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February 23, 2024

Ms. Kara Nierenberg, PE
Remedial Project Manager
EPA Region 1
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Subject: Nuclear Metals, Inc. Superfund Site
Concord, Massachusetts
95% Remedial Design for In-Situ Sequestration of Uranium in Overburden within the Holding Basin

Dear Ms. Nierenberg:

The 95% Remedial Design for In-Situ Sequestration of Uranium in Overburden within the Holding Basin as required by Paragraph 3.5 of the Statement of Work provided as Appendix B of the Consent Decree (CD) (Civil Action No. 1:19-cv-12097-RGS) for the Remedial Design / Remedial Action (RD/RA) at the subject site has been uploaded to Project Portal for your review and comment.

If you have any further questions or concerns, please contact me.

Sincerely,

Bruce Thompson
Project Coordinator

Enclosure

cc: Garry Waldeck, MassDEP

Responses to Comments Received January 18, 2024 on the

30% Remedial Design Report for In-Situ Sequestration of Uranium within the Holding Basin

General Comments

1. Is there any concern that the injections will push untreated or partially treated groundwater from areas of high depleted uranium (DU) to downgradient areas of lower DU? There was some very minimal indication of this possibility in the pilot. Mitigation measures are recommended including doing downgradient locations first and monitoring new or existing downgradient monitoring wells.

   Response: The injection process will add both fluids and solids to the treatment area. To provide context for the issue raised in the comment, one must understand that the design is estimated to add a total of approximately 9,308 cubic feet (ft^3) of zero valent iron (ZVI)[1] and 58,295 ft^3 of guar slurry within the footprint of the barrier wall (estimated as the average slurry volume used per fracture for Pilot Test 2 injections, 664 gallons/fracture, times 655 fractures inside the barrier wall). In comparison, the saturated pore volume within the barrier wall, assuming a porosity of 0.25, is about 240,800 ft^3 (see calculation 3-2 in Attachment 3). By comparing these volumes, the upper limit is that amendments could displace <30% of a pore volume.

   Concern that adding <30% of a pore volume of solids and fluid during ISS will result in significant mobilization of uranium mass from the holding basin (HB) is not a large concern because:

   a) Approximately 98% of uranium mass in the HB exists in the sorbed phase on soils as opposed to in groundwater (see calculation in Attachment 3 of the revised 30% Remedial Design [RD]). Sorbed uranium will not migrate.

   b) Injections will occur from the base of the aquifer upward. This sequence will emplace treatment amendments in the less-contaminated deep overburden before amendments are injected closer to the water table where aqueous concentrations are higher.

   c) Ambient groundwater discharge from the HB is 7 to 10 gallons per minute (gpm; see section 3.5.2.4 of the 2014 Remedial Investigation [RI] report). If one assumes a worst-case that the injected guar and ZVI slurry displaces groundwater downgradient, then the ISS would push 67,600 ft^3 (i.e., the total volume of ZVI and guar slurry injected inside the barrier footprint) of groundwater westward. This potential worst-case displacement volume is equal to ambient groundwater flux through the HB over 35 to 50 days. Putting this into context, the volume of groundwater migrating out of the HB under ambient groundwater flow over the expected duration needed to implement

[1] This is based on 1,801,250 lbs of ZVI added inside the proposed containment wall (see 30%RD Drawing 6) and a ZVI bulk density of 3.1 g/cm^3 (193.5 lb/ft^3) for CERES F2 blend ZVI.

the remedial action (estimated 7 months) is more than 4 times greater than the volume of groundwater that could potentially be pushed downgradient by ISS.

Given the above facts, a large displacement of uranium downgradient is not expected from ISS. However, as an added precaution, Section 4.3 of the 95%RD has been revised to recommend injections start in the apron area and proceed eastward, if possible given logistics and sequencing with other site activities (e.g., if soil excavations are ongoing in the courtyard when the remedial action is implemented).

2. In the pilot testing, the seal around the PVC casing was allowed to set up for two months before injection. Please address if that be necessary or advisable in full-scale? The seal is referred to as "cement", "cement grout" and "cement-bentonite grout". Please provide a more detailed description of the sealing materials and set up time.

   Response: Seals for casing used during pilot testing cured for two months due to both logistical constraints and to evaluate if the cement seals for the cased holes affected groundwater pH or alkalinity (and potentially increase the solubility of uranium). Specifically, the seals around the casings cured for two months because:

   - Casings at pilot test locations were installed in January 2022 (following approval in December). It was not practicable to perform injections during the coldest winter months due to fluids handling, so injections were performed in March/April 2022.

   - The alkaline challenge during treatability testing resulted in remobilization of uranium from the columns and increases in aqueous-phase uranium in the column effluent (*In Situ Sequestration Treatability Study Report*, Geosyntec 2022). A component of pilot testing was to monitor downgradient of the casings after their installation to assess whether the grout seals affected groundwater alkalinity (results indicated they did not; see *Predesign Investigation Report for In-Situ Sequestration of Uranium in Overburden Groundwater*, Geosyntec 2023). This monitoring was a PDI activity and not necessary for the full-scale implementation.

   Seals used for HB ISS will be the same as used for the pilot test (i.e., neat cement grout) and used for monitoring well construction performed at the site, which requires only a couple days to harden. While it is anticipated that there will be at least one month between casing installation and ISS injections, injections as soon as 48 hours after casing installation are acceptable as specified in the design.

   The 95% RD has been revised to use consistent terminology of neat cement grout (grout) and now references SOP NMI-GW-003 for specificity.

3. Post treatment verification monitoring is recommended and should be provided in future design documents. Groundwater should be sampled at some point after injection and before cap placement to determine effectiveness of injections. Downgradient groundwater monitoring during and after injections should also be conducted.

> **Response:** The goals and scope of monitoring proposed in this comment were discussed with the Agencies during calls on January 30th and February 7th. The 95%RD now includes a section describing groundwater monitoring during the period between ISS and wall/cap construction. This new section, section 4.4, incorporates the purpose and scope that the team agreed was reasonable. It is noted in the 95%RD, but worth reiterating, that the interim monitoring program is not for comparing uranium concentrations to clean-up levels; rather, it is only to observe initial changes in groundwater chemistry resulting from ISS.

Specific Comments

4. Section 2.3, Page 8, Paragraph 1. The text states that the injection locations in the apron area extend over accessible locations where uranium concentrations exceed 30 µg/L. Drawing 5 shows the apron area locations to extend to the 30 µg/L contour on the north and south sides; however, the western extent of the apron area is not bounded by the 30 µg/L. Please edit the text to clarify the bound of the western extent of the apron area.

   Response: This sentence has been clarified.

5. Section 2.4, Page 8, Paragraph 2. Use of sand is discussed as a proppant. A brief specification for sand is recommended and that the sand be tested for contaminants prior to use.

   Response: This sentence (and elsewhere throughout the design) has been revised to be clearer that sand is not needed for the HB remedy although it is sometimes used as a proppant during jet injection.

6. Section 4.1, Page 12, Paragraph 3. The text states that wells remaining near ISS locations will be capped using a pressure cap prior to ISS. Please clarify if this will maintain the well integrity to be used as a monitoring well, if the cap will minimize daylighting of injection fluids, and/or if the cap has another purpose.

   Response: This sentence has been revised to state that capping wells in the injection area is done to avoid short-circuiting of amendments to the ground surface through the wells. While capping the wells can increase the potential for wells near the injection points to be maintained, it is generally assumed that monitoring well screens within the 15-ft design ROI of the injections will not be usable after injections.

7. Section 4.3, Page 13, Paragraph 5. Once the enzymatic breaker is mixed into the injection slurry how long can it sit before it begins to break down the guar gel? Please edit the text to include a timeframe (in minutes or hours) in which the mixture must be used before the slurry begins to degrade.

   Response: The reaction between enzymatic breaker and guar is not a sudden event and takes longer than the time to inject ZVI. Information provided by the vendor indicates a timeframe of 24 to 48 hours, but this is variable depending on the dose. The text has not been revised to dictate the timeframe in which mixture must be injected (but does state breaker will be added “immediately prior to injection”) because jet injection means and methods are for the contractor to determine. In this case, the contractor is a firm specializing in the mixing and use of these amendments as well as hydraulic fracturing. EPA’s concern is being addressed contractually using a performance specification that the contractor is required to meet. This specification prescribes the mass of ZVI per fracture (e.g., Drawing 6) and that the contractor is required to manage guar and breaker doses and timing in order to successfully meet these quantities.

8. Section 4.3, Page 14, Step 5. Consider adding “after verifying that the pressure between packers is sufficiently low, the packers will be deflated”. It is recommended to wait until the pressure is reduced, otherwise ZVI and sand will run up the hole and make it difficult to get a seal at the next interval.

   Response: The text has been revised to include the suggested wording.

9. Section 4.4, Page 14, Third Bullet. Please edit the text to clarify how the liquid IDW generated during ISS injections will be managed and treated (treated on-site by existing system, treated on-site by new temporary system, off-site disposal, etc.).

   Response: Text has been added to the IDW section describing handling IDW generated during ISS injections. In general, this slurry will be discharged into a tote at the ground surface. When possible, this slurry will be reinjected into a subsequent fracture. If slurry cannot be reinjected, it will be containerized and managed as IDW (i.e., characterized and transported off-site for disposal at an approved facility).

10. Section 4.4, Page 14-15. The text states that the consequences of cross contamination are minimal, and all ISS remedial action tools and equipment will be decontaminated prior to leaving the site. EPA agrees that while equipment does not require full decontamination

between non-principal threat waste (non-PTW) locations, the equipment should be fully decontaminated between PTW and non-PTW locations. In addition, all tools and equipment should be decontaminated and scanned prior to leaving the Holding Basin/ISS construction or exclusion area. No ISS tools and equipment should be used outside of the Holding Basin/ISS construction area prior to decontamination. Please edit the text to reflect the need for decontamination of tools and equipment.

Response: Section 4.6 has been added and explains how drilling equipment will be decontaminated per Standard Operating Procedure NMI-007 when transitioning from locations that may encounter PTW (i.e., the 9 locations identified with blue-filled circles on Drawing 5) and all other locations.

11.Section 4.6, Page16, Third Bullet. The text states that some ZVI can be produced as a by-product of manufacturing. Will it be clear if the material used on the NMI Site is a by-product of manufacturing or if it created from virgin sources?

Response: A decision has been made to not use a ZVI generated from a recycled or by-product source. Rather, ZVI will be a manufactured product that is intended for in-situ groundwater remediation applications. The sentence noted in this comment has been removed.

12.Section 5.4, Page 19. The text should be edited to state that "the HB VBW and cap design is also expected to include **contaminant and** hydraulic monitoring outside of the VBW to observe new groundwater flow that develops after the RA as groundwater is diverted around the VBW." The words "contaminant and" should be added in front of "hydraulic monitoring".

Response: This sentence was intended to inform the reader that there will be monitoring outside the VBW and cap once that remedy component, which follows ISS, is compete. We removed the word "hydraulic" instead of implementing the requested change. This avoids an interpretation that the ISS design speaks to monitoring for the VBW which has yet to be designed. Monitoring for the VBW will be provided in the VBW and cap design.

13.Figure 3. This figure should be edited to show the current surface elevation of the Holding Basin and note that clean fill was used to bring the Holding Basin up to the surrounding grade. Please edit the figure as necessary.

Response: The figure has been modified. Drawings are also modified to reflect the as-built ground surface elevation of the backfilled HB.

14.Drawing 2. Please add sand to the list of materials being used.

Response: The design has been revised to clarify that sand is not being used. See response to specific comment 5.

15.Drawing 5. To aid the reader, please add a filled in circle to the legend to indicate these ISS injections extend through the unsaturated zone.

Response: No change required. The label in the legend currently states that "Filled ROIs show ISS injections that extend through unsaturated zone to the base of the former Holding Basin."

16.Drawing 7. Please clarify if it is necessary to tremie cement grout in place. If it was tremied in the pilot test, then it is recommended this technique be used during the ISS. Please edit the drawing as necessary.

Response: A note has been added to the detail for case-hole construction specifying that casing installation and grouting shall follow SOP-GW-003. The SOP specifies use of a tremie pipe and has been cited, instead of just describing tremie placement, because the SOP also contains other helpful construction information for the driller.

17.Attachment 5, CQA Plan, Section 3.2, Page 11, Sixth Bullet. The text states that the ISS injection locations will be finished with 2-foot stick-ups. Following ISS injections, will these stickups be grouted and cut? Will this work be performed as part of the ISS Remedial Action so that the area is prepped for the Holding Basin wall and cap construction? Please edit the text as necessary.

Response: After ZVI injections, the drilling contractor will return to the Site to grout ISS casings and cut casings flush with the ground surface. This step of the remedial action is described in the Proposed Sequence of Work section of Drawing 2 and in Section 4.3, note 6 of the Design. Additional text was added into note 6 to clarify the cased-hole decommissioning.

18.Attachment 5A, Jet Inject Log. Please add a column "Evidence of Daylight (if Yes, approximate volume)" to the log form.

Response: The form has been revised.

Attachment 1
CREW Comments on 30% ISS in HB Remedial Design

1. We note that the properties of the glacial till are important factors in the remedial design. The February 2023 30% Remedial Design for the Holding Basin Containment Wall and Cap identified additional investigations that would be conducted to characterize the glacial till along the containment wall path and the data obtained from these investigations should be considered in the revised remedial design for ISS within the holding basin.

Response: Borings being performed around the HB for design of the cutoff wall are ongoing, and the depth to till at these locations will be reviewed by the ISS design team when the results of these borings are available.

2. The remedial design specifies that the ISS borings would be advanced to the top of glacial till and that the deepest injection interval would be approximately 4 to 5.5 feet above the bottom of the PVC well casing to accommodate the down-hole injection tooling. Advancing the ISS borings into the glacial till was not recommended because of concern that the borings would create vertical preferential pathways through the glacial till. However, based on the expected glacial till thickness identified in the profile provided in February 2023 30% Remedial Design HB Containment Wall and Cap (Figure C-403), the glacial till thickness in the containment wall path appears to range from approximately 6 feet to greater than 30 feet, which is greater than the height needed to accommodate the down-hole tooling. Therefore, extending the borings into the glacial till to accommodate the down-hole tooling would not be expected to penetrate through the till and create a vertical preferential pathway. Extending the ISS borings so that the deepest injection interval is directly above the glacial till should be considered, particularly in areas where the glacial till is thicker than the down-hole tooling.

Response: We note that this comment is contradictory to CREW's comment #4 which states "the presumed low permeability of the glacial till, is an important factor of the remedial design", so it is unclear what CREW's position is related to drilling into till versus avoiding creating potential pathways for vertical groundwater flow through the till. That said, the design does not call for intentionally extending borings into till any further than needed to identify the top of till, even if the till might be greater than 6 feet thick, for the following reasons:

- Drilling introduces a risk of creating vertical flow paths in the till, even if the boreholes do not fully penetrate through the till to bedrock. This could compromise the hydraulic competency of till that is critically important for the containment component of the remedy.
- Uranium concentrations in soil generally decrease with depth beneath the HB, (see Attachment 2 to the 30% RD), with higher concentrations, including samples representing principal threat waste, located in relatively shallow soils beneath the former bottom of the HB. Risking a breach of the till in an attempt to add one more fracture to better treat the lowest uranium concentrations has too much risk relative to the potential benefit.

3. We note that, although the remedial design specifies that the ISS borings would be advanced only to the top of glacial till, identification of the glacial till will be based on drilling resistance and observations of glacial till in the core samples. This suggests that the borings will actually need to be advanced some distance into the glacial till in order to positively identify the soil as glacial till.

Response: We acknowledge that borings must advance into till, even if only a few inches, in order to identify till, but the program is intended to minimize penetration into till to the extent feasible, because:

1) The design uses an interpolated surface of till based on prior borings in and around the HB, so the field team will go into the drilling program informed about the most likely elevation of till at each location. This information allows the team to have heightened awareness as the drilling approaches the expected top of till.
2) Casing will be installed using sonic drilling, so the field team will have continuous cores to observe when making a determination of the till interface.
3) The Geosyntec, *de maximis*, and H&A team has extensive institutional knowledge because of previously drilling to and through the till multiple times at the Site.
4) The design includes drilling to the top of till at 73 locations spaced roughly 20 feet apart. It is reasonable to think that the driller and field team will quickly become proficient at identifying top of till based on drilling resistance/soil hardness, texture, change in soil composition, etc., after the initial few borings. The field team will also have the benefit of knowing top of till at adjacent borings as the program progresses.

In instances where a boring is advanced slightly into till (e.g., several feet), it will immediately have a solid casing installed and sealed in-place using neat cement, thereby plugging whatever penetration may have occurred into till.

4. Identification of glacial till in the field will be based on drilling resistance reported by the driller and inspections of the soil cores by the field engineer. The identification appears to be somewhat subjective and there is the potential for different drillers or field engineers to have different qualitative criteria as to what conditions constitute glacial till. Because positive and consistent identification of the glacial till, and the presumed low permeability of the glacial till, is an important factor of the remedial design, additional criteria (including quantitative criteria) should be considered in identifying the glacial till.

   Response: The design is based on a robust historical and pre-design data set consisting of soil borings in and around the ISS treatment area. Collecting additional data about the top of till from each of the 73 injection locations is unlikely to enhance the design (e.g., revise the soil volume appreciably) or improve the implementation of ISS. Please see response to CREW comment #3.

5. Neat cement grout will be used to seal the ISS well casings in place and also to backfill the ISS well casings after the ISS injections are completed. Although bentonite is not specified in the

information in the remedial design about the neat cement grout, adding bentonite to the grout should be considered to reduce potential grout shrinkage during curing and also reduce the permeability of the cement grout.

Response: Neat cement grout was used for the seal on cased wells during the ISS pilot test and is specified for full-scale based on a strong recommendation from the injection contractor. Additionally, the fracturing process that will occur shortly after casings are installed will slice through the well casings and the seals every three vertical feet. The fracturing process will therefore significantly compromise the hydraulic integrity of the seal – thus, the permeability of the seals around cased wells is functionally irrelevant for ISS.

Attachment 2

2229 Main Street Oversight Committee Comments on 30% ISS in HB Remedial Design

These comments are from individual committee members and are not necessarily a consensus of the committee.

1) Introduction, Page 3: 50-97% reduction in uranium was achieved using zero valent iron. That is a significant spread in the results. Why were the reductions not more uniform between the pilot test locations.

Response: The sentence noted in this comment was included to inform the reader that ZVI has yielded substantial decreases in uranium concentration in-situ and cites the recent pilot test report for more detail. The percentages referenced in this comment include the groundwater results from monitoring wells located approximately 25 ft to 45 ft downgradient of the ZVI injection points and at different depths, soil types, and initial uranium concentrations. The commenter is referred to the pilot test report for more information.

2) Which areas of the site are expected to reach drinking water standards. Does that include the entire site excluding the holding basin or will drinking water standards gradually be attained further downgradient from the vertical barrier wall. Hypothetically if a drinking water well was installed within feet outside of the wall following remediation, what would the expected uranium concentration be.

Response: As stated in the Record of Decision (ROD), the cleanup level for uranium in groundwater at the Site is 30 µg/L everywhere except within the HB. The area within the vertical barrier wall and below the cap is a Waste Management Area and does not have a cleanup level for groundwater. It is not anticipated that uranium concentrations will meet the site cleanup level at all locations outside the Waste Management Area immediately after ISS. Rather, the remedy includes several components (e.g., a barrier wall, cap, ISS inside the HB, and downgradient ISS) and will have a monitoring program to track groundwater concentrations as they achieve the site cleanup levels over time.

Furthermore, the scenario of placing a drinking water well adjacent to the vertical barrier wall is unrealistic because the selected remedy includes application of an Activity and Use Limitations that will prohibit such a use.

3) If 90-99% of the principal threat waste will be immobilized within the holding basin, what is the fate of the other 1-10%.

   Response: Principal threat waste (PTW; i.e., soils within the HB with uranium concentrations greater than 2,310 milligrams per kilogram) is limited to a small fraction of shallow overburden soils beneath the former HB. The remedy where there is PTW, and a large area around PTW, is ISS plus hydraulic containment. The ISS injections will stabilize and sequester uranium in groundwater (i.e., reduce mobility and toxicity), the hydraulic barrier and cap will prevent mobility and exposure to uranium potentially desorbing from PTW, and the Activity and Use Limitations will prevent exposure. With these remedies, risk to uranium from all PTW will be addressed.

4) In Attachment 3.1- Calculations. The soil dry bulk density is estimated as 110 pounds per cubic foot. Doesn't the density depend on the type of soil present which in turn will affect the dosing. How was that number arrived at. According to Figure 3, there are at least three distinct grain size distributions within the proposed ISS injection area: sand and silt, f-m sand, sand and gravel, and fine to coarse sand and silt. The locations of the different strata are fairly well defined. Rather than one dry bulk density for the entire holding basin, is it appropriate to target each strata with its own bulk density.

   Response: The dry bulk density used is consistent with literature values for a medium silty sand. Moreover, the dry bulk density used in the HB design is the same as was used for designing the ISS pilot tests (which were successful), meaning that the mZVI dose prescribed for the HB remedy is the same as the mZVI dose applied for the pilot test.

5) Figure 2 – April 2023 Groundwater Elevations. The groundwater elevations appear to reflect a groundwater divide in the vicinity of MW-S18 east of the holding basin. What is the reason for this. Is it an artifact of the contouring program.

   Response: The area around MW-S18 has historically been a local groundwater elevation high point (see groundwater elevation contours in Annual Monitoring Report submittals). This area is upgradient of the HB, and uranium concentrations in groundwater are below 30 ug/L, so this is not relevant to this design.

Attachment 3

Dr. Kate Campbell, USGS, Comments on 30% ISS in Holding Basin Remedial Design

The 30%-R1 document clearly describes the scope and how the previous results lead to the current design for the phased ISS within the HB/VBW area.

1. mZVI requirements and analysis: The compositional requirements of mZVI as outlined in Attachment 6 are excellent for the needs of this application. I also support the planned periodic analysis of mZVI during the injection process. I would suggest, if there is a starting sample available, either from the contracted supplier or the pilot test materials (if the same supplier), analyzing that sample prior to the start of the injections; if there is an issue with the material, it would be best to know before the start of the work.

   Response: We agree with your recommendation. ***de maximis*** has already obtained chemical analysis of ZVI from potential ZVI suppliers (all met the specification) and intends to obtain a sample from the selected vendor for verification testing prior to shipping material to the Site.

2. Treatment footprint: The footprint has been extended to the N/NW of the new VBW boundary. This is an excellent approach and provides needed coverage in an area that has relatively high concentrations outside the boundary, while protecting the integrity of the VBW after it is installed.

   Response: The goal of expanding the perimeter of the cut-off wall was to capture more of the high-concentration groundwater, so we are pleased that you recognize and agree with the design change.

3. Timing of the VBW: By necessity, there is a delay between the ISS-HB treatment described here and the installation of the VBW and cap. How long is that planned delay?
   - HB filling and liner: With the recent addition of a liner and clean soil fill in the HB, it seems like the injection wells will need to punch through the new liner. Ultimately, it seems like this is not an issue because of the planned VBW and cap. However, before the VBW/cap installation, does the presence of a high density of injection wells pose any issue to the system? Will the drainage system for the liner continue to work during this time, or if not, is it an issue?

   Response: Time between completing ISS and capping is expected to be one to three years (depending on design progress, approvals, contractor availability, and construction duration). While borings for cased holes will penetrate the buried liner for the HB, the borings will immediately have casing installed and a neat cement grout placed in the annulus to seal the boring. This seal will also fill the hole in the liner created by sonic drilling. After injections are completed, the fractured casing will be grouted to further seal potential pathways during the interim period between ISS and capping. Additionally, the design currently has one ZVI fracture above the water table at all locations as a safeguard for potential vertical leakage.

- Monitoring wells: The existing wells in the HB area will be removed or capped, which makes sense given the injection technique being applied across the basin. Is there a plan to continue to monitor the water chemistry in the wells outside/downgradient of the injection field? If so, what is the frequency of that sampling? This seems particularly relevant after the ISS injections but before the VBW is installed.

Response: Please see new section 4.4 of the 95%RD regarding temporary groundwater monitoring shortly after completing the ISS injections inside the HB. Further, monitoring is planned for downgradient of the HB after all remedies have been implemented (i.e., the VBW, cap, downgradient ISS) since this is the aquifer where the Site cleanup criteria apply (inside the cutoff wall is a Waste Management Area where cleanup criteria do not apply). This monitoring program will be presented in the forthcoming design for ISS downgradient of the HB.

The team is attempting to preserve existing monitoring wells downgradient of the HB, although several had to be decommissioned due to other ongoing site activities and wells may have to be removed for barrier wall and cap construction. New wells, once downgradient monitoring is determined, will most likely be installed after the installation of the VBW, cap, downgradient ISS and soil excavations to avoid having monitoring wells hamper these remedial actions.

4. Although I have mentioned it previously, I want to reiterate that the injection approach and the slurry composition is very well designed. It is a clever, technically sound, and novel approach. In addition, the plan includes flexibility and contingencies for challenges that will inevitably arise during full-scale implementation in the field.

   Response: We appreciate your endorsement of the approach and design.

5. I spot checked the calculations in Attachment 3. The assumptions are realistic and the margin of safety (5x above the total estimated mass of U) seems reasonable.

   Response: Thank you for the independent verification.

Attachment 4
Optimization Recommendations for *30% Remedial Design Revision 1 for In-Situ Sequestration of Uranium in Overburden within the Holding Basin*

1. General Comment: Consider adding the option for alternative injection methods. Seal in place schedule 40 PVC then jet injection was considered successful in the pilot and is proposed for the full-scale. It is agreed that there was distribution of ZVI in the saturated soils in the pilot and agree that this method should be described in the full-scale design documents. However, AECOM suggests considering some flexibility in approach to allow other methods/bidders to propose alternatives. For example, AECOM has had recent success injecting ZVI/guar slurry under similar geological conditions by using sonic to predrill to depth, backfill with bentonite (hydrated, packed, let sit for >24 hours) and then use direct push injection tooling. This "should" alleviate the running sand issue and issues getting to target depth. It avoids the issue of having to adapt the double packer system to get at the bottom interval. For an AECOM recent project, the bentonite method allowed a more uniform injection (essentially over the entire vertical profile, instead of lenses every 3 feet). This alternative avoids buying and leaving in place 7,300 feet of PVC casing. Adding this option or allowing bidders to present other options may allow getting more bidders and possibly at lower cost. As written these specifications only allow for one firm – FRx - to bid. As with the seal in place PVC method, any alternative would have to preclude increasing the pH of the aquifer. A performance-based contract (get the ZVI into the aquifer or you don't get paid) should be considered.

   Response: We appreciate the suggested alternative approach and consideration for making the construction open to more contractors. While your suggestion is valid, FRx has site-specific experience, we vetted their approach during pilot testing (e.g., DPT didn't work so we transitioned to cased holes), and we have performance data for fractures installed by FRx. Our goal, as expressed in section 5.1, is to deliver the specified mass of ZVI with an expected distribution. At this point, we feel that is it too risky to consider contractors with alternative implementation approached that are unproven at the Site when we know that FRx can be successful.

2. Section 4.3: The idea of using a single packer and relying on the PVC end cap to hold 600 psi pressure is presented here. There may be difficulties with this approach such as having to remove all the tooling to install the second packer and then running the double packer system back down the hole. This would be further complicated if the aquifer remains pressurized and the hole fills up with ZVI and aquifer sand. We recommend adding text to give the drilling firms the ability to propose other options for getting at the last few feet of depth or consider not directly treating that final depth interval. In theory any DU left in the till material that weeps into the overlying sandy materials will encounter ZVI and be treated.

Response: The single-packer approach was developed in conjunction with FRx and they feel it is feasible. As noted, this approach is more costly and time consuming because it requires the single-packer to be removed after one injection and a double-packer lowered down the well. However, the design team felt it was worth the effort and expense to place ZVI closer to the top of till.

3. Attachment 6: The ZVI specifications are acceptable. AECOM agrees that recycled iron from uncontrolled scrap sources should be excluded. Given the anticipated tonnage (1,000 tons), cost and availability are possible issues. AECOM has had good success with zero valent iron derived specifically from excess casting material and casting sand. The product is typically less expensive and possibly "greener" than other ZVI products.

   Recommend adding "Recycled iron from a casting process would also be an acceptable source". To add another possible ZVI source beyond the two used in bench and pilot would require a bench trial with the new ZVI. Getting competitive bids then deciding if another bench test is worthwhile is suggested. The requirements for sulfur and phosphorus are doable but seem unnecessarily strict. Consider increasing these from <0.15% to <0.30%.

   Response: See response to specific comment 11. In summary, the project team is specifying ZVI that is produced from ore and/or metallurgical processes and manufactured specifically for in-situ groundwater remediation use. The ZVI specifications are stringent because ZVI is the single most important component of the project, and a potential cost savings is not worth the risk of switching to a product that may have inferior performance or deleterious side effects.

95%REMEDIAL DESIGN REPORT

IN-SITU SEQUESTRATION OF URANIUM IN OVERBURDEN WITHIN THE HOLDING BASIN

Nuclear Metals Inc. Superfund Site
Concord, Massachusetts

Prepared for

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CERTIFICATION

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I have no personal knowledge that the information submitted is other than true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

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Carl R. Elder, PhD, PE — Date

Engineer-of-Record

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LIST OF ACRONYMS AND ABBREVIATIONS

30% RD-Rev 1	30% Remedial Design Report – Revision 1
95% RD	95% Remedial Design Report
100% RD	100% Remedial Design Report
ARARs	Applicable and Relevant or Appropriate Requirements
CQA	construction quality assurance
CQA/QCP	Construction Quality Assurance/Quality Control Plan
DPT	direct push technology
ft	feet
gpm	gallons per minute
GPS	Global Positioning System
HB	Holding Basin
IDW	investigation-derived waste
ISS	in-situ sequestration
MCL	Maximum Contaminant Level
mg/kg	milligrams per kilogram
mZVI	microscale zero valent iron
NMI	Nuclear Metals, Inc.
ORP	oxidation-reduction potential
PDI	predesign investigation
psi	pounds per square inch
PVC	polyvinyl chloride
QC	Quality Control
RA	Remedial Action
RAO	Remedial Action Objective
RD	Remedial Design
RDWP	Remedial Design Work Plan
RI	Remedial Investigation
ROD	Record of Decision
ROI	radius of influence
TMW	temporary monitoring well

USEPA	United States Environmental Protection Agency
VBW	vertical barrier wall
µg/L	micrograms per liter

1. INTRODUCTION

On behalf of ***de maximis, inc.*** (*de maximis*), Geosyntec has prepared this 95% Remedial Design Report (95% RD) as an update to the revised 30% Remedial Design – Revision 1 (30% RD-Rev 1) submitted in November 2023. The report presents the design and planned implementation of in-situ sequestration (ISS) for uranium in overburden within and around the Holding Basin (HB) at the Nuclear Metals, Inc. Superfund Site (the NMI Site or Site) located in Concord, Massachusetts (EPA ID MAD062166335; **Figure 1**). This 95% RD incorporates responses to comments provided by the United States Environmental Protection Agency (USEPA) in a letter dated January 18, 2024 on the November 2023 30% RD-Rev 1. Specific responses to USEPA's draft comments are included as **Attachment 4** to this report.

This 95% RD is being presented ahead of the ISS design for overburden groundwater downgradient of the HB because ISS in the HB must be implemented before the vertical barrier wall (VBW) around the HB and the cap above the HB are installed. The remedial design (RD) for ISS of uranium in overburden groundwater downgradient of the HB will be presented in future submittals and the remedial action (RA) for groundwater downgradient of the HB will be implemented after the HB VBW and cap are constructed. This construction sequencing is necessary so that performing ISS inside the HB does not damage the VBW or cap and to coordinate the RA contractor access to the work area, since contractors cannot construct the VBW and perform ISS in the same area at the same time. A further benefit of this RA construction sequencing is that the HB ISS will cut off the source of uranium in overburden groundwater, thereby reducing the potential for uranium mobilization during wall construction. The reduction in both groundwater flow and uranium flux out of the HB will enhance the effectiveness of ISS in downgradient groundwater.

This 95% RD summarizes the results of laboratory treatability studies and a field pilot test for ISS in overburden at the NMI Site. Greater detail on treatability studies is provided in the *In-Situ Sequestration Treatability Study Report* dated April 8, 2022 (Geosyntec, 2022). More information on field pilot testing of ISS is provided in the *Predesign Investigation Report for In-Situ Sequestration of Uranium in Overburden Groundwater* dated June 29, 2023 (PDI ISS-2 Report; Geosyntec, 2023).

1.1 Purpose and Objectives

Historical releases of waste sludge to the HB resulted in uranium contamination in the overburden soils and groundwater underlying the HB. As noted in the Record of Decision (ROD; USEPA, 2015), although the average concentration of uranium in soils beneath the HB is 93 milligrams per kilogram (mg/kg), some of the soils below the HB have uranium concentrations resulting in classification as "principal threat waste". Specifically, principal threat waste is defined as source material where toxicity and mobility combine to pose a risk level of 10^{-3} or greater (USEPA, 1991), which equates to soil at the NMI Site with uranium concentrations greater than 2,310 mg/kg (USEPA, 2015). Approximately 980 soil samples were collected in the HB during the Remedial Investigation (RI), and these revealed six soil samples from three locations within the HB with uranium concentrations exceeding the threshold for principal threat waste. These soils are within the area where ISS will be implemented and within the boundaries of the VBW.

The RI also revealed uranium impacts to soil below the HB at concentrations less than the principal threat waste threshold. Much of this soil will also be subject to the HB ISS remedy and contained within the VBW as described in subsequent sections of this report. As described in Section 2.1, contamination in the HB has leached into groundwater and resulted in a uranium plume downgradient of the HB.

The remedy selected in the ROD for uranium-contaminated soils and groundwater in the HB includes ISS to stabilize and sequester uranium and a VBW and cap to contain HB soil and groundwater. Collectively, these two remedy components are expected to achieve the 90% to 99% reduction in concentration, mobility, and/or toxicity necessary for principal threat waste.

The purpose of this 95% RD is to describe the design and implementation of the ISS portion of the HB remedy; the design of the VBW and cap are provided under separate cover. Components of the full HB remedy will be installed in phases: ISS in the HB area will be completed first, and then VBW and cap will be installed.

The ROD provides eight Remedial Action Objectives (RAOs) for the Site. The following RAOs are applicable to ISS of uranium in soil and groundwater beneath and downgradient of the HB.

1. Prevent migration of uranium from soils in the HB that would result in groundwater concentrations exceeding Applicable and Relevant or Appropriate Requirements (ARARs).
2. Restore groundwater within the contaminant plumes to its beneficial use as a potential drinking water supply by meeting ARARs including federal Maximum Contaminant Levels (MCLs), or in their absence, by meeting cleanup levels protective of human health.
3. Limit migration of volatile organic compounds, semivolatile organic compounds, uranium (depleted and/or naturally occurring), polycyclic aromatic hydrocarbons, and other inorganics in groundwater within the contaminant plumes at concentrations that would exceed ARARs or risk-based standards.

As described in the *Remedial Design Work Plan* (RDWP; *de maximis,* 2020), successful implementation of the combined HB remedy (ISS plus the VBW and capping) is designed to achieve RAO 1 above. The HB remedy, when combined with other Ras at the Site (e.g., the downgradient ISS remedy) also supports achieving RAOs 2 and 3 above.

The VBW and cap is expected to achieve substantial (greater than 90%) reduction in mobility of principal threat waste due to a reduction in groundwater seepage leaving the HB (Haley & Aldrich, Inc., 2023). Containment is supplemented with ISS inside the containment wall, which is expected to reduce uranium concentrations in groundwater within the HB and mitigate potential migration of uranium on principal threat waste soils to groundwater. As explained in the PDI ISS-2 Report (Geosyntec, 2023), pilot testing of microscale zero valent iron (mZVI) has yielded reductions in uranium concentration in groundwater of 50% to 97% for a pilot mZVI application consisting of three injection locations. The HB remedy described herein is substantially larger with 57 injection locations within the VBW. Additionally, the HB RA includes the VBW and cap which will prevent influx of precipitation and ambient groundwater flow. This will render groundwater stagnant within the VBW and consequently enhance ISS treatment beyond what was seen in pilot testing by maintaining reducing conditions. Thus, successful implementation of ISS as described in this design is expected to achieve decreases in uranium concentrations similar to or greater than in the in-situ pilot test. Therefore, the combined effects of ISS, the VBW, and the cap are collectively expected to achieve RAOs for the HB.

The specific objective for ISS in the HB is to deliver the total design mass of the selected amendments into the target zones, which are defined as the saturated overburden within the VBW and unsaturated overburden at a subset of the area within the VBW where principal threat waste exists. Achieving this target is expected to constitute a successful RA. Demonstration of compliance, presented in Section 5, is aimed at assessing this target following implementation.

As noted above, an objective for the Site is to reduce uranium concentrations in groundwater downgradient of the HB to below the 30 micrograms per liter (μg/L) MCL. This objective applies outside of the VBW, since the VBW defines the border of a Waste Management Area. The objective of achieving uranium concentrations below 30 μg/L in groundwater outside the VBW will partially be achieved by the HB remedy since the HB RA will cut off the ongoing source of uranium to downgradient groundwater and reduce uranium concentrations in the source. The objective of reaching MCLs in the downgradient plume will be achieved by implementing ISS in overburden groundwater in the uranium plume downgradient of the HB. As described above, the RD for ISS downgradient of the HB will be presented in a later design submittal.

2. BASIS OF DESIGN

This section describes the basis of design for ISS of uranium in overburden soil and groundwater within the bounds of the former HB. The ISS design follows in Section 3, and the design drawings are presented in **Attachment 1**.

2.1 Site Hydrogeology and Conceptual Site Model for Depleted Uranium

Site geology consists broadly of three geologic units—surficial stratified drift, glacial till, and bedrock. The stratified drift unit, which is the unit targeted by ISS, consists generally of sand and silty sand with some gravel. A Site layout of the HB is shown in **Figure 2** and a cross section through the HB and the uranium plume in overburden groundwater along the approximate direction of groundwater flow is presented in **Figure 3**.

The HB is a constructed depression in the southeastern portion of the NMI Site that was used for disposal of waste sludge, including neutralized nitric acid containing dissolved copper and depleted uranium from industrial processes (*de maximis,* 2020). Discharge of the waste sludge to the HB resulted in elevated concentrations of uranium in overburden soil and groundwater beneath the HB. Results of predesign investigations (PDIs) at the NMI Site indicate the highest concentrations of uranium in soil at the Site are within the HB with an average concentration of 93 mg/kg, and a maximum concentration of approximately 12,000 mg/kg (*de maximis,* 2020). Uranium has migrated in the overburden aquifer to the northwest in the direction of groundwater flow.

Near the HB, uranium impacts in groundwater extend from the water table in stratified drift into the glacial till. The area of highest uranium concentrations in overburden groundwater is interpreted to extend from beneath the HB near former monitoring well HB-13 (3,086 µg/L in April 2021) to near MW-S24 (3,076 µg/L in April 2021 before the start of the ISS pilot test; **Figures 2 and 3)**. Uranium impacts also exist in bedrock groundwater; however, uranium in bedrock groundwater is predominantly natural uranium that was released from rock when the geochemistry of bedrock groundwater changed caused by historical releases at the Site. In contrast, uranium in overburden is depleted uranium resulting from releases into the HB. This design is specific to uranium in overburden.

Further downgradient, the uranium plume in overburden groundwater is generally confined to the shallower groundwater zones in the stratified drift (**Figure 3**). Also, the rate of migration of uranium in overburden groundwater is relatively slow due to natural sorption and/or sequestration of uranium by the soil matrix. The strong retardation of uranium transport in overburden groundwater is exhibited by the fact that uranium concentrations greater than 30 µg/L have only migrated approximately 400 feet (ft) from the downgradient edge of the HB, which is a short distance considering that (a) the release began more than 50 years ago and (b) groundwater velocities are estimated at 274 ft per year in this area (Geosyntec, 2022b). Further discussion of sorption and retardation of uranium in the overburden plume can be found in the RI Report (*de maximis*, 2014).

As described in the RDWP, a VBW will be installed around the HB and a cap will be installed above the VBW to limit migration of groundwater through the HB and infiltration into HB soils. Stagnant groundwater with a reducing geochemistry is expected to develop in saturated overburden below the HB after installation of the VBW and cap due to a combination of microbial and abiotic processes, hydraulic isolation from aerobic upgradient groundwater, and lack of infiltration of precipitation. Correspondingly, the mobility of uranium in groundwater is expected to decrease following containment of the HB as uranium (VI), which is more soluble and exists under aerobic conditions, is transformed to less soluble uranium (IV) under reducing conditions. This reduction reaction and corresponding change in solubility is expected to cause uranium precipitation. Amendments injected into the HB will also stabilize uranium via sorption and co-precipitation (i.e., ISS reactions), and will also promote and maintain anaerobic conditions that stabilize uranium through reduction. Further, ISS amendments will provide long-term protection against potential mobilization of uranium in the unlikely situation where oxidizing groundwater leaks through the cap or VBW.

2.2 ISS Amendment and Dose Selection

mZVI was selected as the amendment for ISS of uranium in the HB at a dose of 1.5% by weight based on the effectiveness of mZVI to sequester uranium as observed in laboratory treatability studies, positive results from a field pilot test using mZVI, and the benefits of creating and maintaining reducing conditions within the contained HB. **Attachment 6** provide the minimum requirements for mZVI to be injected. Amendments must be approved by the Engineer prior to injection, although mZVI specifications allow using either the mZVI that was tested in the treatability studies or the mZVI that was injected in the field pilot test.

Potential ISS amendments for groundwater beneath the HB, consisting of Apatite II[1] and mZVI, were evaluated in a treatability study (TS ISS-1). This treatability study included column tests in which Site groundwater with background uranium concentrations was pumped through soils with elevated uranium concentrations collected from the HB to simulate groundwater flow through the HB. Both amendments were able to achieve column effluent uranium concentrations less than 30 μg/L. A second treatability study, TS ISS-2, also examined the use of Apatite II and mZVI for sequestration using lower concentration soils but influent groundwater with nearly 1,800 μg/L of uranium. TS ISS-2 also showed that both amendments were effective and able to maintain uranium concentrations less than 30 μg/L in column effluent for more than 100 pore volumes. The results of TS ISS-1 and TS ISS-2 were summarized in the *In-Situ Sequestration Treatability Study Report* (Geosyntec, 2022).

The treatability study report recommended that Apatite II be used for ISS of uranium in HB soils at a concentration of 1.5% by weight. This recommendation was based on the Apatite II column test achieving the lowest uranium concentration in the column effluent over the duration of the

[1] Apatite II is the tradename of a meta-stable fishbone-derived hydroxyapatite product produced by PIMS NW, Inc. (http://pimsnw.com).

test. TS-ISS-1 results also showed that amending soils with mZVI at a dose of 1.0% by weight reduced the uranium concentration in the column effluent by an order of magnitude and to below the MCL. In addition, the mZVI-amended column leached the least total mass of uranium over the entire length of the column test compared to the Apatite II-amended column and the unamended control column.

Analyses performed during the treatability study showed that mZVI sequesters uranium primarily through coprecipitation of uranium with, and adsorption of uranium to, mZVI corrosion products (i.e., iron oxyhydroxide minerals). These coprecipitation reactions yield stable sequestration of uranium, which is more stable than the formation of low-solubility uranium (IV) solids caused by reducing geochemical conditions alone. Thus, mZVI has the benefits of stabilizing uranium via co-precipitation reactions as well as by creating long-term reducing and anaerobic conditions which will reduce uranium to the less-soluble uranium (IV) form. Combined, these mechanisms are expected to provide robust and long-term stabilization of uranium (Geosyntec, 2022).

Field pilot tests were performed after the treatability study to evaluate injection methods for ISS amendments and in-situ performance of Apatite II and mZVI. During pilot testing, these two amendments were injected into separate areas of the uranium plume in saturated overburden at doses of 1.0% by weight and 1.5% by weight, respectively. As summarized in Section 4.3 of the PDI ISS-2 Report (Geosyntec, 2023), post-injection groundwater results indicate mZVI reduced uranium concentrations in overburden groundwater by 50% (in the lowest concentration area) to more than 90% and yielded consistent results across the full thickness of the aquifer where high dissolved iron concentration were observed. This is better performance than observed for Apatite II. The field performance of mZVI combined with its effectiveness in treatability testing favor the use of mZVI for HB ISS.

As an additional step to verify the design dose of 1.5% mZVI, a calculation was performed to determine the quantity of mZVI required to sequester all uranium mass in groundwater within the saturated treatment volume plus uranium sorbed to principal threat waste soils in the unsaturated zone (**Attachment 3**). The calculation demonstrates that the 1.5% mZVI dose provides more than 5 times the quantity of mZVI required to sequester this aqueous and sorbed uranium mass. Thus, the selected 1.5% dose provides a surplus of sequestration capability and incorporates significant conservatism into the design.

In summary, although treatability study results initially favored use of Apatite II for ISS below the HB, mZVI has been selected instead of Apatite II for the following reasons:

- mZVI has shown better in-situ performance than Apatite II.
- Treatability testing showed that mZVI can reduce uranium concentrations to less than 30 µg/L.
- mZVI has secondary benefits, including better treatment of arsenic in groundwater, ability to reduce uranium (VI) to lower solubility uranium (IV), and less sensitivity

than Apatite II to carbonate and/or calcium impacts that may cause uranium leaching (as shown in the carbonate challenge performed in TS ISS-2).

2.3 Identification of Treatment Zone

As described in Section 1.1, a purpose of the HB remedy, including ISS and the VBW, is to reduce mobility, toxicity and/or concentrations of principal threat waste below the HB by at least 90% and, in combination with the RA for overburden groundwater outside the HB, reduce the concentration of uranium in groundwater downgradient of the HB to below the MCL of 30 µg/L. Therefore, the selected target treatment zone for ISS in the HB is defined:

- laterally by the outline of the VBW around the HB (**Drawing 3**),
- vertically from the top of saturated overburden (i.e., the groundwater table) to above the top of glacial till (**Figure 3**), and
- at locations where principal threat waste exists, vertically from the bottom of the existing HB liner to above the top of glacial till (**Figure 3**).

The vast majority of higher uranium concentrations in soil, including soil that meets the criteria for principal threat waste, is located in the shallow portions of stratified drift within the HB, and uranium concentrations in soil generally decrease with depth below the HB. Historical sampling included collecting approximately 1,000 soil samples in and around the HB to delineate uranium concentrations. These data were presented in horizontal cross sections and isoconcentration maps at several elevations in the RI Report (*de maximis*, 2014); selected figures from the RI Report are included in **Attachment 2** as a reference to past work to assess the uranium distribution in HB soils. These data show that soil with uranium concentrations exceeding 2,310 mg/kg, which constitute principal threat waste, exist at three locations, predominantly in the unsaturated zone and shallow saturated overburden.

Treatment of the till beneath the HB with ISS is not planned as part of the RA for the HB. While there is uranium in groundwater in the till (**Figure 3**), the till has lower concentrations of uranium and a significantly lower hydraulic conductivity (and consequently lower groundwater flux) compared to the stratified drift, so groundwater flow in the till contributes minimal uranium mass to the downgradient plume (*de maximis,* 2020). Moreover, the low permeability of the till is an integral component of the physical containment remedy because the VBW will rely on the till to resist groundwater flow into and out of the HB from the bedrock. Therefore, implementing ISS in till is not advised because it will emplace permeable fractures (i.e., hydraulic pathways) throughout the till and potentially compromise the integrity of the containment system.

As discussed above, the treatment footprint for this RD includes the area within the VBW. In addition to this footprint, an apron of ISS treatment is included that extends approximately 45 ft to the northwest of the VBW and approximately 30 ft to the north of the VBW (**Drawing 5**). This apron of ISS injection points outside of the expected extent of the VBW is included so that ISS for the downgradient plume, which will be presented in a separate RD report and will occur after the

VBW has been constructed, will not require injections close to the VBW where they might damage the VBW and cap. As described in Section 2.4, the approach that will be used to emplace mZVI involves fracturing the soil matrix to create lenses filled with amendment. As shown in **Drawing 5**, ISS points in this apron area are located on the downgradient and north sides of the HB and extend from north to south over accessible areas within the width of the groundwater plume within approximately 45 ft of the VBW where uranium concentrations in overburden groundwater exceed 30 µg/L.

2.4 Injection Methods

ISS via jet injection was selected in the ROD as the remedy for addressing uranium in overburden groundwater because amendments selected for sequestration are granular solids and therefore cannot be pumped through soil pore spaces. Additionally, jet injection is preferable to alternatives such as soil mixing because of the depth to groundwater at the HB area (~50 ft below ground surface after enabling earthwork activities) and the health and safety risks associated with exposure to HB soils.

Jet injection methods combine high-pressure water jetting and hydraulic fracturing using specialized dual-fluid injection tooling to create horizontal fractures filled with amendments. Further details of the injection process are provided in Section 4. In addition to mZVI, the amendment slurry sometimes includes sand as a proppant to increase the permeability of the lenses and/or add volume to the slurry injected. However, because of the mZVI quantity specified for each fracture and the specified grain size for the mZVI, sand is not necessary for the HB remedy. Groundwater flowing through these lenses contacts the reagent. In addition to chemical reactions occurring within the reagent lenses, mZVI dissolves into groundwater (e.g., Fe^{+2}) between fractures where it can react with contaminants. Jet injection has been successfully used to inject mZVI at the Site during pilot testing and can achieve distribution of mZVI into a relatively large area of influence from the injection point (see Section 2.5).

As described in the PDI ISS-2 Report (Geosyntec, 2023), direct push technology (DPT) jet injection methods faced challenges from flowing sand at the Site during pilot testing, especially at deeper depths. Because of these challenges, pilot testing switched from a DPT jet injection approach to a cased-hole jet injection approach. Both approaches use a similar method of high-pressure water jetting followed by slurry injection to create amendment-filled fractures in the subsurface. The methods principally differ in that the DPT approach pushes the injection tool to the target depth whereas the cased-hole approach lowers the tooling within a pre-installed polyvinyl chloride (PVC) casing. As a result, the cased-hole approach is less susceptible to flowing sands because the casing provides support that protects the injection tooling.

The cased-hole jet injection method was successfully used at the Site to inject granular solid amendments, including mZVI and Apatite II, during ISS-2 pilot testing. The cased-hole method partially mitigated the challenges associated with running sands noted above and was able to distribute mZVI in fractures at the design dose throughout the saturated zone. Its success during pilot testing confirmed the cased-hole approach as the planned method for full-scale ISS at the Site.

2.5 Radius of Influence and Fracture Spacing

The design will rely on a radius of influence (ROI) of fifteen (15) ft. The feasibility of achieving a 15-foot ROI was verified during ISS pilot testing by performing a series of borings after amendments were emplaced. Amendment distribution to a ROI of up to 15 ft was confirmed through observation of amendments in soils recovered from these borings (Geosyntec, 2023). The geochemical effects of mZVI, such as elevated dissolved iron in groundwater and lower oxidation-reduction potential (ORP), were seen in monitoring wells beyond 15 ft during pilot testing.

A vertical fracture spacing of 3 ft is used for design of ISS in the HB. This is the minimum (i.e., closest) fracture spacing that can be consistently achieved and was the spacing used for the ISS pilot test. This design criterion is feasible for full-scale ISS at the Site because fractures were successfully created at 3-ft spacing between the water table and top of till during the pilot test. Similar to the pilot test, the full-scale design uses the approach of staggering the depth of fractures at adjacent points by 1.5 vertical ft, to the extent possible, such that fractures are offset where the ROIs overlap (see **Figure 4**).

2.6 Enabling Work

As mentioned above, the HB was a depression used for past disposal practices at the Site. The topography created for the HB's prior use was incompatible with the construction required to implement ISS and construct a VBW and cap. Therefore, in 2023, the HB was filled as one of several enabling activities performed at the Site. When the HB was filled, the liner and stormwater drainage were maintained. The liner was buried under compacted soil placed in the HB, and the drainage system for the liner was maintained to prevent ponding of percolating rainwater on the liner. Retaining the liner continues to prevent the percolation of rainwater through soil and into groundwater under the HB while construction of the VBW and cap is in progress.

Filling the HB consisted of placing and compacting lifts of clean soil to fill the HB to the approximate height of surrounding berms. This created a working surface that is accessible to the heavy equipment required to implement the ISS and VBW/cap Ras. Since soil used to backfill the HB was clean and placed above the liner and water table, ISS will only be performed below the liner and former bottom of the HB.

Another component of enabling work was to abandon many existing wells in the HB area to prepare the area for the forthcoming Ras. Drawings provided with this design show the pre-enabling topography as well as the current grades created by filling the HB.

3. AMENDMENT INJECTION DESIGN

This section describes the design for the ISS of uranium in the HB area via cased-hole jet injection to deliver mZVI into the saturated overburden and unsaturated zone where principal treat waste exists.

3.1 Injection Point Layout

The design treatment area for ISS in the HB includes areas within the perimeter of the proposed VBW and an apron outside and downgradient of the HB as described in Section 2.3. To treat this area, approximately 73 injection points will be advanced at the approximate locations shown on **Drawing 5**. This includes 57 locations within the VBW alignment and 16 locations in apron areas.

Injection locations are spaced assuming a 15-foot ROI (Section 2.5) as shown on **Drawing 5**. This number of injection points was selected to achieve the target dose of mZVI (i.e., 1.5% by weight) throughout the treatment area based on the amount of mZVI that can be injected per fracture and number of fractures achievable per location. The locations shown on **Drawing 5** represent, on average, a 25% overlap of the area of influence for adjacent locations. In some instances, injection locations were adjusted to account for drill rig access, especially in the northwest corner of the treatment area where stormwater drainage features have steeper slopes. Additionally, injection points were not included upgradient of the HB, which is south and east of the proposed VBW, where uranium concentrations in groundwater are less than 30 µg/L.

3.2 Injection Depth Intervals

At each injection location, a boring will be advanced to the top of till and solid schedule 40 PVC casing will be grouted into place as described in Section 4.3. Discrete injections of the mZVI slurry will then be conducted at specified depth intervals to create fractures every three vertical ft (Section 2.5) starting at the bottom of the cased hole and going up to the water table. At each location, at least one additional fracture will be emplaced above the water table as a safeguard.

The elevation of discrete injection intervals at adjacent injection locations have been offset, to the extent possible, by approximately 1.5 ft to promote more even vertical distribution of amendments (see **Figure 4**). The estimated number of injection intervals and mass of mZVI that will be injected at each interval at each injection point is presented in the table on **Drawing 6**. The injection locations and mass of mZVI prescribed for each injection interval will achieve the target dose of 1.5% mZVI to soil by dry weight throughout the target treatment volume. A calculation of the mass of mZVI per injection is presented in **Attachment 3**.

As mentioned previously, principal threat waste was found during the RI at three boring locations in the HB. These locations are shown in **Drawing 5**. At locations near soil samples representing principal threat waste, injections will continue up through the unsaturated zone to the base of the liner in the HB (i.e., to the base of the HB prior to its backfill with clean fill during enabling work) to address principal threat waste in the unsaturated zone. This includes five ISS injection points where a historical principal threat waste sample is located within the 15-ft ROI (IP-31, IP-24, IP-

21, IP-15, and IP-14). As a conservative measure, four additional injection points (IP-20, IP-29, IP-30, and IP-22) will also have ISS performed through the full thickness of the unsaturated zone. These four locations are near where principal threat waste was found during the RI and were not identified as having uranium concentrations below the principal threat waste level, so ISS will be implemented at these locations as if they intercept principal threat waste.

The deepest injection interval at each location, provided in **Drawing 6**, will be approximately 4 ft or 5.5 ft above the bottom of the PVC casing to accommodate the dimensions of the down-hole injection tooling (Section 4.3). While this results in the deepest injection being slightly above the top of till, drilling deeper into the till to accommodate the length of ISS tooling is not recommended due to the potential to create vertical preferential pathways through the till. Furthermore, as described in Section 2.3 and shown in **Attachment 2**, higher concentrations of uranium in soil and groundwater, including concentrations constituting principal threat waste, are typically located in shallow saturated overburden and unsaturated overburden beneath the HB, not deep overburden.

During the RA, slight adjustments may also be made to fracture elevations at each location if the top of till is encountered at different depths than anticipated during installation of cased holes. Adjustments in the field may shift the elevations where mZVI is injected, but they will not decrease the mass of amendment added during the RA or the overall mZVI dosing.

4. PROCESS DESCRIPTION AND SEQUENCE OF WORK

This section describes how the RA is expected to be performed and is based on experience injecting mZVI at the Site during the ISS pilot testing as well as experience with application of similar remedies at other sites.

4.1 Site Preparation

Slopes of the HB were too steep to allow implementation of the RA, so the HB was filled in 2023 to create a platform for ISS equipment (i.e., drill rigs to install the cased-holes and mixing/injection equipment for jet injection) as well as subsequent construction for the VBW (see Section 2.6). The interim ground surface elevation of the backfilled HB is shown on **Drawing 4**. A detailed design for constructing the interim grades in the HB was submitted to USEPA in a separate Enabling Design.

Injection locations will be identified by the field engineer or geologist using a handheld Global Positioning System (GPS) unit or by a surveyor; these locations will be marked using a wooden stake or pin flag. For locations where a stake cannot be driven, such as on concrete, spray paint will be used to mark the injection location. Prior to cased hole installation, the drilling subcontractor will inspect the injection locations to assess drill rig access and equipment layout.

Selected monitoring wells located within and around the HB have been decommissioned as part of enabling work. This mitigates the likelihood of short-circuiting of amendments or damage to wells. Any wells remaining near ISS locations after enabling activities will either be capped with a pressure cap or decommissioned prior to ISS injections to avoid short-circuiting of amendments to the ground surface through these wells.

4.2 Cased Hole Installation

At each ISS injection location, rotosonic drilling methods will be used to core an 8-inch diameter borehole to the top of till (**Drawings 5 and 6**).[2] The top of till will be identified by resistance to drilling reported by the driller and inspection of cores by the construction quality assurance (CQA) Engineer. Till will be visually identified by a siltier, harder, and more cohesive soil compared to the overlying stratified drift as observed in prior drilling. Drilling will go deeper or terminate shallower than the estimated top of till elevations in **Drawing 6** if the top of till is encountered at a different depth than anticipated. Soil cores will be collected in 5-ft runs starting approximately 10 ft above the estimated top of till to avoid drilling into till.

Once the borehole is advanced to the top of till, a 4-inch diameter schedule 40 PVC casing, capped on the bottom, will lowered into the borehole and sealed in place using neat cement grout (used

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[2] Following the installation of cased holes, the depth to till at all locations will be known and the fracture elevations presented in Drawing 6 may be revised.

interchangeably with grout, see SOP NMI-GW-003) as shown on **Drawing 7**. The grout will be allowed to cure for a minimum of 48 hours before conducting injections at that location.

4.3 Jet Injection

The cased-hole jet injection process relies upon three categories of equipment: (1) the down-hole injection tooling; (2) the high-pressure water injection system; and (3) the amendment mixing and injection system. A process flow diagram illustrating the equipment used for cased-hole jet injection is presented in **Figure 5**.

- The down-hole injection tooling consists of high-pressure water jets and a slurry injection line, which are mounted on a straddle packer assembly. A hoist or truck-mounted mobile crane is required to lower the injection tooling into the cased hole.
- The high-pressure water injection system is used to deliver water to the injection tooling line for high-pressure jetting, which cuts through the PVC casing and grout seal and creates a kerf in the surrounding soil. The high-pressure water pump will be capable of producing a flow rate of 10 to 40 gallons per minute (gpm) at a minimum pressure of 10,000 pounds per square inch (psi).
- The amendment mixing and injection system includes equipment to stage and meter the granular solid and liquid components of the slurry, an auger mixer to prepare the slurry for injection, and a slurry injection pump to inject the highly viscous amendment slurry. The slurry injection pump will be a progressing cavity positive displacement pump (or similar) capable of injecting at a minimum flow rate of 8 gpm at 600 psi. The slurry injection line will be equipped with a pressure gauge to monitor the pressure during slurry injection and a data logging pressure transducer to record the slurry injection pressure.

Prior to injection, hydrated guar gum will be prepared by mixing guar gum and water. mZVI will then be mixed with the hydrated guar gum, which will be crosslinked using borax. The addition of the borax will form guar gel, a viscous slurry capable of suspending the solid reagents thereby promoting delivery and limiting aggregation of solids during injection. An enzymatic breaker (e.g., Rantec LEB-H™ or similar) will also be added to the slurry at a concentration based on the manufacturer's instructions immediately prior to injection. The enzymatic breaker will decompose the guar gel after the slurry is emplaced to increase the permeability of the mZVI-filled fractures. Water used for injections will be sourced from the potable water supply on Site.

The following steps outline the cased-hole injection process for delivery of the amendment formulation to the subsurface to create a mZVI-filled fracture.

1. The down-hole injection tooling and straddle packer assembly[3] will be lowered to the deepest injection depth at an ISS injection location; injections will be performed using a bottom-up approach (i.e., starting above the top of till and progressing upward).
2. A viscous slurry composed of water, guar gel, enzymatic breaker, and mZVI will be mixed just prior to the start of injection at each depth interval. The injection contractor will adjust the quantity of guar gel and the dosing of the crosslinker.
3. A high-pressure water jet (up to 10,000 psi) on the injection tool will be used to cut a horizontal disc shape through the PVC casing and grout, and into the surrounding formation. During this step, cuttings and water (often approximately 20 gallons) may be generated in backflow from the injection tooling. Backflow will be collected in an open-top tank using a diversion tee on the slurry injection line.
4. The straddle packers will be inflated to create a seal against the inside of the PVC casing and focus the injection stresses from the injection tooling. Next, the slurry containing the design quantity of mZVI will be injected under sufficient pressures (approximately 150 to 600 psi) to create amendment-filled horizontal fractures.
5. After the target volume of slurry has been injected and the pressure between packers is sufficiently low, the packers will be deflated, and the injection tooling will be hoisted upward to the next injection interval. Steps 3 and 4 are then repeated at the next fracture depth.
6. After all injections at a location are complete and the injection tooling is removed, the PVC casing will be cut to or slightly below the ground surface and backfilled with neat cement grout in accordance with the established well decommissioning procedures (i.e., SOP-GW-003) to limit potential vertical migration of groundwater within the casing. Based on contractor availability and ongoing activities, the PVC casings of completed injection locations may be backfilled immediately after injections at a single location are completed or in a batch (or batches) as injections at several locations are completed.

During the jet injection process, the ground surface and nearby PVC casings will be monitored visually for breakthrough of the injection slurry. If breakthrough occurs, then injection at the current depth interval will immediately cease, and any remaining quantity of slurry targeted for that interval will be added at the next injection interval at that location or at a nearby injection location and similar depth.

Injections are not expected to push a significant amount of untreated or partially treated groundwater from areas of higher uranium concentrations to downgradient areas of lower uranium

[3] Straddle packer assemblies are approximately 7 ft in length. To reach the deepest injection interval that is 4 to 5.5 ft from the base of the cased hole, the lower packer will be removed from the assembly and the cap on the bottom of the cased hole will serve as a lower barrier to flow. After injecting in the deepest interval, the lower packer will be reconnected and the two-packer assembly will be used to perform all subsequent/higher injections at the location.

concentrations. However, as an added precaution, it is recommended that jet injections begin in the apron area and proceed eastward if possible given logistics and sequencing with other Site activities (e.g., if soil excavations are ongoing in the courtyard when the remedial action is implemented). This approach is recommended so that if untreated or partially treated groundwater is pushed downgradient, it is likely to flow through a treated interval.

4.4 Interim Groundwater Monitoring

After the ISS injections are completed, four temporary monitoring wells (TMWs) will be installed within the footprint of the ISS injections to assess changes in groundwater conditions following delivery of mZVI. While a groundwater cleanup level does not apply inside the VBW, and ISS is only a portion of the remedy, this monitoring will allow a qualitative assessment of groundwater changes inside the HB after ISS and before installation of the VBW and cap. The proposed TMWs are positioned at the approximate locations of historical Site monitoring wells that have been or are planned to be decommissioned prior to commencing ISS injections. Screening TMWs where prior monitoring was performed allows historical data to define baseline concentrations for comparison with post-ISS groundwater conditions measured from the TMWs.

Two shallow overburden TMWs are proposed inside the HB (TMW-HB-13 and TMW-HB-PZ2R) screened at the same location and vertical interval as past monitoring wells HB-13 and HB-PZ2R. One shallow and one deep overburden TMW are proposed in the apron area (TMW-S24 and TMW-SD24) and will be built to coincide with the screened intervals for monitoring wells MW-S24 and MW-SD24. These locations are shown in Drawing 5 (**Attachment 1**). Each TMW will be constructed according to the details provided in **Attachment 1** and according to the SOP NMI-GW-003. Following installation, the TMWs will be developed in accordance with the SOP NMI-GW-002.

During installation of the TMWs, soil within the screened intervals of the wells will be inspected for mZVI. A qualitative screening for mZVI will be performed by collecting and homogenizing soil (e.g., mixing in a bucket) from each 1-ft section of drill core across the screened interval of the TMW. A sample of the homogenized soil from each 1-ft section will then be collected and placed into a jar containing enough water to make a dilute slurry with a magnet taped at the bottom. I jar will be sealed with a lid and contents of the jar shaken to suspend particles. The content of the jar will be poured into another container, and the magnet will be visually inspected for evidence of capturing mZVI. The field test is intended to be informational about possible fracture locations near TMWs, and results will be binary regarding the presence/absence of an observable quantity of mZVI within the 1-foot interval. Results from this test will be noted on the boring log for the TMW.

Each TMW will be sampled on a quarterly basis according to the sample plan provided in **Table 1** using the low-flow procedures described in the SOP NMI-GW-010. Field geochemical parameters (i.e., temperature, pH, specific conductance, dissolved oxygen, and ORP) will be recorded while purging and sampling each TMW to evaluate geochemical indicators of mZVI (i.e., low dissolved oxygen and ORP indicate reducing conditions). Groundwater samples will be provided to the analytical laboratory for analysis of total and dissolved iron and uranium. Sample results will be compared against baseline conditions (i.e., recent geochemistry and concentrations at HB-13, HBPZ-2R, MW-S24 and MW-SD24) prior to their decommissioning.

Prior to the installation of the VBW and cap around the HB, these TMWs will be decommissioned using procedures described in SOP NMI-GW-004 to provide access to the work areas; this will conclude the interim groundwater monitoring. Additional monitoring downgradient of the HB will be addressed in a future remedial design for ISS in overburden groundwater outside of the HB.

4.5 Investigation Derived Waste Management

The following investigation-derived waste (IDW) is expected to be generated during ISS implementation.

- Soil cuttings and water generated during installation of the PVC casings
- Soil cuttings and water generated during the jetting phase of jet injection
- Water generated while decontaminating drilling, injection, and groundwater sampling equipment
- Used PPE and other waste potentially in contact with subsurface soils.

IDW generated during casing installation will be containerized[4] by the driller. The Site Radiation Safety Officers, DDES, will be integral to the execution of work in the HB, including performing a radiation scan of IDW. Containers of IDW will be moved to a staging area by the driller or *de maximis*. IDW will be further characterized by *de maximis* in coordination with DDES and will be transported off-site for disposal at an approved facility. IDW handling, classification, packaging, shipping, and disposal will follow established waste protocols (e.g., SOP HP-NMI-19 and HP-NMI-23).

IDW generated during the jet injection process may include soil cuttings generated during the high-pressure jetting step. In some cases, these cuttings are washed up the PVC casing to the ground surface as a slurry with returns of the water used for jetting. IDW may also include slurry that returns up jet injection tooling when pressure is relieved. This slurry will be re-injected into the subsurface at the same location, if possible. Residual slurry not re-injected will be containerized in drums or totes near the injection location. These containers and their contents will subsequently be managed similarly to IDW generated during casing installation (i.e., characterized and handled by *de maximis* and DDES prior to off-site disposal).

4.6 Equipment Decontamination

RA implementation will be divided into two subareas as:

[4] Soils may be deposited into roll-off (as was done in prior work) or drums based on the discretion of *de maximis*.

- One subarea consisting of drilling that may intercept principal threat waste (i.e., blue-filled circles on Drawing 5, specifically locations IP-14, 15, 20, 21, 22, 24, 29, 30, and 31)
- All ISS injection location not listed above.

Drilling and injection equipment that contacts the subsurface will be decontaminated and scanned for radiation when moving between the two subareas per SOP NMI-007. Within each subarea, clods of soil will be removed from drilling and injections equipment between locations and disposed of as IDW, but equipment will not be decontaminated. Full decontamination between ISS injection locations within a subarea is not necessary because the consequences of potential cross contamination are minimal since the full soil volume will subsequently be treated by ISS. Also, the majority of drilling/injection locations are within the volume that will be contained within the VBW and cap. Full decontamination in accordance with SOP NMI-007 will occur prior to equipment leaving the Site. In addition, tools and equipment will also be screened by the Site Radiation Safety Officer prior to leaving the exclusion zone and Site.

4.7 Construction Quality Assurance

A construction quality assurance program will be implemented to verify that the proper amendments are used for the RA, and confirm target amendments and doses are delivered at the depths and locations specified in this design. A Construction Quality Assurance/Quality Control Plan (CQA/QCP) which describes the construction quality assurance and quality control (QC) program for the RA is included as **Attachment 5**. This plan outlines roles and responsibilities of various parties involved in implementing the RA; evaluation, testing and documentation that will be performed (including sample field forms); and lines of communication and approval for deviations from the RD or if problems are encountered.

4.8 Greener Cleanup

The RA described herein will be implemented in a manner that minimizes environmental footprint of the cleanup activities in accordance with the USEPA Principles for Greener Cleanups (USEPA, 2009) as required by Section 3.5 of the 2018 Statement of Work (USEPA, 2018).

ISS intrinsically has a smaller environmental footprint compared to alternative remedies. The following outline the environmental benefits from using ISS.

- Land Management and Ecosystem Protection – work activities have been designed to remain outside of mapped wetlands. ISS also requires a smaller work footprint than other methods, has minimal disturbance to land and creates minimal to no dust.

- Material Management and Waste Reduction – ISS adds amendments directly into the subsurface thereby reducing waste since soils do not need to be extracted and then replaced (except for the borings for cased-holes). Additionally, ISS is a passive remedy that does not require ongoing operations and maintenance, which tends to require replacement of expendable parts (e.g., filters) and media (e.g., granular activated carbon) or disposal of the treatment system at the end of its usable life.

- Minimization of energy and water usage – ISS adds amendments directly into the subsurface instead of excavating, treating the soils or groundwater ex-situ and then replacing it. Because of this, ISS has lower overall energy requirements than many other technologies. Additionally, ISS is a passive remedy, therefore, it has no energy or water usage after completion of the RA.
- Minimization of Air Pollutants and Greenhouse Gas Emissions – to the extent possible, local labor will be used to reduce emissions associated with transportation. As noted above, ISS is a passive technology so there is no long-term operation of equipment (e.g., pumps, blowers, etc.) that create emissions or power needs which indirectly create emissions from a power plant. The reactions occurring during ISS will also occur in-situ and therefore create no air discharge.

5. DEMONSTRATION OF COMPLIANCE

5.1 Demonstration of Compliance

The goal of the ISS RA, as summarized from Section 1.1, is to:

- Deliver the total design mass of the selected amendment, mZVI, into the treatment volume at the design locations and depths to achieve the design amendment dosing.

Successful implementation of the RA in accordance with the design will be verified by implementing a CQA/QC program during the RA. The scope of this program is introduced in Sections 4.7 and 5.2, and a detailed CQA/QCP is provided in **Attachment 5**. Among other things, this program will demonstrate successful implementation of the RA by documenting the appropriate type and total mass of mZVI injected into saturated and unsaturated overburden within the treatment area at the design locations and elevations. mZVI was successfully injected during the ISS pilot test, so delivering mZVI into the saturated and unsaturated zone beneath the HB is expected to be achievable at full scale. Completion of the RA will be documented in a Remedial Action Completion Report.

As discussed in Section 1.1, ISS using mZVI has proven effective at reducing uranium concentrations in groundwater at the Site by more than 50%. When combined with the reduction in mobility expected from the VBW and cap, the mobility, toxicity and/or concentration of principal threat waste will be reduced by at least 90%. Therefore, the HB ISS remedy will achieve its goals if mZVI is successfully injected in accordance with the design.

The remedy for depleted uranium in overburden groundwater will achieve RAOs by completing the HB remedies and ISS in overburden groundwater downgradient of the HB beyond the extent of the VBW. A RD for the downgradient plume will be presented in a future submittal.

5.2 Construction Quality Assurance Program

The systematic activities that provide assurance that the RA has been implemented according to the design are described in a CQA/QCP provided as **Attachment 5**. In summary, this plan describes:

- Organizational structure for the RA including Project Coordinator, Remedial Project Manager, Engineer-of-Record, CQA Engineer, and Remediation Contractors;
- The responsibilities of the entities listed above;
- Standards to meet when injecting mZVI into the HB;
- Verification to be performed to ensure materials delivered to the Site meet the design requirements;
- A description of measurements that will be collected during the RA to ensure amendment doses and injection locations meet the specified locations and depths in the design;

- Field forms for documenting implementation of the RA; and
- Procedures for managing and documenting change, deficiencies and addressing problems.

5.3 Operations and Maintenance

ISS will not have operation and maintenance requirements because:

- ISS is a passive technology with no equipment, moving parts or required energy input after the amendments are emplaced in the subsurface, and
- the remedy is expected to act for decades and not require supplemental injections of amendments. Supplemental injections will be infeasible after the HB is capped.

Because the HB ISS RA will not require operation or maintenance, an operations and maintenance plan is not included in this RD.

5.4 Measure of Success

Success in achieving the RA goal of reducing the mobility, toxicity and/or concentration of uranium within the treatment area will be achieved through successful implementation of the two-part HB remedy which includes: (1) successful implementation of ISS within the footprint of the VBW, followed by (2) successful construction of the VBW and cap.

The ISS RA will be deemed successful and effective if:

- Cased holes can be installed to the top of till to allow the deepest injection at each location to be performed 4 to 5.5 ft above the top of till;
- The injection contractor can deliver amendments into the formation by emplacing mZVI into fractures over the design treatment interval which includes saturated overburden and the unsaturated zone where principal threat waste has been found;
- The total mass of mZVI described in the ISS design is delivered throughout the footprint shown in the design drawings, which includes 57 ISS injection points within the VBW; and
- mZVI can be emplaced in apron areas to allow the VBW to subsequently be installed.

Data used to assess if these criteria have been met will be obtained through execution of the CQA/QCP during the RA. If CQA/QC confirms that the RA has been implemented in accordance with the design, then the HB ISS remedy will be deemed successful and the RA effective for its intended purpose.

The design for the HB VBW and cap and the associated CQA/QC and post-construction monitoring that will be used to measure its success are being presented under separate cover. However, it is anticipated that the VBW and cap will have similar measurements of success (e.g., CQA/QC testing to verify that the permeability of VBW backfill meets the design thresholds, and construction oversight confirms that the cap is constructed according to the design using specified materials). The HB VBW and cap design is also expected to include monitoring outside of the VBW to observe new groundwater flow that develops after the RA as groundwater is diverted around the VBW.

6. SCHEDULE

The following is the anticipated sequence of events for ISS in the HB.

Task	Completion Date
1) Approval of 30% RD-Rev 1 by USEPA	January 18, 2024
2) Submit 95% RD	February 2024
3) Submit RAWP	March 2024
4) USEPA comments on 95% RD	April 2024
5) USEPA comments on RAWP	May 2024
6) Submit 100% Remedial Design Report (RD) and RAWP	May 2024
7) USEPA Approval of 100% RD and RAWP	June 2024
8) Mobilization of drill rig to install cased holes*	June 2024
9) Mobilization of jet injection equipment to create mZVI-filled fractures*	August 2024

* The duration of drilling and jet-injection activities will be provided once contractors have submitted proposals for the work.

* Drilling may initiate earlier as at-risk work to push the schedule ahead of what is shown above.

7. REFERENCES

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Geosyntec. 2023. *Predesign Investigation Report for In Situ Sequestration of Uranium in Overburden Groundwater.* Nuclear Metals Superfund Site. Revision 1 submitted June.

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TABLES

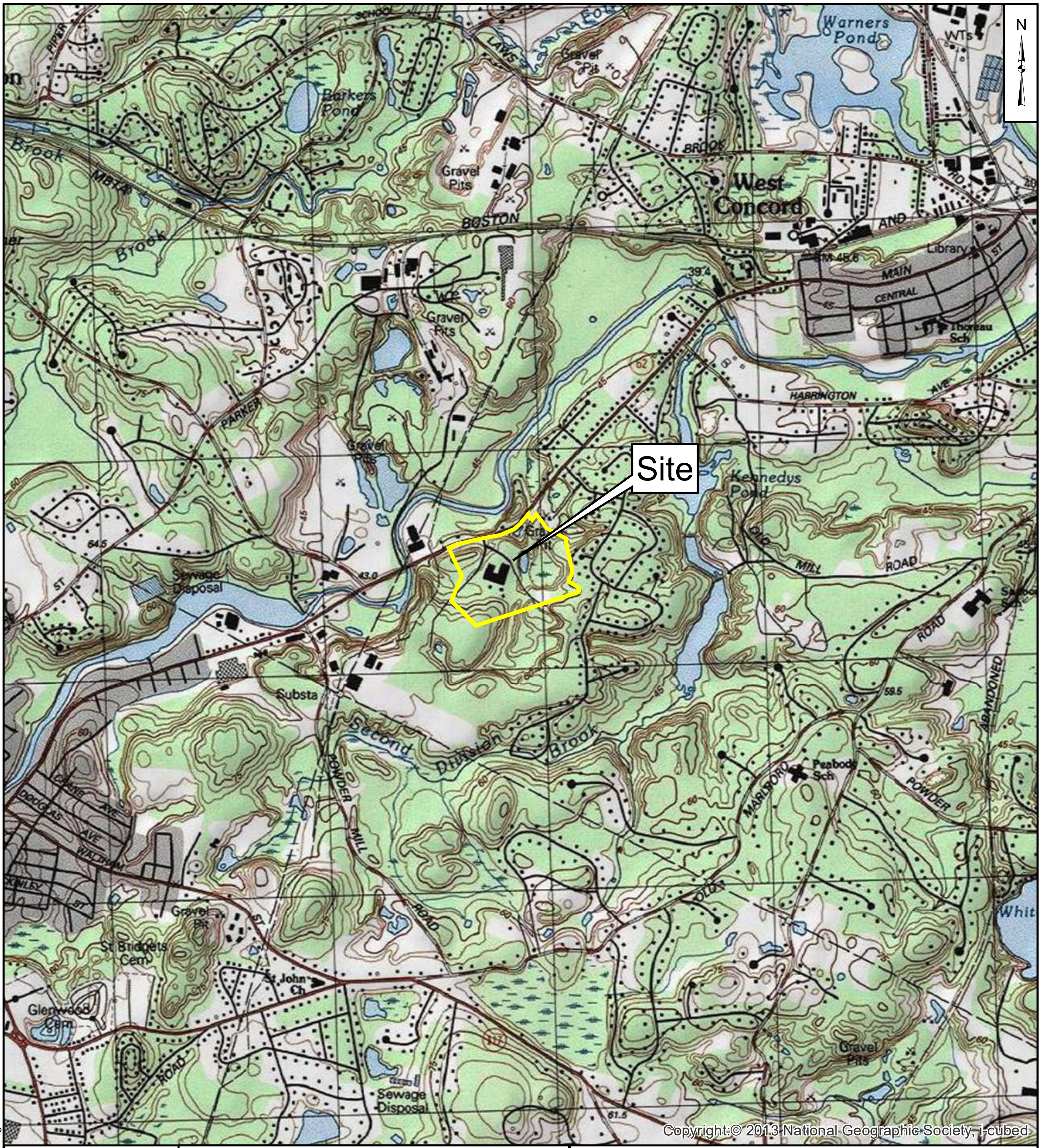
Table 1
Temporary Monitoring Well Construction and Sample Plan
Nuclear Metals Inc. Superfund Site
Concord, Massachusetts

Temporary Monitoring Well ID	Geologic Unit	Location	Screen				Field Monitoring		Analytical Monitoring	Temporary Monitoring Well Location Rationale
			Diameter (in)	Top Elevation (ft)	Bottom Elevation (ft)	Length (ft)	Water Level	Geochemical Parameters	Total and Dissolved Metals	
TMW-HB-13	Upper Stratified Drift	Within Holding Basin, Near Former HB-13	2	132.4	122.4	10	X	X	X	- Evaluate geochemical parameters and groundwater conditions between the completion of injections and the installation of the cutoff wall within the Holding Basin
TMW-HB-PZ2R	Upper Stratified Drift	Within Holding Basin, Near Former HB-PZ2R	2	138.82	123.82	15	X	X	X	- Evaluate geochemical parameters and groundwater conditions between the completion of injections and the installation of the cutoff wall within the Holding Basin
TMW-S24	Upper Stratified Drift	In Apron Area, Near Former MW-S24	2	131.9	121.9	10	X	X	X	- Evaluate geochemical parameters and groundwater conditions between the completion of injections and the installation of the cutoff wall in the apron area
TMW-SD24	Lower Stratified Drift	In Apron Area, Near Former MW-SD24	2	119.46	109.46	10	X	X	X	- Evaluate geochemical parameters and groundwater conditions between the completion of injections and the installation of the cutoff wall in the apron area

Notes:
1. Elevations are provided in ft NGVD1929.
2. "X" indicates parameters that will be collected at each sampling location.
3. Metals analysis includes uranium and iron.
4. Field geochemical parameters include temperature, pH, specific conductance, dissolved oxygen, and oxidation reduction potential.
5. Samples for dissolved metals will be field filtered.
6. Temporary monitoring wells will be installed following the completion of ISS injections in the Holding Basin. The wells will be decommissioned prior to the installation of the vertical barrier wall. The groundwater field and analytical monitoring will be conducted quarterly while the wells are installed.

Abbreviations:
ft: feet
in: inches
NGVD1929: National Geodetic Vertical Datum of 1929

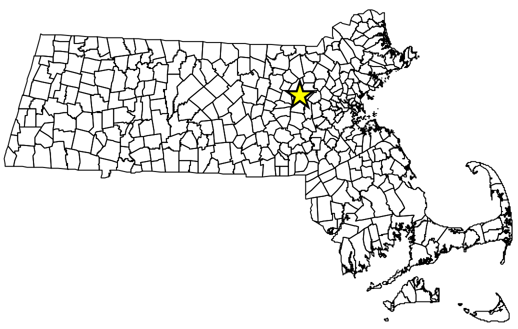
FIGURES



Legend

★ Site Locus

Nuclear Metals, Inc. Property Boundary



Notes:
USGS Topo Imagery from ESRI

1,000 500 0 1,000 2,000
Feet

Site Locus

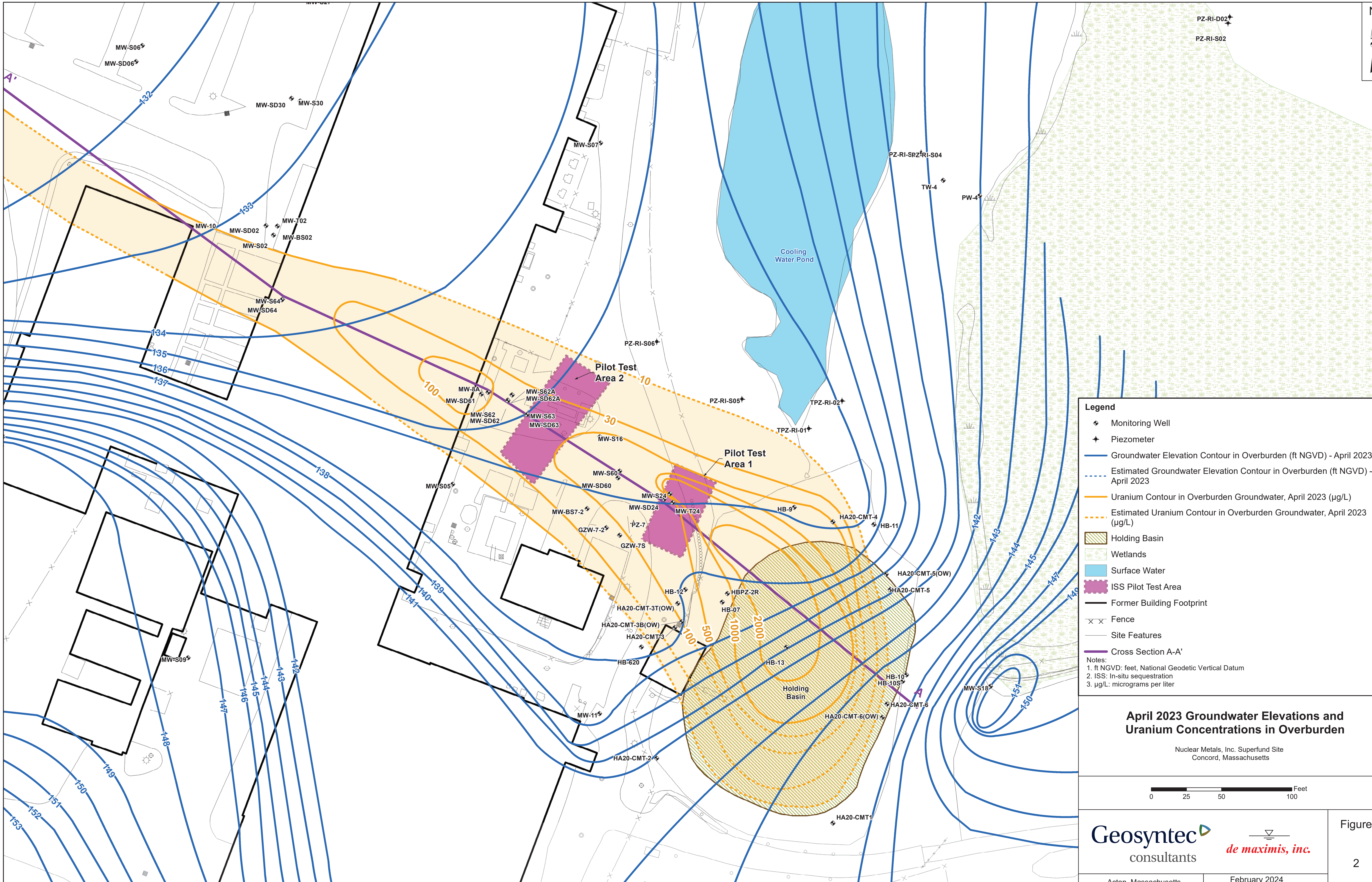
Nuclear Metals, Inc. Superfund Site
Concord, Massachusetts

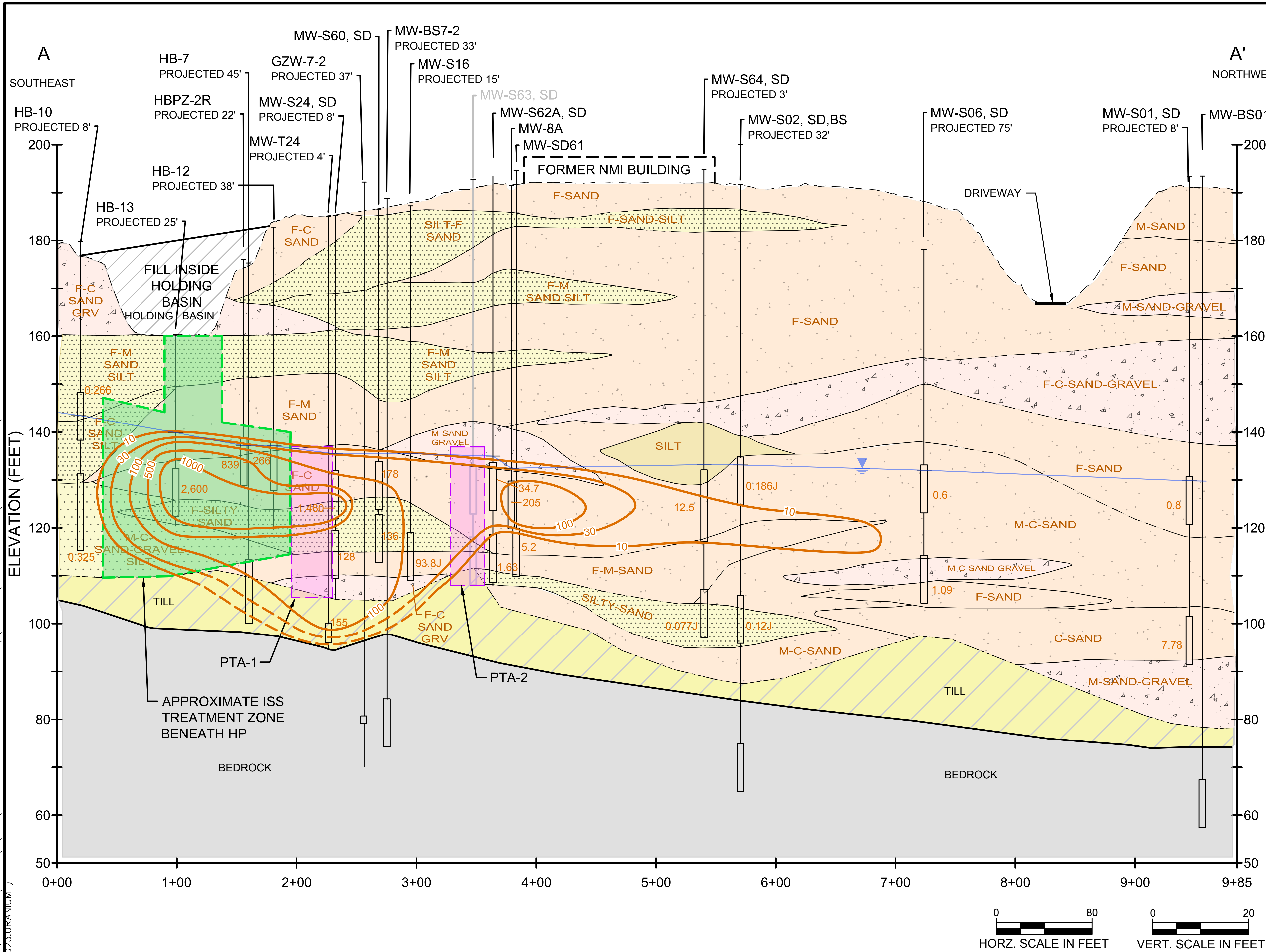
Geosyntec consultants | de maximis, inc.

Acton, MA | February 2024

Figure 1

Q:\GISProjects\BR0090-NMISite\Projects\Updates_2020\Figure 2-1 - Site Locus.mxd


N
Cooling Water Pond
Pilot Test Area 2
Pilot Test Area 1
Holding Basin
A'
A
Legend
Monitoring Well
Piezometer
Groundwater Elevation Contour in Overburden (ft NGVD) - April 2023
Estimated Groundwater Elevation Contour in Overburden (ft NGVD) - April 2023
Uranium Contour in Overburden Groundwater, April 2023 (µg/L)
Estimated Uranium Contour in Overburden Groundwater, April 2023 (µg/L)
Holding Basin
Wetlands
Surface Water
ISS Pilot Test Area
Former Building Footprint
Fence
Site Features
Cross Section A-A'
Notes:
1. ft NGVD: feet, National Geodetic Vertical Datum
2. ISS: In-situ sequestration
3. µg/L: micrograms per liter
April 2023 Groundwater Elevations and Uranium Concentrations in Overburden
Nuclear Metals, Inc. Superfund Site
Concord, Massachusetts
Feet
0 25 50 100
Geosyntec consultants
de maximis, inc.
Figure
2
Acton, Massachusetts
February 2024



LEGEND

- Existing ground surface (note 1)
- Top of till
- Top of bedrock
- 30 Total uranium contour (μg/l)

Monitoring well
- Water table
- Screened interval
- 7.41 Total uranium (μg/l)

- Pilot test treatment zone
- Approximate ISS treatment beneath HB

GEOLOGIC CLASSIFICATIONS
- SILT
- SAND AND SILT
- SAND
- SAND AND GRAVEL
- TILL
- BEDROCK

Notes:
1. Ground surface is from topographic map titled "existing conditions plan 2229 main street, concord mass" prepared by Feldman Land Surveyors, dated 2020-6-19,from an aerial map flown in November 2001 prepared by Sanborn inc., and from "interm As-Built Plan" prepaes by A-Plus Construction Service Corporation, and is approximate.
2. Water level data collected on 3 April 2023.
3. Total uranium data is most recent sample between April 2021 and April 2023.
4. Wells MW-S63, SD are shaded gray to indicate they were destroyed during pilot test injections in March 2022.
5. Abbreveations:
   μg/L - micrograms per liter
   PTA - pilot test area

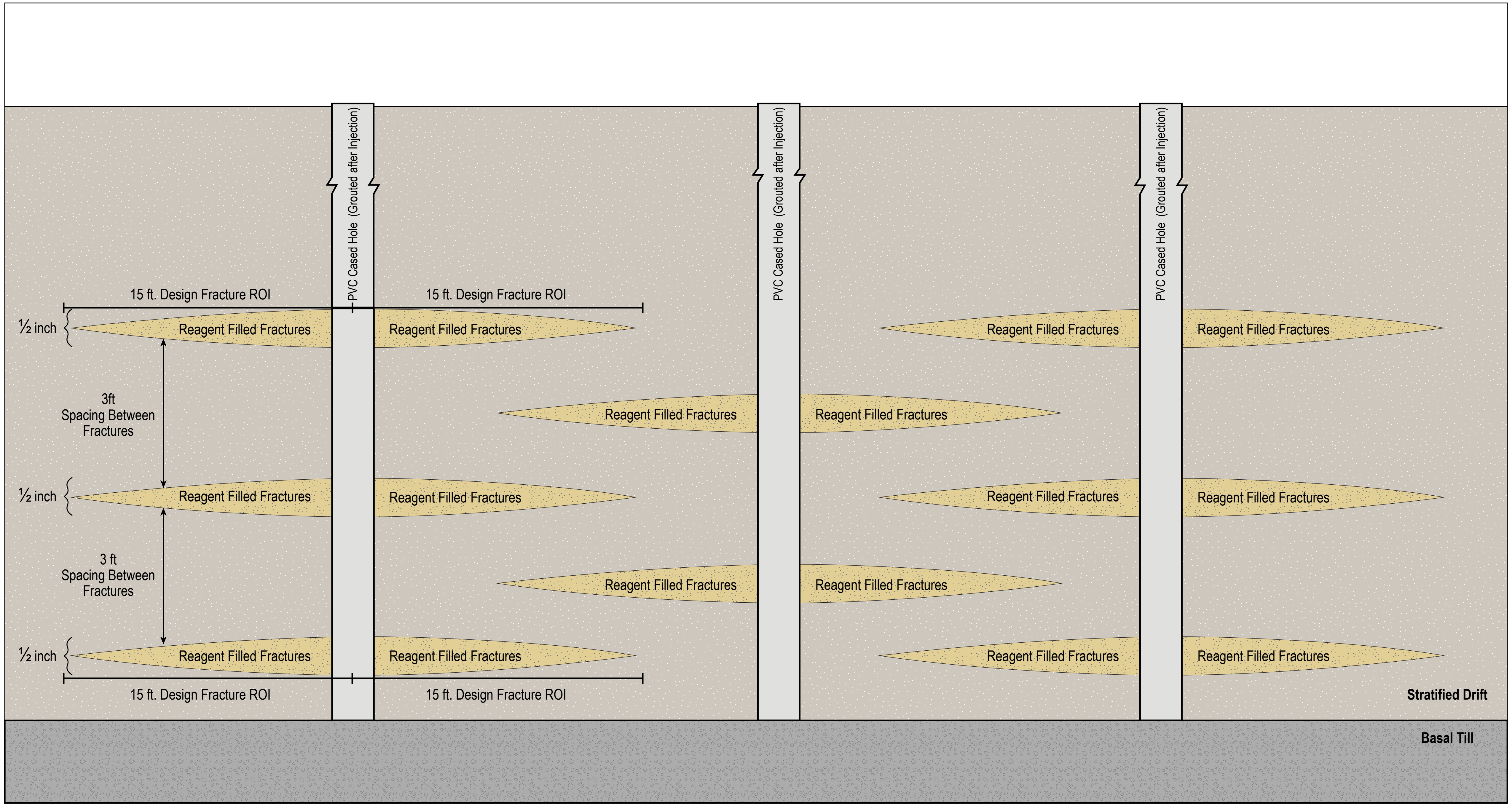
DRAFT

Cross-Section A - A'
Depleted Uranium Plume in Overburden Groundwater April 2023
Nuclear Metals, Inc. Superfund Site
Concord, Massachusetts

Geosyntec consultants

FIGURE 3

ACTON, MA | FEBRUARY 2024



Not to scale

Acronyms and Abbreviations

ROI = Radius of Injection

ft = feet

PVC = Polyvinyl Chloride

Conceptual Cross Section of
ISS Reagent Lenses Emplaced with Jet Injection

Nuclear Metals, Inc. Superfund Site, Concord, Massachusetts

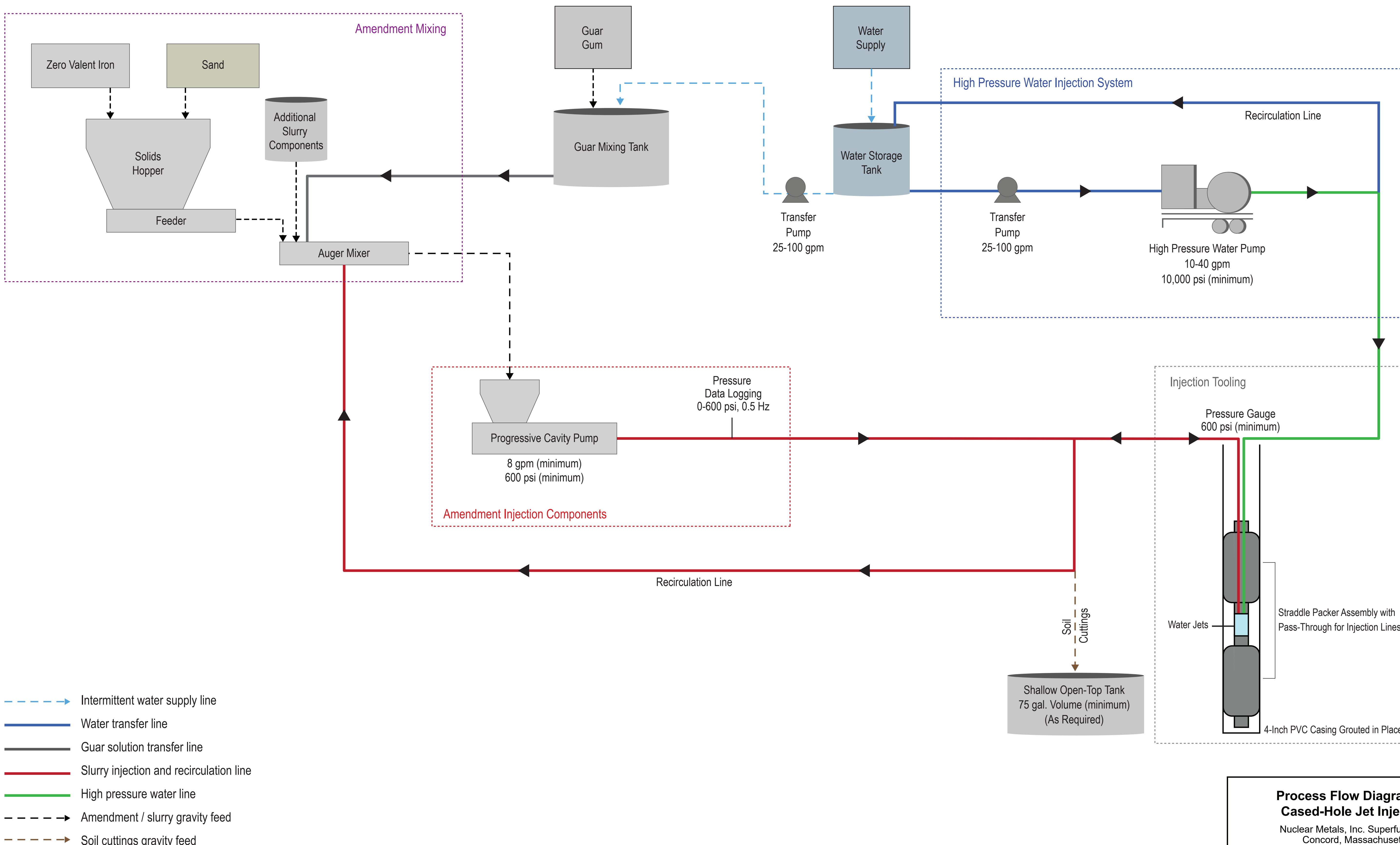
de maximis, inc.

Geosyntec consultants

Figure **4**

Acton, Massachusetts

February 2024



Process Flow Diagram for Cased-Hole Jet Injection

Nuclear Metals, Inc. Superfund Site
Concord, Massachusetts

Geosyntec consultants | de maximis, inc.

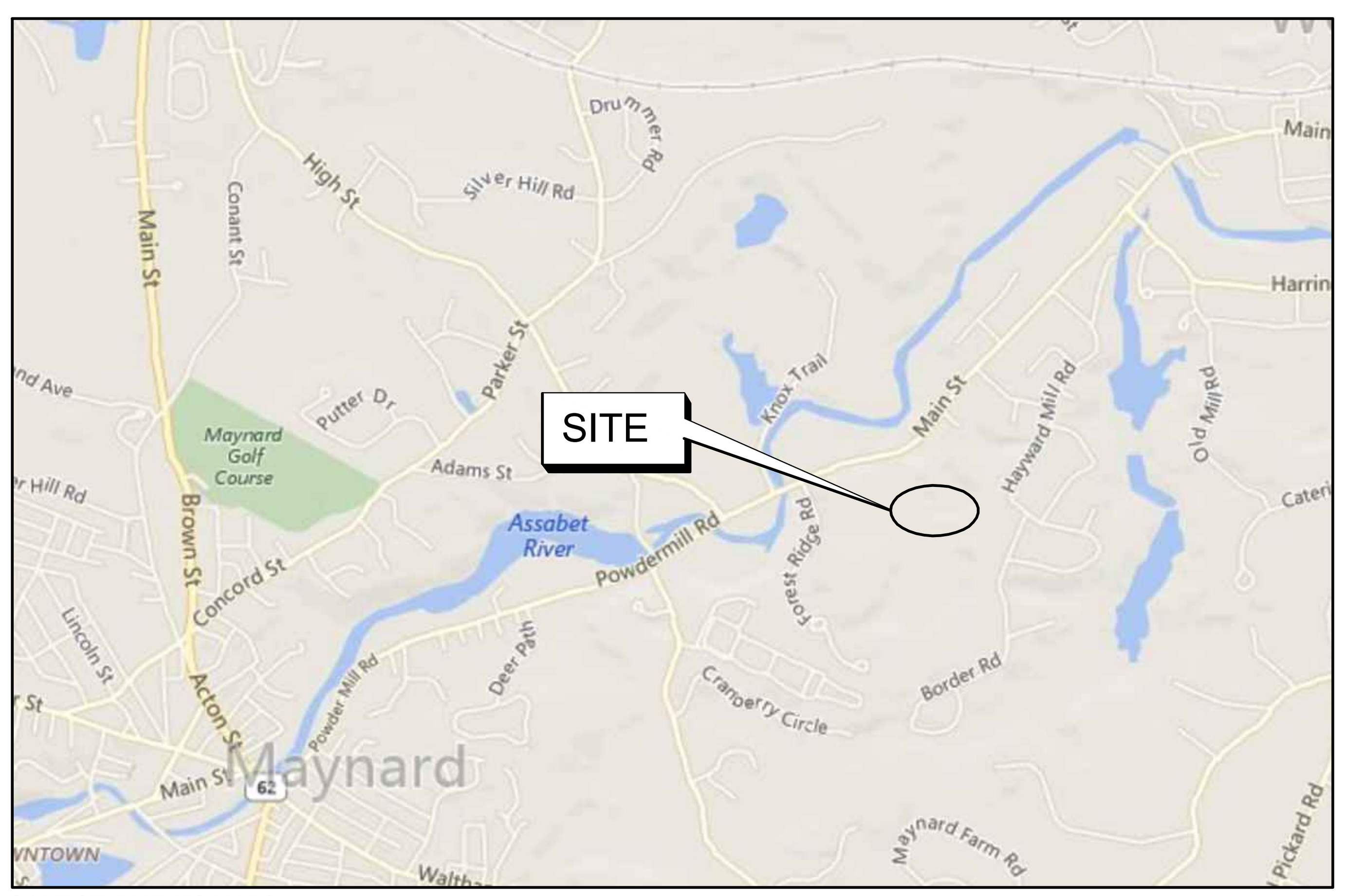
February 2024

Figure 5

Attachment 1

Drawings

95% REMEDIAL DESIGN: IN SITU SEQUESTRATION OF URANIUM IN OVERBURDEN GROUNDWATER WITHIN THE HOLDING BASIN
NUCLEAR METALS, INC
SUPERFUND SITE
CONCORD, MASSACHUSETTS
FEBRUARY 2024

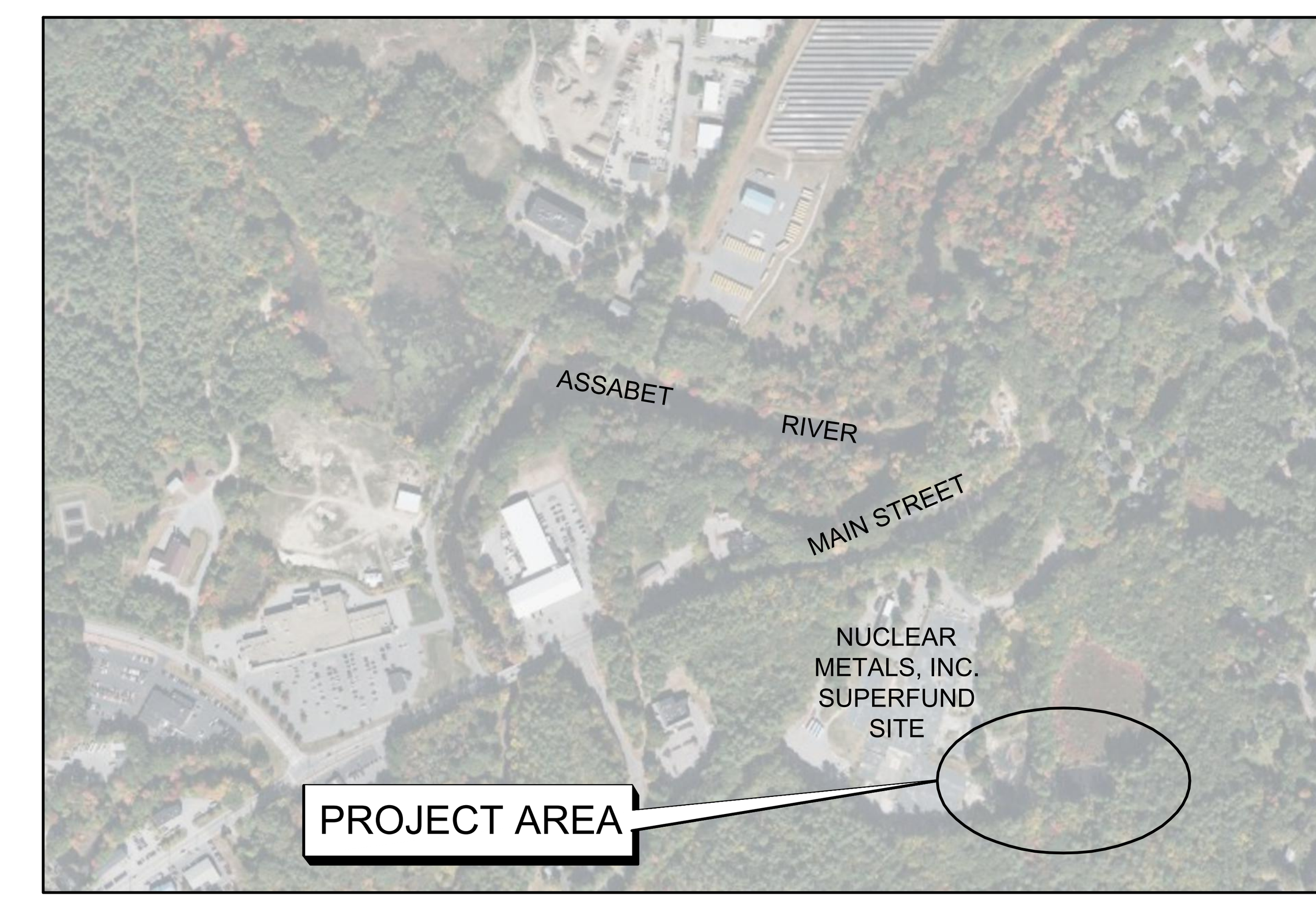


SOURCE: BY BING MAPS.

VICINITY MAP
NOT TO SCALE

N

DRAWING INDEX	
Sheet Number	Sheet Title
1	COVER SHEET
2	GENERAL NOTES AND SPECIFICATIONS
3	PRE-ENABLING WORK CONDITIONS AND PROPOSED CUTOFF WALL
4	GRADES FOLLOWING ENABLING WORK AND WORK AREA
5	PROPOSED CASED-HOLE INJECTION POINT LAYOUT
6	INJECTION SUMMARY TABLE
7	DETAILS



SOURCE: MA GIS

LOCATION MAP
NOT TO SCALE

N

PREPARED FOR:
de maximis, inc.
200 DAY HILL ROAD, SUITE 200
WINDSOR, CONNECTICUT 06095

DETAIL NUMBER
4
C-07
SHEET ON WHICH ABOVE DETAIL IS PRESENTED

DETAIL NUMBER
4
C-01
SHEET ON WHICH ABOVE DETAIL WAS FIRST REFERENCED
DETAIL
TITLE OF DETAIL
SCALE: 1"=2'

EXAMPLE: DETAIL NUMBER 4 PRESENTED ON SHEET NO. 6 WAS REFERENCED FOR THE FIRST TIME ON SHEET NO.3.

ABOVE SYSTEM ALSO APPLIES TO SECTION IDENTIFICATIONS.

DETAIL IDENTIFICATION LEGEND

REV	DATE	DESCRIPTION	DRN	APP

de maximis, inc.

Geosyntec consultants

TITLE: COVER SHEET

PROJECT: 95% REMEDIAL DESIGN: IN SITU SEQUESTRATION OF URANIUM IN OVERBURDEN GROUNDWATER WITHIN THE HOLDING BASIN

SITE: NUCLEAR METALS INC. SUPERFUND SITE CONCORD, MASSACHUSETTS

DESIGN BY:	GKW	DATE:	FEBRUARY 2024
DRAWN BY:	BEG	PROJECT NO.:	BR0090E
CHECKED BY:	DGJ	FILE:	BR0090C D001.DWG
REVIEWED BY:	CSM	DRAWING NO.:	
APPROVED BY:	CRE	1 OF 7	

DRAFT

(1in) (2in) (3in) (4in)

SCALE IS BASED ON 22" X 34" NON-REDUCED SHEET SIZE (BORDER = 21" X 32")

GEOSYNTEC-PW-01\DOCUMENTS\CLIENTS\NNMI - NUCLEAR METALS INC\BR0090C - ISS REMEDIAL DESIGN - OVERBURDEN GROUNDWATER\CADD\01 - ISS DESIGN\DRAWINGS\SHEETS\BR0090C D001.DWG

GENERAL NOTES

1. REFERENCE: NUCLEAR METALS, INC SUPERFUND SITE
   2229 MAIN STREET,
   CONCORD, MASSACHUSETTS
2. PROJECT TEAM
   a. GENERAL AND SUPERVISING CONTRACTOR - DE MAXIMIS, INC
   b. ENGINEER - GEOSYNTEC CONSULTANTS
   c. INJECTION CONTRACTOR - FRx
   d. DRILLER - TO BE DETERMINED (SUBCONTRACTOR TO DE MAXIMIS)
   e. CONTRACTORS - UNLESS NOTED OTHERWISE, CONTRACTORS SHALL MEAN BOTH DRILLER AND INJECTION CONTRACTOR AS APPROPRIATE FOR THEIR WORK TASKS
   f. RADIATION SAFETY OFFICER - DDES, INC.
3. THE PROJECT AREA IS LOCATED AT THE SOUTHEAST PART OF THE SITE AT 2229 MAIN STREET, CONCORD, MA 01742
4. NORMAL WORK HOURS ARE FROM 7:00 AM TO 5:00 PM MONDAY THROUGH FRIDAY. APPROVAL FROM THE PROJECT COORDINATOR IS REQUIRED FOR WORK OUTSIDE OF THESE HOURS.
5. WORK SHALL REFER TO ALL ACTIVITIES, EQUIPMENT AND MATERIALS TO COMPLETE AMENDMENT INJECTIONS INCLUDING BUT NOT LIMITED TO ALL PREPARATORY (E.G., SUBMITTALS) ACTIVITIES, LABOR, DRILLING ACTIVITIES, INJECTION OF AMENDMENTS AND PROCUREMENT OF EQUIPMENT AND MATERIALS UNLESS NOTED OTHERWISE IN THE DESIGN.
6. EXISTING UTILITIES SHOWN ON THE DRAWINGS ARE APPROXIMATE.
7. CONVENTIONAL INDUSTRY STANDARD DETAILS SHALL APPLY WHERE NO SPECIAL DETAIL IS SHOWN. SUCH DETAILS SHALL BE APPROVED BY THE ENGINEER.
8. CONTRACTORS SHALL PERFORM ALL WORK WITHIN THE DESIGNATED LIMITS OF WORK SHOWN ON THE DRAWINGS, UNLESS OTHERWISE APPROVED.
9. CONTRACTORS SHALL VERIFY ALL DIMENSIONS AND CONDITIONS SHOWN ON THESE DRAWINGS. SCALES, SHOWN ON THE DRAWINGS, IF PROVIDED, ARE FOR GUIDANCE ONLY.
10. ALL EXISTING UTILITY LOCATIONS MAY NOT BE SHOWN ON THE DRAWINGS
    a. THE CONTRACTORS SHALL COORDINATE WITH THE UTILITY COMPANIES, TOWN OF CONCORD, DE MAXIMIS, AND ENGINEER TO VERIFY UTILITY LOCATIONS PRIOR TO THEIR SUBSURFACE WORK. THE CONTRACTORS SHALL VERIFY ALL UTILITY DEPTHS AND LOCATIONS PRIOR TO CONSTRUCTION AND COORDINATE ANY NECESSARY RELOCATIONS. UTILITIES DAMAGED BY A CONTRACTOR SHALL BE REPAIRED AND REPLACED BY THE CONTRACTOR AT NO ADDITIONAL EXPENSE TO THE PROJECT, DE MAXIMIS OR ENGINEER.
    b. THE GENERAL AND SUPERVISING CONTRACTOR HAS REMOVED UTILITIES FROM WITHIN THE LIMITS OF WORK.
11. NO CHANGES ARE TO BE MADE ON THESE PLANS WITHOUT THE KNOWLEDGE AND CONSENT OF THE ENGINEER.
12. THE CONTRACTORS SHALL COORDINATE ALL WORK AND MATERIALS PROVIDED BY THEIR SUBCONTRACTORS.
13. ALL MATERIALS USED FOR CASED HOLE CONSTRUCTION SHALL BE NEW EXCEPT WHERE SITE SOILS ARE SPECIFIED.
14. UNLESS SPECIFICALLY NOTED ON THE DRAWINGS, ALL MATERIAL SHALL BE PROVIDED BY THE CONTRACTORS.
    a. DRILLER SHALL PROVIDE ALL EQUIPMENT AND MATERIALS TO INSTALL CASED HOLE INJECTION POINTS.
    b. INJECTION CONTRACTOR SHALL PROVIDE ALL EQUIPMENT AND INJECTION AMENDMENTS, EXCEPT ZVI AND WATER, NEEDED TO PERFORM THE WORK.
16. TEMPORARY EXCLUSION ZONES WILL BE ESTABLISHED WITHIN THE WORK AREA BY THE SITE RADIATION SAFETY OFFICER. THE CONTRACTORS SHALL FREQUENTLY MONITOR THE WORK AREA FOR PERSONNEL AND EQUIPMENT GOING INTO AND OUT OF THE EXCLUSION ZONE. PERSONNEL NEED TO HAVE APPROPRIATE PPE, AS DIRECTED BY THE RADIATION SAFETY OFFICER, TO ENTER THE EXCLUSION ZONE. PERSONNEL AND EQUIPMENT NEED TO BE SCREENED INTO AND OUT OF THE EXCLUSION ZONE BY THE SITE HEALTH PHYSICIST.
17. THE INJECTION CONTRACTOR SHALL COORDINATE WITH THE ENGINEER PRIOR TO PERFORMING INJECTION ACTIVITIES.
18. THE CONTRACTORS SHALL HAVE CURRENT AND APPLICABLE LICENSES AS REQUIRED BY THE WORK PERFORMED.
19. THE CONTRACTORS ARE RESPONSIBLE FOR KEEPING THE SITE VISUALLY CLEAN AND REMOVING ALL TRASH, DEBRIS, AND WASTES ACCORDING TO THE TRASH, DEBRIS AND WASTE TYPES, CLASSIFICATIONS, AND HANDLING PROCEDURES.
20. THE CONTRACTORS ARE RESPONSIBLE FOR PROTECTING FROM DAMAGE ALL EXISTING IMPROVEMENTS THAT ARE TO REMAIN. SUCH IMPROVEMENTS THAT ARE DAMAGED BY THE CONTRACTORS SHALL BE REPLACED AT THE CONTRACTOR'S SOLE EXPENSE. THIS INCLUDES, BUT IS NOT LIMITED TO, MONITORING WELLS, ROADS, GRASS.
21. THE CONTRACTORS SHALL ASSUME SOLE RESPONSIBILITY OF THE WORK AREA DURING THE COURSE OF THE IMPLEMENTATION OF THIS PROJECT, INCLUDING SECURITY AND SAFETY OF ALL PERSONS AND PROPERTY.
22. ALL SIGNING, BARRICADES, AND DRUMS UTILIZED IN TRAFFIC CONTROL SHALL BE PROVIDED, ERECTED, AND MAINTAINED BY THE CONTRACTORS. TRAFFIC CONTROL SHALL BE IN CONFORMANCE WITH THE MANUAL OF UNIFORM TRAFFIC CONTROL DEVICES (MUTCD), LATEST EDITION.
23. CONSTRUCTION STAKING IS TO BE PROVIDED BY A SURVEYOR UNDER CONTRACT TO DE MAXIMIS. SURVEY STAKES, BENCHMARKS, AND PROPERTY PINS DESTROYED BY THE CONTRACTORS SHALL BE REPLACED AT THE CONTRACTORS' EXPENSE.
24. THE INJECTION CONTRACTOR'S SUPERVISOR/SITE MANAGER AND DRILLERS' SUPERVISOR/LEAD DRILLER SHALL ATTEND A TAILGATE MEETING WITH THE SITE CONSTRUCTION MANAGER AND ENGINEER REPRESENTATIVES AT THE BEGINNING OF THE PROJECT. ALL INJECTION CONTRACTOR AND DRILLER EMPLOYEES SHALL ALSO ATTEND DAILY TAILGATE MEETINGS WITH A REPRESENTATIVE OF THE ENGINEER AND/OR DE MAXIMIS. DURING THESE DAILY MEETINGS, CONTRACTORS' SUPERVISOR/SITE MANAGER/LEAD DRILLER SHALL REPORT ON (1) SAFETY PERFORMANCE AND STATISTICS, (2) SITE MANPOWER, (3) DAILY EQUIPMENT COUNT AND DESCRIPTION, (4) SCHEDULE STATUS AND (5) WORK PLANNED FOR THE DAY. ONCE PER WEEK DURING THE TAILGATE MEETING, THE CONTRACTORS SHALL PROVIDE THE ENGINEER REPRESENTATIVES WITH AN UPDATED SCHEDULE, IN WRITING AND CONTAINING THE INFORMATION SPECIFIED UNDER THE CONSTRUCTION SCHEDULE SPECIFICATION, AND DISCUSS WORK PROGRESS, DELAYS AND SCHEDULE PROJECTIONS.

SCHEDULE

1. THE DRILLER AND INJECTION CONTRACTOR SHALL PREPARE AND SUBMIT A CASED HOLE INSTALLATION AND INJECTION SCHEDULE FOR THEIR WORK TO DE MAXIMIS AT LEAST TWO WEEKS PRIOR TO ANY WORK AT THE SITE SO THAT DE MAXIMIS CAN INTEGRATE THE SUBCONTRACTORS' SCHEDULES WITH OTHER SITE ACTIVITIES.
2. CONTRACTORS AND SUBCONTRACTOR SCHEDULES ARE SUBJECT TO APPROVAL BY DE MAXIMIS AND THE ENGINEER.
3. PROPOSED SCHEDULES SHALL BE PRESENTED IN GANTT CHART FORMAT SHOWING ESTIMATED START DATE, DURATION, AND COMPLETION TIMES FOR EACH ACTIVITY.
4. CONTRACTORS SHALL CONTINUOUSLY MAINTAIN A CONSTRUCTION SCHEDULE WITH A DETAILED TWO-WEEK LOOK-AHEAD. THIS SCHEDULE WILL BE PROVIDED TO DE MAXIMIS WEEKLY AND WHENEVER REQUESTED.

SURVEY BASE PLAN NOTES

1. THE BASEMAP AND ELEVATION SURVEY WERE PROVIDED BY FELDMAN LAND SURVEYORS IN THE "EXISTING CONDITIONS PLAN", DATED MAY 15, 2020, AND BY A-PLUS CONSTRUCTION SERVICES CORPORATION IN THE "INTERIM AS-BUILT PLAN", DATED DECEMBER 20, 2023.
2. BASEMAP DATUM - MASSACHUSETTS STATE PLANE COORDINATE SYSTEM NGVD 1929.
3. BENCHMARK INFORMATION:

   TEMPORARY BENCHMARKS SET

   - TGS-1: MAGNETIC NAIL SET UP 1' ON THE SOUTHERLY SIDE OF UTILITY POLE AT THE INTERSECTION OF MAIN STREET AND THE DRIVEWAY TO #2228 MAIN STREET, ELEVATION=151.79'
   - TGS-2: MAGNETIC NAIL SET UP 1' IN UTILITY POLE, ELEVATION=167.98'
   - TBM PS-1: CHISEL SQUARE SET IN NORTHWEST CORNER OF LIGHT POLE BASE, ELEVATION=172.60'
   - TBM PS-2: CHISEL SQUARE SET IN NORTHWEST CORNER OF LIGHT POLE BASE, ELEVATION=193.53'
4. PLANIMETRIC SITE FEATURES WERE OBTAINED BY AERIAL MAPPING AND CONTOURS FROM LIDAR PREPARED BY BLUE SKY GEOSPATIAL, LTD. RECEIVED ON JUNE 3, 2020. ADDITIONAL FEATURES WERE VERIFIED BY INSTRUMENT SURVEYS BY FELDMAN LAND SURVEYORS BETWEEN APRIL 14 TO JUNE 16, 2020.
5. ALL UNDERGROUND UTILITIES (ELECTRIC, GAS, TEL, WATER, SEWER DRAIN SERVICES) ARE SHOWN IN SCHEMATIC FASHION, THEIR LOCATIONS ARE NOT PRECISE OR NECESSARILY ACCURATE. NO WORK WHATSOEVER SHALL BE UNDERTAKEN UNTIL CONTRACTORS LOCATES UNDERGROUND SERVICES BY CONSULTING WITH THE PROPER AUTHORITIES CONCERNED WITH THE SUBJECT SERVICE LOCATIONS AND BY USING SOFT DIG TECHNIQUES.
6. CONTRACTORS SHALL CALL DIG-SAFE AT 1-888-DIG-SAFE AT LEAST 72 HOURS PRIOR TO PERFORMING ANY INVASIVE WORK.

SAFETY/CLEAN-UP

1. ALL INJECTION AREAS SHALL BE CLEARLY MARKED AS DESCRIBED IN THE SITE HEALTH AND SAFETY PLAN (HASP) TO RESTRICT ACCESS AND PROVIDE A SAFE WORK ENVIRONMENT.
2. PRIOR TO BEGINNING FIELD ACTIVITIES, THE INJECTION CONTRACTOR AND DRILLER MUST EACH PROVIDE DE MAXIMIS WITH A SITE-SPECIFIC HASP, OR JOB SAFETY ANALYSIS (JSA), WRITTEN SPECIFICALLY FOR THEIR TASKS AND PERSONNEL, TO THE EXTENT THE APPROVED SITE HASP NEEDS TO BE SUPPLEMENTED BY THE INJECTION CONTRACTOR OR DRILLER. THE HASP MUST COMPLY WITH THE SITE HASP AND BE DEEMED ADEQUATE IN WRITING BY THE GENERAL AND SUPERVISING CONTRACTOR'S SITE HEALTH AND SAFETY LEAD BEFORE WORK CAN BEGIN.
3. THE INJECTION CONTRACTOR AND DRILLER SHALL MAINTAIN A CLEAN AND ORDERLY SITE, CONTAIN LOOSE DEBRIS, AND STORE CASING INSTALLATION AND INJECTION MATERIALS ON A DAILY BASIS PRIOR TO LEAVING THEIR WORK AREA(S).
4. REQUIRED PERSONAL PROTECTIVE EQUIPMENT (PPE) INCLUDING BUT NOT LIMITED TO STEEL-TOED BOOTS, SAFETY GLASSES, HARD HATS, AND SAFETY VESTS SHALL BE WORN BY ALL CONTRACTORS' PERSONNEL AND SUBCONTRACTORS AT ALL TIMES WHILE ON SITE. HEARING PROTECTION SHALL BE WORN AS NECESSARY. WHEN WORKING INSIDE THE EXCLUSION ZONE, ADDITIONAL PPE, INCLUDING COVERALLS AND BOOT COVERS, WILL BE WORN AS DIRECTED BY THE RADIATION SAFETY OFFICER. FAILURE TO WEAR REQUIRED PPE MAY RESULT IN TERMINATION OF CONTRACTOR, SUBCONTRACTOR OR EMPLOYEE. ANY AND ALL HEALTH AND SAFETY NEAR MISSES, INCIDENTS, OR CONCERNS SHALL BE IMMEDIATELY CONVEYED TO DE MAXIMIS. FAILURE TO DO SO MAY RESULT IN TERMINATION OF THE DRILLER/CONTRACTOR/ SUBCONTRACTOR. ALTERATIONS IN SCHEDULE DUE TO HEALTH AND SAFETY NONCOMPLIANCE SHALL BE SOLELY AT THE INJECTION CONTRACTOR AND/OR DRILLER'S EXPENSE.
5. ALL WORKERS AT THE SITE SHALL HAVE CURRENT 40-HOUR OSHA TRAINING AND WILL BE REQUIRED TO TAKE SITE-SPECIFIC RADIATION TRAINING PROVIDED BY DE MAXIMIS.

MATERIALS

1. mZVI - HEPURE FEROX FLOW, RIO-TINTO ATOMET 57 OR APPROVED EQUIVALENT MEETING THE mZVI SPECIFICATION INCLUDED IN THIS DESIGN
2. G150 GUAR GUM
3. LEB-H ENZYME BREAKER
4. BORAX
5. POTABLE WATER AVAILABLE AT THE SITE ENTRANCE, ON-SITE TRAILER OR TREATMENT SYSTEM BUILDING
6. PORTLAND CEMENT

SURVEY AND BACKFILL

1. SURVEYING SHALL BE PERFORMED BY A SURVEYOR SUBCONTRACTED BY DE MAXIMIS. MINIMUM SURVEY PRECISION SHALL BE ONE TENTHS OF A FOOT VERTICALLY AND ONE FOOT LATERALLY.
2. DEPTH TO THE TOP OF TILL IS ESTIMATED BASED ON CLOSEST KNOW BORING LOCATION AND SHALL BE CONFIRMED BY THE ENGINEER DURING CASING INSTALLATION.
3. DEPTH TO THE TOP OF THE WATER TABLE IS ESTIMATED BASED ON GROUNDWATER ELEVATIONS FROM THE APRIL 2022 WATER LEVEL GAUGING EVENT.
4. THE TOP OF HOLDING BASIN LINER IS BASED OF SURVEY DATA PRIOR TO HOLDING BASIN BACKFILL.

PROPOSED SEQUENCE OF WORK

THIS SEQUENCE OF WORK IS INTENDED TO DESCRIBE THE OVERALL ISS INJECTION PROJECT AND A GENERAL SEQUENCE OF ACTIVITIES. UNLESS OTHERWISE NOTED, IT IS NOT INTENDED TO ESTABLISH A RIGID OR REQUIRED CONSTRUCTION SEQUENCE. IF POSSIBLE GIVEN LOGISTICS AND SEQUENCING WITH OTHER SITE ACTIVITIES, IT IS RECOMMENDED THAT JET INJECTIONS BEGIN IN THE APRON AREA AND PROCEED EASTWARD.

SITE PREPARATION

1. INJECTION LOCATIONS WILL BE MARKED BY THE GENERAL AND SUPERVISING CONTRACTOR OR SURVEYOR USING WOODEN STAKES, FLAGS, OR SPRAY PAINT. PRIOR TO DRILLING, THE DRILLING CONTRACTOR WILL INSPECT THE INJECTION LOCATIONS WITH THE GENERAL AND SUPERVISING CONTRACTOR AND THE ENGINEER TO CONFIRM ACCESS. LOCATIONS SHOWN ON THE DRAWINGS ARE APPROXIMATE.
2. INJECTION CONTRACTOR AND DRILLER SHALL CREATE STAGING AREAS FOR MATERIALS AND EQUIPMENT SUCH AS CASING INSTALLATION MATERIAL, INJECTION AMENDMENTS, AND SUPPORT EQUIPMENT.
3. CONTRACTORS SHALL INSTALL AND MAINTAIN MARKINGS AND OTHER SIGNAGE TO DEMARCATE APPROPRIATE SUPPORT, CONTAMINANT REDUCTION, AND EXCLUSION WORK ZONES. THESE ZONES SHALL BE APPROVED BY THE SITE RADIATION OFFICER. CONTRACTOR SHALL MAINTAIN ANY MARKINGS INSTALLED BY THE GENERAL AND SUPERVISING CONTRACTOR TO DEMARCATE RAD ZONES.

CASED HOLES INSTALLATION

1. DRILLER SHALL VERIFY THE TYPE AND LOCATION OF ALL UTILITIES WITHIN THEIR LIMITS OF WORK PRIOR TO THE START OF WORK, ESTABLISH SURVEY CONTROL, AND VERIFY EXISTING CONDITIONS SHOWN ON THE PLANS ARE ACCURATE. AT LEAST 72 HOURS PRIOR TO COMMENCING ANY SUBSURFACE ACTIVITIES, IT IS THE RESPONSIBILITY OF THE DRILLER TO NOTIFY UNDERGROUND SERVICES ALERT AND LOCATED UNDERGROUND UTILITIES IN ADVANCE OF THEIR WORK.
2. DRILLER SHALL MOBILIZE EQUIPMENT, MATERIALS AND PERSONNEL.
3. WELL DRILLER SHALL INSTALL CASED HOLES IN ACCORDANCE WITH THE DESIGN DRAWINGS AND SOIL AND ROCK DRILLING SOP SOP-S-004 AND SOP-GW-003 USING ROTOSONIC METHODS OR ANOTHER METHOD APPROVED BY THE ENGINEER. DRILLER SHALL COMPLETE THE CASING AS A STICKUP.

AMENDMENT INJECTIONS

1. INJECTION CONTRACTOR SHALL MOBILIZE INJECTION RIG AND SUPPORT EQUIPMENT.
2. INJECTION CONTRACTOR SHALL LEAK TEST ALL PIPING AND PIPE CONNECTIONS FOR ANY LEAKS. CONTRACTOR SHALL INSTALL PROTECTIVE MEASURES ON HIGH PRESSURE HYDRAULIC HOSES/LINES INCLUDING WHIP CHECKS AND EMERGENCY SHUT OFF VALVES AND/OR BUTTONS.
3. INJECTION CONTRACTOR SHALL INITIATE INJECTIONS FROM THE BOTTOM OF EACH CASING TO THE TOP AT THE INTERVAL SPECIFIED IN THE DESIGN AND SPACE INJECTIONS AT APPROXIMATELY 3 FOOT VERTICAL INTERVALS.
4. AFTER COMPLETION OF THE INJECTION, THE DRILLING CONTRACTOR SHALL GROUT THE ENTIRE CASED HOLE AND THEN CUT THE CASING TO GROUND SURFACE.

IDW MANAGEMENT

1. THE INJECTION CONTRACTOR AND DRILLER SHALL BE RESPONSIBLE FOR MANAGEMENT, CONTAINMENT, LABELING, AND TRANSPORTATION OF ALL SOIL AND WATER, NON-HAZARDOUS AND HAZARDOUS WASTE GENERATED BY THEIR WORK. CONTRACTORS SHALL REPORT QUANTITIES OF WASTE GENERATED BY THEIR WORK TO DE MAXIMIS DURING DAILY TAILGATE MEETINGS. MANAGEMENT OF INVESTIGATIVE DERIVED WASTE FOR VARIOUS ACTIVITIES IS DESCRIBED BELOW. PPE AND OTHER TRASH OR DEBRIS FROM WITHIN THE EXCLUSION ZONE SHALL BE DISPOSED SEPARATELY AS DIRECTED BY THE RADIATION SAFETY OFFICER.
2. CONTRACTORS SHALL PLACE IDW FROM THEIR SCOPE OF WORK INTO DRUMS OR A ROLL-OFF AS DIRECTED BY DE MAXIMIS.
3. IDW WILL BE TRANSPORTED BY CONTRACTORS TO THE ONSITE WASTE DISPOSAL AREA FOR OFFSITE TRANSPORTATION AND DISPOSAL BY DE MAXIMIS.

REV	DATE	DESCRIPTION	DRN	APP

de maximis, inc.

Geosyntec consultants

TITLE: GENERAL NOTES AND SPECIFICATIONS

PROJECT: 95% REMEDIAL DESIGN: IN SITU SEQUESTRATION OF URANIUM IN OVERBURDEN GROUNDWATER WITHIN THE HOLDING BASIN

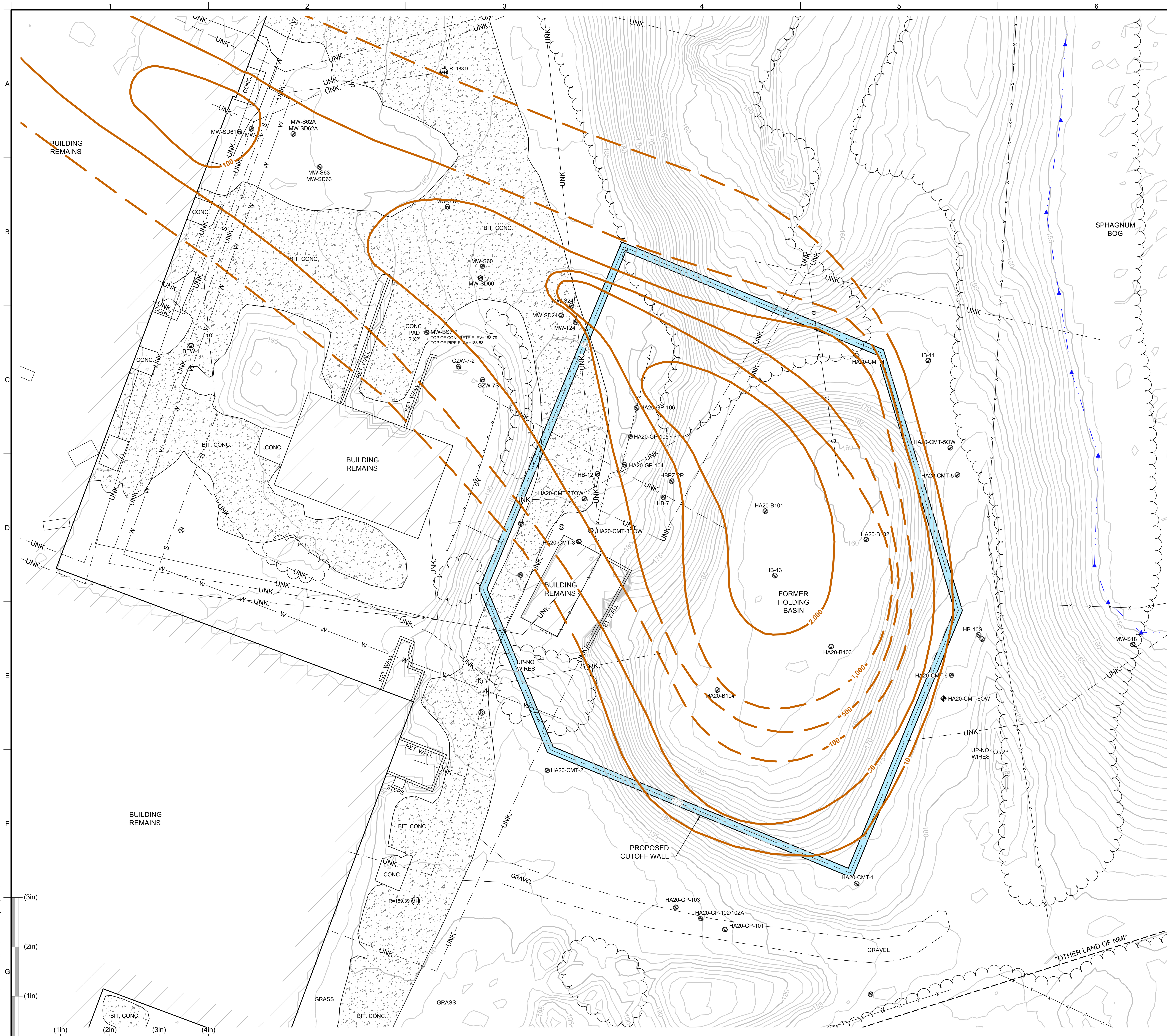
SITE: NUCLEAR METALS INC. SUPERFUND SITE CONCORD, MASSACHUSETTS

DRAFT

DESIGN BY:	GKW	DATE:	FEBRUARY 2024
DRAWN BY:	BEG	PROJECT NO.:	BR0090E
CHECKED BY:	DGJ	FILE:	BR0090C D002.DWG
REVIEWED BY:	CSM	DRAWING NO.:	
APPROVED BY:	CRE	2 OF 7	

(1in) (2in) (3in) (4in)

SCALE IS BASED ON 22" X 34" NON-REDUCED SHEET SIZE (BORDER = 21" X 32")



LEGEND

Symbol	Description
HB-11	MONITORING WELL
	UTILITY POLE
	CATCH BASIN
	DRAIN MANHOLE
	UTILITY MANHOLE
170	EXISTING GRADE ELEVATION - MAJOR CONTOUR
	EXISTING GRADE ELEVATION - MINOR CONTOUR
	PROPERTY LINE
	WETLAND BOUNDARY WITH FLAG
W	UTILITY - WATER LINE
D	UTILITY - DRAIN LINE
S	UTILITY - SEWER LINE
UNK.	UTILITY - UNKNOWN LINE
X	FENCE LINE
	GUARD RAIL
	TREE LINE
BIT. CONC.	ASPHALT ACCESS ROAD
GRAVEL	GRAVEL ACCESS ROAD
	PROPOSED CUTOFF WALL
1,000	URANIUM CONTOURS IN OVERBURDEN GROUNDWATER (µg/L) - APRIL 2023 (DASHED WHERE INFERRED)

N

NOTES

1. EXISTING CONDITIONS BASE MAP FROM DRAWING C-201, SHEET 2 OF 17, PROJECT NO. 131884, TITLED HOLDING BASIN GRADING WITH FEATURES, OF THE REMEDIAL DESIGN AOI 1 HOLDING BASIN 30% DESIGN, BY HALEY & ALDRICH, OF BOSTON MA., DATED 1/31/2022.
2. SURVEY FOR THE BASE MAP PREPARED BY FELDMAN LAND SURVEYORS, BETWEEN APRIL AND JUNE 2020.
   - HORIZONTAL CONTROL: MASSACHUSETTS STATE PLANE, NAD83, US SURVEY FEET
   - VERTICAL CONTROL: NGVD29
3. PROPOSED CUTOFF WALL ALIGNMENT IS PRELIMINARY AND BASED ON DRAWING PROVIDED BY HALEY & ALDRICH IN AUGUST 2023. ALIGNMENT MAY CHANGE AS THE CONTAINMENT DESIGN ADVANCES.

0 20 40
SCALE IN FEET

REV	DATE	DESCRIPTION	DRN	APP

de maximis, inc.

Geosyntec consultants

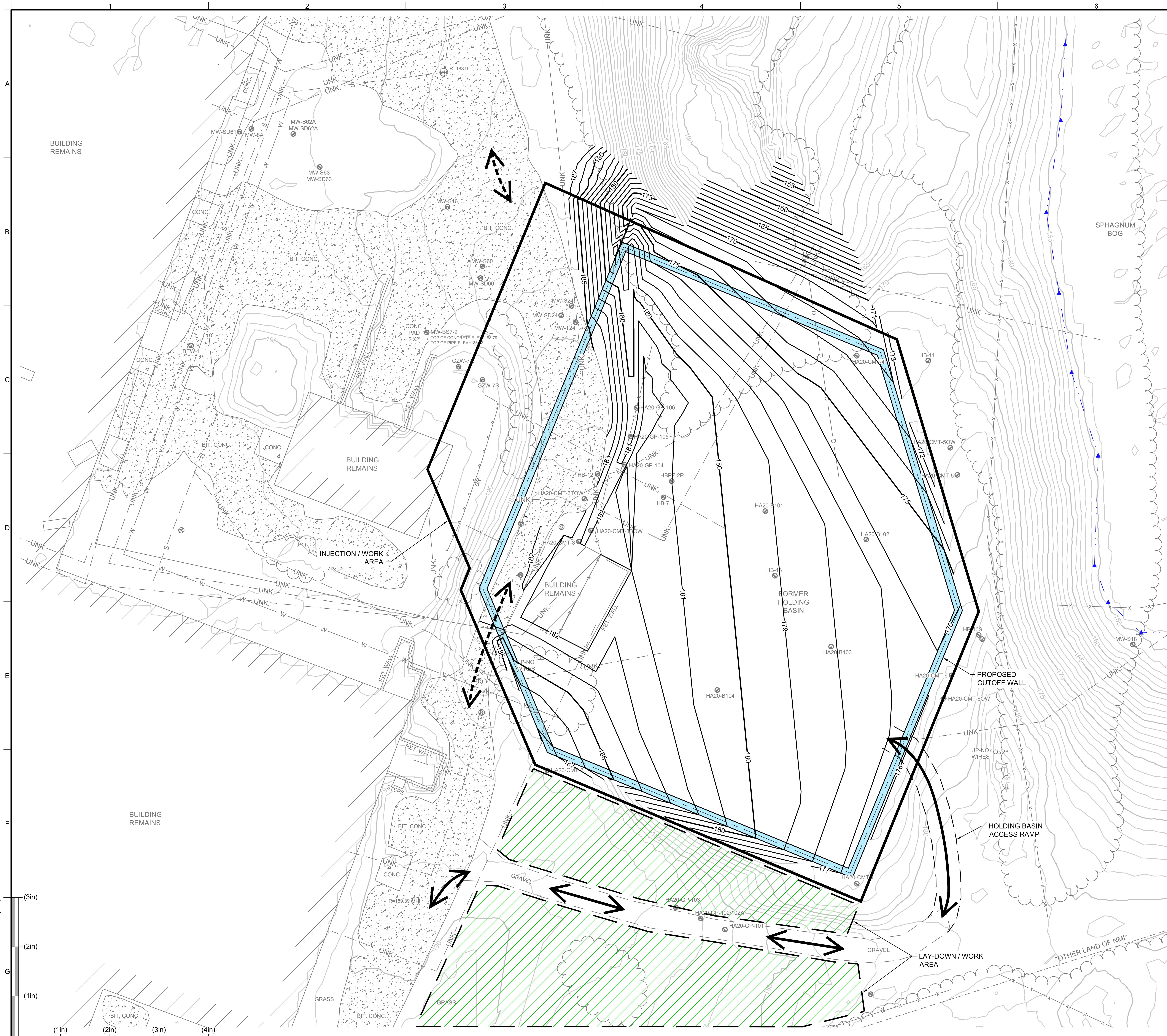
TITLE: PRE-ENABLING WORK CONDITIONS AND PROPOSED CUTOFF WALL

PROJECT: 95% REMEDIAL DESIGN: IN SITU SEQUESTRATION OF URANIUM IN OVERBURDEN GROUNDWATER WITHIN THE HOLDING BASIN

SITE: NUCLEAR METALS INC. SUPERFUND SITE CONCORD, MASSACHUSETTS

DRAFT

DESIGN BY:	GKW	DATE:	FEBRUARY 2024
DRAWN BY:	BEG	PROJECT NO.:	BR0090E
CHECKED BY:	DGJ	FILE:	BR0090C D003.DWG
REVIEWED BY:	CSM	DRAWING NO.:	
APPROVED BY:	CRE	3 OF 7	



LEGEND

Symbol	Description
HB-11	MONITORING WELL
	UTILITY POLE
	CATCH BASIN
	DRAIN MANHOLE
MH	UTILITY MANHOLE
170	EXISTING GRADE ELEVATION - MAJOR CONTOUR
	EXISTING GRADE ELEVATION - MINOR CONTOUR
170	INTERIM GRADE ELEVATION - MAJOR CONTOUR
169	INTERIM GRADE ELEVATION - MINOR CONTOUR
	PROPERTY LINE
	WETLAND BOUNDARY WITH FLAG
W	UTILITY - WATER LINE
D	UTILITY - DRAIN LINE
S	UTILITY - SEWER LINE
UNK.	UTILITY - UNKNOWN LINE
x	FENCE LINE
	GUARD RAIL
	TREE LINE
BIT. CONC.	ASPHALT ACCESS ROAD
GRAVEL	GRAVEL ACCESS ROAD
	PROPOSED CUTOFF WALL
	TRAFFIC FLOW DIRECTION
	ANTICIPATED TRAFFIC FLOW DIRECTION FOLLOWING ROAD CONSTRUCTION / MAINTENANCE
	PROPOSED ACCESS RAMP EXTENSION
	INJECTION / WORK AREA
	PROPOSED LAYDOWN / WORK AREA

N

NOTES

1. GRADES FOLLOWING ENABLING WORK BASED ON "INTERIM AS-BUILT PLAN" PROVIDED BY A-PLUS CONSTRUCTION SERVICES CORPORATION, DATED DECEMBER 20, 2023.
2. TRAFFIC FLOW MAY BE ADJUSTED PRIOR TO OR DURING WORK BASED ON SITE CONDITIONS AND ACTIVITIES.
3. IDW WILL BE HANDLED AT EACH INJECTION POINT.

0 20 40
SCALE IN FEET

REV	DATE	DESCRIPTION	DRN	APP

de maximis, inc.

Geosyntec consultants

TITLE: GRADES FOLLOWING ENABLING WORK AND WORK AREA

PROJECT: 95% REMEDIAL DESIGN: IN SITU SEQUESTRATION OF URANIUM IN OVERBURDEN GROUNDWATER WITHIN THE HOLDING BASIN

SITE: NUCLEAR METALS INC. SUPERFUND SITE CONCORD, MASSACHUSETTS

DRAFT

DESIGN BY:	GKW	DATE:	FEBRUARY 2024
DRAWN BY:	BEG	PROJECT NO.:	BR0090E
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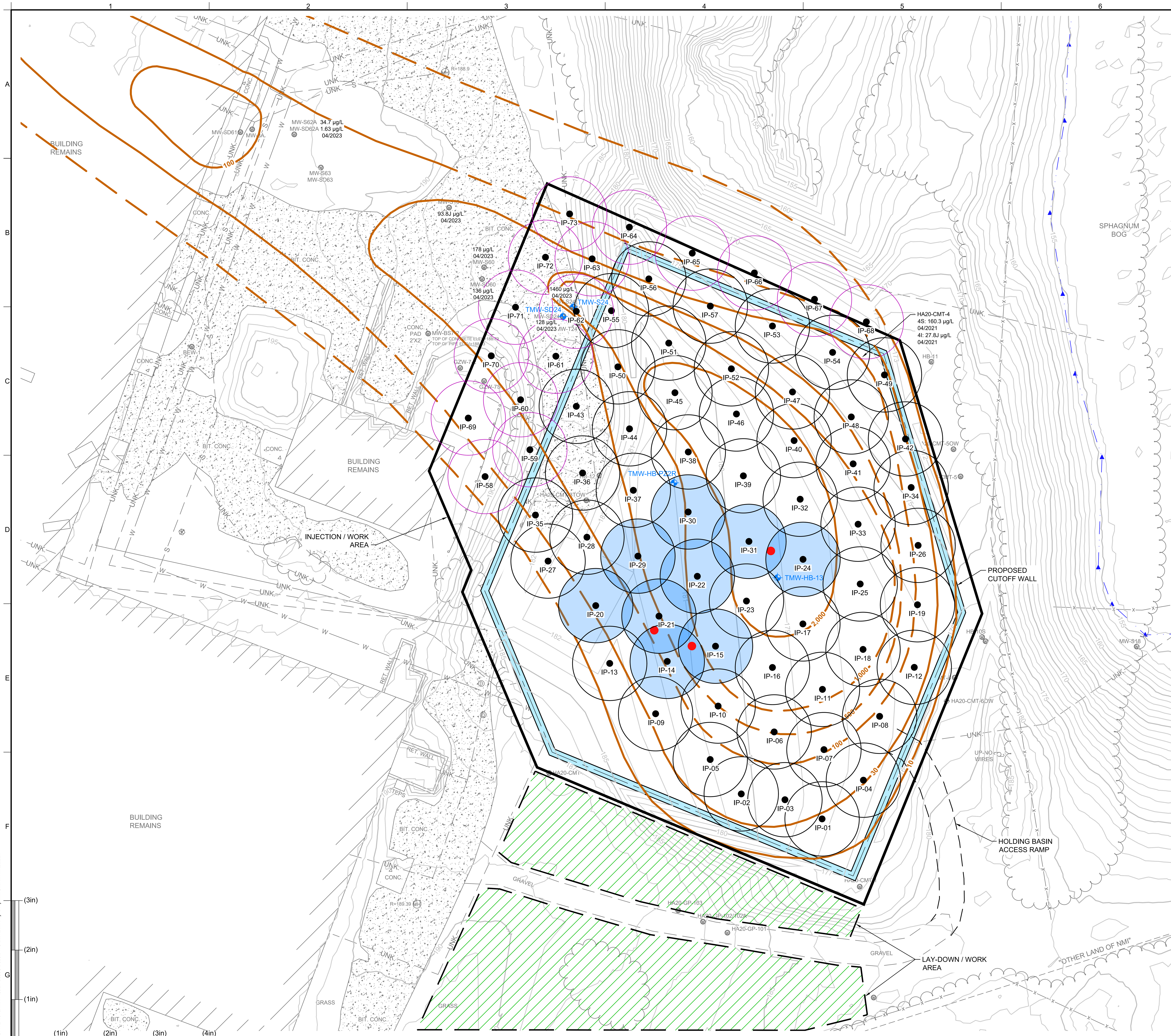
APPROVED BY:	CRE	4 OF 7	

(3in) (2in) (1in) (1in) (2in) (3in) (4in)

SCALE IS BASED ON 22" X 34" NON-REDUCED SHEET SIZE (BORDER = 21" X 32")

C:_GEOPWDS01\DMS11489\BR0090C D004.DWG Last Edited by: Benjamin.Girardet on 2/22/24

GEOSYNTEC-PW-01\DOCUMENTS\CLIENTS\NMI - NUCLEAR METALS INC\BR0090C - ISS REMEDIAL DESIGN - OVERBURDEN GROUNDWATER\CADD\01 - ISS DESIGN\DRAWINGS\SHEETS\BR0090C D004.DWG



LEGEND

- EXISTING MAJOR CONTOUR
- EXISTING MINOR CONTOUR
- PROPOSED CUTOFF WALL
- 1,000 — URANIUM CONTOURS IN OVERBURDEN GROUNDWATER (µg/L) - APRIL 2023 (DASHED WHERE INFERRED)
- HISTORICAL BORING LOCATIONS WHERE PRINCIPAL THREAT WASTE WAS ENCOUNTERED
- IP-01 — ISS RADIUS OF INFLUENCE OF 15 FEET
  - FILLED ROIs SHOW ISS INJECTIONS THAT EXTEND THROUGH UNSATURATED ZONE TO THE BASE OF THE FORMER HOLDING BASIN
  - PURPLE ROIs SHOW ISS IN APRON AREAS
  - BLACK DOT IS THE LOCATION OF CASED BORINGS FOR ISS
- INJECTION / WORK AREA
- PROPOSED LAYDOWN / WORK AREA
- TMW-SD24 — PROPOSED TEMPORARY MONITORING WELL

N

0 20 40
SCALE IN FEET

REV	DATE	DESCRIPTION	DRN	APP

de maximis, inc.

Geosyntec consultants

TITLE: PROPOSED CASED-HOLE INJECTION POINT LAYOUT

PROJECT: 95% REMEDIAL DESIGN: IN SITU SEQUESTRATION OF URANIUM IN OVERBURDEN GROUNDWATER WITHIN THE HOLDING BASIN

SITE: NUCLEAR METALS INC. SUPERFUND SITE CONCORD, MASSACHUSETTS

DRAFT

DESIGN BY:	GKW	DATE:	FEBRUARY 2024
DRAWN BY:	BEG	PROJECT NO.:	BR0090E
CHECKED BY:	DGJ	FILE:	BR0090C D005.DWG
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APPROVED BY:	CRE	5 OF 7	

SCALE IS BASED ON 22" X 34" NON-REDUCED SHEET SIZE (BORDER = 21" X 32")

GEOSYNTEC-PW-01\DOCUMENTS\CLIENTS\NMI - NUCLEAR METALS INC\BR0090C - ISS REMEDIAL DESIGN - OVERBURDEN GROUNDWATER\CADD\01 - ISS DESIGN\DRAWINGS\SHEETS\BR0090C D005.DWG

Cased Hole Injection Location			In-Situ Stabilization Target Treatment Zones																Injections		Amendment Quantity per Injection		Amendment Quantity per Location	
			Treatment Interval			Injection Elevations (bottom to top)																		
Location ID	Easting (ft)	Northing (ft)	Estimated Groundwater Elevation (ft NGVD29)	Top of treatment zone (ft NGVD29)	Estimated Top of Till (ft NGVD29)	Lowest (1st) Injection Interval (ft NGVD29)	2nd Interval (ft NGVD29)	3rd Interval (ft NGVD29)	4th Interval (ft NGVD29)	5th Interval (ft NGVD29)	6th Interval (ft NGVD29)	7th Interval (ft NGVD29)	8th Interval (ft NGVD29)	9th Interval (ft NGVD29)	10th Interval (ft NGVD29)	11th Interval (ft NGVD29)	12th Interval (ft NGVD29)	13th Plus Intervals (ft NGVD29)	Top of Injection Interval (ft NGVD29)	Injection Depth Spacing (ft)	Number of Injection Depths	Sand (lbs)	mZVI (lbs)	Sand (lbs)	mZVI (lbs)
ISS Locations Within Vertical Barrier Wall Alignment																									
IP-01	677764.1	2985742.6	139	142	115.4	120.9	123.9	126.9	129.9	132.9	135.9	138.9	141.9						141.9	3	8	-	2,750	-	22,000
IP-02	677731.4	2985752.7	139	142	115.7	121.2	124.2	127.2	130.2	133.2	136.2	139.2							139.2	3	7	-	2,750	-	19,250
IP-03	677749.1	2985750.3	139	142	115.3	119.3	122.3	125.3	128.3	131.3	134.3	137.3	140.3						140.3	3	8	-	2,750	-	22,000
IP-04	677780.8	2985758.3	139	142	112.5	116.5	119.5	122.5	125.5	128.5	131.5	134.5	137.5	140.5					140.5	3	9	-	2,750	-	24,750
IP-05	677716.8	2985769.1	139	142	114.9	118.9	121.9	124.9	127.9	130.9	133.9	136.9	139.9						139.9	3	8	-	2,750	-	22,000
IP-06	677744.8	2985777.7	139	142	113.3	117.3	120.3	123.3	126.3	129.3	132.3	135.3	138.3	141.3					141.3	3	9	-	2,750	-	24,750
IP-07	677764.9	2985770.6	139	142	112.9	118.4	121.4	124.4	127.4	130.4	133.4	136.4	139.4						139.4	3	8	-	2,750	-	22,000
IP-08	677787.3	2985784.0	139	142	109.6	115.1	118.1	121.1	124.1	127.1	130.1	133.1	136.1	139.1					139.1	3	9	-	2,750	-	24,750
IP-09	677696.9	2985785.1	139	142	115.8	121.3	124.3	127.3	130.3	133.3	136.3	139.3							139.3	3	7	-	2,750	-	19,250
IP-10	677722.1	2985788.2	139	142	112.6	116.6	119.6	122.6	125.6	128.6	131.6	134.6	137.6	140.6					140.6	3	9	-	2,750	-	24,750
IP-11	677764.3	2985794.9	139	142	112.0	116.0	119.0	122.0	125.0	128.0	131.0	134.0	137.0	140.0					140.0	3	9	-	2,750	-	24,750
IP-12	677801.4	2985803.8	139	142	105.4	109.4	112.4	115.4	118.4	121.4	124.4	127.4	130.4	133.4	136.4	139.4			139.4	3	11	-	2,750	-	30,250
IP-13	677678.3	2985805.4	139	142	114.4	119.9	122.9	125.9	128.9	131.9	134.9	137.9	140.9						140.9	3	8	-	2,750	-	22,000
IP-14	677701.5	2985806.2	139	160	114.3	118.3	121.3	124.3	127.3	130.3	133.3	136.3	139.3	142.3	145.3	148.3	151.3	every 3 ft to =>	157.3	3	14	-	2,750	-	38,500
IP-15	677721.1	2985812.4	139	160	114.0	119.5	122.5	125.5	128.5	131.5	134.5	137.5	140.5	143.5	146.5	149.5	152.5	every 3 ft to =>	158.5	3	14	-	2,750	-	38,500
IP-16	677744.1	2985803.8	139	142	112.9	118.4	121.4	124.4	127.4	130.4	133.4	136.4	139.4						139.4	3	8	-	2,750	-	22,000
IP-17	677756.4	2985821.4	139	142	112.2	116.2	119.2	122.2	125.2	128.2	131.2	134.2	137.2	140.2					140.2	3	9	-	2,750	-	24,750
IP-18	677780.7	2985811.1	139	142	109.1	113.1	116.1	119.1	122.1	125.1	128.1	131.1	134.1	137.1	140.1				140.1	3	10	-	2,750	-	27,500
IP-19	677802.6	2985829.1	139	142	103.2	108.7	111.7	114.7	117.7	120.7	123.7	126.7	129.7	132.7	135.7	138.7	141.7		141.7	3	12	-	2,750	-	33,000
IP-20	677672.7	2985828.8	139	182	110.3	114.3	117.3	120.3	123.3	126.3	129.3	132.3	135.3	138.3	141.3	144.3	147.3	every 3 ft to =>	182.0	3	23	-	2,750	-	63,250
IP-21	677698.2	2985824.6	139	160	112.3	117.8	120.8	123.8	126.8	129.8	132.8	135.8	138.8	141.8	144.8	147.8	150.8	every 3 ft to =>	159.8	3	15	-	2,750	-	41,250
IP-22	677713.7	2985840.7	139	166	113.1	117.1	120.1	123.1	126.1	129.1	132.1	135.1	138.1	141.1	144.1	147.1	150.1	every 3 ft to =>	166.0	3	17	-	2,750	-	46,750
IP-23	677733.5	2985830.7	139	142	113.6	119.1	122.1	125.1	128.1	131.1	134.1	137.1	140.1						140.1	3	8	-	2,750	-	22,000
IP-24	677756.4	2985847.5	139	160	109.3	114.8	117.8	120.8	123.8	126.8	129.8	132.8	135.8	138.8	141.8	144.8	147.8	every 3 ft to =>	159.8	3	16	-	2,750	-	44,000
IP-25	677779.5	2985837.6	139	142	106.9	110.9	113.9	116.9	119.9	122.9	125.9	128.9	131.9	134.9	137.9	140.9			140.9	3	11	-	2,750	-	30,250
IP-26	677802.9	2985853.1	139	142	101.7	107.0	110.0	113.0	116.0	119.0	122.0	125.0	128.0	131.0	134.0	137.0	140.0		140.0	3	12	-	2,750	-	33,000
IP-27	677653.4	2985846.8	139	142	109.8	115.3	118.3	121.3	124.3	127.3	130.3	133.3	136.3	139.3					139.3	3	9	-	2,750	-	24,750
IP-28	677669.1	2985856.4	139	142	106.2	110.2	113.2	116.2	119.2	122.2	125.2	128.2	131.2	134.2	137.2	140.2			140.2	3	11	-	2,750	-	30,250
IP-29	677689.7	2985848.8	139	178	108.4	113.9	116.9	119.9	122.9	125.9	128.9	131.9	134.9	137.9	140.9	143.9	146.9	every 3 ft to =>	178.0	3	22	-	2,750	-	60,500
IP-30	677710.0	2985866.6	139	174	109.7	115.2	118.2	121.2	124.2	127.2	130.2	133.2	136.2	139.2	142.2	145.2	148.2	every 3 ft to =>	174.0	3	20	-	2,750	-	55,000
IP-31	677734.6	2985854.7	139	160	111.3	115.3	118.3	121.3	124.3	127.3	130.3	133.3	136.3	139.3	142.3	145.3	148.3	every 3 ft to =>	157.3	3	15	-	2,750	-	41,250
IP-32	677755.3	2985871.8	139	142	107.2	111.2	114.2	117.2	120.2	123.2	126.2	129.2	132.2	135.2	138.2	141.2			141.2	3	11	-	2,750	-	30,250
IP-33	677778.7	2985861.7	139	142	104.7	110.2	113.2	116.2	119.2	122.2	125.2	128.2	131.2	134.2	137.2	140.2			140.2	3	11	-	2,750	-	30,250
IP-34	677800.1	2985876.5	139	142	100.6	106.1	109.1	112.1	115.1	118.1	121.1	124.1	127.1	130.1	133.1	136.1	139.1		139.1	3	12	-	2,750	-	33,000
IP-35	677648.3	2985865.4	139	142	108.8	114.3	117.3	120.3	123.3	126.3	129.3	132.3	135.3	138.3	141.3				141.3	3	10	-	2,750	-	27,500
IP-36	677667.3	2985882.4	139	142	106.4	111.9	114.9	117.9	120.9	123.9	126.9	129.9	132.9	135.9	138.9	141.9			141.9	3	11	-	2,750	-	30,250
IP-37	677687.9	2985875.4	139	142	105.6	109.6	112.6	115.6	118.6	121.6	124.6	127.6	130.6	133.6	136.6	139.6			139.6	3	11	-	2,750	-	30,250
IP-38	677710.1	2985890.9	139	142	109.3	113.3	116.3	119.3	122.3	125.3	128.3	131.3	134.3	137.3	140.3				140.3	3	10	-	2,750	-	27,500
IP-39	677732.3	2985881.3	139	142	109.2	114.7	117.7	120.7	123.7	126.7	129.7	132.7	135.7	138.7	141.7				141.7	3	10	-	2,750	-	27,500
IP-40	677752.8	2985895.5	139	142	105.1	110.6	113.6	116.6	119.6	122.6	125.6	128.6	131.6	134.6	137.6	140.6			140.6	3	11	-	2,750	-	30,250
IP-41	677776.6	2985886.1	139	142	103.1	107.1	110.1	113.1	116.1	119.1	122.1	125.1	128.1	131.1	134.1	137.1	140.1		140.1	3	12	-	2,750	-	33,000
IP-42	677797.8	2985896.1	139	142	99.6	103.6	106.6	109.6	112.6	115.6	118.6	121.6	124.6	127.6	130.6	133.6	136.6	139.6	139.6	3	13	-	2,750	-	35,750
IP-43	677664.8	2985909.4	139	142	106.8	110.8	113.8	116.8	119.8	122.8	125.8	128.8	131.8	134.8	137.8	140.8			140.8	3	11	-	2,750	-	30,250
IP-44	677686.3	2985900.3	139	142	106.0	111.5	114.5	117.5	120.5	123.5	126.5	129.5	132.5	135.5	138.5	141.5			141.5	3	11	-	2,750	-	30,250
IP-45	677704.7	2985914.9	139	142	104.1	109.6	112.6	115.6	118.6	121.6	124.6	127.6	130.6	133.6	136.6	139.6			139.6	3	11	-	2,750	-	30,250
IP-46	677729.5	2985906.2	139	142	105.5	109.5	112.5	115.5	118.5	121.5	124.5	127.5	130.5	133.5	136.5	139.5			139.5	3	11	-	2,750	-	30,250
IP-47	677752.1	2985915.1	139	142	102.9	106.9	109.9	112.9	115.9	118.9	121.9	124.9	127.9	130.9	133.9	136.9	139.9		139.9	3	12	-	2,750	-	33,000
IP-48	677775.9	2985905.0	139	142	101.7	108.0	111.0	114.0	117.0	120.0	123.0	126.0	129.0	132.0	135.0	138.0	141.0		141.0	3	12	-	2,750	-	33,000
IP-49	677789.3	2985922.0	139	142	99.6	105.0	108.0	111.0	114.0	117.0	120.0	123.0	126.0	129.0	132.0	135.0	138.0	141.0	141.0	3	13	-	2,750	-	35,750
IP-50	677681.6	2985925.3	139	142	105.4	109.4	112.4	115.4	118.4	121.4	124.4	127.4	130.4	133.4	136.4	139.4			139.4	3	11	-	2,750	-	30,250
IP-51	677702.2	2985934.9	139	142	103.8	108.5	111.5	114.5	117.5	120.5	123.5	126.5	129.5	132.5	135.5	138.5	141.5		141.5	3	12	-	2,750	-	33,000
IP-52	677727.5	2985924.5	139	142	102.5	108.0	111.0	114.0	117.0	120.0	123.0	126.0	129.0	132.0	135.0	138.0	141.0		141.0	3	12	-	2,750	-	33,000
IP-53	677744.1	2985941.8	139	142	101.2	105.2	108.2	111.2	114.2	117.2	120.2	123.2	126.2	129.2	132.2	135.2	138.2	141.2	141.2	3	13	-	2,750	-	35,750
IP-54	677768.4	2985931.1	139	142	100.5	106.0	109.0	112.0	115.0	118.0	121.0	124.0	127.0	130.0	133.0	136.0	139.0	142.0	142.0	3	13	-	2,750	-	35,750
IP-55	677679.0	2985948.0	139	142	104.2	109.7	112.7	115.7	118.7	121.7	124.7	127.7	130.7	133.7	136.7	139.7			139.7	3	11	-	2,750	-	30,250
IP-56	677694.1	2985960.8	139	142	103.0	107.0	110.0	113.0	116.0	119.0	122.0	125.0	128.0	131.0	134.0	137.0	140.0		140.0	3	12	-	2,750	-	33,000
IP-57	677719.0	2985949.8	139	142	102.0	107.5	110.5	113.5	116.5	119.5	122.5	125.5	128.5	131.5	134.5	137.5	140.5		140.5	3	12	-	2,750	-	33,000
																				Total within VBW	655	-	-	-	1,801,250
ISS Locations in Apron Areas																									
IP-58	677628.0	2985880.9	139	142	110.6	114.6	117.6	120.6	123.6	126.6	129.6	132.6	135.6	138.6	141.6				141.6	3	10	-	2,750	-	27,500
IP-59	677646.1	2985891.8	139	142	107.8	111.8	114.8	117.8	120.8	123.8	126.8	129.8	132.8	135.8	138.8	141.8			141.8	3	11	-	2,750	-	30,250
IP-60	677642.3	2985912.0	139	142	108.0	113.5	116.5	119.5	122.5	125.5	128.5	131.5	134.5	137.5	140.5				140.5	3	10	-	2,750	-	27,500
IP-61	677656.6	2985929.6	139	142	107.0	112.5	115.5	118.5	121.5	124.5	127.5	130.5	133.5	136.5	139.5				139.5	3	10	-	2,750	-	27,500
IP-62	677664.8	2985947.7	139	142	105.1	109.1	112.1	115.1	118.1	121.1	124.1	127.1	130.1	133.1	136.1	139.1			139.1	3	11	-	2,750	-	30,250
IP-63	677671.2	2985968.9	139	142	104.0	109.5	112.5	115.5	118.5	121.5	124.5	127.5	130.5	133.5	136.5	139.5			139.5	3	11	-	2,750	-	30,250
IP-64	677686.2	2985981.8	139	142	104.0	108.0	111.0	114.0	117.0	120.0	123.0	126.0	129.0	132.0	135.0	138.0	141.0		141.0	3	12	-	2,750	-	33,000
IP-65	677711.6	2985971.3	139	142	102.7	108.9	111.9	114.9	117.9	120.9	123.9	126.9	129.9	132.9	135.9	138.9	141.9		141.9	3	12	-	2,750	-	33,000
IP-66	677736.7	2985963.2	139	142	101.8	105.8	108.8	111.8	114.8	117.8	120.8	123.8	126.8	129.8	132.8	135.8	138.8	141.8	141.8	3	13	-	2,750	-	35,750
IP-67	677761.1	2985952.6	139	142	100.9	106.4	109.4	112.4	115.4	118.4	121.4	124.4	127.4	130.4	133.4	136.4	139.4		139.4	3	12	-	2,750	-	33,000
IP-68	677782.0	2985943.5	139	142	100.2	104.2	107.2	110.2	113.2	116.2	119.2	122.2	125.2	128.2	131.2	134.2	137.2	140.2	140.2	3	13	-	2,750	-	35,750
IP-69	677621.2	2985904.6	139	142	109.7	115.2	118.2	121.2	124.2	127.2	130.2	133.2	136.2	139.2					139.2	3	9	-	2,750	-	24,750
IP-70	677630.5	2985929.7	139	142	108.5	114.0	117.0	120.0	123.0	126.0	129.0	132.0	135.0	138.0	141.0				141.0	3	10	-	2,750	-	27,500
IP-71	677640.3	2985949.4	139	142	106.3	111.8	114.8	117.8	120.8	123.8	126.8	129.8	132.8	135.8	138.8	141.8			141.8	3	11	-	2,750	-	30,250
IP-72	677652.3	2985969.6	139	142	104.8	108.8	111.8	114.8	117.8	120.8	123.8	126.8	129.8	132.8	135.8	138.8	141.8		141.8	3	12	-	2,750	-	33,000
IP-73	677662.1	2985987.1	139	142	105.7	111.2	114.2	117.2	120.2	123.2	126.2	129.2	132.2	135.2	138.2	141.2			141.2	3	11	-	2,750	-	30,250
																				Total for Apron Areas	178	-	-	-	489,500
																				Total for ISS Program	833	-	-	-	2,290,750

NOTES:

1. ABBREVIATIONS: FT - FEET, LBS - POUNDS, mZVI - MICROSCALE ZERO VALENT IRON
2. TREATMENT ZONE THICKNESS IS FROM 4 FT ABOVE TILL TO 3 FT ABOVE THE WATER TABLE.
3. AVERAGE TILL ELEVATION IS 108 FEET BASED ON INTERPOLATION OF 25 BORINGS TO TILL IN AND AROUND THE HOLDING BASIN.
4. TREATMENT ZONE THICKNESS ASSUMES A GROUNDWATER ELEVATION = 139 FT WHICH IS THE AVERAGE GROUNDWATER ELEVATION MEASURED AT OVERBURDEN WELLS AROUND THE HOLDING BASIN IN APRIL 2022.
5. MASS OF mZVI SPECIFIED IS EQUIVALENT TO 1.5% BY MASS OF DRY SOIL IN THE SATURATED ZONE IN THE TREATMENT INTERVAL (SEE CALCULATION 3-1). THIS DOSING WAS DETERMINED IN THE TREATABILITY TESTING AND MATCHES WHAT WAS IMPLEMENTED FOR THE ISS PILOT TEST USING mZVI.
6. THE FRACTURE DEPTHS ARE ADJUSTED BY 1.5 VERTICAL FEET BETWEEN ADJACENT ISS LOCATIONS, TO THE EXTENT FEASIBLE, TO PROVIDE BETTER VERTICAL COVERAGE.
7. GRAY SHADING INDICATES ISS LOCATIONS TREATING PRINCIPAL THREAT WASTE. ISS EXTENDS THROUGH THE UNSATURATED ZONE TO THE BOTTOM OF THE HOLDING BASIN (PRIOR TO BACKFILLING).
8. PRESCRIBED QUANTITIES OF mZVI PER FRACTURE ARE ROUNDED UP TO WEIGHTS THAT MAKE THE PROGRAM MORE IMPLEMENTABLE IN THE FIELD (I.E., 2,750 LBS/FRACTURE INSTEAD OF 2,734 LBS).

REV	DATE	DESCRIPTION	DRN	APP

de maximis, inc.

Geosyntec consultants

TITLE: INJECTION SUMMARY TABLE

PROJECT: 95% REMEDIAL DESIGN: IN SITU SEQUESTRATION OF URANIUM IN OVERBURDEN GROUNDWATER WITHIN THE HOLDING BASIN

SITE: NUCLEAR METALS INC. SUPERFUND SITE CONCORD, MASSACHUSETTS

DRAFT

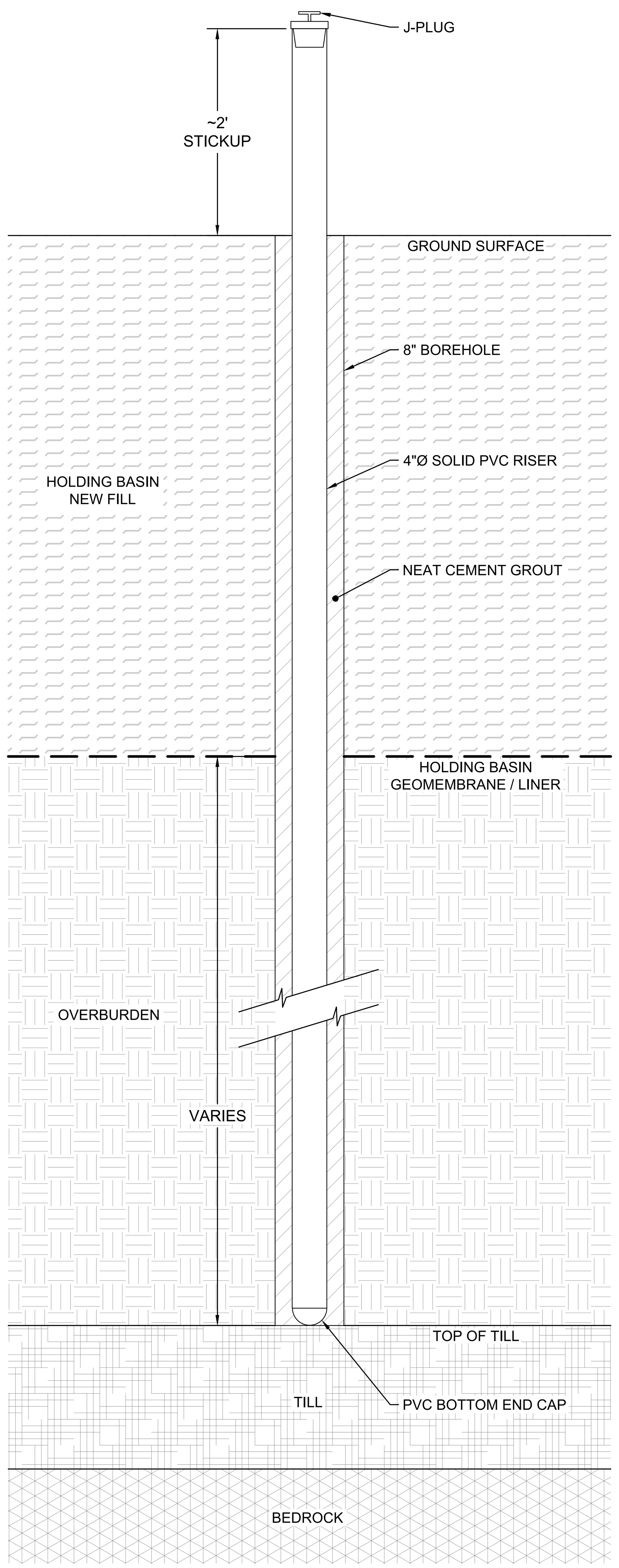
DESIGN BY:	GKW	DATE:	FEBRUARY 2024
DRAWN BY:	BEG	PROJECT NO.:	BR0090E
CHECKED BY:	DGJ	FILE:	BR0090C D006.DWG
REVIEWED BY:	CSM	DRAWING NO.:	
APPROVED BY:	CRE	6 OF 7	

(1in) (2in) (3in) (4in)

SCALE IS BASED ON 22" X 34" NON-REDUCED SHEET SIZE (BORDER = 21" X 32")

C:_GEOPW\DS01\DMS11489\BR0090C D006.DWG Last Edited by: Benjamin Girardet on 10/18/23

GEOSYNTEC-PW-01\DOCUMENTS\CLIENTS\NMI - NUCLEAR METALS INC\BR0090C - ISS REMEDIAL DESIGN - OVERBURDEN GROUNDWATER\CADD\01 - ISS DESIGN\DRAWINGS\SHEETS\BR0090C D006.DWG

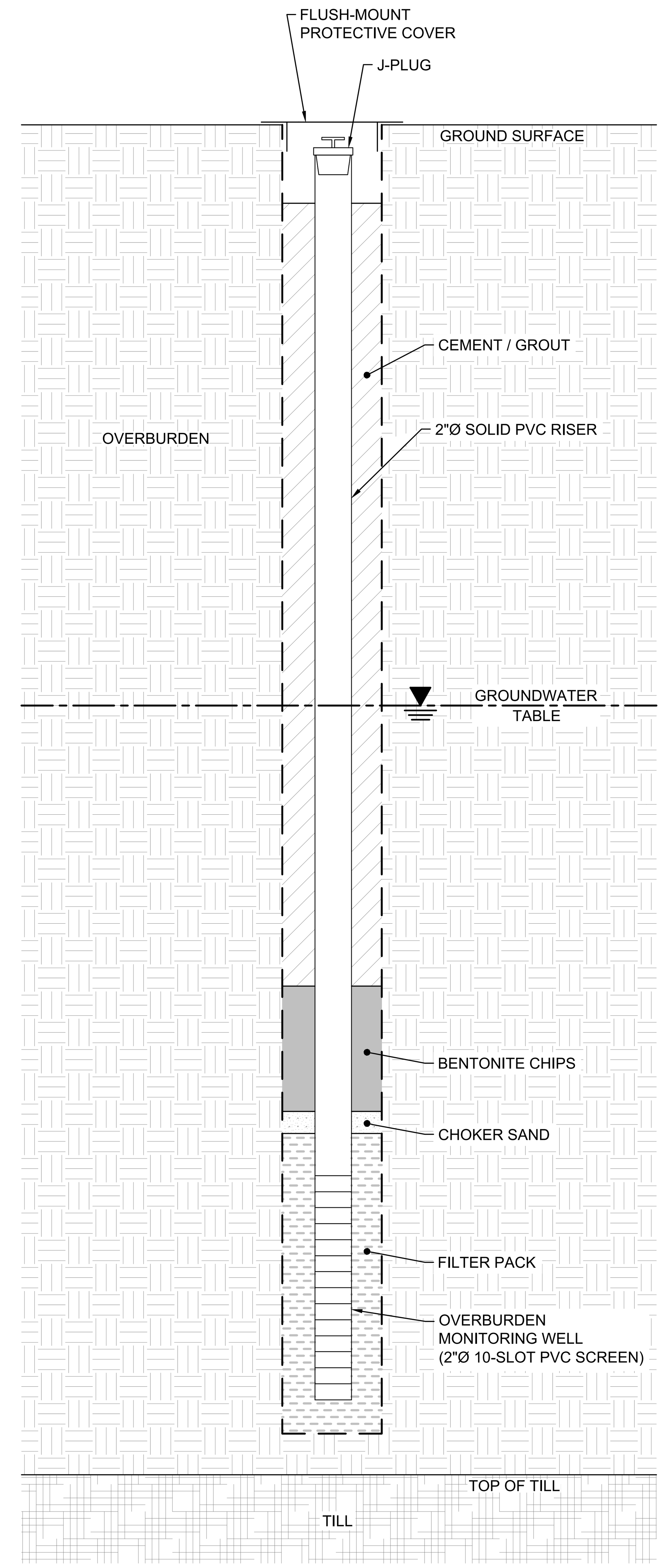


1/5 CASED-HOLE CONSTRUCTION DETAIL

SCALE: NTS
FILE: BR0090C DET001

NOTES

1. THE INJECTION POINT SHALL BE CONSTRUCTED WITH A SCHEDULE 40 PVC CASING WITH A BOTTOM END CAP.
2. THE CASING SHALL BE FINISHED WITH APPROXIMATELY A 2-FOOT STICK-UP.
3. SEE SOP-GW-003 FOR INSTRUCTIONS ON CASING INSTALLATION AND GROUTING.
4. CENTRALIZERS SHALL BE INSTALLED APPROXIMATELY EVERY 10 FEET ALONG THE PVC RISER OR IN ACCORDANCE WITH THE MANUFACTURER'S SPECIFICATIONS.



2/-- TEMPORARY MONITORING WELL CONSTRUCTION DETAIL

SCALE: NTS
FILE: BR0090C DET002

NOTES

1. TEMPORARY MONITORING WELLS TO BE INSTALLED AFTER THE ISS INJECTIONS.
2. TEMPORARY MONITORING WELL SCREEN ELEVATIONS (SHOWN IN NATIONAL GEODETIC VERTICAL DATUM OF 1929 - NGVD29) PROVIDED IN TABLE BELOW.

Temporary Monitoring Well ID	Screen	
	Top Elevation (feet)	Bottom Elevation (feet)
TMW-HB-13	132.4	122.4
TMW-HB-PZ2R	138.82	123.82
TMW-S24	131.9	121.9
TMW-SD24	119.46	109.46

(1in) (2in) (3in) (4in)
SCALE IS BASED ON 22" X 34" NON-REDUCED SHEET SIZE (BORDER = 21" X 32")

REV	DATE	DESCRIPTION	DRN	APP

de maximis, inc.
Geosyntec consultants

TITLE: DETAILS

PROJECT: 95% REMEDIAL DESIGN: IN SITU SEQUESTRATION OF URANIUM IN OVERBURDEN GROUNDWATER WITHIN THE HOLDING BASIN

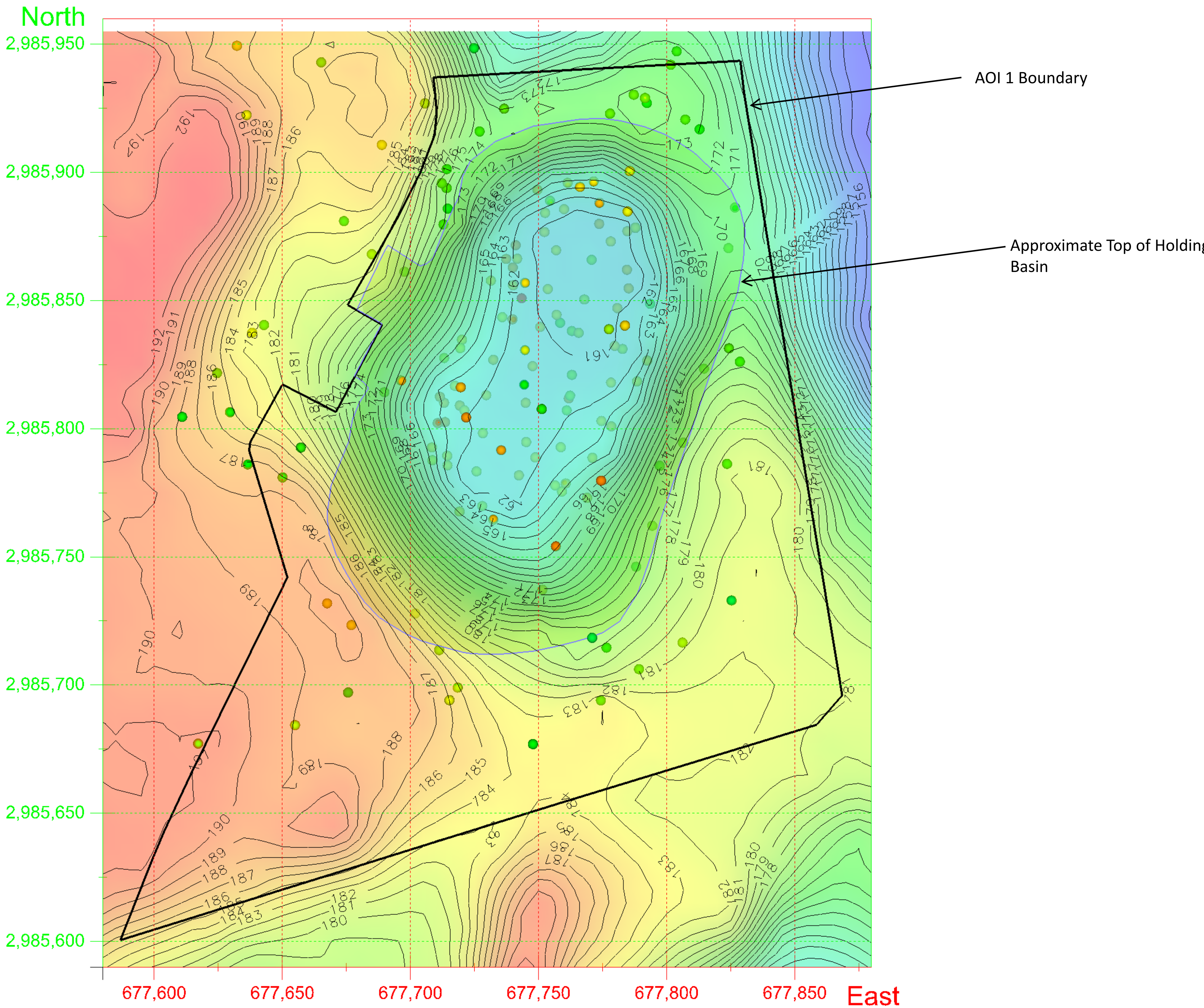
SITE: NUCLEAR METALS INC. SUPERFUND SITE CONCORD, MASSACHUSETTS

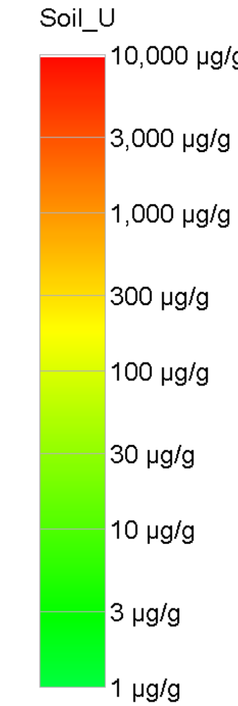
DRAFT

DESIGN BY:	GKW	DATE:	FEBRUARY 2024
DRAWN BY:	BEG	PROJECT NO.:	BR0090E
CHECKED BY:	DGJ	FILE:	BR0090C D007.DWG
REVIEWED BY:	CSM	DRAWING NO.:	
APPROVED BY:	CRE	7 OF 7	

Attachment 2

Distribution of Uranium in Soils beneath the Holding Basin
(from the 2014 Remedial Investigation)





The colors in the legend above are for the dots showing where soil samples were collected. Shading and contours on the figure are used to show ground surface topography in feet.

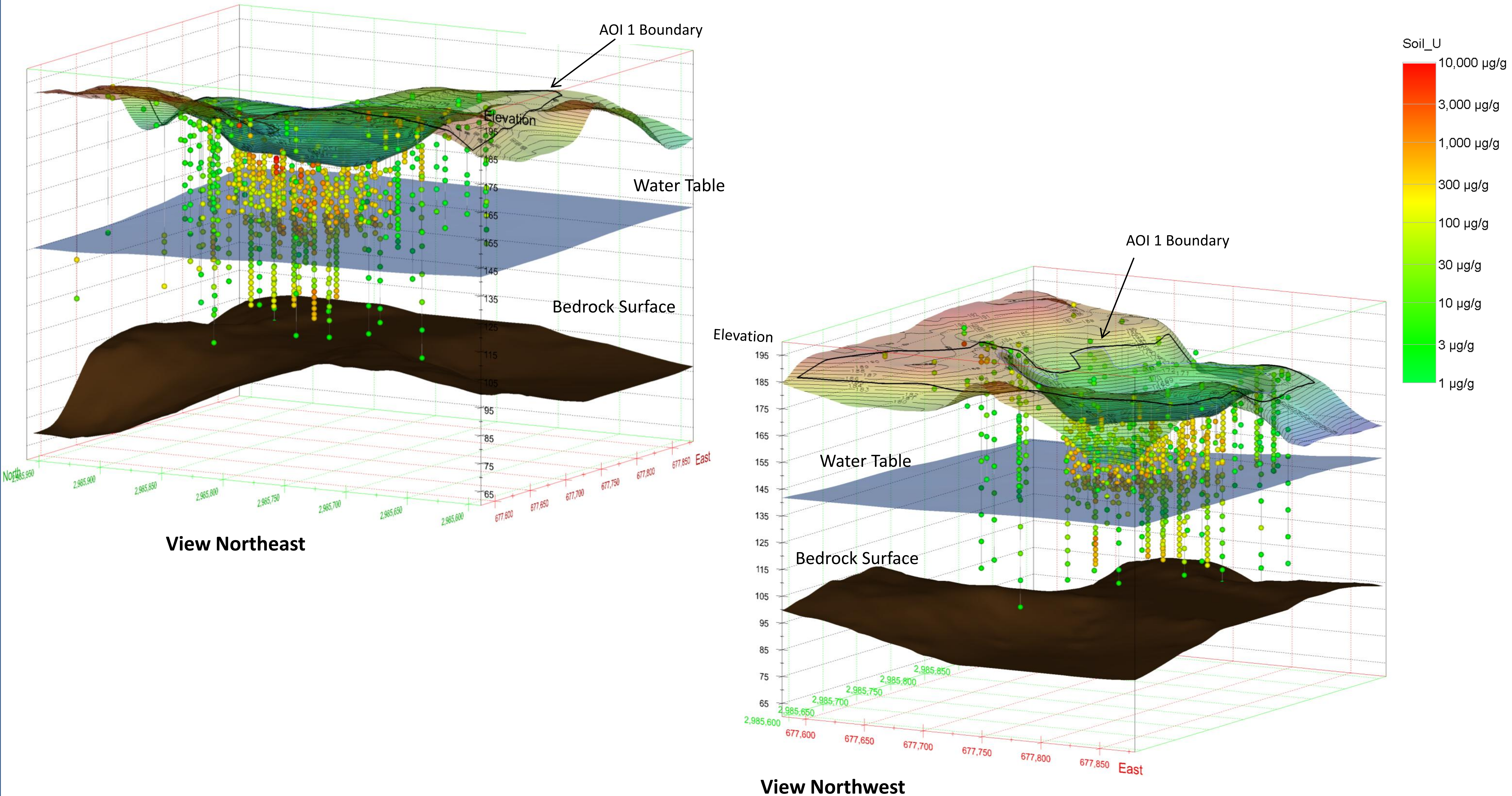
Coordinates in State Plane feet
Red-colored axis denotes easting coordinates
Green-colored axis denotes northing coordinates
Vertical exaggeration= 2:1
Geologic layers are translucent

Depleted Uranium in Soil in AOI 1
Topography and Soil Sampling Locations
Nuclear Metals Superfund Site
Concord, Massachusetts

Geosyntec consultants

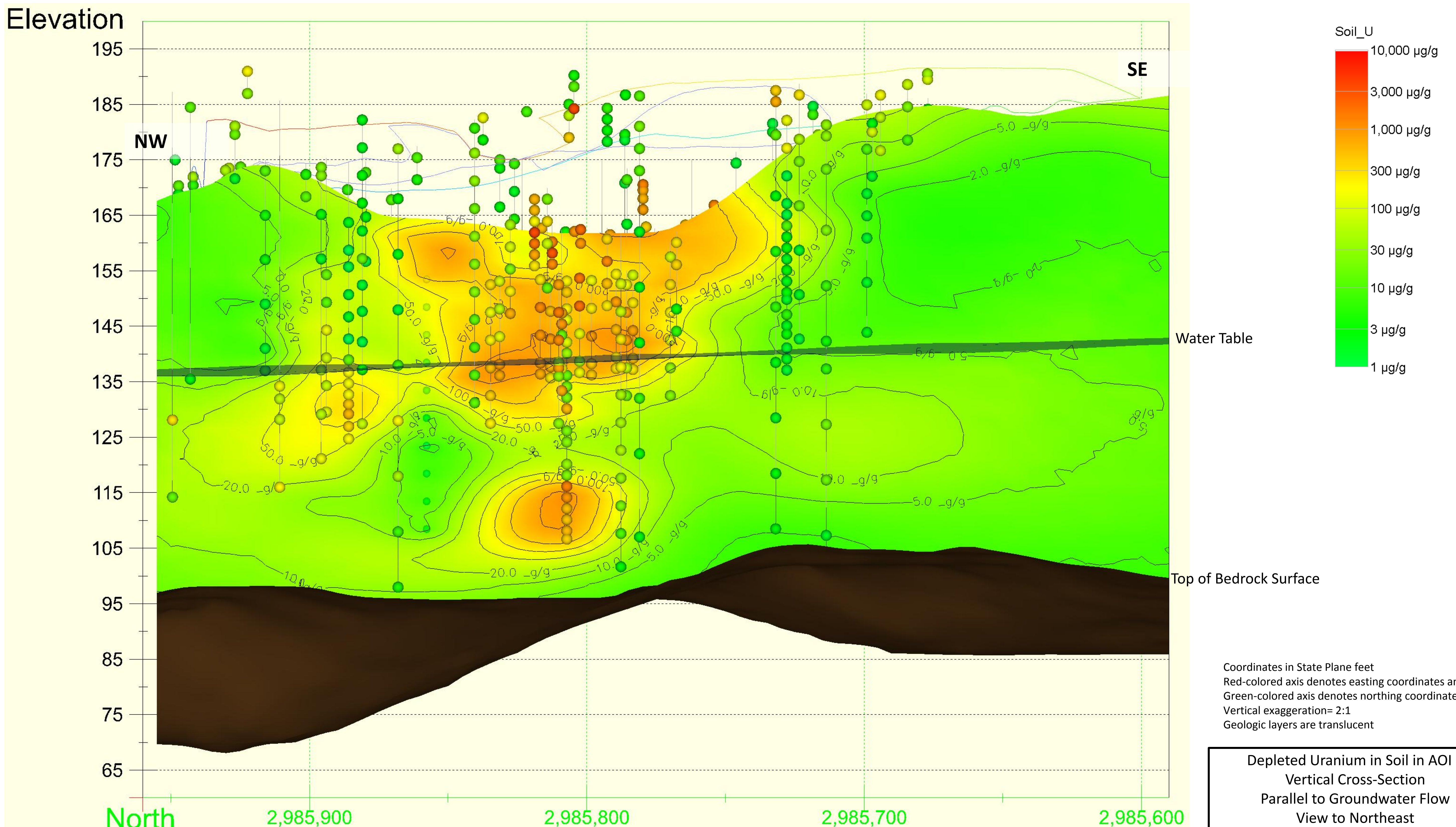
ACTON, MASSACHUSETTS | OCTOBER 2010

Figure 4.9.40



Coordinates in State Plane feet
Red-colored axis denotes easting coordinates
Green-colored axis denotes northing coordinates
Vertical exaggeration= 2:1
Geologic layers are translucent
Contour Interval 10 foot

Depleted Uranium in Soil in AOI 1 Boring and Soil Sampling Locations Nuclear Metals Superfund Site Concord, Massachusetts		
Geosyntec consultants		Figure 4.9.41
ACTON, MASSACHUSETTS	OCTOBER 2010	



Coordinates in State Plane feet
Red-colored axis denotes easting coordinates and
Green-colored axis denotes northing coordinates
Vertical exaggeration= 2:1
Geologic layers are translucent

Depleted Uranium in Soil in AOI 1
Vertical Cross-Section
Parallel to Groundwater Flow
View to Northeast
Nuclear Metals Superfund Site
Concord, Massachusetts

Geosyntec consultants

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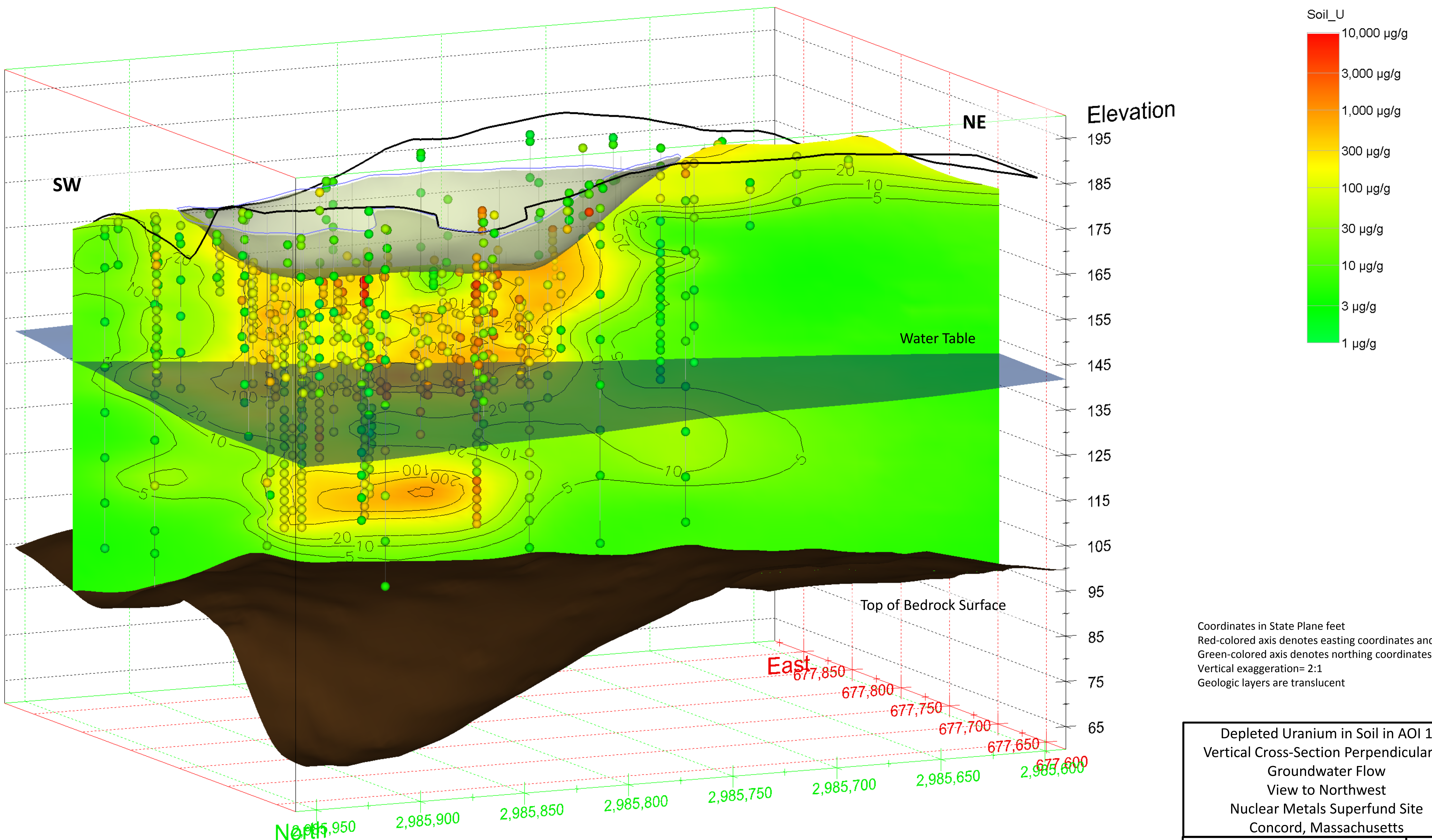
Figure 4.9.42



Coordinates in State Plane feet
Red-colored axis denotes easting coordinates and
Green-colored axis denotes northing coordinates
Vertical exaggeration= 2:1
Geologic layers are translucent

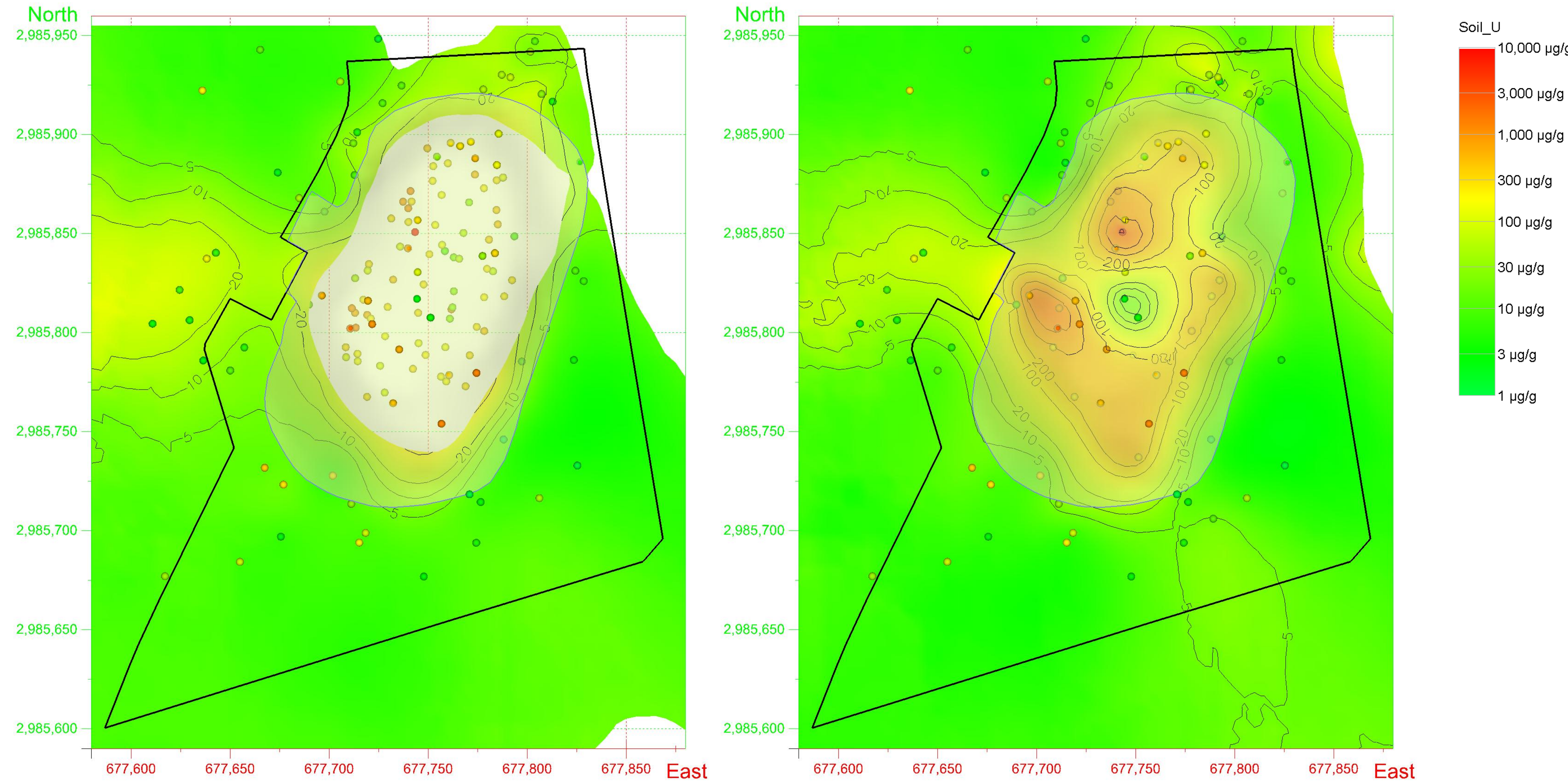
Opaque white shading represents air space above the base of the holding basin

Depleted Uranium in Soil in AOI 1
Vertical Cross-Section Perpendicular to Groundwater Flow
View to Northwest
Nuclear Metals Superfund Site
Concord, Massachusetts

Geosyntec consultants

Figure 4.9.43

ACTON, MASSACHUSETTS | OCTOBER 2010



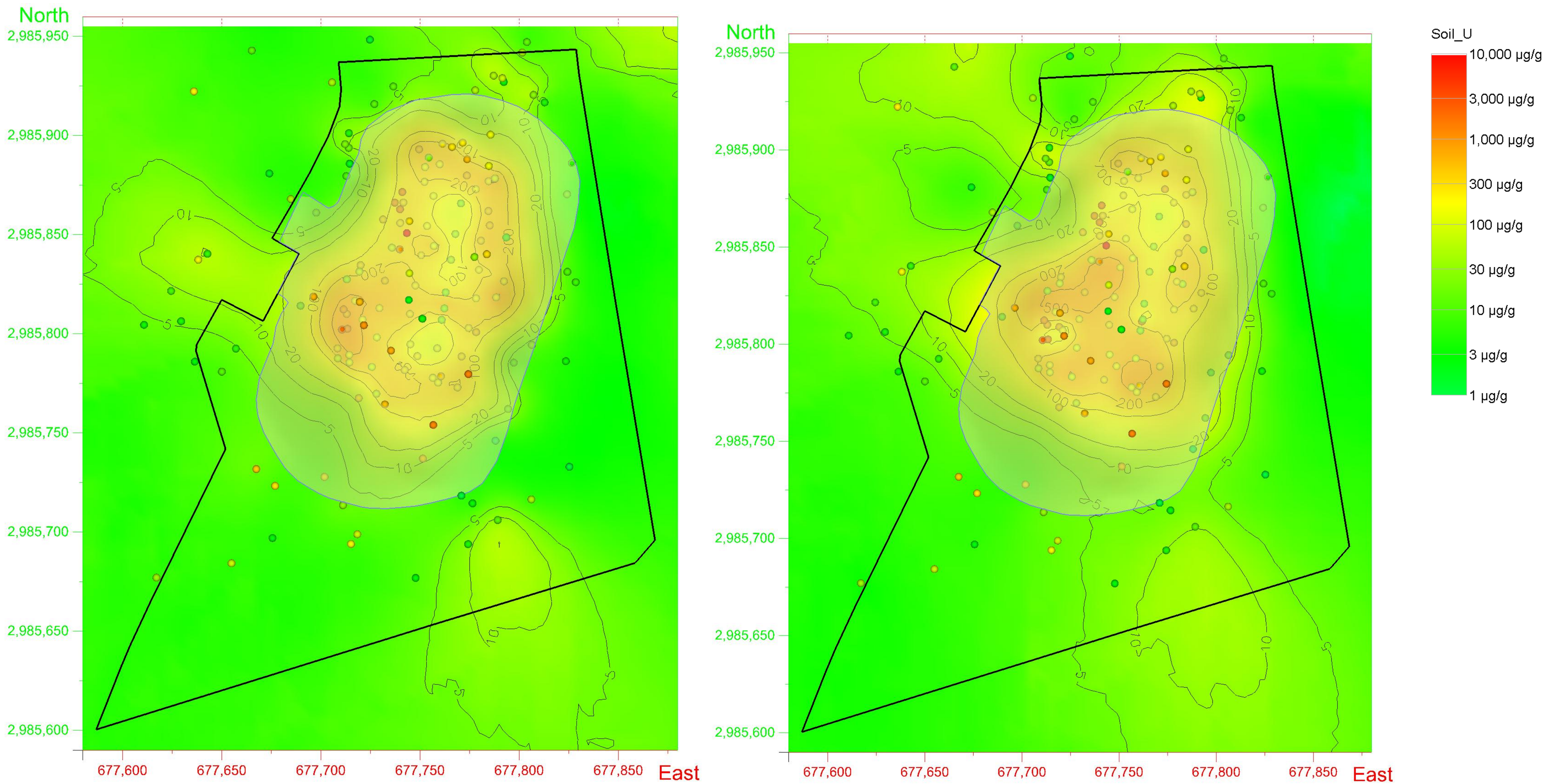
Elevation 170 ft

Elevation 160 ft

Opaque white shading represents air space above the base of the holding basin at elevation 170 ft

Coordinates in State Plane feet
Red-colored axis denotes easting coordinates and
Green-colored axis denotes northing coordinates
Vertical exaggeration= 2:1
Geologic layers are translucent

Depleted Uranium in Soil in AOI 1 Horizontal Sections, 170 & 160 ft Elevation Nuclear Metals Superfund Site Concord, Massachusetts	
Geosyntec consultants	Figure 4.9.44
ACTON, MASSACHUSETTS	OCTOBER 2010	



Elevation 150 ft

Elevation 140 ft

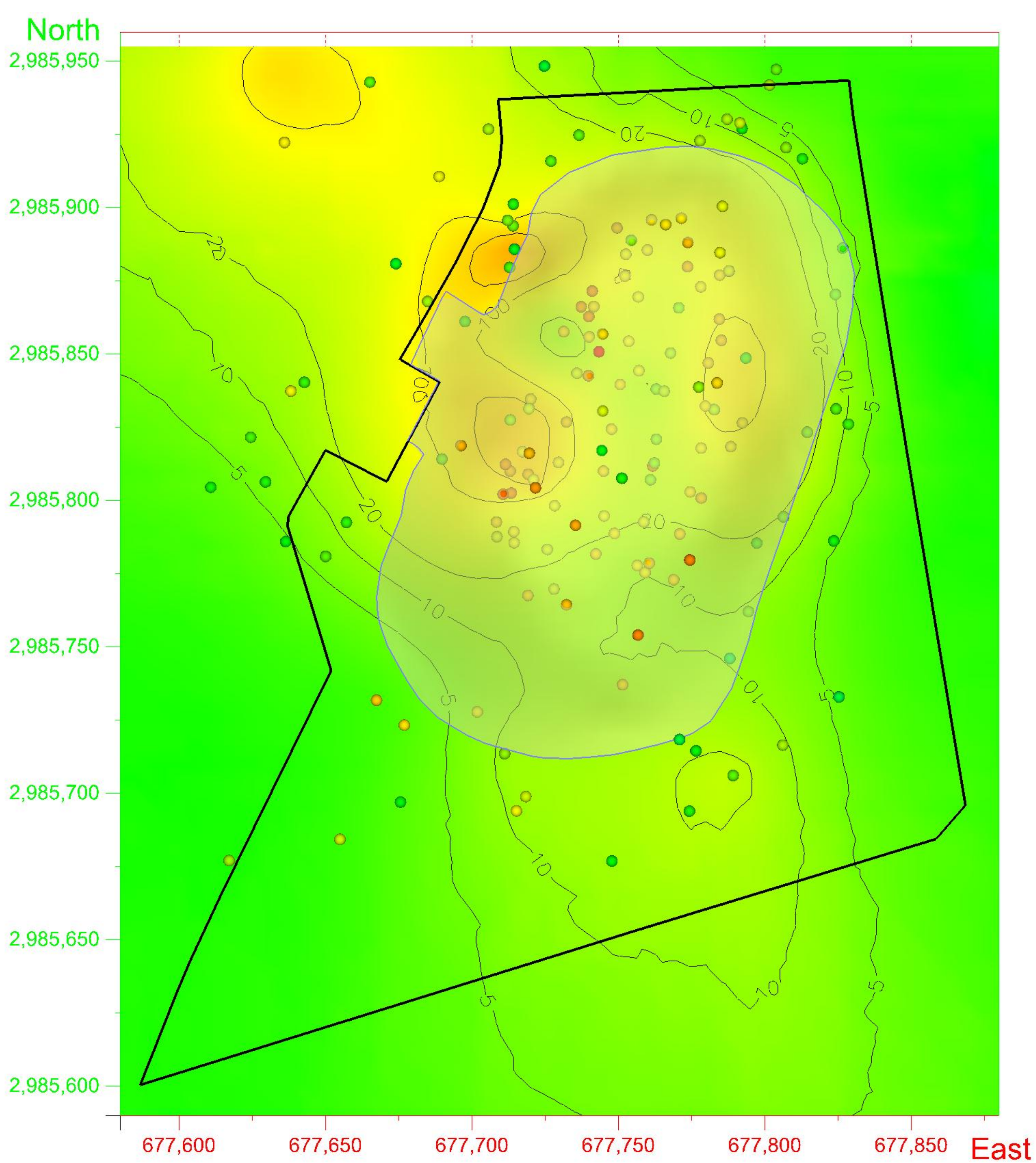
Coordinates in State Plane feet
Red-colored axis denotes easting coordinates and Green-colored axis denotes northing coordinates
Vertical exaggeration= 2:1
Geologic layers are translucent

Depleted Uranium in Soil in AOI 1
Horizontal Sections, 150 & 140 ft Elevation
Nuclear Metals Superfund Site
Concord, Massachusetts

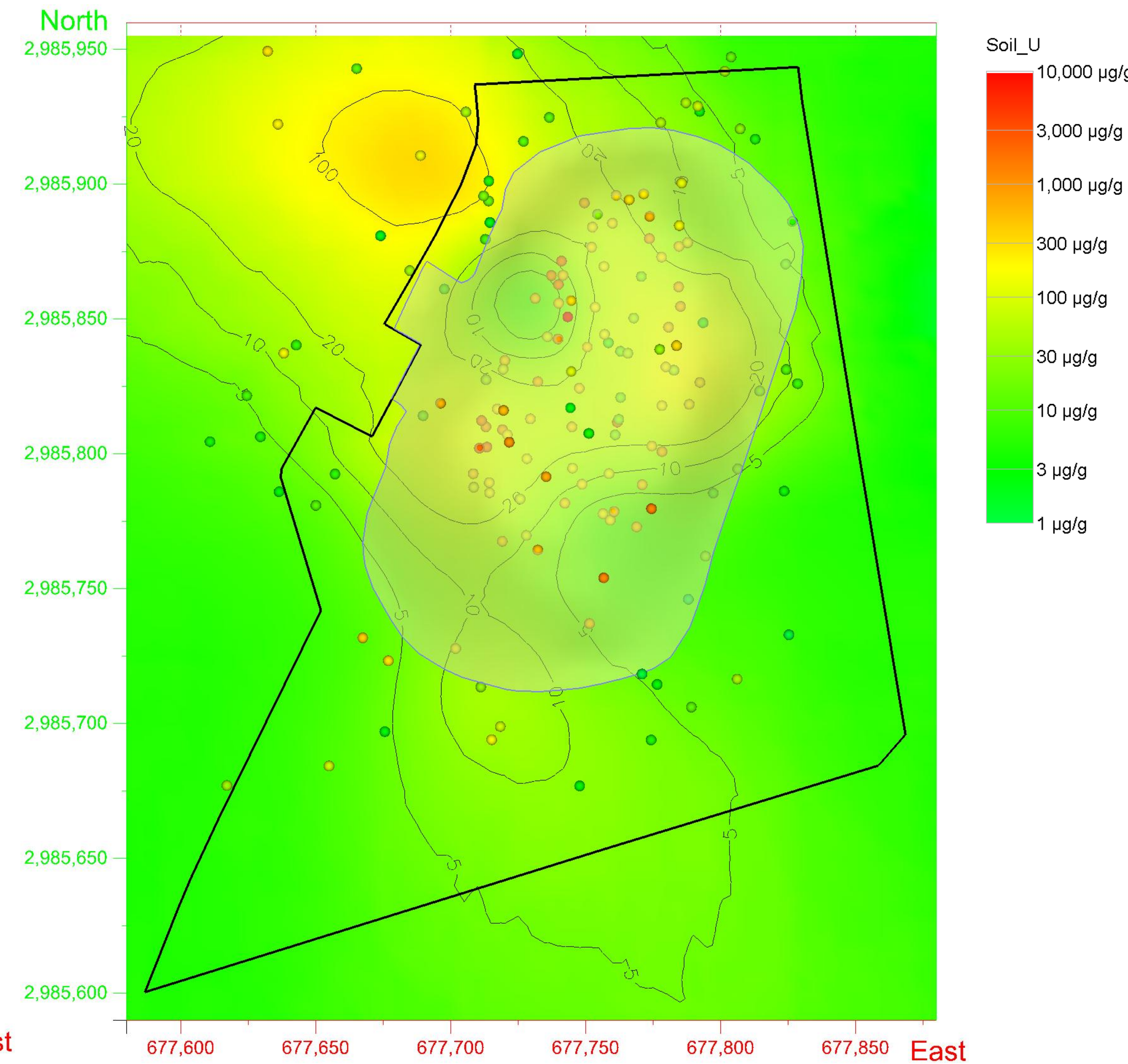
Geosyntec consultants

Figure 4.9.45

ACTON, MASSACHUSETTS | OCTOBER 2010



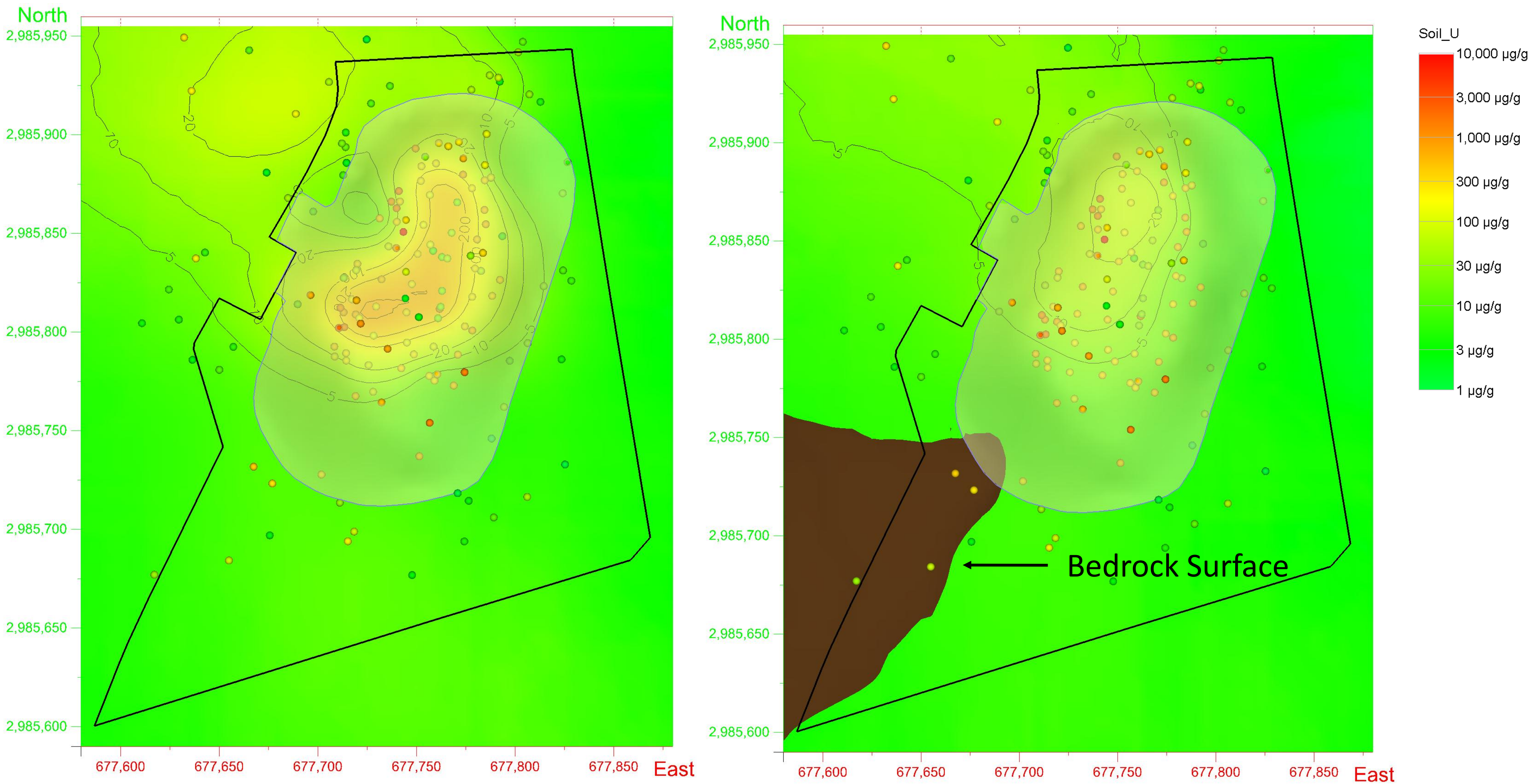
Elevation 130 ft
(below water table)



Elevation 120 ft
(below water table)

Coordinates in State Plane feet
Red-colored axis denotes easting coordinates and
Green-colored axis denotes northing coordinates
Vertical exaggeration= 2:1
Geologic layers are translucent

Depleted Uranium in Soil in AOI 1 Horizontal Sections, 130 & 120 ft Elevation Nuclear Metals Superfund Site Concord, Massachusetts	
Geosyntec consultants	Figure 4.9.46
ACTON, MASSACHUSETTS	OCTOBER 2010	

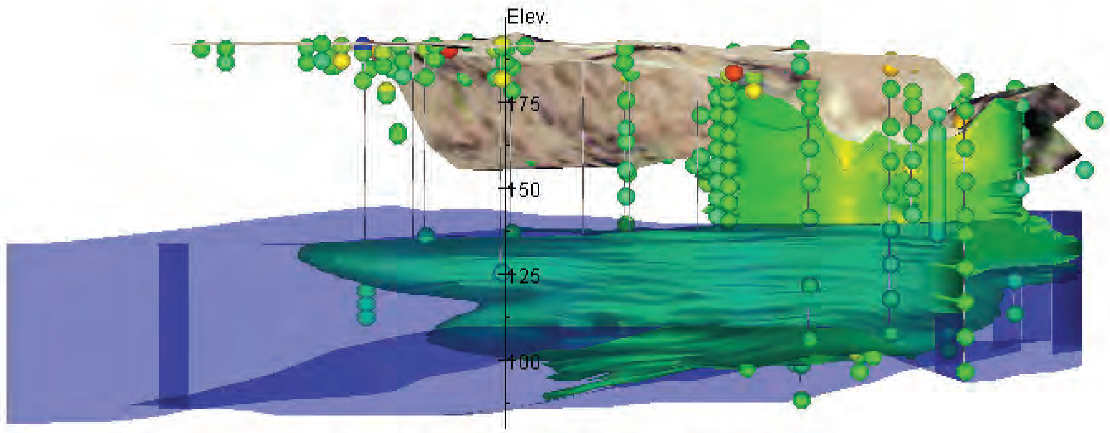


Elevation 110 ft
(below water table)

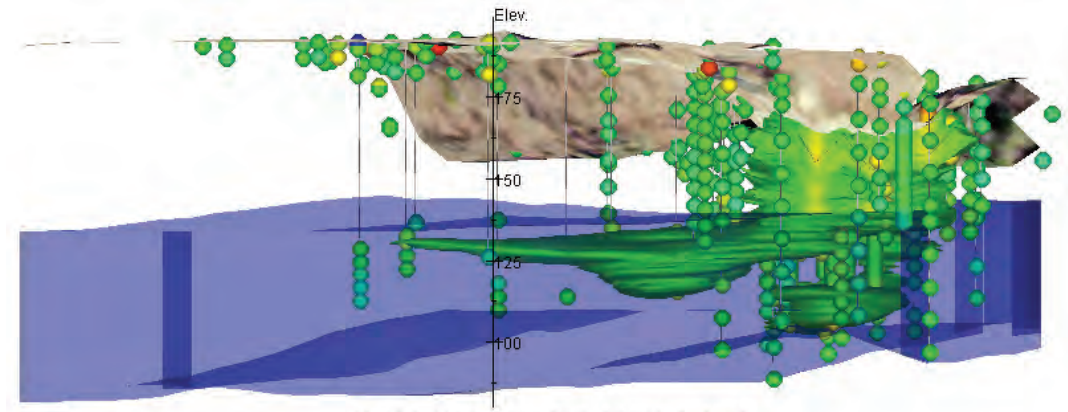
Elevation 100 ft
(below water table)

Coordinates in State Plane feet
Red-colored axis denotes easting coordinates and
Green-colored axis denotes northing coordinates
Vertical exaggeration= 2:1
Geologic layers are translucent

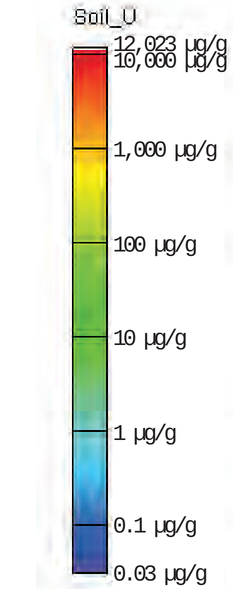
Depleted Uranium in Soil in AOI 1 Horizontal Sections, 110 & 100 ft Elevation Nuclear Metals Superfund Site Concord, Massachusetts	
Geosyntec consultants	Figure 4.9.47
ACTON, MASSACHUSETTS · OCTOBER 2010	

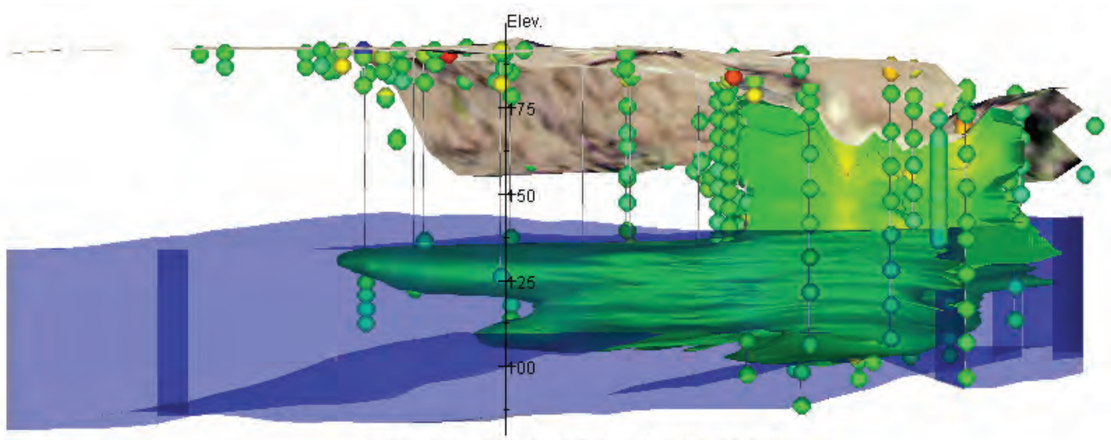


Depleted Uranium in Soil - 5 µg/g Isolevel
Total Depleted Uranium Mass = 7,472 kg

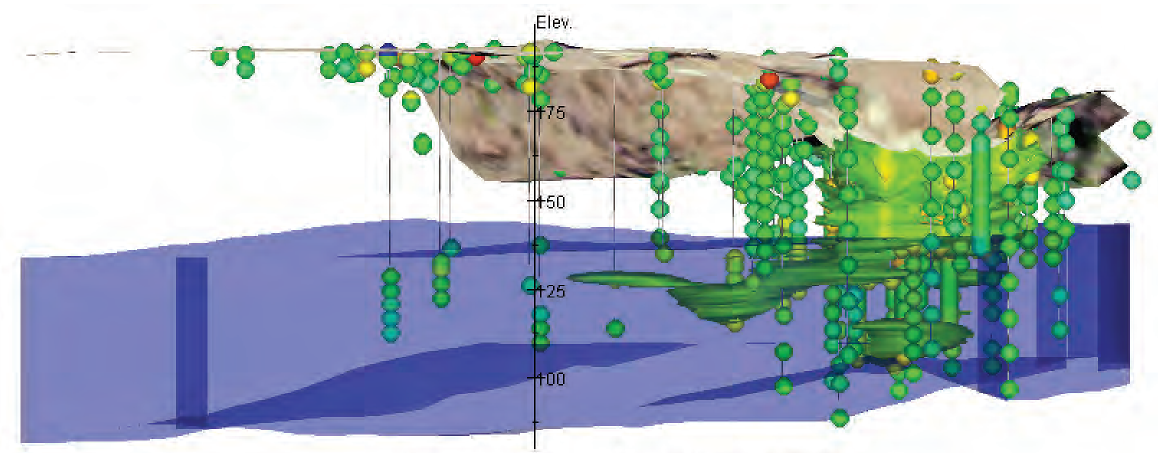


Depleted Uranium in Soil - 50 µg/g Isolevel
Total Depleted Uranium Mass = 5,513 kg



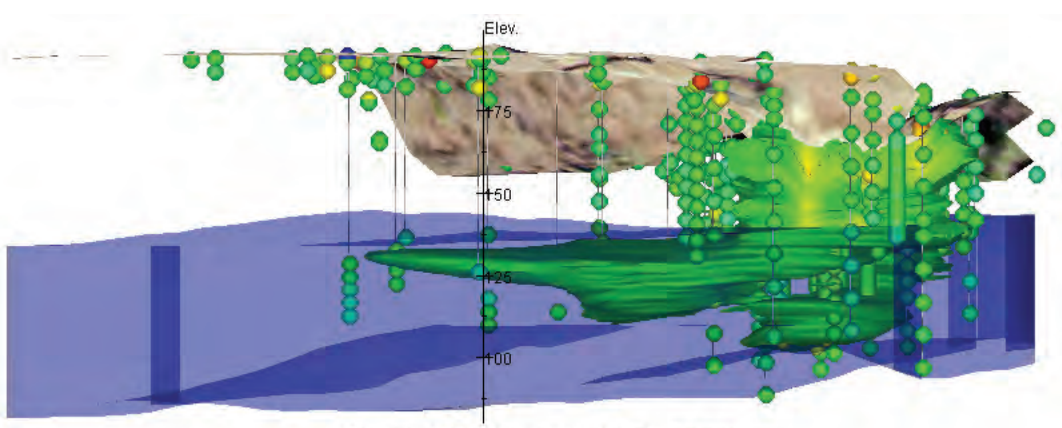


Depleted Uranium in Soil - 10 µg/g Isolevel
Total Depleted Uranium Mass = 7,120 kg

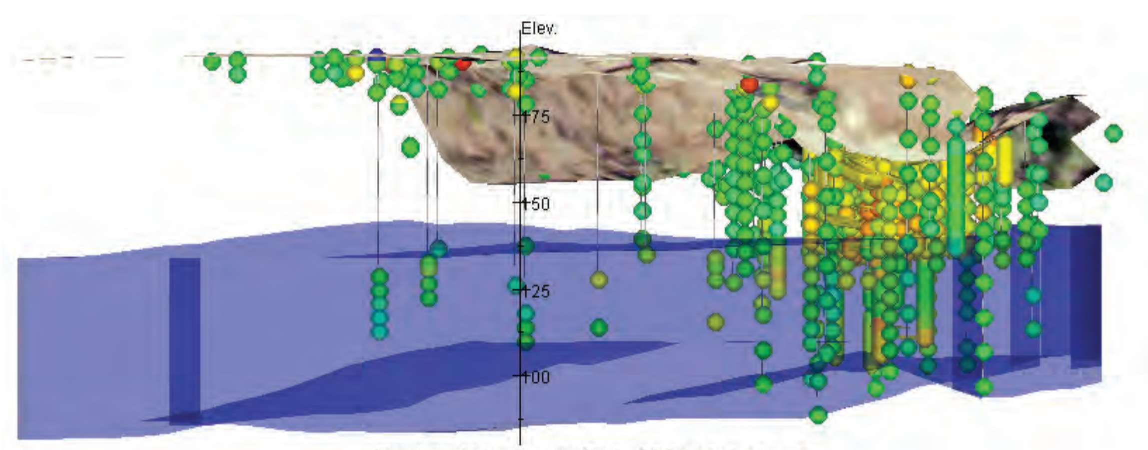


Depleted Uranium in Soil - 100 µg/g Isolevel
Total Depleted Uranium Mass = 4,199 kg

Soil Isoconcentration (mg/Kg)	Mass Estimate of Soil within Isoconcentration (Kg)
5	7500
10	7100
30	6200
50	5500
100	4200
500	600



Depleted Uranium in Soil - 30 µg/g Isolevel
Total Depleted Uranium Mass = 6,161 kg



Depleted Uranium in Soil - 500 µg/g Isolevel
Total Depleted Uranium Mass = 588 kg

Depleted Uranium in Soil Beneath Holding Basin Iso-Concentration Areas and Mass Estimates

Nuclear Metals Superfund Site
Concord, Massachusetts

Geosyntec consultants

5.2.1

Elevations in feet National Geodetic Vertical Datum

Attachment 3

Calculations

Written by:	George Wanjiru	Date:	2022 / 10 / 05 (YYYY MM DD)	Reviewed by	Carl Elder	Date	2023 /9 /27 (YYYY MM DD)
Client:	*de maximis, inc.*	Project:	Nuclear Metals, Inc. Superfund Site	Project/Proposal No.:	BR0090D	Task No:	D72

ATTACHMENT 3-1

CALCULATION OF TREATMENT ZONE VOLUME AND AMENDMENT DOSING

PURPOSE

This calculation package presents the basis for the mass of microscale zero valent iron (mZVI) to be injected for in-situ sequestration (ISS) in saturated overburden in the Holding Basin (HB) area at the Nuclear Metals Inc. (NMI) Superfund Site in Concord, Massachusetts (the Site).

ASSUMPTIONS

Assumptions for the mass calculations are described below and summarized in **Table A1**.

- The treatment area footprint is estimated as the total area within the vertical barrier wall shown on **Drawing 5**. This area is 32,115 square feet. The basis for selecting the layout of the injection points and the 15-foot radius of influence (ROI) is explained in the design report.
- The treatment zone thickness is calculated as follows:
  - The top of the treatment zone is assumed to be three feet above the water table.[1]
  - The bottom of the treatment zone is assumed to be 4 feet above the top of glacial till, which is the closest the injection can be to the bottom of a cased hole installed in the stratified drift given the dimensions of the straddle packer injection tooling and 3-foot vertical spacing between injections.
- The water table is assumed to be flat across the treatment zone at 139 feet elevation. This is equal to the average groundwater elevation measured in April 2022 at three overburden monitoring wells within and around the perimeter of the HB (HB-13, HBPZ-2R, and HA20-CMT-3T(OW)).
- The average top of till in the treatment zone is estimated to be 108 ft elevation. This is the average depth to till inside the VBW based on a 3-dimensional model interpolating between soil borings where glacial till was encountered. Data used to calculate the average elevation for the water table and top of till are tabulated below in **Table A1**.
- With the top and bottom elevations of the treatment zone as described above (i.e., 3 ft above the water table and 4 ft above the top of till), the average treatment zone thickness is 30 ft.
- The soil bulk dry density in the treatment zone is assumed to be 110 pounds per cubic foot (lb/ft^3).
- The target mass dosing rate for mZVI in the treatment zone is 1.5% by dry soil weight.
- There are 57 injection locations within the VBW (**Drawing 5**).

[1] The design includes injections through the full thickness of the saturated zone at 9 injection points. This calculation is specifically for the quantity of mZVI to be injected in the saturated zone. However, treated areas of the unsaturated zone will receive a comparable mZVI dose by performing injections with the same spacing and mZVI quantity as in the saturated zone.

Table A1: Summary of Groundwater and Top of Till Elevations for Wells Within and Around the Holding Basin

Location	Top of Glacial Till (ft NGVD29)	Overburden Groundwater Elevation April 2022 (ft NGVD29)
HA20-B102	106	--
HA20-B104	111.5	--
HA20-CMT-1	112.5	--
HA20-CMT-2	119.9	--
HA20-CMT-3B(OW)	105.53	--
HA20-CMT-3T(OW)	106.42	137.80
HA20-CMT-4	99.9	--
HA20-CMT-5	97.5	--
HA20-CMT-6	102.5	--
HB-13	--	141.01
HBPZ-2R	--	138.17
Average	**108.0 (per interpolation)**	**138.99**

Notes:

1. -- = not measured; ft = feet.
2. Groundwater elevation estimated from only overburden monitoring wells.

MASS CALCULATIONS

The total mass of mZVI to be injected in the HB is calculated by finding the treatment area volume, converting the treatment volume to a mass of soil, and then multiplying by the desired mZVI mass dosing rate as described below.

1. **Target treatment zone volume (V):** The target treatment zone volume is the product of the treatment area footprint (A) and the treatment zone thickness (H). The treatment zone thickness (H) is 30 ft based on the metrics stated above.

$$V = A * H$$
$$V = 32{,}115\ ft^2 * 30\ ft$$
$$V = 963{,}450\ ft^3$$

Written by:	George Wanjiru	Date:	2022 / 10 / 05 (YYYY MM DD)	Reviewed by	Carl Elder	Date	2023 /9 /27 (YYYY MM DD)
Client:	*de maximis, inc.*	Project:	Nuclear Metals, Inc. Superfund Site	Project/Proposal No.:	BR0090D	Task No:	D72

2. **Mass of soil in treatment zone (M_{soil}):** The total mass of soil in the treatment zone is the product of the target treatment zone volume and the soil bulk dry density.

$$M_{soil} = V * \text{soil bulk density}$$

$$M_{soil} = 963{,}450\ ft^3 * 110\ lbs/ft^3$$

$$M_{soil} = 105{,}979{,}500\ lbs$$

3. **Total mass of mZVI ($M_{Total\ mZVI}$):** The total mass of mZVI to be injected in the treatment zone is the product of the soil mass in the treatment zone and the mZVI dosing rate.

$$M_{Total\ mZVI} = M_{soil} * 1.5\%$$

$$M_{Total\ mZVI} = 105{,}979{,}500\ lbs * 1.5\%$$

$$\boxed{M_{Total\ mZVI} = 1{,}589{,}693\ lbs}$$

4. **Injection point layout:** The layout of injection points within the HB was developed assuming a 15 ft ROI with 25% overlap as described in the design report. This layout results in 57 injection points within the HB. The elevations of discrete injection depths at each injection point were assigned based on the estimated bottom of till at each location as interpolated from surrounding soil boring data. The resulting design includes 581 discrete injection intervals targeting the saturated zone (**Drawings 5 and 6**), excluding the unsaturated zone injections at 9 locations.
5. **Mass of mZVI per injection ($M_{mZVI/injection}$):** The mass of mZVI at each discrete injection interval (i.e., fracture) is obtained by dividing the total mass of mZVI for the saturated zone in the HB by the number of injection intervals.

$$M_{mZVI/injection} = M_{Total\ mZVI} \div \text{no. of injection intervals}$$

$$M_{mZVI/injection} = 1{,}589{,}693\ lbs \div 581$$

$$\boxed{M_{mZVI/injection} = 2{,}736\ lbs}$$

For ease of implementation in the field, this quantity was rounded up to a target dose of **2,750 lbs** per discrete injection interval.

Written by:	George Wanjiru	Date:	2022 / 10 / 28 (YYYY MM DD)	Reviewed by	Carl Elder	Date	2023 /9 /27 (YYYY MM DD)
Client:	*de maximis, inc.*	Project:	Nuclear Metals, Inc. Superfund Site	Project/Proposal No.:	BR0090D	Task No:	D72

ATTACHMENT 3-2

CALCULATION OF THEORETICAL URANIUM SEQUESTRATION CAPACITY IN HOLDING BASIN ISS TREATMENT ZONE

BACKGROUND AND PURPOSE

The purpose of this calculation package is to illustrate the theoretical/expected mass of uranium that could be sequestered by addition of microscale zero valent iron (mZVI) in comparison to the mass of uranium estimated to be in Holding Basin (HB) groundwater and sorbed to soil exceeding the threshold of Principal Threat Waste[1].

Results of the bench scale treatability study (TS) to evaluate in-situ sequestration (ISS) of uranium in HB soils (TS ISS-1) indicated that microscale zero valent iron (mZVI) applied at a dose of 1.0% of dry soil weight was effective at treating uranium concentrations in the column effluent to less than the MCL of 30 µg/L. Based on these results and the results of a field pilot test evaluating the injection of mZVI, a dose of 1.5 % mZVI will be injected during in-situ sequestration (ISS) for saturated overburden for the HB area.

APPROACH

Estimating the theoretical mass of uranium that could be sequestered by mZVI in the HB requires estimating (1) the mass of uranium that can be sequestered per mass of mZVI and (2) the total mass of mZVI to be injected in the HB overburden.

The results of the TS ISS-2 column study were used to estimate the potential loading of uranium on mZVI after ISS implementation. In the TS ISS-2 column test, uranium-rich groundwater was pumped through columns of soil with background uranium concentrations. The study included amended and unamended control columns. Soil from each end of the flow-through columns was analyzed for solid-phase uranium content after the column test. An empirical estimate for the mass loading of uranium on mZVI was obtained by subtracting the uranium concentration sequestered in the soil-only control column from the uranium concentration sequestered in the soil-mZVI column (Geosyntec, 2022):

- Concentration of solid-phase uranium at the soil-mZVI column inlet ($C_{mZVI\ inlet}$) = 136 milligrams of uranium per kilogram of mZVI-amended soil (mg U/kg soil)
- Concentration of solid-phase uranium from the control column inlet ($C_{Control\ inlet}$) = 70 milligrams of uranium per kilogram of soil

[1] The ROD (pages 15 and 16) states that ISS is for uranium-contaminated principal threat waste soils in the HB to prevent leaching of uranium to groundwater. The ROD (page 36) also defines principal threat waste as soils with a uranium concentration exceeding 2,310 mg/kg.

It is assumed that the uranium in the control column inlet represents natural sequestration of uranium by soils, while the additional uranium sequestered by the mZVI-amended column was due to mZVI sequestration. Therefore, the concentration of uranium sequestered by mZVI ($C_{U/mZVIsoil}$) is:

$$C_{U/mZVIsoil} = C_{mZVI\ Inlet} - C_{Control\ Inlet}$$

$$C_{U/mZVIsoil} = 136\frac{mg\ U}{kg\ soil} - 70\ \frac{mg\ U}{kg\ soil}$$

$$\boxed{C_{U/mZVIsoil} = 66\frac{mg\ U}{kg\ soil}}$$

Since the mZVI dose in the TS ISS-2 amended column was 1.5%, the mass of uranium sequestered per mass of mZVI ($C_{U/mZVI}$) is:

$$C_{U/mZVI} = C_{U/mZVIsoil} \div 1.5\%$$

$$\boxed{C_{U/mZVI} = 4{,}400\frac{mg\ U}{kg\ mZVI}}$$

The total mass of saturated[2] soil in the HB ISS treatment zone was estimated in **Attachment 3-1** as 105,979,500 pounds (lbs) or 48,071,550 kg. With a mZVI dose of 1.5%, the total mass of mZVI to be injected in the HB ISS treatment zone is 1,589,693 lbs, or 721,073 kg (**Attachment 3-1**).

Assuming the HB soil sequesters uranium at a similar mass loading to the TS column after the soil is amended with mZVI, the total mass of uranium able to be sequestered ($M_{U\ sequestered\ in\ HB}$) will be:

$$M_{U\ Sequestered\ in\ HB} = C_{U/mZVI} * M_{mZVI}$$

$$M_{U\ Sequestered\ in\ HB} = 4{,}400\frac{mg\ U}{kg\ mZVI} * 721{,}073\ kg\ mZVI * 1\frac{kg}{1{,}000{,}000\ mg}$$

$$\boxed{M_{U\ Sequestered\ in\ HB} \approx 3{,}173\ kg\ U}$$

To evaluate if the selected amendment dose of 1.5% mZVI by weight is sufficient to sequester all uranium in HB groundwater plus uranium that may desorb from principal threat waste soil, the total mass of uranium from

[2] While the ISS design includes mZVI injections in the unsaturated zone at a subset of the injection points, it is conservative to use mass of saturated soil in this calculation because this yields a smaller quantity of mZVI than using a treatment volume equal to the saturated and unsaturated zone. Further, the analysis herein is for uranium in groundwater and desorbing from soil, neither of which exist in the unsaturated zone, so it is conservative to omit stabilization capacity of mZVI injected in in the unsaturated zone.

these sources was estimated and compared to the mass of 3,173 kg uranium able to be sequestered by the amount of mZVI being injected.

Holding Basin Groundwater

The total mass of uranium in the HB groundwater was estimated from the measured concentration of uranium in the HB groundwater and the estimated pore volume of the HB ISS treatment area. An average concentration of uranium in HB groundwater ($C_{U\ HB}$) of 2,000 micrograms per liter (µg/L) was selected based on the concentration of uranium detected in overburden monitoring well HB-13 and wells on the edge of the HB. This uranium concentration was selected as a conservative estimate of groundwater concentrations within the HB ISS treatment area.

The pore volume (PV) for the HB is calculated using an assumed overburden porosity (n) of 0.25 for site soils and the saturated ISS treatment zone volume (V) for the HB calculated in **Attachment 3-1** as follows.

$$PV = V * n$$

$$PV = 963{,}450\ cubic\ feet\ (ft^3) * 0.25$$

$$PV = 240{,}863\ ft^3$$

$$PV = 240{,}863\ ft^3 * 28.317\ liters/ft^3$$

$$PV = 6{,}820{,}503\ liters$$

Therefore, the mass of uranium in HB groundwater ($M_{U\ HB}$) is:

$$M_{U\ HB} = C_{U\ HB} * PV$$

$$M_{U\ HBGW} = 2{,}000\ \frac{\mu g}{liter} * 6{,}820{,}503\ liters$$

$$M_{U\ HBGW} = 1.364 * 10^{10}\ \mu g * \frac{1\ kg}{1{,}000{,}000{,}000\ \mu g}$$

$$M_{U\ HBGW} \approx 13.6\ kg$$

Desorption from Soils

The mass of uranium that could desorb from principal threat waste soils and require sequestration is added to the mass of uranium in groundwater. The Remedial Investigation (RI) provided estimates of the mass of uranium on soil in the HB (see RI Figure 5.2.1, included in Attachment 2 of the 30% RD Report). The RI does not specifically present this mass for principal threat waste (i.e., soils with uranium concentrations greater than 2,310 mg/kg), but the RI does present a uranium mass on soils with a concentration greater than 500 mg/kg uranium. The calculations below rely on the uranium mass for soils with concentrations greater than 500 mg/kg uranium because (1) this is a very conservative value since it encompasses principal threat waste *plus* soils with concentrations more than 4-fold lower, and (2) the mass estimate from the RI is an accepted value since little additional soil data have been collected from the HB. The mass of uranium on these soils ($M_{U\ HBSoil}$) is approximately 600 kg as reported on Figure 5.2.1 of the RI.

$$M_{U\ HBSoil} \approx 600\ kg$$

Assuming all uranium mass in groundwater requires stabilization (i.e., 13.6 kg) and all uranium sorbed to soils with uranium concentrations greater than 500 mg/kg (i.e., 600 kg) desorbs[3], the uranium mass in the HB requiring stabilization ($M_{U\ HB}$) by mZVI is 614 kg.

$$\boxed{M_{U\ HB} \approx 614\ kg}$$

CONCLUSIONS

Based on the above calculations, the mass of mZVI that will be injected into the saturated zone for the HB ISS remedy will theoretically sequester approximately 3,173 kg of uranium. This **stabilization "capacity" is more than 5 times the estimated mass of uranium in HB groundwater plus uranium sorbed to soils inclusive of principal threat waste**. This analysis shows that the ISS remedy for the HB is appropriate and conservative for stabilizing uranium in groundwater and potential leaching of uranium to groundwater from principal threat soils.

REFERENCES

Geosyntec Consultants. 2017. *Remedial Investigation Report, Nuclear Metals, Inc. Superfund Site, Concord, MA*. April.

Geosyntec Consultants. 2022. *In Situ Sequestration Treatability Study Report, Nuclear Metals, Inc. Superfund Site, Concord, MA*. April.

[3] Assuming all uranium desorbs from HB soils is another level of conservatism incorporated into the calculation. Site soils have a demonstrated ability to sorb uranium (e.g., uranium concentration in the control column for TS ISS-2 presented above), so while uranium mass may transfer from soil into the aqueous phase, some uranium is very likely to remain bound to the soil.

Attachment 4

Response to Comments on November 2023 30% Remedial Design

Responses to Comments Received January 18, 2024 on the

30% Remedial Design Report for In-Situ Sequestration of Uranium within the Holding Basin

General Comments

1. Is there any concern that the injections will push untreated or partially treated groundwater from areas of high depleted uranium (DU) to downgradient areas of lower DU? There was some very minimal indication of this possibility in the pilot. Mitigation measures are recommended including doing downgradient locations first and monitoring new or existing downgradient monitoring wells.

   Response: The injection process will add both fluids and solids to the treatment area. To provide context for the issue raised in the comment, one must understand that the design is estimated to add a total of approximately 9,308 cubic feet (ft^3) of zero valent iron (ZVI)[1] and 58,295 ft^3 of guar slurry within the footprint of the barrier wall (estimated as the average slurry volume used per fracture for Pilot Test 2 injections, 664 gallons/fracture, times 655 fractures inside the barrier wall). In comparison, the saturated pore volume within the barrier wall, assuming a porosity of 0.25, is about 240,800 ft^3 (see calculation 3-2 in Attachment 3). By comparing these volumes, the upper limit is that amendments could displace <30% of a pore volume.

   Concern that adding <30% of a pore volume of solids and fluid during ISS will result in significant mobilization of uranium mass from the holding basin (HB) is not a large concern because:

   a) Approximately 98% of uranium mass in the HB exists in the sorbed phase on soils as opposed to in groundwater (see calculation in Attachment 3 of the revised 30% Remedial Design [RD]). Sorbed uranium will not migrate.

   b) Injections will occur from the base of the aquifer upward. This sequence will emplace treatment amendments in the less-contaminated deep overburden before amendments are injected closer to the water table where aqueous concentrations are higher.

   c) Ambient groundwater discharge from the HB is 7 to 10 gallons per minute (gpm; see section 3.5.2.4 of the 2014 Remedial Investigation [RI] report). If one assumes a worst-case that the injected guar and ZVI slurry displaces groundwater downgradient, then the ISS would push 67,600 ft^3 (i.e., the total volume of ZVI and guar slurry injected inside the barrier footprint) of groundwater westward. This potential worst-case displacement volume is equal to ambient groundwater flux through the HB over 35 to 50 days. Putting this into context, the volume of groundwater migrating out of the HB under ambient groundwater flow over the expected duration needed to implement

[1] This is based on 1,801,250 lbs of ZVI added inside the proposed containment wall (see 30%RD Drawing 6) and a ZVI bulk density of 3.1 g/cm^3 (193.5 lb/ft^3) for CERES F2 blend ZVI.

the remedial action (estimated 7 months) is more than 4 times greater than the volume of groundwater that could potentially be pushed downgradient by ISS.

Given the above facts, a large displacement of uranium downgradient is not expected from ISS. However, as an added precaution, Section 4.3 of the 95%RD has been revised to recommend injections start in the apron area and proceed eastward, if possible given logistics and sequencing with other site activities (e.g., if soil excavations are ongoing in the courtyard when the remedial action is implemented).

2. In the pilot testing, the seal around the PVC casing was allowed to set up for two months before injection. Please address if that be necessary or advisable in full-scale? The seal is referred to as "cement", "cement grout" and "cement-bentonite grout". Please provide a more detailed description of the sealing materials and set up time.

Response: Seals for casing used during pilot testing cured for two months due to both logistical constraints and to evaluate if the cement seals for the cased holes affected groundwater pH or alkalinity (and potentially increase the solubility of uranium). Specifically, the seals around the casings cured for two months because:

- Casings at pilot test locations were installed in January 2022 (following approval in December). It was not practicable to perform injections during the coldest winter months due to fluids handling, so injections were performed in March/April 2022.

- The alkaline challenge during treatability testing resulted in remobilization of uranium from the columns and increases in aqueous-phase uranium in the column effluent (*In Situ Sequestration Treatability Study Report*, Geosyntec 2022). A component of pilot testing was to monitor downgradient of the casings after their installation to assess whether the grout seals affected groundwater alkalinity (results indicated they did not; see *Predesign Investigation Report for In-Situ Sequestration of Uranium in Overburden Groundwater*, Geosyntec 2023). This monitoring was a PDI activity and not necessary for the full-scale implementation.

Seals used for HB ISS will be the same as used for the pilot test (i.e., neat cement grout) and used for monitoring well construction performed at the site, which requires only a couple days to harden. While it is anticipated that there will be at least one month between casing installation and ISS injections, injections as soon as 48 hours after casing installation are acceptable as specified in the design.

The 95% RD has been revised to use consistent terminology of neat cement grout (grout) and now references SOP NMI-GW-003 for specificity.

3. Post treatment verification monitoring is recommended and should be provided in future design documents. Groundwater should be sampled at some point after injection and before cap placement to determine effectiveness of injections. Downgradient groundwater monitoring during and after injections should also be conducted.

Response: The goals and scope of monitoring proposed in this comment were discussed with the Agencies during calls on January 30th and February 7th. The 95%RD now includes a section describing groundwater monitoring during the period between ISS and wall/cap construction. This new section, section 4.4, incorporates the purpose and scope that the team agreed was reasonable. It is noted in the 95%RD, but worth reiterating, that the interim monitoring program is not for comparing uranium concentrations to clean-up levels; rather, it is only to observe initial changes in groundwater chemistry resulting from ISS.

Specific Comments

4. Section 2.3, Page 8, Paragraph 1. The text states that the injection locations in the apron area extend over accessible locations where uranium concentrations exceed 30 µg/L. Drawing 5 shows the apron area locations to extend to the 30 µg/L contour on the north and south sides; however, the western extent of the apron area is not bounded by the 30 µg/L. Please edit the text to clarify the bound of the western extent of the apron area.

   Response: This sentence has been clarified.

5. Section 2.4, Page 8, Paragraph 2. Use of sand is discussed as a proppant. A brief specification for sand is recommended and that the sand be tested for contaminants prior to use.

   Response: This sentence (and elsewhere throughout the design) has been revised to be clearer that sand is not needed for the HB remedy although it is sometimes used as a proppant during jet injection.

6. Section 4.1, Page 12, Paragraph 3. The text states that wells remaining near ISS locations will be capped using a pressure cap prior to ISS. Please clarify if this will maintain the well integrity to be used as a monitoring well, if the cap will minimize daylighting of injection fluids, and/or if the cap has another purpose.

   Response: This sentence has been revised to state that capping wells in the injection area is done to avoid short-circuiting of amendments to the ground surface through the wells. While capping the wells can increase the potential for wells near the injection points to be maintained, it is generally assumed that monitoring well screens within the 15-ft design ROI of the injections will not be usable after injections.

7. Section 4.3, Page 13, Paragraph 5. Once the enzymatic breaker is mixed into the injection slurry how long can it sit before it begins to break down the guar gel? Please edit the text to include a timeframe (in minutes or hours) in which the mixture must be used before the slurry begins to degrade.

   Response: The reaction between enzymatic breaker and guar is not a sudden event and takes longer than the time to inject ZVI. Information provided by the vendor indicates a timeframe of 24 to 48 hours, but this is variable depending on the dose. The text has not been revised to dictate the timeframe in which mixture must be injected (but does state breaker will be added "immediately prior to injection") because jet injection means and methods are for the contractor to determine. In this case, the contractor is a firm specializing in the mixing and use of these amendments as well as hydraulic fracturing. EPA's concern is being addressed contractually using a performance specification that the contractor is required to meet. This specification prescribes the mass of ZVI per fracture (e.g., Drawing 6) and that the contractor is required to manage guar and breaker doses and timing in order to successfully meet these quantities.

8. Section 4.3, Page 14, Step 5. Consider adding "after verifying that the pressure between packers is sufficiently low, the packers will be deflated". It is recommended to wait until the pressure is reduced, otherwise ZVI and sand will run up the hole and make it difficult to get a seal at the next interval.

   Response: The text has been revised to include the suggested wording.

9. Section 4.4, Page 14, Third Bullet. Please edit the text to clarify how the liquid IDW generated during ISS injections will be managed and treated (treated on-site by existing system, treated on-site by new temporary system, off-site disposal, etc.).

   Response: Text has been added to the IDW section describing handling IDW generated during ISS injections. In general, this slurry will be discharged into a tote at the ground surface. When possible, this slurry will be reinjected into a subsequent fracture. If slurry cannot be reinjected, it will be containerized and managed as IDW (i.e., characterized and transported off-site for disposal at an approved facility).

10. Section 4.4, Page 14-15. The text states that the consequences of cross contamination are minimal, and all ISS remedial action tools and equipment will be decontaminated prior to leaving the site. EPA agrees that while equipment does not require full decontamination

between non-principal threat waste (non-PTW) locations, the equipment should be fully decontaminated between PTW and non-PTW locations. In addition, all tools and equipment should be decontaminated and scanned prior to leaving the Holding Basin/ISS construction or exclusion area. No ISS tools and equipment should be used outside of the Holding Basin/ISS construction area prior to decontamination. Please edit the text to reflect the need for decontamination of tools and equipment.

Response: Section 4.6 has been added and explains how drilling equipment will be decontaminated per Standard Operating Procedure NMI-007 when transitioning from locations that may encounter PTW (i.e., the 9 locations identified with blue-filled circles on Drawing 5) and all other locations.

11. <u>Section 4.6, Page16, Third Bullet</u>. The text states that some ZVI can be produced as a by-product of manufacturing. Will it be clear if the material used on the NMI Site is a by-product of manufacturing or if it created from virgin sources?

Response: A decision has been made to not use a ZVI generated from a recycled or by-product source. Rather, ZVI will be a manufactured product that is intended for in-situ groundwater remediation applications. The sentence noted in this comment has been removed.

12. <u>Section 5.4, Page 19.</u> The text should be edited to state that “the HB VBW and cap design is also expected to include **contaminant and** hydraulic monitoring outside of the VBW to observe new groundwater flow that develops after the RA as groundwater is diverted around the VBW.” The words “contaminant and” should be added in front of “hydraulic monitoring”.

Response: This sentence was intended to inform the reader that there will be monitoring outside the VBW and cap once that remedy component, which follows ISS, is compete. We removed the word “hydraulic” instead of implementing the requested change. This avoids an interpretation that the ISS design speaks to monitoring for the VBW which has yet to be designed. Monitoring for the VBW will be provided in the VBW and cap design.

13. <u>Figure 3.</u> This figure should be edited to show the current surface elevation of the Holding Basin and note that clean fill was used to bring the Holding Basin up to the surrounding grade. Please edit the figure as necessary.

Response: The figure has been modified. Drawings are also modified to reflect the as-built ground surface elevation of the backfilled HB.

14. Drawing 2. Please add sand to the list of materials being used.

Response: The design has been revised to clarify that sand is not being used. See response to specific comment 5.

15. Drawing 5. To aid the reader, please add a filled in circle to the legend to indicate these ISS injections extend through the unsaturated zone.

Response: No change required. The label in the legend currently states that "Filled ROIs show ISS injections that extend through unsaturated zone to the base of the former Holding Basin."

16. Drawing 7. Please clarify if it is necessary to tremie cement grout in place. If it was tremied in the pilot test, then it is recommended this technique be used during the ISS. Please edit the drawing as necessary.

Response: A note has been added to the detail for case-hole construction specifying that casing installation and grouting shall follow SOP-GW-003. The SOP specifies use of a tremie pipe and has been cited, instead of just describing tremie placement, because the SOP also contains other helpful construction information for the driller.

17. Attachment 5, CQA Plan, Section 3.2, Page 11, Sixth Bullet. The text states that the ISS injection locations will be finished with 2-foot stick-ups. Following ISS injections, will these stickups be grouted and cut? Will this work be performed as part of the ISS Remedial Action so that the area is prepped for the Holding Basin wall and cap construction? Please edit the text as necessary.

Response: After ZVI injections, the drilling contractor will return to the Site to grout ISS casings and cut casings flush with the ground surface. This step of the remedial action is described in the Proposed Sequence of Work section of Drawing 2 and in Section 4.3, note 6 of the Design. Additional text was added into note 6 to clarify the cased-hole decommissioning.

18. Attachment 5A, Jet Inject Log. Please add a column "Evidence of Daylight (if Yes, approximate volume)" to the log form.

Response: The form has been revised.

Attachment 1
CREW Comments on 30% ISS in HB Remedial Design

1. We note that the properties of the glacial till are important factors in the remedial design. The February 2023 30% Remedial Design for the Holding Basin Containment Wall and Cap identified additional investigations that would be conducted to characterize the glacial till along the containment wall path and the data obtained from these investigations should be considered in the revised remedial design for ISS within the holding basin.

Response: Borings being performed around the HB for design of the cutoff wall are ongoing, and the depth to till at these locations will be reviewed by the ISS design team when the results of these borings are available.

2. The remedial design specifies that the ISS borings would be advanced to the top of glacial till and that the deepest injection interval would be approximately 4 to 5.5 feet above the bottom of the PVC well casing to accommodate the down-hole injection tooling. Advancing the ISS borings into the glacial till was not recommended because of concern that the borings would create vertical preferential pathways through the glacial till. However, based on the expected glacial till thickness identified in the profile provided in February 2023 30% Remedial Design HB Containment Wall and Cap (Figure C-403), the glacial till thickness in the containment wall path appears to range from approximately 6 feet to greater than 30 feet, which is greater than the height needed to accommodate the down-hole tooling. Therefore, extending the borings into the glacial till to accommodate the down-hole tooling would not be expected to penetrate through the till and create a vertical preferential pathway. Extending the ISS borings so that the deepest injection interval is directly above the glacial till should be considered, particularly in areas where the glacial till is thicker than the down-hole tooling.

Response: We note that this comment is contradictory to CREW's comment #4 which states "the presumed low permeability of the glacial till, is an important factor of the remedial design", so it is unclear what CREW's position is related to drilling into till versus avoiding creating potential pathways for vertical groundwater flow through the till. That said, the design does not call for intentionally extending borings into till any further than needed to identify the top of till, even if the till might be greater than 6 feet thick, for the following reasons:

- Drilling introduces a risk of creating vertical flow paths in the till, even if the boreholes do not fully penetrate through the till to bedrock. This could compromise the hydraulic competency of till that is critically important for the containment component of the remedy.
- Uranium concentrations in soil generally decrease with depth beneath the HB, (see Attachment 2 to the 30% RD), with higher concentrations, including samples representing principal threat waste, located in relatively shallow soils beneath the former bottom of the HB. Risking a breach of the till in an attempt to add one more fracture to better treat the lowest uranium concentrations has too much risk relative to the potential benefit.

3. We note that, although the remedial design specifies that the ISS borings would be advanced only to the top of glacial till, identification of the glacial till will be based on drilling resistance and observations of glacial till in the core samples. This suggests that the borings will actually need to be advanced some distance into the glacial till in order to positively identify the soil as glacial till.

Response: We acknowledge that borings must advance into till, even if only a few inches, in order to identify till, but the program is intended to minimize penetration into till to the extent feasible, because:

1) The design uses an interpolated surface of till based on prior borings in and around the HB, so the field team will go into the drilling program informed about the most likely elevation of till at each location. This information allows the team to have heightened awareness as the drilling approaches the expected top of till.
2) Casing will be installed using sonic drilling, so the field team will have continuous cores to observe when making a determination of the till interface.
3) The Geosyntec, *de maximis*, and H&A team has extensive institutional knowledge because of previously drilling to and through the till multiple times at the Site.
4) The design includes drilling to the top of till at 73 locations spaced roughly 20 feet apart. It is reasonable to think that the driller and field team will quickly become proficient at identifying top of till based on drilling resistance/soil hardness, texture, change in soil composition, etc., after the initial few borings. The field team will also have the benefit of knowing top of till at adjacent borings as the program progresses.

In instances where a boring is advanced slightly into till (e.g., several feet), it will immediately have a solid casing installed and sealed in-place using neat cement, thereby plugging whatever penetration may have occurred into till.

4. Identification of glacial till in the field will be based on drilling resistance reported by the driller and inspections of the soil cores by the field engineer. The identification appears to be somewhat subjective and there is the potential for different drillers or field engineers to have different qualitative criteria as to what conditions constitute glacial till. Because positive and consistent identification of the glacial till, and the presumed low permeability of the glacial till, is an important factor of the remedial design, additional criteria (including quantitative criteria) should be considered in identifying the glacial till.

   Response: The design is based on a robust historical and pre-design data set consisting of soil borings in and around the ISS treatment area. Collecting additional data about the top of till from each of the 73 injection locations is unlikely to enhance the design (e.g., revise the soil volume appreciably) or improve the implementation of ISS. Please see response to CREW comment #3.

5. Neat cement grout will be used to seal the ISS well casings in place and also to backfill the ISS well casings after the ISS injections are completed. Although bentonite is not specified in the

information in the remedial design about the neat cement grout, adding bentonite to the grout should be considered to reduce potential grout shrinkage during curing and also reduce the permeability of the cement grout.

Response: Neat cement grout was used for the seal on cased wells during the ISS pilot test and is specified for full-scale based on a strong recommendation from the injection contractor. Additionally, the fracturing process that will occur shortly after casings are installed will slice through the well casings and the seals every three vertical feet. The fracturing process will therefore significantly compromise the hydraulic integrity of the seal – thus, the permeability of the seals around cased wells is functionally irrelevant for ISS.

Attachment 2

2229 Main Street Oversight Committee Comments on 30% ISS in HB Remedial Design

These comments are from individual committee members and are not necessarily a consensus of the committee.

1) Introduction, Page 3: 50-97% reduction in uranium was achieved using zero valent iron. That is a significant spread in the results. Why were the reductions not more uniform between the pilot test locations.

Response: The sentence noted in this comment was included to inform the reader that ZVI has yielded substantial decreases in uranium concentration in-situ and cites the recent pilot test report for more detail. The percentages referenced in this comment include the groundwater results from monitoring wells located approximately 25 ft to 45 ft downgradient of the ZVI injection points and at different depths, soil types, and initial uranium concentrations. The commenter is referred to the pilot test report for more information.

2) Which areas of the site are expected to reach drinking water standards. Does that include the entire site excluding the holding basin or will drinking water standards gradually be attained further downgradient from the vertical barrier wall. Hypothetically if a drinking water well was installed within feet outside of the wall following remediation, what would the expected uranium concentration be.

Response: As stated in the Record of Decision (ROD), the cleanup level for uranium in groundwater at the Site is 30 µg/L everywhere except within the HB. The area within the vertical barrier wall and below the cap is a Waste Management Area and does not have a cleanup level for groundwater. It is not anticipated that uranium concentrations will meet the site cleanup level at all locations outside the Waste Management Area immediately after ISS. Rather, the remedy includes several components (e.g., a barrier wall, cap, ISS inside the HB, and downgradient ISS) and will have a monitoring program to track groundwater concentrations as they achieve the site cleanup levels over time.

Furthermore, the scenario of placing a drinking water well adjacent to the vertical barrier wall is unrealistic because the selected remedy includes application of an Activity and Use Limitations that will prohibit such a use.

3) If 90-99% of the principal threat waste will be immobilized within the holding basin, what is the fate of the other 1-10%.

   Response: Principal threat waste (PTW; i.e., soils within the HB with uranium concentrations greater than 2,310 milligrams per kilogram) is limited to a small fraction of shallow overburden soils beneath the former HB. The remedy where there is PTW, and a large area around PTW, is ISS plus hydraulic containment. The ISS injections will stabilize and sequester uranium in groundwater (i.e., reduce mobility and toxicity), the hydraulic barrier and cap will prevent mobility and exposure to uranium potentially desorbing from PTW, and the Activity and Use Limitations will prevent exposure. With these remedies, risk to uranium from all PTW will be addressed.

4) In Attachment 3.1- Calculations. The soil dry bulk density is estimated as 110 pounds per cubic foot. Doesn't the density depend on the type of soil present which in turn will affect the dosing. How was that number arrived at. According to Figure 3, there are at least three distinct grain size distributions within the proposed ISS injection area: sand and silt, f-m sand, sand and gravel, and fine to coarse sand and silt. The locations of the different strata are fairly well defined. Rather than one dry bulk density for the entire holding basin, is it appropriate to target each strata with its own bulk density.

   Response: The dry bulk density used is consistent with literature values for a medium silty sand. Moreover, the dry bulk density used in the HB design is the same as was used for designing the ISS pilot tests (which were successful), meaning that the mZVI dose prescribed for the HB remedy is the same as the mZVI dose applied for the pilot test.

5) Figure 2 – April 2023 Groundwater Elevations. The groundwater elevations appear to reflect a groundwater divide in the vicinity of MW-S18 east of the holding basin. What is the reason for this. Is it an artifact of the contouring program.

   Response: The area around MW-S18 has historically been a local groundwater elevation high point (see groundwater elevation contours in Annual Monitoring Report submittals). This area is upgradient of the HB, and uranium concentrations in groundwater are below 30 ug/L, so this is not relevant to this design.

Attachment 3
Dr. Kate Campbell, USGS, Comments on 30% ISS in Holding Basin Remedial Design

The 30%-R1 document clearly describes the scope and how the previous results lead to the current design for the phased ISS within the HB/VBW area.

1. mZVI requirements and analysis: The compositional requirements of mZVI as outlined in Attachment 6 are excellent for the needs of this application. I also support the planned periodic analysis of mZVI during the injection process. I would suggest, if there is a starting sample available, either from the contracted supplier or the pilot test materials (if the same supplier), analyzing that sample prior to the start of the injections; if there is an issue with the material, it would be best to know before the start of the work.

   Response: We agree with your recommendation. ***de maximis*** has already obtained chemical analysis of ZVI from potential ZVI suppliers (all met the specification) and intends to obtain a sample from the selected vendor for verification testing prior to shipping material to the Site.

2. Treatment footprint: The footprint has been extended to the N/NW of the new VBW boundary. This is an excellent approach and provides needed coverage in an area that has relatively high concentrations outside the boundary, while protecting the integrity of the VBW after it is installed.

   Response: The goal of expanding the perimeter of the cut-off wall was to capture more of the high-concentration groundwater, so we are pleased that you recognize and agree with the design change.

3. Timing of the VBW: By necessity, there is a delay between the ISS-HB treatment described here and the installation of the VBW and cap. How long is that planned delay?
   - HB filling and liner: With the recent addition of a liner and clean soil fill in the HB, it seems like the injection wells will need to punch through the new liner. Ultimately, it seems like this is not an issue because of the planned VBW and cap. However, before the VBW/cap installation, does the presence of a high density of injection wells pose any issue to the system? Will the drainage system for the liner continue to work during this time, or if not, is it an issue?

   Response: Time between completing ISS and capping is expected to be one to three years (depending on design progress, approvals, contractor availability, and construction duration). While borings for cased holes will penetrate the buried liner for the HB, the borings will immediately have casing installed and a neat cement grout placed in the annulus to seal the boring. This seal will also fill the hole in the liner created by sonic drilling. After injections are completed, the fractured casing will be grouted to further seal potential pathways during the interim period between ISS and capping. Additionally, the design currently has one ZVI fracture above the water table at all locations as a safeguard for potential vertical leakage.

- Monitoring wells: The existing wells in the HB area will be removed or capped, which makes sense given the injection technique being applied across the basin. Is there a plan to continue to monitor the water chemistry in the wells outside/downgradient of the injection field? If so, what is the frequency of that sampling? This seems particularly relevant after the ISS injections but before the VBW is installed.

Response: Please see new section 4.4 of the 95%RD regarding temporary groundwater monitoring shortly after completing the ISS injections inside the HB. Further, monitoring is planned for downgradient of the HB after all remedies have been implemented (i.e., the VBW, cap, downgradient ISS) since this is the aquifer where the Site cleanup criteria apply (inside the cutoff wall is a Waste Management Area where cleanup criteria do not apply). This monitoring program will be presented in the forthcoming design for ISS downgradient of the HB.

The team is attempting to preserve existing monitoring wells downgradient of the HB, although several had to be decommissioned due to other ongoing site activities and wells may have to be removed for barrier wall and cap construction. New wells, once downgradient monitoring is determined, will most likely be installed after the installation of the VBW, cap, downgradient ISS and soil excavations to avoid having monitoring wells hamper these remedial actions.

4. Although I have mentioned it previously, I want to reiterate that the injection approach and the slurry composition is very well designed. It is a clever, technically sound, and novel approach. In addition, the plan includes flexibility and contingencies for challenges that will inevitably arise during full-scale implementation in the field.

   Response: We appreciate your endorsement of the approach and design.

5. I spot checked the calculations in Attachment 3. The assumptions are realistic and the margin of safety (5x above the total estimated mass of U) seems reasonable.

   Response: Thank you for the independent verification.

Attachment 4
Optimization Recommendations for *30% Remedial Design Revision 1 for In-Situ Sequestration of Uranium in Overburden within the Holding Basin*

1. General Comment: Consider adding the option for alternative injection methods. Seal in place schedule 40 PVC then jet injection was considered successful in the pilot and is proposed for the full-scale. It is agreed that there was distribution of ZVI in the saturated soils in the pilot and agree that this method should be described in the full-scale design documents. However, AECOM suggests considering some flexibility in approach to allow other methods/bidders to propose alternatives. For example, AECOM has had recent success injecting ZVI/guar slurry under similar geological conditions by using sonic to predrill to depth, backfill with bentonite (hydrated, packed, let sit for >24 hours) and then use direct push injection tooling. This "should" alleviate the running sand issue and issues getting to target depth. It avoids the issue of having to adapt the double packer system to get at the bottom interval. For an AECOM recent project, the bentonite method allowed a more uniform injection (essentially over the entire vertical profile, instead of lenses every 3 feet). This alternative avoids buying and leaving in place 7,300 feet of PVC casing. Adding this option or allowing bidders to present other options may allow getting more bidders and possibly at lower cost. As written these specifications only allow for one firm – FRx - to bid. As with the seal in place PVC method, any alternative would have to preclude increasing the pH of the aquifer. A performance-based contract (get the ZVI into the aquifer or you don't get paid) should be considered.

   Response: We appreciate the suggested alternative approach and consideration for making the construction open to more contractors. While your suggestion is valid, FRx has site-specific experience, we vetted their approach during pilot testing (e.g., DPT didn't work so we transitioned to cased holes), and we have performance data for fractures installed by FRx. Our goal, as expressed in section 5.1, is to deliver the specified mass of ZVI with an expected distribution. At this point, we feel that is it too risky to consider contractors with alternative implementation approached that are unproven at the Site when we know that FRx can be successful.

2. Section 4.3: The idea of using a single packer and relying on the PVC end cap to hold 600 psi pressure is presented here. There may be difficulties with this approach such as having to remove all the tooling to install the second packer and then running the double packer system back down the hole. This would be further complicated if the aquifer remains pressurized and the hole fills up with ZVI and aquifer sand. We recommend adding text to give the drilling firms the ability to propose other options for getting at the last few feet of depth or consider not directly treating that final depth interval. In theory any DU left in the till material that weeps into the overlying sandy materials will encounter ZVI and be treated.

Response: The single-packer approach was developed in conjunction with FRx and they feel it is feasible. As noted, this approach is more costly and time consuming because it requires the single-packer to be removed after one injection and a double-packer lowered down the well. However, the design team felt it was worth the effort and expense to place ZVI closer to the top of till.

3. Attachment 6: The ZVI specifications are acceptable. AECOM agrees that recycled iron from uncontrolled scrap sources should be excluded. Given the anticipated tonnage (1,000 tons), cost and availability are possible issues. AECOM has had good success with zero valent iron derived specifically from excess casting material and casting sand. The product is typically less expensive and possibly "greener" than other ZVI products.

   Recommend adding "Recycled iron from a casting process would also be an acceptable source". To add another possible ZVI source beyond the two used in bench and pilot would require a bench trial with the new ZVI. Getting competitive bids then deciding if another bench test is worthwhile is suggested. The requirements for sulfur and phosphorus are doable but seem unnecessarily strict. Consider increasing these from <0.15% to <0.30%.

   Response: See response to specific comment 11. In summary, the project team is specifying ZVI that is produced from ore and/or metallurgical processes and manufactured specifically for in-situ groundwater remediation use. The ZVI specifications are stringent because ZVI is the single most important component of the project, and a potential cost savings is not worth the risk of switching to a product that may have inferior performance or deleterious side effects.

Attachment 5

Construction Quality Assurance/Quality Control Plan (CQA/QCP)

DRAFT

CONSTRUCTION QUALITY ASSURANCE/ QUALITY CONTROL PLAN (CQA/QCP)

IN-SITU SEQUESTRATION OF URANIUM IN OVERBURDEN WITHIN THE HOLDING BASIN

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ATTACHMENTS

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1. INTRODUCTION

This Construction Quality Assurance/Quality Control Plan (CQA/QCP) establishes the quality assurance monitoring and documentation procedures that will be used by the Construction Quality Assurance (CQA) Engineer during the Remedial Action (RA) implementation of in-situ sequestration (ISS) for uranium in overburden within the Holding Basin (HB) at the Nuclear Metals, Inc. Superfund Site in Concord, Massachusetts (the NMI Site or Site). The location where the remedy is being implemented includes the footprint within the vertical barrier wall (VBW) and cap around and above the HB, respectively, as well as the area immediately north and west of the HB, referred to as the apron area.

1.1 Purpose of the CQA/QCP

The CQA/QCP shall be used by the CQA Engineer to verify that construction of the RA is accomplished in accordance with the requirements of the design, specifications (including prescriptive and performance specifications), and other applicable construction documents herein collectively referred to as Construction Documents. Additionally, this CQA/QCP is intended for use by the parties involved to assure the quality of construction and complete execution for this project and is herein incorporated into the Construction Documents.

1.2 Construction Quality Assurance and Construction Quality Control

The CQA/QCP is a Site-specific document which addresses the following: (i) project personnel and their respective roles, responsibilities, and authorities, (ii) monitoring and testing activities that will be performed during construction of the remedy components, and (iii) CQA documentation and reporting requirements. In the context of this document, CQA and construction quality control (QC) are defined as follows:

- CQA refers to means and actions used by the CQA Engineer to assess whether materials and construction at the Site meet the requirements of the Remedial Design Report and Contract Documents (e.g., construction is performed in accordance with the means and methods and using the materials specified in the design). CQA will be provided by Geosyntec Consultants, Inc. (Geosyntec) under contract to and working on behalf of the General Contractor, ***de maximis, inc.*** (*de maximis)*. The CQA Engineer will be independent from the Remediation Contractor selected to install and implement the ISS RA and any material suppliers for the RA.
- Construction QC refers to those actions taken by the contractor, sub-contractors, manufacturers, or suppliers, including their designated representatives, to ensure that the materials and the workmanship meet the requirements of the design, specifications, and other applicable construction documents. Construction QC actions and activities (e.g., material testing requirements) are generally defined in the project specifications.

1.3 Roles and Responsibilities

The CQA/QC program's organizational structure is provided in **Figure 5-1**. The duties, responsibilities, and authorities of the entities and personnel identified in this figure as they relate to the CQA/QC program are described below.

1.3.1 Settling Defendants

The Settling Defendants of the Site are Textron Inc. and Whittaker Corporation, as defined in the Site Consent Decree approved by the United States District Court on December 6, 2019. The Settling Defendants are responsible for the completion of the RA and have contracted *de maximis* to serve as their General Contractor for the Site.

1.3.2 Agencies

The lead regulatory agency providing oversight for this project is the United States Environmental Protection Agency (USEPA). Project deliverables and pertinent communications, as described in this CQA/QCP, will be submitted to the USEPA for their review and approval. The Massachusetts Department of Environmental Protection (MassDEP) will also provide review and comments regarding the state regulatory aspects of this project. MassDEP review of RA documents will occur concurrently with that of the USEPA.

1.3.3 Project Coordinator

Bruce Thompson of *de maximis* is the Project Coordinator selected by the Settling Defendants. The Project Coordinator will coordinate and supervise all work under this RA. The Project Coordinator will manage communications with USEPA and MassDEP, as well as communications with the Settling Defendants.

1.3.4 Engineer-of-Record

Carl Elder of Geosyntec is the Engineer-of-Record for the HB ISS RA. Geosyntec has developed the RD Report and will be present throughout the RA to provide clarifications about the design. In their role, Geosyntec will review and approve material submittals, and any changes to the RD will require approval by the Engineer-of-Record.

For this project, Geosyntec will also serve as the CQA Engineer (Section 1.3.7).

1.3.5 General Contractor

de maximis is the General Contractor and will retain Remediation Contractors to implement the Contract Documents in accordance with the RD. As General Contractor, *de maximis* is on Site daily, has overall control of the Site including Site security and safety, is responsible for subcontractor management, and will manage coordination of the HB ISS RA work with other activities ongoing at the Site. Additionally, as stated in Section 1.3.7 and shown in **Figure 5-1**, *de maximis* will retain the CQA Engineer to verify that remediation activities are completed per the RD Report and Contract Documents.

de maximis will oversee the RA, contract Remediation Contractors and procure some materials. Specifically, *de maximis* will procure the microscale zero valent iron (mZVI), hire the drilling contractor who will install cased holes for injections, hire the injection contractor to perform the injections, hire other subcontractors supporting the work (e.g., surveyor, earthwork, radiation safety officer, etc.), and hire Geosyntec as the Engineer-of-Record and CQA Engineer. *de maximis* will also manage funding, change orders, schedule, health and safety, and contractor coordination.

1.3.6 Remediation Contractors

Remediation Contractors are firms hired by *de maximis* for the implementation of the RA. The principal remediation contractors are expected to be a drilling contractor to be selected and FRx, Inc. (FRx) as the injection contractor. Other Remediation Contractors hired by *de maximis* will also participate in implementation of the RA and include firms such as the site surveyor, environmental laboratory (Alpha and GEL), site radiation safety officer (DDES, LLC), site earthwork contractor, and O&M, Inc.

The scope of the Remediation Contractor's activities is to implement work to construct the remedy as set forth in the Contract Documents.

1.3.7 CQA Engineer

Geosyntec will serve as the CQA Engineer and work as a contractor to *de maximis*. As such, the CQA/QC program will be directed and supervised by Geosyntec. The CQA Engineer will be directly accessible to the General Contractor for technical direction during construction.

The responsibilities and duties of the CQA Engineer include the following:

- review and be familiar with the design calculations used to develop the RD Report and subsequent revisions;
- review conformance of material and construction to verify compliance with the intent of the requirements of the RD and Contract Documents;
- review and be familiar with other Site-specific documentation, including the Remediation Contractors' bids;
- conduct periodic Site inspections;
- participate in project meetings as set forth specified in Section 1.5 of this CQA/QCP;
- perform routine CQA activities (e.g., review field reports and interact with the Remediation Contractors on a frequent basis);
- oversee field CQA/QC documentation preparation and organization;
- inspect materials being injected to verify they match those specified in the design;
- verify injection locations match those specified in the design;
- document concentrations and quantities of remediation amendments and total injection volumes for each depth interval and location, and compare these to the quantities specified in the design;
- document potential issues with individual injection locations and depth intervals (e.g., surfacing, incomplete injection, etc.);
- document equipment deficiencies or breakdowns;
- review the Remediation Contractors' submittals;
- document and report deviations from the RD and Contract Documents;

- prepare a drawing of final injection points and accompanying table with amendment quantities injected by location and depth; and
- prepare and certify (Professional Engineer stamp) the RA Completion Report.

The CQA Engineer may designate a CQA Site Manager to oversee aspects of the RA.

1.3.8 CQA Site Manager

The CQA Site Manager will be an employee of Geosyntec working under the direction of the CQA Engineer. The CQA Site Manager supervises CQA activities on the project and is generally present on Site daily. The CQA Site Manager will have on-Site field CQA work experience and an understanding of the scope of the RA. The responsibilities and duties of the CQA Site Manager include:

- attend meetings described in Section 1.5 of this CQA/QCP;
- oversee daily activities performed by the Remediation Contractors;
- prepare daily CQA field reports and observation logs;
- document and report any unresolved deviations from the Contract Documents to the CQA Engineer; and
- provide updates and maintain communications among the Remediation Contractors, CQA Engineer and General Contractor.

Additional responsibilities and duties may be assigned by the CQA Site Manager by the CQA Engineer (e.g., documentation of equipment deficiencies and breakdowns, report preparation, field decisions, etc.). The CQA Engineer and the CQA Site Manager may be used interchangeably throughout the Contract Documents.

1.4 Applicable References

References made herein to any standards issued by an organization, society, institute, association, or governmental agency that apply to the RA construction are presented for reference. Requirements provided in the drawings and project specifications shall govern the RA construction activities. Where standards are mentioned, the most current edition issues by that entity that is in effect as of the date of this CQA/QCP pertain, unless stated otherwise.

1.5 Project Meetings

Three types of meetings will be used to review and maintain the elements of this CQA/QCP:

- preconstruction meeting(s);
- progress meetings; and
- problem or work deficiency meetings.

Each meeting type is described in the following sections.

1.5.1 Preconstruction Meeting

Prior to initiating construction activities, requirements set forth in the RD and Contract Documents for the project will be addressed in a preconstruction meeting. At a minimum, the preconstruction meeting will be attended by the General Contractor, Engineer-of-Record, CQA Engineer, and Remediation Contractor(s). The meeting also may be attended by the USEPA, MassDEP, or their designee. Multiple preconstruction meetings may be performed if the work is executed in phases (e.g., one preconstruction meeting with the drilling contractor for installation of cased holes and a second preconstruction meeting with the injection contractor for the amendment injections).

The purpose of this meeting is to begin planning for coordination of construction tasks, present the schedule and sequence of work, discuss anticipated problems that might cause difficulties and delays in construction, and present the procedures for clarifications and/or changes to the RD and Contract Documents.

The preconstruction meeting should include, but not be limited to, discussions pertaining to the following activities:

- review the roles and responsibilities of each party;
- confirm the lines of authority and communication, and update/finalize project personnel and points of contact;
- review health and safety expectations;
- review Remediation Contractor work plans and critical design details of the project;
- address approved modifications to the RD Report and Contract Documents so that the fulfillment of design specifications or performance standards can be achieved;
- establish an understanding by the parties of the CQA/QCP, and CQA/QC procedures;
- establish work area security and safety protocol in accordance with the Contractor's health and safety plan and site radiation safety requirements;
- confirm investigation-derived waste handling practices and procedures;
- confirm equipment and material laydown locations and traffic flow patterns;
- confirm the methods for preparing and distributing documents and reports;
- confirm acceptance and approval process; and
- establish procedures for processing change notification (i.e., field change forms), change orders, and applications for payment.

Items discussed during the preconstruction meeting will be documented by a person designated at the beginning of the meeting, and minutes will be distributed after the meeting.

1.5.2 Progress Meetings

A progress meeting (via teleconference and/or at the Site) will be held each week (at a minimum) during construction. Progress meetings will be attended by the Remediation Contractor(s), CQA Engineer, and the General Contractor. USEPA and MassDEP representatives may also attend. Topics covered at the progress meetings will normally include:

- health & safety;
- status of work performed to date;
- planned activities for upcoming work;

- status of submittals, field clarifications, and design changes; and
- general open discussion.

Matters requiring action raised in the progress meetings will be communicated to the appropriate parties. Minutes of the progress meetings will be distributed to each party present at the meeting promptly after each meeting by the General Contractor. Minutes of the weekly progress meetings will also serve as weekly field summaries throughout the RA construction.

Daily progress meetings are expected on most days and may include the General Contractor, CQA Site Manager, and the Remediation Contractor(s). These are likely to occur prior to the start of work in the mornings or at the end of each day. The purpose of these meetings will be to discuss health & safety topics, review the previous day's activities, review the upcoming day's activities, coordinate work to be performed during the day, and identify prerequisite activities or potential construction challenges.

1.5.3 Problem or Work Deficiency Meetings

Special meetings will be held if problems or deficiencies are present or determined to be likely. At a minimum, these meetings will be attended by the Remediation Contractor(s), the CQA Site Manager or Engineer, and the General Contractor but may involve other project personnel as deemed necessary. The purpose of these meetings will be to define and resolve the problem or work deficiency as follows:

- Define and discuss the problem or deficiency;
- Review alternative solutions; and
- Implement an action plan to resolve the problem or deficiency.

Items discussed during these meetings will be documented by the General Contractor, and if deemed necessary, written follow-up (e.g., an email) will be transmitted to the affected parties.

2. DOCUMENTATION

2.1 Submittals

Submittals required by the RD and the Contract Documents (e.g., verification that the mZVI material meets the technical specifications) will be logged in at the time of receipt by the Engineer-of-Record. The Engineer-of-Record will review submittals for compliance with the RD and the Contract Documents. A copy of the submittal review form prepared by the Engineer-of-Record indicating the final status of the reviewed submittal will be returned to the Remediation Contractor. A record of the submittal and review form indicating review status will be kept on file by the Engineer-of-Record.

2.2 Daily Logs

Daily logs will be completed in the field by the CQA Site Manager, on behalf of the CQA Engineer, to document the CQA/QC activities. Logs may be supported with photos at the discretion on the CQA Site Manager. At the end of RA construction, the CQA Engineer will provide an RA Completion Report as described later in this section to document as-built conditions and record any deviations from the RD and Contract Documents. The RA Completion Report will also serve as a repository of supporting construction documentation such as observation logs, photographs and test results (if applicable).

2.2.1 Daily Field Reports

The CQA Site Manager will prepare daily field reports. The reports will provide a daily record of construction progress, summarize quality assurance activities, and highlight matters requiring the Remediation Contractors' action.

The daily report will typically include the following information:

- project name, location, and date;
- weather conditions (temperature, wind, and precipitation);
- construction activity in progress;
- equipment and personnel on Site;
- work completed at each injection location;
- quantity and type of materials used;
- compliance with design requirements;
- records of CQA/QC data or measurements;
- items requiring action and/or resolution;
- documentation of meetings; and
- field modifications, including any deviations as further described in Section 4.

An example Daily Field Report is included in **Attachment 5A**.

2.2.2 Cased Hole Construction Log

The CQA Site Manager will prepare records of drilling and construction activities for the cased hole at each injection point. These construction logs will provide the following information:

- field personnel, weather, date, and injection point identification number;
- quantity of water used during drilling;
- general lithology, including depth to top of till;
- depth to bottom of the cased hole; and
- types and quantities of materials used for construction of the well and annular seal.

2.2.3 Injection Logs

The CQA Site Manager will document mZVI injection details for each injection point and each vertical injection interval (i.e., fracture). These injection logs will provide the following information for each injection:

- field personnel, weather, date, and injection point identification number;
- injection depth;
- time injection started;
- time injection completed;
- average water and slurry injection pressures (if available from Injection Contractor);
- mass of mZVI injected;
- volume of guar gel injected;
- quantities of any additional material used for each injection;
- comments on issues encountered, such as amendment slurry daylighting or high back pressure; and
- communications/approvals for field modifications by the CQA Engineer.

A sample injection log is provided in **Attachment 5A**. The CQA Site Manager will utilize a tracking table similar to the table in Sheet 6 of the drawings which specifies the location, elevation and materials to inject at every injection interval during the program. The CQA Site Manager will compare elevations and quantities injected against this tracking table and note deviations on the Injection Log.

<u>Documenting Changes in Injection Amount</u>

Due to the heterogeneity of soils, deviation from design injection quantities may occur at some injections. Injection logs should identify depths where the injected quantity of amendments did not meet design objectives. These locations should be recorded on the injection log and/or a tracking table to provide a running log during the RA on deviations in injected amendment quantities and the balance to ensure the total design volume is met. In situations where the prescribed mass of mZVI cannot be injected at a depth, the design allows material that is unable to be injected at one depth to be added to the mass injected at a nearby fracture. When an amount less than the design amount is injected, logs should note where the residual amendment was injected.

2.3 Photographic Documentation

The CQA Site Manager will be responsible for photographing the construction progress on a frequent basis. Photographic documentation will serve as a record of work progress, materials used, problems, and mitigation activities. These photographs will be stored in a logical order, such as chronological or by task, and available for review. Selected photographs may be included as part of the Daily Field Reports and RA Completion Report.

2.4 RA Report

Upon completion of the injections, the CQA Engineer will prepare a RA Report requesting USEPA's determination that the RA been completed. The RA Report will include

- statements by the Engineer-of Record and by the Project Coordinator that construction of the RA is complete and that the RA is functioning properly and as designed;
- supporting documentation that construction of the system is complete and that the system is functioning properly and as designed; and
- as-built drawings signed and stamped by the Engineer-of-Record.

The RA report will be prepared in accordance with Chapter 2 (Remedial Action Completion) of USEPA's Close Out Procedures for National Priorities List Sites (June 2022) and be certified in accordance with Section 6.5 of Appendix B of the Consent Decree.

2.5 Storage of Records

During the project, reports and records will be stored on-Site or made available upon request allowing for easy access to these documents by the CQA Engineer, CQA Site Manager, General Contractor, or inspection by regulatory personnel.

3. CONSTRUCTION QUALITY ASSURANCE AND QUALITY CONTROL

The following construction tasks and associated CQA/QC activities are expected to be conducted to complete the ISS RA.

3.1 Site Preparation

Prior to performing ISS, the HB will be filled the ground surface grades as part of enabling work to provide a working platform for ISS equipment (i.e., drill rigs to install the cased holes and mixing/injection equipment for ISS) as well as subsequent construction for the VBW.

Injection locations (**Figure 5-2**) will be marked by the General Contractor using a handheld GPS unit and marked using a wooden stake or pin flag (alternatively, locations may be identified and staked by a professional land surveyor). For locations where a stake cannot be driven, such as on concrete, spray paint will be used to mark the injection location. The CQA Site Manager or CQA Engineer will verify locations. Upon mobilization, the drilling subcontractor will inspect the injection locations as part of the pre-construction meeting to assess access, and locations will be adjusted, as needed, in consultation with the Engineer-of-Record.

Most monitoring wells located within and around the HB were decommissioned as part of enabling work. Monitoring wells that remain and are within the radius of influence (ROI) of injection points will be capped with a pressure cap or decommissioned prior to ISS.

Monitoring activities during Site preparation will include the following:

- confirming with the General Contractor that enabling earthwork activities have been completed sufficiently so that the area is ready for ISS work to begin.
- verifying proposed injection locations;
- verifying that work is not proposed to be performed beyond the limits of work;
- verifying that minimal disturbance to surrounding areas occurs during equipment staging activities, and that any such areas are restored by the Remediation Contractor;
- verify that restricted zone(s) have been demarcated and identified (in partnership with the radiation safety officer); and
- verify that IDW handling and equipment and materials laydown area are identified.

3.2 Cased Hole Installation

Prior to cased hole installation, the CQA Site Manager or CQA Engineer will discuss with the driller and General Contractor the planned approach for cased hole installation and determine if it conforms with the requirements of the cased hole installation specification. Additionally, the CQA Site Manager or CQA Engineer will inspect the drilling equipment and materials proposed for use to assess the following:

- general condition of the equipment (e.g., functionality, leaks, operable safety devices, etc.)
- appropriate tooling, casing, and other equipment needed to complete the installation are used; and
- materials brought to the site by the drilling contractor conform with the design.

During installation, the CQA Site Manager or CQA Engineer will verify the following:

- rotosonic drilling methods (or an approved alternative) are used;
- an 8-inch borehole is cored;
- boreholes remain stable and vertical;
- soil cores are inspected to verify that borings reach the top of till (i.e., transition from the stratified drift deposits, which are generally coarser-grained and non-cohesive, to glacial till, which generally consists of a more cohesive, silty matrix); top of till will also be judged based on input from the driller regarding resistance to drilling;
- 4-inch diameter schedule 40 polyvinyl chloride (PVC) casing, capped on the bottom, is lowered into the borehole as specified in the RD Report and Contract Documents;
- the casing is left with a "stick-up" as specified in the RD Report and Contract Documents;
- neat cement grout seals are placed as specified in the RD Report and Contract Documents; and
- grout is allowed to cure for a minimum of 48 hours prior to injections.

The General Contractor (*de maximis*) will direct Remediation Contractor activities, manage health and safety activities, and the containerization and management of IDW generated during the cased-hole installation process.

3.3 mZVI Material Testing

The selected mZVI supplier will be required to provide documentation confirming the mZVI material meets the specifications in the RD. These data will be provided to the CQA Engineer for approval. During the RA, the General Contractor in coordination with the CQA Engineer will periodically collect samples of the mZVI material for analysis of grain size, oil and grease, and elemental analysis in accordance with the table below and provide results to the CQA Engineer.

Test	Method	Frequency
Particle size distribution	ASTM D422	1 per 250,000 pounds
Oil and grease	EPA Method 9071B	1 per 250,000 pounds
Elemental and leaching analysis	Iron - EPA 200.7 modified Silicon - EPA 200.7 modified Sulfur – EPA 200.7 modified Phosphorus - EPA 200.7 modified Thorium – Modified HASL 300 Uranium – Modified HASL 300	1 per 250,000 pounds
Leaching Analysis	SPLP (EPA method 1312) for: Arsenic Barium Cadmium Chromium	1 per 250,000 pounds

	Lead Mercury Selenium Silver	
Polychlorinated Biphenyls	EPA Method 8082	1 per 250,000 pounds

Allowable limits for the above CQA analyses are provided in the ZVI specification (Appendix 6 of the Remedial Design).

3.4 ISS Injections and Cased Hole Abandonment

Prior to conducting injections, the CQA Engineer will review the Remediation Contractor's injection plan describing the tooling and procedures for high pressure jetting and amendment mixing. The tooling should allow the injection contractor to perform the deepest injection within 4 feet of the bottom of the cased hole. The mixing procedures should produce a homogenous injectate with appropriate dose of remedial amendments.

Prior to initiating injection work, the CQA Site Manager or CQA Engineer will verify the following:

- the general condition of the injection equipment is satisfactory (e.g., functionality, no leaks, operable safety devices, etc.);
- materials brought to the Site by the injection contractor conform with the RD Report and Contract Documents;
- mZVI being used conforms with the RD Report and Contract Documents;

During injections, the CQA Site Manager or CQA Engineer will record material quantities and injection depths on field forms, monitor the surrounding ground surface and PVC casings for breakthrough or surfacing of injection amendments, and document any deviations from the design. The CQA Site Manager or CQA Engineer will verify the following:

- injection depth intervals for each location match the design specification;
- the target volume of amendments has been injected into each injection location and depth; and
- where applicable, corrective actions are undertaken when amendment surfacing is observed and/or less than the design dose is added at an injection interval.

At the completion of injections at a location, the CQA Site Manager or CQA Engineer will confirm that the cased hole is abandoned by filling the casing to the ground surface with grout. Injection cased holes may be decommissioned in batches if better for work flow. The General Contractor (*de maximis*) will direct Remediation Contractor activities, manage health and safety activities, and manage IDW generated during the injections and cased hole abandonment.

3.5 Temporary Monitoring Well Installation and Development

Prior to cased hole installation, the CQA Site Manager or CQA Engineer will discuss with the General Contractor and driller the planned approach for temporary monitoring well (TMW) installation and determine if it conforms with the requirements of the TMW installation specification.

Prior to the TMW installation, the CQA Site Manager or CQA Engineer will inspect the drilling equipment and materials proposed for use to assess the following:

- general condition of the equipment (e.g., functionality, leaks, operable safety devices, etc.)
- appropriate tooling and other equipment needed to complete the installation are used; and
- materials brought to the site by the drilling contractor conform with the design.

During installation, the CQA Site Manager or CQA Engineer will verify the following:

- the TMWs are located at approximately the same locations and are screened in the same elevation intervals as the former monitoring wells they are replacing; and
- the TMWs are installed as specified in the RD Report and Contract Documents and according to SOP NMI-GW-003.

Following installation, the CQA Site Manager or CQA Engineering will verify the following:

- the TMWs are developed in accordance with the SOP NMI-GW-002.

The General Contractor (*de maximis*) will direct Remediation Contractor activities, manage health and safety activities, and the containerization and management of IDW generated during the TMW installation process.

3.6 Site Cleanup and Demobilization

Following completion of remediation activities, Remediation Contractors will demobilize. Prior to demobilization, the CQA Engineer will verify the following:

- construction activities have been completed in accordance with the RD Report and Contract Documents and with approval from all relevant parties;
- decontamination is conducted in accordance with SOP NMI-007 prior to equipment leaving the Site;
- tools and equipment are screened by the radiation safety officer prior to leaving the exclusion zone and Site; and
- IDW is properly stored and secured in the location designated by the General Contractor.

Multiple demobilization events may occur if the project is performed in phases (e.g., one demobilization for the drilling contractor after cased hole installation, and a second demobilization by the injection contractor after amendment delivery).

4. DEFICIENCIES, PROBLEMS, AND REPAIRS

The following sections describe procedures to address changes in the field as well as how to address common deficiencies or problems associated with ISS.

4.1 Management of Change

Clarifications and/or changes to the drawings, specifications or other Contract Documents may be necessary during construction. In such cases, the CQA Site Manager or CQA Engineer will notify other project personnel as appropriate.

The General Contractor may submit a written request for information (RFI) to request clarification of a Contract Document or RD requirement. The CQA Engineer will submit back to the Remediation Contractor a response to each RFI providing the requested clarifying information.

The General Contractor may submit a written request for a change or variance of the Contract Documents or RD requirements via a Field Change Form (FCF). The CQA Engineer will evaluate the request, technical equivalency (if appropriate), and issue a response to the FCF. If a proposed change is deemed a major change by the CQA Engineer, changes will be formally approved only with the written agreement of the CQA Engineer, Engineer-of-Record, Project Coordinator, and potentially USEPA. Minor changes may be approved by only the CQA Engineer. All accepted FCFs will constitute a formal change to the Contract Documents and major changes accepted through the FCF process may be subject to a monetary change order per the Contract Documents.

An exception to the written FCF process is made for changes of injection amendment quantities at individual injection intervals. Due to heterogeneities in the overburden soils, it is anticipated that some injection depths may not accept the total design quantity of amendments. The RD includes flexibility in this regard without a FCF by allowing material that cannot be injected into a given injection interval to be reallocated to a nearby injection interval (e.g., a subsequent injection interval at the same location, or an injection interval at a similar elevation at an adjacent location). To prevent delays, the CQA Site Manager or CQA Engineer will verbally discuss such a change with the General and Remediation Contractor and make a field decision about where the reallocated amendments will be injected. This change may occur without a FCF but will be documented in the injection log.

4.2 Deficiencies and Problems

If a deficiency or non-compliance is discovered, the CQA Engineer (or the CQA Site Manager if designated by the CQA Engineer), will promptly evaluate the extent and nature of the defect. Potential examples of a deficiency and problem might be the Contractor providing the wrong pipe for cased holes, mZVI not meeting specifications, or equipment mobilized by the Remediation Contractor arriving in disrepair. Examples of implementation deficiencies/problems include drilling more than 5 feet into till, equipment breakage during project execution, or loosing equipment "down-hole" when drilling or performing an injection. The extent of the deficiency/problem will be evaluated by observations, a review of records, and/or other means deemed appropriate.

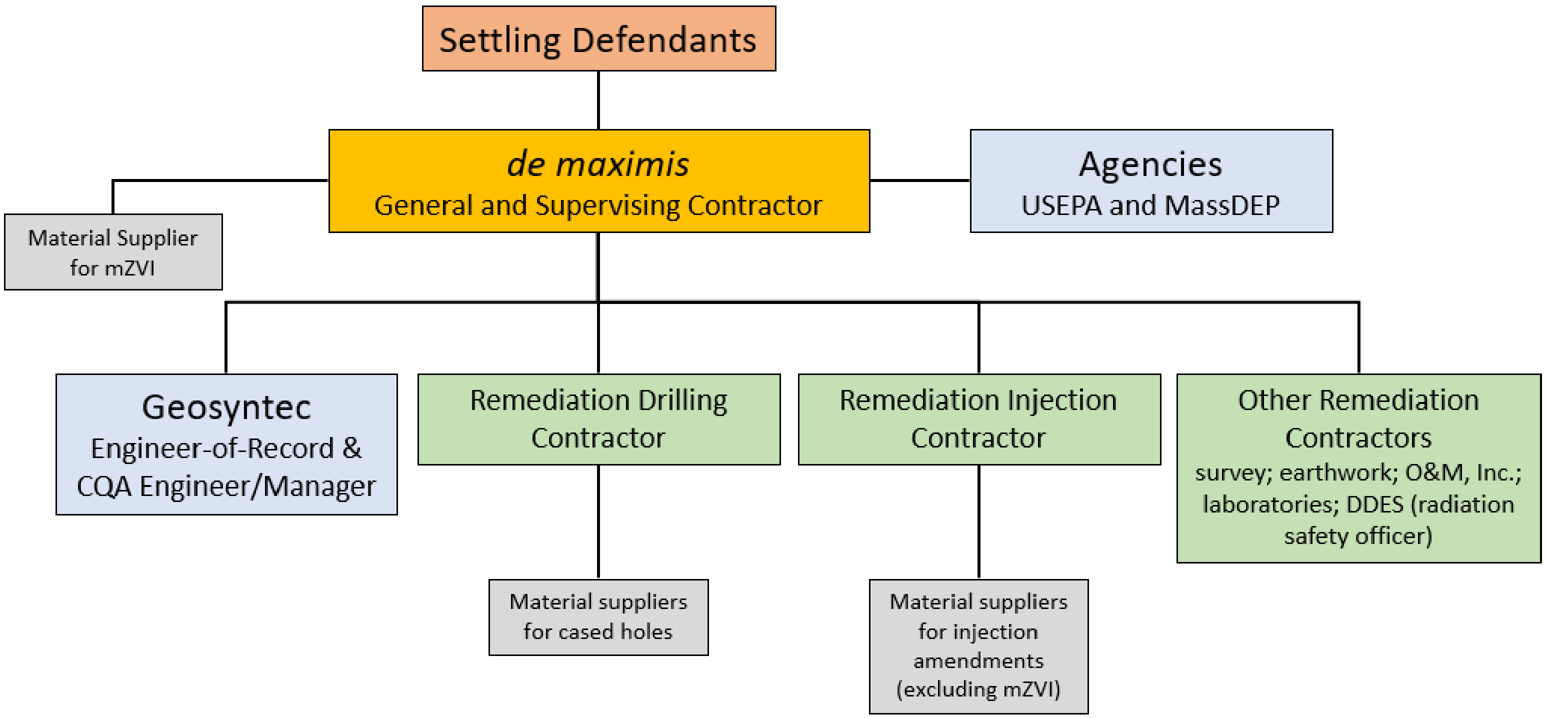
After defining the extent and nature of a deficiency/problem, the CQA Engineer or CQA Site Manager will promptly notify the Remediation Contractor and General Contractor to schedule appropriate resolution.

The Remediation Contractor shall correct the deficiency/problem to the satisfaction of the CQA Engineer, the General Contractor and the Engineer-of-Record (if a design change). If a project specification criterion cannot be met, or unusual weather conditions hinder work, then the General and Remediation Contractor shall develop and present to the alternative solutions as a FCF for review and approval.

FIGURES

FIGURE 5-1

CQA/QC ORGANIZATIONAL STRUCTURE
REMEDIAL ACTION



LEGEND

- EXISTING MAJOR CONTOUR
- EXISTING MINOR CONTOUR
- PROPOSED CUTOFF WALL
- 1,000 — URANIUM CONTOURS IN OVERBURDEN GROUNDWATER (µg/L) - APRIL 2023 (DASHED WHERE INFERRED)
- HISTORICAL BORING LOCATIONS WHERE PRINCIPAL THREAT WASTE WAS ENCOUNTERED
- IP-01 — ISS RADIUS OF INFLUENCE OF 15 FEET
  - FILLED ROIs SHOW ISS INJECTIONS THAT EXTEND THROUGH UNSATURATED ZONE TO THE BASE OF THE FORMER HOLDING BASIN
  - PURPLE ROIs SHOW ISS IN APRON AREAS
  - BLACK DOT IS THE LOCATION OF CASED BORINGS FOR ISS
- INJECTION / WORK AREA
- PROPOSED LAYDOWN / WORK AREA
- TMW-SD24 — PROPOSED TEMPORARY MONITORING WELL

REV	DATE	DESCRIPTION	DRN	APP

de maximis, inc.

Geosyntec consultants

TITLE: ISS INJECTION POINT LAYOUT IN THE HOLDING BASIN

PROJECT: 95% REMEDIAL DESIGN: IN SITU SEQUESTRATION OF URANIUM IN OVERBURDEN GROUNDWATER WITHIN THE HOLDING BASIN

SITE: NUCLEAR METALS INC. SUPERFUND SITE
CONCORD, MASSACHUSETTS

DRAFT

DESIGN BY:	GKW	DATE:	FEBRUARY 2024
DRAWN BY:	BEG	PROJECT NO.:	BR0090E
CHECKED BY:	DGJ	FILE:	BR0090C D005.DWG
REVIEWED BY:	CSM	FIGURE NO.:	5-2
APPROVED BY:	CRE		

SCALE IS BASED ON 22" X 34" NON-REDUCED SHEET SIZE (BORDER = 21" X 32")

GEOSYNTEC-PW-01\DOCUMENTS\CLIENTS\NMI - NUCLEAR METALS INC\BR0090C - ISS REMEDIAL DESIGN - OVERBURDEN GROUNDWATER\CADD\01 - ISS DESIGN\DRAWINGS\SHEETS\BR0090C D005.DWG

ATTACHMENT 5A

SAMPLE FIELD FORMS

DAILY FIELD REPORT

Geosyntec consultants
289 Great Road
Acton, Massachusetts, 01720
(978)263-9588 Fax (978)263-9594

Project Name: ______________________ Date: ______________________ Page ___ of ___

Project Number: ______________________ Primary Activities: ______________________

Field Personnel: ______________________

Recorded By: ______________________

Weather: ______________________

Time	Description of activities - **location of work, work performed, equipment & personnel used, incidental information**

Geosyntec consultants

engineers | scientists | innovators

Project: NMI Superfund Site

Project No. : BR0090D

Borehole ID:

Drilling Co. :

Date :

Drillers:

Weather:

Method:

Borehole Diameter:

Geologist:

Total Depth of Boring:

Depth to Water:

Cased Hole Construction Diagram		Boring Information	
Construction Diagram		Depth (feet)	Soil/Rock Description
		0	
		5	
		10	
		15	
	<--- seal material:	20	
		25	
		30	
		35	
	<----- casing material	40	
	<----- casing diameter	45	
		50	
		55	
		60	
		65	
		70	
		75	
		80	
		85	
		90	
	Bottom ft bgs	95	
scale to right does not apply to cased hole construction. Depth to bottom noted above.		100	

Additional Notes:

Jet Injection Log

Project Name:	NMI Superfund Site		Page ____ of ____
Project Number:	BR0090D	**Date:**	
Field Personnel:		**Weather:**	

Location ID	Injection Depth (ft bgs)	Time Injection Started	Time Injection Completed	Guar Gel (gal)	ZVI (lbs)	Water Blaster Injection Pressure (psi)	Average Slurry Injection Pressure (psi)	Evidence of Daylight (Y/N; if Y, gal)	Comments (e.g., where daylighting observed, difficulty with tooling, why injection cannot be completed at specified depth)
			Totals						

Additional Notes

Geosyntec
consultants
289 Great Road
Acton, Massachusetts, 01720
(978) 263-9588 Fax (978) 263-9594

Well Completion Record

Well ID ____________________ Site Location ____________________
Project Name ____________________ Field Personnel ____________________
Project Number ____________________ Recorded By ____________________

Permit Number ____________________
Installation Date(s) ____________________
Drilling Method ____________________
Borehole Diameter ____________________
Drilling Contractor ____________________
Driller ____________________
Drilling Fluid ____________________
Fluid Loss During Drilling ____________________

Materials Used

Riser Pipe: Diameter ____________
Construction
☐ PVC schedule ____________
☐ Stainless Steel
☐ Other ____________

Slotted Area: Length ____________
Diameter ____________
Slot Size ____________
Construction
☐ PVC schedule ____________
☐ Stainless Steel
☐ Other ____________
Silt Trap Used ☐ Yes ☐ No

Bottom End Cap: ☐ Male ☐ Female ☐ Slip
☐ PVC
☐ Stainless Steel (flat bottom)
☐ Other ____________

Top Cap: ☐ Male ☐ Female ☐ Slip ☐ J Plug
☐ PVC
☐ Stainless Steel
☐ Other ____________

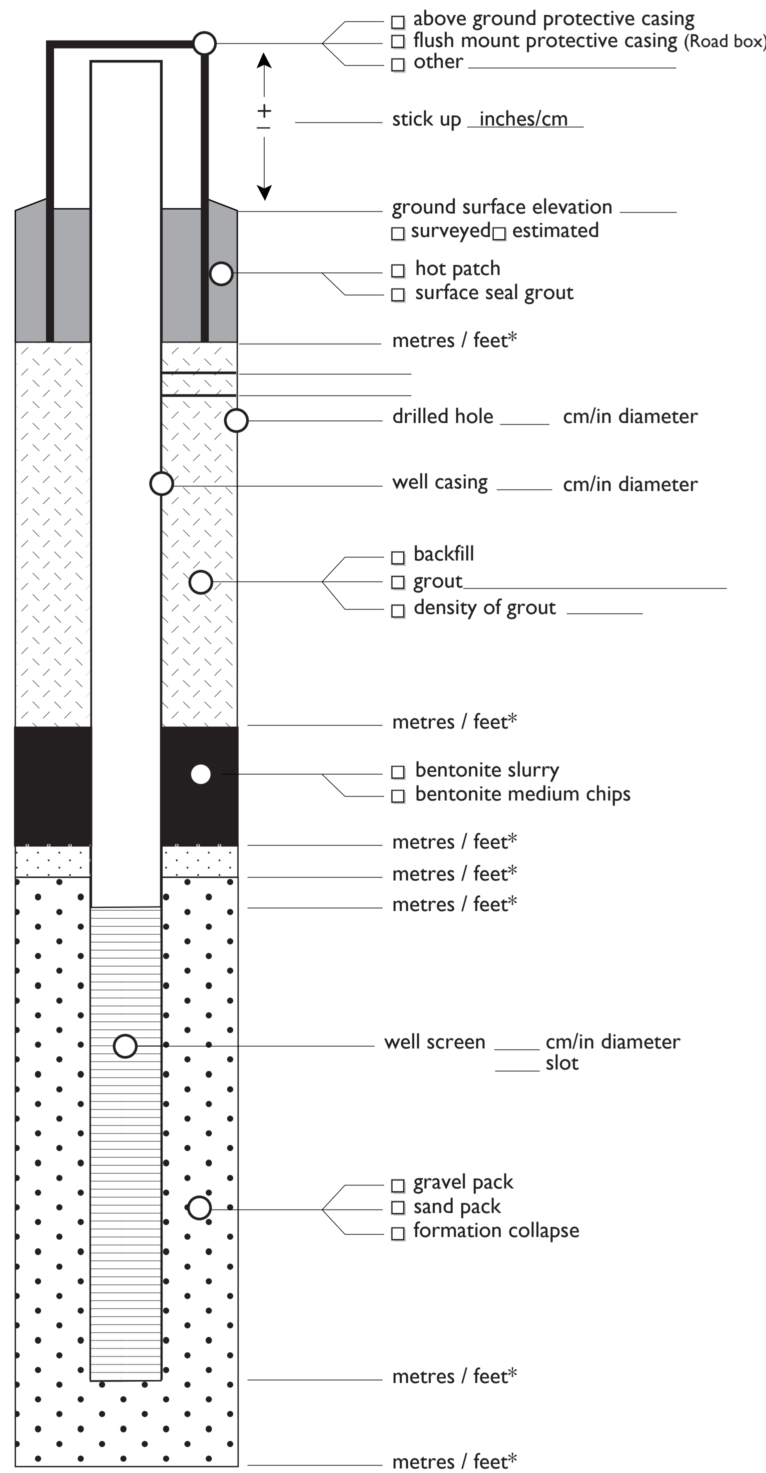
Protective Casing: Length ________ ft/m
Diameter ____________
Construction
☐ Cast Aluminum
☐ Cast Steel
☐ Other ____________

Casing Installation: Length ________ metres/feet
Diameter ________ cm/inches
Material ____________

Sandpack:
Coarse Sand: ___bags of___ kg/lb per bag Size ________
Fine Sand: ___ bags of___kg/lb per bag Size ________

Seal:
Bentonite Pellets: ___ bags of___ kg/lb per bag Type ________
Bentonite Slurry: ___ bags of___ kg/lb per bag Type ________

Grout:
Cement: ___ bags of___ kg/lb per bag Type ________
Bentonite: ___bags of___ kg/lb per bag Type ________



Measuring Point is Top of Well Casing
Unless Otherwise Noted

* Depth Below Ground Surface

MONITORING WELL DEVELOPMENT PURGING & SAMPLING RECORDS

Geosyntec consultants
289 Great Road, Suite 202
Acton, Massachusetts, 01720
(978)263-9588 Fax(978)263-9594

Well ID:______________________ Well Diameter:______________ Intake Depth:__________
Project Name:______________________ Total Depth of Well:______________________
Project Number:______________________ Initial Depth to Water:______________ Time:__________
Date:______________________ Casing Volume:______________________
Recorded By:______________________ Depth to Water after Purging:______________ Time:__________
Sample ID:______________________ Method of Purging:______________________
Duplicate ID:______________________ Method of Sampling:______________________
Weather:______________________ Multi-meter ID:______________ Turbid ID:__________

Time	Depth to water	Pumping rate	Cumulative volume	Temp	pH	Specific conductance	D.O	ORP	Turbidity	Comments
	(ft btoc)	mLpm	L or gals	°F or °C	(units)	(µS / cm)	(mg / L)	(mV)	(NTU)	odor, color, sediment load, well condition, presence of product

Samples collected	Time collected	Container type	Container size	Preservative

Notes: (well condition, nearby activities or changes in land use, odors, problems, deviations from plan, etc.)

Attachment 6

Zero Valent Iron Specification

Minimum Specification for Zero-Valent Iron (ZVI) for ISS in the Holding Basin

A. The ZVI must be designed and manufactured specifically for groundwater remediation and in-situ use. ZVI must also be compatible with subsurface delivery using pressure injection.

B. The ZVI material shall be a high-purity, granular iron powder free of debris, waste, foreign objects, iron oxides, and oil/grease. ZVI shall be produced from ore and/or metallurgical processes and not from scrap metal.

C. Particle size shall meet the minimum gradation requirements below. Preference will be given to products with particle size distributions resulting in higher permeability of the ZVI material when emplaced in the subsurface by injection (e.g., larger particle size within the specified range, more uniform particle size).

Sieve Opening Size	Percent Passing by Weight
75 microns	< 10%
150 microns	< 30%
600 microns	> 80%

No particles shall be larger than 2 mm.

D. The ZVI material shall meet or exceed the chemical analysis below:

Parameter	Weight % or milligrams per kilogram (mg/kg)
Iron	> 93%
Carbon	< 3.5%
Oxygen	< 3.0%
Silicon	< 2.5%
Sulfur	< 0.15%
Phosphorus	< 0.15%
Poly Chlorinated Biphenyls	< 1 mg/kg (note 3)
Thorium	< 7.4 mg/kg (note 3)
Uranium	< 2.7 mg/kg (note 3)
Oil & Grease	Non-detect (note 4)
Parameter	**Leaching analysis by SPLP (notes 1 and 2)**
Arsenic	<10 ug/L (note 3)
Barium	<2,000 ug/L
Chromium	<100 ug/L (note 3)
Lead	<15 ug/L
Cadmium	<5 ug/L
Mercury	<2 ug/L

Selenium	<50 ug/L
Silver	<100 ug/L (note 5)

1 – Synthetic Precipitation Leaching Procedure (SPLP) test performed per SW-846, method 1312.

2 – Maximum allowable SPLP concentrations are USEPA Maximum Contaminant Level (MCL) for drinking water.

3 – Maximum allowable SPLP concentration coincides with the Site clean-up level in overburden groundwater (ROD, Table L-1) or soil clean-up levels (ROD, Table L-2).

4 - Oil & grease to be non-detect when analyzed by SW-846 method 9071B.

5 – For compounds without a primary MCL, the secondary MCL applies.