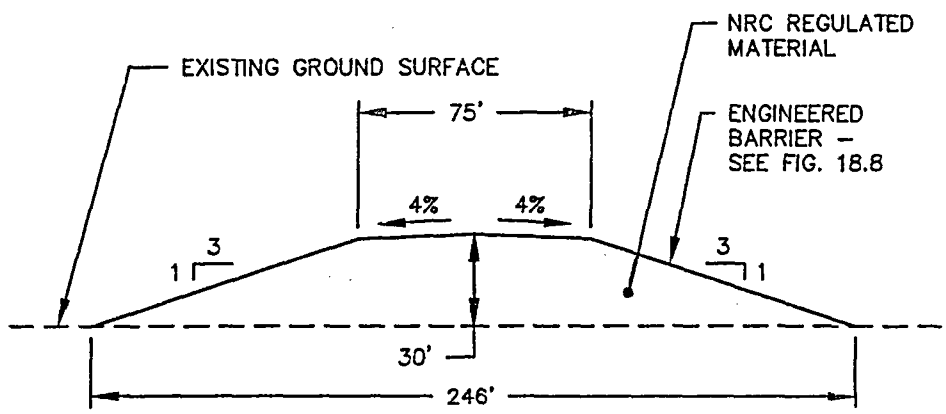

SECTION B-B'

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FIGURE 18.7
ENGINEERED BARRIER PILE SECTIONS

Date: 06/06 | Project No. 26770-0000-00000

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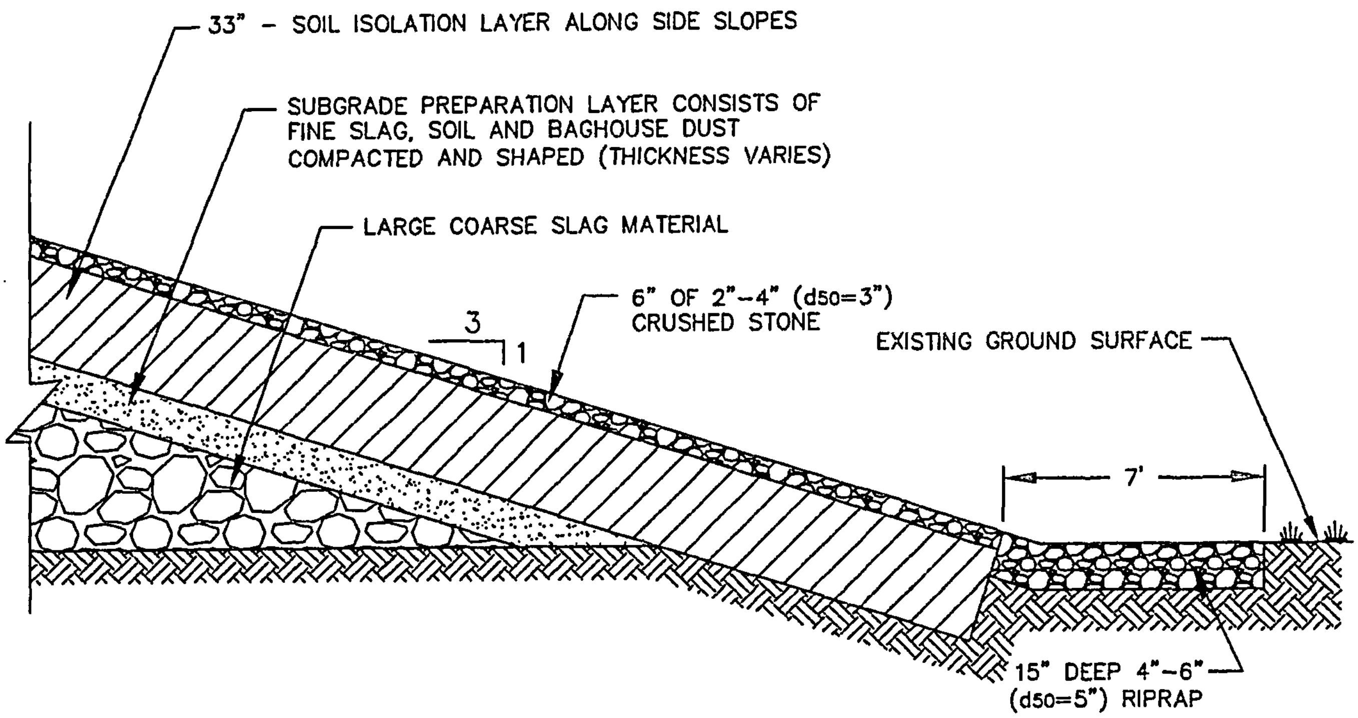

TYPICAL ENGINEERED BARRIER SIDE SLOPE DETAIL

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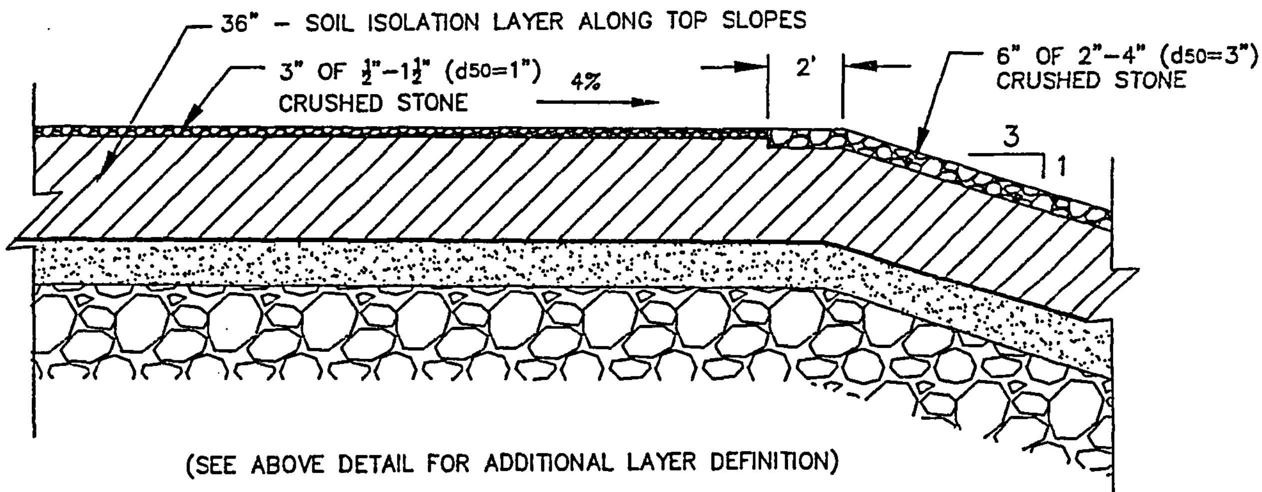

TYPICAL ENGINEERED BARRIER TOP DETAIL

N.T.S.

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FIGURE 18.8
ENGINEERED BARRIER CONSTRUCTION DETAILS

Date: 06/06 | Project No. 26770-0000-00000

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FIG-18.8 v3.dwg Layout:Model June 21, 2006-4:25PM KHOLLENBECK

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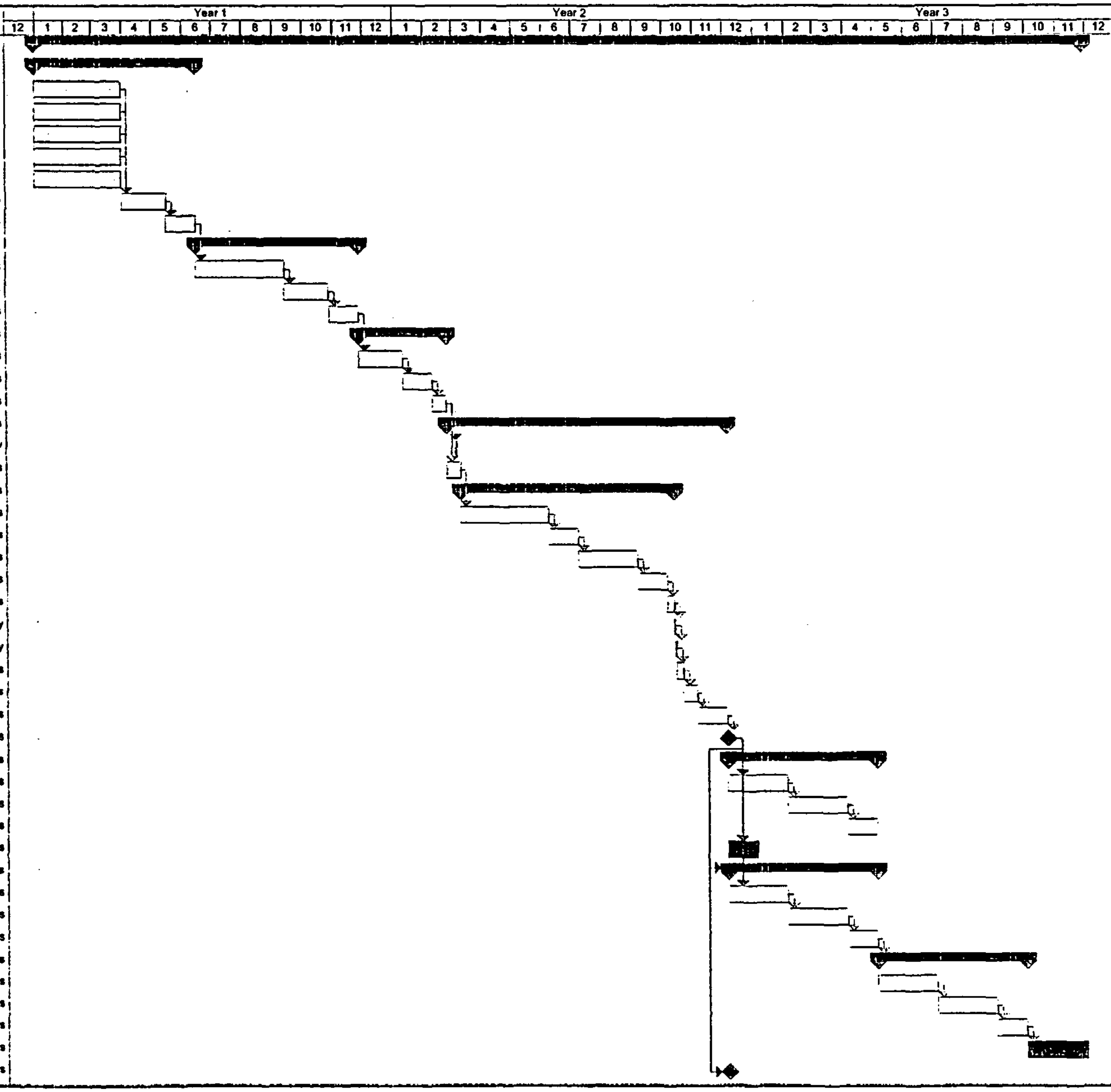
Figure 18.9
Project Schedule
Shieldalloy Metallurgical Corporation, Newfield, New Jersey

ID	Task Name	Duration
1	**On-Site Stabilization and Long-Term Control Campaign**	759 days
2	**Work Plan**	118 days
3	Prepare Work Plan (WP)	90 edays
4	Prepare Quality Assurance Project Plan (QAPP)	90 edays
5	Prepare Field Sampling Plan (FSP)	90 edays
6	Prepare Construction Quality Assurance Plan (CQAP)	90 edays
7	Prepare Performance Standard Verification Plan (PSVP)	90 edays
8	NRC Review and Comment	45 edays
9	Submittal of Final WP, QAPP, FSP, CQAP, and PSVP	30 edays
10	**Final Design (100%)**	118 days
11	Prepare Final Design	90 edays
12	NRC Review and Comment	45 edays
13	Submittal of Revised Final Design	30 edays
14	**Bidding and Award**	63 days
15	Solicit Bids	45 edays
16	Bid Evaluation	30 edays
17	Contract Award	14 edays
18	**Implementation of Decommissioning Activities**	204 days
19	Preconstruction Inspection and Conference	1 eday
20	Mobilization of Sediment/Erosion Controls	14 edays
21	**Engineered Barrier Construction**	155 days
22	Material Relocation/Pile Construction/Shaping	90 edays
23	Subsoil Confirmatory Sampling	30 edays
24	Placement of Soil Layer	60 edays
25	Placement of Rock Surface Layer	30 edays
26	Site Cleanup	7 edays
27	Prefinal Construction Conference	1 day
28	Prefinal Inspection	1 day
29	Submittal of Prefinal Inspection Report	7 edays
30	Regulatory Review & Comment	14 edays
31	Completion of Outstanding Construction Items	30 edays
32	Final Inspection	0 edays
33	**Construction Completion Report & Certification**	106 days
34	Preparation of Report	60 edays
35	NRC Review and Comment	60 edays
36	Submit Revised Report	30 edays
37	**Final Status Survey Performance**	30 edays
38	**LTC Plan Preparation**	106 days
39	Draft LTC Plan	60 edays
40	NRC Review & Comment	60 edays
41	Submit Final LTC Plan	30 edays
42	**Final Decommissioning and Final Status Survey Report**	108 days
43	Draft Final Report	60 edays
44	NRC Review & Comment	60 edays
45	Submit Final Report	30 edays
46	**Amendment of License No. SMB-743**	60 edays
47	**Initiation of Operation and Maintenance**	0 edays



Project: Project Schedule
Date: Wed 6/21/06

Task ——— Milestone ◆ Summary

Appendix H - Revised Chapter 16 Sections

[The following selected sections of Chapter 16 of the DP have been revised and have been captured in Rev. 1a of the DP.]

16.2 Eligibility Demonstration

From Chapter 7, there are three alternatives for the decommissioning of SMC's Newfield facility. These are: (1) On-site stabilization of residual radioactivity, followed by partial restriction of the site under the provisions of an long term control license (i.e., LTC Alternative), with the remainder of the site released for unrestricted use; (2) Off-site disposal of residual radioactivity, followed by release of the entire site for unresticted use and license termination (i.e., LT Alternative) and (3) no action or license continuation (i.e., LC Alternative). From an ALARA perspective (see Section 7.3.10), the following are the total costs associated with each of the alternatives:[14]

- LTC Alternative - $18,028,800
- LT Alternative - $83,264,981
- LC Alternative - $53,077,467

It is clear that implementation of the LTC Alternative results in radiation dose potential that is as low as reasonably achievable, and that further reductions in radioactivity at the site, such as that associated with the LT Alternative, would result in net public harm. Therefore, SMC is eligible for the restricted release option in 10 CFR 20.1403 on a dose basis.

On the other hand, Chapter 5 and Table 17.8 demonstrate that with all controls in place, a maximally-exposed hypothetical individual has the potential to incur a radiation dose of only 0.6 millirem TEDE (the industrial worker scenario) for the 1,000-year time period after decommissioning of the Newfield site has been implemented. And even if all controls should fail, a maximally-exposed hypothetical individual has the potential to incur a radiation dose of only 17 millirem TEDE (suburban resident scenario). Therefore, the dose limits for unrestricted release in 10 CFR 20.1402 could be met for the site in its entirety. However, because the radiological constituents of interest at the Newfield site are long-lived with respect to the 1,000-year time period, the USNRC would consider the Newfield site to be "higher risk" under the graded approach to institutional controls, thus lending further support to the acceptability of the LTC license option.[15]

Finally, in Rev. 0 of the SMC Decommissioning Plan, SMC proposed retaining title to the Newfield property until such time as all remaining plant operations cease, at which time, title would be turned over to the Borough of Newfield, along with sufficient funds to insure the property's perpetual care. However, the USNRC did not feel that the Borough could not be considered a durable institutional control.

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[14] Total cost takes into account the monetary cost of the decommissioning, waste transport and disposal, worker accidents, traffic fatalities during transport, dose received during decommissioning and transport, dose to the public from excavation, transportation and disposal, and other ancillary costs.

[15] U.S. Nuclear Regulatory Commission, *Results of the License Termination Rule Analysis*, SECY-03-0069, May 2, 2003.

In verbal communications with representatives of the NJDEP during SSAB meetings, and from letters from State representatives to the USNRC, it was clear to SMC that the State has no interest in serving as the trustee or durable institutional control for the site. Therefore, the LTC Alternative presented the only viable institutional control available to SMC, and was thus included in the DP. Because the LTC Alternative is only open to SMC if there are no other viable alternatives, and because there is no written record clearly indicating the State's refusal to serve as the durable institutional control, the State was formally petitioned to serve in this capacity.[16] As of the date of this DP, no response has been received.

16.3.1 Description of Legally-Enforceable and Durable Institutional Controls

The primary means of ensuring institutional control over the restricted area of the decommissioned Newfield site will be perpetual federal regulation and oversight of the provisions outlined herein. The form of control will be the amendment of License No. SMB-743 to a LTC license. This license, to be issued by a federal (US) regulatory agency (i.e., the USNRC), has the force of law. The USNRC, in guidance supplied to SMC, has agreed to issue the LTC license as part of the overall approval of this Decommissioning Plan.

The purpose of the LTC license is to provide the legally enforceable and durable institutional controls required by 10 CFR 20.1403(b) to ensure the long-term protection of the public health, safety, and the environment. The conditions written into the LTC license by the USNRC would specify the necessary controls to limit site access and land use that SMC must monitor and maintain and that the USNRC would inspect and enforce, if necessary. The LTC license would also specify other required long-term control activities to be conducted by SMC as described in the LTC Plan (see Section 8.3.6).

The secondary means of ensuring institutional control is the filing of a deed notice with Gloucester County that prohibits agricultural, residential and industrial activities within the restricted area, or any other activities that might result in the removal or breech of the engineered barrier. It will also contain a statement that no land use other than that specified in Section 16.4, below, is permitted for within the restricted area. The contents of the deed notice will be prepared and submitted for USNRC approval as part of the final decommissioning and final status survey report (see Section 14.3.15). Once filed, it will also serve to alert any future landowners owners that the property brings with it all of the obligations of License No. SMB-743.

The duration of these controls will be permanent in light of the long half-life of the radioactivity consolidated under the engineered barrier. However, the LTC license will be renewed in five-year increments. Independent oversight of SMC's performance in light of LTC license requirements will be provided by the USNRC during routine inspections and license renewal activities. In the event of SMC default in the terms and conditions of the LTC license, the USNRC has the authority to terminate the license, assume control of the funds held in trust, and contract the services of a third party to implement the license requirements.

16.5.4 Evaluation of SSAB Advice

As the minutes will show, the preponderance of Meetings 1 and 2 were spent discussing the decommissioning plans, other options . . .*[Final Paragraph]*. . . Other input beyond that required in the 10 CFR 20. 1403(d) was provided by SSAB members during meetings, in response to the distribution of minutes for

[16] Smith, D. R., Shieldalloy Metallurgical Corporation, "Decommissioning the Newfield Facility – Request for State of New Jersey Position on State Ownership, Control, or Oversight", to Commissioner Lisa P. Jackson, New Jersey Department of environmental Protection, May 24, 2006.

review/approval, and in response to the solicitation of SSAB Input Forms (see Appendix 19.7). The detriments to using the LTC license, as relayed by the SSAB to SMC, are as follows:

- Preventing development of the rest of the site and surrounding properties;
- Concerns about not being able to sub-divide the property; and
- Concerns about property values and rateables.

Appendix I - Letter to the New Jersey DEP

SHIELDALLOY METALLURGICAL CORPORATION

DAVID R. SMITH
RADIATION SAFETY OFFICER
Newfield Operations

12 WEST BOULEVARD
P.O. BOX 768
NEWFIELD, NJ 08344-0768
TELEPHONE (856) 692-4200

USPS Certified Mail: 7005 1820 003 9602 1440

May 24, 2006

Commissioner Lisa P. Jackson
State of New Jersey
Department of Environmental Protection
401 East State Street
7th Floor, East Wing
P.O. Box 402
Trenton, NJ 08625-0402

Re: Decommissioning the Newfield Facility -- Request for State of New Jersey Position on State Ownership, Control, Or Oversight

Dear Commissioner Jackson:

Shieldalloy Metallurgical Corporation ("SMC") holds source material license SMB-743 from the U.S. Nuclear Regulatory Commission ("NRC") for its facility in Newfield, NJ (the "Site"). SMC requests the State of New Jersey either to accept or to reject the role as the governmental institution responsible for assuring long term control and maintenance of the restricted release portion of the Site and for oversight and administration of the associated trust fund.

On October 24, 2005, SMC submitted Revision 1 of its Decommissioning Plan ("DP") to the NRC identifying SMC's intent to apply to amend License SMB-743 to be a Long-Term Control ("LTC") license. In a letter dated January 26, 2006, the NRC rejected Revision 1 of the DP, in part because the DP was missing information demonstrating "[e]ligibility for the LTC license option, including a demonstration that SMC was unable to arrange other types of institutional controls and independent third party arrangements, such as a letter from the State rejecting responsibility for ownership, control, or independent third party oversight."

Consistent with the NRC letter, SMC requests a State position in writing as to whether it "reject[s] responsibility for ownership, control, or independent third party oversight" of the Site. SMC believes amending SMB-743 to be a LTC license as described in Revision 1 to the DP is consistent with the State of New Jersey position. Written confirmation of the State's position would facilitate NRC review of the DP.

The alternative to amending the SMB-743 to be a LTC license would be to terminate SMB-743 in accordance with the regulations for restricted release and having the State responsible for ownership, control, or independent third party oversight of the Site. The alternatives to an LTC license are more fully described in Supplement 1 to NUREG-1757, *Consolidated NMSS Decommissioning Guidance; Updates to Implement the License Termination Rule Analysis*, draft issued on September 29, 2005. Specifically, the NRC draft guidance identifies three alternatives to an LTC license: (A) legally enforceable controls on privately owned land, (B) legally enforceable institutional controls on government owned land, or (C) institutional controls based on sovereign or police powers.[1]

While SMC is requesting the State's position on implementing State ownership, oversight, or control consistent with the NRC draft guidance, such guidance does not supersede the obligations of SMC under its NRC license. Pursuant to its licensing obligations, SMC has committed to the NRC to resubmit the DP by June 30, 2006. Timely input by the State would materially assist NRC review of the DP and would be appreciated.

Sincerely,

David R. Smith
Radiation Safety Officer

cc:	Eric E. Jackson	SMC
	Kenneth L. Kalman	USNRC
	Amy Snyder	USNRC
	Marjorie McLaughlin	USNRC-Region I
	Donna L. Gaffigan	NJDEP
	Carol D. Berger	IEM
	Jean Oliva	TRC Environmental
	Robert Haemer	PillsburyShaw

Mayor Richard Westergaard
Assm. David Mayer
Assm. Paul Moriarty
Assm. Fred Madden
Congressman Frank LoBiondo
Congressman Robert Andrews

[1] NUREG-1757, Supplement 1, Section 17.7.2.2.2.

State of New Jersey
DEPARTMENT OF ENVIRONMENTAL PROTECTION

JON S. CORZINE
Governor

LISA P. JACKSON
Commissioner

Environmental Regulation
PO Box 423
Trenton, New Jersey 08625-0423
Phone (609) 292-2795
Fax (609) 777-1330

June 21, 2006

Jack Strosnider, Director
Office of Nuclear Material Safety and Safeguards
US Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Strosnider:

On May 31, 2006, the New Jersey Department of Environmental Protection (DEP) received a letter from Shieldalloy Metallurgical Corporation (SMC) dated May 24, 2006, requesting that the State of New Jersey either accept or reject the role as the governmental institution responsible for assuring long term control and maintenance of the restricted release portion of the Site.

We assume that this request is being made to comply with Title 10 of the Code of Federal Regulations Part 20.1403(c)(4). This regulation requires that the licensee provide sufficient financial assurance to enable an independent third party, in this case the State of New Jersey, to assume and carry out responsibilities for any necessary control and maintenance of the site. Before we can answer the request from SMC, we want to be certain that we understand the ramifications of our decision. To that end, we have the following questions.

What are the differences between ownership, control, and independent third party oversight? What are the responsibilities of each?

It is our understanding that in order to proceed with an Long Term Control (LTC) license, the licensee has to demonstrate that unrestricted and restricted decommissioning are not obtainable. This can only be demonstrated through an approved decommissioning plan with these options included, reviewed and approved by the NRC. Will the decommissioning plan that SMC submits address these options? As it stands now, the DEP does not know if further reductions in residual radioactivity at the site to meet the unrestricted use criteria in 10 CFR 20.1402 would 1) result in net public or environmental harm, or 2) are not being undertaken because the residual radioactivity levels are as low as reasonably achievable (ALARA). The NRC has not documented that either of these conditions are met because the staff has not completed a technical review of SMC's decommissioning plan.

If the State were to accept ownership or control, would SMC have to comply with the requirements of the License Termination Rule (Subpart E of 10 CFR 20)? In other words, would the LTC license be denied by the NRC, and would SMC be required to remediate the Site to restricted use standards? If so, would SMC be held to the requirements of 10 CFR 20.1403(e) which specifies dose criteria if institutional controls fail? Would there be a cap allowed under the requirements of the License Termination Rule? If a cap is allowed, will the dose assessment assume that the cap has completely failed? Does the NRC envision a scenario where the 500 mrem/y would be exceeded with or without a cap? If so, would the NRC allow SMC to decommission under the alternate criteria for license termination (10CFR20.1404)? Could the license be terminated without any remediation of the slag pile?

If the answer to any of the questions above would result in the remediation of the slag, will the State be responsible for the cost of this remediation in any way if the State assumes ownership, control, or third party oversight? Can the State request further financial assurance under the required arrangement specified in 10CFR20.1403(c)(4)?

More questions arise considering that Governor Corzine has recently issued a Letter of Intent for New Jersey to become an Agreement State. Assuming that New Jersey agrees to the transfer of the SMC license, will our radiological remediation standards at N.J.A.C. 7:28-12.1 *et seq.* be applicable to the SMC site once they are revised to include source and by-product material? If so, will the DEP be able to require SMC to remediate further once we become an Agreement State? As you know, our dose criterion is 15 mrem/y compared to the NRC's 25 mrem/y, and our "all controls fail" dose criterion is 100 mrem/y, whereas the NRC has an allowance for up to 500 mrem/y.

If New Jersey assumes ownership or control, can we impose our cleanup criteria on SMC before becoming an Agreement State?

When New Jersey becomes an Agreement State, can it be both regulator and owner of the SMC Site? Will the ownership have to be transferred to the local government? What if the local government does not accept this responsibility?

As you know, we had extensive comments on Draft NUREG 1757 Supplement 1, *Updates to Implement the License Termination Rule Analysis.* Before making a determination as to whether to assume ownership, control, or third party oversight, we expect written responses to our comments and the opportunity to review the final document.

Does SMC meet any of the criteria in 10CFR20.1401(b)? In other words, is SMC considered a grandfathered site?

We would appreciate a written response to these questions so that we have sufficient information to consider SMC's request.

Sincerely yours,

Jill Lipoti for NW

Nancy Wittenberg,
Assistant Commissioner

c: Dave Smith, SMC
Irene Kropp, Assistant Commissioner, Site Remediation and Waste Management

Appendix J - Revised Chapter 15 Sections

[The following selected sections of Chapter 15 of the DP have been revised and have been captured in Rev. 1a of the DP.]

15.1 Cost Estimate

Decommissioning cost estimates were developed based on the characteristics of the facility, using standard cost estimating methodologies, supported . . .*[Second-to-last bullet on page 151]*. . .

- In accordance with USNRC guidance, a 25 percent contingency has been added to both the capital costs and the long-term surveillance and monitoring costs of all alternatives.

- Present worth estimates of long-term surveillance and monitoring costs are calculated for a return on investment of 1%.

Calculating costs over a long-term period requires the selection of a representative discount rate. The alternatives with the greatest long-term surveillance and monitoring costs (i.e., the LTC and LC alternatives) are affected the most by the discount rate, with the recommended 25 percent contingency on the capital and long-term surveillance and monitoring costs further impacting the ultimate effect of the selected rate of return on the final total decommissioning cost. As noted above, a 1% discount rate is used in calculating the present worth of long-term surveillance and monitoring costs based on guidance provided by USNRC.[17]

15.2 Certification Statement

Operating funds will be used to implement this decommissioning plan. However, the cost of all activities are secured with an irrevocable stand-by letter of credit. A signed, original Certification Statement has been forwarded to the USNRC under separate cover.

15.3 Financial Assurance Mechanism

Upon approval of this Decommissioning Plan by the USNRC, SMC will petition the USNRC to release the money in the existing Trust Fund, and SMC will petition the USEPA and the NJDEP to release any additional financial assurance required by the USNRC from the Joint Financial Assurance Fund required pursuant to Section 16A and 16B of the Bankruptcy Settlement Agreement of 1997.[18,19] SMC will then establish a

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[17] Proposed Update to NUREG 01757 (Supp. 1, "Sufficient Financial Assurance").

[18] United States Bankruptcy Court, Southern District of New York, re: Metallurg, Inc. and Shieldalloy Metallurgical Corporation, "Settlement Agreement of Environmental Claims and Issues by and Between the Debtors and the United States of America and the State of New Jersey", Nos. 93 B 44468 (JLG); 93 B 44469 (JLG), April, 1997.

[19] Paragraph 14 of the Bankruptcy Settlement Agreement establishes the required financial assurance with respect to the performance of the work at the Newfield site and with this paragraph lists "NRC Slag Pile Remediation" as the Environmental Project, with a Dollar Estimate of $5.0 million. The agreement goes on in paragraphs 16 A., B. & C. to explain the steps SMC will follow to provide, create or make available the fund as financial assurance for the benefit of the United States and the State of New Jersey with respect to the list of Environmental Projects (including the Slag Pile). Pursuant to Section 16.A, SMC would purchase a letter of credit (LOC) in the amount of $4.25 million for the benefit of the United States and the State of New Jersey. Section 16.B required that SMC establish another financial

separate financial assurance mechanism (Trust Fund) for the construction and implementation phase of the decommissioning project, and create a fully-funded Long Term Control (LTC) License Trust Fund for the benefit of the USNRC in the amount of $5,065,449 (including 25% contingency) to address the costs associated with the following over a 1,000-year period:

- Site surveillance of access and land use restrictions;
- Engineered barrier maintenance;
- Radiological monitoring;
- Reporting;
- Records retention; and
- Trustee fees and expenses.

If the balance substantially exceeds the amount needed to produce sufficient annual income for funding over the long-term, the USNRC will petitioned for return of excess funds. The duplicate signed originals of all fully-executed trust agreements will be forwarded to the USNRC.

SMC intends to use operating funds and/or parent-company funds to implement this decommissioning plan. The source of funds for the LTC Trust have already been set aside as part of the prior bankruptcy agreement, with the USNRC already in possession of the trust instrument.[20] Supplemental SMC funding of the LTC Trust will only be provided to cover the difference between the amount needed and the amount currently held in trust. However, immediately upon approval of this Decommissioning Plan, a replacement instrument will be executed, and SMC will request that the USNRC, the USEPA and the NJDEP release their interest in an irrevocable stand-by letter of credit that was also established as part of the bankruptcy settlement for the construction and implementation portion of the decommissioning.[21] The LTC Trust will remain in place and be drawn upon to pay for the on-going cost of the operation, maintenance and licensing of the restricted portion of the Newfield site in accordance with 10 CFR 40.36.[22]

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assurance instrument equal to an amount money the government would release to SMC upon entering into the Settlement Agreement. USNRC was directed to draw down the existing LOC post for their benefit in the amount of $750, 000 and deposit it into a separate trust account for the benefit of USNRC.

[20] United States Bankruptcy Court, Southern District of New York, re: Metallurg, Inc. and Shieldalloy Metallurgicial Corporation, "Settlement Agreement of Environmental Claims and Issues by and Between the Debtors and the United States of America and the State of New Jersey", Nos. 93 B 44468 (JLG); 93 B 44469 (JLG), April, 1997.

[21] SMC will then purchase a letter of credit for the benefit of USNRC equal to the amount necessary for the completion of the approved Decommissioning Plan. Upon successful completion of the Decommissioning Plan and amendment of License No. SMB-743 into a LTC license, SMC will demand the release of the letter of credit.

[22] Integrated Environmental Management, Inc., Report No. 94005/G-9194 (Rev. 2), "Decommissioning Funding Plan for the Newfield, New Jersey Facility", submitted to Shieldalloy Metallurgical Corporation, September 10, 2001.

Appendix K - Signed Original of the Certification Statement and Ancillary Documents

SHIELDALLOY METALLURGICAL CORPORATION

ADMINISTRATIVE OFFICES:
545 BECKETT ROAD, SUITE 201
SWEDESBORO, NJ 08085-1548

TELEPHONE (856) 241-4620
FAX (856) 241-4655

Certification of Financial Assurance

U.S. Nuclear Regulatory Source Material License No. SMB-743

Location:
35 South West Boulevard
Newfield, New Jersey 08344

Mailing:
545 Beckett Road, Suite 201
Swedesboro, New Jersey 08085-1548

Issued to: U.S. Nuclear Regulatory Commission

I certify that Shieldalloy Metallurgical Corporation is licensed to possess the following types of source material in any chemical and / or physical form of Thorium and Uranium in the following amounts:

A.	Thorium	A. Any form	A.	303,050 kilograms
B.	Uranium	B. Any form	B.	45,000 kilograms

I also certify that financial assurance in the amount of required in the United States Bankruptcy Court, Southern District of New York **Settlement Agreement of Environmental Claims and Issues By and Between the Debtors and the United States or America and the State of New Jersey**

In re

Metallurg, Inc. and
Shieldalloy Metallurgical Corporation, **Nos. 93 B 44468 (JLB)**
93 B 44469 (JLB)

Debtors

REQUIRED FINANCIAL ASSURANCE WITH RESPECT TO PERFORMANCE OF THE WORK AT THE NEWFIELD SITE

Paragraph 14. NRC Slag Pile Remediation $ 5.0 million

In accordance with Paragraph 16.C., a separate trust account for the benefit of NRC was established in the amount of $750, 000. The trust account has accrued earnings and has present balance in the amount of $ 2,033,554.42 (Account Statement Period 05/01/2006 through 05/31/2006). The trust account was established in fulfillment of the Bankruptcy Settlement Agreement for the purpose of decommissioning as prescribed by 10 CFR Part 40. In addition, Shieldalloy Metallurgical Corporation has established a letter of credit in the amount of $4.25 million dollars for the benefit of the United States and New Jersey specifically for the NRC Slag Pile Remediation Project. Furthermore paragraph 26 of the Settlement Agreement states.

> *"In the event that a decommissioning plan relating to the Newfield site is approved by the NRC and the NRC requires Shieldalloy to provide additional or separate financial assurance for the NRC Slag Pile Remediation Project which is identified in paragraph 14 of this Settlement Agreement, then for the purposes of calculating the Refund Amount as described in paragraph 19 above, the Posted Financial Assurance Fund will be increased by the additional financial assurance actually purchased or acquired by Shieldalloy pursuant to any decommissioning plan up to a maximum of an additional $4.25 million. In addition, the U.S. and New Jersey agree that any additional financial assurance required by the NRC may, at Shieldalloy's option, reduce the Joint Financial Assurance Fund required pursuant to Section 16A and 16B (up to an aggregate of $4.25 million), and the U.S. and New Jersey agree to release or refund an amount equal to such financial assurance provided for the benefit of the NRC, to the extent funds are available, at the time such additional financial assurance is provided to the NRC."*

Eric E. Jackson, President
Shieldalloy Metallurgical Corporation

6/23/06
Date

14201 DALLAS PARKWAY / 6TH FLOOR
DALLAS TX 75254

Account Statement

000308 002/003 GPS-2Z 00 2006152 - CL0000088206
SHIELDALLOY METALLURGICAL CORPORATION
ATTN: CONTROLLER
545 BECKETT ROAD
SWEDESBORO NJ 08085

Statement Period 05/01/2006 through 05/31/2006

Account T/A 7/19/90 SHIELD ALLOY METAL & MB
132406.1

Relationship Manager
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AUDREY.MOHAN@CHASE.COM

Administrator
JOANNE OSBORN
412-291-2027
JOANNE.OSBORN@CHASE.COM

Visit us at www.jpmorganchase.com

Asset Summary

Asset description	Number of shares Par value	Cost	Market value	Estimated annual income	Yield on market	Accrued income
CASH & CASH EQUIVALENTS	2,033,554.420	2,033,554.42	2,033,554.42			7,728.86
ENDING BALANCE	2,033,554.420	2,033,554.42	2,033,554.42	0.00	0.00 %	7,728.86

Transaction Summary

Transaction description	Cash	Cost	Realized gains/losses
BEGINNING BALANCE	0.00	2,026,713.24	
DISTRIBUTIONS & WITHDRAWALS	-422.14		
INCOME	7,263.32		
PURCHASES	-6,841.18	6,841.18	
ENDING BALANCE	0.00	2,033,554.42	

1257

UNITED STATES BANKRUPTCY COURT
SOUTHERN DISTRICT OF NEW YORK

In re	Chapter 11
METALLURG, INC. and SHIELDALLOY METALLURGICAL CORPORATION,	Nos. 93 B 44468 (JLG) 93 B 44469 (JLG)
Debtors.	(Jointly Administered)

SETTLEMENT AGREEMENT OF ENVIRONMENTAL CLAIMS AND ISSUES BY AND BETWEEN THE DEBTORS AND THE UNITED STATES OF AMERICA AND THE STATE OF NEW JERSEY

WHEREAS Metallurg, Inc., ("Metallurg"), a New York corporation, and Shieldalloy Metallurgical Corporation ("Shieldalloy"), a New York corporation (collectively, the "Debtors"), filed with the United States Bankruptcy Court for the Southern District of New York (the "Court") voluntary petitions for relief under Title 11 of the United States Code (the "Bankruptcy Code") on September 2, 1993 (the "Petition Date") (collectively, the "Chapter 11 Cases").

WHEREAS the State of New Jersey ("New Jersey"), on behalf of the New Jersey Department of Environmental Protection ("NJDEP"), filed Proofs of Claims numbered 91, 96, 357 and 358, respectively (the "New Jersey Proofs of Claim"), in the Chapter 11 Cases on or about August 12, 1994, alleging, _inter alia_, liability of the Debtors to New Jersey under the New Jersey Spill Compensation and Control Act, N.J.S.A. 58:10-23.11 _et seq._

NYFS05...:\40\63140\0003\180\AGRN226L.22J

("Spill Act"), and the Comprehensive Environmental Response, Compensation and Liability Act of 1980, as amended, 42 U.S.C. § 9601 et seq.

WHEREAS New Jersey alleged in the New Jersey Proofs of Claim, inter alia, that the Debtors were jointly and severally liable for response costs incurred and to be incurred by New Jersey in the course of responding to releases and threatened releases of hazardous substances into the environment.

WHEREAS the United States of America (the "United States"), on behalf of the United States Environmental Protection Agency ("EPA"), the United States Department of the Interior ("DOI"), and the United States Nuclear Regulatory Commission ("NRC"), filed proofs of claim in the Chapter 11 Cases on or about August 14, 1994 (the "Federal Proofs of Claim"), alleging, inter alia, liability of the Debtors to the United States under the Comprehensive Environmental Response, Compensation and Liability Act of 1980, as amended, 42 U.S.C. § 9601 et seq. ("CERCLA"), the Resource Conservation and Recovery Act, as amended, 42 U.S.C. § 6901 et seq. ("RCRA") and the Atomic Energy Act of 1974, as amended, 42 U.S.C. § 2011 et seq. (the "Atomic Energy Act").

WHEREAS the United States alleged in the Federal Proofs of Claim, inter alia, that the Debtors were jointly and severally liable for response costs incurred and to be incurred by the United States in the course of responding to releases and threatened releases of hazardous substances into the environment from certain Sites.

WHEREAS on or about February 18, 1994, the United States of America, through its Department of Treasury, Internal Revenue Service (the "IRS"), filed a Proof of Claim against Metallurg on account of due and owing, but unpaid, federal withholding, Federal Insurance Contribution Act ("FICA") and income tax liabilities, together with prepetition interest and penalties accruing thereon, in the total amount of $9,742,894.69 (the "IRS Prepetition Claim").

WHEREAS Metallurg is entitled to an income tax refund from the United States for the 1989 tax year in the total amount of $723,714 (the "Tax Refund Amount").

WHEREAS the Tax Refund Amount consist of two components: (1) $594,249 owed to Metallurg for the 1989 Tax Year, and (2) $129,465 owed to Frankel Metal Co., a non-debtor subsidiary of Metallurg, for the tax period ending July 31, 1989 which amount shall be paid to Metallurg.

WHEREAS after a review of the IRS Prepetition Claim, the IRS has determined that Metallurg is indebted to the United States on account of prepetition federal tax liabilities in the total amount of $105,847.00 (the "Tax Amount Due").

WHEREAS unless the automatic stay imposed by Section 362(a)(7) of the Bankruptcy Code is modified to permit the

Government to offset the Tax Refund Amount against the Tax Amount Due, the United States may not effectuate such a setoff.

WHEREAS the United States and Metallurg have agreed that, subject to the Court's approval, the United States will offset the Tax Refund Amount against the Tax Amount Due.

WHEREAS as a result of such setoff, the Debtors' prepetition federal tax liabilities shall be satisfied in full, and the principal amount of the Tax Refund Amount shall be reduced to $618,367 (the "Net Tax Refund Amount").

WHEREAS Metallurg owns all of the outstanding stock of Shieldalloy.

WHEREAS Shieldalloy owns and operates a metal alloy and specialty metals manufacturing facility located in Newfield, New Jersey (the "Newfield site").

WHEREAS on October 5, 1988, Debtors and the NJDEP entered into an Administrative Consent Order which, as amended in August 1989 and September 1992, requires the cleanup and/or remediation of hazardous substances and pollutants known or subsequently discovered at the Newfield site.

WHEREAS Shieldalloy owns and operates a metal alloy and specialty metals manufacturing facility in Cambridge, Ohio (the "Cambridge site").

WHEREAS in the absence of this Settlement Agreement, the Debtors would have objected to the New Jersey Proofs of Claim.

WHEREAS the Debtors and New Jersey desire to resolve the New Jersey Proofs of Claim including certain alleged environmental liabilities of the Debtors and the amount of financial assurances to be posted by the Debtors in connection with the Newfield site.

WHEREAS in the absence of this Settlement Agreement, the Debtors would have objected to the Federal Proofs of Claim.

WHEREAS the Debtors and the United States desire to resolve the Federal Proofs of Claim, including certain alleged environmental liabilities of the Debtors and the amount of financial assurances to be posted by the Debtors in connection with the Newfield and Cambridge sites.

WHEREAS in exchange for Shieldalloy's agreement to post certain financial assurance for the cleanup and remediation of the Newfield site, and the other terms set forth below in this Settlement Agreement, the United States will withdraw the Federal Proofs of Claim to the extent that they assert claims for environmental response costs and natural resource damages assessment to be incurred by the United States in the future at the Newfield site.

WHEREAS in exchange for Shieldalloy's agreement to post certain financial assurance for the cleanup and remediation of the Cambridge site pursuant to the entry of a final Consent Order in the action entitled State of Ohio v. Shieldalloy Metallurgical Co., Guernsey County Court of Common Pleas, Case No. 95-CV-242, and the other terms set forth in that final Consent Order and below in this Settlement Agreement, the United States will withdraw the Federal Proofs of Claim to the extent that they assert claims for environmental response and natural resource damages assessment costs to be incurred by the United States in the future at the Cambridge site.

WHEREAS in consideration of, and in exchange for, the promises and covenants herein, and intending to be legally bound hereby, the Debtors and New Jersey through their authorized representatives hereby agree to the terms and provisions of this Settlement Agreement.

WHEREAS in consideration of, and in exchange for, the promises and covenants herein, and intending to be legally bound hereby, the Debtors and the United States through their authorized representatives hereby agree to the terms and provisions of this Settlement Agreement.

WHEREAS settlement of the matters governed by this Settlement Agreement is in the public interest and an appropriate means of resolving these matters.

NOW THEREFORE, without the admission of liability or any adjudication on any issue of fact or law, and upon the consent and agreement of the parties to this Settlement Agreement by their attorneys and authorized officials, it is hereby agreed as follows:

DEFINITIONS

In this Settlement Agreement, the following terms shall have the following meanings:

a. "Administrative Expense Claim" has the meaning as defined in the Second Amended Plan of Reorganization.

b. "Allowed General Unsecured Claim" shall have the meaning as defined in the Second Amended Plan of Reorganization.

c. "Allowed Claim" shall have the meaning as defined in the Second Amended Plan of Reorganization.

d. "Atomic Energy Act" shall mean the Atomic Energy Act of 1974, 42 U.S.C. § 2011 et seq., as now in effect or hereinafter amended.

e. "CERCLA" shall mean the Comprehensive Environmental Response, Compensation and Liability Act of 1980, 42 U.S.C. § 9601 et seq., as now in effect or hereinafter amended.

f. "Claims" has the meaning as defined in the Second Amended Plan of Reorganization.

g. "Disclosure Statement" shall mean the disclosure statement filed by the Debtors with the Bankruptcy Court on May 15, 1996, as may be amended from time to time.

h. "DOI" shall mean the United States Department of the Interior and any legal successor thereto.

i. "Effective Date" shall have the meaning as defined in the Third Amended Plan of Reorganization.

j. "Environmental Projects" shall mean those projects to be performed pursuant to the NJ ACO; provided, however, that nothing in this Settlement Agreement shall affect any additional obligations of the Debtors under the NJ ACO.

k. "EPA" shall mean the United States Environmental Protection Agency and any legal successor thereto.

l. "Federal Proofs of Claim" shall mean all of the proofs of claim filed by the United States on behalf of the EPA, DOI and NRC in the Chapter 11 Cases.

m. "Final Order" shall mean any order of the Court as to which the time to appeal, petition for certiorari, or move for reargument or a rehearing has expired and as to which no appeal, petition for certiorari, or other proceedings for reargument or rehearing shall then be pending or as to which any right to appeal, petition for certiorari, reargue or rehear shall have been waived, in writing in form and substance satisfactory to the Debtors. Additionally, in the event that an appeal, writ of certiorari, or reargument or rehearing thereof has been sought, such order of the Court shall have been affirmed by the highest court to which such order was appealed, or certiorari has been denied or from which reargument or rehearing was sought, and the time to take any further appeal, petition for certiorari or move for reargument or rehearing shall have expired.

n. "LOC Trust Account" shall mean that certain Mellon Bank, N.A. account no. 102-71K maintained by Shieldalloy for the benefit of the NJDEP pursuant to the Administrative Consent Order dated October 5, 1988 as amended in August 1989 and September 1992, which includes (1) the cash proceeds derived from the letter of credit no. 693 issued by National Westminster Bank PLC for the benefit of NJDEP, (2) the letter of credit in the amount of $8.0 million issued by Deutsche Bank for the benefit of NJDEP, or the cash proceeds (3) the letter of credit in the amount of $200,000 issued by Midlantic Bank for the benefit of the NJDEP or the cash proceeds, and (4) all accrued earnings in respect thereof.

o. "NJ ACO" shall mean the Administrative Consent Order dated October 5, 1988, as amended in August 1989 and September 1992, entered into by the Debtors and the NJDEP.

p. "NPL" shall mean the National Priorities List, 40 C.F.R., Part 300, Appendix B.

q. "New Jersey" shall mean the State of New Jersey and "NJDEP" shall mean the New Jersey Department of Environmental Protection.

r. "Plan of Reorganization" or "Plan" shall mean any Plan of Reorganization that has been confirmed or becomes effective in the Chapter 11 Cases, as it may be amended from time to time. -

s . "Preconfirmation" refers to the period of time preceding confirmation of the Plan.

t. "Postconfirmation" refers to the period of time on or after confirmation of the Plan.

u. "Prepetition" refers to the time period prior to September 2, 1993.

v. "Postpetition refers to the time period from and after September 2, 1993.

w. "RCRA" shall mean the Resource Conservation and Recovery Act, 42 U.S.C. § 6901 et seq., as now in effect or hereinafter amended.

x. "Refund Amount" shall mean the excess, if any, when the Revised Predetermined Cost is subtracted from the Posted Financial Assurance Fund.

y. "Second Amended Plan of Reorganization" refers to the certain joint plan of reorganization dated May 24, 1996 as filed by the Debtors with the Bankruptcy Court for the Southern District of New York, as may be amended from time to time.

z. "Settlement Agreement" shall mean this Settlement Agreement.

aa. "Sites" shall mean the Cambridge and Newfield facilities described above.

bb. "United States" shall mean the United States of America.

cc. Environmental terms not otherwise defined shall have the same meaning provided by the governing environmental law at issue.

dd. Bankruptcy terms not otherwise defined shall have the same meaning provided by the Bankruptcy Code or in the Second Amended Plan of Reorganization, as may be further amended.

JURISDICTION

1. The Court has jurisdiction over the subject matter hereof pursuant to 28 U.S.C. §§ 157, 1331, and 1334, and 42 U.S.C. §§ 9607 and 9613(b), and 33 U.S.C. § 1319.

PARTIES BOUND; SUCCESSION AND ASSIGNMENT

2. This Settlement Agreement applies to, is binding upon, and shall inure to the benefit of New Jersey, the United States, the Debtors and, to the extent provided herein, the Debtors' legal successors and assigns, and any trustee, examiner or receiver appointed in the Chapter 11 Cases. Nothing contained in this Settlement Agreement, including without limitation this paragraph 2, shall be used as evidence that any entity other than the Debtors is a "successor" or "assign" of any of the Debtors.

INTERNAL REVENUE SERVICE PREPETITION CLAIM

3. Subject to the approval of this Court, Metallurg and the United States agree that the automatic stay imposed by Section 362(a)(7) of the Bankruptcy Code shall be modified for the limited purpose and to the limited extent of permitting the United States to offset the Tax Refund Amount against the Tax Amount Due (the "Setoff").

4. As a result of the Setoff, Metallurg's prepetition federal tax liabilities shall be satisfied in full.

5. Within a reasonable time after the entry of this Settlement Agreement, the United States shall refund the Net Tax Refund Amount plus accrued interest, if any, to Metallurg (the "Total Net Tax Refund").

6. The United States hereby withdraws the IRS Prepetition Claim.

ALLOWANCE OF CLAIMS

7. With respect to the treatment of the Federal Proofs of Claim and the New Jersey Proofs of Claim, under the Debtors' Plan of Reorganization the Debtors and the United States and New Jersey agree as follows:

A. Allowance of Federal Claims

a. The United States shall have an Allowed General Unsecured Claim against Shieldalloy in the amount of $178,192.92 for prepetition response costs incurred by EPA at the Newfield site;

b. The United States shall have an Allowed General Unsecured Claim against Shieldalloy in the amount of $41,562.35 for prepetition response costs incurred by EPA at the Cambridge site;

c. The United States shall have an Allowed Administrative Claim against Shieldalloy relating to the Newfield site (i) in the amount of $191,177.23 for EPA's postpetition response costs, and (ii) in the amount of $4,967.00, for DOI's postpetition natural resource damages assessment costs;

d. The United States shall have an Allowed Administrative Claim against Shieldalloy relating to the Cambridge site (i) in an amount of $108,046.73 for EPA's postpetition response costs, and (ii) in the amount of $4,714.67 for DOI's postpetition natural resource damages assessment costs;

e. The NRC shall have an Allowed General Unsecured Claim against Shieldalloy in the amount of $41,613.63 for prepetition licensing fees owed by Shieldalloy in connection with the Newfield and Cambridge sites.

f. The NRC's postpetition licensing fees owed by Shieldalloy in connection with the Newfield and Cambridge sites shall be paid in the ordinary course of business.

g. Within six months after substantial consummation of the Plan of Reorganization, or such other time as the parties may agree, Shieldalloy shall commence the enhancement, restoration and creation of certain wetlands in and around the Newfield site as set forth in the attached July 24, 1996 workplan (Exhibit 1). Shieldalloy shall obtain approval from DOI for the enhancement project to be performed. Completion of the enhancement, restoration and creation of such wetlands shall be in full and complete satisfaction of DOI's prepetition claim for natural resource damages at the Newfield site. New Jersey and DOI agree to utilize their best efforts to coordinate their approvals of the implementation and completion of enhancement project to be performed under this paragraph. Such enhancement shall not be considered complete absent DOI's certification that the enhancement is complete.

h. Within six months after the earlier of the Effective Date or the entry of a Consent Order for Permanent Injunction to be filed in Ohio State Court, Shieldalloy shall purchase and commence enhancement of certain acreage adjacent to or near the Cambridge site in accordance with the final Consent Order in the action entitled State of Ohio v. Shieldalloy Metallurgical Co., Guernsey County Court of Common Pleas, Case No. 95-CV-242. Shieldalloy shall obtain approval from DOI for the property purchased and the enhancement project to be performed thereon. Completion of the enhancement of such acreage shall be in full and complete satisfaction of DOI's prepetition claim for natural resource damages at the Cambridge site. Such enhancement shall not be considered complete absent DOI's certification that the enhancement is complete.

B. Allowance of New Jersey Claims

i. New Jersey shall have an Allowed General Unsecured Claim against Shieldalloy in the amount of $638,508.20 for prepetition response costs incurred by NJDEP;

j. New Jersey shall have an Allowed General Unsecured Claim against Shieldalloy in the amount of $1,196,982.84 for prepetition New Spill Fund Authorization;

k. New Jersey shall have an Allowed Administrative Claim against Shieldalloy in an amount of not less than $262,912.12, but not more than $270,242.69, subject to Shieldalloy's receipt and approval of NJDEP Office of Natural Resources cost documentation for the period from September 9, 1993 to April 12, 1996, for NJDEP's postpetition response costs at the Newfield site;

1. Within six months after substantial consummation of the Plan of Reorganization or such other time as the parties may agree, Shieldalloy shall commence the enhancement, restoration and creation of certain wetlands in and around the Newfield site as set forth in the attached July 24, 1996 workplan (Exhibit 1). That wetlands project shall not be considered complete until the NJDEP Office of Natural Resource Damage has certified the completion of the project. In compensation for the claim for natural resource damages for interim lost use of groundwater, New Jersey shall have an allowed general unsecured claim against Shieldalloy in the amount of $1,311,000 Shieldalloy estimates that the total recovery on account of this claim under Class 4F of the Plan will result in a cash distribution to New Jersey on the Effective Date in the amount of $275,000. The completion of these actions shall constitute full satisfaction of New Jersey's pre-petition claims for damages to wetlands, and for interim lost use of groundwater.

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ALLOWED CLAIMS FOR PENALTIES

A. Allowance of Federal Penalty Claims

8. The United States shall have an Allowed General Unsecured Claim against Shieldalloy in the amount of $497,000 (the "Civil Penalty Claim") in full resolution and satisfaction of the civil penalty amounts claimed by the United States in United States of America v. Shieldalloy Corporation, Civil Action 86-4016, District of New Jersey. The Civil Penalty Claim shall be entitled to the treatment under the Plan described below in paragraph 10 of this Settlement Agreement.

B. Allowance of New Jersey Penalty Claims

9. New Jersey on behalf of NJDEP shall have an Allowed General Unsecured Claim against Shieldalloy in the amount of $100,000 in full resolution and satisfaction of penalty amounts claimed by New Jersey under the Solid Waste Management Act, N.J.S.A. 13:E-1 et seq., and the Water Pollution Control Act, N.J.S.A. 58:10A-1 et seq. ("WPCA"), and in the amount of $38,000 in full resolution and satisfaction of penalty amounts claimed under the WPCA. The Penalty Claim shall be entitled to the treatment under the Plan described below in paragraph 10 of this Settlement Agreement.

TREATMENT OF ALLOWED CLAIMS

10. All Allowed General Unsecured Claims under or pursuant to the terms of this Settlement Agreement shall be classified as "Shieldalloy Environmental Claims" under the Plan,

and in the event the Plan is confirmed by the Bankruptcy Court and the Plan is consummated, the holders of Claims in that Class shall on the Effective Date, or as soon thereafter practicable, receive a cash payment on a pro rata basis equal to the sum of:

i) 50% of the total value of New Common Stock (as stated in the Disclosure Statement) that would have been distributed under the Plan to the holder of such Allowed General Unsecured Claim had it been, as of the Effective Date, the holder of an Allowed Claim in "Class 4C-SMC Unsecured Claims" as defined in the Second Amended Plan of Reorganization; and

ii) 66 2/3% of the principal amount of New Secured Notes that would have been distributed to the holder of such claim on a pro rata basis had it been, as of the Effective Date, the holder of an Allowed Claim in "Class 4C-SMC Unsecured Claims" as defined in the Second Amended Plan of Reorganization; and

iii) the pro rata amount of cash that would have been distributed to the holder of such Allowed General Unsecured Claim had it been, as of the Effective Date, the holder of an Allowed Claim in "Class 4C-SMC Unsecured Claims" as defined in the Second Amended Plan of Reorganization.

In consideration of the cash payout on account of the Allowed General Unsecured Claims as described above in this paragraph, the United States hereby waives any right to receive any Common Stock, any New Secured Notes, or any payment on account of accrued interest in respect of the New Secured Notes, or any other payments made to holders of Allowed Claims under the Plan whether paid upon consummation of the Plan or anytime thereafter. Further, except as provided for in this Agreement, the United States waives any right to receive any distribution under the Plan on account of the Federal Proofs of Claim filed against Metallurg.

In consideration of the cash payout on account of the Allowed General Unsecured Claims as described above in this paragraph, New Jersey hereby waives any right to receive any Common Stock, any New Secured Notes, or any payment on account of accrued interest in respect of the New Secured Notes, or any other payments made to holders of Allowed Claims whether paid upon consummation of the Plan or anytime thereafter. Further, except as provided for in this Agreement, New Jersey waives any right to receive any distribution under the Plan on account of the New Jersey Proofs of Claim filed against Metallurg.

11. In no event shall the general unsecured claims allowed or to be allowed pursuant to this Settlement Agreement be subordinated to any other allowed general unsecured claims pursuant to any provision of the Bankruptcy Code or other applicable law that authorizes or provides for subordination of allowed claims, including without limitation, Sections 105, 510 and 726(a)(4) of the Bankruptcy Code.

12. The New Jersey Proofs of Claim shall hereby be deemed amended to include all matters addressed in this Settlement Agreement but not already included in the respective Proofs of Claim.

13. The Federal Proofs of Claim shall hereby be deemed amended to include all matters addressed in this Settlement Agreement but not already included in the respective Proofs of Claim.

REQUIRED FINANCIAL ASSURANCE WITH RESPECT TO PERFORMANCE OF THE WORK AT THE NEWFIELD SITE

14. For purposes of determining financial assurance only, Shieldalloy and New Jersey and the United States have identified the Environmental Projects to be performed at the Newfield site. Shieldalloy and the United States have agreed that for purposes of determining financial assurance only, the dollar amounts assigned to each of the Environmental Projects (the "Predetermined Costs") are as follows:

The Environmental Projects	Dollar Estimate (in millions)
Phase II Lagoon Closure	
Remediation of Chromium Hydroxide Sludge (including removal, filter press, shipment and disposal)	$3.3
Removal of Liners, Sampling of Soils, Any Treatment or Removal of Contaminated Soil and Final Grading and Seeding of Area	2.3
Soil Remediation	
Capital Costs	1.8
Operation and Maintenance Costs	.5

Sediment Remediation	
Sediment Capital Costs	1.2
Operation and Maintenance Costs	.4
Groundwater Remediation	9.4
Future Oversight Costs	.7
NRC Slag Pile Remediation	5.0
Wetlands Restoration	.514
Building Decontamination	.3
Stormwater Control	.2

15. The total cost, for financial assurance purposes only, of completing the Environmental Projects (the "Total Predetermined Cost") is $25,614,000.

16. Shieldalloy agrees to provide, create or make available the following fund as financial assurance for the benefit of the United States and New Jersey with respect to the Environmental Projects required to be performed at the Newfield site:

A. At or prior to the Effective Date, Shieldalloy shall establish a cash reserve, letter of credit, or a combination thereof, in the amount of $4.25 million dollars for the benefit of the United States and New Jersey.

B. Within five business days of Metallurg's receipt of the Total Net Tax Refund Amount as provided in paragraph 5 above or the Effective Date of the Plan, whichever is later, Shieldalloy shall (i) deposit cash into a trust account for the benefit of the United States and New Jersey in an amount equal to the Total Net Tax Refund Amount, or (ii) purchase a letter of credit for the benefit of the United States and New

Jersey in an amount equal to the Total Net Tax Refund Amount. The Total Net Tax Refund Amount shall be above and beyond the $4.25 million that Shieldalloy shall provide pursuant to paragraph 16A above.

C. The existing letter of credit previously posted for the benefit of the NRC in connection with the Newfield site in the amount of $750,000 shall be drawn down by the NRC and the proceeds shall be deposited into a separate trust account for the benefit of NRC; provided, however, that at Shieldalloy's option it may obtain a new letter of credit for the benefit of the NRC in the amount of $750,000 in return for the proceeds of the prior letter of credit (the "NRC Financial Assurance Fund").

D. The financial assurance posted by Shieldalloy pursuant to paragraphs 16A-16C above, including any accrued earnings thereon, shall constitute the "Joint Financial Assurance Fund."

17. Shieldalloy previously established three letters of credit for the benefit of the State of New Jersey to secure the cleanup of the Newfield site:

1. Letter of Credit No. 693 issued by National Westminster Bank PLC (which has been drawn down upon and the proceeds reside in Mellon Bank Trust Account No. 102-71K);
2. Letter of Credit No. 839-51177 issued by Deutsche Bank; and

3. Letter of Credit No. 701175 issued by Midlantic Bank in the amount of $200,000.

Neither these letters of credit nor the proceeds derived from these letters of credit or the accrued earnings thereof are assets of the Debtors' estates. These letters of credit and the proceeds and accrued earnings derived from the letters of credit shall not be subject to the continuing jurisdiction of the Court pursuant to this Settlement Agreement but are referred to herein only to describe the parties' agreement with respect to the Joint Financial Assurance Fund. Nothing in this paragraph shall affect the dispute resolution procedures set forth in paragraphs 28-36, including the Bankruptcy Court's jurisdiction, pursuant to paragraph 34, to adjudicate any dispute between EPA and the Debtors as to whether a refund is to be made from the LOC Trust Account. These letters of credit and the proceeds and accrued earnings derived therefrom are referred to herein as the LOC Trust Account.

18. At any time after the Effective Date, Shieldalloy may request written confirmation from the United States and New Jersey that any of the Environmental Projects identified in paragraph 14 of this Settlement Agreement has been completed, and demand the appropriate Refund Amount in accordance with paragraph 19 below. Such request by Shieldalloy shall be accompanied by documentation supporting its claim that the Environmental Project has been completed. Within sixty (60) days of Shieldalloy's

request and demand, EPA and New Jersey and DOI (as to wetlands remediation only) shall each either (i) confirm, in writing, completion of the project and approve the Refund Amount, or (ii) otherwise notify Shieldalloy in writing of their respective positions with respect to the completion of such project and the Refund Amount. If the position of the United States or New Jersey, in their discretion, is that such project has not been completed, then that party shall specify in its response the reasons why it believes the project has not been completed and set forth the remaining Work to be done. EPA and New Jersey and DOI (as to wetlands remediation only) agree to employ their best efforts to coordinate their respective reviews of Shieldalloy's request and demand and expedite their respective responses. If the position of the United States is that an Environmental Project has not been completed, then the dispute resolution procedures set forth in paragraphs 28-36 below shall apply.

19. In the event that the United States and New Jersey both confirm in writing that an Environmental Project described in paragraph 14 above has been completed, the Predetermined Cost for that project (together with the Predetermined Costs for all other completed projects) shall be deducted from the Total Predetermined Cost so as to arrive at a revised Total Predetermined Cost (the "Revised Predetermined Cost") for the remaining Environmental Projects. If the Revised Predetermined Cost is less than the sum of the Joint Financial Assurance Fund

and the LOC Trust Account (the sum of the Joint Financial Assurance Fund and the LOC Trust Account shall hereinafter be referred to as the "Posted Financial Assurance Fund"), then the United States and New Jersey shall cause the excess amount, the "Refund Amount," to be refunded to Shieldalloy in a timely manner such that the Posted Financial Assurance Fund equals the Revised Predetermined Cost. To the extent such refund requires that letters of credit constituting part of the Posted Financial Assurance Fund be reduced, the United States and New Jersey hereby agree to the replacement or reduction of the posted letters of credit in accordance with paragraphs 20-22 with letters of credit in a form and from an institution reasonably acceptable to New Jersey and the United States and in compliance with applicable regulations.

Thus, for example, if the Total Predetermined Cost is $25.614 million, the Posted Financial Assurance Fund is $22.614 million, and the United States and New Jersey certify that Shieldalloy completed the Phase II Lagoon Closure project (which has been assigned a dollar value of $5.6 million for financial assurance purposes only), then the Total Predetermined Cost would be reduced by $5.6 million to arrive at a Revised Predetermined Cost of $20.014 million ($25,614,000 - $5,600,000 = $20,014,000). Because the Posted Financial Assurance Fund would then exceed the Revised Predetermined Cost by $2.6 million ($22,614,000 - $20,014,000 = $2,600,000), the United States and New Jersey would be required to either (i) allow $2.6 million to be refunded to Shieldalloy in a timely manner, or (ii) allow the letters of credit which constitute part of the Posted Financial Assurance Fund, other than the letter of credit listed in paragraph 16C, to be reduced or replaced in a total amount of $2.6 million such that the Posted Financial Assurance Fund equaled the Revised Predetermined Cost.

20. Except as provided in paragraph 21 below, refunds of the Refund Amount pursuant to paragraph 19 above upon the completion of any of the Environmental Projects shall be made first from the proceeds of the LOC Trust Account. In the event that the LOC Trust Account does not have sufficient funds to refund the Refund Amount, the United States and New Jersey shall cause the remainder of the refund to be made from the Joint Financial Assurance Fund first from those items set forth in paragraph 16A and 16B (as elected by Shieldalloy) and then, subject to paragraph 22 below, from the NRC Financial Assurance Fund listed in paragraph 16C.

21. Refunds of the refund amount pursuant to paragraph 19 above upon the completion of the NRC Slag Piles Remediation Project shall be made first from the Joint Financial Assurance Fund in the order that the accounts are listed in paragraph 16, provided, however, that no refund shall be made out of the NRC Financial Assurance Fund posted pursuant to paragraph 16C unless the NRC, New Jersey, and the United States certify in writing

that the NRC Slag Piles Environmental Project has been completed. In the event that the Joint Financial Assurance Fund does not have sufficient funds to refund the Refund Amount upon completion of the NRC Slag Piles Remediation Project, New Jersey shall cause the remainder of the refund to be made from the LOC Trust Account; provided all the Environmental Projects listed in paragraph 14 above are completed, or, if they have not been completed, New Jersey in its discretion agrees to the refund from the LOC Trust Account.

22. Notwithstanding any provision in this Settlement Agreement, absent the express written consent of the NRC, the NRC Financial Assurance Fund posted for the benefit of the NRC in connection with paragraph 16C above may only be reduced or replaced in the event that (i) the NRC, New Jersey, and the United States certify in writing that the NRC Slag Piles Environmental Project has been completed, and (ii) the other conditions set forth in paragraphs 19 and 20 above have been satisfied.

23. To the extent that New Jersey incurs oversight costs recoverable under New Jersey or federal law, or EPA incurs oversight costs not inconsistent with the National Contingency Plan in respect of any Environmental Project, the Debtors shall reimburse the EPA and New Jersey for such costs. To the extent that DOI incurs oversight, assessment, or restoration planning costs, the Debtors shall reimburse DOI for such costs. On each

occasion that the Debtors reimburse (i) New Jersey or EPA for oversight costs incurred in respect of any Work, or (ii) DOI for oversight, assessment, or restoration planning costs, the dollar value assigned to future oversight costs for financial assurance purposes only in paragraph 14 shall be reduced dollar for dollar for the amounts reimbursed (up to a total collective maximum of $700,000) so as to arrive at a Revised Predetermined Cost. In the event that the Revised Predetermined Cost is less than the Posted Financial Assurance Fund, then the United States and New Jersey shall cause the excess amount (the "Refund Amount") to be refunded in accordance with paragraphs 19 through 21 above.

24. At any time Shieldalloy may replace any cash deposits in the LOC Trust Account with a letter of credit in the equivalent dollar amount for the benefit of New Jersey. At any time Shieldalloy may replace any cash deposits in any of the accounts comprising the Joint Financial Assurance Fund -- with the exception of the letter of credit described in paragraph 16C -- with a letter of credit in the equivalent dollar amount for the benefit of New Jersey and the United States. Any letter of credit provided pursuant to this paragraph for the benefit of New Jersey or the United States shall be in a form and from an institution reasonably acceptable to New Jersey and/or the United States, and shall comply with applicable regulations. Debtors shall not be permitted to draw down on, replace, reduce, or

withdraw monies from the Posted Financial Assurance Fund except as specifically authorized in this Settlement Agreement.

25. Shieldalloy shall forego its right of reimbursement for what was known as the Phase I Lagoon Closure, which has already been completed.

26. In the event that a decommissioning plan relating to the Newfield site is approved by the NRC and the NRC requires Shieldalloy to provide additional or separate financial assurance for the NRC Slag Piles Remediation Project which is identified in paragraph 14 of this Settlement Agreement, then for purposes of calculating the Refund Amount as described in paragraph 19 above, the Posted Financial Assurance Fund will be increased by the additional financial assurance actually purchased or acquired by Shieldalloy pursuant to any decommissioning plan up to a maximum of an additional $4.25 million. In addition, the U.S and New Jersey agree that any additional financial assurance required by the NRC may, at Shieldalloy's option, reduce the Joint Financial Assurance Fund required pursuant to Section 16A and 16B (up to an aggregate of $4.25 million), and the U.S. and New Jersey agree to release or refund an amount equal to such financial assurance provided for the benefit of the NRC, to the extent funds are available, at the time such additional financial assurance is provided to the NRC.

27. Nothing in this Settlement Agreement is intended to preclude any decision by the NJDEP or EPA or DOI (as to

wetlands remediation only) to reduce or change the form of financial assurance for the Newfield site under applicable New Jersey or federal financial assurance regulations or guidelines, subject to the agreement of NJDEP and EPA.

27A. Notwithstanding the foregoing, if, on a semiannual basis, the Total Predetermined Cost is less than the Posted Financial Assurance Fund by reason of the accrual of earnings on such fund or otherwise, a Refund shall be made to Shieldalloy as set forth in paragraphs 20, 21, and 22 of this Agreement. Earnings on the Joint Financial Assurance Fund and the LOC Trust Account that are refundable shall begin to accrue as of the date of substantial consummation of the Plan. Until that date, accrued earnings shall remain a part of the Joint Financial Assurance Fund and the LOC Trust Account.

DISPUTE RESOLUTION

28. Unless otherwise expressly provided for in this Settlement Agreement, the dispute resolution procedures provided in paragraphs 28-36 herein shall be the exclusive mechanism to resolve disputes arising between the Debtors and the EPA under or with respect to this Settlement Agreement. However, the procedures set forth in paragraphs 28-36 shall not apply to actions by EPA to enforce obligations of the Debtors that have not been disputed in accordance with paragraphs 28-36.

29. Any dispute which arises between the Debtors and the EPA under or with respect to this Settlement Agreement shall

in the first instance be the subject of informal negotiations between the parties to the dispute. The period for informal negotiations shall not exceed twenty (20) days from the time the dispute arises, unless it is modified by written agreement of the parties to the dispute. The dispute shall be considered to have arisen when one party sends the other party a written Notice of Dispute.

30. In the event that the parties cannot resolve a dispute by informal negotiations under paragraph 29, then the position advanced by the EPA shall be considered binding unless, within fifteen (15) days after the conclusion of the informal negotiation period, the Debtors invoke the formal dispute resolution procedures by serving EPA with a written Statement of Position on the matter in dispute, including, but not limited to, any factual data, analysis or opinion supporting that position and any supporting documentation relied upon by the Debtors.

31. Within fifteen (15) days after receipt of the Debtors Statement of Position, EPA will serve on the Debtors its Statement of Position, including, but not limited to, any factual data, analysis, or opinion supporting EPA's position and all supporting documentation relied upon by EPA. Within ten (10) days after receipt of EPA's Statement of Position, the Debtors may submit a Reply.

32. EPA shall maintain an administrative record of the dispute which shall contain all Statements of Position, any

Reply, and the supporting documentation submitted by both parties. Where appropriate, EPA may allow submission of supplemental Statements of Position by the parties to the dispute.

33. The Director of the Emergency and Remedial Response Division, EPA Region 2, will issue a final administrative decision (the "Final Decision") resolving the dispute based on the administrative record described in paragraph 32. The Final Decision shall be binding upon the Debtors, subject only to the Debtors' right to seek judicial review pursuant to paragraph 34 below.

34. The Final Decision shall be reviewable by the United States Bankruptcy Court for the Southern District of New York, provided, however, that the Debtors must file a motion requesting judicial review of the decision with the Bankruptcy Court and serve it on all parties within fifteen (15) days of receipt of the Final Decision. The motion shall include a description of the matter in dispute, the efforts made by the parties to resolve it, the relief requested, and the schedule, if any, within which the dispute must be resolved to ensure orderly implementation of this Settlement Agreement. In proceedings on any dispute governed by this paragraph, the Debtors shall have the burden of demonstrating that the Final Decision is arbitrary, capricious or otherwise not in accordance with law. Judicial

review of the Final Decision shall be based on the administrative record.

35. This Settlement Agreement shall not add to or subtract from the right of the Debtors to dispute the validity of the provisions of the RODs issued in connection with the Sites.

36. The invocation of the formal dispute resolution procedures under paragraphs 28-34 of this Settlement Agreement shall not extend, postpone or affect in any way any obligation of the Debtors under this Settlement Agreement that is not directly in dispute, unless EPA or the Bankruptcy Court provides otherwise.

36A. Any dispute between Debtors and New Jersey concerning issues regarding the LOC Trust Fund, whether any Environmental Project is complete, and whether a refund is to be made from the Joint Financial Assurance Fund or the LOC Trust Fund, shall be resolved as provided in the NJ ACO. The dispute resolution procedures set forth in paragraphs 28-34 of this Settlement Agreement and any resolution of a dispute thereunder shall not be binding on New Jersey. Nothing in this paragraph shall affect the dispute resolution procedures set forth in paragraphs 28-36, including the Bankruptcy Court's jurisdiction, pursuant to paragraph 34, to adjudicate any dispute between EPA and the Debtors as to whether a refund is to be made from the LOC Trust Account.

PROVISIONS IN THE EVENT OF A DEFAULT

37. The Joint Financial Assurance Fund shall be subject to draw down and/or withdrawal by New Jersey or the United States to be used for the purpose of remediating and restoring the Newfield site in the event that New Jersey or the United States certifies in writing that Shieldalloy has failed to perform its obligations under the NJ ACO, an NRC-approved decommissioning plan for the Newfield site, and/or any other judicial or administrative order then in effect with respect to the remediation or restoration of the Newfield site, provided, however, that the proceeds of the account listed in Paragraph 16C above shall not be subject to draw down or withdrawal without the express written consent of the NRC.

COVENANT NOT TO SUE AND RESERVATION OF RIGHTS; BANKRUPTCY DISCHARGE

38. Except for those claims specifically settled pursuant to paragraphs 7, 8 and 9 of this Settlement Agreement, Shieldalloy's environmental liabilities at the Newfield site, including its liability to the United States and New Jersey, shall be excepted from discharge and shall pass through Shieldalloy's Chapter 11 case unaffected. The Plan of Confirmation or the Order confirming the Plan shall contain a provision identical to this paragraph 38. The parties agree that the post-confirmation date response costs claims of the United States and New Jersey against Shieldalloy are not being settled under this Settlement Agreement.

39. Except for those claims specifically settled pursuant to this Settlement Agreement, Shieldalloy's environmental liabilities at the Cambridge site, to the United States, shall be excepted from discharge and shall pass through Shieldalloy's Chapter 11 case unaffected. The Plan of Reorganization or the Order confirming the Plan shall contain a provision identical to this paragraph 39.

40. It is agreed and understood that the Predetermined Costs as identified in paragraph 14 of this Settlement Agreement in no way constitute a cap or limitation on Shieldalloy's continuing obligations to comply with state and federal environmental laws or with the NJ ACO.

41. Except as specifically provided in paragraphs 7(g) and 7(l) of this Settlement Agreement, the United States and New Jersey reserves all rights they may have against the Debtors under existing law or the law as it may be amended, to compel the Debtors to cleanup and/or remediate any hazardous substances and pollutants known or subsequently discovered at the Newfield site, and/or recover the United States' or New Jersey's response costs, oversight costs and natural resource damages, if any, associated therewith; provided, however, that nothing contained in this Settlement-Agreement shall broaden or limit the discharge granted to Metallurg pursuant to section 1141(d) of the Bankruptcy Code.

42. Except as specifically provided in paragraph 7(h) of this Settlement Agreement, the United States reserves all

rights they may have against the Debtors under existing law or the law as it may be amended, to compel the Debtors to cleanup and/or remediate any hazardous substances known or subsequently discovered at the Cambridge site, and/or recover the United States' response costs, oversight costs, or natural resource damages assessment costs, if any, associated therewith; provided, however, that nothing contained in this Settlement Agreement shall broaden or limit the discharge granted to Metallurg pursuant to section 1141(d) of the Bankruptcy Code.

43. Except as otherwise provided for herein, the terms of this Settlement Agreement do not constitute a release of Shieldalloy or any prior or subsequent owner or operator of the Newfield or Cambridge sites from any other liability under any state or federal environmental law, decree, or order, for the assessment, cleanup, remediation, correction, restoration or other response to any condition at the Newfield or Cambridge sites that exists now, will exist in the future, or was created before Shieldalloy took ownership of the Newfield or Cambridge sites. Nothing in this Settlement Agreement shall release Shieldalloy or a subsequent owner or operator of the Newfield or Cambridge sites from complying with applicable state and federal environmental laws.

44. Shieldalloy agrees that all response or natural resource damages assessment costs claims incurred or to be incurred postconfirmation by the United States in connection with

the Newfield and Cambridge sites shall be entitled to administrative priority in a subsequent Chapter 7 or 11 bankruptcy case of Shieldalloy.

45. Shieldalloy agrees that all response costs claims incurred or to be incurred postconfirmation by New Jersey in connection with the Newfield site shall be entitled to administrative priority in a subsequent Chapter 7 or 11 bankruptcy case of Shieldalloy.

46. The Joint Financial Assurance Fund shall be held in trust for the benefit of the United States and New Jersey, and the LOC Trust Account shall be held in trust for the benefit of the NJDEP and both accounts shall be excepted from the Debtors' bankruptcy estate or in any subsequent bankruptcy case, except to the extent the Debtors are entitled to any refunds therefrom pursuant to paragraphs 18 and 19 above. In the event of a subsequent bankruptcy, any dispute as to whether a refund is due is to be determined between EPA and the Debtors pursuant to the dispute resolution provisions herein, and between New Jersey and the Debtors pursuant to the NJ ACO. In the event the Debtors file a subsequent bankruptcy case, the Joint Financial Assurance Fund shall be subject to draw down and/or withdrawal by New Jersey or the United States and the LOC Trust Account shall be subject to draw down and/or withdrawal by New Jersey to be used for the purpose of remediating and restoring the Newfield site, provided, however, that the proceeds of the account listed in

Paragraph 16C above shall not be subject to draw down or withdrawal without the express written consent of the NRC. It is agreed and understood that the Joint Financial Assurance Fund and the LOC Trust Account are held in trust exclusively for the purpose of remediation and restoration of the Newfield site.

47. In the event that this Settlement Agreement is approved by the Bankruptcy Court and the Plan of Reorganization is confirmed and consummated, the United States and New Jersey will not object to Metallurg being granted a discharge pursuant to section 1141(d) of the Bankruptcy Code. Nothing in this Settlement Agreement shall broaden or limit the scope of that discharge.

48. Nothing in this Settlement Agreement shall constitute a limitation on Shieldalloy's obligation to comply with the complete terms of the NJ ACO or any other existing or future state or federal administrative or court order or decree relating to the Newfield site.

49. The Debtors' and the United States' entry into this Settlement Agreement is conditioned on the entry of a final Consent Order in the action entitled State of Ohio v. Shieldalloy Metallurgical Co., Guernsey County Court of Common Pleas, Case No. 95-CV-242.

50. Nothing in this Settlement Agreement shall be construed to affect the NRC's regulatory authority over the Newfield site or the Cambridge site, including, but not limited

to, the NRC's authority relating to the decommissioning of the Sites, and the NRC's authority to require Shieldalloy to post separate financial assurance, above and beyond the amounts set forth in this Settlement Agreement.

51. Debtors agree not to assert any claims or causes of action against the New Jersey Spill Compensation Fund, or against the United States, or its contractors or employees, with respect to Prepetition and Postpetition Claims, including but not limited to:

i) any direct or indirect claim for reimbursement from the EPA Hazardous Substance Superfund established by 26 U.S.C. § 9507, based on sections 106(b)(2), 107, 111, 112, or 113 of CERCLA, 42 U.S.C. §§ 9606(b)(2), 9607, 9611, 9612, or 9613, or any other provision of law; and

ii) any claims arising out of the response or natural resource damages assessment actions at the Sites for which the United States' Prepetition and Postpetition claims were incurred.

52. Nothing in this Settlement Agreement shall be deemed to constitute approval or preauthorization of a claim within the meaning of Section 111 of CERCLA, 42 U.S.C. § 9611, or 40 C.F.R. 300.700(d).

53. In any subsequent administrative or judicial proceeding initiated by New Jersey, the United States or any agency of the United States, for injunctive relief, recovery of response or natural resource damages assessment costs, or other

appropriate relief relating to the Sites, Debtors shall not assert, and may not maintain, any defense or claim based upon the principles of waiver, res judicata, collateral estoppel, issue preclusion, claim splitting, or other defenses based upon any contention that the claims raised in the subsequent proceeding were or should have been brought in the instant case; provided, however, that nothing in this paragraph: (i) affects the settlement of the Prepetition and Postpetition Claims specifically settled pursuant to paragraph 7 of this Settlement Agreement; and (ii) affects Metallurg's right to raise the discharge granted to it pursuant to section 1141(d) of the Bankruptcy Code as a defense in any subsequent proceeding before an agency or court of competent jurisdiction.

PAYMENTS MADE PURSUANT TO THIS AGREEMENT

54. Payments to be made under this Settlement Agreement on account of EPA's and DOI's response and natural resource damages assessment cost claims pursuant to paragraph 7 and the Civil Penalty Claim pursuant to paragraph 8 shall be made by check made payable to the "United States of America" and sent to:

Chief, Environmental Protection Unit
United States Attorney's Office
Southern District of New York
100 Church Street, 19th floor
New York, New York 10007

At the time of any payment of EPA's response cost claims relating to the Newfield site pursuant to paragraph 7, Shieldalloy shall send notice that such payment has been made to:

U.S. EPA Region II
Emergency and Remedial Response Division
New Jersey Remediation Branch
Southern New Jersey Remediation Section
Attn: Shieldalloy Superfund Site Remedial Project Manager

U.S. EPA Region II
Office of Regional Counsel
New Jersey Superfund Branch
New Jersey Superfund Section
Attn: Shieldalloy Superfund Site Attorney

At the time of any payment of EPA's response cost claims relating to the Cambridge site pursuant to paragraph 7, Shieldalloy shall send notice that such payment has been made to:

U.S. EPA Region V
77 West Jackson Boulevard
Chicago, Illinois 60604-3507
Attn: Shieldalloy Superfund Site Attorney

At the time of any payment of DOI's claims pursuant to paragraph 7, Shieldalloy shall send notice that such payment has been made to:

Ms. Teresa Tancre
Fish and Wildlife Service
Division of Finance
4401 N. Fairfax Drive, Suite 380
Arlington, VA 22203

55. Payments of the NRC's licensing fees claims pursuant to paragraph 7 shall be made by check payable to the "Nuclear Regulatory Commission" and sent to :

Ms. Diane B. Dandois

U.S. Nuclear Regulatory Commission
Office of the Controller
2 White Flint North
11545 Rockville Pike
Rockville, MD 20852

56. Payments to be made under this Settlement Agreement on account of EPA's oversight costs pursuant to paragraph 23, shall be made by check made payable to "EPA Hazardous Substance Superfund." Each check shall reference the name and address of the party making payment, the Site name, the docket number for this action, and the United States Attorney's Office Case Number and shall be sent to:

EPA - Region II
Attn: Superfund Accounting
P.O. Box 360188M
Pittsburgh, PA

At the time of such payment, Shieldalloy shall send notice that such payment has been made to:

U.S. EPA Region II
Emergency and Remedial Response Division
New Jersey Remediation Branch
Southern New Jersey Remediation Section
Attn: Shieldalloy Superfund Site Remedial Project Manager

U.S. EPA Region II
Office of Regional Counsel
New Jersey Superfund Branch
New Jersey Superfund Section
Attn: Shieldalloy Superfund Site Attorney

57. Payments to be made under this Settlement Agreement on account of DOI's oversight, assessment, or restoration planning costs pursuant to paragraph 23, shall be made by check made payable to "Department of the Interior." Each

check shall reference the name and address of the party making payment, the Site name and location, fund account number 14X5198, the docket number for this action, and shall be sent to:

Fish and Wildlife Service
Division of Finance
4401 North Fairfax Drive
Room 380
Arlington, VA 22203

58. Payments to be made under this Settlement Agreement on account of New Jersey's

a. Prepetition response cost claims pursuant to paragraph 7i,

b. Prepetition Spill Fund Authorization claim pursuant to paragraph 7j,

c. Administrative claim pursuant to paragraph 7k for costs postpetition in the amount of $245,825.88, and

d. Penalty assessments pursuant to paragraph 9,

shall be made by separate checks each made payable to the "Treasurer, State of New Jersey" and sent to:

NJDEP, Bureau of Revenue
CN 417
Trenton, NY 08625-0417

Payments to be made under this Settlement Agreement on account of New Jersey's

a. Administrative claim pursuant to paragraph 7k, in the amount of not less than $17,086.24 but not more than $24,416.81 as set forth in paragraph 7k, and

b. Natural resource damage claim for ground water pursuant to paragraph 71,

shall be made by <u>separate check</u> payable to the "Treasurer, State of New Jersey" and sent to:

Martin McHugh, Chief
NJDEP, Office of Natural Resource Damages
CN 404
Trenton, NJ 08625-0417

RETENTION OF RECORDS

59. Until 10 years after the effective date of this Settlement Agreement, Debtors shall preserve and retain all records and documents now in their possession, custody or control, or which come into their possession, custody or control, that relate in any manner to response actions taken at the Sites or to the liability of any person for response actions conducted and to be conducted at the Sites, regardless of any corporate retention policy to the contrary. This shall not supersede the document retention requirements in the NJ ACO, and such requirements shall remain in effect.

60. After the conclusion of the document retention period in the preceding paragraph, Debtors shall notify the United States and the State of New Jersey at least 90 days prior to the destruction of any such records or documents, and, upon request by the United States or the State of New Jersey, Debtors

shall deliver any such records or documents to the United States or the State of New Jersey. Debtors may assert that certain documents, records, or other information are privileged under the attorney-client privilege or any other privilege recognized by federal or state law. If Debtors assert such a privilege, they shall provide the United States and New Jersey with the following: 1) the title of the document, record, or information; 2) the date of the document, record, or information; 3) the name and title of the author of the document, record, or information; 4) the name and title of each addressee and recipient; 5) a description of the subject matter of the document, record or information; and 6) the privilege asserted. If a claim of privilege applies only to a portion of a document, the document shall be provided to the United States and the State of New Jersey in redacted form to mask only the privileged information. Debtors shall retain all records and documents that they claim to be privileged until the United States and the State of New Jersey have had a reasonable opportunity to dispute the privilege claim.

61. By signing this Settlement Agreement, Shieldalloy and Metallurg each certifies individually that, to the best of its knowledge and belief, it has fully complied in all material respects with any and all requests from the United States and New Jersey for information regarding the Sites.

NOTICES AND SUBMISSIONS

62. Whenever, under the terms of this Settlement Agreement, written notice is required to be given, or a report or other document is required to be sent by one party to another, it shall be directed to the individuals at the addresses specified below via U.S. certified mail, return receipt requested, unless those individuals or their successors give notice of a change of address to the other parties in writing. All notices and submissions shall be considered effective upon receipt, unless otherwise provided. Except as otherwise provided in this Settlement Agreement, written notice as specified herein shall constitute complete satisfaction of any written notice requirement in the Settlement Agreement with respect to the United States, EPA, DOI, New Jersey, NJDEP, and the Debtors, respectively.

a. <u>As to the State of New Jersey</u>:

Donna Gaffigan, Case Manager
NJDEP, Bureau of Federal Case Management
CN 028
Trenton, NJ 08625-0028

Martin McHugh, Chief
NJDEP, Office of Natural Resource Damages
CN 404
Trenton, NJ 08625-0417

Kenneth W. Elwell, Deputy Attorney General
25 Market Street
Justice Complex
CN 093
Trenton, NJ 08625-0093

b. <u>As to the United States of America</u>:
The United States EPA
Office of Regional Counsel
290 Broadway
New York, New York 10007
Attn: Shieldalloy Site Attorney

The United States EPA
Office of Regional Counsel
Emergency and Remedial Response
Division
290 Broadway
New York, New York 10007
Attn: Remedial Project Manager

United States Department of the Interior
Division of Conservation and Wildlife
1849 "C" Street, NW
Washington, D.C. 20240
Attn: Shieldalloy Attorney

United States Attorney's Office
Southern District of New York
100 Church Street
New York, New York 10007
Attn: Chief, Environmental Protection Unit

c. <u>As to the Debtors</u>:

Shieldalloy Metallurgical Corporation
P.O. Box 768
12 West Boulevard
Newfield, NJ 08344
Attn: Environmental Manager

Weil, Gotshal & Manges LLP
1615 L Street, N.W. Suite 700

Washington, DC 20036
Attn: David Berz, Esq.

LODGING AND OPPORTUNITY FOR PUBLIC COMMENT

63. The United States agrees that notice of this Settlement Agreement shall be expeditiously published in the Federal Register in accordance with CERCLA section 122(i), 42 U.S.C. § 922(i), and that public comments, if any, will be taken and considered during the required 45 day notice and comment period. The United States reserves the right to withdraw or withhold its consent to the Settlement Agreement if the public comments disclose facts or considerations which indicate that the Settlement Agreement is inappropriate, improper or inadequate.

64. The Debtors shall request that this Settlement Agreement be approved by the Bankruptcy Court pursuant to the order confirming the Debtors' Plan of Reorganization.

65. If for any reason (i) the Court by Final Order should decline to approve this Settlement Agreement, (ii) the Settlement Agreement is withdrawn by the United States as provided in paragraph 63, (iii) the Settlement Agreement is not approved by a Final Order, or (iv) the Chapter 11 Cases are dismissed or converted to cases under Chapter 7 of the Bankruptcy Code before the effective date of a Plan of Reorganization: (a) this Settlement Agreement shall be null and void and the parties shall not be bound hereunder or under any documents executed in connection herewith; (b) the parties shall have no liability to

one another arising out of or in connection with this Settlement Agreement or under any documents executed in connection herewith; (c) the Federal Proofs of Claim shall not be deemed to be discharged and the Debtors may, unless the Chapter 11 Cases are dismissed or converted to cases under Chapter 7 of the Bankruptcy Code, file objections and/or file a motion for estimation of such claims (which the United States may oppose); (d) the New Jersey Proofs of Claim shall not be deemed to be discharged and the Debtors may, unless the Chapter 11 Cases are dismissed or converted to cases under Chapter 7 of the Bankruptcy Code, file objections and/or file a motion for estimation of such claims (which New Jersey may oppose); (e) this Settlement Agreement and any documents prepared in connection herewith shall have no residual or probative effect or value, and it shall be as if they had never been executed; and (f) this Settlement Agreement, any statements made in connection with settlement discussions, and any documents prepared in connection herewith may not be used as evidence in any litigation between the parties.

66. The Debtors shall not propose any Plan of Reorganization or take any other action in the Chapter 11 Cases that is inconsistent with the terms and provisions of this Settlement-Agreement. The United States and New Jersey reserve all of their rights to object to any Plan of Reorganization filed by the Debtors, except that the United States and New Jersey agree that they will not object to any provisions in the Plan of

Reorganization that are consistent with this Settlement Agreement.

INTEGRATION AND COUNTERPARTS

67. This Settlement Agreement and any other documents to be executed in connection herewith constitutes the sole and complete agreement of the parties hereto with respect to the matters addressed herein, and supersedes any prior understandings or oral or written agreements concerning the subject matters of this Settlement Agreement. Except as otherwise provided herein, it is understood and agreed that this Settlement Agreement does not supersede the NJ ACO. This Settlement Agreement may not be amended except by a writing signed by the party or parties sought to be bound thereunder.

68. This Settlement Agreement may be executed in counterparts each of which shall constitute an original and all of which shall constitute one and the same agreement.

RETENTION OF JURISDICTION

69. Except as provided below with respect to the NJ ACO and the LOC Trust Account, the United States Bankruptcy Court for the Southern District of New York shall retain exclusive jurisdiction of the subject matter of this Settlement Agreement and the parties hereto for the duration of the terms and provisions of this Settlement Agreement with respect to the (i) dischargeability of any claims referred to under this Agreement and (ii) any issues with respect to the Joint Financial Assurance

Fund for the purpose of enabling any of the parties to apply to the Court, in accordance with the dispute resolution procedures set forth in paragraphs 28-36 for such further order, direction and relief as may be necessary or appropriate for the construction or interpretation of the foregoing matters under this Settlement Agreement or to effectuate or enforce compliance with its terms. The New Jersey Superior Court shall retain exclusive jurisdiction over any issues that may arise with respect to the NJ ACO and the LOC Trust Account. With the exception of the dischargeability of claims referred to under this Settlement Agreement, this Settlement Agreement does not confer jurisdiction on the Bankruptcy Court for the Southern District of New York over the Debtors' obligation to remediate or otherwise address environmental violations at the Newfield site. Any dispute between the Debtors and New Jersey concerning the LOC Trust Fund, whether any Environmental Project is complete, whether a refund is to be made from the Joint Financial Assurance Fund or the LOC Trust Account, and the nature and extent of the Debtors' obligations under the NJ ACO, shall be resolved as provided in the NJ ACO. Nothing in this paragraph shall affect the dispute resolution procedures set forth in paragraphs 28-36, including the Bankruptcy Court's jurisdiction, pursuant to paragraph 34, to adjudicate any dispute between EPA and the Debtors as to whether a refund is to be made from the LOC Trust Account.

THE UNDERSIGNED PARTY ENTERS INTO THIS SETTLEMENT AGREEMENT FOR THE STATE OF NEW JERSEY:

Peter Verniero
Attorney General of New Jersey
Attorney for New Jersey
Department of Environmental Protection

By: [signature]
Kenneth W. Elwell
Deputy Attorney General

THE UNDERSIGNED PARTY ENTERS INTO THIS SETTLEMENT AGREEMENT FOR THE DEBTORS:

[signature]
David R. Berz
DB 4517
A Member of the Firm
Weil, Gotshal & Manges LLP
Attorneys for Debtors in Possession
767 Fifth Avenue
New York, New York 10153
(212) 310-8000

THE UNDERSIGNED PARTIES ON THE ATTACHED PAGES ENTER INTO THIS SETTLEMENT AGREEMENT FOR THE UNITED STATES OF AMERICA:

SO ORDERED this 26th day
of ~~February,~~ March 1997

[signature]
United States Bankruptcy Judge

NYFS05...:\40\63140\0003\180\AGR#224L.22J

MARY JO WHITE
United States Attorney for the
Southern District of New York
Attorney for the United States
of America

By: [signature]
EDWARD A. SMITH (ES-2461)
JEFFREY OESTERICHER (JO-8935)
Assistant United States Attorneys
100 Church Street -- 19th Floor
New York, New York 10007
Tel. No.: (212) 385-4477

1/21/92

LOIS J. SCHIFFER
Assistant Attorney General
Environmental and Natural Resources
Division
U.S. Department of Justice
Washington, D.C. 20530

1/29/92

HENRY S. FRIEDMAN
Senior Attorney
Environmental Enforcement Section
Environmental and Natural Resources
Division
U.S. Department of Justice
P.O. Box 7611
Washington, D.C. 20044-7611

FOR THE UNITED STATES ENVIRONMENTAL PROTECTION AGENCY, REGION II

BY: Jeanne M. Fox

JEANNE M. FOX
Regional Administrator
Region II
U.S. Environmental Protection Agency

DATED: 12/27/96